WADI FAYNAN SERIES VOLUME 2

LEVANT SUPPLEMENTARY SERIES VOLUME 6

ARCHAEOLOGY AND DESERTIFICATION

The Wadi Faynan Landscape Survey, Southern Jordan

Edited by
Graeme Barker, David Gilbertson, and David Mattingly

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Aerial photograph of the eastern section of the wide braid-plain of the Wadi Faynan, southern Jordan looking east, showing its confluence at Khirbat Faynan. (APA98/SL38.22, 20 May 1998 = Kennedy and Bewley 2004, 214, fig. 11.10A.)

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Dedicated to the people of Faynan

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List of contributors

ADAMS, R. 3536 Faner Hall, Department of Anthropology, Southern Illinois University, Carbondale IL 62901-4502, USA
rbadams@siu.edu

BAILEY, D. M. The Department of Greek and Roman Antiquities, The British Museum, Great Russell Street, London, WC1B 3DG, UK
dbailey@thebritishmuseum.ac.uk

BARKER, G. McDonald Institute for Archaeological Research, Downing Street, Cambridge, CB2 3ER, UK
gb314@cam.ac.uk

BEECH, M. Head of Division - Cultural Landscapes, Historic Environment Department, Abu Dhabi Authority for Culture and Heritage (ADACH), P.O. Box 2380, Abu Dhab, United Arab Emirates
mark.beech@cultural.org.ae

BOWSHER, J. Museum of London Archaeology Service (MoLAS), Mortimer Wheeler House, 46 Eagle Wharf Road, London, N1 7ED, UK
jbowsher@molas.org.uk

CREIGHTON, O. Department of Archaeology, University of Exeter, Laver Building, North Park Road, Exeter, EX4 4QE, UK
o.h.creighton@exeter.ac.uk

DALY, P. Asia Research Institute, National University of Singapore, 469A Tower Block, Bukit Timah Road, #10-01, Singapore, 259770
aripd@nus.edu.sg

DULLER, G. Institute of Geography and Earth Sciences, The University of Wales, Aberystwyth, Llandinam Building, Penglais Campus, Aberystwyth, Ceredigion, SY23 3DB, Wales, UK
ggd@aber.ac.uk

GILBERTSON, D. School of Geography, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK
david.gilbertson@plymouth.ac.uk

GILLMORE, G. School of Earth Sciences and Geography, Kingston University, Penrhyn Road, Kingston upon Thames, Surrey, KT1 2EE, UK
G.Gillmore@kingston.ac.uk

GRATTAN, J. Institute of Geography and Earth Sciences, The University of Wales, Aberystwyth, Ceredigion, SY23 4PP, UK
jpg@aber.ac.uk

HUNT, C. School of Geography, Archaeology and Palaeoecology, Queen's University Belfast, Archaeology Building, 42 Fitzwilliam Street, Belfast, BT7 1NN, Northern Ireland, UK
c.hunt@qub.ac.uk

JOHNSON, E. Archaeological Services, University of Leicester, University Road, Leicester, LE1 7RH, UK
embe1@leicester.ac.uk

MATTINGLY, D. School of Archaeology and Ancient History, University of Leicester, University Road, Leicester, LE1 7RH, UK
djm7@leicester.ac.uk

MCLAREN, S. Department of Geography, University of Leicester, Leicester, LE1 7RH, UK
sjm11@leicester.ac.uk

NEWSON, P. Department of Archaeology, Durham University, Durham, DH1 3LE, UK
p.g.newson@durham.ac.uk

PALMER, C. Council for British Research in the Levant, c/o 10 Carlton House Terrace, London, SW1Y 5AH, UK
carol.palmer11@btinternet.com

PARTON, H. School of Archaeology and Ancient History, University of Leicester, University Road, Leicester, LE1 7RH, UK
hlp6@le.ac.uk

PHILLIIPS, P. SITA Centre for Sustainable Wastes Management, University of Northampton, Park Campus, Boughton Green Road, Northampton, NN2 7AL, UK
paul.phillips@northampton.ac.uk

PYATT, F. B. Interdisciplinary Biomedical Research Centre, School of Science and Technology, Nottingham Trent University, Clifton Lane, Nottingham, NG11 8NS, UK
brian.pyatt@ntu.ac.uk

Reynolds, T. School of Continuing Education, Birkbeck College, University of London, 26 Russell Square, London, WC1B 5DQ, UK
te.reynolds@bbk.ac.uk

el-Rishi, H. Department of Geography, Gar Yunis University, Bengazi, Socialist People's Libyan Arab Jamahariya

Smith, H. The School of Conservation Sciences, Bournemouth University, Tolpuddle House, Talbot Campus, Poole, Dorset, BH12 5BB, UK
hsmith@bournemouth.ac.uk

Tomber, R. Visiting Fellow, Department of Conservation, Documentation and Science, The British Museum, London, WC1B 3DG, UK
rtomber@thebritishmuseum.ac.uk

Preface and acknowledgements

The Wadi Faynan is a harshly beautiful and desertic landscape in southern Jordan, situated between the lowland hyper-arid deserts of the Wadi 'Arabah to the west and the rugged and wetter Mountains of Edom to the east. *Archaeology and Desertification* presents the results of the Wadi Faynan Landscape Survey, an inter-disciplinary study of landscape change undertaken in the Wadi Faynan between 1996 and 2000 by a team of archaeologists and geographers with the goal of contributing to present-day desertification debates by providing a long-term perspective on the relationship between environmental change and human history. We embarked on the project because the abundant archaeological remains already known in the Wadi Faynan – settlements, cemeteries, field systems, and mining residues – indicated that its past had been characterized by episodes of settlement and land use very different from those of today, so the Wadi Faynan seemed an ideal location for investigating the long-term 'archaeological history' of interactions between a desertic landscape and its human inhabitants. Whereas archaeologists, historians, and geographers – and the popular press – have generally focused on either climatic change or human agency as the primary culprit of desertification, the Wadi Faynan Landscape Survey instead reveals changing and complex interactions between environment and people from the early Holocene to the present day. In partnership with the other projects working in the study area, the project provides a long-term perspective on the strategies by which the ancient inhabitants of Wadi Faynan managed their challenging environment, the solutions they developed, their successes and failures, and their short- and long-term environmental impacts. We demonstrate that the modern landscape of the Wadi Faynan is a complex palimpsest of multiple episodes of aridification, desertification, and partial recoveries; of episodes of changing technologies; of human and economic impacts with different intensities and at different scales. It is a story of fragility and sensitivity of people and landscape in the face of a litany of problems, but it is also a story of resilience of the landscape and its human inhabitants. Over the last ten thousand years the interactions between climate, climatic change, biodiversity, agriculture, economic, and political activities have been manifestly complex. The richness of the project's palaeoclimatic, archaeological, and palaeoecological data provides no simple cause-and-effect models but rather an environmental/cultural history of complex pathways, synergies, and feedbacks operating at many different geographical scales, rates, and intensities. We hope that the project's findings on the complexity of past and present people:environment relations in the Wadi Faynan affirm the power of interdisciplinary landscape archaeology to contribute significantly to the desertification debate. With global warming through the course of this century likely to threaten the lives of millions of people in the semi-arid and arid lands that comprise over a third of the planet, with potentially dire consequences for adjacent populations in better-watered regions, understanding the complexity of past responses to aridification has never been more urgent.

A second large theme of the research has concerned the creation and operation of landscapes of power – here characterized by the emergence of complex states in the Iron Age and Nabataean periods and by the incorporation of the Jordanian desert into the Roman empire. As we shall see, the concurrence of new forms of political order and the industrial-scale exploitation of natural resources had profound environmental consequences.

The initial seasons of the Wadi Faynan Landscape Survey were funded by the Humanities Research Board of the British Academy, the University of Leicester's Research Fund, and the British Institute at Amman for Archaeology and History, the later seasons by the Arts and Humanities Research Board, the Council for British Research in the Levant, and the Society of Antiquaries. Analytical work at the University of Wales Aberystwyth was supported by funds from the Arts and Humanities Research Board, the British Academy, the Council for British Research in the Levant, and the University of Wales Aberystwyth. Thanks are expressed to all these institutions. We would also like to acknowledge the support of the Government of the Socialist People's Libyan Arab Jamahariya for the Doctoral Research Scholarship of Mohamed el-Rishi (Hwedi Mohamed) that enabled him to undertake the palynological analyses at the University of Huddersfield, and the Natural Environment Research Council for the Doctoral Research Studentship that enabled Paul Newson to undertake the GIS analysis of the Faynan 'field system' data.

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Glossary

Amygdaloid: almond-shaped – refers to a particular form of biface (see below)

Anastomosing: the wadi floor has several small distributary channels that branch and then rejoin; as a result the channels may be separated by small linear barriers of boulders, cobbles, or gravel.

Aplite (granite): a light-coloured even- and fine-grained granitic rock that contains much quartz.

Arkosic: a sandstone with much quartz that contains more than 25% feldspar in its composition.

Biface: a stone tool worked on both faces, made on a flake or from a nodule. Often completely worked on both faces with a working edge around its entire periphery and commonly known as a handaxe. It is a type fossil for the Acheulean techno-complex which dates from between 1.4 Myrs and *c.*150,000 yrs BP and is found in Africa and Eurasia excluding the Far East and Southeast Asia.

Boulder trains: a line or thin layer of boulders that appears to stream out from, and can be traced back to, an identified source area.

Calcretized: soils or sediments that have been cemented by (mainly) calcium carbonate, producing a calcrete.

Cation: a term used in physics and chemistry to describe a positively charged ion.

Clast: a fragment or particle of broken-down rock.

Cordiform: a heart-shaped biface.

Diagenesis: changes that have taken place within a deposit as a result of its partial burial and minor changes caused by pressure or temperature, such as recrystallization, dissolution, cementation.

Diamicton: an unlithified and unsorted conglomeratic deposit, typically containing a wide range of sizes of particles.

Diatom: a type of unicellular algae, its presence pointing to an aquatic environment.

Dinoflagellate cyst: a type of microfossil that is the resting stage of a type of algae, its presence pointing to an aquatic environment.

Distributary: a natural stream channel.

Down-throw: the relative displacement downwards of rocks on one side of a geological fault compared with material on the other side of the fault.

Enceinte: fortification wall.

Epsilon cross-bedding: a type of cross-bedding, that is stratification, produced by the lateral accretion of a bar on a river bed.

Fluvial: produced by a stream or river.

Fluviatile: sediments of fluvial origin.

Graben-infill: sediments that have infilled the depression caused by the movement downwards between faults of a linear-shaped block of the earth's crust.

Horst: a block of the earth's crust that has been uplifted between faults.

Imbricated: where the sedimentary particles overlap one another in the manner that tiles overlap on a roof; the type of sedimentary structure that requires moving water; the particles 'lean' towards the direction from which the flow has come.

Indurated: hardened areas in sediments or soils that have been produced by exposure to the atmosphere, desiccation, cementation, or crystallization within the materials.

Induration: the processes of hardening in sediments or soils; typical processes are exposure to the atmosphere, desiccation, cementation, or crystallization within the materials.

Lacustrine: of lakes, ponds, or pools.

Lithification: the processes which change loose, unconsolidated, sediments into rock.

Monocotyledonous: belonging to one of the group of plants such as grasses or sedges, in which the embryo bears a single cotyledon – an embryonic leaf.

Morpho-stratigraphic: in which sediments or landforms are organized into relative age groupings based upon their relative elevations and positions in the landscape.

Ovate: an oval-shaped biface.

Palaeochannel: an old channel.

Ped: an aggregate of soil with distinctive structure, strength, and shape that contribute to the overall structure of the soil.

Pedogenesis: the process whereby soils develop over time.

Penecontemporaneous: approximately the same age; or perhaps shortly before or after by an indeterminate amount of time.

Phytoliths: minute particles, typically of opaline silica, formed inside a plant.

Pull-apart basin: an area of the earth's crust that has been pulled apart by forces acting within the crust, which has allowed an area of the earth's crust to move downwards.

Pyroclastics: volcanic rocks of fragmented particles produced by explosive volcanic events.

Shocked gravels: sediments that have been shaken and mixed, presumably by the shaking effects of earthquakes.

Strike-slip faulting: displacement of one portion of the earth's crust with respect to another as a result of wrench- or tear-faulting producing lateral – horizontal – movements along or parallel to the fault.

Sub-arkosic: properties approaching those of arkosic sediments: that is, comparatively rich in feldspars.

TIMS: depending upon the context, a type of remote sensing typically from an aircraft or satellite using thermal infra-red multi-spectral scanners or Thermion Mass Spectrometry; a type of rapid geochemical analysis that is used as an alternative to ICPMS.

Toposequence: a sequence of soils or landforms with distinctive characteristics that are related to their topographic situation, typically where older materials are higher (but this interpretation may need to be justified).

Unlithified: sediments that have not been transformed into rock.

VAM: Vesicular Arbuscular Micorrhyzae, a type of microfossil. VAMs are fungal symbionts on the roots of plants, the outer wall surviving as balloon-shaped palynomorphs which are highly resistant to oxidation. Since VAMs originate in soil profiles, they can only be incorporated into waterlain deposits if liberated by soil erosion.

Volcaniclastics: fragmented volcanic rocks.

PART I
Research Themes, Methods, and Background

1. The Wadi Faynan Landscape Survey: research themes and project development

Graeme Barker, David Gilbertson, and David Mattingly

1.1 Introduction

> Desertification: land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNEP 1992).

> I searched for palaeohydrological clues to determine whether processes of flooding and desertification in the past were a function of climate changes or human activity. A good example is the desertification of the cities and agricultural farms that flourished in Nabataean, Roman, and Byzantine times in the arid part of the Levant. Most contemporary archaeologists, historians, and ecologists maintain this desertification was for anthropogenic reasons. (Whilst) this investigation was progressing … the natural cause became more and more convincing (Issar 2003: xiii).

This book explores the evolution of the human and natural landscapes of the Wadi Faynan in southern Jordan, situated at the mountain front where the lowland hyper-arid deserts of the Wadi ʻArabah in southern Jordan meet the rugged and wetter Mountains of Edom (Figs 1.1, 1.3). It seeks to demonstrate how interdisciplinary landscape archaeology can provide a long-term perspective on how people in the past coped with and managed the risks of living in what is now a difficult and arid environment – the research problems emphasized in the definition and quotation above.

A common feature of a well-structured final publication of an archaeological and palaeoenvironmental field project such as the Wadi Faynan Landscape Survey is an introductory chapter that outlines the aims and objectives of the field programme. This normally begins with the general research problems that interested the project director(s) at the time the project was being planned, followed by the justification of the selection of the site (in the case of an excavation) or the study area (in the case of a survey project) as the ideal 'laboratory' where these problems could be appropriately addressed. Usually the next stage is to elaborate the methodologies used: commonly we learn that the need for a multi-disciplinary approach was recognized at the outset, and a multi-phase strategy was then devised for its effective implementation. In publishing their previous field projects, the authors of this chapter have written exactly these kinds of introductory discussions (Barker 1995; Barker *et al.* 1996a; Coccia and Mattingly 1993; Gilbertson *et al*. 1996; D. Mattingly 1992; Mattingly *et al.* 2003).

Yet all fieldworkers know that the practical reality of how a major field project actually develops on the ground is invariably rather different, a combination of vision (we hope!), strategic planning, and tactical responses to successes and failures and to new opportunities and setbacks, all shaped by other factors such as financial constraints, career changes of personnel, and the effects (especially in arduous and difficult terrain) of weather conditions, equipment failures, injury, health and safety considerations, and much more besides. But in the midst of this confusing reality, the interaction between theory and practice, between changing questions and changing data, remains the cornerstone of the fieldwork process; on it rests the intellectual framework in which the discipline is practised. In this chapter we reflect on the development of, and interaction between, the project's research goals and methodologies, as an introduction to the chapters that follow dealing with the evidence gathered by the project's field and laboratory investigations and their contribution towards those research goals.

1.2 Background and research context

The background to the project was a visit made by one of us (Graeme Barker, then at the University of Leicester) to the Wadi Faynan in early spring 1995 as a member of a review committee of the British Academy visiting BIAAH, the British Institute at Amman for Archaeology and History (later, following the review, incorporated within a new Council for British Research in the Levant). BIAAH

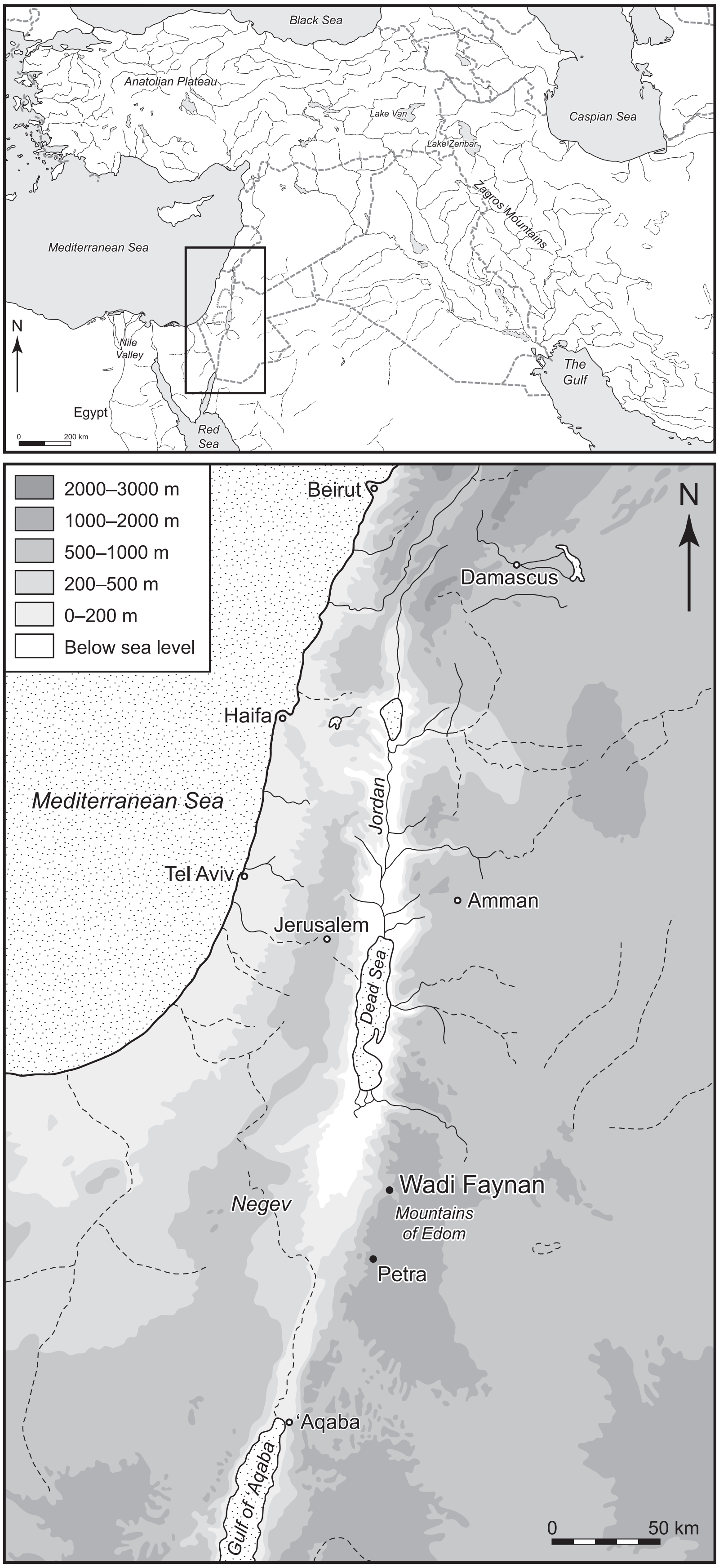


Figure 1.1 *Southern Levant, showing the location of the Wadi Faynan in its regional context. (Illustration: Dora Kemp.)*

was one of the series of overseas British Schools and Institutes that the British Academy funds to facilitate research by British scholars in the humanities. Archaeology has traditionally been a major focus of interest for these institutes, and in common with their sister institutions subject to the review, BIAAH arranged visits to areas of current archaeological fieldwork to illustrate their activities to the committee. It was within this context that the BIAAH staff took the review committee for a short tour of southern Jordan that included a few hours visiting Wadi Faynan, which is situated about 50 km south of the Dead Sea and about 50 km northwest of Petra.

The Wadi Faynan forms as three main tributary wadis (the Dana, Ghuwayr, and Shayqar) combine after they have cut through the mountain front that forms the western edge of the tablelands of the Jordanian Plateau, and to the south, the rugged Mountains of Edom (Fig. 1.2). The wide and shallow gravel floor of the braid-plain of the Wadi Faynan then passes due westwards through gently-sloping colluvial and alluvial fans for about 5 km and then, as the Wadi Fidan, swings northwest for about the same distance before debouching onto the floor of the rift valley of the Wadi 'Arabah (Fig. 1.3). The plateau above the Wadi Faynan, at *c*.1100 m above sea level, receives more than 200 mm of rainfall a year, so a Mediterranean-style rain-fed agriculture is practised by the modern inhabitants, whereas the Wadi Faynan just 4–5 hours' walk lower down has an extremely dry desertic climate that is rainless for most of the year and its sparsely-vegetated landscape is used predominantly by bedouin goat herders. (Present-day land use is described in Chapters 2 and 12.)

The richness of the archaeological remains in the Wadi Faynan has long been known to European travellers and explorers (Glueck 1935; Musil 1907). The main focus of their visits was a complex of imposing structures at the foot of the escarpment near the confluence of the three tributary wadis, dominated by a major archaeological monument called Khirbat Faynan, 'the Ruin of Faynan' (Figs 1.4, 1.5), which they dated to Nabataean, Roman, and Byzantine times (*c*.300 BC–AD 700) on the basis of its surface pottery. Amidst a dense tumble of sandstone masonry Glueck was able to discern a large central rectangular complex surrounded by subsidiary buildings, including two

Figure 1.2 *Looking westwards from the mountain front near Dana Village down the gorge of the Wadi Dana towards the lowlands of the Wadi Faynan. (Photograph: Graeme Barker.)*

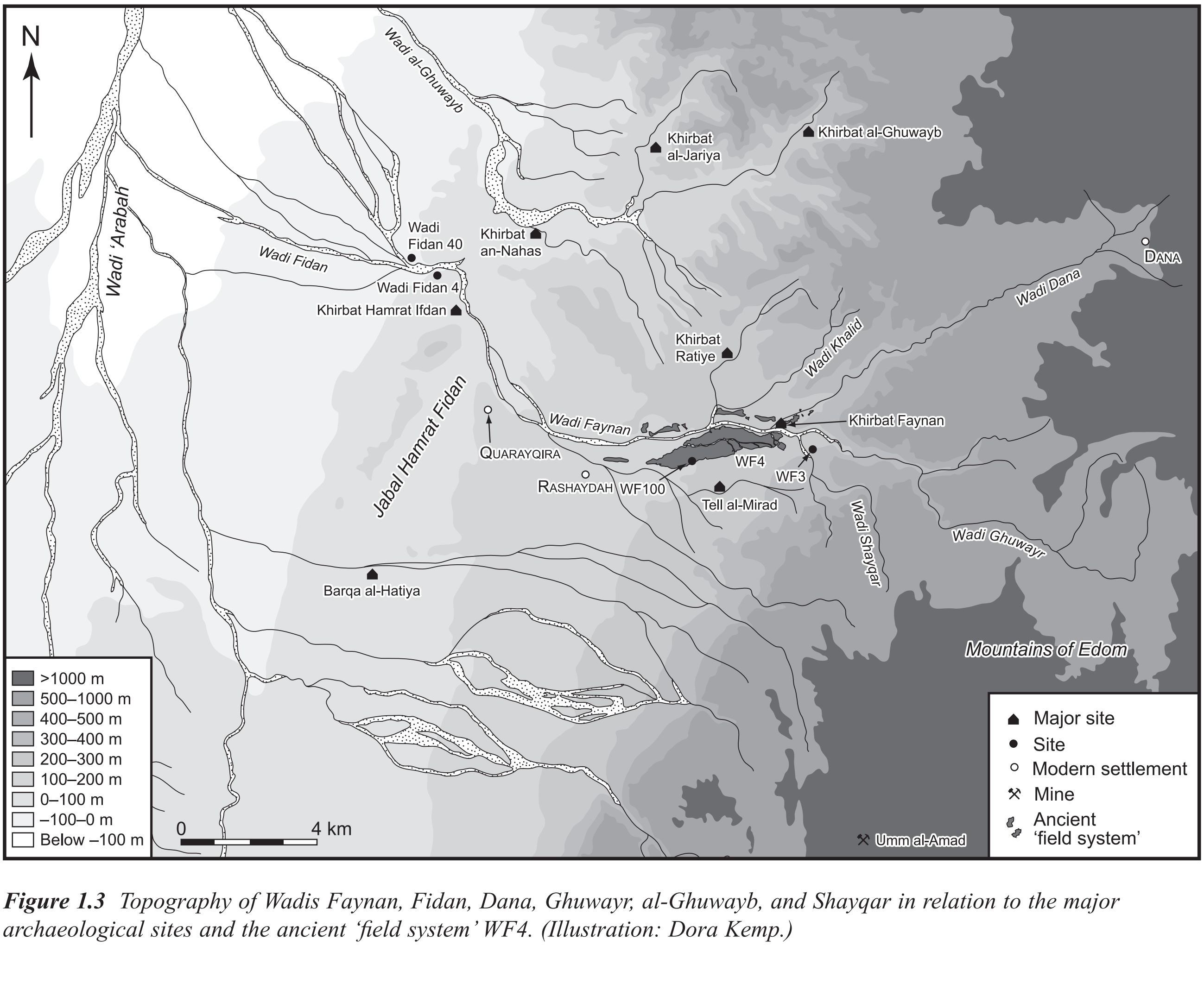


Figure 1.3 *Topography of Wadis Faynan, Fidan, Dana, Ghuwayr, al-Ghuwayb, and Shayqar in relation to the major archaeological sites and the ancient 'field system' WF4. (Illustration: Dora Kemp.)*

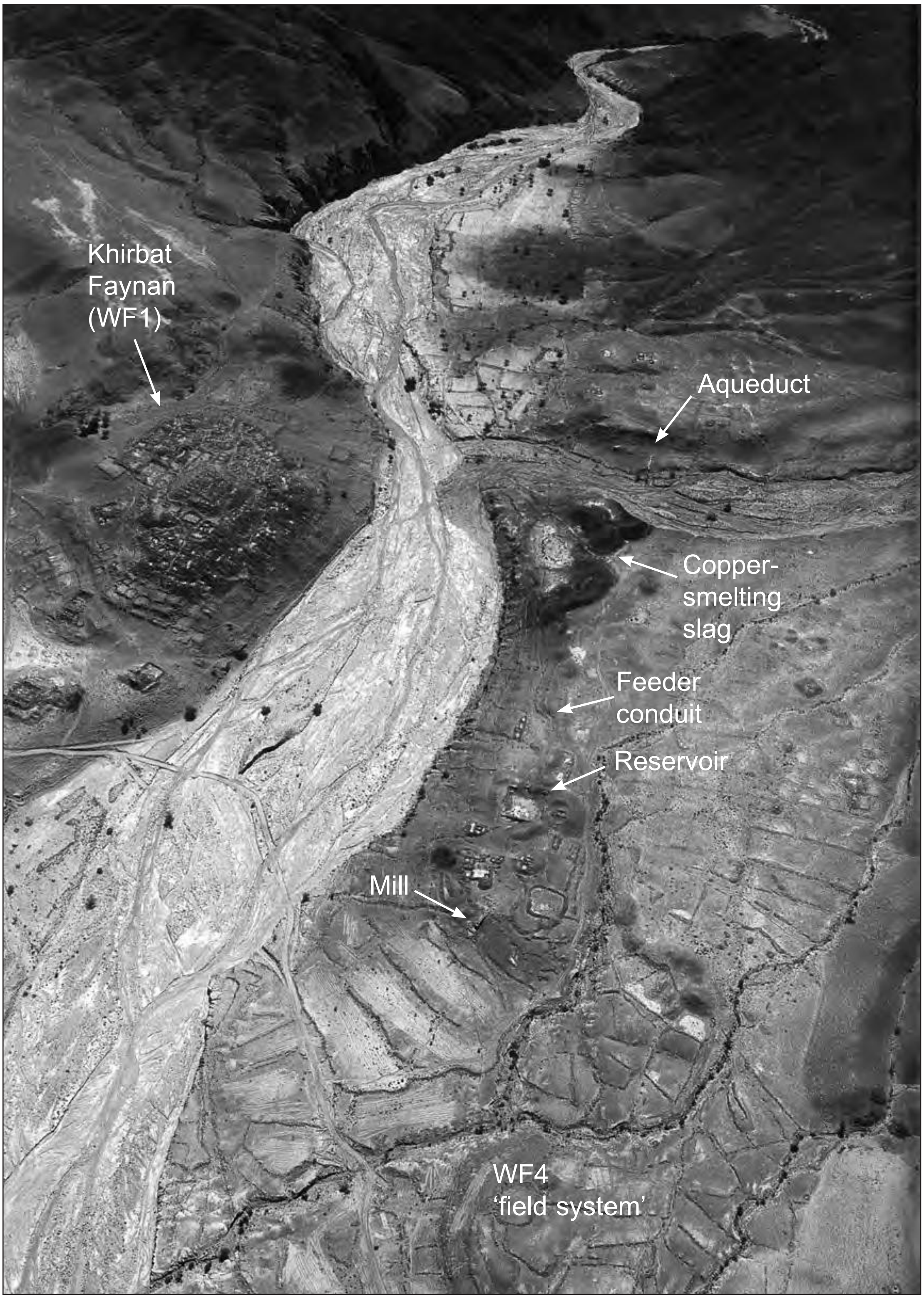


Figure 1.4 *Aerial photograph of the eastern section of the wide braid-plain of the Wadi Faynan, looking east, showing its confluence at Khirbat Faynan. Upstream of this confluence are the braid-plains of the Wadis Dana, Ghuwayr and Shayqar. The major ancient (Nabataean, Roman, Byzantine) settlement of Khirbat Faynan is on the promontory on the north bank of the Wadi Faynan; to the west, on the south bank, is a vast near-circular mass of black slag as a result of copper smelting. Further west is the large square reservoir and its feeder conduit, the linear feature to its east. Further east of the slag mound are the remnants of the aqueduct at the eastern margin of the Wadi Shayqar. Networks of walls – ancient fields – are visible both to the south (WF4) and north of the Wadi Faynan. (APA98/SL38.22, 20 May 1998 = Kennedy and Bewley 2004, 214, fig. 11.10A.)*

Byzantine churches. On the opposite (southern) side of the main channel were further monuments, apparently of similar antiquity, including an aqueduct, a reservoir, and a watermill. The hill-slopes around these monuments were black with slag, the residues of ancient copper smelting, and in places, the surrounding hills were honeycombed with ancient mining shafts (Fig. 1.6). It had long been recognized that Khirbat Faynan was very likely to be the ancient settlement variously named *Pinon, Punon, Phunon, Phaino* in the Bible and in Greek and Latin sources and described as the centre of a copper-mining industry (Hauptmann 2007: 39; Lagrange 1898), including references to Christians of Palestine and Egypt being transported there as slave labour in the third and fourth centuries AD. As he travelled down the Wadi Faynan after visiting Khirbat Faynan, Glueck also noticed walls made of cobbles and boulders indicating 'large stretches of formerly cultivated fields … strewn with Nabataean sherds' (1935: 35). These 'field systems' extended for several kilometres down-wadi from Khirbat Faynan, especially along the southern side of the wadi channel. (Throughout this report, the terms 'field' and 'field system' are to be read as though within inverted commas: see below, Chapter 5 for a discussion of the complex interpretational issues and potential problems with the presumption that all such walls in the landscape demarcate fields.)

The northern side of the Faynan channel forms the southern boundary of the Dana Nature Reserve managed by the Royal Society for the Conservation of Nature. In March 1995 a small team from BIAAH conducted a reconnaissance survey of the wadi's archaeology in order to assist the RSCN with the development of its management plan for the reserve (Barnes *et al*. 1995; Ruben *et al.* 1997). The survey, conducted as a series of approximately north–south transects at right angles to the west–east orientation of the main wadi channel, found widespread evidence for ancient settlement in the form of surface collections of stone tools and/or pottery, often associated with stone-built structures, both within the zone of ancient fields and in the hills on the northern side of the wadi. It also suggested, from the evidence of the surface finds, that the main field system flooring the wadi (classified as WF4 in the team's survey register) probably dated to Nabataean, Roman, and Byzantine times, like Khirbat Faynan. Another team made the first detailed ground plan of Khirbat Faynan in terms of the structures that could be discerned on the surface without excavation. In the decade before our project, the ancient mines and mining technologies of the Faynan region had also been the subject of intensive study by the Bochum Mining Museum, work that had demonstrated a rich prehistory and history of copper mining and smelting beginning in the Chalcolithic period in the fourth millennium BC and continuing with greater intensity up to and including the Byzantine period, with a brief resurgence in Islamic times (Hauptmann 1989a,b; 1990; 1992; 1997; 2000; 2007; Hauptmann *et al.* 1992). At the time of the British

Figure 1.5 *Wadi Faynan, looking east, showing the ancient settlement Khirbat Faynan in the middle distance, field systems of comparable age in front of it, and the gorge of the Wadi Dana. (Photograph: Graeme Barker.)*

Figure 1.6 *A typical ancient mine (WF1469) in Wadi Khalid, a northern tributary of the Wadi Faynan; looking northeast across the Wadi Faynan to the Mountains of Edom. (Photograph: Graeme Barker.)*

Academy's review visit, BIAAH was also coordinating a programme of rescue excavation, in collaboration with Yarmouk University, of a large cemetery of mainly Byzantine date, termed the South Cemetery (WF3: Fig. 10.26), at the foot of the escarpment on the southern side of the Wadi Ghuwayr, at the request of the Department of Antiquities in response to the threat to the site from extensive grave robbing. The British Academy's review committee was brought to see Faynan's remarkable archaeological monuments, the site of the cemetery rescue excavation, and the location of the survey, because BIAAH was keen to build on the fruitful collaborations it had established in Faynan and to facilitate further involvement by British archaeological teams.

The main focus of interest for the rest of the committee members during the visit was Khirbat Faynan and its churches, and the aqueduct, reservoir, and mill nearby, but the field system, though far less prepossessing, struck a particular chord with Graeme Barker. At the time of the review he was engaged in the preparations for the final publication of an archaeological survey project he had co-directed in the Tripolitanian Pre-desert in northwest Libya, termed the UNESCO Libyan Valleys Survey, the principal focus of which were Roman-period farmsteads and their associated wall and field systems (Barker *et al.* 1996a). These remains were *prima facie* evidence that the desert margins of Libya, now inhabited by semi-nomadic pastoralists, had been characterized in Roman times by settlement and land-use systems very different from those of today. In funding the project, UNESCO gave the team the specific brief to try to understand when, how, and why the desert margins of Libya had been settled and farmed intensively in antiquity, to inform modern plans for agricultural development in the same region. The project found that the indigenous Libyan population had moved from subsistence to cash-crop farming in response to the economic opportunities of the Roman empire, but the team's environmental scientists established that there were no reasons to believe that the climate of the region in the Roman period was profoundly different from that of today, so agricultural intensification did not necessarily need to be explained in terms of a significantly wetter, more benign, climate. Instead, the project concluded that the settlement transformation had been made possible by the development of rather sophisticated systems of floodwater farming: the people built enormous numbers of dry-stone walls, many of them very substantial, to collect the floodwaters of seasonal downpours on higher ground, guide them down to the wadi floors, and trap them there in wall-enclosed fields – technology and practices that we identified could still be found in the region today.

The apparent similarities between the Tripolitanian and Faynan field systems posed obvious questions about the latter. Did they represent similar solutions by Classical farmers in Jordan to coping with a similarly arid environment? When had they been built? For how long had they been used? Did the almost 5 km of the main field system (WF4: Figs. 1.3, 1.4) represent something that had grown organically and piecemeal over a long period, or a planned system laid out and maintained more or less as an integral system, or a combination of both? What did the walls represent in terms of systems of land use? What were the social and economic contexts in which such an investment in wall-building became attractive or necessary? And when and why did the field systems go out of use and the present-day system of pastoral-dominated settlement develop? The study of such issues relates to wider debates about the past, present, and future of arid lands that formed the primary research context for the project, that is, about the processes of 'desertification' as defined by UNEP (1992) given at the beginning of this chapter.

1.3 Archaeology and desertification

In their archaeological evidence that there must once have been intensive phases of settlement in what are now dry and degraded environments, the Tripolitanian Pre-desert and the Wadi Faynan are typical of many dryland regions around the world (Barker and Gilbertson 2000a). Archaeologists, historians, and geographers have frequently speculated about the causes of desertification in the past, generally identifying climatic change or human agency as the primary culprit. Perhaps the longer-term climate shifted to significantly greater aridity? Or was it that people over time sowed the seeds of their own destruction through their own actions, for example by developing inefficient irrigation systems that poisoned the land by salinization, or by stripping the landscape for fuel wood, or by allowing their livestock to 'overgraze' the vegetation resulting in extreme soil erosion?

In general, the debate on desertification or land degradation in the archaeological and historical past has been characterized more by confident assertion than well-founded argument: indeed, many explanations can be seen to be mutually incompatible or irreconcilable (Barker and Gilbertson 2000b). In writing up the Tripolitanian work we had become aware that, in contrast with most archaeological literature on past desertification processes, contemporary ecological theory for drylands, that introduced ideas of disequilibrial relationships and changing landscape sensitivity to natural and human impacts, suggested that interactions between dryland environments, climate, and people are by no means simple (Beaumont 1993; Gilbertson 1996; Thomas and Allison 1993). Modern case studies demonstrated that drylands could sometimes be remarkably resilient, recovering relatively quickly from alleged 'overgrazing' or 'overexploitation', and that simple procedures by farmers could often protect against the latter (Mortimore 1998; Thomas and Middleton 1994; Tiffen *et al*. 1994).

We were also aware of similarly marked differences between past and present thinking on the nature of climatic change through the Holocene, the modern climatic era that developed after the end of the Pleistocene (the 'Ice Ages') *c*.10,000 years ago. In his influential book *Water, Weather, and Prehistory* (1967 [1984]), the engineer-hydrologist Robert Raikes, one of the pioneers of palaeoenvironmental research in the Faynan, concluded

Figure 1.7 *Ploughing within the zone of the ancient field systems, looking northwest, in 1996. (Photograph: Graeme Barker.)*

that, throughout the region (and perhaps the world), there had been no significant change of climate within the last *c*.9000 years: arguments to the contrary reflected a lack of awareness of the capacity of people to manage or change their environments, and mistook the products of one or a series of extreme meteorological-geomorphological events such as major floods or intense local droughts as evidence for a general change in climate. In contrast, more recent palaeoenvironmental research was frequently advancing evidence for abrupt and significant climatic fluctuations in the Holocene (Lamb *et al*. 1995). An archaeological-palaeoenvironmental investigation in an adjacent area of Southwest Asia, in an arid environment similar to that of Wadi Faynan, had concluded that

> one thing is nevertheless inescapable. The Holocene climate was far from stable and benign. Bad things happened to climate and Man in the Holocene long before the advent of modern polluting, high technology society (Dalfes *et al*. 1997b: v–vii).

This was the context in which the Wadi Faynan Landscape Survey was planned, to contribute to the desertification debate by applying modern interdisciplinary landscape archaeology and geoarchaeology to a regional case study, in order to provide a long-term perspective on the relationship between environmental change and human history in arid lands. How had the Faynan environment developed in physical terms, and to what extent could changes in the landscape be related to climate and/or the actions of people? How did the socio-economic and biophysical spheres interact? How had past societies responded to changing opportunities and hazards? Why did they take the choices they took? Given its abundant archaeological remains – settlements, cemeteries, field systems, and mining residues – indicating that its past had been characterized by episodes of settlement and land use very different from those of today, the Wadi Faynan seemed an ideal location for investigating the long-term 'archaeological history' of interactions between a desertic landscape and its human inhabitants. The longer time-depth of its known archaeology, compared with the Roman emphasis of desert-edge farming in Tripolitania, was a particular attraction.

1.4 Initial frameworks

Following his initial visit, Graeme Barker returned to Faynan for a three-day reconnaissance in July 1995 with two physical geographers, David Gilbertson (then at Aberystwyth, who had coordinated the palaeoenvironmental programme of the Libyan Valleys Survey) and Sue McLaren, a Leicester colleague with primary research interests in arid-zone geomorphology. The purpose of the visit was to assess the suitability of the archaeology for a landscape study in terms of the state of survival of the field system and the nature of the wider archaeological landscape, and for a programme of palaeoenvironmental investigation in terms of, for example, accessible exposures of Late Quaternary sequences and landforms.

The results on both counts were positive, but one unwelcome discovery was that the field systems, whilst generally still as well preserved as in 1970s air photographs in the BIAAH archive, were in some locations being visibly damaged by the recent and rapid expansion of market gardening (Fig. 1.7; and see Chapter 2, §2.2.5). Water was being piped in plastic tubing several kilometres down the length of the Wadi Faynan from a spring in the Wadi Ghuwayr, stored in reservoirs formed by bulldozing square earth embankments and filling the interior with plastic sheeting, and then pumped into irrigation piping feeding surrounding fields. For the most

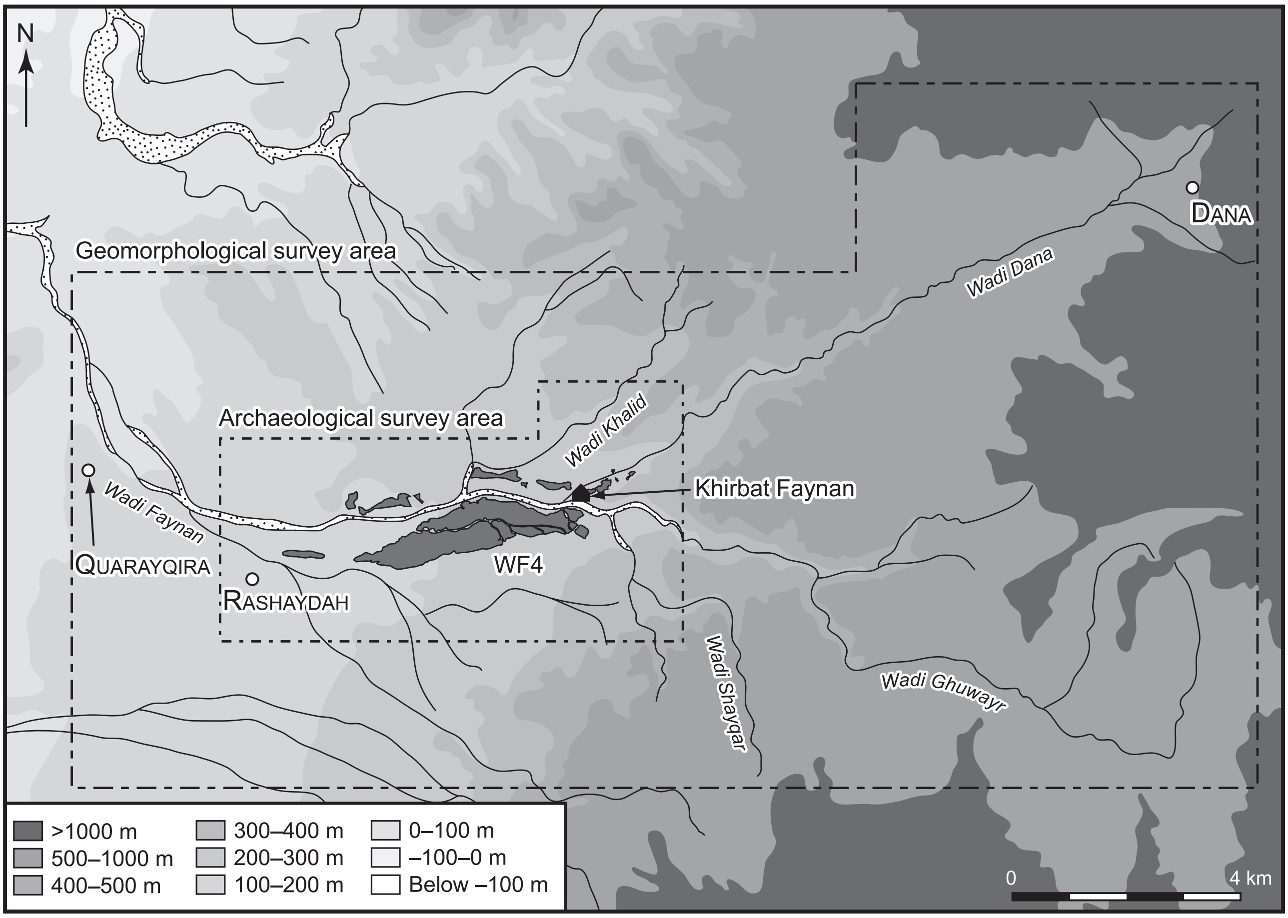


Figure 1.8 *The Wadi Faynan showing the extent of the geomorphological survey area, topography, the boundaries of the archaeological survey area, and location of the main ancient field system WF4. (Illustration: Dora Kemp.)*

part these modern fields were being established within the ancient fields for convenience, and the main ancient walls forming their boundaries were solid enough to withstand the onslaught of the tractors (they simply broke the ploughshares of the careless or foolhardy), but in many places it was evident that smaller walls were being ploughed up. The farmers were under pressure to abandon their fields and concentrate on their traditional lands in the Wadi ʻArabah on the other side of Quarayqira, but given the uncertainties it was clear that the first priority for the archaeological survey had to be the field systems rather than the archaeology on their margins or further at a distance in the surrounding hills.

From the outset we envisaged that, whilst the geomorphological fieldwork would necessarily range across the Faynan basin and its feeder channels (the Dana, Ghuwayr, and Shayqar), the archaeological fieldwork would have an initial focus on the field system WF4 and its associated systems and structures, followed by the expansion of the investigation to the archaeology of the surrounding landscape of the main Faynan basin (Fig. 1.8). The use of Geographical Information Systems (GIS) technology for the analysis of the data was envisaged from the start, and played its part in shaping the recording methodology.

The first field season was planned for the following spring, with a small team. Graeme Barker asked David Mattingly, who had collaborated with him and David Gilbertson in the Libyan Valleys Survey, to join him to head the archaeological investigation, given their common interests in arid-zone landscape archaeology but respective expertise in prehistoric and Roman archaeology. In addition to Sue McLaren, David Gilbertson brought in Chris Hunt (now at Queen's University Belfast), another member of the Libyan Valleys team, for his complementary expertise in palaeoecology, including molluscan and pollen analysis. This small team was augmented by two postgraduates, Oliver Creighton (Leicester) and David Thomas (the BIAAH computer officer).

The geomorphological team only had access to small-scale topographic maps and geological sheets concerned mainly with solid geology (Rabb'a 1994), and limited air photographic cover, as the basis for identifying locations and ancient sites capable of providing worthwhile information on past environmental changes and their possible natural and human causes. From the outset, therefore, their fieldwork in the unfamiliar and difficult terrain of the Wadi Faynan and the gorges of its feeder channels had to depend to a large degree on chance detections

__Figure 1.9__ Geomorphological fieldwork at the Late Neolithic/Chalcolithic site Tell Wadi Faynan. Beneath the upright poles at the top-left of the 5–10 m high cliff – produced by erosion along the southern margin of the incised braid-plain of the Wadi Faynan – are the remains of the excavation, where a geomorphologist is kneeling whilst sampling the overlying Tell Loams at site WF5022. Further right at site WF5021, other geomorphologists are using a modern talus cone of collapsed cliff to gain access to the early–mid Holocene fluvial deposits exposed at their level by erosion. The lower 2–4 m of gravels are of Late Pleistocene age. (Photograph: Graeme Barker.)

of natural exposures, or locations that could be cored or excavated, during ground reconnaissance conducted primarily on foot (Chapter 3). These conditions raised a host of problems familiar to all field geomorphologists but still crucial in terms of the evidence gathered and the reliability of the interpretations based on it:

- about identification and interpretation of modern and past processes and events;
- the degree of representativeness of the evidence through time;
- the extent to which interpretation could be reliably scaled up from the find-site to the wadi to the region;
- the magnitude and frequency of the inferred processes and events through time;
- the degrees of precision and accuracy that might be inferred;
- the exact age and longevity of the features or events;
- the response-times and 'time-lag effects' as well as the likely changing 'sensitivity' of the landscape over time;
- the relationships between past causes and effects in an arid landscape whose modern properties and functional systems were poorly known.

These difficulties were challenging, and much time was spent in successive seasons re-checking exposures and interrogating team members' previous interpretations as understanding developed, in particular as frameworks of relative and absolute dating strengthened.

Despite these difficulties, the 1996 reconnaissance succeeded in establishing a preliminary outline of the Quaternary and hence the palaeoclimatic sequence. In the feeder channels and the upper Wadi Faynan, this sequence included: gorge erosion; the development of large alluvial fans, and of colluvial, aeolian, and fluvial deposits; and distinct episodes of downcutting. Some of the sediments were found to contain prehistoric lithics (stone artefacts) including Lower Palaeolithic forms implying ages beyond 150 kya (thousands of years ago) (see Chapter 6). Geomorphological mapping in the lower part of the Wadi Faynan showed that the WF4 field system was in part built upon fluvial and aeolian deposits that were named the Faynan Member and the Tell Loam Member. There were distinctive traces of more recent fluvial-aeolian deposits on the floor of the main wadi that were termed the Upper and Lower Dana Wadi Members. An important indicator of the antiquity of the Faynan Member was the presence in an exposure in the wadi-cliff at Tell Wadi Faynan of cultural material that had been investigated in trial excavations by a Jordanian team, identified as of Pottery (Late) Neolithic/Chalcolithic type, and radiocarbon-dated from charcoal to

Figure 1.10 *Coring a sediment trap within Roman-period smelting deposits, to locate pollen-rich sediments. (Photograph: Graeme Barker.)*

the sixth/fifth millennia BC (al-Najjar *et al.* 1990; Fig. 1.9): the archaeological layers could be seen to be associated with the fluvial deposits of a perennial stream ascribed to the Faynan Member. The geomorphology and palaeoecology of the fluvial sediments associated with the site contained indicators of active biological conditions implying an early Holocene climate substantially wetter than that of today, very different from Raikes's (1967 [1984]) model. A first impression of the emerging geomorphological sequence was published in the report on the first field season (Barker *et al.* 1997: fig. 5). Various natural and archaeological sediment traps were cored by Chris Hunt to establish whether or not pollen survived (Fig. 1.10).

The main focus of the archaeological fieldwork in the first season was the trialling of a series of methodologies for the investigation of the 250-hectare field system WF4, which was calculated to contain about 1000 fields (Chapter 5). The first of these was the task of mapping the entire system using surface examination to check or 'ground truth' a map prepared in the UK before the field season from vertical air photographs (Fig. 1.11, upper). The second approach envisaged was detailed surveying of selected areas using a 'Total Station' (an electronic laser-based theodolite), but we needed to establish the utility of the data that might be collected by this means in selected zones (as realistically we could probably only expect to plan selected zones by this means) compared with the faster but more schematic mapping of the entire field system. The other approaches we needed to trial included the collection of surface artefacts, the recording of archaeological sites within and adjacent to the fields, the recording and classifying of wall types, and the identification and mapping of any structures within the field system indicative of ancient systems of water control, such as the stone sluices and baffles used by the floodwater farmers of Roman Tripolitania. Within the first few days of fieldwork it became clear that the field system had undergone considerable change since the air photographs were taken, and also that there was considerable variability in wall building, field layout, and surface pottery. If we were to understand its history, it was clearly going to be necessary to map the WF4 field system in detail. To facilitate this, David Mattingly subdivided it into twenty sub-units defined according to major constructional features, significant breaks in topography, and natural features such as wadi channels. These were numbered as Units WF4.1 to WF4.20, and each field within each unit was also numbered separately, such as WF4.1.5, WF4.13.20, and so on (Fig. 1.11, lower).

The finds on the surface of many of the fields were extraordinarily dense, so rather than having all field walkers pick up all visible material, a system was devised whereby all material on a metre-wide corridor was collected from one in every three transects, the latter being 10 m apart (Fig. 1.12). The material in the intervening transects was recorded using clicker counters, to give an assessment of density of pottery and lithics to compare with the counts of the collected material. Unit WF4.13 encompassed a major settlement of Early Bronze Age date (*c*.3600–2200 BC) mapped in the 1995 BIAAH survey as site WF100, and during our first field season Dr Karen Wright (University

Figure 1.11 (upper) Initial mapping of the Wadi Faynan 'field systems', drawn up from vertical air photographs; (lower) map of the 'field system' WF4, showing the sub-divisions devised for its recording and analysis. (After Barker et al. *1997: figs 7 and 8.)*

Figure 1.12 *Collecting surface artefacts within the WF4 'field system', and mapping the field walls; photograph looking west down the Wadi Faynan to the Wadi Fidan. (Photograph: Graeme Barker.)*

College London) was carrying out a reconnaissance season on the site in preparation for excavating it the next year, when she was also planning a detailed surface pick-up. It was therefore agreed with her that our project would trial its artefact collection system in Unit WF4.13, which would ensure that we had data collected from it using the standard methodology we wished to apply to the rest of the field system. In addition to the development of the artefact collection systems, a segment of terrain around Tell Wadi Faynan, measuring some 500 by 150 m, was mapped with the Total Station, and a preliminary classification was established of wall types and other archaeological structures in walls or in fields such as cairns, terraces, and sluices.

The immediate realization from this initial archaeological fieldwork was that we were not looking at a repetition of Roman-period floodwater farming systems in Tripolitania. Most obviously, there seemed to be very few water-harvesting catchment walls on the slopes outside the field system to collect and divert water into wadi-floor fields. In parts of the southern portion of the system (in Units 4.4 and 4.5, for example), where the ground sloped quite sharply, there were substantial terrace walls unlike anything we had observed in Libya, where most of the wall-building concentrated on the floors of long narrow wadis. Yet large parts of the field system (Units 4.2, 4.3, 4.6, 4.7, 4.9, 4.10, 4.15–4.20) were on gently undulating or virtually flat terrain. The one thing that was clear was that the ancient fields were not being irrigated, like the modern fields, by water brought down from the Wadi Ghuwayr spring: the system looked as if it must be rainfed, but exactly how remained unclear, though a series of parallel walls inside the field system seemed likely to be an important clue.

The second main conclusion from the 1996 season was that WF4 was likely to represent a palimpsest of wall-building and land-use systems. Most of the pottery on the surface of the fields was clearly Nabataean, Roman, and Byzantine, but there was certainly prehistoric pottery at several locations, not just in Unit 4.13, and a series of circular silt-filled enclosures with such pottery found in and just outside the southeast corner of Unit 4.12 suggested some kind of water-management strategy. Neolithic agriculture, by contrast, appeared to have operated in a wetter climate and more vegetated landscape, and to have focused on stream-side locations. This was true not just of Tell Wadi Faynan but also of an earlier Neolithic settlement termed Ghwair I being excavated by an American-Jordanian team (Simmons and al-Najjar 1996; Simmons and Najjar 2006), which was situated immediately by the Wadi Ghuwayr spring at the mountain edge. This site had been identified from its material culture as belonging to the Pre-Pottery Neolithic B (PPNB) period (*c.*8500–7000 BC), the period when agricultural villages sustained by the cultivation of wheat, barley, and legumes and the herding of sheep and goats were first established throughout Southwest Asia.

Alongside the field system survey, we undertook limited reconnaissance survey on the upper slopes south of the field system. This found a suite of archaeological remains including terrace walls, lithic scatters, domestic structures, graves, boulders decorated with pictographs (incised pictures or motifs), and what looked like recently-abandoned bedouin campsites, implying that the hinterland around the field system was likely to contain an equally rich, if different, archaeology, both prehistoric and historic. As we concluded in the first report,

> dating this archaeology is likely to be extremely difficult, but the potential clearly exists in the archaeological record outside the field system, as within it, to document changing patterns of arable and pastoral activity, and the extent to which they were integrated or separated in terms of social organization, from the time of the first agricultural settlement in the Wadi Ghuwayr to the present day (Barker *et al.* 1997: 38).

For the second season, the environmental team was strengthened by the addition of John Grattan (Aberystwyth) and Hwedi el-Rishi Mohamed, a Libyan PhD student working on the Faynan with Chris Hunt. Their geomorphological field studies concentrated on the tributary wadis above the area of study for the archaeological survey, as these were more likely to contain a record of deep-time alluvial activity than the flatter topography of the lower valley, where recent sedimentation predominated. The complicating effects of tectonic activity became apparent, but the fieldwork was able to yield a refined geomorphological map for the confluence area, with different episodes of fluvial activity recognized within the Ghuwayr and Shayqar Beds (Barker *et al.* 1998: fig. 1). The team now included a lithics specialist, Tim Reynolds (Birkbeck, London), and lithic/sediment associations confirmed the late Pleistocene age suspected for these beds.

Another critical advance came with the successful extraction of pollen from one of the 1996 cores, taken from the sediments built up against a prominent barrage wall constructed at the foot of Khirbat Faynan (Fig. 1.13). The assumption was that the barrage was built by the Khirbat Faynan community, presumably in Nabataean, Roman, or Byzantine times, so though this still meant anywhere within a thousand years (*c.*300 BC–AD 700), the hope was that the pollen diagram would give us a first indicator of vegetation change from the Classical period (loosely defined) to the present day. The initial analysis (Hunt and Mohamed 1998) suggested two distinct vegetational phases: a steppic landscape in which cereal and olive cultivation was practised developed at some stage into an extremely degraded landscape. The transformation suggested climatic aridification, or humanly-induced degradation (from, for example, overgrazing), or a combination of both. When the second fieldwork report was in press, a radiocarbon date of *c.*2500 BP for the basal sediments indicated that the sequence probably began in Nabataean times; later we were to revise this interpretation (Chapters 3 and 10).

The archaeological fieldwork in 1997 was unexpectedly complicated by a back injury to David Mattingly

Figure 1.13 *The ancient barrage below Khirbat Faynan, that created a sediment trap that proved a source of invaluable information about the development of climate, environment, and industrial history over the past 2000 years. Photograph looking northeast, across large areas of slag and polluted sediments, up the Wadi Dana. A scale is provided by the person sitting on the far end of the barrage. (Photograph: Graeme Barker.)*

shortly before the field season. The original intention was that Graeme Barker and David Mattingly would share the fieldwork, one running the team for the first part of the 1997 season and the other the second half, but the injury meant last-minute changes of plans, one result of which was Oliver Creighton finding himself running the project on his own for ten days in the middle. The unexpected benefit was that his research interests shifted dramatically from his PhD in medieval English landscapes to include landscape methodologies more generally, the result being his increasing role in the team in the ensuing seasons in developing the project's survey methodologies and classification systems (Chapter 4).

The main focus of the archaeological fieldwork was the application of the wall recording and surface pick-up methods trialled the previous year in WF4.13 to other parts of the field system. Recording forms had been designed in the light of the experience of the first season to streamline the recording of the field system walls and for logging the count and weight data from the field collections. By the end of the 1997 season, some two-thirds of the system had been surveyed. The survey was facilitated by an improved photogrammetric map produced for BIAAH by Leoni Blank (University College London), enabling rapid ground-truthing by the wall-recording teams to produce detailed maps of each of the WF4 sub-units (Fig. 1.14). These maps included increasingly confident identifications of structures related to water control: a typology of sluices, baffles, spillways, and channels began to be developed. Indeed, a vital component of the field system recording was the identification and examination of all associated structures, including numerous cairns, enclosures, and small buildings as well as hydraulic features. The upper slopes of the part of the field system nearest Khirbat Faynan (in WF4.1–WF4.3 and WF4.5) were studied in particular detail, and an interpretation was suggested in the second report that they represented small-scale diversion systems: floodwaters were blocked by small barrages in the wadi channels as they arrived at the field system, guided along the contours by diversion walls, and then allowed to flow through sluice gaps downslope over terraced fields, to return to the wadi channels lower down. Systems of parallel walls seemed to be the key to how water was diverted from wadi channels to fields at lower elevations. The preliminary study of the ceramics from these units by Russ Adams, a prehistoric pottery specialist then at Sheffield who joined the team in 1997, indicated that, along with much Nabataean material, the upper slopes had significant quantities of Iron Age pottery of the seventh–sixth centuries BC. Also, a Roman sherd was found in the make-up of a wall of a parallel-wall system.

Hence at the end of the second season we had better understanding of Pleistocene environmental history, at one end of the sequence, and at the other, indications of an Iron Age–Nabataean–Roman constructional history for the field system, with indications of functional differentiation relating to that sequence. We also had palynological

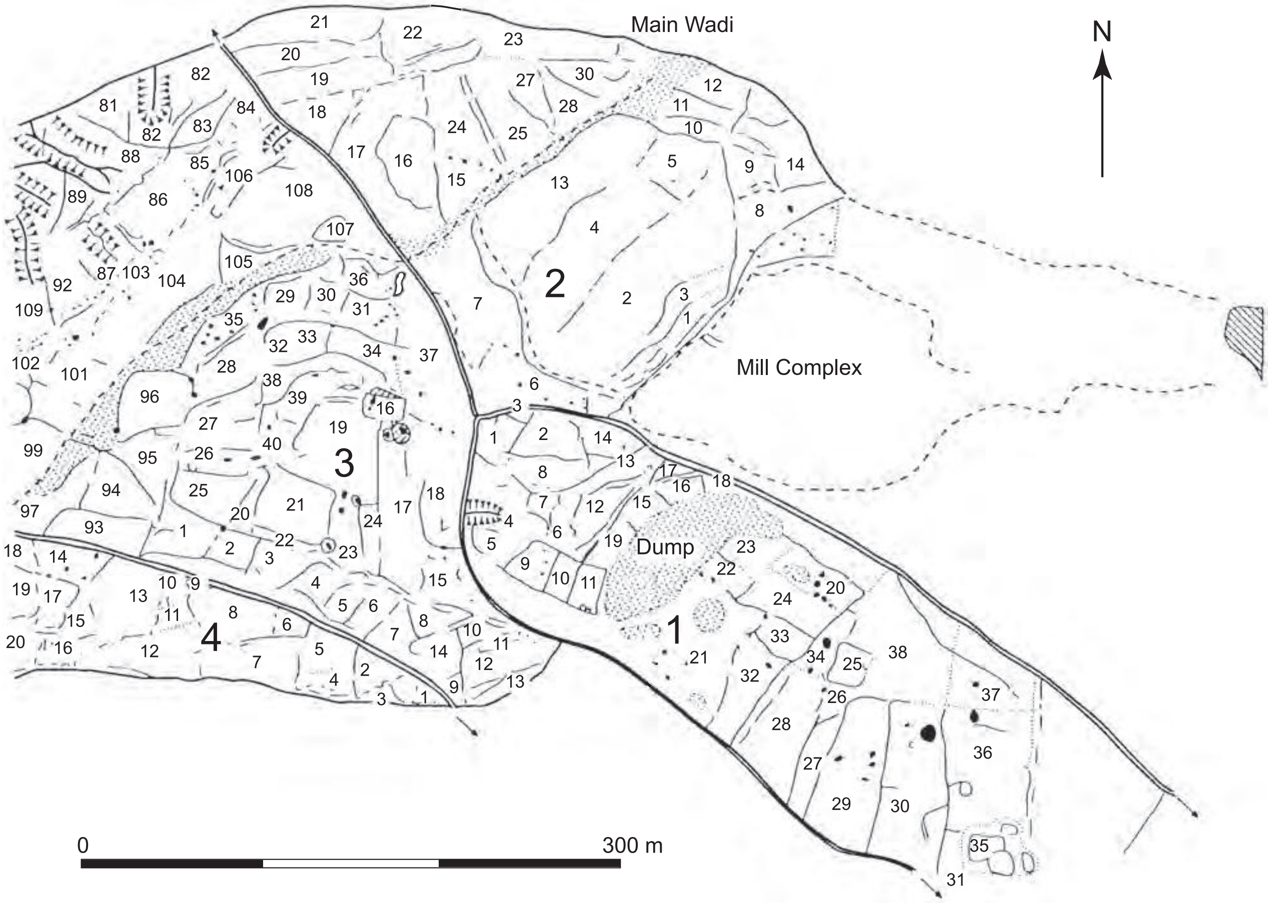


Figure 1.14 *Field map of part of the WF4 'field system', after ground verification of the photogrammetric map in the 1997 field season. (After Barker* et al. *1998, fig. 4.)*

evidence for a poorly vegetated degraded landscape – that we initially wrongly attributed to Nabataean rather than the Roman-Classical period – that developed some time later into desert, before reverting over the last one hundred years or so to the modern steppe vegetation. As we concluded at the end of the second report,

> one important goal for our future fieldwork must be to investigate whether the eventual abandonment of the field system coincided with the significant landscape changes that can be inferred from the pollen diagram and if so, the extent to which this process of desertification was climatically- and/or humanly-induced (Barker *et al.* 1998: 25).

The field system survey was producing many sporadic prehistoric lithic artefacts, but it was clear from reconnaissance that the densest spreads of lithic material were on the surrounding hills. For the middle part of the sequence, Karen Wright's excavations of WF100 concurrent with our own fieldwork had yielded excellent information on the character of a major Early Bronze Age settlement (Wright *et al.* 1998). Trial excavations later that year by Bill Finlayson and Steve Mithen at site WF16 a few hundred metres west of the Ghwair I PPNB settlement (Finlayson and Mithen 1998) revealed it to be an even earlier Neolithic settlement of the Pre-Pottery Neolithic A period, the first thousand years of the Holocene (*c.*9500–8500 BC), when indicators of cultivation and herding first become widespread in Southwest Asia but when hunting, fishing, and gathering remained the mainstays of subsistence for most communities.

1.5 New perspectives, new questions

The specialist personnel in the team increased further in the third season, as team members suggested areas where further input would help (Barker *et al.* 1999). Darren Crook applied the insights he had gained in his PhD fieldwork on irrigation systems on dry Swiss mountains to Roman irrigation technology in Faynan as represented by the aqueduct system (Crook 1999). The finds team was augmented by Roberta Tomber (then at the Museum of London), to take on the challenging task of analysing the mass of Classical and later pottery. Paul Newson, who had participated as a student in the second season, embarked on a NERC-funded PhD at Leicester on Roman-period water-management systems in the Levant, a core component of which was planned to be a GIS analysis of the WF4 field system. A chronology of the Quaternary sequence started to emerge through AMS dating and more specifically through Optically-stimulated Luminescence dating undertaken by Geoff Duller at the Aberystwyth OSL laboratory, though unfortunately the sediment samples were found to be so naturally-radioactive that it was very difficult to date deposits beyond *c*.170–220 kya.

John Grattan, in addition to his work on the Quaternary sequence, was developing new research interests in the use of geochemistry to measure environmental pollution histories using the Inductively Coupled Mass Spectroscopy (ICP-MS) facilities at Aberystwyth and Energy Dispersive X-ray Micro-Analysis (EDMA) facilities at Nottingham Trent. He, along with Brian Pyatt and David Gilbertson, realized that the techniques had the potential to link the metallurgical history of Wadi Faynan, as proposed by the Bochum team, with our developing understanding of climatic, environmental, and land-use history, because sediment samples from geomorphological and archaeological exposures could be analysed by ICPMS and EDMA to measure the changing concentrations of metal pollution caused by past mining and smelting activities. The techniques thus had the potential to measure changing scales of industrial activity independent of the Bochum team's arguments based on their studies of the mining and smelting sites. The team was augmented in the field by Brian Pyatt (Nottingham Trent), an environmental biologist with interests not just in past people–environment interactions but also present-day ecology and health. The final addition to the team was Carol Palmer, an archaeobotanist (then at Bradford) who had conducted ethnoarchaeological research on a north Jordanian farming community for her PhD (Palmer 1998) but who had developing research interests in bedouin pastoralism and its interactions with farming. The project directors were becoming increasingly aware that understanding the landscape history of Faynan had to include its contemporary and recent inhabitants, and our needs and Brian Pyatt's and Carol Palmer's research interests neatly coincided.

The geomorphological fieldwork continued to refine understanding of the Quaternary sequence in the tributary wadis, their inter-relationships, and through the application of OSL dating, their approximate date ranges, confirming the estimates based on associations with archaeological artefacts. The latter included a handsome Acheulean (Lower Palaeolithic) handaxe found by the geomorphologists in a fluvial terrace 40–50 m above the modern floor in the gorge of the Wadi Dana (Fig. 6.14). The Dana fieldwork also located early Holocene sediments with molluscan and plant remains confirming the Tell Wadi Faynan evidence for significantly wetter environments. Another important piece in the jigsaw was the extraction of pollen from three geomorphological sequences, one of definite and two of probable Early Bronze Age date, which indicated relatively diverse steppic landscapes, drier and more open than those of the Neolithic but more vegetated than the degraded steppe of the Nabataean period and the succeeding extremely degraded desertic environments. Evidence for the latter had been strengthened

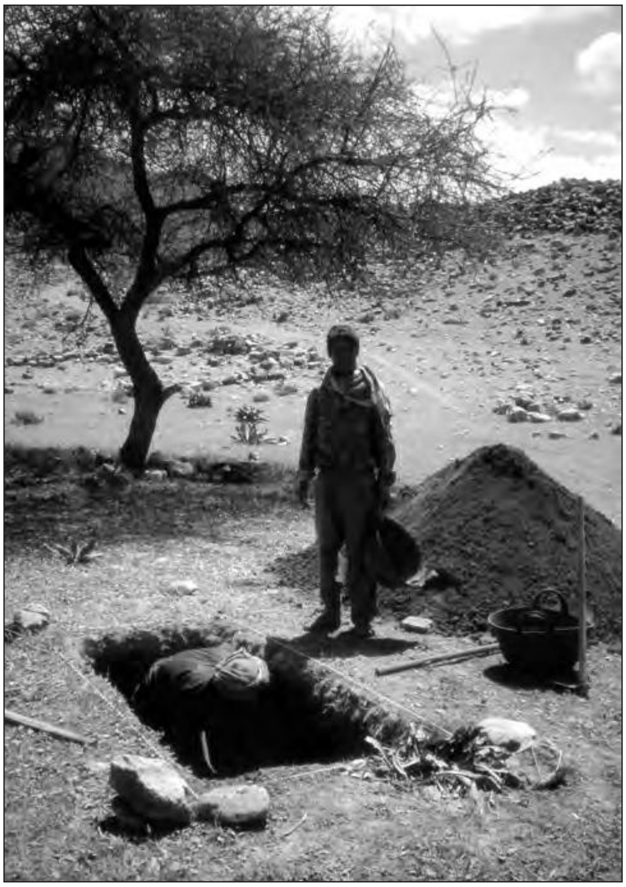


Figure 1.15 *Excavating the sediments at site WF5012 immediately up-wadi of the Khirbat Faynan barrage for palynological and geochemical research. Looking south across a small catchment to the intermediate skyline and the watershed-boundary provided by the rubble of the Khirbat Faynan, to the distant Mountains of Edom which are partially obscured behind the Acacia. (Photograph: Graeme Barker.)*

by detailed sampling of a trench excavated in the infill sediments behind the Khirbat Faynan barrage (Fig. 1.15), to add to the data obtained by the earlier coring. During the 1998 season the archaeological teams completed the survey of the main field system, and of the outlying field systems on the northern margins of the wadi. From these studies it was becoming possible to propose a provisional sequence of wall technologies indicating how systems of 'floodwater farming' had developed from the Bronze Age to (at least) the Byzantine period.

The ICPMS and EDMA studies of sediments at Tell Wadi Faynan and in the barrage sequence added new and remarkable insights into this emerging story of landscape development. The Tell Wadi Faynan archaeological and aeolian sequence, representing accumulation between the Late Neolithic settlement and the Roman/Byzantine field system on the present-day surface, showed small-scale episodes of intense metalliferous pollution caused by smelting. There was a reverse sequence in the barrage sediments: extremely high levels of metal pollution at the base, and lower levels high up, though with minor peaks in between. The implication was that Roman/Byzantine industrial activities severely polluted the contemporary landscape. Furthermore, significant levels of pollution were found in the modern plants and animals in the area, and it was also found that biomass and cover values increased in barley plants with distance from the contamination 'hot spots'. The obvious conclusion was that modern pollution has its origins in the activities of ancient miners, particularly those of Roman and Byzantine times. Not only had they helped sustain a desert but, it seemed, they had created a legacy of metalliferous pollution for future generations into the bargain.

1.6 Developing research themes

As we began to discern some of the principal characteristics of the environmental and settlement histories of Wadi Faynan, we began to break down the overarching research interest of the project in desertification into four subsidiary but inter-related research themes.

Within the first theme, of *understanding aridification*, we first needed to establish in as much detail the evidence for developments in climate and environment. We then needed to relate those histories to the human history, of how people had lived in the study area, a history in which the interaction of sedentary and mobile lifestyles over time was clearly going to be one of the critical threads. How had people farmed at different times in the past? How, in certain periods, had they practised what appeared to be, on the evidence of the wall building, labour-intensive sedentary systems, and in what environments and with what environmental impacts? Had phases of intensive sedentary agriculture alternated with phases of less-intensive land use, such as mobile pastoralism? If pastoralism was practised alongside agriculture in particular periods, was it closely integrated or practised by more or less independent and socially-separate groups?

That kind of question introduces the second major theme, of *marginality*, of the social, economic, and political relations between the settlement histories of arid regions and those of adjacent better-watered more densely-settled regions, between 'the desert' and 'the sown' in one striking phrase. This relationship is an example of the more general phenomenon of core/periphery relations that archaeologists, geographers and historians study, of the linkages between regions regarded as economically and politically 'core' in a particular period and surrounding regions regarded as 'peripheral' to that core. Obvious examples of the latter are subject territories controlled by imperial powers, or client states beyond the imperial frontier (like the Late Iron Age petty kingdoms of southeast England prior to the Roman conquest), but core/periphery networks frequently involve economic rather than political hegemonies (Wallerstein 1974). It is generally accepted that most mobile pastoralists living in arid lands today and in the past are not relics of some kind of natural 'free-living' mode of self-sufficiency but have close economic relations with settled peoples in adjacent better-watered regions. The history of Wadi Faynan had to be understood in terms not just of the prevailing climate and local environment, and of people's relationships with them, but also of relations with the world beyond. The interactions between the various bedouin tribes using the Wadi Faynan today in part relate to the regional politics and global economic forces of the late twentieth century (Chapter 2). In particular, the expectation had to be that throughout history powerful but metal-poor states in the wider region would have had a significant interest in an environmentally-marginal but metal-rich zone such as the Wadi Faynan, whether considering the rise of the first significant (and metal-using) elites of the Levant in the Chalcolithic (*c*.5000–3600 BC) and Early Bronze Age (*c*.3600–2200 BC), or the Biblical Iron Age states, or the Roman imperial economy, or the various Islamic states. Whilst the Wadi Faynan was likely to be on the 'periphery' side of core-periphery networks, the location, scale, and nature of the core or core regions to which it related, and the nature of those relationships, could of course be expected to differ substantially.

The third theme was the history of *degradation and well-being* of the habitats and peoples of arid lands, stimulated in particular by the geochemical studies of pollution signatures that caused us to extend the focus of our interest from the arable and pastoral archaeologies of field systems and sites to the smelting sites and mines. An important underlying focus of interest, though, was the boom-and-bust character of the settlement histories of most drylands, something we were reminded forcefully of in the Wadi Faynan as the evidence of its dramatically changing settlement history began to accumulate over the first seasons of fieldwork, with periods of more or less intense occupation apparently alternating with periods of far less intensive settlement, or even abandonment. From the outset it became clear that we were not dealing with a neo-evolutionary story of increasingly sophisticated irrigation systems, for example, linking each major cultural phase inexorably to its successor, but a complex and cyclical story of expansions and contractions. Similarly complex histories could be expected in the case of the pastoral and industrial sectors, and in the inter-relationships between arable, pastoral, and industrial over the millennia and centuries. Any holistic model of desertification could be expected to build on and integrate such histories along with changing histories of aridification and changing notions and relations of marginality.

At the same time, all these sub-themes in turn interlinked with the fourth theme, of *methodologies* in arid-zone landscape archaeology. One of the major challenges confronting any archaeological investigation of diachronic settlement trends is distinguishing an absence of evidence for occupation in any particular period from evidence of absence of occupation. In arid zones this problem is particularly acute in relation to the archaeology of pastoralism: does pastoralism, especially as practised by mobile shepherds and herders, create an ephemeral archaeology of organic materials (tents, thorn-bush corrals, artefacts of skin and hide, and so on) that does not survive in the archaeological record; or do arid-zone pastoralists use an archaeology of vestigial stone structures that, whilst much less substantial than the archaeology of settled farmers, can nevertheless be recognized? This problem had been the focus of lively debate in the southern Levant, with survey work in the Negev in particular indicating that pastoralists *could* be recognized by archaeologists, the implication being that periods with no apparent archaeology were genuinely periods of abandonment, rather than periods of less intensive settlement forms such as seasonal pastoralism (Finkelstein 1995; Finkelstein and Gophna 1993; Finkelstein and Perevolotsky 1990; Rosen 1994; Rosen and Avni 1993).

Recognizing pastoralists, however, depends in part on their building stone structures (such as tent footings) that can be recognized by archaeological surveyors, but also on their using non-organic materials that can be dated, notably pottery – otherwise a collection of stones from a tent placement might equally well be prehistoric or twentieth century. One of the striking reminders of the problems of dating evidence was the discovery of wooden vessels in Iron Age burials in Wadi Fidan (Levy *et al*. 1999a; Chapter 9), interpreted as evidence of the presence of aceramic (non-pottery using) pastoralists in a period hitherto assumed to be one of abandonment. In our own survey, one of our most critical challenges was producing convincing evidence to demonstrate that periods of 'bust' in apparent boom-and-bust cycles were either periods of genuine abandonment or periods when different lifestyles and technologies created different archaeological signatures in the landscape from periods of 'boom'. Separating absence of evidence from evidence of absence was clearly going to be critical for any theories arising from the project regarding aridification, marginality, and landscape degradation and well-being. We could employ a range of signatures of changing intensities and modes of settlement, including the archaeological remains in the landscape, indicators of land use in the palynological and geochemical records, and ethnoarchaeological studies of the people using the Wadi Faynan today and in the recent past.

1.7 Integration

One insight from the initial ethnographic studies and interviews with the present-day inhabitants of Wadi Faynan was that land-use patterns and technologies had altered profoundly in recent years in response to particular social and economic constraints or opportunities, suggesting at least the possibility of complex interactions between arable, pastoral, and industrial activities in the past as well (Palmer 1999; and see Chapters 2 and 12). It was in this context that the next stage of the archaeological survey was designed in the fourth field season (1999) to investigate the archaeology outside the field system (Barker *et al*. 2000; and see Chapter 4).

At this stage, the convergence of the data we had gathered so far on the agricultural system (the field system evidence, and the palynology) and on the environmental impacts of ancient mining (the geochemistry) was highlighting the Roman period as of potentially greater importance in the Faynan story than had been recognized hitherto – the work of the Bochum team had focused primarily on the early technology and history of metallurgy in Faynan, in the Bronze and Iron Ages especially (Hauptmann 2000; 2007). A whole new set of questions now opened up relating to the operation of Roman imperialism on the ground and the way in which the Faynan landscape increasingly became one of power and exploitation. In order to examine these aspects, and to have an understanding of how they differed from earlier phases of exploitation, it was necessary to ensure that our archaeological survey also included the mining archaeology as well as all the other archaeology beyond the field systems, even though at the beginning of the project we had planned to focus on the main field system and the archaeological sites of the surrounding hills, rather than engage with the mining evidence further afield that had been studied so thoroughly by the Bochum team.

Until this point, the external boundaries of the project had never been formally defined. As already mentioned, the environmental scientists needed information from the upper tributary wadis (the Dana, Ghuwayr, and Shayqar) to identify sequences of fluvial activity and their implications for climatic and tectonic history, but the steeply dissected landscape above those tributaries was only really amenable to reconnaissance archaeological survey rather than systematic coverage. The boundaries of the photogrammetric map we were using for the pedestrian survey work were generally at the foot of steep mountains (Fig. 1.16), so they encompassed much of the main catchment of the Faynan that the archaeologists needed to survey to understand landscape use beyond the field system as well as within it. One difficulty with defining where exactly we would place the boundaries of the survey was the lack of detailed cartography, so it was difficult to reconcile the photogrammetric and normal topographic maps within the area covered by the former, and still more difficult to map the landscape beyond at a scale appropriate for the archaeological enquiry.

However, the introduction of hand-held GPS technology at this time gave us the means at this stage in the project to develop a methodology for systematic survey of the hinterland beyond the field system, whether or not the terrain was within the photogrammetric map. The irregular outline of the photogrammetric map was set within a rectangular frame measuring 8 km west–east by 3.5 km north–south with the field system at its centre, aligned with the UTM (Universal Transverse Mercator) grid (Fig. 1.17). An additional 1 × 2.5 km was added at the northeast corner of the rectangle to incorporate the major zone of ancient mines explored by the Bochum team.

The initial investigation of the survey zone outside the field system comprised two separate stages. The densities of the surface archaeology beyond the field system were first established by collecting artefacts on 17 north–south transects corresponding to the edges of 500 × 500 m squares

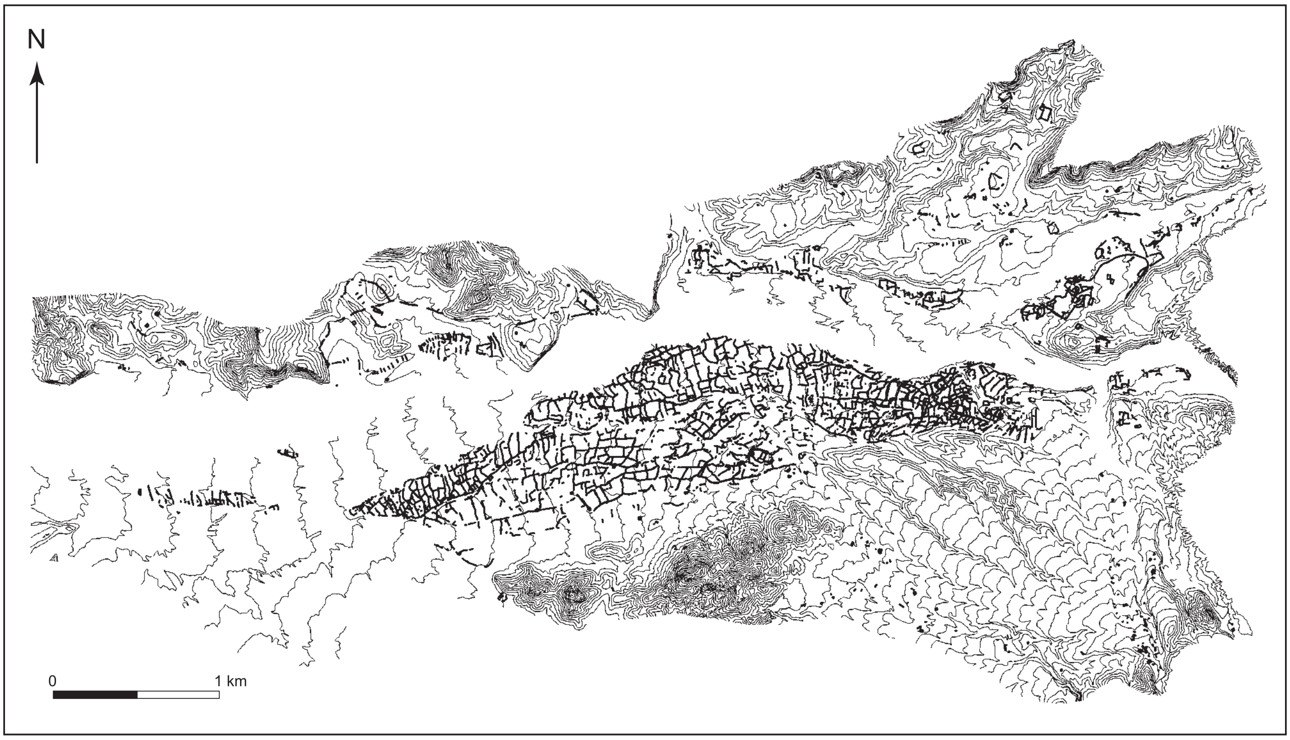


__Figure 1.16__ The photogrammetric map that formed the primary base map for the survey, limiting the fieldwork until the availability of hand-held GPS technology (for altitudes, see Fig. 1.3).

defined by the UTM grid (Fig. 1.17). The total length of these north–south transects was 65.5 km across arduous terrain in places, covering 13.1 ha (allowing for a 2 m wide visibility and collection corridor). This allowed us to compare artefact densities inside and outside the field system and to get a preview of the sort of archaeology to be encountered. The overall densities of surface artefacts were much lower than within the field system WF4, except in a few places where our transect lines crossed major sites (cf. Table 5.6 and Fig 5.43).

The archaeology was then mapped and recorded in detail within each 500 × 500 m square defined according to the UTM grid. Each square was systematically and intensively criss-crossed by a team using GPS units to define the margins of the square and to position accurately all archaeological features encountered. Some 1000 'sites' were recorded, of many different forms and of all periods of antiquity (Fig. 1.17). These included: lithic scatters; domestic structures and enclosures of dry-stone construction; field walls; graves and cemeteries; pictographs and inscriptions; mining- and smelting-related features; and recent bedouin encampments.

The ethnographic programme of fieldwork was expanded at the same time to help develop interpretative models for understanding the survey record. Graeme Barker had heard Helen Smith (Bournemouth) give a conference paper on the results of her ethnoarchaeological research on a series of Norse longhouses in the Outer Hebrides of Scotland. Intensive sampling of floor sediments for bioarchaeological remains enabled her to gain insights into the use of domestic space and the functions of the buildings, and the hypotheses were tested on sediments from a recently-abandoned croft whose former inhabitants were still alive and so could describe how the structure had been used. The implications of this approach for Faynan were obvious: if we could understand the use of space in recently-abandoned campsites from their inhabitants, and recognize 'archaeological signatures' for such activities in terms of differences in floor sediments and cultural residues, we could look for similar archaeological signatures in the archaeological sites being recorded by the survey as an aid to their interpretation. Mapping recently-abandoned bedouin campsites in 1999 and 2000, together with detailed interviews with local people, enabled Carol Palmer and Helen Smith to discern patterning in seasonal behaviour reflected in different camp architectures, and to model rates of destruction of different classes of material culture; the work was then extended by Carol Palmer to the present-day settlements of farmers and shepherds (including some of the Faynan transhumant shepherds) on the plateau edge above Faynan (see Chapters 2 and 12). Sediment samples were taken from a series of modern sites known to be of primarily arable, or primarily pastoral, use, and from various prehistoric, Nabataean, and Roman sites for comparison.

The primary emphasis of the final seasons of the palaeoenvironmental fieldwork was on refining knowledge of Quaternary environmental change and collecting samples for further AMS dating. The final phase of the programme also involved increasing integration between the environmental and archaeological fieldwork, with sediments from

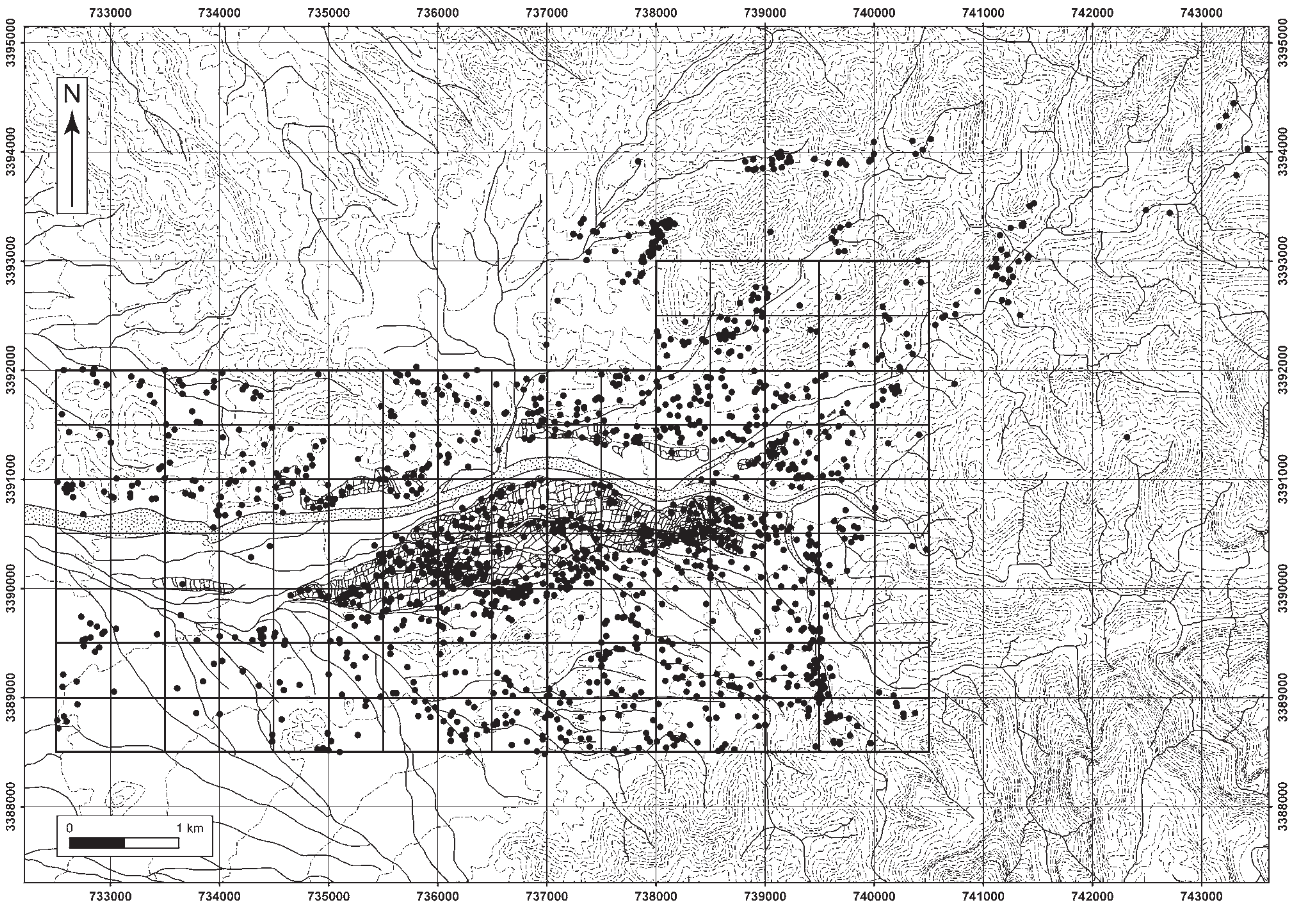


Figure 1.17 *The area of the Wadi Faynan Landscape Survey as ultimately defined, showing the 'field system' WF4, the grid used for the survey outside it, and the recorded archaeological sites. (Illustration: Paul Newson.)*

archaeologically-secure contexts and modern bedouin camps sampled for ICPMS analysis and palaeoecological indicators. One important focus of study was a series of parallel-wall systems thought to be water conduits of Roman date: trenches cut across a selection of these confirmed their date and their use for water channelling, and column samples were taken for detailed analysis of sediment sequences and associated indicators of the contemporary environments in which the hydraulic systems operated (Chapter 10). The geochemical programme concentrated on establishing the scale and extent of modern ground pollution beyond the 'hotspots' of the ancient smelting sites.

The main task of the final season of archaeological fieldwork was to elucidate information on site morphology, development, and function through a survey of a representative sample of sites located during the 1999 field season. Over 100 detailed plans were made of selected structures and landscapes at a variety of scales from 1:100 to 1:2000, differences in architecture and material culture suggesting a variety of arable, pastoral, and industrial (metallurgical) activities from Early Bronze Age to Byzantine times that it was hoped would yield specific sediment 'signatures' that might be informed by inferences from the ethnoarchaeological work. A representative group of 'petroglyphs' or 'pictographs' of prehistoric date was also planned in detail, and a tentative sequence developed from overlays of motifs, differences in patination, and the location of some pictographs in prehistoric settlement sites. Re-walking of the entire WF4 field system by Paul Newson and Patrick Daly, integrating the records from the twenty artificial units we had used for the earlier recording, indicated that it might be possible to use the comprehensive GIS to discern territorial (estate) boundaries of the Nabataean and/or Roman/Byzantine periods as well as wall layouts relating to land use and floodwater control (Chapters 9 and 10). Our explorations of the mining landscape confirmed the evidence of the geochemical studies that the Roman period marked a particularly significant phase of copper exploitation in the valley, with striking synchronicity apparent in the subsequent abandonment of the mines, the abandonment of the field system, the palynological evidence for an empty degraded landscape, and the geochemical evidence for a grossly polluted landscape.

The methodologies used in the different phases of the archaeological survey are summarized in Table 1.1. The variations in sampling strategy were designed to be fit for purpose in relation to the goals of each phase of the work. For example, the focus in the early seasons was to have close spatial and quantifiable control of the material

	Spacing of transects/walkers	Width of corridor	Collection method	Units of collection
Phase 1 Within WF4	10 m	1 m	1 in 3 transects collected, rest clicker-counted with judgemental 'grab' sample of diagnostics; all collected material counted and weighed	Systematic and grab samples from field units; some grab collections from identified sites/structures
Phase 2 Transects outside WF4	500 m between north–south lines walked	2 m	All artefacts encountered collected; all collected material counted and weighed	250 m stints along the north–south transect lines (following GPS-determined UTM grid lines), but no pick up within field-system zones crossed by transect lines
Phase 3 UTM 500 × 500 m squares	10–20 m depending on terrain and visibility; squares covered in a series of parallel sweeps	5 m	Artefacts only collected in association with sites (though pot and lithic scatters were recognized categories)	Mainly judgemental collections from identified sites, to provide a representative sample of artefacts, not simply diagnostics
Phase 4 Further recording and planning of sites	n/a	n/a	Grab only	Mainly diagnostics
Phase 5 Sites beyond the core survey area (e.g. mines and mountain sites)	Reconnaissance survey using GPS to record location of visible sites and mine workings in mountain valleys	n/a	Artefacts only collected in association with sites	Mainly judgemental collections from identified sites, to provide a representative sample of artefacts, not simply diagnostics

Table 1.1 *Summary of field survey recording methods used in the different phases and operations of the Wadi Faynan Landscape Survey.*

within the field system. Similar methods were applied to the long north–south transects across the landscape in the second phase of the survey, so that we could understand the relative densities of material within the WF4 field system and in the wider landscape. Artefact distributions on many sites located in the third and fourth phases were spatially discrete (in relation to ancient middens at settlements or to robbed graves within a cemetery). Arbitrary transects could easily have missed the main focus of artefacts, so the emphasis was primarily on the recovery of a representative 'grab' sample of artefacts. This involved at least one member of the team methodically searching the site for artefacts, taking as much time as was required to make a thorough search of its overall extent.

1.8 Conclusion and structure of this book

As this review of the development of the Wadi Faynan Landscape Survey fieldwork has described, the overarching interest of the project in contributing a long-term case study in landscape archaeology to the desertification debate stayed the same from its inception to the completion of the fieldwork, but the focus shifted significantly in the different phases of the research. There was always a clear sense amongst the project leaders of where the project should end up, but not all the methodologies had been worked out in detail, and they were re-evaluated as the project developed. The first phase concentrated on establishing what was likely to be possible, and what was most urgent to do in the face of modern development. In the second phase the emphases of the environmental and archaeological research separated somewhat – literally, in fact, as the geographers refined the Quaternary and geoarchaeological sequences in the tributary wadis especially, and the archaeologists established the main characteristics of the field systems in the main Faynan basin – as the two groups started to establish key landscape histories by building on the foundations they had laid in the first season. In the later seasons the process of integration and feedback accelerated: the archaeological survey put the field system evidence into the context of its surrounding landscape; the geomorphological survey moved from the surrounding landscape into the detailed laboratory investigations of geoarchaeological materials obtained from barrages, mines, smelting sites, water catchments, and field systems; the ethnographic and ethnoarchaeological studies helped to link past and present societies and the archaeologies they created; and the geochemical studies provided a further critical link between the landscape models of the present project with those of the Bochum team on mining history.

The major strengths of a landscape archaeology study such as the Wadi Faynan Landscape Survey are the spatial and chronological scales of the data accumulated, and their multi-disciplinary nature, in our case integrating especially the approaches of archaeology, ethnoarchaeology, geochemistry, geomorphology, and palaeoecology. The major weakness of such a project is the lack of detailed and tightly-dated information that only major excavations can provide, about particular activities at particular locations at particular moments in the past, and of circumscribed contexts where particular sets of archaeological and palaeoenvironmental information can be investigated in detail and their potential relationships established with reasonable confidence levels. Any holistic study of landscape development of course needs both approaches.

Our project has been extremely fortunate, though, in that we have been able to compare our data with, and relate our results to, the significant amount of excavation work undertaken and being undertaken by other teams in the Wadis Faynan and Fidan of sites relating to most of the major periods of settlement in the past. Critical information about settlement forms and activities in the Wadi Faynan in the early and mid Holocene has been provided by the major excavations at the Pre-Pottery Neolithic A settlement at WF16 (Finlayson and Mithen 2007) and at the adjacent Pre-Pottery Neolithic B settlement Ghwair I (Simmons and al-Najjar 1996; Simmons and Najjar 2006), and smaller excavations at the Pottery Neolithic/Chalcolithic settlement of Tell Wadi Faynan (al-Najjar *et al*. 1990) and the Early Bronze Age settlement WF100 (Wright *et al*. 1998). Our understanding of the local prehistory has been enormously enhanced by the survey and settlement and cemetery excavations of the Wadi Fidan (Jabal Hamrat Fidan) Project led by Professor Tom Levy of the University of California, San Diego, and Dr Mohammed al-Najjar of the Department of Antiquities of Jordan. This project developed more or less in tandem with our own work but with a particular focus on the social implications of ancient mining and metallurgy; subsequently Levy's team have extended survey and excavation into the Wadi al-Jariya and Wadi al-Ghuwayb, immediately north of the Faynan catchment (Adams 2000; Adams and Genz 1995; Levy 2004; 2006; Levy and Higham 2005; Levy *et al*. 1999a,b; 2001a,b; 2003; 2004a,b; 2005a; Muniz 2006; Weisgerber 2003; 2006). This work has complemented the technologically-focused studies of the Bochum Mining Museum, brought together in particular by Hauptmann (2000; 2007).

The result is that, as described in the later chapters of this book, we can establish the principal components of the landscape history of the Wadi Faynan. Changing and complex interactions can be discerned between herders, farmers, and miners from the early Holocene to the present day. In partnership with the other projects working in the study area, the project provides a long-term perspective on the strategies by which the ancient inhabitants of Wadi Faynan managed their challenging environment, the solutions they developed, their successes and failures, and their short- and long-term environmental impacts, a perspective that we believe provides eloquent testimony of the power of landscape archaeology to contribute significantly to the desertification debate. The book is divided into two main sections. Part I is concerned with the research themes, methods and background. Chapter 2 presents an overview of the present-day Faynan region, summarizing the landforms, environment, climate, geology, and recent history and economy of the main human groups living in or exploiting the zone. In Chapter 3, the methodologies and approaches of the geoarchaeological specialists are presented in further detail, with particular attention on chronostratigraphies, palynology, geochemical and pollution studies, and the investigation of radon gas and other health risks afflicting mining communities. The two following chapters focus on the archaeological survey and the descriptive typologies of sites (Chapter 4), and the investigation of the field systems (Chapter 5). The latter in particular is as much concerned with the methodologies of fieldwork and GIS analysis of complex, multi-period field and wall systems, as it is with explaining our overall interpretation. We believe strongly that the Faynan represents an interesting methodological exemplar of how such work may be undertaken. The diachronic evolution of the field system as we understand it is presented in the relevant chapters in the second half of the book.

Part II presents our chronological syntheses of the various periods of human activity in the Faynan region, combining the archaeological and environmental story in each case. Chapter 6 focuses on the Pleistocene and the activity of hominins (early humans) against a backdrop of major changes in climate and landforms in the period 450,000–9500 BC. The early Holocene environment and the transitions to farming 9500–5000 BC are the subjects of Chapter 7. The Chalcolithic and Bronze Age phases (5000–1200 BC) saw the initiation of mining and metallurgy and more intensive patterns of settlement in a changing environment (Chapter 8). The Iron Age and Nabataean periods (1200 BC–AD 106) represent successive phases of exploitation of the region by early states, with particularly large-scale metallurgy in the Iron II period (Chapter 9). Chapter 10 presents the evidence for a landscape of imperial exploitation in the Roman and Byzantine ages, AD 106–636. The evidence for the degradation of the landscape and the human consequences of pollution linked to the metallurgy are especially notable in this phase. The following Islamic–Ottoman periods (AD 636–1918) stand in stark contrast as human activity returned to a level and intensity that is much harder to identify and evaluate (Chapter 11). The final chronological study (Chapter 12) concerns the ethnoarchaeological study of the modern bedouin, providing improved understanding of their elusive material traces, with significant implications for future investigations of pastoral groups in earlier periods of activity.

The final chapter provides a set of conclusions and responses to the questions laid out in this introduction. Many field survey projects focus above all on reconstructing settlement patterns or changing demographic profiles across time and we would emphasize at the outset that this was not the prime objective of our project (though we do of course have much to say on these issues at the appropriate places). We hope that the results of the Wadi Faynan Landscape Survey will be consulted as much for our insights concerning the methodologies and approaches of interdisciplinary research relating to a series of broad questions about the interactions of people and environment implicated in processes of desertification.

2. The Wadi Faynan today: landscape, environment, people

Carol Palmer, David Gilbertson, Hwedi el-Rishi, Chris Hunt, John Grattan, Sue McLaren, and Brian Pyatt

2.1 Landscape and environment

A sense of quiet, calm, timelessness, and uniformity pervades the Wadi Faynan today, but it is deceptive. As this volume describes, in significant part this dramatic wilderness is the result of profound industrial dereliction. It is a landscape that can be, and has been, a place of dramatic and rapid change, both in space and time. Understanding the history of this extreme environment and its people requires an awareness of, first, the important and complex relationships between the modern topography, bedrock geology, mineralizations, hydrology, climate, vegetation, and geomorphological processes, and second, of how these relationships have altered dramatically over long periods of time both naturally and as the result of interactions with human activities.

The Wadi Faynan lies in the hot and hyper-arid Jordanian Desert, at a distinctive and spectacular mountain front that reaches 1500 m above the desert floor (Figs 2.1, 2.2, 2.5–2.10, 2.15). This landform marks the eastern margin of the desert lowlands of the great Jordanian Rift Valley, with the trough of the Wadi ʻArabah to the south and west, and the Highlands of the Mountains of Edom and the Jordanian Tablelands to the east and north (Bender 1975). The Wadi ʻArabah, with its dunes, sand sheets, gravel-filled wadi floors, scrub, and rock, extends for 175 km from the Dead Sea, where it is at *c*.394 m below sea level, southwards to the Gulf of ʻAqaba (Jordanian National Geographic Centre 1984). To the east of the Wadi ʻArabah are the high and flat regions of the Jordanian Tablelands, reaching altitudes of 1100–1600 m above sea level. The Wadi Faynan lies at the northern margin of a complex of large alluvial fans that line much of the mountain front, and the rugged relief, composed of Precambrian and Palaeozoic rocks, of the Jabal Zureiq el Mirad (or Zurayd al-Mirad) that rises to *c*.300 m. To the south are the much lower and softer broken hills of the Jabal Madsus ad Dahal (160–300 m), composed of Cretaceous rocks. The present study focuses upon the Wadis Dana, Ghuwayr, and Shayqar, and their continuation to the west as the Wadi Faynan beyond their confluence at the Khirbat Faynan (Figs 2.2, 2.3). The Wadi Faynan becomes the Wadi Fidan as it approaches the low ridge of the Jabal Hamrat Fidan in a shallow gorge, before it enters the great shallow trough and rift basin of the main Wadi ʻArabah draining north to the Dead Sea.

2.1.1 Climate

The study area is separated from the climatic influences of the Mediterranean by distance and by the uplands west of the Wadi ʻArabah, and influenced instead by the hot dry climate of the Saharo-Arabian desert belt to the south and east, but it also varies notably with passage westwards from the Jordanian Tablelands down the mountain front to the desert basin. The mean summer temperature on the Jordanian Tablelands is in the order of 17°C, though the mean monthly summer temperature in the upland town of Shawbak south of the Wadi Dana is 29°C and sometimes reaches over 38°C, compared with a February minimum there of about 12°C (Rabb'a 1994). In January, the coldest month, temperatures on the desert floor in the Wadi Faynan are estimated seldom to fall below 12°C, whilst in summer they frequently reach 40°C. The region is characterized by frequent and occasionally very strong winds throughout the year (Table 2.1) that, in combination with the aridity, promote widespread deflation and redistribution of dusts. The prevailing west winds bring rain in winter, whilst on occasion, katabatic winds driven by cold dense air develop on the plateau which drain and may funnel through the gorges, moving fine sands from east to west. Sand blow was readily observed in the area in the late 1990s after

* *Landscape and environment:* David Gilbertson, John Grattan, Chris Hunt, Sue McLaren, Brian Pyatt, Hwedi el-Rishi; *Ethnoarchaeology – the Bedouin Camp Survey:* Carol Palmer.

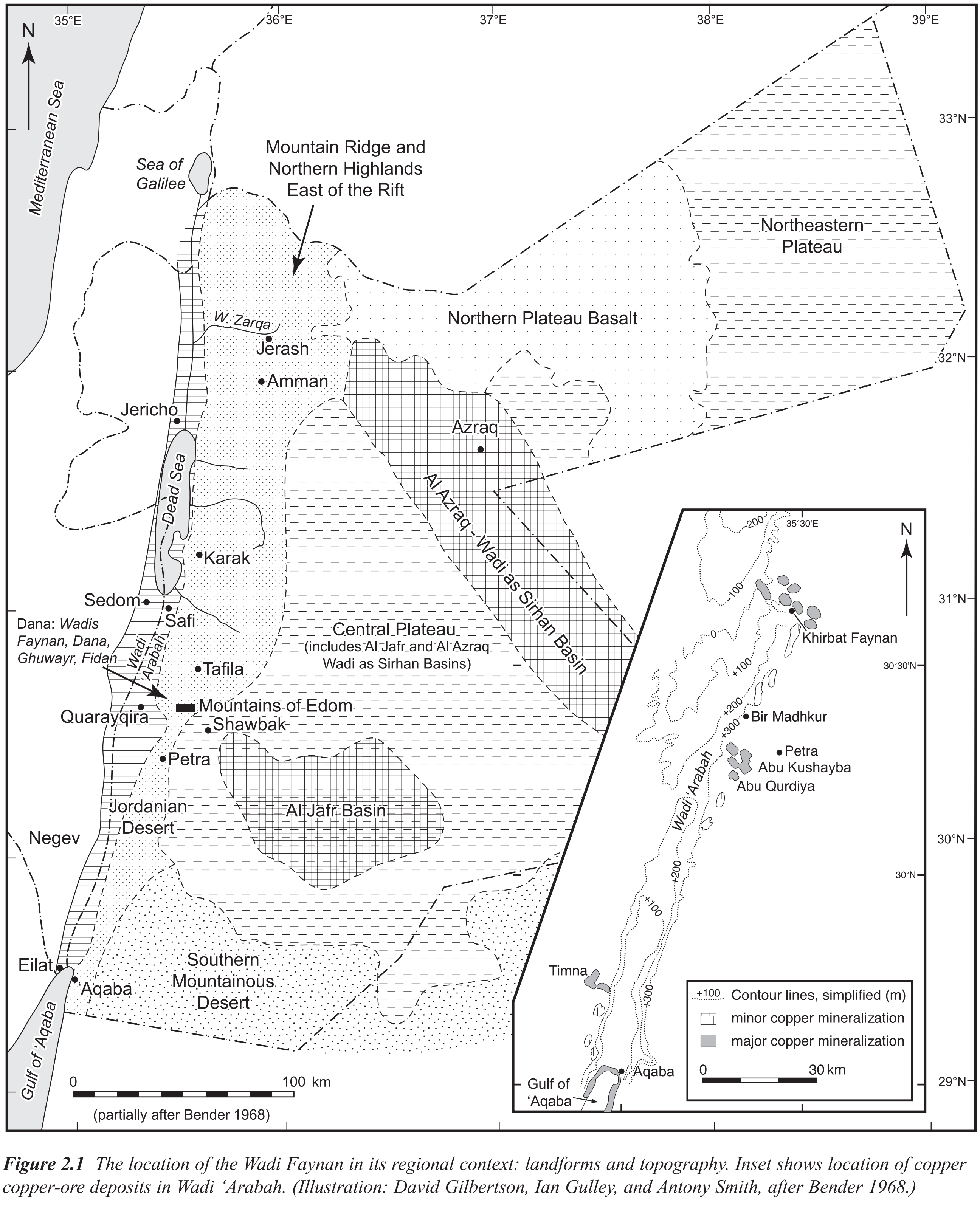


Figure 2.1 *The location of the Wadi Faynan in its regional context: landforms and topography. Inset shows location of copper copper-ore deposits in Wadi ʻArabah. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Bender 1968.)*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction of wind (°N)	255	255	239	278	282	293	296	292	287	257	263	247
Mean wind speed (knots)	4.7	4.7	5.1	4.8	4.2	4.3	4.5	3.9	3.4	3.5	3.8	4.2

Table 2.1 *Mean monthly wind speeds and dominant direction in the study area. (After Rabb'a 1994.)*

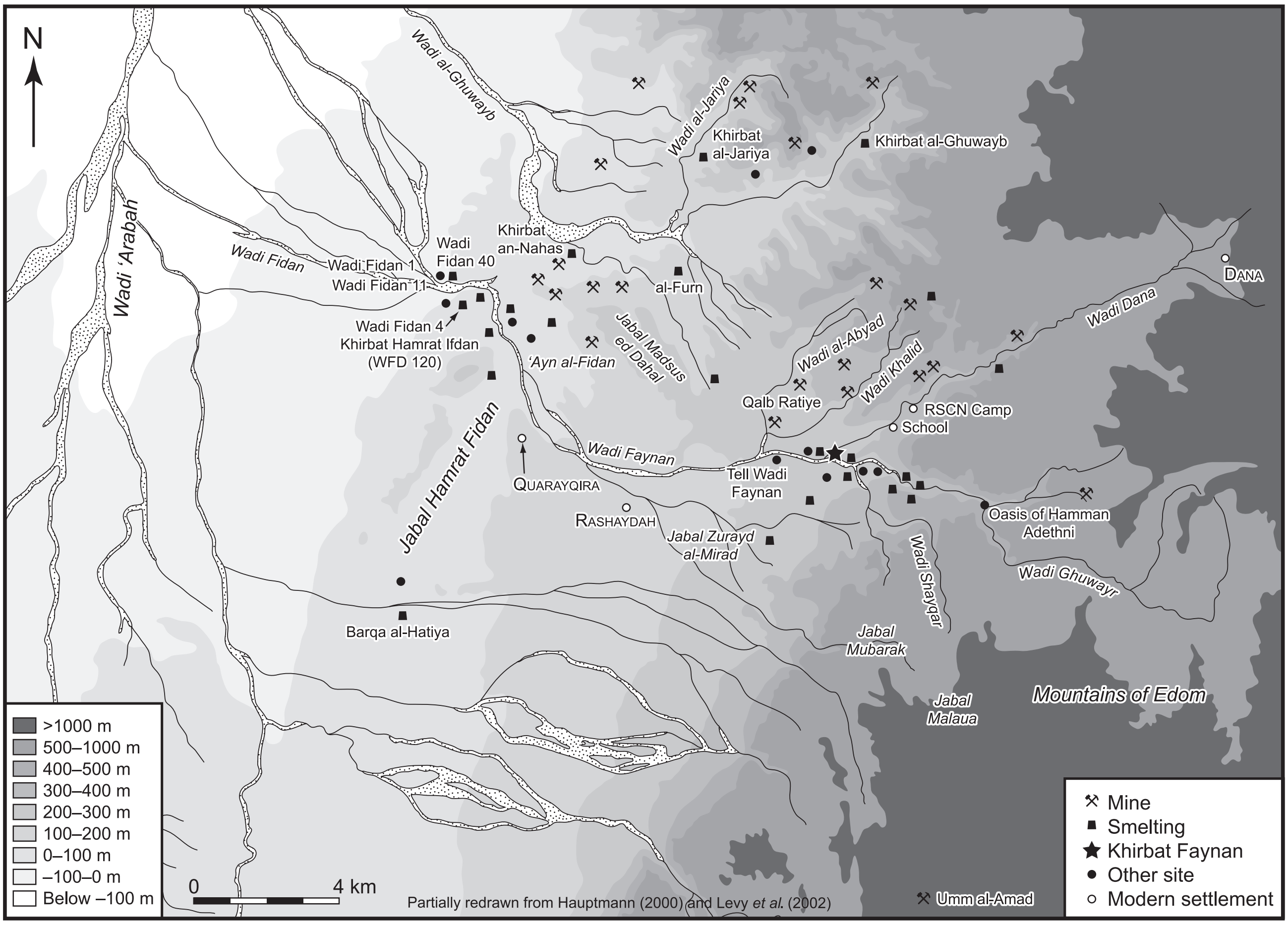


Figure 2.2 *The major features of the topography, wadis, modern villages, and the industrial landscape in the study area, including the distribution of some of the larger ancient sites, mines, adits, and slag deposits. (Illustration: Dora Kemp, Ian Gulley, and Antony Smith, after Hauptmann 2000, and Levy* et al. *2002.)*

wall-clearance and ploughing south of the Khirbat Faynan (Fig. 1.7).

Seasonality is strong, with most rain falling between December and March and virtually no precipitation occurring between June and September. Rabb'a (1994) recorded a mean monthly rainfall of 17 mm for January, falling to 0.0–0.1 mm from June to September, rising to 17 mm in December. The Jordanian Tablelands, at altitudes of 1100–1600 m, have an average precipitation exceeding 200 mm per year (annual rainfall at Kerak, for example, is over 250 mm a year: Aresvik 1976), whereas annual rainfall in the lower Wadi Faynan is around 63 mm and even less in the Wadi 'Arabah: the coastal port of 'Aqaba receives 30 mm p.a. (Bruins 2006). The present climatic regime in the Wadi Faynan is exceedingly arid and controlled mainly by altitude and aspect, but rainfall is also highly variable: Raikes (1980), using his detailed local engineering knowledge, estimated that annual rainfall near the study area varies between 150 mm in a wet year and 50 mm in a dry year. Discussions of local climatic variability over the last 50 years are given by Cohen and Stanhill (1996) and more widely in Bolle (2003), Hashemite Kingdom of Jordan Meteorological Department (1988), and Jordanian National Geographic Centre (1984). Also, in some locations including the sites of the springs in the gorges (see next section), field observation indicates that microclimate varies notably and significantly from location to location, even over short distances. These variations reflect the local interactions of topography, exposure, shade, local water, susceptibility to desert winds, and density-driven airflow in the wadis, all of which have considerable importance for plants, animals, and people.

2.1.2 The Faynan wadi system

The headwaters of the Dana and Ghuwayr are at 1200–1400 m above sea level. In their upper parts, the Dana and Ghuwayr form relatively wide valleys with gentle slopes, eroded through Cretaceous limestones and Cenozoic basalts (Fig. 2.3); the distinctive terrains of these Cretaceous bedrocks are characterized by frequent major landslides. The Cretaceous limestones rest unconformably upon a complex of mineralized Precambrian and Palaeozoic rocks (Barjous 1992; Ionides and Blake 1939; Rabb'a 1994; Fig. 2.4). Through these bedrocks, the Wadis Dana and Ghuwayr have breached the mountain front with spectacular steep-sided rocky gorges, often 300–400 m deep (Figs 1.2, 2.5). These

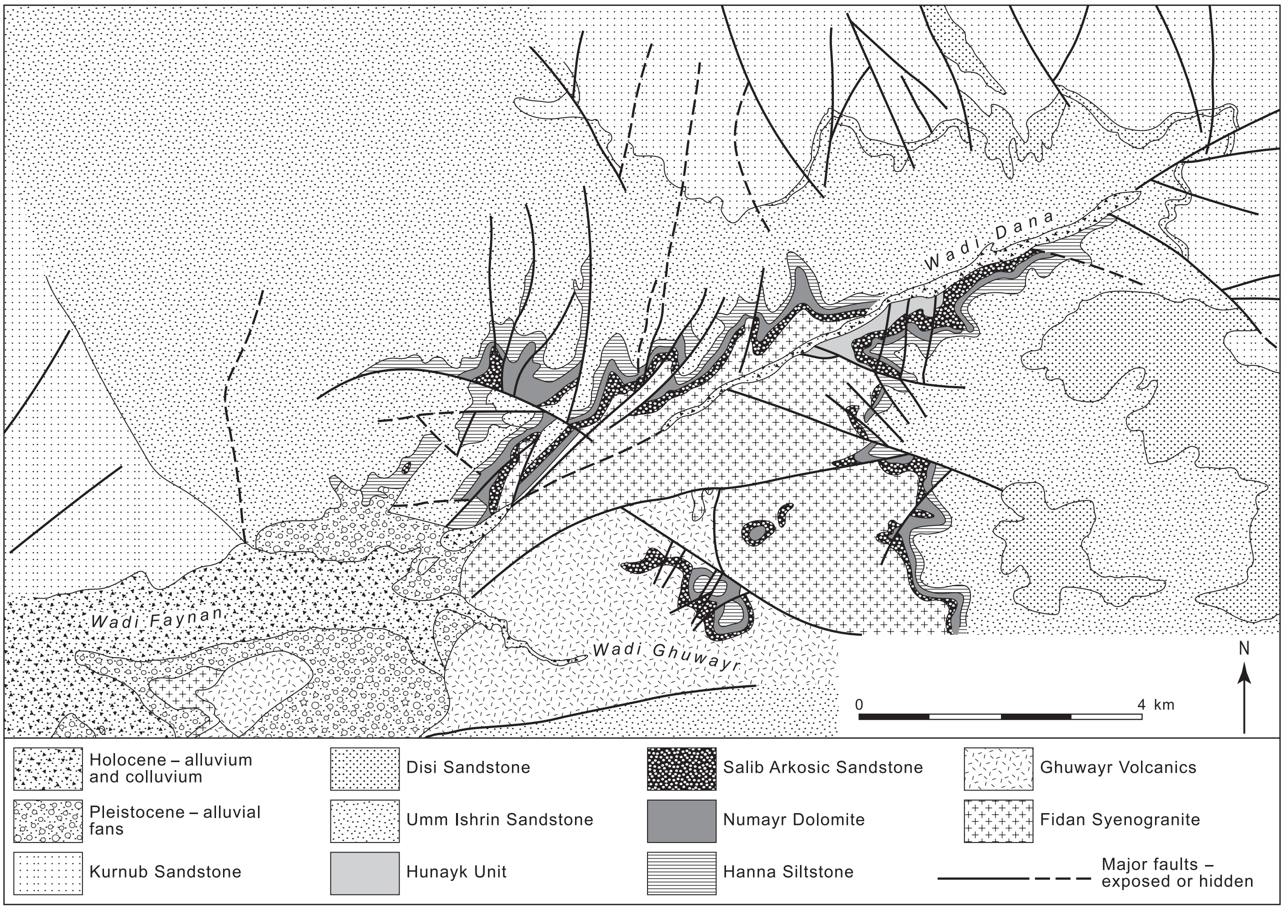


Figure 2.3 *Summary of the bedrock geology of the study area. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Barjous 1992; Rabb'a 1994.)*

gorges are often rectilinear in overall shape and pattern – planform – reflecting the controls exercised by the region's complex sequences of geological faults. The Wadi Shayqar also begins as a similar gorge on the rocky mountain front of the Jabal Mubarak to the south of Khirbat Faynan, but it then forms a 10–20 m-deep trench some 50–200 m wide, along the northeast margin of a large and complex alluvial fan that has accumulated at the front of this rugged mountain massif (Fig. 2.6). In winter, particularly powerful floods may occur and the gorges may be in receipt of both torrential water from the steep mountain fronts and also more sustained gentler run-off from the Jordanian Tablelands. The run-off from these powerful floods, locally augmented by overland flow from the adjacent slopes, may re-work boulders, trees, and surface sediments many kilometres down the Wadi Faynan (Ionides and Blake 1939: 49; Fig. 2.7).

Springs in the upper Wadi Dana sustain the gardens of Dana village (Fig. 2.24), and within the lower Wadis Dana and Ghuwayr are other series of perennial springs that yield good water throughout the year and that may be surrounded by reed-swamp, mitigating the impacts of extreme heat and aridity for plants and animals. Some of these springs sustain lush oases of trees, palms, plant and animal life, such as the oasis of Hamman Adethni in the gorge of the Wadi Ghuwayr (Fig. 2.8). Even in times of extreme summer heat, the springs continue to feed small perennial streams that flow along the wadi floors before evaporating or sinking into the braid-plain gravels (Ionides and Blake 1939: pl. 77). The presence of such springs must have been of profound importance in the past.

Beyond the mountain front, the Wadi Faynan is open in form, with a braid-plain: the sand and gravel floor of the wadi is occupied by many inter-laced channels and branches which join and separate, filling with water and shifting in times of strong flows. Such environments and processes are typical of arid-land rivers. The braid-plain of the Wadi Faynan is up to 1 km wide, and is variously incised 0–10 m through the immediate desert landscape (Figs 2.7, 2.9, 2.10). The braid-plain is highly active, with unstable shifting flow patterns. Braided river channels on the alluvial ground frequently migrate during flow events, so that they flow along different courses during successive events: Graf (1983b), for example, noted that the main-flow channel in the Salt River in Utah migrated laterally up to 1.6 km in response to high-magnitude (i.e. powerful) low-frequency (i.e. frequent) floods. The flow regime of arid-zone rivers is characteristically unsteady and the uncertainties of hydrologic input, coupled with the highly variable effects of water loss through seepage or evaporation, make their behaviour difficult to predict: the discontinuous operation of the fluvial system precludes the

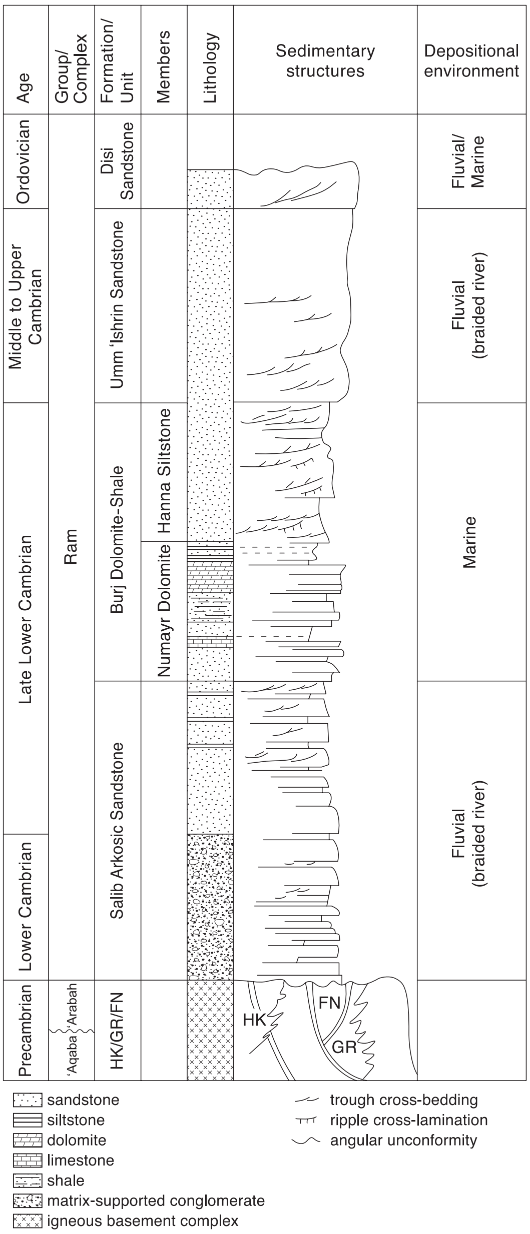


Figure 2.4 *Summary of the geological succession of ore-rich Precambrian and Lower Palaeozoic rocks in the study area. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Barjous 1992; Mohamed 1999; Rabb'a 1994.)*

Figure 2.5 *Looking east from the south side of the Khirbat Faynan towards the eastern margins of the Mountains of Edom. The view leads from the braid-plain of the Wadi Ghuwayr (with occasional trees of* Acacia *sp.), which floods after heavy rain storms. Beyond this is the steep-sided gorge of the Wadi Ghuwayr. In the far distance, shown by lighter tones, is the outcrop of Cretaceous bedrocks that underlie the Jordanian Tablelands. The 10–20 m-high cliff to the left of the braid-plain is an exposure of the Ghuwayr Beds at their type site. The minor terraced landforms 0.5–1.5 m high to the right of the modern braid-plain are an outcrop of the Dana Wadi Beds – a late Holocene fluvial and aeolian deposit, which gives way to Pleistocene fluvial and colluvial sequences. (Photograph: Graeme Barker.)*

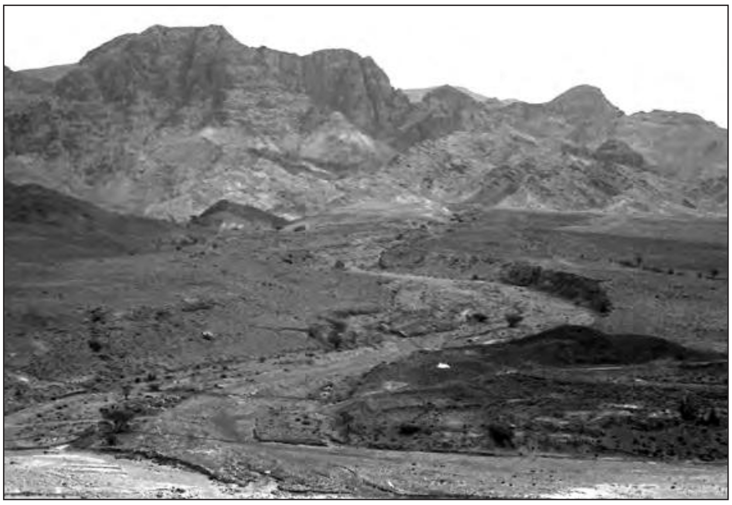


Figure 2.6 *Looking southeast from Khirbat Faynan up the Wadi Shayqar to the Mountains of Edom. In the foreground, the braid-plain of the Shayqar is eroding into slag heaps from the smelting of copper; with poor exposure to the right of the braid-plain of the Shayqar Beds and Asheiair Beds (see McLaren* et al. *2004; and Chapter 6). On the far side of the Wadi Shayqar is a large alluvial fan, the Shayqar Beds of McLaren* et al. *(2004). The Wadi Shayqar was traversed by a Roman aqueduct that brought water down from a spring in the Wadi Ghuwayr to the Roman-period field systems. (Photograph: Graeme Barker.)*

Figure 2.7 *The Wadi Faynan in flood, April 2002, looking east. (Photograph: Steven Mithen, reproduced with kind permission.)*

Figure 2.8 *The Oasis of Hamman Adethni in the gorge of the Wadi Ghuwayr demonstrates the lushness and diversity of plant and animal life that occurs where there is a good supply of water (in this case perennial water from springs and mountain run-off), and areas of (semi-stable) surficial deposits facilitating plant growth (in this case a complex of alluvial fans and colluvium). (Photograph: David Gilbertson.)*

Figure 2.9 *Looking west down the shallow multi-channel, gravel-bedded, braid-plain of the Wadi Faynan from Khirbat Faynan. The braid-plain of the Wadi Ghuwayr enters from the left and the less well-marked braid-plain of the Wadi Dana enters from the right. (Photograph: Graeme Barker.)*

Figure 2.10 *Looking north over the Wadi Faynan from the Nabataean fort site Tell al-Mirad (WF592) over the surface of the large, partially dissected, alluvial fans of the Shayqar Beds that front the Mountains of Edom, to the Khirbat Faynan and up the gorge of the Wadi Dana to the distant higher tablelands (beyond Dana village at its head). (Photograph: Graeme Barker.)*

mutual adjustments between form and process normal in rivers in more humid environments (Knighton and Nanson 1997). According to Graf (1988) two situations prevail: one when processes control forms during catastrophic flow events, and the other when forms control processes during smaller flow events. Braided rivers are also known to vary over much longer periods of time (Cooke and Reeves 1976). These properties are readily evident in the survey, with the consequence that few if any significant built-structures that were intended to last would ever have been established on the braid-plain, where their prospects for survival would be poor.

2.1.3 Geology and mineralization

The geology and mineralization of the region are complex, but the details have significance for archaeological and environmental interpretation, because one of the central themes running through this book concerns the nature and consequences of the exploitation of the ore minerals of the highly mineralized bedrocks exposed in the mountain front (Hauptmann 2000; Overstreet *et al.* 1982). The Faynan region is one of the world's most ancient and important centres of copper extraction and smelting (Fig. 2.1 inset). Within a few kilometres of Khirbat Faynan there are over 250 copper mines and adits, including tunnels and chambers up to 150 m long, the most impressive being the Roman-period mine traditionally called Umm al-Amad, the 'Mother of Pillars', so called because of the rock pillars left in place to support the roof of the excavated cavern (Figs 2.2, 10.4). In excess of 250,000 tons of ancient copper slag remain at the surface within the *c.*12 km^2 main zone of ancient mining and smelting, which still contains an estimated 19.8 million metric tons of copper. Overall, the Faynan Orefield covers an area of about 500 sq. km.

The Faynan Orefield appears to be the equivalent to, and a complex extension of, the more widely known Timna Orefield located *c.*90 km to the south-southwest, to the west of the Dead Sea Transform Fault System, from which the Faynan has been separated by strike-slip faulting (Fig. 1.1; Atallah 1992; Bender 1965; 1974a,b; Quennell 1958; Ken-Tor *et al*. 2001; Klinger *et al*. 2000; see also Rothenberg 1990). This fault system separates the Arabian Plate from the Sinai Sub-plate, which is an appendage of the African Tectonic Plate. The fault system has formed what is readily envisaged as a pull-apart basin – a *graben* – that also began subsiding in the late Tertiary. According to Shapira (1997), the average geological slip rate is 5–10 mm per year. The basin has accumulated approximately 107 km of movement in two main episodes of activity, in the Miocene and earliest Pliocene (Brew *et al*. 2001; Klinger *et al*. 2000; Quennell 1984). The Arabian Plate has moved northward relative to the African Plate. There have also been several kilometres of complex *graben*-infill accumulation in parts of this rift system (Horowitz 1979).

The most recent descriptions of the local geology are given by Barjous (1992) and Rabb'a (1994); wider perspectives for the region are provided by Bender (1968; 1974b), Brook and Ibrahim (1987), French National Public Institute (1974), Gold (1964), Hauptmann (1992; 2000), Ionides and Blake (1939), McCourt and Ibrahim (1990), Powell (1988; 1989a,b), Rabb'a and Ibrahim (1988), and van den Boom and Ibrahim (1965). The Late Precambrian and Palaeozoic Formations summarized in Figures 2.3 and 2.4 follow the terminology and spellings of Rabb'a (1994). The landscape of the region is developed primarily on a complex of volcanic, granitic, and sedimentary rocks variously of Proterozoic and Lower Palaeozoic age, which have been extensively affected by faulting. The ancient bedrocks and their contained ores have been spectacularly exposed in the study area by the erosion and retreat of the mountain front and the development of the gorges of the Dana and Ghuwayr.

2.1.3.1 Late Proterozoic 'Aqaba Complex and Late Proterozoic 'Arabah Complex

The volcanic and granitic bedrocks that are present are of Late Precambrian age and are allocated to either the 'Aqaba or 'Arabah Complexes (Fig. 2.4). The 'Aqaba Complex comprises the Ahaymir and the older Ghuwayr Volcanic Suites and the Hunayk Monzogranite. The Ghuwayr Volcanics include green basic lavas, tuffs, pyroclastics, and silty volcaniclastics (fragmentary rocks originally of volcanic origin). Copper mineralization is present in all three sets of bedrocks. There are locations with enrichment in silver, and presumably also in lead. Two crush zones produced by strike-slip faulting – that is lateral movement of one block with respect to the other in a direction that is approximately parallel to the orientation of the outcrop – in the Hunayk Monzogranite and the Minshar Monzogranite reported 9–10 km northwest of Khirbat Faynan displayed substantial enrichment in manganese, copper, lead, zirconium, bromine, chromium, and molybdenum, with some beryllium. The 'Arabah Complex, which may be younger, contains graniodiorites, the Minshar Monzogranites, the Al Bayda' quartz-feldspar porphyrys of the Ahaymir Volcanic Group, the Fidan Syenogranites, various pegmatites, and perhaps a lower part of the Ghuwayr Volcanics. These basement rocks are extensively faulted, as is the overlying sedimentary sequence that makes up the Ram Sandstone Group.

2.1.3.2 Palaeozoic: Ram Sandstone Group

This sedimentary group crops out extensively in the locality and is known to have been exploited for copper in antiquity (Hauptmann 2000). Over the millennia it has yielded prodigious quantities of complex suites of metal-enriched sediments through natural erosional processes acting on the extensive natural outcrops in the wadis, augmented by the re-cycling effects of wind and water acting on mining and smelting wastes and spoil tips.

2.1.3.2.1 Massive Brown Sandstone ('MBS')

The lowest member of the Ram Sandstone Group is the Salib Arkosic Sandstone Formation, referred to as the 'Massive Brown Sandstone' (MBS) by Hauptmann *et al*. (1992; and earlier papers), as well as by subsequent archaeological surveys. It consists of yellow-brown, purple, medium- to coarse-grained arkosic and sub-arkosic bedded sandstones (i.e. rich and moderately rich in the feldspar minerals) with a distinctive tabular bedding. In large part, these sediments appear to have been deposited by braided rivers. At their base is a conglomerate which marks the beginning of the Cambrian. The MBS has a thickness ranging from 0 to 70 m in the study area and is widely exposed, overlying the Late Proterozoic complexes. In the Wadi Malqua, *c*.15 km south of Khirbat Faynan, this formation yielded very substantial concentrations of copper, manganese, and barium (5000 ppm), lead (10,000 ppm), and cobalt (750 ppm), as well as significant quantities of silver (Rabb'a 1994: 52). The ores represent local copper mineralizations occurring along an irregular network of veinlets or joints where surface efflorescences of chlorides also indicate a high salt content (Hauptmann *et al*. 1992). The veins are of low spatial density. The main mineral is malachite, with relics of chalcocite (Cu_2S) and 'tile ore' (iron hydroxide+cuprite) and ubiquitous but minor paratacamite, often in brecciated ores (i.e. ores that have been fractured into angular fragments). Locally the copper content can reach up to 55 per cent, iron occasionally to up 15 per cent, and sulphur up to 3.5 per cent; the ores are very low in manganese and lead. At present, no ancient mines appear to have been recorded for this sandstone. The MBS formation appears to thin and to 'pinch-out' to the south, and even though mineralized rocks of this age crop out at the land surface only 3 km north of the Umm al-Amad Roman mine, the ores may not have been easily accessible to ancient miners.

2.1.3.2.2 Dolomite-Limestone-Shale ('DLS')

The overlying Late-Lower Cambrian Burj Dolomite-Shale Formation consists of dolomites, siltstones, and sandstones several hundred metres thick (Barjous 1992; Rabb'a 1994). It has been divided into three Members to the north on the Shawbak Geological Sheet (Powell 1988; Tarawneh 1996), but in the study area only two of these members have been identified: the Numayr Dolomite Member (Powell 1988), and the overlying Hanna (Hanneh) Siltstone Member.

The Numayr Dolomite Member is the 'DLS', or Dolomite-Limestone-Shale Unit, of Hauptmann *et al.* (1992; Hauptmann 2000, and related papers). Varying in thickness between 25 and 30 m, it has a marine origin and consists of rose to white, medium- to fine-grained sandstone passing upward to buff, silty, sandstone, intercalated with black shale; in the upper parts it contains irregular concentrations of copper and manganese minerals. The main ore body is a 1–2 m-thick layer of secondary copper ores, primarily copper silicates (chrysocolla $CuSiO_3 \times 2H_2O$), malachite, 'tile ore', and paratacamite (copper chloride), with black intergrowths of manganese oxides (Barjous 1992; Hauptmann *et al*. 1992; Rabb'a 1994). Locally these manganese ores may be replaced by haematite. The DLS bedrocks are rich in copper, lead (up to 6 per cent), and occasionally manganese, with notable frequencies of dolomites, phosphorites, and barites. They are largely free of sulphur and cobalt, especially in comparison with the MBS, but have ten times higher concentrations of lead, zinc, nickel, cobalt, and arsenic, the ratio of antimony/arsenic is also higher, and concentrations of tellurium and uranium are notably larger. Concentrations of trace elements such as arsenic, antimony, silver, cobalt, nickel, and bismuth are very low, below 100 μg/g. This metal-enriched layer also penetrates to a depth of several decimetres into what Hauptmann (1992) termed the Variegated Sandstone-Shale Unit (referred to as the 'VSU-cb3' in Hauptmann 1992), named the Hanna (Hanneh) Siltstone of the Burj Dolomite-Shale Formation by Barjous (1992) and Rabb'a (1994), where secondary copper ores are also associated with oxidic manganese ores.

2.1.3.2.3 Hanna Siltstone

The overlying Hanna (Hanneh) Siltstone is of Late Cambrian age and appears to have been deposited in a shallow sub-tidal to inter-tidal environment. It has a thickness of 30–50 m and is now regarded as consisting of two lithological units. The Lower Shale Unit is green to dark brown and is intercalated with a thin bed of sandstone rich in copper and manganese mineralizations in the form of cavity and fracture infillings in pores and along bedding planes. The Upper Sandstone Unit is a distinctive white to yellowish-white colour. Termed the Variegated Sandstone Unit or 'VSU' by Hauptmann *et al*. (1992), it has secondary copper ores associated with oxidic manganese ores.

Some sedimentary members within the Burj Dolomite-Shale Unit contain concentrated pure ores as a result of secondary enrichment: for example, there is a 20 cm-thick sandstone layer within the Hanna Siltstone which is up to 11 per cent copper from secondary enrichment and which is associated with oxidic manganese ores. Silver is also carried by the copper ores. The mix of high-grade ores with occasional intergrowths of manganese oxide minerals led Hauptmann (1990) to postulate that these deposits may have been valued in antiquity because they provided their own manganese smelting flux.

2.1.3.2.4 Umm 'Ishrin Sandstone

The Hanna Siltstone is overlain locally by the Umm 'Ishrin Sandstone of Late-Lower/Middle Cambrian to Upper Cambrian age. This formation has a thickness of 220–300 m and consists of yellow-brown, red-brown, grey and mauve-red medium- to coarse-grained, massive weathered sandstone. It is sub-arkosic in part and is intercalated with thin beds of mauve-red, very finely laminated, micaceous siltstone, reflecting its depositional environment, a fluvial braided river similar to that which provided the context for the deposition of the Salib Formation. Hauptmann (1990) and Rabb'a (1994) noted mineralization in copper (0.01–1.3 per cent) in the lower 30–40 m. Hauptmann (1990) observed that, as a result of the low density of mineralized fissures, the ores of the Umm 'Ishrin Sandstone appear to have been of only limited importance in prehistory, though they were extensively quarried in Roman times, not least at Umm al-Amad.

In contrast with the knowledge of copper mineralization described above, there is little or no deep knowledge of the region's lead sources. Significant lead does occur in some copper-rich slag deposits as a result of a distinct episode of lead mineralization. Hauptmann (2000) observed that the copper-rich Burj Dolomite-Shales contained up to 6 per cent lead in places. There is limited information on distinctive episodes of mineralization by beryllium, manganese, or iron (e.g. van den Boom and Ibrahim 1965), although Ionides and Blake (1939: 114–16) recorded information on the exposure and accessibility of the manganese ores within the Wadi Dana. They noted the richness of these manganese ores and estimated the presence of 'not more than about 5000 tons' of exploitable ore in the locality. Loose manganese-rich boulders were frequent over the course of 2–3 km in the wadi floor of the Dana. One rock specimen analysed contained MnO_2 68.9 per cent, Fe_2O_3 20 per cent, P_2O_5 0.16 per cent, and CuO 1.8 per cent, whereas another sample had a MnO_2 content of 5.9 per cent. Hauptmann (2000) suggested that such manganese-rich rocks might have been selected by ancient miners as self-fluxing ores.

2.1.3.3 Mesozoic and Tertiary

The mineralized Proterozoic and Lower Palaeozoic rocks are overlain by a 500–600 m sequence of relatively soft, flat-bedded, Cretaceous and Cenozoic rocks, often limestones, forming the extensive Jordanian Tablelands. Their complex sedimentary sequences include massive or well-bedded limestones, dolomites, and chalk marls, sometimes with clays, siltstones, calcareous mudstones, thin bands of sandstone, and veins of gypsum, cherts, silicified limestones, and phosphorites. The Dana Conglomerate Formation of Late Oligocene to Miocene age is typically less than 50 m thick and consists of massive beds of poorly-sorted, clast-supported conglomerates, comprising rounded to sub-rounded pebbles and cobbles and boulders of chert, chalk, and chalky limestone within a fine-grained sand/granule matrix. Missing in the immediate study area is the Kurnub Sandstone Group of multi-coloured sandstones dating from the Late Cretaceous to the Middle Eocene.

2.1.3.4 Quaternary

The Quaternary deposits of this area of Jordan are predominantly fluvial, colluvial, and aeolian (i.e. relating respectively to (fresh)water, hillslope processes and wind), and have proved difficult to interpret. Bender (1974b) identified fluviatile, lacustrine, and terrestrial deposits of Quaternary age on the eastern side of the Jordan Valley, which he termed the Shagur Formation. Near Abu Habil he noted hard conglomeratic limestones unconformably overlying mid-Pleistocene basalts, containing humanly-made stone implements. He suggested that there was a distinct erosional episode at about this general period within the Pleistocene when these deposits were accumulating, that produced a distinct 'beveling' at about +250 m altitude on the hills on both sides of the Rift Valley: he identified fluvial sediments at this altitude at Humrat Ma' to the east of the Dead Sea. Before our own investigations, skeletal frameworks of the Quaternary geology of the study area had been published by Barjous (1992) and Rabb'a (1994).

2.1.3.5 Tertiary and Quaternary tectonics and earthquakes

The study area is structurally complex. In addition to numerous small faults with no dominant trend, there are two major faults that follow a general east–west direction, the Dana Fault and the Salawan Fault, bounding a horst known as the Dana Block (Rabb'a 1994; Fig. 2.3). The Dana Fault to the east has a down-throw to the south, but in the west this is reversed and the down-throw is towards the north (Barjous 1992). There is evidence that suggests that this fault has been active during the Cainozoic (Barjous 1992). The Salawan Fault is huge, extending from the Wadi 'Arabah hundreds of kilometres south into Saudi Arabia. It is a normal fault with a down-throw of about 900 m to the south-southeast. It is thought by Barjous (1992) to have been active at various times in the past from the Cambrian through to and including the Quaternary. The topography of the study area, and especially of the gorges, is related to the disposition of these major and minor faults. Basaltic lava in the mountains near to Dana village has been extruded at intersects in the faults during the Quaternary. Folding in the area trends northeast/southwest to the north of the Dana Fault (Rabb'a 1994).

As a result of tectonic activity, the Dead Sea *graben* and its environs are prone to earthquakes. Marco *et al.* (1996) established a 50,000-year continuous record of earthquakes within the Lisan Formation here. At various times in the past, earthquake shock waves were strong enough to fluidize and re-suspend the sediments at the bottom of Lake Lisan, displacing layers up to 2 m; about 30 such mixed layers have been identified. Thermal ionization mass spectrometry (TIMS) dates of aragonite layers suggest an average sedimentation rate of 0.8 mm per year, giving an average recurrence interval of 1400 years for strong earthquakes in the Dead Sea basin. In the upper Wadi al-Hasa to the north of the Wadi Dana, a combination of tectonic events, climatic change, and geomorphological processes played key roles in impounding and then draining Lake Hasa, a focus for human settlement in the late Palaeolithic (Schuldenrein and Clark 1994; 2001). In the Holocene, the destructive effects of earthquakes on the ancient cities of Jericho, Sodom, and Gomorrah have been discussed by Neev and Emery (1995; see also Harris and Beardow 1995). The widespread impacts of earthquakes within the historical period have been investigated by the Wadi 'Arabah Earthquake Project, with notable earthquakes reported for AD 363, AD 749, and AD 1067/8, as well as in more recent times (Marco *et al*. 2003; Niemi *et al.* 1997; see also: Ben Menahem 1979; Ellenblum *et al*. 1998; El-Isa 1985; Ken-Tor *et al*. 2001; Pella Museum n.d.). Further south along this same fault line near Eilat, the last major seismic event was dated to *c*.1000 years ago (Rivka *et al.*

2002). The mean return period for earthquakes greater than 6.2 was reported to be about 4100 years, whilst faulting there began at about 37,000 years ago. Mohamed (1999) illustrates structures attributed provisionally to earthquake shock that affect Holocene alluvial fan and fluvial deposits in the gorge section of the Wadi Dana. Though poorly known, therefore, earthquakes may well have been of considerable significance for past populations in the study area.

2.1.4 Soils and surface sediments

The soils in the study region are often skeletal and sometimes show evidence of significant erosion and re-deposition. Many mountain slopes on Proterozoic or Palaeozoic bedrocks are bare rock, or scree and colluvium. Alluvial sediments and alluvial soils have developed in wadi floors such as the Wadi Faynan, or in similar shallow basins, as a consequence of fluvial deposition. Such materials are common throughout desertic Jordan and vary in texture from fine silt clays to coarse sands and gravels on floodplains (Aresvik 1976). Sand dunes over 5 m high occur in the lower Faynan near Quarayqira (McLaren *et al*. 2004; Chapter 6) and in the Wadi ʻArabah aeolian inputs to the soils of the study area appear common and widespread. Yellow Soils occur widely in the area on *in situ* and displaced limestones at the head of the wadis, on deposits of calcareous loess, and more widely on the limestone bedrocks of the Jordanian Tablelands. Desert Soils in the lowlands beyond the mountain front display evidence of erosion and reworking by wind and by water and characteristically lack organic matter. The soils and superficial sediments of the extensive Precambrian and Phanerozoic (Palaeozoic) bedrocks of the mountain front contain notable but patchy concentrations of black metalliferous smelting slag, and erosional products derived from it, as a result of past mineral extraction, processing, and smelting. Vegetation-free sediments lose cations in surface metal-rich materials through a variety of processes including sheet and gully erosion, erosion by wind, leaching, other surface geomorphic processes, and by grazing animals (Pyatt *et al*. 2002b). Commonly, ʻovergrazing' by herds of sheep and goats, together with the demise of woodland for timber and crops, are asserted to be responsible for inferred accelerated soil erosion, past and present, in Jordan.

In the late 1930s, a Jordan-wide and historical-landscape based approach to soil erosion was developed by Ionides and Blake (1939) during their survey of the Wadi Dana and elsewhere. They observed how easy it was to conclude, from the tone of the times (e.g. Jacks and Whyte 1938), that accelerated and adverse soil erosion was taking place and that the cause lay in unwise land use or aridification – outcomes nowadays subsumed in the term ʻdesertification' (see Chapter 1). However, they suggested that modern soils were slowly recovering from a period of accelerated net erosion in the not-so-distant past, and were not experiencing accelerated erosion as a result of current land use. They suspected that this past episode had been followed by a period of relative erosional stability that they associated with low biological and low agricultural productivity. Critically, Ionides and Blake also emphasized that two aspects of eroding soils need to be recognized in arid landscapes such as southern Jordan: first, that erosion and deposition are always taking place; and second, that what really matter are rates, distributions, balances, and the reliable identification of the causes of change. As the later chapters discuss, their observations about the complexity of the relationship between climate, soils, and people in arid lands, resonate strongly with our own findings in the Wadi Faynan.

2.1.5 Vegetation

The nature of the present and past vegetation of the study region is critical for understanding the lives, well-being, and economies of people in the region and the complex interactions produced by climatic change, geomorphological and biological processes, and past human activities. The regional distribution of vegetation in this area of southern Jordan has been described by several authors (Baierle *et al.* 1989; Candollea 1977; Khammash 2002; Kurschner 1986) and is summarized in Figure 2.11. Southern Jordan is one of the most important geobotanical regions in Southwest Asia because it is the meeting place of the Mediterranean, Irano-Turanian, and Saharo-Arabian regions (Kurschner 1986). A characteristic feature is the conspicuous changes over relatively short distances of both the structure and the species composition of the vegetation.

The relationships between vegetation, topography, and rainfall are illustrated in the transect diagram from the Wadi ʻArabah to the Mountains of Edom (Fig. 2.12). The distribution of vegetation in the study area, and in Jordan more generally, roughly follows the variations in the quantities of precipitation that in turn are mainly a consequence of the topography. Details of the dominant local vegetation types are shown in Table 2.2. In brief, where there is enough precipitation or water, then forest can exist; where there is little rain, there is steppe; where there is no rain, there is desert. Rainfall, however, is not the only factor controlling the distribution of the vegetation: topography, soil type, geology, surface and underground waters, microclimate, and differences in temperature, all play important roles in determining the pattern of the vegetation. The presence of springs and the concentration of run-off along drainage lines are locally important.

In the desert region, where annual rainfall is generally below 100 mm, the vegetation is extremely poor in both variety and density, except in wadi bottoms, channels, and depressions. After times of rain-storm, there may be a short-lived flush of vegetation. In the typical flint-strewn rock desert, there are large surfaces bare of any vegetation. In the sandy desert, such extensive bare surfaces are not common, with occasional short annual grasses in between individual shrubs and ground bare of vegetation. Xeromorphic dwarf shrubs, mostly *Haloxylon persicum* and *Retama raetam*,

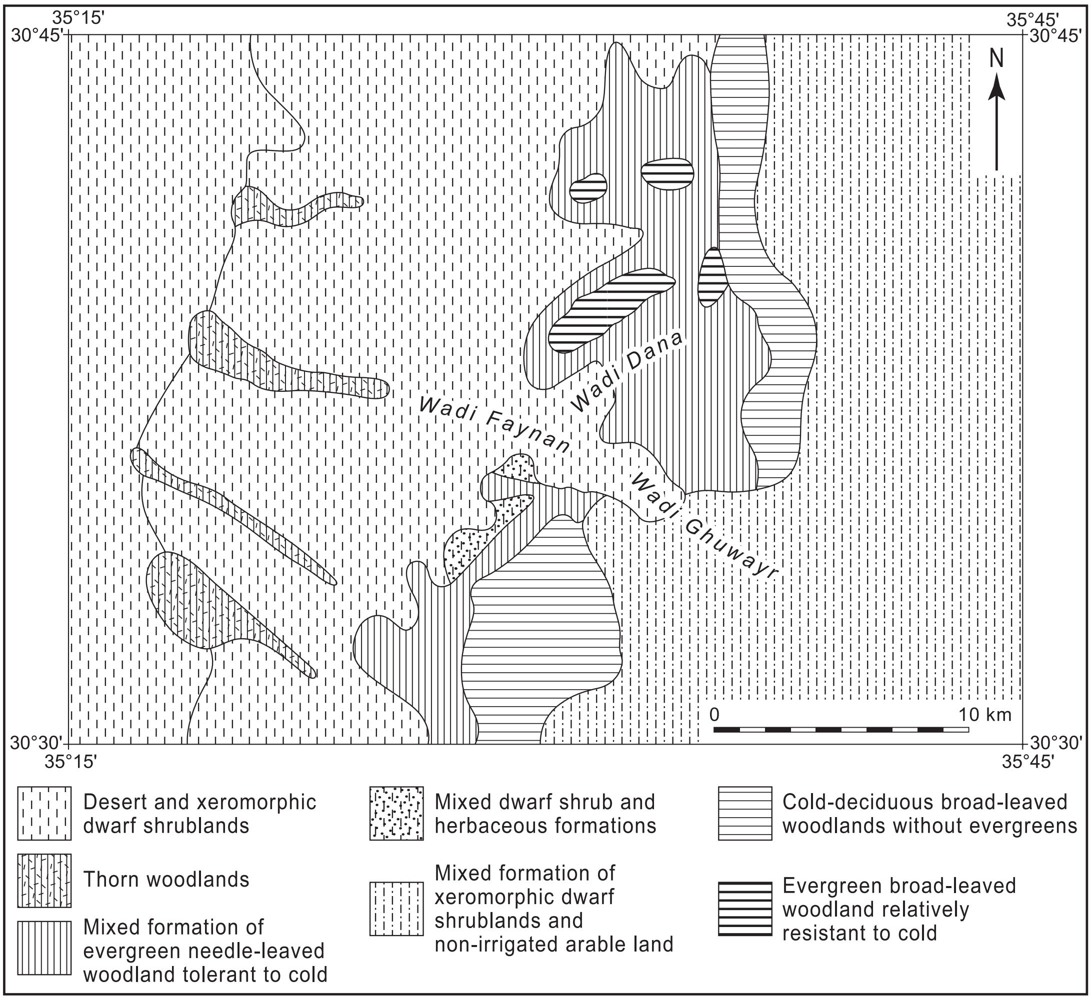


Figure 2.11 *The distribution of major vegetation units in the region. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Kurschner 1986.)*

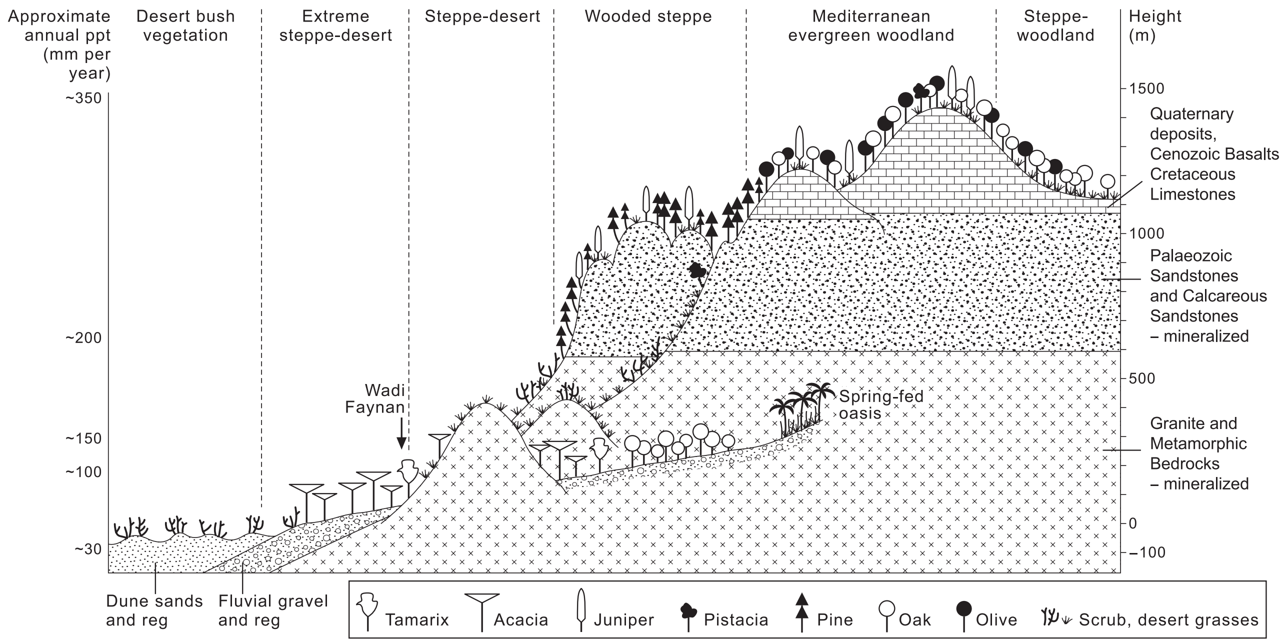


Figure 2.12 *Summary vegetation transect through the Wadi ʻArabah and into the Mountains of Edom. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Baierle* et al. *1989; Mohamed 1999.)*

Figure 2.13 *Acacia trees growing on the barrage-infill sequences of colluvial and fluvial deposits immediately east of the rubble mound of Khirbat Faynan that dominates the local skyline. To the right of the trees is the barrage wall (WF441) and beyond that an apron of complex colluvium, walls, and slag deposits that lead down to the braid-plain of the Wadi Dana. The barrage impounds lateral sub-surface drainage and heavy rain storms can lead to temporary water depths of 10–20 cm. The raised soil moisture levels and shade promote grazing and better nutrient enrichment from the manure of grazing animals, looking southwest. (Photograph: David Gilbertson.)*

	Desert-bush vegetation	**Extreme steppe desert**	**Steppe desert**	**Wooded steppe**	**Mediterranean evergreen woodland**	**Steppe woodland**
Dominant vegetation	*Haloxylon persicum*	*Acacia* *A. radiana* *Anabasis articulata* *Traganum nudatum*	*Anabasis* *Gymnocarpos* *Halogeton* *Salsola* *Zygophyllum*	*Juniperus* *Artemisia* *Helianthemum* *Salsola*	*Quercus* *Phoenix dactylifera*	*Pistacia*
Woody species	*Retama raetam* *Calligonum comosum*	*Ochradenus* *Retama raetam* *Ziziphus*	*Acacia* *Moringa* *Juniperus* *Retama* *Phoenix*	*Amygdalus* *A. korschinskii* *Atriplex halimus* *Pistacia* *Retama*	*Colutea* *Crataegus* *Daphne* *Pistacia*	*Crataegus*
Wadi vegetation	*Acacia* *Haloxylon persicum* (*Tamarix*) (*Retama*)	*Retama raetam* *Tamarix* *Ziziphus* *Acacia* (*Haloxylon*)	*Populus* *Salix* (*S. pseudosafsaf*)	*Salix* *S. pseudosafsaf* *Nerium* *Retama* (*Tamarix*)	(*S. pseudosafsaf*) (*Nerium*) *(Retama)* *(Tamarix*)	-

Table 2.2 *Summary of the vegetation zones in the Mountains of Edom and the Wadis Faynan and Dana. (Modified from Baierle* et al. *1989.)*

are interspersed with patches of *Acacia*-dominated thorn-woodlands, with some *Tamarix* where damper substrates occur on wadi floors and in distributary channels on alluvial fans. In the lower parts of the Wadi Faynan, its tributaries, and on the lowest slopes of the escarpment up to about 100 m elevation, there is an extreme steppe-desert vegetation characterized by *Acacia, Anabasis, Traganum, Retama*, and *Zizyphus* (Fig. 2.13). Plantations and single specimens of *Eucalyptus* now grow in desert plantations near Quarayqira and on the wadi floor at the former RSCN camp in the lower Wadi Dana, whilst she-oaks (*Casuarina* sp.) have been planted in Dana village.

There is a broad transitional zone between the steppe and desert regions, linked to steadily decreasing precipitation levels (Aresvik 1976). In the steppe regions, where the climate is more continental than Mediterranean, the *c*.150–300 mm annual rainfall promotes a plant cover of grass and *Artemisia*, especially where soils are relatively stable. On wadi floors and lower slopes of the mountain front at *c*.100–600 m altitude, where rainfall is higher and slightly more reliable, a degraded steppe-desert is often present, characterized by *Anabasis, Gymnocarpos, Salsola*, and *Halogeton*. Occasional woody taxa such as *Acacia, Moringa, Juniperus, Retama*, and *Phoenix* are present in localities where goats are excluded by steepness or other barriers. Dense reedy areas of *Typha, Phragmites*, and *Nerium*, the oleander, with substantial poplars (*Populus*) and willows (*Salix*), are present in the wetter wadis. Oleanders are poisonous and therefore not grazed by goats, and since their deep roots are resistant to floods, they can dominate wadi floors that are heavily-grazed.

Between 600 and 1100 m there is a wooded steppe degraded by grazing, dominated by dwarf shrubby *Helianthemum, Artemisia*, and *Salsola.* Woody taxa such as *Juniperus, Amygdalus, Pistacia*, and *Retama* are sometimes still present. Wadi vegetation includes *Salix, Nerium, Retama* and *Tamarix.* At high altitudes, over 1100 m, where the annual rainfall is more than 300 mm, the vegetation is often of distinctly Mediterranean type, with evergreen Mediterranean woodland species such as *Quercus, Phoenix, Cupressus, Colutea, Cretaegus, Daphne,* and *Pistacia*.

Although the amount of vegetation cover during historical times is subject to discussion (see Chapter 11), undisturbed woodland is now rare. The narrow and discontinuous strip of vegetation found today along the eastern escarpment of the Rift Valley, and the occasional patches on top of the highlands, are thought to be relict zones that have survived the pressures of grazing, agriculture, and firewood-cutting (Zohary 1973). The years between 1908 and 1917 have been identified as particularly destructive for the upland forests of Jordan, as timber was cut to construct and fuel the Hijaz railway from Damascus to Medina in what proved to be the final years of the Ottoman Empire.

The importance of rapid vegetational change in relation to topography and climate is evident in the detailed local studies by Swenne (1995) of the flora of the RSCN Wadi Dana Nature Reserve and of its surroundings. The plant list for the Reserve identified three plant 'zones'. At high altitude on the Jordanian Plateau was 'Mediterranean Semi-Arid Vegetation', with 379 species identified; photographs of this vegetation in the 1930s are provided in Ionides and Blake (1939: pls. 7–9). The slopes of the Wadi Dana had 'Indo-Turanian Mid-Altitude Steppe', with 310 species. The lower part of the Wadi Dana and the Wadi Faynan had 'Low-level *Acacia* Sub-Tropical Vegetation', with 282 species present. All of the project's locations of palynological-based studies of past vegetation change (Chapter 3) came from within this vegetation type.

2.1.6 Animals

The vertebrate fauna of the Dana Reserve and surrounding area is described in 'Amr *et al.* (1996), more widely in Mountfort (1985), and in the on-line data base and information files maintained by both the Biodiversity Group in the Jordanian Government and the Jordanian Royal Society for the Conservation of Nature in the Hashemite Kingdom. Some 286 animal species are known to be resident and 'passing through', including a number of rare species.

2.2 People

2.2.1 Bedouin society

Bedouin, *badu* (or *bedu*), desert, steppe or 'open country' dwellers, appear as romantic figures in the writings and iconography of the nineteenth and early twentieth centuries, the literature replete with references to their black goat-hair tents, camels, horsemanship, proud oral traditions, rugged individualism, warlike tendencies, and disdain for authority. For travellers in the region at that time the bedouin possessed a reputation for unrivalled fierceness leavened by great hospitality, honour, and graciousness. The nomadic lifeway has always been highly romanticized yet equally maligned.

Today, bedouin are still pre-eminent in much of rural southern Jordan, though most are largely settled, with households involved in a range of activities from employment in the army or public sector to agriculture, tourism, and commerce, or, indeed, raising livestock. To be 'bedouin' today is not necessarily bound to ranging the landscape with animals, especially camels, in search of grazing, but to subscribe to a feeling of common ancestry and particular codes of conduct. However, there is more to bedouin identity in modern Jordan than this, for it is multi-faceted: a nomadic way of life, a system of values, a particular family ancestry, authenticity, an appeal to both local and more distant tourists (usually much enamoured of bedouin life), a statement of loyalty to the king, or, at its broadest, an appeal to a sense of universal Arab ancestry (bedouin are also known as *'arab*). However, not all inhabitants of southern Jordan call themselves bedouin, nor did they in the recent past. Some inhabitants of goat-hair tents call themselves 'fellahin', which is usually translated as 'villagers', 'peasants' or, more literally, 'cultivators' (Palmer 1998).

A more inclusive and accurate way to describe the human landscape of southern Jordan, however, is to say that it is 'tribal'. Bedouin, villagers or fellahin, as well as townsfolk – in a whole variety of modern occupations – are all members of tribes. Though ties have weakened with the growth of the state, it is still the basis of local social organization. Tribes are still associated with particular villages and, in towns, sub-divisions of them. One's neighbours are usually also one's close relatives. Tribal identity is much more than what one does for a living. As the survival of the tribal system today shows, it is both an ideology and a support network (Abu-Lughod 1989: 280–84), with tribal identity bestowing on its holders 'privileged access to economic, social and political life' (Lancaster and Lancaster 1999: 10).

Tribes are traditionally defined on the basis of a common patrilineal descent. The key element is a feeling of common ancestry with genealogies providing the theoretical and moral foundation for social integration (Lancaster and Lancaster 1992). A strong ancestor is usually considered the founder and gives a lineage its name. There is some flexibility, however, and affiliations between tribes and sub-lineages can change through manipulation of orally recited genealogies, which are, in any case, generally not time-specific. In this way, new alliances can be made and old ties broken to maintain the perceived proper order as well as to facilitate current political expediency. History, here as elsewhere, serves the present and validates the current order, and to analyse these histories too deeply in search of the 'truth' is a treacherous task (Shryock 1997). Furthermore, tribes may represent themselves as more coherent to an 'outsider' than they are, in practice, internally (LaBianca 1990: 39; Lancaster 1981).

In the past, the tribe as a whole, not individuals, 'owned' territory, bore the responsibility of hospitality to guests, participated in raids and acts of vengeance, and took care of families fallen on hard times. Tribes had territories, but these shifted with time following a raid or if the tribe simply moved on to something perceived as 'better'. Sometimes the only links that remain to recall past association with an area may be the maintenance of burial grounds; Musil (1908 [1989]) lists burial grounds that were, at the time of writing, some distance away from the tribe's current territory, for example. The oral history of the area is replete with stories not only of inter-tribal friction but also of conquest and bloody evictions. One of the frequently stated ways for a new area to be occupied was as the consequence of a killing (often reprisal), when the offender and his closest kin (the *khamsa*, up to five generations) could be sent away by tribal law.

Pastoralism was a strong component of subsistence for most groups in rural southern Jordan in the recent past, whether or not the group concerned would describe themselves as bedouin, and despite perhaps appearing as such to visiting outsiders. All rural communities exhibited some degree of nomadism. The current convention is to use pastoralism to refer to raising livestock on natural pasture and nomadism to refer to moving the home base and household from place to place in a regular cycle (Galaty and Johnson 1990; Salzman 2004: 17–18). Khazanov (1994) distinguishes 'pastoral nomadism proper' characterized by the absence of agriculture from 'semi-nomadic pastoralism', 'semi-sedentary pastoralism', and 'herdsman husbandry'. The differences lie in the degree of involvement with agriculture, the presence of a village and the extent to which it is occupied throughout the year, and the duration of migrations in terms of both time and distance in a variety of combinations that are not mutually exclusive. The old tribes of the southern Jabal (or Djebal) and northern Shara (or Shera) mountains, the tribes who visit or formerly visited Wadi Faynan, were mostly semi-nomadic to semi-sedentary pastoralists in Khazanov's terms, not 'pure pastoralists', but many of them called themselves bedouin, and do so to this day (Fig. 2.14).

For some authors, the only true bedouin were camel-breeding tribes and their descendents who, by tradition, ranged over large distances penetrating deep into the eastern Arabian Desert, or *badia*, away from interfering state machinery. These are the groups that best conform to Khazanov's notion of 'pastoral nomadism proper'. Tribes that had parts of their traditional territory (*dirah*) in Transjordan and possessed large numbers of camels included, for example, the Rwala (Lancaster 1981; Musil 1928), the Bani Sakhr (Lewis 1987: 124–47), and members from the Huwaytat confederacy of southern Jordan (Oppenheim 1943 [1983]: 291–5). In the nineteenth century, the camel-breeding bedouin (though they possessed other livestock too) were often pre-eminent, looking down in particular on villagers or any group engaged in plough agriculture from whom they often received forced payments or tribute, the 'brotherhood tax' known as *khuwa*.

The tendency to idealize camel nomadism and regard camel nomads as the only true *badu* is strongly connected to the fact that this notion is, indeed, widespread in the Middle East and historically very deep (Dickson 1951: 110; Ibn Khaldun 2005; Jabbur 1995). These bedouin historically epitomize the tribal idiom because the shared ideals of egalitarianism, collective responsibility, and honour were most intensive amongst them. In addition, camel nomads are also historically viewed as the most independent of domination, evading taxation for a large part of Ottoman rule. Much recent literature has moved away from these stereotypes, however, reflecting a broader view of bedouin culture and identity, as well as recognizing its complexity in the contemporary context (Layne 1994; Young 1999). Khazanov (1994) makes a strong case that his so-called 'pure nomadic pastoralists', although seeing themselves as free, were economically the most strongly dependent of all pastoral groups, relying on grain cultivated by villagers, usually taken as *khuwa*, as well as through trade and robbery. Consequently, in the history of nomadic pastoralism, camel nomadism is viewed as a relatively late development, in part because of the relatively recent – late second-millennium BC – arrival of domesticated camels in the region (Horwitz and Rosen 2005: 126–8; see also Chapter 8, §8.12).

Tribalism as a model for ancient social organization has received increasing interest from archaeologists. Recent work on the Iron Age kingdoms of the southern Levant – Edom, Moab, Ammon, Israel, and Judah – draws on insights from nineteenth- and twentieth-century accounts to reconstruct ancient society using a tribal model (Bienkowski and van der Steen 2001; Knauf 1992a,b; LaBianca and Younker 1995; van der Steen 2004; and see Chapter 9, §9.2). Tribalism has very deep roots in the region, and LaBianca and Younker (1995: 411) cite it as an example of Braudel's (1972) *longue durée*,

> a deep historical undercurrent which has enabled and facilitated the response of Transjordan's population to ecological, political, and economic uncertainties and changes since the dawn of history.

The antiquity of the tribal idiom as a system of social organization is probably beyond question, but can it be 'dug

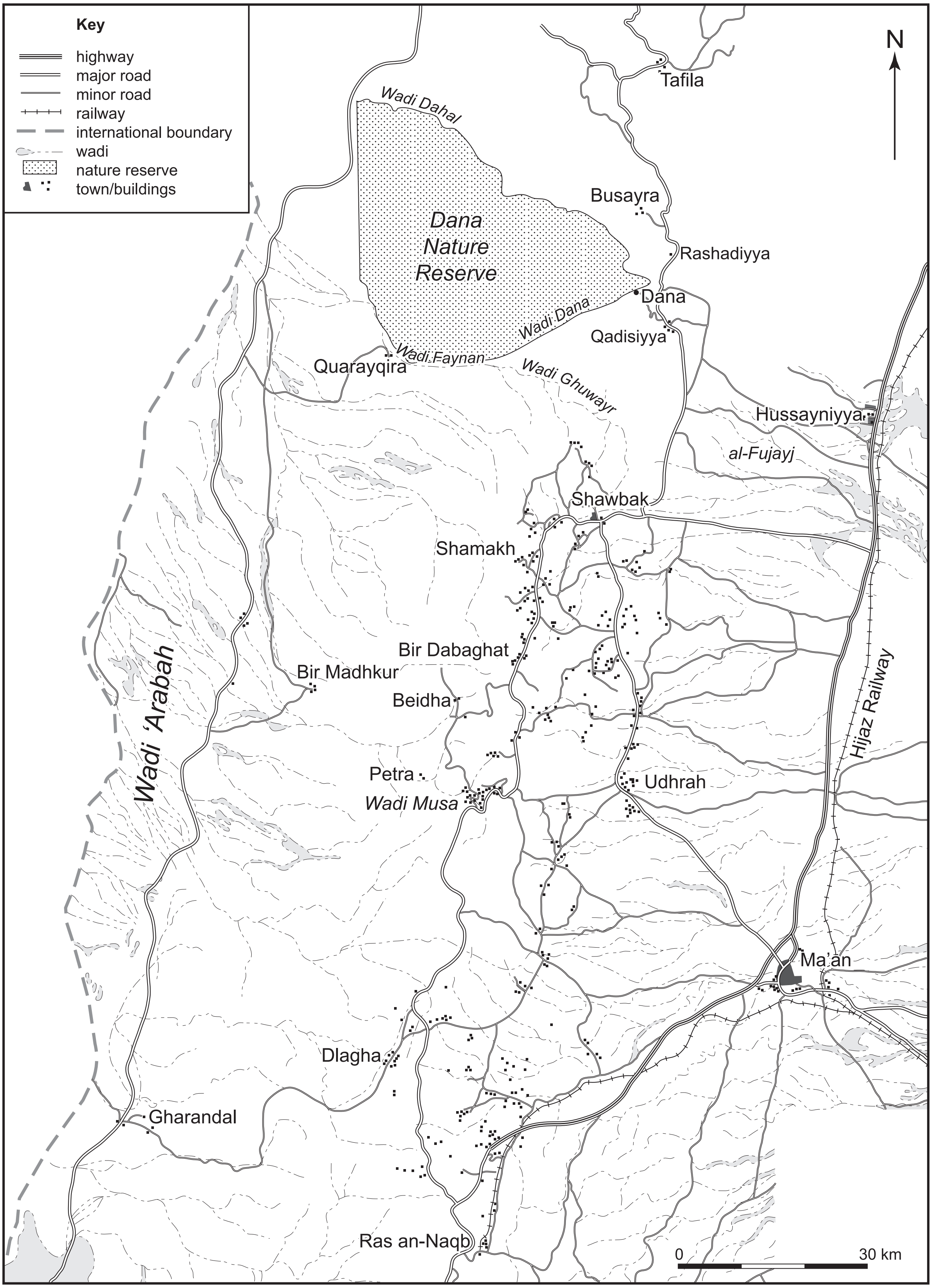


Figure 2.14 Wadi Faynan in its present-day social and historical context: principal locations and regions mentioned in the text. (Illustration: Dora Kemp and Carol Palmer.)

up', to corrupt a famous sentiment of the anthropologist, Edmund Leach, a man very critical of archaeological interpretation of past societies (Leach 1973)? This is perhaps one of the reasons why archaeological investigations have tended to focus on the material identification of nomadic pastoralism.

The concept of tribe in this region is useful because it helps to blur the false dichotomy between pastoralists and agriculturalists (subsistence patterns that have been reified in so much archaeological discourse) and between more mobile and sedentary lifeways (equally reified). Tribes and sub-sections of tribes were in the past involved in a range of subsistence practices from camel nomadism to sheep and goat husbandry and from arable farming to tree and vegetable cultivation, as well as engaging in trade. Lancaster and Lancaster (1999) found the modern economic opportunities adopted by bedouin entirely consistent with the older lifeway because flexibility and multiple resource use continue as guiding principles.

The rest of this chapter reviews and summarizes the recent history of the area around Wadi Faynan and the people who lived there from the time of the early European accounts to the situation in the mid-1990s when the Wadi Faynan Landscape Survey began. Tribes are still very much a part of the human environment (Fig. 2.15).

Figure 2.15 *View looking south from the Wadi Khalid over bedouin tents and the braid-plain of the Wadi Dana to the rubble mound that is the Khirbat Faynan. Beyond are the alluvial fans of the Shayqar Beds and the steep and rugged mountain front – the rift escarpment – of the Mountains of Edom. In the far distance is the flatter terrain of the Jordanian Tablelands of the Shawbak area. (Photograph: Carol Palmer.)*

2.2.2 Wadi Faynan in recent historical context

Early European visitors (Burckhardt 1822; de Laborde 1836; Palmer 1871; Robinson and Smith 1841; Seetzen 1855–59) wrote about the tribes of the Shara and Jabal almost as an equal part of the impressive landscape they were negotiating, which could not be traversed without their co-operation, but their fascination is clear and observations of the prevailing social order invaluable (van der Steen 2006). It was only around the turn of the twentieth century, however, that the people themselves became the subject of serious ethnographic investigation (Musil 1908 [1989]; Oppenheim 1943 [1983]; Jaussen 1907 [1948]), at a time when Ottoman state rule was being reasserted. Tribal histories are enmeshed with the emergence and development of Jordan as a state (Peake 1958) and continue to be a source of fascination to this day, with numerous local publications enriching the available literature and continuing to play a role in the contemporary political scene (Shryock 1997).

In the nineteenth century Jordan as a political unit did not exist. It was nominally part of the Ottoman Empire, and only during the latter part of the century was Ottoman hegemony re-established (Rogan 1999). Camel-breeding bedouin were wholly in control of the desert east of the Hajj route. The Huwaytat were paramount in the Shara (Musil 1926: 7), only ceding to Ottoman rule in the 1890s. Egypt had a considerable influence during the early part of the century under the rule of Pasha Mohammad Ali. In 1831, Mohammad Ali's forces defeated the Ottomans in Syria, and there was Egyptian hegemony over the region until 1841. These broader political events were played out in the friendships and rivalries between the tribes and their leaders. Trade and external relations tended to operate along a mostly west–east axis, such that there were particularly strong interactions with Palestinian towns, as well as centres further southeast in the Hijaz. There were strong trade links with Gaza and Hebron, and traders from Hebron were commonly encountered by Burckhardt (1822). In addition, the Huwaytat organized large trade caravans to Egypt, where livestock from the region was also traded at Gaza and, later, Beersheba, as well (Bailey 2006: 251). Ma'an, the regional centre, lay on the Hajj route, at a junction that linked Greater Syria to Egypt through 'Aqaba, and its people and the strong bedouin around it lived off the proceeds brought by Hajj pilgrims travelling to and from the Hijaz and the holy cities of Mecca and Medina (Burckhardt 1822: 426–7; Doughty 1888 [1926]: 32–3). Although Ma'an had extensive irrigated gardens, its inhabitants, like the camel-raising bedouin tribes of the area, depended on their westerly neighbours in the Jabal and Shara for grain (Burckhardt 1822: 426).

The Wadis Faynan, Ghuwayr, and Dana were primarily places of winter migration during this period. Burckhardt

Figure 2.16 *The Crusader castle at Shawbak, with terraces and caves in the foreground developed in flat-bedded limestones. (Photograph: Carol Palmer.)*

(1822: 411) states that the Ghuwayr was 'a favourite place of encampment for all the Bedouin of Djebal and Shera'. The northern limit of the Jabal is, historically, the Wadi al-Hasa, and the main town is Tafila, with Busayra and Dana the southernmost villages. The Shara mountains, stretching south to Ras an-Naqab, are the mountain range often associated with biblical Se'ir (Musil 1926: 252–5) that includes, as well as Shawbak, the centre of the northern Shara, Wadi Musa, and Petra. Shawbak was not a specific town or settlement, but a reference to the Crusader castle (Fig. 2.16), and the tribes that used the castle as a focal point and camped in its hinterland, including both fellahin and bedouin. According to local tradition it was the tribes of the southern Jabal, especially villagers from Dana, and bedouin tribes from Shawbak, who mainly took advantage of the mild winter conditions and abundant springs at the foot of the Wadi Dana and in the Ghuwayr.

When Burckhardt visited Shawbak in 1812, 'Ibn Rashid' was the principal sheikh of the Huwaytat (Burckhardt 1822: 412–17). The sheikh himself was away at the time, helping to transport Pasha Mohammed Ali's army across Egypt in support of the Pasha's campaign against the Wahabis, which was causing considerable disruption to the Hajj trade. As surmised by Russell (1993: 24) from travellers' accounts, there appears to have been a sub-tribal fission among the Huwaytat shortly after Burckhardt's visit to the area, probably stemming from an alliance between 'Abou Raschid' and Sheikh Yousef al-Majali of Karak (Irby and Mangles 1844: 116–23). The Majali represented Ottoman interests and had aspirations to control the Shara. In 1823, when de Laborde (1836: 131–2, 144–6) visited Petra, the Huwaytat were described as divided into three sections: the 'Alawin, the Huwaytat Ibn Jazi and the followers of Ibn Rashid. However, Ibn Rashid's brother and nephews had become allied with the 'Alawin, and a nephew was later to become their paramount, Sheikh Hussein Abu Muhammad in 1836 (Oppenheim 1943 [1983]: 307). Under his leadership, the 'Alawin gained control over trade from Egypt to 'Aqaba and the lucrative Egyptian Hajj, as well as the right to conduct foreigners to the ruins of Petra (Russell 1993: 24). The followers of Ibn Rashid became the Rashaydah (Musil 1908 [1989]: 59–60) that today claim Wadi Faynan as part of their traditional territory.

Towards the end of the nineteenth century, Egyptian influence waned and Ottoman rule over southern Jordan asserted itself. The completion of the Suez Canal in 1869 curtailed many of the region's trading activities with Egypt, and the Egyptian Hajj was subsequently undertaken by sea, with the fort at 'Aqaba ceded to the Ottomans in 1892. As part of this economic downturn, the 'Alawin declined and the Huwaytat Ibn Jazi, under the leader 'Arar Ibn Jazi, came to control the Shara between the 1870s and 1890s (Doughty 1888 [1926]: 29; Jaussen 1907 [1948]: 302). Ottoman aspirations, however, were also growing stronger and more concrete. In 1893 Turkish troops and officers moved into Karak, and by 1895 there were Turkish troops at Shawbak (Rogan 1999: 190–91), when there was an altercation between the people of Shawbak and the Ottoman authorities over – there are two versions – either taxation or a demand that local women draw water for the soldiers' horses. The outcome of this dispute, however, is not contested: the Ottoman soldiers won and the period of overwhelming rule of the tribes was over. The whole of Transjordan's paramount tribes suffered a further blow following completion of the rail route between Damascus and Ma'an, the Hijaz railway, in September 1904 (Naval Intelligence Division 1943: 503). This caused a

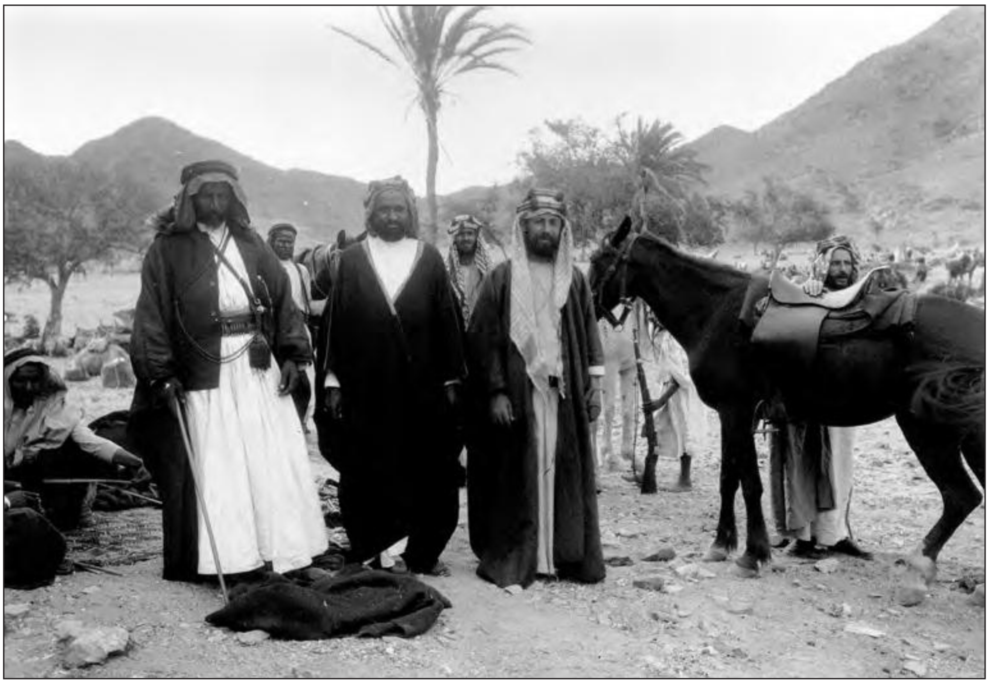


Figure 2.17 *Auda Abu Tayi (left) and his kinsmen on the first day of the march from Wejh to the Huwaytat (Huweitat) in their spring pastures of the Syrian Desert, May 1917. (Lawrence 1939, pl. 64, reproduced courtesy of the Imperial War Museum, London; negative number Q59187.)*

Figure 2.18 *Saleh, Hamad, and Mohammad Ibn Jazi at Rashadiyya,* c.*1961–2. (Photograph: Jean Weddell, reproduced with kind permission.)*

major decline in income from reduced sales of camels and the loss of what was essentially a protection tax levied on passing travellers.

The defeat of the Ottomans during the Hashemite-led Arab Revolt (1916–18) dramatically shifted the geo-political order of the region. The Huwaytat of southern Jordan, including prominent figures such as Auda Abu Tayi, nephew of ‘Arar Ibn Jazi (Peake 1958: 212–13; Fig. 2.17), were fundamental to the success of that campaign, and are a large part of the reason why the strongest, most supportive, tribes of that time continued to have a high profile in the years to follow. Local examples of this influence are represented by the gift of Rashadiyya (a police outpost, the Goethe Forest, and a large house subsequently built there) between Busayra and Qadisiyya that was given to a prominent member of the Huwaytat Ibn Jazi, as a reward for services rendered during the Arab Revolt (Weddell 2004; Fig. 2.18). A special status was assigned to recognize Jordanian 'Bedouin' tribes, mostly from the original camel-breeding bedouin, for their role in establishing the nation.

The state of Transjordan emerged from a temporary agreement between the Hashemite Amir Abdullah, second son of Sharif Hussein of Mecca, and Britain in 1921 – the culmination of British strategic concerns and the political aspirations of the Amir (Wilson 1987: 45–53). In Mary Wilson's (1987: 58) words, 'Transjordan's existence hinged on European interests rather than on a local or regional rationale'. These powers originally intended that the region of southern Jordan south of Shawbak would be part of the Kingdom of the Hijaz (Peake 1958: 105; Wilson 1987: 99–100), a reflection of the area's then greater social integration with lands to the south. This never came to pass, however: through the actions of the Amir, who, early on, made a politically astute trip through the whole territory, the south became part of Transjordan (Russell 1993: 29). During the Mandate Period that followed, there were many infrastructural developments – the paraphernalia of state legislature and government, land registration, the establishment of a strong army and police force, the beginnings of the road system, development of modern agriculture, health care provision, and schools – all primarily geared towards giving the new country command over its newly defined territory (Amadouny 1994). The powerful camel-breeding tribes suffered quite considerably from the imposition of national borders, failure of imperial policy, droughts, and a feud with the Ibn Sa'ud (Bocco and Tell 1994), but became the heart of the Arab Legion by the end of the Mandate under the influence, in particular, of its leader 'Glubb Pasha', John Bagot Glubb (Glubb 1948).

Among villagers in the uplands, the main difference older people talk about between the former way of life and that of today is employment. People are no longer bedouin or fellahin, but employees. The Mandate was the period when this transition started in earnest, the first major early employer being the army. The economic importance of army employment – and state employment, in general – is that it not only provides an income during the years of service, but also a pension in retirement. The social importance of the army is that it brings together many men from different tribes – people ascribing themselves as both bedouin and fellahin – under one banner, that of the state. State infrastructural growth had other effects on local people. Many more local children started going to school: literacy was required for recruitment into the army and sons of army men often received scholarships to train, among other things, as teachers, doctors, and lawyers, as well as to serve in the army. Arable land was registered in the name of the tribes, or sub-sections of them, and 'forested' land, where local people grazed their animals and collected firewood, declared state-owned property, as were the whole of the Wadi 'Arabah, archaeological monuments, and any other disputed land. Fellahin, who formerly lived year round in tents, began building stone houses, and those who had previously built them already started spending more of the year in them. The mid years of the Mandate, the 1920s and 1930s, were also years of drought in the whole region. In Juhayr near Shawbak, an old man from the Tawara (pers. comm. 1999), a fellahin tribe, remembered the later years of the Mandate and the terrible hardships of the 1930s. Men then used to go to Palestine to find work, he exclaimed, because there was nothing to eat at home. He himself worked on the West Bank and then at the Jewish Potash Company at the Dead Sea before joining the Jordanian army for 16 years from 1949.

In 1946 Transjordan became independent and Abdullah was crowned King of Jordan. The war that followed Britain's decision to withdraw from Palestine had a dramatic effect upon the newly independent Jordan, placing severe strain on the country at the same time as further raising its political importance. Critically, the influx of Palestinian refugees and incorporation of the West Bank in 1948 meant an estimated tripling of the population. Most refugees to the East Bank settled in the vicinity of Amman and in the north of Jordan, but a sizable bedouin population from the Negev came to the south. Mohammad Eid Shannag (pers. comm. 1999), a retired soldier from the village of Sawn in northern Jordan, was in the mounted police force and stationed at Karak during the 1950s. He remembered the almost total destitution of the Negev refugees in the Wadi 'Arabah and most notably, the 'Azazma. The Sa'idiyyin tribe, members of whom still camp in the Wadi Faynan, was split in two. The long-standing west–east trade network was severely damaged, although it was not until 1967 and the Israeli occupation of the West Bank that the links with Hebron were ended. In future, commercial and government communications would come from the north and south. Wadi 'Arabah, owing to its proximity to the Israeli state, became a highly sensitive military zone.

In the 1950s, there was a concerted development push in Jordan, focusing on technological innovation, though with difficulty in a country of limited natural resources (Kingston 1999). Moraiwid Tell (pers. comm. 2000), a member of a prominent northern Jordanian family and with a long career in development work in the Kingdom, gained some of his early experiences in Wadi Faynan during this time. He was involved in expeditions to Wadi Faynan to visit two engineers investigating the possibility of starting modern copper mining. He recalled carrying dynamite in the back of a Land Rover from Amman and on donkey-back down local trails, guided by villagers from Dana village. Despite their efforts, and the fact that they felt they could overcome the high manganese content of the ore, the copper content was too low to make the project economically viable.

A number of our informants grew up during the 1950s and 1960s, and their adult lives became intimately bound up with the development of the Kingdom of Jordan. During the early years of independence the use of 'tribesmen in uniform' helped secure the Hashemite Kingdom as the only country of the Arab Levant with the elite that had co-operated with colonial rule still in place (Tall 2000: 95–6). Many of the sons of the Rashaydah had army careers, including, most notably for Faynan, the present 'Pasha' Sayal Mohammad Rashaydah, who, as the title suggests, rose to high military office. His father and uncle served in the army before him under Glubb Pasha, the British commander and trainer of the Arab Legion (1939–56): a man who possessed great political influence into the early reign of King Hussein before circumstances forced his dismissal, and who won huge affection from his men in part based on his intimate knowledge of the dialects of the tribes (Glubb 1957). The present Wadi Faynan Pasha was born in 1943 in Wadi Rum, where his father was stationed and the family tent pitched. He spent part of his childhood in the Karak area (the Rashaydah maintained a strong connection with the paramount Majali of Karak and have a settlement there), later attending military school in Amman (pers. comm. 2006).

Throughout this time, increasing numbers of men from the bedouin and fellahin were becoming employees, the majority serving in the armed services. This took them away from herding and crop cultivation and, as a consequence, their families became less economically dependent on these activities, though animals were maintained for the meat and milk they provided for the family. A salary meant that large herd sizes, especially for those families with men in employment, were no longer required. Smaller herds do not need to be ranged as widely as larger ones and can be maintained from home, with, in the case of those practising agriculture, crop by-products or fodder crops providing the main feed. This happened to coincide with the time that the refugee bedouin from the Negev, and particularly the 'Azazma, were moving into the Wadi 'Arabah and lower areas of the Rift escarpment. It is, therefore, perhaps unsurprising that the 'Azazma claim that the areas they moved into were largely unoccupied. In addition, local people did not visit the Wadi 'Arabah regularly during the summer months owing to its excessive heat and lack of water and, as the Rashaydah recall, owing to the serious risk of developing life-threatening diseases, including malaria. To this day, a local man in Faynan is paid to spray local water sources in order to keep mosquito infestation under control.

In the 1950s and 1960s in the uplands, other important changes occurred. In *c.*1952–53 agricultural land was registered in individual rather than tribal name and, following this, the harvest was no longer taxed directly. There were restrictions on people entering the state-owned 'forested' land, especially to collect wood; a license had to be purchased to do this under strict time restrictions. Population at this time was rising, more children were going to school, health services were introduced (Weddell 2004), and more stone houses were built. The first tractors came in the 1960s and were deployed on the accessible land on the plateau, where traction animals had been employed for ploughing previously. A man from the 'Ata'ata tribe from Dana (pers. comm. 1998) cultivating in the orchards there said that numbers of cattle declined with the introduction of tractors, but increasing restrictions on forestry on state-owned land meant that there was insufficient grazing for them. There was a concerted campaign to settle the bedouin (Bocco 2000), and to the east, when the Desert Highway was paved, bore holes were sunk and a string of bedouin settlements was established along it including Hussayniyya (the name is a tribute to King Hussein), a Huwaytat Ibn Jazi settlement.

In 1976 (or 1973: Lancaster and Lancaster 1999: 154–5), the village of Quarayqira was founded at the lower end of the Wadi Faynan at its junction with the Wadi Fidan. The key player was the influential Sharif Hussein bin Nasser, and Moraiwid Tell said he first introduced the Sharif to the area based on the knowledge he gained during his mineralogical expeditions in the 1950s. It was the Sharif who first financed the sinking of a deep well at Wadi Fidan and, later, at the request of the tribes, helped them form a co-operative agricultural project, taking a one-third share in the co-operative. The relationship between the Sharif and the tribes was not entirely trouble free and accounts vary as to how the Sharif became involved: some say that it was following an armed dispute between the 'Ammarin and Sa'idiyyin, others that the dispute came later after the well was sunk and that the agricultural project was a means to pacify the situation. Eventually, after some years, Sharif Nasser withdrew following a series of disagreements. The greatest disagreements appear to be after his sons took active control of the project and, ultimately, led to the family's complete withdrawal, in exchange for some other land in the Wadi Fidan. However, the project does appear to have successfully brought together the 'Ammarin and Sa'idiyyin. According to Swenne (1995: 42), the co-operative had 1300 members from Ghor As-Safi to Bir Dabaghat at the time of his survey, but only 1000 dunum (100 hectares) can be irrigated at any one time due to water availability. The agricultural scheme uses pumps and a piped irrigation system to cultivate such crops as tomatoes, potatoes, and watermelons. The Rashaydah elders reported that they were invited to join the scheme, but declined.

At Wadi Faynan, Moraiwid Tell remembered that a prospection station constructed near one of the churches at Khirbat Faynan during his previous visit in the 1950s had been destroyed by the Fedayeen, Palestinian guerrillas, who had recently hidden there following the 1967 war. They were presumably using the area as a base from which to launch incursions into Israel, but were evicted following the events of Black September (1970). Their occupation of Wadi Faynan is a reflection of the isolation of the area and its military sensitivity during this time. The Natural Resources Camp (NRA) at Faynan appears also to have been developed during the 1970s, with the track leading to it cleared at that time.

Figure 2.19 *Mother and child at Bir-al-‘Ata‘ata, the former summer camping ground of Dana villagers,* c.*1961–62; threshing with donkeys is just discernible in the background. The child is a recovered case of kwashiorkor (protein deficiency). (Photograph: Jean Weddell, reproduced with kind permission.)*

In the late 1970s and early 1980s Moraiwid Tell was back again in the region. His office was involved with the establishment of the cement factory behind Jabal al-‘Ata‘ata (*c.*1980) and the planned movement and settlement of Dana villagers and Shawbak tribes to more accessible roadside settlements from their more inaccessible spring-side settlements lower down the rocky, rugged, escarpment. The move and associated developments came largely in response to requests by the tribal members themselves, and many local people date the start of the move to the plateau to the 1970s. Owing to the substantial rise in population there was increasingly too little space in the old settlements to accommodate expansion. People also wanted to be closer to the main road because of the access this gave them to modern conveniences such as piped running water, electricity, and motorized transport.

The new settlement, Qadisiyya (a reference to Saddam Hussein and the 1980–1988 Iran–Iraq War, and also to an early Islamic battle between Arab forces and Persia), was established for the villagers from Dana at Bir-al-‘Ata‘ata (the ‘cistern of the ‘Ata‘ata’) on the plateau above, formerly the old summer camping ground (Fig. 2.19). Further south, the tribes of Shawbak were moved eastwards onto or close to their arable lands: for example, members of the Habahbah tribe occupying Abu Makhtub below Shawbak Castle were moved east to Az-Zubariyya, where a deep well was sunk to provide water for them, and they were encouraged to begin apple cultivation. This re-settlement was given to the Habahbah in part in recognition for its members’ service as guards of the King’s palace in Amman. Thus, the contemporary lay-out of Shawbak reflects the tribal origin of its people. It is not so much a town as a series of settlements and housing stretching along the roadside, with Nijil, the early administrative centre, established some decades previously at its core. New buildings were constructed of concrete supplied by the new cement factory north of Qadisiyya (Fig. 2.26), which also provided work for local people. The large extraction pits associated with it are cited as another area from which grazing access was lost.

From the 1980s, the pace of change was becoming ever more rapid. Road systems, improved health care, schools, telecommunications, government and public sector employment opportunities, were all advancing apace. At the same time, in the uplands, many of the old villages were falling into disrepair, the most notable being the picturesque village of Dana. The abandoned old stone houses in the Shawbak area started to be rented by bedouin, and especially those originating from the Negev, who were increasingly working as share-croppers in the spring-side orchards, as well as ranging their animals. The Natural Resources Authority (NRA) Faynan camp at the foot of the Wadi Dana started to be used and developed by archaeologists from the German Mining Museum (Bochum, Germany) and some local people started to get casual employment work in archaeology.

As early as 1979 the IUCN (International Union for the Conservation of Nature and Natural Resources or, since 1990, World Conservation Union) and the WWF (formerly, World Wildlife Fund) made a proposal that a protected area be established around Dana (Swenne 1995: 1). In 1988, the Royal Society for the Conservation of Nature (RSCN), a Jordanian NGO (non-governmental agency), approached the Ministry of Agriculture with the request that a protected area be established in the Dana area and a formal agreement was signed the following year. It was not until 1993, however, that the Reserve was established with a US$3.3 million grant secured from the Global Environmental Facility. The total area of the Reserve is *c.*308 km^2 (Swenne 1995), extending from semi-arid Mediterranean uplands around Dana to the arid lowlands of the Wadi ‘Arabah. The Wadi Faynan forms part of the southern border of the Dana Nature Reserve. Thus a large part of forest land registered to the state in the Mandate Period and allocated to the Ministry of Agriculture (Forestry and Range Management Department) became the current Dana Nature Reserve, managed by the RSCN. This also reflects a change in development orientation from Royal or state initiation (through Ministries) towards NGOs, although funding usually derives from major international and governmental sources, and such agencies (NGOs) often enjoy Royal patronage.

By the 1990s, rapid economic developments alongside a changing political climate were facilitating access to the Wadi ‘Arabah. Following the peace agreement with Israel in 1994, the Wadi ‘Arabah became a less sensitive military zone and permit requirements for non-locals lifted, as well as the number of army checkpoints reduced (though this has subsequently varied from time to time according to the political situation). Quickly following the 1994 peace settlement, the road down the eastern side of the Dead Sea was opened, making access from Amman to the Wadi ‘Arabah much easier, not least for researchers coming to work on the BIAAH’s ‘Wadi Faynan Project’ (McQuitty 1998). Not long after that, the road from Tafila to Fifa was completed, reducing vehicle journey times between the Shawbak area to Faynan to *c.*2.5 hours for local tribespeople migrating between the two areas, as well as facilitating access to Tafila’s shops, garages, and hospital.

As modern opportunities and the modern state have developed, so too has the reliance of local people on their own livestock and crops diminished. Southern Jordan still has a strong pastoral economy but, for many families today, this is often supplemental, rather than a primary source of income. Lancaster and Lancaster (1993b: 3:5:2) estimated that only 1–1.5% (8–15 families) of Dana and Qadisiyya villagers depended primarily on livestock husbandry, though the situation is very different in Wadi Faynan (Rowe 1997) and, generally, among groups identifying themselves today as bedouin rather than villagers or, for that matter, employees.

2.2.3 Population estimates and growth

The impression given by European travellers traversing through the then ‘wild lands’ that are now the Hashemite Kingdom of Jordan was that the population was very low during the 1800s. The population in the north was higher than in the south, as it is today. In the south, fear of the tribes, and the tribes’ fear of taxation, disarmament, and conscription, meant that it was difficult even for the Ottomans to make any kind of register of land or attempt a census, as had been achieved in the north (Mundy and Saumarez Smith 2007). Plans to introduce mandatory land registration contributed to the major anti-Ottoman uprising in Karak in 1910, and all the then existing Ottoman records for the region were destroyed by the insurgents (Fischbach 2000: 49). Essentially, population pressure was not high enough yet for land registration to be an important issue – the tribes more-or-less took land as they pleased.

Tribe	No. of families
‘Ammarin	50
Inhabitants/‘family’ *(ahali)* of Dana (‘Ata‘ata)	70
Manaja‘	6
Rashaydah	50
Sa‘idiyyin	200
Inhabitants/‘family’ *(ahali)* of Shawbak (Showabka)	200
Total	**576**

Table 2.3 *Estimate of the number of families per tribe. (From Musil (1908 [1989]).)*

Caza/Ottoman administrative unit	Men	Women	Total
Tafila	4394	3356	7750
Ma‘an	3052	2700	5752

Table 2.4 *Estimate of population in the Ottoman administrative units,* caza*, of Tafila and Ma‘an, 1915. (Ruppin 1917, cited in Konikoff 1943: 14.)*

Alois Musil (1908 [1989]) does provide some relative measure of the strength of the tribes at the turn of twentieth century by including estimates of the number of family units in each. Table 2.3 lists the size of the tribes known to have visited or to have claimed land rights in the Wadi Faynan and nearby Wadi Fidan. He refers to tribes with settlements as *ahali* (‘family’ or inhabitants) of their settlement, including the tribes associated with Shawbak. The tribes would be spread out across their traditional territories and not everyone, of course, would visit Faynan or visit it every year. The ‘Azazma are not listed because their territory was in the Negev at this time. It is difficult to define the size of a family unit, but this is likely to refer to an extended family unit living together. If family size was approximately five to eight individuals, this gives a total population of between 2880 and 4608.

In 1915, the estimated total population of what is now approximately Jordan was 131,788 (Ruppin 1917, cited in Konikoff 1943: 14), although this figure was later thought to be something of an underestimate, and the population at the start of the Amirate in the early 1920s given as approximately 200,000 (Konikoff 1943: 14; Naval Intelligence Division 1943: 265). Table 2.4 gives the estimated populations of the Ottoman administrative units, or *caza*, of Tafila and Ma‘an

	Total structures		Permanent structures		Other structures (e.g. tents, caves, etc.)	
Administrative unit in 1952	**Structures**	**Households**	**Structures**	**Households**	**Structures**	**Households**
Tafila sub-district	2972	3211	1945	2185	1027	1056
Shawbak *nahiya*	1031	1039	511	515	520	524

Table 2.5 *Number of structures and households in the Tafila and Shawbak administrative units, 1952. (Hashemite Kingdom of Jordan Department of Statistics 1952.)*

	Male		Female		Total	
Administrative unit in 2004	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**
Tafila governorate	24,400	14,078	23,308	13,481	47,708	27,559
Shawbak district		5285		5802		11,087

Table 2.6 *2004 census figures for the Tafila governorate and Shawbak district. (Hashemite Kingdom of Jordan Department of Statistics 2004 - http://www.dos.gov.jo/dos_home/census2004/census2004_e.htm.)*

in 1915. Tafila includes Dana and Busayra, and the Ma‘an district included at that time Shawbak, Wadi Musa (Petra) and ‘Aqaba. These figures emphasize that the population was, indeed, low, with an estimated 13,502 people in the whole extended region.

Towards the end of the Mandate, when still no official census had been conducted, the total population of Transjordan was estimated to be between 300,000 and 350,000 (Konikoff 1943: 15; Naval Intelligence Division 1943: 265). In 1952, the first survey of housing and households not only reveals that settlement density was still relatively sparse, but also gives a sense of the extent to which the population was mobile. Table 2.5 is a list of the number of structures and households in the Tafila and Shawbak administrative districts. (Tafila was at this time a sub-division of the Karak district, and Shawbak a sub-division, *nahiya*, of a sub-district in the Ma‘an district.) Tafila encompasses a larger population with more substantial town and village settlements, including Busayra and Dana. There were approximately twice as many built habitations as tents at that time. The number of permanent structures and tents in the Shawbak is almost equal. Assuming a household size of five to eight individuals (and, thereby, making the assumption that they are approximately the same as Musil's family units), the population of the Tafila sub-district was 16,055–25,688 and 5195–8312 in the Shawbak *nahiya*.

The latest census conducted by the Hashemite Kingdom of Jordan Department of Statistics (http://www.dos.gov.jo/dos_home/census2004/census2004_e.htm) in 2004 reveals both the extent to which the population has grown (Table 2.6), as well as the strong sedentarization of the area in the past 50 years. In terms of population growth, Musil (1908 [1989]: 62) estimated that the population of Busayra (*ahali* Busayra, the Sa‘udiyyin) consisted of 200 families, approximately 1000 to 1600 people, assuming a family size, again, between five to eight. The population of Busayra in 2004 was 19,343 – representing a 12- to almost 20-fold increase in approximately 100 years – reflecting an increased birth-rate and survival. Almost two-thirds of the population of the Tafila governorate (broadly equivalent to the earlier 1952 sub-district, but now administratively independent from Karak) is classified as urban, i.e. people living in settlements of more than 5000 people. The entire Shawbak district (broadly equivalent to the earlier 1952 *nahiya*), on the other hand, is still considered rural, and a reflection of the fact that the Shawbak tribes settled disparately on their previous tribal lands. Of a recorded 12,989 private households in the Tafila governorate, just 236 tents were included in the census. Using the figures given in Table 2.6, approximate household size is 5.8 individuals for Tafila. In the large ‘Aqaba governorate, in which Wadi Faynan is now placed (within the Wadi ‘Arabah sub-district), of an estimated 17,352 private households, there were 219 tents at the time of the survey. In the Ma‘an governorate, which includes much of the eastern desert as well as Shawbak, the number of private households was 14,946, including 471 tents. The population of the Shawbak sub-district does not appear to have risen as quickly as that of the more urban governorate of Tafila.

2.2.4 Seasonal movements

In living memory, tribes followed a variety of seasonal rounds, with villagers usually undertaking more circumscribed routes closer to their home village than groups who lived all year round in tents. Chief among the latter were tribes describing themselves as bedouin. Tribes adopted three broad local patterns. The bedouin who wintered in the Wadi ‘Arabah, specifically around Wadis Ghuwayr, Faynan, and Fidan, would move southeast in summer to the upper reaches of the escarpment between Shawbak and Petra. Tribes such as the ‘Ammarin and Rashaydah followed this pattern, with the Sa‘idiyyin also exploiting lands further south. The fellahin either wintered in their houses including, for some, the ruins of the former Crusader castle itself at Shawbak, or those with large herds moved into the rugged mountains (the *wa‘ir* or rough ground), spending all year in tents. Houses were mainly places to store things, and only places to live in winter. In summer, the fellahin moved to the higher arable lands to their east, including flat stretches

	Goats	Sheep	Camels	Donkeys
1993 (Average numbers during course of 1 year)	3364	58	28	Not recorded
March 1995	6288	585	195	Not recorded
May 1996–May 1997 (Lower Reserve area only)	4960	277	81	87

Table 2.7 *Livestock grazing numbers in the RSCN Dana Nature Reserve. (Sources: Lancaster and Lancaster 1993a,b; Rowe 1997; Swenne 1995.)*

of plateau, for the harvest and summer period of crop work on the threshing floor, as well as to their orchards to harvest grapes, figs, and vines. In winter, people living in the *wa'ir* lived not only in tents, but also in caves (*mugharah*) and rock-shelters (*tiran*). The migration routes of the bedouin and fellahin of the mountain front – the Rift escarpment – crossed in summer with that of what will be referred to here as the eastern bedouin, such as the Huwaytat Ibn Jazi. The eastern bedouin previously held more camels and migrated deep into the eastern desert in the winter, beyond the Hajj route. They returned to the plateau and uplands of the Jabal and Shara in the late spring and summer to graze their flocks and obtain grain (Musil 1926: 13). Among these tribes were the paramount bedouin, to whom those who cultivated paid *khuwa*, or 'brotherhood' tax.

Today, due to the lifting of restrictions on movement provided by the transfer of *dirah* (tribal lands) to the state, herding families have the potential to migrate outside their traditional areas and some go as far as Dissi and Rum, to the south, and north to the Karak plateau. Unlike in the past, migration now is most likely to involve a single extended family unit (or even sub-unit) rather than a sub-division of the tribe or larger related group (*goum*). Those camping in winter at Wadi Faynan from the 'Ammarin and Sa'idiyyin, as well the 'Azazma, the newer group from the Negev, still tend to stay at these lower altitudes in the winter and mostly move higher up as temperatures in the Wadi 'Arabah area start to soar. Wadi Faynan is only one part of their grazing round, with people moving to Shawbak, around Busayra, and even as far as Karak in the spring and for the summer months. Families also move up the Wadi 'Arabah to As-Safi and the Ghor, where there are residues from irrigated agriculture to provide fodder. In addition to their tents, many families also have houses in bedouin settlements.

Only a few villagers from Dana still range their animals. They no longer camp at the foot of the Wadi Dana, but some do still have seasonal grazing permits from the RSCN to camp in the rugged al-Barra (literally, the 'outside') area from October to April and on the plateau in summer. Eastern bedouin can still be found grazing their animals – now mostly sheep, rather than camels – on the al-Fujayj plateau and east of Busayra. Some families from as far away as Saudi Arabia come to the Qadisiyya and Busayra area, as they did in the past before they found themselves on the opposite sides of the more recently created international borders. Some villagers from Busayra have specialized in animal husbandry and can be found, in summer, camping alongside the tents of eastern bedouin. One family said that, although originally villagers, they are now more like eastern bedouin. The loss of grazing in the Busayra area – the land taken over by the Ministry of Agriculture, the Goethe Forest, cement factory, and RSCN – and the large flocks they have acquired mean that they have to go east deep into the steppe desert (*badia*), like the eastern bedouin, to graze their animals in winter.

2.2.5 Land use and economic resources

Livestock-holding has always been an expression of wealth and status in the Wadi Faynan. As in the past, different groups specialize in slightly different combinations of animals because some animals are better adapted to particular terrains and species vary in the way they can be used and are valued. Some families and groups are wealthier than others, though animal ownership is not always an indication of wealth in contemporary contexts. In fact, sometimes large herds are a reflection of a group's relative poverty and their attempt to maximize production in the absence of other economic opportunities. Table 2.7 shows estimated proportions of livestock in the area of the Dana Nature Reserve in the 1990s.

Sheep and goats are the main livestock held in the Dana Nature Reserve and, more broadly, the Jabal and Shara. Goats, typically black goats, are the main livestock held in Wadi Faynan and in the hilly areas that surround it. They manage to scale the mountain sides with ease, browsing the trees, low bushes, and herbs. Goats are raised for their milk, meat, and hair. Kidding usually starts around December but, because mating is spaced, can last all the way into March, thereby prolonging the milking period. Young females start breeding in their second year and, in any one herd, there are usually *c.*20–25 adult does per billy goat. Goats generally attain a lower marketable value than sheep but, according to local informants, sheep cannot cope with the rugged, stony, mountainous terrain and quickly develop serious foot problems. Sheep, the local Awassi or 'fat-tailed' sheep, predominate on the upland plateau where the terrain is less challenging, and they are better able to withstand the cold winters (Lancaster and Lancaster 1993a: 3:4:3), presumably owing to their thick wool coats. The higher marketable value of sheep compared with goats is because the meat is considered sweeter (though opinions do vary) and their milk-products are of higher quality due to the high fat content (see Horwitz and Rosen 2005: table 1), although at least the latter attribute is closely matched by products made from goat's milk, even if the meat is less preferred.

Camels were and are highly valued and are still husbanded in the flat stretches of the Wadi 'Arabah and on the

Figure 2.20 *The Ottoman railway branch and watermill at Nijil, Shawbak. This railway was used to transport the region's timber for use in the construction of the Hijaz Railway. (Lawrence 1939, pl. 31, reproduced courtesy of the Imperial War Museum, London; negative number Q59362.)*

plateau by some members of the area's tribes. In winter and spring, they visit the Wadi Faynan on their way to drink in the Ghuwayr springs. Camels require less regular watering than sheep and goats, thrive on the area's arid vegetation, and are less demanding to herd, but their wide, flat, feet limit them to more open landscapes and gentler trails. Camel milk is still consumed in the area and, in common with other areas of the southern Levant (see Horwitz and Rosen 2005: 124–5), is believed to have powerful medicinal properties. In addition to milk, camel hair is highly valued for weaving, the meat marketable, and, as a by-product, camels excrete the best dung fuel. Among the tribes occupying the Rift escarpment, camels were formerly mainly used for transportation, and there was a subsequent decline in numbers following the arrival and widespread adoption of motorized vehicles. Among the former camel-dependent tribes of the east, camel numbers have declined whereas sheep numbers have increased dramatically (Chatty 1986; Lewis 1987).

The enduring local transportation animals are donkeys and, to a lesser extent, mules, both of which can also be used to plough. Horses are rarer but were previously the favoured, more agile, mount of many bedouin (Doughty 1888 [1926]: 30–31). One important difference in animal-holding compared with that of a hundred years ago is that there appear to have been extensive cattle herds in the area then, as asserted by villagers at Dana, for example, and recorded in travellers' accounts (Burckhardt 1822: 410; Doughty 1888 [1926]: 46). These cattle would have been the small, brown, and black local varieties, rather than the black and white ('Holland') cattle used in contemporary farming. The presence of cattle reflects the availability of water and grazing in the area, as well as of forested areas, many of which, as noted previously, subsequently suffered extensive clearance during and after the construction of the railway. A branch of the Hijaz railway – build to transport timber – once ran through the Shawbak area (Fig. 2.20).

The region that includes the Wadi Faynan is famous for its springs not only in the lower reaches of the Wadis Dana, Ghuwayr, and Fidan, as described earlier in the chapter, but also at higher altitudes in a band around the mountain sides where many of the old villages are located. These villages often have extensive irrigated orchards and gardens associated with them, such as the spectacular gardens at Dana, below Shawbak in the aptly named Wadi al-Bustan ('garden'), which connects with the Ghuwayr lower down, and at Shamakh. Fig, vine, pomegranate, and olive are the main tree crops, but there are also apricot, walnut, quince, pear, and apple trees, among others (see al-Kayed 1994: tables 1 and 2). A variety of vegetables and summer fruits is cultivated, including tomatoes, squash, aubergines, beans, and okra, as well as fodder legumes such as bitter vetch, though much less now than in the past.

Rain-fed agriculture, focusing primarily on barley and wheat, takes place on the plateau, especially on the al-Fujayj plain south of Qadisiyya, on the slopes of the Kula west of Busayra, to the east of Qadisiyya and Busayra, and south of Shawbak, where there is a Mediterranean climate. Barley and wheat are the main crops, with some lentil and chickpea. Average annual precipitation from Shawbak to Tafila is

Figure 2.21 Mansaf*, the feast dish of the region. (Photograph: Carol Palmer.)*

Figure 2.22 Khubz saj*, 'bedouin' bread, prepared on a metal pan over a fire. (Photograph: Carol Palmer.)*

*c.*300 mm on average, 150 mm in drought years, and up to 400–500 mm in wet years (Bruins 2006: 36), a variability that means a high variability in yields. A cereal-fallow or cereal-pulse (in good years) rotation is normally used, especially for wheat, but in drier areas or years there may be no strict rotation, with barley sown every time there is deemed to be sufficient rain. Almost all precipitation received is between November and April and, by May to June, everything is harvested or, in poor years or drier areas, the crop is sold for grazing (stubble grazing is traditionally free access). Today, much of the arable land is share-cropped.

Irrigation schemes involving modern plastic piping, fertilizers (including chicken manure), and clearance by tractors have become very common. Major enterprises in the vicinity of Wadi Faynan are, of course, Quarayqira, the first; Wadi Dahal, near the new 'Azazma settlement at Ghuwayb(ah); and in Wadi Faynan itself (Fig. 1.7). These schemes tend to accompany bedouin settlement. The market availability of the fresh fruits and vegetables these types of schemes produce, combined with the products grown in the extensive Ghor plantations, have tended to undermine the impetus to cultivate in difficult-to-access spring-fed orchards.

The traditional diet of the area was one based on milk products and cereals (Palmer 2002). Milk is processed into a range of storable products, principally *jamid* (defatted dried yoghurt), and *samn* (clarified butter or ghee). Cereals were cultivated by groups themselves, traded, or received as tribute, with the threshing floor a common site of exchange. Many villagers commented that bread from their ovens was usually made from barley, not wheat. Roughly ground (on a hand quern), boiled wheat grains flavoured with *samn* was a typical, indeed good, meal. Villagers possessing valuable spring-side gardens had more vegetables and fruits in their diet than bedouin, and dried fruits were the main form of sweet food consumed, as well as important exchange items. The main traded items from the region reflected the pastoral base and presence of spring-fed gardens: *samn* and *jamid*, live sheep and goats, and dried fruits. Doughty (1888 [1926]) notes, for example, that the Rifaya nomadic fellahin traded dried grapes (*zabib*) at Gaza.

The diet today is based on bread (from wheat), rice, sugar (mostly drunk in tea), and in villages, factory-farmed chicken. The traditional feast dish, and the meal served to special guests, however, has not changed. *Mansaf* (Fig. 2.21) is at least one whole animal, chopped into pieces and boiled either in fresh or dried defatted yoghurt and served on a platter lined with flat unleavened bread, *khubz saj* (Fig. 2.22), most often served with rice too. Canned foods, especially sardines and tuna, have become common among the bedouin and a favourite lunch food for shepherds. A good milk supply from their goats is still very important to the bedouin households in the Wadi Faynan and drought years, when milk runs dry, cause considerable hardship.

In the past, both villagers and bedouin used many wild local resources. There were *ghazal* (Dorcas gazelle) in the Wadi 'Arabah, no longer present today, whilst *badn* (ibex), still present but now protected, were hunted in the mountains. Members of the Rashaydah tribe remember hunting gazelle earlier in the twentieth century and preparing the meat for consumption in a traditional roasting pit or *zarb*. A range of smaller birds and animals was also consumed. Many wild plants have economic uses, only a few of which are mentioned here. Most notable are the fruits from pistachia trees (*Pistachia atlantica* and *P. palaestina*) growing in the uplands, and, in the low-lying areas, butter made from *Moringa peregrina* seeds and the fruits of the Christ's Thorn tree (*Ziziphus spina-christi*), all much appreciated locally. Also in the more arid areas, the small seeds of *samh*, *Opophytum forskalii*, were harvested and used in the past for flour by bedouin. Wild greens were collected in spring, together with a range of aromatic herbs

Figure 2.23 *The Rashaydah at Wadi Faynan, April 2006. Back row, left to right: Talab Damaythan (Abu Fawaz), Mohammad Sayal (the Pasha's son), the 'Pasha' Sayal Mohammad, Suleiman Damaythan, and Za'al Damaythan. In front: Sayal Mohammad (left, the Pasha's grandson) and friend. (Photograph: Carol Palmer.)*

used in tea and claimed to have medicinal purposes. Many herbs were used to flavour clarified butter, *samn*, each tribe having its own particular recipe.

2.2.6 The human landscape

The main tribes living in the Wadi Faynan when the Wadi Faynan Landscape Survey began were the 'Ammarin, 'Azazma, Sa'idiyyin, Rashaydah, and the Manaja'. There are several tribes with either current or historic interests in the Wadi Faynan, particularly the 'Ata'ata from Dana and the Shawabka, the Shawbak tribes. As well as the tribes, there are also organizations representing state and also non-state sponsored interests, which have, in recent years, played an important role in the wadi, the most notable of which in recent years has been the Royal Society for the Conservation of Nature (RSCN). Archaeological institutes and teams have also had an impact on the local people, providing occasional and longer-term employment and changing the way in which they view their archaeological landscape and heritage. Looting of artefacts, mainly from graves, became a recognized problem (Findlater *et al*. 1998).

In the mid 1990s the size of the population of Faynan and Quarayqira varied considerably through the year due to the spring and summer migration in search of better grazing. In the summer the population is smaller than it is during the winter. In 1993, Lancaster and Lancaster (1993b: 3:1:8) estimated the population of Faynan as between 33 to 39, and quoted previous census figures as high as 102 in 1979, but an alternative source gave the population as 20 in 1993. The population of Quarayqira appears to have been more stable and was given as 190 in 1979 and 120 in 1993.

Land in the Wadi 'Arabah area is, in general, officially state-owned and not available for legal ownership except as building units in designated settlements. Certain tribes do have traditional rights over particular areas, with their claims recognized to some extent by the state. The establishment of Quarayqira and the agricultural co-operative are an early example of this, with the government recognizing the tribal claims of the Sa'idiyyin and 'Ammarin at Wadi Fidan. Agricultural development of land usually bestows ownership, while grazing does not.

2.2.6.1 Rashaydah

The Rashaydah are recorded as blood-brothers of the Huwaytat by Musil (1908 [1989]: 59–60) and once received tribute, *khuwa,* from local tribes. They held supremacy over the more settled and peasant-like Shawabka, who cultivated for them (Burckhardt 1822; Musil 1908 [1989]). In some accounts, the Rashaydah also held supremacy over 'Les Arabes de Showbak', the 'Ammarin and al-Gawafleh (Jaussen 1907 [1948]: 393). The Sa'udiyyin (a different group to the Sa'idiyyin), who now live in Busayra but once lived in Shamakh, south of Shawbak, were also once dependent on them (Jaussen 1907 [1948]: 393). The

Rashaydah's status as 'real' bedouin was recognized in the Bedouin control law of 1929 which added them to the then official bedouin of the south and included them as original Huwaytat (Naval Intelligence Division 1943: 467).

The Rashaydah living in Wadi Faynan today (Fig. 2.23) name their ancestor as Mal'ab, some ten ancestoral generations from the present-day CBRL guard Abu Fawaz, who was born around 1952. Musil (1908 [1989]: 60) lists the Ghuwayr as a key watering-place of the Mal'ab section. They camped in the Wadi Faynan, or Ghuwayr, in the winter months, moving up to their lands around their modern settlement of Howalah, near Shawbak, in the summer. They recount that their grandfathers cultivated at Faynan earlier in the twentieth century. It is unclear whether Mal'ab was the leader who received payments from Muhammad Ali of Egypt to protect the Hajj, as is claimed by some, or lived earlier, sometime in the seventeenth or eighteenth centuries as claimed by others. He was known as 'two pockets' because when the Egyptian ruler found out he was giving away money he gave him to poor people outside the court, he doubled his gold payment to enable him to continue to show this generosity without personal loss. In other words, he was, indeed, a great leader.

Towards the end of his army career the Pasha, Sayal Mohammad Rashaydah, having attained high military office, wanted to start cultivating land in Faynan. He started laying irrigation pipes for tomato cultivation in 1992, using 'Azama workers from northern Jordan, men who had previously worked for Sharif Nasser (the co-founder of Quarayqira), though on another project (Lancaster and Lancaster 1993a: 4.12). As noted above, cultivation of land is a way to gain official title and, because the Rashaydah claim was contested by some of the people from Shawbak, the Shawabka, confrontation inevitably followed. On the first occasion, the Rashaydah say they were tricked into attending an event for King Hussein in Hussayniyya, while the plots were cleared with bulldozers; but, on a second occasion, the Rashaydah were more careful to guard their investment and there was an armed confrontation when the authorities' vehicles were fired at by the Rashaydah (also see Lancaster and Lancaster 1999: 122–3). Cultivation continued through to the mid 1990s, destroying parts of the ancient field system and, in part, prompting the survey presented in this volume (see Chapter 1, p. 9; Fig. 1.7).

2.2.6.2 'Ammarin

It is widely accepted that, with the Sa'idiyyin, the 'Ammarin have the longest association with the Quarayqira and Wadi Fidan areas and seasonally cultivated there prior to 1948 (Rowe 1997: 16). They are also known to have a long tradition of camping at the foot of the Wadi Dana as well. Although today counted within the Huwaytat, the 'Ammarin appear to have been an independent group in the nineteenth century (Musil 1908 [1989]; Oppenheim 1943 [1983]). Lancaster and Lancaster (1993a: 6) link them with the Ibn Gad Huwaytat, also known as the 'Alawin. However, descendence from the Bani 'Atiya is commonly claimed. There is a link with the Huwaytat because the Bani 'Atiya are the tribe that, according to local tradition, fostered the boy who became the man, Huwayt, who founded the Huwaytat lineage. In his time, Musil (1908 [1989]: 58) noted that the 'Ammarin were 'goat-breeders and notorious robbers'.

Today there are 'Ammarin settlements at Beidha, near Petra, at Bir Dabaghat, south of Shawbak, Bir Madhkur, and at Quarayqira. The 'Ammarin bedouin campsite at Beidha is regularly visited by tourists and has its own website (http://www.bedouincamp.net/). The 'Ammarin have prominence at Faynan because one of them has been a long-term employee of the NRA, guarding the Faynan camp at the foot of the Wadi Dana. His brother is the Head Ranger of the RSCN, formerly a forestry employee.

2.2.6.3 Sa'idiyyin

The Sa'idiyyin formerly wintered in the Wadi 'Arabah and moved in summer to mountains south of Wadi Musa (Oppenheim 1943 [1983]: 19). Their main watering holes were at Gharandal and its hinterland to the south (Musil 1908 [1989]: 46–7), and they cultivated on flats, the so-called *qa'a al-Sa'idiyyin*, in that area where water would collect after winter rain. Before the establishment of modern national borders, the Sa'idiyyin had territory on both sides of the Wadi 'Arabah, bordering on 'Azazma traditional lands to the west. Contemporary people tend to divide the Sa'idiyyin into a western and eastern group – east and west of the Wadi 'Arabah – as is also noted in ethnographic accounts. The eastern Sa'idiyyin have long territorial associations with Wadi Fidan, and this accounts for their involvement with the Quarayqira co-operative. The Sa'idiyyin held substantial camel herds and goats, as well as cattle, in the past. Doughty (1888 [1926]: 46) encountered a party of Sa'idiyyin men in the Hisma forest camping with their cattle, which they had brought for spring grazing. He called them 'Aarab of the Ghror', and part of the Huwaytat. Today, the Sa'idiyyin are also included within the Huwaytat confederacy, although like the 'Ammarin, they appear previously to have been given an independent status. They have a number of settlements, and there is Sa'idiyyin housing in Gharandal, Bir Madhkur, Dlagha, Fifa, and Quarayqira, but those with livestock still camp in the Wadi 'Arabah and Shara region, and south of Wadi Musa more broadly.

2.2.6.4 Manaja'

The Manaja' are the smallest group visiting Faynan (and see Table 2.3). Rowe (1997) reports that they are a section of the Huwaytat tribe that arrived after 1948, but their entry in Musil (1908 [1989]) suggests they have a longer association with the area. They have strong links with the Sa'idiyyin, and are included within the Quarayqira agricultural co-operative. Lancaster and Lancaster (1993b: 6) state that the Manaja' are from the Ibn Gad Huwaytat (also Musil (1908 [1989]: 60) and were involved in protecting traders between Palestine and the Hijaz. This long-distance trade association probably explains why Rowe reported that they

Figure 2.24 The picturesque village of Dana at the head of the Wadi Dana; beyond is the flatter terrain of the Jordanian Tablelands, looking north. (Photograph: Carol Palmer.)

were originally from Palestine; indeed, they once had very strong connections there too.

2.2.6.5 ʻAzazma

The ʻAzazma, now the most numerous group camping in the Wadi Faynan, are bedouin originally from the Negev (Musil (1908 [1989]: 41–4) and came to the area following the formation of the State of Israel in 1948. They associate themselves strongly with Beersheba and often refer to themselves as ʻBeershebans'. Lancaster and Lancaster (1993a: 2.6) state that the ʻAzazma used to range their animals on the eastern flanks of the Wadi ʻArabah as part of their traditional grazing territory, but this is denied by the ʻAzazma (see also Rowe 1997). The ʻAzazma do say that they would travel into the Shara to obtain grain in drought years in the Negev and that they knew the Transjordanian tribes, but otherwise they remained on the western side of the ʻArabah. Furthermore, there are strong dialectal differences between the ʻAzazma and the other tribes and, in many ways, the Wadi ʻArabah represented a strong, though traversable, barrier between the populations (Bailey 2006; van der Steen 2006).

The ʻAzazma were mainly sheep herders in the Negev, with some camel herds, and practised small-scale wheat and barley cultivation immediately prior to 1948. They are a very large tribe and after 1948 many members dispersed to other regions of Jordan. The people living in the Faynan area are part of the Sarahin sub-group. Following their migration, the ʻAzazma in the Wadi ʻArabah quickly sold their sheep and specialized in goat herding owing to the mountainous rocky terrain (Rowe 1997). Many have also subsequently become involved in cultivation, working as share-croppers on the privately-held land of others, including at the Quarayqira agricultural co-operative. In the uplands today they often rent or are starting to buy the old abandoned houses of the fellahin. Until the mid-1990s, they were burying their dead, in the Islamic tradition, in a cemetery close to Khirbat Faynan among more ancient graves.

It was not until the 1980s or early 1990s that most of the ʻAzazma in the Wadi Faynan area acquired full legal status in Jordan, obtaining so-called ʻfamily books'. A strong impetus to acquire the latter seems to have been because they granted access to subsidized fodder (Rowe 1997). The lack of official status meant that, prior to this date, the ʻAzazma did not have access to state employment or facilities. As well as this the ʻAzazma do not have or claim traditional rights to land, only access to state land to graze their herds. The founding in 1989 of the primary school in the Wadi Faynan near the RSCN camp, with the new building erected in 1992, has meant that more from the younger generation can read and write, although in the mid-1990s relatively few were completing education to 18. There is no tradition of service in the Jordanian army for the ʻAzazma owing to their previous lack of status and education.

For them, livestock holding continues to be the primary source of income, although frequently subsidized by other activities – mostly casual employment, for example, on archaeological excavations, as well as hiring themselves and their vehicles to rent and conducting some mobile trade. Livestock trading was particularly profitable in the 1980s and early 1990s (Lancaster and Lancaster 1993a,b), while there was a subsidy on barley fodder, and milk-products continue to play a significant part in the daily diet. The ʻAzazma's strong reliance on livestock prompted some villagers around Shawbak to comment that they are the only real bedouin left in the area. In the mid 1990s, land for an ʻAzazma village was allotted to the north at Ghuwayb(ah), by the side of the Wadi ʻArabah road in response to a request following a visit by Prince Hassan, King Hussein's brother.

2.2.6.6 Ahali Dana, or ʻAtaʻata

The ʻAtaʻata are villagers who live at Dana (Fig. 2.24) and the newer settlement of Qadisiyya. There are three main sub-divisions within the tribe: the Hawaldah, Naʻnaʻ and Khasabah (also see Musil 1908 [1989]: 61; Oppenheim 1943 [1983]). Qadisiyya is now very large and was granted

Figure 2.25 *An early sign designating Dana Nature Reserve, erected by the Royal Society for the Conservation of Nature, looking north. (Photograph: Carol Palmer.)*

baladiya, or urban, status in 1991 (Lancaster and Lancaster 1993b: table I & 2:2:9), which means the population had then attained *c.*5000 individuals. Approximately 100 years earlier, Musil (1908 [1989]: 61) estimated the *ahali* Dana to be 70 families (Table 2.3). As noted above, most of the ‘Ata‘ata have left their traditional lifeways, taken on employment, and become more urbanized. By the early 1990s, the village of Dana and its 200 hectare spring-fed gardens had become very dilapidated following the removal of most of the population to Qadisiyya, with only the old and very young remaining in the old houses. The huge rise in population and the tradition of divided inheritance meant that many of the houses and gardens had multiple owners, which was also a problem for continued use – people often did not agree on how the land should be managed or who should live in a house. This and a general suspicious attitude to the intentions of outsiders caused considerable misunderstandings between villagers and ‘The Friends of Dana’, a charitable organization set up at the beginning of the 1990s to restore and improve conditions for people of one of Jordan’s most picturesque villages and gardens (Lancaster and Lancaster 1993b).

Within living memory, the ‘Ata‘ata used to camp with their animals at the foot of the Wadi Dana, and Lancaster and Lancaster (1993a: map 6) note that there is disputed land between the ‘Ammarin and ‘Ata‘ata on the north bank of the Wadi Faynan, between Wadi Dana and Wadi Khalid. The track between Dana and the Faynan camp was an important route for local people between the Faynan and uplands, before it was closed as part of the establishment of the Dana Reserve.

2.2.6.7 Ahali al-Shawbak, the Shawabka

The Shawabka (inhabitants of Shawbak) are the group of tribes living in the hinterland of Shawbak castle. Tribes included within this broad group are the Malahim, Habahbah, Tawara, Lowama, Rowashdah, Shiqayrat (according to local tradition, the descendents of Crusaders), Ghunaymim, and Rifaya (see also Musil 1908 [1989]: 61; Oppenheim 1943 [1983]: 285–6). They had herds and also cultivated, and referred to themselves as fellahin. Tradition holds that the Shawabka first used the Crusader castle as their centre, living there and camping in its hinterland, and then started spreading to spring-side settlements (and where there were often ancient ruins), first storing their produce in caves and, later, constructing stone houses for both accommodation and storage. By the 1990s they had left their spring-side settlements and were almost all living on the plateau, mostly working as employees, in a similar way to the ‘Ata‘ata of Dana. The Shawabka feature in the history of Faynan because some members claim cultivation rights there and were involved in a dispute with the Rashaydah over land rights and because they opposed the Pasha’s irrigation scheme. The disputed land is recorded to be southwest of the ancient field system WF4 (Lancaster and Lancaster 1993a: map 6:6).

2.2.6.8 Royal Society for the Conservation of Nature

The RSCN’s relationship with the people of the Reserve did not begin well because the organization appeared to represent another step in a process of land alienation for local inhabitants. Furthermore, the RSCN’s mission to conserve the area’s biodiversity initially promoted a culture of exclusion and regulation epitomized, for example, in the erection of signs forbidding access to the Reserve (Fig. 2.25) and the closure of the track from Dana to Faynan. This was not an uncommon attitude to conservation schemes in Arabia where local people tended to be viewed as obstacles to conservation (Chatty 1998: 2). All early commentators conducting surveys for the RSCN as part of the establish-

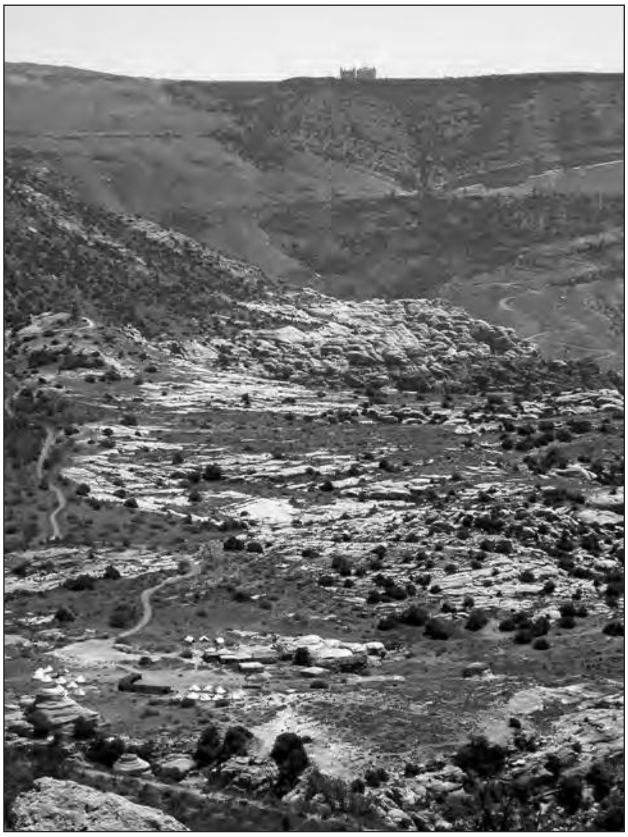


Figure 2.26 *The RSCN (Royal Society for the Conservation of Nature) eco-tourism campsite at Rummana (lower foreground). The Dana gardens are in centre view and the cement factory on the mountain above, looking southeast. (Photograph: Carol Palmer.)*

ment of the Reserve reported the considerable suspicion and animosity of the local people towards the organization (Lancaster and Lancaster 1993a,b; Rowe 1997; Swenne 1995). Much of the fear focused on the restriction and elimination of grazing rights that the establishment of the Reserve meant.

The RSCN quickly realized that some serious mistakes had been made (Johnson and Abul Hawa 2002) and that a new approach was required. Indeed, the GEF (Global Environmental Facility) grant to set up the RSCN Dana Reserve provided for the establishment of socio-economic projects to mitigate income loss for local people, though an emphasis on conservation over a measured perspective towards the needs of the people dominated at first. The project was intended to be in line with key outcomes from the Rio de Janeiro 1992 United Nations conference which recognized that, in order for conservation schemes to be successful and sustainable, they needed to work in partnership with local communities (Chatty 1998; 2002). The logo the RSCN adopted sought to stress this: 'helping nature, helping people'.

As a consequence, and as part of the establishment of the infrastructure of the Reserve, a number of initiatives was established linking conservation and eco-tourism to help promote the area's natural heritage, raise local awareness of conservation issues, and provide local employment. At Dana village, an RSCN guest house, gift shop, and silver workshop were established alongside the Reserve headquarters, as well as schemes to regenerate Dana's orchards and sell its products, and a fruit-processing plant built to make jams and dried fruit products. All products sold emphasize nature and conservation – including use of environmentally-friendly packaging – and are primarily aimed at the tourist market. Ecotourism camps were established at the scenic Rummana (Fig. 2.26), overlooked by a gateway tower and wildlife look-out point, and at the NRA Faynan camp. Wildlife walks and tours were established around Dana village and as a means to take tourists from Dana to the Faynan camp, all offering spectacular views along their routes. Most socio-economic schemes initially focused around Dana and among the local community there, in part due to the Reserve Headquarters being located there, but later the RSCN realized they needed to devote more attention towards the Faynan area. As a consequence, the anthropologist Alan Rowe was commissioned to look for opportunities for the 'Azazma, the largest group dependent on pastoralism and originally refugees from Palestine, who had also been affected by the lifting of the fodder subsidy in 1996. One of the things he promoted was the idea of a goat-fattening scheme to rear goats outside the protected area (Rowe 1997).

The Dana Reserve Management Plan drawn up in 1996 represented an attempt to balance ecological aims with the needs of local people. Grazing was left unlimited in the lower parts of the Reserve and around Faynan. Although ecological assessments reported severe over-grazing (Swenne 1995), the difficult economic conditions groups living there faced and the lack of economic alternatives to pastoralism resulted in a cautious approach. The upper Reserve's forested landscapes were protected, however, with complete exclusion around the Rummana camp, a traditional grazing area for villagers from Busayra, and seasonally limited grazing at al-Barra, a traditional winter grazing area for Dana villagers. Local people were prevented from cultivating in the Reserve both in the uplands and in the lower areas where bedouin had previously cultivated barley and tobacco in small run-off irrigation plots. In addition, hunting was prohibited, necessarily for a nature reserve, and firewood collection controlled.

2.2.6.9 Archaeological teams

Professor Andreas Hauptmann and colleagues from the German Mining Museum (Bochum, Germany) began archaeometallurgical explorations and mining studies in the Wadi Faynan region in 1983. In addition to the German teams, Dr Mohammed al-Najjar, from the Department of Antiquities, also conducted research at Tell Wadi Faynan, and Professor Alan Simmons and Dr al-Najjar at the PPNB settlement, Ghwair I. Professor Tom Levy and colleagues, beginning in the 1990s, continued research into the region's copper-related heritage with emphasis on sites in the area of Khirbat Hamrat Ifdan. In summary, by the mid-1990s

Figure 2.27 *Jouma' 'Aly Zanoon, an experienced field archaeologist and local guide. (Photograph: Carol Palmer.)*

archaeologists were very much part of the Faynan landscape. All this activity meant that, by the time the British Institute at Amman for Archaeology and History chose the area for its flagship 'Wadi Faynan Project' (McQuitty 1998), there was a history of archaeological investigation in the area, and when our own archaeological fieldwork began in 1996, and that of the Reading team (Finlayson and Mithen 2007), we were both able to draw on archaeological excavation experience and expertise within the local population (Fig. 2.27). The Faynan camp was also well established as an ideal base for visiting archaeological teams.

BIAAH's involvement in the archaeology of the Wadi Faynan, the platform on which the present project was developed, was very much bound up with the establishment of the Dana Nature Reserve by the RSCN in 1993 because William Lancaster (then Director of BIAAH) and Fidelity Lancaster were the anthropologists commissioned to conduct the first survey of local people (Lancaster and Lancaster 1993a,b). Through their contact with the Pasha from the Rashaydah, who was then developing his agricultural project on the floor of the Wadi Faynan on the site of the ancient field system, the BIAAH researchers developed strong connections with this tribe, appointing a site guard, Abu Fawaz, from their number. The Rashaydah were not initially involved in the establishment of the Dana Reserve as, technically, their territorial areas were outside the Reserve's boundary (they also shared local inhabitants' suspicion of the RSCN). Alison McQuitty (BIAAH Director 1994–99) signed an agreement with the RSCN to run the Faynan camp jointly as a base for archaeological researchers as well as an RSCN eco-tourism camping site. As described in the Postscript to Chapter 13, balancing the needs of protecting the natural and archaeological heritage, on the one hand, and promoting the economic well-being of the present-day inhabitants, on the other, is inevitably proving to be a complex and delicate process, but the long-term sustainability of the Reserve will only be secure when these interests genuinely merge, when local people have a significant economic stake in the protection of their remarkable natural and archaeological landscape.

3. The past and present landscapes of the Wadi Faynan: geoarchaeological approaches and frameworks

Hwedi el-Rishi, Chris Hunt, David Gilbertson, John Grattan, Sue McLaren, Brian Pyatt, Geoff Duller, Gavin Gillmore, and Paul Phillips

3.1 Fieldwork strategy and methodologies

This chapter sets out the rationale behind the geoarchaeological studies carried out to establish the nature and significance of desertification in the Wadi Faynan landscape, and summarizes the team's principal findings. As a result, it has the following major objectives. The first is to address the academic and practical issues that concern the relationships between field realities and research goals in geoarchaeological field studies. The second is to set out for the period of most intense human activity in the Faynan – the Holocene – an overall palaeoenvironmental framework within which the more detailed accounts in Chapters 7–11 can be understood. The third is to describe the project's geochemical evidence for the pollution of the modern landscape by past metallurgical activities, and to discuss the potential implications of this evidence for understanding the nature and scale of mining and smelting in the past. The last goal is to investigate the Wadi Faynan and regional data sets for recurrent patterns or anomalies in terms of the complex potential interactions between climatic fluctuations, vegetation, and human activities from the late Pleistocene through the Holocene to the present day.

'Patchy', 'discontinuous', and 'episodic' are terms that describe the reality of geoarchaeological research in the Faynan area, as in arid lands elsewhere (Huckleberry 2001). Patchiness and discontinuity are the inevitable consequences of the topography and geomorphological dynamism of a landscape such as the Wadi Faynan, in which episodic geomorphic activities can significantly erode, re-work, and re-shape the evidence of longer-term changes driven by climate, ecology, tectonics, and people. At the start of the project there was little idea of what, if any, geomorphic sequences might be found, dated, or correlated; which if any deposits might be capable of sustaining detailed palynological, geochemical, or palaeoclimatic investigations; and, if such deposits *could* be located, whether the evidence gathered by those investigations could be understood in terms of the complex of 'natural' and 'human' processes understood within the term desertification.

The primary evidence available before our investigation was the study of Quaternary deposits in the Wadi Faynan by Rabb'a (1994), who had identified a series of alluvial fan deposits and undifferentiated fluvial and colluvial facies, together with the large-scale mass-movement of Cenozoic bedrocks, in the upper catchments of the Wadis Dana and Ghuwayr (Table 3.1). Whilst general guidance on the nature and location of these larger landforms was potentially available to us through map and air-photograph interpretation, the ability to locate and investigate materials for particular palaeoenvironmental purposes had to depend upon ground reconnaissance with restricted vehicle-support, a property that limited both the daily survey range and our capacity to take field samples in this difficult landscape. Further difficulties lay in the logistics of conserving samples, once taken, in the (initially rudimentary) facilities of the field camp, and then their removal from the field camp and export to distant laboratories.

Natural and archaeological features were located, mapped, and then interpreted in the field from the original high-quality black-and-white vertical air photographs taken by the Royal Air Force in the 1930s, which pre-date most modern changes in the landscape. These photographs were generously provided by Professor David L. Kennedy of the University of Western Australia from *The Archaeological*

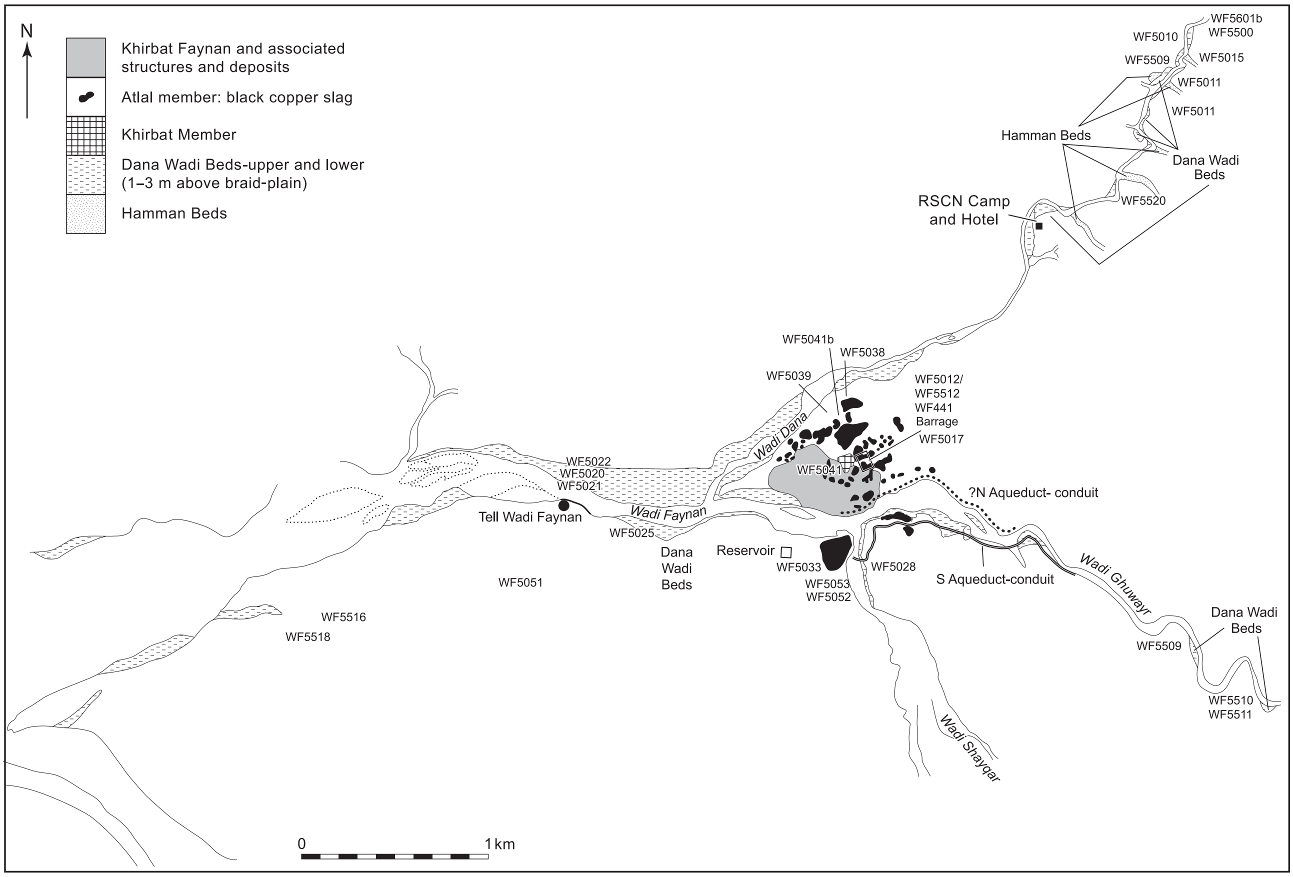


Figure 3.1 *The location of the principal Holocene deposits and main geomorphological and palynological sites of Mid- to Late Holocene age in the Wadi Faynan. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, adapted from Hunt* et al. *2007a; McLaren* et al. *2004.)*

	Description	Suggested age
Al	Trough cross-bedded sands and gravels containing abundant mine spoil debris	Holocene
Al	Trough cross-bedded gravels passing into clay plugs and overbank loams containing a Neolithic site	Pleistocene
Plf	Trough cross-bedded gravels, sands and loams, fragmentary carbonate, indurated, with Middle Palaeolithic artefacts resting on their surface.	Pleistocene
Plg 2	Trough cross-bedded gravels, loams and muddy diamicton and containing occasional Middle Palaeolithic artefacts, and with Middle and Upper Palaeolithic artefacts resting on their surface	Pleistocene

Table 3.1 *Summary of information on Quaternary deposits in the Wadi Faynan prior to the present project. (After Barjous 1992; Rabb'a 1994.)*

Air Photograph Archive for Jordan (catalogue references 41.018–20; 42.059–61; 42.114–16; 43.017–22). Likewise of use were: the original diapositives and prints at 1:25,000 from the 1954 Huntings Aero Surveys Ltd *Air Photograph Survey of 1954*; the Jordanian 1:50000 Topographic Maps in Series K737 - Sheets 3051 II (Jebel Hamrat Fidan) and 3151 III (Shaubak); and the published geological sheets (Barjous 1992; Rabb'a 1994). At the end of the project, we also used DEM data that became available on the NASA 3DEM website, and the interpretative work after the fieldwork also benefited from the excellent oblique helicopter-based colour images of Kennedy and Bewley (2004).

Field reconnaissance was undertaken on foot by one or two groups of three or four people (drawn from HR, DG, JG, CH, SMcL, and BP). In the early field seasons, field position was estimated by reference to photocopies of air photographs, but the scale and complexity of the terrain on the mountain front and in the gorges caused many uncertainties and mistakes that took time to be recognized and rectified. Hand-held GPS systems in the later seasons proved an immediate boon in the open landscape, but problems persisted in the gorges where there was often limited intervisibility with the GP satellites. Hand-held surveying aneroid barometer altimeters (kindly provided by Professor John Gunn, University of Huddersfield, in the first season) proved helpful in identifying the comparative elevation of deposits and were especially useful in the recording of multiple episodes of fluvial down-cutting or aggradation found in the gorges. We often sought the perspective and visibility provided by the highest ground, exploring the landscape on the basis of accessibility, the usefulness of map support, visible sequences, risk assessment, and our increasing knowledge and experience. In the time available we probably traversed less than 5 per cent of the landscape, but saw considerably more than this.

The fieldwork in the first year of the project brought comparative success in locating and mapping, but not dating, important geoarchaeological deposits. Also, the large areas of undifferentiated copper smelting slag described in the published papers of the Bochum team were identified in the vicinity of Khirbat Faynan (Fig. 3.1) and the adjacent confluence of the Wadis Shayqar, Ghuwayr, Dana, and Faynan. The ancient mines and adits cut in bedrock previously mapped in detail by the Bochum group were located on the mountain front or in the wider wadis and gorges. At the same time, however, innumerable small patches of clasts of black copper-smelting slag were also discovered in the ancient field systems, and small scatters of smelting slag and scorched ground were found on terraces or interfluves developed on Pleistocene deposits, or upon eroded bedrock surfaces, in the western parts of the gorges of the Dana and Ghuwayr. Although the latter were too small to map systematically, they gave a new perspective on the extent of smaller-scale smelting activity in antiquity.

Meanwhile, observation of the movements of goat herders and other local people indicated that the floors of gorges other than of the Wadi Dana (with its through-track from Dana village on the edge of the Jordanian Tablelands down to and across the Wadi Faynan to the Wadi 'Arabah) not only served as important pathways but also contained a range of habitats (palm-rich oases, reed-rich ponds, terraced gorge-cliff 'gardens' and continuous waterfalls: e.g. Fig. 2.8) that were absent elsewhere. Survey strategy, therefore, had to embrace the gorges as much as the main archaeological zone of Khirbat Faynan and the ancient fields and sites on the floor of the Wadi Faynan. We began to recognize the importance of seeing and exploring the landscape from standpoints that were different from those provided from the obvious modern tracks, a feature highlighted by the difference between the circuitous route of a modern vehicle track from Khirbat Faynan to the Umm al-Amad Roman mine and the direct line across the mountain front of a pre-existing track.

Continued reconnaissance on foot showed that the walls of the gorges contained numerous different types of previously unknown deposits and landforms: large and small alluvial fans; screes; colluvium; ore-bearing, dark-coloured screes/colluvium that might reflect the natural weathering and erosion of the ore-rich bedrocks or material derived from former mine waste; residual smears of fossiliferous fluvial deposits 5–10 m high; and various fluvial and fan deposits, some with stone artefacts and/or pottery. These deposits indicated that the lowland edge of the mountain front had been a major sediment trap not only for material coming down the mountains to form fluvial, alluvial, and fan deposits, but also aeolian deposits blown in from desert lowlands. The date at which particular deposits were discovered interacted with the resources of time and staff available to determine what analyses were carried out on which deposit.

3.1.1 Stratigraphic approaches adopted

In the field, attention was given to identifying: outcrops and the three-dimensional shape of sediment bodies; sedimentary properties; notable sedimentary and pedological structures; apparent natural and/or anthropogenic hiatuses (cuts, pits, surface or stone clearances) within sediments; and apparent breaks or erosional episodes that might be of wider stratigraphic importance (Fig. 1.9). The period of time represented by a visible hiatus in a section was often not clear. Thin palaeosols – the remnants of 'old' or 'fossil soils' – were recognized on the basis of evidence of induration – in this example, hardening through desiccation, and the incipient deposition of carbonates near the sediment surface to produce calcrete, especially in aeolian deposits.

To help distinguish between description, which we hope is an empirical, accurate, and reliable description of the situation of the materials studied, and interpretation (what we think it means and which is also more likely to change with time), we have tried to employ a more formal stratigraphic approach and terminology in our account of the discoveries made during the survey. As a result, the following stratigraphic concepts and terms are used in this account. A Stratotype is a section, exposure, or locality, which is defined at the 'type section' (in other words the 'standard' or point or reference) where a lithostratigraphic or biostratigraphic unit, and/or a fossil or cultural assemblage, is described formally. A Member is a lithostratigraphic unit composed of one or more beds. The term lithology refers to rock, specifically the physical properties of the deposit. Scale is critical, in that a Member can be traced and mapped across country, whereas a Bed is a locally-present layer of rock or sediment, with a clear set of characteristics which make it definably different from other beds at the same locality. Beds are not usually traceable across country. Observable variations in the lithological character of deposits have been recognized through the use of the term Lithofacies. This term describes the facies (that is, the aspect) of a rock or sediment in a formal way. Different lithofacies have been defined by sedimentologists, each sediment-body having a particular and defined set of characteristics.

Our work was organized into each of the following: a lithostratigraphy, which is a stratigraphy composed of rock or sediment units defined by their sedimentary characteristics. The lithostratigraphy is composed of lithostratigraphic units, which in ascending order of size are Beds, Members, Formations, Groups, and Supergroups; in the case of our Faynan studies, only the first two levels have been used. Lithological *units* have been recognized informally in our descriptions of the exposures to refer to the smallest, coherent, body of sediments, including distinctive bodies of slags/polluted deposits identified at various sites in the field. Field mapping has also sought to establish a morphostratigraphy. This is a stratigraphy that is defined by a series of geomorphological features, usually erosional benches or terrace-like surfaces. Tipping

(2007) also broadly followed this approach in the lower Wadi Ghuwayr. Typically, the assumption is made that the highest features are the oldest, but experience in this and other regions has led to the recognition that complex geomorphological situations occur where this assumption is incorrect (see Chapter 6).

A stratigraphic goal of the pollen-analytical work in the area was to establish a Biostratigraphy. This is a stratigraphy of rocks or sediments defined not by their lithological properties but by their fossil content (including microfossils such as pollen or palynomorphs: see below). The components of a biostratigraphy are a series of biozones, characterized by distinctive assemblages of fossil remains. Obviously given the manner in which habitats and life vary from place to place (Chapter 2: Fig. 2.12, Table 2.2), the geographical range across which a biozone might be recognized in the Faynan area is not likely to be large. We have also followed the parallel procedure for geochemical data as advocated by Pyatt *et al*. (1995) and Grattan *et al*. (2007) for recent anthropogenic deposits: coherent bodies of sediment with essentially the same geochemical signature have been allocated to a distinct geochemical zone or unit ('chemizone') assumed in the first place to be of purely local significance. The principle is identical to that involved in the definition of local pollen assemblage zones or biozones. As a result, there may or may not be equivalence in the attributed lithostratigraphic, pollen-biostratigraphic, and geochemical zonations we have recognized, but whilst these terms sometimes proved slightly awkward and not always fully suited to the Faynan situation, our processes of description and analysis were more explicit than is sometimes the case. In particular, there was no inherent or 'automatic' assumption of any chronological correlation existing between geomorphic, palynological, pollution or other forms of 'human' events and processes recognized. Chronostratigraphy is concerned with correlating bodies of sediment or biological remains on the basis of information on their age expressed in years, typically in this study from historical sources, radiocarbon dating, or OSL dating.

Basic stratigraphic evidence of superposition was sought at all times in order to establish a primary lithostratigraphic and morphostratigraphic sequence applicable to the Late Quaternary in the area, including anthropogenic deposits. In gorges through the mountain front and in the more open Wadi Faynan, recurrent if episodic phases of infilling, erosion, and down-cutting were recognized. Many deposits and landforms were seen to be the result of several processes, including local ones that brought about major changes in their shape, thickness, and sometimes character, though the details of these relationships were rarely clear. As a result of this evident complexity in the field, with deposits of different antiquity sometimes occurring in close proximity, we could not assume that particular lithofacies at similar heights or in similar topographic positions were of the same antiquity. Rather, we recognized, mapped, and formally named as Members or Beds, only those distinctive lithofacies that we had located in situations where there was further evidence for dating and correlation and from which further palaeogeographically-important information about depositional processes and environments could be determined.

To determine sedimentary properties, samples were taken from each sedimentary unit or palaeosol thought to be significant. Sampling was more systematic on materials thought likely to be important for dating, palynology, geochemistry, and sedimentology. The section faces were cleaned back a minimum of 0.1 m to avoid problems of contamination or oxidation of organic matter, which can be a severe problem in hot arid lands (Horowitz 1992). We were not able to undertake micromorphological research on the geoarchaeological materials. All samples were bagged in labelled polythene self-seal bags and then further double-bagged, for transport to the laboratory. Sampling was constrained by the need to be able to air-freight samples to the UK, as well as by the substantial analytical costs incurred in the extensive OSL-dating, palynological, thin-section, and geochemical investigations that followed. The determination of simple and routine physical and chemical properties (hand texturing, and subsequent laboratory particle size analysis; % carbonate; % Loss-on-Ignition; thin section; air-dried colour; and magnetic susceptibility) followed standard approaches (Bascomb 1961; Dearing 1994; Ellwood *et al*. 1996; Gale and Hoare 1991; Gardiner and Dackombe 1983; Harwood 1988; Metson *et al.* 1979; Nelson *et al.* 1982; Rock-Color Chart Committee 1991). The objectives were to characterize the materials studied; to further determine the character of the environment at local and regional scales; and less commonly but importantly in this desertic landscape, to explore any post-depositional processes that might have affected microfossils (pollen and palynomorphs), sediments, and metals.

3.2 Chronostratigraphies

Chronostratigraphic evidence for geomorphological features and landforms was obtained in a variety of ways. Important 'ranging' evidence was provided by the historical records for various sites, notably in the case of Khirbat Faynan, and by field associations between archaeological features such as ceramic debris, mines, adits, water catchments, or the exposures of settlement exposures such as at Tell Wadi Faynan (al-Najjar *et al*. 1990). Otherwise, chronostratigraphic information was derived, for the Late Pleistocene, from luminescence dating based upon optically-stimulated luminescence (OSL) measurements on quartz; and for the Holocene, from AMS or conventional ^{14}C dating.

The OSL determinations were carried out at the Luminescence Laboratory of the Institute of Geography and Earth Sciences at the University of Wales, Aberystwyth. OSL dates calculate the number of calendar years since the last exposure to daylight of minerals (in this case quartz) in the deposits being investigated. Luminescence dating was especially appropriate for the analysis of aeolian samples,

Figure 3.2 *A geomorphologist beneath the light-proof aluminium cover, taking samples for OSL dating. (Photograph: Graeme Barker.)*

since it was reasonable to assume that all the mineral grains would have been exposed to daylight at the time of deposition. However, because some samples might be a mixture of grains reset to different degrees at deposition, replicated measurements were made of each sample so that the distribution of apparent dose could be assessed. General accounts of this technique and its application to Quaternary sediments are given in Duller (1996; 2004) and Stokes (1999).

Samples were obtained by hammering thick light-proof plastic tubes into freshly cleaned faces, often under a light-proof cover (Fig. 3.2). These samples were further protected by the immediate use of thick light-proof seals. Light was also excluded during transport and initial analysis. A combination of thick-source alpha counting and beta counting was used to assess the radioactive dose arising from radionuclides of the decay series of uranium, thorium, and potassium (McLaren *et al*. 2004: 136–7). The contribution of cosmic rays was calculated on the basis of depth of burial using the equations of Prescott and Hutton (1994). The luminescence measurements were taken from quartz grains in the size range 180–211 µm following treatment to remove carbonates with HCl and in H_2O_2 to remove organic materials. Heavy minerals and most feldspars were removed by density separation using solutions of sodium polytungstate with specific gravities of 2.62 and 2.70 (these were quoted incorrectly in McLaren *et al*. 2004). Grains with a density between these values were then etched with 48% HF for 40 minutes to remove any remaining feldspars and to etch away the alpha-irradiated outer layer of the grains. The OSL measurements were made by Susan Packman using a Risø automated TL.OSL reader using blue light emitting diodes (470 nm) for optical stimulation. The resulting luminescence was detected through two U-340 filters whose peak transmission is in the ultra-violet at 340 nm. The single aliquot regenerative dose (SAR) procedure of Murray and Wintle (2000) was used to assess the equivalent dose (D_θ) from individual aliquots (~10 mg mass) of each sample. Between 8 and 24 aliquots were analysed for each sample, and the mean (D_θ) from these was used to calculate the time since burial (the age) of the sediments. In three samples (Aber-18/JA2, Aber-18/JA9, and Aber-18/JA10) the luminescence signal was close to saturation – the level at which the luminescence signal ceases to increase even when the sample is exposed to additional radiation. This saturation provides an upper limit for luminescence dating, and for these three samples, the calculated ages are only minimal values. As the OSL dates obtained by the project all refer to the Pleistocene (studies of Holocene materials have not been completed), they are listed in Chapter 6 where the Pleistocene environmental and archaeological evidence is discussed (Table 6.2).

The radiocarbon dates obtained by the project are all AMS dates on wood or charcoal. The presence of 'old' wood or charcoal being re-worked at the modern land surface and observations in exposures of the deep penetration of the woody roots of some arid land shrubs or invertebrates even on the most polluted of substrates (Chapter 2) led to particular caution in selecting pieces of charcoal for radiocarbon dating. As a result of field experience, we recognized that in this area, and especially when attempting to date or correlate within the very polluted sands and slags of the Atlal Member, it is important not to assume that the antiquity indicated by a radiocarbon date (or indeed a sherd) is necessarily the same age as the sediment (or pollen, palynofacies, metal record etc.) within which it was located. Similarly, it is important not to assume that the rate of sedimentation between materials dated by radiocarbon date was uniform. It was probably otherwise.

One example of these matters arose early in the fieldwork, in the case of the borehole WF5017 drilled into the Khirbat Faynan barrage infill deposits using an Edelman auger head. We obtained two identical 'ranging' dates of 2630±50 BP or 910–594 cal. BC (Beta-110840; Beta-110841) from two distinct sets of charcoal fragments extracted from the sediment core at depths of 2.0 m and 2.3 m respectively, prompting suspicion that 'old' charcoal had been re-worked during the accumulation of these deposits. Likewise, field observation suggested that in some locations such materials can descend sediment profiles by infiltration into cracks or burrows with some vertical transport of small charcoal through the profile by invertebrates or water. Adding to this complexity, observations of sedimentary structures in the trench WF5012 excavated adjacent to the WF5017 borehole (Fig. 1.15) suggested that some bodies of metal-rich polluted sediment (Lithofacies 6 and 5) might have moved through forms of mass-movement such as flows or slumping, with the potential to cause the outcomes of natural processes operating on polluted materials to be misconstrued as the result of distinct phases of industrial activity. (NB: sediments from WF5012 and WF5017 were also wrongly assigned the numbers WF5512 and WF5517 respectively in some of the laboratory analyses, so we refer to the locations as WF5012 = WF5512 and WF5017 = WF5517.)

Great care was exercised in the collection of wood or charcoal for radiocarbon dating from the excavation faces. As a result, in general, we believe our analyses of the sediments and the radiocarbon dates are cautious and circumspect and probably give reliable indications of the ages of the materials collected. Nearly all the radiocarbon samples analysed were obtained by Chris Hunt and Hwedi Mohamed (Hwedi el-Rishi) using steel spatulas or trowels. Samples taken in the field for radiocarbon dating, once fully dry, were secured inside aluminium foil before further wrapping; a similar process was used for samples extracted in the laboratory. At Beta Analytic, such samples went through standard pre-treatment with crushing in de-ionized water, and washing in hot HCl to remove carbonates and then in NaOH solution to remove secondary organic acids.

Our radiocarbon dates can be added to the suite of radiocarbon dates published by previous and current projects in the Wadis Fidan and Faynan, spanning from the earliest Holocene to recent centuries. For ease of reference in support of the later period-based chapters in this volume, the published radiocarbon dates have been assembled in a single list in Appendix 1, all calibrated using CALIB (http://calib.qub.ac.uk) and showing the upper and lower intercepts and median probability.

3.3 The Late Quaternary geomorphological framework

The application of the strategies and methodologies described in the previous section enabled us to recognize a series of fluvial, alluvial-fan, colluvial, aeolian, and anthropogenic deposits and palaeosols of Late Quaternary (i.e. Late Pleistocene and Holocene) age. Technical formal descriptions providing the details of the Stratotypes, Members, Beds, Lithofacies, and Lithological Units identified in this study have been given elsewhere (Hunt *et al.* 2004; 2007a; McLaren *et al.* 2004). The deposits of late Pleistocene age, shown in bold in Table 3.2, are described in detail and illustrated in Chapter 6. To summarize that evidence in terms of calendar years: the Quabbah Member is probably the oldest Quaternary unit in the study area, but has not been numerically dated; the Ghuwayr Beds, which we equate with the Plg2 deposit recognized by Barjous (1992) and Rabb'a (1994), are older than 225,000 years; the Madrasah Beds are older than 208,000 years; the Yass Fad Member, which contains an Acheulean handaxe (Fig. 6.14), is older than 109,000 years; the Mokeim, Dahlat, and Naqqazah Members are probably younger than 109,000 years and older than 10,000 years; the Asheiair Beds are *c.*55,000 years old; the Shayqar Beds that form the large and complex alluvial fans that lie before the mountain front (Fig. 3.3), which can be equated with the Plf deposit of Barjous (1992) and Rabb'a (1994), are likely to be late

	Fluvial deposits	heights (m)	Alluvial fan deposits	Aeolian deposits	Anthropogenic deposits
oldest	**Quabbah Member**	*c.*125–130	**Ghuwayr Beds**	**Quarayqira (= Gregora) Member**	*Atlal Member*
↓	**Fass Yad Member**	*c.*30–35	**Madrasah Beds**		*Khirbat Member*
	Mokeim Member	*c.*22–25	**Asheiair Beds**	*Tell Loam Member*	
	Dahlat Member	*c.*15	**Shayqar Beds**		
	Naqqazah Member	*c.*10–12	**'Aqaba Beds**		
	Faynan Member	*c.*5–7	*Hamman Beds*		
	Upper Dana Wadi Member	*c.*2–3			
youngest	*Lower Dana Wadi Member*	*c.*1–1.5			

Table 3.2 *The Quaternary deposits in the Faynan area identified by the project, with those of Pleistocene age in bold and those of Holocene age italicized; there is no implication of equivalence of age between the columns in the table. The heights shown are in metres above the present wadi floor. The Quarayqira Member is referred to as the Gregora Member in previous reports. The Khirbat Member contains aeolian, lacustrine, and anthropogenic facies. (After McLaren* et al. *2004.)*

Pleistocene in age but too small exposures were found to study them in detail. The same applies to the ʻAqaba Beds. The distinctive aeolian Quarayqira (= Gregora) Member is Late Glacial, having formed in the order of 14,000 years ago. Our understanding of both these deposits and the sequence they comprise has inevitably developed over time (Grattan *et al.* 2007; Hunt and Gilbertson 1998; Hunt *et al.* 2004; 2007a; McLaren 2004; McLaren *et al.* 2004).

A summary of the lithological properties of the Depositional Members identified in the Holocene sequence in the area is set out in Table 3.3. Despite the evident complexity of this record, the fundamentals of a geomorphological framework of the wider human and palaeoecological history of the area over a period of approximately 8000 years can be illustrated at three locations: Tell Wadi Faynan; the Khirbat Faynan barrage; and the Dana Wadi Beds (Fig. 3.1).

A key exposure of early to mid-Holocene fluvial deposits of the Faynan Member (upper component) was logged as site WF5021, which is approximately 100 m west of the Neolithic/Chalcolithic excavated site Tell Wadi Faynan (Figs 1.9, 3.3, 3.4). The exposure rests upon fluvial gravels that gave OSL dates of 58.6±3.8 kya (Aber-18/JA7) at site WF5020 and 15.8±1.3 kya (Aber-18/JA8), a little further down-wadi. The Holocene sequence forms the upper part of a 4–5 m-high cliff overlooking the braid-plain of the modern wadi channel, and is attributed to the upper component of the Faynan Member; it is further illustrated in Figures 7.4 and 8.3. The deposits, 1.5 m thick, occupy a channel perhaps 10–12 m wide, probably aligned east/west. They consist of epsilon cross-bedded (a distinctive type of stratification associated with fluvial processes) pale grey silts, stony silty diamicts (a wide range of sizes of materials present – i.e. they are poorly sorted), and ash-rich beds, many with charcoal, bone, and potsherds. At the southern part of the exposure they overlie fine gravels containing charcoal debris. These features indicate the presence of human activity nearby, associated with the abundant use of fire (the lithological evidence of sustained human activity characterized by ash-charcoal and pottery fragments indicates that the burning should be attributed to people rather than wildfire). Discard of refuse from the settlement zone into the channel and/or pooled water produced the layers of ash, bone, and other debris found interbedded with the fluvial-pool deposits. Charcoal associated with ash from the middle of the WF5021 sequence (Sample G) gave a radiocarbon date of 6200±40 BP or 5296–5045 cal. BC (Beta-205964) (Fig. 7.4). Traces of reed rhizomes and desiccation cracks are visible in the exposure at several levels. Fluvial deposits of this type and age are relatively common in this region (Hunt *et al*. 2004; 2007a) Contacts between the deposits are often sharp. On occasion, the upper surfaces of some layers appear to be mud-cracked, suggesting desiccation and the beginnings of soil formation. The sequence is inter-bedded with anthropogenic deposits at the adjacent Late Neolithic/Chalcolithic site of Tell Wadi Faynan *c.*100 m to the east (al-Najjar *et al.* 1990).

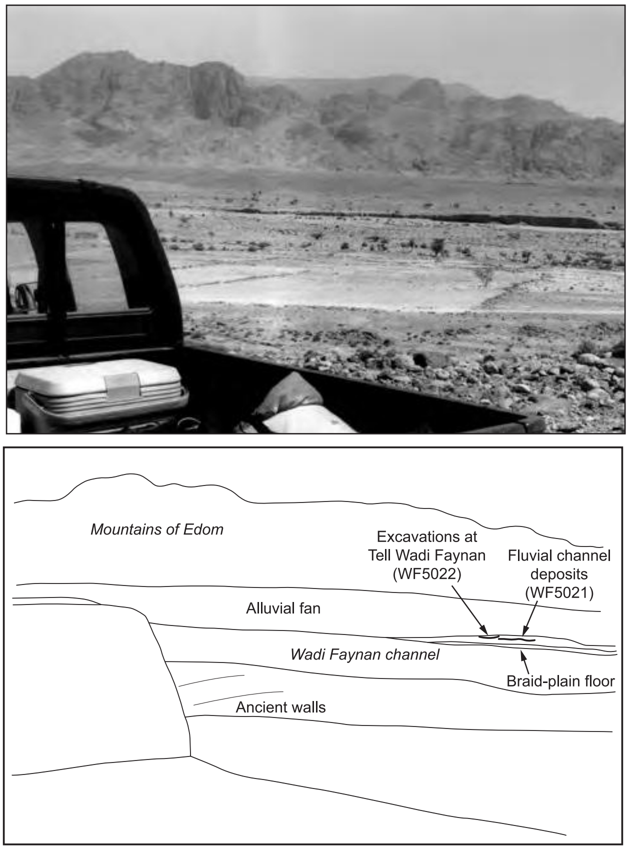


Figure 3.3 *Looking south across the Wadi Faynan channel to the excavated site Tell Wadi Faynan and fluvial channel deposits* c.*100 m to its west (WF5021); behind are the large alluvial fans of the Shayqar Beds, and beyond, the Mountains of Edom. (Photograph: David Gilbertson.)*

In brief, the entire fluvial sequence spans the period from about 7500 to 6300 radiocarbon years and any component of this sequence may represent a very short period of time within this time span. The sequence becomes more fine-grained upwards, in particular at the location of the archaeological site, where it is overlain with relative conformity by the silt-rich, water-washed, aeolian deposits and palaeosols (some with thin calcrete) of the Tell Loam Member. The latter indicate notable aridification characterized by episodes of deposition, erosion, and weak soil development, a quite different geomorphic regime to that which had occurred previously in the Holocene, and which with minor fluctuations has persisted to the present day. Aeolian deposits of this type and age are also relatively widely known in the region (Hunt *et al*. 2004; 2007a). Incision of the braid-plain of the Wadi Faynan left this sequence exposed in the upper parts of the low cliff.

The vicinity of Khirbat Faynan is dominated by anthropogenic smelting deposits classified as the Atlal Member. The spatial field relationships between these deposits suggest that much of the Atlal Member dates primarily to Iron Age to Byzantine times, but other materials are nearly six thousand years of age and some are over a thousand years younger (WF5741; Figs 9.16, 9.17). Thin layers of

Lithological member	Summary of lithology, interpretation, dating, and correlation	WF sites	Age
Faynan Member (upper component) (mainly fluvial)	Epsilon cross-bedded silts and sandy gravels (sometimes anthropogenic deposits – ash, charcoal), and overbank deposits in channels in the main wadis; flood-overbank deposits in gorges; key exposure of these fluvial deposits at WF5021 at Tell Wadi Faynan, resting unconformably upon Pleistocene fluvial component of the Faynan Member and overlain conformably by the Tell Loam Member. *Dating:* field relationships, archaeological associations, and radiocarbon dates: at WF5015, 7240±90 BP or 6353–5919 cal. BC (Beta-111121); at Tell Wadi Faynan adjacent to WF5022 and WF5021 as described in al-Najjar *et al.* (1990), where the archaeological sequence spans the period from 6408±114 BP or 5612–5076 cal. BC (HD-10567) to 5740±35 BP or 4688–4499 cal. BC (HD-12337); site WF5021 in Faynan Member (upper component), with sample WF5021G giving radiocarbon AMS date of 6200±40 BP or 5296–5045 cal. BC (Beta-205964).	WF5510 (base) WF5500– WF5015 WF5021*	Early Holocene
Dana Wadi Member (fluvial and aeolian)	Trough-cross-bedded sandy gravels or well-sorted fine sands in the Wadis Dana, Faynan, and lower Ghuwayr: with upper and lower components: braided-fluvial and or wind-blown deposits. *Dating:* field relationships, archaeological associations, radiocarbon dates: Dana Wadi Member at WF5025 overlies charcoal dated 390±50 BP or cal. AD 1435–1635 (Beta-115214); charcoal at WF5509 within the Dana Wadi Member dated 110±50 BP or cal. AD 1673–1954 (Beta-119600); wood overlying Dana Wadi Member at WF5520 dated 1220±40 BP or cal. AD 685–892 (Beta-119620); charcoal underlying Dana Wadi Member at WF5511k dated 1210±40 BP or cal. AD 687–936 (Beta-203398).	WF5025 WF5509 WF5520* WF5617 WF5511k	Late Holocene to *c.*650–100 calendar years BP
Tell Loam Member (aeolian-water-washed soils)	A quasi-continuous sequence of laminated silts with calcareous nodules and layers; thin calcareous layers and dunes with water-washed aeolian deposits and thin calcrete-palaeosols; associated human activity, archaeological remains, and palaeosols on low-angle slopes west of Khirbat Faynan. Best exposed at Tell Wadi Faynan on a low 'hill-top' site, 5–10 m above the surrounding area and over-looking the braid-plain of the Wadi Faynan. *Dating:* This site, WF5022, extends from surface copper-smelting slag with ash and pottery attributed to the Roman-Byzantine period (*c.*2000–1600 years ago) down through similar water-washed aeolian deposits to the upper parts of the Late Neolithic/Chalcolithic site of Tell Wadi Faynan at 5375±30 BP or 4331–4069 cal. BC (HD-12336). Overlies sample WF5021G from within the Faynan Member (upper component) at WF5021, which has a date of 6200±40 BP or 5296–5045 cal. BC (Beta-205964). Detailed field examination of the excavation face that produced site WF5022 is summarized in Figure 3.4. This profile has a transitional lower boundary with the Faynan Member, and is a semi-continuous aggradation (without pits or cuts) of gently undulating layers of wind-blown water-washed silts/sands that often include materials re-worked from the immediate area before its burial, and a weakly-developed soil profile, all overlain by black copper smelting debris (Hunt *et al.* 2007).	WF5022	Middle Holocene (Late Neolithic/ Bronze Age) to present day

***Table 3.3** Summary of the main lithological members of Holocene age recognized in the Wadi Faynan area. * = upper part of sequence; + = lower part of sequence. The lower component of the fluvial Faynan Member is Late Pleistocene in age, with an OSL date at WF5021 of 58.6±3.8 kyr (OSL Aber-18/JA7). (For further information see: Barker* et al. *1997; 1998; 1999; 2000; Grattan* et al. *2007; Hunt* et al. *2004; 2007a; McLaren 2004; McLaren* et al. *2004; Mohamed 1999.)*

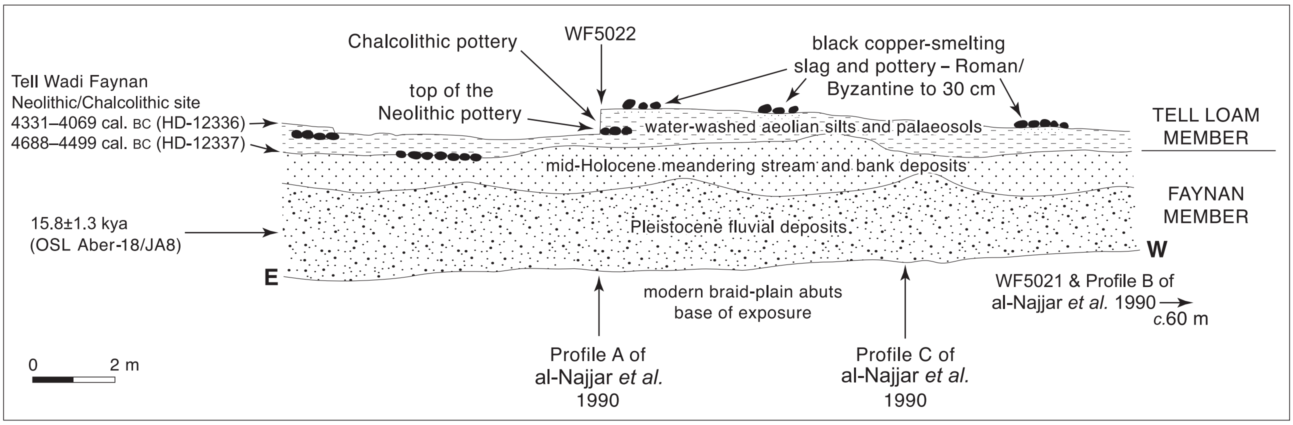


***Figure 3.4** Summary of the lithological features and stratigraphic relationships associated with the Late Neolithic/ Chalcolithic archaeological site of Tell Wadi Faynan: the exposure is adjacent to that of channelized fluvial deposits of the Faynan Member of Holocene age at WF5021. Overlying is site WF5022, which provides exposures of the Neolithic site of Tell Wadi Faynan and the overlying deposits of water-washed aeolian silts and thin palaeosols of the Tell Loam Member. The surface is a palimpsest of reworked copper slag and polluted sediments mixed with modern wind-blown materials – all comprising the Atlal Member. Field mapping shows that the uppermost aeolian silts accumulated as small dunes associated with an extensive ancient wall network, particularly to the east; OSL = optically stimulated luminescence date (see also Fig. 1.9). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2007a; McLaren* et al. *2004.)*

Lithological member	Summary of lithology, interpretation, dating, and correlation	WF sites	Age
Khirbat Member (pond and aeolian)	Massive or laminated sandy and lacustrine fine sands and silts, occasional gravel layers – fluvial; aeolian, pond-lacustrine; colluvium and industrial deposits; on the wadi floor and then impounded by the Khirbat Faynan barrage at excavation WF5012 and borehole WF5017. *Dating:* Excavation, archaeological associations, pollen-biostratigraphy, radiocarbon dates. The Member rests apparently conformably upon 70 cm of a pond facies of the Atlal Member that dates to 3390±40 BP or 1867–1536 cal. BC (Beta-203402). Lacustrine sediments plus a mix of fluvial, aeolian, and colluvial material accumulated behind a constructed barrage until about 600 years ago. Since then, aeolian sands, colluvium, and fluvial sediments have completely infilled the reservoir basin. From *c.*100 years ago, more clay- and organically-rich deposits have accumulated in a slightly wetter climate.	WF5012* WF5017* WF5051 WF5518	*c.*2000 cal. years BP: classical to modern
Hamman Beds (colluvium and alluvial fans)	Small alluvial fans and colluvium; poorly-sorted breccias, gravels, sands, silts; multiple layers separated by eroded slope surfaces; sometimes with ash occasionally interbedded on slopes with anthropogenic deposits or pits, or with fluvial deposits in wadis. Typically located at the margins of the main wadis. Colluvial deposits have slumped into mine entrance WF5040 in Wadi Khalid. Field relationships and reference to associated fluvial deposits dated by radiocarbon dating and archaeological associations.	WF5509 WF5510+ WF5015* WF5520 WF5040	? Middle Holocene to modern
Atlal Member (slag from copper smelting)	Copper and lead-rich smelting slags, ore-processing deposits, pond-lacustrine deposits affected by ore-processing and smelting; heterogeneous mixture of rubble, mud bricks, potsherds, building stones – anthropogenic deposits as large mounds and innumerable patches. Slumped mine waste in the entrance to mine WF5040. *Dating:* Two accumulations of metal slags with ash, radiocarbon, one dated to 5690±40 BP or 4681–4523 cal. BC (Beta-203413) and one with Nabataean and Roman pottery. These are located between the Khirbat Faynan and the edge of the braid-plain of the Wadi Dana at sites WF5738 and WF5741. In the basal 20 cm at WF5738, copper slag and ash were interbedded with fluvial braid-plain sands. The lowest 70 cm of exposure up-wadi of the Khirbat Faynan barrage was produced by colluvial and metallurgical processes and dated to 3390±40 BP or 1867–1536 cal. BC (Beta-203402). The lower 70 cm all accumulated rapidly as a result of metallurgical and colluvial processes. Further radiocarbon dates and field relationships with archaeological remains suggest most deposits are of Iron Age–Nabataean–Roman–Byzantine date (Appendix 1; Baierle *et al.* 1989; Engel 1992; 1993; Frey *et al.* 1991; Hauptman 2000). The youngest slag identified is WF5741, dated 430±40 BP or cal. AD 1414–1624; Beta-203412).	WF5039 WF5041 WF5038 WF5053 WF5022* WF5012+ WF5017+	Mainly Nabataean to Byzantine; but other components include Bronze Age and Abbayid/ Mamluk
Modern land surface	Modern wind-blown, colluvial, and water-washed silts and sands common throughout; modern braid-plain sands, cobbles, boulders with logs; sometimes ploughed or otherwise disturbed. At many sites, especially within the ancient wall networks, this surface is a palimpsest of *in situ* and re-worked deposits.		

Table 3.3 *(cont.)*

fluvial deposits occur within these black slag-rich deposits. One piece of charcoal within such interbedded slags-fluvial deposits gave the (initially) unexpectedly early date of 5290±40 BP or 4238–3993 cal. BC (Beta-203414).

The lower 70 cm of the deposits – Lithofacies 6 – exposed by excavation at WF5012 up-wadi of the Khirbat Faynan barrage (Fig. 3.5; Table 3.4) were the result of colluvial and metallurgical processes dated at the base to 3390±40 BP or 1867–1536 cal. BC (Beta-203402). They are overlain, apparently conformably, by the lacustrine and then the aeolian silt-sands of the Khirbat Member (Lithofacies 3–1), the formation of which spans the period from late Classical times to the present day. The rainfall–run-off relationships implied by the pond-lacustrine sequence of Lithofacies 4 and 5 suggest a wetter climate than exists nowadays, a depositional environment coincident with intensive industrial and agricultural activity in late Roman/Byzantine times (see Chapters 9 and 10). The sequence is dated by a series of radiocarbon dates from WF5017 and WF5022. As mentioned earlier, the two identical ones from borehole WF5017 of 2630±50 BP (Beta-110840; Beta-110841) are thought to represent re-worked materials. The other dates from WF5012 are 1610±40 BP or 349 cal. BC–AD 547 (Beta-203399), 1800±40 BP or 92 cal. BC–AD 339, and 1870±40 BP or cal. AD 142–238 (Beta-203400).

The overlying (largely aeolian) Lithofacies 2 can be correlated with the distinctive fluvial and aeolian deposits that are recognized as the Dana Wadi Member, an outcrop of which (WF5025) is illustrated as Figures 3.6 and 3.7. These complex fluvial and aeolian deposits have a distinctive terraced landform and provide evidence of prolonged drought, occasional flood, and earthquake shock. On the basis of radiocarbon dates and pollen biostratigraphy (see below) they can be assigned to the period *c.*600–100 years ago, which is broadly equivalent in time to the European 'Little Ice Age'. The key radiocarbon dates are 1210±40 BP or cal. AD 687–936 (Beta-203398), 390±50 BP or cal. AD 1435–1635 (Beta-115214), and 660±40 BP or cal. AD 1274–1397 (Beta-203403). The last one hundred years of slightly wetter climate are represented by the slightly more organic uppermost stratum (Lithofacies 1) in the Khirbat Faynan. There are two relevant radiocarbon dates, at WF5509 of 110±50 BP or cal. AD 1673–1954 (Beta-119600), and at WF5520 of 100±50 BP or cal. AD 1676–1954 (Beta-119602).

The correlation of these deposits with other lithological sequences in the smaller side wadis, as well as with the

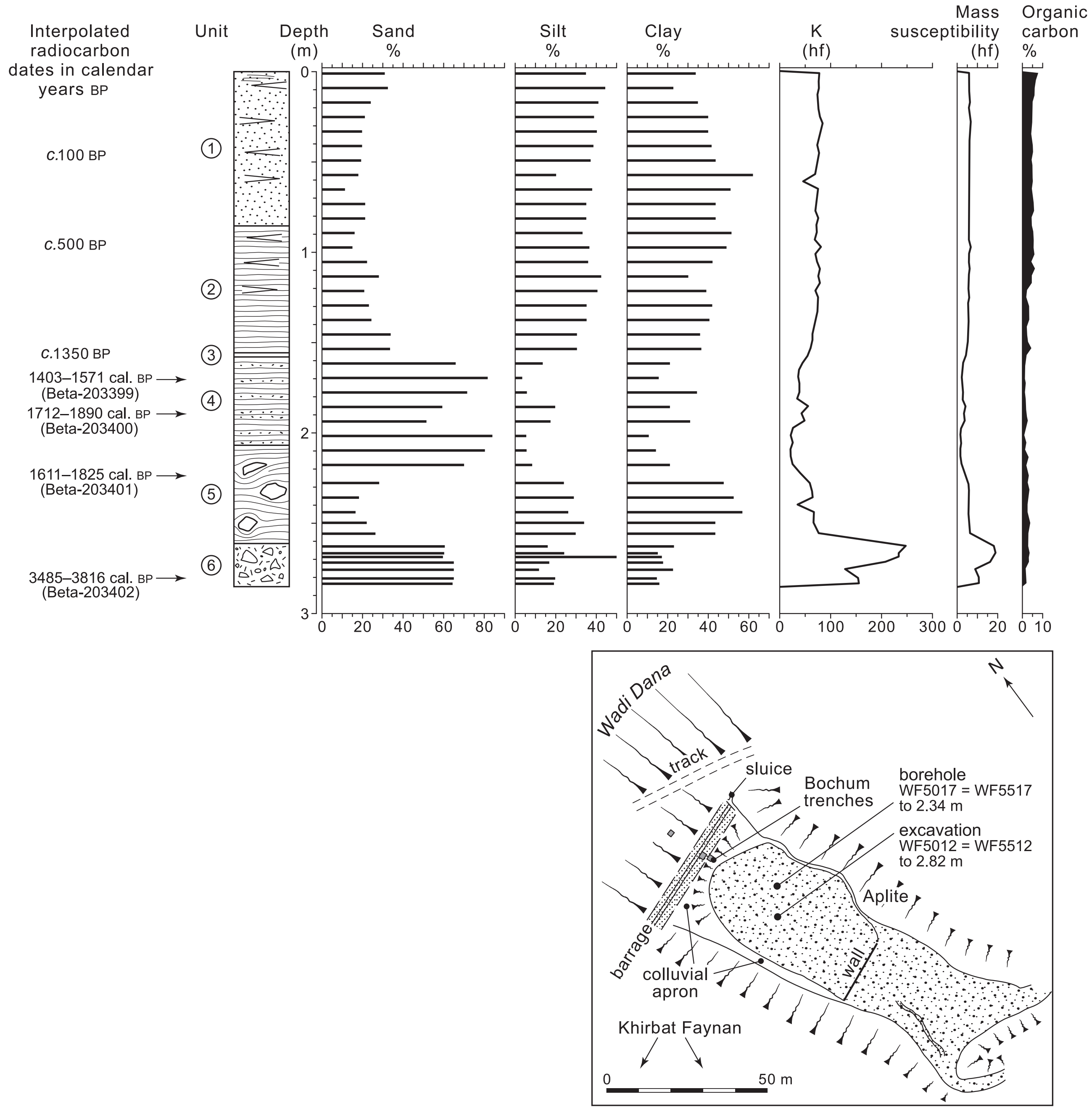


Figure 3.5 *Map of the Khirbat Faynan barrage (WF441) and its up-wadi catchment; showing its topographical relationships, sluice, and sampling locations, together with (above) a summary of the physical properties of the sediment infill sequence in the wadi floor (WF5012, WF5017). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

alluvial fans and rocky hillslopes, is less clear. However, sufficient information was obtained to allow us to establish an outline geomorphological framework for the region through the Holocene, within which other human and palaeoecological evidence can be interpreted (Fig. 3.8). In comparison with other new evidence discussed below, this framework suggests the over-riding importance of climatic factors, rather than human activities, in determining the nature and intensity of fluvial and aeolian geomorphic outcomes and, by extension, the timing and causes of desertification with the passage of time.

3.4 Palynological, palynofacies, and macrofossil investigations

The palynological studies in the Wadi Faynan undertaken within our project and summarized in this section are the work of Hwedi el-Rishi (Hwedi Mohamed) and Chris Hunt.

Before the advent of radiocarbon dating, pollen analysis provided one of the few techniques that could provide an independent chronology – known formally as a biostratigraphy – for prehistoric sites, and it is still valuable in this respect as a rangefinder technique and for establishing

Lithofacies	Depth (cm)	Summary description and interpretation
1	0–86	Layers of clay and silt; sometimes with leaf remains; interbedded with layers of fine and medium sand, often well-sorted; typically structure-less and homogeneous; individual layers bioturbated; pale brown; occasional roots; occasional large boulders; transitional lower boundary. *Interpretation:* wind-blown and water-washed and barrage-pool deposit of reworked sand with boulders from catchment, boulders introduced by or fallen from adjacent archaeological remains; clay-silt layers and organic debris are intermittent periods of pond-sedimentation. Khirbat Member. *Dating:* Attributed to the last 100 years.
2	86–157	Clay, silt, and sand; sands often well-sorted, often in couplets of coarse to fine sands *c.*3 mm thick, but ranging 1–8 cm in thickness; pale brown; slightly irregular surfaces. *Interpretation:* aeolian deposits with episodes of barrage-pool sedimentation at times of storm, some events with large sediment load. Khirbat Member. *Dating:* Post-Byzantine in age.
3	157–8	Fine sand with grit, forming irregular laminae, pale brown. *Interpretation:* distinctive flood-lag deposit in the barrage-pool. Base of Khirbat Member.
4	158–205	Pale brown, fine, quartz and limestone sand; not copper ores; distinctive laminations; typically well-sorted; marked fining-upward laminae, with granite-derived grit and fine pebbles in lag deposits at the base of each laminae. Greater % sand than Lithofacies below; sometimes with brown hues. Roman potsherds at 1.95 m. No evidence of any of the following was found: ash, charcoal, copper slag, colluvial activity, local turbidity currents, mass-movement or sediment deformation, intra-sequence desiccation cracks, induration, or mineral deposition. *Interpretation:* run-off and storm deposits into a perennial pool behind the barrage-pool; moving water re-working surface materials in the immediate area. Little or no industrial activity evident in the geochemical record above *c.*1.65 m; substantial pollution took place below this depth. *Dating:* Radiocarbon dates at 1.74–1.76 m depth: 1610±40 BP or 349 cal. BC–AD 547 (Beta-203399); 2.04–2.06 m 1870±40 BP or cal. AD 142–238 (Beta-203400). Biostratigraphic correlation indicates the top of this deposit can be correlated with the period about 1350 years BP (Hunt *et al.* 2004; 2007b).
5	205–60	Fine sand, often with much clay, some silt; irregularly laminated with laminae between 1 and 3 mm thick; lenses of sorted sands, including lenses of sorted sand-sized, green copper ores; comminuted charcoal present throughout; some large clasts of charcoal but less comminuted charcoal than Lithofacies 6 beneath; cobbles and boulders common that have deformed underlying laminae producing distinctive 'bird's eye deformation-loading structures'; comparatively high % LOI and very high magnetic susceptibility. Nabataean potsherd at 2.35 m depth; Roman potsherd at 2.28 m. Between 240–260 cm the clay-rich sediment is deformed; overall poor sorting; occasional lenses of well-sorted, sand-sized grains of copper ore, slag and ash, colour varies – sand matrix pale brown; ore sands – green; ash – grey. No evidence found of intra-sequence desiccation cracks, induration, or mineral precipitation. Infrequent pollen that are typically corroded. *Interpretation:* complex of individual mass flow deposits and local turbidity currents, and deposits of ponded-water and moving-water that accumulated rapidly at a wadi-floor location that was 'permanently wet' – often in shallow water. Frequent local use of hot fires producing ash and charcoal hereabouts and some smelting nearby; at the site there was mass-movement and deformation of wet sediment and fluvial re-working, with perennial water; where crushed ores had been crushed, graded, and size-sorted (perhaps in a flume or sluice), but not yet smelted. The high clay content and corroded pollen are derived by erosion from exposed surfaces and profiles. No evidence of dryland colluvial activity or dry wadi floor. Unpublished work by Gilbertson *et al.* suggests a hiatus exists at or immediately below 2.3 m depth, the materials beneath differing geochemically from those above this point. *Dating:* Radiocarbon date: *c.*2.24–2.26 m depth: 1800±40 BP or 92 cal. BC–AD 399 (Beta-203401). Biostratigraphic and lithological comparisons with deposits in adjacent borehole WF5017 indicate correlation with two identical radiocarbon dates of 2630±50 years BP or 910–594 cal. BC (Beta-110840 and Beta-110841) which as a result are now regarded as charcoal re-worked into younger deposits (see Hunt *et al.* 2004; 2007a).
6	260–85	Diamicton; matrix supported; abundant sand-sized materials of different materials; some silt and clay; with numerous angular clasts of angular of slag-clinker; angular cobbles of limestone, no evidence of abrasion, grit and pebbles that are matrix supported; much comminuted charcoal but no charcoal clasts were seen; overall very poorly sorted; stratification not clear; rests upon a very hard, impenetrable layer of clay-sand that is located on a bedrock surface; black to dark brown colours. No evidence of intra-sequence desiccation cracks, induration, mineral deposition, slip planes, ponded or moving water. Comparatively raised % LOI and magnetic susceptibility. Pollen grains rare. *Interpretation:* product of ore-smelting involving fire, 'anthropogenic colluvium' and mass movement, with minor impact of deposits of airfall ash and silts from catchment, and overland flow, in a wadi floor that was dry, suggesting a hot and arid climate. The abundant sand-sized materials related to disintegration of the bedrock and ore materials. *Dating:* Radiocarbon date at 2.8 m depth: 3390±40 BP or 1867–1536 cal. BC (Beta-203402). Sedimentological and pollen-biostratigraphic correlation with radiocarbon dates from adjacent borehole WF5017 also suggests an age older than 2630±50 BP or 910–594 cal. BC (Beta-110840); these dates are now regarded as re-worked charcoal (see Hunt *et al.* 2004; 2007a).
Oldest		

Table 3.4 *Summary of the stratigraphic and sedimentary properties and dating evidence at sites WF5012 (= WF5512) and WF5017 (= WF5517), immediately up-wadi of the Khirbat Faynan barrage. The infill deposits were initially sampled using an Eijkelkamp corer with a 6 cm Edelman sampling head (WF5017) to 232 cm with particular care to avoid contamination; and the sequence confirmed later to the southwest through a pit dug to* c.*3 m depth (WF5012 = WF5512; Fig. 1.15). Further data on sedimentary structures, simple textural, geochemical and mineral magnetic properties, together with %LOI (Loss-on-ignition) of the deposits and palynological information, are set out in Chapters 9–11.*

Figure 3.6 *The Dana Wadi Member at WF5025. For description see Figure 3.7. (Photograph: Hwedi el-Rishi.)*

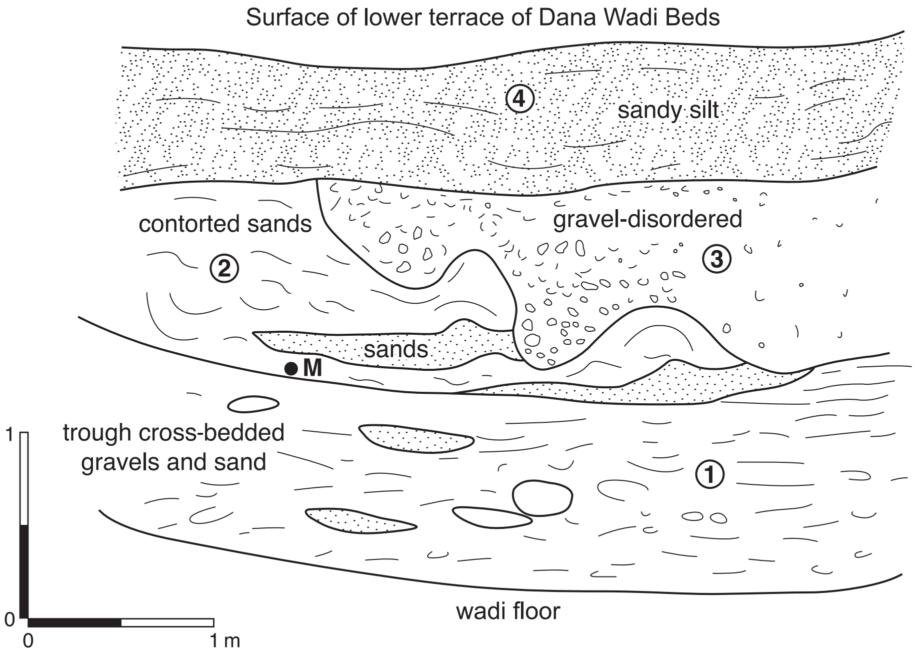


Figure 3.7 *The stratigraphic relationships of the fluvial sequence forming part of the Dana Wadi Member (lower component) at WF5025, perhaps affected by earthquake shock (see Fig. 3.6). In summary, from the base: Unit 1 – 1.0 m of trough cross-bedded gravels and (Unit 2a) a fine sand horizon 0.02 m thick, deposits and structures resembling those in the braided sectors of the modern gorge; Unit 2 – 0–0.9 m thick weathered and contorted sand body; Unit 3 – 0.3–1.5 m thick poorly-sorted 'shocked sands and gravels' with deformed sediment boundaries – braided flow deposits with the contacts and structures of the sediment bodies disrupted by loading or shock, perhaps by earthquake shock; Unit 4 – 0.8 m of aeolian silts unaffected by post-depositional disturbances. Cross-walls have been built on the terrace surface eroded across all these deposits. M ('middle sand unit') marks the location of the wood at the base of Unit 2 which yielded a radiocarbon date of 390±50 BP or cal. AD 1435–1635 (Beta-115214). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith following Mohamed 1999.)*

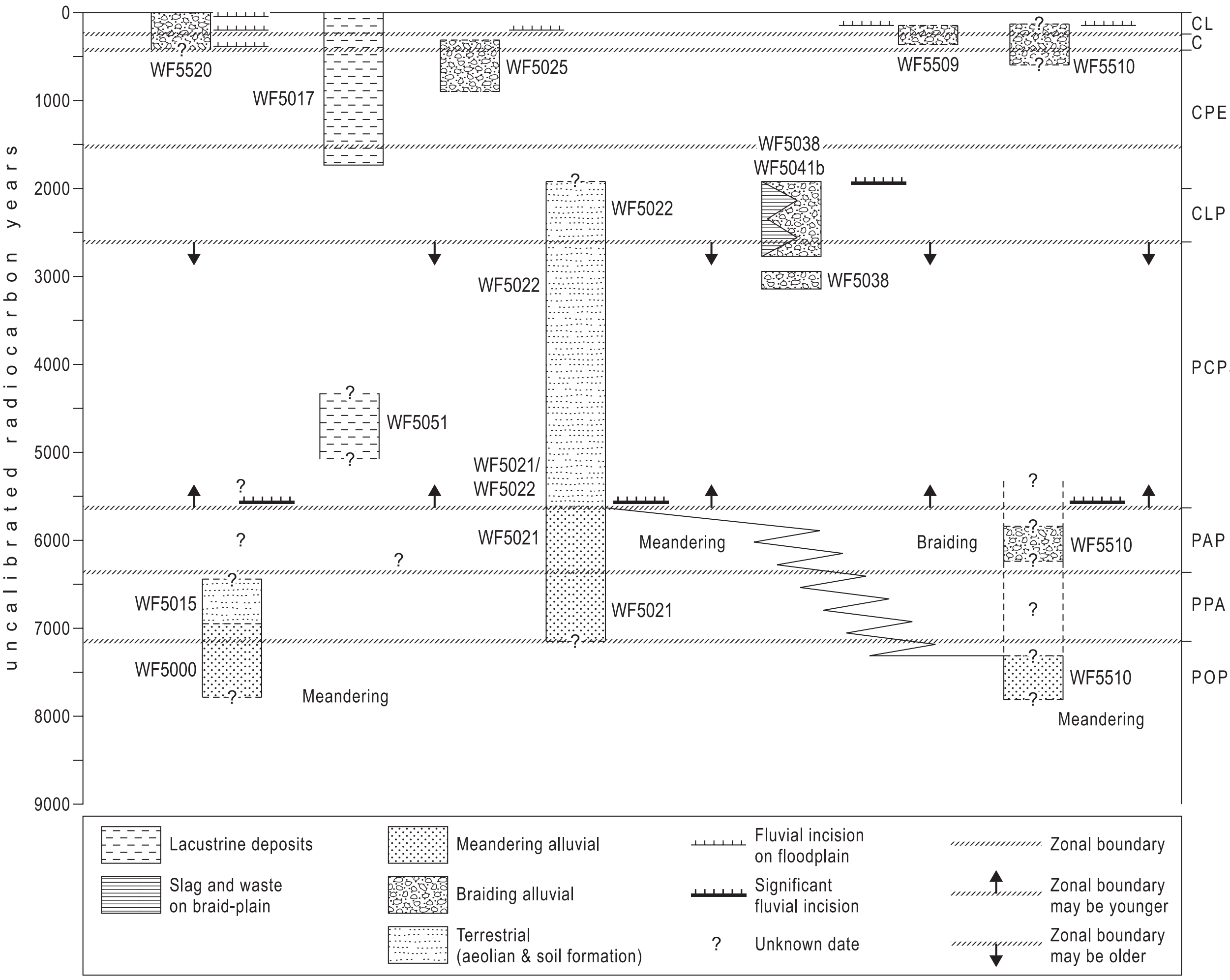


Figure 3.8 *Summary of deposition, erosion, and stratigraphic relationships in 'natural' and 'created' wadi-floor environments through the Holocene in the upper Wadi Faynan and in the lower Wadi Dana; they suggest the overall dominance of climatic as opposed to human factors determining local geomorphic activity over the last 8000 years. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2004; 2007.)*

an independent chronology at sites with little material amenable to modern dating techniques. For many years, however, the main use for pollen analysis has been to provide a means of assessing the ecological setting of archaeological sites and Quaternary depositional environments, since it can be used to reconstruct past vegetation patterns. From these patterns, data can be gleaned which relate to past climates, the ecological resources open to past societies, the use of land, and human interactions with vegetation (e.g. Faegri and Iversen 1964; Moore and Webb 1978). In more recent times, the analysis of non-pollen components of palynological assemblages has widened the capabilities of the palynologist (Combaz 1964). Such components now include green algal spores (van Geel 1976), fungal microfossils (Pals *et al*. 1980), dinoflagellate cysts (aquatic microscopic unicellular organisms, often regarded as algae, although they are protists that are best known from the propensity of some to form toxic accumulations known as 'red tides' in the sea: Hunt *et al.* 1985), and palynofacies (i.e. the whole organic particulate assemblage: Hunt and Coles 1988). The latter provide additional or alternative perspectives on the environment to the regional or sub-regional picture provided by pollen. Often this new information reflects the situation at the exact site of deposition because that is the environment where the algae and fungi, which are strongly substrate controlled, actually lived. As a result, they may throw light on factors such as the local presence or absence of seasonal or permanent water bodies, the presence of sunlight on the site, and the presence of materials such as rotting wood or animal dung. Palynofacies analysis, because it provides data from the whole organic assemblage, also throws light on issues such as soil erosion and recycling, the presence of macroscopic plants on the deposition site, and on certain patterns of human activity on site such as the nature and type of fires (Hunt 1994; Hunt *et al.* 2001).

Historically, the application of palynology has been rare outside the temperate zone for a number of reasons, including preconceptions about the unsuitability of arid-zone sediments for palynological analysis and the rarity of practitioners in arid zone countries. As Horowitz (1992) pointed out, however, many arid-zone sediments are suitable for palynology, but may require different approaches and techniques from those regarded as standard in temperate-zone environments. In particular, pollen and other palynomorphs are often highly diluted by mineral sediments which typically accumulate rapidly in arid lands, so sample size has to be much larger than would be normal in investigations of temperate zone deposits, necessitating the adoption of different sample preparation protocols. Low-impact sample preparation protocols are also necessary because the biologically- and chemically-aggressive depositional environments common in the arid zone lead to palynomorphs commonly being corroded to some extent and thus vulnerable to rigorous processing techniques (Hunt 1985; Hunt *et al.* 2004).

3.4.1 Terminology and methodologies

Several technical terms are used repeatedly in this discussion and it is helpful to be aware of their meaning at this stage. *Pollen analysis* is the extraction from sediment, identification, and counting of pollen grains and spores in order to reconstruct past vegetation. *Palynology* is the study of all acid-insoluble microscopic particulate organic matter recovered by the extraction process. Within this material *palynomorphs* are microscopic acid-insoluble particulate organic matter with a regular and defined structure, including: pollen grains; lower plant spores; dinoflagellate cysts; algal vegetative structures, spores, zygospores and cysts; fungal spores, zoospores, and vesicular arbuscular mycorrhyzae (VAMs); acritarchs; microforaminifera; scolecodonts; chitinozoans; amoeboid cysts; and prasinophyte phycomas. *Palynofacies* are all microscopic acid-insoluble structured- and unstructured particulate organic matter including all palynomorphs. *VAMs* are fungal root symbionts of some higher plants, called '*Glomus*' by some American pollen analysts. They are of especial interest in this study because they can be recycled into waterlain deposits following the erosion of exposed soil profiles.

Pollen nomenclature in this discussion follows Moore *et al*. (1991), except in a few indicated cases. Pollen of the Family Compositae is identified into the sub-families Lactuceae, for fenestrate pollen, and Asteraceae for non-fenestrate, echinate pollen which is not attributable to individual genera. Older terminology is retained for brevity where the new terminology is long-winded. The term 'Filicales', for example, was retained rather than 'Pteropsida (monolete) indeterminate' as suggested by Bennett *et al*. (1994). The total numbers of pollen recovered from the Faynan sediments were surprisingly large given the nature of the habitat and depositional environment, but even so, counts were typically less than 500 grains per 25 ml. Hence samples of at least 0.25 kg were taken wherever possible, to allow for pollen dilution. In practice, this normally gave assemblages of between 50 and 300 pollen grains, though in some cases assemblages contained as few as 2 or as many as 1000+ pollen grains. Sample preparation took account of the extremely fragile nature of arid-zone pollen by adopting the low-impact method of Hunt (1985), which has been used successfully in arid-zone environments (Gilbertson *et al*. 2000; Hunt *et al*. 1986; 1987). The 'sieving and swirling' technique of Hunt (1985), sometimes augmented by heavy liquids (Guillet and Planchais 1969), is a method derived from protocols for the extraction of micro-fossils from pre-Quaternary geological materials. The technique is suitable for processing very large samples since it relies on disaggregation and deflocculation of material followed by gravity and size-separation, whereas the standard hydrofluoric acid and acetolysis method uses dissolution in strong and highly dangerous chemicals (Brown 1960; Moore and Webb 1978), is expensive, and difficult to scale up to the large sample sizes necessary to cope with the pollen dilution factors to be expected in this type of environment. Hydrofluoric acid and acetolysis, especially in combination, can give poor results when used in arid-zone sediments where pollen is likely to be 'fragile' (Fish 1985; Hunt 1985).

In order to recover the maximum quantity of information from the palynological research relating not only to the regional vegetation but also to localized questions relating to site formation, the decision was taken at the start of the research to analyse not just pollen but also algae and palynofacies in all samples. It was expected, for instance, that issues of the permanence or otherwise of water bodies, the presence of active soil erosion, and the presence or absence of local vegetation and the nearby presence of human activity, would all have relevance for questions of landscape development and human settlement history. The whole particulate organic matter residue remaining after processing was therefore examined. All pollen, spores, and all other organic walled microfossils were identified and recorded. Pollen was identified using our own collection of arid-land pollen supported by appropriate texts (e.g. von der Breilie 1961; Al-Eisawi 1986; Al-Eisawi and Dajani 1987; 1988; Haddad 1961; Karim and El-Oqlah 1989; Moore *et al*. 1991; El-Oqlah 1983; Rossignol and Pastouret 1970). A palynofacies count was made for each sample: one or more randomly chosen transects were made, near the centre of the slide, and all palynomorphs and organic particulates encountered were identified, counted, and analysed using terminology adapted from published sources (Batten 1982; Berch and Warner 1985; Branigan *et al.* 1988; Brown 1960; Hart 1986; Hunt and Coles 1988; Hunt and Mohamed 1998; Hunt *et al*. 2001; Tolonen 1986; Tyson 1995).

At the start of the research project comparatively little was known about the taphonomy of pollen and palynofacies in the study area. As a result we have endeavoured to 'anchor' this study through the investigations summarized in Chapter 2 of local habitats and the factors that influence them. This information has informed our local ecological interpretation of the pollen assemblages recovered – obviously we rarely dealt with pollen from a plant taxon that indicates unequivocally just a single type of habitat or ecological situation. The information is characteristically more ambivalent and its elaboration must always be read with appropriate caution and circumspection. Important work relating to the patterns of pollen rain along an altitudinal profile was published during the life-time of this project (Davies and Fall 2001). We also collected a series of surface samples in a range of types of depositional environments in the research area, to enable control for depositional environment and habitat or ecosystem type. These unpublished studies of pollen taphonomy, set out in Mohamed (1999), complement previous published taphonomic studies of arid-land pollen and palynofacies in the region and further afield (Ayyad *et al*. 1992; Bottema and Barkoudah 1979; Al-Eisawi and Dajani 1987; 1988; Fall 1987; Horowitz 1992; El-Moslimany 1990; Rossignol and Pastouret 1970). Particle size analyses of the matrix of palynological samples were undertaken to determine whether high frequencies of Chenopodiaceae, *Artemisia*, other Tubuliflorae, *Pinus,* and Fern spores, perhaps associated with turbulent water, might be associated with coarse sandy alluvium, and whether a preponderance of clay-sized particles might correlate significantly with *Pinus*, *Quercus*, and *Populus* pollen (Fall 1987; Hunt and Gilbertson 1995). In practice, for most of the studied sites the pollen types were also allocated on the basis of field observation and previous biogeographical studies into ecologically-significant groups which included 'far-travelled', plateau, cultivated, waterside, steppe-land, dryland, indeterminate, algae, and fungal.

The study employed a Fluorescence Microscope (an Olympus BH2-RFCA) in which specimens were illuminated with intense ultraviolet light. This facility was useful for recognizing reworked grains, for studying very thin-walled material, and for discriminating between particles of different botanical origin. Fluorescence microscopy can sometimes demonstrate a difference in fluorescence level between *in situ* and reworked palynomorphs (Traverse 1988; Hunt *et al.* 2007a). Reworked palynomorphs are usually (but not always) more poorly preserved than palynomorphs that came into the basin of deposition from contemporaneous vegetation and can be recognized by their corroded, ragged or thin walls, or their different natural colour. Such grains also fluoresce further to the red end of the spectrum than *in situ* grains. Fluorescence microscopy was also used to check for modern contamination. Most palynomorphs examined under fluorescence microscopy fluoresced a dark red colour or did not fluoresce at all. Assemblages showed relatively uniform fluorescence characteristics, suggesting an absence of contamination and little detectable recycling.

3.4.2 An outline palaeoecological framework for the Holocene

In this study, as the numbers of grains counted are relatively low in comparison with the frequencies found in water or wetland environments, pollen assemblage biozones have had to be recognized in terms of qualitative changes in vegetation spectra rather than by statistical analyses. Unusually in geoarchaeological studies, these biozones are defined formally in this account, in order to aid the interpretation of pollen diagrams from types of materials and situations rarely studied hitherto. The local pollen assemblage biozone is a partial description of local vegetation for a period of time. The detection of recurrent groupings from different and separated sediment bodies through the study area has led to the recognition of regional vegetation and its changes, which are discussed further on a period-by-period basis in the later chapters. This information is synthesized here as a formal pollen assemblage-biostratigraphy (Table 3.5) and shown in a summary pollen diagram for the Holocene in the area (Hunt *et al*. 2007b; Fig. 3.9). Table 3.5 also corrects some typographical errors in the previous reporting of these biozones and also incorporates new radiocarbon dates (see Hunt *et al.* 2007b).

3.4.2.1 Poaceae-Ostrya-Pinus *assemblage biozone (POP)*

The type locality for this biozone is site WF5510 in the Wadi Ghuwayr, where assemblages of this biozone have been recovered from the basal 1.5 m of the section. It can also be recognized at site WF5015/WF5500 in the Wadi Dana. The pollen assemblage biozone is defined from the high proportions of Poaceae (16–32%), *Pinus* (5–70%), *Ostrya* (4–32%), and *Plantago* (4–20%), and the sometimes high occurrence of Liliaceae (4–18%), *Juniperus* (0–15%), and *Artemisia* (0–15%). Other characteristic species often present include *Quercus* (0–4%), *Ulmus* (0.5–2.5%), and Caryophyllaceae (0–2%). Other species are present occasionally, such as *Rumex* (0–1%), *Hippophae*, *Potentilla* (0–0.5%), *Pistacia* (0–0.5%), *Malva* (0–1.5%), Cyperaceae (0–2%), *Centaurea* (0–1.0%), and *Helianthemum* (0–0.5%). The end of this biozone is defined at the distinctive decline of *Ostrya*, a small decline of *Pinus* and Poaceae, and the disappearance of *Ulmus*. The assemblage predates 7240±90 BP or 6353–5919 cal. BC (Beta-111121) at site WF5015. Assemblages earlier than this biozone have not yet been found in the study region.

The high frequencies of Poaceae, *Plantago*, and other herbaceous species such as *Artemisia*, *Malva*, *Rumex,* Cyperaceae, *Centaurea*, and *Helianthemum* are characteristic of steppic landscapes (Bottema and Barkoudah 1979; Mohamed 1999). The relatively high proportions of the particular tree pollen are dissimilar to the composition of all modern vegetation types now present in the Levant. The modern plateau flora still has relict stands of *Juniperus* and *Pinus* (Figs 2.11, 2.13). *Ostrya* and *Ulmus* are, nowadays, completely absent from the region and in the absence of macrofossil evidence, their former position in the landscape is uncertain. It is possible that these species were part of a former richer, more diverse, plateau flora; alternatively, they may have been living in sheltered valley floor sites adjacent to springs and standing water, alongside other waterside species such as the ferns and *Tamarix* (Fig 2.8). Macrofossils of *Quercus* and *Olea* from site WF5510

Pollen assemblage biozone	**POP**	**PPA**	**PAP**	**PCPJ**	**CLP**	**CPE**	**C**	**CL**
Approximate dates uncal. BP	pre– *c.*7200	*c.*7200– *c.*6400(?)	*c.*6400(?)– *c.*5700(?)	*c.*5700(?)– *c.*3000(?)	*c.*3000(?)– *c.*1800(?)	*c.*1800– <1300(?)	*c.*350–*c.*100	*c.*100–0
Plateau								
Ulmus	0.5–.5●							
Ostrya	4–32▲	0–2●		0–1*			0–2*	0–7*
Quercus	0–4*	0–2*		0–1.5*	1–4*	0–4*	0–3*	0–3.5*
Rhamnus	0–2*	0–1*			0–0.5*			
Pinus	5–70▲	7–19▲	5–14▲	0–6●	1–7●	2–18●	0–5*	1–13●
Juniperus	0–15●	0–8●	0–2●	1–3●	1.5–8●	0–10●		0–3.5
Pistachia	0–0.5*	0–1*	0–2*		0–1.5*	0–10*	0–0.5*	0–7*
Olea	0–0.5*	0–3*		1–2*	1–2*	0–1*	0–0*	0–4*
Acer		0–1*						0–1*
Cupressaceae			0–*					0–2*
Steppe-like								
Poterium	0–0.5*			0–0.5*	0–0.5*			0–1*
Artemisia	0–13*	12–18▲	3–5*	5–12▲	0–9*	0–9*	0–2*	1–8●
Poaceae	16–2▲	10–38▲	22–8▲	6–19●	4–9●	0–7*	0–6*	1–19●
Plantago	4–20▲	3–11▲	5–7●	11–9▲	1–4●	1.5–4●	0–0.5	0–19●
Rumex	0–1*	1–2.5*		0–1*	0–3.5*	0–0.5*		0–2*
Caryophyllaceae	0–2*	1–16●	0–4*	15–5▲	0–10*	2–12●	0–5*	1–30▲
Liliaceae	4–18●	1.5–4●	3–6●	1–4●	0–0.5*		0–2*	0–3.5
Acacia				0–1*	0–1*			0–0.5*
Cereals	0–2*	0–2.5*	0–5*	1–3*	0–4*	1–2*		0–5*
Asteraceae	0–4*	1–5●	0–3	6–22▲	4–13▲	4–15▲	1.5–8▲	2–16▲
Lactuceae	0–8*	3–6●	5–7●	1–5●	16–5▲	17–36▲	6–21▲	1.5–7▲
Desert-like								
Chenopodiaceae	0–13*	2–35▲	5–9●	1–8●	4–47▲	22–45▲	57–87▲	0–40●
Ephedra	0–0.5*	0–6*		1–4●	1–17▲	1.5–9●	0–7●	0–6●

Key

▲ Major characteristic taxon
● Minor characteristic taxon
* Less significant taxon

POP Poaceae-*Ostrya*-*Pinus* assemblage biozone
PPA Poaceae-*Pinus*-*Artemisia* assemblage biozone
PCPJ *Plantago*-Caryophyllaceae-Poaceae-*Juniperus* assemblage biozone
CLP Chenopodiaceae-Lactuceae-Poaceae assemblage biozone
CPE Chenopodiaceae-*Pinus*-*Ephedra* assemblage biozone
C Chenopodiaceae assemblage biozone
CL Chenopodiaceae-Lactuceae Assemblage Biozone

Table 3.5 *Summary of the pollen-assemblage biostratigraphy in the Wadi Faynan. The approximate dates shown are uncalibrated radiocarbon years, revised from Hunt* et al. *(2007b) as a result of further radiocarbon dating.*

suggest that these particular taxa were living in the wadis, close to the watercourses. *Ostrya* and *Ulmus* may have been growing in similar locations (see also Table 3.4). The presence of occasional cereal-type pollen might indicate the activities of early farmers or merely reflect the fact that wild cereals were growing naturally in the area.

*3.4.2.2 Poaceae-*Pinus-Artemisia *assemblage biozone (PPA)*

The type locality for this assemblage biozone is a fossil soil horizon (1.2–1.7 m) at site WF5015 in the Wadi Dana (Fig. 7.5). The biozone can also be recognized at WF5021, Tell Wadi Faynan (zone A) (Fig. 7.4). It is defined by high proportions of Poaceae (10–38%), *Pinus* (7–19%), and *Artemisia* (12–18%), a moderate presence of *Plantago* (3–11%), and variable Chenopodiaceae (4–35%). Often present are *Ostrya* (0–2%), *Quercus* (0–2%), *Rhamnus* (0–3%), *Juniperus* (0–7%), *Olea* (0–3%), Caryophyllaceae (1–16%), Liliaceae (0–4%), and cereal pollen (0–2%). Other taxa which are sometimes present include *Acer* (0–2%), *Balanites* (0–1%), and *Ephedra* (0–4%). The base of this assemblage biozone is defined at the top of the preceding biozone POP, and the top is defined by the disappearance of *Ostrya*, *Pistacia*, *Quercus*, and *Rhamnus*. The biozone is dated to 7240±90 BP or 6353–5919 cal. BC (Beta-111121) at site WF5015, an age consistent with the Neolithic artefacts at the site. At site WF5021 the top of the biozone is imprecisely associated with a series of radiocarbon dates, such as 6730±40 BP or 5471–5231 cal. BP (HD-12335), the loss of the sample site precluding more precise recognition of these stratigraphic relationships. In archaeological terms the material can be ascribed to the Pottery or Late Neolithic period (al-Najjar *et al*. 1990).

The high proportions of Poaceae and *Artemisia*, together with moderate *Plantago* and the frequent occurrence of Caryophyllaceae, Liliaceae, and other typically steppic taxa, suggest a predominantly steppeland landscape (Bottema and Barkoudah 1979). The high counts for *Pinus*

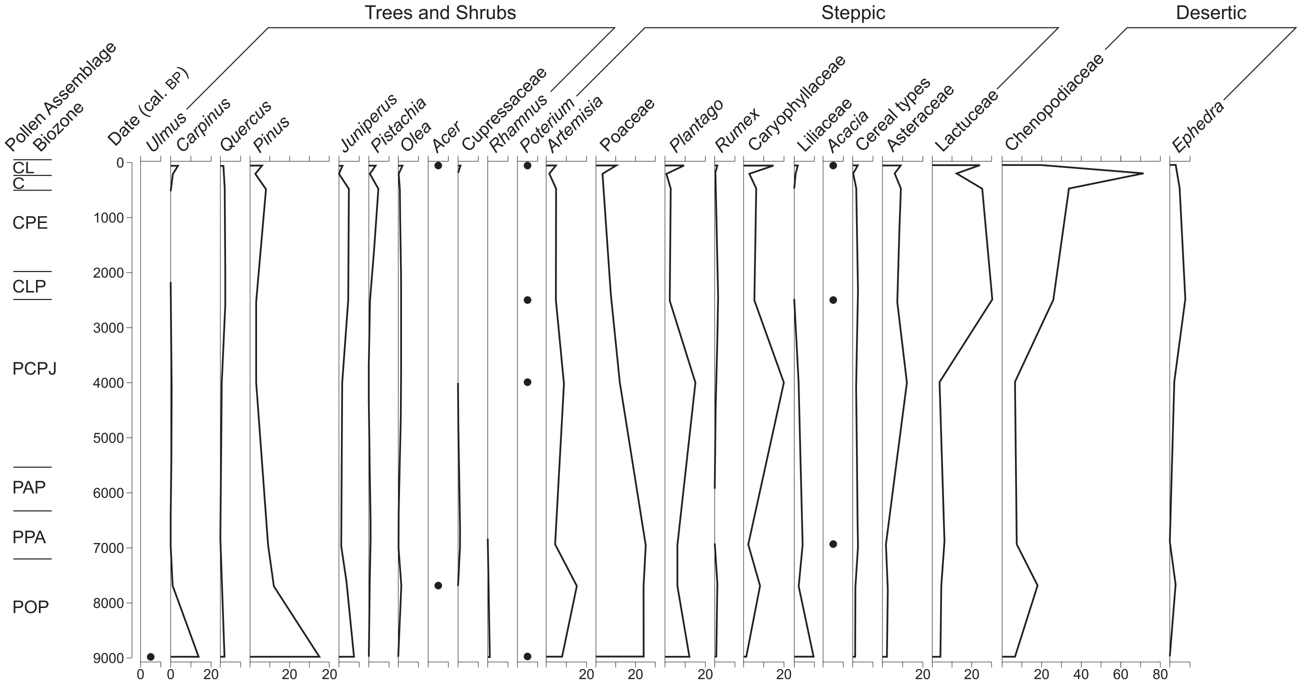


Figure 3.9 Schematic summary composite pollen diagram grouped into primary local habitat types for the vicinity of the Khirbat Faynan for the last 9000 years; pollen assemblage biozones are defined in the text. The black dots refer to a small but significant presence of that taxon at that point in time. Source pollen counts and the component pollen diagrams are given in Mohamed (1999) and Hunt et al. *(2004; 2007b).*

and frequent occurrence of *Juniperus*, *Ostrya*, *Olea*, and *Quercus* all suggest the presence of a Mediterranean-woodland biotype. Waterside plants such as the ferns, palms, and *Balanites* are indicative of occasionally rich waterside vegetation. The rise of Chenopodiaceae and *Ephedra* suggests areas of very dry, possibly disturbed, ground. As in the case of the POP biozone, the occurrence of cereal-type pollen in this biozone may reflect the activities of early farmers, or just the presence of wild cereals growing in the area.

*3.4.2.3 Poaceae-*Artemisia-Plantago *assemblage biozone (PAP)*

The type locality for this assemblage biozone is site WF5510 in Wadi Ghuwayr; the biozone has also been recognized at Tell Wadi Faynan (WF5021). Its base is located on the top of the preceding (PPA) assemblage biozone. The PAP biozone is defined by significant proportions of Poaceae (22–28%) and *Pinus* (5–14%), and moderate quantities of *Artemisia* (3–5%), *Plantago* (5–7%), Liliaceae (3–6%), Chenopodiaceae (5-9%), and Lactuceae (5–7%). Other taxa which are sometimes present include *Juniperus* (0–2%), Cupressaceae (0–2%), *Pistacia* (0–2%), and Ericaceae (0–1.5%). Cereal-type pollen (0–5%) is also present occasionally. The base of the biozone is dated at Tell Wadi Faynan to *c.*6400 radiocarbon years, in the order of 5500–5250 calendar years BC (see above). A piece of charcoal from Sample G within the fluvial infill sequence at WF5021 gave an AMS date of 6200±40 BP or 5296–5045 cal. BC (Beta-205964). By reference to al-Najjar *et al.* (1990) and the field stratigraphy, the top of the WF5021 is dated to 5740±35 BP or 4688–4499 cal. BC (HD-12337), a radiocarbon date that is, in local archaeological terms, within the Chalcolithic period.

The significant proportions of Poaceae, moderate *Plantago*, and *Artemisia* suggest a steppic environment, but one with fewer signs of disturbance and drought than the preceding biozone. Some waterside vegetation including *Pistacia* and some plateau flora including *Pinus* and *Juniperus* existed, so the vegetation was much like the modern one in this aspect, although apparently less degraded than today.

3.4.2.4 Plantago-*Caryophyllaceae-Poaceae-*Juniperus *assemblage biozone (PCPJ)*

The type locality for this pollen assemblage biozone is site WF24/WF5051, a water system infill associated with artefacts of Early Bronze Age (*c.*3600–2200 BC) age (Hunt and Gilbertson 1998; Figs 3.10, 8.23). The assemblage is defined by high proportions of *Plantago* (11–19%), Caryophyllaceae (15–25%), and Poaceae (6–19%), and moderate *Pinus* (0–6%) and *Juniperus* (1–3%). A decline of *Ostrya* (0–1%) and *Quercus* (0–1.5%) was recorded through this biozone. A slight decrease in Poaceae and a slight increase in *Artemisia* have been recorded at the base. There is one record of Palmae at the top.

The presence of *Plantago*, Caryophyllaceae, Poaceae, and *Artemisia* suggests a steppic environment (see Bottema

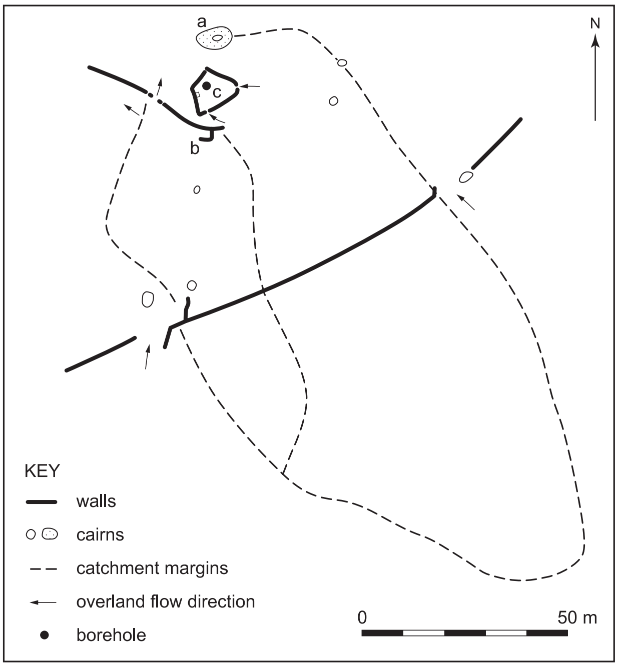


Figure 3.10 *WF24, a water-catchment structure associated with artefacts of Early Bronze Age (*c.*3600–2200 BC) date, containing sediments (WF5051) associated with pollen assemblage biozone PCPJ (see also Fig. 8.23): a) spoil heap; b) small structure with Bronze Age/Chalcolithic potsherds attached to catchment wall; c) infilled cistern and sample location (black dot). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt and Gilbertson 1998.)*

and Barkoudah 1979), albeit one which was slightly degraded. Caryophyllaceae can tolerate disturbance and the presence of Chenopodiaceae and *Ephedra* could indicate drought (El-Moslimany 1990). The minor re-appearance of the waterside vegetation together with *Ostrya* and *Quercus* indicates a return of the type of vegetation that occurred in the area during the Early Holocene. Cultivated taxa include olive, *Olea*. The domestic and/or wild status of cereal-type grains is unclear. The significant quantities of Lactuceae and Asteraceae, which are resistant to degradation in the soil (Havinga 1984), suggest that grains of these taxa may have been recycled from old soils, possible evidence for soil erosion from agriculture.

3.4.2.5 Chenopodiaceae-Lactuceae-Poaceae assemblage biozone (CLP)

This pollen assemblage biozone is defined at site WF5017, the sediments behind the Khirbat Faynan barrage WF441, between depths of 2.36 and 1.90 m (Figs 1.15, 3.5). It is defined by high proportions of Chenopodiaceae (4–47%), Lactuceae (16–45%), Asteraceae, (4–13%), Poaceae (4–9%), and *Ephedra* (1–17%), and moderate counts for *Plantago* (1–4%), Caryophyllaceae (0–10%), *Pinus* (1–7%), *Juniperus* (1.5–8%), and *Olea* (1–2%). It is characterized by a dominance of Chenopodiaceae. The top of the biozone is marked by increases of *Pinus* and *Quercus* and the absence of *Pistacia*. There is a slight increase of Poaceae towards the top of this biozone and a steady increase in the percentage of Lactuceae. Separate fragments of charcoal found in two different samples near the base of the reconnaissance borehole WF5017 gave two identical radiocarbon dates at different depths of 2630±50 BP or 910–594 cal. BC (Beta-110840 and Beta-110841) in the borehole WF5017. The adjacent excavated trench WF5012 yielded from excavated materials a radiocarbon date at 2.24–2.26 m depth of 1800±40 BP or 92 cal. BC–AD 339 (Beta-203401). Earlier, an extrapolated date of *c.*1850 BP (*c.*AD 100) was made for the base of the reservoir fill containing the biozone, but this is now discounted because the two 2.6 kya dates are now regarded as reworked (see Chapter 3 earlier). A date in the order of perhaps the end of the first millennium BC, and more certainly the early first millennium AD, seems more likely. The age of the top of the zone has not been determined directly. It is above a radiocarbon date obtained from excavated materials in WF5012 at 1.74–1.76 m depth of 1610±40 yrs BP or 349 cal. BC–AD 547 (Beta-203399). These deposits were accumulating in a basin with what appears to have been relatively rapid sedimentation. As a result an interpolated age for the top of biozone CLP is in the order of AD 450–550.

The presence of significant quantities of Poaceae, Caryophyllaceae, and *Plantago*, and the members of the local desertic flora such as Chenopodiaceae and *Ephedra*, suggest a degraded, desiccated, steppe environment, though there are sporadic pollen and algal indications of the occurrence of water at the site. The substantial numbers of Lactuceae, Asteraceae, and VAMs point to significant erosion of surface- and near-surface materials in the surrounding area, contemporary with, and probably related to, the substantial metallurgical activity being undertaken in the area in this period (Hauptmann 2000). Longer-distance inputs of a small number of grains from the different vegetation on the plateau or high mountain front are suggested by occasional grains of *Quercus*, *Pinus,* and *Juniperus*.

*3.4.2.6 Chenopodiaceae-*Pinus-Ephedra *assemblage biozone (CPE)*

This assemblage biozone is defined at borehole WF5017 behind the Khirbat Faynan barrage between depths of 1.90–1.05 m. There is a radiocarbon date at 1.74–1.76 m depth in WF5012 of 1610±40 yrs BP or 349 cal. BC–AD 547 (Beta-203399). Previously the interpolated age of its base was put at *c.*1300 BP or *c.*AD 650 (Hunt *et al.* 2007a). The biozone was also identified at site WF5025 in the Wadi Dana (Fig. 3.7), where it is much older than 390±50 BP or cal. AD 1435–1635 (Beta-115214). The biozone is defined by high proportions of Chenopodiaceae (22–45%), *Pinus* (2–18%), and *Ephedra* (1.5–9%), and moderate numbers of grains of *Plantago* (1.5–4%), *Artemisia* (0–9%), Poaceae (0–7%), cereal-type pollen (1–2%), and Caryophyllaceae (2–12%). Taxa occasionally present include *Trifolium* (2–13%) and *Juniperus* (0–10%), the latter declining at the top of the biozone, whereas *Pistacia* (0–10%), *Quercus* (0–4%), and *Olea* (0–1.5%) all increase here.

The frequencies of Chenopodiaceae, Lactuceae, and Asteraceae, and some *Ephedra*, *Plantago*, Caryophyllaceae, Liliaceae, *Glaux,* and *Rumex* in pollen biozone CPE suggest a degraded steppe environment, but algal spores and some pollen (such as *Tamarix* and *Nerium*) suggest the kind of waterside locations that are associated nowadays with permanent springs and discontinuous surface water in the Faynan gorges. There is continued palynofacies evidence of the erosion of surface and near-surface materials. The relatively high frequencies noted for *Pinus*, *Juniperus*, *Quercus,* and *Pistacia* are therefore anomalous, and are likely to reflect trees growing higher up on the mountain front or on the plateau. (This kind of 'exaggeration' of distinctive tree pollen in areas of low local pollen production is associated with desert environments: Horowitz 1992.) The occurrence of both *Olea* and cereal-type Gramineae, however, is evidence that farming might have been taking place in the area. There are significant differences between this biozone and the earlier CLP biozone, especially the decline of Poaceae and of true steppe indicators such as *Poterium* in the CPE biozone, suggesting the development of more arid conditions.

3.4.2.7 Chenopodiaceae assemblage biozone (C)

Assemblages of this biozone have been recovered at three locations: the Khirbat Faynan barrage infill (WF5017) at 0.60–1.05 m depth; the basal unit (Unit 5) of site WF5520, an alluvial fan deposit in the Wadi Dana; and site WF5509 in the Wadi Ghuwayr (Chapter 11). There are no radiocarbon dates for the base of this biozone, but its field relationships suggest that it is older than the radiocarbon date of 390±50 BP or cal. AD 1435–1635 (Beta-115214) at site WF5025 (Fig. 3.7): it may have started to develop in late medieval or early post-medieval times. A radiocarbon date of 110±50 BP or cal. AD 1673–1954 (Beta-119600) at WF5509 is associated with a pollen assemblage assigned to this biozone, whilst an assemblage of the succeeding biozone is associated at WF5520 with a radiocarbon date of 100±50 BP or cal. AD 1676–1954 (Beta-119602; this radiocarbon determination has two sets of intercepts on the radiocarbon calibration curve). It seems probable that the top zone of the assemblage lies between 110 and 100 BP radiocarbon years, most likely in the late nineteenth century AD. It is characterized by high proportions of Chenopodiaceae (57–87%) and significant frequencies of Lactuceae (6–21%). Other important taxa are Poaceae (0–6%), Caryophyllaceae (0–5%), *Ephedra* (0–7%), *Artemisia* (0–2%), and Liliaceae (0–2%). The top of the biozone is defined by the decline of *Pinus* (0–3%) and the disappearance of *Juniperus* and *Pistachia*. Taxa that suggest cultivation become rare: *Olea* declines to 0–5%, and cereal-types disappear.

The high frequency of grains of Chenopodiaceae and relatively high frequency of Lactuceae, together with the presence of *Ephedra* and Caryophyllaceae, suggest a degraded steppe environment and/or a steppe-desert environment (El-Moslimany 1990). The presence of relatively high proportions of *Pinus* and other plateau taxa may not be a sign of these plants increasing in abundance on the ground, but might indicate that the proportions of grains transported from long distances are being exaggerated by a low production of local pollen. Any or all of these features suggest a significant decline in rainfall. Pollen and algal indicators of the local presence of water are minimal but do occur. Likewise the VAMs suggest fluctuations in the extent of ground surface erosion, the most typical situation suggesting relatively limited erosion compared with earlier times. The radiocarbon dates, consideration of the duration of sedimentation, and the general character of the local environment, all suggest that this biozone is the local arid equivalent of the period recognized as the 'Little Ice Age' in temperate Europe, though on several occasions rainstorms prompted temporary pools in impoundments sufficient to sustain algal and occasional waterside vegetation – features that were evident in the local geomorphological record for this period.

3.4.2.8 Chenopodiaceae-Lactuceae assemblage biozone (CL)

Pollen assemblages of this biozone have been recovered from two locations: the Khirbat Faynan barrage infill (WF5017) at 0–0.55 m depth; and alluvial fan deposits (Units 2 and 4) at WF5520 in the Wadi Dana. Its base has been dated to 100±50 BP or cal. AD 1676–1954 (Beta-119602), and the biozone extends to the present day. (The calibration of this date reflects the presence of two distinct intercepts on the calibration curve.) The biozone was recognized by Mohamed (1999) as local biozone KH-4 between 0.6 m and 0.0 m at the Khirbat Faynan barrage infill sequence. It is defined by high proportions of Chenopodiaceae (0–40%), Lactuceae (1.5–47%), and Caryophyllaceae (1–30%), and moderate Poaceae (1–19%), Asteraceae (2–16%), *Plantago* (0–19%), *Artemisia* (1–8%), *Pinus* (1–8%), *Ostrya* (0–7%), and *Pistacia* (0–7%). Other taxa include *Juniperus* (0–3.5%), *Olea* (0–4%), *Acer* (0–1%), *Rumex* (0–2%), Liliaceae (0–3.5%), *Poterium* (0–1%), and potential cultivated taxa such as cereal-type grasses (0–5%). The appearance of grains of *Casuarina* and *Eucalyptus* at the top of the biozone has also been recorded at the Khirbat Faynan site.

Biozone CL is essentially modern, and contrasts with the previous biozone in being characterized by a rise of taxa such as Poaceae, *Artemisia*, *Plantago*, Liliaceae, and Caryophyllaceae, and a decline of Chenopodiaceae. This combination suggests a degraded steppe, but less desertic than that recorded in the earlier biozone C. More tree taxa are present. There are limited and patchy indications of the local presence of water. Grains of *Pinus*, Cupressaceae, *Olea*, *Quercus*, and *Juniperus* were probably mostly derived from the vegetation on the plateau. There may also be far-travelled taxa present such as *Acer,* possibly from Europe, perhaps reflecting changes in ambient winds,

Environment-typical growth habitat	Characteristic spp.	Neolithic			Chalcolithic Fidan 4	Early Bronze Age - Barqa al-Hatiya	Early Bronze Age - Faynan 9	Late Bronze Age - Faynan 9	Late Bronze Age - Faynan 16	Iron Age	'Persian Age'	Roman Age	Mamluk
Chronology - start date in uncalibrated radiocarbon years BP, until 'Persian Age'. (After Goldberg and Bar-Yosef 1990.)		*c*.9000			*c*.6500	*c*.5250				*c*.3150	2536	1913	696
Uncalibrated radiocarbon dates quoted from charcoal studied from copper smelting slags		5340–5240 BC	5210–9410 BC	4330–4165 BC				2900–2500 BC	2570–2330 BC	900–700 BC	550–400 BC	AD 100–400	AD 1260–1516
Habitat	**Taxon**												
Mediterranean	*Quercus calliprinos*						7.3	3.7–5	12.2	15			62.3–84.7
	Pistacia atlantica					1.0	30.8						
	Olea europea						15.1	11.2–15.6	7.2	0–7.1			5.9–13.6
Steppe-woodland	*Juniperus phoenecia*						14.1	63–67	59.7	0–5.4			15.3–28.6
	Retama raetma						10.0						
Dry steppe	*Tamarix*				40	95	1.6	3.5–5.2	3.9–4.7	55.2–91.6	52.4		2.5–3.4
	Zygophyllum-dumosum						0.05						
	Moringa peregrine						2.9						
	Phoenix dactylifera									0–30.8	0.8–3.2		
Very dry steppe	*Acacia* spp.					0.1	1.2				7.2–11.1	12.1–13.8	
	Retama raetma		85.2	100	60			1.0–2.2	2.3–4.7	2.0–10.2	22–32	14.3–19.0	
	Zizyphus spina-christi	91.2	14.8				1.0						
	Lycium shawi	8.8					0.2						
Desert	*Haloxylon persicum*					4.0			3.4–4.7	1.6–13.3	4.5–4.7	58.6–68.9	
	Ephedra						0.1					1.1–2.6	

Table 3.6 *Summary of the percentages of the most frequent wood types recovered as charcoal and wood and their possible source habitats in the region during the Holocene. See text for discussion. After the summary in Mohamed (1999) and Hunt* et al. *(2007b), derived from Baierle* et al. *(1989), Frey* et al. *(1991), and Engel (1993).*

with more winds coming from the northwest during the flowering season, as well as the katabatic winds described in Chapter 2. The appearance of exotic genera introduced from Island Southeast Asia and Australia is also noteworthy. Eucalypts were introduced to the area at the old mining camp (the present RSCN camp-hotel) in the Wadi Dana in the 1930s, as well as further south in the Faynan and on the plateau, and she-oaks (*Casuarina* sp.) were planted at the same time on the high slopes and plateau above the Wadi Dana for both ornament and shade.

3.4.3 Macrofossil analysis

The macroscopic remains of charcoal from earlier investigations provide one of the most important sources of palaeoenvironmental information available to this study (Baierle *et al*. 1989; Engel 1993; Frey *et al*. 1991). Some of this material was obtained from mines dated to the Bronze Age, but most of it was from slag deposits of younger age. Distinct changes over time were noted in the types of wood used for smelting (Hunt *et al*. 2007b; Table 3.6). Whereas timbers of high calorific value from upland taxa such as *Juniperus* and *Quercus* were used in the Bronze Age, the Iron Age was marked by charcoal from the smaller lowland and wadi shrubs such as *Tamarix, Retama, Haloxylon,* and *Acacia*, together with taxa from springs, oases, or irrigated land such as *Phoenix dactilyfera* (Fig. 2.12, Table 2.2). The original authors were not certain whether or not it was a change in climate or in the nature of fuel procurement during the Iron Age that produced the apparent loss of good fuel trees such as *Juniperus* and *Quercus* from the lowlands in the gorges and the mountain front. The consensus of the new evidence presented later (Chapters 9 and 10) is that these changes are more likely to reflect the impact of wood procurement to support the metal-extraction industry, rather than any climatically-driven effect.

In our own project, all coarse fractions of samples subjected to sediment analysis were also examined for non-bone macrofossils, which were separated using a 500 µm sieve. The molluscan and plant macrofossils found were identified by Chris Hunt and are reported as appropriate in the later chapters.

3.5 Geochemical studies

A distinctive feature of the project's methodology was the extensive use of geochemical investigations of suites of metals within sediments. These metals, stemming from a variety of sources, were thought likely to be of significance for a variety of reasons. Unusually, beryllium is relatively widespread in the immediate area, the result of a distinctive mineralization (Chapter 2); this light metal is more often discussed as a component of the gemstone emerald. Before 2002, the predominant immediate modern source of the heavy metals reported in this study area was emissions from the half dozen or so motor vehicles owned by the local community of bedouin herders, occasional visitors to the RSCN camp and adjacent school, and a handful of visiting professionals such as archaeologists, biologists, conservation managers, and geologists (Chapter 2). The more potent sources of metals are, however, the bedrocks of the study area that are extensively mineralized with suites of toxic and poisonous metals that are continuously being liberated naturally into the landscape (Grattan *et al.* 2007; Hauptmann 2000; and Chapter 2).

It was clear from the Bochum work that ores of different composition and sources had been worked, transported, and processed by technologies that had changed over time (Hauptmann 2000), suggesting that different suites of emission products might have been released at different rates and times into the atmospheric, terrestrial, biological, and cultural environments. If systematic and widespread changes over time could be conclusively demonstrated in the types and distributions of metals released by ore-mining and smelting, it might be possible to use metal combinations and concentrations as stratigraphic markers to correlate sediment bodies. Also, changing emissions of suites of heavy metals entrained, released, and re-deposited by water, wind, or mass-movement might be signatures of complex anthropogenic activities and disturbance, as well as degradation, or their re-location by natural processes (Grattan *et al*. 2007). The comparative rate of movements of these materials through ecosystems is considered in Chapter 12, not least longer-term recycling of pollutants after the times of industrialization. As a result, the present studies of post-Byzantine deposits, in particular, provide information on the recovery of fundamental ecological mechanisms that make a landscape work such as biogeochemical cycles, and are critical for understanding the health and well-being of its components parts: people, plants, livestock, and wild animals exposed to metals by inhalation, ingestion, and skin absorption.

Copper and lead were extensively mined and smelted in the area and are the main subjects of the geochemical studies reported here. Their importance extends beyond their potential to elucidate ancient metallurgical processes. Copper is essential to life, although in significant quantities, like lead, it becomes dangerous. Moderate symptoms of copper toxicity include for example: salivation, epigastric pain, nausea, ulceration of the nasal septum, vomiting, and diarrhoea (Cohen 1979; Mason 1979). Copper appears to induce pulmonary inflammation (Rice *et al*. 2001). Serious health problems include acute renal tubular failure, hepatic necrosis and failure, haemoglobinuria, hypertension, intravascular haemolysis, proteinuria, tachycardia, coma; leading with sufficient exposure to death (Williams 1982). Lead, unlike copper, has no known physiological requirements. In the body it behaves like calcium and accumulates in bone, whereupon it can be mobilized and enter the bloodstream to pass onto other organs (Harte *et al*. 1991). Lead has a wide range of notorious impacts on human health which are well documented (e.g. Foulkes 1990; Harte *et al*. 1991; Venugopal and Luckey 1978). At low levels, symptoms of lead poisoning are often vague and non-specific including pallor, vomiting, abdominal pain, constipation, listlessness, stupor, loss of appetite, irritability, learning and speaking difficulties, behavioural problems, and loss of coordination. Mobilization of this metal from the adult female skeleton may pose a threat to both the foetus and the nursing infant. In adults, it poses a risk for osteoporosis and it may disrupt the normal formation of calcium hydroxyapatite, critically weakening the bone (Skinner 2000; Wittmers *et al*. 1988). A relevant recent example of lead poisoning was described by Tandon *et al*. (2001), where refiners were exposed to lead as the result of the smelting of silver, a situation not dissimilar to that anticipated for metal workers in Faynan in antiquity, with lead being released through the smelting of ores for copper. The symptoms found included anaemia, abdominal colic, blue lining of the gum, and muscular wasting. In sufficient quantities, lead is fatal.

The Faynan landscape also yielded suites of other toxic, noxious, and poisonous elements. Individually or synergistically, if present as the appropriate chemical species in sufficient quantity in the right place, many may have entered organisms to the latters' detriment. They include beryllium, vanadium, chromium, nickel, arsenic, cadmium, antimony, mercury, thallium, bismuth, and uranium, whose properties and significance are summarized by Harte *et al*. (1991). The heavy elements vanadium and uranium in particular can be associated with organic or biological materials. Thallium, a dangerous, volatile, and poisonous metal, was of particular interest for our study, because it has its origins in the various ores (such as of copper, lead, thorium, zinc) that are abundant in the Faynan Orefield. Typically thallium may be released into the environment during 'primitive' smelting as metal-rich vapours and dusts that condense onto the surface of fuel-wood or hot ash, to fall back to the land surface, where the metal can persist in the soil (Kazantzis 2000). As a result, the concentrations of thallium offer an alternative perspective on the nature and scale of ancient metal working to that provided by the abundance of slag or the concentrations of copper and lead.

Our work also used the abundance of strontium, together with geomorphological observations, as potential surrogate indicators of the input of allochthonous carbonate-rich sediments. The most immediate and mobile sources of strontium in the area are in Quaternary carbonate-clasts and aeolian dusts (McLaren *et al*. 2004), the widespread, thick Cretaceous limestones exposed in the uppermost parts of the gorges and to the east of the Faynan Orefield, and to a lesser degree the resistant Palaeozoic Limestones that are exposed in the gorges and along the mountain front.

3.5.1 Analytical procedures

Geochemical analysis investigated surface samples taken in the field from the top 1–2 cm of the surface materials of the modern landscape in order to understand more of the relationships between its sources, including intermediate sources such as industrial wastes, and its movements in the modern environment. Sample locations were at least 100 m distant from all vehicle tracks and past and present bedouin encampments, as well as from components of modern bedouin camps.

The samples in Holocene deposits were also typically 1–2 cm thick and taken from cleaned exposures or newly excavated pits (e.g. WF5012; Fig. 3.11). Our earlier studies at the Khirbat Faynan barrage site reported in Barker *et al*. (1998; 1999; 2000; 2001) were based upon the samples from the WF5017 borehole. Initially geochemical investigations were carried out using Flame Atomic Absorption Spectrophotometry (AAS) for the analysis of copper and lead. A more broad-brush and rapid approach was provided by EDMA (Energy Dispersive X-ray Microanalysis) surveys. More wide-ranging analyses of our small samples of metals were undertaken using ICPMS (Inductively Coupled Plasma Mass Spectroscopy) and most recently by ICP-AES (Atomic Emissions Spectrophotometry). At various times all three approaches were applied to archaeological bone, modern tree and other plant samples, the remains of invertebrates and other animals, and other surface materials.

Flame Atomic Absorption Spectrophotometry used a Perkin Elmer 3110 AAS instrument at the University of Wales Aberystwyth and another at the Nottingham Trent University, both analyses adopting the same analytical protocols. Following air-drying and acid digestion of materials, concentrations of three replicates of biological or sedimentary/pedological materials were determined taking the average of three replicates. All materials had been transported in sterile sealed containers, and were thoroughly cleaned with de-ionized water which was followed by the appropriate acid digestion.

AAS analyses were carried out on human bones of Bronze Age date, and from skeletons excavated in 1996 from the Wadi Faynan South Cemetery, dating to the fourth–seventh centuries AD (Findlater *et al*. 1998; Grattan *et al*. 2005; Karaki 1999) and stored in the University of Yarmouk (Irbid, Jordan). All surface samples of bone were cleaned using an air brush, sometimes with pure silica abrasives, to minimize the risks from post-mortem contamination. Samples were air-dried to 105°C, finely ground, and approximately 2.5 g of the dried bone were digested overnight in 30% concentrated HNO_3, cooled, and filtered into a 25 mL flask. The cleaned bone samples were then placed under protective covers in a dust-free atmosphere and allowed to air-dry for 48 hours. The samples were weighed, bagged, and re-labelled ready for analysis. All materials then underwent a standard acid digestion procedure and were subsequently analysed by AAS. Replicates and blanks were analysed to ensure the accuracy of the analyses. The analytical results are typically the average of five replicates. Detailed investigations of possible physiologically-based partitioning of metals in human skeletal remains were carried out by determining the concentrations of metals across the surface of the bones, on specific anatomical parts of the bones, and after careful partial sectioning across the bones (Grattan *et al*. 2005). Where available, sub-samples of the sectioned bones were removed and placed in an ultrasonic bath for five minutes. Sediment samples taken at the time of the excavation from the bone find-spots were likewise examined, according to the particular stratigraphic circumstances, to examine the nature of the pre-industrial landscape geochemistry, and the extent to which bone chemistry reflected post-mortem diagenetic changes in bone chemistry brought about by burial in metal-polluted ground.

Energy Dispersive X-ray Microanalysis (EDMA) has the advantage of being a relatively quick, broad-brush reconnaissance procedure in geoarchaeology that provides semi-quantitative information on a wide range of elements to be determined (Goldstein *et al*. 1984; 1992). It was the primary basis for many of the reconnaissance studies reported in Barker *et al*. (1998; 1999; 2000) using a Jeol-6100 instrument. This was associated for data-handling with a Link System 860 Series 2 Computer using a ZAF-4 program at the Nottingham Trent University. This detected the presence and relative proportion of every element from and above sodium. To ensure representativeness and accuracy, ten random areas were examined in each case, with three replicates of each analysis. The EDMA approach generates data in the form of percentage values, which inevitably limit direct comparisons with the type of information provided by more conventional techniques such as AAS but which is typically applied to far fewer elements. This has resulted in occasional misunderstanding of its use and significance (Grattan and Gilbertson 1999). Although EDMA is capable of identifying most of the elements in the spectrum, the results of such an analysis would produce an overwhelming volume of data. In order to reduce this information to manageable and more meaningful dimensions, a range of elements is selected, typically those that comprise the great majority of the elements noted as well as those selected for a particular reason. The relative proportion in each of the chosen elements specified is then calculated by the ZAF-4 program and normalized to 100%. This process is not as subjective as it may sound, since the program will identify, and warn, if unspecified elements are present in significant quantities. The main strength of the procedure is in comparative studies of contaminated materials from diverse sources. There is also a visible check, as the probe operator observes the acquisition of the spectrum graphically on a computer monitor which will identify any elements which have not been selected. This process may, however, ignore fluctuations in the ratio of elements present in trace concentrations, and these must be selected with care. Unpublished EDMA analyses also provided analytical information on manganese together with other elements of potential human interest which are the subject of further enquiry.

The concentrations of metals in sediments were determined using 5 g samples of sieved and ground fine-grained sediment matrix by ICPMS analyses at the Institute of Geography and Earth Sciences at the University of Wales Aberystwyth, and most recently by ICP-AES in the School of Science and Technology at the Nottingham Trent University. Full analytical protocols for the University of Wales Aberystwyth instrument were published by Perkins *et al*. (1993). In brief, samples were digested for 72 hours in 10 mL of concentrated HNO_3. Ruthenium and blanks were used as standards for all analyses. After digestion, the samples were filtered through a #1 Whatman filter into 100 ml volumetric flasks. Subsequently, 2 mL of Ru (5 µg mL^{-1}) was added to each flask and then made up to 100 mL with Milli-Q water. Analytical consistency has been maintained by reference to blank samples that were also prepared at this time. Before sample analysis, a blank sample was analysed (×3) followed by the 'all elems' solution (×3). Each of the digested samples was then analysed (×1), every fifth analysis being made in duplicate. At the end of each session, a repeat analysis of the initial blank and 'all elems' was performed to check for instrument drift. All aberrant analyses were rejected and the material re-investigated. We are confident that the determinations made reflect those in the original sediment, not a chance aberration of the procedures used. Unpublished work on the concentrations of bioavailable metals using EDTA extractions at the modern lands surface and in the Khirbat Faynan infill deposits is given in Condron (2000). ICP-AES protocols at Nottingham were described in full by Wilson *et al*. (2005).

Concentrations determined by AAS, ICPMS, and ICP-AES have been converted to ppm for consistency of reporting. Diagrams that show the variations in concentrations through exposures and borehole samples were prepared using Tiliagraph by Gary Rushworth. The analyses were carried by Alan Condron, John Grattan, David Hine, Brian Pyatt, and Harry Toland; some data have been reworked from Sykes (1997).

3.5.2 The stratigraphic stability of heavy-metal concentrations

Existing research indicates that heavy metals might over long periods of time have migrated up and down through the types of sediment bodies found in the Faynan, as a result of biological, hydrological, or geomorphic processes taking place during or after deposition, though at other locations heavy-metal concentrations appear to have remained much the same at their original stratigraphic position (see: Ali *et al*. 2001; Alloway 1995; Badri *et al.* 1996; Bogoch and Brenner 1994; Gee *et al*. 1997 (temperate climate); Graf 1988; Grattan *et al*. 2007; Korte *et al*. 1976; Maskell and Thornton 1998; Maskell *et al.* 1995; 1996 (for temperate climates); Pulford and Dickinson 2005; Pyatt *et al*. 1999, 2002a; Reichmann 2002; Saffarini and Lahawani 1992; El-Shazly *et al*. 1971; 1977; Wray 1998). Clearly, evidence of the latter outcome is needed for palaeoenvironmental reconstructions such as this study that require clarity about the relationships between evidence of dating, human activities, industrial processes, environmental changes, and correlation with variations in metal concentrations. These questions are most readily addressed here through consideration of geochemical studies of the barrage infill sequence of sediments at Khirbat Faynan.

Three features of the present data are of particular importance. First, there is clear parallelism between the geochemical data sets from two distinct sets of sediments, those from the excavation (WF5012; Fig. 3.11 and Table 3.7) and those published previously from borehole core WF5017 (Fig. 11.10), suggesting the primary importance of depositional processes rather than post-depositional processes in determining total concentrations of key metals in the sediments. Second, the detailed study at 2 cm intervals in the excavation at WF5012 demonstrates the presence of notable distinctive peaks and troughs, exhibiting characteristic patterns of change and composition, rather than the 'averaging' or 'homogenizing' of concentrations that might stem from secondary post-depositional mobilization of metals by processes such as bioturbation. Third, the unpublished thesis of Condron (2000) demonstrates that the proportions of bioavailable (EDTA-extractable) heavy metals to total metals are relatively low throughout these excavated deposits, again indicating that there has only been minor upward recycling by tree roots, plants, and animals, or upward-moving soil moisture, or downwards movement from infiltrating biological sediment or downwards-percolating waters. In particular, Condron's comparisons between the bio-available and total metal concentration data show that post-depositional vertical mobility within these deposits is of small and secondary importance in comparison with the metal burden originally introduced by human and natural processes. There is also an evident association in the upper deposits of Chemizone C1 between small peaks in bioavailable elements and more organic-rich silt-clay sediments with layers with leaves, twigs, and soil fauna that once accumulated upon the aggrading land surface. All these studies suggest that the concentrations of copper, lead, and thallium detected in Chemizones C3-1 at WF5012 primarily reflect the original abundances of these metals when they were deposited onto the aggrading surface of the barrage-infill sediments. Accumulation is still underway at the present land surface as a result of re-cycling by water, wind, and organisms.

We conclude from this evidence for the magnitude of surface and sub-surface processes that the overall progressive decline in concentrations in copper and lead upwards evidenced through Chemizone 1 to the present surface in the barrage sediments appears to be the result of three types of geomorphic-biological processes: re-working of remnant pollution by surface geomorphic processes of run-off and wind; the progressive introduction (by wind especially) of ‘unpolluted materials’ from elsewhere in the catchment that diluted re-cycled polluted materials at the accreting sediment surface; and the differential re-cycling of heavy metals from the lower deposits in the Khirbat Faynan Member to the land surface through soil biota, tree roots, and via the above-ground components of trees and shrubs. The last of these appears to have been of comparatively minor importance. With appropriate caution and due regard to associated information, we conclude that post-depositional changes in sediment geochemistry do not appear to represent a major interpretative problem at the sites studied.

Chemizone	Depth (cm)	Summary description and interpretation
1	0–160	Typically copper less than 1000 ppm, lead typically 300–500 ppm; minimal fluctuations after an overall decline in concentrations upwards from the initial copper concentrations of *c*.2100 ppm at 159 cm, strontium 320–450 ppm and thallium *c*.1.5–2.5 ppm. There is a marked abrupt change to Chemizone 2 below. *Interpretation*: recycling by wind and run-off of natural and exposed smelting products.
1b	*c*.55	Copper 800 ppm
1c	*c*.80–90	Copper 1800 ppm

Table 3.7 *Details of Chemizone 1 recognized at borehole WF5017 (= WF5517), the infill deposits that accumulated behind the barrage at the Khirbat Faynan, on the basis of distinctive associations of key metals. There are two distinctive peaks in the WF5017 borehole illustrated in Barker (2000) and Barker* et al. *(2000) that are respectively two or three times the concentrations of those in adjacent parts of the core.*

3.6 The industrially-polluted landscapes of the Wadi Faynan

Before the present study, knowledge of the distribution of metal-polluted land in the area was limited to reports on the large spreads of copper-rich slag reported by Hauptmann (2000) and Overstreet *et al*. (1982) and summary information on their contents of copper and lead reported by Grattan *et al*. (2003a,b; 2007) and Pyatt *et al*. (1999; 2000; 2002a; Wilson *et al.* 2005). New information is presented in Figures 3.13 and 3.14 on the distribution of this legacy of metalliferous polluted slags (part of the Atlal Member reported in this research) and the relationship they have with metalliferous pollution detected via ICPMS-analyses

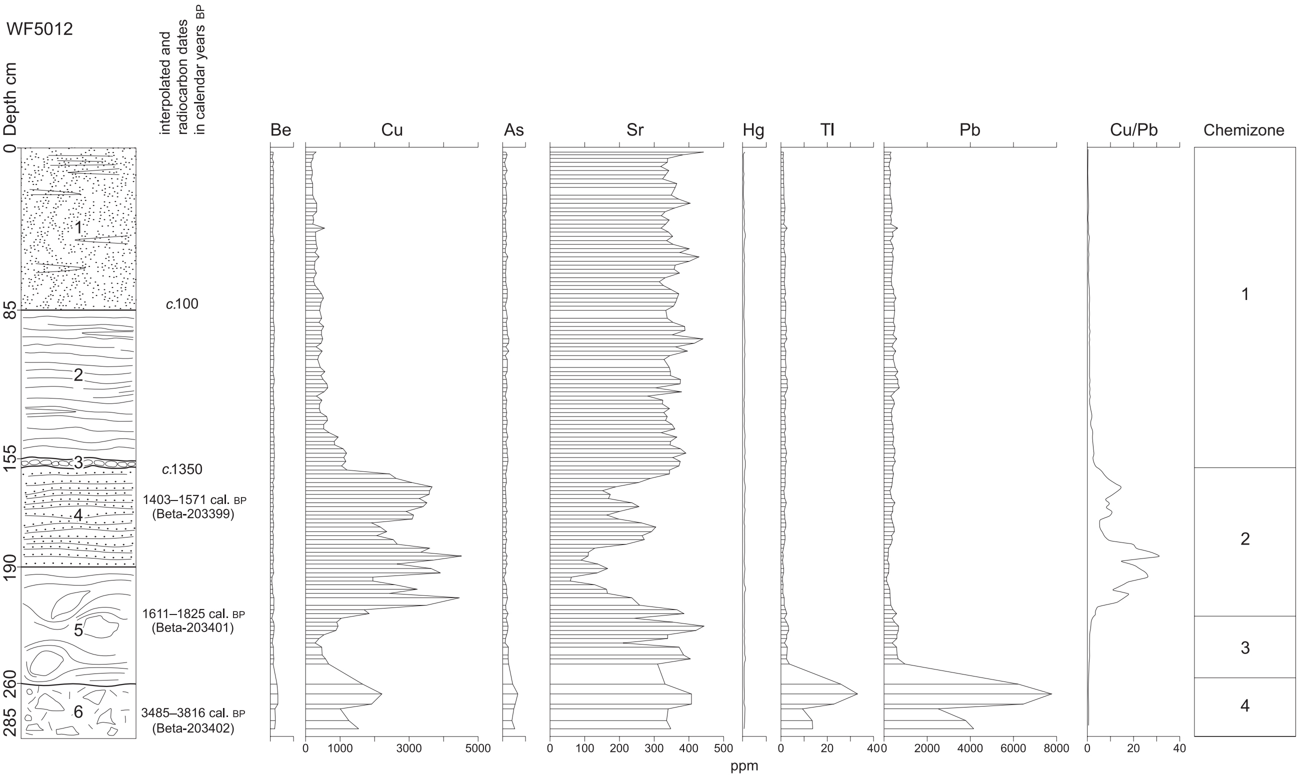


Figure 3.11 *Outline geochemical record retained at WF5012 from the wadi-infill sediments exposed by excavation behind the Khirbat Faynan barrage. Unpublished work indicates that the lowermost components of Lithofacies 5 – mainly Chemizone 3 – represents materials that have been re-worked from the underlying Lithofacies 6 dated to the Middle Bronze Age. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, partially after Grattan* et al. *2007.)*

of surface sediment samples taken between 1996 and 1998. The various natural and artificial features were interpreted in 1995 from black and white, vertical, air photographs taken by the Royal Air Force in 1930s, studied at the Archaeological Air Photograph Archive for Jordan at the University of Western Australia. The photographs pre-date the partial clearance of the ancient wall network, pipe laying, and ploughing that took place in 1995–96 (Fig. 1.7). This air photograph-based analysis misses many archaeological features found in the subsequent wall surveys of the Wadi Faynan Project (e.g. compare Figs. 3.13 and 4.2), but it provides a better guide to the relationships between the legacy of metalliferous pollution and the Holocene geomorphology on this gently undulating terrain which has restricted surface visibility. Large areas of *in situ* black copper-rich slag are concentrated in three areas: adjacent to the Khirbat Faynan barrage, and to the north and south of the confluence of the Wadis Ghuwayr and Shayqar. This pattern is also indicated in the oblique low-level air photographs of Kennedy and Bewley (2004, fig. 11.10B; Fig. 3.12). Large deposits of slag do not occur in the vicinity of the major burial grounds such as the South Cemetery (WF3), nor in the network of ancient walls west of Khirbat Faynan (the WF4 field system). However, geomorphological and archaeological survey established that innumerable small remnants of copper-smelting slag that are too small to display are present within this wall system and many other areas including within the gorges (e.g. Fig. 3.13: Tell Wadi Faynan WF5022, and surface sediment samples SP7, 19, and 24–31).

As well as the powerful floods through the Faynan/Fidan system in winter (Fig. 2.7), significant overland flow also takes place along small watercourses and down gentle slopes; during the rest of the year, there are small spring-fed water flows in the main wadis 1–2 km up-channel from the Khirbat Faynan (Fig. 2.15). As a result, especially in winter, surface metal pollutants are likely to be transported by fluvial processes from east to west along the braid plains. In classical antiquity, another possible mechanism may have been the practice of manuring indicated by the extraordinarily large quantities of broken pottery visible on the surface in the spaces between the wall of the WF4 field system, if the ceramics are derived from vessels used to transport animal manures, plant wastes, and human night-soil from the main settlement zone around the Khirbat Faynan to the fields (see Chapter 10). Unexpected by-products would have been the introduction of material with high concentrations of metals occurring as a result of bio-

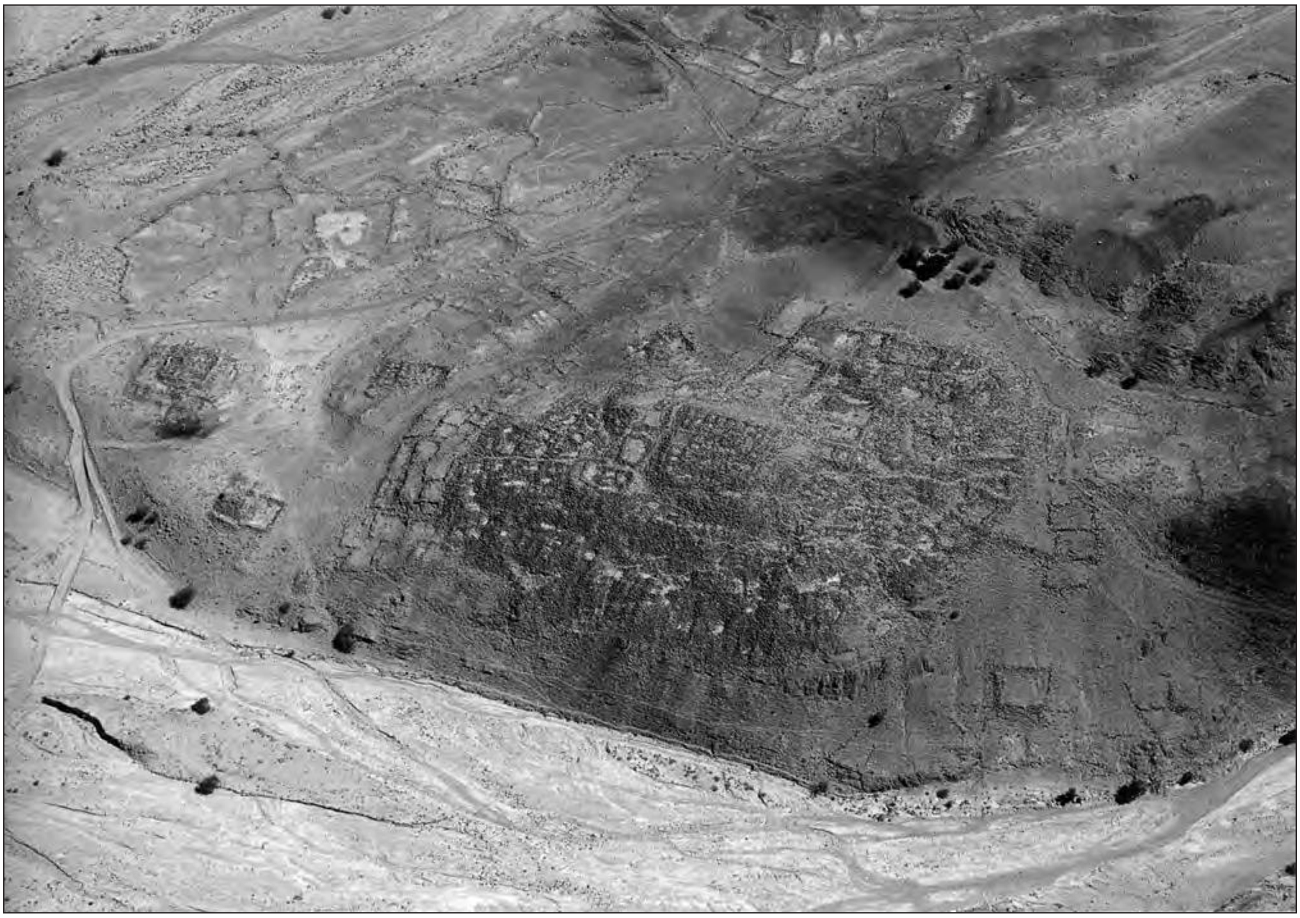


Figure 3.12 *Aerial photograph looking north over Khirbat Faynan, showing the pattern of black copper-rich slag concentrated in three areas in the northeast corner. (APA98/SL38.19, 20 May 1998 = Kennedy and Bewley 2004, 215, fig. 11.10B.)*

Figure 3.13 *(above) The distribution of walls, water courses, wadi floor, and aeolian deposits mapped from air photographs dating from the 1930s and modern ground reconnaissance in the Wadi Faynan, and (below) the location of the geochemical sampling transects. The wall distribution determined by modern ground survey is shown in Figure 4.2. Black indicates areas of slag – the Atlal Member. The existence of the conduit shown north of the Wadi Ghuwayr in the upper map is not certain – the feature is poorly defined and very eroded; but is not a sheep-goat track. (Illustration: David Gilbertson, Ian Gulley and Antony Smith, partially after Grattan* et al. *2007.)*

accumulation and the liberation as dust to the atmosphere of any metal-enriched topsoil by ploughing. Larger-scale meteorological mechanisms that could transfer liberated metal pollutants as dust from the Faynan area to the global atmosphere were established by Dayan *et al*. (1991) and Singer *et al*. (2003) on the basis of NOAA satellite-based observations of substantial and frequent uprising-columns of dust from this area.

Clear associations between polluted ground and evidence of ancient metal working (in the form of black copper slag) were detected near Khirbat Faynan (Figs 3.12, 3.13) (surface samples SP32–5), and in the eastern part of the WF4 wall network (SP24–31). Further to the west, and downwind in terms of katabatic winds from the main smelting centre of Khirbat Faynan (SP19–23), the data do not display any systematic east-to-west trends in metal concentrations that would correspond to progressive concentration or dilution by aeolian-fluvial earth surface processes, or indeed by human agencies working down the wadi. A partial downwind-distance-decay effect does, however, appear to be present along the north–south transect with increasing distance south up the alluvial fan away from the main Faynan channel. Sample SP1, where there is a small outcrop of slag, is the exception. This particular north–south decay trend was also detected by parallel geochemical studies using atomic adsorption of sediment and biological materials (Pyatt *et al*. 2002a).

Outside the areas of abundant slag, the field evidence of pockets of black copper smelting slag (SP24–35) is seen to provide only a partial guide to the relative concentrations of copper detected in surface sediments. SP6 and SP18 did not contain visible slag, but they *do* have significant peaks in copper indicating the presence of sand-sized grains of copper-rich ores that were not evident in the sampling. With the notable exception of SP20, significant concentrations in lead are more reliably identified by the visible presence of black slag, suggesting the residual pollution consequences of small-scale site processes intended to extract copper.

Overall, these pollution survey data point to a clear association between areas with evidence of past intensive

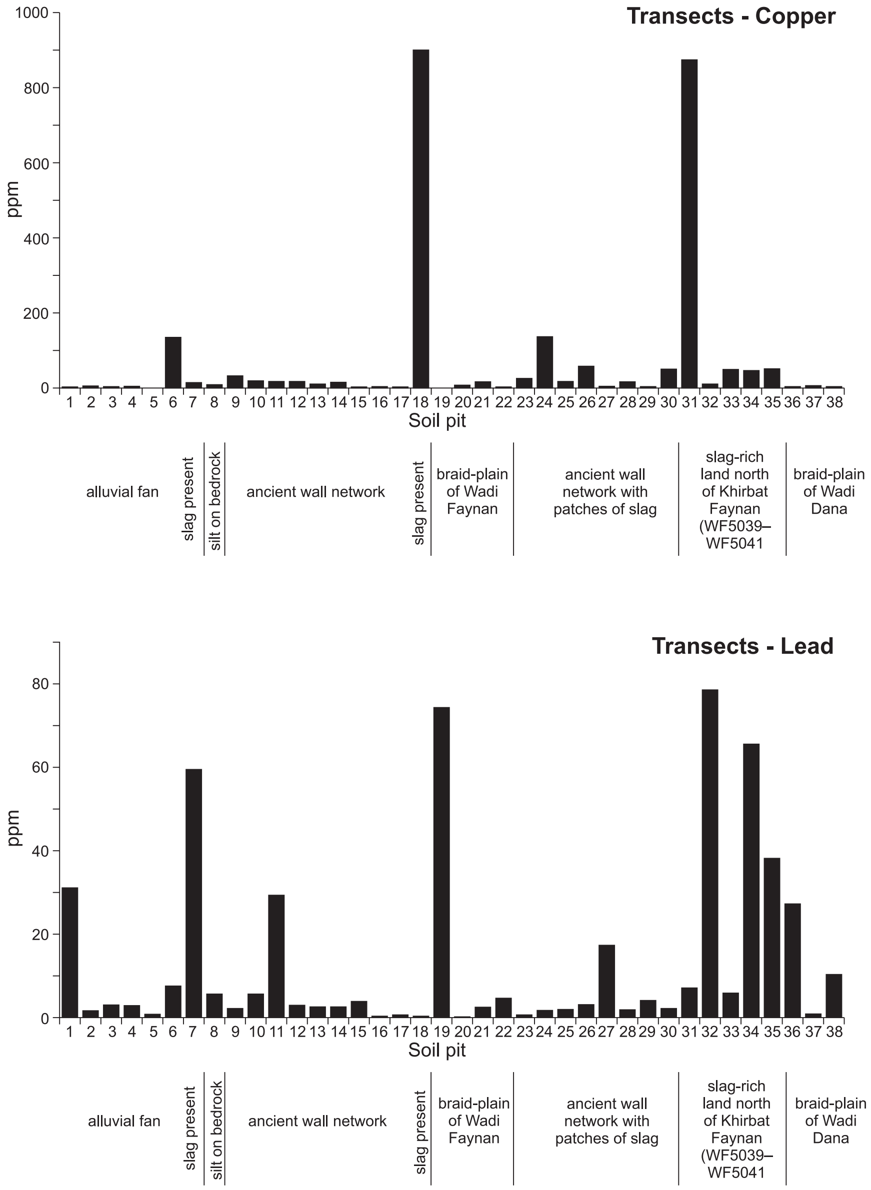


***Figure 3.14** Histograms showing the concentrations of copper and lead detected via ICPMS analyses of surface sediments/soils taken with ground-truth and transect-surveys at the modern land surface between 1996 and 1998. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, partially after Grattan* et al. *2007.)*

smelting and areas with high concentrations of copper and lead. The evidence suggests that there may also once have been a decrease in metal pollution from wind-transported dust with increasing distance from the Faynan channel upslope to the south. This feature is not detectable down-wadi along the southern banks of the Faynan, but this is a geomorphologically-active, sandy, wind-blown, and water-washed environment that was significantly disturbed by wall-clearance, ploughing, and irrigation in the 1990s.

The concentrations of copper and lead in the coarse clastic deposits on the modern braid-plain of the Wadi Dana (SP36–38) are markedly lower than those in the adjacent polluted ground, suggesting dilution and/or removal of heavy metals by occasional winter floodwaters. The relative reductions of concentrations in copper appear to be larger than for lead in these geomorphologically-active environments, especially for SP36–38 adjacent to the most polluted ground, though the number of samples is small. Such comparative differences are also evident in sediments on the surface of the alluvial fan to the south of the Wadi Faynan (SP1–7). Concentrations of lead in the braid-plain of the Wadi Dana are higher than those determined for the downstream transect across the Wadi Faynan, whereas the converse is true for copper. Such behaviour in fluvial systems in arid lands, especially the presence of heterogeneities in concentrations of copper and lead, has been previously identified at various locations (Badri *et al*. 1996; Bogoch and Brenner 1994; MacKenzie and Pulford 2002;

Wray 1998). A range of mechanisms is suggested by these authors: poor retention properties of sandy sediments; differential entrainment and transport of ores; and distances from ore-sources and smelting sites.

3.7 Metal-pollution burdens and pathways in plants, animals, and the agricultural economy

The modern vegetation of metal-polluted areas such as the Khirbat Faynan is not well-known. Surveys by Pyatt *et al*. (1999; 2000; 2002a) describe vegetation of limited diversity with low biomass per unit area. Common species are *Asphodelus fistulosa*, a short perennial with numerous fleshy roots, and *Ephedra alte*, a member of the Jointed Pine family bearing distinctive green rush-like leaves. Also present are the composite *Gymnarrhena micrantha*, with a well-defined rosette growth form, together with *Haloxylon salicornia*, *Hordeum glaucum* (wild barley), *Plantago coronopus*, and the poisonous *Urginea maritima*. Comparison with cover values on the less-polluted control site *c*.2.5 km distant on the alluvial fan indicates that significant metal pollution substantially reduces both frequency and percentage cover values (Table 3.8).

Analyses of the copper and lead contents of plant materials from the polluted and control sites shown in Table 3.9 also demonstrate the larger uptake of lead that takes place within the relatively few plants that live on the smelting spoil. Comparisons with studies elsewhere (Bowen 1979) suggest that concentrations of lead and copper reported on the smelting slag would be phytotoxic in many normal situations. The fact that plants continue to grow and exist on this spoil indicates that over time there has evolved locally in the Faynan both an ability to sustain their life here and to bioaccumulate these metals. The same phenomenon has been noted at a variety of other sites with recent histories of substantial metal pollution (Baker 1987; Mandl *et al*. 1975; Symeonidis *et al*. 1985; Walley *et al.* 1974), suggesting that it can emerge within decades or a few centuries of episodes of intense mining, smelting, and pollution. In general, the highest concentrations were detected in the roots of plants, indicating the route by which plants re-cycle these metals from inert slag into the living biological environment. In the field, some roots did appear to penetrate deeply into the deeper, and more toxic, sub-surface materials. Comparisons of the metal concentrations in such roots with those in stems and leaves point to these plants having filtering mechanisms that reduce the transport of cations to other tissues.

The absorption of copper and lead by these plants is also seen to be significant at the less-polluted control site SP1 on the alluvial fan *c*.2.5 km distant from Khirbat Faynan (Fig. 3.13 lower; Table 3.9). The lead contents of the leaves of the grazed *Plantago coronopus* growing on the smelting slag were sixteen times those at the more distant control site, whilst the copper contents were 5.5 times higher on the polluted ground closer to Khirbat Faynan. Similar relationships are found in *Urginea maritima,* where there is a very high concentration of lead in the bulb (six times the copper content), suggesting that the bulbs have an enhanced ability to bioaccumulate lead, rendering them even more toxic to grazing animals. Bioaccumulation is evident in the high concentrations of lead and copper detected in those parts of plants likely to be grazed by herbivores. The leaves of *Plantago coronopus* and the composite *Gymnarrhena micrantha* on the slag sites were observed to be frequently grazed by sheep and goats.

The woody shrub-trees *Ephedra alte* and *Acacia* spp. have deep roots, and the roots of the latter on the most polluted ground have the highest concentrations of lead detected in this study. It is clear that both of these taxa are bioaccumulating and transmitting significant concentrations of lead and copper from their roots to their leaves, where the metals can be re-cycled by being eaten by grazing and browsing animals or by falling to the surface as leaf

Taxon	**Family**	**Smelting slag WF5053/1**	**Smelting slag WF5053/2**	**Control site SP1/1**	**Control site SP1/2**
Asphodelus fistulosa	Liliaceae	5	0.3	6	0.4
Ephedra alte	Ephederaceae	18	0.7	15	0.6
Gymnarrhena micrantha	Compositae	10	1.3	12	2.2
Haloxylon salicornicum	Chenopodiaceae	11	0.4	15	0.6
Hordeum glaucum	Gramineae	21	2.0	15	2.4
Plantago coronopus	Plantaginaceae	8	0.8	6	0.2
Urginea maritima	Liliaceae	30	1.2	18	0.7
Acacia	Leguminosae	trace			
		Percentage cover values			
Copper in topsoil		11,961 ppm	917 ppm		
Lead in topsoil		15,204 ppm	1564 ppm		

Table 3.8 *Percentage cover values of main plant taxa on smelting spoil near Khirbat Faynan and control sites (modern surface sediment samples SP1/1 and SP1/2 are located on Figure 3.13, the 'control' is located* c.*2.5 km to SSE of the smelting slag site WF5053). Each cover value is the mean of three quadrants each measuring 25 m × 1 m. Lead and copper contents (mg/kg^{-1}) were established by AAS analysis of plant material collected from contaminated and relatively less-contaminated habitats. Each result is derived from a minimum of three replicates from carefully washed samples. (After Pyatt* et al. *2002.)*

litter. Variations in leaf form are also likely to influence the provision of lead and copper to grazing and browsing animals (Ylaranta 1996). For example, *Plantago coronopus* has a low-growing rosette form with a tendency towards the horizontal presentation of its leaves, a leaf form likely to be effective as a depositional sink for wind-blown particulates accumulating in stomata or other surfaces on leaves. In contrast, a taller non-woody taxon such as *Asphodelus fistulosa,* which is not attractive to grazing animals in the area, has a tendency to the vertical presentation of leaves, making it a less-effective particulate trap, and as anticipated the concentrations of lead and copper in its leaves were found to be comparatively low.

The impact of metal pollution on modern ecological and agricultural productivity, with implications for past productivity, is evident in Figure 3.15, which shows seed production of wild barley, *Hordeum glaucum* along the survey line SP1–8. The height achieved by each plant of wild barley – which is one simple measure of plant productivity – did not appear to alter with increasing distance from the slag concentration, but the production of seeds varied notably. Seed production on the main slag site (samples 1 to 6) was typically *c*.15 seeds per plant, whereas it increased progressively to 20 and then 27 seeds per plant with increasing distance from the centre of pollution. Several key points emerge from this study. Evidently, wild barley is tolerant of substantial heavy-metal pollution: even on this most contaminated of land, in this very harsh arid climate, it is possible to obtain a crop. Importantly, however, land 1 km distant from the most contaminated 'hotspots' is at least twice as productive as the more contaminated land nearer the 'hotspots'. Depending upon the particular balance of circumstances in antiquity, attempts in the field systems around Khirbat Faynan to increase the yield through introducing animal manure, night soil, wood, or ash significantly contaminated with metal might have produced progressively lower yields (Pyatt *et al*. 1999; see Chapter 10, §10.4.11). Studies of metal concentrations in surface sediments across the WF4 field system (surface samples SP9–18 and SP24–30) reveal patches of contaminated ground similar to those yielding 15–20 grains per plant in the transect study. It seems likely that these would not have been productive soils. Interestingly, Moustakas *et al*. (1997) showed that the copper concentrations in wheat growing on copper-contaminated soils elsewhere could reach 3.5 times the concentrations produced on uncontaminated controls.

A reconnaissance study of pollution impacts on invertebrates was undertaken in April 1999 and 2000 by Brian Pyatt (Pyatt *et al*. 2002a), following the approaches used in similar desert lands (Ayal and Merki 1994; Mikhail 1993; Tigar and Osborne 1999a,b). Invertebrates play a key role in the cycling of metals within ecosystems, and especially into food-chains and decomposer systems. Three 'spoil' sites were located on metalliferous slag heaps, two control 'pitfall' sites on soils 2 km to the southeast, and an 'ancient field' site on recently ploughed land within the

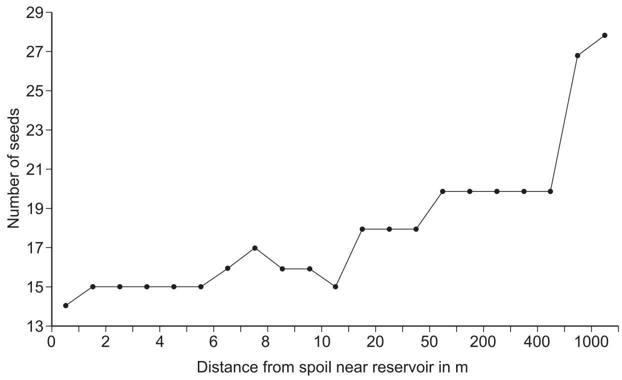


Figure 3.15 *The productivity of wild barley (*Hordeum glaucum*) defined in terms of seed production on soils on the surface of a large alluvial fan at an increasing distance to the south from the centre of ancient copper smelting around the Khirbat Faynan, along the line of transect SP1–8 in Figure 3.13. Each data point is an average based upon the analysis of four plants at each site. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Pyatt* et al. *1999.)*

Plant materials	**Smelting site WF5053**		**Control site SP1**	
	Pb (mg/kg^{-1})	**Cu (mg/kg^{-1})**	**Pb (mg/kg^{-1})**	**Cu (mg/kg^{-1})**
***Acacia* spp.**				
Root	1025	406	124	196
Stem	325	196	54	109
Leaf	209	71	72	40
Urginea maritima				
Bulb	540	95	87	46
Gymnarrhena micrantha				
Roots	386	102	43	58
Leaves	248	96	40	60
Haloxylon salicornicum				
Roots	516	96	96	67
Stems	410	83	65	64
Ephedra alte				
Roots	578	603	94	100
Branches	309	520	82	89
Plantago coronopus				
Roots	622	243	51	57
Leaves	594	211	37	38
Asphodelus fistulosa				
Roots	485	126	36	64
Leaves	116	94	30	42
Copper in topsoil	11,961 ppm		917 ppm	
Lead in topsoil	15,204 ppm		1564 ppm	

Table 3.9 *AAS analyses of lead and copper contents (mg/kg^{-1}) of plant material collected from contaminated and relatively less-contaminated habitats. Each result is derived from a minimum of three replicates from carefully washed samples. (After Pyatt* et al. *2002.)*

Sample	Goat skeletal remains <10 years' antiquity		Freshly-slaughtered goat carcass	
	Pb (mg/kg^{-1})	Cu (mg/kg^{-1})	Pb (mg/kg^{-1})	Cu (mg/kg^{-1})
Goat				
molar	126	48	163	21
molar root	18	4		
molar crown enamel	109	70		
molar enamel *(control)*	49	4		
molar dentine	90	20		
molar dentine *(control)*	16	4		
jaw inner (articulated) end	268	33		
jaw inner (articulated) end *(control)*	20	12		
jaw distal (symphysial) end	270	28		
jaw distal (symphysial) end *(control)*	14	5		
lower mandible (symphysial end)			405	39
lower mandible (articular/inner end)			366	65
femur (middle)			192	25
femur (upper region)			355	61
tibia (upper portion)			219	44
hair			326	124
faeces			590	143
Sheep				
molar root	169	55		
molar root *(control)*	26	8		
molar crown enamel	129	22		
molar crown enamel *(control)*	53	6		
molar dentine	94	20		
molar dentine *(control)*	46	6		
jaw inner (articulated) end	359	45		
jaw inner (articulated) end (*control)*	43	17		
jaw distal (symphysial) end	391	51		
jaw (symphysial) end *(control)*	45	19		
(associated sediment)	16	31	100–15,000 ppm	100–12,000 ppm

Table 3.10 *Lead and copper determined by AAS from: 1) goat and sheep carcasses from sample sites 1, 2, and 3 (Fig. 3.13); 2) sheep and goat carcasses from a control site 12 km to east in which each result is derived from three replicates; 3) fresh goat-faeces and a freshly-slaughtered goat that had grazed copper-smelting slag at the Khirbat Faynan. Each result is the average of 24 replicates. (After Pyatt* et al. *2000; 2002; 2005).*

WF4 wall system near SP9. A total of 27 invertebrate taxa was recorded: a mollusc, eight arachnids (spiders, mites, ticks, and a harvestman), and eighteen insects. Of the latter, five taxa were herbivorous, eleven were detritivores, six were predatory, and five were 'social'. Ants were the most widespread group found, particularly *Cataglyphis*, a predatory desert ant widespread in this region and North Africa (North 1996). The survey demonstrated the capacity of a few invertebrate groups not only to live in very arid and contaminated environments but also to accumulate copper and lead differentially within their bodies, with greater concentrations of lead than copper occurring within their tissues. Copper and lead concentrations in these invertebrates indicate significantly higher levels in the individuals from the polluted smelting sites, the enhancement in lead typically being in the order of a multiple of 2–3. Tissue from the abdomen of *Cataglyphis* living on copper slag had 30 times the concentrations detected on the less-polluted control site. Abdomen-gut samples had greater concentrations than leg tissues, indicating that contact with metals in food led to a greater enhancement than contact with metals at the land surface. Older individuals of a species displayed greater concentrations than younger ones. Overall, the evidence suggests that bioaccumulation of metals by these invertebrate communities is taking place through feeding. Baranowska (1995) noted that drought and low humidity facilitate lead uptake and transport to aerial parts of plants, rendering heavy metals available to later stages of the food chain.

The vertebrate fauna of the Dana Reserve and surrounding area is described in 'Amr *et al*. (1996), and more widely in Mountfort (1985) and in the on-line data base and information files maintained by both the Biodiversity Group in the Jordanian Government and the Jordanian Royal Society for the Conservation of Nature. In total, 286 resident and transitory animal species have been identified, including a number of rare species. The materials available for our study of metal pollution pathways in the vertebrate population were fresh goat faeces, the inedible tissue from one freshly slaughtered goat from a herd that grazed the metalliferous slag heaps of the Khirbat Faynan, and skeletal and dental material from the remains of a sheep and a goat found at the site and estimated to have died within the last decade (Table 3.10). The animals that lived in the polluted environment have much higher concentrations of heavy metals in their tissues than those that lived in the distant control area well removed from archaeological sources of these metal pollutants. Lead content is always in excess of copper, as occurred in the plant data, although the opposite is the case for the surface sediments and soils. These data also demonstrate that partitioning of metals is taking place within biological tissues of these vertebrates: lead and copper concentrations are enhanced in the areas of articulating bone surface of the freshly-slaughtered goat, and the lower mandible (symphysial end) has lead contents ten times greater than copper; similar relationships are evident within a jaw and a tooth. These data indicate that interpretations using bone comparisons need to be based on exact anatomical parallels. Similarly, despite analytical care, the concentrations recorded for hair may reflect materials upon as much as within hair: it is inevitable that people would have come into contact with hair-skin and the lead content of these materials handling live animals or using skins. We cannot generalize with any confidence from such a small sample size, but it seems reasonable to suggest that faeces used as manure or fuel would be another route for metal pollutants to accumulate in the agricultural and domestic economy, with lead enrichment likely to be proportionally higher than copper enrichment at the land surface.

Limited comparative information on the lead and copper contents of goat skeletons and their significance for agriculture and the environment has been found. It is known that goats are considered more resistant than sheep to lead poisoning, with minor poisoning of goats occurring at concentrations of lead in excess of 60 mg/kg^{-1} of overall body-weight, whereas symptoms of copper and lead toxicity have been noted in sheep at concentrations as low as 10 ppm (Leita *et al.* 1991; Todd and Thompson 1965), concentrations that appear likely to be exceeded by animals preferentially grazing upon metal-rich slag heaps. Horses and cattle have become seriously ill or died when grazed on vegetation growing on soil with lead concentrations of *c*.1000 ppm (Thornton *et al*. 1990). The concentrations noted on the distant 'control' site are of this order, and the soils of the area around the Khirbat Faynan may exceed these levels by a factor of ten. Parallel information on metal concentrations on the sheep and goat population of the modern environment is not available. Clearly sheep and goat herds live on, graze on, and breed amongst the polluted areas nowadays, but it seems probable that, especially in times of intensive industrial activity, sheep, goats, horses, and camels, as well as other non-domesticated mammals, would have been vulnerable to health problems stemming from the consumption of forage grown on polluted soils.

The field and laboratory observations discussed in this section are combined in Figure 3.16 with other published research to produce a simple qualitative inventory appropriate to this particular environment, of the sources, pathways, and sinks in the human, agricultural, domestic, and industrial components of the ancient ecosystem, as well as its geological, hydrological, and atmospheric components (Grattan *et al*. 2007). The model highlights the complexity of the functional inter-relationships that exist, and must have existed in the past, between the biotic and abiotic worlds, between people and their desertic world. There is insufficient information in the study area to estimate either the quantities involved or the rates of exchange, although they clearly differ substantially in scale, importance, and duration. Although this model is only a simple compartmentalization of the many events, processes, reservoirs, sinks, and influences that would have interacted in complex ways, the model does serve to emphasize the often unknown complexities of interpreting geochemical records of Holocene sequences in terms of past lives and landscapes, and the likely complexities of the legacies that they left.

3.8 Radon gas and human health in the mines

^{222}Radon (^{222}Rn) gas is a naturally-occurring isotope in the decay series of ^{238}uranium, with a half-life of 3.82 days and decays by α-emission. The decay products are also radioactive, and two progeny, the isotopes of polonium ^{214}Po and ^{218}Po, also decay by α-emission with longer half-lives. These isotopes make substantial contributions to the total radiation received by people living and/or working underground. Information on modern concentrations of ^{222}Rn serves as a proxy measure and summary term for the isotopes of polonium that may damage human health. Whilst ^{222}Rn is present through the world's atmosphere, including soil and underground gases, as well as ground water, the comparative abundance of radioactive isotopes that may be precursors of ^{222}Rn in the Precambrian and Palaeozoic bedrocks of the Faynan Orefield suggests that sustained exposure to this gas may have had significance for human health in the past. Radon gas is not detectable without specialist measuring devices.

The potential health risks that stem from sustained long-term exposure to the decay products of ^{222}Rn are relatively well-documented. When retained in the lung, inhalation of ^{222}Rn may be followed by a potentially large radiation dose being absorbed in the tracheobronchial epithelium from the short-lived alpha particle-emitting products ^{218}Po and ^{214}Po (Brill *et al*. 1994). The magnitude of the radiation dose depends upon the rate of radionucleide deposition and residence time of particles in the lung. The rate and depth of breathing will have an impact on the depth of penetration into the lung, the deeper particles having the longer residence time. Knutson and Tu (1996) have shown that between 5 and 30% of the total potential alpha energy is a result of alpha particle emission from daughter isotopes being bound to relatively coarse (i.e. larger than 1000 nm) dust particles, sizes that would be expected in a modern working uranium mine and in the ancient mines of Phaeno. Gillmore *et al.* (2000a,b; 2001) demonstrated that ^{222}Rn has complex modes of transport and dispersion in caves and mines, with accumulation taking places in localized areas of dead air where the ventilation is poor. One consequence of sustained exposure to radon gas recognized elsewhere is a link between elevated ^{222}Rn concentrations and lung cancer (Behounek 1970; Bilban 1998; Brill *et al*. 1994; Field *et al*. 2000; Hodgson and Jones 1991; Kendall 2000; ICRP 1994; Lorenz 1944; Morrison *et al*. 1998; Phillips and Denman 1997; Sammet *et al*. 1991; Strong *et al*. 1975). In the United Kingdom, within the population at large, everyday exposure to radon-progeny is thought to result in approximately 2000 deaths each year from lung cancer, some 6% of the annual total of 33,000 lung-cancer deaths (Green *et al*. 1992), making radon the second largest cause of lung cancer after smoking (Spear 2000). Henshaw *et al.* (1990) suggested there may also be relationships between elevated radon levels and myeloid leukaemia, cancer of the kidney, and melanoma. Increased concentrations of radon decay products on the skin surface have been implicated in skin cancer (Denman *et al.* 2003).

Vegetation

Composition, form, cover; interception capability; soil drainage; soil biological, physical and chemical properties; bioaccumulation in food chains and decomposer chains; soil binding and protection; long-term changes and responses to climate, colonization and recolonization, fuel gathering, wood for construction, grazing and browsing, clearance and burning; selective uses, susceptibility to toxins especially riparian vegetation.

Regional and local climatology

Global and regional climate changes, wetter early Holocene, mid-Holocene aridification, arid later Holocene. Short-term fluctuation and extreme events, droughts, floods, storms, local climatology. Katabatic winds, wildfire, bioclimatology, shelter and shade, updraughts.

Sources of ore metals in the environment

Bedrocks: Lower Palaeozoic and Precambrian

Natural Quaternary sediments: Polluted sediments and soils; Colluvium; Fluvial sediments; Aeolian sediments; Alluvial fans

Mining, smelting and storage
Wastes/slag/stockpiles/products

Bioaccumulation and human activity

Differential recycling by deep-rooted trees, pasture and crops, grazing and geophagy by invertebrates and vertebrates; defecation by herbivores. Burning wood and manure as fuel that releases or absorbs metals in ash. Human inhalation, ingestion, consumption, contact, washing and cleaning; medicines; dyes and cosmetics, cooking; use of manure as fertilizer, night-soil as fertilizer; waste disposal; open water storage and transport, washing, handling and contact with tents, clothing, textiles, artefacts, animals, fuel, tents, and materials. Metal slag as building material.

Land-surface changes

Inter-connected changes in surface geomorphology and soils, especially soil and slope stability from mass-movement, mining, quarrying of building stone, rock breaking and crushing, smelting; trampling by people, animals, wheeled and sledge vehicles; ploughing, tillage, sowing, harvesting, rain and floodwater collection, transport and use of plant wastes, animal manures and night-soil as fertilizer; changes in infiltration capacity, overland flow, in surface and stream run-off rates; differential erosion, transport and deposition by wind and water, deposition of dust, changes in the size, erodibility, floods and windstorms on the floodplain. Sub-surface differential leaching, translocation and accumulation, and biological concentration and transport by soil fauna and vegetation. Accumulation behind walls, within and from natural and constructed water courses and water-storage facilities; upon and within tents, clothing, artefacts.

Figure 3.16 *An inventory of the natural and human processes that interact with each other as well as with events to influence the past and present concentrations of heavy metals in the Holocene in the desert regions of the Faynan Orefield. (Based upon numerous sources, but especially: Agricola 1556; Badri* et al. *1996; Barker* et al. *1997; 1998; 1999; 2000; Bogoch and Brenner 1994; Clark* et al. *1996; Dayan* et al. *1991; Dias Da Cunha* et al. *2002; Ferguson 1990; Foulkes 1990; Gee* et al. *1997; Giller* et al. *1998; Grattan* et al. *2001; 2002a,b; 2003a,b; 2007; Görres and Frenzel 1997; Jonnalagadda and Nenzou 1997; Jung and Thornton 1997; Leita* et al. *1998; Lewin* et al. *1977; Maskell* et al. *1996; Moreno* et al. *2003; Nriagu 1979; Overstreet* et al. *1982, 106; Pelig-Ba* et al. *2001; Pyatt* et al. *1999; 2002a,b; Rawat* et al. *2003; Rothenburg* et al. *1978; Saffarini and Lahawani 1992; al-Salah and Coate 1995; Sanchez* et al. *1998; El-Shazly* et al. *1971; 1977; Sheppard and Evenden 1994; Singer* et al. *2003; Venugopal and Luckey 1978; Walker* et al. *1997; Wray 1998.)*

The atmospheric radon concentrations in the ancient mines and shafts of Faynan reported here were estimated using passive alpha track-etch time-average devices from NE Technology, a source approved by the National Radiological Protection Board of the United Kingdom. These devices were used because of their robustness, ease of handling, and visibility, and because a number could be placed to record simultaneous values. The standard unit of radiation measurement employed was the Becquerel, one atomic disintegration per second per cubic metre of air (that is, $Bq.m^{-3}$). The concentrations of radon at various locations were determined at mines and adits in the Wadi Dana, the Wadi Khalid, and at the Umm el-Amad mine (Figs 2.2, 4.40–4.42). Attempts were made to distinguish radon concentrations near the front from those in the rear of the mines. The location and recovery of the passive detectors in these mines and adits around Wadi Faynan presented numerous difficulties stemming from the remoteness and inaccessibility of the sampling locations. The placement of the passive detectors within each mine or adit reflected an uneasy compromise in the field between experimental design, preventing deliberate or accidental movement of the detectors, ensuring the detectors could be relocated, and our capacity to revisit these sites on only three occasions. Time-averaged readings of radon concentrations were taken for exposures in the winter 1999–2000, from November to January, and from January to March. As ^{222}Rn is the most soluble of the noble gases, it is possible that radon levels underground in these caves and adits may also have been enhanced by degassing from moving groundwater (Brill *et al.* 1994), but we have no information on ^{222}Rn in such waters.

The eight ancient mines and adits include chambers up to 70 m to 100 m long, with some adits up to 100 m deep, including one of the largest such mines in the ancient world, Umm al-Amad. Field survey showed that most had poor or no ventilation. Wind strengths and directions are shown

Location Wadi	Survey 1 Bq.m^{-3}	Survey 2 Bq.m^{-3}	Entrance	Entrance dimensions: height × width (cm)	Enlarged by recent activity?	Mine type/angle of descent	Length of mine/distance from entrance of detector (m)	Aspect	Ventilation
Dana - mine 1 DLS	540	658	Very exposed	190 × 120	Yes	Adit/5°	45/42	S	Poor
Dana - mine 2 DLS	611	976	Very exposed	180 × 130	Yes	Adit/8°	38/36	S	Poor
Dana - mine 3 DLS	737	806	Very exposed	185 × 140	Yes	Adit/9°	37/35	S	Poor
Khalid - mine 4 DLS?	408	245	Moderately sheltered	200 × 120	Yes	Adit/4°	45+/43	W	Poor
Khalid - mine 5	532	400	Moderately sheltered	175 × 140	Yes	Adit/17°	100/+100	NW	Very poor
Khalid - mine 6	738	2493	Very exposed	190 × 1250	Yes	Adit/10°	50/48	SE	Poor
Khalid - mine 7	1008	996	Very sheltered	90 × 75	No	Adit/5°	75+/60	NW	Very poor
Umm al-Amad 30 m		262	Moderately exposed	250 × 60	No	Adit/0°	150/30	N	Very poor
Umm al-Amad 150 (i)		504	Moderately exposed	250 × 60	No	Adit/0°	150/150	N	Very poor
Umm al-Amad 150 (ii)		323	Moderately exposed	250 × 60	No	Adit/0°	150/150	N	Very poor

Table 3.11 *Modern concentrations of radon gas detected in mines and adits in the study area, together with their key topographic properties. (After Grattan* et al. *2004.)*

in Table 2.1. The atmosphere of these mines was found to be dusty and hot, a feature intermittently augmented in situations in which dust storms from the desert lowlands to the south are not unusual. The mines and adits surveyed penetrated complex ore bodies formed in the Palaeozoic sedimentary bedrocks described previously. Mines 4–6 have been enlarged by recent ore prospection, but Mine 7 appears unaltered from its original state of use. The results obtained from the radon detectors are set out in Table 3.11 together with details of their locations.

In the Wadi Khalid mines, the average radon measurements in surveys 1 and 2 were 671 Bq.m^{-3} and 1033 Bq.m^{-3} respectively. Mine 6 faces southeast and is protected from southwesterly winds and their dust load by recent mining debris. In the second survey period, the radon measurement here reached 2493 Bq.m^{-3}, the highest value measured in this survey. Mine 7, an unaltered ancient adit with a very small and sheltered entrance, returned high radon concentrations in both surveys, 1088 and 996 Bq.m^{-3}. The Umm al-Amad mine appears to present less of a radon risk than the Faynan-Dana-Khalid mines.

The concentrations of ^{222}Rn in the Faynan Orefield are notably higher than those detected elsewhere in recent studies of domestic and industrial situations in Jordan, which are typically associated with limestone bedrocks (Abumurad 2001; Ahmad *et al*. 1997; Khatibeh *et al*. 1997; Al-Kofahi *et al*. 1992; Kullab *et al*. 2001), but they are lower than those reported for recently active or abandoned mines elsewhere, especially where there have also been extensive mineralizations in uranium as well as copper or other ores (Behounek 1970; Gillmore *et al*. 2001; Sengupta *et al*. 2001). Nevertheless, all the Faynan mine readings are above the 200 Bq.m^{-3} Action Level recommended for places of habitation in the UK by the National Radiological Protection Board and most exceed those permitted in a modern UK workplace (400 Bq.m^{-3}).

Estimations of the length of time considered safe for long-term occupation of these particular mines/adits under modern conditions (assuming these recorded concentrations are representative, and they are probably under-estimates) may be made using the approach developed by Denman and Parkinson (1996), who estimated dose from observed radon concentration by:

dose (mSv- milli Sieverts) = [(^{222}radon concentration in Bq.m^{-3}) × (duration in hours)]/126,000.

A basis for estimating the significance of these data for past populations was proposed by Grattan *et al.* (2004), who made the conservative assumption of an exposure time of ancient professional mining staff of only eight hours per day for a year. On this basis, for example, at a radon gas level of 2493 Bq.m^{-3} (such as Khalid mine 6), the dose received could be calculated as 57.77 mSv. This can be compared with the actual recommended maximum for a member of the public in the UK, which is 1 mSv per year (IRR 1999). Assuming an average radon level in a Dana mine to be 721 Bq.m^{-3} (Table 3.11, surveys 1 and 2), then the mine professionals would have experienced a dose of 16.7 mSv, a high dose by modern ICRP recommendations. The average radon gas level in the Wadi Khalid mines is 852.5 Bq.m^{-3}, so the dose here would be in the order of 19.8 mSv. The average level in Umm al-Amad mine is 363 Bq.m^{-3} and hence the dose could be 8.4 mSv. On this basis, derived equivalent doses in the Faynan mines would range from 8.4 mSv to 57.77 mSv.

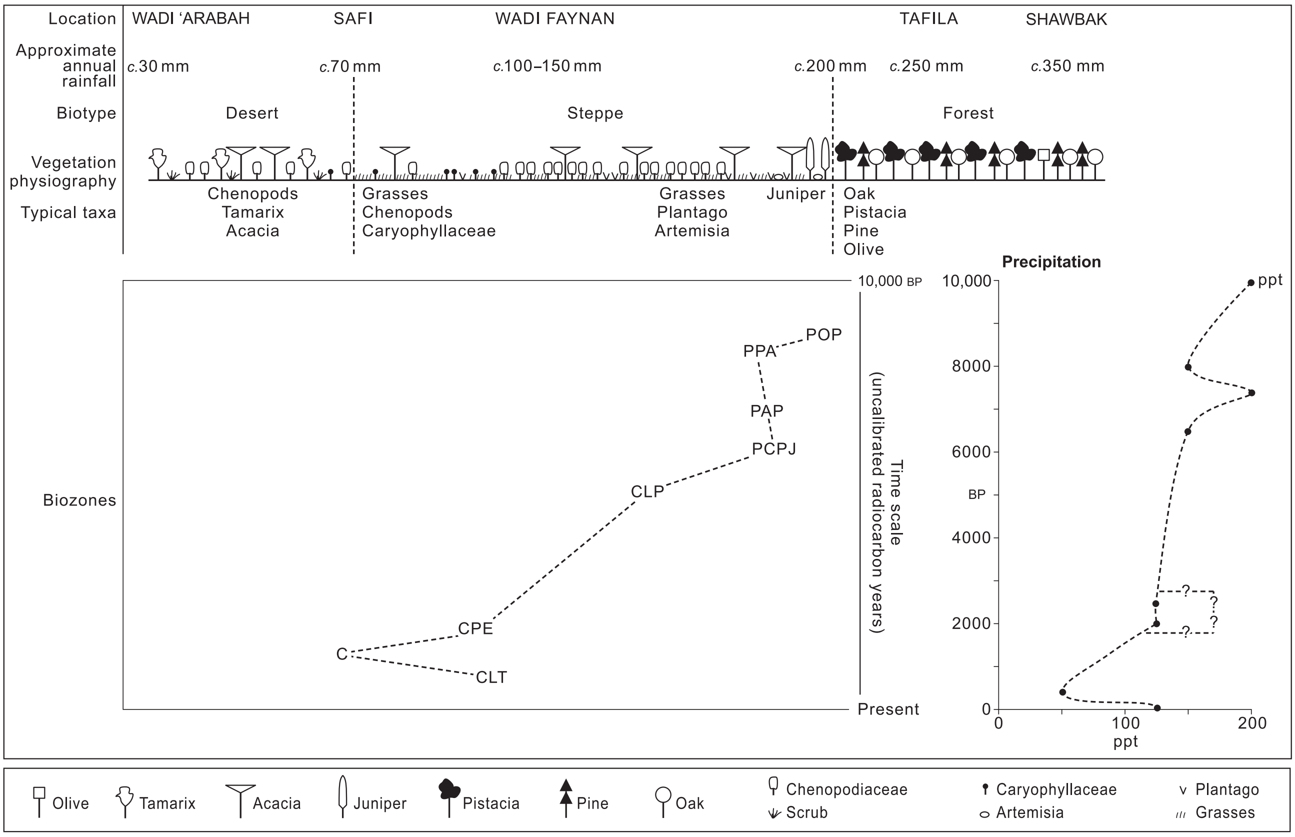


Figure 3.17 *The generalized course of vegetational history as it relates to inferred plant biotype and precipitation (ppt), derived from palynological evidence in the Khirbat Faynan region for the last* c.*9000 years. The wetter period for the classical period, inferred from geomorphological and sedimentological field evidence, but not evidenced in the palynological evidence, is separated and shown by question marks. The geochronology of this history is reconstructed from a small number of radiocarbon dates; caution needs to exercised when correlating events recognized here with others identified outside the wadi. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, partially after Hunt* et al. *2004; 2007b.)*

It is likely that the radon concentrations detected in this study of the ancient mines and adits would have been higher in times of active mining in the past as a result of the greater dust concentrations caused by mining, disturbance, poor ventilation, soot from candles, greater physical exertion, and rock-extraction. Grattan *et al.* (2004) anticipated that professional miners, guards, overseers, and administrators spending much of their working lives in these Faynan caves and adits, already at general risk to their health from exposures to suites of toxic metals in many aspects of their lives, may have been at risk of developing soft tissue cancers in as little as 7–15 years. Doll (1959) suggested that the latent period for disease onset is commonly in the order of 15–30 years in an above-ground modern industrial setting. Behounek (1970) inferred that, in former mines in the Czech Republic, the average induction time for lung cancer was seventeen years, with a minimum of thirteen years during the late 1920s to late 1930s. Harting and Hesse (1879a,b) estimated that 75% of all deaths in miners from the Ore Mountains of Saxony in the period 1869–77 may have been due to induced lung cancer.

3.9 Holocene landscapes in the Wadi Faynan: an outline palaeoenvironmental framework

An outline framework of changes in local environment, especially in precipitation, based upon evidence from palynology and charcoal for the Holocene at the Faynan is set out in Figure 3.17 and Table 3.5. These reconstructions provide an initial basis on which to view the detailed archaeological-industrial-palaeoenvironmental discussions for particular periods of time presented in Chapters 7–11. In the absence of continuous detailed information from a mire or cave-speleothem in the Faynan area, Figure 3.17 and Table 3.5 have been established by syntheses of all available information on the modern topography, biotypes, measured precipitation, modern pollen taphonomy, and the palaeoenvironmental information on the character of the land surface. The reconstructions indicate that, through the study area, past biotopes, like modern biotopes (in terms of vegetation), can be related to altitude. Ancient vegetation deduced from the pollen recovered has then to be matched on the basis of judgement with Kurschner's (1986) vegetation types and altitude to ancient annual precipitation. The project has not tried to calculate a quantitative pollen–climate transfer function. This reconstruction was also supported by examination of pollen taphonomic studies near the Faynan by Mohamed (1999) and by reference to an altitudinal transect of pollen rain for the Jordanian rift-margin edge not far from Faynan (Davis and Fall 2001). Detailed analysis of the prevailing vegetation, climate and human interactions with the environment is provided in Chapters 7–11. Overall, in brief, the reconstruction indicates that wetter conditions occurred in the early Holocene, which encouraged biotopes living higher on the modern mountain front to grow on the wadi floor to a point in the order of *c.*8000 radiocarbon years ago. There was a drier episode (PAP) associated with greater numbers of grasses and other steppe-like plants, after this point, but conditions again became slightly wetter and vegetation became slightly more diverse and woody. This biotope was replaced in the order of *c.*6000 years uncal. BP by vegetation that became ever more steppic and then desertic as overall precipitation declined. The lowest precipitation levels took place between *c.*AD 1400 and 1900, whereupon a wetter climate emerged. The Faynan landscape lost its fully desertic character and took on its modern steppe-like nature.

The outline geomorphic record for the Holocene also suggests an over-riding significance of climate and sustained climatic change for geomorphic systems in the Faynan (Fig. 3.8). Whilst past human activities are recognizable in the geomorphic record, there appears to have been no overwhelming role for human agencies in the overall geomorphological evolution of these wadis. Meandering processes dominated the braid-plain before 6000–7000 years BP. The subsequent inferred climatic aridification evident in the palynological history at *c.*6000 yrs uncal. BP was associated with the loss of meandering streams and the progressive dominance with the passage of time of braided-fluvial and aeolian geomorphic processes. The arid episode *c.*600–100 years ago was associated with widespread aeolian activity interspersed with occasional floods. Clearly various periods or individual events may not be represented in the sequence as we have discovered it so far.

Whilst this overall pattern of events appears reasonable in terms of current understanding of how geomorphic and vegetational systems respond to climatic shifts, one important anomaly emerges when the different lines of stratigraphic, geomorphic, palynological, and geochemical evidence are compared for the Iron Age to Byzantine period. The palynological evidence and the charcoal studies indicate at that period of time a landscape of desertic and steppic terrain, relatively lacking trees, shrubs, or vegetational richness, but the sedimentary evidence from the Khirbat Faynan barrage for Lithofacies 4 implies sustained greater precipitation that ought to have significantly fostered vegetation growth and spread of tree taxa. This anomaly indicates that a simple equation between pollen assemblage and precipitation may not be appropriate for these periods, when vegetation may have been restricted by profound industrial and agricultural impacts in a time of otherwise relatively high precipitation. In the absence of large-scale human industrial activity and wood extraction at this time, this increased surface wetness ought to have led to a notably more productive and diverse vegetation. This anomaly is indicated by question marks in the inferred precipitation record in Figure 3.17.

The patchiness of the surviving sedimentary record observed in the study area emphasizes that geomorphic and palaeoecological inferences derived from a particular deposit may not be representative of the longer periods of time allocated to each pollen biozone in Table 3.5. In particular, significant periods of time are poorly represented or not represented at all, short fluctuations may have been missed, and deposits of different climatic affinities may have been removed or re-worked. These limitations argue that this outline palaeoecological model and its chronology need to be regarded as approximate, certainly as provisional, and any wider implications or correlations must be treated with substantial caution. Nevertheless, despite the limitations of the new evidence, the Holocene palaeoenvironmental framework established for the Wadi Faynan does have similarities with those observed in adjacent regions. Our palaeoclimatic sequence has similarities with other palaeoclimatic sequences proposed for the southern Levant. It also contrasts with palaeoclimate sequences inferred in the northern Levant. The Faynan record supports the view that a climatically-derived vegetational discontinuity appears to separate the northern Levantine countries (Turkey and Iran) from the southern Levantine countries (Jordan, Palestine, parts of Saudi Arabia). Palaeoclimatic patterns seen in the Wadi Faynan can also be recognized in the Gulf States and North Africa. In the latter, several lines of evidence suggest that those areas currently occupied by hot desert were relatively cool and moist during the earlier Holocene *c.*10,000–4000 BP (summarized in Arz *et al.* 2006; Hunt *et al*. 2004; 2007a; Staubwasser and Weiss 2006; Weninger *et al.* 2006; and especially Migowski *et al.* 2006). Not unexpectedly, the coarse scale of the Faynan data precludes the precise local identification of the climatic events now recognized with some precision elsewhere in the region (e.g. at 8.2 kya, 5.2 kya, 4.2 kya). The moist climate of the early Holocene may have been caused primarily by the influence of the southwest monsoon and the behaviour of airflow in the middle and upper troposphere (COHMAP 1988; Ritchie 1991; Staubwasser and Weiss 2006). A stronger monsoonal circulation and a northward shift of tropical convectional rain could have brought much more moisture to the Sahara than it does now, as well as to Arabia and northwest India. Our study suggests that this climatic pattern may have also occurred in Jordan.

Within the second half of the Holocene in the Wadi Faynan, there has been sustained aridity and suggestions of small-scale but significant fluctuations in wetness. In Libya, the dry phase of the second half of the Holocene was interrupted by moister conditions *c.*3000–2000 BP (Pachur and Braun 1980). Mawson and Williams (1984) reported

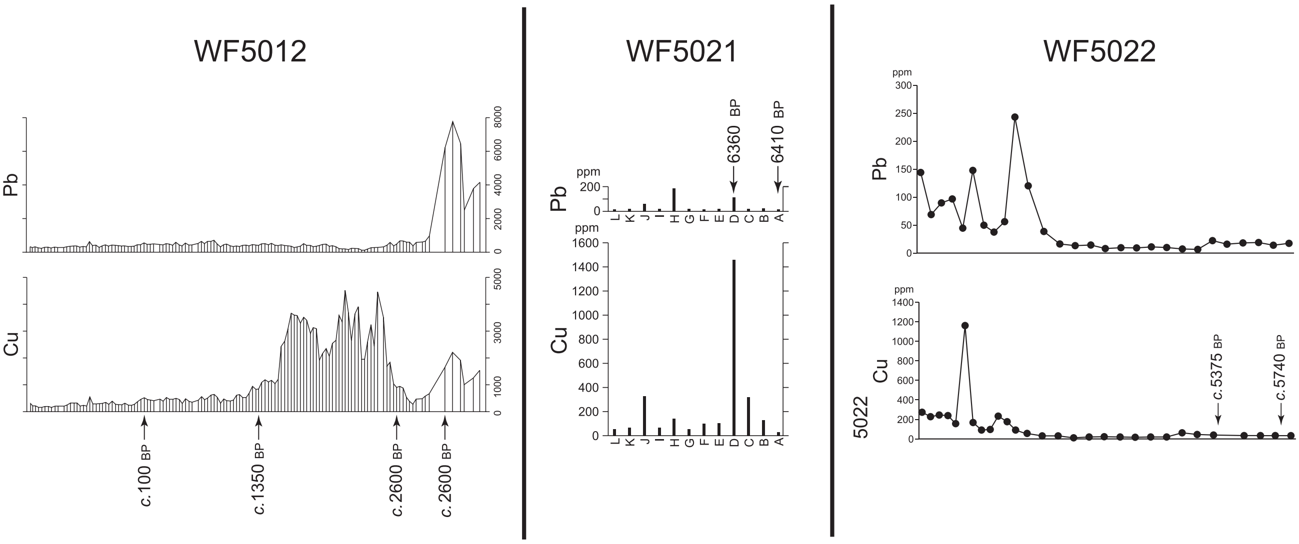


Figure 3.18 *The generalized course of anthropogenic pollution by copper and lead over 8000–9000 years in the Wadi Faynan using information from three sites: WF5012, the excavated sediments behind the Khirbat Faynan barrage; WF5021, fluvial channel sediments* c.*100 m east of Tell Wadi Fayan; and WF5022, Tell Wadi Faynan. The horizontal axis shows the concentrations of copper and lead. The scale of the* x*-axis varies to some degree between sites. The WF5022 record spans from the Late Neolithic/Chalcolithic to the Classical. WF5021 probably dates roughly to the Early Bronze Age (3600–2200 BC). WF5012 spans from the first millennium BC to the present day; it yielded two identical radiocarbon dates of* c.*2600 BP at different depths (see text for discussion). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Grattan* et al. *2007.)*

humid conditions throughout North Africa during the period *c.*2400–1400 BP, much as we have found in the Faynan. Broadly similar patterns of inferred precipitation change have been recognized in the higher resolution records and syntheses of Arz *et al.* (2006) and especially Migowski *et al.* (2006), and Jones *et al.* (2006). Marked changes in precipitation were also reported earlier in Morocco (Lamb *et al*. 1995) and in the Nile head waters (Hassan 1981; 1997). There is clear evidence in the Faynan and its region that overall aridity in the period 600–100 years ago, broadly equivalent to the 'Little Ice Age', was a time punctuated by short rain-storms or brief episodes of wetness. The later local presence of slightly wetter modern conditions has also been detected elsewhere (Heim *et al*. 1997; Hunt *et al*. 2007a; Jones *et al.* 2006; Migowski *et al.* 2006).

As a result of our observations on process, and investigations of aeolian, fluvial, and lacustrine deposits in the Wadi Faynan area, we have also been able to produce an outline history of metal pollution involving copper and lead released from ore-processing and smelting in the area for a period of approximately 7000 years, a reconstruction that makes some allowance for the effects of re-working and re-cycling (Fig. 3.18). Site WF5021 is the oldest for which we have information. Samples D, and perhaps C, H, and J, from the ash and fluvial deposits of the Faynan Member (upper component) have notably higher ppm of copper than occur in the background indicated by the other samples. In Chapter 8 we indicate why these increased concentrations of copper reflect human activity in the Early Bronze Age rather than chance effects in a mineralized environment. The concentrations of copper and lead determined from the overlying wind-blown and water-washed sediments of the Tell Loams at WF5022 are low – often mimimal – for the lower half of that sediment body. Subsequently episodic increases occured in the abundance of copper and lead in the Bronze Age to Classical-period sediments at WF5022. Significant contamination, particularly involving lead, is also present in the Middle Bronze Age deposits of Lithofacies 6 exposed by excavation at WF5012 up-wadi of the Khirbat Faynan barrage (Chapters 8 and 10). These peaks and troughs are associated with ore-processing and smelting from late prehistoric to Classical times (Chapters 8–10). Heavy-metal pollution in copper is at its most profound in WF5012 and displays a series of episodic pulses that span the period from about 2600 years ago to *c.*1400 years ago. Lead pollution was of only minor significance at this time (see Chapters 9 and 10). After this time, the abundance of heavy metals being deposited in the shallow wadi decline dramatically, pointing to the end of most or all ore-processing and smelting at the site. The slow reduction in copper concentrations in the accreting sediment body after the Roman–Byzantine period points to their slow but nevertheless progressive loss from the land surface by natural processes (see Chapter 11). Lead was evidently lost less rapidly over this long period. A small peak in concentrations of copper and lead in the WF5017 borehole, but not in the WF5012 excavation, may or may not correspond to the brief resurgence of ore-processing and increased pollution at *c.*cal. AD 1414–1624 evidenced by the calibrated radiocarbon date of charcoal from copper

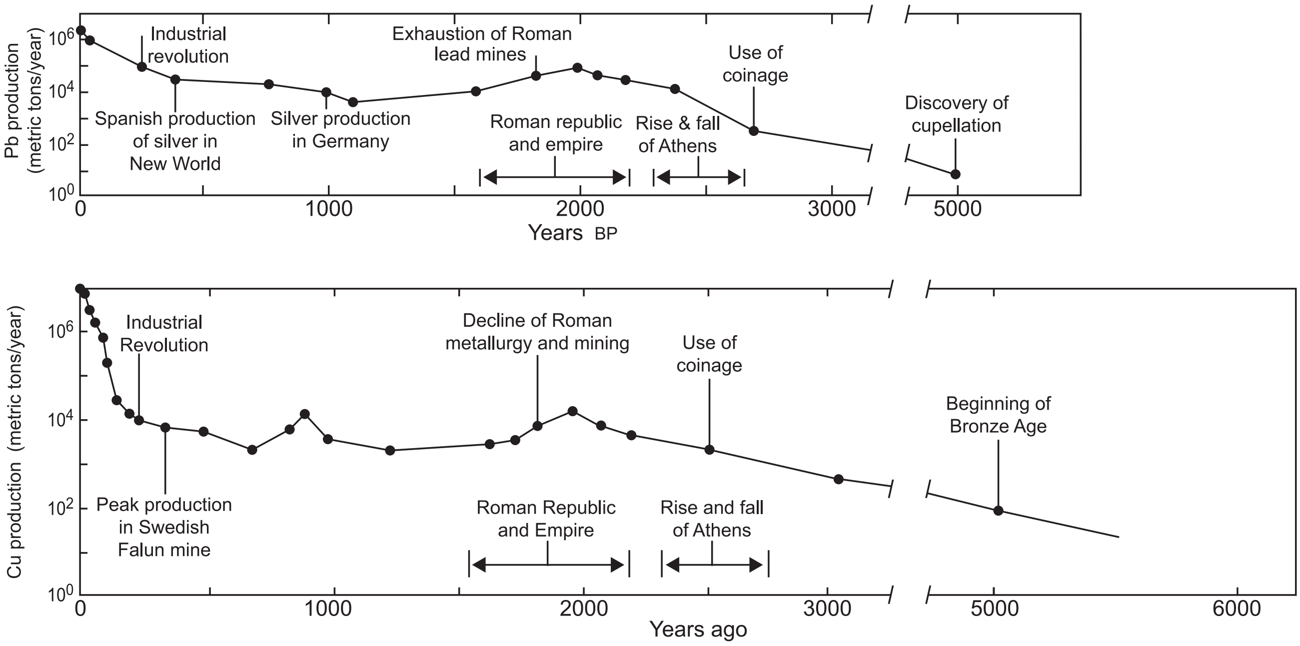


Figure 3.19 *Published records of the estimated influx of heavy-metal pollution evidenced from well-dated ice sheets and mires at high altitudes or high latitudes for the global atmosphere. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Batifol* et al. *1989; Boutron and Patterson 1986; Boutron* et al. *1990; 1995; Shotyk* et al. *1996; 1997; 1998.)*

slag/polluted sediments found near the Khirbat Faynan at WF5741 (Beta-203412; see Chapter 11).

The pattern of heavy-metal pollution indicated by our geochemical studies in the Wadi Faynan displays notable similarities with the changing patterns of metallurgical activity identified by Hauptmann (2000). Most notably, the changing intensity of mining and smelting reconstructed from the Chalcolithic to the classical period is paralleled by the changing intensity of pollution evidenced in the geochemical record. Similarly, the effective loss of industrial activity after the Byzantine period in the Faynan area is matched by the geochemical pollution record, which over the last 1400 years primarily reflects the very slow differential loss of heavy metals brought about by natural processes working at the surface of the landscape. On the other hand, the pattern of metal pollution over time in the Faynan does not demonstrate any significant parallelism with the geomorphological evidence of the prevailing processes of erosion and deposition, nor with any inferred changes in climate, that we have discerned here (Figs 3.8, 3.19). These relationships are examined in more detail on the basis of our new information in Chapters 8–12.

The record of heavy-metal pollution derived from the three Wadi Faynan sites (Fig. 3.18) is compared in Figure 3.19 with published global records of airfall copper and lead derived by studies of particulate fall-out onto ice sheets and mires at high latitudes and/or high altitudes (after Batifol *et al.* 1989; Boutron and Patterson 1986; Boutron *et al.* 1990; 1995; Grattan *et al.* 2007; Shotyk *et al.* 1996; 1997; 1998). Given that Figure 3.19 shows 'global' measures of airfall heavy-metal pollution of the entire northern hemisphere atmosphere, obtained in distant places, with those obtained from a few sites in the Wadi Faynan, the general similarity is remarkable. Obviously pollution from the Wadi Faynan was not driving the global air-pollution record, but it is surely significant that it chimes with the changing nature of industrial activity in the world's large-scale emerging economies (Grattan *et al.* 2007). The significance of these relationships is examined further in Chapter 13.

4. Recording and classifying the archaeological record

Oliver Creighton, Graeme Barker, and David Mattingly

4.1 Introduction

The archaeological record of the Wadi Faynan is dominated by stone. However much past societies in dryland regions made use of organic materials, in these frequently deflated environments survey archaeology will inevitably have a strong focus on the identification and recording of humanly created or altered stone structures. The vast majority of site numbers designated during the archaeological survey therefore relates to features of this type. While it was recognized that what might superficially appear to be discrete archaeological 'sites' were sometimes component parts of more extensive features such as cemeteries, wall or field systems, or settlements, and often inter-related in some way, in the first instance the recording of the Wadi Faynan's surface archaeology had to be based on the designation of individual 'sites'. The project recorded over 1500 such 'sites', ranging in size and complexity from single discrete graves or isolated surface artefacts to multi-phase settlements and industrial complexes. A little under one third of this total lay within the WF4 field system and its outliers, the remainder being located in the surrounding landscape. This is an extraordinary density of archaeological features, for the most part recorded within the core survey area of 30.5 sq. km. The most obvious limitations of the level of recording achieved were the time available to cover such a large number of points and the varying surface preservation and visibility of features. There is no doubt that the data set would repay additional work, notably excavation at selected sites. Our categorization of the sites must be considered provisional in many respects.

Whilst acknowledging the impossibility of total objectivity in field recording, the field survey strategy attempted first to characterize the morphology – or shape and style – of all visible archaeological structures within and outside the field system in as objectively descriptive terms as possible, and then to develop a scheme of classification on the basis of these observations. With the benefit of this information it became possible to build up a series of interpretative categories which could be linked with artefact data and other information about excavated sites in order to form judgements about the possible function, significance, and dating of particular types of archaeological structure. Inevitably, understanding of the range of variability across the full spectrum of site types improved through the lifetime of the project, and there was a steady process of 'lumping' and 'splitting' various categories of site that were recognized, on the basis of an ever-enlarging data set, as discrete entities. Hypotheses about the significance of what we were mapping – and in particular the function or functions of the various site types – developed in parallel with the process of observation and classification.

The typology of site morphology developed for the survey, and which is used in the Survey Gazetteer (Appendix 3), is summarized in Table 4.1. The scheme uses two tiers of classification: major categories (e.g. hydraulic feature), and sub-categories (e.g. aqueduct bridge). In the following text a colon is used to differentiate the major category from the sub-type (e.g. artefact site: isolated find). The purpose of this chapter is to review the evidence for these various categories in turn. Representative examples of different types of structure are described, discussed, and illustrated; important trends in distribution are outlined; and the available dating evidence is summarized.

In parallel with the progressive refinement of morphological categories through the field seasons, the date ranges of particular site types were also actively debated throughout the fieldwork process. The dating of stone-built features in a survey project such as this holds many challenges. Perhaps most important of all, it was apparent at an early stage in the fieldwork, from the evidence of both major monuments with upstanding remains and excavated sites within and near the study area, that no simple linear evolutionary sequence could be assumed for the development of building styles and construction techniques. For example, while the use of regular well-cut blocks in neatly coursed masonry is a recognizable characteristic of much

Major category	Sub-category	No. of examples recorded
Artefact 'site'	ceramics	12
	lithics	31
	mixed	10
	isolated find/finds	5
Domestic structure (1 feature); domestic structures (2–9 features); domestic complex (<9 features)	bedouin encampment	158
	cave	6
	rock-shelter	11
	circular/oval structure, simple	48
	circular/oval structure, complex	5
	circular/oval structure, simple or complex, with enclosure	33
	rectangular structure, simple	101
	rectangular structure, complex	12
	rectangular structure, simple or complex, with enclosure	25
	sub-rectangular structure, simple	10
	circular/oval enclosure	56
	rectangular enclosure	20
	fortified complex	4
	major settlement	4
Excavation	trial trench	10
	section cleaning	5
Field system	simple field system	85
	complex field system	10
	side terraces	6
	possible field system	1
Funerary feature (1 feature); funerary features (2–9 features); funerary complex (<9 features)	cist	11
	grave (undifferentiated)	74
	grave with headstone	16
	stone ring	108
	piled stone grave cover	44
	rectangular kerb grave	4
	rectangular tomb	10
	cairn	171
	cairn with cist	25
	cairn with kerb	30
	cairn with cist and kerb	2

Major category	Sub-category	No. of examples recorded
Hydraulic structure	aqueduct bridge	2
	aqueduct channel	6
	mill	2
	reservoir	2
	channel	5
	parallel walls	63
	barrage	2
	catchment structure	5
	cistern	8
	diversion wall	1
	sluice	42
	spillway	82
Mining feature	adit	49
	entrance chamber	3
	gallery	8
	mine waste	110
	prospect	3
	shaft	29
Metallurgical feature	furnace elements	20
	ore-processing residues	1
	slag heap	16
	slag scatter	29
Miscellaneous structure	cache	2
	cairn	137
	hearth	4
	midden	2
	pen	8
	gateway	1
	rectangular 'box'	3
	stone setting	152
	wall/wall fragment	75
Religious structure	church	2
	mosque	(5?)
Rock engraving	inscription	8
	pictograph	39
	wasm	11

Table 4.1 *Morphological categories of archaeological structures used in the Wadi Faynan Landscape Survey.*

Roman and Byzantine architecture, such technologies are equally identifiable in certain Iron Age, Nabataean, and Islamic sites. Similarly, while small and simple oval and sub-circular structures of rough dry-stone walls were first made by Natufian and Pre-Pottery Neolithic A hunter-gatherers in the region before 10,000 years ago, comparable structures are still made by bedouin communities and we had to assume that similar constructions could have been assembled at any time in the intervening period. Compounding these problems was the likelihood that building materials have been recycled in structures of different dates, as it still clearly apparent in the case of contemporary bedouin sites which re-use building stone from adjacent antique structures. A parallel problem was apparent in the case of mine shafts that may have been re-worked in several episodes between the Chalcolithic and Roman/Byzantine periods, with each successive phase of activity obscuring earlier evidence.

The relative dating of most site types depended on the recording of observable stratigraphical relationships between structures in close physical proximity to one another, or between different elements within a single site. For example, we identified several instances where field walls were observed to be built on top of, so obviously later than, earlier domestic or funerary sites. Such evidence was rare, however, especially where rubble spreads obscured such relationships or where sites had been disturbed by more recent activity. In many cases the precise chronological relationships between closely juxtaposed sites could not be resolved without excavation.

Without excavation, too, the absolute dating of a stone structure to a particular period or periods of the past had to

SITE TYPE	Neolithic	Chalcolithic	Bronze Age	Iron Age	Nabataean	Roman	Byzantine	Islamic/Bedouin
ceramics	●	●	●	●	●	●	●	●
lithics	◖	◖	◖	◖	◆	◆	◆	◆
mixed	●	●	●	◖	◆	◆	◆	◆
isolated finds/finds	❍	❍	❍	❍	❍	❍	❍	❍
bedouin encampment	◆	◆	◆	◆	◆	◆	◆	●
cave	❍	❍	❍	❍	❍	❍	❍	●
rock-shelter	❍	❍	❍	❍	❍	❍	❍	●
circular/oval structure, simple	◖	◖	●	◖	❍	❍	❍	❍
circular/oval structure, complex	◖	◖	●	◖	❍	❍	❍	❍
circular/oval structure, simple *or* complex, with enclosure	◖	◖	●	◖	❍	❍	❍	❍
rectangular structure, simple	❍	❍	◖	❍	●	●	●	❍
rectangular structure, complex	❍	❍	❍	❍	●	●	●	❍
rectangular structure, simple *or* complex, with enclosure	❍	❍	❍	❍	●	●	●	❍
sub-rectangular structure, simple	❍	❍	❍	❍	●	●	●	❍
circular/oval enclosure	❍	❍	❍	❍	❍	❍	❍	❍
rectangular enclosure	❍	❍	❍	❍	❍	❍	❍	❍
fortified complex	◆	◆	❍	❍	●	●	●	❍
major settlement	◆	◆	●	●	●	●	●	❍
simple field system	❍	❍	❍	❍	◖	◖	◖	◖
complex field system	◆	◆	❍	❍	◖	●	●	●
side terraces	◆	◆	❍	❍	◖	◖	◖	◖
possible field system	◆	◆	❍	❍	◖	◖	◖	◖
cist	❍	❍	❍	❍	❍	❍	❍	❍
grave (undifferentiated)	❍	❍	❍	❍	❍	❍	❍	❍
grave with headstone	❍	❍	❍	❍	❍	●	●	●
stone ring	❍	◖	❍	❍	❍	◖	◖	❍
piled stone grave cover	❍	❍	❍	❍	❍	❍	◖	◖
rectangular kerb grave	❍	❍	●	❍	◆	◆	◆	◆
rectangular tomb	❍	❍	●	❍	❍	❍	●	◆
cairn	❍	❍	❍	❍	❍	❍	❍	❍
cairn with cist	❍	❍	●	❍	❍	❍	❍	◆
cairn with kerb	❍	❍	●	❍	❍	❍	❍	◆
cairn with cist and kerb	❍	❍	●	❍	◆	◆	◆	◆

SITE TYPE	Neolithic	Chalcolithic	Bronze Age	Iron Age	Nabataean	Roman	Byzantine	Islamic/Bedouin
aqueduct bridge	◆	◆	◆	◆	◆	●	●	❍
aqueduct channel	◆	◆	◆	◆	◆	●	●	❍
mill	◆	◆	◆	◆	◆	●	●	❍
reservoir	◆	◆	◆	◆	◆	●	●	❍
channel	◆	◆	◆	◆	❍	●	●	❍
parallel walls	◆	◆	◆	◆	❍	●	●	❍
barrage	◆	◆	◆	◆	◆	●	●	❍
catchment structure	◆	◆	●	❍	❍	❍	❍	❍
cistern	◆	◆	◆	◆	❍	●	●	●
diversion wall	◆	◆	◆	◆	❍	●	●	❍
sluice	◆	◆	◆	◆	❍	●	●	❍
spillway	◆	◆	◆	◆	❍	●	●	❍
adit	◆	❍	●	●	❍	●	●	❍
entrance chamber	◆	◆	◆	◆	◆	●	●	❍
gallery	◆	❍	●	●	❍	●	●	❍
mine waster	◆	❍	●	●	❍	●	●	❍
prospect	◆	◆	●	●	❍	●	●	❍
shaft	◆	❍	●	●	❍	●	●	❍
furnace elements	◆	◆	●	●	❍	●	●	❍
ore-processing residues	◆	◆	●	●	❍	●	●	❍
slag heap	◆	◆	●	●	❍	●	●	❍
slag scatter	◆	❍	●	●	❍	●	●	❍
cache	◆	◆	◆	◆	◆	◆	◆	●
cairn	❍	❍	❍	❍	❍	❍	❍	❍
hearth	◆	◆	◆	◆	◆	◆	◆	●
midden	◆	◆	◆	◆	◆	◆	◆	●
pen	◆	◆	◆	◆	◆	◆	◆	●
gateway	❍	❍	❍	❍	❍	❍	❍	●
rectangular 'box'	◆	◆	◆	◆	◆	●	●	◆
stone setting	❍	❍	❍	❍	❍	❍	❍	❍
wall/wall fragment	❍	❍	❍	❍	❍	❍	❍	❍
church	◆	◆	◆	◆	◆	●	●	❍
mosque	◆	◆	◆	◆	◆	◆	◆	●
inscription	◆	◆	◆	◆	❍	❍	❍	●
pictograph	◆	◆	◖	❍	❍	❍	◆	◆
wasm	◆	◆	◆	◆	◆	◆	◆	●

Key
- ● Site can be reliably dated to the period in question
- ◖ Site is likely to date to the period in question
- ❍ Site might possibly date to the period in question
- ◆ Site does not date to the period in question

Figure 4.1 *Suggested dating for morphological site categories used in the Wadi Faynan Landscape Survey; see text for detailed description of the dating evidence. (Illustration: Oliver Creighton.)*

rely heavily on the discovery of dateable cultural materials, most commonly pottery sherds or lithic artefacts, in close physical association with it. (The methodologies used by the project members studying the artefact assemblages collected in the fieldwork are described where appropriate in Chapters 6–11.) It is clear that the structure and location of these surface assemblages of artefacts had often been influenced by geomorphological processes as well as human agency: the landscape was visibly affected by wind action, variously resulting in areas of deflation and deposition, while wadi floors were, unsurprisingly, washed by powerful run-off in seasonal storms. These processes ensured that such materials were predominantly found as surface scatters lying on rock, sand, or gravel surfaces, rather than being contained in stratified sediments demonstrably related to structures, and surface artefacts of more than one period were commonly found in conjunction with a single site. At the same time, however, the generally open character of the Wadi Faynan landscape also presented excellent conditions of visibility, meaning that the surface artefact assemblages could be identified and collected with relative ease. In most cases, the dating of a structure could only be indicative, based on the relative frequencies of artefacts of particular periods observed to cluster within and/or in the immediate vicinity of a stone structure, with a marked decline in frequency beyond. The difficulties inherent in this approach, though, which all archaeological survey projects have to recognize (Francovich *et al*. 2000), cannot be under-emphasized. Different societies and economies produced different quantities of pottery, for example, the industrial-scale production of the Roman economy standing in obvious contrast with domestic-scale production in many periods of prehistory. Different kinds of pottery may be more durable than others, with wheel-made pottery made of highly processed clay fired in controlled kilns at one end of the scale, and hand-made pottery with crude temper bonfire-fired at low temperature at the other. The archaeological period for which a particular style of pottery is recognized as definitive may span millennia or centuries or a just a few decades.

Nevertheless, despite these difficulties with dating individual sites, it has been possible to establish a general chronological framework for the Wadi Faynan sites by linking the chronological evidence of excavated sites (by the project, and by other teams within and close to the survey area) with the cumulative evidence of repeated associations – and repeated absences of associations – of particular site types and particular dating materials (Fig. 4.1). It is of course indicative only, because it is inevitable with the kind of dating evidence available to us that some classes of site have relatively robust evidence for being dated to a particular period or periods along with indications at varying degrees of uncertainty of occupation in other periods, and some classes of site cannot be assigned to any particular periods of the past with absolute certainty. The likelihood that a given site type might have been built, re-built, or used in some way in a designated period is indicated in Figure 4.1 using one of four categories: where the site can be *reliably* dated to the period in question; where the site is *likely* to date to the period in question; where the site might *possibly* date to the period in question; and where the possibility that the site dates to this period can *positively be ruled out*.

4.2 Artefact 'site'

An *artefact 'site'* is a spatially concentrated occurrence of humanly-created or modified artefacts without evidence of associated structures. Clusters of cultural material contained within or surrounding discrete structures, such as buildings or funerary monuments, were recorded as part of that site, and not allotted a separate site number. Three sub-categories can be defined: ceramics – sherds of pottery; lithics – humanly-modified chipped stone flakes; and locations where artefacts are mixed (ceramics and lithics). Only in a small number of cases, however, were these main artefact types mixed, with most artefact concentrations consisting of either lithics or pottery. Lithic scatters comprised the majority of recorded artefact sites, with a pronounced clustering of separately recorded sites in the northwest portion of the survey area, particularly among the line of low hills flanking the northern edge of the main wadi channel (e.g. WF613, WF616, WF671, WF677: Fig. 4.2). The far smaller numbers of recorded pottery scatters were, by contrast, restricted largely to the more level topography of the southwest part of the survey zone, especially on low rises between the many minor braided wadis flowing into the Wadi Faynan (e.g. WF465, WF564, WF644, WF607).

The word 'site' is in inverted commas in recognition of the likelihood that some of these locations – perhaps the majority in the case of those comprising lithics only – are component parts of far more extensive but discontinuous low-density spreads of material across the landscape. Such material remains have been termed 'off-site' or 'non-site' archaeology by survey archaeologists (e.g. Bintliff 2000; Bintliff and Snodgrass 1988; Foley 1981; Thomas 1975), contrasting with concentrated clusters of material such as the structural remains defined as 'sites'. Many contemporary hunter-gatherers and pastoralists practising mobile patterns of settlement create such 'non-site' as opposed to 'site' archaeology (Foley 1981). These communities may return every year to the same location in a particular season, for example to a particular source of water, but tend to camp in the general vicinity rather than make use of exactly the same camp-site location, unless there is a specific reason for doing so such as the availability of a suitable rock-shelter or cave. It is therefore tentatively assumed that much off-site archaeology, especially prehistoric lithic scatters, was created by similarly mobile systems of settlement.

Another activity that is thought to create low-density spreads of archaeological artefacts across a landscape is manuring by farmers (Hayes 1991; Wilkinson 1989). As observed today, many non-industrialized agriculturalists collect the dung of their animals into a single manure heap close to their settlement. The probability that the same heap is also used as a domestic rubbish dump ensures that when the manure is carted to the fields and spread by hand onto the land, sherds of broken pottery and other debris are likely find their way onto the land as well (Haselgrove 1985: 16–17). Recognition of this process means that no simple correlation can be assumed between the distribution of pottery on the land surface and the locations and densities of past settlements. As discussed in Chapter 10 (§10.4.11), large-scale manuring appears to be the principal process responsible for the major spreads of Classical pottery across large field systems such as WF4. The intensity of this process is reflected in the fact that densities of ceramic material recorded on the land surface within WF4 rivalled and in some areas exceeded densities at settlement sites.

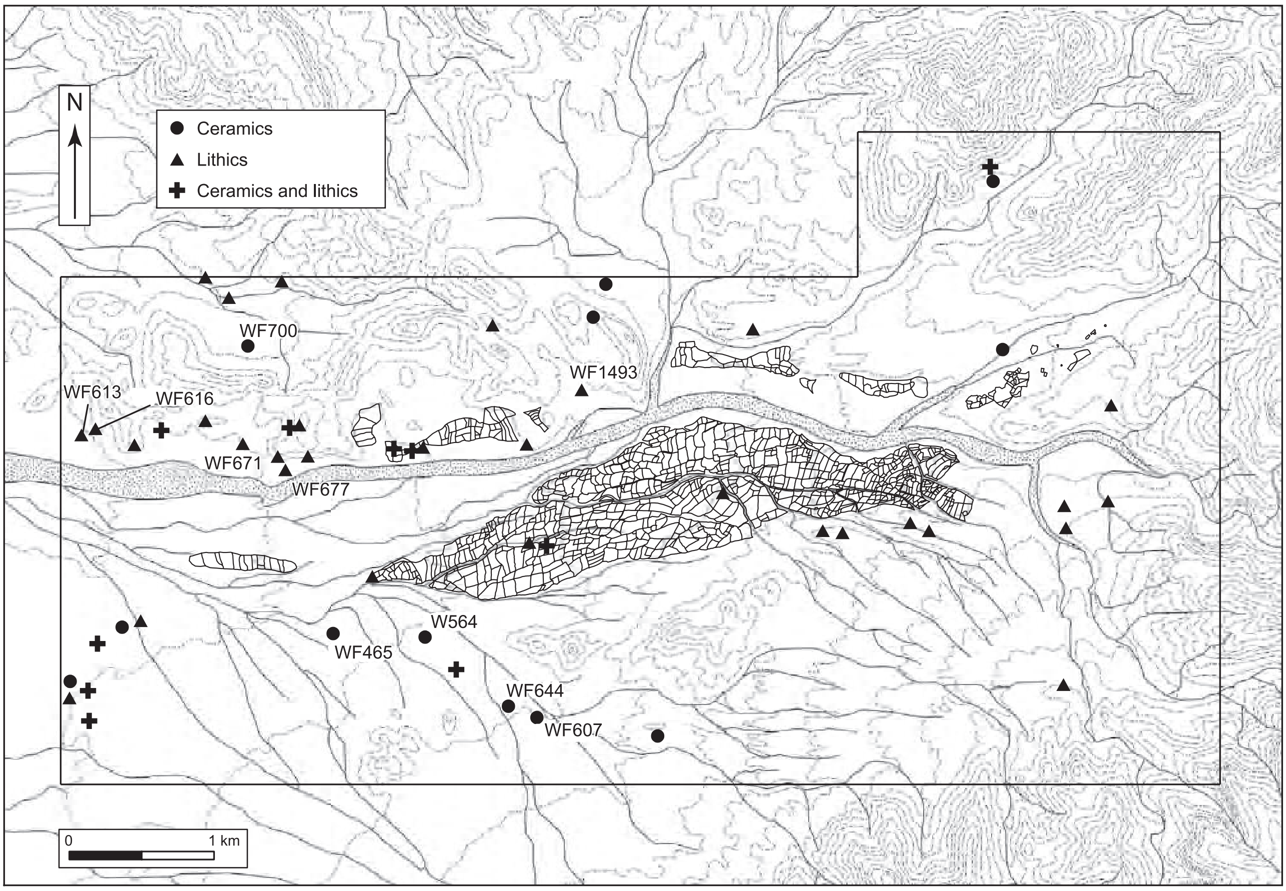


Figure 4.2 *Distribution of artefact scatters. (Illustration: Paul Newson.)*

Unsurprisingly, given the palimpsest nature of a deflated landscape such as the Wadi Faynan, lithic artefact ‘sites’ show an extremely broad date range (see Chapters 6–8), and most scatters of pottery or ceramics also dated to more than one cultural period. While in some cases the mixed nature of the material found at a particular locality doubtless demonstrates multi-phase activity in the immediate vicinity of the scatter, it is likely that in many cases mixed ‘assemblages’ accumulated through natural processes such as deflation and surface wash. Among the relatively rare ‘single period’ pottery scatters were WF644, a concentration of Early Bronze Age pottery, and WF700, a collection of scores of Islamic sherds apparently from a single vessel; WF1493 was a rare example of a lithic knapping scatter.

In a small number of cases, particularly dense or otherwise clearly defined surface scatters of lithics, surface assemblages were selected for more detailed recording. Depending on the character of the scatter, one of two methods was used. First, where time and logistics allowed, 100% pick-up of all visible artefacts took place, on a grid. Second, in the case of more extensive scatters, the surface assemblage was sampled through artefact collection along a series of regularly spaced 1 m-wide ‘corridors’, supplemented by the separate collection of any particularly diagnostic artefacts, after the manner of artefact collection within the main field system. Details of the sampling strategy employed for each site were recorded on the pro forma Site Record Sheet.

The term ‘isolated find’ or ‘isolated finds’ was used to describe single artefacts or a very small group of artefacts (generally fewer than five) found in close isolation on the land surface. Like surface scatters of material, they represent a broad date range. Isolated finds in the form of Palaeolithic (Acheulean) handaxes formed some of the earliest evidence of human activity recorded in the Wadi Faynan (e.g. WF1517: Fig. 6.18). Other examples include scrapers (e.g. WF1443) and querns or grinding stones found both on the land surface (WF547) or incorporated into field walls (e.g. WF48). When such artefacts were clearly associated with a structure, as for instance with the large number of mortar fragments found within buildings, they were given a ‘small find’ number recorded under the main WF site number.

4.3 Domestic structure

A *domestic structure* was defined as a site where the layout and construction characteristics of a stone-built feature implied an autonomous bounded human living space. Groups of between two and nine such features were recorded as *domestic structures*, with the term *domestic*

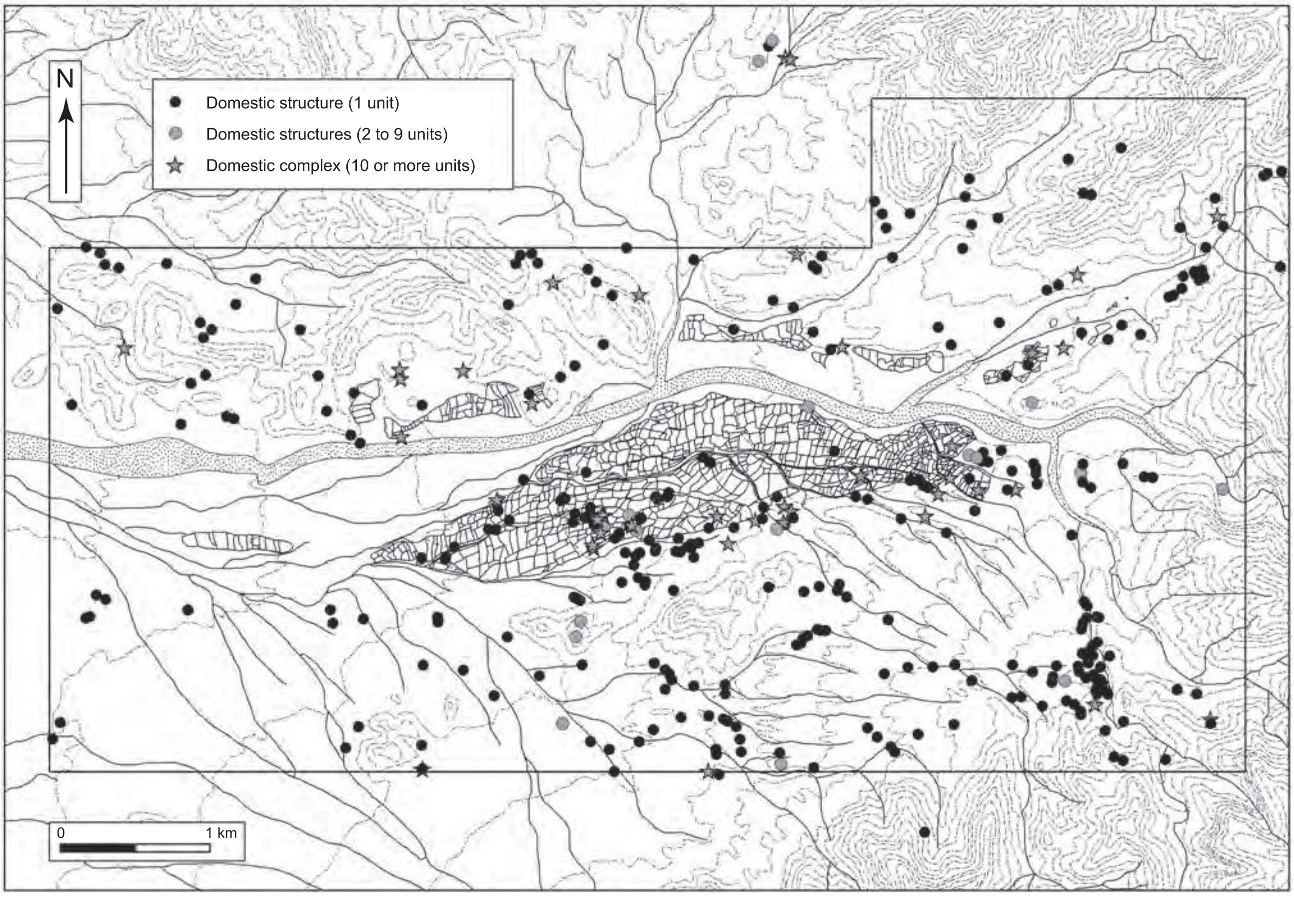


Figure 4.3 *Distribution of domestic structures. (Illustration: Paul Newson.)*

complex being used to define an arrangement of ten or more separate buildings. Domestic structures are distributed particularly widely across the survey zone, with most parts of the Faynan catchment, except the floors of the main wadi channels, containing some evidence of such sites. Most *domestic complexes* were found on the south side of the Faynan basin, especially on the fringes of the WF4 field system, whereas the hills flanking the north side of the main Faynan channel are characterized by more single-unit domestic sites (Fig. 4.3). Different types of domestic structure were differentiated using three basic criteria: plan morphology (circular/oval, sub-rectangular or rectangular); whether or not the structure appears to have been roofed (height and construction of walls and width of structure); and the level of plan complexity (evidence of internal rooms or sub-divisions). A series of sub-categories was identified using these criteria, as described below.

4.3.1 Bedouin encampment

Primarily for reasons of speed and economy of effort during the field survey, a miscellany of structures built and used by contemporary bedouin communities was recorded under this umbrella term. The overall distribution of these sites shows a marked bias towards the southern side of the Faynan catchment, especially in the vicinity of the Wadi Shayqar and along the incised plateau to its west, although large numbers were also found on the terrace-surfaces above the Wadi Dana (e.g. Fig 12.6). Several bedouin encampments were situated within or in the immediate vicinity of antique sites, such as settlements and field systems, and were recorded separately. Various sub-categories of site relating to bedouin activity were identified during detailed ethnoarchaeological fieldwork in the 1999 and 2000 field seasons, and representative examples surveyed and sedimentological samples collected from them. Besides tent sites, some of the more common sub-categories recorded were: *hearths*; *kid pens*; *laban platforms* (on which skin bags of yoghurt are stored during the manufacturing process); and *sleeping platforms* (see Chapter 12 for full discussion and illustration). In addition, a number of sites recorded under the category *miscellaneous structures* (see below), such as the sub-categories *pen*, *cache*, and *hearth*, are likely to be of recent or contemporary bedouin origin. While some of these are isolated features, others are likely to be outliers or component parts of encampments that are separately recorded or which have left no tangible physical traces.

4.3.2 Cave; rock-shelter

A number of cave and rock-shelter sites with possible evidence for human use or occupation was recorded. The evidence most commonly related to the penning of animals (including simple pens built of timber or brush, crude


Figure 4.4 *Examples of a cave, WF850 (left) and rock-shelter, WF862 (right). (Photographs: David Mattingly.)*

Figure 4.5 *An example of a simple circular/oval structure (WF43), looking east. (Photograph: Graeme Barker.)*

stone-built walls, and layers of droppings) in addition to the sorts of simple hearths and other stone-built features that might be expected from episodic pastoral use. The distinction between *cave* and *rock-shelter* is that, while the former is a natural physical space surrounded on at least three sides by living rock (e.g. WF177, WF850), the latter is a semi-enclosed space below a rock overhang (e.g. WF862, WF864, WF1407, WF1450) (Fig. 4.4). Rock-shelters were encountered during the survey more commonly than caves, a large proportion being also associated with stone walls projecting from the rock face to form a small enclosure, typically D-shaped or rectangular in plan. Mines and probable mines have not been classified as caves, but distinguished separately as *mining features* (see below). No certain evidence of prehistoric occupation was identified at these sites, nor were places identified where stratified earlier occupation deposits are likely to be preserved to any great depth, and the very limited number of surface artefacts recovered from such sites made dating of associated activity difficult. An exceptional case was site WF592, where a partly natural cave lay within a fortified complex of likely Nabataean date and may have been incorporated into structures around the entrance to the complex. In dating the use of caves and rock-shelters more generally, however, while activity during any period cannot be ruled out, the main evidence for their use related to the very recent past.

4.3.3 Circular/oval structure, simple

Comprising an enclosed empty space up to *c.*5–6 m in diameter (when round) or along the longer axis (when oval), these common structures are defined by their simple layouts. Typical examples include WF43 (Fig. 4.5), WF628 (Fig. 4.7), WF1010, WF1059, and WF1325. A considerable degree of variability is apparent in terms of wall construction and height. For instance, the enclosing wall may consist of a single line of stones or larger boulders, or a double row with a core of small stones and sediment in between. In most cases there is a single entrance, sometimes demarcated by an orthostatic stone placed on either side of the gap with a paved threshold stone in between. The walls of some of the more substantial of these structures appear to represent the lower levels of once higher walls which presumably enclosed roofed areas – in some cases the height of the orthostatic stones at the entrance makes this almost certain. In other cases, however, the original walls must have been little higher than the structures surviving today, suggesting that they formed the footings for tents or perhaps *pisé* (mud-brick) structures. In other cases, especially when structures were built up against field walls, they seem more likely to have been unroofed animal pens rather then roofed habitation structures (see also *enclosure: circular/oval*; and *hydraulic feature: catchment structure*). Indeed, many simple circular/oval structures lie either within the WF4 field system or are located on its southern fringes; some are attached to and built against field walls (e.g. WF43: Fig. 4.5).

4.3.4 Circular/oval structure, complex

A circular/oval structure is defined as 'complex' when it has five or more cells or room units. These are usually arranged in irregular fashion, often around a dominant central unit, giving the impression of a site that has grown up over several phases (Fig. 4.6). In most cases these sites are associated with, and organized around, enclosures or courtyards (see below); where no enclosure is present (e.g. WF615, WF1055), it is possible that this feature has been cleared or destroyed.

4.3.5 Circular/oval structure, simple/complex, with enclosure

The room or cell structures at these sites are associated with an enclosure (Fig. 4.7). Individual units are attached to the enclosure wall, on either the interior or exterior side, or in some cases on both sides, to give the impression of multiple rooms grouped around a larger central space (e.g. WF516, WF628, WF661). There is at least one entrance to the enclosure, often in a part of the wall without an attached unit, though in other cases access was only through a room structure attached to the enclosure wall. In some cases entrances are marked with orthostatic stones (e.g. WF637, WF797) and examples with two entrances are known (e.g. WF840). Another variant is where multiple enclosures are present (e.g. WF841). Other circular/oval enclosures might also belong to this category of domestic site when the disturbed condition of its structure prevented the secure identification of internal or external units.

The distribution of circular/oval domestic structures in general and those with attached enclosures in particular is notable in showing a marked clustering in the hills in the northwest and central northern portions of the survey

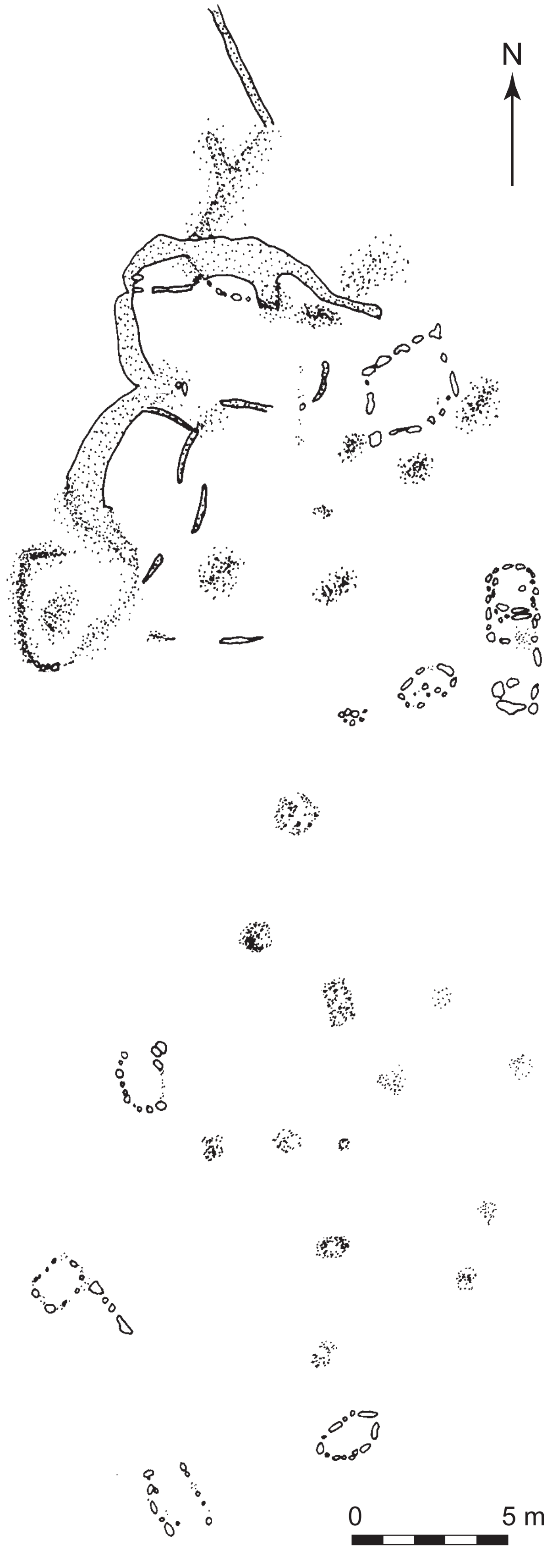


Figure 4.6 *Plan of a complex circular/oval structure (WF615). (Illustration: David Mattingly and Mike Hawkes.)*

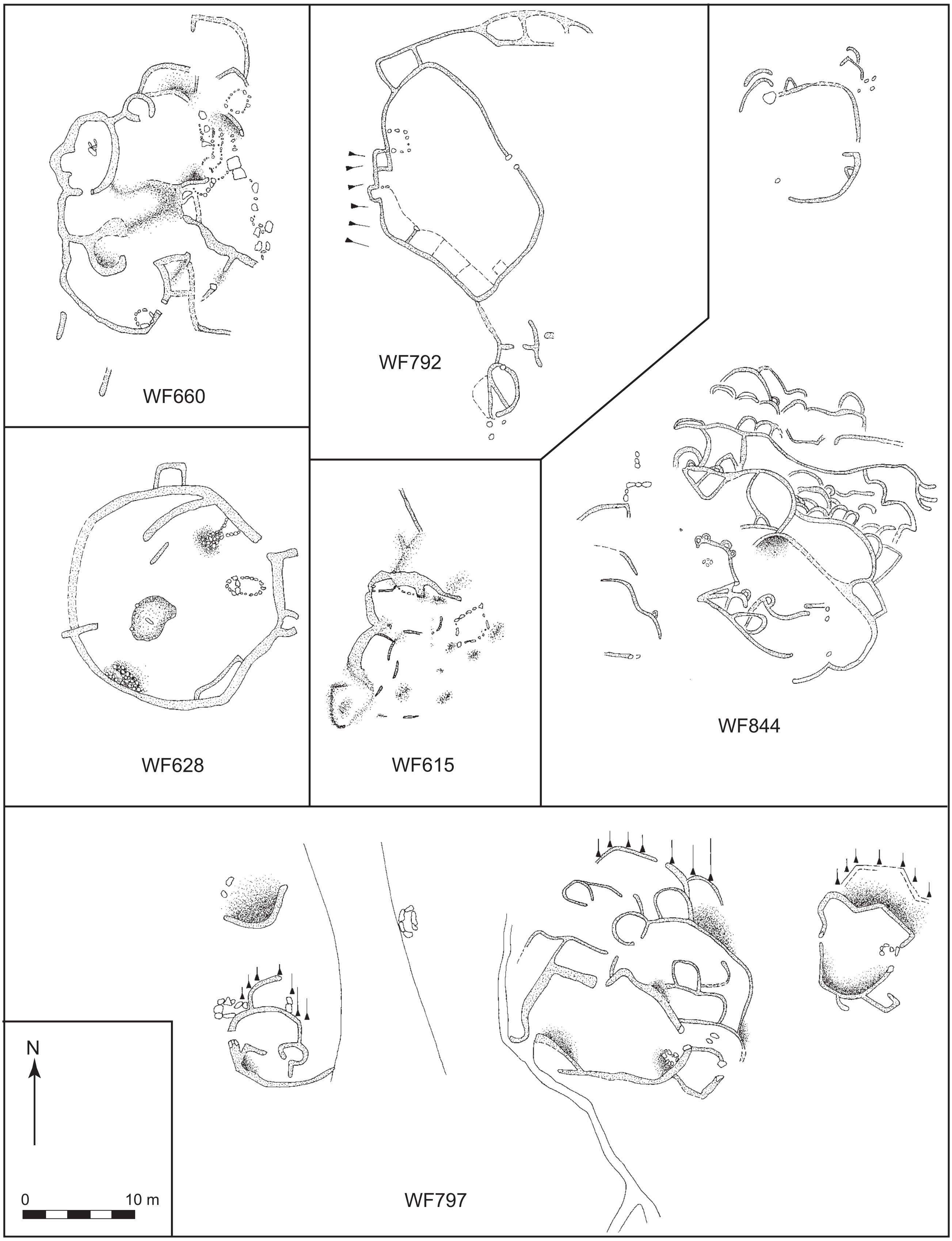


Figure 4.7 *Examples of Early Bronze Age settlement forms in Wadi Faynan: simple circular/oval structures with enclosure (WF628); complex circular/oval structure (WF615); complex circular/oval structure with enclosure (WF660, WF792, WF797, WF844). (Illustrations: David Mattingly, Mike Hawkes, and Dora Kemp.)*

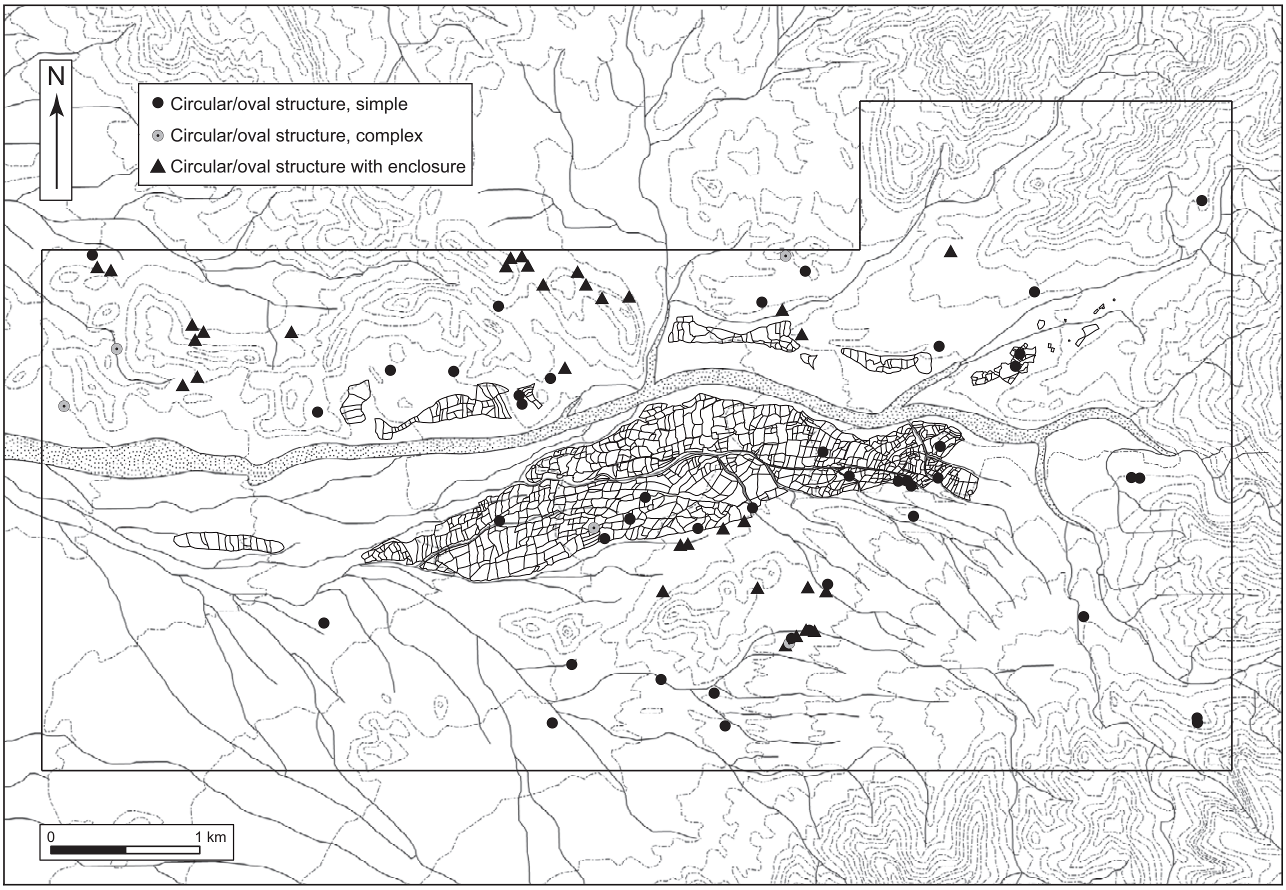


Figure 4.8 *Distribution of circular/oval structures. (Illustration: Paul Newson.)*

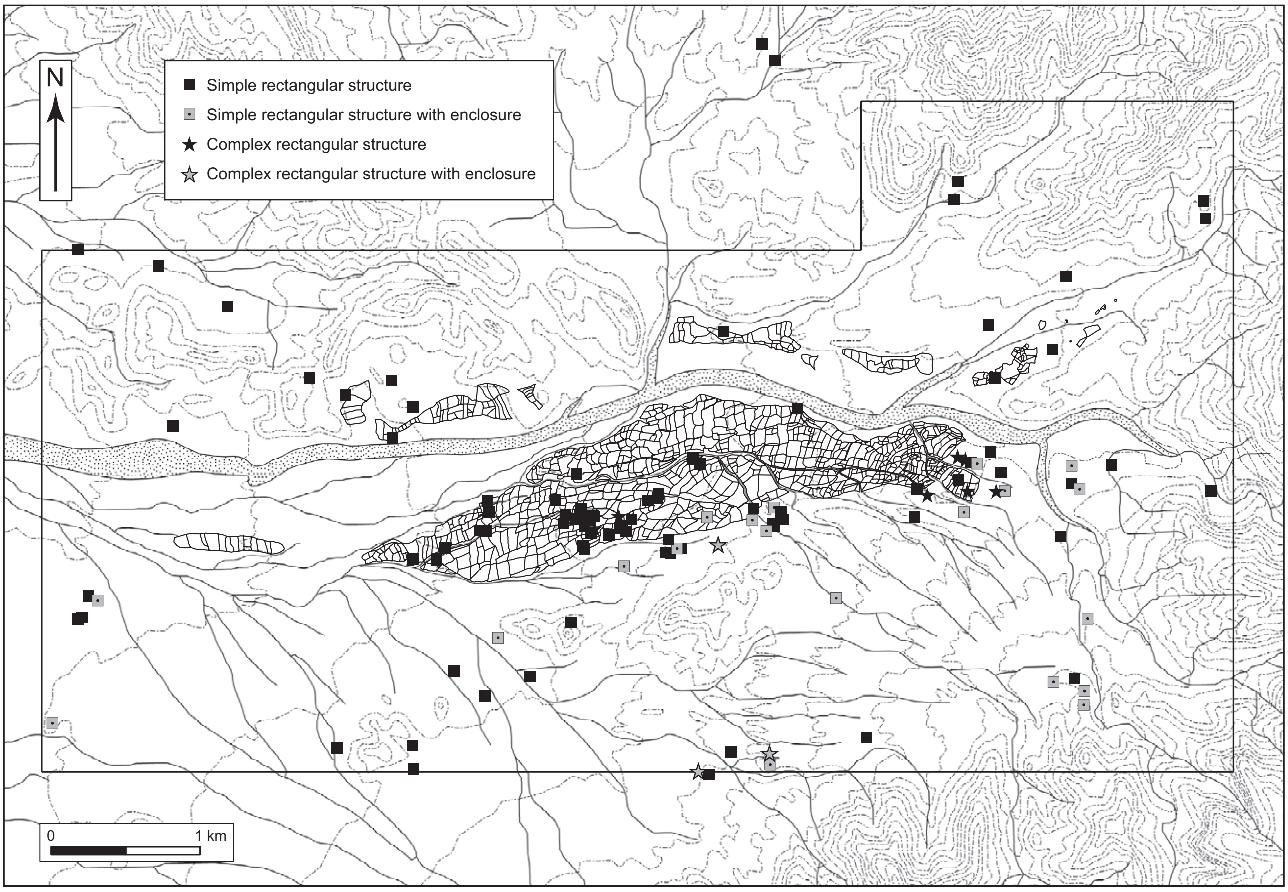


Figure 4.9 *Distribution of rectangular structures. (Illustration: Paul Newson.)*

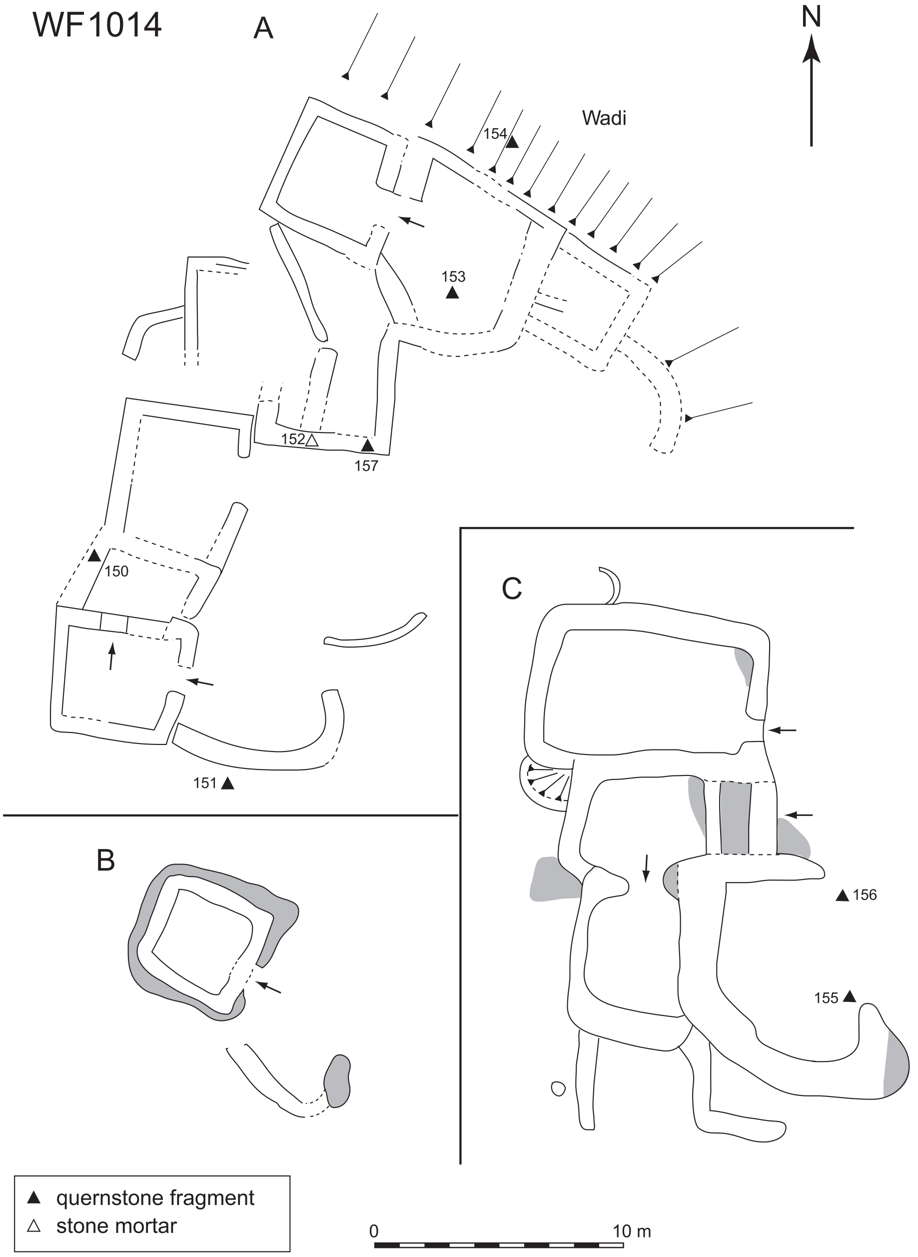


Figure 4.10 *Plans of rectangular structures at WF1014 (numbers are small finds). (Illustration: David Mattingly, Debbie Miles-Williams, and Dora Kemp.)*

area (Fig. 4.8) The artefact assemblages associated with circular/oval domestic sites were invariably multi-period. Nonetheless, a basic trend is apparent in the dating of these assemblages that applies to both simple and complex structures and those with and without enclosures: a high concentration of Bronze Age, especially Early Bronze Age, ceramics. Very occasionally the associated ceramics were more or less exclusively Early Bronze Age in date (e.g. WF797, WF799), but in most cases small quantities of Iron Age and Classical material were also present. On balance there is a strong likelihood that most circular/oval domestic structures are prehistoric in origin, with a strong bias towards the Early Bronze Age, but given the inherent simplicity and utility of the building style, earlier and later building, and rebuilding and re-use, cannot be ruled out. One surface structure in the circular/oval morphological category (WF16) has been revealed by excavation to be of Pre-Pottery Neolithic date, for example (Finlayson and Mithen 2007; Finlayson *et al.* 2000).

4.3.6 Rectangular structure, simple

A key distinction to be drawn is between large and complex rectangular buildings (few in number) and the majority of small rectangular one- or two-roomed structures (Figs 4.9, 4.10). A second distinction relates to the presence or absence of associated enclosures. A third distinction is between isolated rectangular structures and clusters of buildings. Several locations in the field survey area were

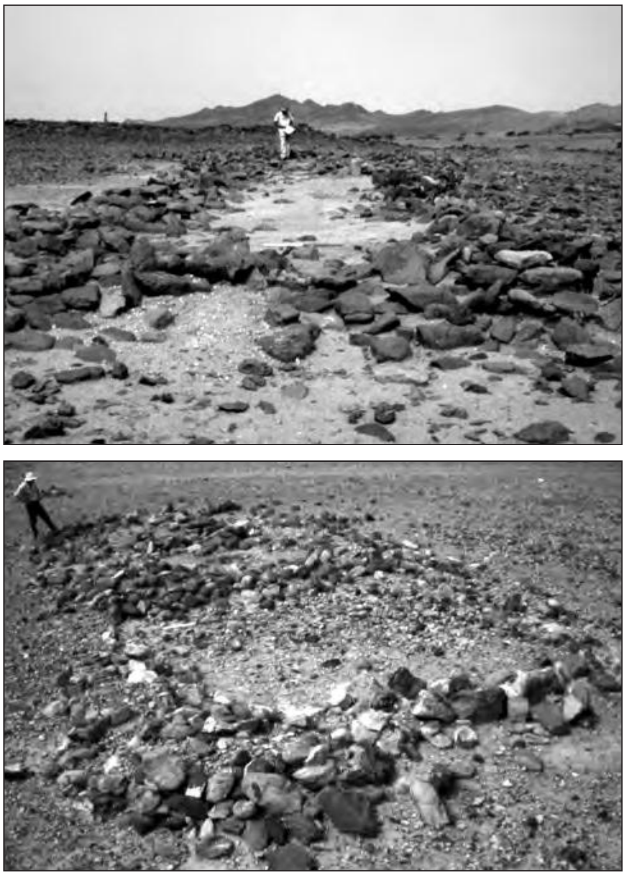


Figure 4.11 Examples of simple rectangular structures, WF664 (above) and WF1282 (below). (Photographs: David Mattingly.)

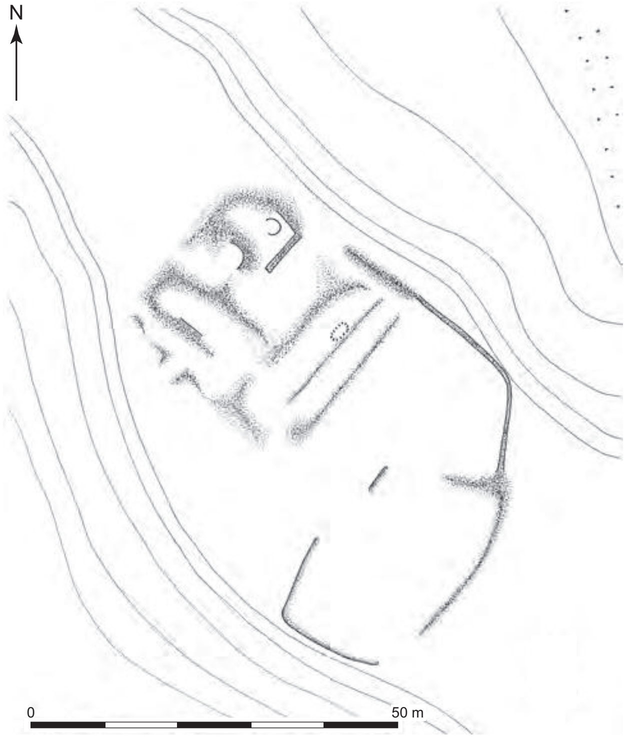


Figure 4.12 Plan of a complex rectangular structure WF1242. (Illustration: Oliver Creighton and Mike Hawkes.)

found to contain significant groupings of rectangular and sub-rectangular structures, suggestive of nucleated communities that might be characterized as hamlets or villages.

The category *rectangular structure, simple* includes a wide range of simple quadrilateral buildings, usually with a single entrance, and fewer than five separate units or rooms (Fig. 4.11). They are among the more common types of domestic site and found both individually and in significant groupings (e.g. WF36, WF1282), where settlements comprise strings of such structures along ridge tops. A number of distinct sub-types can be recognized. The smallest buildings recorded under this category were square structures, almost exclusively without evidence of internal subdivision, averaging *c.*5 × 5 m and formed from medium-quality coursing, usually with well-fashioned right-angled corners. Architectural details observed in especially well-preserved examples included dressed orthostatic stones forming parts of doorways, and monolithic lintels. Some examples are known with small attached yards in front of the doorway. Basic single-range rectangular buildings with dimensions of *c.*12 × 5 m formed a second clear sub-group. Whilst most structures consist of a single room, subdivisions are very occasionally visible as alignments of stones projecting slightly above the land surface. A third sub-group comprised more elongated rectangular buildings with slightly concave long sides (e.g. WF664, WF666). These buildings were typically *c.*20 × 6 m, with the entrance – where visible – in the centre of one of the long sides. While the significance of the concave building form is far from clear, the distribution of these structures shows evidence of patterning, with all examples recorded in the northwest portion of the survey area. For the second two categories, it should be noted that a number of buildings with more than one room might be conglomerate structures, demonstrating progressive extensions to a single room core. In a number of cases, successive additions to an original simple rectangular structure can be distinguished by butt joints and/or differences in constructional technique.

While it is quite clear that, as a general rule, rectangular structures are largely Classical in date (see below), the possibility that some simple forms had earlier origins cannot be ruled out entirely: in some cases, for example, associated surface assemblages exhibit more evidence of prehistoric (especially Bronze Age) than Classical activity (e.g. WF66, WF192).

4.3.7 Rectangular structure, complex

This category describes buildings with five or more room units in a single structure (Fig. 4.12). They are fairly rare outside the 'urban' context of Khirbat Faynan and its associated settlements (WF1, WF2, WF11), which incorporate many such buildings closely grouped together. Some of

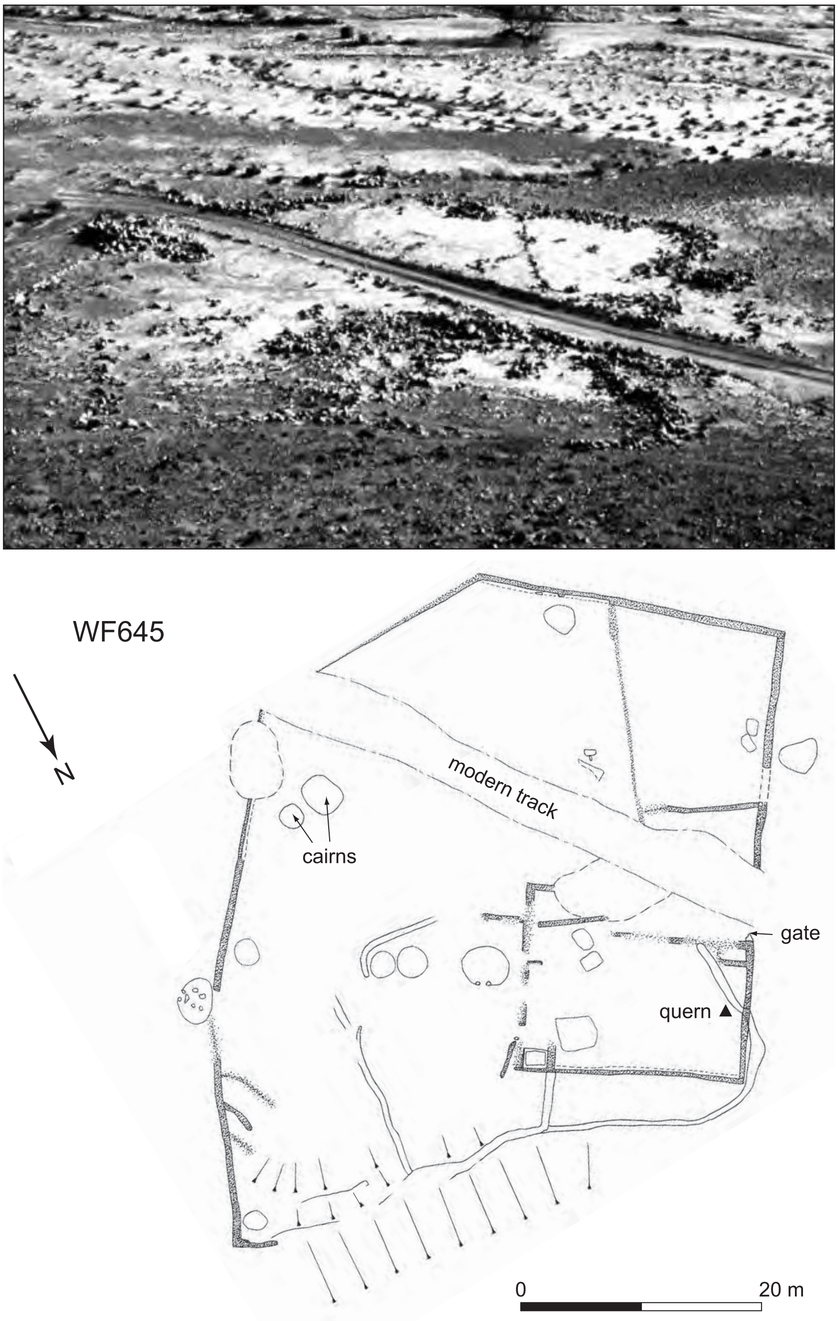


Figure 4.13 *Photograph (looking south) and plan of WF645, a rectangular structure with enclosure. (Photograph: Graeme Barker; illustration: Mike Hawkes.)*

these sites appear to have been more than one storey in height (e.g. WF1242). A few rectangular complexes can be identified close to the edge of the WF4 field system, especially immediately to the south of WF11. Those outside the 'urban' periphery are more often found associated with enclosures (see below). Another clear concentration of rectangular structures in general is on the terrace immediately west of the Wadi Shayqar and continuing to the southwest, giving the distinct impression of an arc of rectangular domestic sites flanking the broad plateau south and southeast of the WF4 field system.

4.3.8 Rectangular structure, simple/complex, with enclosure

An important component of some complex rectangular structures is an enclosure forming a yard or courtyard (Fig. 4.13). These features range in size from *c.*0.25 ha to *c.*0.005 ha, suggesting that, even if they are all contemporary, they must have been built for a variety of functions and in a wide range of social contexts. A good example of a larger type of rectangular complex with an enclosure is WF645, comprising a rectangular range of rooms (*c.*20 × 15 m) attached to a polygonal courtyard (*c.*50 × 40

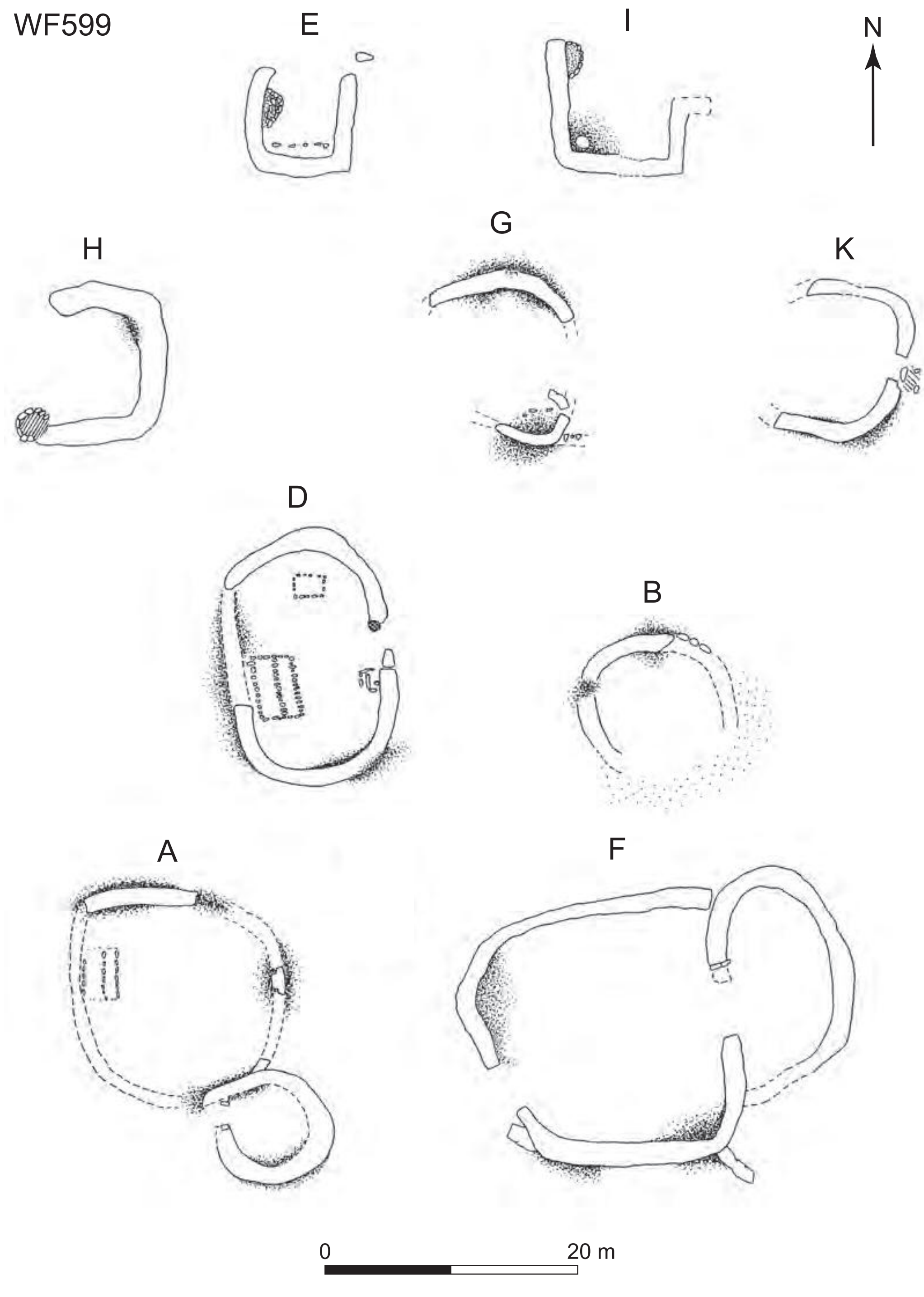


Figure 4.14 *Examples of sub-rectangular structures (WF599). (Illustration: David Mattingly and Mike Hawkes.)*

m) that was sub-divided internally into two zones. Most other structures have rectangular courtyards (e.g. WF481); L-shaped variants consisting of two linked units are also recorded (e.g. WF1242). There are also numerous examples of simple one- or two-room domestic units, linked to small enclosures or yards. At the smallest end of the scale, these sites might comprise a *c.*5 × 5 m building with a *c.*6 × 6 m yard. The presence of the yards could indicate a variety of activities, but is suggestive of agricultural activity, in particular an involvement with livestock. At least one example (WF689) has a courtyard with an entrance clearly marked by orthostatic stones.

There can be little doubt that rectangular structures both with and without enclosures were important components of the Wadi Faynan landscape in the Classical period, when they probably functioned as farmsteads. Scatters of pottery associated with these sites are invariably dominated by large volumes of Nabataean, Roman, and/or Byzantine

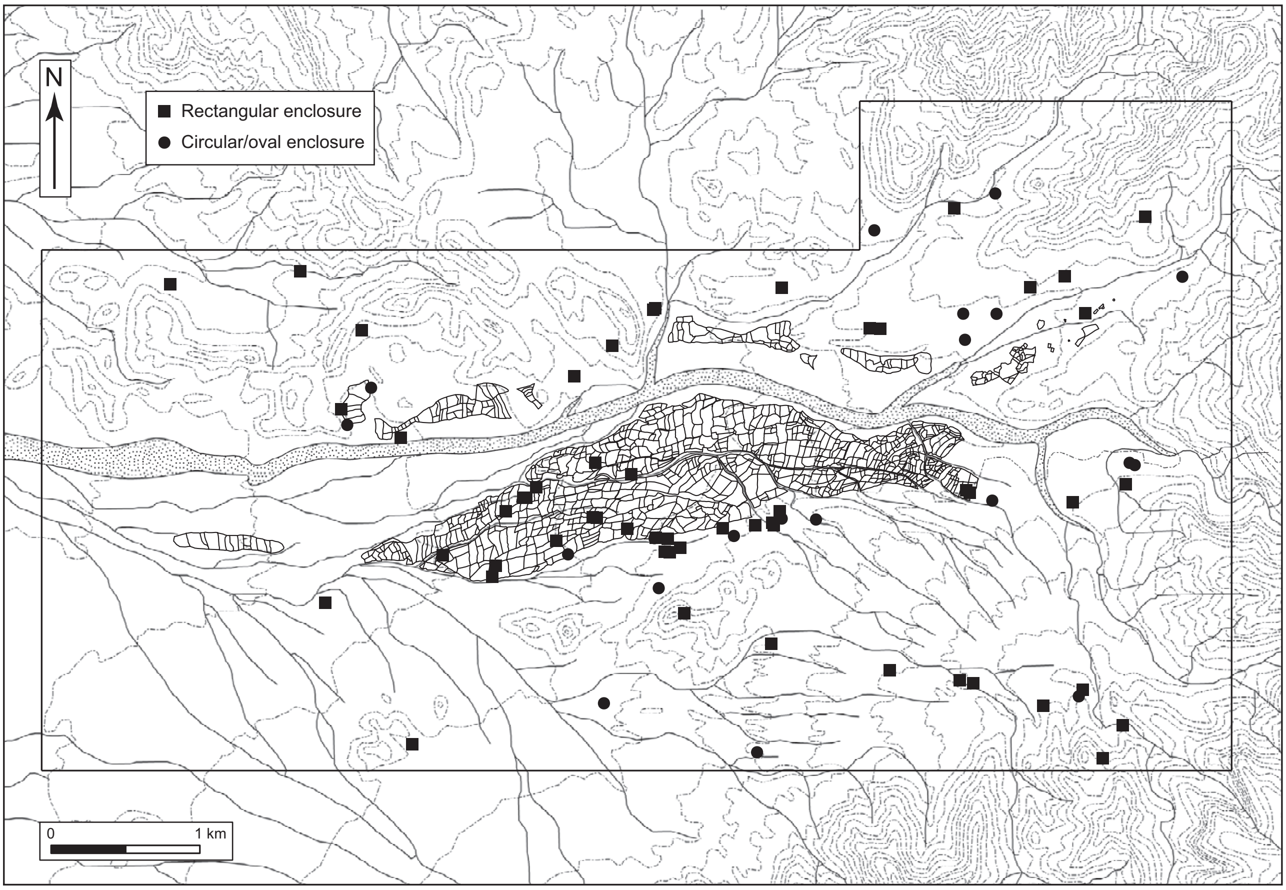


Figure 4.15 *Distribution of circular/oval and rectangular enclosures. (Illustration: Paul Newson.)*

material, although small quantities of earlier material are not uncommon.

4.3.9 Sub-rectangular structure, simple

This category consists of a building form with rounded corners and sides that are approximately straight or bow outwards (Fig. 4.14). They rarely have more than two rooms. Some examples are three sided, with the fourth side open as an entrance; others have both of the shorter ends open as entrances. Sub-rectangular or oval one- or two-roomed structures are relatively common and are usually found in groups and appear to be contemporary. (For example, WF1001 consists of three separate buildings of this type, WF599 contains eleven structures and WF1446 contains fourteen structures.) The typical sub-rectangular building is *c.*6 × 6 m, with slightly bowed sides and rounded internal corners. The surviving walls are always low broad foundations, with limited rubble around, suggesting that the superstructure of these buildings may have been in mud or some other perishable material. A minority of examples appears to have had open fronts, rather than the more common narrow doorway. A variant on this is illustrated by some of the 'two-room' examples, where the outer room is simply an open veranda with flanking walls. In a number of these buildings there are traces of internal features, suggestive of benches and hearths, rectangular in the centre of the room and semi-circular against the wall.

4.3.10 Enclosure (circular/oval; rectangular)

Two forms of enclosure were defined on the basis of their plans, circular/oval and rectangular (Fig. 4.15), although in reality a continuum existed between the two types, from perfectly circular examples through oval shapes and sub-rectangular forms to regular rectangular plans. It is clear that the chronology of enclosures of both basic forms is extremely broad. The enclosures are demarcated either by a single line of un-faced boulders and smaller stones, commonly one course high, or by more substantial walls formed of two outer faces of unshaped boulders and smaller intervening stones, containing a fill of small stones and sediment (e.g. WF1361) (Fig. 4.16). Versions with semi-circular layouts (presumably due to erosion and/or clearance) are also known (e.g. WF1362). The enclosure walls are commonly less than *c.*0.5 m high, though a few examples have more courses or stones piled on top to give a height up to *c.*0.75 m. There is always one entrance, sometimes two, and occasionally more. Some of these sites may be very similar in appearance and construction to the *domestic structure: simple circular/oval* category, the allocation to one or other depending on whether it seemed feasible that the structure could have been roofed. It is

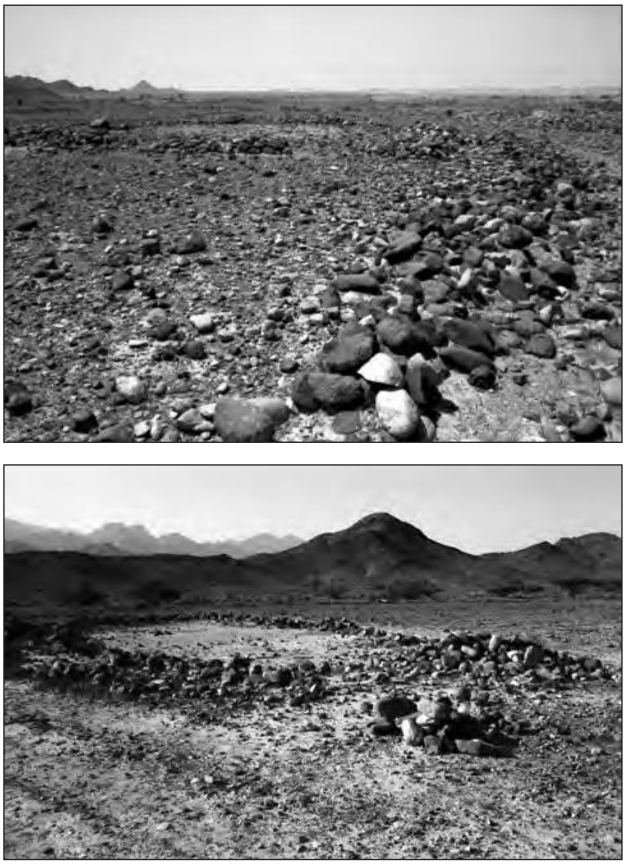


Figure 4.16 Examples of circular/oval (WF135) and rectangular enclosures (WF148) looking west (upper) and southwest (lower). (Photographs: Graeme Barker.)

certainly possible that some of these enclosures might also be domestic, the disturbed or fragmentary condition of the walls preventing the secure identification of any additional units attached to the enclosure wall, though their presence may be suspected (see also *domestic structure: circular/oval structure with enclosure*). The division between *simple circular/oval enclosure* and *hydraulic structures: catchment structure* depended on whether the enclosure contained a significant depth (*c*.0.3–0.5 m) of waterlain sediment. In the case of *rectangular enclosures*, while the enclosing wall is usually of similar height to the *circular/oval enclosures*, their wall-building technologies often differ in the more common usage of substantial two-faced construction techniques. Some of these enclosures are, strictly speaking, sub-rectangular rather than rectangular in terms of the wall alignment, but most have well-formed corners (e.g. WF148, WF1340). A distinct group of especially large rectangular enclosures was identified in the Wadi Khalid area, close to the ancient mines, suggestive of an association between these and mining activities (see Chapter 10, §10.4).

4.3.11 Fortified complex

This term covers a small but exceptional group of structures with structural remains or topographical positions indicative of a military or defensive function. The two main criteria for definition as a fortified complex are: substantial walls of high-quality masonry, with elaboration such as towers or other defensive features; and a location in a naturally defensible or prominent location such as a hilltop. The physical traces of these sites are overwhelmingly Classical in date, although the topographical prominence of their sites makes it not unlikely that they perpetuate earlier settlements. Three sites are included in this category: two are late Roman/Byzantine structures associated with the copper mines (Khirbat Faynan, WF1: Figs 10.2, 10.9, 10.10), and Khirbat Ratiye, WF1415: Figs 10.15–10.17); the other is Tell al-Mirad, a Nabataean hill-top site on the south side of the wadi system (WF592: Figs 9.2, 9.22, 9.23). In each case there is a central nucleus occupying the highest and most defensible part of the site, and the fortified complex is associated with outlying structures that are likely to be contemporary and probably related to its functioning. Thus Khirbat Faynan is linked to a series of settlements and associated agricultural and industrial sites (e.g. WF2, WF4); Khirbat Ratiye stands in close physical proximity to a field system and a series of discrete settlements and cemeteries (WF1446, WF1515, WF1516, WF1518); and the Nabataean hillfort WF592 is connected to what may to be a dependent settlement on a spur beneath the main complex (WF693). All three sites command extensive views over large tracts of the wadi system, including many of its key resources and the principal communication routes through it. They may have also been designed and sited in part for visual impact: their architecture was not intended simply for defence, but as a symbol of power in the landscape (see especially Chapter 9, §9.83 and Chapter 10, §10.4.5).

4.3.12 Major settlement

This term is only applied to a single site complex, that of Khirbat Faynan (WF1) and its satellite settlements on the opposite (south) side of the Wadi Ghuwayr (WF2, WF11: Fig. 10.9). The main criteria that set these sites apart are the spatial extent of the settlements (covering over 20 ha in total) and the complexity of their layout and buildings. The structures comprising these sites stand out for the quality of their masonry, the range of materials employed (including imported, specially manufactured, or treated elements), and their architectural sophistication. Within the complex can be identified at least five churches, an aqueduct system, and a central fortified unit, as well as dense housing including numerous multi-roomed domestic structures organized around a street system, with clear evidence of zoning into different activity areas (Figs 10.9, 10.10). The three component zones of this settlement almost certainly together constitute the documented ancient centre known as Phaino (Ruben *et al*. 1997).

4.4 Excavation

The Wadi Faynan Landscape Survey included within its record a series of sites excavated or in the process of excavation by other teams. Principal among these are: WF16, a Pre-Pottery Neolithic A settlement under excavation by CBRL and the University of Reading (Finlayson and Mithen 1998; 2007; Mithen *et al.* 2000); WF38 or 'Wadi Ghwair I', a Pre-Pottery Neolithic B settlement being excavated by the University of Nevada and the Jordanian Department of Antiquities (Simmons and al-Najjar 1996; Simmons and Najjar 2006); WF25, Tell Wadi Faynan, the Pottery Neolithic and Chalcolithic settlement investigated with test trenches by the Jordanian Department of Antiquities in 1988 (al-Najjar *et al*. 1990); and WF100, an Early Bronze Age settlement excavated in 1997 by a University College London team (Wright *et al*. 1998).

Whilst our own project did not carry out any large-scale excavations, a small number of more limited archaeological interventions formed an important part of the work. These fell into two categories: *trial trenches*, and *section cleaning*.

The former were excavated for one of two reasons. First, as part of the programme of palaeoenvironmental research, trenches were excavated at locations holding potential for the preservation of stratified deposits amenable to geomorphic, palynological and/or geochemical analysis. As described in the previous chapter, one important such site was the area behind the Khirbat Faynan barrage (WF441), where small-scale excavation recovered deep and well-preserved sediments (Figs 1.13, 1.15, 2.13). Other excavations of this sort were used to sample areas of assumed midden deposits associated with Khirbat Faynan, and deposits of industrial waste. The second category of trial trenching involved small-scale excavations targeted to test hypotheses concerning the function of recorded features, or to clarify stratigraphic relationships between different sites or parts of the same site for relative dating. One such example is the series of sections cut through parallel walls within the WF4 field system in order to investigate their assumed function as conduit channels for floodwater (e.g. WF1427, WF1525, WF1526; see Chapter 5, §5.4.5).

The cleaning and recording of artificially exposed sections formed the second type of small-scale archaeological excavation carried out by the project (Fig. 1.9). The initial phases of the field survey recognized a number of locations where significant stratigraphy had been exposed in section. The principal process giving rise to this type of feature was the seasonal flow of water along minor wadis, gullies and within wall-systems (e.g. Figs 5.34–5.39), resulting in rapid down-cutting through past land surfaces, field walls, or other archaeological sites, as evident for instance at sites WF1524 and WF1535. In a number of cases, these sections were cut back to expose and clarify stratigraphical relationships prior to recording and, where appropriate, to facilitate the recovery of buried sediments for environmental analysis.

4.5 Field system

This category covers a great variety of arrangements of stone walls assumed to have enclosed agricultural/farming areas, so unlike in the case of the other morphological categories identified in the WFLS, 'field system' is not an objective descriptive term but incorporates an element of interpretation. In investigating these features we have tried not to make this interpretation uncritically at the outset, but to look carefully at their structural history, identifying features of earlier or later date than the main phase of layout (for further discussion, see Chapter 5, §5.1). It is clear also that the various walls and minor structures that in combination made up a 'field system' had many different functions and attributes. However, the term is usefully employed to distinguish the site types described under this major category from the walls of domestic and other structures. The different levels of sophistication observed in the plans of field systems within the study area were reflected through their classification as either *simple* or *complex*, while in cases where doubts persisted regarding positive identification the term *field system, possible* was used. The principal Wadi Faynan field systems, at least in their developed states in the Classical period, appear to have been strongly related to practices of run-off and floodwater farming (see Chapter 5), and frequently contain structures associated with the capture, diversion, channelling, and control of overland flow and/or floodwaters (see below, *hydraulic structures*). The term 'field system' is restricted here to the primary walls demarcating the edges of fields and terraces, and does not incorporate the intervening land surfaces.

4.5.1 Simple field system

This sub-category was used almost exclusively to describe arrangements of cross-wadi walls (check dams) built at right angles to the direction of water flow (Fig. 4.17). Such simple systems were built to impede the flow of water and thus trap sediment within the field units. They are widely known across the region (e.g. Evenari *et al*. 1958; 1971; 1982 [1971]; Newson 2002; Wilkinson 2003), and are broadly comparable to those recorded in the UNESCO Libyan Valleys Survey, which are generally thought to date to the Romano-Libyan period (Barker *et al*. 1996a: 191–225). The walls are of generally crude construction, typically no more than two courses of stones or boulders

Figure 4.17 *An example of a simple field system (WF744), looking north. (Photograph: David Mattingly.)*

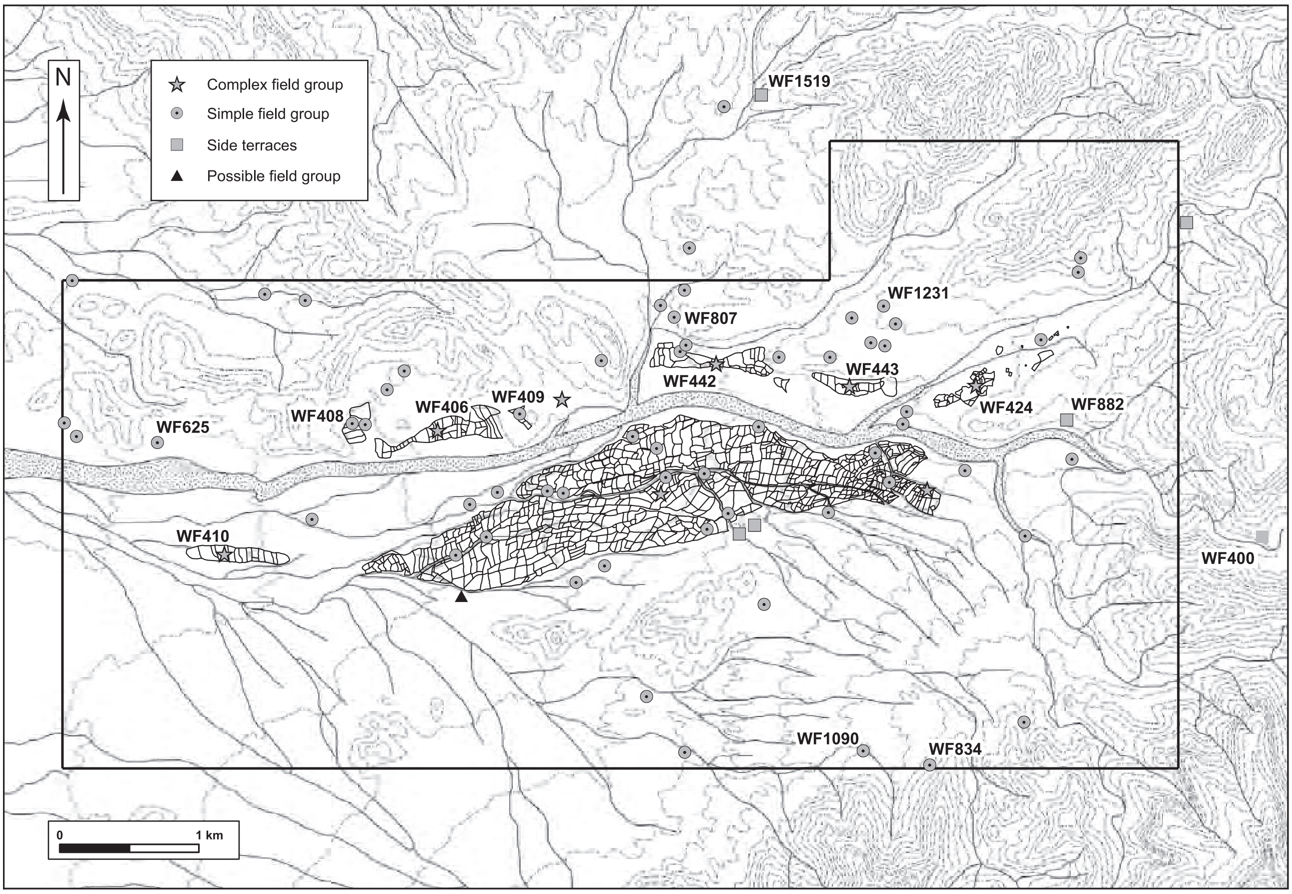


Figure 4.18 *Distribution of field systems beyond the WF4 system and its major outliers. (Illustration: Paul Newson.)*

deep, although the stones could, on occasion, be larger than was typical within *complex field systems*. Although the placement of simple field systems within the landscape was obviously conditioned by the location of wadis with suitable levels of seasonal water flow, they seem to have been adapted to remarkably varied types of physical topography, and are distributed widely across the central portion of the survey area (Fig. 4.18). In certain cases, they are positioned in natural gullies in the foothills more than two kilometres to the south of the main wadi channel (e.g. WF834, WF1090), although most are situated within wadis running between the low hills on the north side of the Faynan (e.g. WF807, WF1231)

A particular characteristic of the preservation of these systems was that the cross-wadi walls only rarely survived to their original length; typically the central portion of each wall had been entirely washed out or severely eroded by the flow of water, and in some cases only the stubs of walls survived, projecting from either side of a natural gully. In such cases, wadi down-cutting had clearly occurred after the field system's disuse. Individual field units within simple field systems were generally only bounded on two sides by walls constructed across the natural contours, the remaining sides being mostly marked by natural breaks of slope at the edge of alluvial sediments. These systems therefore usually comprised only a single strip of fields running along a minor wadi, with the size of field units often decreasing at either extremity.

The recovery of surface artefacts from systems of cross-wadi walls was extremely rare, probably partly due to the fact that in many cases the individual field units were heavily eroded and materials presumably washed away. Where associated assemblages were dateable they tended to represent a long time span, typically from the Early Bronze Age into the Classical period (e.g. WF408, WF409, WF625). Some simple systems probably represent the earliest attempts to control water and to farm wadi floor alluvium (Chapter 8, §§8.7, 8.9), whilst others may be of relatively late date, representing a return to the type of smaller-scale systems still continuing in use to the present day among the bedouin (Fig. 12.28).

4.5.2 Complex field system

This type of field system, of which WF4 is the outstanding example, comprised more sophisticated combinations of walls and terraces to create a patchwork of individual field units. In terms of area, WF4 was several times larger than other complex field systems (e.g. WF406, WF408, WF410, WF424 WF442, WF443), most of which formed satellites of the main system, being located primarily on the low terraces running along the north side of the main Wadi Faynan channel. The larger of these complex field systems were demonstrably not single-phase creations but complex palimpsests bearing the imprint of multiple episodes of construction and growth, in many cases incorporating and adapting earlier features such as settlements and funerary monuments. In the later phases of use, almost certainly dating to the Classical period, these systems clearly employed techniques of floodwater farming on a large scale, as indicated by the high densities of *hydraulic features* (e.g. *parallel wall*s, *sluices*, and *spillways*) recorded separately within them. In addition, areas within complex field systems might contain distinct arrangements of walls (e.g. *cross-wadi walls*, *side terraces*) that could form discrete sites elsewhere, and employed a variety of building technologies (e.g. single-faced wall, double-faced wall, terrace wall) that were recorded in detail during the initial phase of field system survey (see Chapter 5 for detailed discussion).

4.5.3 Side terraces

These are terraces formed behind walls, often of single-faced construction using large fluvial boulders, built approximately parallel to the contours on valley slopes. Their principal functions appear to have been to minimize the erosion of sediment from natural slopes, to encourage sediment deposition, to retain manure/nutrients, and so create small level cultivable strips of land on otherwise difficult terrain. Side terraces were the least common type of field system encountered, and were generally restricted to small areas within steep-sided valley systems, such as the upper courses of the Wadis Dana and Ghuwayr (e.g. WF141, WF882). They are extremely difficult to date and, like the cross-wadi walls that formed simple field systems, the inherent simplicity of their building technology suggests that they were built over a long chronological range. In those few cases where associated surface artefacts were recovered, both the Early Bronze Age and Classical periods were represented (e.g. WF400, WF1519).

4.5.4 Possible field system

A 'possible' field system comprises one or more walls, often fragmentary in form, observed in locations typical of run-off farming systems, such as wadi beds, floodplains, and valley sides. Given their vestigial nature such features are virtually impossible to date. It often proved difficult to exclude other possibilities for the function of these poorly preserved features, and most dubious examples were accordingly recorded under the category *miscellaneous structure* as *wall fragments* or *wall*.

4.6 Funerary structure

The classification of funerary monuments presented particularly acute challenges, for three main reasons: most monuments had been exposed to processes of destruction and degradation that had tended to obscure their original morphologies; individual funerary monuments displayed high levels of reuse and adaptation; and essentially similar forms of construction were repeated over long periods of time. Many burials were marked at the surface, if at all, by relatively slight structures prone to degradation by natural or human agency, leaving ambiguous arrangements of stones that could not always be assigned with confidence to a particular original form. As described below, in many cases the term *stone setting* was used to record ambiguous structures of this type. In addition, detailed survey of bedouin encampments revealed a range of small stone features, such as *sleeping platforms,* that when degraded could easily be confused with funerary structures (see above and Chapter 12, Fig. 12.25).

Grave robbing was identified as another important process that presented challenges for the recording of funerary monuments. Many graves in the Wadi Faynan have been robbed in the remote or recent past; the South Cemetery (WF3: Fig. 10.26) was a particular target in the 1980s, with over 700 burials believed to have been robbed (Findlater *et al.* 1998: 71). The process of grave robbing often obliterates most evidence of the original form of the burial and of above-ground structures, though occasionally can reveal details of tomb structure, such as subterranean cists or the presence of sub-chambers within a stone-lined inhumation. The reuse of funerary structures can be illustrated by the interpretation of cairns within the field system area. These features were commonly encountered built into field boundaries, sometimes showing clear signs of having been used as dumping areas for the clearance of stone from the fields. An important question was whether they have earlier origins as funerary monuments. While there is positive evidence of this where funerary structures were visible in their centres, in the majority of cases it was uncertain whether such cairns originated in this way. Burials can also be found inserted into or overlying earlier sites, making the sequencing of related features difficult. One of the simplest forms of burial in an arid zone is a shallow grave covered with a low mound or cairn of stones. It is likely that this type of monument has been an enduring feature of the Wadi Faynan over millennia, but only excavation could establish for certain the date of many such features. Surface artefacts around burials can also provide clues to dating, but bearing in mind the complex effects of patterns of artefact deposition, geomorphological processes, and so on, spatial associations should be treated with caution as a straightforward guide to the date of a stone monument.

These methodological problems were compounded by a lack of well-published parallels available for southern Jordan or the Negev, either from other surveys or from excavation. Useful examples of publications of funerary structures include Haiman (1992a; 1996) for the Bronze Age, Levy *et al*. (1999a) for the Early Iron Age, and Findlater *et al*. (1998) for the Late Roman/Byzantine periods. Our approach, therefore, had to be based on broad morphological characteristics, in part making judgements retrospectively on the basis of field notes and plans. We tried to err on the side of caution in cases of uncertainty: many features that share characteristics with funerary structures, and that may well have been such structures, have been classified as *miscellaneous structures*. In such cases three main criteria

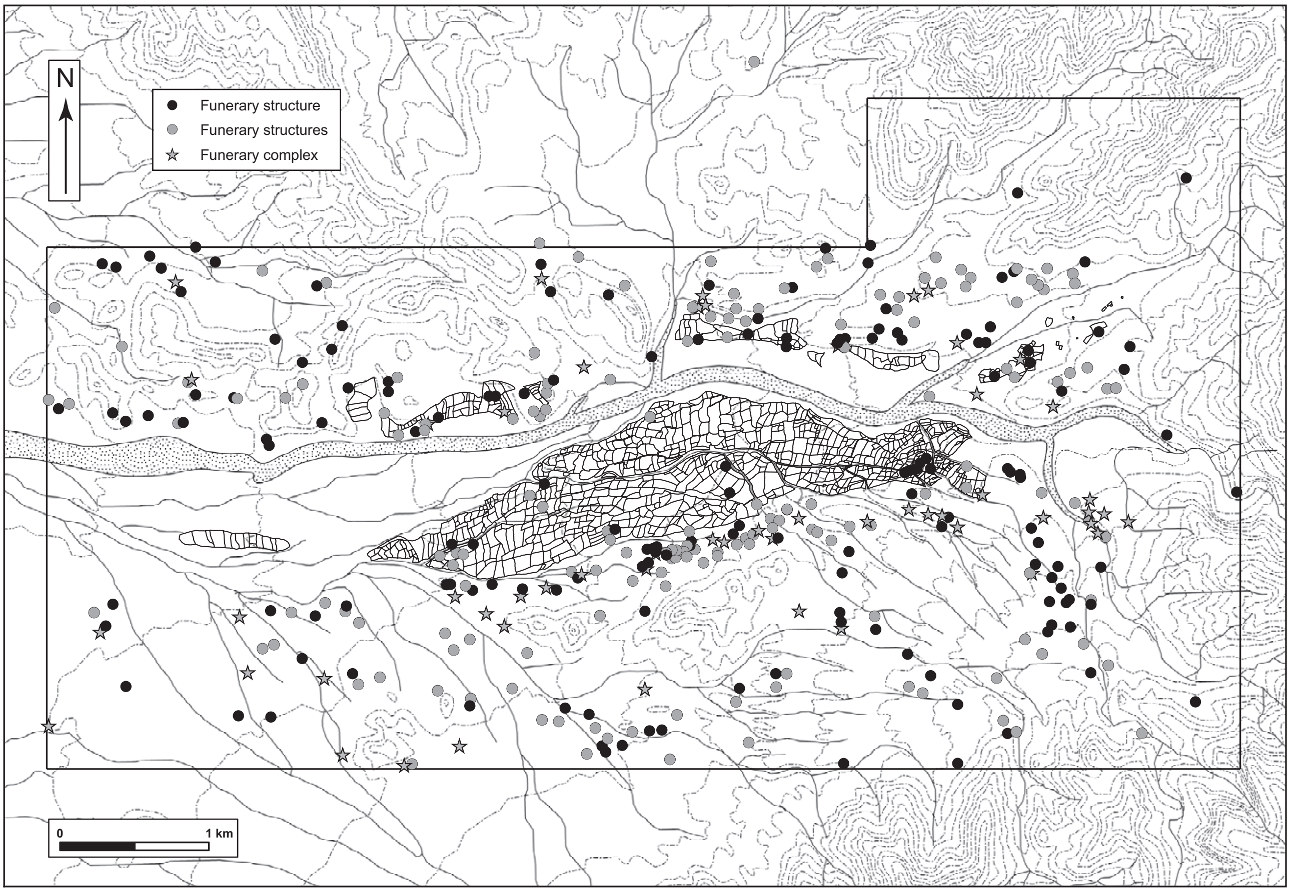


Figure 4.19 *Distribution of funerary structures. (Illustration: Paul Newson.)*

were followed: whether the structures were grouped or in close proximity to known funerary sites; whether robbing had taken place; and the topographical setting, in that cemeteries were frequently found on prominent topographic features such as ridge tops. It is likely that in all periods the predominant burial ritual has been inhumation rather than cremation, though without excavation the nature of burial arrangements below the surviving monument remains in most cases unclear.

Funerary sites were also classified according to individual burial features. An isolated burial feature was defined as a *funerary structure*; between two and nine examples constitute *funerary structures*; and ten or more form a *funerary complex* (Fig. 4.19, cf. Figs 4.23, 4.32). While the funerary features were distributed widely across most parts of the landscape other than in areas with especially sharp relief in the extreme northeast and east of the survey area, two especially significant clusters can be identified. An exceptionally dense belt of funerary monuments runs for approximately 3.5 km from southwest to northeast along the southern edge of the WF4 field system, comprising a remarkable mixture of individual and multiple burials, along with large burial complexes constructed mainly on terraces and low hillocks (e.g. WF775: Figs 4.23, 4.32). Areas of this 'funerary landscape' were surveyed in detail and its relationship with settlements and the field systems assessed. Likely to belong primarily to the Early Bronze Age, it is described in detail in Chapter 8 (Figs 8.14, 8.15). A second concentration of funerary features was along the series of hills flanking the north side of the Wadi Faynan, in the centre of the study area. While the overall density of funerary features within this zone was not as great as in the area south of WF4, the topographical positions chosen for both individual burials and cemeteries were often dramatic, and a number of such complexes was singled out for detailed survey.

Figure 4.20 *An example of a cist (WF692). Scale: 1 m. (Photograph: Graeme Barker.)*

The survey recording was not entirely consistent in allotting site numbers to funerary features. Occasionally site numbers refer to individual monuments of particular importance standing within larger cemeteries that have separate numbers, or else form parts of more extensive funerary landscapes with sparsely distributed graves. With these various provisos in mind, the following eleven sub-categories of funerary feature were defined.

4.6.1 Cist

This comprises a box or small chamber formed of vertically-set stone slabs (Fig. 4.20, cf. Fig. 4.32). While most cists were subterranean features without visible superstructures, they were also observed within funerary *cairns* (Fig. 4.23 and see below). In both cases, cists were only visible because of grave-robbing activities or particularly severe natural erosion, suggesting that the frequency of this type of site is probably greatly underestimated in the survey. Two main forms of cist were noted: rectangular and square. Both are of fairly small dimensions and unlikely to be suited for extended inhumations, although some larger examples could feasibly have been used for child burials; typical sites include WF673 and WF694. Cist-like graves are likely to have been built across a range of periods in prehistory. Those set within cairns seem likely to have a particular association with the Early Bronze Age (see below).

4.6.2 Grave (undifferentiated)

This term was used to denote a funerary site of uncertain type and date due to poor preservation or disturbance through grave-robbing. The grave may be cut into with grave-robbing holes or slots or sufficient other disturbance to have obscured the original form (e.g. WF27, WF28, WF37). As grave robbers are unlikely to target for excavation (or persist with deep excavation) structures of non-funerary origin, it is assumed that small-scale crude and undocumented excavations relate to this type of activity. Nonetheless, the ethnoarchaeological survey suggested that a small number of contemporary bedouin structures of superficially grave-like appearance but alternative function showed signs of attempted robbing, and it is possible that at least some sites recorded under the *grave (undifferentiated)* category, especially those with only vestigial or heavily disturbed remains, may not have originated as funerary structures. A marked cluster of undifferentiated graves in the vicinity of Khirbat Faynan and the South Cemetery reflects an area singled out for particularly severe grave robbing. In these sites, the grave-robbing process has removed all or part of the grave architecture, making it impossible to differentiate between different types of funerary structure.

4.6.3 Grave with headstone

This category refers to graves marked by a single prominent marker stone that sometimes featured an inscription, engraved cross, or *wasm* (a symbol of tribal loyalty), or a combination of markings (Fig. 4.21). Where these stones survived *in situ*, they were usually set orthostatically at the head of the burial, although in several cases disturbances mean that the stone had been removed from its original context. A small number of graves had larger and smaller stone markers respectively set at the head and foot of the burial (e.g. WF185). Graves of this type mostly occurred in groups of more than ten, to form *funerary complexes* (e.g. WF1123), although occasional single examples were recorded as sites (e.g. WF1294). It was not unknown for graves with headstones to be found in cemeteries displaying mixed funerary architecture (e.g. WF722, WF799). There is a small concentration of these structures in the area of Khirbat Faynan, but otherwise no obvious trends are apparent in their distribution.

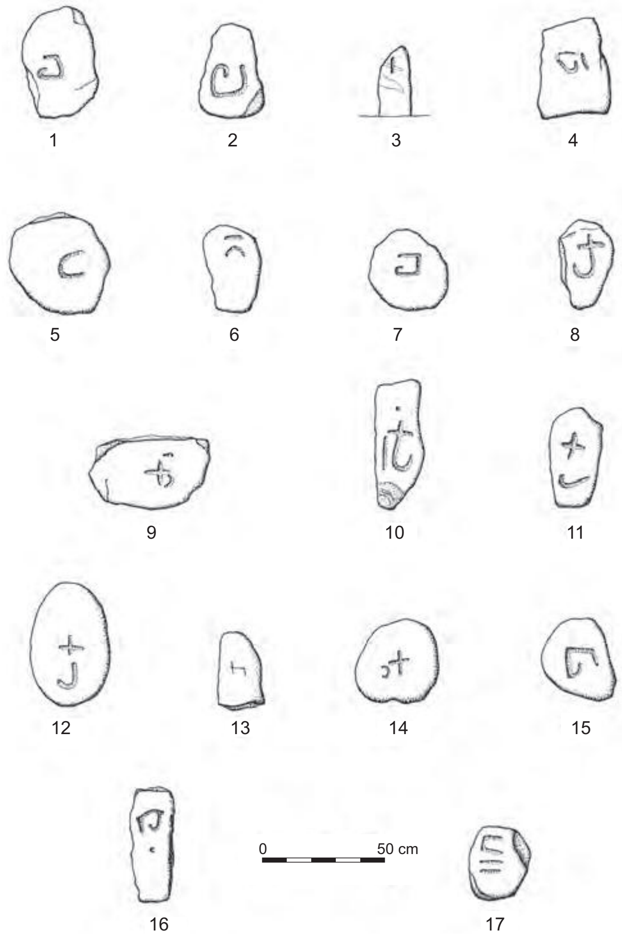


Figure 4.21 *Examples of engraved headstones (WF437). (Illustration: Oliver Creighton and Mike Hawkes.)*

Many Christian burials of late Roman/Byzantine date in the South Cemetery (WF3: Fig. 12.26) were only marked at the surface by a headstone placed at the west end of the grave cut, although it is possible that low earthen mounds have been eroded away (see Findlater *et al.* 1998: 72–4). Other examples (e.g. WF437) have oval/sub-rectangular stone rings marking the outline of the grave cut, with headstones at the west end. Islamic burials are also commonly aligned close to east–west, so as to face Jerusalem in the early period and Mecca later (Mershen 1991; and see Toombs 1985 for the Islamic burials at Tell al-Hasi in the Negev), and both

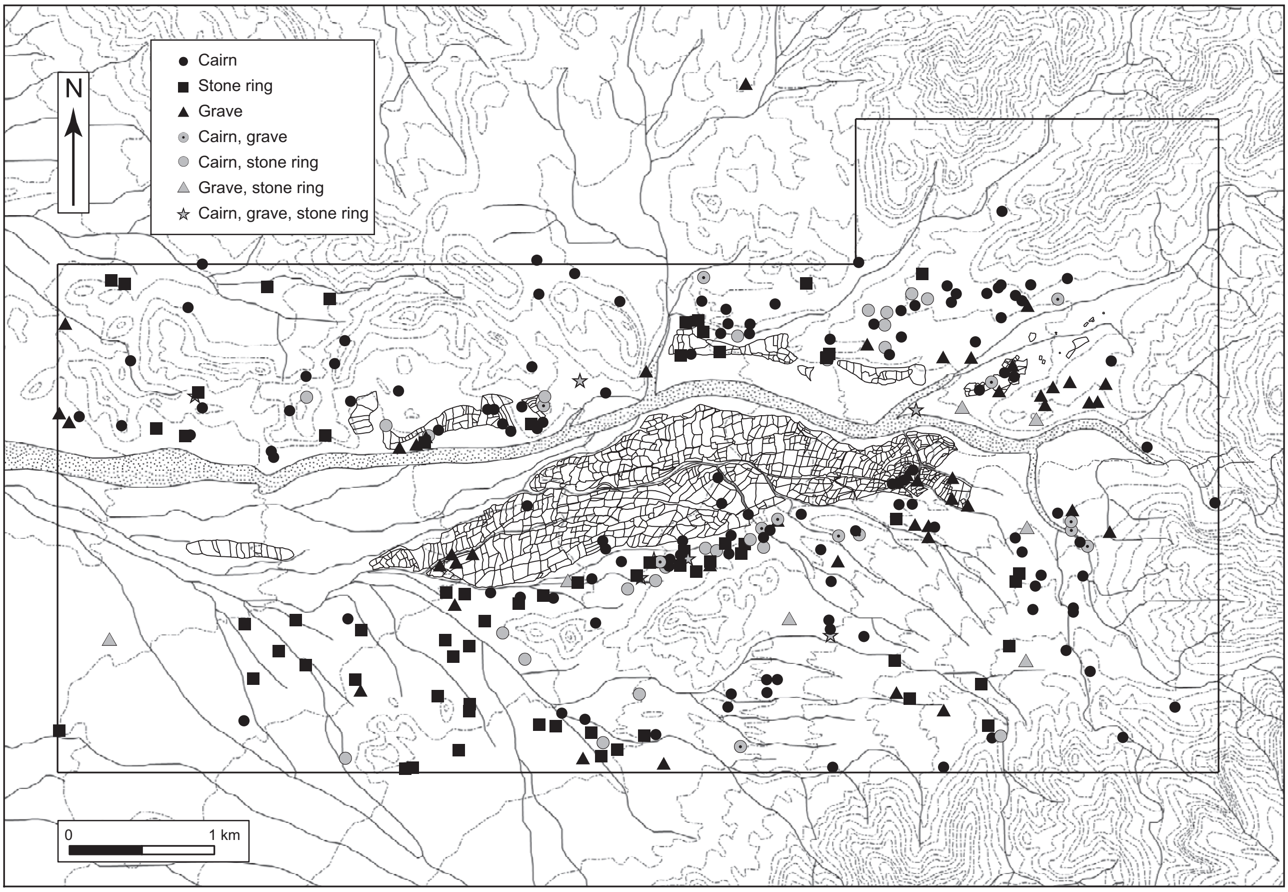


Figure 4.22 *Distribution of stone rings, graves, and cairns. (Illustration: Paul Newson.)*

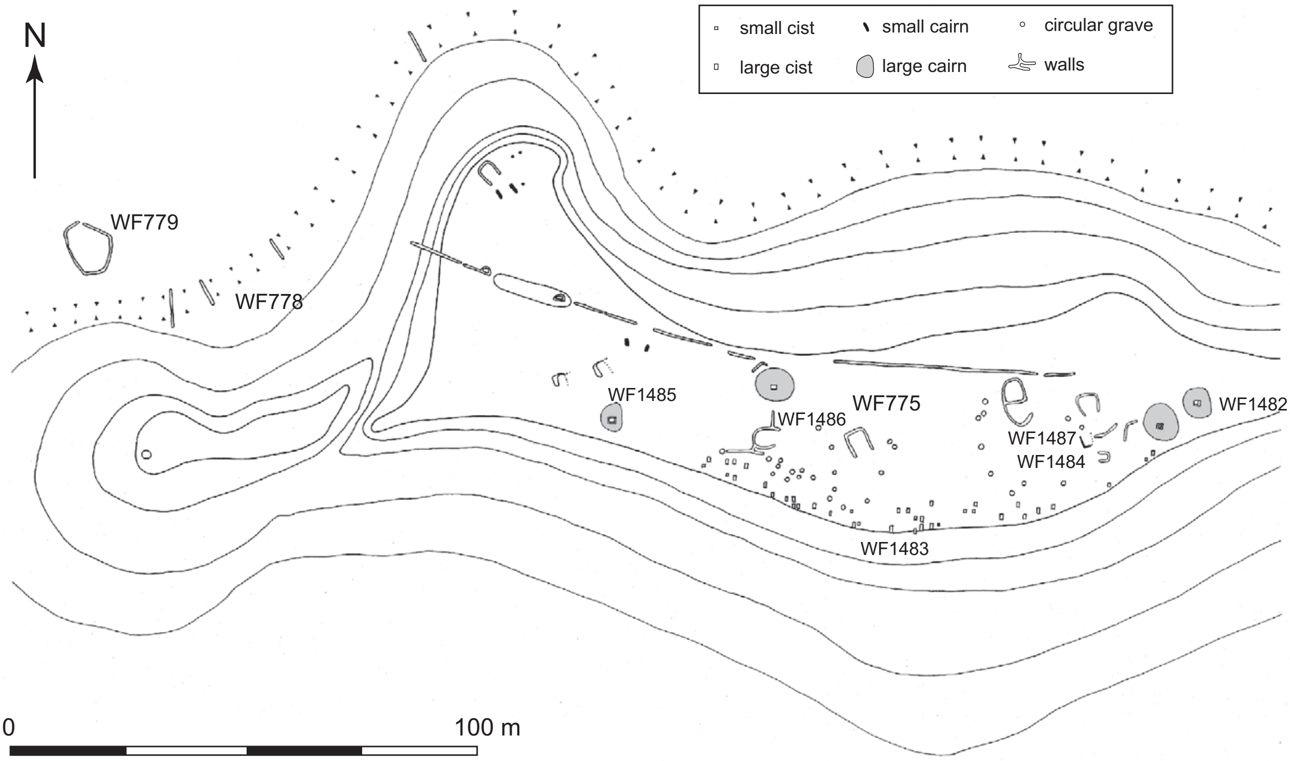


Figure 4.23 *Cemetery WF775 with mixture of cairns, rectangular and circular graves (see also Fig. 4.32). (Illustration: Oliver Creighton and Mike Hawkes.)*

headstones and footstones may be present on these graves too. Some relatively recent Islamic burials are also marked with a *wasm* carved on the headstone. Thus, while some burials around Khirbat Faynan and within nearby Byzantine cemeteries appear to be of recent date, they are structurally very similar to late antique examples. On the whole, graves with headstones are likely to date from any period between Roman times and the present day.

4.6.4 Stone ring

This type of grave comprises a ring of stones set on or just into the ground surface to delineate a grave cut or shaft. Such features have a diameter of *c.*1.5–3 m, and while most examples were approximately circular, other variations were recorded under the same category, including oval, elongated, and sub-rectangular forms. Sometimes the interior surfaces of these stone rings contained traces of 'paving': settings of flat stones, small stone chippings, or gravel.

Stone rings are one of the most common funerary monuments in the study area and occur in association with many other types (Figs 4.22, 4.27). While some single examples were recorded as sites in their own right (e.g. WF512, WF515), most formed component parts of larger funerary complexes (e.g. WF101, WF437) as well as occurring in field systems (e.g. WF15). They have been a particular target of grave robbers, so the original size of the cut or shaft, and the presence or absence of stone or gravel laid within the ring, were sometimes hard to establish. While many stone ring graves have been robbed (e.g. WF1487, WF1488), intact examples were also recorded (e.g. WF1436, WF1486). The criteria used to identify them as funerary structures included: the occurrence of structures in groups rather than as isolated examples; their location in topographical positions typical of many other funerary structures (e.g. the crests of ridges); the occurrence of headstones; and evidence of robbing. Inevitably, however, a few structures identified as stone rings may simply be disturbed *cairns* of uncertain function, or recent bedouin features such as *sleeping platforms* (Fig. 12.8).

Excavations of a stone ring cemetery in the nearby Wadi Fidan demonstrated that it dated to the tenth century BC, though a Chalcolithic date had been expected based on the grave morphology (Levy *et al.* 1999a). As variants on the stone ring grave form are also present in Roman and Byzantine cemeteries in the Wadi Faynan, it is clear that their overall chronological range is extremely broad.

4.6.5 Piled stone grave cover

This monument is a structured arrangement of placed stones on the ground surface to create a low sub-rectangular or lozenge-shaped platform of average dimension *c.*2 × 1 m (Fig. 4.24). This relatively common class of monument (Fig. 4.25) was differentiated from *cairn* by the comparatively low profile of the stone pile and the deliberate arrangement of stones, as opposed to their piling in more or less random fashion in cairns. The grave type also differs from the *stone ring* in that the size of material comprising

Figure 4.24 *An example of a piled stone grave cover (WF513). Scale: 1 m. (Photograph: David Mattingly.)*

a piled grave cover is more uniform, without the distinction between larger perimeter stones and an internal fill of smaller stones. The orientation of these features varies, but a proportion at least is aligned east–west and is suspected of being late antique or Islamic in date. It is likely, however, that graves from a range of prehistoric periods have left similar traces. As with *stone rings*, there is a danger of confusing a single isolated piled stone grave cover with a range of bedouin structures (see above). Many examples were found in large funerary complexes containing several different grave types, with an intermixing of *stone rings* quite common (e.g. WF506, WF513, WF519, WF536), although cemeteries consisting almost entirely of piled stone grave covers are not unknown (e.g. WF647).

4.6.6 Rectangular kerb grave

The edges of some rectangular graves are delineated by raised kerbs of carefully arranged pebbles or rough stone blocks. Many of these structures had been exposed by tomb-robbing, although a small number of undisturbed examples was recorded where the stones forming the perimeter kerb projected slightly above the present land surface. This grave type has been differentiated from the *stone ring* by the fact that examples have right-angled corners and by the approximately vertical outer faces to their kerbing. In poorly preserved examples, however, this distinction may be blurred and due allowance must be given for a certain degree of overlap between categories. These rectangular structures are often aligned north–south, but differ from *rectangular tombs* (see below) because of their less monumental structure and, generally, smaller sizes. The most striking concentration of these features was on top of and around the bases of prominent ridges and knolls immediately to the south of the central part of field system WF4 (Fig. 4.25), forming part of the Early Bronze Age funerary landscape mentioned earlier. Large and well-preserved examples include WF1305, WF1306, and WF1437, where the graves display a variable length of *c.*3–5.5 m and a consistent width of *c.*2.5 m (Fig. 4.26). The robbing of a number of these examples had

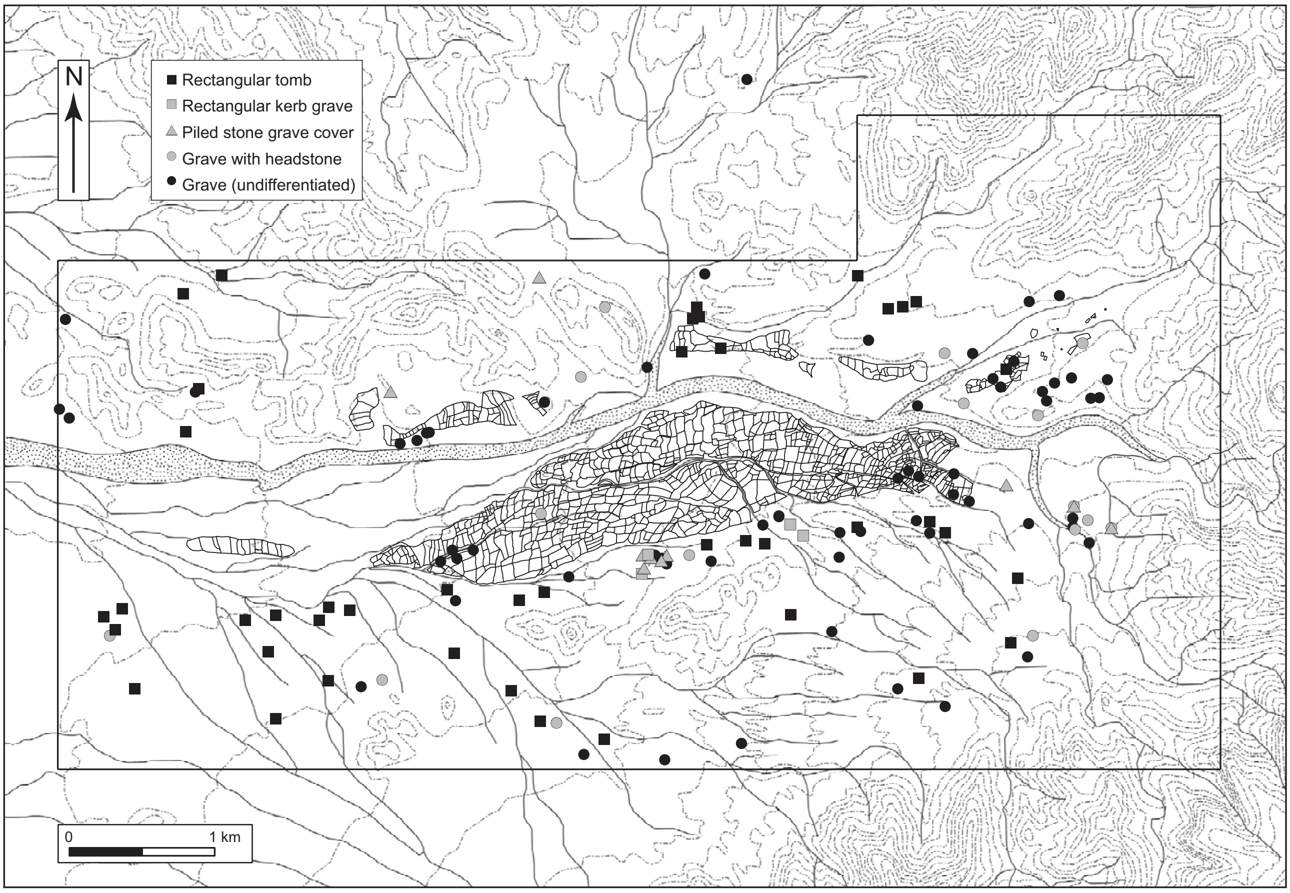


Figure 4.25 Distribution of grave types: rectangular kerb grave, rectangular tomb, piled stone grave cover, grave with headstone, and grave (undifferentiated). (Illustration: Paul Newson.)

Figure 4.26 (left) An example of a rectangular kerb grave, looking northwest (WF1439). (right) An example of a rectangular tomb, looking south (WF1438). Scales: 1 m. (Photographs: David Mattingly.)

left sufficient human bone debris to confirm that they had contained inhumations.

4.6.7 Rectangular tomb

This category comprises above-ground rectangular tomb structures usually made of well-coursed masonry, sometimes including substantial cut blocks and double-faced walls, singling them out as monumental funerary structures. The structures are also consistently larger than *rectangular kerb graves*. They are most commonly aligned north–south or northwest–southeast. In several cases the internal tomb architecture is visible due to grave robbing, and in some cases fragments of human bone were present. Good examples include WF1438 (*c*.6.2 × 3 m), or the even larger WF791 (*c*.9 × 3 m) and WF715 (*c*.12 × 3 m) (Figs 4.26, 4.27). Some of these more elaborate examples have architectural details, such as small ‘entrances’ defined by orthostatic stones (WF1416, WF1435,

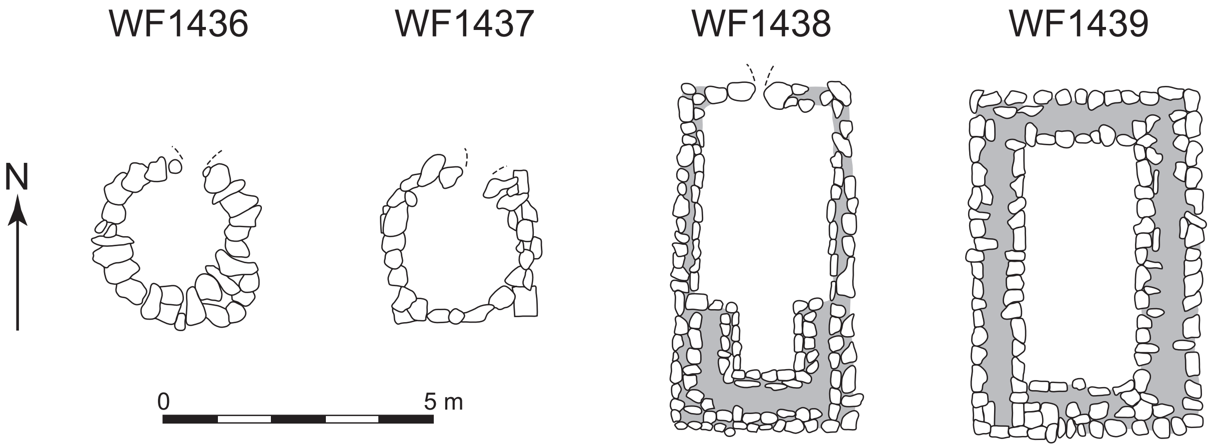


Figure 4.27 *Stone rings WF1436 and WF1437, and rectangular tombs WF1438 and WF1439. (Illustration: Dora Kemp.)*

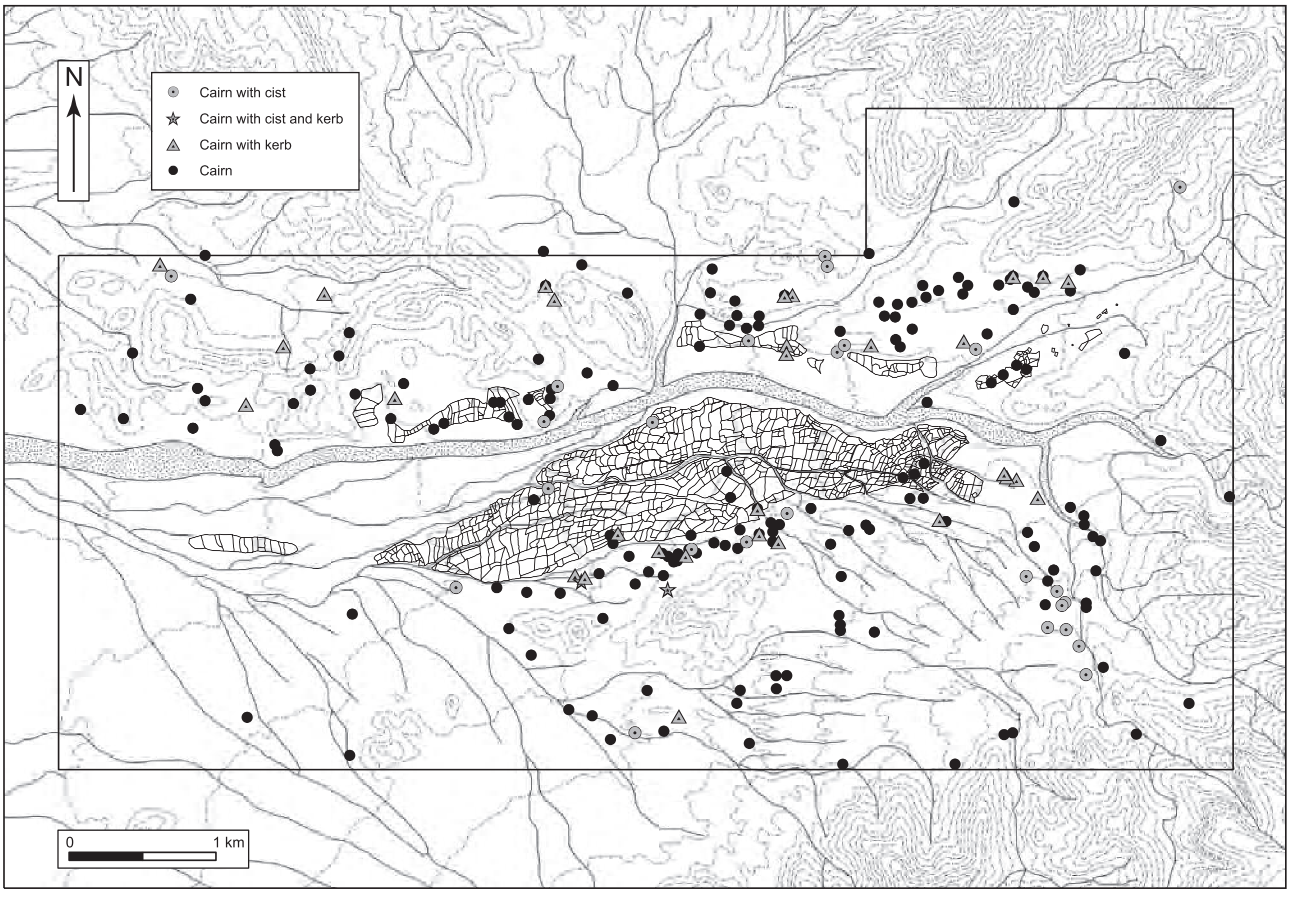


Figure 4.28 *Distribution of cairn types: simple cairn, cairn with cist, cairn with kerb, and cairn with kerb and cist. (Illustration: Paul Newson.)*

WF1438) and sub-chambers or internal cists (WF791). Size, orientation, and the presence of additional features such as sub-chambers, indicate considerable variability, although in poorly preserved examples some of these characteristics cannot be fully determined. The date of these features is presently uncertain, and more than one phase may be possible. While these are among the least common types of funerary monument recorded during the survey (Fig. 4.25), the architectural sophistication of these sites may suggest that they were high-status features. The date range of this grave type is likely to be very wide, as similar structures are known from Early Bronze Age to Christian contexts. Christian Byzantine examples are perhaps the most clear-cut sub-group: the South Cemetery (WF3) contains at least nine (possibly ten) rectangular tombs, all aligned east–west and with average dimensions of *c*.2.5 × 1.5 m. They were originally covered in white plaster and probably featured funerary inscriptions (Findlater *et al.* 1998: 72–4).

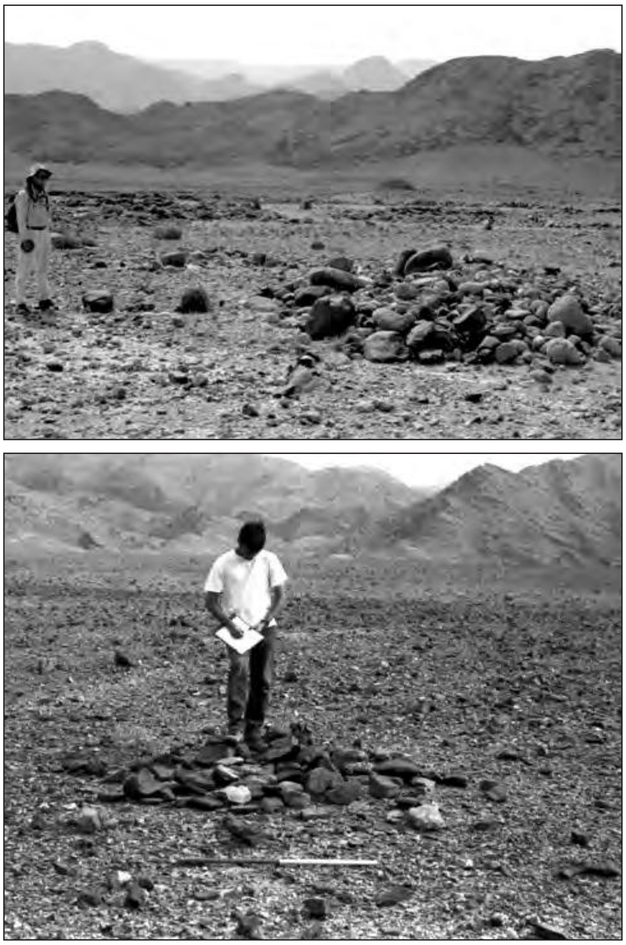


Figure 4.29 Some typical cairns (WF100 and WF1216), looking south. Scale: 1 m. (Photographs: Graeme Barker.)

Figure 4.30 An example of a cairn with a cist (WF17), looking north. (Photograph: Graeme Barker.)

Figure 4.31 An example of a cairn with a kerb (WF725), looking southeast. (Photograph: Graeme Barker.)

4.6.8 Cairn

Comprising artificial heaps of stones found in a wide variety of shapes and sizes, cairns were among the most common types of site recorded during the archaeological survey (Figs 4.28, 4.29). Funerary cairns are found in a variety of physical contexts, both alone and as component parts of wider funerary and other sites, although groups are common (e.g. WF118, WF120, WF534, WF1141), often in topographically obvious positions. Most of these features were circular or oval in plan, though sub-rectangular, square, and more irregularly shaped examples were also recorded. The sizes of cairns were classified as follows: *small* (<1 m diameter, <0.60 m high); *medium* (1–2 m diameter, <1 m high); or *large* (2–7 m diameter, 1–3 m high). The construction techniques used to create these features varied from the piling of loose stones in apparently random fashion to the more structured use of sorted stone blocks, particularly to form the lower portions of the cairn. The possibility must be recognized that a proportion of cairns may represent the vestiges of more sophisticated forms of grave architecture that have been disturbed, eroded, or obscured by stones gathered from field-clearance activities (see also below: *miscellaneous structures* for non-funerary *cairns*).

4.6.9 Cairn with cist

This category describes cairns covering square or rectangular stone chambers or cists formed of slabs or naturally-faced stones set on edge (Figs 4.30, 4.32). Both subterranean cists buried beneath cairns and others set above ground surface with the cairn piled up around them have been recorded. While most examples are in the region of *c.*2–4 m in diameter, cairns up to *c.*7 m across were recorded (e.g. WF1482). In most cases the cist has been exposed as a result of tomb robbing, sometimes leaving fragments of human bone that provide clear evidence of a funerary function (e.g. WF17, WF1103). In at least one case the cairn contained two separate cists. Early Bronze Age pottery was recovered in close association with many of these structures. A particular concentration was found on the terrace marking the eastern edge of the Wadi Shayqar (Fig. 4.28).

4.6.10 Cairn with kerb

These types of cairns were among the largest recorded during the field survey, typically in excess of *c.*3 m in diameter, although only relatively small numbers were encountered (Fig. 4.31). The bases were surrounded by an outer boundary 'kerb' formed of a single line of laid

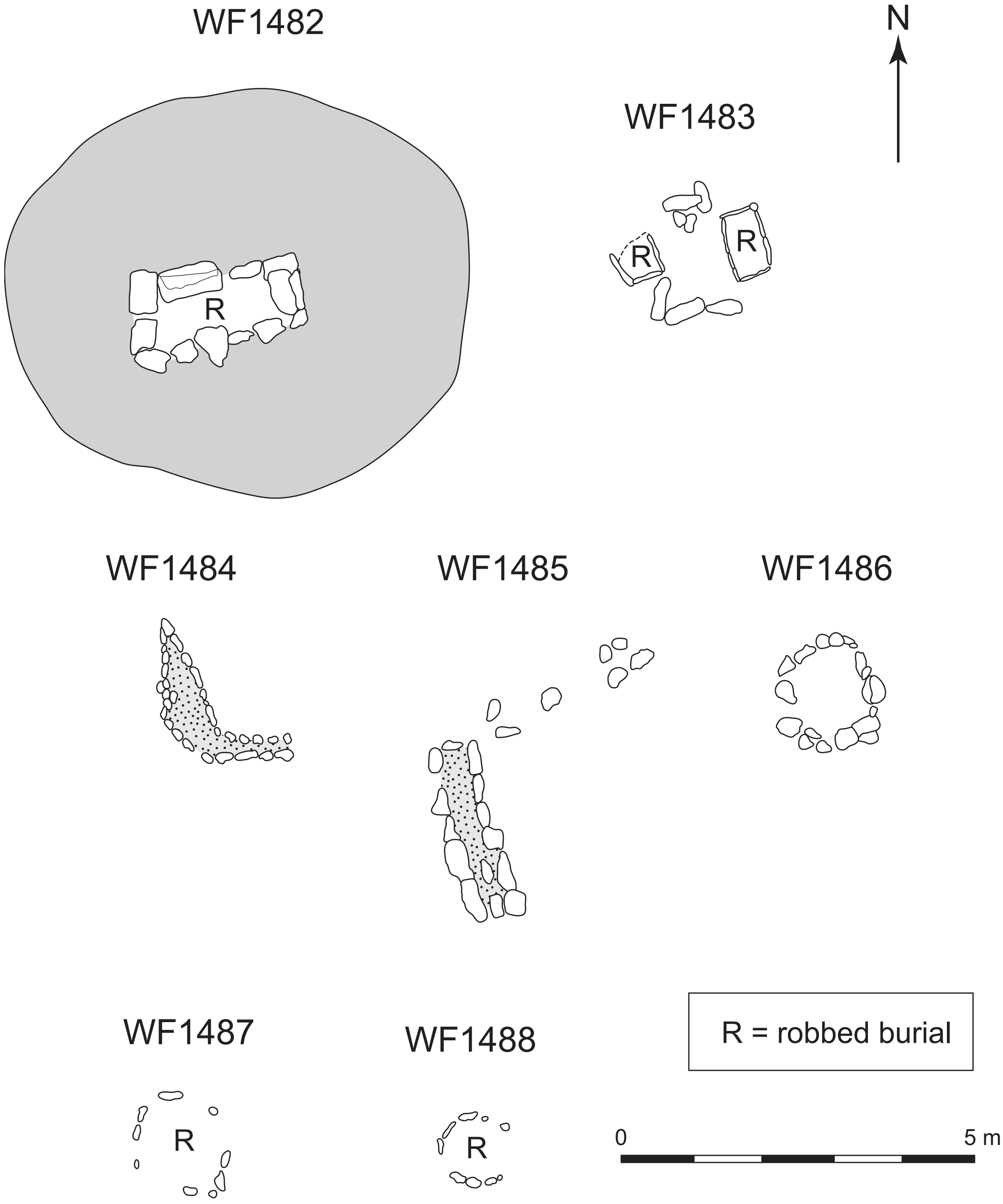


Figure 4.32 *Detail plans of a range of burial features within cemetery WF775 (see also Fig. 4.23). (Illustration: Dora Kemp.)*

stones (often rounded pebbles), set so that there is a vertical face on the exterior side. Among the largest examples were WF725 (*c*.12 × 8 m) (Fig. 4.31) and WF1629 (*c*.15 × 5 m). While circular/oval forms predominate, rectilinear kerbs are also occasionally found. In those cases that were robbed (e.g. WF725, WF1440) it was clear that the cist was not always positioned centrally but might be offset to one side. Many examples were associated with Early Bronze Age pottery, although a significant proportion produced Classical material, and a broad date range is likely.

4.6.11 Cairn with cist and kerb

This type of cairn, relatively rare in the survey (Fig. 4.28), combines the characteristics of the two categories above: it has a square or rectangular stone chamber or cist at its centre, and an outer boundary kerb or edge formed of a single line of stones, so that there is a vertical face around the exterior. Such features could only be positively identified where conditions of preservation were exceptionally good, such as WF685. The associated pottery indicates that they are likely to be Early Bronze Age in date.

Figure 4.33 *Three sections of the channel of aqueduct WF31/WF33: (left) the well-preserved extension to the aqueduct feeding the mill at WF11, looking east; (centre) detail of channel on aqueduct bridge over Wadi Shayqar, showing two phases of waterproof lining (lower marked by 10 cm scale), looking west; (right) rock-cut channel in south edge of Wadi Ghuwayr gorge, looking west. Scale: 1 m. (Photographs: Darren Crook.)*

4.7 Hydraulic structure

4.7.1 Aqueduct bridge

The main Classical settlement at Khirbat Faynan was served by an aqueduct (WF31/WF33) to its southern settlement area, WF11. The aqueduct (Figs 1.4, 10.11, 10.14) crossed the Wadi Shayqar for a distance of 120 m on a bridge structure that originally incorporated at least twelve arches. The bases of three piers survive close to the east bank, their dimensions showing that each archway had dimensions of *c.*3 × 3 m, although the remainder of the structure has been washed out by the wadi. Parts of the structure were constructed of large faced and mortared sandstone blocks enclosing a rubble core. A second element of the structure is an elevated channel, though not properly a bridge as such, extending west of the large reservoir in the centre of WF11, to the mill. The masonry support here is *c.*4 m high at maximum and extends *c.*11 m between the base of the slope and the side of the mill (see below: *aqueduct channel* and *mill*). The channel on the aqueduct bridge is lined with good-quality mortar and contains traces of two separate phases of lining, each channel being approximately *c.*0.5 m wide and originally *c.*0.4 m deep, indicating that the water-supply system was modified over time.

4.7.2 Aqueduct channel

The channel of the Classical-period aqueduct that fed the industrial and settlement complex of WF11 has been traced at various points in addition to the sections where it was carried over the Wadi Shayqar on an elevated masonry support (Fig. 10.14). A series of rock-cut ledges, designed as channels to guide water flow, has been recorded at various points along the south side of the Wadi Ghuwayr gorge, although evidence was vestigial due to the erosion of the majority of the structure by the wadi and by rock falls. In places there are traces of hydraulic cement on the rock wall of the gorge, and in one place the side of a rocky abutment in the Wadi Ghuwayr contained evidence of three separate (and presumably successive) channels stacked approximately 1.5 m on top of one another (Fig. 4.33). There are also traces of a long linear wall-like feature following the contours around the north side of WF2 and the north edge of the slag heap WF34 that probably represent the foundations of the aqueduct. One of the project geomorphologists reported traces of what may have been a further aqueduct on the north side of the Wadi Ghuwayr to the east of Khirbat Faynan (see Fig. 3.13, upper), though it has not been possible for the archaeological survey to verify this report. It thus remains a hypothesis for future research to test that WF1 had its own independent aqueduct on the sometimes steeply-eroded north bank of the wadi.

A far smaller example of an aqueduct channel was a partly rock-cut feature that fed the cistern within the Roman military/high-status site of Khirbat Ratiye (WF1415). This leat was traced for *c.*100 m following the natural contours of the hillslope behind the site. It seems to have been exploiting a rain-fed catchment rather than a spring, in a manner similar to one of the fortified farms recorded in the Libyan Valleys Survey (Barker *et al.* 1996a). We also found an example of a single boulder being cut through to facilitate water flow within the WF4 field system (Fig. 5.33).

Figure 4.34 *(above) Detail of aqueduct, penstock tower, and mill structure, looking north; (below left) detail of end of aqueduct channel and penstock shaft, looking northwest; (below right) the mill building at foot of penstock tower, looking south. (Photographs: Paul Newson.)*

4.7.3 Mill

The only site under this category is the water mill on the south side of the Wadi Faynan, marking the western limit of settlement area WF11 (Figs 4.34, 10.13). The structure was of the single-towered penstock-type mill (i.e. with the wheel fed from above by a circular drop-tower reservoir) that is typical of Jordan, and in this instance probably of Roman origin, or else on the site of an earlier Roman structure (see Chapter 10 for further discussion). Evidence from elsewhere within Jordan suggests mills of broadly similar type are of Islamic date (McQuitty 1995), and later re-use of the structure in the Wadi Faynan cannot be ruled out. However, there is a growing body of evidence to show that this type of mill probably originated in the Roman/Byzantine period (Wikander 2000: 371–400; Wilson 1995) and the context and mortar analysis (Morgan 1997; Table 5.4) favour the earlier date here. The mill tower, fed by a stone-lined leat, stood *c*.4 m high, and contains a vertical shaft of *c*.0.2 m diameter and *c*.1.5 m length that fed an approximately round wheel-house.

4.7.4 Reservoir

This term is used to describe artificial structures used as major water-storage facilities. Two examples were recorded, both related to high-status settlements. WF1348 was a part of a Classical-period industrial and settlement complex (WF11) near Khirbat Faynan. The reservoir comprised a large stone-lined subterranean feature, rectangular in plan and measuring *c*.33 × 30 m, with a depth of 4 m (Figs 1.4, 10.12). Evidence of dressed sandstone facing blocks survives. The reservoir was originally lined with hydraulic cement. A small settling tank occupies the area where the

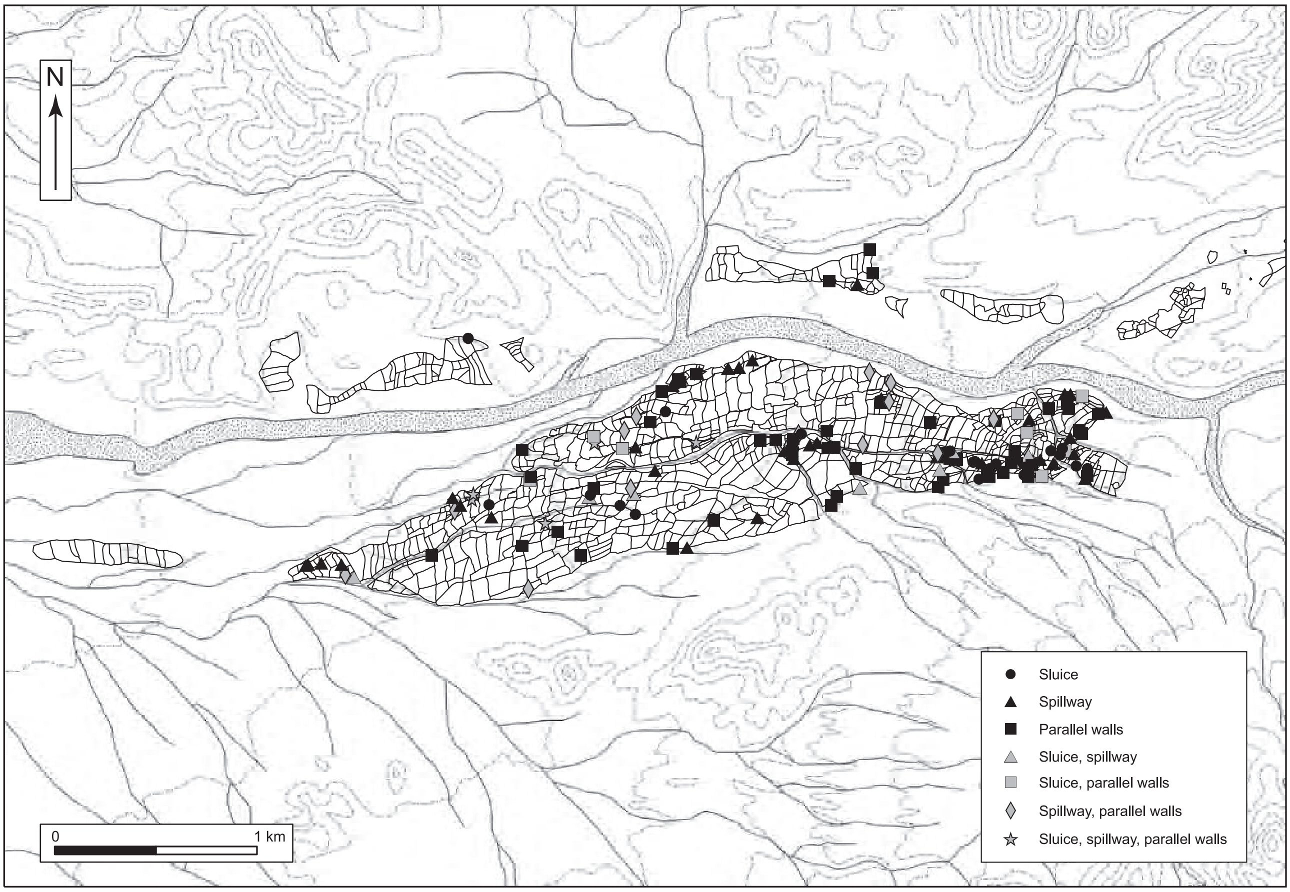


Figure 4.35 *Distribution of water-management features: sluices, parallel walls, and spillways. (Illustration: Paul Newson.)*

aqueduct enters the east side of the reservoir, and a flight of stone steps descends into its northwest corner. The aqueduct appears to have divided at the reservoir, with a branch continuing around its rim to run west in order to feed the watermill. The outflow arrangements for the main reservoir are uncertain and the complex of aqueduct, reservoir and mill undoubtedly merit further investigation in future (see Chapter 10 for discussion). A smaller, but still substantial, subterranean tank was recorded at the Roman high-status site of Khirbat Ratiye (WF1415) (Fig. 10.15). The feature was rock-cut but lined in places with ashlar blocks, and is presumed to have been fed intermittently by rainfall captured from the slopes above via the channel that was visible on the north side of the site.

4.7.5 Channel

Within the WF4 field system was a number of places where *parallel walls* (see below) ran into natural rock outcrops and continued through them as rock-cut channels (e.g. WF49, WF50). Their study (Chapter 5) indicates that they formed components of large floodwater farming systems dating to the Classical period. They are differentiated functionally from the category *aqueduct channel* in that they were mainly built to direct seasonal surface run-off rather than to transport water fed from a continuously-flowing spring.

4.7.6 Parallel walls

These occur, along with other water-management features, within the principal field system WF4 (Fig. 4.35) and comprise pairs of walls, generally built 1–3 m apart and running in parallel for considerable distances across the landscape (e.g. WF243, WF288) (Figs 5.29–5.31). In many cases, the recorded sites are likely to represent small surviving component parts of far more extensive and integrated systems, subsequently obscured by erosion and clearance. However, sequential segments of parallel walls have been traced in many parts of WF4, and in several instances sectioned (see Chapter 5 discussion and *excavation: trial trench* earlier). The trial excavations revealed a sequence of waterlain deposits between the walls (e.g. Fig. 5.35), supporting the interpretation of them as hydraulic in function, either transporting and diverting surface flow or directly tapping wadis. They are commonly associated with *sluices* and *spillways*, allowing the controlled diversion of waters into field units along their length. The distribution of these sinuous features is mainly restricted to areas of predominantly level topography in the northern portion of the WF4 field system. Considerable engineering expertise was necessary for their construction, as they were used to transport water long distances over very shallow gradients.

Figure 4.36 The Khirbat Faynan barrage (WF441), looking southwest. Scale: 1 m. (Photograph: Graeme Barker.)

Figure 4.37 An example of a catchment structure (WF39), looking west. (Photograph: Graeme Barker.)

4.7.7 Barrage

A barrage is a substantial artificial dam built across a water course, normally in excess of 1.5 m high and at a far greater scale than most cross-wadi walls and simple field terraces. The most prominent example is WF441, a double-faced wall of high-quality masonry (*c.*2 m wide at the top, with traces of a possible walkway), presumably of Roman date, that blocked the mouth of a small catchment immediately north of Khirbat Faynan (WF1) (Figs 1.13, 2.13, 3.5, 4.36, 10.10). This enigmatic barrage wall survives for a length of *c.*65 m with an integral sluice at the eastern end. It created an impounded area of *c.*5000 m^2. Whilst the barrage did, as it still does, impound some shallow water in winter rain storms, its primary intention was probably to support industrial-metallurgical processes, perhaps related to ore washing (processes for which the sluice provided an escape for the water used), and to contain heavy, noxious wastes by preventing them from slumping and flowing downslope, as did the other massive walls nearby at WF5738 and WF5739 (see Chapters 3 and 10). Excavation up-wadi of the barrage revealed a build-up of deposits over 2.5 m in depth (Fig. 1.15). A small number of especially well-preserved walls within the field system WF4 also falls within this definition (e.g. WF441, WF496, WF497).

4.7.8 Catchment structure

This category incorporates a small but extremely significant collection of circular stone-built structures in one restricted area, for the most part just outside the southern edge of the main field system WF4 (e.g. WF24, WF39, WF55, WF58, WF269). They are formed by low boulder-built walls incorporating smaller stones, are circular or oval in plan, and average *c.*10 m in diameter (Figs 4.37, 8.23). Trial excavation within one of the better preserved examples revealed water-borne sediment to have been lain to a depth of *c.*0.75 m. On the evidence of the sediments and the palaeoecological signatures contained within them (see Chapter 3, §3.4.2.4 and Chapter 8, §8.8), they are assumed to have functioned at some stage as water-catchment or ponding structures. In any event, the recovery of substantial amounts of Early Bronze Age pottery in and around them suggests that they are relatively early features of the landscape and in Chapter 8 (§8.6) we argue that they represent some of the earliest attempts to capture and store water for agricultural purposes. It is not inconceivable, though, that some catchment structures may represent simple domestic structures or enclosures that have been infilled with water-borne sediment (see also *domestic structure*: *simple circular/oval structure*).

4.7.9 Cistern

This term is used almost exclusively for a series of modern, concrete-lined, water-storage tanks, linked to an aborted scheme of pipe wells constructed to provide water for local people in the 1960s (e.g. WF820, WF821, WF822, WF855, WF1409, WF1507). The only cistern recorded of any antiquity was a rock-cut and partly stone-lined feature within the Roman/Byzantine high-status site of Khirbat Ratiye (WF1415), which was fed via a rock-cut aqueduct channel.

4.7.10 Diversion wall

This structure consists of a wall formed of single stones constructed to capture floodwater from an upslope area, or from a watercourse, and guide its movement downslope and distribute it, usually via a *sluice* or *spillway,* into fields at a lower level. Among the best preserved examples were the substantial boulder-built walls within WF406 which ran for relatively long distances across the base of a hillside to mark the edge of this field system, diverting surface flow from the slopes above into subsidiary field units (Fig. 8.34). In common with the features *sluice* and *spillway* described below, diversion walls appear to have functioned as components within large-scale floodwater farming systems in use especially in the Classical period.

4.7.11 Sluice

A sluice is a purposefully-constructed gap in a field wall, less than a metre wide (most sluices are narrower than this), with stepping or terracing indicating that the gap had a hydraulic purpose (e.g. WF51, WF250, WF1637; Figs 5.22, 5.23). While the size of the gap through the field wall is the main characteristic differentiating a sluice from a *spillway* (see below), in certain conditions of preservation this distinction was not always possible, and some examples may be classified as either (e.g. WF74). In addition, both spillways and sluices could, on occasion, be encountered together within a limited area to form a water management complex and be recorded as a single site (e.g. WF254, WF1494). The purpose of such features within the field system appears to have been to control whether floodwater was allowed through a wall onto lower ground, or prevented from passing through it, for example with a movable timber barrier. The distribution of both these types of feature, along with *parallel walls*, was restricted almost entirely to the principal field systems (Fig. 4.35; and see discussion in Chapter 5). Sluices showed a tendency to be located in the corners of fields in order to distribute water efficiently to multiple field units, as part of the floodwater farming system that appears to have operated in the Classical period (Chapter 10). In some of the more elaborate examples, sluices were associated with 'baffles' that forced flowing water to spread more widely onto the lower surface (e.g. WF234, WF320). It is recognized, however, that some gaps identified as sluices may have been simply gateways, and a few may have been misidentified completely and may just be gaps created by erosion or recent farmers.

4.7.12 Spillway

A spillway is a deliberately-constructed gap in a wall, more than a metre wide, usually with associated stepping or terracing below it, indicating that the gap had a hydraulic purpose (Figs 5.25, 5.28). It is assumed that many such structures (e.g. WF69, WF162) facilitated the spread of diverted water onto field units in the Classical period (Chapter 5). As with sluices, it is recognized that some gaps identified as spillways may have been gaps created through natural erosive processes or by farmers (see also *Miscellaneous structure: gateway*).

4.8 Mining feature

The mining and smelting of copper have been important economic operations in many phases of human exploitation in the Faynan region, from the Chalcolithic onwards. At present, most of the archaeological evidence from Faynan appears to relate to the mining and smelting of copper, although lead ore was probably obtained as a by-product of copper mining and it is possible that there may have been some limited iron working or smithing. Both mining and smelting activities have generated a wide array of archaeological traces in the landscape. In categorizing this material, the WFLS built on, and is greatly indebted to, the work of the Bochum mining museum (see, in particular, Hauptmann 2000; 2003; 2006; 2007: 85–156; Hauptmann and Weisgerber 1987; 1992; 2006; Hauptmann *et al*. 1992; Weisgerber 1989; 1996; 2003; 2006) (Figs 4.38, 4.39).

A critical distinction to be made in the archaeology of the metal industry in Faynan, as elsewhere, is between the primary extraction of mineral deposits from the ground and their secondary processing into metals (see, for instance, Healey 1978; Rihll 2001). In recognition of this, the major category *mining feature,* encompassing sites associated with the primary extraction of minerals (Fig. 4.40), is therefore differentiated from *metallurgical feature,* sites associated with processing and smelting (Fig. 4.46). More explicit descriptions of features specific to each of the primary phases of mining and metallurgy are included in the appropriate period-specific chapters later in this book; here, some generic definitions and descriptions of different types of feature are offered.

4.8.1 Prospect

An initial working to assess the nature, richness of ore, pitch, and practicality of working of an ore body is known as a 'prospect'. These might be relatively small-scale excavations into the bedrock, after stripping of vegetation and topsoil, or quite large opencasts, depending on the scale and success of the enterprise. In some cases prospect shafts might be dug to assess the depth of deposits or the potential of underlying strata, but the more common form of prospects in Faynan appears to have been the horizontal cutting back of the rock face, to create what initially appear to be small rock-shelters. This category was not much used, however, because of the practical difficulties in discriminating between genuine prospects and natural small caves and shelters, although some convincing examples were noted in one of the densest areas of Roman mining, the Qalb Ratiye. Positively identified examples include WF1585 and WF1634 (Fig. 4.41).

4.8.2 Adit

An adit is a simple form of mine consisting of a horizontal or near horizontal tunnel running into the side of a valley, hill, or mountain (Fig. 4.42). Inherently difficult to date, these features were created across a wide timespan from the origins of mineral extraction in the region in the Chalcolithic period, with episodes of re-use and

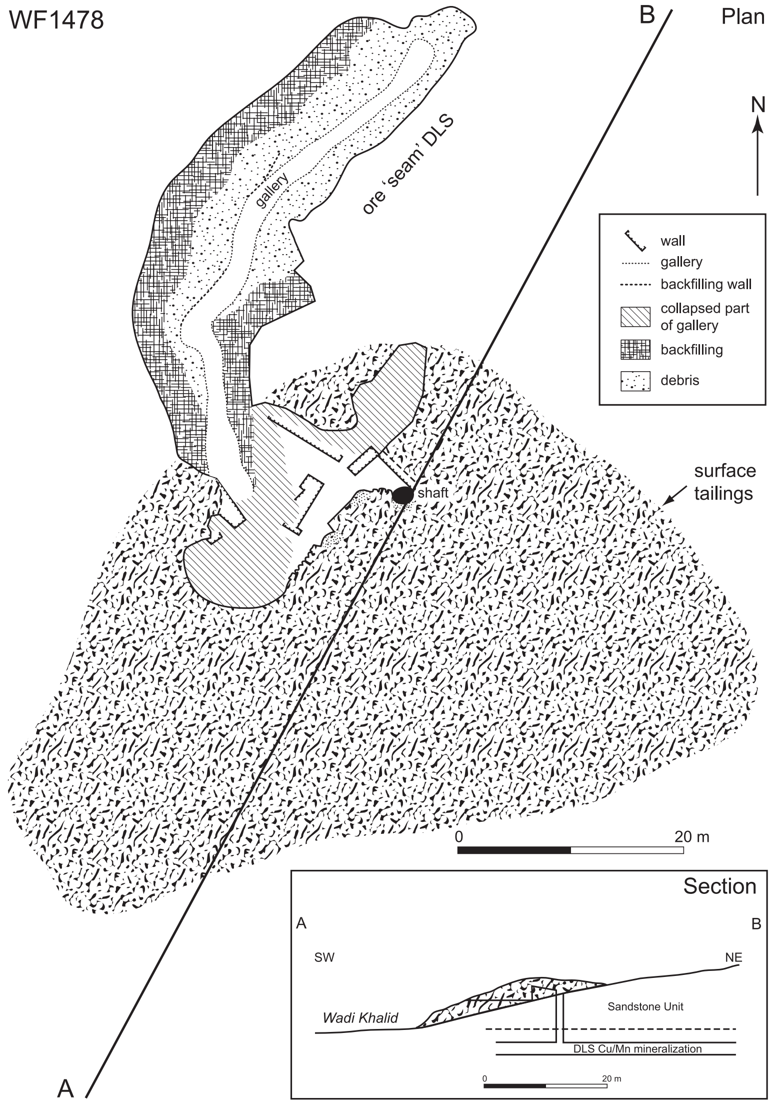


Figure 4.38 *Plan and section of an Iron Age mine in Wadi Khalid (WF1478). (Illustration: Dora Kemp and David Mattingly, after Hauptmann 2007, 118–19.)*

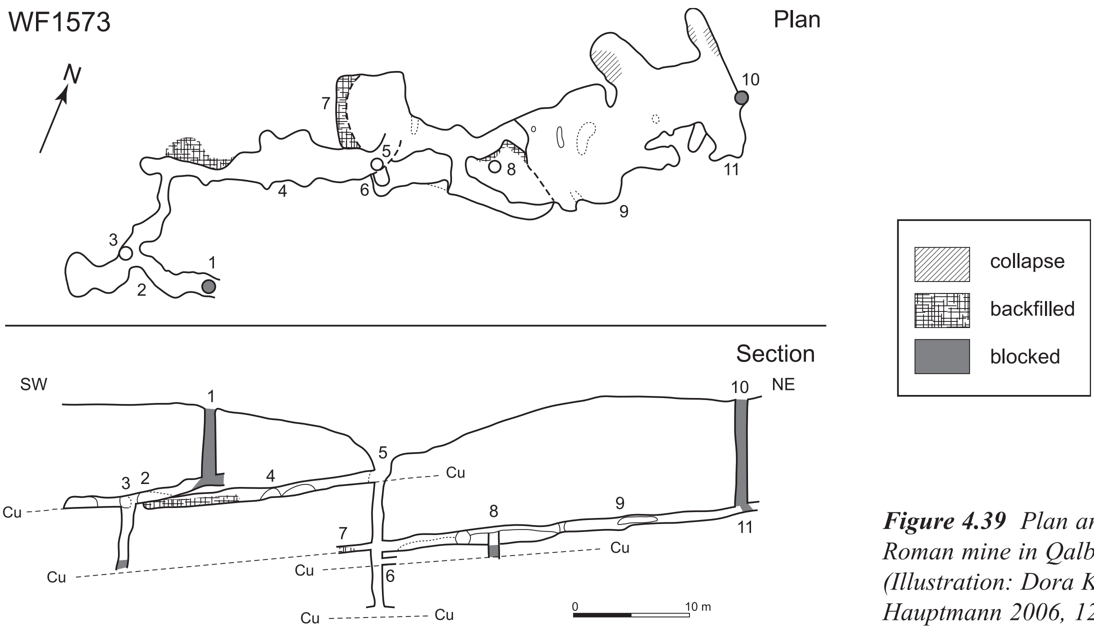


Figure 4.39 *Plan and section of a Roman mine in Qalb Ratiye (WF1573). (Illustration: Dora Kemp, after Hauptmann 2006, 129.)*

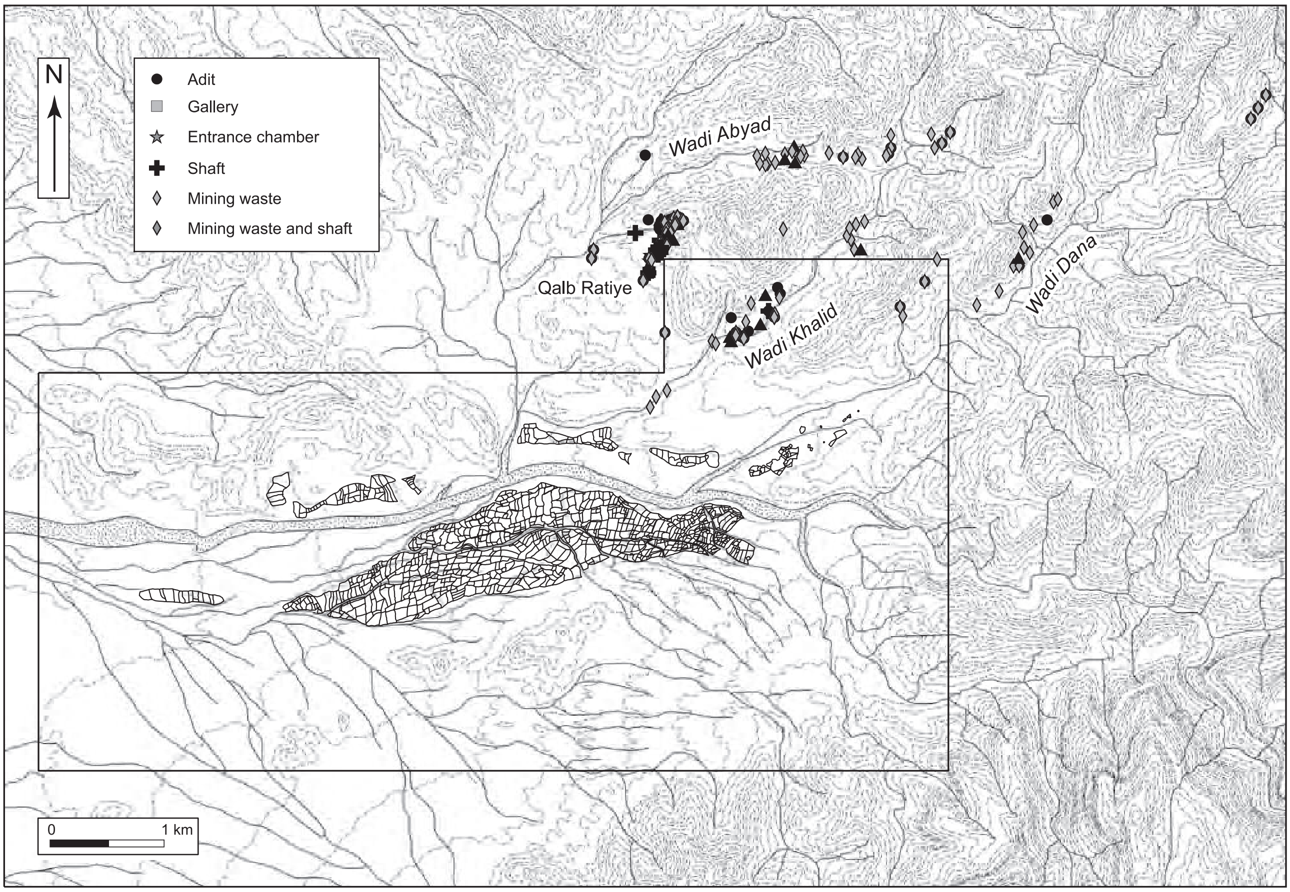


Figure 4.40 *Distribution of mining features: adit, entrance chamber, gallery, mining waste, shaft. (Illustration: Paul Newson.)*

Figure 4.41 *An example of a prospect (WF1634). Scale: 1 m. (Photograph: David Mattingly.)*

Figure 4.42 *An example of an adit (WF1465). Scale: 50 cm. (Photograph: David Mattingly.)*

Figure 4.43 The arcaded gallery at Umm al-Amad. (Photograph: M. Ruiz del Arbol.)

Figure 4.44 An example of a shaft (WF1469). (Photograph: David Mattingly.)

remodelling extremely likely, especially in the Classical period. In most cases adits were clearly constructed to follow the pitch of veins of ore-bearing minerals, usually at quite shallow gradients. Examples were recorded both as discrete features (e.g. WF1152, WF1462) and, more commonly, in association with deposits of mining waste emanating from them (e.g. WF1139, WF1153, WF1465). Variations include examples that were blocked (e.g. WF1559) or collapsed (e.g. WF1553), others that were apparently prospecting features (e.g. WF1585), double adits (e.g. WF1587), and poorly preserved examples where identification was tentative (e.g. WF1156).

4.8.3 Entrance chamber

Some larger mines had elaborate entrance arrangements with clearly defined outer chambers cut into the hillsides, from which smaller galleries were excavated (e.g. WF1576, WF1580, WF1583) (Fig. 10.5). The most elaborate example recorded (WF1577) featured pillars of unmined rock. This technology appears to have been a feature of mineral extraction in the Classical period. It is particularly apparent at some of the Roman mines in the Qalb Ratiye area, and may reflect arrangements for the supervision of large slave-based workforces underground as well as being a practical way of minimizing the risk of collapse.

4.8.4 Gallery

A gallery is similar to an adit in that it relates to an underground tunnel or open chamber of generally horizontal or shallow gradient within a mine (Fig. 4.43). A gallery is a wider and more extensive subterranean feature, however, and usually opens up behind a narrower mine entrance, adit, or shaft. In some cases galleries will have been formed by the removal of substantial volumes of mineral deposits, although elsewhere they were apparently constructed or modified to improve access to other mine workings. Galleries of some sort are likely to have been created from the earliest periods of extractive metallurgy in the region, but the clearest and most accessible examples encountered during the survey were in the complex Roman mines at Qalb Ratiye and Umm al-Amad. One particularly complicated example (WF1583) acted as a junction between four tunnels, although most were simpler in form (e.g. WF1574, WF1576, WF1550).

4.8.5 Shaft

A vertical or near vertical tunnel in a mine is known as a shaft. They are used both for ventilation and to allow access to or egress (of people or materials) from deep workings. Some shafts remain open and can be easily recognized today, although more commonly they have become choked with debris and some may have been deliberately backfilled to prevent mine collapse. They were among the more common mining features recorded, and most were found in association with deposits of waste (e.g. WF1474, WF1565) (Figs 1.6, 4.44, 9.9). Variations included shafts that preserved rock-cut footholds (WF1574) and examples that were blocked (WF1568) and collapsed (WF1584). Like adits, mine shafts are inherently difficult to date in isolation, with the likelihood of re-working making dating on typological grounds hazardous. Nonetheless, rock-cut postholes for winding gear may be diagnostic (Weisgerber 2006: 14–17) and ventilation shafts accompanying the main shaft appear to have been an innovation of the Iron Age (Weisgerber 2003: 84–5; 2006: 11–17). Investigation of one of the large mine waste heaps in the Wadi Khalid by the NRA revealed a unique triple-shaft of two phases (Hauptmann and Weisgerber 1987: 426; Fig. 4.44).

4.8.6 Mine waste

The material extracted from a mine had to undergo preliminary processing before being placed in a furnace. A key point here is that ore-bearing strata often contain a very small percentage of copper ore relative to the overall matrix of rock. The basic principle of ore processing or dressing is to enrich the concentration of ore and remove as much as possible of the material that contains little or no ore, thereby reducing the volume of material to be transported to the furnaces (Rihll 2001: 116–18). This can be done in a variety of ways and often involves a sequence of opera-

Figure 4.45 *Two examples of mine waste relating to different ore bodies: (above) dark tailings from Iron Age mining of DLS ores in Wadi al-Abyad, looking southeast; (below) light pulverized sandstone from MBS workings in Qalb Ratiye, looking northeast (WF1561). (Photographs: David Mattingly.)*

tions that starts at the mine with the separation of ore from the parent rock and overlying and underlying strata. The unwanted rock will often have been brought to the surface and broken up into small fragments, with any material showing signs of mineralization being set to one side and sterile material being dumped (Fig. 4.45). The deposits of mine waste (or spoil/tailings) are usually accumulated close to the mine workings in slumped heaps or fans running downhill from the processing areas and represent some of the most diagnostic features of ancient mining landscapes. As discussed in detail in Chapters 3 and 10, the residual heavy metals make the spoil heaps fairly poisonous for plant growth and in the arid landscapes of Faynan the ancient heaps of mine waste are often distinguishable, being differentiated in colour from their surroundings. Deposits were recorded in association with the majority of adits and shafts recorded during the fieldwork. The work of the Bochum team demonstrated that the composition of mine waste can provide indications of the date of its extraction, and the different sets of ores in mine waste could often be linked to particular ores. The DLS (Dolomite-Limestone-Shale; see Burj Dolomite Shale Formation in Chapter 2,

§2.1.3) ores exploited predominantly in the Bronze and Iron Age produce a characteristic dark grey mine waste in the Wadis Khalid, Dana, and al-Abyad, while the MBS (Massive Brown Sandstone, see Umm ʻIshrin Sandstone in Chapter 2, §2.1.3) ores of the Qalb Ratiye area exploited in Roman times (and on a limited scale in the Chalcolithic) generated a much lighter coloured and more sandy type of tailings (Figs 2.4, 4.45).

4.9 Metallurgical feature

4.9.1 Furnace elements

A furnace is a purpose-built structure designed to reach and maintain high temperatures in which minerals are converted to metals and unwanted materials are separated as slag waste. Usually found in batteries of closely spaced structures under the crests of hills (Fig. 4.46), they were constructed primarily of clay but also sometimes incorporated stone and slag pieces. The earliest copper smelting in the Faynan region probably took place in crucibles and has left little or no tangible traces. The field evidence relates to the period from the Early Bronze Age to the Roman period, with metallurgy becoming progressively centralized so that activity in the later period was focused entirely on the area immediately around Khirbat Faynan (Weisgerber 2003: 86–7; 2006: 8–27).

The most commonly surviving element *in situ* is the base of a furnace, sometimes cut down into the bedrock. The field remains of furnaces are often mantled by substantial deposits of slag and later structures, however, making such features difficult to identify without excavation (Fig. 4.47). Successive furnaces were also often built on the same site, forming overlapping sequences of furnace floors and walls, well illustrated at Faynan 9 (see Hauptmann 2000: 74–8, on Bronze Age elements). During the WFLS fieldwork, elements of dismantled furnaces were also recovered in slag heaps or slag scatters, where the hand-formed thick clay fragments stood out against the blackish slag (e.g. WF451, WF453, WF843, WF893).

Crucially, the design and scale of furnaces changed over time, so any surviving traces can be diagnostic to some extent of particular phases of activity. Most ancient furnaces were quite small structures, generally less than *c*.1 m in external diameter, with Early Bronze Age examples tending to be shallow bowls with low domed superstructures and later Iron Age and Roman ones constructed as more upright cylinders (Hauptmann 2000: 141–61). Furnaces were sometimes lined with flat stones, but were more often lined and built up with fine clay, which became hard-fired and vitrified during use (see Hauptmann 2000: 69–74 on Roman and Iron Age furnace elements). The Bronze Age

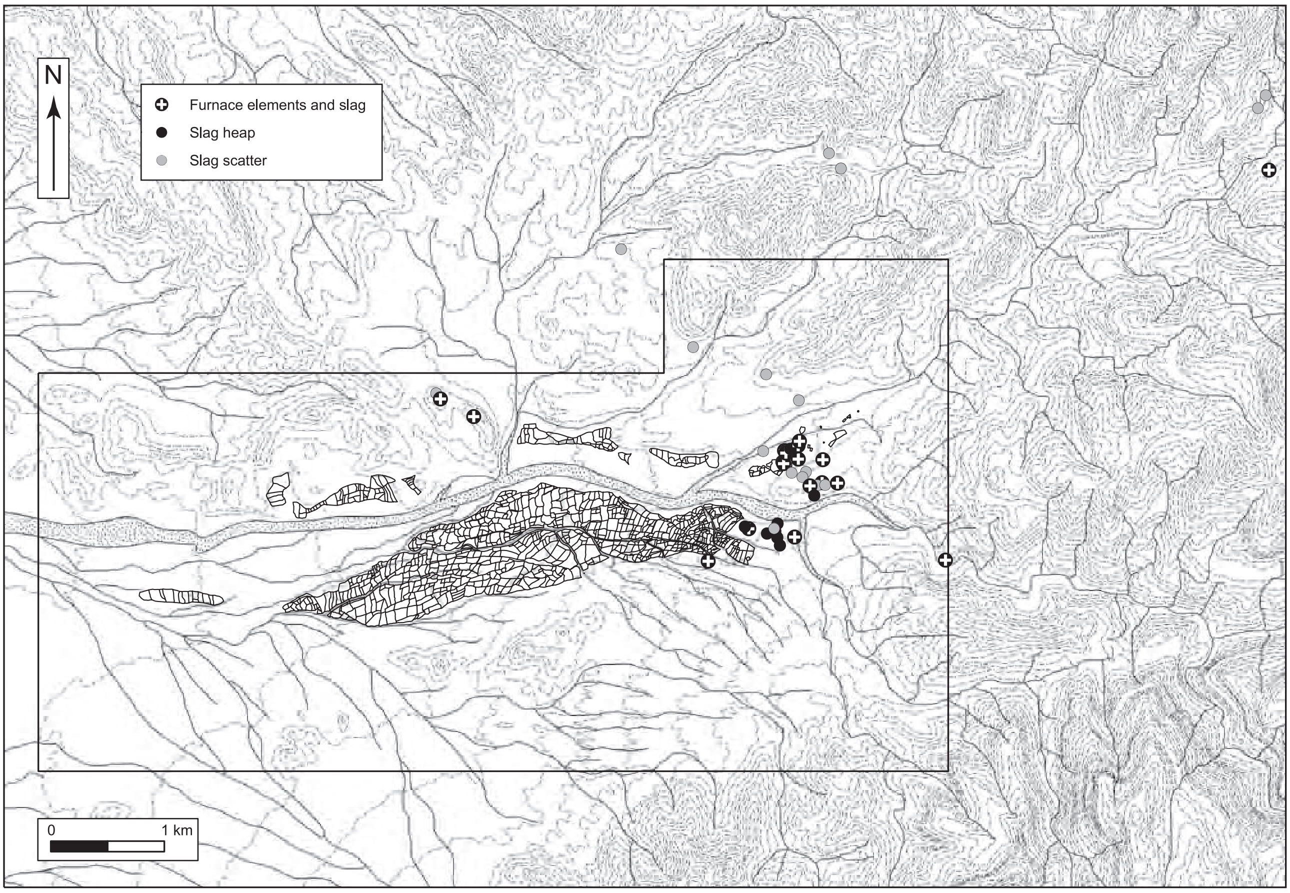


Figure 4.46 *Distribution of metallurgical features: furnace elements, slag heap, slag scatter. (Illustration: Paul Newson.)*

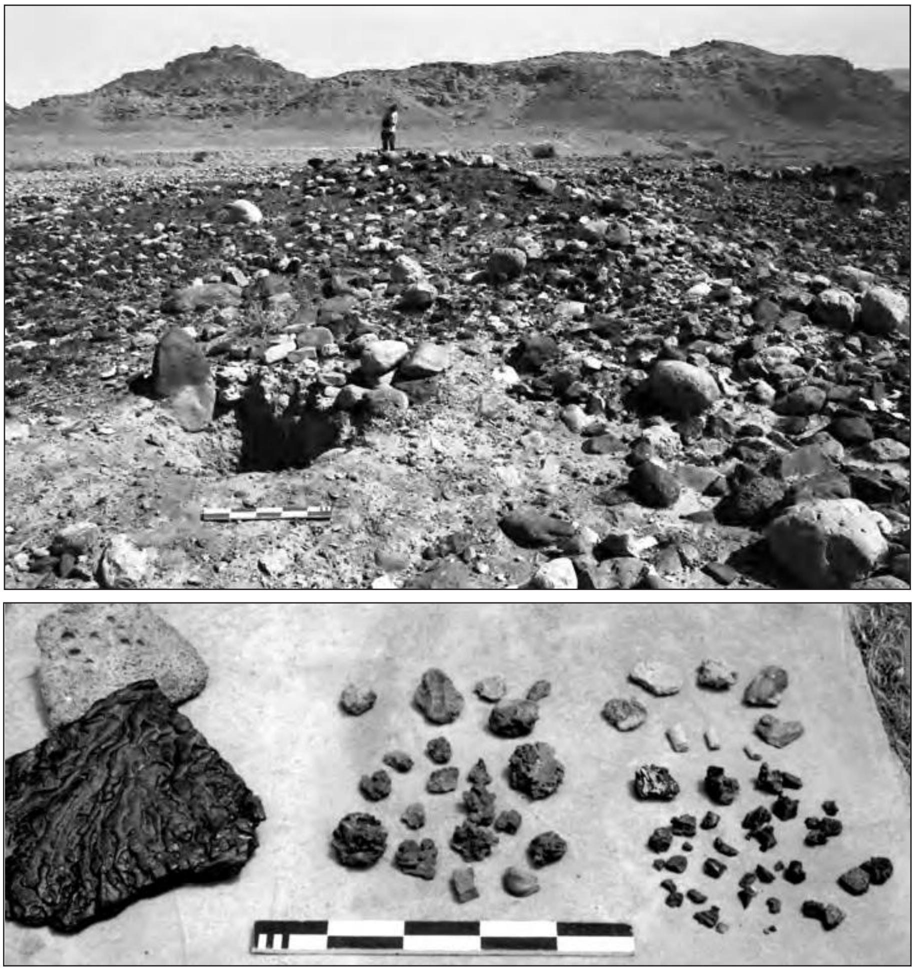


***Figure 4.47** Smelting evidence: (above) site with abundant surface traces of furnace wall fragments and slag, looking north (WF434); (below) typical examples of furnace material and slag from (right to left), Bronze Age, Early Iron Age, later Iron Age and Roman smelting. Scales 50 cm. (Photographs: David Mattingly.)*

furnace walls were generally a few centimetres thick at most and made from relatively clean clays; with Iron Age and Roman furnaces the walls were thicker and heavily tempered with crushed slag.

A peculiarity of some Early Bronze Age furnaces was the use of grilles of thin clay rods, either to provide a good draught in the front of the furnace (Hauptmann 1989a: 129) or as separators between ore and charcoal. These distinctive centimetre-thick clay rods ('ladies' fingers': Fig. 8.38) are often found along with the finely broken-up slag (Hauptmann 2000: 75; 2003: 93). Additional components of furnaces that might survive include *tuyères* (nozzles through which air was blasted in, perhaps by bellows), which seem to have been used from the Late Bronze Age and have been recovered in the past by the Bochum team (see Hauptmann 2000: 72 for illustrations), although no examples were found by the WFLS.

4.9.2 Ore-processing residues

After initial processing of the extracted ore-bearing rock at the mine (see *mining feature: mine waste*), further stages of ore-dressing (beneficiation) were sometimes carried out at some distance from the mines. The ore-rich material initially selected at the mine can be further enhanced by crushing, washing, drying, winnowing, or hand-sorting to obtain higher concentrations of the copper ores (Rihll 2001: 118–19). This is back-breaking and demanding work, requiring nimble fingers and acute eyesight and colour sense, and in many cultures, women have played an important role in beneficiation of ores for the furnace. At every stage in the process there were discarded quantities of rock matrix. Unusual concentrations of finely-crushed rock (*gangue*), again with tell-tale chemical signatures, can indicate the location of this sort of activity. The fine-grained ore that remains was probably formed into pellets using a flammable binding agent such as dried dung. Some gangue heaps have been identified in the field and the finer stages of ore-dressing have been recognized in sections excavated close to Khirbat Faynan. Ore-processing residues (Fig. 4.48) were recorded both as heaped deposits (e.g. WF492) and as scatters of material on level surfaces (e.g. WF158). In the case of

Figure 4.48 *An example of ore-processing elements WF842, looking north. (Photograph: Graeme Barker.)*

one domestic complex (WF516), a stone hammer for ore crushing was found as a surface artefact. These sites could, in principle, date to any of the key periods of metallurgy in the region, although sites positively identified in the survey all produced Early Bronze Age pottery.

4.9.3 Slag heap

A slag heap is a discernible dump of the waste by-products of the smelting process. All the instances recorded from the Faynan district relate to copper slag, although with some significant differences in chemical composition and physical appearance over time (Hauptmann 2000: 101–40; Hauptmann *et al.* 1992) (Fig. 4.47). At the end of the smelt, the copper metal is separated from the waste products, generally comprising a dark and viscous slag. In primitive furnaces, the slag and copper both sat in the bottom of the furnace bowl and required further processing with hammers to extract globules and prills (a needle or droplet) of pure copper. In sites of this type slag is more likely to survive in the form of small and irregular broken chunks. In more advanced furnaces, from the later Iron Age onwards, the improved design of furnaces allowed the slag to be 'tapped' from the base of the furnace in a liquid state, leaving the copper adhering to the furnace base and interior. Tap slag was much less commonly broken up for the extraction of copper prills, although it can contain some residual copper, and was often disposed of in large flattish sheets weighing as much as 40–60 kg (Hauptmann and Weisgerber 1987: 428). Slag heaps vary in size from the numerous small concentrations of 1–2 m diameter, to the colossal Roman tip on the south bank of the Wadi Ghuwayr (WF11, WF34) containing an estimated 40–70,000 tonnes of slag (Hauptmann 2000: 97; Figs 1.4, 2.6). In some cases slag heaps had been contoured to form ramp-type structures associated with furnaces (e.g. WF434). In the Roman period slag deposition appears to have been more concentrated in the zone around Khirbat Faynan (Figs 3.1, 3.12, 3.13), with the immense volumes of material suggesting that ores mined more widely in the Wadi 'Arabah were smelted in the area (Weisgerber 2003: 86). It is certainly to this phase of activity that the largest slag heaps can be dated.

4.9.4 Slag scatter

Where smelting activity had been relatively small scale or of short duration, it could be difficult to discern actual heaps of slag within a broader distribution of slag fragments; the category *slag scatter* describes these lower density deposits (e.g. WF651, WF894, WF1608: Figs 3.12, 3.13). Slag processing in the Early Bronze Age, for example, involved the deliberate breaking down of material into very small fragments and was often carried out at the top of ridges where the furnaces were located, in order to take advantage of winds. As a result, the dispersal of the slag as a thin scatter downslope from the ridge was commonly observed. In many places in field system WF4 small fragments of slag were encountered, for example at the surface of WF5022. Some of these were presumably transported there as part of various sorts of domestic rubbish, although some probably indicate localized small-scale metal processing. The presence of scatters of slag fragments that seemed to rise above background levels were particularly noted and general counts were kept of slag during field-walking within field systems. It was tempting to date many of the low-density deposits of scattered slag to the prehistoric phases of metallurgy

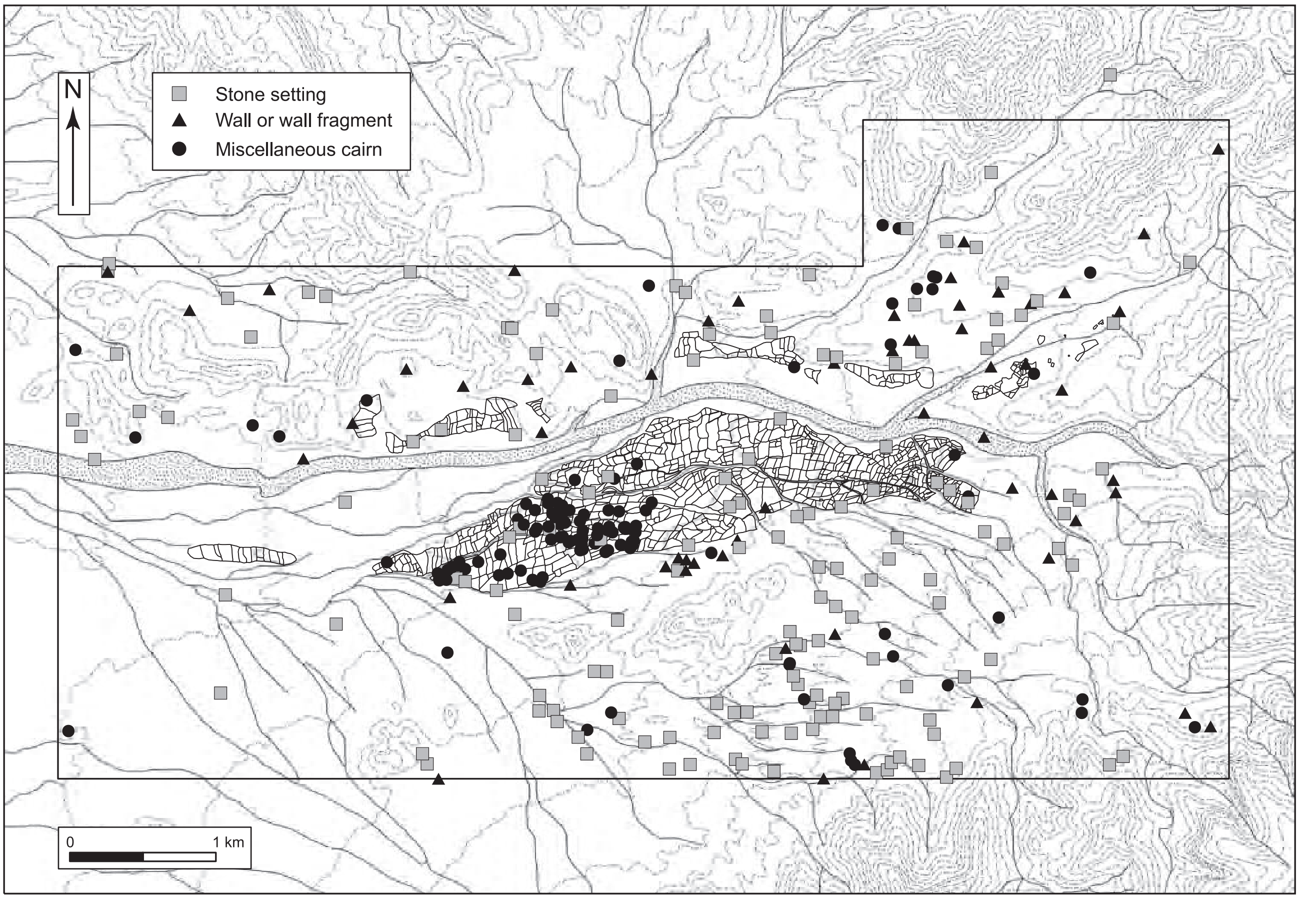


Figure 4.49 *Distribution of miscellaneous structures: cairns, stone settings, and walls and wall fragments. (Illustration: Paul Newson.)*

before the more centralized activity of the Roman period, but the wide chronological range of the associated pottery provides no straightforward dating evidence.

4.10 Miscellaneous structures

4.10.1 Cache

This category describes collections of campsite materials and miscellaneous items that have been deliberately deposited by bedouin who have left the area for seasonal grazing elsewhere, to be available on return. They are protected from interference and the elements by suitable coverings of available material, such as metal sheets and tarpaulins weighed down with stones. Some caches are stored above ground level in the branches of trees (e.g. WF1202, WF1205). These sites are obviously very recent in date.

4.10.2 Cairn

This category incorporates a large number of stone piles of uncertain use and, predominantly, unknown date. Cairns are especially widespread (Fig. 4.49), with many hundreds of examples recorded, and the category displays an extremely wide variety of physical contexts, forms, and origins. Many cairns lie within complex field systems, especially WF4, which contains the greatest density of these features near its western extremity. Cairns in these positions may well have originated, or at least been enlarged, through field clearance for agricultural use. While some cairns or groups of cairns exist as discrete sites within individual field units, many others form component parts of field walls, and were recorded under the survey of wall technologies (see Chapter 5); others are found in groups and lines. Several cairns exhibit clear evidence of multi-phase usage. Many appear to have originated as funerary structures and were incorporated within field systems in later periods, often forming important nodal points at the junction of field boundaries and being enlarged through piecemeal clearance of the surrounding zone. Such sequences, however, can be difficult to verify given imperfect preservation (see also *funerary structure: cairn*). Other cairns appear to post-date associated domestic or funerary features, and comprise collapsed stone-built structures surmounted by agricultural clearance debris.

4.10.3 Hearth

A hearth is a small and simple stone structure (usually less than *c.*1 m across), made of stones (or occasionally cement blocks) set in a neat circle or rectangle. These sites are generally assumed to be bedouin features of relatively recent origin (e.g. WF478, WF884, WF885; see Chapter

Figure 4.50 *An example of a gateway (WF287), looking southwest. (Photograph: Graeme Barker.)*

12, §12.7.1 Fig. 12.7). The surfaces of the hearth stones commonly show evidence of burning and more recently used examples were often associated with deposits of ash and surrounded by modern debris such as tin cans. Our ethnographic research suggests that these features were usually built within tents, marking a focus within the 'public' zone of the living space (Chapter 12). This identification is confirmed where hearths are closely associated with arrangements of larger stones lying on the land surface (possibly weights for guy ropes) and other modern cultural debris indicating the sites of former encampments. A far less substantial form of hearth is the simple arrangement of three small stones used to prop up a tea pot. As well as occurring in and around bedouin habitation sites, such features are sometimes found in isolation, in the latter case suggesting one-off use by shepherds during their movements across the landscape with their livestock.

4.10.4 Midden

These are mounded accumulations of sediment mixed with cultural debris such as potsherds and lithics. Some of them were exposed by natural gullying. In all cases middens are clearly derived from nearby settlement complexes or high-status sites and contain domestic refuse, the main examples identified being dated to the Early Bronze Age (WF161) and the Roman/Byzantine periods (WF1415) (e.g. Fig. 8.9).

4.10.5 Pen

This common sub-category of site comprises an animal penning area, usually marked by a circular or oval arrangement of dry-stone walling, although the use of other materials such as barbed wire was also observed (e.g. WF720, WF877). In cases where structural evidence had been removed, the penned zone was defined by an accumulation of compacted animal dung (Figs 12.10, 12.18). Pens are most commonly found in isolation or in association with bedouin encampments and are likely to be of very recent date (see Chapter 12). In a significant number of cases, however, such pens were built within earlier sites, in part re-using building materials (Fig. 12.12). WF276 is an example of a pen built against the wall of an earlier field system, while several complexes of domestic buildings contain later superimposed pens (e.g. WF23, WF514, WF1004, WF1284). In most such cases the pens can be differentiated from the earlier structures by their crude construction.

4.10.6 Gateway

A gateway is defined as a distinct gap in a field wall, in the clearest of cases delimited by a substantial orthostatic stone on either side (e.g. WF287; Fig. 4.50). These features, which are extremely difficult to date, were differentiated from water-management features set within field systems by the absence of identifiable artificial stepping or terracing (see *hydraulic structure: sluice* and *spillway*). It is recognized, however, that owing to poor levels of preservation, a small proportion of such hydraulic features may have been erroneously interpreted as gateways and *vice versa*. A possibility also exists that some such features might simply be gaps in walls created by gullies or modern farming activities.

4.10.7 Rectangular 'box'

These rare features comprised narrow rectangular structures *c.*2–15 m in length, characterized by small stone slabs set vertically into the land surface. These features are particularly unobtrusive, as only the very tops of the stones are visible, and are probably under-represented in the survey gazetteer. In some cases the structures had been sub-divided with walls of similar construction set transversely to create a series of internal cells, and L-shaped variants are also known. These features were associated with rectangular domestic structures (e.g. WF1001, WF1004), either singly or in pairs, and associated surface material makes it extremely likely that they are of Classical date. While their purpose remains uncertain, possible explanations are that they are animal troughs or storage features.

4.10.8 Stone setting

This term covers a miscellany of small stone features generally set in the land surface or constructed to a low height. Most are undated and, indeed, undateable. In certain respects, these features may have some similar characteristics to other site types, in particular *funerary structures* (e.g. *cairns, graves, piled stone grave covers* and *stone rings*), and a variety of minor features related to bedouin encampments and land use (e.g. *hearths, laban platforms, pens,* and *sleeping platforms*: see Chapter 12, §12.7.3). Where there were no associated diagnostic features to aid identification, or where the level of detail recorded by field teams was insufficient to enable discrimination between alternative possibilities, *stone setting* was the default interpretation. Some features recorded under this umbrella term may be of very recent date, but a significant proportion is likely to be misidentified funerary sites or features of considerable antiquity but unknown purpose.

While stone settings were among the most commonly recorded features encountered during the field survey, it is notable that their distribution shows a marked bias towards the central southern part of the survey area (Fig. 4.49). Two explanations may be put forward to explain this. At a broad scale, large numbers of stone settings are found in the same general area as the densest concentrations of *bedouin encampments*, suggesting that many of them relate to relatively recent pastoral activities. However, this area of the landscape was also characterized by a particularly dense network of minor wadis flowing to the northwest, raising the possibility that processes of erosion related to seasonal water flow may have been disproportionately severe in this area, making domestic, funerary, and other types of archaeological sites more likely to survive in vestigial form, as stone settings.

4.10.9 Wall and wall fragment

Included in this category are isolated lengths of walling with insufficient evidence through erosion or burial to confirm an association with settlements or cemeteries, or that they formed parts of field or water-management systems which, if more fully understood, might have contributed further to an overall understanding of systems shown in Figure 4.49. Extremely difficult to date, in many cases such sites are likely to represent small surviving fragments of formerly more extensive features. In the majority of cases the rest of the masonry will have been removed through natural erosion or artificial clearance, although in at least one case (WF459) a short surviving length of walling projects from a terrace, suggesting that the remainder of the structure has been mantled and obscured by later deposits. The subcategory *wall* was used to define such features over *c.*5 m in length; *wall fragment* identifies more vestigial remains.

4.11 Religious structure

4.11.1 Church

In the immediate vicinity of the main settlement of Khirbat Faynan a total of between five and six churches has been

Figure 4.51 *An example of a 'desert mosque' (WF916), looking southwest. (Photograph: Graeme Barker.)*

recorded which are visible as prominent rubble spreads (far larger than those associated with settlements) with occasional signs of facing stones and other architectural details. All these sites are of Late Roman/Byzantine origin (see Fig. 10.10 for locations). The best-preserved structures are located prominently on the eastern flanks of the Khirbat: Church 1 measures *c*.25 × 15 m with a number of capitals and column drums visible in the rubble, some of which have apparently been re-used from earlier structures; Church 2 measures *c*.23 × 14 m but is less well preserved. The 'Monastery' (Church 6) is situated on the lower slopes to the west of the Khirbat; it has an extensive cemetery grouped around it and is thought to have been re-used in the Islamic period. Church 3 is close by and measures *c*.25 × 14 m (Ruben *et al.* 1997: 438–9; Schick 1996).

4.11.2 Mosque

While there are no permanent mosques in the study area, the detailed recording of episodically-used bedouin encampments did identify a small number of open 'desert mosques' of very recent date (Fig. 4.51). Usually situated on the peripheries of areas cleared to form campsites, these sites comprised a rectangle formed from a single line of loose stones placed on the land surface, with a niche *(mihrãb)* in the side facing in the direction of Mecca.

4.12 Rock engraving

4.12.1 Inscription

This category covers a range of written forms inscribed on stones or rock surfaces (Fig. 4.52). A high proportion of inscriptions was recorded at funerary sites, where they often acted to identify headstones (Fig. 4.21). Examples are found both in extensive cemeteries where a range of forms has been identified, usually scratched into sandstone markers (e.g. WF3, WF437), and accompanying single graves (e.g. WF1099). In certain cases the script can be tentatively identified as Arabic (WF1449), although elsewhere lettering seems to be intermixed with more symbolic and abstract designs and dating is less certain.

4.12.2 Pictograph

Pictographs are differentiated from *wasms* due to their depiction of a wide variety of motifs created by pecking the face of a rock to create an indented image (Figs 4.52, 4.53). Pictographs occur both in the form of single images or as multiple scenes, which are in certain cases superimposed. The usual contexts for pictographs are the faces of natural *in situ* boulders, although interesting variations include those inscribed on boulders that have (presumably subsequently) been incorporated into domestic and other structures (e.g. WF36, WF1002, WF1417) and others on 'portable' stones found in the vicinity of other structures (e.g. WF518,

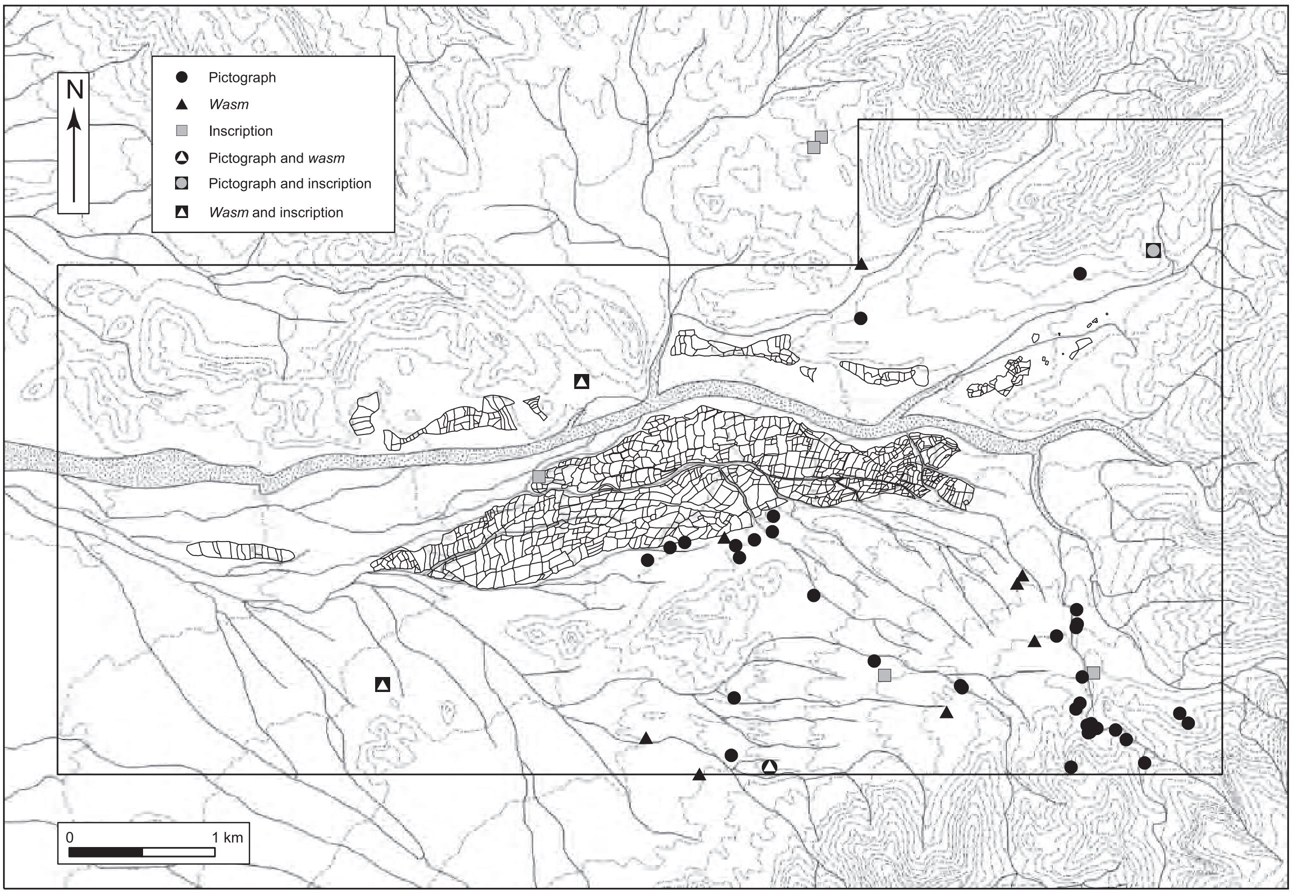


***Figure 4.52** Distribution of rock carvings: inscriptions, pictographs, and* wasms*. (Illustration: Paul Newson.)*

WF1444). The forms represented are both animals (ibex, camel, dog, goat) and human (standing and mounted figures) as well as more abstract forms (stars, dots, and geometric shapes) and other cases where designs are less well preserved and cannot be identified securely. In most cases a patina layer over the pecked image indicates that depictions are of considerable antiquity. The likely age and significance of many of the pictographs are discussed in particular in Chapters 7 (§7.7) and 8 (§8.12), where several are also illustrated (see Figs 7.20–7.23, 8.16, 8.20, 8.40–8.48).

4.12.3 Wasm

A *wasm* is a symbol of tribal identity carved or scratched on a stone surface. Ethnographic evidence suggests that bedouin communities still brand these symbols on to their camels and goats in order to indicate ownership; the marking of both naturally-occurring rocks and humanly-created stone structures in a comparable way (Fig. 4.54) is likely to represent similar claims to land rights and other resources such as shelter caves and water sources. *Wasms* were most frequently observed marked on the headstones or stone settings associated with individual isolated graves (e.g. WF1203, WF1294, WF1403), although other examples were also recorded in more extensive funerary complexes and cemeteries (e.g. WF437: Fig. 4.21). Less common were examples pecked on stone blocks set in the walls of domestic structures (e.g. WF1004, WF1014), seeming to demonstrate the re-use of relict buildings and ancient settlements as territorial markers.

Figure 4.53 *Rock engravings: an example of a pictograph (WF20), looking southeast. Scale: 10 cm. (Photograph: Graeme Barker.)*

Figure 4.54 *Rock engravings: an example of a* wasm *(WF437). Scale: 10 cm. (Photograph: David Mattingly.)*

4.13 Conclusion

This chapter has presented an initial picture of the Wadi Faynan's rich surface archaeology, while providing indications of the considerable challenges involved in its recording, classification, and interpretation. The terrain and climate presented obvious practical and logistical issues for the field teams, while the area's dynamic geomorphology and changing patterns of land use have resulted in a complex, indeed kaleidoscopic, pattern of archaeological preservation and destruction. The archaeological site survey strategy sought to take these and other factors into consideration, striking what was hoped to be a judicious compromise between the practical need to complete the survey within the constraints of time and budget, and the desire for precision in recording. The outcomes demonstrated the value of a multi-phase data collection programme: rather than the site recording adhering to a rigid classificatory scheme defined from the outset, information acquired during the earlier stages of fieldwork fed actively into an evolving methodology. Furthermore, at all stages, the programme of recording surface archaeology ran in concert with the geomorphological, palaeoecological, and ethnographic/ethnoarchaeological programmes: throughout, dialogue and collaboration between teams of specialists served to enrich techniques of data collection and aid the identification of site types and their interpretation.

The fact that the area's above-ground archaeology consisted almost entirely of stone-built structures presented both the principal challenge and opportunity for the archaeological survey. On the one hand, such features have proved remarkably durable and are amenable to relatively straightforward techniques of archaeological recording, mapping, and classification. On the other hand, uncertainty over both the chronological development (or otherwise) of building techniques and the relationship between structures and artefacts ensures that the dating of these features can never be straightforward. Despite these circumstances, however, enough has been gleaned to enable a reasonably robust classificatory system of site types to be developed. This system forms the basis for the gazetteer of sites and monuments contained in Appendix 3, while the scheme of dating outlined here (Fig. 4.1) provides the foundation for Chapters 6 to 12, which trace the chronological development of the Wadi Faynan landscape from early prehistoric to recent times. The next chapter, Chapter 5, examines the recording and analysis of the surface archaeology represented by the field systems, the initial focus of the archaeological fieldwork given the threats being posed to them at that time by modern agricultural development (see Fig. 1.7).

5. The Wadi Faynan field systems

Paul Newson, Graeme Barker, Patrick Daly, David Mattingly, and David Gilbertson

5.1 Introduction

Until the Wadi Faynan Landscape Survey, no systematic work had been undertaken on the several ancient field systems in the Faynan basin to characterize their function, development, and possible relationships to the settlement of the valley or to the mining industries. Several observers had noted that substantial numbers of surface sherds dating to the Nabataean, Roman, and Byzantine periods could be found within these fields. Thus Glueck described the most prominent of these field systems as 'large stretches of formerly cultivated fields … strewn with Nabataean sherds' (Glueck 1935: 35). (Such typical first impressions upon a visitor of the 'fields' in the area are shown in Figures 1.5 and 1.7.) We may note that the straightforward assumption of most observers of these complex and large-scale systems of walls and terraces is that they were fields related to farming of some sort. While we have utilized the terms 'fields' and 'field system' in our project as classificatory terms, we have attempted to devise methodologies to investigate the potentially complex and varied evolution and functionality of the walls that define them. The prime purpose of this chapter is to explain those methodologies (notably the use of GIS) and to characterize the main structural elements recorded. The main focus is on observable simple stratigraphic relationships – what types of walls do we have in what sorts of topographic situations? what cut across what? what butted against what? what relationships were observable with other features? – without imposing from the outset assumptions about function and date. The functional analysis looks at competing alternative hypotheses, and does not assume that every feature was related to water control; or that all enclosed spaces were agricultural fields. Given that the overall structural evolution of the WF4 'field system' spans a period of several thousand years starting from (at least) the Bronze Age and that accurate dating of individual elements is extremely difficult, this general discussion is necessary before we attempt in subsequent chapters a more speculative reconstruction of the individual phases of its development.

The largest area of fields through which Glueck travelled, and which seems to form a single entity, lies along the southern bank of the wadi course of the Faynan itself. This was designated WF4 by the original BIAAH survey team (Barnes *et al*. 1995) and became the subject of detailed fieldwork and analyses by the present project (Fig. 5.1). A number of other systems of various size and distribution occurs along the northern and southern margins of the Wadi Faynan channel. These were also the focus of fieldwork, though were not incorporated within the detailed GIS analysis, in part because of the relatively simple and homogeneous nature of their wall structures. However, the information gleaned from them proved invaluable for our understanding of the development of the operating mechanisms of run-off farming systems within the valley, and for the interpretation of structures within WF4. Beyond these were identified some traces of other smaller systems, particularly along the southern banks of the Wadi Ghuwayr on either side of the WF2 settlement, but these proved too fragmentary to warrant intensive investigation. Other collections of fields, of different types and varying degrees of complexity and size, were noted during the area survey, but most were small in size and/or fragmentary, or consisted of simple diversion walls or barrage walls across wadis.

The rainfall in Faynan in most phases after the Neolithic wetter period has been sporadic, but concentrated and unpredictable, making some degree of irrigation necessary for agriculture. This was most readily achieved through run-off farming. The mountainous catchment was capable of generating violent flash floods in the main wadi channels, but these were hard for farmers to manage. The main braid-plain of the Wadi Faynan is incised well below the

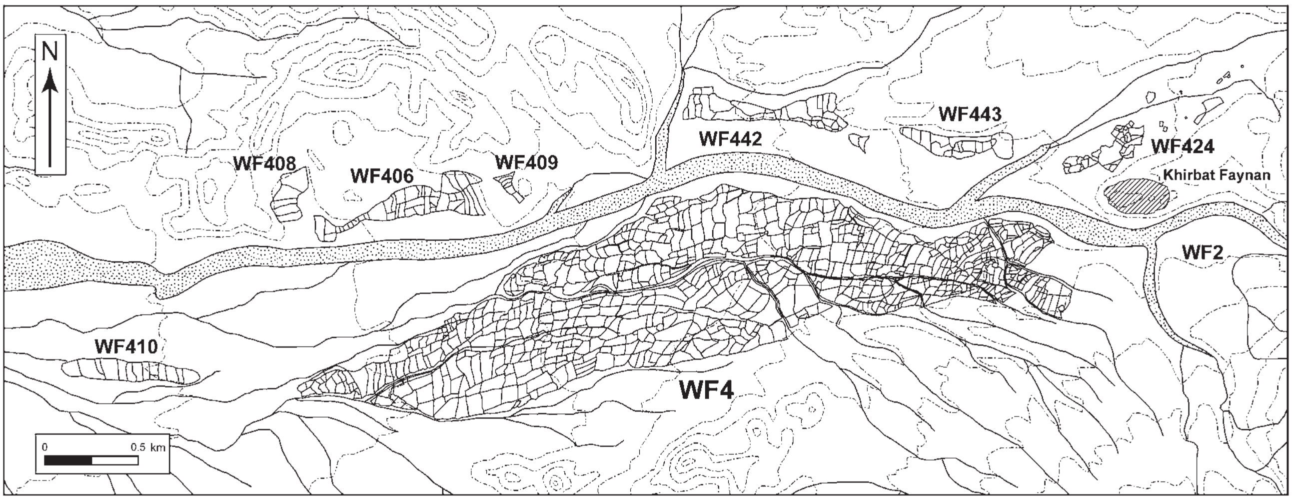


Figure 5.1 *Wadi Faynan, showing the principal locations mentioned in the text including the main ancient field systems recorded by the Wadi Faynan Landscape Survey. (Illustration: Paul Newson.)*

level of the surrounding flatter terrace-surfaces, making it very difficult to utilize its floodwaters directly by diversion to irrigate the adjacent lands in one of the familiar mechanisms of floodwater farming (Hauptmann 2007: 47). In the absence of evidence of a major diversion dam-barrage in the primary braid-plains/channels, the interpretation of the wall systems that seem to have related to water control and distribution thus focuses on the more manageable run-off from the immediate vicinity of the field systems and from minor tributary streams of the main wadi. We have also looked carefully at the possibility that permanent springs in the Wadis Ghuwayr and Dana, as for example sustain the Oasis of Amman Adethni (Fig. 2.8), might have been tapped for continuous irrigation, though we have not found convincing evidence to support that thesis. However, it must be stressed at the outset that, although many features of the field systems can be best interpreted as evidence of run-off-based farming, a long sequence of evolution and a range of functions of walls and enclosed spaces can be demonstrated.

The archaeology discussed in this chapter consists, in objective terms, of stone lines and other stone-built structures, and we need to acknowledge that terms such as 'field' and 'field system', whilst often convenient, are also interpretative rather than descriptive. In fact, our reconnaissance surveys identified little actual evidence of cultivation within the 'fields' formed by enclosing stone walls (some plough marks on boulders within WF4.13 provided the most graphic example: Fig. 9.29). Nevertheless, the many parallels between these archaeological features (in terms of types of relationships between wall shapes and locations, local topography, and their assumed palaeohydrology) and those that have been previously detected in other areas of Southwest Asia and North Africa justify the use of terms such as 'fields' and 'field systems' (see Barker 2001; examples of other work include: Barker and Gilbertson 2000a; Betts and Helms 1989; Bruins 1986; Bruins *et al.* 1986; Brunner 1997; Costa 1983; Evenari *et al.* 1982 [1971]; Geyer 1990; Gilbertson 1986; Gilbertson and Chisholm 1996; Gilbertson *et al.* 1984; Helms 1981; Hillel 1982; Kennedy 1982; 1995; Lavee *et al.* 1997; Lawton and Wilkie 1979; Mattingly *et al.* 1998; Mayerson 1962; Oleson 1992; Pacey and Cullis 1986; Shaw 1995; Wilkinson 2003; Yair 1983). At the same time, our studies of the Faynan wall archaeology, informed by recent literature on ancient and modern wall networks and fields in semi-desert environments, also suggest that many walls within the ancient 'field systems' may have been more concerned with controlling occasional overland water flow (seasonal floodwaters) than defining the margins of cultivated land. Many walls may have been associated with one or more of a wide variety of other possible functions, both in a single phase of use and through time (see Gilbertson and Chisholm 1996; Gilbertson and Hunt 1996b). The potential uses for walls and other stone features in these arid lands include delineating areas of different land use or crops or grazing animals; marking different ownership, control, or power; creating boundaries and markers of inclusion and/or exclusion for people and/or animals; visual identifiers of routeways and pathways associated with movement of stock, food, equipment, or materials; providing an unusual microclimate with shelter from sun and grazing pressures but richer in soil moisture to aid the germination and growth of woody taxa; and managing the erosional, depositional and agricultural complex that involves managing water, sediments, soils and nutrients (Gilbertson *et al.* 1984). The robust identification of the possible intended purposes of different stone-piles, walls, and enclosed spaces required their accurate mapping in relation to what could still be ascertained of their original topographic, geomorphic, and hydrological settings, their relative antiquities, the observed archaeological contexts, and the likely local consequences upon them of the passage of time.

WF site no.	No. of fields	Orientation	Length (m)	Width (m)	Area (m²)
4	785	E–W	4210	890	2,092,790
406	41	E–W	940	230	109,093
408	5	N–S	250	110	36,532
409	6	N–S	160	100	8363
410	14	E–W	740	120	67,564
424	45				57,080
442	34	E–W	880	180	103,424
443	16	E–W	610	110	57,469
Total	**901**				**2,475,238**
Total including WF424	946				2,532,319

Table 5.1 *The principal characteristics of the Wadi Faynan field systems. The data for WF424 are based on the overall extent of fields recorded, which in part are not contiguous.*

Whilst the use of the term 'field' was not straightforward, we used it to denote definable real space, whether delineated by boundary walls, other geographical features, or in some cases by arbitrary limits assumed to mark where ancient wall lines had once been. Collections of contiguous or adjacent 'fields' were regarded as a 'field group'. A field group was considered a 'field system' when a continuous or near-continuous wall enclosed a group of fields, and/or when common attributes were present at a number of locations within the field group such as a specific type of wall construction.

At first glance the field systems within the Faynan basin appeared to be quite homogeneous, in terms of both their construction and in their general topography and location, but real differences became apparent early in the fieldwork between and within individual field systems (Table 5.1). The 209-hectare WF4 field system, for example, consists of *c.*800 fields and extends for over four kilometres eastwards from Khirbat Faynan and up to one kilometre from north to south at its widest point (Fig. 5.1), whereas the six fields of WF409 cover around 0.9 hectares. All the larger and more complex wall networks and associated field systems are in close location to the main modern braid-plain of the Wadi Faynan, and run parallel to it. Along the north side of the Wadi Faynan is a number of compact systems, numbered from east to west WF442, WF443, WF409, WF406 (classified as WF9 in the BIAAH reconnaissance survey), and WF408. To the south of the main wadi course and to the west of the Wadi Ghuwayr are WF4 and WF410. At the base of Khirbat Faynan is the agglomeration of fields WF424, whilst to the east of the Wadi Shayqar and WF2 is a number of other small fragmentary fields.

The northern side of the Wadi Faynan channel is markedly different from the southern side in terms of underlying bedrocks and topography (Figs 2.3, 2.9, 2.10), differences that have a fundamental impact on the distribution of field systems in each area. To the north, the Mesozoic limestone bedrocks with their particular styles of folding and faulting, and the comparative lack of deep fluvially-incised wadis and gorges have resulted in an undulating landscape of ridges and narrow tributary wadi valleys (Fig. 5.2). The largest open valley area is that formed by the Wadis al-Abyad and Khalid which drain down from the northeast and provide an extensive flat valley. Abutting the mouth of this wadi valley is a narrow 2-km length of level ground along the margins of the Wadi Faynan itself, the location of two of the field systems, WF442 and WF443. To the west of these, much of the northern bank is characterized by scarp faces of folded sedimentary rocks of Mesozoic age. Small wadis have developed in the undulating dips between these cliffs, which in a number of instances are also locations of small field systems such as WF406, WF408, and WF409.

South of the Wadi Faynan, the topography is quite different in character. Instead of a series of isolated wadi valleys between hills of folded sedimentary layers, the area is characterized by wide, almost flat, areas of alluvium

Figure 5.2 *Looking north across the Wadi Faynan channel to the undulating scarps and the intervening 'basins' on the northern side that were the locations for settlements and field systems. (Photograph: Graeme Barker.)*

Figure 5.3 *The topography of the southern side of the Wadi Faynan channel, looking north over the field system WF4 extending downslope over the Shayqar Beds and over the flatter the Dana Beds. (Photograph: Graeme Barker.)*

deposited on the braid-plain floor of the Wadi Faynan. The Faynan Member and Dana Wadi Member, as they have been designated (Chapters 3, §3.3 and 6, §6.3; Fig. 6.4), slope gently down towards the west, falling from a height of 285 m to 135 m above sea level, a drop of 150 m over 6.5 kilometres. To the south, the Faynan Member abuts the older and more gravel-rich Shayqar Beds which rise gradually towards the southeast. The WF4 field system extends from the Faynan to the Shayqar Beds (Figs 5.3, 6.4). The small linear fields of system WF410 are situated downstream from WF4, quite close to the present course of the Wadi Faynan. A number of minor tributary wadis emanates from the large alluvial fan to the southeast of WF4 (Fig. 1.4). One of these wadis flows north to join with the Wadi Shayqar, with the remainder uniting directly with the main course of the Wadi Faynan. Some of them trend in a northerly direction towards the Wadi Faynan, but most trend towards the northwest. At the point where these wadis cross from the Ghuwayr to the Shayqar Beds from a landscape with a steep incline to one of gentler gradients, a marked change in their direction occurs, from northwest to west-northwest. Eventually the separate wadi courses coalesce to form three or four wadis which run parallel to the main wadi course in a westerly direction before eventually merging with it (Fig. 3.13, upper). These small tributary wadis have the effect of dissecting the WF4 field system into a number of distinct compartments or sections that formed the basis for the organization of the initial fieldwork (Fig. 1.11).

These WF4 survey 'units' exhibited different physical characteristics that reflect a number of different factors, but in particular their respective relationships to either the Faynan or the Shayqar Beds. The individual fields within the units on the Faynan Beds were observed to be generally larger and more rectangular than the fields in the units on the Shayqar Beds, which were smaller, more linear, and frequently terraced in response to the topography. In addition, the surface of the Shayqar Beds is densely covered in a carpet of gravel and stones, with less surface soil than in the field units on the Faynan Member. The latter, although strewn with stones of small to medium size, mainly consist of thick alluvial deposits of gravels and fine-grained sediment, in places up to 6.5 metres in depth. The other field systems along the banks of the Wadi Faynan (WF406, WF408, WF409, WF410, WF442, WF443) were also constructed in locations rich in alluvial sediments, though the fields of WF410, WF442, and WF443, being for the most part constructed on top of the recently formed fluvial-aeolian deposits of the Dana Wadi Member, have more boulders and large rocks than the other northern field systems. By contrast, WF408, WF409, and parts of WF406, in locations remote from the alluvial actions of the main wadi, contain significantly fewer fluvially-deposited boulders and rocks.

In all the field systems, the materials available in the immediate vicinity were used in an unaltered state in the construction of the field walls and other features. Most structures and field walls were built of fluvially-deposited and water-rolled stones and boulders of the various sizes that would have been to hand within the immediate vicinity, apart from in a few cases where substantial structures were constructed with dressed stones. Some of the structures, especially the field walls and cairn structures in some parts of WF406, WF408, and WF409, were constructed of the sedimentary rocks on which these field systems stood. Although most field walls were constructed of similar materials, a variety of construction methods was used, and a variety of other structures was also observed, as described in the following sections.

5.2 The field system survey

Faced with several thousand field walls, hundreds of other structures, and abundant archaeological remains on the surfaces enclosed by the walls, the team used the initial field seasons to test a variety of recording methods in order to develop a standardized methodology with which to tackle the field systems.

A series of aerial photographs taken in 1978 provided the initial point of entry. From these air photographs, a detailed photogrammetric map was drawn up for BIAAH by Leoni Blank (University College London), which was to form the base map for the primary archaeological fieldwork (Fig. 1.16). Information highlighted on the photogrammetric map included: every observable wall relating to the field systems; height contours; the courses of small tributary wadis that crossed the fields; and any additional structural feature, such as apparent cairns, or rectilinear structures (perhaps buildings), that could be distinguished. A priority during the preliminary season was to check the accuracy of the photogrammetric map, so much time was taken up in a 'ground-truth' exercise in which features observed on the ground were compared with the information detectable on the aerial photographs and photogrammetric map. This exercise revealed many features that were obscured on the air photographs, and added many new features which had been omitted from the photogrammetric map (Mattingly *et al.* 1997: 27; Fig. 5.5).

To aid the systematic recording of the large and complex WF4 field system, we divided it into twenty units, their boundaries determined by major topographical features such as the tributary wadis dissecting the system. These were numbered Units WF4.1 to WF4.20 (Fig. 1.11). Each field within a unit was then allocated an individual identifying number, a process carried out during the successive field seasons as each sub-unit was recorded and sampled. A reconnaissance study was first undertaken of each unit to establish whether its fields conformed to the layout details as represented on the photogrammetric map. In most cases a number of adjustments had to be made. Typical was the situation when a field was found to have a wall not shown on the photogrammetric map, dividing the field into two, in which case separate field numbers would be given for each section of the original field. In some areas, walls shown on the photogrammetric map were found to have been destroyed by the agricultural development programme that was underway in the initial seasons in order to make conveniently-sized fields for tractor ploughing (Fig. 1.7). In this case, separate zones within the modern field were assigned individual field numbers to reflect, as best we could judge, the size of the original fields. These adjustments were then plotted on a new trace map (the Field Unit Map) over the photogrammetric map. The individual field was allocated its own *pro forma* sheet (the Field Record Sheet). Thus the 38 fields within Unit WF4.1 were given records numbering from WF4.1.1 to WF4.1.38.

The Field Record Sheet was designed to cover the structural and stylistic aspects of the walls defining each individual field. A sketch of the field in question was drawn on one side of the form, to show shape, the layout of walls, orientation with adjoining fields, and an indication of slope and thus the direction of potential surface water flow. Most fields were approximately rectangular in shape, so their perimeters could be divided into four 'wall' sides or boundaries, which would be labelled Walls 1–4, with a fifth or sixth wall number being required for irregularly-shaped fields. Each of these wall boundaries was then catalogued using the Field Record Sheet according to ten different wall categories that were defined as a result of the observations and trial recording undertaken in the first two seasons (Table 5.2).

Wall categories
Type 1: cairn line
Type 2: terrace wall – not visible
Type 3: single-faced terrace wall
Type 4: double-faced terrace wall
Type 5: single-faced wide terrace wall
Type 6: double-faced large terrace wall
Type 7: un-faced wall
Type 8: double-faced, free-standing wall
Type 9: wide free-standing wall
Type 10: other walls
Wall dimensions
Maximum length
Maximum width
Maximum height
Wall construction
Number of visible phases (in wall construction)
Wall composition (plus average dimensions)
Boulders
Medium blocks
Small blocks
Construction arrangement
Un-coursed rubble
Irregular coursed
Rough coursing
Neat coursing
Diagonally-bedded terrace
Other class
Additional wall features
Walls well preserved
Walls damaged
L-shaped cairn junction
T-shaped cairn junction
Integral cairn
Parallel walls
Wide gap/gate
Narrow gap/sluice
Sluice with baffle
Spillway
Attached circular/oval structure
Attached square/rectangular structure
Associated structure numbers and brief description

Table 5.2 *The ten wall types and associated features used in the recording of the Wadi Faynan field systems. (See text for discussion.)*

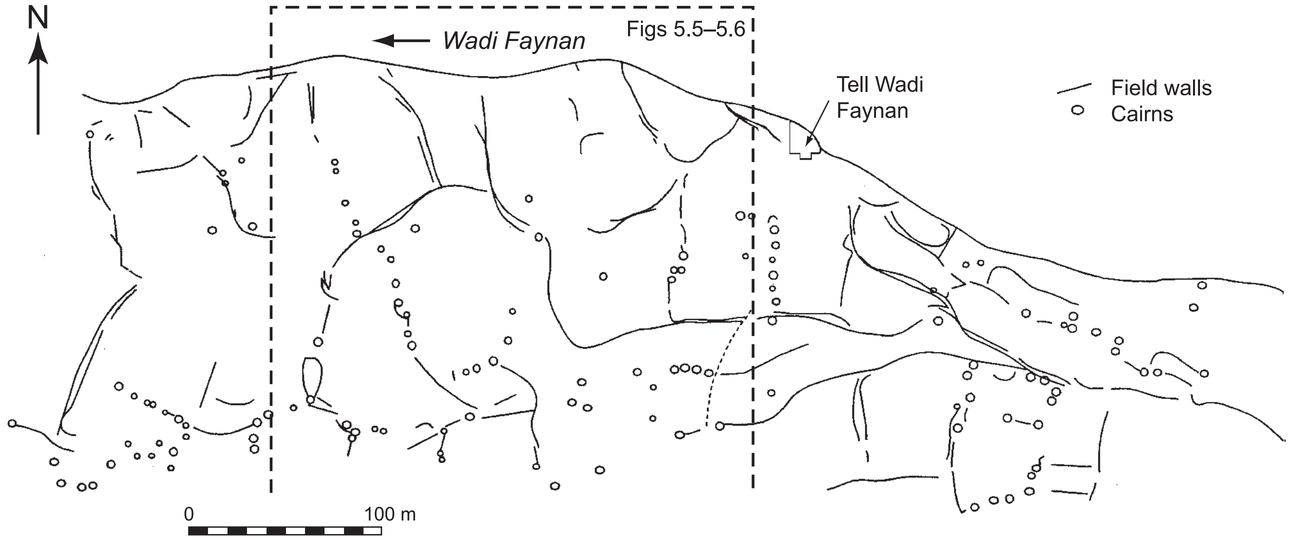


Figure 5.4 *The northern section of Units WF4.6 and WF4.7 as mapped by Total Station survey. (Illustration: Oliver Creighton and Debbie Miles.)*

Figure 5.5 *Part of the photogrammetric map covering Unit WF4.7. The photogrammetric map served as the basis for the recording of the field units in the initial 'ground-truthing' exercise. (Illustration: Leoni Blank and Paul Newson.)*

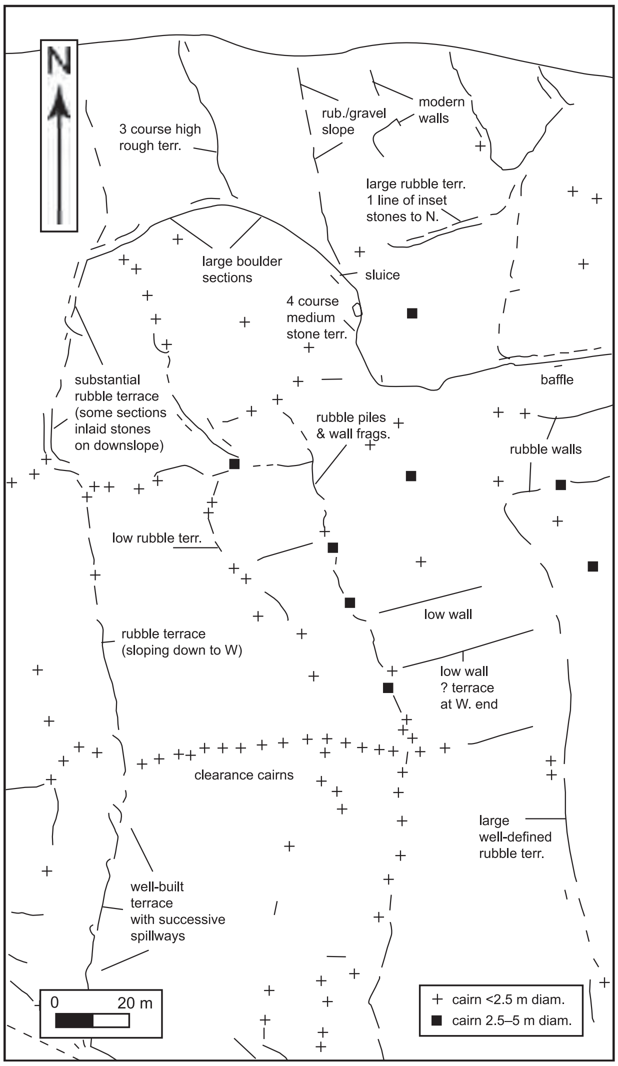


Figure 5.6 *A section of the Corrected Field Observation Map with additional observations on field and wall attributes for part of the area covered in Figure 5.5. (Illustration: Paul Newson.)*

'Wall Type 1: cairn line' was a common category, where a wall had been demolished and reconstituted as a line of stone piles. 'Wall Type 2: terrace wall – not visible' was used when the position of a former wall was marked by the presence of shallow gullies or occasional short lengths of inset stones. The other eight Wall Categories represent extant walls. Terrace walls (Types 3–6) had their upslope side infilled or partially filled by sediment and their downslope side fully exposed, whereas free-standing walls (Types 8 and 9) had both sides exposed. Type 3 and Type 5 'single-faced' walls consisted of a line of stones with a single face, Type 5 ('wide') being distinguished from Type 3 by being constructed greater than 0.5 m in width. Type 4 and Type 6 'double-faced' walls consisted of two parallel lines of stones placed back-to-back, Type 6 ('wide') being distinguished from Type 4 as Type 5 was from Type 3. A Type 7 wall ('un-faced') was of irregular construction and lacked any dressed stones. In addition to classifying a wall using the ten Wall Categories, and noting its dimensions, a range of other information was recorded – such as the stone type from which the wall was composed, the average dimensions of the stones, and the arrangement of the stones within the wall ranging from un-coursed rubble to neatly-coursed walling (Table 5.2). We also recorded additional features providing an indication as to the original purpose and use of a wall, and perhaps its age, such as cairns and structures incorporated into a wall, or structures identified as likely to relate to water control.

Most walls formed the boundaries between fields and so were recorded twice, one side being recorded on the Field Record Sheet for the field it faced, and the other side for 'its' field. Recording both sides of the walls separately brought out many differences, with some terrace-edge walls appearing on the up-slope side as a low rubbly free-standing wall and on the down-slope side as a high neatly-coursed terrace wall. A particular wall might contain a number of wall types along its length, in which case multiple entries were made for it on the Field Record Sheet. Other information was collected in specified categories which required 'true' or 'false' statements, such as: 'is there good surface visibility of the sherds?' ('good' in this case signifying that 60–80 per cent of the ground surface was not obscured by vegetation or stones). Any other structural feature deemed of sufficient difference from the main field walls was noted on the Field Record Sheet but also usually given a unique WF Site Number and recorded separately on a Site Record Sheet according to the morphological categories described in Chapter 4. These typically included domestic structures, burial cairns, and well-preserved structures relating to water control such as sluices, baffles, and spillways.

The recording of the mass of surface finds littering the fields of WF4 was undertaken using a scheme of systematic field-walking (Barker *et al.* 1998: 9; Fig. 1.12). The density of surface artefacts (greater than anything seen by the team in other arid-zone surveys) was such that the decision was taken to collect a systematic sub-sample of the material, rather than to attempt total collection (Table 5.3). Each field was traversed along its longest axis by a team of field-walkers in a series of transects, each member walking 10 m apart from the others, with the surface scanning being restricted to a 1 m-wide strip along the path of each individual's transect. Artefact density in the field was calculated as a result of a combination of two methods of recording used during the field-walking process: counts of visible surface sherds recorded by a hand-held clicker counter and collections of surface artefacts. Between every two 'clicked' transects a 'picked' (sherded) transect was completed in which all the sherds and other artefacts visible on the ground surface within the 1 m-wide strip were collected by the designated field-walker. Usually a combination of two 'clicked' and one 'picked' transect would be sufficient to cover the width of the field to be sampled, with additional alternating clicked' and 'picked' transects added at 10 m intervals if the field was wider. The number and length of 'clicked' and 'picked' transects were noted, so that the total area of the field and the proportion samples could be calculated. The combination of 'pick' and 'click' transects in theory represented 10 per cent coverage of the field, though (for a variety of reasons) in practice the total area covered by transects within the field systems averaged between 7 and 8 per cent (Table 5.5). All transects were covered at a regular walking pace (rather than stopping and starting, and moving from one intensive collection episode to another) to ensure that a uniform sample of the material evidence was collected or recorded. In addition, the walkers on the 'clicked' transects would collect a 'grab' sample of particularly interesting or diagnostic sherds such as rims or bases observed along the length of the transect. These artefacts were kept separate from the systematically-collected material.

The information collected from the field-walking exercise was entered onto another *pro forma* form for each field within a unit, the Unit Sheet. The information recorded included the number of 'sherded' and 'clicked' transects, and the numbers of pieces of pot, stone, and other artefact categories observed by clicking. This information was collected in the field, with counts and weights of the artefacts collected in the 'systematic' and 'grab' samples being added to the same record sheet later when the material was processed at camp.

In the second season we also made accurate topographic surveys of some small selected zones in the WF4 field system using a Total Station – an electronic theodolite – to assess the gain in accuracy compared with the maps based on the aerial photographs and pedestrian 'ground truthing', and especially to investigate the feasibility of obtaining computer-generated maps to explore, for example, how surface floodwaters might have flowed over the landscape and the effects of the different walls on water flow. The exercise demonstrated that greater accuracy was achieved (Fig. 5.4), but not of such a degree of enhancement compared with the main mapping procedure as to justify the considerable commitment that full mapping of the entire field system would have entailed.

Using the two methodologies of wall/structure recording and artefact collection/counting, thirteen of the twenty units in WF4 were recorded in the 1997 season, and the remainder in 1998 and 1999, along with the smaller outlying field systems (WF406, WF408, WF409, WF410, WF424, WF442, WF443). The information collected on all three types of recording form (Field Record Sheet, Site Record Sheet, Unit Sheet) was collated and used to create the Wadi Faynan Data Base. On completion of the basic recording, emphasis was then placed on the detailed refinement and verification of the evidence gathered from the WF4 field system in the previous seasons, specifically for the preparation and development of an analytical GIS (Daly and Newson 2000). For example, as we began to assess the field data, we realized that the recording of the WF4 system in the twenty survey units, whilst convenient in terms of the organization of the fieldwork, had in some instances masked linkages or relationships between individual units. Some walls of the same construction, for example, had been cut by the tributary wadis forming the unit boundaries, suggesting that they had originally been built to span what we had defined and recorded as different units. Some substantial wall constructions, again of the same construction techniques and dimensions, could be traced across several units. A large number of widely-spaced (*c*.1.5–5 m) parallel walls had been recorded as a succession of separate wall boundaries, but looking across the unit maps it seemed clear that some of these wall systems were continuous arrangements which appeared to be demarcating channels running through the fields, circumstantial evidence that the WF4 field system, at some stage in its use, had been characterized by an extensive water-distribution system (Barker *et al.* 1999). We shall return below to the issue of whether these channels were fed by periodic flood episodes or by a permanent water source.

At the conclusion of the first phase of wall recording, therefore, the initial unit boundaries were put aside and all the relationships between walls and related features were re-assessed. A series of maps was prepared in which general observations were made with a new set of criteria including: the similarities between the structural integrity of series of walls and groups of adjoining fields, particularly in their shape and topographical location; the relationship between types of archaeological structures such as burial cairns and the positions and terrain on which they were to be found; the estimated direction of any surface water flow across the field system; and the series of inter-linked wall systems and other structures organized to facilitate this flow to maximum effect. These Corrected Field Observation Maps contained sketch information showing the position of similar walls, locations of groups of features, and information on possible surface-water flow across whole areas (Fig. 5.6).

5.3 Constructing the GIS

The five years of fieldwork yielded a mass of information of different kinds relating to the field systems: on the fields and their constituent parts; the variety of wall construction; the presence and character of associated structures; and surface artefact distributions, types, and frequencies. The construction of a GIS offered us the potential to manipulate, integrate, and compare these large and varied data sets, and to reveal spatial relationships that would not otherwise have been easily discernible (Conolly and Lake 2006). Hence in considering the required functions of the GIS, it was important that the spatial data base constructed should be usable not only as an elaborate map-linked data base, but also as a tool for the analytical exploration of the landscape (Newson 2002). The primary analysis was directed towards yielding insights into the processes of development, chronology, and operation of the WF4 field system, as the ground survey of the structure and relationships of the walls and materials in adjacent sediments had shown that it was clearly a complex palimpsest landscape rather than a unitary phenomenon.

The initial stage was to perform a number of operations to transfer the information on the Wadi Faynan Data Base from the various map sets to a format that could be accessed and manipulated in a GIS package. First, discrepancies within the data set had to be corrected. The next phase was to establish a number of separate digitized maps for the core component features to be assessed within the GIS: topography, walls, and fields.

The primary digitized map coverage was of the WF4 fields, which were represented in the GIS as a series of discrete contiguous polygons. Each polygon represented an individual field, with lines (arcs) representing its boundaries. Three different sets of maps were used in the digitizing process: the photogrammetric map drawn from the recent aerial photographs; the Field Unit Map based on the photogrammetric map; and the corrected Individual Field Operation Maps. It is important to emphasize the unavoidable inaccuracies in these, and their potential impact on the final representation of the WF4 field system as a digitized coverage and on the modelling based on it. The most accurate in terms of topography and spatial relationships across the field system was the photogrammetric map, but even with this there are difficulties, with walls missed out, or slightly out of line, or appearing disproportionately larger on the map than on the ground, or depicted on the map but removed on the ground by the recent agricultural works. Also, it was used at an enlarged scale of 200 per cent as the base map for the production of the second set of maps, the Field Unit Maps, so a certain amount of distortion arises from the photocopying process. The Field Unit Maps formed the base map for the digitizing process, because each provided information on a particular field as a discrete individual entity, but the recent bulldozing of many field walls resulted in problems of orientation and errors in identifying particular fields, whilst the digitizing process also had to include as walls the arbitrary field boundaries we had sometimes had to draw up in the field-walking to facilitate the recording of the surface artefacts on a field by field basis, particularly where walls had been destroyed by the bulldozing.

Figure 5.7 *Plots of the field wall data bases A and B. (Illustration: Paul Newson.)*

The next task was to integrate the wall data collected during the fieldwork seasons under the categories listed in Table 5.2, compiled within an Access data base, with the digitized map of the WF4 fields. This was critical for the GIS for two reasons. First, the wall data provided the opportunity for constructing an approximate dating sequence for the construction of the walls and hence the field system as a whole, through comparative analyses between walls of similar construction and their relationship to diagnostic sherds collected in their immediate vicinity by the field-walking. Second, the data base included much information of great potential value for modelling aspects of land use, particularly water flow. The exercise proved problematic, however, because the basic element upon which both the digitized map and the wall data base had been based was the individual field, rather than the walls forming its boundaries, so the focus of both had to be re-engineered so that the lowest common element would be walls rather than fields. This involved altering the polygon boundaries on the digitized map to reflect the positions of the field walls, associated structures, and gaps where no walls were present. Using the three sets of base maps, the boundaries of each of the field units were broken into a series of linked compositional parts, with new nodes being inserted along the arc lines whenever a section of wall ended or a structure such as a large cairn was present.

This process caused certain constraints on the collation of the wall information, as each particular wall (an arc composed of a string of vertices in a GIS) could only support one set of applicable attribute information. The only practical solution was to construct two separate data bases of attributes for the digitized wall arcs (labelled Field Wall Data Base A and Field Wall Data Base B). Each data base contained the information recorded for each wall within the field system from both its aspects, and in most cases each wall would have been recorded as two separate faces on two or more Field Record Sheets. The arc-based coverages for each of the data bases were then plotted separately (Fig. 5.7). This did not present a problem within a GIS environment, as information contained within separate coverages could be compared and conjoined. Once the whole field system had been covered, and the appropriate nodes inserted, each fragment of the polygon boundaries (*c*.6000 in total) was assigned an individual identity reflecting the presence or absence of walls and certain important features. The new identities were then matched with the information provided in the Wadi Faynan Data Base.

One of the benefits of the insertion of numerous nodes to indicate short lengths of walling, rather than one node at the end of an arc to reflect the whole length of wall on one particular side of the field, was the level of detailed information that could in many cases be assigned to the field boundaries from the data base, greatly increasing the scope of the questions that could be asked of the wall data. For example, in terms of wall construction date, a wall of a particular kind of structure could be isolated within the GIS-based wall map, the map could be queried through the linked data base for other examples with similar characteristics, and their distribution could then be compared with the period-based sherd coverages (see Surface Artefact Distributions below). The other main area of enquiry concerned the operational use of the field system, in particular modelling possible floodwater flow and the effects of particular walls and wall arrangements upon it, which required information on spot heights and the distribution of modern stream flows across the system. A Digital Elevation Model (DEM) was therefore constructed of the Wadi Faynan valley using the contour information on the photogrammetric map. The DEM also allowed observations to be made on topographic relationships, for example which field units were on sloping ground and which on flatter surfaces.

Once all the elements were completed through the processes outlined above, they were integrated into a single spatial data base within the *Arcview* GIS programme.

5.4 Walls, channels, and hydraulic technology

5.4.1 Free-standing walls

The analysis of the data base indicated that the walls of both the WF4 field system and the other smaller field systems could be divided into two broad groups: free-standing, and terraced (Fig. 5.8). The two groups can be seen to overlap, in part because of the variability of constructions within a particular wall and in part from the different interpretations of the wall recorders. Further sub-categories can be distinguished within these two groups, particularly in the case of the terrace walls. The major groups of walls identified in the GIS analysis are listed in Table 5.3 and their distribution is shown in Figure 5.9.

The free-standing walls of Group 1 show the least variation in terms of construction, the simplest being linear structures which are not continuous walls but merely lines of large orthostatically-placed stones, ranging in size from large stones to large boulders (Fig. 5.10). These boulder lines or free-standing walls concentrate in the western half of the WF4 field system, and in parts of the WF442 and WF443 field systems on the northern side of the Faynan channel. Little evidence remains for intact free-standing walls (Wall Group 6), with rubble piles or cairns where once a wall may have stood. In some locations the footings of a double-faced wall could be observed, either at points within the rubble lines or along field boundaries where the upper parts of the wall stones had been cleared away at some point in the past. Free-standing walls include long linear walls bisecting the western portion of WF4.12 and WF4.13. Others concentrate in the northeastern and southwestern edges of WF4.15, and there is a number comprising internal field divisions within the northern area of WF4.3.

At a few locations there were remains of very wide and impressive free-standing walls, with stone rubble infills between the double faces. Within Unit WF4.12, for example, is a long and impressive double-faced free standing wall, still in parts almost 1.5 m high and nearly

Wall Group 1: Cairn lines
Type 1: Cairn line
Wall Group 2: Single-faced terrace walls
Type 3: Single-faced terrace wall
Type 5: Single-faced wide terrace wall
Wall Group 3: Single-faced wide walls
Type 5: Single-faced wide terrace wall
Type 9: Wide free-standing wall
Wall Group 4: Double-faced terrace walls
Type 4: Double-faced terrace wall
Type 6: Double-faced large terrace wall
Wall Group 5: Double-faced walls
Type 4: Double-faced terrace wall
Type 6: Double-faced large terrace wall
Type 8: Double-faced free-standing wall
Wall Group 6: Free-standing walls
Type 8: Double-faced free-standing wall
Type 9: Wide free-standing wall

Table 5.3 *The major groups of walls identified in the GIS analysis; their distribution is shown in Figure 5.9.*

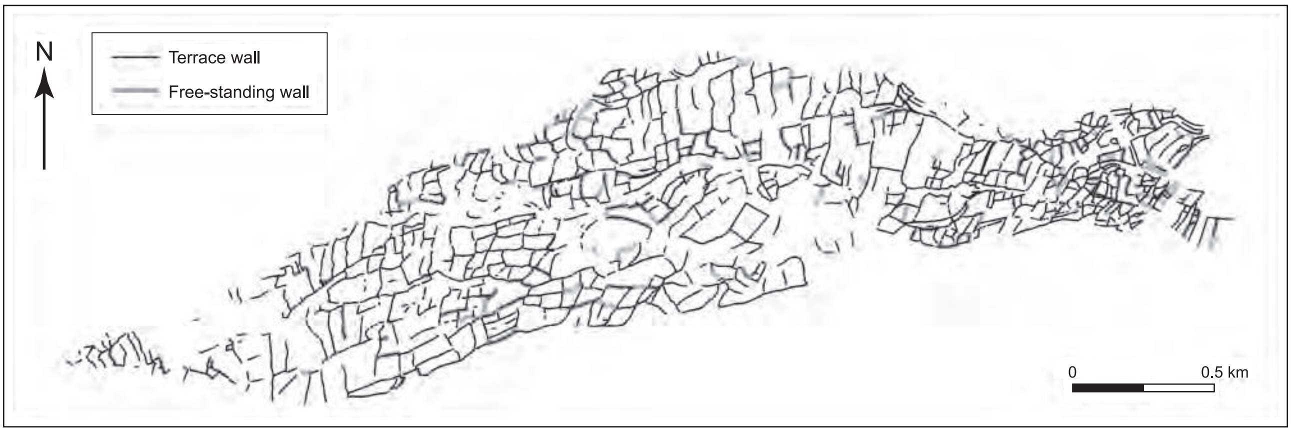


Figure 5.8 *The distribution of free-standing and terraced walls within the WF4 field system. (Illustration: Paul Newson.)*

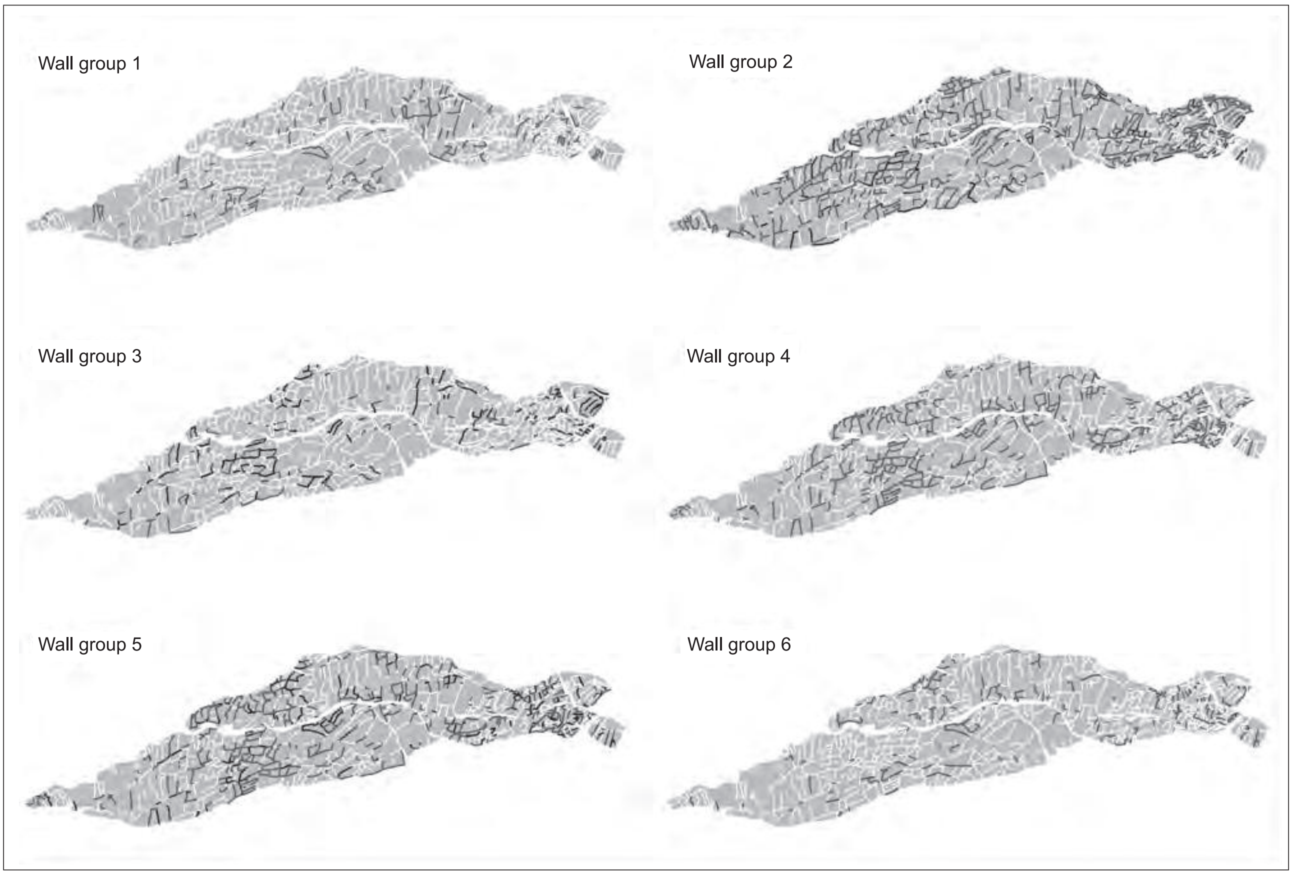


Figure 5.9 *The distribution of the major wall groups (classes 1–6) within the WF4 field system. (Illustration: Paul Newson.)*

Figure 5.10 *The orthostatic wall at the southeastern field WF4.15.64, looking east; an example of Wall Group 1. (Photograph: Paul Newson.)*

Figure 5.11 *The large and impressive double-faced free-standing wall in Unit WF4.12, looking northwest. (Photograph: Paul Newson.)*

Figure 5.12 *The large wide wall at the edge of field WF4.10.3, looking east. (Photograph: Paul Newson.)*

Figure 5.13 *The large wide stepped terrace of Unit WF4.12 (fields 7–9), looking east. (Photograph: Paul Newson.)*

1.8 m in width, forming a boundary between the long field WF4.12.19 and fields WF4.12.7, WF4.12.8, and WF4.12.9 (Fig. 5.11). This wall compares well with that found along the northern and southern sides of WF4.10.3, a double-faced wall measuring 2 m in width and surviving in several courses to a height of 1.5 m, with a filling of small stones and gravel (Fig. 5.12). We can only speculate on the purpose of these walls and the reason or reasons for their massive construction, but it is noteworthy that fields WF4.12.7–WF4.12.9 form a distinct three-field terrace unit that occupies the total descent length of a short east-to-west slope. To the south, fields WF4.12.5–WF4.12.7 and WF4.12.24–WF4.12.6 are on a slightly higher level than those of WF4.12.7–WF4.12.9 but again step evenly down the slope; each is roughly of equal size (Fig. 5.13). If, as appears to be the case, this set of walls and fields formed a unitary system, the large free-standing wall would have marked a boundary between it and others to the north, so it may have had a primary function as some kind of ownership boundary. The walls of WF4.10.3, situated on level ground at the lowest point for the group of fields in the northwestern 'peninsula' of Unit WF4.10 by the main wadi channel, are more difficult to understand. Perhaps they served a specialized purpose, for example as a large water-storage area, or the area may have contained an usually large number of stones, or the walls may have been constructed in a period when this particular style and method of construction were prominent.

5.4.2 Terrace walls

By far the majority of walls in the WF4 field system, located throughout it, consisted of terraced walls (Fig. 5.9). Many different forms were defined in the field recording, with many walls having two or three different constructions within the same wall length/side. This variety probably reflects a mixture of two processes that are difficult if not impossible to disentangle: different functions of a field edge at particular points along its length in a particular period; and the maintenance, repair, and upkeep of the same length of wall over different periods.

Figure 5.14 *The large boulder boundary wall of field WF4.3.16, looking southeast. Scale: 1 m. (Photograph: Paul Newson.)*

Figure 5.15 *Looking west towards the well-built terrace wall along the northern edge of field WF4.14.31 (which faces a tributary wadi seen on the right). (Photograph: Paul Newson.)*

Figure 5.16 *A wall within the lower units of the WF4 field system composed of medium-sized stones, fronted by a single line of parallel stones, looking west. The wall lies on the western edge of field WF4.7.30, which forms the background of the photograph. Scale: 1 m. (Photograph: Paul Newson.)*

Figure 5.17 *A single-face terrace wall built of medium-sized stones within the lower units of the WF4 field system, looking northwest. The wall is situated along the northern edge of field WF4.9.1. Scale: 2 m. (Photograph: Paul Newson.)*

Well-preserved sections of terrace walls several courses high are particularly common in the steep eastern areas of the WF4 field system, particularly in Units WF4.1–WF4.3 and on the similarly steep gradients of the southern parts of Units WF4.4 and WF4.5 and the northern part of Units WF4.8 and WF4.11. In these regions there can in some cases be as much as a *c*.1.5 m drop in the surface level from the upper to the lower field on either side of the terrace wall. The average height difference between levels is usually much less, though, averaging *c*.0.5–0.75 m.

There is a great variety in the construction of terrace walls on the steeper terrain and particularly fronting onto a number of tributary wadis. For example the terrace walls forming the down-slope boundary to field WF4.3.16 are formed of very large boulders (Fig. 5.14), whereas in WF4.8 and WF4.11 there are some lengths of coursed walls of medium-sized (*c*.30 cm) stones of quite regular diameter still standing up to seven or eight courses high, with sediment and fill packed to the top of the terrace wall behind (Fig. 5.15). Most of the terrace walls within these units, however, are much lower in height and are often now tumbled, forming rubble masses at the edges of the fields.

In the flatter regions immediately south of the Wadi Faynan channel (Units WF4.6, WF4.7, WF4.9, WF4.10, and WF4.15), many of the walls, particularly those running north–south, can also be regarded as terrace walls, but commonly have deteriorated into low unstructured stone heaps. Those that remain usually consist of walling two or three courses high. The result is that the low-elevation areas of the WF4 field system appear as a series of low steps descending to the west. Some of these are more substantial, with steeper


Figure 5.18 *A double-faced terrace wall within the lower units of the WF4 field system, from above showing wall structure and looking at the south wall face. This wall lies between fields WF4.9.11 and WF4.9.24. Scale: 1 m. (Photograph: Paul Newson.)*

Figure 5.19 *A terrace wall built of large stones within the lower units of the WF4 field system (WF4.10.20), looking north. Scale: 2 m. (Photograph: Paul Newson.)*

drops, whereas some of the north–south running walls are simple field divisions rather than terraces. In many cases, the wall is fronted on the downslope side by a parallel wall, often consisting simply of a line of stones set into the earth parallel to the line of the terrace wall, at an average distance of 1–2 m (Fig. 5.16). Many of the low terraces are composed of single-faced walls built of medium-sized stones, others have double-faced walls, and there are a few walls formed of single lines of large boulders (Figs 5.17–5.19).

5.4.3 Cross-wadi walls, dams, and deflection walls

A series of structures was observed within the WF4 field system and in the smaller field systems which have similarities with water-management structures known in other regions of Southwest Asia and beyond (e.g. Barker *et al.* 1996a; Bruins *et al.* 1986; Evenari *et al*. 1982 [1971]: 95–119; Gilbertson and Kennedy 1984; Gilbertson *et al.* 1984; Kennedy 1995; Mayerson 1962; Meshel 2000; Oleson 2001; Wilkinson 2003). The first of these, and the simplest in design, are cross-wadi walls, commonly known elsewhere as check dams: series of terrace walls constructed at right angles across the line of water flow in a wadi channel. Cross-wadi wall systems are designed to interrupt and slow the flow of floodwaters, causing the increased infiltration of water into the ground, retain manure, control erosion, and encourage the deposition of sediments/soils. Some of the smaller groups of fields, such as WF409, consist entirely of such structures; other examples form components of larger field groups. Much of WF406 conforms to a cross-wadi wall system, and parts of the WF4 field system have small runs of check dams or cross-wadi walls, such as WF200 (Fig. 5.20).

Figure 5.20 *A system of cross-wadi walls or check dams (WF200), looking northeast. Scale: 2 m. (Photograph: Paul Newson.)*

Figure 5.21 *The large boulder wall (WF52), looking northwest, apparently built to prevent stream erosion in field WF4.10.8. (Photograph: Graeme Barker.)*

Some short lengths of linear walling, particularly along the northern edges of the fields immediately beside the main Faynan channel, can be interpreted as structures built primarily to limit severe fluvial erosion and gullying. An impressive example is WF52 in WF4.10.8, where extremely large boulders have been used to block the erosive effects of a tributary wadi near its confluence with the main Faynan channel (Fig. 5.21).

Conclusive evidence for the former presence of major diversion barrages was not found during the survey, but structures of this kind built of boulders or boulder and earth mixes may have existed at certain points along the course of the tributary wadis to slow the flow of floodwaters before they entered the field system, especially on the steeper terrain to the south of the WF4 field system. A rubble structure immediately south of Unit WF4.4 is a possible candidate. It is likely that walls and barrages built within major wadi channels would have been washed away once regular maintenance ceased. What Unit WF4.4 and other field groups such as WF406, WF408, and WF424 do demonstrate is the use of deflecting-diversion walls for the capture and distribution of surface run-off water from the adjacent slopes. Unit WF4.4, for example, has a perimeter wall running just above the base of the slope which forms the southern boundary of the unit. It may be that this wall, as well as capturing, controlling, and distributing surface run-off and sediments collected from the short slope immediately behind, also acted as a conduit and distribution structure for floodwaters captured from the tributary wadi flowing into this unit from the south (Fig. 5.22). The best example of a diversion system is at WF406, discussed later.

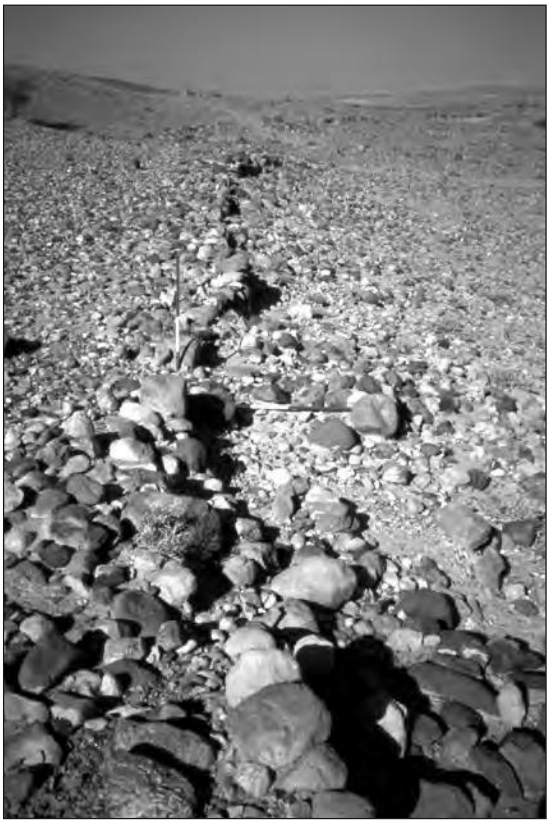


Figure 5.22 *The southern perimeter wall of Unit WF4.4, looking west, with a concave sluice in the foreground. Scale: 1 m. (Photograph: Graeme Barker.)*

Figure 5.23 *A simple sluice (WF250), looking southeast. (Photograph: Graeme Barker.)*

Figure 5.24 *The remains of a simple cascade spillway (WF258) in field WF4.4.25, looking east. Scale: 2 m. (Photograph: Graeme Barker.)*

5.4.4 Sluices and spillways

Gaps were observed at certain points along the length of the southern boundary wall of Unit WF4.4, the position and construction of which strongly suggest their use as water-management structures. Usually there is one gap in a wall per field, positioned at the optimum location for the delivery of water to the field in question. The short gaps are interpreted as sluices (WF234, WF240, WF262) and the larger ones as spillways (WF260, WF264). A few of the spillways had structural elements visible in the form of a baffle, a centrally-placed stone group set immediately below and downstream of the gap within the wall. Such baffles would have controlled and managed the entry of floodwaters into the field, maintaining a steady flow and limiting their erosive power, and would also have increased the field area to which water would have been distributed by 'splaying' the flow outwards. WF250 (Fig. 5.23) is a good example of a simple sluice formed by the vertical insetting of two flat-sided stones to create a V-shaped funnel through which surface flow would have been directed between the adjoining fields. WF258 consisted of the remains of several stone courses laid in a number of loose horizontal steps to create a rudimentary cascade spillway (Fig. 5.24). This structure would have facilitated the controlled entry of high quantities of surface flow between the fields here, which are located on steeply-falling ground.

Such inferred sluices and spillways occur throughout the WF4 field system but especially in the steeper, more terraced, terrain, for example where small fields step down to the edge of a tributary wadi in the northern part of Unit WF4.8. The terrace walls here are unusually well preserved, standing in places 8–9 courses high, creating 'step' sluices and 'drop' spillways. A good example of a well-preserved drop spillway is WF1497, a small concave semi-circular construction of stones built into a steep-sided north-facing terrace wall, between fields WF4.8.4 and WF4.8.5 (Fig. 5.25). There was an extensive system of step sluices (WF326) regularly spaced along the next terrace wall downslope, between fields WF4.8.5 and 4.8.7 (Fig. 5.26). Forward of the terrace wall was another low wall of 1–2 courses running parallel to it, which also had gaps at quite regular intervals that may have been sluices.

Figure 5.25 The remains of a well-preserved drop spillway in Unit WF4.8 (WF4.4), looking southwest. (Photograph: Graeme Barker.)

Figure 5.26 A step sluice (WF326), looking north. (Photograph: Graeme Barker.)

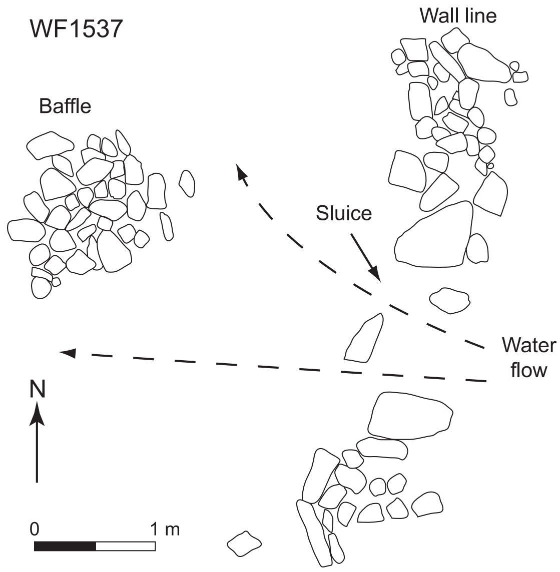


Figure 5.27 (left) Complex arrangements of spreading structures or baffles in the walls of Units WF4.6–WF4.7, looking southwest. (Photograph: Graeme Barker.) (right) Plan of sluice and baffle WF1537 in Unit WF4.3. (Illustration: Dora Kemp, Daniel Lowenborg, and Lars Gustavsen.)

A combination of a terrace wall containing simple sluices and/or spillways running parallel with another wall composed of short sections of single courses of medium-sized stones was often encountered in the units adjacent to the main course of the Wadi Faynan. In Units WF4.6 and 4.7, for example, the sluices and spillways sometimes consisted of gaps in low tumbled terrace walls. The short length of stones in front of the terraces acted as low-level baffles to deflect and disperse surface floodwaters across these large and level fields. More complex patterns of terrace sluices, spillways, and baffles occurred particularly in Units WF4.6, WF4.7, and WF4.9 (Fig. 5.27). The scale of such structures increased in Units WF4.10 and WF4.15 in line with the size of the stones used for building the terrace walls. Impressive examples of possible spillways were found on the northern fields of WF4.10, for example at WF4.10.2, where there were two large banks formed of boulders and rubble, between which lay a slope of stones (Fig. 5.28). Somewhat similar spillways or drop structures, though of a more complex build, were encountered in the Negev desert by Evenari *et al*. (1982 [1971]: 104) and in the Wadi Umm al Kharab in the Libyan Pre-desert (Gilbertson and Chisholm 1996).

5.4.5 Parallel walls

Whilst parallel walls were observed across the whole of the WF4 field system, their variability makes it clear that they cannot all have served the same function or functions. Nevertheless, a number of them have similar locations along the boundaries of contiguous fields, have similar east/west alignments, and begin immediately downstream of and connect with one of the tributary wadis dissecting the field system. Excavations (described below) demonstrate that these parallel walls are the visible edges of channels filled with waterlain sediments. In combination, the evidence suggests that they are highly likely to have been feeder channels for the distribution of surface floodwaters flowing over the field system after storms. In many cases they distributed water into a network of secondary channels running in a generally north–south direction along the down-slope side of terrace walls, the water then entering the fields in a generally westerly direction. It is not clear

Figure 5.28 *A large spillway in WF4.10.2, looking southeast. (Photograph: Paul Newson.)*

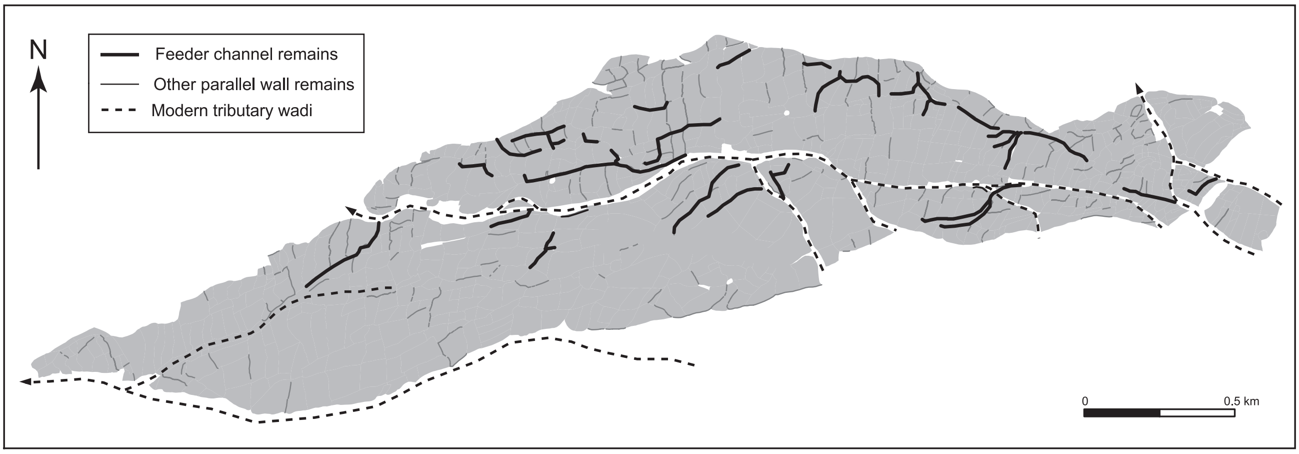


Figure 5.29 *The distribution of the main parallel wall systems in the WF4 field system. (Illustration: Paul Newson.)*

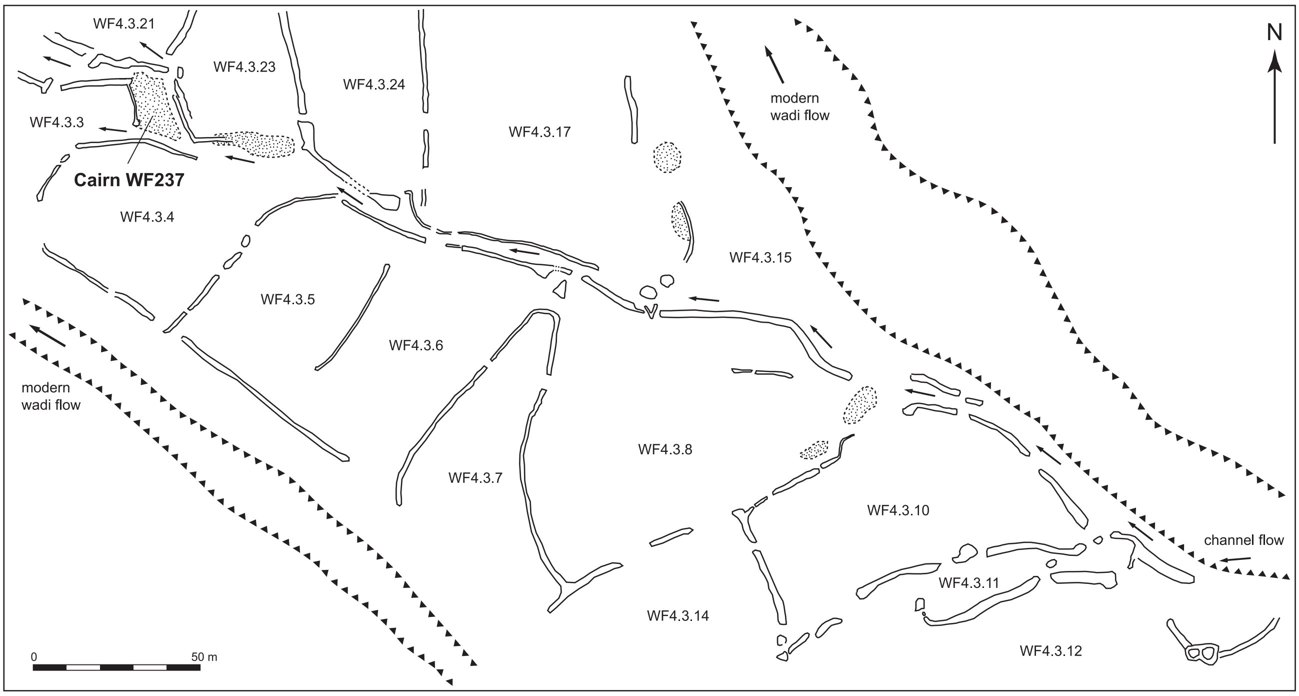


Figure 5.30 *A well-preserved example of a channel network, WF243. (Illustration: Paul Newson.)*

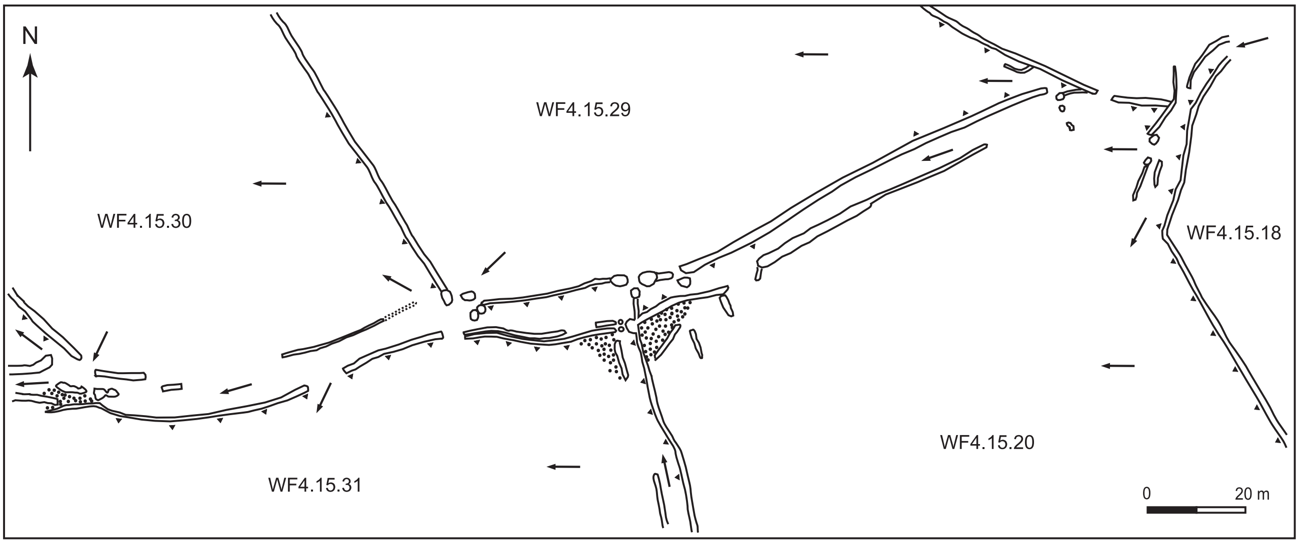


Figure 5.31 *Part of the network of feeder channels and fields (WF85) which were linked to the main channel network (WF53/WF75/WF350) 150 metres to the south. (Illustration: Paul Newson.)*

whether there were further minor channels-conduits to distribute the water across the fields as occurs in some irrigation systems today (e.g. Gilbertson and Hunt 1996b; Lancaster and Lancaster 1999: 145–7), or whether the water was allowed simply to wash over the ground. It is possible that a variety of methods was used depending on factors such as the local topography, the position of the field in relation to the main channel system (and thus the likely velocity of water to be controlled) and the nature of the crops – cereals or tree crops, for example. Furthermore, the measuring of water infiltration rates at several points across the main field group WF4 indicated that levels were uniformly low, so surface run-off rates under current conditions are high with little loss, suggesting that locations with even very low gradients have the capacity to provide run-off facilities (Crook 1999: 278). In sum, though, the evidence of primary and secondary distribution channels indicates that at least one phase of the WF4 field system was characterized by a complex, well-organized, and notably integrated technology for the capture and distribution of surface run-off (Fig. 5.29). As described below, our excavations indicate that this phase belongs to the Roman/Byzantine period.

A well-preserved example of these channel networks was found in Unit WF4.3, focused on the large channel WF243 (Barker *et al.* 1998: 9–17; Figs 5.30, 5.40). The entrance to the channel swerves away from the course of a tributary wadi, which has cut down from this point and whose bed is currently 1.5 m below the present surface of the channel. The present-day surface of the channel is *c.*1–1.5 m wide and is bounded by two parallel lines of stones. On either side of the channel is a series of sub-rectangular fields, the side walls of which diverge from the spine of the channel at a consistent angle from the direction of flow to create a herring-bone arrangement; for the fields to the south of the channel this angle is around 60°, for the fields to the north around 78°, accommodating the local topography. At the junction between the channel wall and the upslope wall of each field was a sluice or gap through which floodwater flowing down the channel would enter the field. Several of these sluices contained what appeared to be stone baffles to control and direct the incoming flow. The channel appeared to terminate by the side of a large cairn (WF237) around which a complex arrangement of outlets allowed the water to be conveyed in different directions towards separate groups of fields (Barker *et al.* 1998: 16).

Different arrangements of fields and associated parallel wall networks were recorded further to the west. For example, the remains of a remarkably wide (*c.*5 m), long (*c.*500 m), and continuous series of parallel walls was recorded in Units WF4.10–4.15 as WF53, WF75, and WF350, running east–west from the channel of a tributary wadi at the upslope end and connecting down its length with a series of distribution channels, subsidiary channels, and associated fields (Fig. 10.29). Although it is difficult to trace the channel beyond this length today, there are hints that it was even more substantial in the past. To the north of the main channel, and on the same alignment, are some short lengths of parallel walls and water management structures (WF49, WF50, WF82–WF85: Figs 5.31, 5.32). The main channel splits into two *c.*175 m from its starting point, with a subsidiary branch running to the north and the main branch continuing to the west. Although the parallel walls of the northern branch are replaced within a few metres by a single wall, the latter then follows the line of the contour until it merges into the parallel walls WF82 *c.*300 metres to the northwest. It may be that the single wall at that location was sufficient to guide floodwaters rather than a normal parallel wall channel, or a normal parallel wall system may have been remodelled at some later stage. (Evidence for remodelling of this kind was evident in the main channel, as it had been blocked at the

Figure 5.32 *The channel WF85 and a subsidiary channel, looking northeast. (Photograph: Paul Newson.)*

Figure 5.34 *The fragmented remains of the WF288 parallel wall system in field WF4.4.35, looking northeast. Scale: 1 m. (Photograph: Graeme Barker.)*

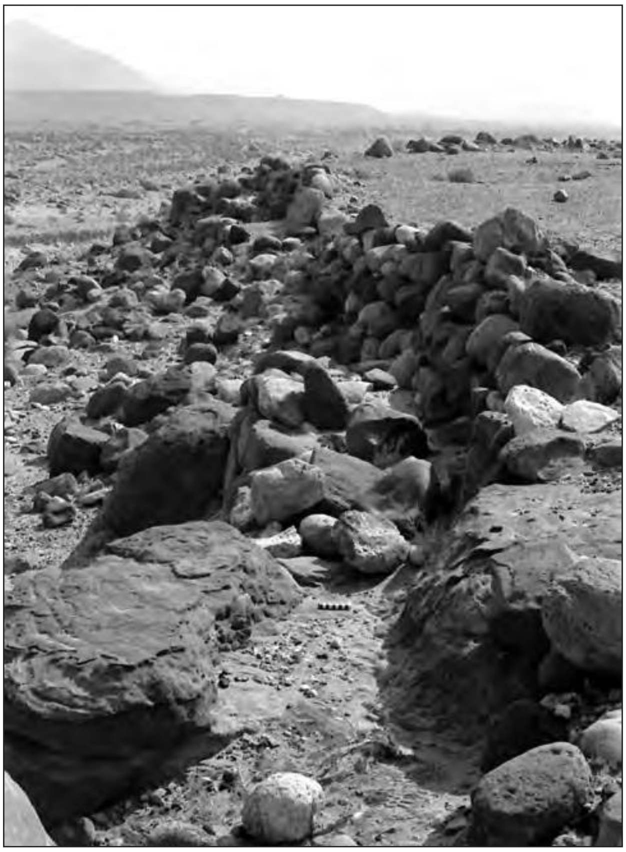


Figure 5.33 *A large boulder in the north terrace of field WF4.9.1, with a groove cut through it to allow the passage of floodwaters down the channel it otherwise blocked, looking east. Scale: 10 cm. (Photograph: Graeme Barker.)*

channel junction by a wall line of large inset boulders: see Fig. 10.29.) Further channels *c*.1.5 m wide formed of field walls and single lines of inset stones parallel to them led floodwaters from the WF82 channel into fields WF4.10.31, WF4.10.33, and WF4.10.35.

An unusual example of the investment in parallel wall technology was found in the walls running along the northern edge of Unit WF4.9. The path of the floodwaters along the southern edge of these walls would have been blocked by a large (*c*.2 m diameter) boulder. Rather than divert the system around the boulder (and lose the advantage of the topography in the process), the builders preferred to chisel out a large groove through it to allow the waters to pass unhindered (Fig. 5.33).

A number of small excavations was undertaken (Trenches 1–10) to test the hypothesis that most of the parallel wall systems were water conduit systems. For eight of the trenches the results proved positive, with lenses of fluvially-deposited silt and clay and layers of fine gravel being observed. These sediments exhibited the scour-and-fill bedforms commonly found in sand-bed streams, typically in those that dry up regularly and have flashy discharge regimes. Such bedforms are consistent with quite rapid flows (Ashley 1990), in this case probably between 0.2 and 0.4 m per second at peak flow. The evidence of the fluvial deposits suggests short periods of water distribution separated by prolonged periods of drying (Hunt pers. comm.).

Trench 1 (WF1530) was placed in a small channel formed by parallel walls (WF288) which appeared to be diverting water off a modern tributary wadi within Unit WF4.4. The channel continued across into Unit WF4.5 (via channel WF259), but a few metres on was cut by another tributary wadi which runs between Units WF4.4 and WF4.5 (Barker *et al.* 1998: 15–16; Fig. 5.34). The finds included a number of prehistoric (Early Bronze 1 and 2–3, and Iron Age) sherds along with some Classical period sherds, though this in itself is not conclusive evidence for the age of the operation of the channel. The fluvial deposits in Trench 1 (Fig. 5.35) demonstrate that the parallel walls here had originally demarcated a diversion channel; that it distributed water from some point within the upper field system to an area of fields in the central part of Unit WF4.5 that appears to have been a small self-contained system; and that the landscape, and in particular the drainage, were significantly different when the field system was in operation compared with today. The contours show that the channel diverted water from the natural course of a tributary running west–east, which must have existed in some form prior to the construction of the diversion channel. At a later date a tributary wadi running south–north returned to its original course, dissecting the diversion channel in the process. Clearly the landscape of the WF4 field systems has been highly dynamic, with major re-modellings and related changes occurring within relatively short periods of time.

Trenches 2 and 7 also revealed developments and remodelling of the channel systems over time, perhaps in part as a response to the loss of soils in some parts of the system and accumulation in others. Trench 2, to the north of Trench 1, was placed in the middle of a long pair of parallel walls (WF1531) forming the eastern edge of field WF4.6.47 (Fig. 5.36). The excavation revealed waterlain sediments and below these, much narrower lines of parallel-set large flat boulders, the remnants of an older conduit (Daly and Newson 2000: 43; Fig. 5.37). Roman pottery was recovered from the infill, suggesting that the conduit was used in the Roman period and then remodelled at a later date.

Trench 7 was placed across a low line of boulders (WF1526) a third of the distance along the westward course of an impressively large series of parallel walls (WF50 and WF85) traversing Units WF4.10 and WF4.15. The boulder line cuts right across the course of the parallel walls, blocking the supposed channel flow, but the excavation revealed that the parallel walls lined the edge of a very large channel that was filled with waterlain silts, clays, and gravels (Fig. 5.38). The boulder wall obstruction suggests that, at a late date in the channel's history, efforts were made to divert floodwaters to another area of fields, perhaps when the fields further downstream had gone out of use.

Figure 5.35 *Trench 1, excavated through the WF288 parallel wall system showing the channel filled with fluvial sediments, looking east. Scale: 10 cm. (Photograph: Graeme Barker.)*

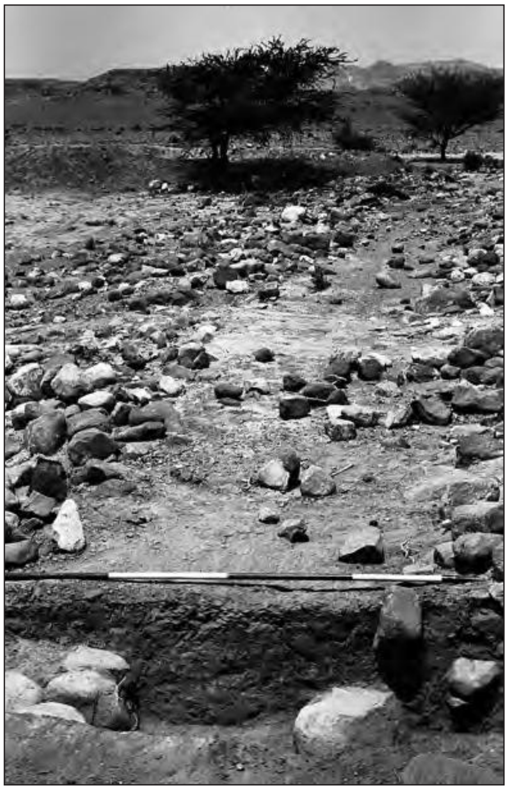


Figure 5.36 *The WF1531 parallel wall system in field WF4.6.47, looking north. Scale: 2 m. (Photograph: Graeme Barker.)*

Figure 5.37 *Trench 2, excavated through the WF1531 parallel wall system, showing underlying boulder structure, looking north. Scale: 2 m. (Photograph: Graeme Barker.)*

Figure 5.38 *Trench 7, excavated across part of a parallel wall system that traverses Units WF4.10 and WF4.15 (WF85), revealing a channel filled with water-lain silts, clays, and gravels. Scale: 1 m. (Photograph: Paul Newson.)*

Figure 5.39 *The rock-cut aqueduct conduits feeding water from the Wadi Ghuwayr springs to the large reservoir and mill (WF11) complex. There are traces of two or three phases of remodelling, marked by different channel recuts in the rock wall at different levels. (Photograph: Darren Crook.)*

5.5 Other water-management structures

In addition to the many water-management features and technologies contained within the main field groups, a number of other structures was recorded relating to water management. The most impressive is the channel/aqueduct system near Khirbat Faynan, which Frank (1934: 217–25) had recognized fed first a large reservoir (Fig. 10.12) and then a stone '*arubah* penstock' or 'drop tower' watermill (Fig. 10.13) (*arubah* being the hollow cylindrical stone tower: Avitsur 1960). Mills of this type using the same water supply obtained more power than a conventional mill through the creation of high water pressure and the use of a primitive turbine. High pressure was obtained by channelling the water flow to the top of a vertically-set thin tube or penstock, generally less than 1 m in diameter. The penstock narrowed towards the base, constricting the flow of water and so creating a constant head of water and high pressure. A small waterwheel or turbine was placed horizontally at the base of the penstock and was rotated at high speed by the outflow of the pressurized water.

The water to feed the reservoir and the mill was siphoned off several kilometres upstream in the Wadi Ghuwayr where a strong flow of perennial water, from springs aided by discharge from the wetter uplands, could be guaranteed. Evidence for a conduit was discovered skirting the edge of the steep gorge cliffs of the wadi (Crook 1999: 279–80). In part cut through the bedrock and in part supported on stone walling, it had a plaster lining that had been re-lined on at least one occasion (Fig. 5.39). This led to an impressive stone aqueduct, of which only the part of two arches survives (Fig. 10.11), built to carry the stream-water over the course of the Wadi Shayqar to the reservoir (Fig. 10.12). The latter is a spectacular and well-built rectangular structure measuring 31 m by 22.4 m, with ashlar-faced stone walls descending at least four metres in depth from an overflow, giving the tank a potential capacity of around 2798 cubic metres (Crook 1999: 280).

Some scholars have suggested that the aqueduct and reservoir were linked directly with the irrigation of the WF4 field system (Hauptmann 2007: 48–9), but our detailed examination on the ground did not find any evidence to support such an interpretation. It is likely that the reservoir was used mainly for storing water for both drinking and for the industrial processes associated with copper smelting, given its association with substantial slag heaps to the west and south (Fig. 1.4), and with a number of stone-built rectangular structures which may be connected with ore processing and smelting. The line of a channel is cut into the stonework along the western rim of the reservoir, leading to the mill leat and a smaller tank. Although Crook (1999: 280) suggested that the water for the leat came directly from the reservoir, it seems probable that this channel connected directly with the main channel leading from the aqueduct to the reservoir, presumably to overcome problems of water supply when the reservoir level was low.

The aqueduct/reservoir/mill system has commonly been regarded as of Roman–Byzantine date on technical grounds (Wikander 2000; Wilson 1995), although there have been doubts about the age of the mill as many examples of this type date to the Islamic period (Gardiner and McQuitty 1987; McQuitty 1995). The composition of two samples of the plaster lining of the mill leat was compared with samples taken from the plaster lining the reservoir feeder and exit channels (Morgan 1997: 38; Table 5.4). The earlier of the mill leat plasters (Sample A2 in Table 5.4) and those of the two reservoir channels are all similar in composition and colour (white). The later plaster in the mill leat (Sample A1) is pink, and though strongly lime-based in the manner of a typical Roman *opus signinum* has numerous inclusions of brick and tile like the plaster of the water channels at Ma'an dating to the late Byzantine or early Islamic periods

(Findlater 2004; Genequand 2003; Newson 2002). The evidence suggests that the penstock mill preserved today is in fact a later rebuild of a Roman/Byzantine-age mill contemporary with the building of the reservoir.

As, already noted, an alternative interpretation of the aqueduct and reservoir would be to connect them with irrigation within the main field system. However, there are serious objections to this, not least the lack of any visible outflow connection between the reservoir and the field system. Although the parallel walls within the northern sector of WF4 are evidence of sophisticated irrigation, there is no evidence to suggest that this involved year-round aqueduct-fed supply, rather than the channelling of periodic floodwaters. Taken together, the spatial relationship between minor gullies bisecting the field system, the long parallel wall/channel systems, and the nature of the sediment deposition within the channels, strongly indicate that the form of irrigation practised here was a variant on run-off farming. There is no evidence to suggest a connection between the parallel wall systems and the aqueduct and reservoir near its eastern end. Indeed, the outflow from the mill appears to have been carried by a channel directly into the main wadi, rather than being used to irrigate a group of adjacent fields.

The other possible reservoir known is immediately to the north of Khirbat Faynan, where a wall built of coarse stones dams the outflow from a shallow side-wadi between the Khirbat and the margin of the next hill to the north (Fig. 1.13). This is an important and enigmatic feature that has to be seen in its wider topographic and archaeological setting. At first glance the form and location of this barrage suggest that it may have provided an earlier water-storage area for the settlement of Khirbat Faynan, its animals, and its industry that was perhaps abandoned when the large reservoir was built. However, the evidence elaborated in Chapter 10 suggests that this may have been only partly, or perhaps not at all, the case. The many figures we have included of this barrage (e.g. Figs 2.13, 4.36, 10.10, 11.9) indicate that it was a most substantial structure. It has outwards-sloping outer-faces of carefully-placed large stone blocks, as well as boulders taken from the wadi floor. These enclose a core of packed boulders. Less obvious is that the structure is higher at the ends than in its middle, This could be an original design-feature, or the result of two millennia of localized erosion caused by people and animals heading for the better grazing and shade south of the barrage – themselves a consequence of the barrage impeding the lateral movement of sub-surface water. Integral to the structure, immediately behind the sitting person in Figure 1.13, is a narrow designed sluice through the structure. The floor of the sluice has an elevation *c.*1.5–2 m above the original depth of the wadi. Visiting the site in winter or spring indicates that this barrage does trap surface water in times of rain storm to a depth of *c.*0.3–4 m.

It is difficult to understand how this barrage could have been intended (even inadvisably) to provide a reliable *long-term* supply of the large quantities of water that would have been needed in Classical and perhaps late prehistoric times if the climate was wetter, as it seems to have been (see Chapters 9–11). The first difficulty is that the up-wadi catchment is very small and above the level of the barrage, is often underlain by porous Pleistocene clastic deposits (Chapter 6). There are no signs that water was delivered to the barrage by a local spring. The barrage and up-wadi impounded area can never have been connected to any putative water-supply conduit (see Chapter 10) on the north side of the Ghuwayr because of the height of the interfluve at its southern border, overlooking by many metres both this barrage and the putative conduit (Fig. 10.10). For the same reason, the massive design of the barrage cannot have been to withstand large floods coming down the side-wadi. Nevertheless, the stratigraphic evidence in Table 10.2 indicates that in Roman–Byzantine times it did impound ponds sufficiently deep (?1 m) to permit small turbidity currents with water-disturbance taking place. However, the oldest deposits found within the basin that display sedimentary structures that provide evidence of the presence of water (Lithofacies 5; Fig. 3.11) also display the properties that suggest the presence of copper ores and the waste products from ore treatment, sorting, and smelting, indicating that the barrage is older or approximately coeval with these events, estimated by radiocarbon dating to be Roman in age (Chapter 10). Examination of the other walls, tens or so metres immediately to the north and northeast of the northeast end of this barrage, reveals other walls, some of which are fragments of very substantial large walls (shown by excavation to be 2+ m high and 0.5–1+ m thick), of similarly careful and robust construction. They also have a rectilinear surface outcrop that has no understandable relationship with topography and hence with attempts to impound water from the side wadi, or the main channel of the Wadi Dana (Fig. 10.9). On excavation, these walls were found to enclose large quantities of very toxic and poisonous wastes from smelting (sites WF 5738, WF5739, WF5741: Fig. 9.16; Chapters 9–10) that are part of a generalized spread of smelting slag (Figs 3.12, 3.13) – the Atlal Member – to the northeast of the Khirbat Faynan. All this evidence suggests that the Khirbat Faynan barrage, massively over-engineered and inappropriately located to impound and store water, did on occasion impound shallow water, but that its primary purpose was to sup-

Sample	Gravel >2 mm	Sand <0.15–2 mm	Silt <0.15 mm	Soluble %	Comments
A1	3	63	34	69	with brick and tile
A2	83	12	5	46	
B	67	25	8	43	
C	55	30	15	48	

Table 5.4 *Composition of plaster samples from water-management structures near the Khirbat Faynan: A1 = mill leat, second phase; A2 = mill leat, first phase; B = exit channel from reservoir; C = entrance channel to reservoir (see text for discussion). (After Morgan 1997: 38.)*

Figure 5.40 *Cairn WF237 (where figure is standing), the node point of a complex water-distribution system (WF243), looking west (see Fig. 5.30 for a plan of the network). (Photograph: Graeme Barker.)*

port industrial-metallurgical processes, perhaps related to ore washing (processes for which the sluice provided an escape for the water used), and to contain heavy noxious wastes by preventing them from slumping and flowing downslope (as did the other walls at WF5738, WF 5739). The proximity of extensive and intensive smelting in the immediate area, and the polluted status of the catchment sediments evidenced in the geochemistry of the ponded sediments indicate that the water that undoubtedly did collect would have been of doubtful utility for people, animals, or crops (Fig. 3.11).

The survey found very little evidence for other Classical-period water supply structures within the valley, apart from a large open cistern associated with a group of structures at Khirbat Ratiye (WF1415) to the northwest of Khirbat Faynan. These structures had marble fragments that may have related to a government building, bathhouse, or chapel (see Chapter 10, §10.4.5).

5.6 Other structures

A variety of structures was noted within the field groups, all of which were recorded, though only the more visibly or structurally significant were recorded separately as WF sites and allocated individual site numbers (small-scale structures were recorded otherwise on the Field Record Sheet). The most common were piles of stones or cairns, varying considerably in construction, location and, probably, purpose(s). They were particularly numerous within the WF4 field system in Units WF4.6, WF4.7, WF4.9, WF4.13, and WF4.18, as well as in the outlying field systems WF406, WF424, and WF442. In Units WF4.6, WF4.7 and WF4.9 there were many lines of small cairns of loosely piled stones forming field boundaries, with the occasional very large cairn (again of jumbled stones, some of which were quite large in size) within the central region of a field. Patterns of patina and residue soil marks on individual stones indicate that the small linear series of cairns is very recent in date, probably the result of field clearance for piped-irrigation farming. In other parts of the WF4 field system there are examples of cairns forming wall lines, for example at the southern, terraced, end of Unit WF4.3, but these are much larger than the recent clearance cairns and often in prominent positions. In the southeast corner of field WF4.3.16, for example, is a large cairn forming a notable boundary point for walls built up to it. Cairn WF237 (Figs 5.30, 5.40) was built at the end of a channel network to form the centre point of a complex water distribution system, though it is unclear whether it was built before the channel feeder complex and incorporated into it, or built as part of it. In the WF442 field system, cairns WF506, WF507, and WF510 were located on or close to the junction of field walls and WF508 was the meeting point of four field walls, these cairns almost certainly pre-dating the walls. A series of large (*c*.4–10 m) cairns in the southern parts of the WF4 field system also probably pre-dates the field walls, in this case being carefully walled off by enclosures (e.g. in WF4.12.11) or left in prominent positions in a field (e.g. in WF4.13.6).

Cairns were rarely structurally complex, though there were a few examples with kerbs (e.g. WF121 in WF4.13.6, and WF508 in WF442) and with an internal cist (e.g. WF510 in WF442). These examples suggest that some cairns probably represent burial sites built before the field system and incorporated into it. Others may be ancient clearance cairns, whilst WF121 proved on excavation to be a midden associated with the Early Bronze Age settlement WF100 (Wright *et al*. 1998).

A variety of domestic structures was also found within the field systems (Fig. 5.41). Many complex rectangular structures (Chapter 4, §4.3.7) were found in Unit WF4.13, the focus of the Early Bronze Age settlement WF100, and the adjacent Unit WF4.16, with smaller clusters in WF4.19 and at the junction of Units WF4.18 and WF4.19/20. These vary from large buildings with double-faced walls to small

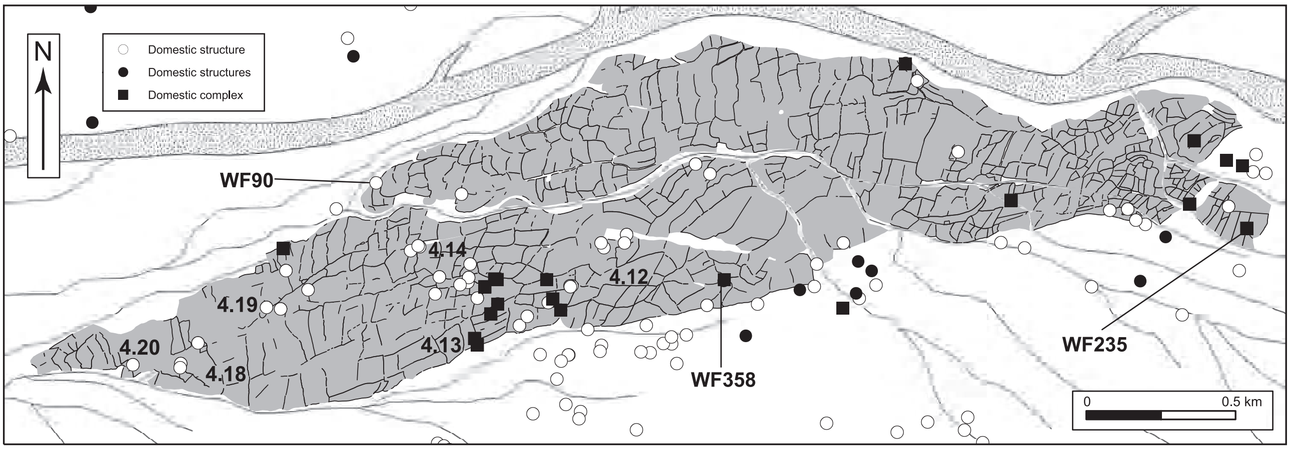


Figure 5.41 *Distribution of domestic structures within the WF4 field system. (Illustration: Paul Newson.)*

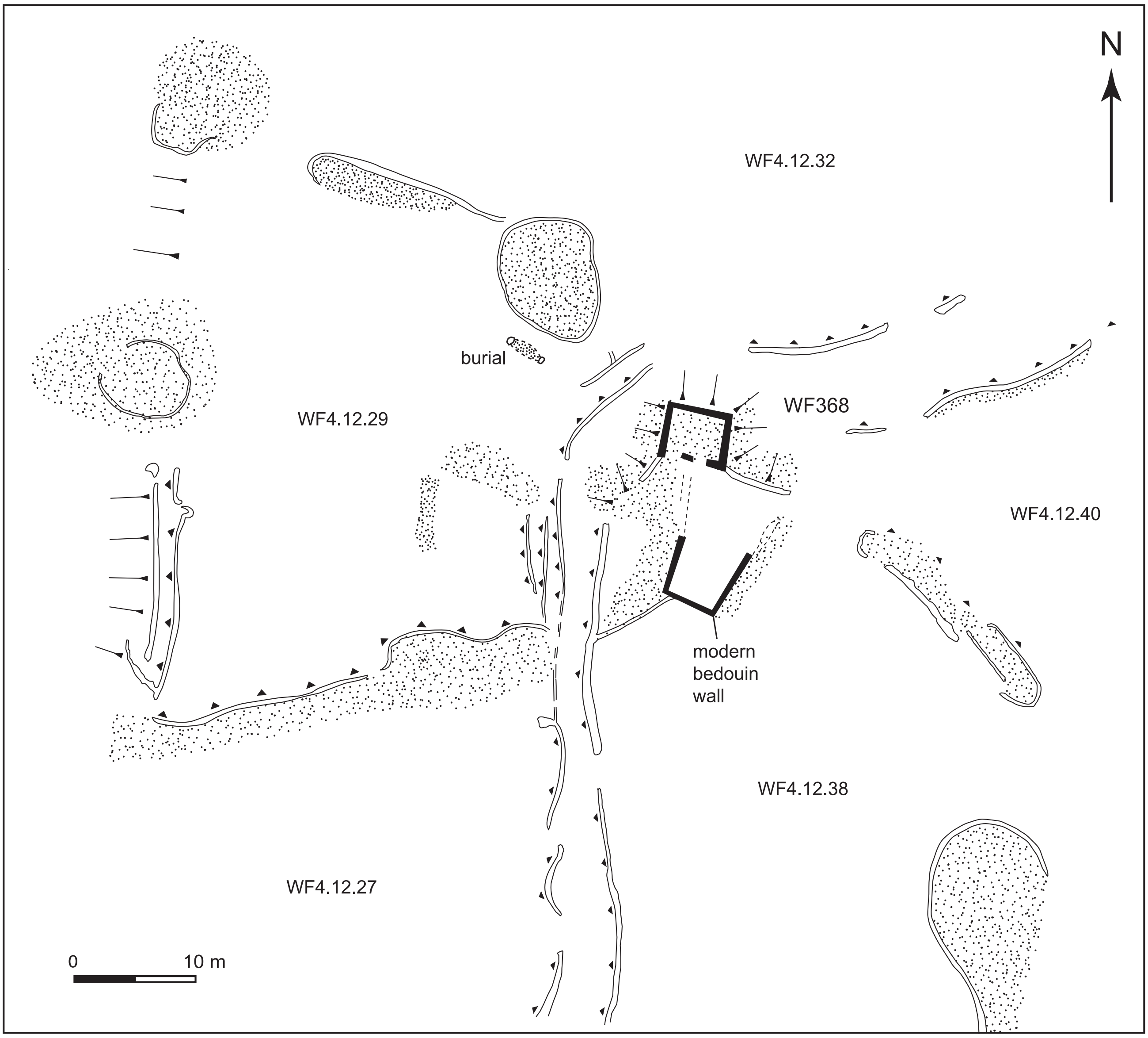


Figure 5.42 *Plan of site WF358 and its surrounding fields. (Illustration Paul Newson.)*

square low-walled pens, the latter usually built up against a field wall. Circular/oval structures were less common, being found especially in the eastern sector of the WF4 field system. The position and construction of the smaller rectangular and circular/oval structures suggest that they were probably built for agricultural purposes, such as penning animals or storing materials, though some might have been shelters for people working the fields. In contrast to these are a few large substantially-built rectangular structures, generally found on the periphery of the WF4 field system, particularly in or near Units WF4.12 and WF4.13. WF368, for example, a large building together with ancillary structures, was located in a prominent position on the summit of a low mound within the field system, within its own enclosure (Fig. 5.42). Another example of a settlement complex within the field system is WF235. Two very unusual structures were site WF62, a semi-circle of orthostatic boulders in field WF4.15.4, and site WF90, a large well-built and high-walled circular enclosure in field WF4.15.53.

5.7 Surface artefact distributions

In total, 25,241 sherds of pottery were collected from the systematic transects walked in the various field systems, along with 5932 worked fragments of flint, 2438 fragments of slag, glass, several coins, and examples of worked metal, such

	Fields	N–S transects
Total no. of sherds collected	25,241	488
Total weight of sherds collected (kg)	236.666	6.611
Total no. of flints collected	5932	378
Total weight of flints collected (kg)	63.688	6.612
Total pot/lithics collected	31,173	866
Total weight of pot/lithics collected (kg)	300.354	13.223
Area of collected transects (ha)	6.76	11.37
Average collection number density/ha	4.611	105
Average collection weight (kg)/ha	44.431	1.603
Maximum collection density/ha	123,929	1600

Table 5.6 *Comparison of transect collections inside and outside the field systems. The relative density inside the field systems and the general sparseness of surface finds in the landscape outside are clear.*

	WF4	WF406	WF408	WF409	WF410	WF424	WF442	WF443	Totals
Total no. of sherds clicked	95,480	412	24	41	138	3066	755	409	100,325
Total no. of sherds collected	23,702	156	6	37	37	791	373	139	25,241
Total weight of sherds collected (g)	214,811	2450	90	345	555	14,040	2690	1685	236,666
Average sherd weight	9.1	15.7	15.0	9.3	15.0	17.7	7.2	12.1	9.4
Total no. of flints clicked	21,905	670	121	47	303	651	1718	910	26,325
Total no. of flints collected	5297	173	5	21	60	41	282	53	5932
Total weight of flints collected (g)	56,259	1600	100	405	1045	1089	2205	985	63,688
Average lithic weight	10.6	9.2	20.0	19.3	17.4	26.6	7.8	18.6	10.7
Area of fields (sq. m)	2,092,119	109,094	36,532	8363	67,565	57,081	103,425	44,465	2,518,643
Total area (ha)	209.21	10.91	3.65	0.84	6.76	5.71	10.34	4.45	251.86
Area of field system covered by clicked transects (sq. m)	97,105	5640	1252	315	3075	5108	4794	1490	118,779
Clicked area (ha)	9.71	0.56	0.13	0.03	0.31	0.51	0.48	0.15	11.88
Rough average % area of a field system covered by clicked transect	4.6	5.2	3.4	3.8	4.6	8.9	4.6	3.4	4.7
Area of field system covered by collection transects (sq. m)	55,309	3453	501	284	1728	2796	2682	864	67,617
Collected area (ha)	5.53	0.35	0.05	0.03	0.17	0.28	0.27	0.09	6.76
Rough average % area of a field system covered by collection transect	2.6	3.2	1.4	3.4	2.6	4.9	2.6	1.9	2.7
Total area transected (sq. m)	152,414	9093	1753	599	4803	7904	7476	2354	186,396
Total % area of field system transected	7.3	8.3	4.8	7.2	7.1	13.8	7.2	5.3	7.4
Density of clicked sherds/ha	9833	730	192	1302	449	6002	1575	2745	8446
Density of collected sherds/ha	4285	452	120	1303	214	2829	1391	1609	3733
Calculated average density of sherds/ha	7904	631	166	1289	367	4895	1498	2343	6806
Calculated number of sherds	1,653,554	6886	607	1078	2479	27,942	15,497	10,416	1,714,306
Calculated total weight of sherds (kg)	14,986.14	108.15	9.10	10.05	37.18	495.96	111.76	126.27	16,073.77
Density of clicked lithics/ha	2256	1188	966	1492	985	1274	3584	6107	2216
Density of collected lithics/ha	958	501	100	739	347	147	1051	613	877
Calculated average density/ha	1805	949	671	1229	765	890	2712	4233	1752
Calculated number of lithics	377,602	10,357	2451	1028	5168	5078	28,051	18,823	441,333
Calculated weight of lithics (kg)	4010.48	95.79	49.01	19.82	90.01	134.87	219.33	349.83	4738.31
Total surface assemblage of pot and lithics	2,031,156	17,243	3057	2106	7647	33,019	43,548	29,239	2,155,639
Total weight surface assemblage (kg)	18,996.62	203.94	58.11	29.87	127.19	630.82	331.09	476.10	20,812.07

Table 5.5 *Numbers, weights, and densities of finds collected and counted (clicked) in systematic transects in the various field systems recorded by the Wadi Faynan Landscape Survey.*

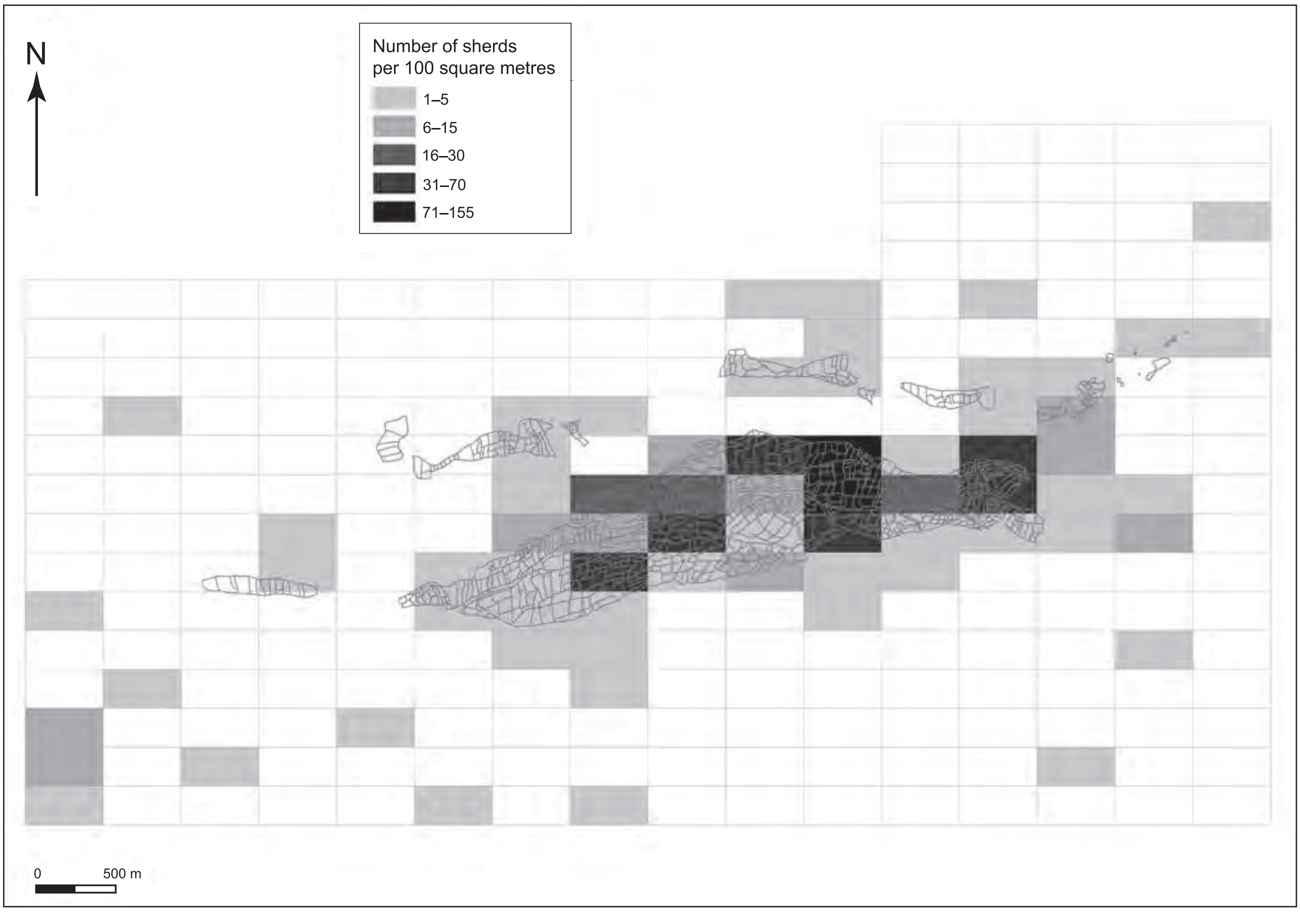


Figure 5.43 *Density distributions of surface sherds inside and outside the field systems. (Illustration: David Mattingly and Paul Newson.)*

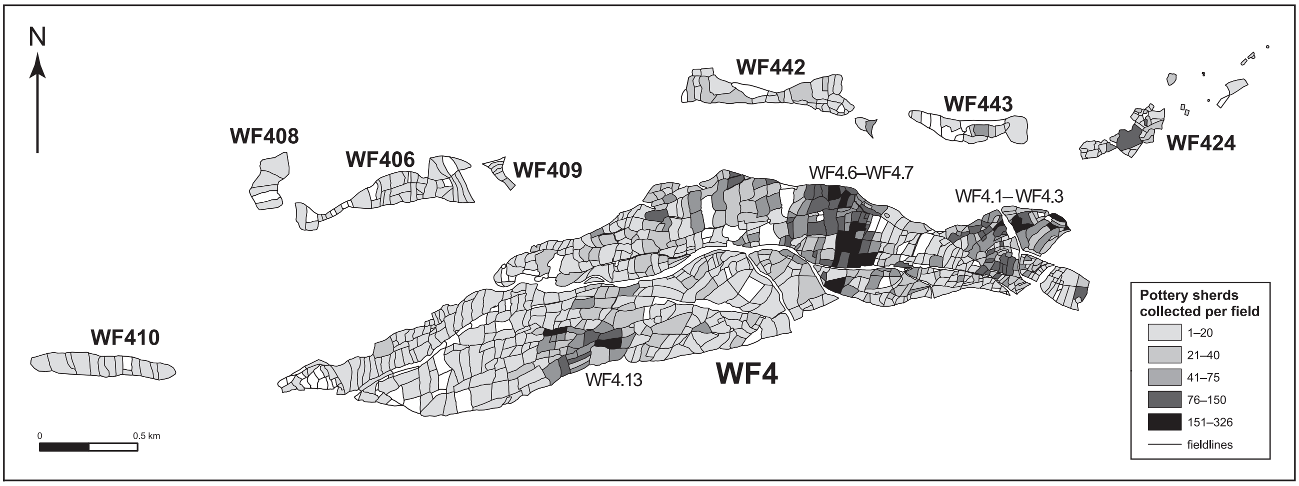


Figure 5.44 *Distribution of total sherds per field collected in the sherded transect for all the major field units. (Illustration: Paul Newson.)*

as bracelet pieces (Table 5.5). The total 'clicked' (counted) material from the field system transects adds another 100,325 sherds and 26,325 lithics, resulting in an overall estimated surface assemblage of 2,155,639 pottery sherds and lithics lying within the 252 ha of fields (or an average density of *c*.8500 artefacts per ha). These are very large totals for rural survey and fully justify the adopted strategy of a combined clicker count and systematic sample collection. The density of material in the largest field system WF4 far exceeded that in the smaller field systems and exceeded an artefact every sq. m across 209 ha. The atypicality of the density distribution is emphasized by comparing the densities of material inside the various field systems with those encountered by the north–south linear transects that were walked at 0.5 km

Note to Figures 5.45–5.47 *These figures are just three of the numerous density-distribution maps which can be generated using the different categories of information concerning the surface pottery encountered in the eastern WF4 fields. Whilst of different magnitudes, the same 'hotspot' areas of high density were generated whatever the basic category of information used.*

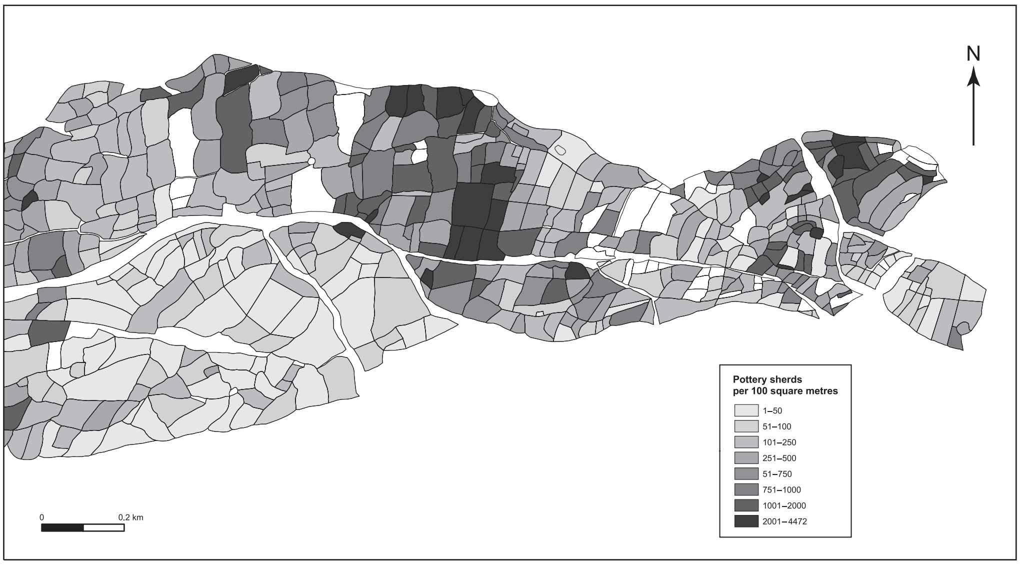


Figure 5.45 *The density in each field of 'clicked' sherds. 'Clicked' sherds refer to the counts of visible surface sherds within the path of a transect. (Illustration: Paul Newson.)*

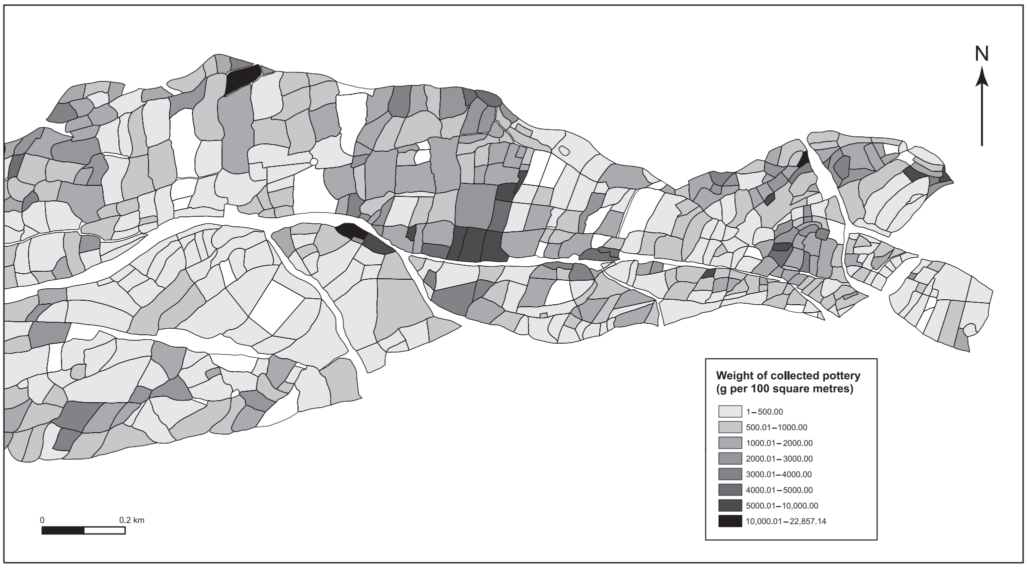


Figure 5.46 *The density per field of pottery in terms of the total weight of the sherds collected from each field along the 'picked' transect. (Illustration: Paul Newson.)*

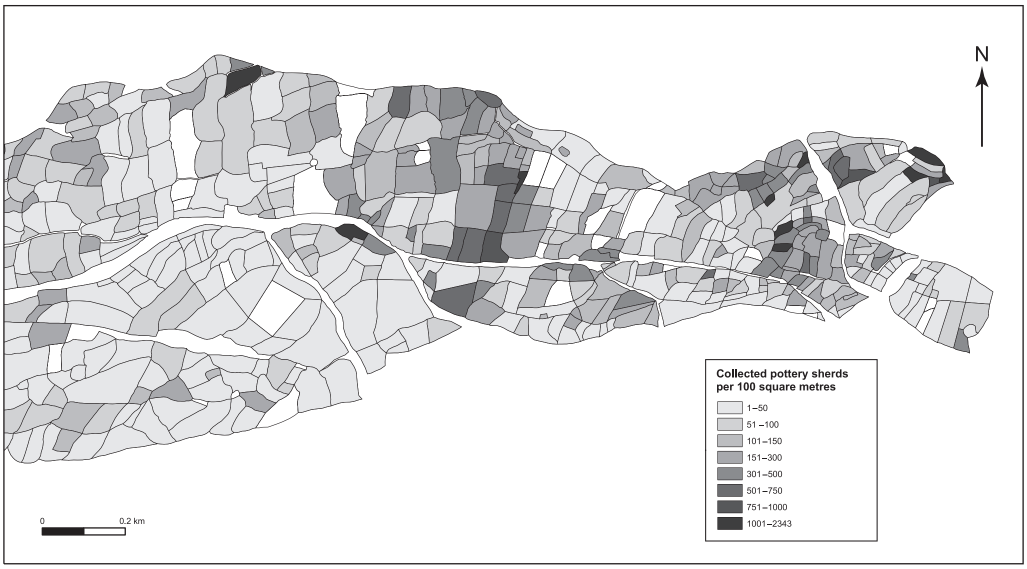


Figure 5.47 *The density per field of pottery in terms of the total numbers of sherds collected from each field along the 'picked' transect. (Illustration: Paul Newson.)*

intervals throughout the survey area (Table 5.6). Although the total area covered by the north–south transects was almost double the size of the area covered by the transects from which artefacts were systematically collected inside the field systems, the former yielded only a tiny fraction of the finds (in the ratio of 1:44). The maximum density encountered in the field system was *c.*124,000 sherds and lithics per ha for WF4.2.5 (the equivalent of more than 10 sherds per sq. m), while the highest density figure recorded in the line walking was the equivalent of 1600 lithics and pot sherds per ha. In Figure 5.43, the density values have been averaged for 500 × 250 m areas in proportion to the area actually surveyed. The higher density of material within and in close proximity to field systems in general is clear. Most of the higher density blocks away from field systems are the result of a transect line crossing a site. While various explanations can be advanced to account for the high sherd densities in and around field systems – including the long-term focus of settlement and farming in this part of the landscape – we believe that the overall volumes appear to have been significantly enhanced by the disposal of household waste for the purpose of manuring the fields, as discussed in Chapter 10 especially.

After inputting the information into the GIS environment, the distributions of this material could be quickly generated for the field groups in a number of different forms, such as density of objects per field, or raw number distributions, or period-based distributions of pottery types according to sherd numbers or sherd weights. Although the densities of surface sherds in the field systems were high compared with the rest of the survey area, the numbers of identifiable fine-ware sherds were generally very low. In some cases the fine-ware sherds in a particular field might be fragments from a single vessel dropped and broken there, but the analysis of the data base suggests that the probability of this phenomenon explaining the fine-ware distributions is low: whilst the sherds are often of the same fabric, except in the case of the Nabataean finewares, they are commonly from identifiably-different vessel types.

The overall distribution of pottery (total number of sherds) across the WF4 field system illustrates the unevenness in the material, already observed in the field work, with low (1–15) sherd numbers in many of the fields and significant concentrations or 'hot-spots' in three zones: WF4.1–WF4.3; WF4.6–WF4.7, and parts of the adjoining Unit WF4.5; and WF4.13 (Fig. 5.44). Density maps of numbers of 'clicked' sherds, pottery weights, and total sherd numbers in the eastern sector of the WF4 field system (Units WF4.1–WF4.12) bring out further detail, confirming the two 'hot-spot' regions here but also demonstrating considerable variations according to the measure used (Figs 5.45–5.47). High densities of pottery could reflect a variety of processes: activity associated with a particular domestic or funerary site; manuring processes, with particular land being selected for greater investment (Wilkinson 1982); processes of soil erosion and floodwater movement; and methodological biases. Separating these processes is difficult. In the case of the 'hot-spot' centred on Units WF4.6–4.7, our fieldwork methodologies might account for some of the frequency: this was in the zone selected for the pilot survey in 1996 because it had not yet been disturbed by recent ploughing, and soil deflation may have increased the visibility of the sherds on the surface compared within the surrounding fields. However, manuring in antiquity may also have shaped the artefact distributions in this central area, because in terms of topography and soil coverage this is – and probably was – one of the most agriculturally favourable parts of the field system. The frequencies in and around Unit WF4.13, especially of prehistoric pottery, certainly relate to the fact that this zone was a focus for intensive settlement in the Early Bronze Age (Chapter 8, §8.6). The WF4.1–WF4.3 hotspot is probably explained by its adjacency to Khirbat Faynan and thus its prime accessibility for manuring with waste from the settlement. The range of material in these fields chimes with the evidence for Khirbat Faynan being a long-lived settlement, and it is likely that this part of the field system was an important agricultural resource for its community throughout its history.

5.8 The palimpsest landscape

This chapter has described the methods used to record and analyse the structural sequence and function of the different components of the field systems. The development and operation of the Wadi Faynan field systems were clearly an intricate and detailed story, that we shall try to illustrate in period-by-period detail in Chapters 8–10. The evidence available to us includes: the distribution of particular water-management structure types; the distribution of channels and channel networks; individual field morphology; the distribution of surface artefacts; the analysis of wall construction; the presence and potential associations of other structures with the fields; the position of tributary wadis and evidence of their past locations; and excavations. The principal outcome of the analysis of this evidence is the strong indication it provides of the variety of floodwater farming techniques, of different ages and complexity from the Bronze Age to (at least) the Byzantine period, but all designed to harness, control, entrain, and distribute surface water flowing down wadi channels after flash floods.

The systems to the north of the main wadi course, that is WF406, WF408, WF409, WF424, WF442, and WF443, are very different from the WF4 system in wall structure and field layout. In terms of water-management technology, all of the systems except WF424 are located along the line of small tributary wadis that have cut shallow valleys through the hills down to the main Faynan channel (Barker *et al.* 1999: 274), and are dominated by simple cross-wadi walls or check dams some of which, as will be argued below and in Chapter 8, are likely to be Bronze Age in date. The fields of WF406 indicate at least three cross-wadi wall systems superimposed one on top of the other (Fig. 5.48). One of these appears to have

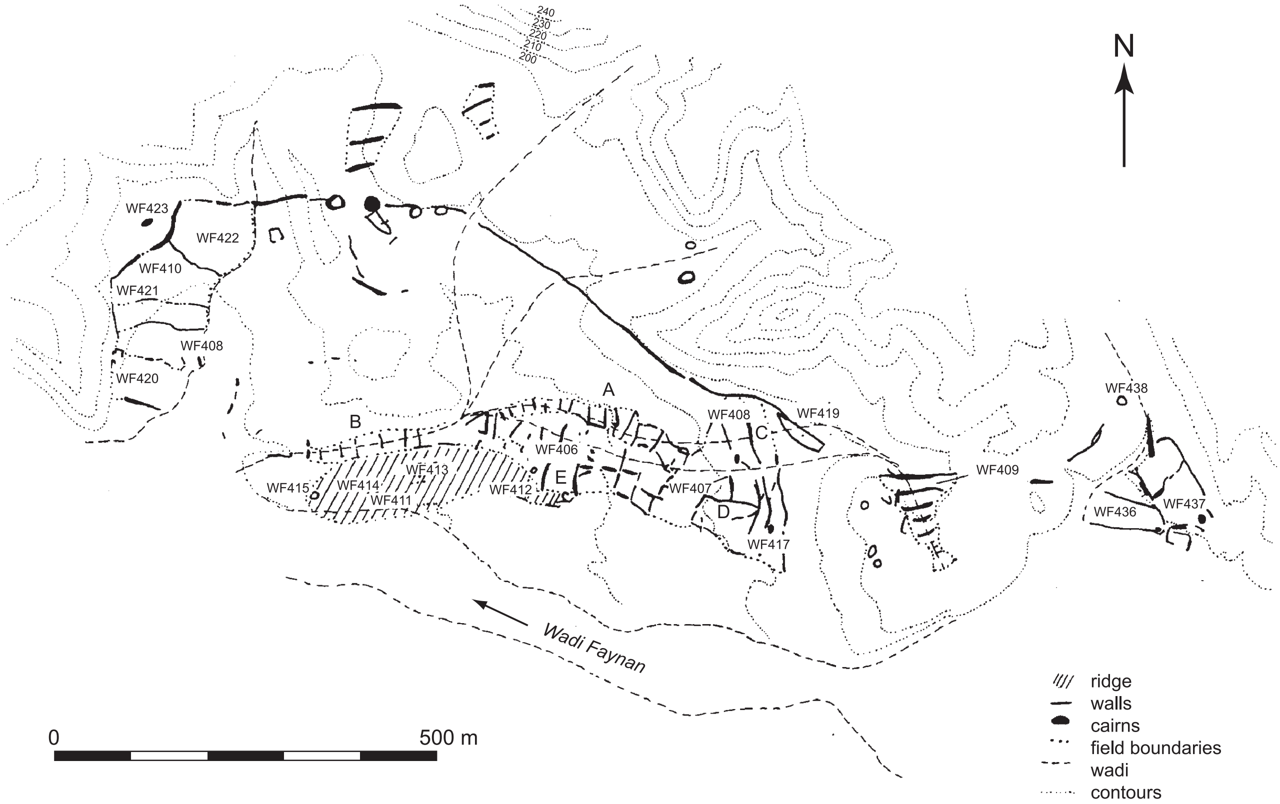


Figure 5.48 *The palimpsest landscape of WF406 and related sites (see text for discussion). (Illustration: Debbie Miles and Lucy Farr.)*

consisted of large, high, and wide walls, forming a series of banks of cairn-like rubble (Fig. 5.48: areas C, D, and E). On top of these banks, and between them, were narrower walls on the same north–south alignment, at right angles to the water flow. By contrast, the walls in areas A and B were check-dams consisting of simple lines of orthostatic boulders (Fig. 8.28). Some Classical-period sherds were collected from regions C, D, and E of WF406, but most of the pottery from these areas was of Iron Age date. In contrast, the few sherds of pottery from areas A and B of WF406 were of Bronze Age date, as was the majority of sherds from WF442. The distributions of period-specific sherds suggest an Iron Age date for the large wall-banks in WF406, and a Classical date for the narrower walls superimposed upon them, with the single lines of orthostatic boulders probably representing the remnants of simpler systems dating to the Bronze Age.

Similar groups of simple check-dams are located within the main WF4 field systems, especially across small tributary channels in the western part of the system where the topography is gentler and water flow would have been slower than on the steeper ground. Other check dams and simple diversion walls were found to the south of the WF4.13 unit in similar topographical situations (Fig. 8.24). In all these cases there were numbers of Bronze Age sherds on the adjacent surfaces, in statistically significant correlations with the adjacent walls, suggesting that these walls are likely to be remnants of Bronze Age fields and floodwater farming systems (Chapter 8). Substantial fragments of orthostatic boulder walls in Units 4.13 are likely to be associated with the major Early Bronze Age settlement WF100 (Fig. 8.12). Similar boulder alignments in parts of Unit WF4.12 appear to have been re-used as the foundations of walls built later, probably in Roman/Byzantine times.

The main walls in the WF4 field system indicate different forms of run-off and floodwater irrigation: a marginal zone exploiting localized rainfall and surface run-off from higher elevations, and a primary zone enhancing the available irrigation water from rainfall and run-off with channelled floodwater deflected out of shallow streams and gullies (Fig. 5.49). It must be stressed that both areas appear to have depended on irrigation related to the exploitation of seasonal rainfall, rather than from continuous spring-fed irrigation. Most of the simple surface run-off systems are on the more steeply terraced fields at the southern edges of the field system. The fields in these zones are smaller than those at lower elevations, arranged in narrow terraces to limit erosion and retain sediment, with a variety of sluices and spillways being used to guide rainwater down the terraces. Iron Age sherds were found lodged within a terrace wall of one of these systems in WF4.2.18, which was overlain by a rubble wall associated with Classical pottery (Fig. 5.50), suggesting that the origins of the terraced run-off systems might also lie in the Iron Age,

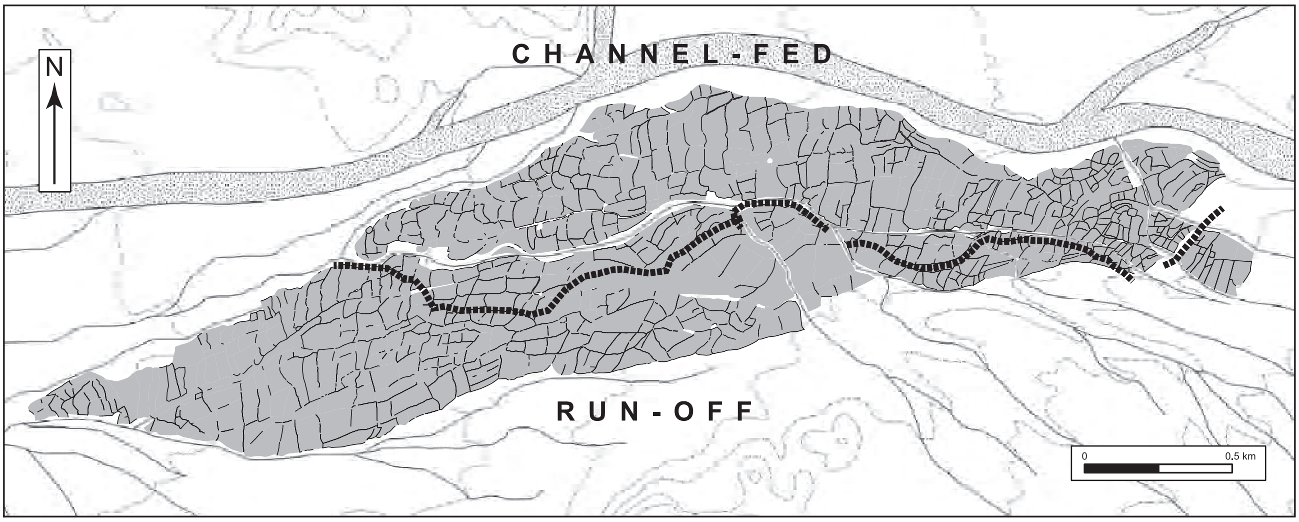


Figure 5.49 *Schematic map of areas primarily using channelled floodwater and run-off water. (Illustration: Paul Newson.)*

Figure 5.50 *A buried terrace wall in WF4.2.18 (visible in the section on the right of the picture) in which Iron Age sherds were lodged, overlain by a rubble wall associated with Classical pottery, looking northeast. (Photograph: Graeme Barker.)*

though these fields were certainly used extensively in ensuing periods. The channel technology may also be of similar antiquity: the channel formed along the high perimeter walling of Unit WF4.4, capturing floodwaters at the highest point upstream and using them to irrigate the area immediately adjacent to the capture wadi, certainly has parallels with the major diversion walls in WF406 thought to be of Iron Age date.

As with the majority of field-terrace systems, most of the channel systems would appear to date to Classical times. Such systems transported stormwater from tributary wadis to distant parts of the field system well away from the point of capture, especially on the relatively level northern parts of the WF4 field group near the main channel of the Wadi Faynan (where normal run-off flow between adjacent fields may have been sluggish). Placing their development and main phase or phases of use more accurately within this substantial time period (over a thousand years, spanning the later centuries of the first millennium BC and the first half – at least – of the first millennium AD) is very problematic, but the combination of wall data, artefact distributions, and excavations allows some tentative conclusions. The distribution of terraced walls with a subsidiary wall in front correlates broadly with the distribution of Byzantine sherds; large cairns and burial sites correlate in particular with the distribution of sherds of Bronze Age date (Fig. 5.51); and the distributions of rectangular structures also correlate strongly with those of Early Roman/Nabataean pottery (Fig. 5.52).

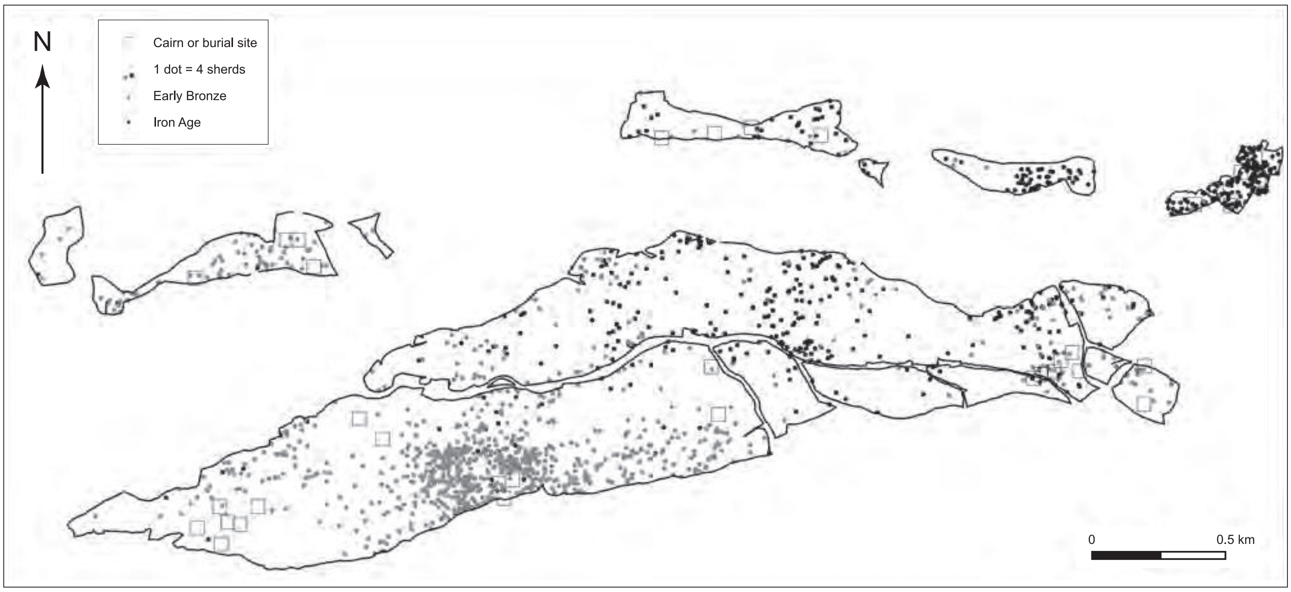


Figure 5.51 *The distribution in the WF4 field system of Bronze Age and Iron Age sherds, and of cairns and burials. (Illustration: Paul Newson.)*

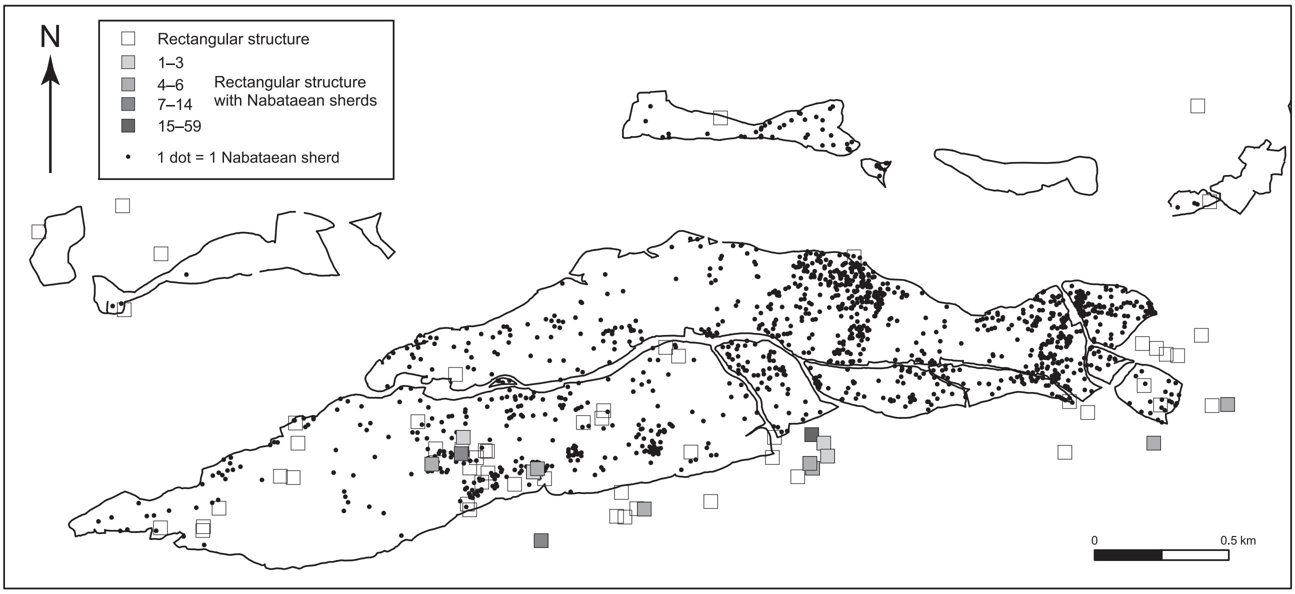


Figure 5.52 *Distribution in the WF4 field system of Early Roman/Nabataean sherds, and of rectangular structures. (Illustration: Paul Newson.)*

Mapping the ratio of field areas to perimeter lengths, whilst in part reflecting factors such as topography (with small linear fields clustering in terraced areas for example), indicates that there are groups of fields with very similar ratios, and thus design, in different parts of the WF4 field system (Fig. 5.54). Notable groups of fields with similar attributes, such as within Units 4.7, 4.9, and 4.12, are suggestive of a broad template in field design, which in turn implies a broadly contemporaneous construction for each group.

The GIS reveals varied densities of surface finds for a succession of chronological periods, varied distributions of different types of technological infrastructure such as sluice and channel networks, and correlations between distinct groups of fields with comparable structural and area attributes, either as discrete entities (such as WF410 and WF442) or as self-contained groups of contiguous fields within WF4. Further information to aid interpretation of individual fields or groups of fields is provided by environmental factors such as local topography, soils, geology, slope, and predicted water flows. Most of the smaller field groups, with perhaps the exception of WF424, appear to represent distinct individual units of fields with similar attributes, designed for a particular suite of floodwater farming methods and constructed within a discrete period

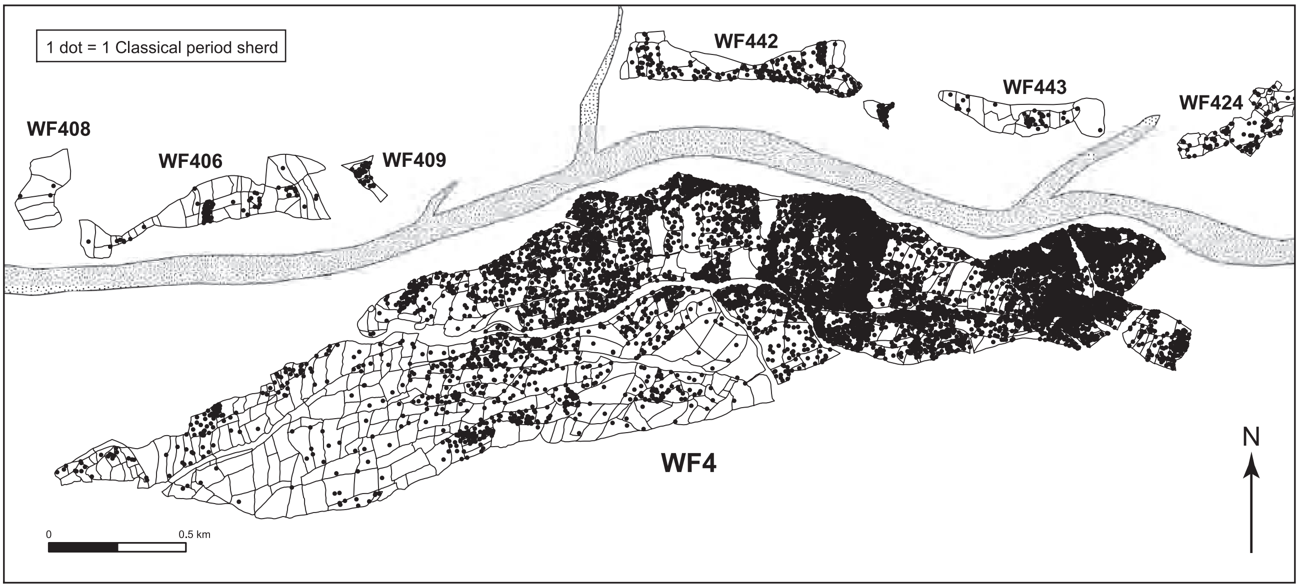


Figure 5.53 *Overall distribution of Classical sherds in field system WF4. (Illustration: Paul Newson.)*

Figure 5.54 *Map of the ratio between field area to perimeter length for WF4. (Illustration: Paul Newson.)*

of time, though subject to re-use and adaptation later. The heterogeneous WF4 field system, on the other hand, clearly incorporates a number of disparate elements with distinct histories of development and function. Thus some parts of the system have significant clusters of cairns, and some have large burial cairns incorporated into later structures, whereas other parts of the system have few cairns. Several zones (the western part of WF4.18, for example) have coherent systems of walls and related structures of similar construction and function.

A number of processes, both cultural and environmental, has clearly been responsible for this spatial and chronological variability, with changing agricultural and/or socio-cultural considerations interacting with changing environmental configurations. The arid nature of the environment has ensured that the erosive and depositional actions of water have been both dominant and uneven. The infrequent and intermittent flash floods and ephemeral streamflows mean that in some years there is a greater potential for a higher volume of water and associated transportation of sediment than in others, with varied effects on the fields in terms of incision by tributary wadis and the shifting of sediment carried across the fields by channel flow and surface run-off, as well as by aeolian processes (Grattan *et al.* 2007). The layout of fields, construction of walls and associated structures, and technologies employed to harness, control, and transport the floodwaters of tributary wadis, all had to be adapted to combat and balance these changes. Socio-cultural factors such as changing forms of ownership and land-use strategies were equally important, the intricate diversion systems and network channels of the Classical period suggesting particularly complex and unifying organizational factors characterized by the sharing of water resources, whether by cooperation or coercion (Barker 1999: 289–90; and see Chapter 10, §10.4.11).

Whilst we can clearly discern change in the construction and use of the 'field' walls of Wadi Faynan, it is important not to assume that change was necessarily linear or constant. Relatively short time periods of rapid change may have been followed by periods of little change. The variability within the WF4 field system, with indicators of multi-period development in some parts but more restricted phases of construction and use in others, is strong evidence for its non-linear development. Some zones, perhaps initially developed outside prime areas for run-off or floodwater farming and for primary purposes other than farming, or in periods when water-control techniques were not as sophisticated as in others, may not have been used on a continuous basis, whereas the central zone (Units 4.6–4.9) appears to have provided attractive conditions for floodwater farming in several phases. Explanations of relatively short-term use may help explain the dearth of surface finds in some parts of the WF4 field system, though different farming practices and erosion histories also have to be taken into account. Nevertheless, the principal trend that can be discerned from the analysis of all the various categories of information from the WF4 field system described earlier in this chapter is one of increasing complexity over many periods in terms of size, methods of construction, and water-management technologies. As described in Chapters 8–11, constant negotiation between the actions of people and physical processes helped sculpture the dynamic landscape of WF4, creating a palimpsest that we have only begun to disentangle but which certainly represents a complex conglomeration of several field groups and systems superimposed one on top of the other, developed at different times for different purposes.

PART II
Chronological Syntheses

6. Pleistocene environments and human settlement

Sue McLaren, Tim Reynolds, David Gilbertson, John Grattan, Chris Hunt, Hwedi el-Rishi, Graeme Barker, and Geoff Duller[*]

6.1 Introduction

An important goal of the project was to establish the character, extent, and timings of environmental and ecological events and processes in the Wadi Faynan through the Quaternary (the Pleistocene and Holocene), as well as the relationships between these and human settlement. This chapter discusses the evidence for the Pleistocene, a period that in terms of the human occupation of Southwest Asia spans the first movement of hominins out of Africa up to the first settled farming communities, an extent of time of at least 800,000 and likely to be over a million years.

Our current understanding of Quaternary landscape development and environmental history is largely derived from investigations of the sedimentary deposits and landforms preserved in the Faynan area (Hunt *et al.* 2004; 2007b; McLaren 2004; McLaren *et al.* 2004; Fig. 6.1). The data and interpretations presented here are the result of our extensive field study and mapping along the wadis as well as across the mountain front. In the later stages of this work we were able to use a GPS to locate study points, and an aneroid barometer to help with altitudinal survey. The heights of deposits and of erosional surfaces that may be associated with them were measured from the base of the modern wadi to the base of the terraces along transects. These measurements were simple to make where the rock-cut channel was still in existence, but less easy to determine with 'boulder trains' (scattered lines or layers of boulders, cobbles and pebbles following palaeochannels: Fig. 6.9) particularly where some material had later moved downslope. The complexity of the topography and Quaternary deposits resulted in some uncertainties of our precise location in relation to the wider landscape or published maps. On the mountain front and in the gorges of the Wadis Dana and Ghuwayr aerial photographs provided some, albeit limited, assistance for mapping and interpretation.

It is important to emphasize the uncertainties that exist concerning the Quaternary deposits and sequence described in this chapter, especially given the evidence we identified for complicated facies relationships between deposits and complex issues of super-position, compounded by the difficulties of reaching and interpreting many of them, and the practical constraints on the types of studies that we were able to carry out in the field in the time available. Our recognition of the limitations of our own survey work emphasized in Chapter 2, of our knowledge and understanding of this area, is repeated here. As a result, it seems to us that it is too early to seek to integrate the outcomes of our research (Hunt *et al*. 2004; 2007b; McLaren 2004; McLaren *et al*. 2007) with the recent account of the Wadi Ghuwayr by Tipping (2007) as part of the Dana-Faynan-Ghuwayr Early Prehistory Project (Finlayson and Mithen 2007), the immediate geomorphic starting point of that study being the publications of Barker *et al*. (1997; 1998; 1999; 2000). Not least this is the case because of differences in approach between the two teams as to what to map (with the particular focus of the Tipping study on 'surfaces' as opposed to exposures of deposits), the properties of the features being reported, and the stratigraphic nomenclature deployed. There are also some similarities, but even here, the sense in which the same word is used can differ between the two teams. The differences emphasize the need for caution, and the still-preliminary nature of the findings on the changing Quaternary environments of the Wadi Faynan represented by the sum of the work of the two projects to date.

The type sites for all the deposits were described by McLaren (2004) and McLaren *et al*. (2004), following the exploration of the area reported by Barker *et al*. (1997; 1998; 1999; 2000). The following account provides a more

[*] *Archaeology:* Tim Reynolds, Graeme Barker. *Geomorphology:* Sue McLaren, David Gilbertson, John Grattan. *OSL dating:* Geoff Duller. *Palaeoecology:* Chris Hunt, Hwedi el-Rishi.

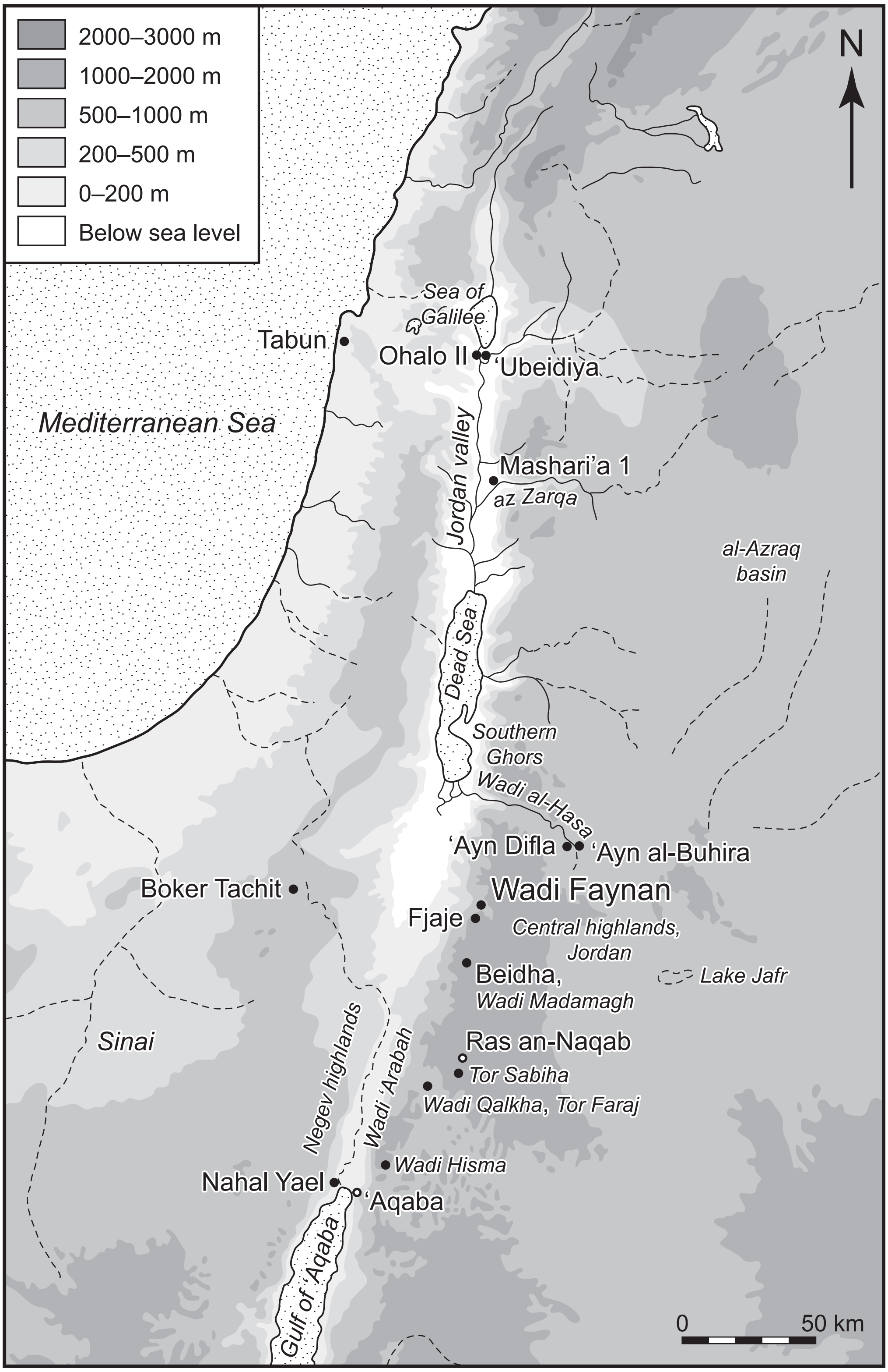


Figure 6.1 *The southern Levant, showing the principal regions and places outside the Wadi Faynan study area mentioned in Chapter 6. (Illustration: Dora Kemp.)*

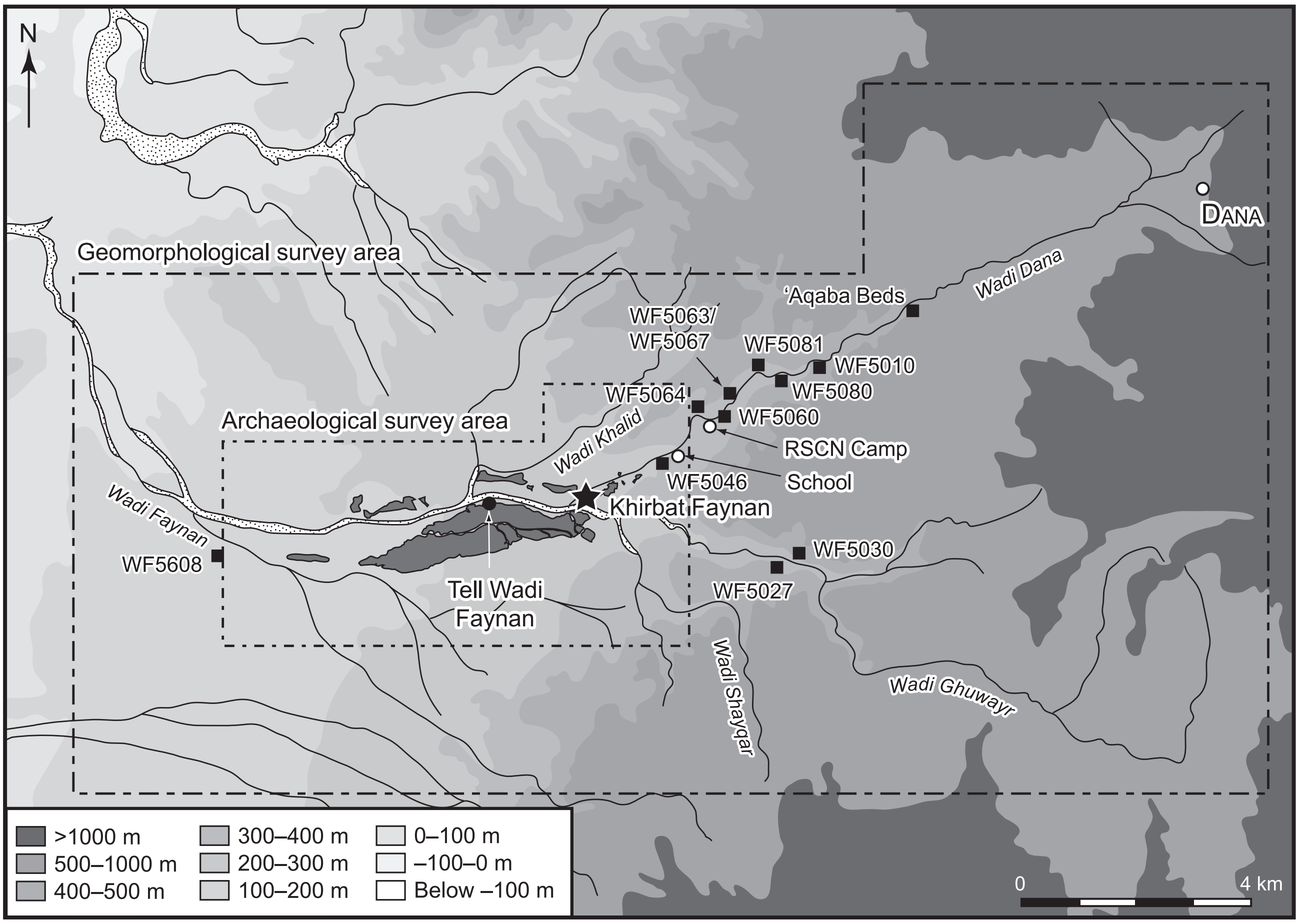


Figure 6.2 *The Wadi Faynan study area, showing the location of the WFLS survey zone and the principal geomorphological type sites discussed in Chapter 6. (Illustration: Dora Kemp and Paul Newson.)*

general description of the deposits and sequences in the Wadis Dana, Ghuwayr, Shayqar, and Faynan (Fig. 6.2). (NB: following international stratigraphic conventions, the transliteration of location names is that used when they were first defined.)

Estimates of the age of the Pleistocene deposits identified were obtained by stratigraphic relationships, associations with archaeological artefacts, and the application of Optical Stimulated Luminescence (OSL) dating. Typically, but not always, the higher the abandoned relics of fluvial deposits on the mountain front or in the wadis, the older the deposit. OSL dates proved useful for several younger Late Pleistocene and Holocene deposits, but because some deposits were 'saturated' with natural radioactivity the OSL dates obtained from them are minimum estimates. Downstream in the Wadi Fidan, Tipping (2007) was able to obtain one potentially much older OSL date of 406,000 +infinity –125,000 BP, but this deposit is also saturated. In general, all this evidence suggests that it is likely that the antiquity of much of the older Quaternary sequence in this region described here lies outside the range of OSL dating currently available to us.

The evidence for the human utilization of the Wadi Faynan in the Pleistocene consists entirely of surface collections of struck stone. This material could span a minimum period of 100,000 years and could quite reasonably be considered to span a far greater period. The basic lithic analysis was guided by reference to those used by Bordes (1961), Baird (2001), Gebel and Kozlowski (1994), Goring-Morris (1995), Neeley (1992), and Rosen (1997). In general, though, the evidence from southern Jordan is more limited than in areas west of the Rift Valley, and much of the basic pattern recognition and definition of research issues has to draw heavily on work there (e.g. Bar-Yosef 1995b; Belfer-Cohen and Goring-Morris 2003; Gilead 1995; Goren-Inbar 1995; Goring-Morris 1995).

It is important to be aware of the major limitations in an archaeological data set consisting entirely of surface artefact scatters. First, though sample collection on the basin floor within the boundaries of the ancient 'field systems' was systematic (as described in Chapter 1, and see Chapters 4 and 5 for our discussion of the term 'field system'), it was undertaken by a variety of people with varied skills of recognizing struck lithic material, so an element of bias is introduced within the methodology where the ability to recognize material may be distorting the mapping of distributions. Second, the methodology chosen could recognize 'sites' on an encounter basis but, with the exception of grid collections of lithic material undertaken at a few selected locations, did not then subdivide and sample the identified sites in a systematic manner, limiting the amount that can be said about Pleistocene human behaviour and landscape use. Also, given that the presence and absence or relative frequencies of different 'artefact types' largely define the chronology and to an extent the interpretation of the site, the variability in the size of the samples resulting from the field methodology used has significant effects on the ability to recognize and define sites by cultural and/or chronological groups. This is a problem not just for the Wadi Faynan Landscape Survey but for landscape surveys as a whole: for example, it has been well described in a survey of the Southern Ghors, the area to the north of the Wadi Faynan (Neeley 1992). It is preferable, though, to the biases created by using a methodology that is too tightly constrained by specific questions (e.g. Miller 1991). Another problem is the frequency of multi-period palimpsests. The last major challenge for the lithic analysis, the effects of a dynamic environment on landforms, is particularly an issue in the Wadi Faynan where walled field systems and irrigation practices from mid-Holocene times have altered the natural patterns of sediment movement, creating areas of rapid erosion and sediment traps.

Despite the many limitations to the geomorphological and archaeological data, the project has succeeded in establishing some of the major components of Pleistocene landscape change in the study area. The development of the physical landscape over this long time-scale was the result of complex interactions between tectonic activity, climatic fluctuations, geomorphic and ecological processes, significant natural events, and the impacts of people. The archaeological materials inform on when humans were present and what tools and technologies they were using, and provide hints at how human populations exploited and adapted to the challenging environments they encountered.

6.2 Pleistocene climates

The Quaternary Sub-system has been characterized by the repeated growth and decay of ice sheets in many areas of high latitude and/or altitude, resulting in numerous alternations from cold (glacial) to warm (interglacial) conditions. In North Africa, glacial conditions appear to have coincided with arid phases and interglacial phases with more humid episodes (Brooks *et al*. 2003; Fontes and Gasse 1991; Gasse *et al*; 1990), as a result of the southward shift of atmospheric westerly flow and cyclonic activity towards the latitudes of the Mediterranean Sea and North Africa, and the subsequent displacement further southwards of the subtropical high pressure cells (Ruddiman and Prell 1997). In the Levant, there has been much debate about whether glacial episodes resulted in cold and dry conditions (e.g. Goodfriend and Magaritz 1988; Huckreide and Wieseman 1968) or cold and wet conditions (e.g. Bowman 1990; Horowitz 1979; 1992; Neev and Emery 1995). Such contradictions may arise because of the different lines of evidence used in terms of different deposits, fossils, dating techniques, spatial locations, and covering dissimilar periods of time.

Substantial climatic change in the region has been reported for the period from 80,000 to 10,000 years ago in several studies (Fig. 6.3). Henry (1986), working in the central Negev Highlands, has identified evidence for wetter conditions at 80,000±10,000 years ago (based on a uranium-series date on travertine). Freshwater deposits suggest moist and cool conditions between 80,000 and 60,000 BP, whereas Lake Jafr dried up and evaporites were deposited between 60,000 and 55,000 BP. Geomorphic and palynological data from Wadi Hisma indicate that between *c*.55,000 and *c*.20,000 years ago conditions dried out after an initial wet phase. Horowitz (1979), on the other hand, proposed that the climate was arid for 12,000 years starting from *c*.40,000 years BP and then moist until 22,000 BP. Groundwater isotopes in the Negev and Sinai (Issar and Bruins 1983) and sedimentary studies in northern Jordan (Macumber 1992) suggest that last glacial conditions were sometimes relatively wet. In the Central Highlands of Jordan, a wetter lacustrine phase has been OSL-dated to between 111,000 and 16–18,000 BP (Moumani *et al*. 2003).

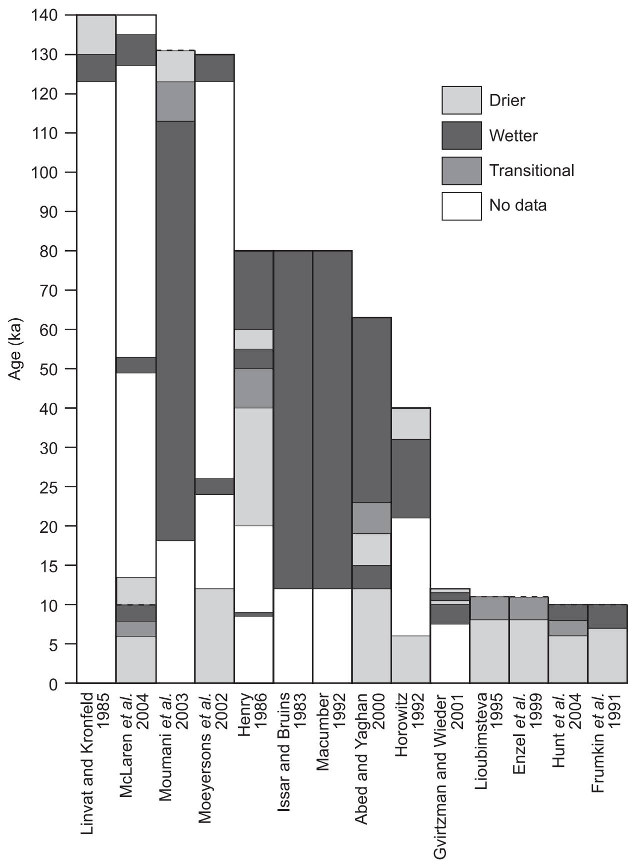


Figure 6.3 *Published evidence for wetter and drier periods in the Levant over the past 140,000 years. (Adapted from McLaren* et al. *2004; ©Elsevier, reproduced with permission.)*

The lacustrine Lisan Marls in and around the Dead Sea have provided the most detailed evidence for late Quaternary palaeoenvironments in Jordan (Abed and Yaghan 2000). Dated freshwater sediments indicate that Lake Lisan was in existence between 63,000 and 15,000 years ago. This deposit is capped by gypsum, and represents the driest phase when conditions were brackish during the Last Glacial Maximum (LGM) *c*.23,000–15,000 BP. Wetter conditions returned between 15,000 and 12,000 years ago with the formation of Damya Lake. Abed and Yaghan (2000) argued that climate rather than tectonics was the dominant control on the basis that the rate of downward movements of the Dead Sea *graben* (rift system) has been fairly continuous throughout the Holocene, whereas sea level has fluctuated significantly, and because of a lack of major unconformities that would be associated with fault movement. However, Frostick and Reid (1987b; 1989), Neev and Emery (1995), and Horowitz (1979; 1992) have all suggested that basin subsidence may have contributed to these implied climatic fluctuations.

Climatic change in the region during the period 20,000-11,000 BP was complex. It is thought that there were alternating moist and dry cycles each lasting *c*.2000–3000 years, with monsoonal rains extending into the interior of southern Levant during warmer and wetter episodes (Abed and Yaghan 2000). Henry (1986; 1998) proposed that there was a dry peak at 19,000, amelioration between 15,000 and 13,000 cal. yr BP, followed by a drier phase between 13,000–12,000 cal. yr BP, and then wetter conditions from about 12,000–10,800 cal. yr BP.

In the remainder of this chapter the geomorphological evidence for the evolution of the Pleistocene landscape is discussed first, organized in terms of geomorphological processes (alluvial, fluvial, aeolian, erosional, etc.), followed by a discussion of the archaeological evidence for human settlement organized according to the major cultural/chronological divisions that can be recognized in the material.

6.3 Geomorphological processes and deposits

The Dead Sea lies in part of a linear trough formed in the mid-Miocene about twelve million years ago, down-throwing the floor of the block. Such significant geological events have had strong effects on the types and scales of a variety of geomorphological processes taking place at the edge of the rift system, involving the entrainment, transportation, and deposition of sediment to create the present-day landforms (Chapter 2, §§2.1.3, 2.1.4). In order for sediment to be made available for erosion, rocks needed to be weathered and broken down, resulting in materials varying in size from huge boulders to clays. The weathered debris was then available for movement downslope by processes such as gravity, overland flow, or wind. As summarized in Table 6.1 and Figure 6.4, geomorphic processes identified as operating both presently and in the past in the study area have resulted in three major types of landforms: alluvial fans, wadi deposits, and aeolian sediments.

6.3.1 Alluvial fans

At the base of mountains where rivers exit from their source area (the apex), deposition occurs in a cone shape that radiates out away from the mountain front (Harvey 1997; Rabb'a 1994). Rivers flowing from mountains are capable of carrying large quantities of debris. A stream spreads out when it reaches the end of a confining channel, so that increase in width is accompanied by reduction in depth and/or velocity, causing sedimentation (Bull 1991). The resulting alluvial fans are controlled by three major factors: tectonics, climate, and geology. Tectonics are often seen as the primary control on the location of the fan, the rate of dissection versus accumulation, and the style of sedimentation (Harvey 1997). Sporadic but high-magnitude rainfall events were identified by Frostick and Reid (1989) as the key factor in the deposition of coarse alluvium around the Dead Sea. Lithological variations in hardness, durability, and a rock's susceptibility to modification also affect the nature of alluvial fan deposits (Bull 1991). However, the relative importance of climatic versus non-climatic controls on fan evolution is difficult to untangle, particularly due to problems of dating (Dorn 1996).

6.3.1.1 Ghuwayr Beds

The Ghuwayr Beds (Type Site WF5030; Fig. 6.2) are massive accumulations of locally-sourced alluvial fan material (talus fan and braid-plain beds) exposed in cliffs in the mouth of the Wadi Ghuwayr. They are some of the most distinctive exposures in the Faynan area (Fig. 6.5).

Erosion in the Wadi Ghuwayr has incised through these fan deposits exposing up to 40 metres of locally-derived alluvium and colluvium. The fan sediments are largely made up of frequently-imbricated angular black igneous rock in a fine-grained matrix directly received from the mountains behind. The Ghuwayr Beds are susceptible to erosion: significant gullying is evident on the exposures on the

Fluvial deposits height (m)	Alluvial fan deposits	Aeolian deposits
Quabbah Member (*c*.125–130) **Fass Yad Member** (*c*.30–35) **Mokeim Member** (*c*.22–25) **Dahlat Member** (*c*.15) **Naqqazah Member** (*c*.10–12) Faynan Member (*c*.5–7) Upper Dana Wadi Member (*c*.2–3) Lower Dana Wadi Member (*c*.1–1.5)	**Ghuwayr Beds** **Madrasah Beds** **Asheiair Beds** **Shayqar Beds** **'Aqaba Beds** Hamman Beds	**Quarayqira (= Gregora) Member** Tell Loam Member

Table 6.1 *The Quaternary deposits identified in the Faynan area, with those of Pleistocene age highlighted in bold. The heights shown are in metres above the wadi floor.*

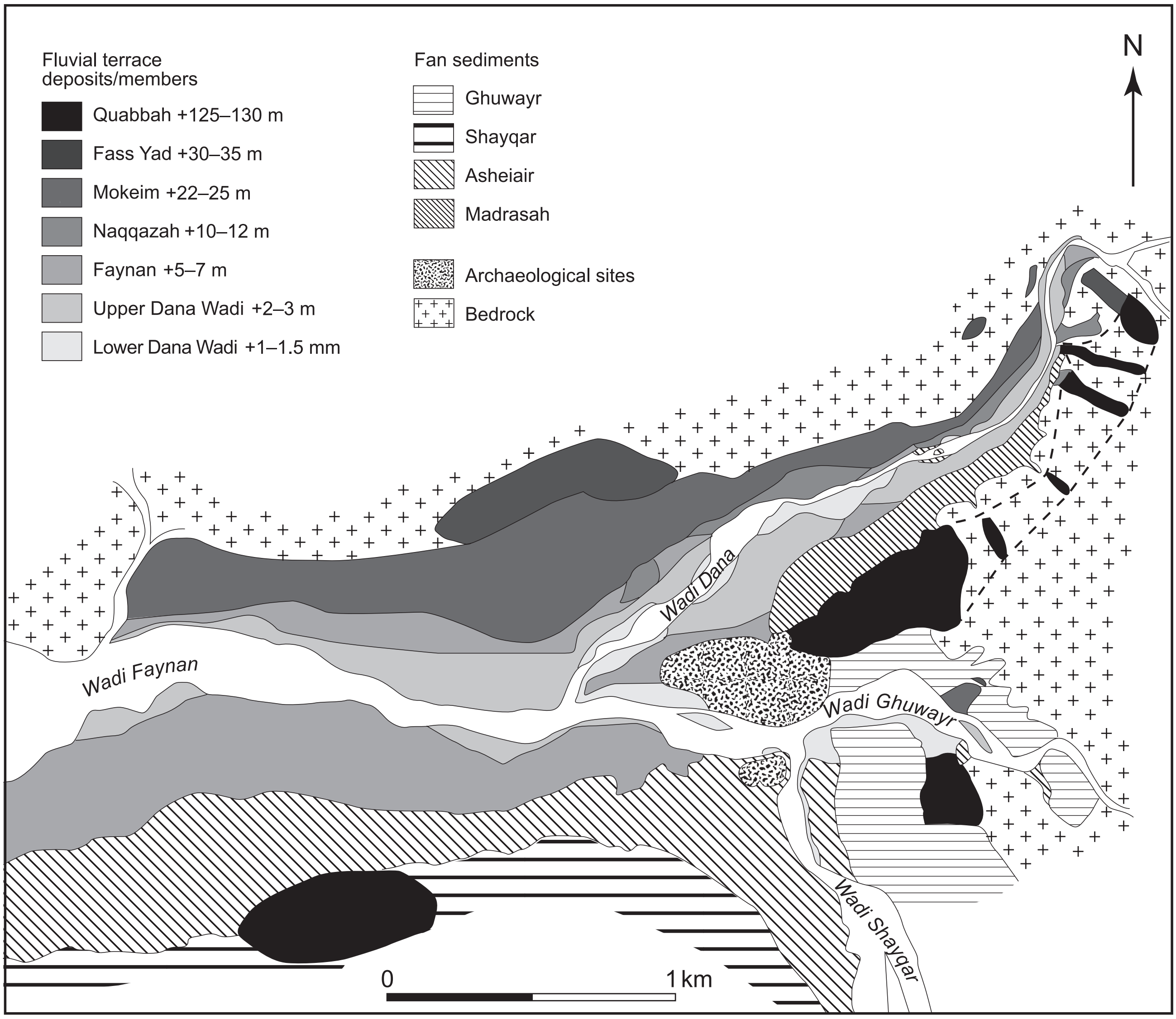


Figure 6.4 *Map of the main Quaternary deposits in the area around the confluence of the Wadi Faynan. The Dahlat Member is not shown as it crops out further up the Dana and Ghuwayr wadis. (Adapted from McLaren* et al. *2004; ©Elsevier, reproduced with permission.)*

Laboratory code	Depth (m)	Beta dose rate (Gy/ka)#	Gama dose rate (Gy/ka)#	Cosmic dose rate (Gy/ka)#	Total dose rate (Gy/ka)#	Equivalent dose (Gy)	Age (kya)
Aber 18/JA5	1.5	0.50±0.02	0.34±0.02	0.17±0.02	1.02±0.04	13.9±0.04	13.6±0.6
Aber 18/JA4	2.0	0.45±0.02	0.31±0.02	0.16±0.02	0.93±0.03	12.7±1.0	13.7±1.2
Aber 18/JA6	1.2	0.57±0.02	0.46±0.03	0.18±0.02	1.21±0.04	16.5±1.4	13.7±1.2
Aber 18/JA8	1.1	0.77±0.02	0.50±0.03	0.18±0.02	1.46±0.04	23.0±1.7	15.8±1.3
Aber 18/JA3	3.0	0.51±0.02	0.44±0.03	0.15±0.02	1.10±0.04	60.4±2.0	55.2±2.8
Aber 18/JA7	6.0	0.34±0.01	0.37±0.03	0.10±0.01	0.82±0.03	48.1±2.5	58.6±3.8
Aber 18/JA2	2.0	0.54±0.02	0.45±0.03	0.16±0.02	1.15±0.04	≥125	≥109
Aber 18/JA10	1.7	0.48±0.02	0.32±0.02	0.17±0.22	0.96±0.22	≥200	≥208
Aber 18/JA9	5.5	0.39±0.01	0.39±0.03	0.11±0.01	0.89±0.04	≥200	≥225

Table 6.2 *OSL measurements from Wadi Faynan sediments. A water content of 2±2% has been assumed for all samples. Dose rate conversion factors are those of Adamiec and Aitken (1998). The contribution from cosmic rays was calculated using the equations given by Prescott and Hutton (1994). The dates in the last column are in thousands of years before the present.*

Figure 6.5 *View of the Ghuwayr Beds looking across the Wadi Ghuwayr towards the northeast. The exposed sediments are sourced from the mountains behind rather than from the Wadi Ghuwayr, that flows from right to left in the image foreground. (Photograph: Sue McLaren.)*

Figure 6.6 *The Madrasah Beds that are mainly exposed below the line of the track which is sometimes located on their 'terrace surface'. (Photograph: Sue McLaren.)*

Figure 6.7 *The Asheiair Beds. (Photograph: Sue McLaren.)*

northern bank of the Wadi Ghuwayr. Further west (downstream) there is evidence of the mixing of the colluvial deposits with material from the gorge of the Wadi Ghuwayr introducing more rounded gravels, cobbles, and pebbles made up of a variety of different lithologies. Near the top of the alluvial fan, at heights of approximately +22 m and +30 m above the modern wadi, there is evidence of incision by streams and the subsequent deposition of rounded clasts of gravels, pebbles, and small boulders. The material is clast-supported and the rock types present include basalt, sandstone, limestone and flint – all materials found upstream. It is likely that these fluvial units are of a similar age or post-date the fan sediments as they cut into the latter (McLaren *et al*. 2004: 144–5). As these fluvial materials are eroded they move downslope and mix with the colluvium; this is particularly evident in some of the gullies. Fluvial boulder trains at heights of approximately +30 m and +22 m suggest that these deposits are either of similar age to the upper parts of the fan sequence or post-date the main formation of the Ghuwayr Beds (McLaren *et al*. 2004: 145).

The recovery of Palaeolithic implements from both the base and the top of these beds demonstrates the presence of hominins during, or perhaps before, their aggradation. Unrolled artefacts of Middle Palaeolithic type were found within the fan sediments and on their surfaces (Barker *et al*. 1997: 24, 26). Finlayson *et al.* (2000) and Finlayson and Mithen (2007) also report Lower/Middle Palaeolithic artefacts from these surfaces. An OSL date (Aber-18/JA9) from a sample taken 1 m above the level of the braid-plain in the Wadi Ghuwayr gave a date of >225,000 years ago (Table 6.2). This sample was found to be saturated, so the date must be older than that estimated.

6.3.1.2 Madrasah Beds

The Madrasah Beds (Type Site WF5046; Fig. 6.2) form a fairly small sequence of alluvial fans at the foot of the hills on the southern side of the Lower Wadi Dana. The exposures can be seen from the floor of the current Wadi Dana to a height of approximately 6 m (Fig. 6.6). A mix of alluvial fan and slopewash sediments is evident in exposures. There is a clear unconformity at a depth of about 1.5 m from the surface, with a later phase of fan activity deposited on top. This alluvium is made up of silts and sands, with occasional gravel layers.

6.3.1.3. Asheiair Beds

Feeding down the mountains directly to the south of Khirbat Faynan is a sequence of alluvial fan deposits that most recently have been dissected by the Wadi Shayqar. These

Figure 6.8 The 'Aqaba Beds. (Photograph: Sue McLaren.)

Figure 6.9 'Boulder trains', scattered lines of pebbles and boulders following palaeochannels in the Wadi Faynan. (Photograph: Sue McLaren.)

were designated the Asheiair Beds (Type Site WF5027: Figs 6.2, 6.7) in the original description by McLaren *et al*. (2004: 145). As is typical with many alluvial fan deposits, their stratigraphy is quite complex and variable. The clasts consist largely of gravels and sand-sized particles, deposited by fluvial processes, with some coarser beds deposited by debris-flow processes. The clasts display imbrication and point upwards towards the mountain front behind the fans rather than up the Wadi Shayqar. Frequently there is about 1 m of silt resting unconformably on top of these Beds.

6.3.1.4. Shayqar Beds

The morphology of these fan deposits, shown on the map in Figure 6.4, can be clearly recognized on aerial photographs. Unfortunately, no significant exposures were found in the field, and their age is unknown. They are likely to have been accumulating and eroding over a very long period of time.

6.3.1.5 'Aqaba Beds

The 'Aqaba Beds (Type Site: Fig. 6.2) are found in the upper Wadi Dana (Fig. 6.8), feeding off the slopes to the south and onto the floor of the modern wadi. These slope deposits, particularly close to the modern wadi floor, are inter-layered with fluviatile sediments. Three metres of a mix of slope wash (rich in aplite granite) and alluvial fan sediments are present in exposures, with clast sizes ranging from gravel through to pebble.

6.3.1.6 Age and interpretation

All of these fan sequences are Pleistocene in age, and all except the 'Aqaba Beds have Middle Palaeolithic artefacts (plus some younger artefacts) on their surfaces. Based on the interpretation of seeing them as a toposequence, the Madrasah, Asheiair, Shayqar, and 'Aqaba Beds all appear to be considerably younger than the Ghuwayr Beds. The Madrasah Beds have an OSL date (Aber-18/JA10) from near the base of the deposits indicating an age in the order of >208 kya, again likely to be a minimum age given that the deposits are saturated (McLaren *et al*. 2004: 145). The Asheiair Beds are significantly younger: an OSL date (Aber-18/JA3) of 55.2±2.8 kya from the toe of the alluvial fan indicates their formation in the last glacial (McLaren *et al*. 2004). The 'Aqaba Beds are mid/late Pleistocene in age: there is evidence of fluvial terrace deposits eroded into the fan sediments on the south side of the valley at heights of +10–12 metres and below.

Although it must be borne in mind that tectonic activity may have been the main trigger for alluvial fan development rather than climate, the common features of these alluvial fan deposits – thick units of beds of poorly-sorted and poorly-stratified cobbles and pebbles, alternating with thin layers of sands and gravels – are indicative of a semi-arid slightly wetter environment than today, characterized by periods with floods of moderate intensity and short duration.

6.3.2 River processes

The higher rates of rainfall in the mountains east of the study area can lead to significant amounts of water moving through the catchment areas via the gorges that run down through the mountain front towards and into the rift basin (Bowman 1997; and Chapter 2). According to Bender (1974b,c), the downward movement of the rift basin has led to a fairly constant lowering of the base level of the wadis that drain to the west. As base level is lowered, the wadis (when in flow) are forced to incise deeper through the bedrock because there is an increase in the potential energy as a result of the increase in total relief (Goudie and Thomas 2002). Vast quantities of sediment can be moved by the wadi systems during flash floods (Fig. 2.7). The steep mountain escarpment and the resistant bedrock have resulted in initially-restricted, narrow gorge-like channels that in places after flash floods become blocked or choked with sediment, in contrast with the low-dipping wide braid-plain of the Wadi Faynan beyond the confluence of the Wadis Dana, Ghuwayr, and Shayqar. After a flood wanes, the sediment being transported is gradually deposited in the wadi channels and across its banks, where it remains until the next flood event that is capable of transporting material

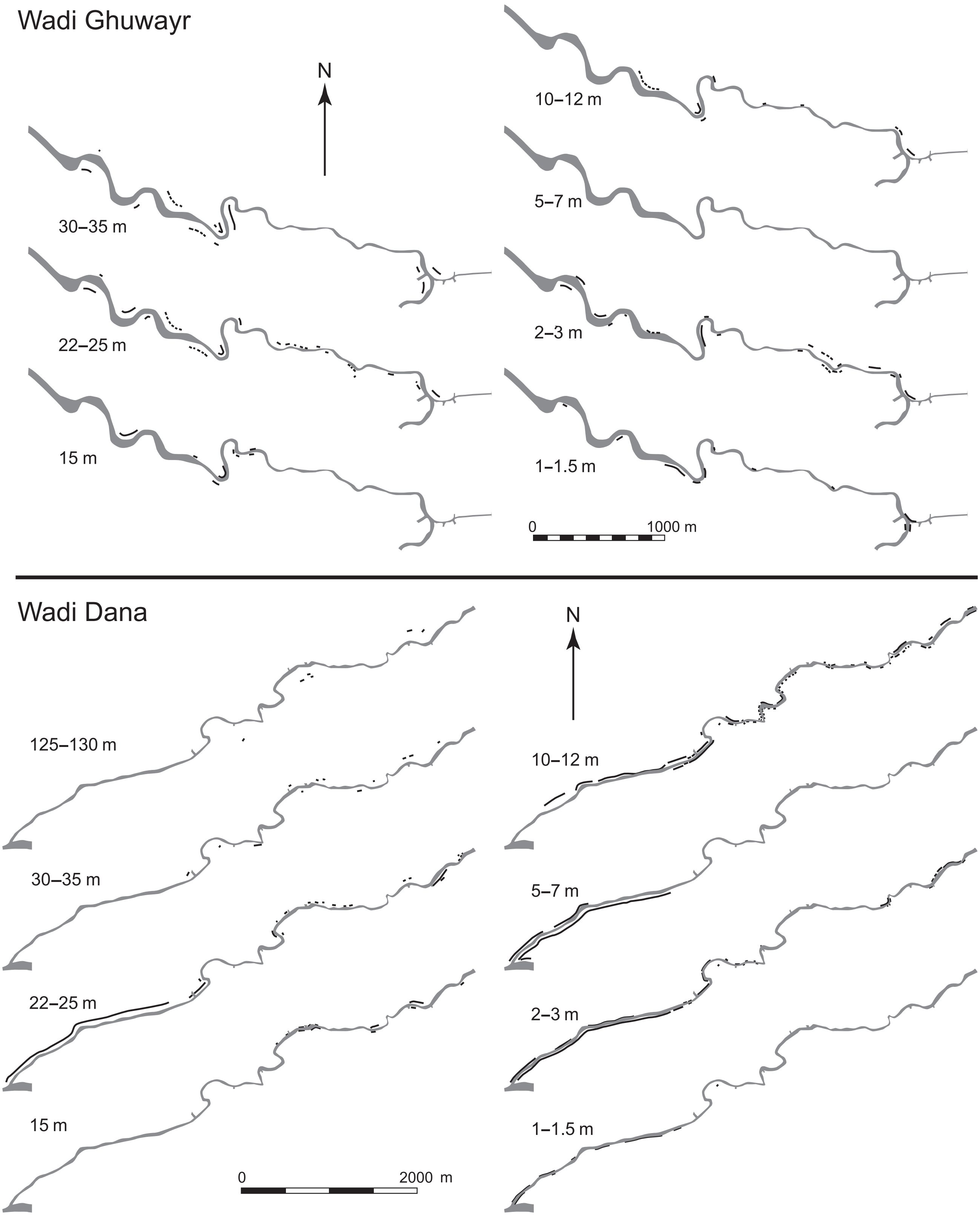


***Figure 6.10** The distribution of the main fluvial 'terrace' deposits identified in the Wadi Dana draining from east-northeast to west-southwest (lower diagram) and the lower Wadi Ghuwayr draining southeast to northwest (upper diagram), the two wadis meeting at their confluence immediately west of the Khirbat Faynan. (Reprinted from McLaren* et al. *2004; ©Elsevier, reproduced with permission.)*

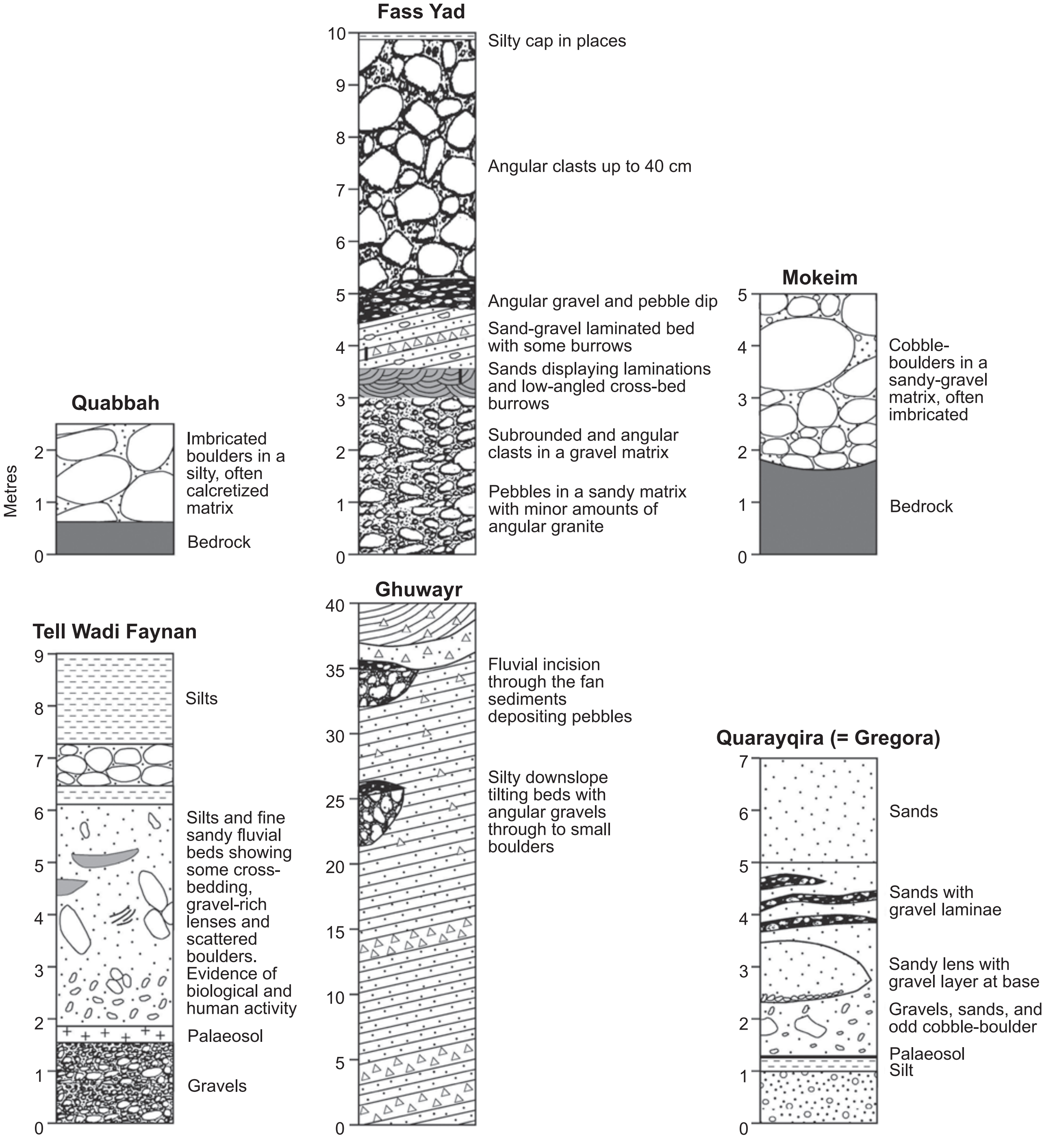


Figure 6.11 *Schematic sedimentary logs of the principal Members identified in the Wadi Faynan study area. (Redrawn from McLaren* et al. *2004; © Elsevier, reproduced with permission.)*

of that size. In the study area, deposition often occurs in the form of boulder trains, scattered lines of pebbles and boulders that follow the trend of the palaeochannels (Fig. 6.9). If the deposit remains *in situ* for long enough, it may become cemented by calcium carbonate until it becomes calcretized (McLaren 2004). A series of fluvial terrace deposits was identified in the study area, especially in the Wadi Dana. Their heights are shown in Figure 6.10 and the schematic sedimentary logs in Figure 6.11.

It needs to be re-emphasized here that correlations of 'terrace deposits' on the basis of matching 'flatter surfaces' that appear to be of similar altitude within a wadi and especially in different wadis must be treated with caution; nevertheless, we have done this where we felt it to be correct. The channel networks are not always fully integrated because rainfall is spatially highly variable and often localized in drylands, run-off is ephemeral, and these factors often only affect part of a wadi system at

Figure 6.12 *Quabbah Member Type Site WF5080 (+125 m terrace) in the Wadi Dana, showing the poorly sorted but rounded loose boulders making up this 'terrace deposit' on the ridge tops +125 m above the Wadi Dana. (Photograph: Sue McLaren.)*

Figure 6.13 *Quabbah Member Type Site WF5080 (+125 m terrace) in the Wadi Dana: heavily weathered boulder showing significant cavernous development. Scale: geological hammer. (Photograph: Sue McLaren.)*

any one time. A flow in a higher-order tributary can cause incision that leaves lower-order tributaries hanging, and a tributary valley flood may deposit sediment in a high-order valley, blocking it or deflecting flow. Correlations may be complicated further by material from older higher deposits slipping downslope to lower terraces. Thus Schick (1974) noted that terrace sequences in the Nahal Yael research watershed in Israel did not necessarily correlate within and between drainage basins, because significant flow events varied in space and time. However, this does not appear to be the case in the Faynan area, where the number and altitude of terrace gravels in the Wadis Dana and Ghuwayr are essentially the same, and on this basis it is argued here that these deposits are likely to be contemporaneous. If this interpretation is correct, it implies a synchronous response to changes in base level in both the Wadi Dana and the Wadi Ghuwayr. Resolving such problems must ultimately lie with further targeted and repeated application of radiometric dating techniques to the Quaternary fluvial sequences found by the WFLS team and by Tipping (2007). Given the dating limitations in this study, stratigraphic interpretations have been established on the basis of two judgements reached in the survey: first, that (unless there was evidence to the contrary) the working hypothesis was that relative altitude and topographic position of the fluvial terraces were an indication of relative antiquity; and second, that similarities observed between the fluvial sequences in the Wadis Dana and Ghuwayr were *prima facie* evidence that these sequences developed essentially in parallel, despite the evident geomorphic differences between these two wadis.

6.3.2.1 Quabbah Member

The highest fluvial sediments found in the Wadi Dana, *c*.125–130 m above the wadi floor, are termed the Quabbah Member (Type Site WF5080: Figs 6.2, 6.12). These deposits comprise poorly-sorted silts through to boulders more than a couple of metres in length, and are visible as loose boulder trains extending across the hilltops. Over time, much material has moved downslope as a result of gravity and overland flow. In a few places, the fluvial material is preserved within a bedrock channel, cemented by calcium carbonate (McLaren 2004). The material making up the Quabbah Member has a wide variety of lithologies reflecting the complex geological nature of the wadis providing the source area: granite, flint, quartz pebbles, limestone, and two types of sandstone are abundant, although basalt (which is present in all the lower terraces) is absent. Owing to the considerable age of this deposit, the boulders show significant evidence of both weathering (cavernous, pitting, shattering, exfoliation) and coating by desert varnish (Fig. 6.13).

Elsewhere in the upper Wadi Dana, on the north side of the wadi (see Fig. 6.10 that maps the distribution of the Quabbah Member in the Wadi Dana), is another deposit similar to WF5080: exposures here reveal large (*c*.3–4 m in length) boulders, many with desert varnish, perched high on the hillside at about 100–125 m above the wadi floor. Many of the boulders have rolled downslope. This hilltop deposit can be traced across the landscape in the lower Wadi Dana as far as Khirbat Faynan. Each of the ridges immediately above and to the east of the former RSCN camp is draped with fluvially-derived material consisting of basalt, granite, limestone, flint, sandstone, and quartz. The size range for clasts within this deposit was considerable, from large boulders over a metre in diameter to pebbles. At Khirbat Faynan it is found either on the ridge tops or as debris trains on rock slopes. Remnants probably also exist on the hilltops to the south. The boulder trains have largely been let down the hill slopes as the mountain front has eroded back and down, resulting in the older material becoming intermixed with younger sediments (from which it is often distinguishable by the degree of pitting and desert varnish on the surfaces of the boulders). A likely extension of this highest 'terrace deposit' is draped over a bedrock ridge at the boundary of the Shayqar and Asheiair Beds in the Wadi Faynan area (Fig. 6.4). There are also a few scattered remnants in the Wadi Ghuwayr: there are large boulders visible in some exposures at about 120 m above the wadi floor, but they not readily accessible in the field so their relative altitude could not be determined, though they appear to be at a similar height above the present wadi as the Quabbah Member in the Wadi Dana.

Given the height above the modern channel, the degree of weathering and the extent of desert varnish, the Quabbah Member is likely to be early Quaternary in age, possibly slightly older. No archaeological artefacts were found within the sediments. Deposition would appear to have taken place under arid conditions probably similar to today, characterized by low frequency but powerful flood events.

6.3.2.2 Fass Yad Member

The Type Site deposit WF5063/WF5067 (Fig. 6.2) is preserved in the upper Wadi Dana as a *c*.10 m-thick fill in a bedrock channel 30 m wide × 30 m deep that appears to have taken advantage of a fault line. The deposit is made up of layers of clast-supported boulders, gravels, and sands interbedded with angular (locally-derived) granite slope deposits (McLaren *et al.* 2004: 139–40). Overlying these lower beds is about 50 cm of well-sorted, laminated fine sands containing some animal burrows. The laminae dip downstream (220°N) at between 5° and 15°. In places there is evidence of weak lithification and/or carbonate nodules. The next unit, 0.4–1.5 m thick, consists of rounded to angular clasts in a sandy, cemented matrix representing a further mixing of fluvial and colluvial material. In one of the fluvial layers there was an Acheulean handaxe (Figs 6.14, 6.18).

Elsewhere in the upper Wadi Dana, preserved on bedrock on the northern side of the wadi, there are calcreted units *c*.2 m thick and *c*.13 m long that consists predominantly of material up to pebble size with loose boulders of limestone, aplite, and basalt present. Manganese staining is evident. Figure 6.10 shows the distribution of the Fass Yad Member in the Wadis Dana and Ghuwayr. Many deposits were difficult to distinguish because of downslope movement, but there were *in situ* deposits that remain uncemented with a silty matrix and clear imbrication. A wide range of lithologies exist, generally in the size groups of pebbles and cobbles. At WF5081 (Fig. 6.2) there is a *c*.28 m-long boulder train, calcretized in places. Rounded pebbles and boulders dominate, commonly made from limestone, sandstone, and basalt.

In the lower Wadi Dana, at the point where a tributary joins the main channel by the former RCSN camp (WF5064: Fig. 6.2), is a slope-wash deposit containing fluvially-derived pebbles. At about 30 m above the wadi floor, cut into the side of the valley, there is a large rock-cut channel (the bedrock is aplite) filled with a calcreted and heavily indurated boulder conglomerate. The deposit follows the same alignment as the modern wadi and dips down-valley. It is a perched erosional remnant of a palaeo-wadi formed by the erosion and down-cutting of the Wadi Dana and its tributaries. The infill deposit, *c*.6–7 m thick and *c*.25 m wide, mostly consists of pebbles and cobbles, but near the base there are larger more angular boulders of locally-derived aplite. The fluvially-transported clasts are imbricated. Loose boulders on top of the deposit, coated in desert varnish, probably derive from the Quabbah Member above.

There is another 30 m terrace on the other side of the Wadi Dana next to the former RSCN camp at WF5060 (Fig. 6.2). A fluvial deposit infills a channel cut into purple-coloured Cambrian Sandstones, display-

Figure 6.14 *WF5063 (+30 m terrace) in the Wadi Dana: Acheulean handaxe, perhaps* in situ*; note the poorly sorted but moderately-rounded sediment clasts. Scale: 10 cm. (Reprinted from McLaren* et al. *2004; © Elsevier, reproduced with permission.)*

ing an erosive contact topped with gravels and pebbles, similar to the WF5064 palaeo-wadi channel. On the top of the fluvial sediments are scatters of Middle Palaeolithic tools, suggesting that the upper surface is at least 50,000 years old. Interbedded sands and gravels dip to the southwest. There is some evidence of fluvial cross-bedding in the finer units. Another related deposit crops out in a tributary wadi on the north side of the Wadi Dana immediately up-wadi of the modern schoolhouse (Fig. 6.2): it consists of sub-angular boulders, cobbles, and pebbles, mainly of limestone/dolomite and many with signs of weathering and desert varnish. In some places the clasts are loose, in others within an uncemented silty matrix. The deposit is better cemented where it occurs in a rock-cut channel.

There are more vestiges of the *c*.30 m terrace gravels in the Wadi Ghuwayr, often as drapes on bedrock (Fig. 6.10). The deposits consist of a wide range of clast sizes with some silt matrix, which typically does not display any signs of cementation. There is some evidence of imbrication, although the situation is confused by the quantity of material that has moved downslope.

The age of the *c*.30 m Fass Yad Member is suggested by the Acheulean handaxe, that shows no sign of abrasion, and a saturated OSL date of 109 kya (Aber-18/JA2), the latter indicating that the deposit is older than this. The prevalence of thick sequences of sands, gravels, and larger clasts, along with evidence of biological activity, suggest that the climate at the time the Fass Yad Member was deposited was at times slightly cooler and consistently wetter than prevails today: semi-arid through to moderately arid. The inference of slightly cooler and moister conditions is supported by the evidence for significant slope activity at this time, as well as the observed intermixing of the fluvial deposits with debris flow sediments.

6.3.2.3 Mokeim, Dahlat, and Naqqazah Members

The Mokeim, Dahlat, and Naqqazah Members, located respectively at *c*.22–25, +15 m, and *c*.10–12 m above the present wadi floors, are similar in appearance and are found patchily distributed in the Wadis Dana and Ghuwayr (Fig. 6.10).

The Type Site deposit for the Mokeim Member, WF5010 (Fig. 6.2), is in a massive rock-cut channel hanging *c*.22–25 m above the present floor of the Wadi Dana (Fig. 6.15). The sediments vary in size from silts and sands through to boulders, some of which are imbricated. The wide variety of rock types includes porphyritic microgranite, limestone, sandstone, and basalt. Two phases of down-cutting are evident, the first of which is shallow and wide (*c*.1 m × *c*.45 m), the second much deeper and narrower (*c*.8 m × *c*.23 m). This difference perhaps indicates a more frequent but gentler flow at first, followed by a change in base level and more rapid incision (McLaren *et al*. 2004: 141). The deposit has become heavily indurated by calcrete with some displacement of the smaller clasts, although the boulders tend to remain in clast contact (McLaren 2004). Floods within the Wadi Dana incised sideways through the wadi at a later date, leaving the channel cross-section exposed.

Other notable sites of the Mokeim Member at *c*.22 m above the present wadi floor are shown in Figure 6.10. The clasts range in size from sands to boulders that are 30 cm+ in length and all grains are well rounded. The deposit is moderately well sorted with the larger clasts imbricated. The matrix is silty in nature and the deposit is well indurated. There are distinct pebble and sandy layers

Figure 6.15 *WF5010, the Type Site deposit for the +22 m 'terrace-deposits' classified as the Mokeim Member: a hanging valley (highlighted by the white line) filled with calcretized fluvial material 8–10 m thick. (Photograph: Sue McLaren.)*

and in places cross-laminations are present. The calcrete is dark brownish in colour due to manganese staining. The deposit rests on bedrock and is wedged against the side of the valley. The main rock types present are basalt and limestone. In the Wadi Ghuwayr, the +22 m terrace gravels are normally preserved as loose gravel/boulder spreads on fluvially-eroded/planed surfaces. These are usually uncemented, although some silt matrix is present. Gravity has mixed some of the fluvial gravels with slope deposits.

A +15 m uncemented boulder train is preserved at the Type Site of the Dahlat Member at Transect C in the Wadi Dana, though some loose material has rolled down to *c*.13 m above the modern wadi. The uncemented material is mostly clast-supported, with a small amount of 'silty' matrix present. The basal metre has become calcretized where it rests on a bedrock channel. The material is boulder-rich in nature, and some clasts show evidence of imbrication. There are also loose boulders, pebbles, and cobbles spread across the surface from about 20 m down to the modern wadi channel. The higher boulders may represent remnants of an uncemented +22 metre terrace deposit affected by gravity. Rounded clasts of limestone, sandstone, and basalt along with angular local quartz porphyry are all present, indicating a mix of alluvial and colluvial deposits.

The distribution of the Naqqazah Member (*c*.10–12 m above the wadi floor) can be seen in Figure 6.10. The deposit varies from being well-indurated to uncemented. Clast size varies from sands through to small boulders, with bedding evident in the finer sediments. In some locations there are four clear sequences in which the smaller particle sizes became more dominant upwards through each sequence (technically 'fining-upwards sequences'), representing four separate flow events. The deposits are often capped by loose boulders that have rolled down from upslope. Where the boulder-rich deposits are preserved in rock-cut channels, the deposits have been preserved from later erosion. Elsewhere there is only a drape of pebbles and boulders deposited on fluvially-eroded bedrock surfaces at a variety of heights – not all are *in situ*. In such locations the Naqqazah deposit remains uncemented and shows little evidence of weathering or development of varnish. There is very little preservation of any matrix or structure in the deposit. Much of the material has been moved downhill by gravity or by people clearing fields etc.

Figure 6.16 *WF5608, the type site of the Quarayqira (= Gregora) Member. (Photograph: Sue McLaren.)*

Loose gravel and boulder spreads also commonly occur on fluvially-eroded/planed bedrock surfaces at +10 m in the Wadi Ghuwayr. These are mostly not cemented, though some silt matrix is present. Some of the material has been affected by gravity and it is often mixed with slope deposits. The mean size of material is in the cobble to boulder range, the material generally consisting of rounded clasts often showing imbrication and made up of a wide variety of rock types.

The Mokeim, Dahlat, and Naqqazah Members have similar characteristics. Generally they consist of imbricated rounded gravels through to boulders. Where the deposits are preserved in rock-cut channels they tend to be calcreted from water being evaporated gradually and leading to the concentration of calcium carbonate (McLaren 2004). Elsewhere the terrace deposits exist as unlithified boulder trains. Although the boulder size is smaller, these deposits are broadly similar in appearance to the *c*.+125 m terrace deposits. They appear to have been deposited in an arid regime not unlike that which exists today, as the sediments are similar to those on the current wadi floor. Though their age is uncertain, they are all likely to date to the mid/late Pleistocene.

6.3.2.4 Faynan, Upper Dana, and Lower Dana Members

These deposits, all of Holocene age, are described in Chapter 7.

6.3.3 Aeolian deposits

The entrainment and transportation by wind of sands and silts can be of importance in dryland environments. Evidence of aeolian activity in deserts indicates that rainfall must be less than 250 mm p.a. (Thomas 1997b) and therefore can be used as an indicator of aridity. As long as there is a source of fine material available for transportation, increasing amounts of aeolian transportation may occur; once lifted into the wind velocity profile, fine silts and clays may be carried long distances by suspension. Increased aeolian activity may be a result of: decreased precipitation; increased wind velocity; natural reduction in vegetation cover; and a variety of anthropogenic factors including the cutting down of vegetation for domestic, agricultural, or industrial purposes, and the impacts of grazing animals. In the Wadis Faynan and Fidan, transportation by saltation and creep has resulted in the formation of low dunes, particularly on the open braid-plains.

6.3.3.1 Quarayqira (= Gregora) Member

The deposit at the Type Site WF5608 is about 5 m thick and consists of interbedded well-sorted aeolian sands and waterlain gravels (Fig. 6.16). The base of the sequence starts about 3 m above the modern wadi. There are *c*.20 cm of exposed gravels and pebbles, overlain by a thin silty horizon that grades up into a palaeosol. The next unit is 30 cm of bedded gravels with occasional cobbles or boulders.

A sand lens up to 40 cm at its maximum thickness follows this unit. Overlying are 25 cm of interbedded sand and gravel layers. The whole unit is capped by up to 3 m of windblown sand. Two OSL dates have been obtained, of 13.6±0.6 kya (Aber-18/JA5) from a fluvial unit in the middle of the exposure and 13.7±1.2 kya (Aber-18/JA4) in the centre of the upper aeolian unit. The characteristics of the unit indicate broadly contemporaneous (i.e. technically 'penecontemporaneous') interbedded fluvial and aeolian sediments similar to the sediments found in the area today around the village of Quarayqira.

6.3.3.2 Tell Loam Member
This Holocene-age deposit is described in Chapter 7.

6.4 Human occupation in the Pleistocene

6.4.1 Lower Palaeolithic (c.450,000–200,000 BP)

The survey recovered a total of six bifaces/biface fragments which may be considered to represent the Acheulean technocomplex (Figs 6.17, 6.18). In addition to the handaxe from WF5063, the exposure of the Fass Yad Member in the Wadi Dana, a biface fragment came from site WF690, a second biface from WF1517, and the line walking recovered a biface at 0737892/3392473, and another fragment from WF4.13.3. Each of these artefacts was found in isolation, and no true assemblages of Acheulean date, or sites of the period, may be discerned, although a denticulate was found at the same site as a biface (WF1443). A number of similar finds has been reported from the Faynan area by the survey associated with the WF16 excavation (Finlayson *et al*. 2000; Mithen *et al.* 2007a: 112–13). Technologically, the handaxe found *in situ* in the Fass Yad Member (Fig. 6.14) is a pebble-butted biface made by soft hammer technique. The broken piece cannot be assigned a form but was also produced using a soft hammer, whilst the WF1517 artefact is a flake-based cordiform biface, also made by soft hammer. The other bifaces were amygdaloid and made on flakes.

Assessment of biface form and technology has been used to classify and crudely date Acheulean sites in the Levant (Gilead 1970), although for this to be effective it requires full assemblages for comparative purposes. There are also issues as to how the Acheulean itself is to be defined in the region. Excavated sites of this period are rare here, and sites such as 'Ubeidiya in Israel (currently the earliest known site in the Levant) have both 'Developed Oldowan' and Acheulean artefacts and assemblage characteristics (Goren-Inbar 1995; Tchernov 1988). In Jordan the earliest known Acheulean site is Wadi Uwaynid in the al-Azraq basin (Rollefson 1984), but the material is not *in situ* and has been subject to sorting during movement. The artefacts are heavily rolled, but a series of bifaces dominated by ovate and Abbevillian classes has been described, often made by

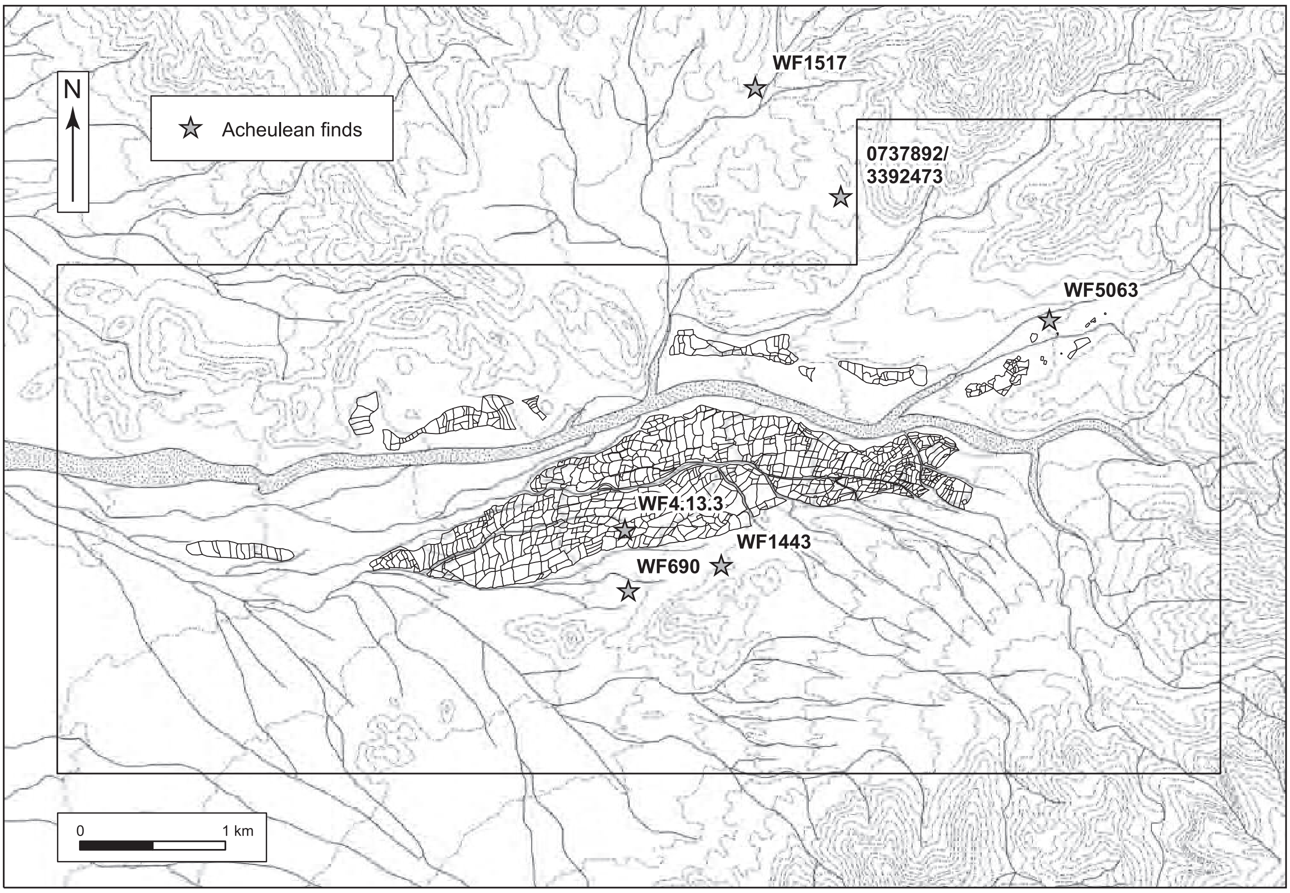


Figure 6.17 *Distribution of Acheulean bifaces collected by the Wadi Faynan Landscape Survey. (Illustration: Paul Newson.)*

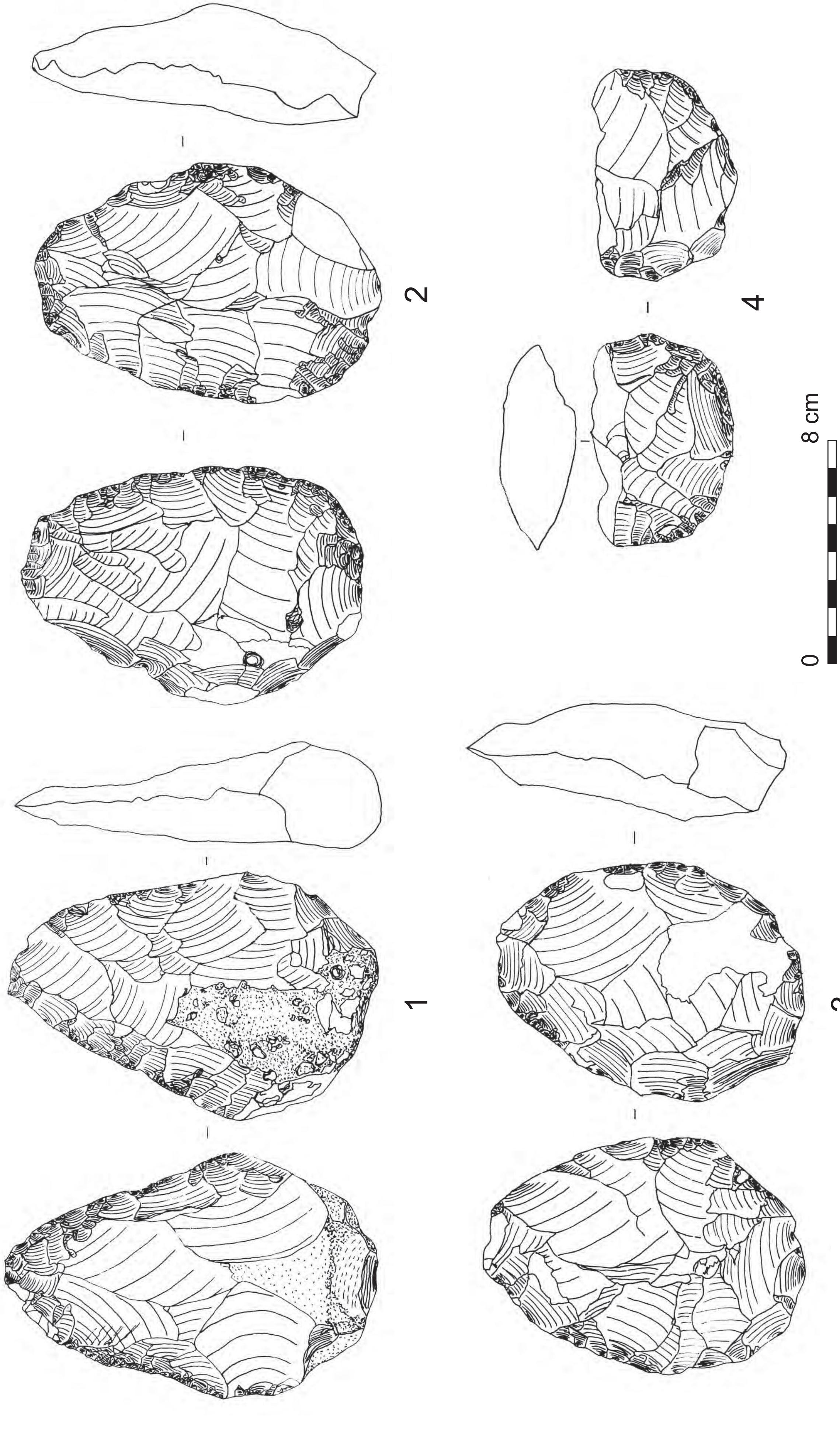


Figure 6.18 *Bifaces from Wadi Faynan: 1) WF5063; 2) WF1517; 3) 0737892/3392473; 4) WF690, fragment of biface. (Drawings: Tim Reynolds.)*

hard-hammer technique. These materials are considered to be 'Middle Acheulean' in a Levantine context. Sites likely to be of the same date occur at Mashari'a 2, 4, and 5 on the 70–80 m terrace of the Dauqara Formation at az Zarqa in the Jordan Valley, but the dating is based upon biface size (there is a regional trend for the average size of bifaces to decrease through time) and a stratigraphic context that underlies sediments with 'Late Acheulean' artefacts (Macumber 1992; Macumber and Edwards 1997). Date ranges have been proposed of 500,000–600,000 BP (Besancon and Hours 1985; Copeland 1988a) and older than 450,000 BP (Olszewski 2001).

Late Acheulean sites include those labelled in the al-Azraq Basin as Desert Wadi Acheulean (DWA) (Copeland 1988a; 1991). Once again materials are mostly derived and rolled, but include bifaces, a few cleavers, large cores and use of a 'proto-Levallois' core-reduction technique (Copeland 1988a; Copeland and Hours 1988). These sites are suggested to date to *c.*500,000–300,000 BP. The DWA is succeeded in the al-Azraq Basin by a better-described Late Acheulean industry which has been excavated as well as collected (Copeland 1988a,b; Garrard and Price 1977; Rollefson 1982; Rollefson *et al*. 1997); cleavers are a significant component of the bifacial elements, whilst Levallois technique is absent. An associated fauna (rare when so much of the evidence is dominated by surface lithic collections) includes camel, hartebeest, wild boar, rhinoceros, aurochs, equids, and elephant. Copeland (1988a) argues that these industries date to *c.*250–200,000 BP. Minimal ages based upon Uranium-Thorium dates on travertines from the al-Azraq sites of Crab Spring and C-Spring indicate minimal ages of *c.*220,000±30,000 BP (Macumber 2001).

In the Jordan Valley, the site of Mashari'a 1 is also *in situ* and produced well-made flake tools including notches as well as biface trimming flakes; bifaces themselves, however, were rare (Macumber and Edwards 1997). Other surface scatters of Late Acheulean artefacts occur on the upland plateau, including Fjaje in the Wadi al-Bustan near Shawbak on the northern edge of the study area. The very rich industry resembles that of Tabun (Israel) in its flake tool element, but is different in terms of the relative frequencies of biface classes and use of Levallois technique (Copeland 1988a; Goren-Inbar 1995). The biface classes are dominated by large to medium-sized ovate, cordiform, or discoid classes, with a débitage that includes thick blades. The bifaces were made using soft hammer technique. Similar material to that of Fjaje has been found at another highland site, Wadi Qalkha, to the south of the Faynan survey zone. Arguments about handaxe form being a reflection of raw material availability (Clegg and Mithen 2007) may have some validity when large assemblages are studied and material sources known, but the data from the Faynan area are not adequate to contribute effectively to the debate.

Acheulean settlement is thought to have been based on residential mobility within broad ranges or territories, and subsistence to have involved a combination of hunting and scavenging. In terms of settlement pattern and environmental exploitation, the al-Azraq sites were in locations well suited to both activities, close to marshes, springs, and lakes surrounded by grasslands, and the Jordan Valley sites occupied similar environments. The highland sites of Fjaje and Wadi Qalkha had good visibility and were well placed as intercept sites at the junction of steppe and light woodland, to exploit seasonally migrating game (Henry 1995a,g; Rollefson 1985). The Acheulean artefacts found as stray finds by the Wadi Faynan Landscape Survey and by the Dana-Faynan-Ghuwayr Early Prehistory Project cannot easily be assigned to any part of the Acheulean sequence with any confidence: they could date to any period between *c.*450,000 and *c.*200,000 BP. In terms of settlement pattern/landscape exploitation data, the fact that they were all found in raised terrace deposits might suggest that they originally came from sites that were on the edge of the escarpment, perhaps from plateau-edge intercept locations like Fjaje and Wadi Qalkha.

6.4.2 Middle Palaeolithic (c.200,000–45,000 BP)

Before the survey two retouched tools on Levallois flakes had been reported from the survey and excavations at Tell Wadi Faynan (al-Najjar *et al*. 1990), and our own project recovered a number of artefacts that are typologically 'Mousterian' (Table 6.3; Figs 6.19, 6.20). This frequency of material is too low to identify Mousterian 'sites' with certainty and some of the pieces may, in fact, be Acheulean or even Upper Palaeolithic in date. The survival of Middle Palaeolithic sites in recognizable form is in any case unlikely in such a geologically and geomorphologically active area. It should also be noted that flake tools and the use of Levallois technique were a component of the Late Acheulean technology (Copeland and Hours 1988). In contrast with the Acheulean, however, our survey indicates a generalized distribution of Middle Palaeolithic material across most parts of the landscape, as the overlapping survey work by the Dana-Faynan-Ghuwayr Early Prehistory project on the hills north and south of the Faynan channel also found (Finlayson and Mithen 1999b; 2007). Though Finlayson and Mithen (2007: 470) rightly observe with regard to these contrasting distributions that 'even very low rates of discard, preservation, and recovery could feasibly lead to the observed densities of artefacts', given the relative timescales that the Lower Palaeolithic and Middle Palaeolithic could represent, it is likely that this represents a real difference in the intensity of use of the landscape.

In Jordan all identified Middle Palaeolithic assemblages have, to date, been attributed to the Levantine Mousterian complex, which is characterized as a flake tool industry using Levallois flake technology. There is some overlap, both typologically and chronologically, with the preceding Late Acheulean. Much of the typological discussion of the complex is based upon comparisons with the sequence excavated from the site of Tabun in Israel, where different forms have been described based on the dominant form of

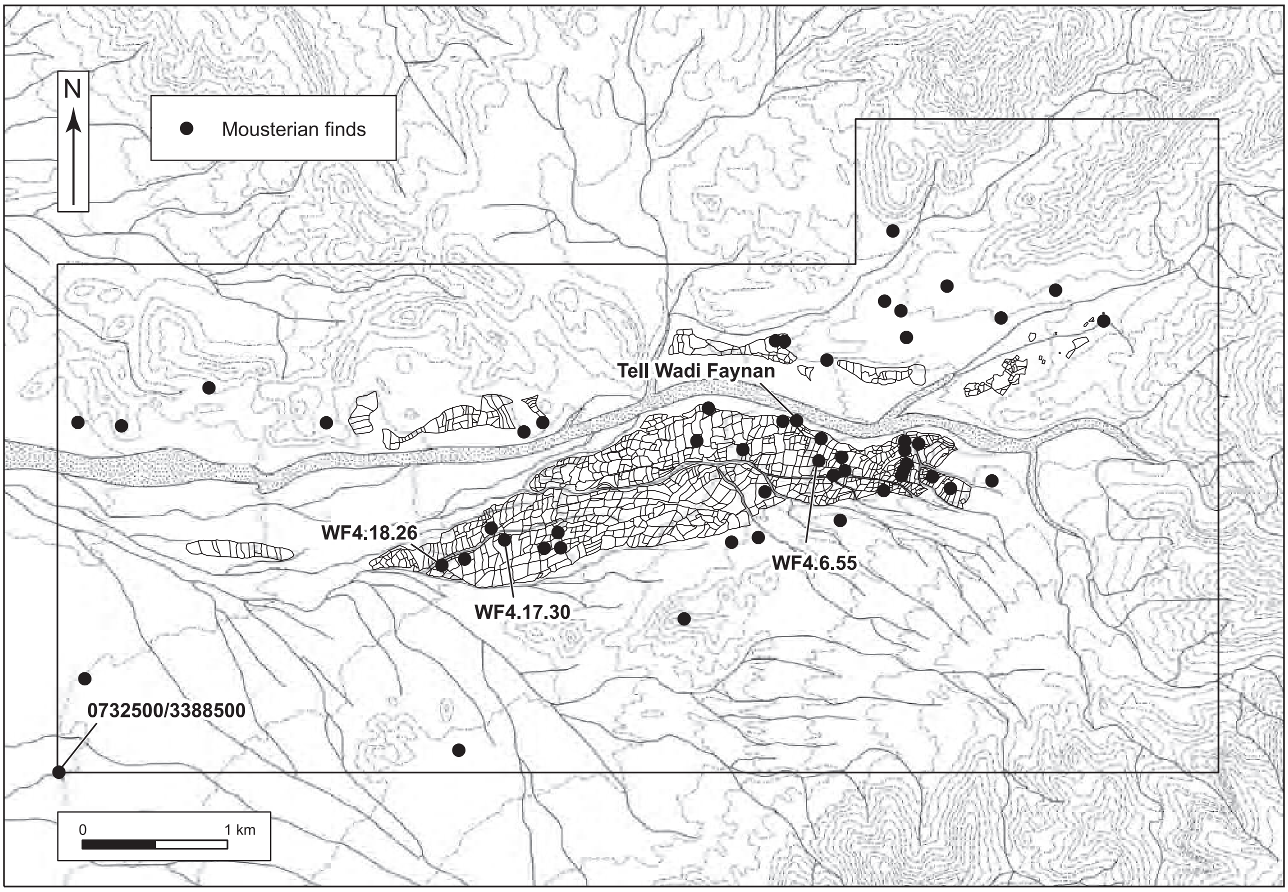


Figure 6.19 *Distribution of findspots with probable Mousterian artefacts mapped by the Wadi Faynan Landscape Survey. (Illustration: Paul Newson.)*

Points	WF4.18.13, WF739
Double-edged side scrapers	WF4.2.17, WF4.3.21, WF4.3.38, WF4.3.40, WF4.3.108, WF4.18.13, WF161, WF613, WF660, WF737, WF775, WF1227, WF1303
Single scrapers	WF4.3.84, WF4.4.12, WF4.6.37, WF4.6.42, WF4.6.45, WF4.8.18, WF4.9.11, WF377, WF542, WF580, WF655, WF735, WF737, WF1141, WF1229, WF1249, WF1365, WF1374, WF1407, WF1442, WF1521
Quina retouched scraper	WF442.13
Notches	WF442.11, WF1521
Denticulates	WF4.7.1, WF4.7.35, WF4.9.4
Elongate point	WF4.18.13
Scraper on Levallois flake	WF484
Pseudo-Levallois point	WF4.19.13
Levallois point	WF705
Levallois flake core	Line walking 3391750/3392000
Levallois point core	WF4.6.23
Disc cores	WF4.1.12, WF4.1.25, WF4.17.9

Table 6.3 *Artefacts of Mousterian type collected by the Wadi Faynan Landscape Survey.*

Levallois blanks. Mousterian assemblages in Jordan tend to be of Tabun D-type, in which the predominant blank form is pointed and in the arid zone comprises elongated points (Olszewski 2001). Dates for this assemblage span between >135,000 BP (‘Ayn Difla: Clark *et al*. 1997) and *c*.69,000 BP (Tor Faraj and Tor Sabiha: Henry 1995a,h; 1998; Henry and Miller 1992).

In contrast with the Acheulean, *in situ* sites have been excavated and are relatively well characterized. At ‘Ayn Difla rock-shelter, for example, excavations recovered a series of assemblages dated to 180,000–90,000 BP that comprised numerous elongate Levallois points, a flake tool component that is small but which included burins, notches, and denticulates, and a fauna with equids, goat or ibex, and gazelle. Equids, gazelle, and ostrich were the main species represented at Tor Faraj and Tor Sabina, with cattle also at Tor Sabina. Both sites are thought to have been situated in open steppe, though Tor Sabina is at a higher altitude and may have been a summer site, whereas Tor Faraj is lower, in a more sheltered area, and with denser evidence, so may have been used for base-camp forms of occupation (Henry 1998). Such a pattern of seasonal movement from lowland to highland in summer matches that suggested for the Late Acheulean site at Fjaje.

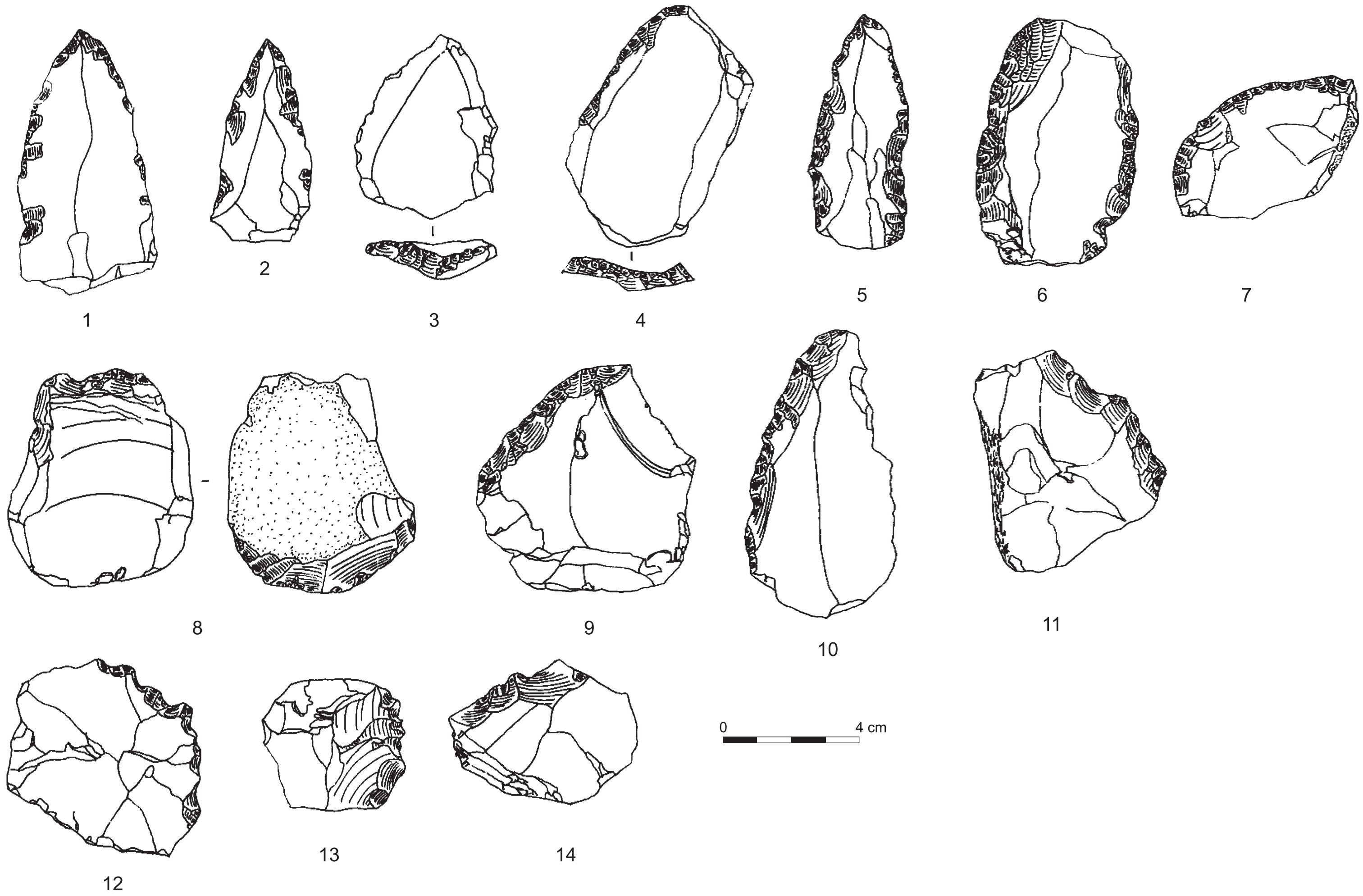


Figure 6.20 *Mousterian artefacts from the Wadi Faynan: 1) Mousterian point, WF4.4.17; 2) Mousterian point, WF4.7.25; 3) Levallois point, WF705; 4) scraper on Levallois flake, WF484; 5) elongate Mousterian point, WF4.18.13; 6) double sidescraper, WF4.18.13; 7) convex sidescraper, 3389000/250; 8) Levallois flake core, 3391750/3392000; 9) convex sidescraper, WF1249; 10) convex sidescraper, WF737; 11) denticulate, WF4.18.8; 12) denticulate, WF1443; 13) denticulate, WF424.1.4; 14) denticulate, WF442.28. (Drawings: Tim Reynolds.)*

The project's geomorphological studies described earlier in this chapter (e.g. of the Fass Yad Member) corroborate the regional picture that the period associated with Middle Palaeolithic settlement in the Levant was in part cool and moist, and sometimes cool and dry though moister than today, resulting in relatively plentiful water sources. The climatic regime favoured the widespread development of steppe/desert, with woodland along rivers. In the latter part of the phase it became drier, but the ecological effects of climate change were mitigated by marshes and seasonal ponds supplementing springs and rivers. Henry (1995f) suggested that the Middle Palaeolithic populations in Jordan were seasonally transhumant, spending the summer in the uplands and the autumn and winter in the lowlands. He argued that they practised 'logistical mobility' on the lowlands, using longer-occupied seasonal base camps and supplementary task camps, and 'residential mobility' in the uplands, with the entire community of each forager band circulating around a series of task camps. In the Negev and Sinai, on the other hand, it has been suggested that residential mobility was practised the year round (Marks and Freidel 1977), a pattern that might also have been the case for parts of southern Jordan. The 'carpet' of Middle Palaeolithic surface lithics across the Wadi Faynan survey zone found by our project and by the Dana-Faynan-Ghuwayr Early Prehistory Project could be used to fit either scenario.

One of the key questions of this period of human occupation is the issue of hominin succession (Bar-Yosef 1995b; 1998; Tchernov 1998). Two hominins (*Homo sapiens neanderthalensis* and *Homo sapiens sapiens*) are present to the west of the Rift Valley, both using Levantine Mousterian industries. Whether one type succeeds the other in the region, or whether the two are contemporary, remains to be conclusively documented. In Jordan, moreover, there are no human remains associated with the Levantine Mousterian, so studies of the lithic industries on their own cannot further the debate, although use wear studies on the material from Tor Faraj and Tor Sabiha are an important development (Shea 1995).

*6.4.3 Upper Palaeolithic (*c.*45,000–20,000 BP)*

Identifying an Upper Palaeolithic component within the small collections and individual artefacts recovered from the surface of the survey area is extremely difficult, because the defining characteristics of the period – punch-struck blade technology using prismatic blade cores, and blade-based tools – are not in fact exclusive to the Upper Palaeolithic in this region. There is overlap between the Upper Palaeolithic and late Levantine Mousterian sites at the start of the period: indeed, at Boker Tachit in the Negev, the Upper Palaeolithic appears to be an *in situ* development from the Mousterian (Fox 2003; Marks 1990). At the latter end of the period, the production of bladelets and the use of microliths overlap with the succeeding Epipalaeolithic, and even with some Holocene industries. None of the collections made by the survey teams is large enough to permit identification of tradition based upon type frequencies and type fossils.

Despite these caveats, however, a possible Upper Palaeolithic presence may be attested in the consistent presence of relatively large blades with broad striking platforms on medium-grained chert. Such blades are not 'classic' Upper Palaeolithic in that they are made by direct percussion and probably hard hammer; they could even be associated with the Late Acheulean, given that large blades can occur in these assemblages, sometimes in significant numbers. A number of blades and a blade core from the Wadi Ghuwayr provide the strongest candidate for an Upper Palaeolithic presence in the study area. There was also a series of blade cores (from WF4.6.55, WF4.18.26, WF4.17.30, and from line walking at 3388500,0732500) which might relate to transitory retooling activity during this period, but they could equally be from other periods. The survey work of the Dana-Faynan-Ghuwayr Early Prehistory Project found similarly slight and ambiguous evidence for an Upper Palaeolithic presence (Mithen *et al.* 2007a: 84).

Olszewski (2001: 42) suggests that the Upper Palaeolithic of Jordan is now relatively well known because of the frequency of *in situ* sites, both open air and caves and rock-shelters, in particular in the Wadi al-Hasa (Coinman 2000; MacDonald *et al*. 1983), Ras an-Naqab (Henry 1979; 1985), and the al-Azraq basin (Copeland and Hours 1988; Garrard *et al.* 1985b; 1986). It has been divided into three main classes (Coinman 1998; 2003; Gladfelter 1997): an early Upper Palaeolithic, an emergent technology with roots in the Levantine Mousterian (termed the Emiran in Israel: Gilead 1989: 232; 1995); the Ahmarian, a 'classic Gravettian' with a marked concentration of tools on well-made blades, and backed blades; and the Levantine Aurignacian, an industry with a significant flake and flake tool component using heavy invasive and scalar retouch, but which also has bladelet technology together with carinated and nosed scrapers. The first of these is significant beyond the region in that the Middle to Upper Palaeolithic transition and its potential link to the Neanderthal/modern human succession have been a major field of research and discussion (Bar-Yosef 1995b; 2000). It is only in this region that a true succession from Mousterian into Upper Palaeolithic industries can be documented, involving the evolution of Levallois technology into blade-producing cores, the transition being dated at Boker Tachit to *c*.49,000 BP (Marks 1990).

The earliest Upper Palaeolithic site in Jordan appears to be Wadi Ajbar rock-shelter in the Ras an-Naqab, with a large-sized pointed blade industry, typical Upper Palaeolithic tool types such as endscrapers and burins, and rare bladelets. The Ahmarian has been divided into an early and late phase (Coinman 1998; Coinman and Henry 1995: 194–5). Survey in the Ras an-Naqab area has identified five early Ahmarian sites, all rock-shelters (Henry *et al.* 1983). None has been dated, but at one of them, Tor Hamar (layers F–G), there is an associated fauna which includes gazelle, caprines, equids, and jackal. A late Ahmarian assemblage at ‘Ayn al-Buhira associated with a fauna including equids and aurochs has been 14C dated to 20,300±600 BP (UA-4395) (Coinman 1993: 19), and one at Yutil al-Hasa has been dated to 19,000±1300 BP (UA-4396). The Levantine Aurignacian is relatively rare, possibly occurring in the al-Azraq basin (Olszewski 2001: 44) and in the Jordan Valley. It is possible that it may be restricted to sites west of the Rift Valley.

In some parts of Jordan, seasonal transhumance may have been a significant aspect of Upper Palaeolithic subsistence behaviour, as it had been in the Middle Palaeolithic (Henry 1995b): Gladfelter (1997), for example, notes that Ahmarian sites are mainly to be found within or immediately adjacent to highland settings. Another important factor was climatic change. The early Ahmarian emerged during a moister phase, with sites in marsh settings in southern Sinai and Jordan. After *c*.25,000 BP, however, the climate became markedly drier, woodland gave way to steppe (for example in the Wadi al-Hasa region), and Upper Palaeolithic groups increasingly preferred ecotonal locations around lakes, marshes, and ponds. An illuminating site for this period is Ohalo II on the edge of the Sea of Galilee, where a collection of stone hut foundations and hearths was preserved dating to *c*.19,000 BP (Kislev *et al*. 1992; Nadel and Werker 1999; Nadel 2003; Piperno *et al.* 2004). The group fished, fowled, and collected forest foods such as acorns and almonds around the lake, and gathered wild cereals and other grasses on the adjacent steppeland, as well as hunting gazelle and a range of smaller game. The indications are that the group was semi-sedentary, spending most of the year fishing, gathering, and hunting in the Jordan valley, and moving away to higher ground for shorter periods of gathering and hunting. As Finlayson and Mithen (2007: 470) also conclude in relation to the paucity of Upper Palaeolithic material recovered by their survey, the Wadi Faynan may have been a location in this kind of system for transitory camps of groups moving between the lakes and streams of the Wadi ‘Arabah (such as Lake Lisan) and the plateau steppelands.

*6.4.4 Epipalaeolithic (*c*.20,000–10,300 BP)*

The caveats noted above for the Upper Palaeolithic apply yet more strongly to the Epipalaeolithic, for its ‘type fossils’ such as lunates and various forms of backed blade and bladelet can in fact be found not just within late Pleistocene but also within various Holocene industries as well. The Epipalaeolithic has been well researched in the Levant – in Jordan alone, nine industries/phases have been recognized (Olszewski 2001). Though the validity of such fine divisions is debated (Henry 1974; 1995c,i; Neeley and Barton 1994; Olszewski 2003), the basic scheme originally devised for Israel still holds true, from the Kebaran (defined as bladelet-rich, with tools on bladelets and non-geometric microliths) via the Geometric Kebaran (dominated by geometric microlith forms) *c*.15,000 BP to the Natufian *c*.12,500 BP (Goring-Morris 1995; Valla 1995). The latter has high frequencies of lunates with Helwan retouch (a bifacial retouch form), microburins, scrapers, burins, notches, and denticulates, together with (after *c*.11,000 BP) abruptly retouched lunates. In Jordan, the earliest defined Epipalaeolithic industries, dated between *c*.20,000 and 15,000 BP, include the Qalkhan, Early Hamran, Madamaghan, and the non-Natufian Microlithic (Edwards *et al*. 1996; Garrard and Byrd 1992; Henry 1995a,e,j). In the al-Azraq basin the equivalent industries to the Kebaran include the Middle, Late, and Final Hamran and other non-Natufian microlithic industries.

The transition to the Geometric Kebaran *c*.15,000 BP coincided roughly with an expansion in Mediterranean woodland as the climate improved following the Last Glacial Maximum. The period was also notable for transformations in settlement forms, characterized by the appearance of complex sites with stone hut circles and organized living spaces, both within the huts and between them. This investment of time and energy into selected localities marked a significant development from the more transitory nature of even the larger sites of the Upper Palaeolithic. There is also evidence for an increasing focus on cereal collecting, processing, and storage. Hence the main research issues for this period focus on the origins of agriculture, the development of sedentism and increased social complexity, and the potential interrelationships between these three processes (Bar-Yosef and Belfer-Cohen 1989; Bar-Yosef and Khazanov 1992a,b; Byrd 1994; Henry 1995i).

Our survey, like that of the Dana-Faynan-Ghuwayr Early Prehistory Project (Mithen *et al.* 2007a: 84), was unable to identify any sites that could be definitely linked solely to the Epipalaeolithic period, for example by the presence of lunates or microburins. As Finlayson and Mithen (2007: 470) observe, the absence is likely to be real and not a function of survey recovery methods or of geomorphological processes, as in the case of the latter, appropriately dated surfaces were available for scrutiny. (The possibility exists that Epipalaeolithic occupation is present below the PPNA occupation at WF16, as micromorphological analysis of basal sediments thought to be natural at the time of excavation subsequently revealed indicators of human presence: Finlayson and Mithen 2007: 471–2; this possibility is to be investigated in a planned second phase of work at the site.)

The nearest early Epipalaeolithic sites are rock-shelters in the Wadi al-Hasa area (Yutil al-Hasa, Tor Sageer, and Tor al-Tareeq) where pollen recovered suggests a mosaic of open steppe and wetland environments. Yutil al-Hasa was a task camp used for exploiting ponds and marshes and adjacent steppe, its fauna including gazelle, equids, aurochs, and tortoise. Tor al-Tareeq (*c*.16,900–15,500 BP) was also associated with lake and pond deposits, and a similar fauna, together with hare, wolf, fox, badger, rock dove, fish, and crabs, whilst grindstones suggest that plant processing was also practised (Neeley *et al*. 1998). The Wadi Madamagh rock-shelter near Petra (Kirkbride 1958) has been interpreted as either a base camp or a regularly visited task site.

The Natufian is represented around the Faynan area at sites such as Beidha near Petra (Byrd 1989; 1991), the Yutil al-Hasa rock-shelter, and two open sites in the Wadi al-Hasa, Tabaqa and WHS 1021. Yutil al-Hasa, with a small assemblage including Helwan lunates, Helwan bladelets, non-geometric microliths, microburins, notches, denticulates, and a few burins, is thought to have been a hunting camp; the associated fauna includes gazelle and aurochs, together with some marine shell fragments. Tabaqa, 6 km away, had an assemblage that has Helwan lunates made by the microburin technique, non-geometric microliths, notches, denticulates, scrapers, and burins, a fauna including gazelle, and grindstones and charred plant remains demonstrating the exploitation of grasses. The site has been interpreted as a seasonal base camp, with WHS 1021 an associated task site. There is little evidence in the region for the complex Natufian foraging societies of the Mediterranean forest zone characterized by buildings, burials with grave goods, and various forms of artistic expression. However, the significant increase in grinding equipment at the Jordanian sites, with forms, decoration, and other evidence indicating increasing formality in food-sharing and of social rituals related to eating (Wright 2000), chimes with the evidence throughout the southern Levant for increasing cereal use and cultivation presaging the emergence of agriculture following the transition to the Holocene (Chapter 7).

6.5 The Pleistocene landscape and its human utilization

Clearly it is unlikely that our geomorphological research has detected all or even most of the distinctive deposits and landforms that are preserved in the modern landscape, nor has it been possible to examine the results of high-frequency, low magnitude, processes and the deposits that result from them in either the modern environment or its diverse antecedents. Nevertheless, several distinct and major phases of geomorphic evolution during the Pleistocene have been identified in the field exposures, maps, and profile diagrams (Table 6.4), indicating that the Quaternary sequence in the Faynan area formed in a dynamic environment of tectonic activity, climatic change, and geological complexity. Despite the differences in approach, the essential thrust of the conclusions from our study is comparable with those of Tipping (2007), in addition to those wider parallels in the region recounted previously by McLaren (2004) and McLaren *et al*. (2004).

Throughout much of the Pleistocene, the area has evidently been affected by a series of fluvial events and the development of large and small alluvial fans. Rivers have incised into wadi floors, eroding both pre-existing surficial deposits and various bedrocks. An overall fall in the base-level through time has resulted in phases of incision interrupted by more stable periods of sedimentation during flood events. The main effect of major floods has been to incise through the bedrock and then deposit further sediments that have been modified only slightly (mainly by processes of weathering, diagenesis, minor pedogenesis, and movement under the influence of gravity) until the next major flood event. Wadi entrenchment has created 'terraces' out of earlier flood zones. Traces of these ancient rivers exist upstream in the form of rock-cut channels, sediments, and erosion surfaces. At the exit from the mountain front to the desert basin, sequences of alluvial fans have been repeatedly aggraded and eroded.

On the evidence of both our survey and that of the Dana-Faynan-Ghuwayr Early Prehistory project, this landscape was periodically exploited during the Pleistocene, with low-intensity hunting and gathering activity. The use of lithics was based upon local raw materials, mostly river cobbles; the abundant supply of raw material for tools could have been one element in the selection of site locations. Technology was mostly expedient, with little effort put into core platform control or design. Levallois technique was present in the Middle Palaeolithic, but blade and bladelet cores in subsequent periods are rare. The surveys confirm the generalized trends recognized in neighbouring parts of the southern Levant. In many phases, the uplands were more arid than today and lowlands such as Wadi Faynan were better watered, and a common feature of interpretations of the regional excavated evidence is arguments for seasonal patterns of movement between the Jordanian uplands and the lowlands. Pending the results of the proposed new excavations at WF16, it appears that it was only with the end of the Pleistocene that the Wadi Faynan can probably be regarded as permanently settled, part of broader territorial exploitation patterns and processes of intensification that led to the emergence of the agricultural populations following the transition to the Holocene that are discussed in the following chapter.

The +125 metre Quabbah Member is probably made up of the oldest Quaternary sediments in the study area but as yet has not been numerically dated.
The Ghuwayr Beds are probably the oldest fan deposits in the Faynan area as they have been incised by the Wadi Ghuwayr the most (over 40 metres have been exposed). Palaeolithic tools have been found near to the base of this unit and on the surface. The deposit is known to be older than 225,000 years.
The Madrasah Beds are more than 208,000 years old.
The +30 metre Fass Yad Member is known to be older than 109,000 years BP and contains an Acheulean handaxe.
The +22 metre (Mokeim), +15 metre (Dahlat) and +10–12 metre (Naqqazah) Members have not been numerically dated themselves, but on the basis of relative stratigraphy may be younger than 109,000 years BP and older than 10,000 years BP.
The Asheiair Beds are Last Glacial in age (one date suggests *c*.55,200 years old).
Aeolian activity is evident at *c*.13,700 years ago in the Wadi Faynan, and. aeolian and fluvial processes resulted in sediment deposition similar to that of today.

Table 6.4 *Summary of the Pleistocene stratigraphy of the Faynan area.*

7. Early Holocene environments and early farming *c*.11,000–7000 cal. BP, *c*.9500–5000 cal. BC

*Graeme Barker, Chris Hunt, Sue McLaren, Tim Reynolds, Hwedi el-Rishi, David Gilbertson, and John Grattan**

7.1 Introduction

The ten thousand years after the Last Glacial Maximum were characterized by distinct fluctuations in world climate, but in the middle of the tenth millennium BC (in calibrated radiocarbon years) temperatures shifted irreversibly to warmer levels, marking the change from the climates of the Pleistocene to those of the Holocene. The ensuing four or five millennia were marked in Southwest Asia by considerable environmental change, on the one hand, and by the development of societies based on the practice of agriculture on the other, though the precise pathways of environmental and cultural change, and their possible inter-relationships, are much debated.

The uncertainties regarding the course of climate change are partly because of the scale and variability of the region and partly because climatic reconstructions in particular locations have often been based on a variety of techniques, yielding results that are difficult to correlate and integrate. However, a synthesis of the varied sources of information suggests that two bio-climatic provinces were present during the Early to Middle Holocene, one northern and one southern (Fig. 7.1). In the north, sites such as Lake Van in southern Turkey (van Zeist and Bottema 1982) and Lake Zeribar in Iran (van Zeist and Bottema 1977) contain pollen assemblages consistent with relatively dry climates and dry steppe-forest in the early Holocene. More detail is provided by geochemical studies of continuously accreting lake sediments from Lake Van (Lemcke and Sturm 1997), and from caves and many other sites in the region (Issar 1998; 2003): relatively cold and humid conditions in the initial Holocene were replaced by warmer humid conditions during the Pre-Pottery Neolithic B or PPNB phase and then by cool but still humid conditions in the Pottery Neolithic phase and first part of the Chalcolithic, with notably drier conditions developing in the fourth millennium BC. Although Moeyersons *et al*. (2002) found evidence for aridity early in the Holocene in the Red Sea mountains of Egypt, across the southern Levant there is consistent evidence otherwise that the early Holocene was humid: sites in Syria have evidence for forest, and sites in Saudi Arabia, Palestine, and Jordan have vegetation assemblages consistent with steppe (Baruch and Bottema 1991; Fish 1989; Frumkin *et al*. 1991; Horowitz 1979; Hunt *et al.* 2004; 2007b; Rossignol-Strick 1993). Probably one of the most detailed studies relevant to the present project is that conducted by Gvirtzman and Wieder (2001), though it was carried out along the Israeli coast, a location that today is cooler and wetter than southern Jordan: soils and sediment studies there revealed the sequence shown in Table 7.1, with oscillations at the Pleistocene/Holocene transition followed by a wetter climate through the early Holocene. These views are now broadly supported by recent studies of more widely located studies in the eastern Mediterranean reported by Weninger *et al.* (2006) that also highlight a period of time, perhaps 250 years long, at about 8200 calendar years ago, when climate in the region became cooler and notably more arid.

Phase (BP)	(approx. BC)	Climate
c.12,500–11,500 BP	11,000–10,000 BC	Cold and dry
c.11,500–10,500 BP	10,000–9000 BC	Wetter
c.10,500–10,000 BP	9000–8500 BC	Dry
c.10,000–7500 BP	8500–5000 BC	Wetter and warmer
c.8200–8100 BP	6200–6100 BC	Cooler and notably arid
c.7500 BP onwards	5000 BC onwards	Oscillating between wet and dry

Table 7.1 *Holocene climatic change on the Israeli coast, as indicated by soil and sediment studies, with approximate dates. (Modified from Gvirtzman and Wieder 2001; Weninger* et al. *2006.)*

* *Palaeoecology and palynology:* Chris Hunt, Hwedi el-Rishi. *Geomorphology:* Sue McLaren, David Gilbertson, John Grattan. *Archaeology:* Tim Reynolds, Graeme Barker.

Southwest Asia has been recognized as one of the world's primary 'hearths of domestication' ever since Gordon Childe's formulation of his concept of the Neolithic Revolution (Childe 1936; 1942). The orthodox (though undoubtedly over-simplistic) model over the past two decades has been that wheat and barley were first domesticated in the southern Levant, in the Jordan valley especially, in the cultural period dating to the first thousand years of the Holocene termed the Pre-Pottery Neolithic A or PPNA phase, that is *c*.9500–8500 cal. BC; that goats and perhaps sheep were domesticated at about the same time to the east, in the Zagros mountains of eastern Turkey, northern Iraq, and southwest Iran; and that in the ensuing Pre-Pottery Neolithic B phase *c*.8500–7000 cal. BC these separate components came together as an integrated system of mixed farming characterized by the cultivation of a range of domestic wheats, barleys, and legumes or pulses such as peas and lentils, and the herding of sheep and goats, and (somewhat later) cattle and pigs, a system that sustained sedentary village communities throughout the uplands of Southwest Asia (e.g. Bar-Yosef and Belfer-Cohen 1992; Bar-Yosef and Meadow 1995; Hole 1996). The PPNB and the later periods of the Neolithic (the PPNC, *c*.7000–6500 cal. BC, and the Pottery Neolithic, *c*.6500–5000 cal. BC) were characterized by increasingly complex societies, with new economic forms, elaborate architecture, more organized use of public space, and elaborate ritual burials (Byrd 1994; 2000; Kujit 2000; Wright 2000).

General theories of why people in Southwest Asia turned from hunting and gathering to the domestication of plants and animals in the early Holocene have commonly divided between 'push' models proposing that people would have been forced to intensify their subsistence with the transition to the Holocene climate because of changes to their resource base, perhaps compounded by the pressures of rising population (e.g. Binford 1968; Cohen 1977), and 'pull' models proposing that factors such as increasing sedentism at the Pleistocene–Holocene transition in response to changes in the resource base would have drawn people unwittingly into new relations with plants and animals (e.g. Harris 1990; Rindos 1984). More recently, several scholars have emphasized the likelihood of competitive

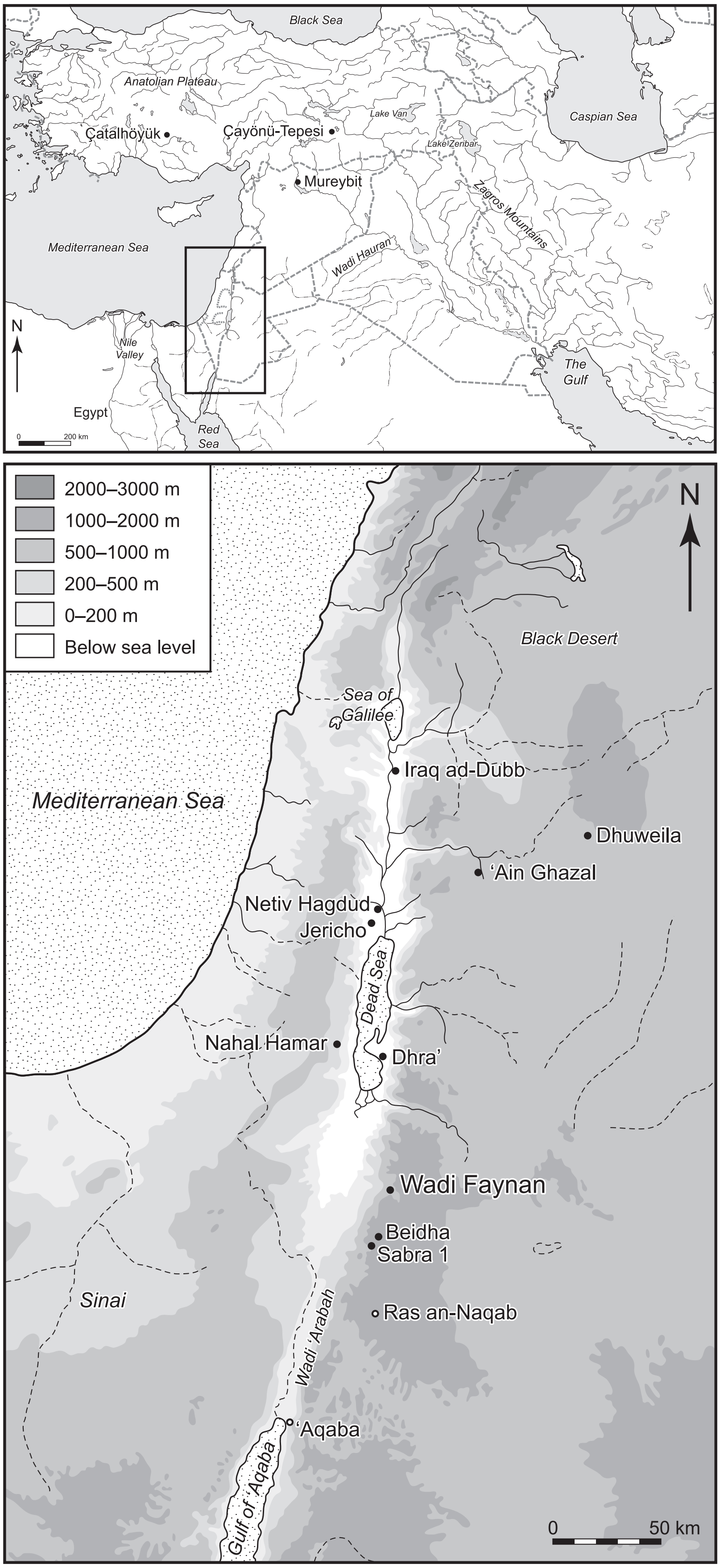


Figure 7.1 *Southwest Asia (above) and the southern Levant (below), showing the principal regions and places mentioned in Chapter 7. (Illustration: Dora Kemp.)*

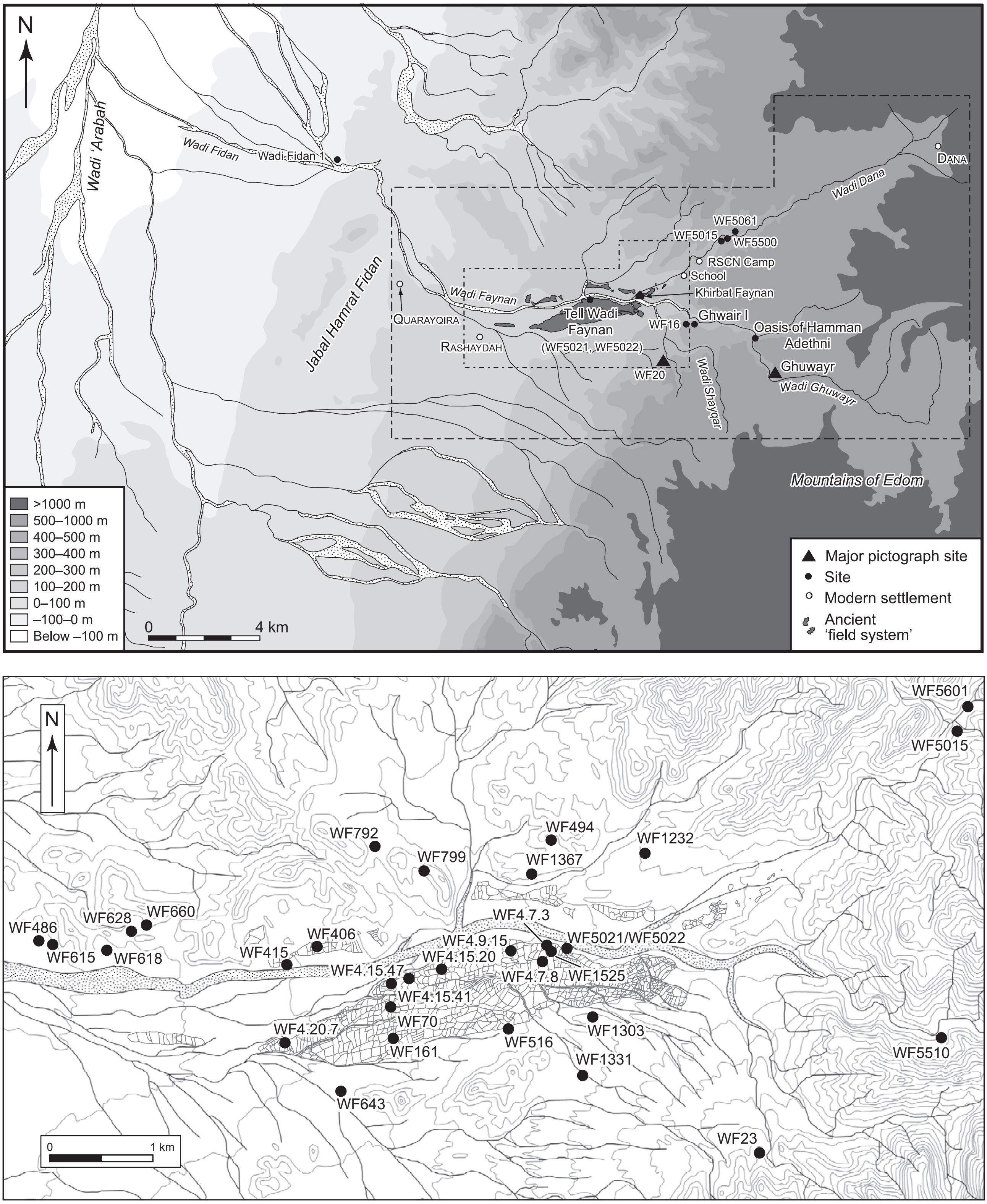


Figure 7.2 *The Wadi Faynan study area, showing the location of the WFLS Survey Zone and the principal geomorphological and archaeological sites discussed in Chapter 7. (Illustration: upper - Dora Kemp, lower - Paul Newson.)*

Fluvial deposits height (m)	Alluvial fan deposits	Aeolian deposits
Quabbah Member *c.* 125–130 Fass Yad Member *c.* 30–35 Mokeim Member *c.* 22–25 Dahlat Member *c.* 15 Naqqazah Member *c.* 10–12 **Faynan Member** *c.* 5–7 Upper Dana Wadi Member *c.* 2–3 Lower Dana Wadi Member *c.* 1–1.5	Ghuwayr Beds Madrasah Beds Asheiair Beds Shayqar Beds Aqabah Beds **Hamman Beds**	Quarayqira (= Gregora) Member **Tell Loam Member**

Table 7.2 *The Quaternary deposits identified in the Faynan area, with those of early to mid Holocene age highlighted. The heights shown are in metres above the wadi floor. The Tell Loam Member is also discussed in Chapter 8.*

Figure 7.3 *The Hamman Beds: a typical view of the Hamman Beds at WF5510 in the Wadi Ghuwayr gorge. The two people seated in the shade at the foot of the cliff are located upon fluvial deposits of the Faynan Member, which are overlain by the 10–15 m-high exposure of alluvial fan and colluvial deposits of the Hamman Beds. The latter occupy a steep-sided rock-channel that slopes downwards into the main gorge of the Wadi Ghuwayr. The steep rock walls of this channel are visible to the right of the image above the surface of the fan deposits; see also Figure 7.6. (Photograph: Hwedi el-Rishi.)*

behaviours and/or changing belief systems amongst the complex hunter-gatherers of the late Pleistocene as key drivers of subsistence intensification (Cauvin 2000; Hayden 1995; Hodder 2001).

Against this background, this chapter discusses the project's evidence for the changing character of environment and human settlement in the Wadi Faynan through the first five thousand years of the Holocene. As in the case of the material discussed in the previous chapter, our project yielded detailed new information for the character of landscape change through this period but only limited evidence for the nature of human settlement, because our primary evidence consists of surface artefacts, lithics especially. However, our evidence can also be integrated with the data from excavations by other teams (Fig. 7.2), notably of the PPNA site WF16 (Finlayson and Mithen 2007), the PPNB settlement Ghwair I (Simmons and al-Najjar 1996; Simmons and Najjar 2006), and the Pottery Neolithic/Chalcolithic settlement Tell Wadi Faynan (al-Najjar *et al*. 19902).

7.2 Environments of the early to mid Holocene

Although the general patterns of climatic change mentioned above had been recognized sufficiently frequently that they seemed likely to apply regionally, the project had to assume that palaeoenvironments in the Faynan may have displayed variations or complications of significance, for two sets of reasons. First, the area encompasses the profound environmental transition from the relatively benign uplands of the Jordanian tablelands via mountain slopes, gorges and alluvial fans to the true lowland desert of the Wadi 'Arabah (Fig. 2.12), so the biogeographic and geomorphic impacts of climatic shifts may have been complex. Second, the nature of the interactions between people and ecosystems in this particular landscape was unknown.

The geomorphological fieldwork identified several important sets of deposits that developed in the early Holocene and mid Holocene, in the period broadly encompassed by this chapter: the upper component of the Faynan Member; and the Hamman Beds and the Tell Loam Member, which are diachronous and which continue to accumulate to the present day (Table 7.2).

7.2.1 Hamman Beds

The Hamman Beds are typically located at the margins of the main wadis, and are exposed as small alluvial fans and colluvial spreads of poorly-sorted breccias, gravels, sands, and silts; as multiple layers separated by eroded slope surfaces; and sometimes with ash occasionally interbedded on slopes with anthropogenic deposits or pits, or with fluvial deposits in wadis. They have been accumulating throughout the Holocene to the present day. Important exposures of early–mid Holocene age occur in the gorge sections of both the Wadi Ghuwayr and the Wadi Dana. Figure 7.3 shows a mix of fluvial and slope deposits that have been preserved about three kilometres up the Wadi Ghuwayr from its junction with the Wadi Dana, in a sharp outside bend which is probably fault-controlled. They are visible as a thick sequence abutting and resting on the steep slope behind. Whether the fluvial units at the base are underlying the slope sediments or have eroded into them on the meander bend is currently unknown, as the junction is hidden by slumping, but they appear to be inter-bedded with the fluvial gravels of the upper component of the Faynan Member (Hunt *et al.* 2004). The characteristics of

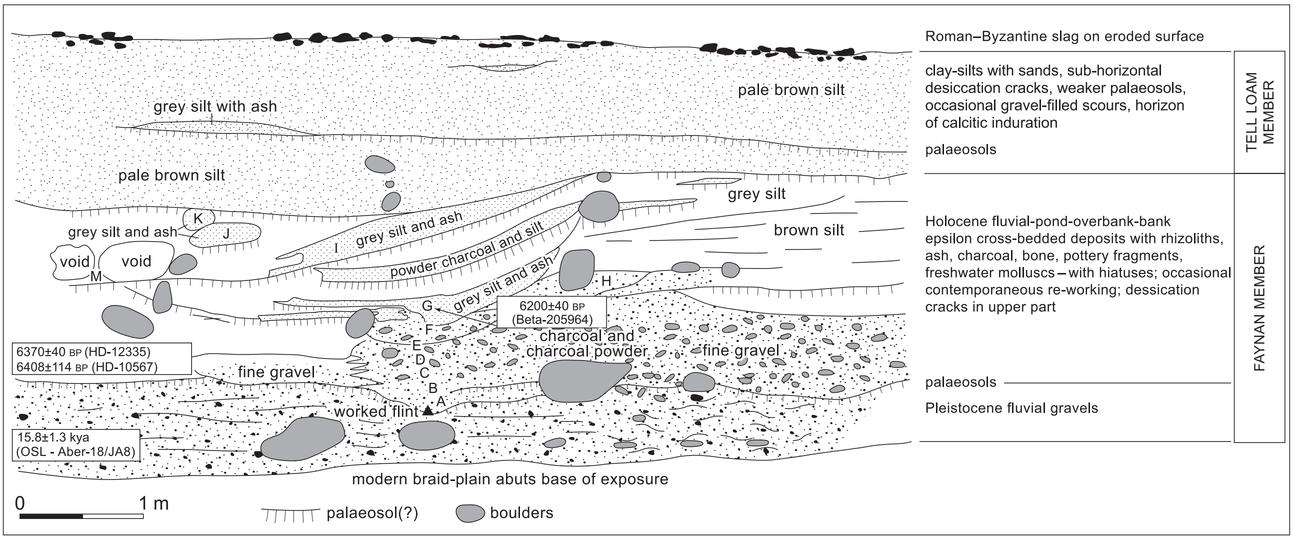


Figure 7.4 *The Holocene fluvial channel infill sequence of the Faynan Member (Upper Component) exposed in the wadi-cliff WF5021, to the west of Tell Wadi Faynan: a summary of the lithological features and stratigraphic relationships of the channelized fluvial deposits and the overlying water-washed aeolian silts and thin palaeosols of WF5022. Charcoal (in a matrix of ash and some silt) at sample location G was radiocarbon-dated to 6200±40 BP or 5296–5045 cal. BC (Beta-205964). These sediments are overlain by the Tell Loam Member (see Fig. 8.3). The discontinuous scatter of slag and polluted sediments at the top of the exposure is part of the Atlal Member. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

these slope deposits suggest that quasi-stable environments existed at the junction between the steep rocky slopes of the gorges and the perennial streams and permanent springs that gave rise to the upper component of the Faynan Member described below.

7.2.2 Faynan Member (Upper Component)

Fluvial deposits occupying palaeochannels of early Holocene age have been found at several locations in the area. The type site for both the Upper and Lower Components of the Faynan Member is immediately to the west of the excavations at Tell Wadi Faynan, the prehistoric settlement on the southern side of the main Wadi Faynan channel, at WF5021 (Figs 1.9, 3.3, 3.4, 7.4, 8.3). The Upper Component is exposed in a wadi-edge cliff *c*.5–7 m above the present wadi floor, where it comprises a distinctive fluvial channel *c*.3–5 m deep and perhaps 10–12 m wide, draining broadly from east to west. The channel is eroded into the much coarser fluvial gravels of the Lower Component of the Faynan Member that here are a 3–5 m-thick exposure of trough cross-bedded sands mixed with coarser gravels, pebbles, cobbles, and occasional boulders. An OSL date of 58.6±3.8 kya (Table 6.2) indicates that these gravels are Late Pleistocene in age. The Upper Component of the Faynan Member is overlain with apparent conformity by the Tell Loam Member. To the east of WF5021 at Tell Wadi Faynan itself, the Holocene channel infill of the Upper Component of the Faynan Member can be mapped in poor outcrop in the collapsing wadi-edge cliff as a distinctive lithostratigraphic entity interbedded with the older component of the archaeological occupation investigated by al-Najjar *et al*. (1990). Inspection of the remaining cliff faces and the sediment descriptions in the excavation report suggest that radiocarbon dates from Tell Wadi Faynan associated with archaeological material of the Pottery Neolithic period, of 6408±114 years BP or 5612–5076 cal. BC (HD-10567) and 6370±40 years BP or 5471–5231 cal. BC (HD-12335) can be traced to the channel infill at this site.

The Holocene fluvial channel infill sequence of WF5021 contains coarse fluvial boulders at its base, the materials grading upwards to moderately well-sorted and stratified finer sediments. There is evidence of cross-bedding and the larger clasts commonly show evidence of imbrication. In the middle and upper parts of the channel infill exposure are pale grey silts displaying epsilon cross-bedding. Exposures indicated that these fine-grained lateral deposits contain evidence of human activity nearby, including a distinctive lens of wood-ash, charcoal, fragments of pottery, occasional worked flints, molluscs, and plant macrofossils. We obtained a radiocarbon date on charcoal at sample G (Fig. 7.4) of 6200±40 BP or 5296–5045 cal. BC (Beta-205964). At the top of this exposure the fluvial sequence is overlain with apparent conformity by the wind-blown water-washed silts and thin palaeosols of the Tell Loam Member, within which is occasional further evidence of biological and human activity including ash, charcoal, potsherds, bones, animal burrows, and root casts. The sedimentary properties of the fluvial sequence at WF5021 record the intersection of a perennial meandering stream or small river flowing roughly from east to west, together with a stream bank on which quiet-water muds accumulated as well as, on occasions, the debris of human occupation activity located at or near the bank. This interpretation is

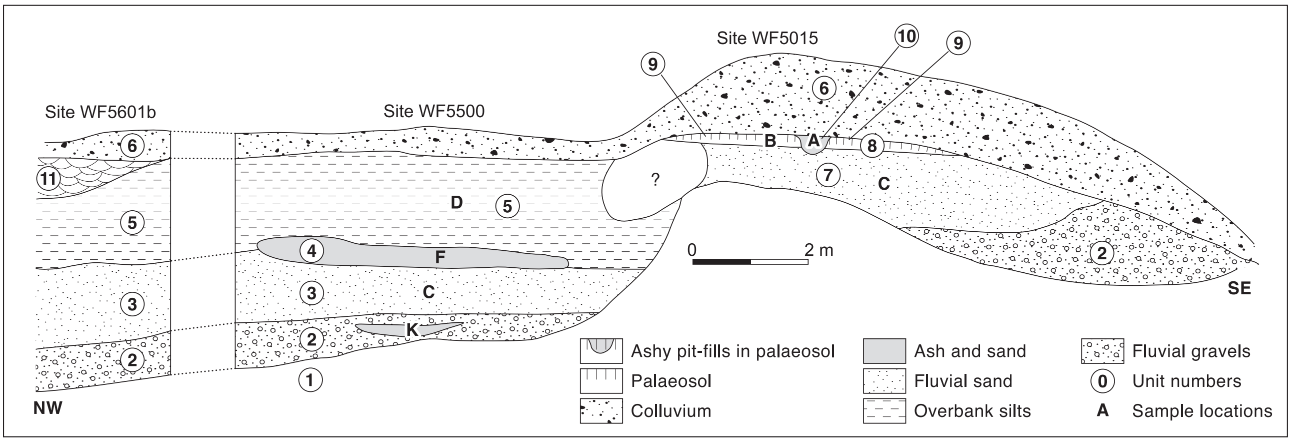


Figure 7.5 *The Faynan Member (Upper Component): stratigraphy of WF5015 and adjoining sites in the Wadi Dana (partly after Hunt* et al. *2004). Unit 1: bedrock; Unit 2: 1.6 m-thick fine shelly gravels with the freshwater mollusc* Melanopsis*, passing laterally into coarse epsilon cross-bedded gravel with lens of ashy sand; overlain conformably by Unit 3: 0.4 m sand with shelly horizons with* Melanopsis *and the land snail* Theba*; Unit 4: large lens 0–0.5 m-thick, ashy silt; Unit 5: 0.7 m overbank silts; Unit 11: 0–0.4 m trough cross-bedded sandy gravel, occupying a channel eroded into Unit 5; Unit 7: 0.5 m sand with shelly horizons, with Lymnaea; Unit 8: 0.2 m palaeosol, clay-enriched, with calcified root-tubules, significant ash, occasional Neolithic artefacts; Unit 9: old land surface with charcoal and Neolithic lithic artefacts; Unit 10: cut pit with ashy infill, dated to 7240±90 BP or 6353–5919 cal. BC (Beta-111121: sample A), cut through Units 9 and 8 and overlain by Unit 6; Unit 6: 0–1.6 m stony and silty poorly-sorted colluvium. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

supported by the recovery from lower silty channel-fill units at WF5021 of rhizomes of *Phragmites* reeds, unrolled shells of the mollusc *Melanopsis praemorsa* (L.), a species of clear perennial running freshwater (Pfleger and Chatfield 1983), and poorly-preserved frustules of the diatom genus *Navicula* which in this desertic context can be considered to be aquatic.

The Upper Component of the Faynan Member has also been recognized in another fluvial channel infill sequence, at WF5015 in the Wadi Dana (Fig. 7.5), which yielded charcoal that gave a radiocarbon date of 7240±90 BP or 6353–5919 cal. BC (Beta-111121). This infill sequence lies on an undulating fluvially-cut surface, eroded across Proterozoic Fidan Syenogranite. The stratigraphy of this Holocene sequence is complex. On the rock surface (1) lies (2) 1.6 m of epsilon cross-bedded, light brown, fine, shelly gravels, with a lens of mid-grey ashy sand. These gravels pass upward into (3) 0.4 m of pale yellow-brown, massive sand, with shelly lenses at its base, which in turn is overlain by (4) 0.5 m of massive, ashy silt. Several Neolithic potsherds and lithic artefacts were found in the ashy silts. Assemblages of boulders up to 0.5 m in diameter that appear to be fragments of walls were embedded in this unit. The ashy silt was overlain by (5) 0.7 m of massive light brown silts, which are cut by (11) a scour containing 1.5 m of fluvial coarse epsilon cross-bedded gravel overlain by (7) up to 0.5 m of structureless silty sand. Developed on the latter was (8) a clay-enriched palaeosol 0.2 m thick containing calcified root tubules, ash, and occasional stone artefacts. Abundant unrolled shells of *Melanopsis praemorsa* (L.) were recovered from the basal shelly gravels and sands, whilst one specimen of *Lymnaea* sp. and two of *Theba* sp. were found in the massive sand below the palaeosol. *Lymnaea* is semi-aquatic, and the genus *Theba* is today associated with relatively dense steppic vegetation in the research area (1998 field observation by Hunt and el-Rishi). The molluscan remains corroborate the sediment studies in pointing to perennial running water at sites immediately adjacent to steppic vegetation.

A little further up channel was a similar exposure of early Holocene fluvial deposits occupying a channel incised into bedrock (WF5601). The channel fill consisted of a basal 0.2 m of imbricated, clast-supported, fine gravel, overlain by up to 0.9 m of pale yellow-brown plane-bedded fine shelly sands; these can be attributed to a meandering fast-flowing stream. Examples of *Theba* sp. and *Melanopsis praemorsa* (L.) were recovered from the plane-bedded sands. The channel fill was overlain unconformably by deposits of quite different character: up to 0.3 m of red-brown trough cross-bedded coarse sand, with abundant shells in the basal few centimetres. Their textures and sedimentary structures suggest that a braided stream replaced the earlier perennially-flowing single channel.

A related deposit was identified in the Wadi Ghuwayr at WF5076/WF5510, above the flood plain (Fig. 7.6). Fluvial deposits attributed to the Upper Component of the Faynan Member occupy a channel incised into older, much coarser, unfossiliferous gravels of Pleistocene date. The basal unit of the Holocene fluvial deposit is an epsilon cross-bedded sequence of very fine gravels 1.2 m thick passing upwards into whitish silts and then pale grey clays. These lower deposits were unconformably overlain by up to 6 m of trough cross-bedded sands, silts, and fine gravels attributed to braided-stream processes. Locally within these fluvial

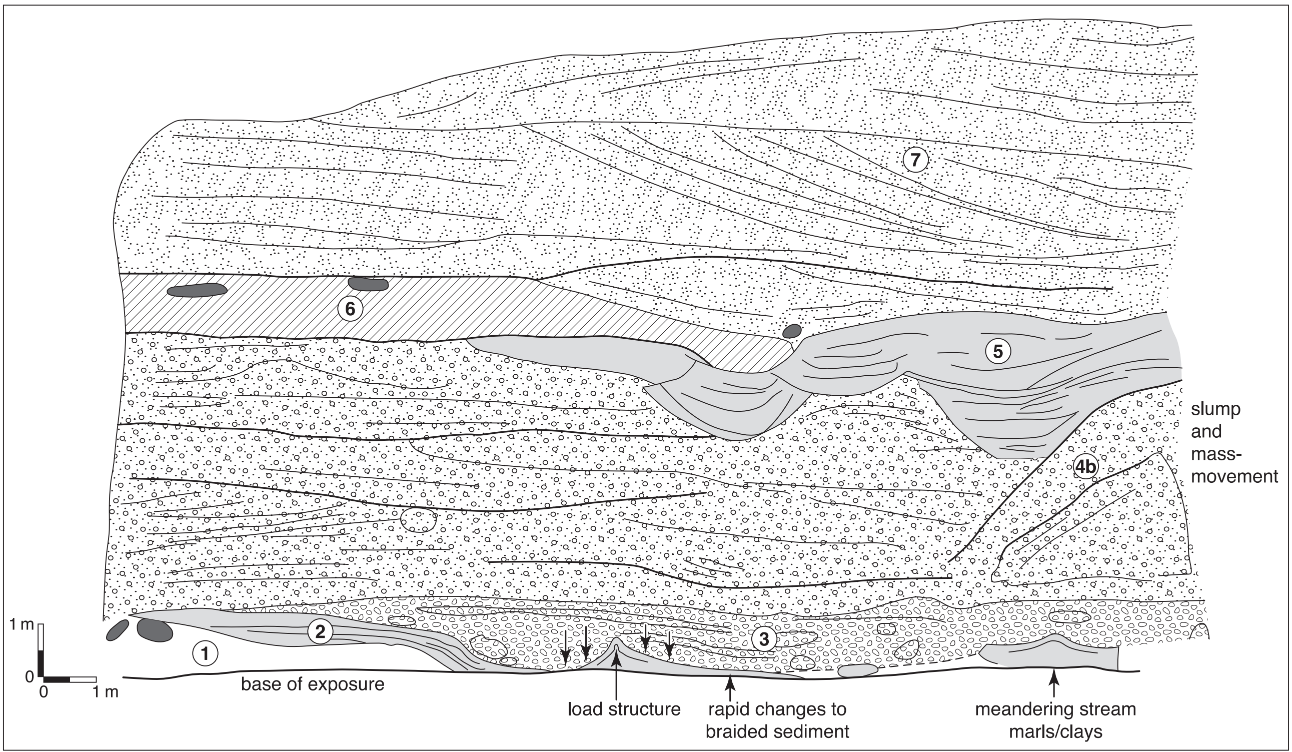


Figure 7.6 *The Faynan Member (Upper Component) stratigraphy at WF5076/WF5510 in the Wadi Ghuwayr, immediately above the braid-plain in the gorge of the Wadi Ghuwayr (partly after Hunt* et al. *2004). Unit 1: 0–1.2 m coarse imbricated gravel; Unit 2: 0–1.0 m fossiliferous marls and clays with leaves of* Quercus ilex *and Cupressaceae, stones of* Olea*, and seeds of Poaceae, Cyperaceae, Chenopodiaceae, Caryophyllaceae, and* Hippuris*, and impression fossils of* Typha *and* Phragmites*, resting conformably on Unit 1 and sometimes deformed by load structures; Unit 3: 0–1.5 m fine sands and very coarse gravels, occasional boulders, trough cross-bedded, erosional, and load-casted contact with Unit 2; Unit 4: 4–4.5 m fine sands and gravels, occasional boulders, large-scale trough cross-bedding, affected by intra-formational mass movement and slump (Unit 4b); Unit 5: 0–2.5 m fine gravels and sandy marls infilling a series of channels incised into Unit 4; Unit 6: 0–1.5 m sands and gravels with small-scale trough cross-bedding; Unit 7: 4–6 m coarse angular gravels, sometimes poorly sorted, occasional sand layers, occasional but distinctive large-scale cross-sets. See also Figure 7.3. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

components are clasts that range in size from rounded gravels to boulders, in general not cemented, the fines (fine sediments) having been winnowed away. Elsewhere a fine silty yellow matrix has been preserved that supports the larger clasts. The clasts themselves show a predominance of sandstone and igneous rocks; some have desert varnish. Many of the loose clasts have, over time, moved downslope, resulting in few places where bedding or any other sedimentary structures are evident. These deposits are in turn overlain unconformably by up to 14 m of late Holocene alluvial fan sediments. The sedimentary structures in the basal Holocene unit are indicative of a meandering single-channelled stream. Impressions of stems and leaves of *Typha* and *Phragmites* were common in the basal unit, together with other poorly-preserved plant macrofossils. A sample of the oak leaves from the basal horizon was submitted for accelerator radiocarbon dating (Beta-119601) but was found to be heavily contaminated with modern carbon, probably through micro-infestation.

These exposures indicate that the Upper Component of the Faynan Member formed in the early to mid Holocene perhaps 8000–7000 years ago (in archaeological terms around the time of the later Pre-Pottery Neolithic and Pottery Neolithic), in a significantly wetter phase than today, one that created a stable floodplain environment characterized by notable biological productivity. Significant perennial streams fed by run-off and groundwater extended from the gorges at least to the location of Tell Wadi Faynan; on occasion they no doubt dried up. These deposits stand in marked contrast to the underlying coarse-grained, braided, fluvial deposits of the late Pleistocene (Chapter 6), on the one hand, and, on the other, to the later Holocene deposits characterized by braided wadi floors and aeolian activity dating from the Bronze Age onwards (Chapter 8).

7.3 Palaeoecology

The pollen assemblages obtained by the project from early to mid Holocene contexts are illustrated as Figures 7.7–7.9 (see also Fig. 3.9, and Table 3.5). They have been divided into three major pollen assemblage biozones that appear to be chronologically and stratigraphically distinct (Hunt *et al*. 2004; Mohamed 1999), and which were illustrated,

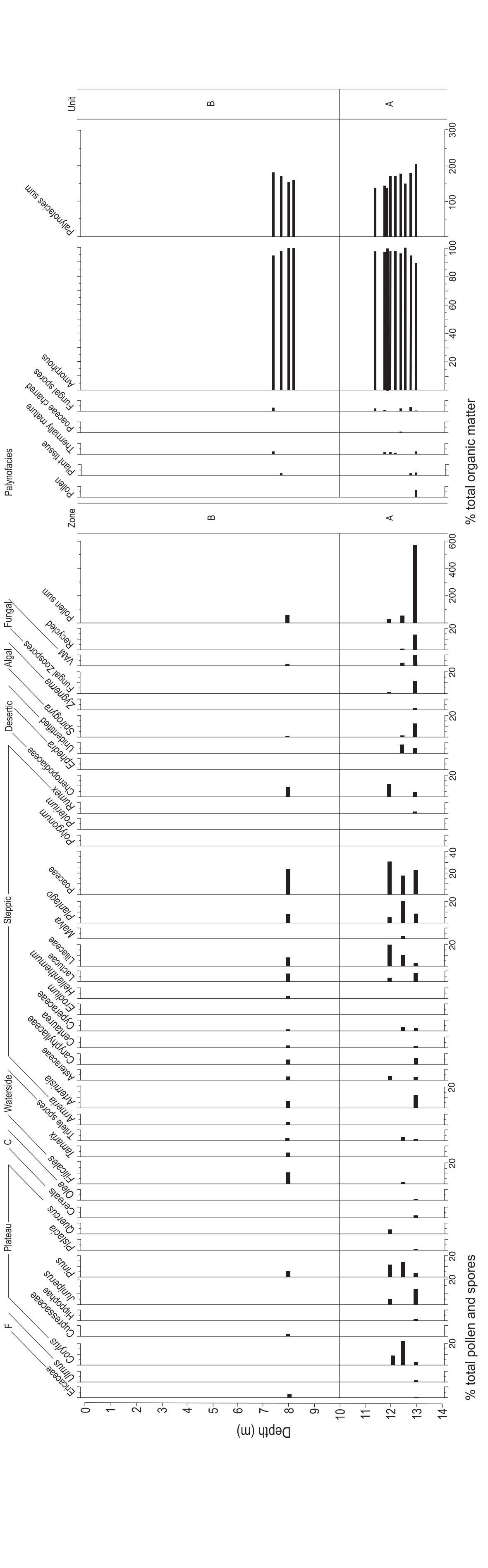


Figure 7.7 *Pollen and palynofacies diagram for site WF5510 in the Wadi Ghuwayr. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2004.)*

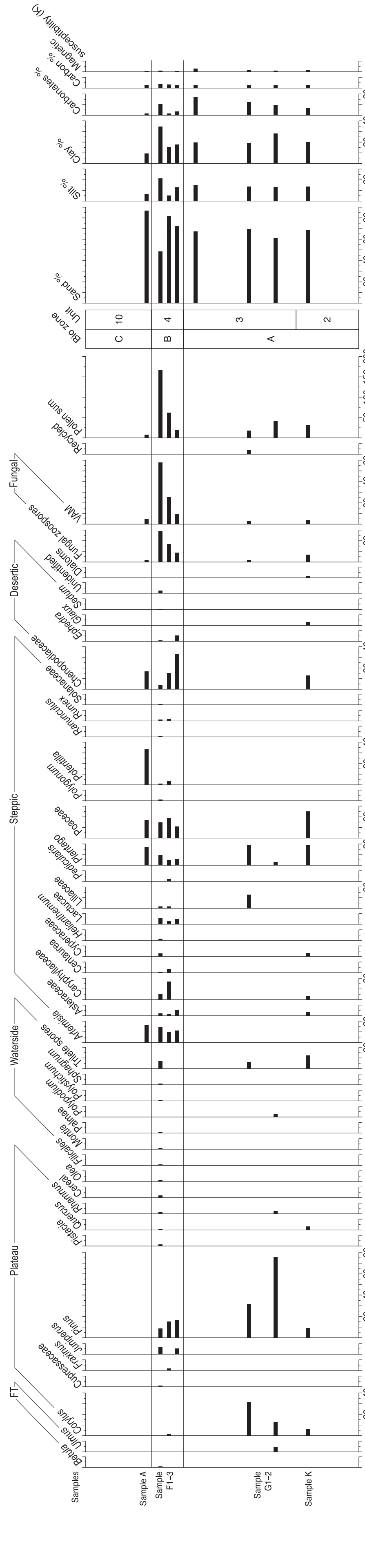


Figure 7.8 *Pollen and palynofacies diagram, together with simple physical properties of sediments, for site WF5015/WF5500 in the Wadi Dana. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2004.)*

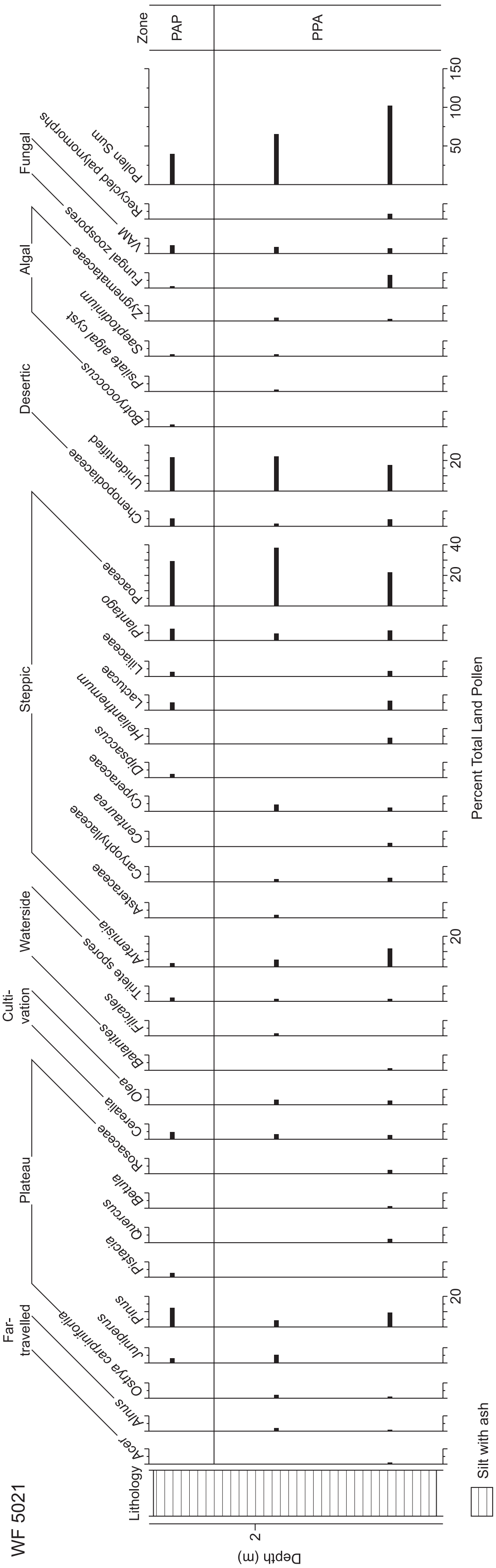


Figure 7.9 *Pollen and palynofacies diagram for site WF5021 (Tell Wadi Faynan) in the Wadi Faynan. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2004.)*

defined, and described in Chapter 3: the Poaceae-*Ostrya carpinifolia-Pinus* assemblage biozone (POP); the Poaceae-*Pinus-Artemisia* assemblage biozone (PPA); and the Poaceae-*Artemisia-Plantago* assemblage biozone (PAP).

The POP biozone predates by an unknown period of time the radiocarbon date of 7240±90 BP or 6353–5919 cal. BC (Beta-111121) at WF5015 in the Wadi Dana, and is also earlier than biozone PPA, which also predates the 7240±90 BP radiocarbon date. Given the observed correlations in the sedimentary record linking dated and undated sediments, the biozone is assumed to date to the (very) early Holocene. In terms of the sequence of archaeological cultures, therefore, it probably correlates with the PPNA and the earlier part of the PPNB.

The high counts for Poaceae, *Plantago,* and other herbaceous species such as *Artemisia*, *Malva*, *Rumex,* Cyperaceae, *Centaurea*, and *Helianthemum* (Fig. 7.8) indicate the development of more steppic landscapes than today (Bottema and Barkoudah 1979; Mohamed 1999), a finding entirely consistent with the geomorphological evidence. The relatively high counts for tree pollen (*Pinus*, *Ostrya carpinofolia*, *Juniperus*, *Quercus*, *Ulmus*) are also dissimilar to the recorded assemblages from all modern vegetation types now present in the southern Levant (Mohamed 1999). The modern flora of the adjacent plateau still has relict stands of *Juniperus* and *Pinus*, but *Ulmus* is completely absent from the region and in the absence of macrofossil evidence, its taphonomy and its position in the ancient landscape are uncertain. *Ostrya carpinifolia, Olea,* and *Quercus* are present today (or in some cases they were in the recent past) in the wetter parts of Southwest Asia, for example in northern Israel, Lebanon, parts of Syria, Iran, and Turkey. It is possible that these taxa were part of a once-richer flora on the plateau, surviving in sheltered valley floor sites in the Wadi Faynan area adjacent to springs and standing water, alongside other waterside species such as the ferns and *Tamarix*. The locations in the Wadis Dana and Ghuwayr were probably near a forest-steppe ecotone. The finds of *Quercus* and *Olea* macrofossils at WF5510 in the Wadi Ghuwayr (Fig. 7.7) are consistent with these genera having lived close to significant watercourses.

The overlying PPA biozone, also predating the radiocarbon date of 7240±90 BP at WF5015 (Fig. 7.8), probably documents landscape conditions around the time of the later PPNB and PPNC. Its high proportions of Poaceae and *Artemisia*, moderate *Plantago*, and frequent occurrence of Caryophyllaceae, Liliaceae, and other typically steppic species all suggest a landscape that was predominantly steppic, a finding corroborated by the occurrence at WF5015 of the terrestrial mollusc *Theba* sp. Whilst it may be tempting to attribute this biogeography to the impacts in

***Figure 7.10** Looking west down the Wadi Faynan over the Pre-Pottery Neolithic A settlement WF16 (marked by the white Landrover). (Photograph: Bill Finlayson and Steve Mithen, reproduced by kind permission.)*

the gorge environment of the cool and notably more arid climate attributed to the local effects of the region-wide 8.2 kya climatic event (Weninger *et al*. 2006), the limited nature of the evidence currently available suggests that such a correlation would be premature. The high proportions of *Pinus* and the frequent occurrence of *Juniperus*, *Ostrya carpinifolia*, *Olea, Pistacia,* and *Quercus* indicate the presence within the catchment, and perhaps on the plateau, of limited areas of Mediterranean woodland of modern type. The ferns, reeds, palms, and *Balanites* are evidence of waterside vegetation, and the aquatic molluscs *Melanopsis* and *Lymnaea* and the aquatic diatoms all indicate perennial streams and adjacent wetland. The increase through the biozone of Chenopodiaceae and *Ephedra* is evidence for the development of areas of very dry, possibly disturbed, ground, perhaps (on the evidence of the cereal pollen) reflecting the activities of farmers.

The age of the PAP biozone is indicated by the date of 7240±90 BP or 6353–5919 cal. BC at WF5015 (Beta-111121) and, for the top of the biozone, the dates at Tell Wadi Faynan (WF5021) of 6408±114 years BP or 5612–5076 cal. BC (HD-10567) and 6370±40 years BP or 5471–5231 cal. BC (HD-12335) associated with the development of the fluvial-stream bank infill sequence. In terms of the archaeological sequence, therefore, it can be correlated approximately with the Pottery Neolithic. The pollen and macrofossils (Fig. 7.9) indicate the continuation of a (quite rich) steppe-land, with perennial rivers, local stands of *Quercus* and other trees, and small-scale cereal cultivation. Such a landscape contrasted strikingly with the relatively treeless steppe that had developed by the mid Holocene *c*.6000 years ago (Chapter 8).

7.4 Initial Neolithic settlement, *c.*9500–8500 BC

The PPNA in the southern Levant is characterized by a stone industry transitional between Epipalaeolithic and full Neolithic forms that includes the presence of 'type fossils' such as El-Khiam stone points, Hagdud truncations, and unidirectional blades and bladelet cores. A chronological subdivision of the PPNA (a Khiamian phase followed by a Sultanian phase) has been proposed by some authors, but the undoubted variability within PPNA lithic assemblages is more likely to be technological and/or the result of variability in the activities carried out at particular locations. Though the PPNA is known from almost 20 sites in the region, in Jordan most information about the character of PPNA settlement comes from four sites: Sabra 1 near Petra (Gebel 1988), Iraq ad-Dubb in the Jordan valley, Dhra' on the eastern shore of the Dead Sea (Bennett 1980; Finlayson *et al*. 2003), and the most extensively investigated, WF16 in Wadi Faynan (Finlayson and Mithen 2007; Mithen and Finlayson 2000; Mithen *et al.* 2000).

The WF16 occupation was focused on a low knoll on the southern side of the Wadi Ghuwayr *c*.200 metres to the west of the junction with the main escarpment uplands and a few hundred metres up from the confluences with the Wadis Shayqar and Dana (Figs 7.10, 7.13). The settlement zone extended to the adjacent knoll, WF328. An extensive suite of radiocarbon dates (Appendix 1) indicates that the primary occupation was in the opening centuries of the Holocene, from *c*.9600 to *c*.8200 BC.

Small-scale excavations revealed, for the first phase of settlement, a *c*.3.5 m-diameter oval structure probably built of mud (*pisé*), with a mud-plaster floor laid on top of a burial of at least one individual (Fig. 7.11). At a later

Figure 7.11 *One of the structures at WF16 (looking west). A human burial had been placed within the dwelling at its eastern end (the foreground). (Photograph: Bill Finlayson and Steve Mithen, reproduced by kind permission.)*

stage in the life of the building the burial was re-opened and disturbed by further burials. It is assumed that such structures probably supported pitched roofs made of vegetation or hides. Other more substantial structures were built on different alignments, with dry-stone walling or *pisé* walls (the latter surviving to at least a metre in height), simple stone hearths, and pitched or flat roofs made of reeds. A rather similar mix of structures has been found at Dhra' (Finlayson *et al.* 2003; Kuijt and Finlayson 2001; Rollefson 2001), the Iraq ad-Dubb cave (Kuijt *et al.* 1991), and Netiv Hagdud in the Negev (Bar-Yosef and Gopher 1997). Geophysical survey and test-trenching indicated that there may have been 20–30 structures on the WF16 and WF328 knolls, the stratigraphic evidence and the pattern of refuse disposal suggesting that, as in the case of other PPNA sites, they probably reflect repeated short-duration visits by small groups rather than substantial long-lived occupation. Differences in the composition of the refuse found in the structures and in pits cut into the sub-soil hint at specialized activities in different parts of the site such as food preparation (grinding plants, butchering animals), tool and ornament manufacture (microwear studies suggest that El-Khiam points may have been used as perforators in bead manufacture), and wood- and hide-working. It is possible that the larger structures were dwellings used by different family groups as shelters and the smaller structures reserved for specific tasks.

The people visiting WF16 were hunting a wide range of game – the faunal list includes *Bos*, an equid, fox, wild cat, hare, tortoise, reptiles, and birds (buzzards, mallard, partridge) – but wild goats and ibex appear to have been their primary meat source, rather than gazelle as in the case of other PPNA sites in the southern Levant. The preferred habitats for the goats and ibex are assumed to have been the rugged uplands east of the settlement (Fig. 7.13), rather than the main basin of the Wadi Faynan to the west, which would have been much more suitable for gazelle. There has been a long-running debate about whether PPNA people in the Levant had started to practise herding as well as hunting, the weight of the regional evidence currently available suggesting that they were not, but in the case of WF16, the excavators believe that the small size of the *Capra* bones, the high frequency of sub-adult animals, and the presence of complete carcasses being butchered *in situ* at the site, are in combination suggestive of herd management. There is no evidence for the stalling of animals immediately in and around the structures (no dung deposits in the refuse, for example), but linear features detected by geophysical survey (Finlayson and Mithen 2007: 452, 454) might be evidence for the ditches or fences of animal pens.

A range of plant foods was processed at the site on the evidence of a variety of cup-hole mortars, pestles, and heavy concave grinding stones, including a cup-hole mortar embedded in the floor of a structure. Such equipment of course need not have been used exclusively for preparing food, but a variety of cereals, pulses, fruits, and seeds was preserved as microfossils. The fact that phytoliths found at the site include many of reeds and grasses, but not those of cereals (which survive equally well), suggests that rather limited use was made of cereals. The simplicity of the food-preparation evidence chimes with that of other PPNA sites, suggesting that cultural practices surrounding meals were 'undramatic and low-key' (Wright 2000: 101), in striking comparison with the evidence for elaborate food rituals at many Natufian sites. Whether the people camping at WF16 were consciously cultivating cereals is unclear, but on the present evidence it appears more likely that they were plant collectors rather than plant cultivators. Mithen *et al*. (2007b) argue that the overlap between the plant species found at WF16 and those growing today at Hamman Adethni in the Wadi Ghuwayr (Fig. 2.8) suggest that this oasis of riverine woodland provides an analogue for the type of woodland exploited by the WF16 inhabitants, an hypothesis that, if correct, implies that 'such woodland would have provided an abundance of plant resources for food, fuel, artefacts, construction and medicines, along with other uses including hunting poisons and bedding' (Mithen *et al*. 2007b: 68).

The ambiguity of the WF16 subsistence data, regarding whether these people were herders as well as hunters, and plant cultivators as well as plant collectors, is rather typical of the Levantine PPNA archaeological record as a whole, for which probably the most striking feature is that no clear subsistence pattern can be observed (Barker 2006; Kuijt 1994). Whilst goats may have been herded at WF16, the consensus view is that the gazelle dominating most PPNA faunal assemblages were hunted rather than herded, whilst the pigs at Çayönü Tepesi in Turkey seem to have been in some kind of intermediary wild-domestic relationship, perhaps with piglets being taken from local wild populations (Ervynck *et al*. 2001). Similarly, various combinations of morphologically-domesticated cereals and legumes have been identified at Iraq ad-Dubb, Jericho, Tell Aswad in Syria, and Çayönü Tepesi in Turkey, but the einkorn, barley, and legumes at Mureybit in Syria were morphologically wild (Colledge 1998; van Zeist and Bakker-Heeres 1982; 1984), and at Netiv Hagdud some of the barley had a tough rachis, taken to be an indicator of domestication, but most had the brittle rachis of the wild varieties (Kislev 1997). Dhra' is interpreted as a seasonal site used for cultivating plants (Edwards *et al.* 2001), Sabra as a seasonal hunting camp. On balance it seems likely that most PPNA people in the Levant lived as foragers, but that some of them, whilst remaining heavily dependent on foraging, were also beginning to cultivate cereals and pulses. Whether this was the case at WF16 is unclear, but certainly wherever there is convincing evidence for tillage, PPNA sites are invariably near springs and beside patches of alluvial soil, just like WF16.

Whatever the precise nature of the subsistence base, WF16 is also typical of other PPNA sites in having evidence for symbolic and ideological activities, in this case including a skull carefully placed on a 'pillow stone', non-utilitarian stone artefacts, decorated bone artefacts, sea shells deriving from the Mediterranean or Red Sea, figurines in human or animal shape, and various phallus-shaped objects. On the evidence of the 'world views' of recent and modern hunter-gatherers we should expect that the symbolic and functional worlds of PPNA communities were intimately inter-connected, with activities such as hunting, food preparation, and meal-taking imbued with symbolic significance. The large numbers of raptor, especially buzzard, bones might mean that these birds also had some kind of special place in PPNA ideologies. Kuijt (1994) argues that rituals were organized at the community level, perhaps coordinated by special-status individuals.

Seasonal indicators derived from the animals and plants represented at WF16 suggest that humans were present on the site in a variety of seasons, but of course this could represent a palimpsest of short visits. However, microstratigraphic analysis indicates continuous activity within many of the structures, with episodes of occupation punctuated by episodes of refuse disposal. It has been postulated that cleaning floors and defining particular zones for the disposal of rubbish at other PPNA sites might have had symbolic significance in the development of new concepts of the home within the context of the increasing if piecemeal engagement with food production (Watkins *et al*. 1989). Combining the evidence of seasonal indicators, the investment in architecture, and the structured nature of refuse disposal, Finlayson and Mithen (2007: 484) conclude that there is a substantial case for sedentism at WF16, and for the site to be legitimately termed a village, though on balance they suggest that the subsistence evidence indicates that most people using the site were hunter-collectors. Cereal pollen identified in the POP biozone in the pollen diagram from WF5015 in the Wadi Dana (Fig. 7.8), likely to be contemporary with the occupation at WF16, cannot help resolve this question, because it might indicate cereal cultivation by early farmers, or the presence of the wild cereals that still grow naturally in the area, or both.

On the evidence of this biozone, the Faynan landscape was certainly more steppic than today at the beginning of the Holocene, with pine, oak, hop-hornbeam, olive, and juniper all well-represented. The plateau was also much more wooded than today, and there were isolated stands of trees in the gorges and wadis leading down and out from the plateau, with ferns and tamarisk growing by springs and standing water. If plant cultivation was practised by the WF16 inhabitants, we can presume that it was by the groundwater springs on the wadi floor below the site. Herding goats today is mainly in the uplands east of the site, but this is partly related to the abundance of feed and partly to land ownership. If people at WF16 kept goats, they might have taken them east up the escarpment to the plateau, or west onto the main floodplain according to the availability and quality of grazing. Hunting goats and ibex would presumably have been mainly in the broken country of the escarpment edge. The wild cattle and equids would have been found on the gentler terrain to the west (Fig. 2.9). The well-watered vegetation along the wadi floor, both in the hills and out on the main channel, was presumably where people hunted birds like mallard and partridge, whether with bows and arrows or traps. The firewood found at the site fits this pattern of movement, most of it (oak, juniper) likely to be reasonably local but some of it, such as pine, probably deriving from the plateau escarpment if not the plateau itself.

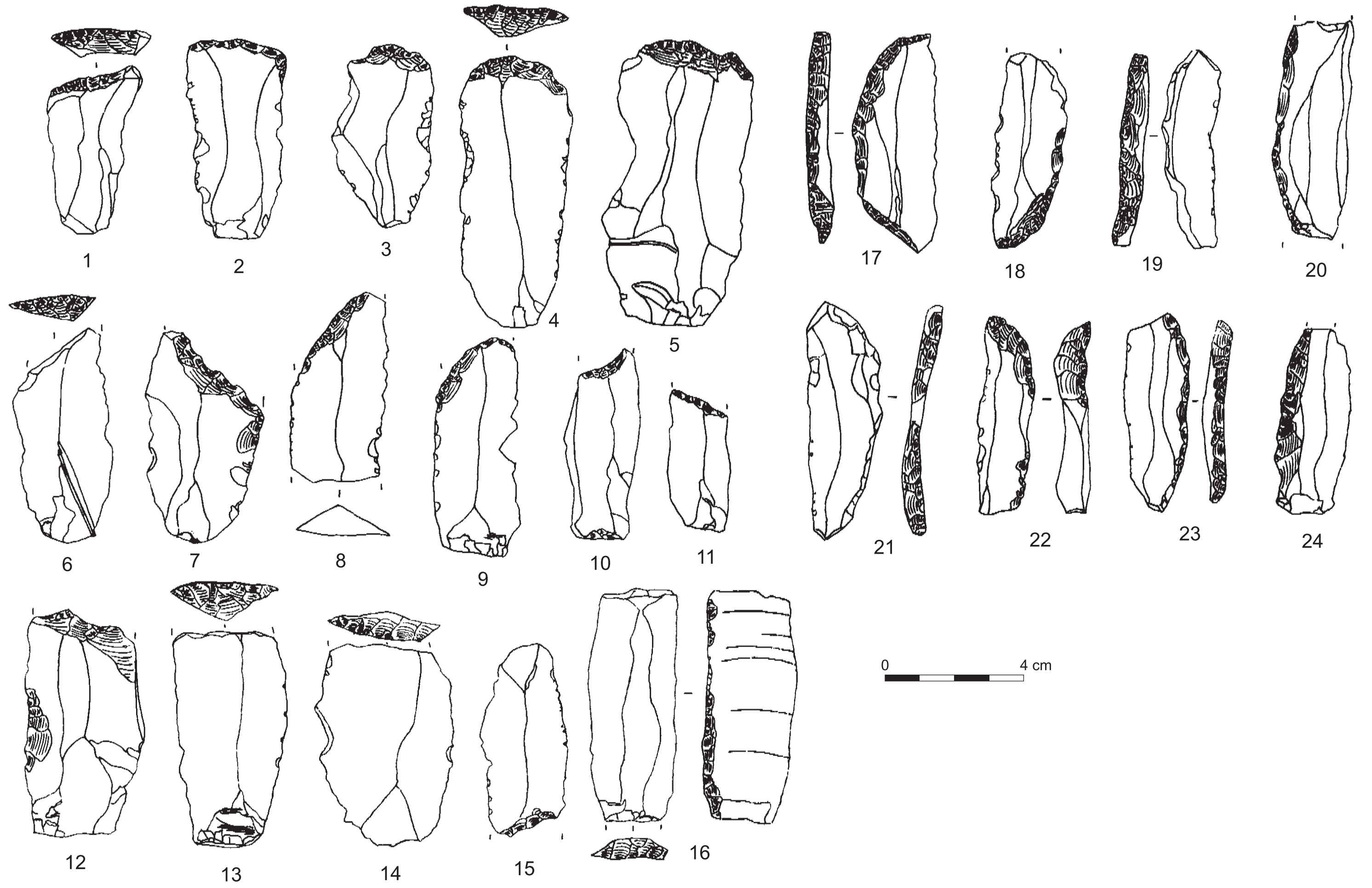


Figure 7.12 *Early/mid Holocene lithic artefacts from the Wadi Faynan: 1) endscraper, WF4.5.46A; 2) endscraper, WF70; 3) endscraper, WF615; 4) endscraper, WF643; 5) endscraper, WF615; 6) obliquely truncated blade, WF1232; 7) obliquely truncated blade, WF1303; 8) obliquely truncated blade, WF161; 9) obliquely truncated blade/endscraper, WF161; 10) bitruncated blade, WF406.2; 11) obliquely truncated blade, WF1331; 12) truncated blade, WF494; 13) truncated blade, WF4.20.7; 14) inversely truncated blade, WF618; 15) truncated blade, WF1525; 16) truncated blade/knife, WF4.7.8; 17) arch-backed blade, WF628; 18) arch-backed blade, WF4.15.20; 19) arch-backed blade, WF4.15.41; 20) backed blade, WF415; 21) arch-backed blade, WF4.9.15; 22) partially backed blade, WF4.7.3; 23) sickle, WF4.5.62; 24) backed blade, WF4.15.47. (Drawings: Tim Reynolds.)*

Whilst the survey conducted by the Dana-Faynan-Ghuwayr Early Prehistory Project (Mithen *et al*. 2007a) did not locate any significant PPNA material apart from within the environs of WF16, our own survey contributes a little further information to our understanding of habitation in the valley in the PPNA period. Our surface collections (Appendix 4; Figs 7.2, 7.12) provide hints of the daily journeys people would have been making out into the Faynan basin from their principal camp-sites at locations such as WF16, or of transits across the valley by people moving between preferred camping locations beyond our study area. The likeliest candidates are the lithic collections from WF516, WF799, WF792, WF792E, and WF486, which yielded a number of awls, borers, and piercers. It may be significant that, with the exception of WF516, these sites are all on the northern side of the study area, especially in the open country to the north of the line of small hills on the northern edge of the main Faynan channel. They contrast with the location of WF16, with which they may be contemporary, and are distant from it. It may be that the greater investment in 'place' seen at WF16 in terms of built architecture, burials, and dug features, required a corresponding 'domestic hinterland' where stock could be grazed and crops maintained. The presence of such a hinterland would have required the occupants to make more distant and possibly seasonal trips to obtain access to additional grazing and other resources. The absence of projectile points in the collections at our northern sites suggests that the latter are unlikely to represent the activities of small hunting bands, whereas the borers, awls, and piercers imply that maintenance tasks were being undertaken at these locations. The presence and absence of particular tool types might reflect our sampling procedures but, given the consistency of the patterning, the argument for these sites representing maintenance sites (possibly used by people watching grazing herds?) is strong. The location of the sites on gentle slopes overlooking open ground would also support this interpretation.

Site WF516 lies on the break of slope of a small range of hills on the southern side of the Wadi Faynan (on the edge of the WF4 field system, which would not have been present at the time, if course). This site does not have any cores, indicating that (allowing for biases from sampling procedures) knapping was not a significant component of behaviour here. The location would still have provided access to a significant amount of grazing land. It may be that the main wadi area was avoided, but it is difficult to take this argument further given the problems with erosion and burial in the area of the WF4 field system.

7.5 Later Pre-Pottery Neolithic settlement, *c*.8500–6500 BC

Whatever the complexities of PPNA subsistence, the development of the PPNB a thousand years into the Holocene marked the emergence of what can be legitimately be termed agricultural villages across a very large area, from the eastern Mediterranean to the foothills of the Zagros and from the southern Levant to the Anatolian plateau (Barker 2006). Most PPNB sites in the southern Levant (as elsewhere in Southwest Asia) are several hectares in size, and the largest sites such as Jericho (Kenyon 1981), Beidha (Kirkbride 1966), and 'Ain Ghazal (Simmons *et al*. 1988) are thought to have had communities numbering in the several hundreds. The PPNB phase lasted for about 1500 years, and during that time there is evidence that settlement forms in the region developed from honeycomb arrangements of small round buildings to substantial rectangular structures made of *pisé*, possibly divided into a lower storey for working and storage and an upper storey for living (Byrd 1994). Although certain buildings appear to have been set aside for public – probably ceremonial or ritual – use, it would be misleading to imagine that people divided their lives into domestic and religious domains on the evidence of the structured and ritually-charged use of both 'domestic' and 'public' space revealed by excavations at Çatalhöyük (Hodder 2005). Storage pits, silos, and hearths are common, invariably within the house, indicating that the household was the primary unit of production and consumption. In the earlier centuries of the PPNB, milling and cooking were mostly undertaken in the visible porch areas of houses or in community space such as courtyards, suggesting that different households interacted during food preparation, whereas meal consumption was a private affair; the marked elaboration in the equipment used compared with that of the PPNA indicates that dining aesthetics and social rules served to reinforce the cohesion of the residential kin group (Wright 2000: 122). In the later centuries of the PPNB, food preparation was increasingly focused on kitchens within houses, and there are signs of the intensified production of prepared foods, for larger residential groups. Stress markers on skeletons indicate that most of the hard work involved in food preparation was done by women, compared with a greater sharing of this labour in Natufian society (Eshed *et al*. 2004).

In terms of lithic traditions, the PPNB was characterized by a move to the production of naviform bi-directional cores (that is, boat-shaped cores from which blades were removed in both directions), alongside an expedient tool industry and an array of grinding equipment. Artefacts included projectile points, burins, and sickle blades with silica gloss on their cutting surface. The PPNB has been divided into three phases (early, middle, and late) on the basis of the lithic industries, but in the southern Levant at least it is unclear the extent to which these are valid distinctions or whether differences in part reflect spatial differences in what people were doing rather than chronological change. However, there does seem to have been a trend to greater refinement in the projectile points, and the sickles gave way to a knife-form with use wear on it from harvesting rather than silica gloss. Axes, picks, adzes, and chisels appear to have been rather rare at the Jordanian sites compared with at sites in the Negev west of the Wadi 'Arabah. The organic materials that survived in the desic-

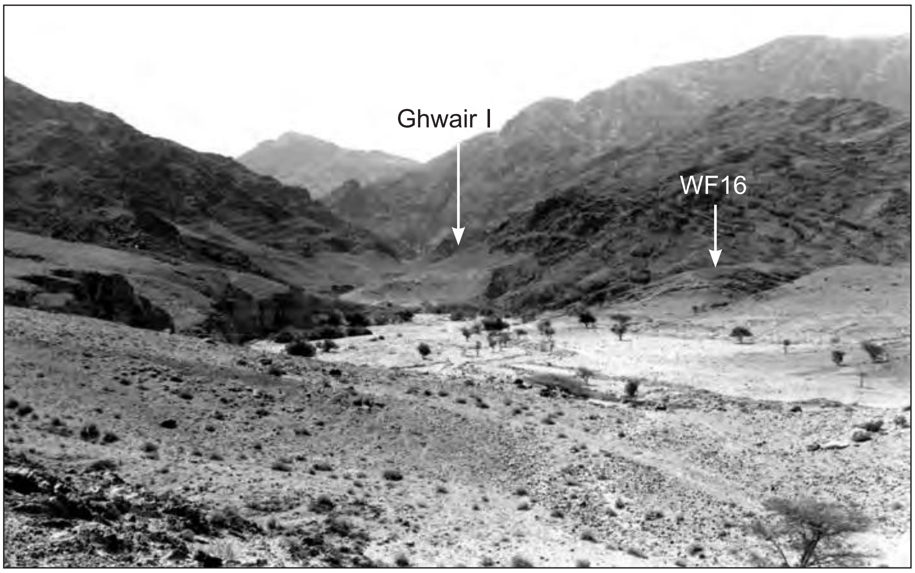


Figure 7.13 Looking east up the Wadi Ghuwayr to the PPNB site Ghwair I, located on the last ridge of the escarpment hills overlooking the main Faynan valley. (Photograph: Graeme Barker.)

Figure 7.14 One of the structures of the Ghwair I PPNB settlement, looking south. (Photograph: Graeme Barker.)

cated conditions of the Nahal Hamar cave west of the Dead Sea – mats, baskets, vessels, nets, quivers, and fragments of linen – are a reminder of how much material culture we are missing at most PPNB sites (Schick 1988).

One significant PPNB habitation is known in the Wadi Faynan, Ghwair I, a few hundred metres east of WF16 (Simmons and al-Najjar 1996; Simmons and Najjar 2006; Figs 7.2, 7.13, 7.14). The site was located on a gravel fan of the Hamman Beds that forms more or less the last line of the plateau escarpment hills, immediately overlooking the point where the Wadi Ghuwayr exits from the hills out onto the main Faynan wadi-floor and braid-plain. Twenty-two radiocarbon determinations date the site to *c.*9700/8500 BP, or *c.*11,500–9700 cal. BP, though the excavators place the primary occupation in the period *c.*8900–8400 BP, in the middle phase of the PPNB. The architecture of the site compared with that of WF16 is a good example of the transformation in settlement complexity and the built environment represented by the PPNB. Three phases of building were identified in the life of the settlement, beginning with a series of substantial cobble and boulder-built structures each some 10 × 10 m in size. Over time these were sub-divided into smaller square rooms, their walls plastered and decorated with geometric designs. Later on, the settlement developed a more honeycomb pattern with two-storey buildings and storage cells grouped around streets and stairways. The excavations recovered a very large lithic assemblage (*c*.100,000 pieces) including tanged points, long blades, scrapers, burins, and sickles, as well as hundreds of querns, slabs, and handstones.

As with sites such as Beidha (Byrd 1994) and ‘Ain Ghazal (Rollefson 1997), the evidence suggests that the Ghwair I settlement witnessed increasing intensity of use during its history of occupation and that its community became more complex and organized to cope with this, though a mixture of residential, ritual, and public spaces appears to have characterized the settlement throughout its history. Burials included an infant interred in a pit under one of the plastered floors, interpreted as a sacrifice or an individual of an important family (Simmons and Najjar 2006: 90). The architectural sequence fits with the evidence for social elaboration amongst PPNB communities throughout the southern Levant, other signatures including the elaboration of personal ornament on the one hand and of public ritual on the other (Wright and Garrard 2003), the growing social importance of food (Wright 2000), increasing standardization in artefact production hinting at the beginnings of craft specialization, and expanding systems of regional and inter-regional exchange involving obsidian and marine shells. Byrd (1994) concludes that, whilst individual households were increasingly autonomous in terms of production and storage, PPNB society was characterized by increasing differentiation between households in terms of access to resources, and hence the need for increasingly elaborate mechanisms (ideological as well as economic) to retain community bonds.

There is widespread evidence throughout Southwest Asia that PPNB villages were sustained by regimes of mixed farming. The botanical residues commonly include morphologically-domestic cultivars, and not just the ‘founder’ crops einkorn, emmer, and two-row barley but also free-threshing bread and hard wheats, naked six-row barley, and a variety of pulses (lentil, vetch, pea, chickpea). Heavier-duty sickles were used compared with Natufian and PPNA examples (Unger-Hamilton 1989), presumably because the ears of the cereals needed to be cleanly cut as otherwise the seeds would fall to the ground from the now-brittle rachis. Crop cultivation was probably increasingly integrated with sheep and goat herding; morphological and biometric signatures of domestication (in any case ambiguous to interpret) are not uniformly apparent in many faunal samples from the southern Levant (Rollefson 2001: 75), but high frequencies of pathologies in the foot bones (phalanges) of the goats at ‘Ain Ghazal may be an indicator of stalling them (Crabtree 1993). In the case of Ghwair I, only preliminary information has been published on the excavations, but a full suite of cereals and legumes was being grown at the site (emmer, einkorn, barley, pea); wild foods collected included fig, pistachio, caper, and date palm (one sample only, the earliest so far found in the region); starch residues on milling equipment indicate the grinding of starchy foods including both seeds and roots or tubers; sheep and goats (the latter especially) dominated the livestock; and gazelle were hunted (Simmons and Najjar 2006: 91). At the regional scale the evidence suggests that goats were herded first, with the sheep/goat herding combination that was to prove so well adapted to Southwest Asian environments developing at sites such as ‘Ain Ghazal by the end of the PPNB (Horwitz and Ducos 1998; Köhler-Rollefson 1997; Wasse 1997). Domestic cattle and pigs start to appear at some sites in the region in the late PPNB. Wild plants and game no doubt remained important sources of food for many if not most PPNB communities, as appears to have been the case at Ghwair I.

Another PPNB settlement was located at the end of the Wadi Faynan/Fidan system, at Jabal Hamrat Fidan (Wadi Fidan 1), where excavations discovered a sequence of archaeological layers beginning with the PPNB. It may well have been a site of comparable scale to Ghwair I, but little has been published so far. Certainly its location is rather similar in that it sits in an ecotonal position, in this case at the junction of the Fidan and ‘Arabah channels (Fig. 7.2).

The geomorphological evidence described earlier in this chapter correlates with many regional indicators that the climate of the southern Levant through the PPNB period (especially the later part) was significantly wetter than today, the upper component of the Faynan Member being indicative of a stable wet stream-bank environment traversed by more or less perennial streams. It is difficult to locate the periods of occupation of the two PPNB settlements within a vegetation regime or regimes given that the boundary between the POP and PPA pollen biozones probably falls somewhere within the PPNB period, but the occupation sequence of the Wadi Ghuwayr settlement is placed within the latter part of the PPNB period by the excavators, so is more likely to relate to the PPA pollen biozone. This would imply that the landscape of the main Faynan/Fidan system was increasingly steppic under the influence of a changing climate compared with previously. It was interspersed with limited areas of Mediterranean woodland, with ferns and palms growing beside the streams and pools. On the evidence of the pollen record at Beidha, the plateau landscape at this time was positively lush, with permanent springs and pools (Fish 1989; see also Hunt *et al*. 2007b and Chapter 3, §3.4.2).

Within this environment PPNB farmers, as in many parts of Southwest Asia, deliberately selected ecotonal situations for their primary settlements: stream-side locations with direct access to adjacent patches of well-watered alluvial soil for their crops, and with easy access to different qualities of grazing and browse for their animals. Ghwair I was at the junction between the escarpment hills to the east and the main Faynan channel to the west, and Wadi Fidan 1 was at the junction between the hills bordering the Wadi Fidan to the east and the low-lying channel of the Wadi ‘Arabah to the west. Both locations were also key strategic points in terms of natural communication routes, between the plateau and the Faynan basin in the case of Ghwair I and up and down the Wadi 'Arabah (and across to the Negev) in the case of Wadi Fidan 1.

The PPA biozone pollen records were assembled from both WF5015 in the enclosed Wadi Dana and from WF5021 near Tell Wadi Faynan in the open Faynan basin, both away from the two known significant PPNB settlements. The fact that both have indicators of dry disturbed ground and cereal pollen likely to derive from arable fields implies that farming was well established in the Wadi Faynan in the PPNB. It is an open question, though, as to how the intervening landscape between the two PPNB settlements was organized and exploited. The limitations of the survey data restrict our ability to ascertain whether the activities of the population from the PPNB settlements were centred around their habitations, or were spread further afield across the terrace surfaces and wadi floors, or were nucleated into specific sub-centres within the area, still less to identify subsistence practices such as cultivation, herding, or hunting. Potential PPNB lithic material (not subdivided into Early, Middle, or Late) might be pieces from WF660/WF1367, WF792, and WF23.B (Appendix 4). The first two sites follow the pattern of the PPNA, one (WF792) also had PPNA material, and they probably represent a continuation of the same pattern of seasonal movement. WF23.B, though, is on the northern side of the main wadi but close to the break of slope of the small range of hills on its northern edge, a location mirroring that of the PPNA site WF516 on the southern side (see above). However, unlike at WF516, cores are present at these localities, showing that an amount of knapping took place. The collections lack hunting equipment. The sites are further from the main PPNB settlement Ghwair I (WG1) than the PPNA sites are from WF16. The large amount of grinding equipment at WG1 suggests extensive cereal exploitation/production, so it may be that a more extensive area of cultivation around it was responsible for the greater distance of the grazing areas indicated by the surface collections we found.

The final phase of the Pre-Pottery Neolithic, PPNC, is generally dated in the region to about 7000–6500 BC, but it has been found at very few sites in the southern Levant, in Jordan principally at 'Ain Ghazal. The PPNC lithic assemblage at this site is very different from that of the PPNB. Naviform technology disappears, and with it the tools based upon its products, projectile points are smaller, and retouch forms more invasive and unifacial. Burins are present and truncation burins are particularly frequent in this class. Bifacially retouched and tabular knives are a feature and scraper forms change from mostly side scrapers to transverse types. Retouched tools become shorter, wider, and thicker, reflecting the move from blade to flake blank selection. Some of these changes might be linked to changes in cultivation practice, but several look more likely to be related to a decline in the importance of hunting, and in particular a move towards bow and arrow hunting rather than using a spear thrower. Interestingly the main game represented at 'Ain Ghazal are gazelle and onager, animals of the steppe desert. It has been suggested on the basis of the changes in the faunal record that pastoral nomadism emerged during this phase (Köhler-Rollefson 1992; Rollefson and Köhler-Rollefson 1993), with an increase in secondary burials (burials where the body had been buried elsewhere first) interpreted as further possible evidence for pastoralism, with deceased seasonal herders being returned to their main home complexes. However, the fact that pigs were being kept by the community (and pig bones were placed as offerings with the burials) suggests that only part of the group moved off with the flocks and herds on a seasonal basis.

The dramatic decline in the regional settlement record from the PPNB to PPNC phases may in part be exaggerated: it is possible that some communities continued to retain PPNB lithic technologies along with the associated lifestyles. Nevertheless, there does appear to have been a significant contraction in the numbers of settlements, and there is some evidence that it coincided with a climatic oscillation towards aridity (Donahue *et al*. 1987; Rollefson and Köhler-Rollefson 1992; Simmons 1997). We found no clear evidence for such a distinctive event at this time in our own studies, but as noted earlier, small-scale or moderate changes in the amount or seasonality of precipitation, or limited degradation caused by human activities, are unlikely to register in the kind of coarse-grained geomorphological and palaeoecological data available to us at the particular sites we found that were of the appropriate age.

Bar-Yosef (2002) suggested that many PPNB communities abandoned the region entirely and shifted instead to the Nile valley, but there is little convincing evidence in the archaeological record of the latter to suggest such an occurrence (Barker 2006). Others have argued that people developed more mobile lifeways reliant on transhumant or nomadic pastoralism, though the argument largely rests on the absence of settlement evidence following the PPNB rather than evidence of changes in subsistence data or shifting settlement forms. It is noteworthy in this respect that mobile hunter-gatherers living in what are now the desert regions of Jordan, Israel, and the Egyptian Sinai during the PPNB and PPNC periods built small multi-room habitation structures (Betts 1998a), so a 'structure-less' pastoral archaeology is difficult to explain. Rollefson (1998: 114) concluded that an increasingly arid climate would have precipitated a process of abandonment of marginal areas in favour of better-watered locations: a process of cultural degradation 'slowly but steadily throttled smaller and ecologically sensitive settlements, forcing a relocation of the affected populations, in part at least to farming villages in more tractable environmental circumstances'. Oddly, though, occupation ceased at this time at Jericho and Beidha, both sites well located for water, and it is also striking that occupation may have continued at Wadi Fidan 1 (given the stratigraphic evidence for some form of habitation continuity) but ceased at Ghwair I, probably the most favoured location for habitation in the Faynan/Fidan catchment in terms of access to water, arable soil, and pasture. It is conceivable that the population from Ghwair I joined with that of Wadi Fidan 1, but we can do no more than speculate, and unfortunately our own surface collections cannot contribute to the debate. On balance, though, it would appear that there was a definite decline in the use made of the Faynan region at this time.

7.6 Later Neolithic settlement

The introduction of fired clay pottery was a significant transformation in Neolithic material culture, though some PPNB communities had started to manufacture storage containers from gypsum and lime plaster (Moore 1995). As well as representing a powerful new medium for social display and cultural 'messaging', pottery transformed food technologies, allowing people not just to roast food (as before, on heated stones) but to mix different foods in casserole-type dishes, to make softer more digestible foods, and to ferment liquids (Wright 2000). Other components of the material culture of the Pottery Neolithic, however, are regarded as direct developments from the PPNC. The Yarmoukian is the best defined Pottery Neolithic culture in Jordan and is seen as a direct development from the PPNC. Lithic technology shows continuity with the PPNC but with an increase in completely bifacial retouch. Burins are still dominated by truncation burins, whilst sickle blades are made on blade segments that are backed and truncated. The cutting edge of these sickles is often denticulated. The Pottery Neolithic is regarded as a period of developed agriculture in Jordan as elsewhere in the Levant, with the cultivation of a full range of cereals and legumes integrated with the husbandry of sheep, goats, cattle, and pigs, with some evidence for the beginnings of the systematic exploitation of the first three not just for their meat but also for the 'secondary products' of the live animal such as milk. Dung deposits in the central Negev dated to *c*.6000 BC provide unequivocal evidence of the penning of sheep and goats by this time, and hint at the development of specialized pastoralism on the margins of the more settled parts of the southern Levant (Rosen *et al*. 2005).

The principal evidence for the character of settlement in the Wadi Faynan during the Pottery Neolithic is from the trial excavations undertaken at Tell Wadi Faynan in 1987 and 1988 (al-Najjar *et al*. 1990). On the evidence of the radiocarbon dates here, the occupation began in the Pottery Neolithic (6408±114 years BP or 5612–5076 cal. BC: HD-10567; 6370±40 years BP or 5471–5231 cal. BC: HD-12335; 6200±40 BP, or 5296–5045 cal. BC at WF5021: Beta-205964) and continued into the Chalcolithic (5740±35 years BP or 4688–4499 cal. BC: HD-12337; 5375±30 years BP or 4331–4069 cal. BC: HD-12336); the dates are supported by character of the archaeological finds. The excavations were on a small scale, and it is not possible to tell from them whether occupation was more or less continuous or intermittent within the more than 1000 years bracketed by the radiocarbon dates. A series of boulder-built structures was discovered, with floors of beaten clay and hearths (Fig. 7.15). Finds of this phase of occupation included a

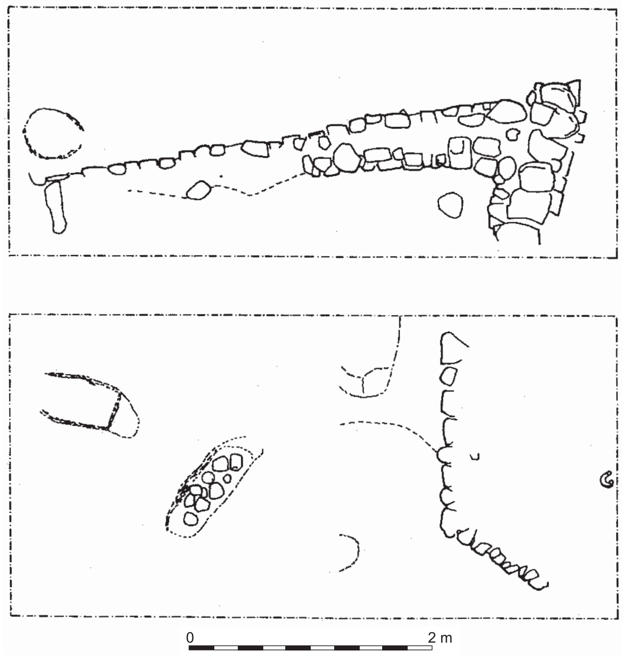


Figure 7.15 *Structures of the Pottery Neolithic occupation phase at Tell Wadi Faynan. (After al-Najjar* et al. *1990, fig. 8.)*

limestone figurine head with 'coffee-bean' eyes, a recognizable Yarmoukian type (Fig. 7.16:1). The pottery was of two fabrics, a coarser one tempered with vegetable materials and reeds and a finer one tempered with grit and sand. The temper in the coarser pottery, as in the clay floors, was a mixture of straw and reeds, the latter an indication of the well-watered nature of this part of the wadi at the time of the occupation, confirmed in our own identification of the signatures of perennial water (sediments, molluscs, and the PAP pollen biozone) at this location in the Faynan Member. Most of the pottery was undecorated, a few sherds having thumb-impressed ledges (Fig. 7.26:3,4). Some of the bases had criss-cross impressions of reed mats on which they had been standing whilst the clay was still damp. Bone tools included spatulae and points (Fig. 7.16:2). Scrapers dominated the lithics, with borers the next most frequent tool class (Fig. 7.17). Sickles were present, but no projectile points were found, the excavators suggesting that this might mean that hunting was contributing little to an otherwise agricultural economy at this site.

Given the small scale of the excavations little direct evidence for the subsistence base of the Pottery Neolithic settlement was recovered from Tell Wadi Faynan, but the data indicate that the community grew cereals and kept goats and sheep, and hunted gazelle, wild goat, and Nubian ibex (Richardson 1997). No subsistence data were recovered from the small occupation site contemporary with Tell Wadi Faynan that we found on the side of the Wadi Dana, WF5015. However, the PAP biozone established from the pollen and macrofossils from the two sites indicates in both cases a landscape of small-scale cereal cultivation (see above), and many of the harvesting blades recovered

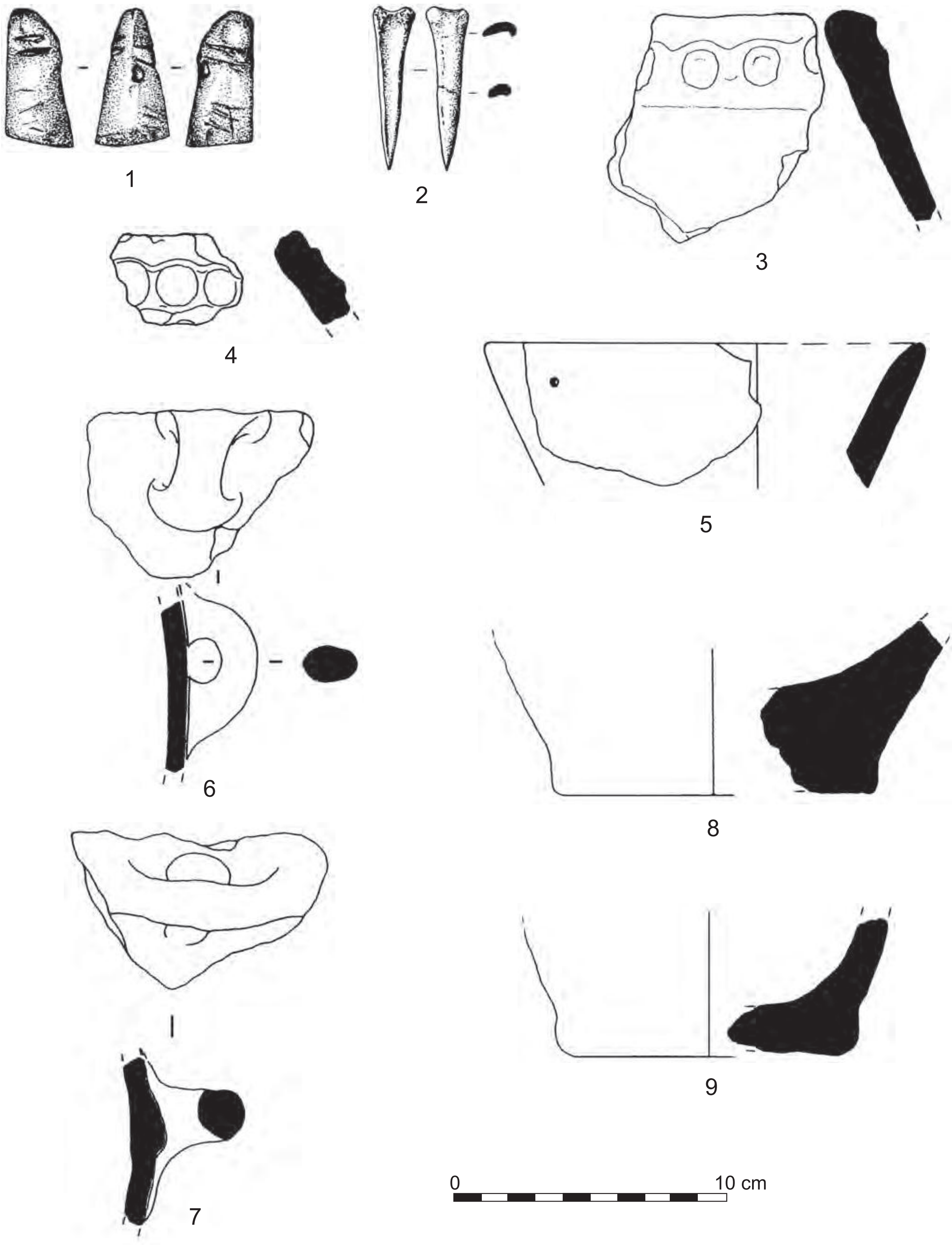


Figure 7.16 *Material from the Pottery Neolithic occupation phase at Tell Wadi Faynan: 1) limestone figurine head; 2) bone point; 3–5) pottery rims; 6, 7) pottery handles; 8, 9) pottery bases. (After al-Najjar* et al. *1990, figs. 5, 10, 11.)*

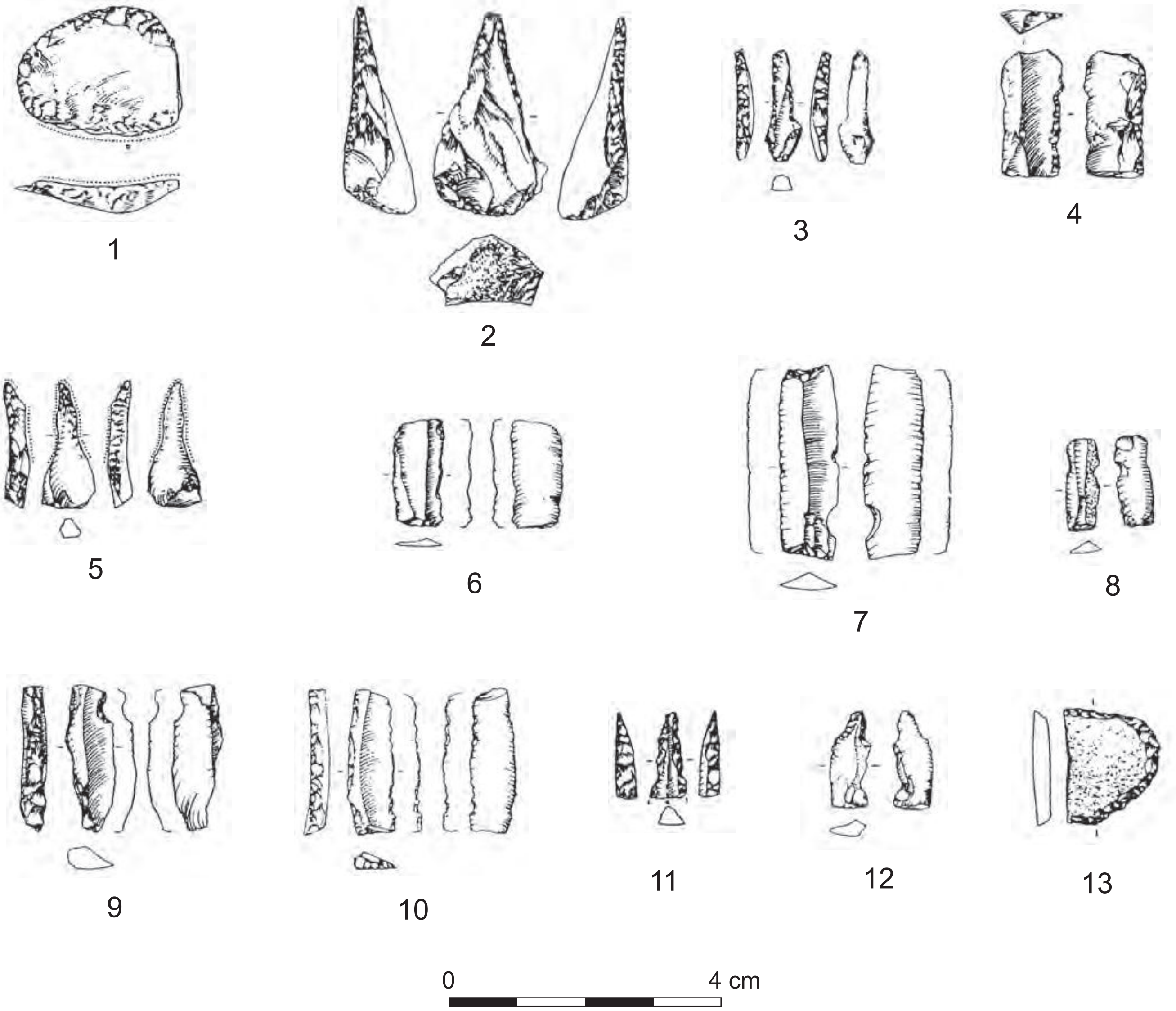


Figure 7.17 *Neolithic lithics from excavated contexts at Tell Wadi Faynan: 1) scraper on a reworked Levallois flake (Context A, 10, 22); 2) borer/pick (Context A, 10, 23); 3) borer (Context A, 10, 24); 4) retouched blade (Context A, 9, 22); 5) borer (Context A,18, 19); 6–10) elements from sickle blades (Contexts A,17, 42, A, 9, 16, A, Loc. 1, Serial No. 14, A, 6, 28 and A, 7, 27); 11) tip of a borer (A, 1, 33); 12) borer (Context A, 4, 39); 13) fragment of a fan-shaped scraper (Context A, 4, 36). (After al-Najjar* et al. *1990, figs 12 and 13.)*

by the survey are likely to date to this broad phase of later Neolithic settlement (Fig. 7.18). Site WF5015 had been eroded by the floodwaters of the Dana, so what we found was just the vestige of what was presumably a more substantial habitation zone extending further towards the stream channel. There were traces of boulder walls, occupation surfaces, and pits filled with ash and other refuse, much as at Tell Wadi Faynan.

One of the finds in the 1987 excavations at Tell Wadi Faynan (which consisted that year primarily of cleaning the visible faces) was a tiny piece of copper ore, *in situ* in a basal Neolithic occupation layer immediately above the wadi gravel (al-Najjar *et al*. 1990: 31), within what we now recognize as the Faynan Member (McLaren *et al*. 2004). It is clear evidence that Pottery Neolithic people were collecting lumps of surface copper ('native' copper) from the adjacent hills, though whether they were beginning to try to transform them by heating, or just hammering them into shapes such as small beads (as can be done with lumps of very pure copper), is unclear: none of the familiar indicators of metallurgy such as smelting slags, crucibles, and so on was recovered in these excavations. However, important new evidence is provided by the geochemistry of the Late or Pottery Neolithic sediments at Tell Wadi Faynan (WF5021) (Fig. 7.19).

Copper and lead concentrations through the WF5021 fluvial deposits are broadly constant and in keeping with the background levels evidenced in Pleistocene deposits in this mineralized region, but there are three notable exceptions, samples D, H, and L, which mainly consisted of charcoal,

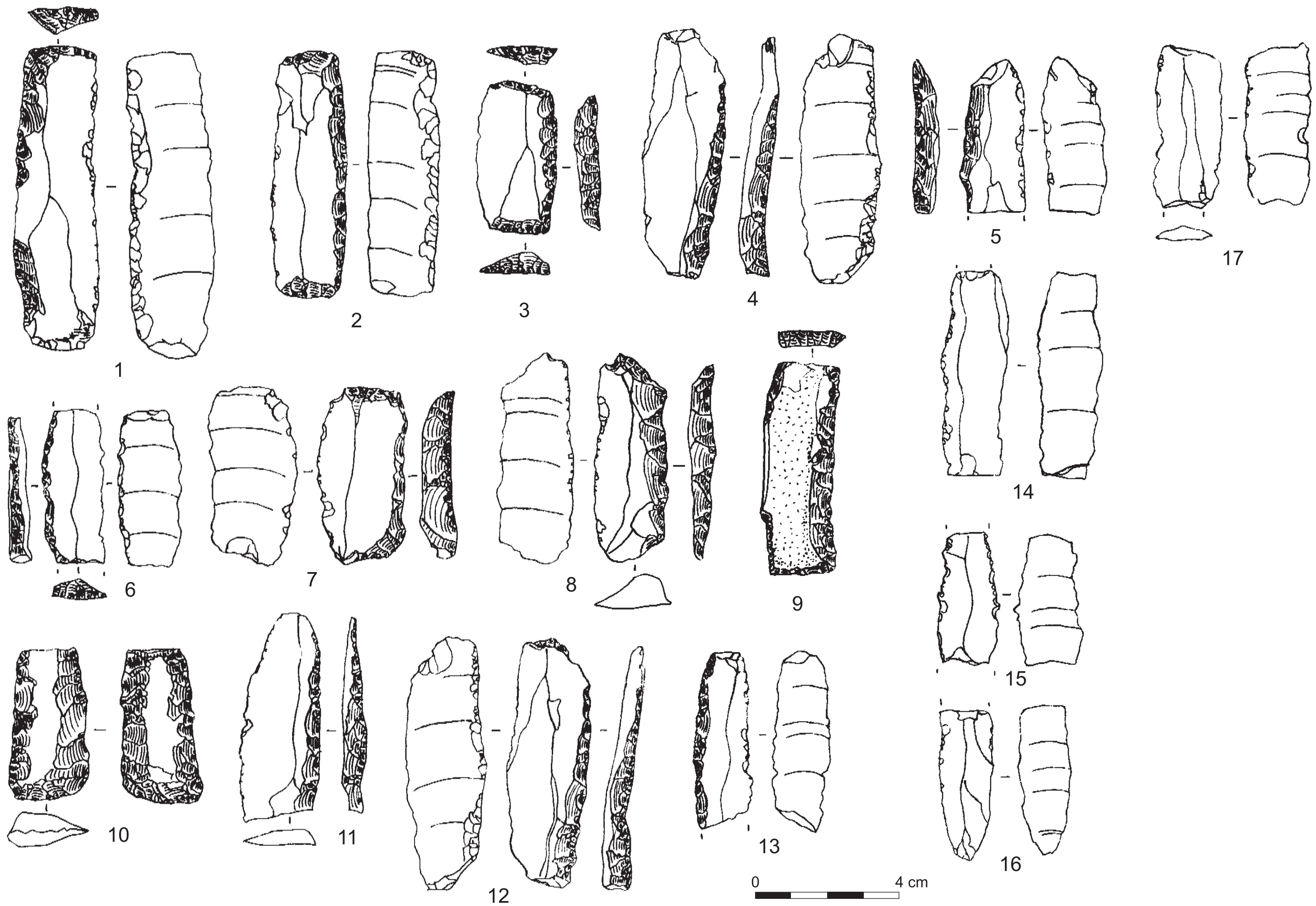


Figure 7.18 *Harvesting blades of mid-Holocene date from the Wadi Faynan Landscape Survey: 1) backed blade sickle: WF442.26; 2) backed and bitruncated, WF4.9.23; 3) backed and bitruncated, WF442.28; 4) backed blade sickle, WF4.17.2; 5) backed blade sickle, WF406.8; 6) backed and truncated, WF592; 7) backed and bitruncated, WF4.3; 8) backed and truncated, WF418.23; 9) retouched,WF4.15.24; 10) retouched,WF4.1; 11) backed blade sickle, WF4.18.3; 12) backed and truncated, WF417.2; 13) backed blade sickle, WF406.24; 14) unworked blade, WF406.1; 15) unworked blade, WF4.15.38; 16) unworked blade, WF4.15.38; 17) unworked blade, WF4.18.11. (Drawings: Tim Reynolds.)*

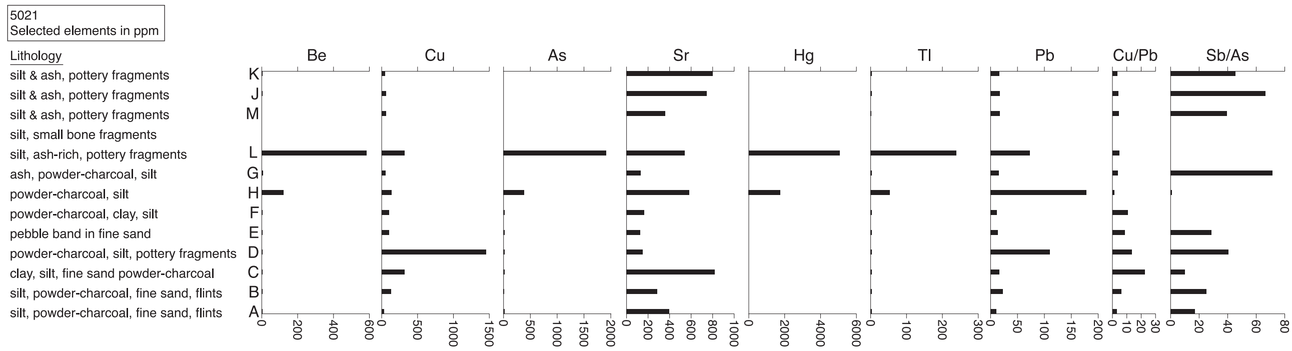


Figure 7.19 Summary of sample properties and geochemical properties of Neolithic age from an exposure of aeolian, water-washed silts and temporary soils at Tell Wadi Faynan (WF5021), in ppm. Sample G included ash and charcoal, the latter giving a radiocarbon date of 6200±40 BP (5296–5045 cal. BC; Beta-205964). (Illustration: David Gilbertson, Ian Gulley and Antony Smith.)

ash, and fragments of pottery, as well as fluvial silt. These samples were adjacent to the charcoal from sample G dated to 6200±40 BP or 5296–5045 cal. BC (Beta-205964). The concentrations of copper and lead in these sediments are markedly high, reaching *c.*1500 parts per million (ppm), though neither clasts of ore-bedrocks nor fragments of pure or refined metals were noted in the samples analysed, which were a mixture of ash and silt. Samples H and L also contained a significant suite of other metal pollutants such as beryllium (Be), copper (Cu), arsenic (As), mercury (Hg), thalium (Tl), and lead (Pb). Analysis of the metal contents of roots, stem, and branches of modern *Acacia* growing on polluted soils in the area suggests that the concentrations detected in WF5021 are unlikely to be the result of burning wood that had grown on metal-rich ores. If there were only one such sample, a conservative explanation would be that people happened to light a domestic fire at a location where crushed ores rich in copper and lead were present at the ground surface. However, the levels of copper, lead, and other metals in the three samples, and the fact that the latter are all associated with evidence of human activity in the form of ash, charcoal, pottery fragments and so on, suggest something more than this. The metal assemblage in sample L in particular implies the heating of metal-rich copper-lead ores which also contained substantial quantities of beryllium (which is known in the area: Rabb'a 1994, and see Chapter 2). The lenses of ash-silt and charcoal associated with the geochemical samples are a further indicator of the deliberate use of fire, perhaps to transform metal ores (rather than the effects of natural wild fires, for example), and it is noteworthy that the frequency of charcoal and ash correlates with the highest levels of metal contamination through the sequence. At the moment, the lower metal concentrations of the other samples from this series are taken as a guide to natural background concentrations. In short, despite the absence of slag and crucibles in the Pottery Neolithic levels excavated at Tell Wadi Faynan, the geochemistry of the sediments provides intriguing hints that already by the end of the sixth millennium cal. BC some communities were starting to practise the purposeful heating of (?crushed) metal-rich ores, presumably to try to extract their metal content.

7.7 Neolithic pictographs?

Numerous pictographs or rock engravings have been noted in the Wadi Faynan region, and it is certain that our project will not have located and mapped all of those in the areas we surveyed, because they are shallowly pecked onto the smooth faces of boulders, especially those darkened by desert varnish, and their visibility varied enormously depending on the intensity of light and shadow. A few were found on boulders set within structures, but most were found on isolated boulders. They were found in most parts of our survey area, but there was a notable concentration in the southeast, especially on either side of the western tributary of the Wadi Shayqar for a hundred metres or so before it emerges from the southern mountains, and for the ensuing hundred metres (Fig. 7.20). Similar pictographs have also been reported from rather similar locations in the middle and upper reaches of the Dana and Ghuwayr tributaries (e.g. Finlayson *et al*. 2000: 7–8; Pinkett and Mithen 2007).

The most common motif is a goat-like four-legged animal with an elongated body, four legs drawn as vertical lines, and curving swept-back horns. This is likely to represent the Nubian ibex (*Capra ibex nubiana*), the range of which was predominantly further south in Arabia but which certainly extended as far north as Beidha and Fidan in the early Holocene (Hecker 1989; Richardson 1997), though it might also represent the wild goat (*Capra aegagrus*), the range of which was more northerly but which extended to the southern Levant (Uerpmann 1987; Wasse 1997: 584). Both prefer rocky habitats, although the ibex is more arid-adapted than the goat. In the following discussion of the pictographs the term 'ibex' is used for convenience. In addition we found anthropomorphic figures standing or riding on horse-like quadrupeds, camels (occasionally being ridden), and a variety of more enigmatic creatures and abstract-like motifs.

Our most detailed study was of WF20, a particular concentration of pictographs found on a boulder-strewn

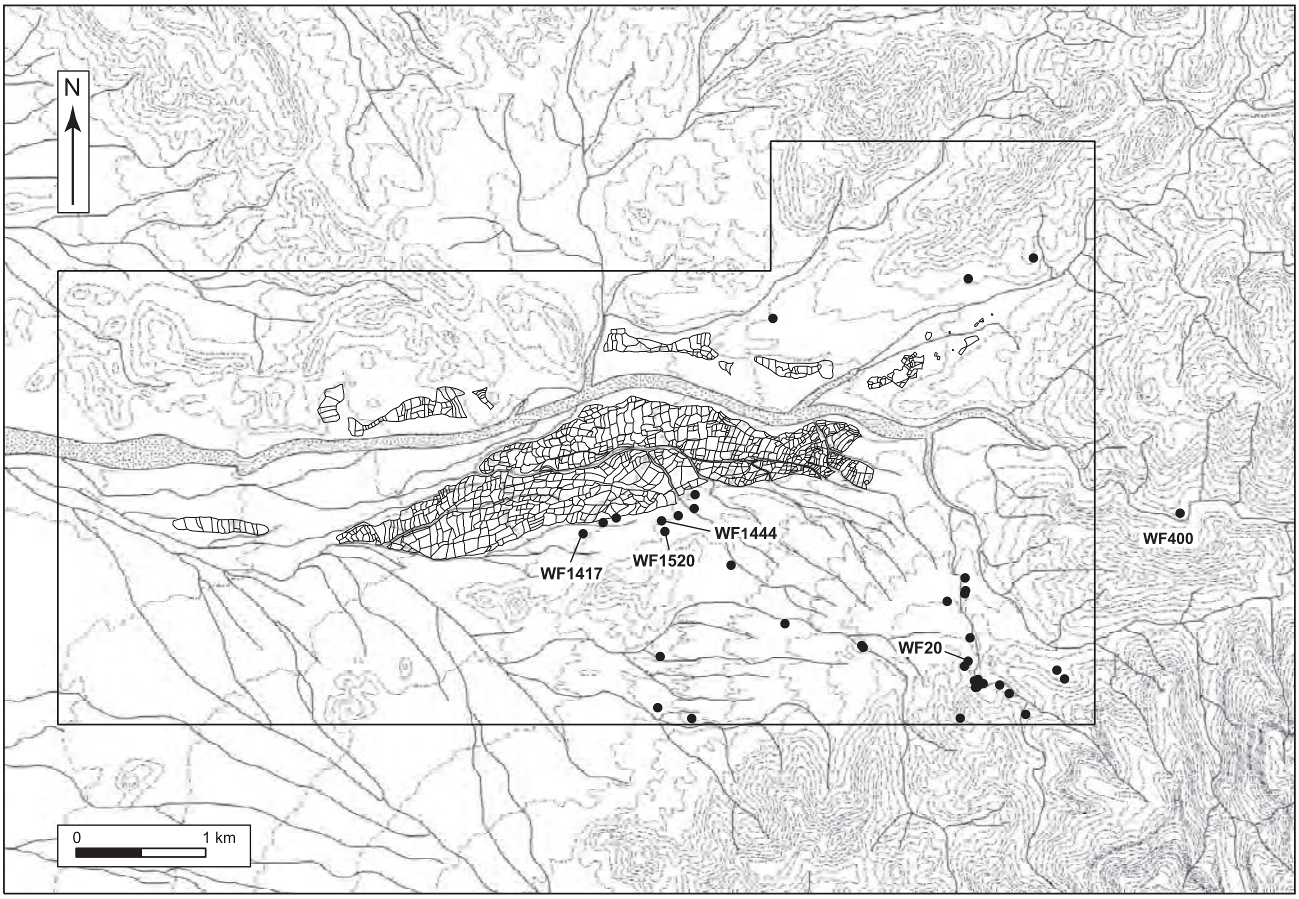


Figure 7.20 *Distribution of pictographs recorded by the Wadi Faynan Landscape Survey and (WF400) the Dana-Faynan-Ghuwayr Early Prehistory Project. The numbered sites are variously discussed in Chapters 7 and 8. (Illustration: Paul Newson.)*

terrace on the left-hand side of, and overlooking, the Shayqar channel just beyond its mountain defile, together with those on a prominent large boulder (WF1394) on the eastern side of the Shayqar channel 100 m to the northeast (Fig. 7.21). The locality, at the foot of the main mountain front of the Mountains of Edom, has magnificent views northwards and eastwards across the Faynan to the Dana hills, is also open to the slightest breeze, and is a favourite camping place for bedouin families today. The WF20 terrace formed a kind of platform, which was strewn with boulders of various sizes deriving from the underlying Pleistocene alluvial fans, and a series of pictographs was found on about twenty of them. Most of the boulders selected for pictographs were on the eastern edge of the terrace overlooking the Shayqar channel, in clusters, though the reason for the selection of the clusters was not clear, given that other suitable boulders were situated in between. In general there are clear views northwards across the Faynan from the northern outlier pictographs of WF20 and from WF1394 (Fig. 8.43), but the terrain closes in to the south, into the mouth of the Shayqar gorge, so the views northwards from the boulders of the main group (WF20:A, B, C, D, E, F, N) and the group on the southern extremity (WF20:J, K, L, M) are much more restricted. The latter also applies to a cluster of pictographs recorded by the Dana-Faynan-Ghuwayr Early Prehistory Project as their WF400, situated about 1 km east of WF16 in the gorge of the Wadi Ghuwayr (Pinkett and Mithen 2007).

There was no clear patterning in the aspect of the WF20 pictographs, either: generally the most suitable (that is, smoothest and most vertical) face of a boulder appears to have been selected. The pictographs generally faced away from the wadi channel, apart from those at the southern extremity of the cluster (WF20:J, K, L, M) which generally faced north or northeast, so in some respects the main group delineates a bounded space. The pictographs on the large boulder WF1394, however, were all on its southern side, so only visible to someone emerging from the Shayqar gorge, but there were other pictographs on boulders further up the Shayqar that were only visible to someone walking up-wadi, not down, and some were in obscure locations that were only visible to someone walking right round a boulder. Most pictographs are on smooth vertical faces of boulders measuring 1–2 m in height, easy to work on for a normal sized person, but some of the southernmost group of the WF20 pictographs were unusual in being on particularly small rocks, protruding no more than 30 cm above the ground surface.

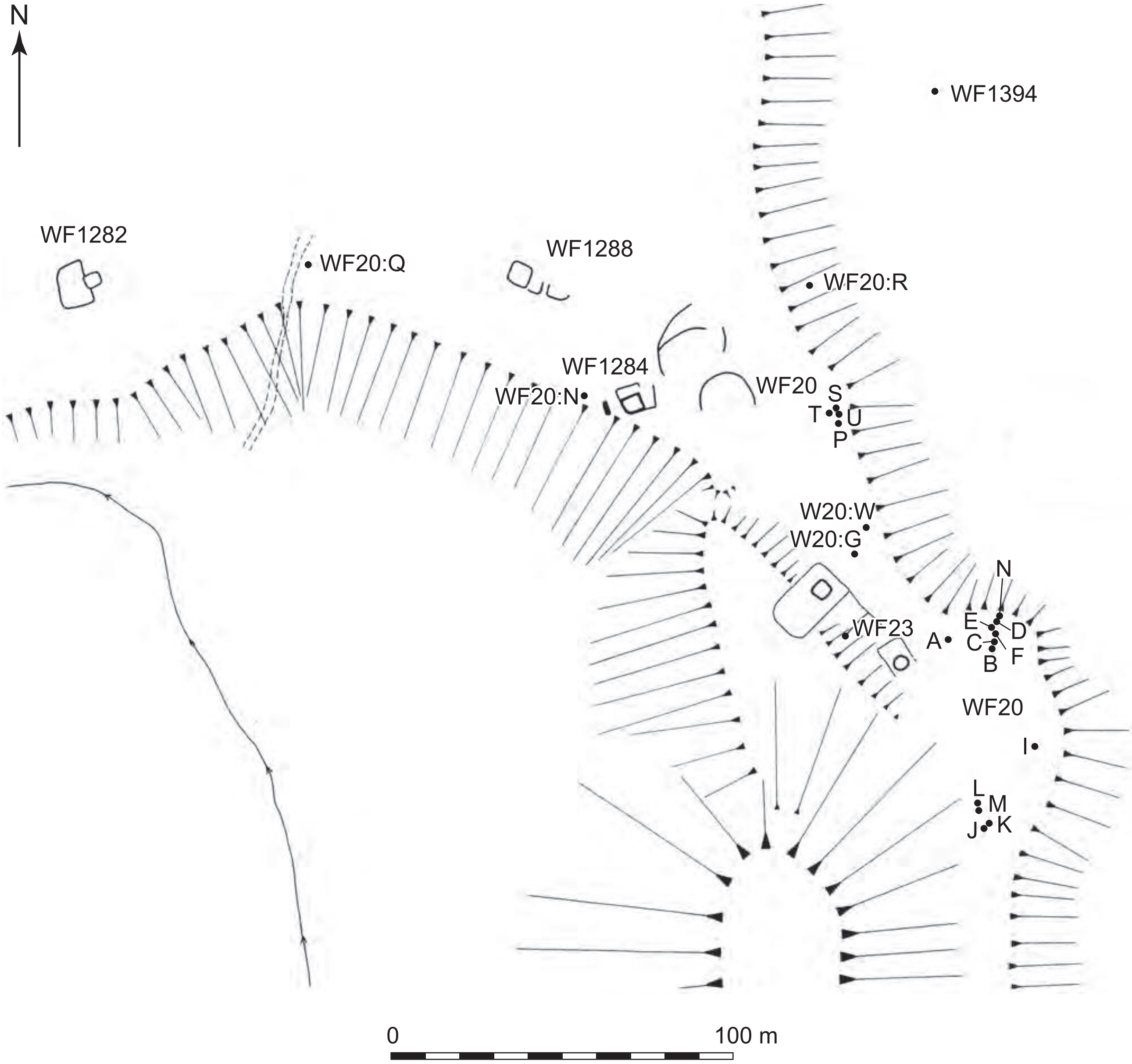


Figure 7.21 *Plan of pictograph cluster and adjacent sites at the head of the Wadi Shayqar (WF20, WF1394). (Illustration: Oliver Creighton and Mike Hawkes.)*

Permatrace tracings were made of selected panels, and all pictographs were also photographed. Three of the boulders are particularly relevant to this chapter, for they have evidence for the superimposition of motifs, the earlier ones of which may date to the early/mid Holocene (Figs 7.22, 7.23).

WF20:B consists of a cluster of pecked motifs 90 cm high by 75 cm wide, on the southwestern side of a *c*.2 m high boulder. There appear to be five ibex motifs: at the top centre is an ibex facing left, below it a possible ibex faces upwards, and there are clearer examples of ibex on either side, the left-hand one facing left and the right-hand facing right, with beyond the latter, another distinct ibex facing downwards. There are two human figures in the centre and lower regions, the upper one perhaps pointing a spear at an ibex, with a smaller figure below with exaggerated hands, perhaps waving. Below is an inverted U-shaped motif with an oval shape between the two legs of the U, and the L motif bottom left appears to be a more 'open' version of the same symbol. There is a prominent swastika motif on the left-hand side of the central panel. The pictographs shown white in Figure 7.22 are dark brown, more heavily patinated than the ones shown as grey, which are more lightly patinated (orangey-brown) figures; they appear to be of greater antiquity. The older motifs clearly include the top centre ibex, the position of which appears to have been carefully respected during the making of the later drawings on each side, and the vertical ibex below it. Given the styles of these particular pictographs, the two vertical lines further down, together with the angled

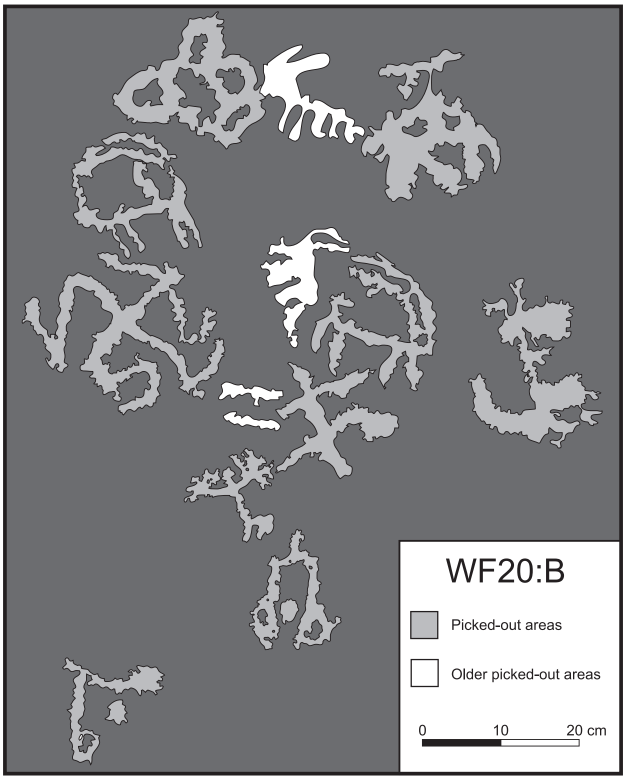


Figure 7.22 *Tracing drawing of WF20:B pictograph. (Illustration: Lucy Farr.)*

Figure 7.23 *WF20:B pictograph. Scale: 10 cm. (Photograph: Graeme Barker.)*

line underlying the swastika, could together be vestiges of another ibex, the two vertical lines being legs and the angled line being the horns.

Similar superimpositions are evident on boulders WF20:F and WF1394. The WF20:F boulder is a few metres north of WF20:B, the pictographs on the side facing west away from the wadi; the area of its pictographs measures 60 by 60 cm. The numerous pictographs on the WF1394 boulder were on the southeast face, covering an area measuring some 230 cm in width by 85 cm in height. Both of these are described in the next chapter, as most of the figures on them are thought to date to the Bronze Age, but on the WF20:F boulder the left-hand two of the four human figures etched at the top right of the panel (Figs 8.41, 8.42) overlie an older motif, more patinated, that is probably a vertically-drawn ibex, and traces of another ibex can be discerned below it under what is probably an ibex facing a U-shaped structure. Similarly in the case of the WF1394 pictographs (Figs 8.42, 8.43), five or six badly preserved and heavily patinated ibex can be discerned in the central section, facing in different directions, overlain by a 'frieze' of orange-patinated ibexes and other figures.

The evidence of sequence in the superimposed drawings on these three panels correlates with different degrees of patination and colouring. Patination of desert rocks is a highly complex process, and different degrees of patination cannot be assumed to be a simple guide to relative age, but in this case it is noteworthy that the degrees of patination correlate with the evidence of superimposition and of differences in motifs. The small ibex drawn underneath the other pictographs on WF20:B, WF20:F, and WF1394 are very abraded, with a desert varnish beginning to develop on their surfaces giving a dark brown patina not dissimilar to the main boulder surfaces, so that they are poorly visible in most light conditions. They appear to be highly stylized as stick figures, contrasting with the execution of the subsequently-pecked animals. Finally, they are drawn both horizontally and vertically and not in any obvious relation to one another, as in the case of the three drawn on totally different axes on WF20:B, in striking contrast with the aligned figures making up what appear to be 'scenes' of animals and humans, including humans riding animals, in the later series of carvings thought to be Bronze Age in date and discussed in Chapter 8.

How early the 'early ibexes' are is extremely difficult to say. From his general survey of pictographs in Anatolia, Arabia, and the Sinai/Negev, Anati (1972) divided the material into four major styles which he suggested could be assigned to four major phases: 'Early Hunters', 'Hunting-Herding', 'Literate', and 'Islamic'. The first two of these may correlate very generally with, respectively, the earlier ibex motifs discussed in this section and the overlying 'scenes' discussed in Chapter 8, but the chronological evidence Anati was able to use to date the styles was very weak. A more helpful detailed study is the Black Desert Survey in eastern Jordan (Betts 1988; 1998a,b). Betts investigated a series of prehistoric sites on the basalt *hamada* that gives this region its name, and concluded that the area was used on a seasonal basis by Neolithic people who were hunter-gatherers rather than pastoralists or agriculturalists. The drawings are incised rather than pecked like the Faynan pictographs, with fine semi-continuous scratched lines, though on occasion pecking was used to add detail to animals' bodies. Anthropomorphic figures were also produced by pecking. The drawings were made on basalt boulders weathered with a thin black patina, which is whitish grey when first exposed and then weathers through yellow to orange, but most of the carvings are weathered further, to more or less the same colour as the boulder surface. The commonest drawings are outline profiles of quadrupeds without horns, shown running singly or in groups, though a few appear to be grazing. Over 80 such pictographs were recorded around the seventh-millennium BC PPN encampment of Dhuweila, and there were incised pictographs in stratigraphic contexts at the site. The faunal evidence from Dhuweila shows that the people who camped there concentrated on hunting gazelle. Given the stratigraphic associations at Dhuweila, Betts (1998b) concluded that the Black Desert gazelle pictographs were most likely to be Early Neolithic in date. There are somewhat similar pictographs, though of cattle as well as goats or gazelle, in Wadi Hauran in western Iraq, also thought to be Neolithic in date (Tyrácek and Amin 1981).

To the south, Henry (1995e: 258–60) reported a series of pictographs from his surveys of prehistoric settlement in the Ras en Naqb area. Panels of pictographs were found on the walls of several rock-shelters in Jabal Hamrat, Jabal Mishraq, and Jabal Muheima. The figures are pecked, much like those of Faynan, and the principal motif is also an elongated 'ibex' with swept-back horns identical to those of Faynan, though Henry prefers to identify them as wild goat, *Capra ibex*, shown both as individuals and in groups. The varnish is described as being in most cases indistinguishable from that of the parent rock, with some examples being so weathered that only the horns can be identified. Pictographs with lighter shades of varnish are also present, and in some cases overlie the ibex figures: these show what Henry identifies as armed horsemen and camel riders, in association with Thalmudic inscriptions which are dated to *c*.500 BC–AD 700. Henry concludes that the abraded ibex figures are most likely to be late Pleistocene in date given the Early Epipalaeolithic (16,000–14,000 BP) artefacts found in the rock-shelters, and the absence of Neolithic material in the vicinity.

Without stratigraphic evidence of the kind found at Dhuweila it is difficult to proceed much further with dating the 'early ibex' of Faynan: they are stylistically most like those of the Ras en Naqb region thought by Henry to be Epipalaeolithic, but the only prehistoric pictographs securely dated are those of Dhuweila, which are Pre-Pottery Neolithic. On balance, the Faynan 'early ibex' seem more likely to be Neolithic rather than Epipalaeolithic, because there are examples of patinated ibex pictographs on boulders at low elevations in the Shayqar defile which are unlikely to have been made by late Pleistocene hunter-gatherers, given the evidence for high storm waters scouring the upper wadis at this time. If these earlier ibex are Neolithic (and the evidence is of course very tenuous), it remains impossible to say whether they were made throughout the 5000 years from the PPNA through to the Pottery Neolithic, or wholly or largely within one phase of this long time period.

As mentioned earlier, it is difficult to see systematic patterning in the specific locations and aspects of the pictographs. The locations of those visible on leaving the mountains and those encountered on entering the mountains do not correlate simply with light conditions, in the sense of all drawings in one of these two groups being well lit at the same time of day, or being equally obscured. What can be said is that most pictographs have been placed in what can be termed a boundary or 'liminal' position at the upland–lowland ecotone, at or close to the junction between the Faynan basin and the rugged mountains of its eastern perimeter, especially within the narrow defiles of the Dana, Ghuwayr, and Shayqar, but occasionally a short distance beyond the defiles into the basin. The location of WF400 (Pinkett and Mithen 2007) fits with this picture. It is possible that the older more patinated ibex were drawn in many different locations but we missed them – that is, that they were only identified by the survey teams during the close examination of the more visible orange-patinated pictographs, However, whilst their poor visibility must be factor, the fact that isolated examples of the more patinated ibexes were noted elsewhere, as were examples of less-patinated ibex, suggests that the 'liminal' locations where Dana, Ghuwayr, and Shayqar emerge from the escarpment hills were consistently selected by the makers of both the older and younger series of pictographs. Of course we cannot tell whether the makers of the later series chose their locations because they recognized them as special places in their own right, or because they recognized them as special places because they had already been selected for drawings by earlier people.

If the early ibex motifs were made by PPNA goat hunters (and herders) of the kind who camped at WF16, it is possible that the images reflects their dependency relationships on these animals, but it is notable that the carvers appear to have selected ibex for depiction rather than goat, when the latter was probably the more common species. If the ranges of both species extended from the Wadi 'Arabah to the Dana plateau, as we suspect, one possibility is that the pictographs located midway in these ranges in the vicinity of the camps like WF16 represented some kind of 'stored knowledge' about key prey animals, rather as Mithen (1990) argued for some Palaeolithic cave art in Europe. If they were made by Neolithic PPNB *protoélevage* herders of the kind who lived in the Ghwair I settlement, and/or the Pottery Neolithic farmers such as those of

Tell Wadi Faynan, we could perhaps envisage the ibex pictographs at the mountain edges as representing some kind of evocation of half-remembered hunting landscapes and lifeways of ancestral generations. It is acknowledged that prehistoric hunter-gatherer art is likely to have been at least as complex in its meaning as the art produced by recent hunter-gatherers, which many studies have shown to be highly metaphorical, with imagery in some cases drawn from states of trance and the act of making the image as pregnant with meaning as the act of viewing it when completed (Lewis-Williams 2002; Lewis-Williams and Dowson 1990). The same is true of the 'Big Game' and 'Pastoral' art produced by prehistoric hunter-herders in the Sahara (Caligari 1993; Muzzolini 2000). It is therefore unwise to regard the early ibex art of the Wadi Faynan as imagery necessarily reflecting in some direct way the lived world of prehistoric hunters and herders, but it is noteworthy that several PPNB and Pottery Neolithic villages in Southwest Asia have wall paintings and sculptures showing images of male groups engaged in real or ritualized hunting that has been interpreted as possible evidence for a male-dominated Neolithic ideology 'emphasising men in groups, virility, domination, and initiation of young men into adulthood' that cross-cut individual kin groups and communities (Wright 2000: 116).

7.8 Conclusion

With the development of moister climates at the beginning of the Holocene *c*.9500 BC, the increasingly steppic and in part forested landscape of the Wadi Faynan was regularly visited by mobile hunter-gatherer groups, whose annual territories probably ranged between the plateau and the Wadi 'Arabah. Some of them started to camp at WF16 near the springs at the foot of the mountain front for several months of the year, and perhaps even on an all-year-round basis. Though many PPNA communities in Southwest Asia remained foragers, the WF16 groups were like others that we can discern throughout the region who were beginning to employ modes of subsistence that we can recognize as components of what was to emerge a thousand or so years later as agriculture (Barker 2006). In the case of the people returning year after year to WF16, they gathered wild plants including cereals, and hunted goats, ranging into the hills and out into the Faynan basin, but they may also perhaps have started to develop new relationships of management and control over goats. A thousand years later, cereal farming, goat herding and probably sheep herding sustained the nearby PPNB village – for such we can legitimately term it – of Ghwair I, and a similar settlement at the end of the Faynan/Fidan system, Wadi Fidan 1, overlooking the Wadi 'Arabah. These PPNB communities were probably characterized not only by a developed commitment to agriculture and to household-based modes of production but also by the profoundly different 'world views' emphasizing fertility and ancestry that we can discern in many early farming societies in Southwest Asia.

Wadi Faynan is typical of much of the southern Levant in the lack of evidence for continuity in village life after the end of the PPNB, from around 7000 cal. BC. The next major settlement in the locality, at Tell Wadi Faynan, dates to around 5500 cal. BC, in the Pottery Neolithic. Many Neolithic archaeologists have argued that there was a collapse in arable-based settlement at the end of the PPNB and a switch to mobile pastoral nomadism, in the context of an oscillation towards aridity (compounded, some have argued, by over-intensive exploitation). We discovered a series of pictographs of ibex that appear to be broadly Neolithic in age, located particularly at key nodes on communication and herding routes into and out of the hills around the Faynan basin. It might be tempting to link them to putative pastoral nomads in the PPNC, but arguments can equally be mustered for them being earlier or later than this. We have not been able to discern with clarity an arid event at the end of the PPNB, though – as we have emphasized before – the nature of our data and their poor chronological resolution are such that such an oscillation is unlikely to have been identified with certainty at the sites that we have found that are of appropriate age. Nevertheless, as it stands, the overall geomorphological and palaeoecological evidence gathered by the project indicates that the Faynan landscape was equally favourable to agricultural settlement at the time of the occupation of Ghwair I *c*.7500 cal. BC and of Tell Wadi Faynan (and the vestigial Neolithic camp we discovered in the upper Dana contemporary with Tell Wadi Faynan) *c*.5500 BC, in terms of having in both periods perennial streams where now there are largely dry torrent beds, and extensive steppe land and clumps of Mediterranean woodland where now there is little or no vegetation except after the rains. The pollen record suggests the possibility of patches of small-scale cereal land in both instances.

The scrap of copper ore found in the Pottery Neolithic levels dating to *c*.5500 cal. BC at Tell Wadi Faynan is evidence that by this time the inhabitants of the Wadi Faynan were certainly aware of the 'strange green stones' outcropping in surrounding hills and it is possible that they were beating lumps of native copper into simple ornaments like many other Neolithic societies. Our geochemical studies of the Tell Wadi Faynan sediments, however, also provide intriguing hints that they may even have started to engage in purposeful experimentation with the effects of heating crushed ores to extract their metal. However that may be, the most significant developments in prehistoric metallurgy only followed in the Chalcolithic and Early Bronze Age periods, as discussed in the next chapter, when they were part and parcel of a suite of dramatic developments in social complexity that transformed the Faynan landscape.

8. Chalcolithic (*c*.5000–3600 cal. BC) and Bronze Age (*c*.3600–1200 cal. BC) settlement in Wadi Faynan: metallurgy and social complexity

*Graeme Barker, Russell Adams, Oliver Creighton, Hwedi el-Rishi, David Gilbertson, John Grattan, Chris Hunt, Paul Newson, Brian Pyatt, and Tim Reynolds**

8.1 Introduction

The fourth, third, and second millennia BC were periods of extraordinary social change throughout the Levant, characterized especially by the development of hierarchical societies in the Chalcolithic (*c*.5000–3600 BC) and the rise, and in places subsequent collapse, of urbanism in the Bronze Age (*c*.3600–1200 BC). Through these millennia the southern Levant was increasingly part of the competing spheres of influence of imperial powers to the east, south, and north (Fig. 8.1). From the middle of the fourth millennium BC there were urbanized societies living in southern Mesopotamia on the alluvial plains of the lower Tigris and Euphrates valleys (in what is now Iraq). These Sumerian communities were highly stratified, their bureaucracies supported by the first writing systems, their cities graced with elaborate public buildings and monumental architecture, their populations sustained by canal-based irrigation systems. The Nile valley was unified within a state system of comparable complexity by the end of the fourth millennium BC, the pyramid-building of the Old Kingdom pharaohs beginning a few centuries later. By the middle of the third millennium BC Mesopotamia was the heartland of the aggrandizing state of Assyria. By the early second millennium the Hittite state was established across much of Anatolia. As with modern states, these ancient states were voracious consumers of resources beyond their heartlands, which they could variously obtain by trade or coercion.

The character and intensity of the power relations between these emerging and established states, and of their impact on southern Levantine communities, are much debated. Wadi Faynan, on the margins of the settled landscape but rich in mineral wealth, was clearly exposed to the effects of these supra-regional transformations in political and economic structures. The role of local elites in facilitating trade in metals with powerful neighbours is frequently regarded as the key factor in the development of Chalcolithic and Early Bronze Age societies in the southern Levant (Adams 1999; Algaze 1993; Finkelstein 1995; Joffe 1993). Our project contributes new data to the wealth of evidence emerging from the region for successive and dramatic transformations in cultural landscapes in the Chalcolithic and Bronze Age, data that contribute significantly to the debates about the nature, scale, and context of urbanism in the southern Levant.

8.2 Climate and environment

Although there are many inconsistencies in the regional palaeoenvironmental information, there is broad agreement that, after the wet conditions of the early Holocene, the climate of the southern Levant became markedly drier after about 5000 BC, with this aridity persisting until about 3500 BC (Goldberg and Rosen 1987; Issar 1998; Migowski *et al*. 2006; Schuldenrein and Clark 2001: 31). The Chalcolithic phase of settlement in the southern Levant, therefore, roughly correlates with this significant trend to aridity. There is then widespread evidence that moister conditions returned in the middle of the fourth millennium BC, broadly coinciding with the transition to the Early Bronze Age. For example, the sediment records of the Dead Sea have evidence of the

* *Archaeology:* Graeme Barker, Russell Adams, Oliver Creighton, Paul Newson, Tim Reynolds. *Geochemistry:* John Grattan, Brian Pyatt. *Geomorphology:* Sue McLaren, David Gilbertson. *Palaeoecology and palynology:* Chris Hunt, Hwedi el-Rishi.

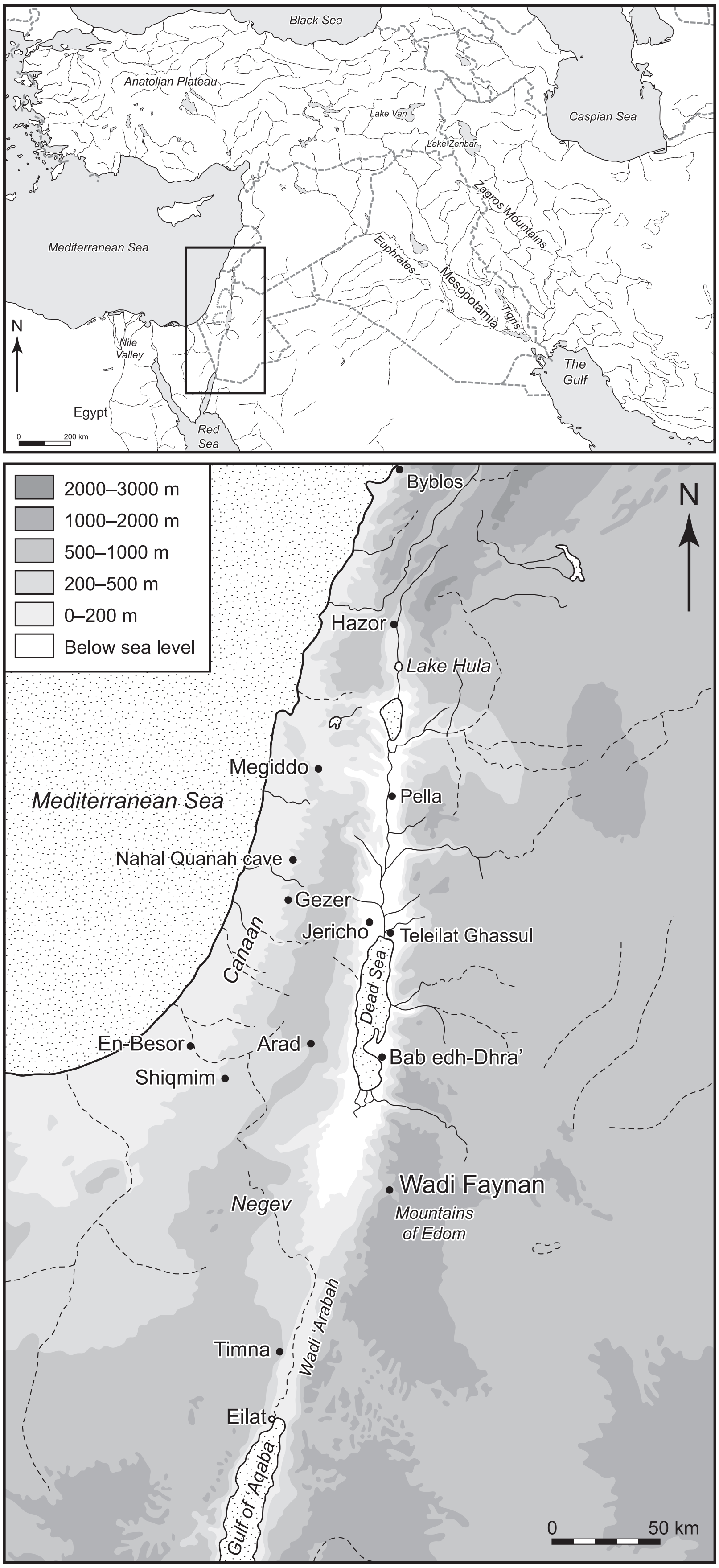


***Figure 8.1** Southwest Asia and the southern Levant, showing the principal regions and sites mentioned in Chapter 8. (Illustration: Dora Kemp.)*

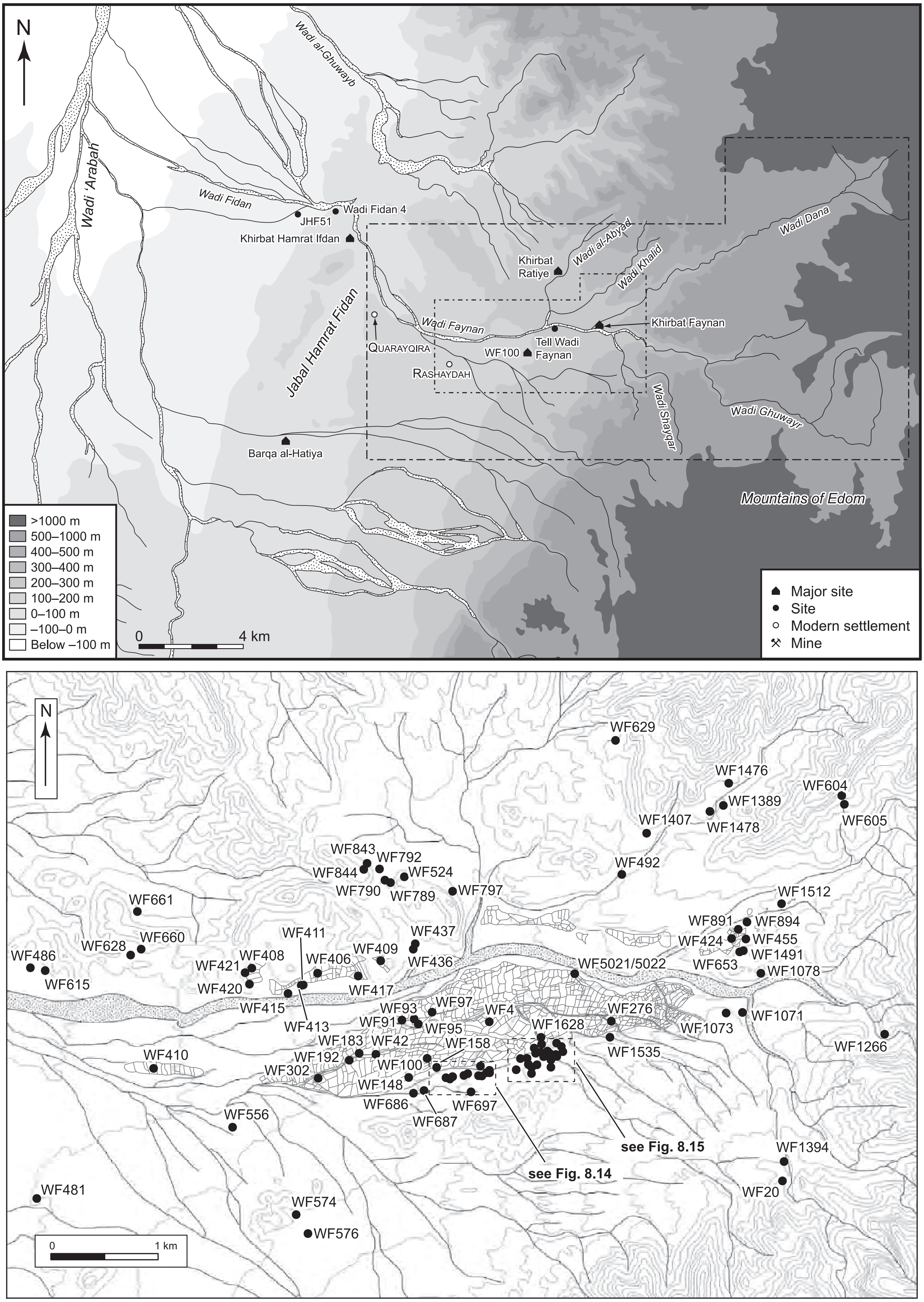


Figure 8.2 *The Wadi Faynan study area, showing the location of the WFLS survey zone and of the other main adjacent sites and locations discussed in Chapter 8. (Illustrations: Dora Kemp and Paul Newson.)*

effects of greater run-off, indicative of a significant shift to wetter conditions (Frumkin *et al.* 1991; Migowski *et al*. 2006). Vegetation shifts in pollen diagrams from Lake Hula suggest fluctuating moist conditions (Horowitz 1971; van Zeist and Bottema 1982), and isotopic data from sequences of terrestrial land snails in the Negev desert indicate moist environments (Goodfriend 1990). Alluvial stratigraphies from both the Negev and the Mediterranean littoral demonstrate widespread alluvial activity and aggrading floodplains, indicative of increased stream activity in response to greater precipitation (Rosen 1991). These and other palaeoenvironmental sequences in the region then document a severe and sudden oscillation to aridity in the later third millennium BC, round about the transition to the Middle Bronze Age (Arz *et al*. 2006; Rosen 1995; Migowski *et al*. 2006), with similar climatic signatures noted from the eastern Mediterranean (Staubwasser and Weiss 2006) to southeastern Arabia (Parker *et al.* 2006).

The principal exposure in Wadi Faynan documenting the environmental transformations of the mid Holocene is the Pottery (Late) Neolithic to Roman-period section exposed by the wadi channel at the Tell Wadi Faynan excavation (al-Najjar *et al*. 1990), categorized as sites WF5021/WF5022 in the geomorphological survey (Fig. 8.2). This is the type site for the Tell Loam Member (Hunt *et al*. 2004; McLaren *et al*. 2004; Mohamed 1999; Tables 7.2, 8.1; Figs 1.9, 3.4, 7.4, 8.3). It consists of 0–2 m of silts, together with minor amounts of clay and sands, and occasional gravel-filled scours. There are sub-horizontal desiccation cracks, which represent palaeosurfaces. In places there are horizons of calcite induration and soft calcitic nodules. The surface of the deposit is deflating and is crossed east to west by a series of small loam-filled gullies following the natural dip of the deposit. On occasion the surface is capped by slag deposits of the Atlal Member (Chapter 3). Walls visible in the uppermost layers of the Tell Loam Member are likely to be field walls of Roman–Byzantine date (within the WF4 field system), and Roman–Byzantine sherds are common between them. Four C14 dates on charcoal obtained by the al-Najjar team from the occupation materials date the Tell Loam Member, two from the basal Unit 11 *c*.1.5 m below the present surface and two from Unit 9 at a depth of 1.05 m. Unit 11 is the Pottery Neolithic occupation deposit dated to the sixth millennium cal. BC, and the Unit 9 dates indicate that both this and the underlying Unit 10 should probably both be attributed to the Chalcolithic. The top of the Bronze Age/base of the Iron Age might be located in the lower part of Unit 4, although this needs to be confirmed.

The most significant feature of the stratigraphic column is that its lithological similarities suggest a broad continuity of events and environments, with an arid envi-

Unit	Height (cm)	Description and interpretation
Top of section		
1	155	Deflation surface on matrix-supported fine sand and silt, visibly wind-blown and water-washed; with discontinuous clasts of mainly non-reworked copper slag (2–3 cm diameter) and fragments of pottery of Roman/Byzantine age. Thin layers of clay and lag deposits of pebbles resting on small surfaces. Copper slag, a local concentration of clinker waste, represents past smelting. Modern deposition is primarily wind-blown fine sand, prone to deflation and water-washing in winter storms. Aeolian deposition in the area has recently been accelerated by widespread ploughing and wall removal in the field system which overlies the site.
2	153–155	Thin crusts, very pale grey-brown compact laminated silt clay, sometimes buff.
3	149–153	Silt, very pale grey-brown, ashy, friable, with Roman/Byzantine pottery; flinty chert, root pores, small peds which are irregular weak, sometimes blocky, and rather disordered. There is a transition over 2–3 cm below to:
4	118–149	Clay-silt, very pale grey-brown, blocky fairly strong peds, root holes, occasional stones and charcoal, often disordered, very pale at base.
5	107–118	Clay-silt, very pale grey-brown, fine strong blocky peds, root pores, occasional stones, charcoal and snails; paler at base where there is a line of dispersed stones, an episode of winnowing or water-overland flow erosion.
6	85–107	Clay-silt; very pale grey-brown, occasionally with grit (former washouts), many root pores, occasional stones, peds with fine blocky structure, snails and charcoal, strong stone line at base.
7	73–85	Clay-silt, very pale grey-brown, occasional irregular soft calcareous nodules, occasional cherts (flints) and pieces of pottery, few root-holes, coarse blocky well-developed peds, clear parting plane at base.
8	49–73	Clay-silt, very pale grey-brown, blocky-fine and columnar strong peds, irregular calcareous nodules soft to 1 cm diameter; some root pores, occasional pottery and charcoal, base transitional over 1 cm below to:
9	49–43	Clay-silt, pale yellow-buff, fine columnar-blocky ped structure, very hard peds, few small root holes, calcium carbonate induration, sharp lower junction. This layer corresponds with the top of the layer 1.4 m from the surface of which al-Najjar *et al*. (1990) obtained charcoal radiocarbon dates of 5375±30 BP or 4331–4069 cal. BC (HD-12336) and 5740±35 BP or 4688–4499 cal. BC (HD-12337).
10	02–43	Silt, some clay; grey-brown to brownish-grey, variously moderately strong peds to poor columnar/blocky peds, sometimes disordered; occasional pebbles, cherts, chips of pottery; some nodules of calcareous materials, calcified root holes; irregular lower boundary.
11	02	The base of the sequence rests upon the base of the previous excavation: clay-silt, moderately strong peds, with signs of human occupation: ash, many pottery fragments, much charcoal, cherts. This is the level which contains the foundation structures of the Late Neolithic buildings of the Tell Wadi Faynan site (Fig. 7.15), with radiocarbon dates at or close to this sequence of 6408±115 BP or 5612–5076 cal. BC (HD-10567), and 6370±40 BP or 5471–5231 cal. BC (HD-12335) (al-Najjar *et al*. 1990: table 1).
Base of section		

Table 8.1 *The stratigraphy at Tell Wadi Faynan (WF5022): sediment sequence.*

ronment post-dating the Pottery Neolithic occupation. The channel fill sequence that was accumulating in a wetter climatic regime in the mid sixth millennium cal. BC had ceased functioning as a stream channel a thousand years later. The change in stream behaviour correlates with the presence of wind-blown material, which also suggests dry conditions beginning after *c.*5000 BC and a lack of vegetation. There is insufficient evidence to establish the extent to which the brief phases of re-working, surface wash, or soil formation detectable within the sediment profile represent variations in the details of the local environment, or whether they reflect the local impact of climatic fluctuations of the wider scale and significance suggested by Bar-Matthews *et al*. (1997), Migowski *et al*. (2006), and Rosen (1997); the former explanation is the more conservative. The presence of fragments of pottery and charcoal throughout the sequence suggests that there was human activity nearby, but such remains are relatively less frequent in lithostratigraphic Unit 8, above the unit with the Chalcolithic date. In the more confined environments within the Wadis Dana and Ghuwayr, the perennial channel flows that had sustained Neolithic settlement were replaced by braided river processes characterized by intermittently high winter discharges and the transport and deposition of very coarse-grained fluvial sediments (Fig. 3.8).

Samples for palynological study were collected from site WF5022 and were investigated, but all were barren of pollen and spores.

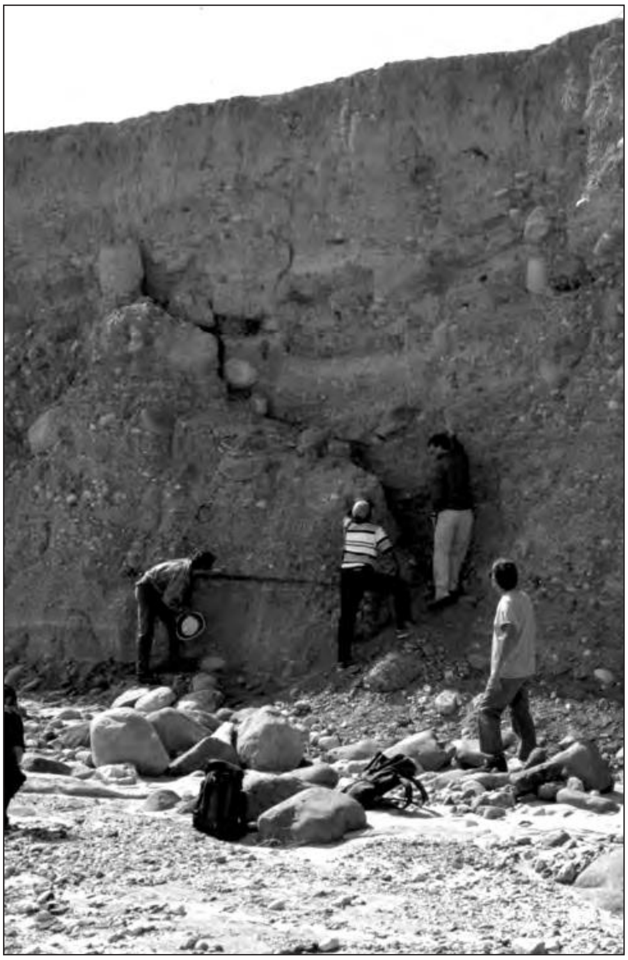


Figure 8.3 *Fine-grained aeolian and slope-wash deposits of the Tell Loam Member about 1.5 m thick overlie the fluvial channel infill-deposits of the Faynan Member (Upper Component) at site WF5021, looking south. Details of the stratigraphy and dating evidence at this exposure are shown in Figure 7.4. (Photograph: David Gilbertson.)*

8.3 Chalcolithic settlement in Wadi Faynan

Chalcolithic societies in the southern Levant (*c.*5000–3600 BC) developed out of the preceding village-based Pottery Neolithic societies, but were characterized in some regions by the emergence of marked social hierarchies and evidence for other social institutions which are commonly regarded as signatures of chiefdom societies (Levy 1995). There is evidence for significant population growth, and for the development of local settlement hierarchies, with larger sites such as Shiqmim in the Beersheva valley (Levy 1987), Teleilat Ghassul (Blackman 1999) in the Jordan valley, and possibly Jericho (Garfinkel 1999) interpreted not just as more substantial villages than the smaller sites around them but as political centres coordinating social, economic, and religious activities within their spheres of influence (Levy 1987; 1995). An alternative view is that Chalcolithic elites were primarily religious specialists (Joffe *et al.* 2002). The archaeological indicators of status include craft workshops, specialized metallurgy, prestige objects, formal cemeteries including child burials with rich grave-goods (like the gold ingots at Nahal Qanah cave: Gopher 1996), and religious buildings or sanctuaries (Alon and Levy 2005).

On the evidence of phytolith studies at Shiqmim, one response to the increased aridity coinciding with the Chalcolithic appears to have been the development of simple systems of floodwater farming or basin irrigation (Rosen and Weiner 1994). There is also the first evidence now for the cultivation of the olive and the date as well as cereals and legumes, and whilst pigs and cattle were kept in the better-watered regions, animal husbandry increasingly concentrated on sheep and goats. Shiqmim has also produced bones of domestic donkeys (Grigson 1993; Ovadio 1992). Whether or not Chalcolithic farmers used ox- or donkey-drawn ards is unclear, though the frequency of heavy stone implements suggests that hand cultivation remained the norm. Beyond the agricultural sphere, further indicators of economic intensification include evidence for specialized craft-workers being based at the major settlements, working materials such as ceramics, copper, gold, stone, shell, and ivory. The metal-working evidence includes slags, crucibles, and broken and half-finished artefacts. Most Chalcolithic metallurgy in the southern Levant appears to have been organized on a household basis for local consumption (‘cottage industries’: Golden *et al*. 2001: 961), although occasional luxury objects such as a disc-shaped macehead found at Shiqmim imply that some of the metallurgists were ‘attached’ to powerful elite figures. Chalcolithic smelting installations, however, seem to have been uniformly small scale, consisting of simple bowl furnaces that were larger versions of the crucibles used in the metal-working.

The Bochum Museum studies indicate that copper mining began in Wadi Faynan in the Chalcolithic period, in the form of simple adits or scoops quarried into the hillside (Hauptmann 1989a,b; 2000; 2007). The dating evidence in direct association with these diggings is rather tenuous, but archaeometallurgical analysis of artefacts and ore at Shiqmim, over 100 km to the west, indicated that they were of Faynan copper (Shalev and Northover 1987). The ores of Timna, on the western side of the Wadi 'Arabah in the southern Negev (Fig. 2.1), were also exploited by the Negev settlements (Weisgerber 2006). Given the presence of ores, slags, crucibles, and prills at Shiqmim and other Negev sites clearly associated with the working of Faynan copper, together with the lack of evidence for any significant infrastructure for metal extraction at this time at Faynan and Timna, the consensus has been that access to the ores was not being controlled by local Faynan elites and that Negev settlements such as Shiqmim were sending working parties to the mining areas and transporting back – presumably by donkey – quantities of ore for smelting and casting (Golden *et al*. 2001; Levy 1995; Levy and Shalev 1989).

We found a number of examples of what are regarded as Chalcolithic lithic forms such as trihedral picks and arch-backed blades, mainly in the survey of the WF4 field system (Reynolds 1998; Appendix 4; Fig. 8.4) We found no evidence for settlements of the scale and elaboration of Shiqmim in the vicinity of the Faynan ores, though the Jabal Hamrat Fidan survey found a 1.5 ha site (JHF51) likely to be of early Chalcolithic age at the mouth of the Wadi Fidan overlooking the Wadi 'Arabah (Fig. 8.2), with pottery and lithic material likened to those of Gilat in the northern Negev and a radiocarbon date (Beta-118580) of 6260±40 BP or 5250–5210 cal. BC (Levy *et al.* 2001b: 10). The nearby site Wadi Fidan 4, at first thought to be a significant Chalcolithic metal-working settlement, was subsequently shown to date to the Early Bronze Age (Adams and Genz 1995; Hauptmann *et al*. 1996; Levy *et al*. 2001a,b). No evidence of metal-working was reported at JHF51.

As described in Chapter 7, our geochemical analyses of the Tell Wadi Faynan sediments provide strong hints of some kind of *in situ* metallurgical activity beginning by the end of the sixth millennium cal. BC (Fig. 7.19). This evidence, combined with the occurrence of slag and copper prills in the Chalcolithic sediments at the site, make a strong case that Chalcolithic people at Tell Wadi Faynan were definitely smelting copper. Furthermore, we also found slags in Chalcolithic-age sediments built up behind a revetment wall (WF1491) northeast of Khirbat Faynan at the foot of the site mound, from which we obtained radiocarbon dates of 5690±40 BP or 4681–4523 cal. BC (Beta-203413) and 5290±40 BP or 4238–3993 cal. BC (Beta-203414). Whilst we do not have in Wadi Faynan any of the evidence for the complex societies of Shiqmim, the indications are that there were certainly communities living in the wadi at this time who were engaged in the extraction and processing of copper ores, though whether they exercised some kind of control of access to the ores by outsiders such as people from Shiqmim is unknown.

8.4 Early Bronze Age 'urbanism'

The Early Bronze Age (3600–2200 BC) witnessed the development of more complex ranked societies in the southern Levant, characterized by many of the indicators of urbanism except writing (Gophna 1995; Joffe 1993; Philip 2001). Dever (1992: 83) lists them as: densely nucleated populations; a distinct settlement hierarchy; a stable and productive agricultural system; a differentiated social system; centralized political administration; advanced technology; monumental art and architecture; and long-distance trade. On the other hand, Early Bronze Age (EBA) societies in this region do not seem to have been characterized by a clear separation between urban and rural communities. Philip (2001) and Chesson and Philip (2003) therefore argue that it may be wiser to accept and attempt to understand the diversity of economic, political, and social complexity without getting fixated on whether or not these societies were or were not truly urban (as were, for example, contemporary societies in Mesopotamia). They suggest that these societies need to be studied not as elite-driven urban polities but as prosperous kinship-based village communities, with overlapping and at times ambiguous and contradictory organizational structures ('heterarchy' rather than 'hierarchy': Crumley 1995), for whom wealth was measured primarily in terms of land and productive facilities rather than the ritual paraphernalia of the Chalcolithic.

In the first sub-phase, EB1 (3600–3000 BC), the most significant urbanized settlements developed on the Mediterranean littoral but a distinct settlement hierarchy can also be discerned in the hill country between the coast and the Jordan valley, including in the northern part of the Negev, the region that was to become Iron Age Canaan. At the lower end of the scale there were numerous open settlements, a hectare in size or less, made up of dispersed groups of oval and curvilinear dwellings, with little evidence for planning in their layout. At the other end of the scale were compact fortified settlements several hectares in size such as Arad (Amiran *et al*. 1978) and Megiddo (Finkelstein *et al*. 2000), with evidence for internal planning. The communities in these settlements included craft specialists working materials such as clay, stone, and metal. The architecture of some of the buildings in the settlements suggests that religious institutions played a significant role, perhaps including the receipt of surplus, but the absence of evidence for major administrative buildings suggests that, whilst an elite ruling class had developed, society continued to be structured according to kin and lineage relations. One indicator of the competitive nature of these societies is evidence for inter-community competition and violence, such as axe wounds on skulls and the hasty burials in burned buildings at Bab edh-Dhra' (Ortner 1979; 1982).

There was a substantial Egyptian presence at this time on the southern coastal plain, possibly coordinated by the

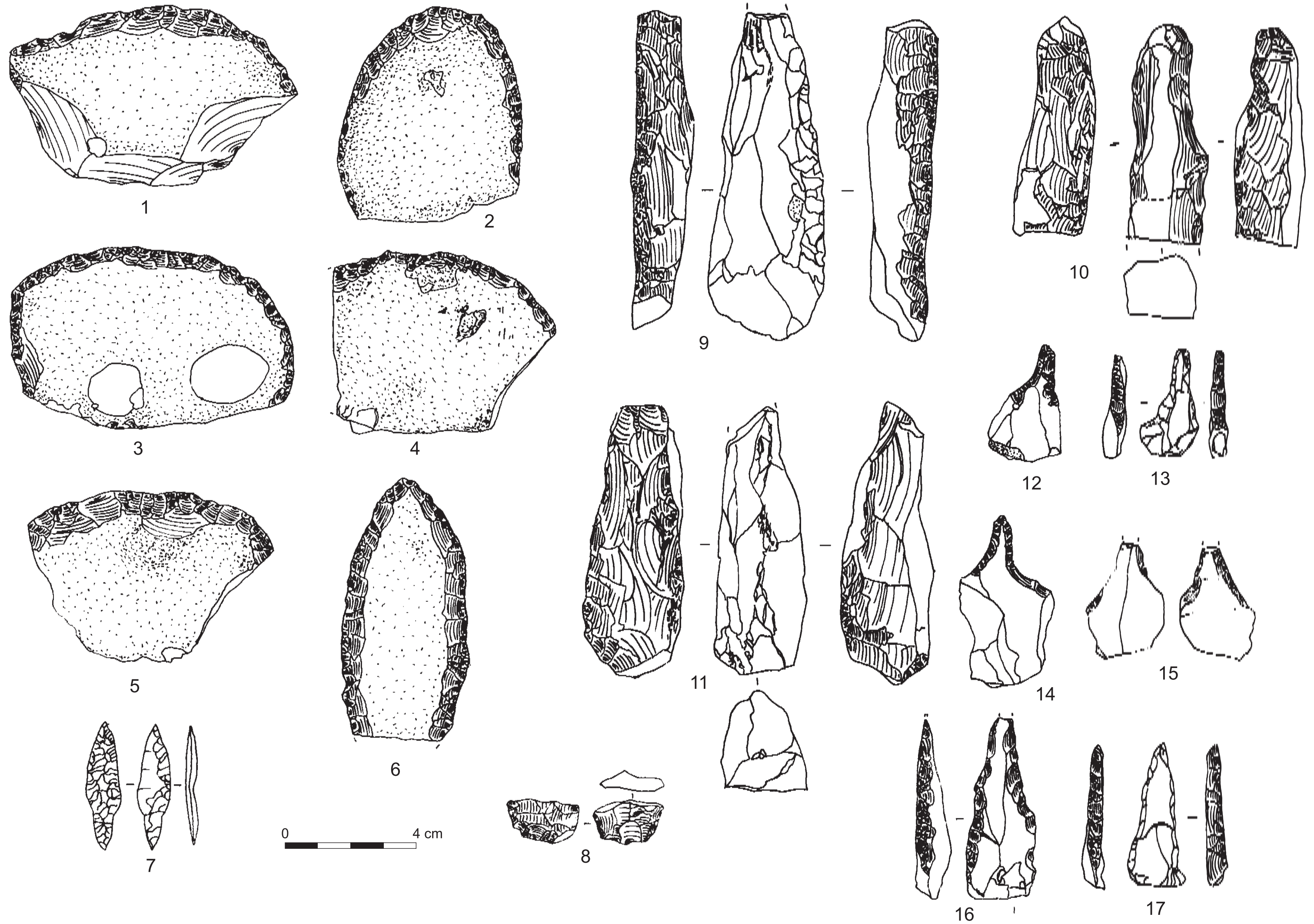


Figure 8.4 *Middle Holocene lithic artefacts from the Wadi Faynan: 1) tabular scraper, WF660; 2) tabular scraper, WF660; 3) tabular scraper, WF660; 4) tabular scraper, WF661; 5) tabular scraper, WF660; 6) tabular scraper/knife, WF686; 7) tanged bifacial foliate projectile point, WF1535; 8) bifacially worked fragment (possibly from a projectile point), WF4.3.26; 9) trihedral pick fragment, WF1442; 10) trihedral pick fragment, WF576; 11) trihedral pick fragment, WF556; 12) flake borer, WF516; 13) flake borer, WF1442; 14) flake borer, WF4.15.66; 15) flake borer, WF4.7.36; 16) borer, WF481; 17) borer, WF4.15.44. (Drawings: Tim Reynolds.)*

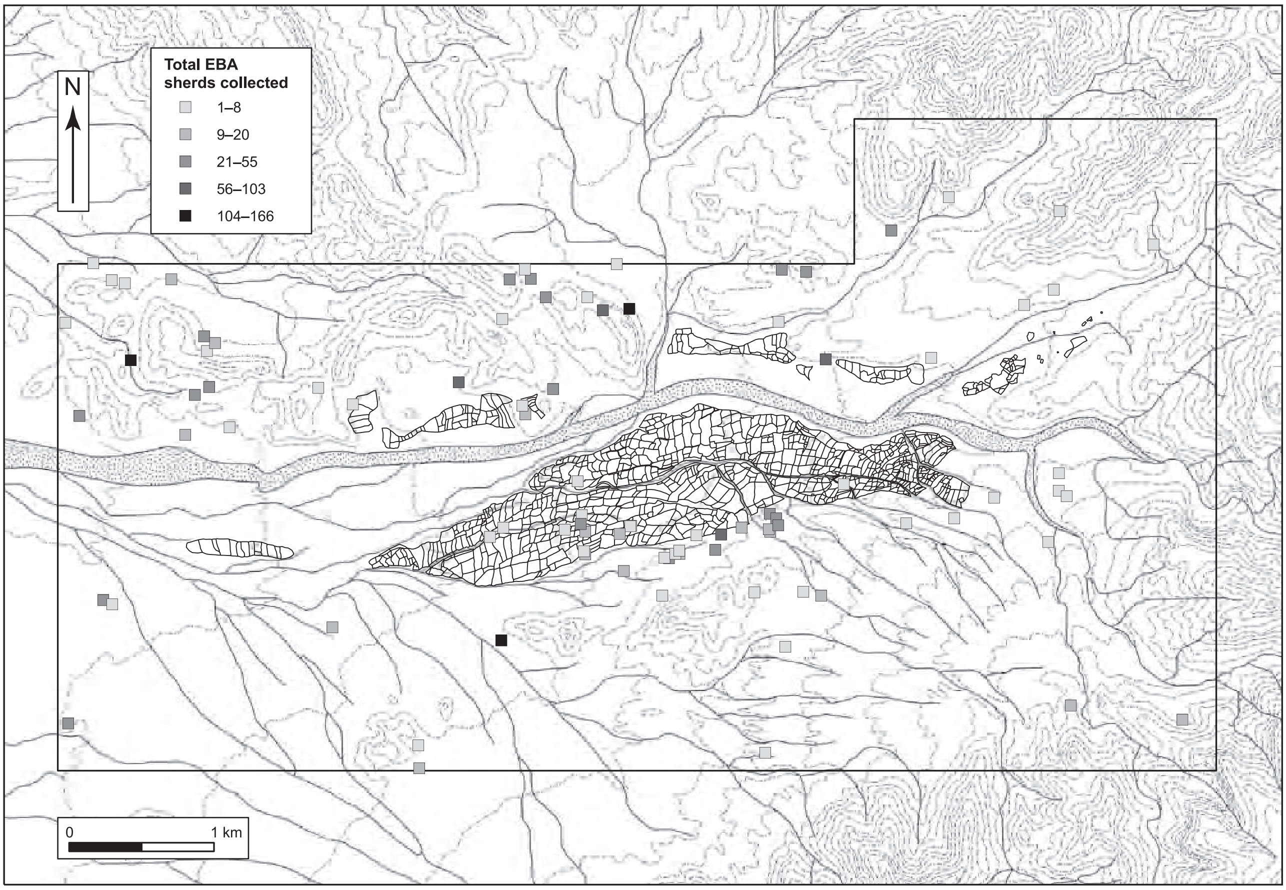


Figure 8.5 *The distribution of EBA 'domestic structures' in the Wadi Faynan survey zone. (Illustration: Paul Newson.)*

site of En-Besor, where there are Egyptian-style brick structures and numerous clay sealings of Egyptian rulers. It is commonly argued that Egyptian trade needs, particularly for olive oil, wine, and metal (copper especially), as well as for products such as bitumen, shell, and semi-precious stones, were an important stimulus in the development of urbanism and statehood in Palestine (Adams 1999; Algaze 1993; Braun 2002; Finkelstein and Gophna 1993; Stager 1985).

Significant investment continued at the major centres during EB2 (3000–2700 BC), though Egyptian presence in the region was drastically reduced as their trade links shifted north to Byblos. Arad at this time was enclosed by a substantial stone wall over 1 km in length, further strengthened by semi-circular towers, and there were as impressive fortifications at Jericho, presumably a reflection not just of defence but of new forms and levels of social control over the surrounding populations (Joffe 1993: 70). The dominant dwelling at Arad was a large rectangular building partitioned into several rooms, with internal stone benches and storage bins. Similar structures have been found at many contemporary settlements in the region, sometimes associated with other buildings grouped round a compound. They are thought to have been the residential loci of nuclear families or households.

Pressing equipment for oil and wine is rather rare in the centres, whereas the latter commonly produce fragments of large open ceramic vessels with spouts that are interpreted as vats for separating oil. The assumption is that the bulk of oil production took place in the countryside, with final preparation at the centres (Stager 1985). The same was probably true of other agricultural products. Vessels of standardized sizes were used to process and package products arriving at the centres. Given the collapse of Egyptian trade in EB2, it seems likely that the surplus controlled by the Levantine elites was now used mainly for local redistribution systems and for inter-communal exchange. There was no simple dichotomy between urban elites and rural peasants, however: the 'cities' seem to have been centres for agrarian elites rather than specialized administrators, much of the urban population probably consisting of agricultural producers. Some rural settlements seem to have been occupied by elite groups. There were pastoral communities on the desertic fringes of the urbanized areas (Haiman 1992a,b).

By the end of EB2 there were significant disruptions to settlement patterns in the southern Levant. Centres such as Arad were abandoned and those that survived were considerably strengthened in their fortifications (Amiran 1978). The agricultural communities of the countryside

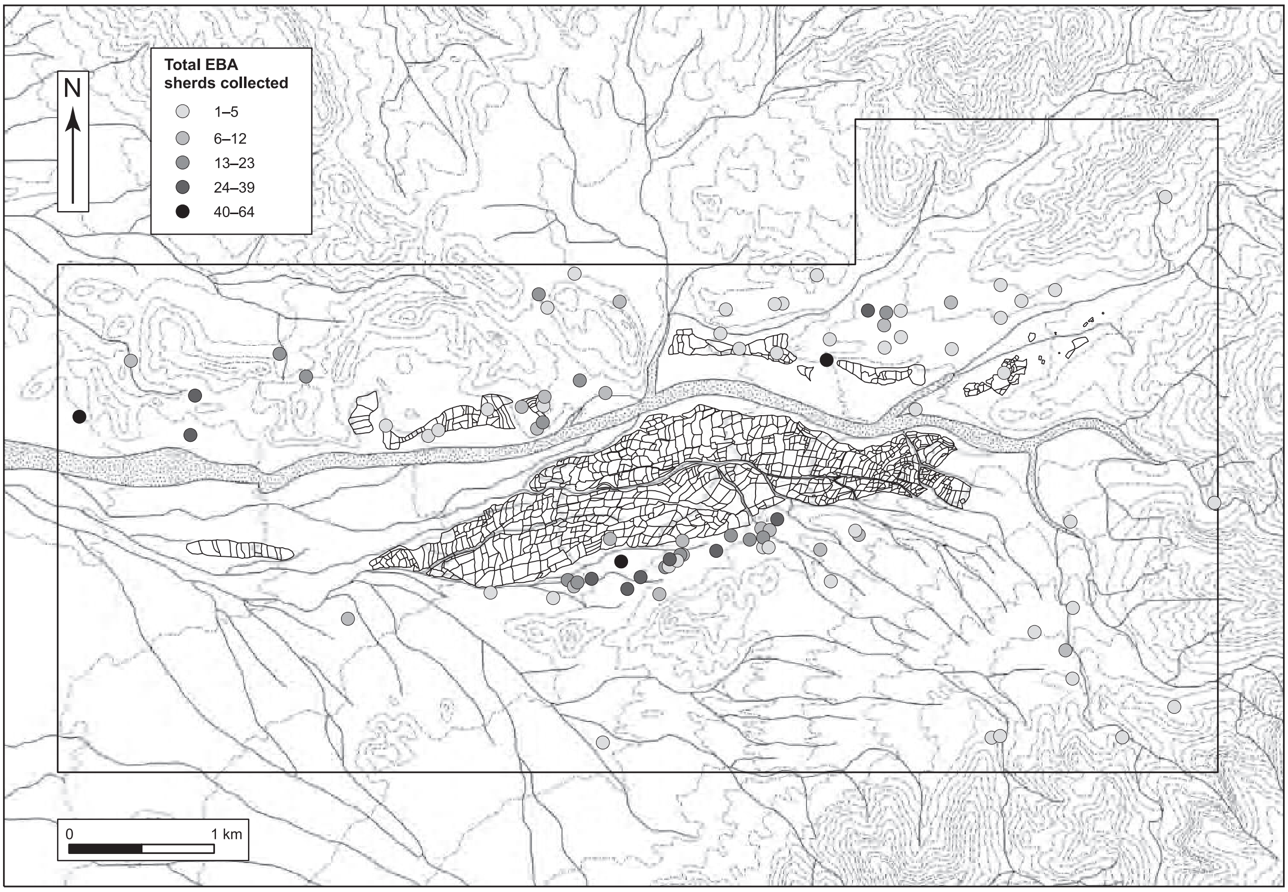


Figure 8.6 *The distribution of EBA 'funerary structures' in the Wadi Faynan survey zone. (Illustration: Paul Newson.)*

either diminished in scale or even disappear from the archaeological record altogether. The process accelerated during EB3 (2700–2200 BC) and EB4 (2200–2000 BC), and by the end of the third millennium BC most of the cities and towns of the region had been abandoned (Seger 1989). The reasons for the collapse of EBA urbanism are much debated, theories including invasions by nomadic Amorite tribes from the Syrian steppe (Kenyon 1956), Egyptian military incursions (Mazar 1990), and the failure of an inherently unstable system to deal with the collapse of international trade (Dever 1989) or with the major drought event at for which there is very strong palaeoenvironmental evidence (Esse 1989; Migowksi *et al*. 2006; Rosen 1989). Theories of internal collapse are generally favoured today, with military incursions from outside regarded as likely to be symptoms of weakness and instability rather than the primary triggers of change, but it is difficult to ignore the dramatic climatic shift to aridity, and the pressures it imposed on agricultural systems, also being part of the equation (Arz *et al*. 2006). Whatever the reasons, the consensus of scholarly opinion is that by the end of the third millennium BC the inhabitants of the urbanized regions of the southern Levant increasingly reverted to small-scale subsistence farming and/or pastoralism (Dever 1992; 1995; Finkelstein 1995; Palumbo 2001).

8.5 Bronze Age monument types in Wadi Faynan

The project recovered EBA pottery from several hundred sites and survey units. Many of these had pottery of later periods on and around them, and assigning structures with certainty to a particular period or periods was impossible without sealed excavation units. However, the clear association of many structures exclusively with EBA material, and of similar structures with a clear preponderance of EBA material, gives confidence to assigning many such sites to this period (Fig. 4.1). Even though individual sites of generic types (that is, simple forms of structures commonly constructed in different phases of settlement) may well have been mis-assigned, the broad trends in EBA monument building are clear.

Although it is highly unlikely that the domestic and religious/ritual domains were clearly separated for the EBA societies of Wadi Faynan in terms of their everyday lives or 'worldviews', for the purposes of classification their archaeology has been divided into the two broad categories of 'domestic' and 'funerary' structures. The ceramic dating evidence associated with these sites demonstrates that the overwhelming preponderance of the material that can be dated to the EBA can be either definitely or very probably assigned to the EB1 phase (3600–3000 BC). The same is true of the pottery from the field systems (Table 8.6). This period appears to have been characterized by an extraordinary explosion in population compared with the centuries before or afterwards.

The simplest type of 'domestic structure' was a circular or oval 'room' 5–6 m in diameter, generally with a single entrance marked by upright stones and sometimes a threshold. The walls were built of a single line of stones or large boulders, or a double row with smaller stones packed in between. The surviving stones of their walls suggest that some of these structures may have been permanently roofed shelters, whereas others were probably more ephemeral constructions with some kind of tenting placed above the stone footings. Structures of such simplicity were certainly a feature of many periods of settlement in the study area, but of the *c*.100 examples with EBA pottery mapped by the project almost 40 had sufficient numbers of EBA sherds to allow us to assign them to the EBA, and to the EB1, with reasonable confidence. All the examples of 'complex' domestic structures with oval or circular cells or room units ('complex' being defined as having five or more units: see Chapter 4 for descriptions and illustrations) can be assigned to the EB1 with certainty in terms of the material culture found in and immediately around them. Some isolated examples of circular or oval rooms may be vestiges of 'complex' domestic structures. Small rectangular structures were the predominant domestic form in Nabataean, Roman, and Byzantine times, but over 60 of these also produced EBA (especially EB1) pottery and many are certainly of this date. Another common class of EB1 monument was an enclosure to which circular, oval, or rectangular rooms were variously attached to the interior or exterior. Most circular/oval enclosures lacking associated rooms or pens also belong to this period.

The EBA 'domestic' structures of these various categories are found throughout the survey area, from the foot of the plateau escarpment at the southern boundary to the mining zones in the far northeast, and from the tributary wadis at the head of Faynan on the east to the boundary with Wadi Fidan on the west (Fig. 8.5). However, two major concentrations are noticeable. The first straddles the lower part of the central section of the WF4 field system and the hillslopes to its south. The second is along the northern edge of the survey zone, on the gravel fans that trend northwards from the ridge of hills separating them from the main wadi channel.

'Funerary' structures likely to be broadly contemporary with the EB1 'domestic' structures include cairns, cairns with cists, cairns with kerbs, and cairns with both (see Chapter 4, §4.6 for descriptions and illustrations). The *c*.300 cairns recorded by the survey, though all defined as cairns from the presence of an artificial pile of stones, vary considerably in shape, height, and stone content. Of course the antiquity, history of use, and function(s) of any cairn can only be established by excavation and without this, interpretation is particularly problematical. Some cairns may be single-period burial locations, others multi-period burial locations, others could be cairns produced by field clearance operations, others could be burial cairns augmented by field clearance, and so on. However, the number of simple cairns that appeared to have EB1 sherds mixed in with their construction material is such as to suggest that many or indeed most are likely to be of this date. Of the *c*.20 or so cairns with visible cists or stone chambers within them, half of them yielded EB1 pottery; the same was true of the *c*.20 cairns with traces of kerbs; and the few examples of well-preserved cairns with both cists and kerbs were all clearly associated with EB1 material. Hence there are good grounds for believing that the majority of funerary cairns dates to this phase of settlement in the study area. Like the domestic structures, they are located throughout the study area (Fig. 8.6), but the two distributions share both similarities and differences. For example, one noticeable concentration is on the low hills south of the central part of the WF4 field system, where many domestic structures are also found. Several cairns are also located on the northern side of the main channel, along with domestic structures. Many, however, are also located on the low hills west of Khirbat Faynan, often in visually prominent situations, forming a distinct 'funerary landscape'.

The various components of this remarkable EB1 landscape are examined in further detail in the following sections of the chapter, beginning with what appears to have been a major focus of settlement, underneath what was to become the south-central zone of the WF4 Nabataean/Roman field system.

8.6 The major settlement complex of WF100

The largest and most impressive EBA site in Wadi Faynan, WF100, was first identified by the BIAAH reconnaissance survey in 1994 and 1995 (Ruben *et al*. 1997). This team noted a dense and extensive concentration of EBA pottery and other material within the WF4 field system, more or less equivalent to the WF4.13 sub-unit defined by our own project (Fig. 1.11, lower), a density that our own survey also confirmed (Fig. 8.7). The indications were of a substantial settlement zone, and to test the theory that it was likely to comprise a single settlement complex, the locality was the focus of survey and excavation work in 1996 and 1997 by a team from University College London led by Karen Wright (Wright *et al*. 1998).

The area defined as WF100 is roughly trapezoidal in shape (Fig. 8.8). It is part of a well-defined linear terrace that slopes gently down from east to west parallel to the main Faynan channel, with an abrupt northern edge up to 2 m high. The southern side of the trapeze is demarcated by the channel of a small tributary wadi. The topography rises to a low (5–10 m) hill in the southeastern sector. Although the WF4.13 unit is divided into 30 fields demarcated by walls of probable Nabataean and later date, one of the reasons for the interest of the site for excavation was the fact that there were traces of more substantial walls forming the outer boundary demarcating the area of dense EBA surface material. Furthermore, there were indications of a

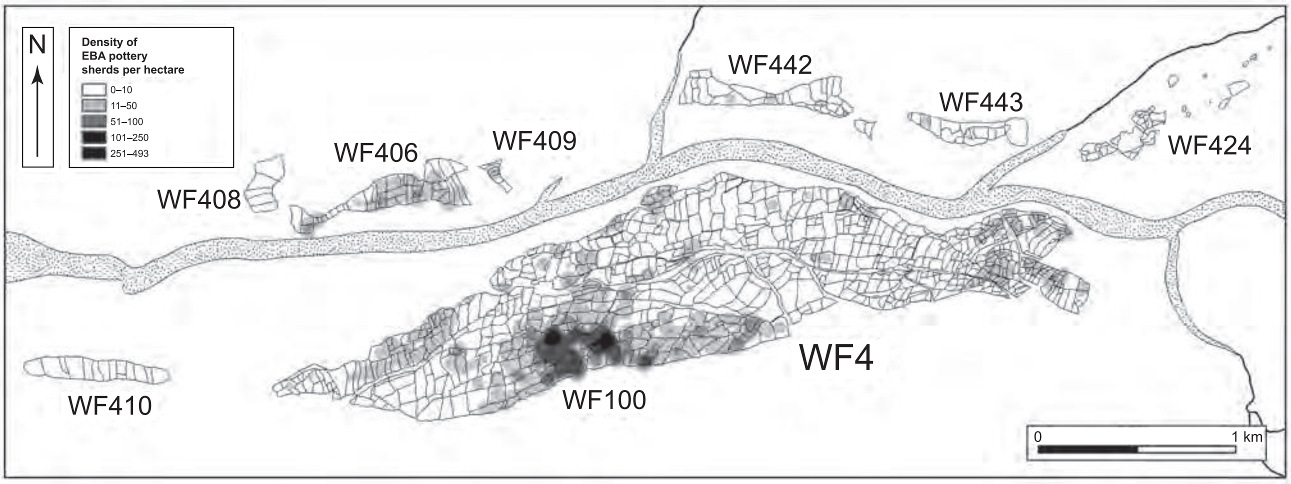


Figure 8.7 *The distribution of EBA pottery within the field systems flooring Wadi Faynan, clearly defining the extent of the major settlement complex WF100. (Illustration: Paul Newson.)*

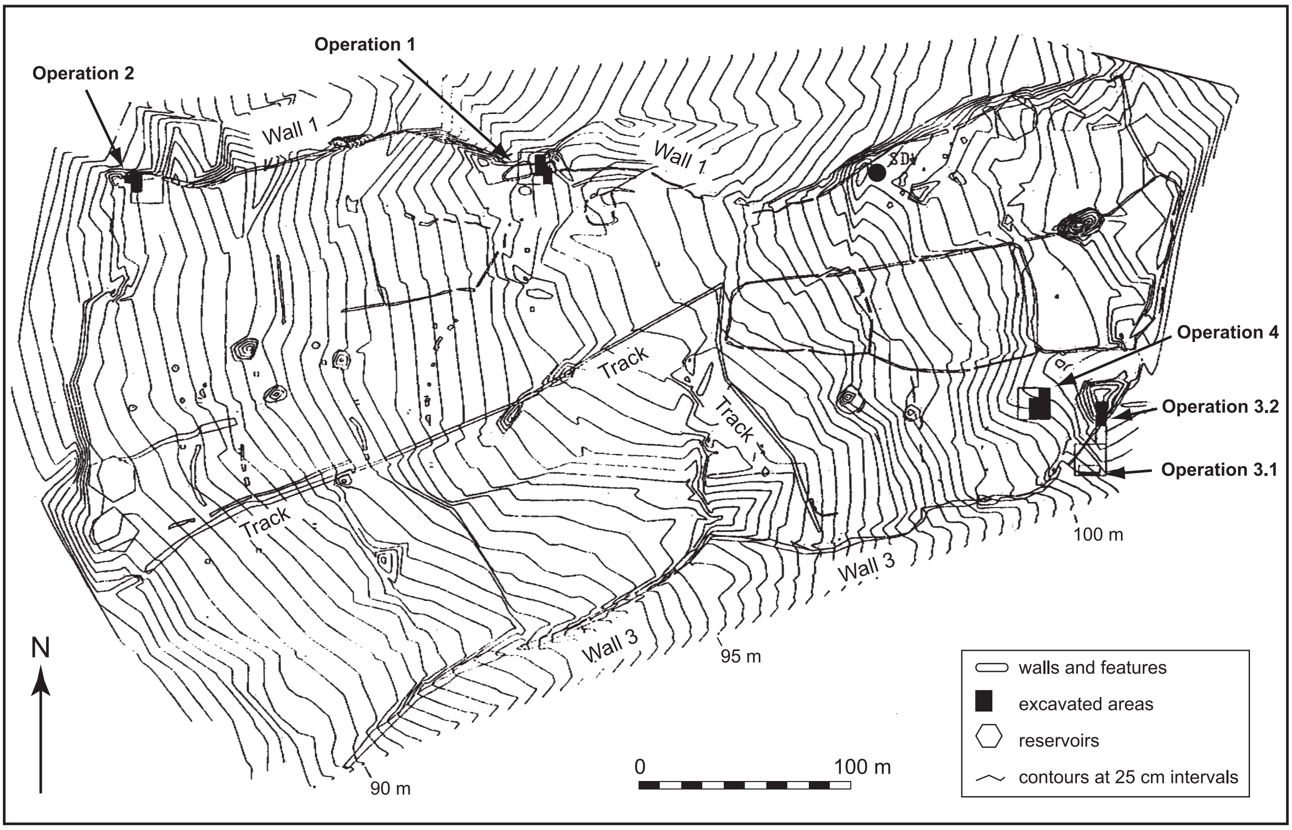


Figure 8.8 *WF100, showing surface features and locations of excavations ('Operations'). (After Wright* et al. *1998, fig. 1.)*

series of roughly semi-circular structures on the external side of the northern wall bearing some resemblances in plan to the defensive turrets of the encircling walls of Arad (Amiran *et al*. 1978), and there were several large mounds resembling EBA tumuli in the Negev, including one built into the possible 'enclosure wall'.

The excavation of one of the external 'turrets' at the northwest corner of the site ('Operation 2') revealed that it was a small rectangular building of Nabataean date (Fig. 9.26), but this trench and another laid out across the northern wall (Operation 1) discovered clear traces of EBA occupation on the inside of the enclosure wall, including fragmentary walls of small sub-rectangular buildings, floor surfaces, and pits cut into the floors. The walls of these buildings varied from being lines of single boulders to more substantial structures with outer courses of large stones

Figure 8.9 *The midden section exposed by Operation 3.2 at WF100, looking north (geomorphological site WF5516); see Tables 8.3 and 8.4. Scale: 1 m. (Photograph: Graeme Barker.)*

filled with rubble, similar to those of Classical date in the Faynan region. One building contained a stone-lined pit, another a large ceramic vessel sunk into the floor (perhaps associated with oil production), and both contained evidence of metal working. One pit contained *c*.1800 sherds, along with lithics, fragments of animal bone, shell, slag, copper ore, spindle whorls, and a crucible fragment. A similar range and density of EBA material were found in the rubble fill of one of the 'tumuli' on the southeastern sector of the site (Operation 3.2), which proved on excavation to be a midden (Fig. 8.9). Finds here indicative of metal-working processes included copper ore, slag, fragments of ceramic moulds, and hammer-stones. Some of the other mounds may be clearance cairns, but others are funerary monuments as originally surmised.

The main exposure of EBA structures was in Operation 4 (Fig. 8.10). Although no single structure could be defined, the indications are of substantial sub-rectangular buildings and associated compounds or yards, rather like those identified at Wadi Fidan 4 (Adams and Genz 1995). The major walls, set into foundation trenches, in part consisted of massive undressed boulders set in line orthostatically, in part of double lines of boulders with a cobble infill like the structure walls found in the other excavations on the site. The minor walls were also of the latter construction. Finds on the occupation surfaces included EBA sherds, lithics, ground stone, animal bone and shell, and copper ore, together with a fragment of a copper awl.

The prehistoric pottery collected from the surface and from the excavations of WF100 was 'coarse in fabric and conservative in form' (Wright *et al*. 1998: 45). The pots were made by the coil technique, mat impressions under some bases suggesting that the vessel under construction was placed on a circular mat which could be rotated by the potter. The coarse gritty fabrics and mottled surfaces of the sherds indicate poor-quality clay and a simple firing technology. The repertoire consisted of various types of open bowls, jars with vertical necks, and 'hole-mouth'

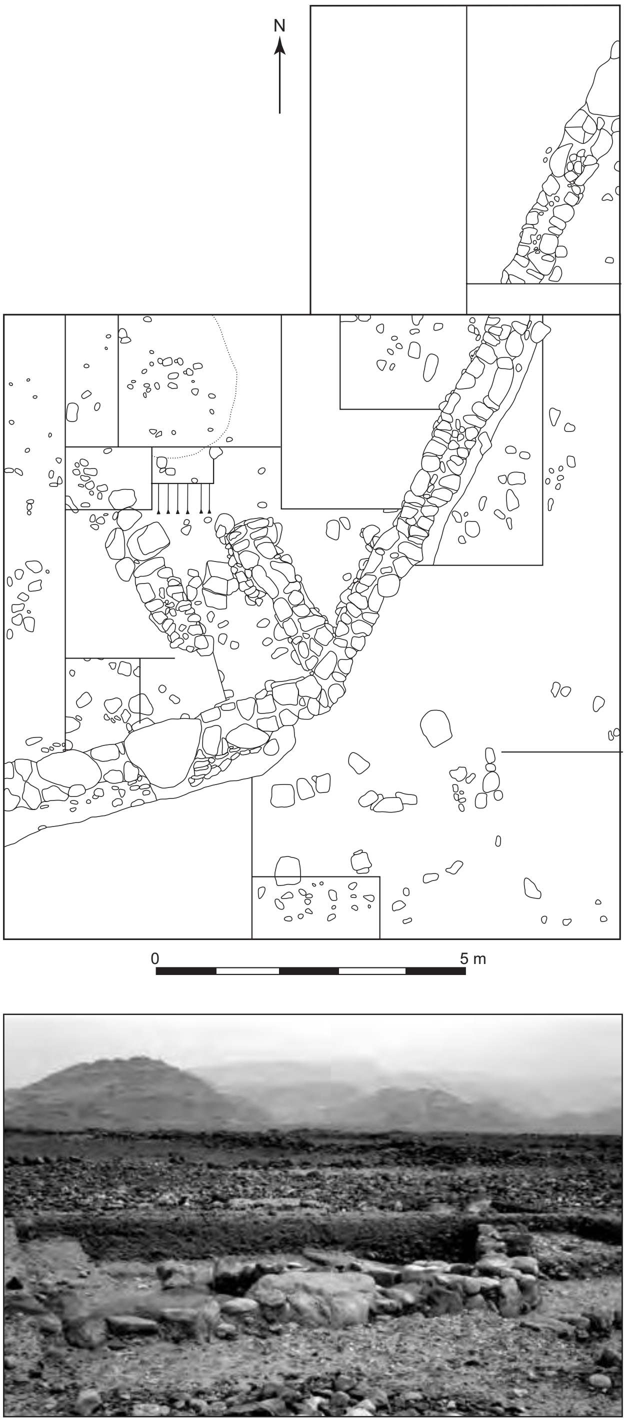


Figure 8.10 *EBA structures at WF100: (above) plan (Illustration: Dora Kemp, after Wright* et al. *1998, fig. 4); (below) looking northeast across Operation 4. (Photograph: Graeme Barker.)*

vessels with incurving rims. These vessels were either left plain or decorated simply, mostly at or near the rim, with finger impressions and incisions cut directly into the clay or into applied cordons. All these factors, together with the other details of the typology such as the shape of ledge handles and their locations on the vessels, point firmly to an EB1 date for the main occupation of WF100 (Wright *et al*.

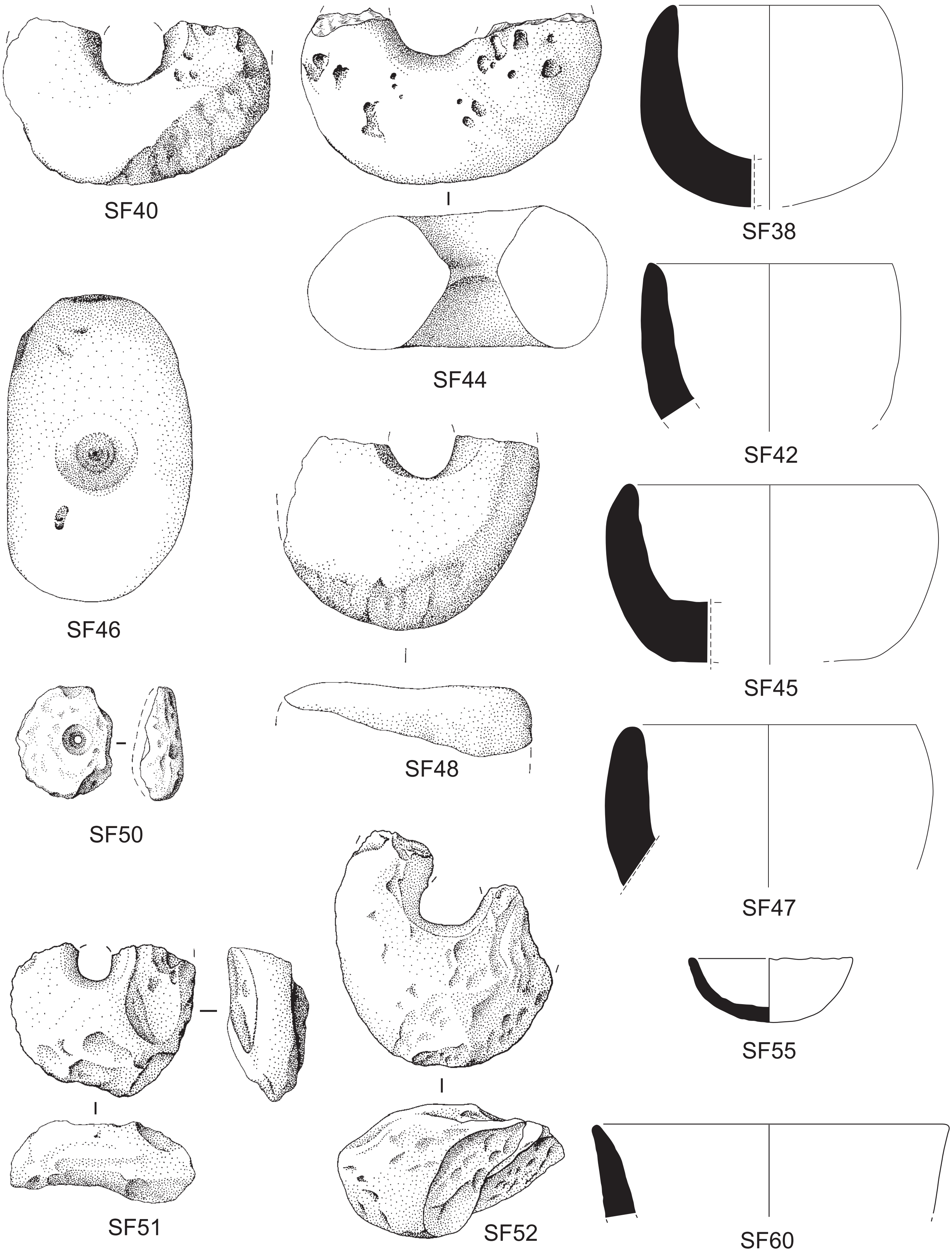


Figure 8.11 *Basalt hammers and bowls from the WF100 area and surrounding fields, likely to be of EBA date and probably used for crushing ore. Scales: SF38, SF42, SF45, SF47, SF60 1:4; rest 1:2. (Drawings: Matthew Pearson, inked by Jenny Doole.)*

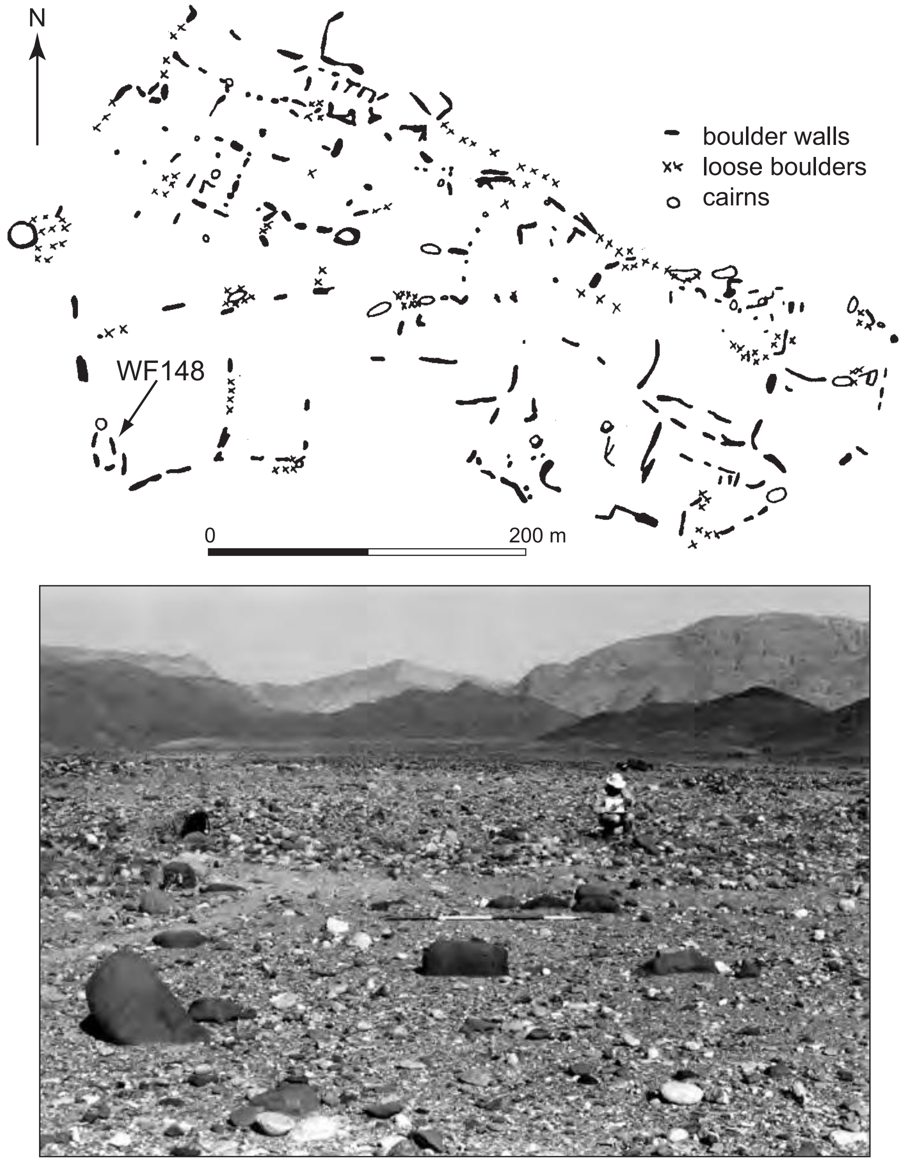


Figure 8.12 *EBA boulder walls within the WF100 settlement complex: (above) plan (Illustration: David Mattingly, in Barker* et al. *1999, fig. 10); (below) examples in the northwest sector, looking southeast. Scale: 2 m. (Photograph: Graeme Barker.)*

1998: 51). A few fragments of stone bowls were collected in the surveys of the WF100 area by the UCL team, and our own surveys found several more in and around the WF100 area (WF4.13: SF [small find] 59, SF60, SF76; WF4.14: SF38, SF42, SF43; WF4.17: SF45, SF47; Fig. 8.11). They were mostly of a close-grained basalt, some fragments deriving from vessels with thick sides and bases (3.0–4.5 cm thick) possibly used, on the basis of the wear traces on their inside surfaces, as mortars for crushing ore. Perhaps related to these are heavy stone hammers, mostly of basalt, with traces of severe wear – again, the UCL team found several in WF100 and we found more here and in the surrounding fields (WF4.12: SF40; WF4.13: SF41, SF48, SF52; WF4.14: SF44, SF46, SF53, SF57; WF4.15: SF50; Fig. 8.11). The flaked lithic assemblage consisted mainly of irregularly retouched pieces fashioned from local wadi cobbles, probably manufactured on site for immediate use, along with a few picks (also of local material) and tabular scrapers and blades with 'sickle gloss'. The latter two classes of artefact were made of a better-quality imported material.

Following these excavations, further study of the WF4.13 unit by our own team as part of the detailed analysis of the WF4 field system revealed numerous features likely to be associated with the WF100 settlement. In particular, either visible within the later Nabataean/Roman walls or breaking the surface within the fields they enclosed, we were able to distinguish lines of walls formed of orthostatic boulders, and walls of the 'double face and rubble infill' category, like the walls exposed in the Operation 4 excavation (Fig.

Figure 8.13 WF148, a water-catchment structure within the WF100 settlement, looking north. (Photograph: Graeme Barker.)

Taxon	No.
Corylus	1
Rosaceae	1
Caryophyllaceae	1
Poaceae	1
Plantago	2
Chenopodiaceae	1
Asteraceae	8
Saeptodinium	1

Table 8.2 *Pollen analysis (numbers of pollen grains) of a basal sediment sample from WF148 (geomorphological site WF5518), a water-catchment structure associated with the EBA settlement complex WF100. The grain of* Corylus *is probably far-travelled to the site.*

Layer	Thickness (m)	Summary description
1239	0.20	Sandy silts deposited by wind, and gravel colluvium.
1241	0.18	Ash layer; cultural layer.
1240	0.10	Clayey material, perhaps derived from mud bricks.
1239	0.45	Coarse sand/silt, gravel: aeolian and colluvial.
1235	0.36	'Dumped', unsorted, angular to very angular gravels with no imbrication; some sherds in this layer.
Upper layer (uncoded)	0.50	Brown, yellow silty sand with scattered gravels of colluvial origin, with land snail (*Helix* sp.)

Table 8.3 *Stratigraphy and field interpretation of WF5516, a midden deposit at the EBA settlement complex WF100 (Fig. 8.9).*

Taxon	5516.1	5516.2	5516.3
Pinus	0	0	1
Juniperus	0	0	4
Olea	0	0	1
Caryophyllaceae	0	0	2
Cyperaceae	0	0	1
Poterium	0	0	2
Poaceae	0	0	6
Cereal-type	0	0	2
Plantago	0	0	1
Chenopodiaceae	0	0	3
Asteraceae	0	0	1
Lactuceae	0	0	1

Table 8.4 *Pollen analysis (numbers of pollen grains) at site WF5516, a midden deposit at the EBA settlement complex WF100 (Fig. 8.9).*

8.12). Although the Nabataean/Roman terrace walls are of similar construction to the latter category, typically they are wider than the excavated EBA walls and have a distinctive core of small stone and mud packing, even when made of reused boulders from dismantled EBA walls or built on top of sections of EBA walls. Of course not all the boulder walls mapped in Figure 8.12 can be guaranteed to be of EBA date, especially as some of the reused boulders were laid in rough courses in Nabataean/Roman walls, but it seems likely that the latter probably derive from boulder-built walls which were originally close by. The southwestern sector of the site has been disturbed by recent agriculture, but the distribution of fragmentary boulder walls in the northeastern and southeastern sectors of the unit, and in the northwestern area behind the major terrace wall, indicates that there were other zones of rectilinear buildings and yards as well as those in and around the Operation 4 excavation, together with fields or paddocks. Large middens of EBA date have also been identified extending beyond both the eastern and western limits of the unit. The cairns within WF100 are more difficult to interpret and date without an extensive programme of excavation; most were certainly being used as field clearance cairns in the Nabataean/Roman period, but many had EBA pottery and lithics on and around them and several appeared to be built over earlier substantial features.

The WF100 settlement complex also included a series of oval structures with walls similar in construction to the fragmentary boulder walls. In 1998 a test pit was excavated near the centre of one of these, WF148, situated at the southwest corner of WF100 and measuring *c.*22 m × 12 m (Figs 8.12, 8.13). The pit revealed about 0.5 m of deposit, of compacted mid-brown (Munsell: 10 YR 5/4) stony sandy silts, the field characteristics indicating a mixture of wind-blown and waterlain sediments that were subject to desiccation and

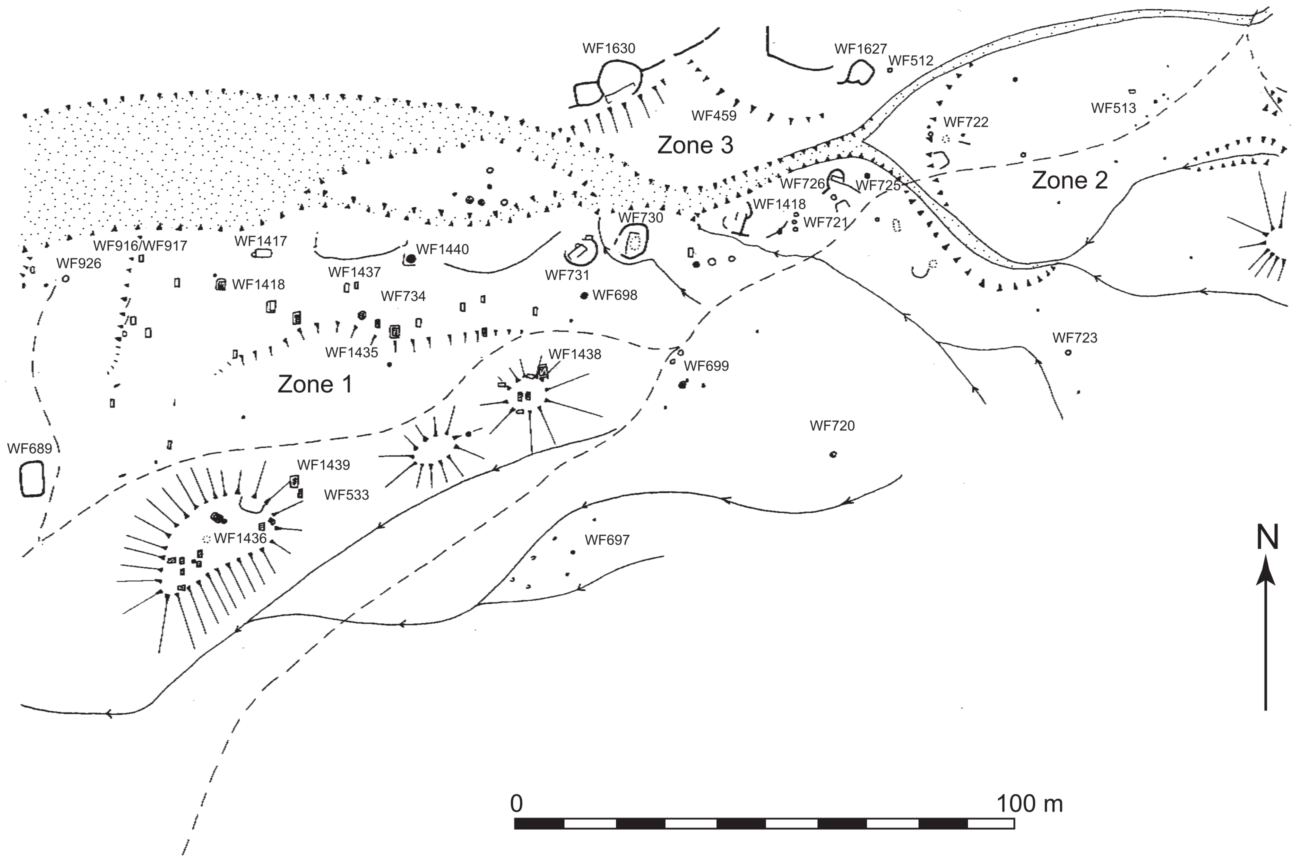


Figure 8.14 *Domestic, funerary, and hydraulic structures in the EB1 landscape south of WF100: western sector. (Illustration: Oliver Creighton and Mike Hawkes.)*

induration. The limited palaeoecological evidence from a sample taken at a depth of 0.5 m (Table 8.2) supports this picture of a dry climate and steppic vegetation, but the cysts of the aquatic algae *Saeptodinium* indicate that the structure itself contained relatively deep and permanent standing water (Mohamed and Hunt 1999: 261). The implication is that the WF100 community had developed technologies to trap and store rainwater to cope with the arid and desertic landscape that had developed by this period.

Further information on the contemporary landscape was obtained from the midden deposits at WF100 exposed by Operation 3.2, sampled with the permission of the excavator as WF5516 (Fig. 8.9; Table 8.3). No pollen survived in two of the samples (WF5516.1 and WF5516.2) and the third (WF5516.3) contained just 25 grains (Table 8.4), but the flora represented by plants such as Poaceae, *Poterium*, and Caryophyllaceae is consistent with a degraded steppeland, with cultivation of cereals and olives in the locality. Some pollen such as *Pinus* and *Juniperus* may be derived from the plateau.

8.7 Domestic, funerary, and hydraulic structures south of WF100

Immediately to the south and southeast of the WF100 settlement, on the other side of a small wadi channel forming part of its southern boundary, is an extremely well-preserved and broadly contemporary landscape of EBA (especially EB1) domestic, funerary, and hydraulic structures. The area measures over 1000 m west–east by *c*.250 m north–south. A series of small wadi channels flowing from southeast to northwest gathers on the eastern edge of the area, and the main channel then flows west along the southern edge of the WF4 field system. The principal zone of EBA monuments here is the gentle slopes lying between this wadi channel and a prominent ridge of hills to the south. The physical topography and surface archaeology were mapped by Total Station at 1:1000 scale, in two contiguous rectangular units (Figs 8.14, 8.15; their location is shown on Fig. 8.2). The area can be divided into seven distinct zones in terms of its physical and archaeological characteristics, which are described in detail below from west to east.

Zone 1 comprises an extensive funerary complex on a triangular terraced zone bordered on the north by the wadi channel and to the south by three low knolls or hillocks. There are over 30 graves, primarily orientated north–south, many aligned along the northern edge of a low terrace. There is little evidence for EBA domestic activity, unless WF1417, a small (10 × 4.5 m) boulder enclosure with an ibex pictograph on the interior face of one of its boulders on the eastern wall (Fig. 8.16), had such a function, though it may have been primarily a funerary structure (see below). There are also two boulder-built curvilinear

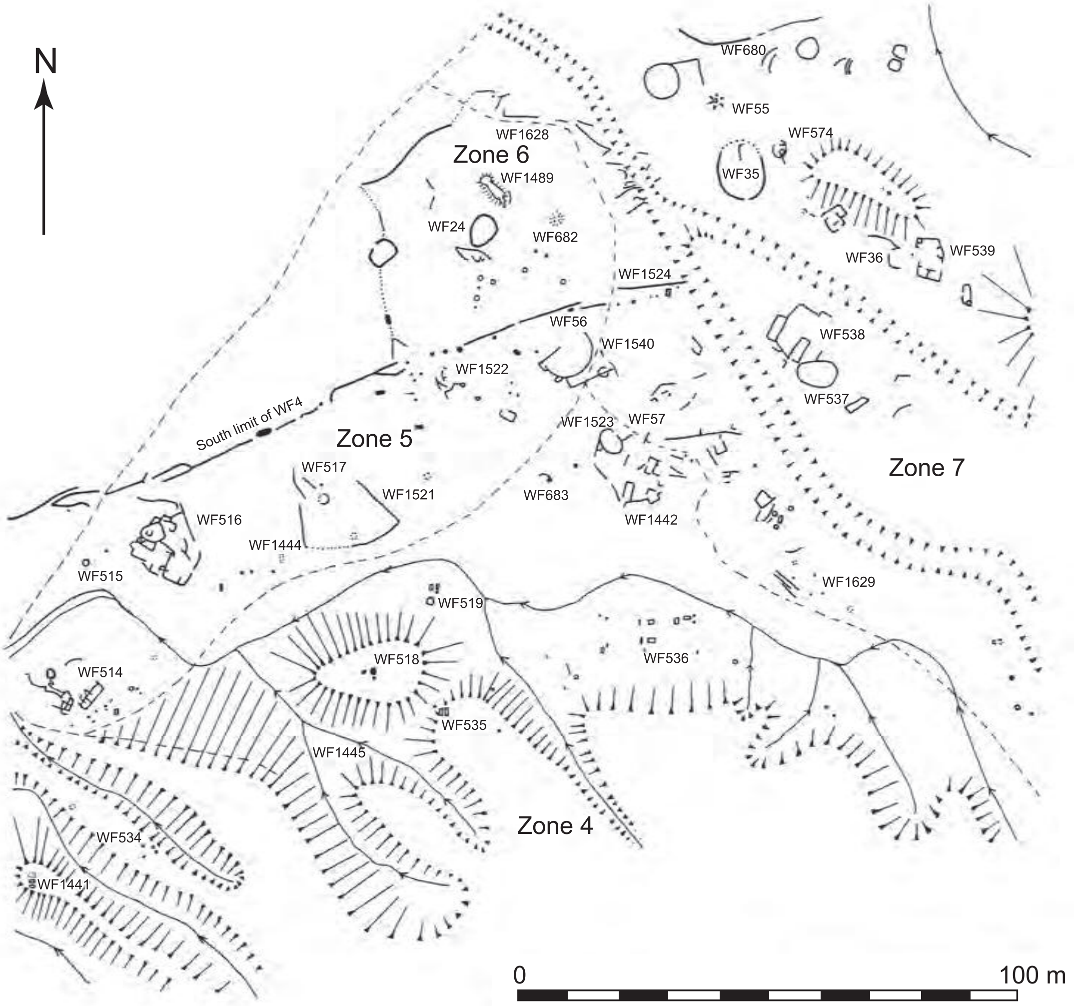


Figure 8.15 *Domestic, funerary, and hydraulic structures in the EB1 landscape south of WF100: eastern sector. (Illustration: Oliver Creighton and Mike Hawkes.)*

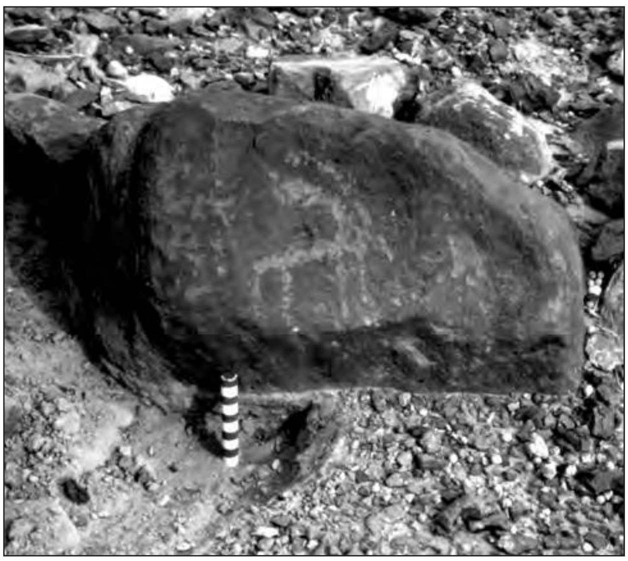


Figure 8.16 *Ibex pictograph on the interior face of one of the boulders on the eastern wall of WF1417, a small boulder enclosure of EBA date. Scale: 10 cm. (Photograph: Graeme Barker.)*

Figure 8.17 *A rectangular tomb, WF1439, part of the EBA cemetery WF533 south of WF100, looking northwest. Scale: 1 m. (Photograph: Graeme Barker.)*

walls along the northern margins of the zone by the wadi channel. Some kind of water-control function is suggested by a probable sluice structure at the downstream end of the western wall. WF1440, a large cairn with right-angled kerbing, lies between these walls. There is evidence of recent bedouin encampments on the northwestern edge of the unit (WF916, WF917, WF926).

Zone 2 consists of three small knolls with flat tops. There are at least 20 graves in clusters or pairs (recorded as WF533), including cairns and rectangular graves both with and without kerbing, located for the most part on the flat hilltops but sometimes on the hill flanks. Almost all of them are visible from the north, that is from Zone 1 and WF100, and have clear viewsheds over the same terrain (Fig. 8.17).

Zone 3 extends both north and south of the wadi bed. The principal archaeology consists of six discrete structures, four on the southern side and two on the northern side. The four structures on the southern side (from west to east: WF731, WF730, WF1418, WF726) are approximately equidistant from each other. Though difficult to distinguish because of the rubble overlying them, similar elements could be identified (Fig. 8.18): a circular perimeter wall enclosing an area *c*.9–16 m in diameter (best preserved in WF726); and, approximately in the centre, a single rectilinear structure, of varying size and orientation. It is not clear whether or not the enclosures and internal buildings were contemporary, or were built in sequence (in whichever order). On the opposite side of the wadi are two substantial oval enclosures approximately 100 m apart (Fig. 8.19): WF1630 to the west and WF1627 to the east. They are attached to alignments of walling that form a funnel shape leading northwards away from the wadi towards the WF100 settlement. Their position on a terrace above the wadi channel, on ground sloping upwards, makes it very unlikely that they had any hydraulic function. WF1630 has similar characteristics to the four structures on the south side, though both the circular enclosed area and the internal rectangular structure are bigger (respectively 20 m diameter, and 15 × 4.5 m). It also has an additional enclosure appended to its western side. Fragmentary walls on the southern side of the WF1627 enclosure may be traces of another internal structure.

Zone 4 is by far the largest of the seven. It consists of a series of low flat-topped ridges or interfluves trending southeast/northwest, and forms the catchment of the channels that feed into the wadi flowing through Zone 3 and along the northern edge of Zone 1. There are at least 100 graves here, some in small clusters (eight at WF697, four at WF519, and more than twenty at WF536), but most occur in no clear pattern. Most are on the lower slopes, though a few are on the ends of ridges or the summits of knolls, such as WF518. There were three cairn graves at the latter site, together with a loose boulder with a pictograph on it (Fig. 8.20) of what may be a representation of a domestic structure and enclosure of the type immediately to the north in Zone 5 (Fig. 8.21). The drawing has a striking resemblance to the view of an enclosure and its attached building; if this was in fact meant to be the case, the pecked dots could be intended to designate animals, though the four pointed lines are more difficult to translate in the same way.

Zone 5 (Fig. 8.15) is a roughly triangular area, bounded to the south by the Zone 4 ridges, to the north by a substantial wall and by a linear arrangement of cairns along the same alignment as the wall, and to the east by a wadi channel. The zone is level and extremely stony, strewn with rubble and larger boulders, making the secure identification of the details of some of the archaeological structures very difficult. Nevertheless, at least six concentrations of

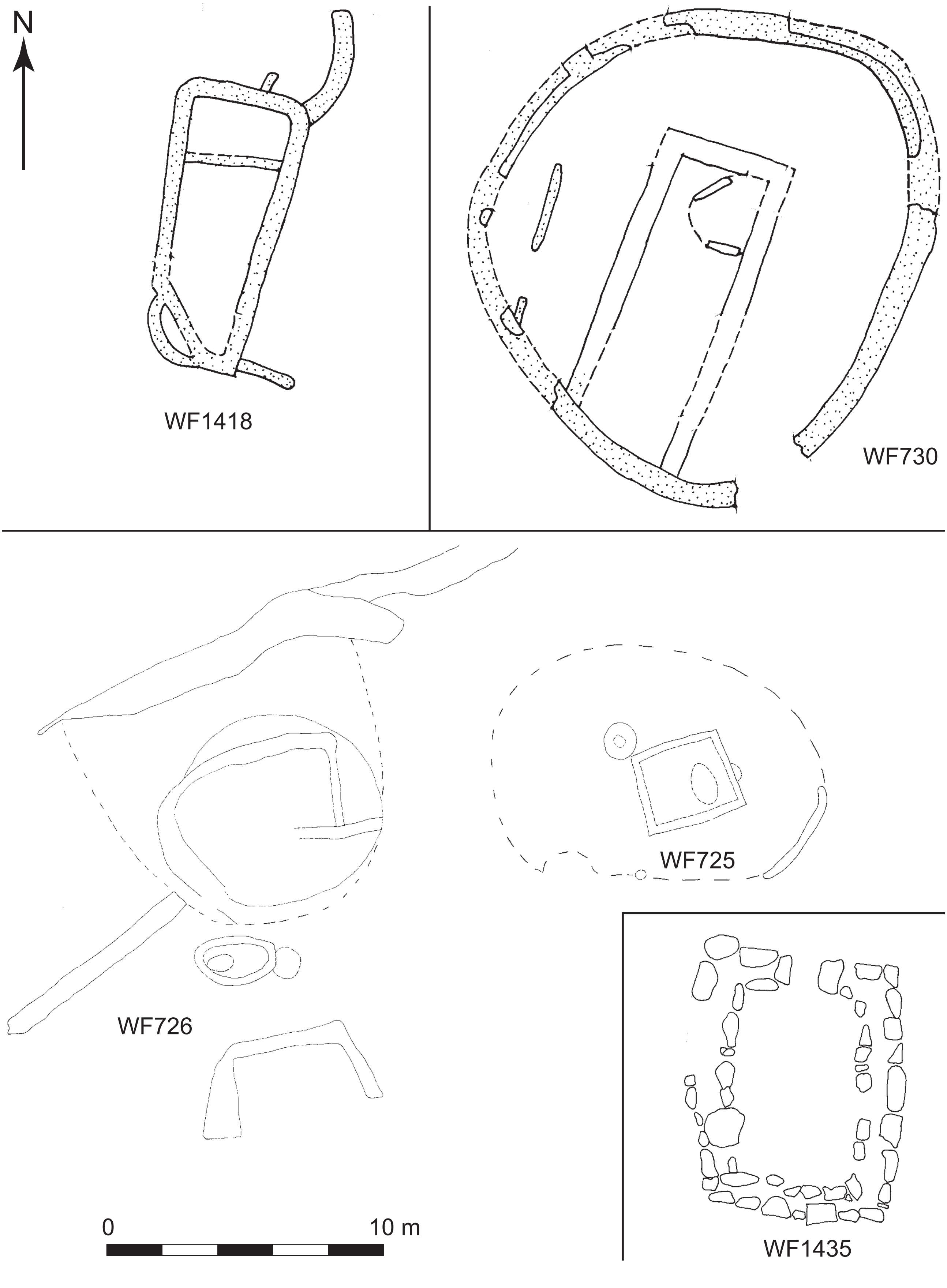


Figure 8.18 Some of the enigmatic, possibly funerary, structures in Zone 3 of the EB1 landscape south of WF100: WF725, WF726, WF730, WF1418, and WF1435. (Illustration: Hugo Lamdin-Wymark, Dan Lowenborg, Rosie Wheeler, Mike Hawkes and Dora Kemp.)

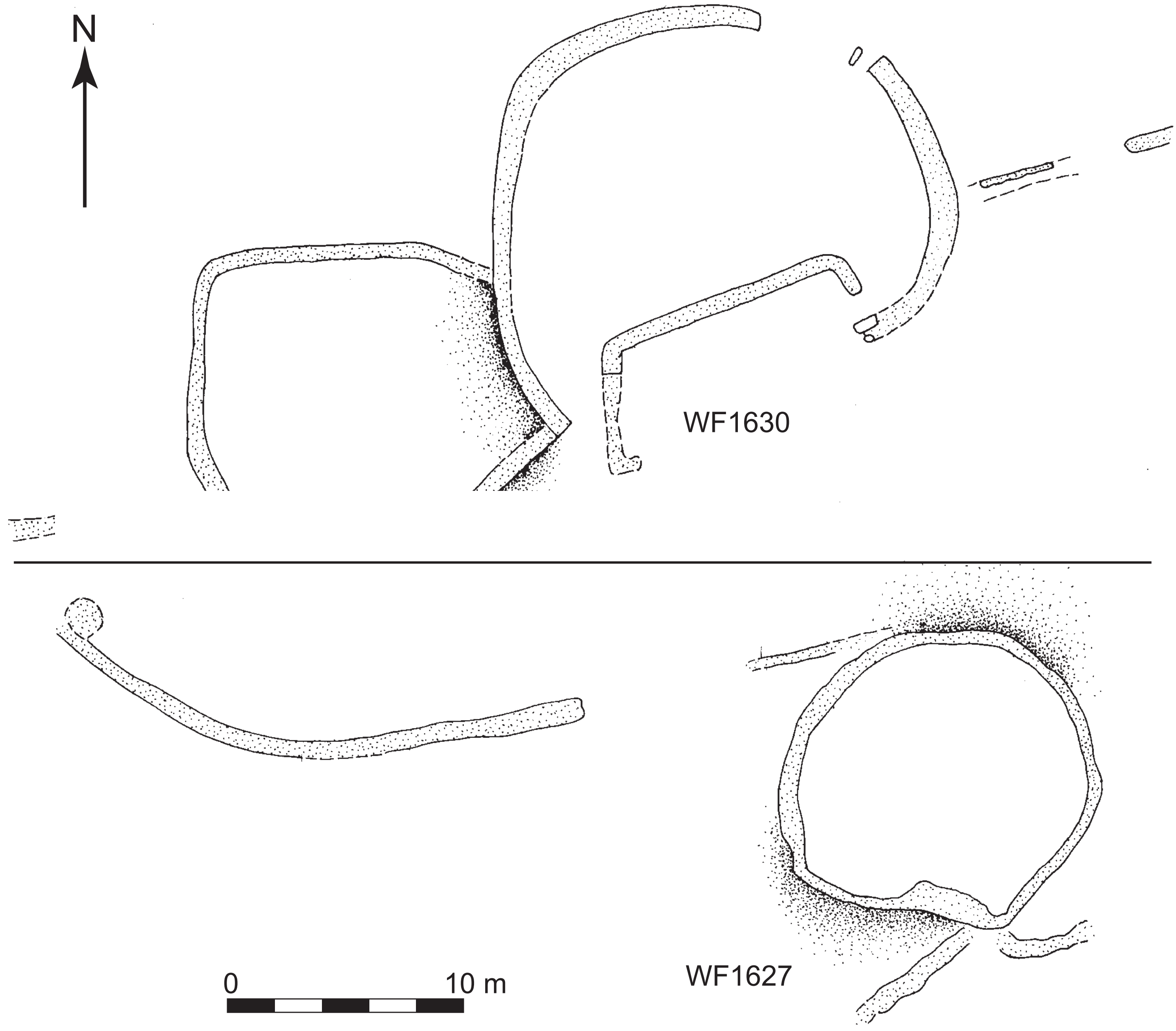


Figure 8.19 *Two enclosures attached to boundary walls in Zone 3 of the EB1 landscape south of WF100: WF1630 and WF1627. (Illustration: Mike Hawkes.)*

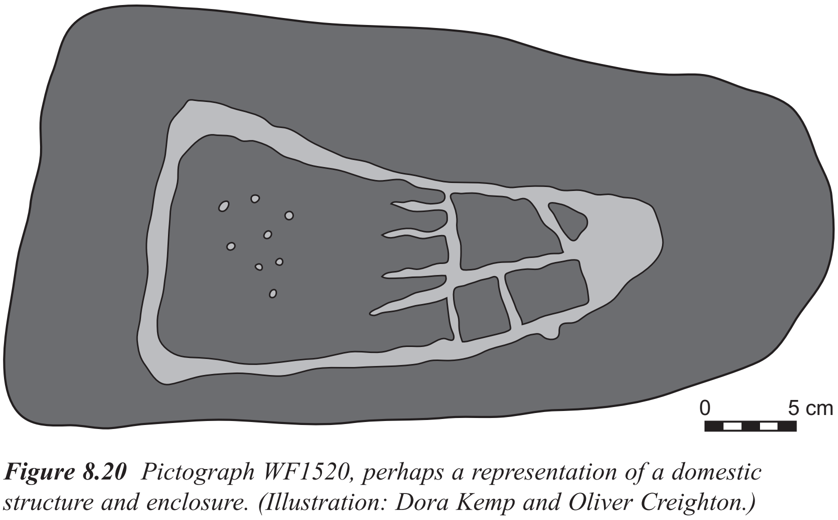


Figure 8.20 *Pictograph WF1520, perhaps a representation of a domestic structure and enclosure. (Illustration: Dora Kemp and Oliver Creighton.)*

Figure 8.21 *Complex domestic structures in Zone 5 of the EB1 landscape south of WF100: WF514, WF516. (Illustration: Hugo Lamdin-Wymark, Rosie Wheeler, and Mike Hawkes.)*

Figure 8.22 *WF57, an oval structure in the EB1 landscape south of WF100, with traces of surrounding rectangular buildings within an enclosure wall (WF1442). (Illustration: Hugo Lamdin-Wymark, Rosie Wheeler, and Mike Hawkes.)*

Figure 8.23 *WF24, a water-catchment structure in the EBA landscape of WF100, looking northwest. See also Figure 3.10. (Photograph: Graeme Barker.)*

structures can be discerned, which from their construction and finds appear to be domestic in character. Starting from the west, WF514 is a complex structure composed mainly of rectangular units, divided into two principal buildings, the western one being attached to what is probably a length of enclosure or courtyard wall (Fig. 8.21). Most of the unit (room?) walls are made of double rows of boulders set vertically into the ground. The finds included a saddle quern. WF516, *c*.60 m to the northeast, also consists of a series of rectangular room units attached to a wall bounding an enclosure or courtyard on the eastern side. The pottery, exclusively EB1, was associated with lithics that included fragments of at least seven trihedral picks, stone mortars and rubbers, and a carved bone object. An oval enclosure at the centre may be a later construction. Fifty metres to the east lies another EB1 domestic complex, the plan of which is not as clear but which seems to have comprised a sub-rectangular building (WF517; the number of units is uncertain) attached to a trapezoidal enclosure (WF1521, measuring 45 × 30 m). This is the unit that is paralleled to a remarkable degree in the WF1520 pictograph. Seventy metres to the northeast lies WF1522, another complex of even more uncertain form, though fragments of linear and curving walling suggest a domestic unit much like the others.

WF1540 is slightly different to the previous four: a large (25 × 15 m) D-shaped enclosure with a fragment of L-shaped walling on the southern side. At least three other small structures (pens?) are attached to it. The extent and character of the structures to the south are difficult to understand, as there are many stubs of walling protruding just above the ground surface, obscured by rubble littered with EBA pottery. However, there appear to be general similarities with WF516: a central oval enclosure (WF57), linear walls indicating rectangular buildings, and a polygonal encircling wall (mapped together as WF1442: Fig. 8.22). The site produced EB1 pottery and lithics, and almost a dozen querns and quern rubbers. Between this complex and the wadi channel to the east can be identified cairns, graves, and fragments of walling that may be the vestiges of further domestic sites.

Zone 6 is the smallest of the zones, level and boulder-strewn like Zone 5 and separated from it by a discontinuous line of boulder walling, some lengths slightly offset from each other, and lines of cairns on the same alignment. It is bounded to south by the walls and cairns, to the east by the same wadi channel that forms the eastern edge of Zone 5, to the north by boulder-built walls, and to the west by fragments of similar walls together with an enclosure and two cairns. The central feature is WF24, an oval enclosure 15 m in diameter (Fig. 8.23). The enclosure is filled with water-lain sediment to a depth of *c*.75 cm. The characteristics of these sediments, together with the presence of small walls upslope that would have channelled any floodwater into the enclosure, strongly suggest that, like the WF148 cistern or reservoir (Fig. 8.13), it was constructed to trap and store water. The palynology of its sediments is discussed in the next section. The other main site is WF1489, a substantial (*c*.18 × 7 m) sub-rectangular rubble cairn, with linear internal walling, conceivably (though very uncertainly) akin to the structures of Zone 3. No sherds or other artefacts were found in or around it. The southern half of Zone 6 contains five circular graves, five cairns (one with internal walling), and various wall fragments.

Zone 7 is a triangular area bounded to the north and east by the limits of the survey area and to the southwest by the wadi channel separating it from Zones 4, 5, and 6. A second channel of this wadi system flows through the zone, and there is a prominent oval knoll to the north of this. On the interfluve between the channels lies a large

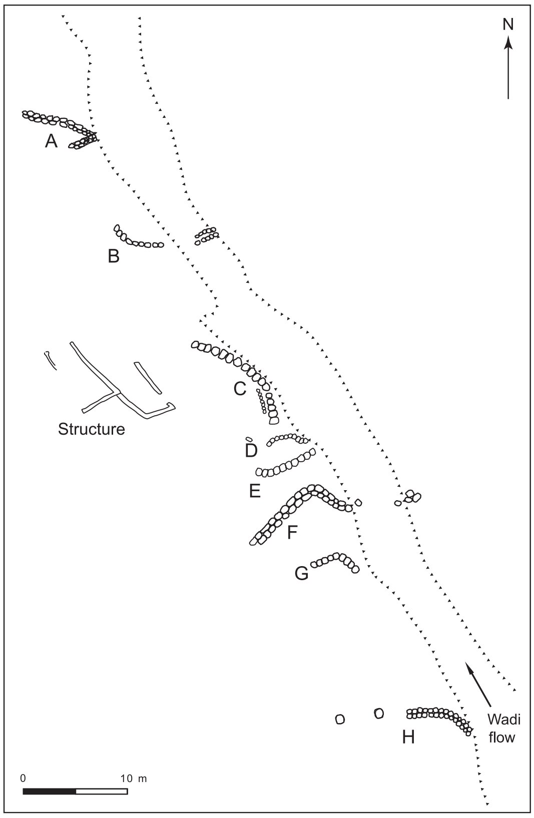


Figure 8.24 *WF1628, a system of check-dams and diversion walls in the EB1 landscape south of WF100: (left) photograph, looking southwest; (right) plan. (Photograph: Graeme Barker; illustration: Paul Newson.)*

domestic complex, consisting of an oval enclosure (20 × 12 m), adjacent rectangular structures, and an attached enclosure or courtyard wall (WF538). There are additional linear wall fragments and a rectangular enclosure upslope (WF537). Though the main complex clearly resembles the EB1 sites WF516 and WF1442, the pottery consisted of a few sherds of EBA and Iron Age date amidst a large collection of Classical pottery (Nabataean/Roman and Byzantine), so in this case it appears likely that the main use of the locality, and possibly the age of the rectangular buildings, post-date the Bronze Age.

The settlement area to the north is also a palimpsest of occupations. The main structure classified as WF55 is a large oval enclosure (28 × 22 m) containing an L-shaped wall. A few metres to the east of this is a smaller version, a 5 × 7 m enclosure with a rectangular structure within it (WF574). These clearly resemble the structures of Zone 3, and produced EB1 pottery. Further east, on the southern and eastern side of the knoll, lies a suite of at least three rectilinear domestic sites of Classical age (mapped by the survey team as two units: WF36 and WF539). These are western outliers of the network of Nabataean farmsteads located on low hills overlooking the WF4 field system along its southern side between here and Khirbat Faynan, discussed in Chapter 9.

Straddling Zones 6 and 7 was a series of walls built on either side of the channel, mapped as WF1628 (Fig. 8.24). Walls A, F, and H are robust structures made of double lines of boulders, whereas the other walls seem to be single-boulder lines. However, whilst Wall B on the western side of the channel is of single boulder construction, visible in the opposite bank were traces of a carefully-built segment with a double face and a rubble core. Wall F could also be traced across the wadi. All except one of the walls appear to have been built to control surface floodwaters, either as check-dams across the wadi channel to stem the main flow, or as diversion walls to fan the floodwaters out onto the surrounding terrain. The exception is Wall C, which curves along the side of the wadi, bowing out towards it, suggesting that its purpose was either to retain water that had been diverted by a wall further upstream, or to prevent water in the channel spilling out at that point in the system. The pottery found in the area of the walls was mostly EB1, with some EB 2–3 sherds as well, with no material of later date, and an EBA sherd was also found in the section of Wall A exposed in the gulley side. The complex provides convincing evidence that EBA farmers in Wadi Faynan had developed floodwater farming techniques to cope with their arid environment: they were building check-dams across the wadi channels to slow down and trap the floodwaters (and the fertile sediment being carried along within them) that would briefly flow down the channels after seasonal downpours, and attaching diversion walls to the ends of the check-dams to force the floodwaters out of the channels to irrigate fields laid out on the adjacent land. WF409 (Fig. 5.20) is another system of cross-wadi walls or check-dams likely to be of EBA date.

A striking characteristic of this landscape is the evidence for the zoning in how it was used. The significant concentrations of substantial graves with monumental funerary architecture are in Zones 1 and 2, those on the hills of Zone 2 forming a clear boundary between the principal EB1 settlement area of the Wadi Faynan and the southern hinterland, with the hills to the east (Zone 4) used for less structured, less elaborate (in terms of the architectural remains), and lower-density burial. If we are correct in interpreting this part of the landscape as primarily reserved for funerary activity, then by implication WF1417, the isolated and unusual enclosure or building with the ibex pictograph inside, may have had a function related in some way to this. Structures which appear to be more domestic in character are found only in Zone 5 (unless WF538 in Zone 7 is also of this type). It is noticeable that they are all located at the bottom of the slopes reserved for funerary structures. The enclosures containing rectangular structures are also located in two discrete groups, one in Zone 3 and the other in Zone 7, with some internal symmetry to one another evident in the Zone 3 grouping. Given the absence within them of artefacts such as the mortars and grindstones that occur in some abundance at the presumed domestic structures in Zone 5, a ritual/ceremonial and/or funerary function seems likely for these.

The isolated walls also seem to have had distinctly different functions. Those of WF1628 provide unequivocal evidence for EBA floodwater farming technology: a series of check dams and small-scale diversion walls, sited to exploit the increased water flow below an upper wadi confluence. The circular or oval catchments such as WF24 and WF148 seem to have been designed to trap and store floodwaters. The two walls between the main wadi channel and Zone 1 form a physical boundary between the burial area and the wadi, their shape suggesting that they would have served to contain floodwater within the wadi channel, the sluice at the western end allowing the force of the floodwaters to be controlled. The walls forming a funnel shape on the north side of Zone 3 are of yet another kind, as they do not appear to have a hydraulic function, or to make a physical barrier, or to demarcate one area of activity clearly from another. Their funnel shape suggests that they would have served best to control or guide people and/or animals, especially those crossing the wadi at this point, for example from the southern hills east of the funerary zone. If the enclosures containing rectangular structures are indeed elaborate ceremonial and/or funerary monuments, it may be that these walls served to guide people to and from them, rather than to guide stock between the WF100 settlement and pasture.

Unit	Depth (m)	Summary description
	0.0	Surface
2	0–0.17	Coherent sandy silt – greyish-orange (10YR 7/4)
1	0.17–0.24	Slightly damp, sandy silt, fragments of terrestrial molluscs – dark yellowish-orange (10YR 6/6)
	0.24–0.28	Gritty sandy silt – dark yellowish-orange (10YR 6/6)
	0.28–0.44	Gravel-rich, sandy silt, loose, – dark yellowish-orange (10YR 6/6)
	0.44–0.50	Gravel-rich, sandy silt – dark yellowish-orange (10YR 6/6)
	0.50–0.53	Very gravel-rich, sandy silt – dark yellowish-orange (10YR 6/6); solid at 0.53 m

Table 8.5 *Stratigraphy and field interpretation of WF24 (geomorphological site WF5051), a water-catchment structure probably of EBA date (Figs 3.10, 8.23).*

The substantial boundary wall and line of cairns dividing Zones 5 and 6 extend westward to become the southern boundary of the WF4 Classical-period field system. The latter is on exactly the same alignment, and has many of the same physical characteristics such as offset walls of similar construction, and cairns. Its construction features suggest that the boundary of the Classical field system in this sector in fact ante-dates the principal use of the field system in Nabataean and later times and that it was part of the EBA landscape, its many gaps and offsets perhaps designed to facilitate movements of stock northwards from the Zone 5 settlements. Why Zone 6 was respected or avoided by Classical farmers when they laid out their fields is not clear.

8.8 The WF24 water catchment: sediments and palynology

The sediments of the WF24 cistern (Fig. 8.23) were explored with an Eijkelkamp auger. The sequence observed is described in Table 8.5.

The sedimentological information indicates two lithological units. Unit 1 lies between depths of 0.17 m and 0.53 m. Sand in this unit generally increases from 45 per cent by weight at 0.17 m to 71 per cent at the bottom of the core. Silt and clay generally display the opposite trend. Silt decreases from 30 per cent at a depth of 0.15 m to 19 per cent at the bottom of the core, and clay also decreases from 30 per cent to 12 per cent. Organic carbon displays no regular pattern through the sequence, decreasing overall from 2–3 per cent at 0.17 m to 1 per cent at the bottom. Carbonate content shows no clear trend and its proportions fluctuate between 5 and 11 per cent. Magnetic susceptibility slightly increases from the bottom (2.5 k) toward the top of the profile (4 k at 0.15 m). Unit 2 is between the surface and a depth of 0.17 m. Sand, 41 per cent by weight at the surface, decreases to 38 per cent at the base of the unit; silt decreases from 36 to 33 per cent; and clay increases from 28 to 32 per cent. Organic carbon decreases with depth from 4 to 2.5 per cent, carbonate increases from 10 to 16 per cent, and magnetic susceptibility decreases from 5 to 3.5 k.

The palynological evidence (Mohamed and Hunt 1999; Fig. 8.25) suggests that the sequence between the surface and 0.53 m should be considered as one biozone. It is characterized by relatively high proportions of Caryophyllaceae (15–25 per cent) and Asteraceae (6–22 per cent), although Poaceae (6–19 per cent), Lactuceae (1–6 per cent), *Artemisia* (5–12 per cent), *Plantago* (11–19 per cent), *Ephedra* (1–4 per cent), Chenopodiaceae (2–8 per cent), and *Liliaceae* (1–4 per cent) are also important. Taxa that occur occasionally include *Centaurea*, *Geranium*, *Poterium*, *Succisa*, and *Rumex*. All of the above taxa are characteristic of steppe-land, whereas tree pollen is present

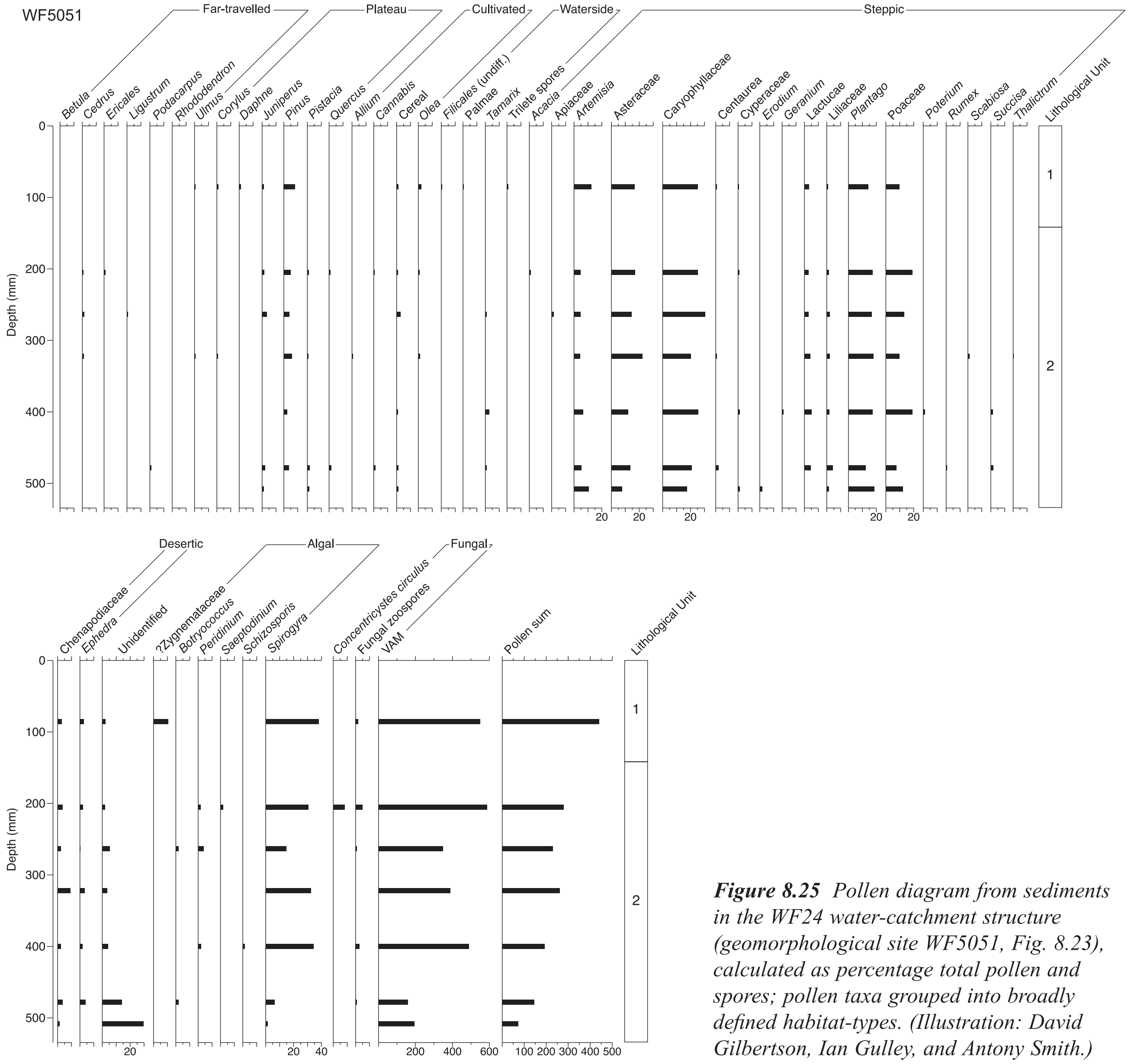


Figure 8.25 Pollen diagram from sediments in the WF24 water-catchment structure (geomorphological site WF5051, Fig. 8.23), calculated as percentage total pollen and spores; pollen taxa grouped into broadly defined habitat-types. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)

but scarce: *Pinus* (0–6 per cent), *Juniperus* (1–3 per cent), and *Quercus* (0.5–1 per cent). Taxa that might represent cultivated plants also occur: cereal-type grasses (1–3.5 per cent) and *Olea* (1–2 per cent). Occasional palm grains may represent water-side vegetation, either cultivated or natural, and other water-side species include *Tamarix* (1–4 per cent) and *Pistacia* (1–3 per cent). Soil fungi are represented by fungal zoospores (1–8 per cent) and huge amounts of VAM (Vesicular Arbuscular Micorrhyzae: 190–600 per cent). Algae indicative of standing water include Zygnemataceae (0–10 per cent), *Concentricystes circulus* (0–9 per cent), *Peridinium* (1–4 per cent), *Botryococcus* (2–3 per cent), and especially *Spirogyra* (7–38 per cent), pond-slime typical of shallow eutrophic (nutrient-rich) sun-warmed waters.

The palynofacies (Fig. 8.26) are characterized by high proportions of amorphous matter that peak at depths of 480 mm (92 per cent) and 410 mm (72 per cent), though they then decrease up the core. Thermally-mature material (21–30 per cent) is concentrated mainly in the lower part of the core, decreasing upwards to 6–4 per cent. Pollen is present in low percentages (2–4 per cent) in the lower part of the core (530–360 mm), and then increases progressively toward the upper part of the core (8–9 per cent). Plant tissue, present in low percentages in the lower part of the core (1–2 per cent), increases in abundance toward the top of the core (10–12 per cent at 80 mm) but decreases near the surface. Degraded plant tissue occurs in very low percentages (1–3 per cent) at depth and decreases further towards the top of the core. VAM increases from the base of the core (9 per cent) towards the top of the core (33 per cent). There are also occasional examples of fungal hyphae, insects, and fungal spores.

These sedimentary and palynological properties corroborate the interpretation of the site as the location of a

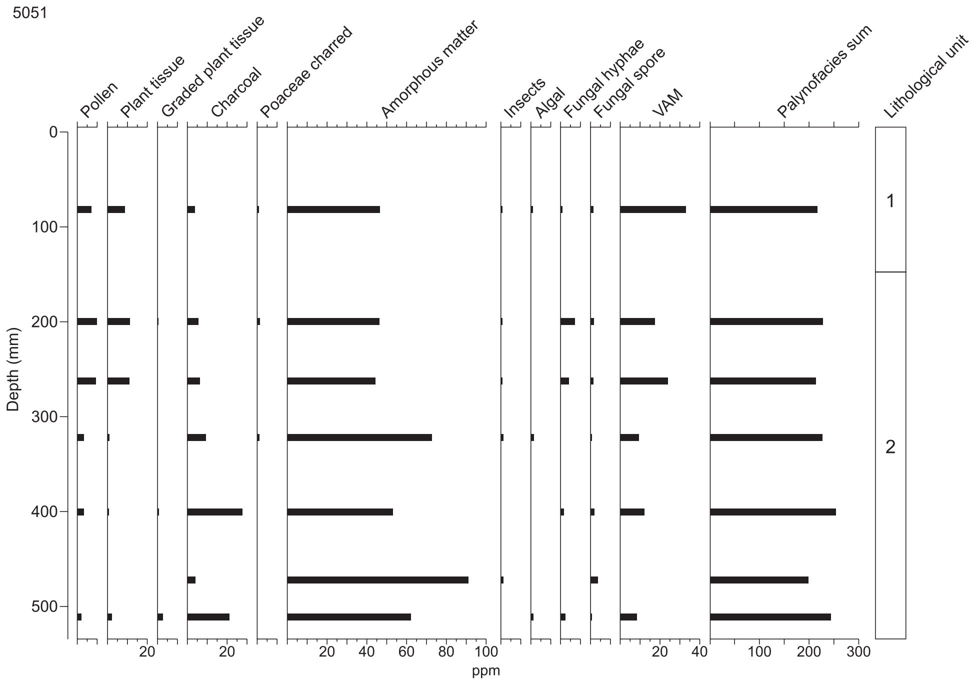


Figure 8.26 *Palynofacies diagram from sediments in the WF24 water-catchment structure (geomorphological site WF5051, Fig. 8.23), calculated as percentage total particulate organic matter. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

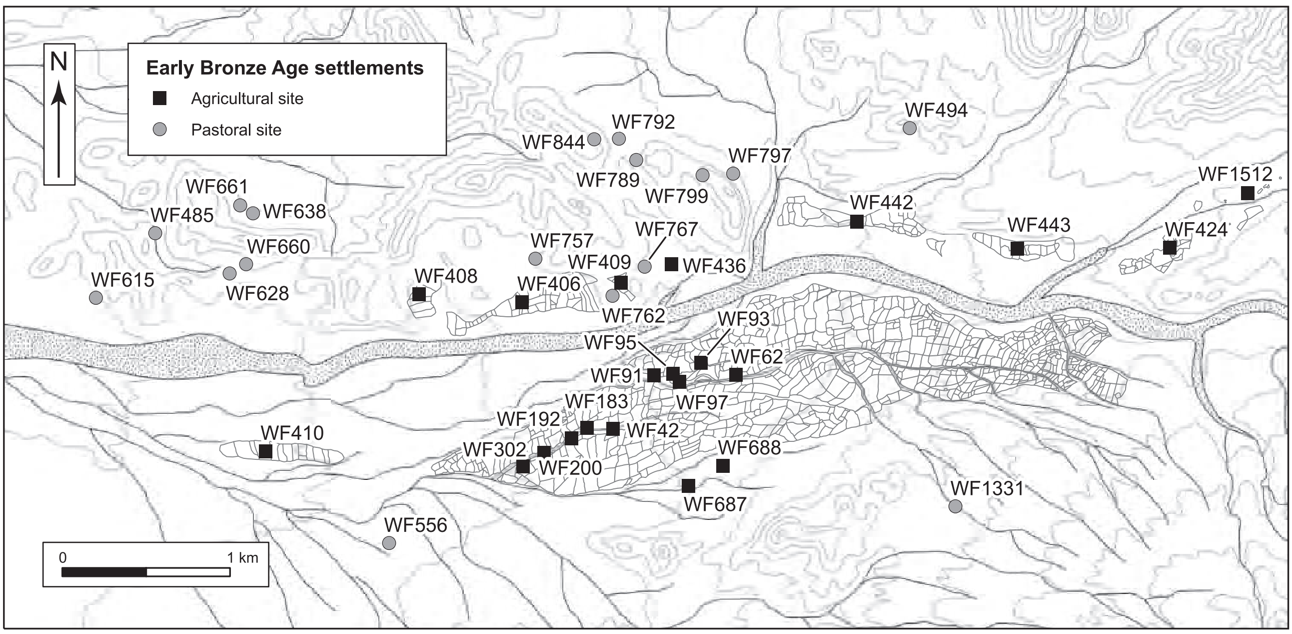


Figure 8.27 *The location of the principal EB1 settlements beyond WF100 identified on the basis of their morphologies, finds, and topographical situations as likely to be primarily agricultural (complexes of structures, enclosures, and field walls) and primarily pastoral (isolated enclosures). See also Figure 8.7. (Illustration: Paul Newson.)*

body of standing water that had been deliberately harvested and impounded. The length of time represented by this body of sediment is unknown – it may be measurable in months or a few decades – but the two distinctive sedimentary units demonstrate that it changed its characteristics through time. The first body of sediment indicates water of high energy that diminished over time, the second indicates water of moderate to low energy. The palynology suggests a diverse steppic and relatively treeless landscape. The rarity of tree pollen probably reflects in part the less humid climate compared with that of the Neolithic, and in part deliberate deforestation by people. Marked changes in magnetic susceptibility are likely to reflect the input through time of increasing quantities of wood-ash transported by wind from adjacent areas in which burning was taking place, and/or increased soil erosion. In most natural environments thermally-mature materials are infrequent (less than 2 per cent), so the high proportions in the lower half of the sequence are likely to be further evidence for burning. Some of the charred material is most probably of monocotyledonous origin and may be charred grass or cereal straw; the high count of amorphous matter supports this interpretation (Hunt and Coles 1988). The increasing amounts of VAM are also indicative of increasing rates of soil erosion. The increase in pollen percentages and decreases in the proportions of thermally-mature grains and amorphous matter in the upper part of the sequence may reflect the cessation of human activity in this locality when the abandoned cistern silted up.

WF site number	Description	No. of EBA sherds
39	Water catchment	12
56	Simple field group	1
400	Simple field terraces	1
498	Simple field group	3
625	Simple field group	2
687	Simple field group; cairns; funerary structures	38
688	Simple field group; cairns; funerary structures	63
747	Simple field group; enclosures; circular/oval structures	1
773	Simple field group	1
1259	Simple field group	2
1512	Simple field group; enclosures; circular/oval structures	14

WF4 field unit	No. of EB1 sherds	No. of EB2–3 sherds
4.1	76	
4.2	62	
4.3	101	
4.4	8	
4.5	12	
4.6	48	
4.7	24	
4.8	15	1
4.9	16	1
4.10	87	
4.11	43	
4.12	514	
4.13	1528	7
4.14	323	
4.15	136	
4.16	46	
4.17	299	
4.18	10	
4.19	191	
4.20	8	3
Total WF4	3547	12
Other field systems		
406	239	
408	10	11
409	10	53
410	2	50
424	8	
442	28	
443	8	
Total, Other field systems	305	114
Total	**3762**	**126**

Table 8.6 *Early Bronze Age sherds collected from (above) discrete 'sites' and (below) fields within the multi-period WF4 field system and its satellite field systems.*

Figure 8.28 *One of the buried cross-wadi walls in WF406, looking north. Notebook in foreground as scale. See also Figure 5.48. (Photograph: Graeme Barker.)*

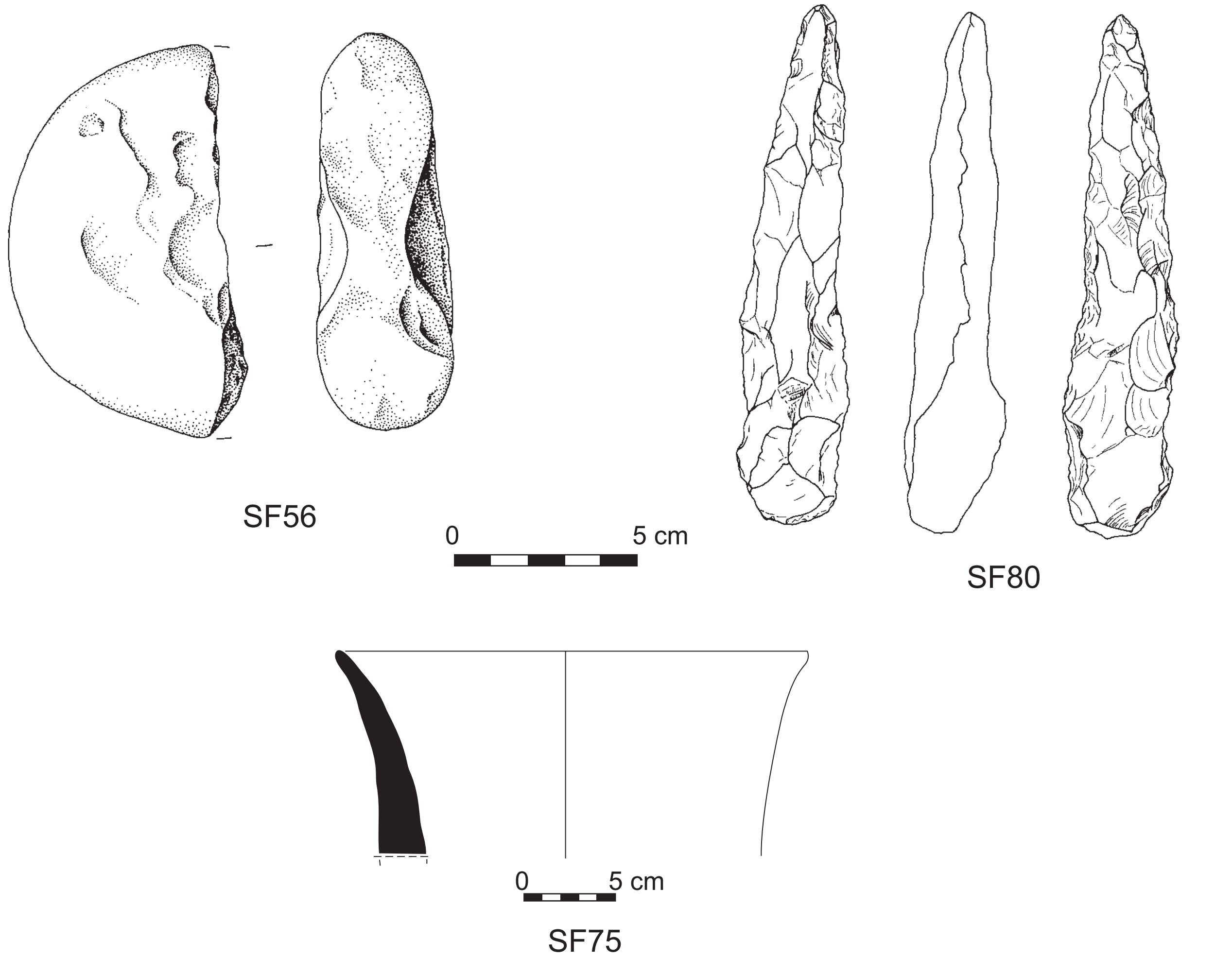


Figure 8.29 *WF406 lithic material: basalt ground stone bowl (SF75), flaked pick (SF80), and an unfinished stone hammer (SF56). (Drawings: Matthew Pearson, inked by Jenny Doole.)*

8.9 EBA settlement beside the Wadi Faynan channel

A series of EB1 settlement complexes, sometimes with adjacent funerary structures, was found on the northern side of the main Faynan channel, and there are indications of similar settlement complexes on the southern side of the channel under and masked by the WF4 field system (Figs 8.7, 8.27; Table 8.6). Several appear to have been discrete agricultural complexes, on three counts. First, they consist of combinations of habitation structures, enclosures, and field walls. Second, they are located on shallow gradients by tributary wadis, where seasonal floodwaters would have been relatively easy to harness without the risk of gullying or out-of-control flooding of steeper gradients and bigger channels. Third, their surface assemblages lack evidence of metal-processing as at WF100 and instead consist entirely of material associated with mixed farming such as grinding equipment, tabular scrapers (Fig. 8.4), the latter a type of tool interpreted by Henry (1995: 372) as possibly used for sheep shearing, and a range of sickles and other harvesting blades (Fig. 7.18).

The first example on the north side of the Faynan channel is WF406 and its ancillary monuments, within a palimpsest of structures of Bronze Age, Iron Age, and later date (Barker *et al*. 1999: 272, 274; Fig. 5.48). A large boulder wall surrounding the complex appears to be a water diversion wall of Iron Age date. This captured any floodwaters running off the hill-slopes to the north and diverted them along its length so that they would flow east to west down the tributary channel towards the main Faynan channel. Substantial terrace walls built across this channel were presumably designed to trap the substantial floodwaters from the big diversion wall, the surface pottery scattered over them is Iron Age and later in date, and there is also a cluster of graves with Iron Age pottery on the low ridge to the south (WF411, WF413). However, there is also series of small check-dams across the wadi channel, almost buried by sediment and of simple construction like those of WF1628 discussed earlier (Fig. 8.28). EB1 and EB2–3 sherds (and one Chalcolithic sherd) were found in their vicinity, and an EB1 sherd was found in sediment below one of the later walls. In addition to the sickles illustrated in Figure 7.18,

Figure 8.30 *View of WF62, a D-shaped enclosure of EBA date made of massive boulders, looking northwest. Scale: 2 m. (Photograph: Graeme Barker.)*

the lithic material from this locality included a typical EBA pick, a fragment of a stone bowl, and an unfinished stone hammer very much like those of WF100 (Wright *et al*. 1998: figs 11, 12; Fig. 8.29). This evidence suggests that there was a rather long-lived EBA floodwater-farming system here. Monuments likely to be associated with the EBA settlement and check dams include a collection of small cairns at the upstream end (WF417) and a 17 × 15 m enclosure (WF415) at the downstream end.

Further collections of simple parallel check-dams with EB1 and EB2–3 pottery were found in the environs of the WF406 system: to the east at WF409 and WF436, and to the west at WF408 and WF410. The WF436 walls were partly enclosed within a boundary wall to which was attached a small (5 × 5 m) rubble enclosure, and there was a funerary complex (WF437) at its upslope end including some cairns that are likely to be EB1 in date (others with inscriptions date to Classical antiquity). The WF408 and WF410 walls were associated with an oval enclosure (WF421) with EB1 pottery.

Another example of an EBA domestic complex on the northern edge of the Faynan channel is WF615 (Fig. 4.6) and adjacent units, situated on a gravel fan some 2 km west of the WF406 group of sites. The site itself consists of a series of attached circular structures or rooms and a possible courtyard, with further traces of enclosure walls. The latter separate it from, to the south, a group of stone-lined cists and small cairns of broadly similar antiquity. About 75 m to the west is a small field system (WF486) consisting of rudimentary check-dams 20–25 m apart constructed across a minor stream channel. Like the field walls at WF406, they comprise single lines of stones. Two of the walls are V-shaped, indicating that they may have served as simple diversion structures to divert floodwaters from the channel onto the surrounding land.

On the southern side of the Faynan channel, within (or rather underneath) the WF4 field system, monumental walls similar to those we mapped at WF100 occur down the length of the WF4 field system, and the frequency of EBA pottery in their environs indicates their likely antiquity. To the south of WF100, a 2 m-wide rubble bank faced with rough boulders (WF56) forming the southern boundary of field WF4.12.42 is very similar in construction to the northern boundary wall of WF4.13 (and of the main WF100 settlement zone). Another bisects the terraced fields of WF4.12. It is notable that half a dozen cairns are situated immediately to the south of the WF56 wall, and appear to follow its line closely. EBA sherds predominate around both the cairns and the wall. Further field groups associated with EBA pottery around WF100 include one in WF4.19. The western extremity of EBA activity on the floor of the main wadi consists of the short lengths of walls intermixed with cairns at WF687 and WF688. Unit WF4.12 also appears to have been a significant zone of EBA activity given the frequency of EBA pottery; there is another example here of a massive double-faced boulder wall with a rubble infill (bordering fields WF4.12.01–WF4.12.10 and WF4.12.26), and several walls within the Classical field system in Unit 4.12 (for example WF4.12.04–WF4.12.06, and WF4.12.07/WF4.12.08) overlie lines of orthostatic boulders like the WF100 walls. The evidence suggests that, whilst much of the terracing here is Nabataean and later in date, the first major phase of wall building was Early Bronze Age. Cairns are common within these fields, and though some of the walls may well have been built to delimit ritual land, the layout of the fields, with simple terraces enclosed within a substantial boundary wall, would have served well to trap, collect, and distribute run-off across the terraces.

One discrete zone of EBA walls was found in a narrow wadi channel to the west of WF100 (Fig. 8.27). At the head of the wadi was a small rectangular structure (WF192) and a circular enclosure built of massive boulders (WF183), the few sherds from them being exclusively EB1. The wadi itself had a long sequence of regularly-spaced single-stone cross-wadi walls built across it (WF42). There were cross-wadi walls further down this channel (WF200) and a circular structure built of large boulders (WF302) near where it debouches today into the main Faynan channel, suggesting another possible settlement complex, but there were no EBA sherds here (the zone is scoured by floodwaters today). The channel to the north of (and running parallel with the northern edge of) WF100 was the location of a similar complex of likely EB1 date: a small rectangular structure (WF93), a possible boulder enclosure (WF95), and small cross-wadi walls built across the feeder channels into the main channel (WF91; WF47, the latter with fragments of mortars or grinding stones built into it [WF48]; and WF92). A rough boulder enclosure 100 m or so to the northeast, WF97, is likely to be part of this cluster of EB1 sites. Also perhaps associated is WF62 *c.*350 m up the channel to the east on its northern side, a 23 × 18 m D-shaped enclosure made of massive (1–2 m) boulders and in places incorporating even larger boulders that were probably lying *in situ* a the time of the structure's construction (Fig. 8.30). Prominent at the centre of the enclosure were three isolated boulders each over two metres in length. There may have been other settlement complexes of the same kind elsewhere under the WF4 field system on the basis of the distributions of EBA pottery (Fig. 8.7), and EB1 sherds were found in an old land surface underneath a terrace wall at WF1524 east of WF100. WF276, *c.*1500 m to the east of WF100, appears to have been an isolated enclosure.

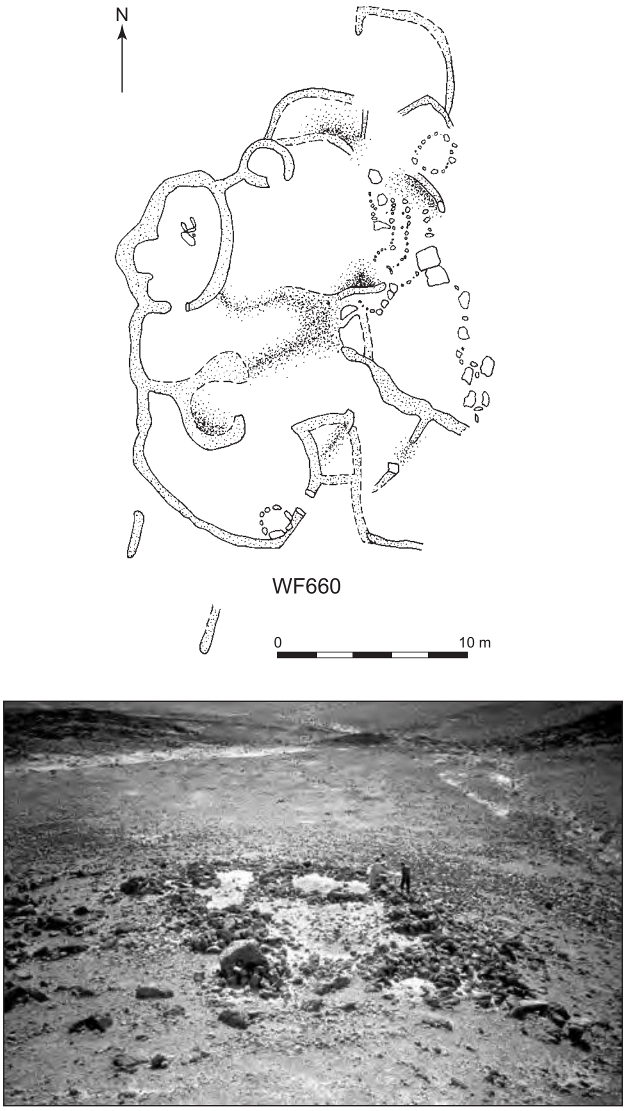


Figure 8.31 *WF660, an EB1 and EB2–3 'pastoral' site with several buildings and pens: (above) plan, (below) photograph, looking north. (Illustration: David Mattingly and Mike Hawkes; Photograph: Graeme Barker.)*

Another group of fields that produced quantities of EBA sherds was WF1512, located at the northeastern extremity of WF424, an important location for Iron Age activity on the south bank of the Wadi Dana at the foot of the Khirbat Faynan mound. Whilst the rest of WF424 has numerous Iron Age sherds, only three were found in WF1512, suggesting that its complex of walls can be assigned to the Early Bronze Age with reasonable confidence. The structure of the walls here is certainly very similar to other field systems thought to be of EBA date, and a long curving perimeter wall is reminiscent of the wall forming the boundary to WF4.13 to the south of WF100. It is conceivable that the WF1512 walls demarcated land holdings linked to the EBA settlement that is assumed to have existed underneath the Classical-age occupation at Khirbat Faynan.

8.10 Pastoral settlement away from the Wadi Faynan channel

The EB1 landscape included a very different kind of domestic site: single enclosures or sets of enclosures generally constructed of single lines of rough limestone boulders and commonly having a variety of structures attached to the enclosure walls. These are located especially on the northern side of the ridge of hills that runs parallel with the main Faynan channel on its northern side: (Fig. 8.27). A few of the structures attached to the enclosure walls may be the bases of small buildings, but most look far more like small pens, and there were also very small structures which we have termed 'stores'. Some of these are strongly reminiscent of the rubble-built holding pens used by the present-day bedouin to protect their young livestock (the goat kids), others are like the facilities they build for keeping water and yoghurt containers cool (see Chapter 12, §12.7.13). Several enclosures also have guiding walls leading to the main entrances, or entrances fashioned by offsetting walls, suggesting that they were designed for controlling the movements of livestock. Though the sites vary in complexity, their constructional features, together with the absence of field systems, and their common topographical situations (hillsides above sloping gravel fans without access to low-gradient floodwaters) combine to suggest that they were primarily pastoral in function, presumably occupied on a seasonal basis. Though their pottery is in most cases predominantly EB1, the sites also regularly yielded EB2–3 sherds (and one site discussed below has more of the latter than the former), indicating that they were a longer-lived settlement form than the EB1 'agricultural' sites discussed earlier. Rather similar 'campsites' and 'corrals' in locations poorly suited to agriculture were mapped in the Wadi al-Hasa and the southern Ghor (MacDonald 1988: 155–66).

A good example is WF660 on the western end of the group we located within our survey area, a collection of circular structures attached to a series of interlocking enclosures (Fig. 8.31). A series of carefully constructed steps gave access to the main enclosure from the sloping ground to the east. The ground was carefully terraced to give a series of relatively flat enclosures. Whether these were all connected internally or whether some could only be accessed from the outside is not clear because of the rubble of collapsed structures covering parts of the site. There are indications of organic growth in the settlement rather than a single construction plan, especially on the northern end of the site and with the boulder wall constructed south of the entrance to form a separate enclosure. Given this evidence for constructional history, it is noteworthy that the surface material was dominated by EB1 sherds but also

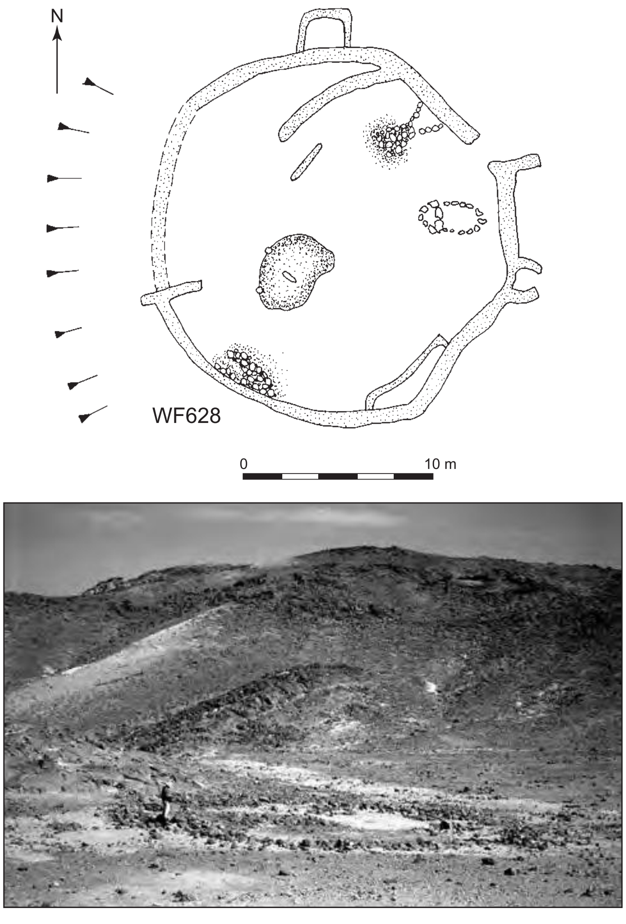


Figure 8.32 *WF628, a simple 'pastoral' site, mainly EB1 but also EB2–3: (above) plan and (below) photograph, looking southeast. (Illustration: Daniel Lowenborg, Maria Ruiz del Arbol, and Mike Hawkes; Photograph: Graeme Barker.)*

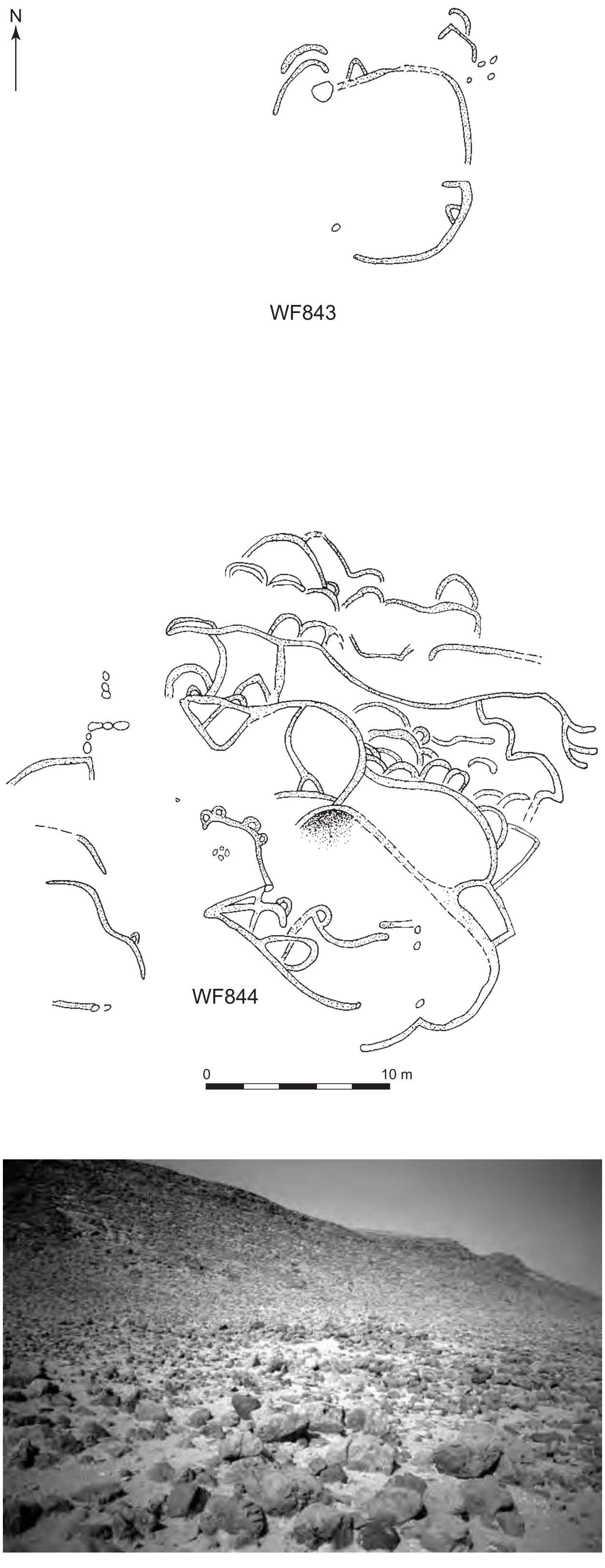


Figure 8.33 *WF844, a complex EB1 'pastoral' site terraced into a steep scarp: (above) plan, also showing WF843, a small enclosure 100 m to the northeast; and (below) photograph, looking southwest. (Illustration: Daniel Lowenborg, Maria Ruiz del Arbol, and Mike Hawkes; Photograph: Graeme Barker.)*

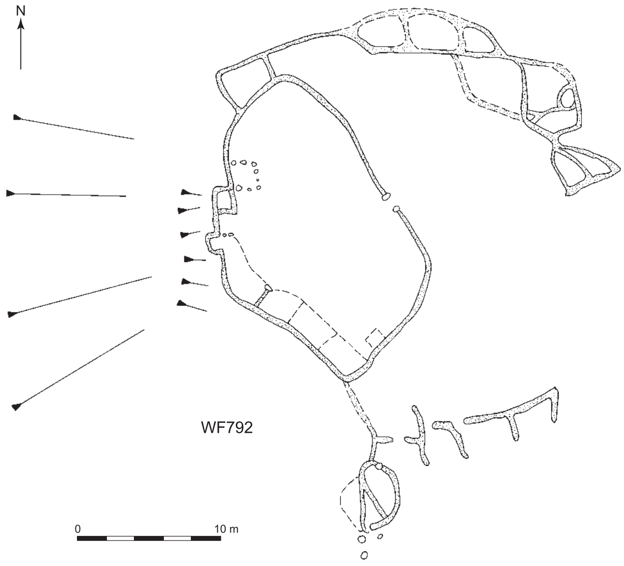


Figure 8.34 *WF792, a complex EB1 'pastoral' site with an inner enclosure and outer pens: (left) plan and (right) photograph of inner enclosure, looking northwest. Scale: 1 m. (Illustration: Daniel Lowenborg and Mike Hawkes; Photograph: Graeme Barker.)*

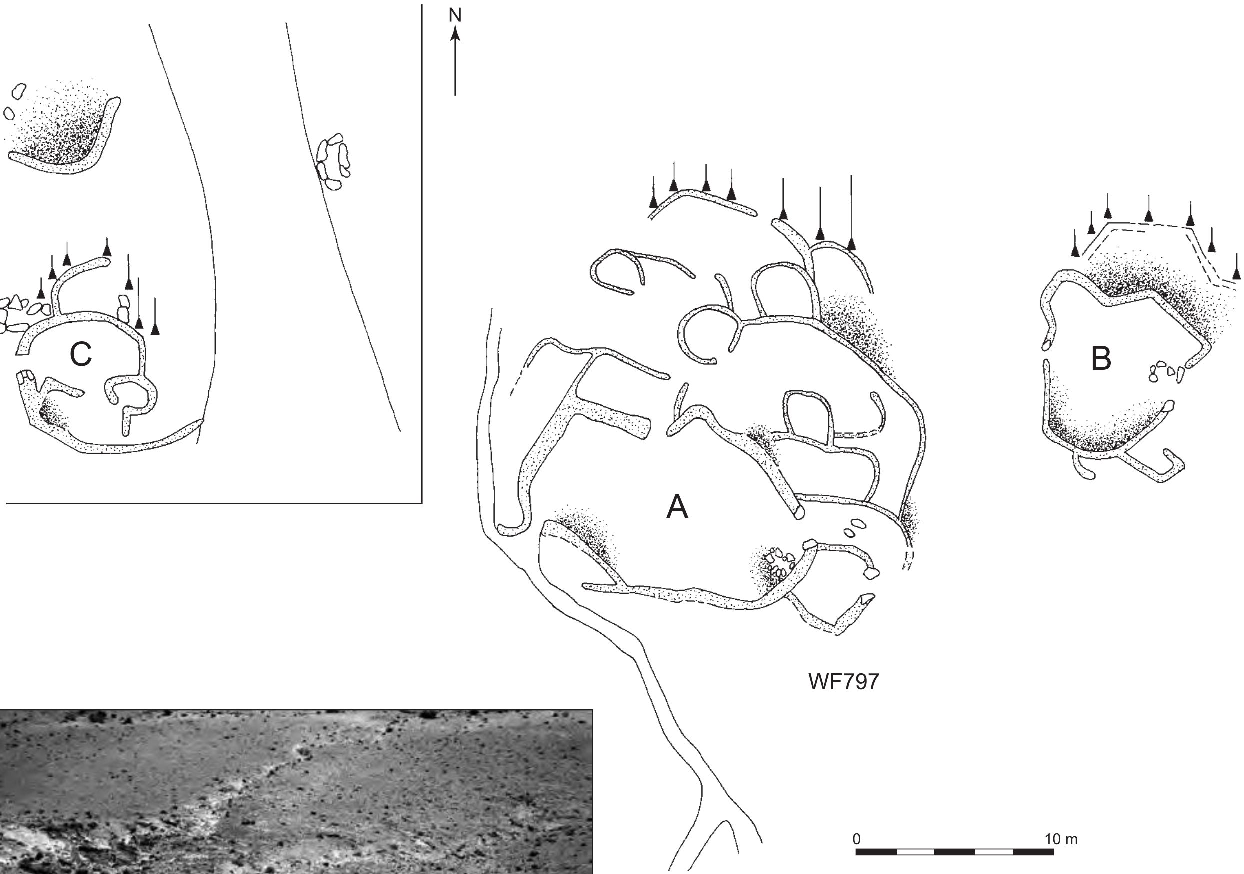


Figure 8.35 *WF797, an EB1 and (especially) EB2–3 'pastoral' site consisting of a main enclosure (A) and two smaller enclosures, one (B) 5 m to the east and one (C) 20 m to the northwest: (above) plan of complex and (left) photograph of main enclosure, looking north. (Illustration: Beatrice Prat, Lars Gustavson, and Mike Hawkes; Photograph: Graeme Barker.)*

included several EB2–3 sherds (along with chipped stone artefacts, stone saddle querns, grindstones, and pounders). A couple of hundred metres to the southwest was WF628 (Fig. 8.32), a single enclosure with one clear entrance on the eastern side with an out-turned entrance wall, and possible indications of a second entrance on the opposite side. Two small structures are attached to the outer side of the enclosure wall, one south of the entrance apparently built as an integral feature (a possible 'store'), another on the northern side perhaps added later. There appear to have been at least two small rooms or storage structures on the inner side of the southern part of the enclosure, and there was some kind of dividing wall in the northern sector. There are robbed graves just inside the entrance, and a crude excavation pit in the centre of the enclosure probably also denotes a robbed grave or graves. As in the case of WF660, the surface pottery was dominated by EB1 sherds but also included several EB2–3 sherds, together with an arch-backed blade, a typical Chalcolithic/EBA type.

Another set of enclosures was found 2 km to the east. WF844 (Fig. 8.33) is a complex of enclosures, smaller yards, pens, and 'storage bins' terraced into a steep scarp. The site could be entered from the southern (upslope) or northern (downslope) sides through entrances formed by offsets in the enclosure wall. In this case the surface pottery was almost exclusively EB1, associated with saddle quern fragments and lithics. WF843 was a small (10 m diameter) simple enclosure *c*.100 m to the northeast, with traces of stone pens or stores attached to the inner and outer walls much like the WF628 enclosure. WF792, 200 m to the east of WF844, was of intermediate form in terms of complexity, with a main enclosure with a single entrance on the eastern side marked by orthostats, a series of poorly-defined rooms or pens on the opposite side, and a well-built 'store' (Fig. 8.34). Further small structures on the eastern side of the main enclosure join together to form two 'arms' of an outer enclosure open to the east.

The third example in the series is about 1 km further to the east. This consisted of a cluster of three enclosures: WF797A, a complex much like WF660 and WF844, and two smaller enclosures, one *c*.5 m to the east (B) and the other *c*.20 m to the northwest (C) (Fig. 8.35). The main enclosure had clear entrances marked with orthostats, one at the southeast giving access to the outside through a distinct corridor, the other on the northern side leading down into a zone of terraced yards and pens. The two smaller enclosures both have traces of small pens or stores attached to their inner and outer walls. What is particularly striking about this settlement complex is that only a third of the pottery belonged to EB1, the rest belonging to EB2–3.

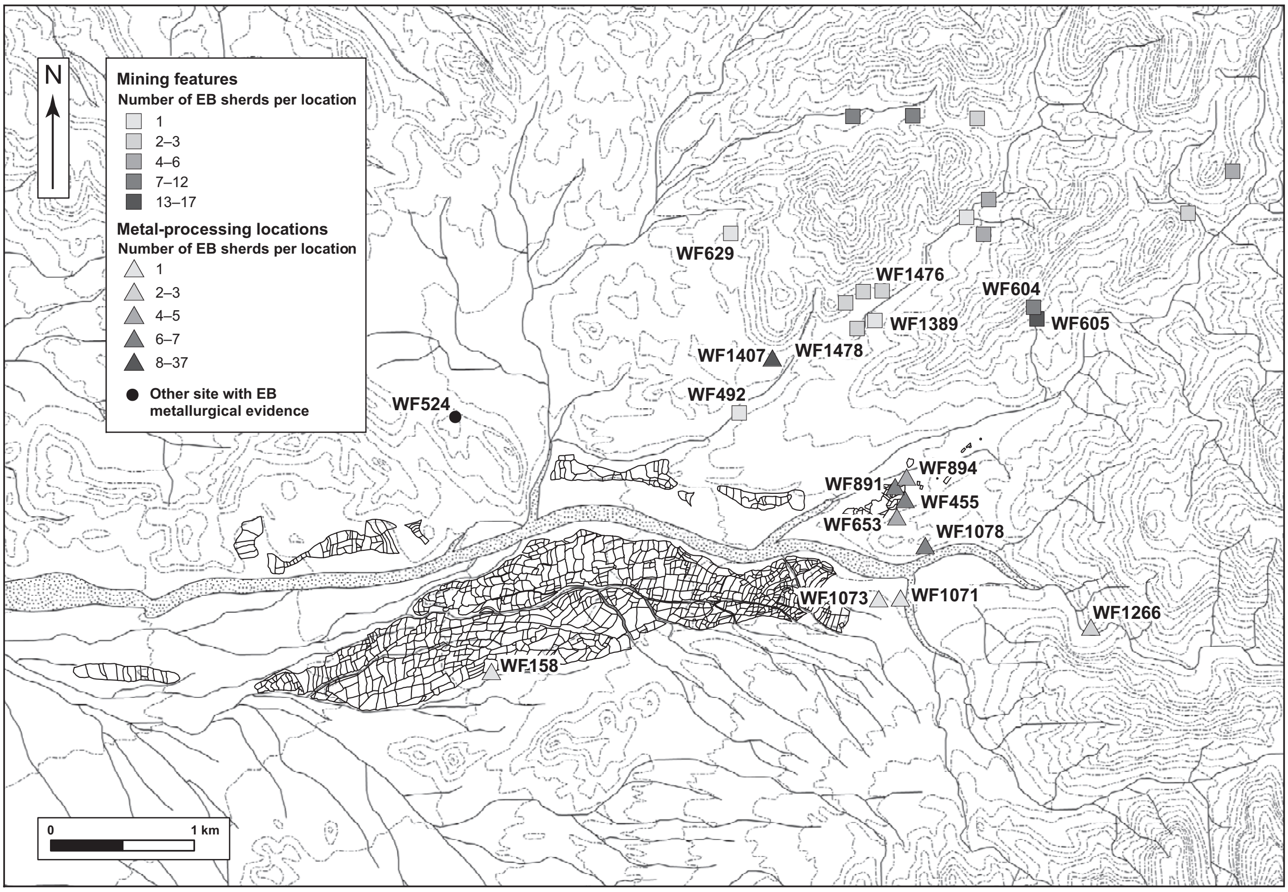


Figure 8.36 *EBA mining and metal-processing locations. (Illustration: Paul Newson.)*

Figure 8.37 *Entrance to WF1389, an EBA mine adit in the Wadi Khalid. looking south. (Photograph: Graeme Barker.)*

Figure 8.38 *Clay rods ('ladies' fingers') from the EBA smelting site WF524. (Photograph: Graeme Barker.)*

8.11 Metallurgical activity

The next significant component of the EBA landscape consists of industrial or metallurgical sites. These divide into two categories: mining locations and metal-processing locations (Fig. 8.36).

The work of the Bochum team demonstrated that, whereas Chalcolithic mining was restricted to primitive adits excavated horizontally into the hillside, EBA mining was technically much more sophisticated (Hauptmann 2000: 97; 2006: 129; Hauptmann and Weisgerber 1987: 424; Fig. 8.37). The miners targeted the rich copper silicates and malachite ores of the dolomite-shale layers, excavating vertical pits or shafts and then opening them out into galleries, leaving vertical pillars as reinforcing structures. One of the galleries explored by the Bochum team was 1–1.5 m in height, over 30 m wide, and could be followed over 50 m into the hillside. EBA sherds were found inside the mine, including one with traces of soot on its edges suggesting that it was some kind of lamp, and in the heaps of mine waste on the surface beside the shafts. The Bochum survey collected EBA pottery from over 50 waste heaps in the Wadi Khalid, the main focus of their fieldwork. Our own project mapped fifteen mining locations associated with EBA pottery in our survey area, in the Wadi Dana, the Wadi Khalid, and the Wadi al-Abyad. Most consisted of heaps of mine waste or tailings, but there were traces of adits at WF604 (Wadi Dana) and WF1476 (Wadi Khalid), shafts at WF629, WF1389 and WF1478 (Wadi Khalid), and ore-processing locations where ore rock had been crushed and sorted at WF605 (Wadi Dana) and WF492 (an outlier

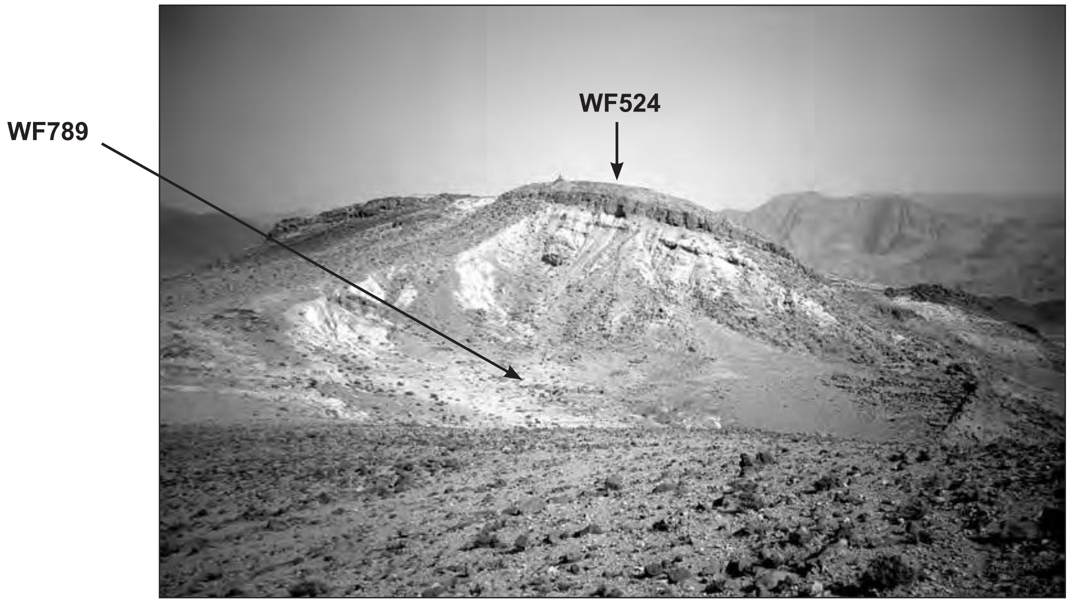


Figure 8.39 Looking west to WF789, a complex domestic site of EB1 date situated below the EBA smelting site WF524, located on the hill-top behind. (Photograph: Graeme Barker.)

of Wadi Khalid). Several other locations with comparable physical evidence probably belong to this phase of mining activity, but did not yield dating materials.

The Bochum team also excavated some EBA smelting sites on the ridge above the Khirbat Faynan. These consisted of simple bowl furnaces, located where the prevailing winds would help the process of heating up the ore/charcoal mix. Experimental reconstructions and analysis of archaeological slags indicated that EBA slags melted at around 1190°C because of the oxygen-rich conditions, compared with 1250–1300°C for Iron Age slags and 1400°C for Roman slags (Hauptmann and Weisgerber 1987: 432–3). Small rods of fired clay ('ladies' fingers': Fig. 8.38) were used to support the ore/charcoal mix to aid the process of the prills of molten copper flowing down freely to the base of the crucible where they could be collected after cooling. The slag produced is very different in both size and appearance from the slags associated with the larger and more efficient smelting furnaces used in later periods (Fig. 4.47), consisting of small nodules that are the residues of the process of hand-smashing of the crucible's contents that was necessary to separate metal from slag (whereas later furnaces had tap systems that allowed the slag to flow out of the furnace).

We located ten EBA smelting sites identified by the association of small slag nodules, clay rods, and EBA pottery. The most substantial site we found (WF1407) was also nearest the ores, at the southern end of the Wadi Khalid, where EBA smelting debris and pottery were found in and around an enclosure attached to a rock-shelter. Several smelting sites were found on the ridges immediately above Khirbat Faynan (WF455, WF653, WF891, WF894, WF1078). Two sites (WF1071, WF1073) were located on low hills to the south of Khirbat Faynan on the southern side of the Faynan channel. Another (WF1266) was found in the southeast part of the survey area on an exposed hillslope between the Wadis Ghuwayr and Shayqar. Small-scale slag deposits were found within the WF100 zone (WF158).

We also found several locations with slag and clay rods but without pottery that almost certainly belong to the same phase of metallurgical activity. A good example is WF524 (Figs 8.38, 8.39), on the ridge bordering the northern side of the Faynan channel near the WF792 'pastoral' enclosure. A complex domestic site of EB1 date (WF789: Fig. 8.40) was located on a shelf at the foot of this hill. It consisted of linked enclosures containing a series of single-cell oval and sub-rectangular structures, one of which may have had a hearth. Nearby was a small EB1 cemetery of cairns, and cairns with kerbs, WF790. Although no slags were found at WF789, it seems likely that it was geared to industrial processing.

8.12 Bronze Age pictographs?

As noted in the discussion of the pictograph sites in Chapter 7 (§7.7), superimpositions indicate that the earliest very abraded images of ibex are overlain by a second much larger group of images that are less abraded, generally patinated to a deep orange, and are frequently characterized by what appear to be relationships between individual motifs, or 'scenes'. They include, as well as ibexes (which are generally larger than the earlier examples), anthropomorphic figures, including people mounted on animals such as horses or donkeys, and camels. On the WF20:B boulder, for example (Figs 7.22, 7.23), with the older ibex

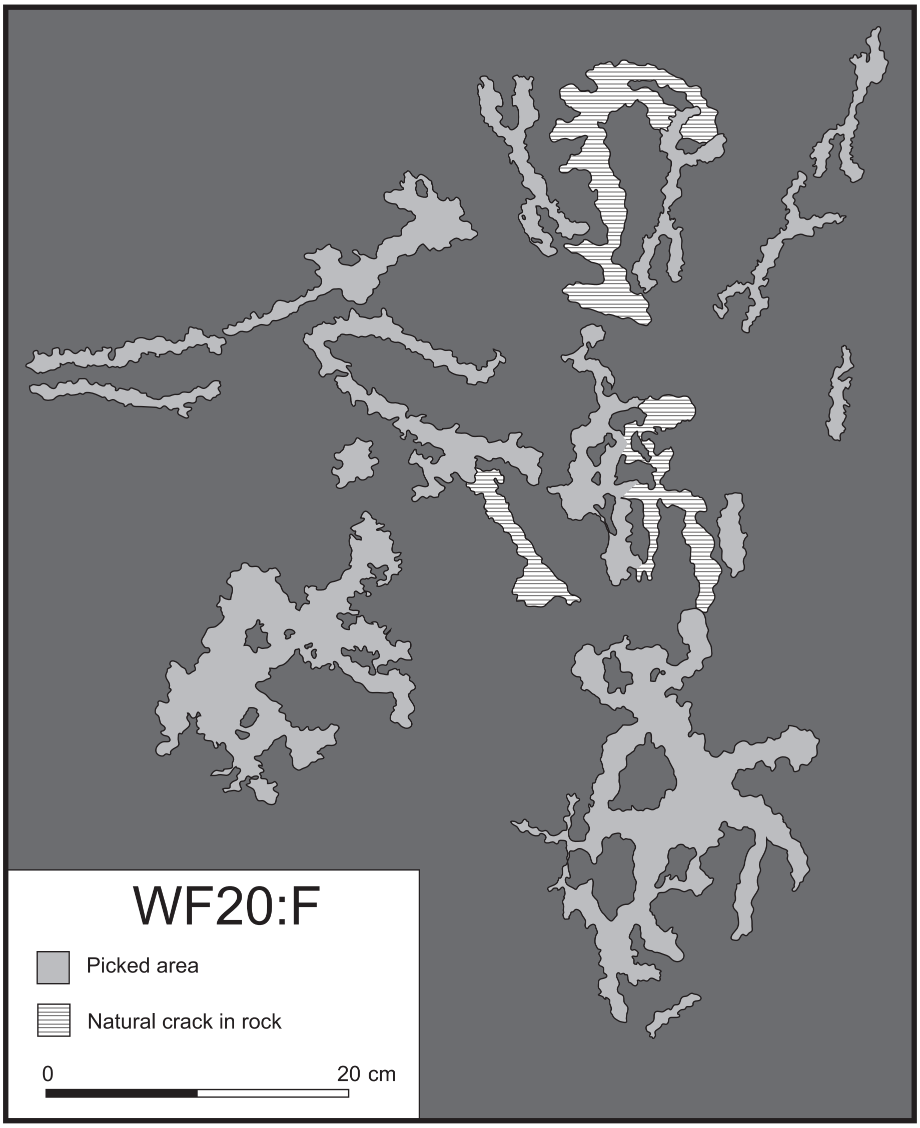


Figure 8.40 *Tracing drawing of WF20:F pictograph. (Illustration: Lucy Farr and Dora Kemp.)*

Figure 8.41 *WF20:F pictograph. Scale: 10 cm. (Photograph: Graeme Barker.)*

Figure 8.42 *Tracing drawing of WF1394, probably showing a hunting 'scene'; see text for description. (Illustration: Lucy Farr.)*

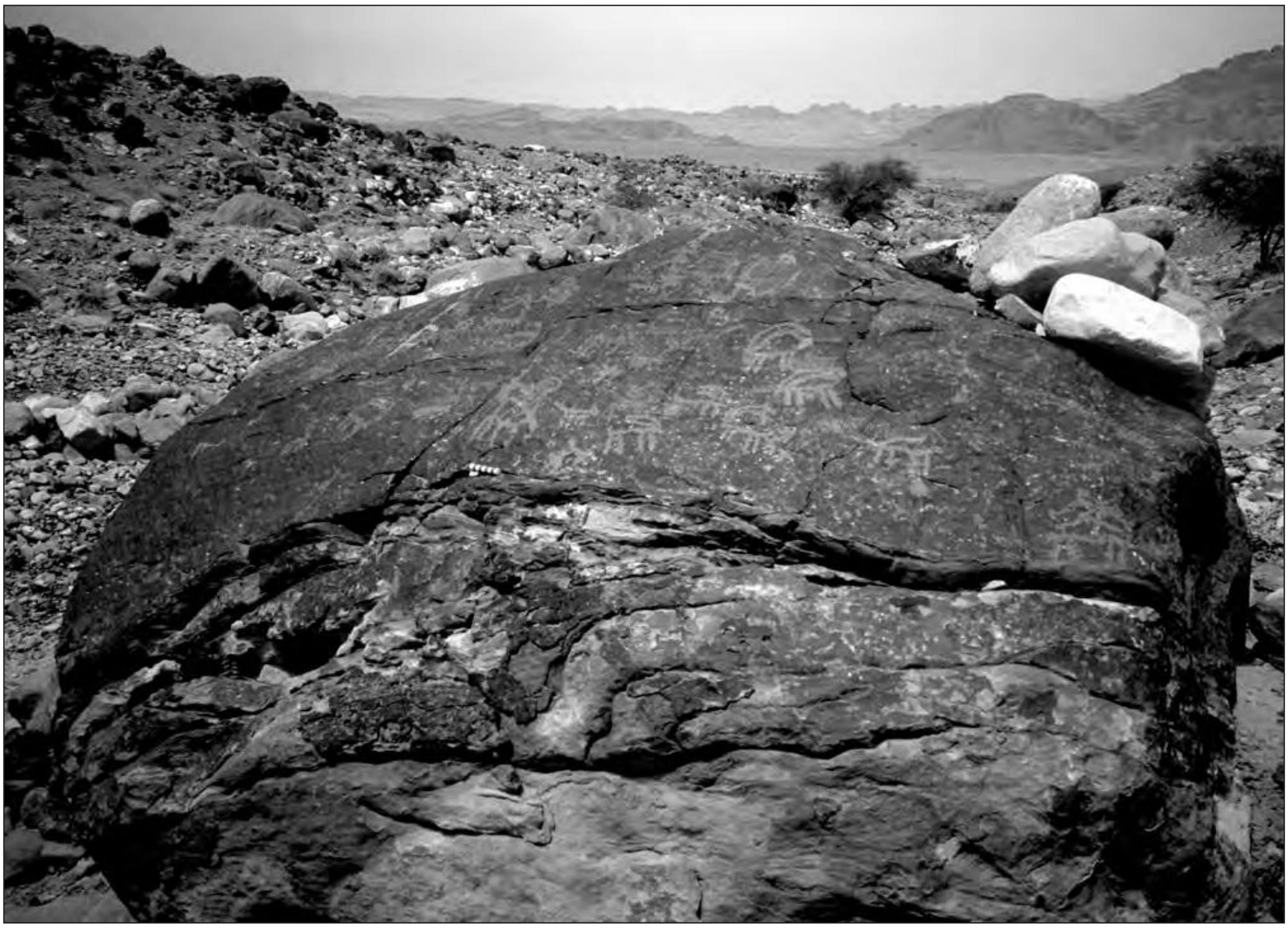


Figure 8.43 *WF1394 pictographs, looking north. Scale: 10 cm. (Photograph: Graeme Barker.)*

Figure 8.44 *Tracing drawing of WF20:H pictograph, showing camels, including being ridden, and ibex; see text for description. (Illustration: Lucy Farr.)*

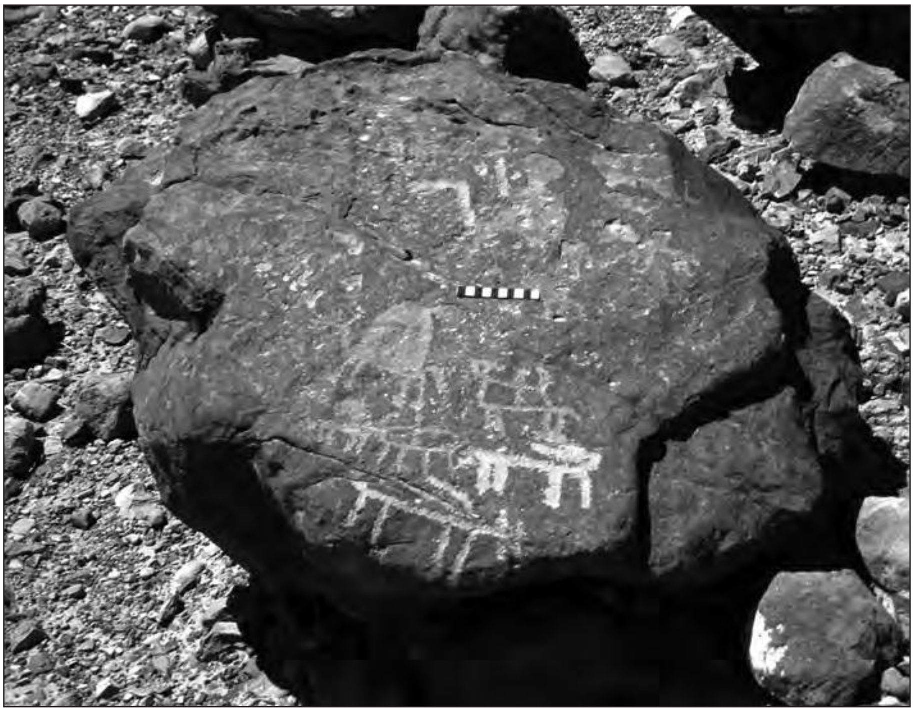


Figure 8.45 *WF20:H pictograph, looking west. Scale: 10 cm. (Photograph: Graeme Barker.)*

extracted, the other motifs make sense as a representation of a hunting scene. The U- and L-like motifs at the bottom can plausibly be identified as the 'kites' that are well known on the desert steppes of eastern Jordan: enclosures made of low stone walls, open at one end, into which hunters could drive animals such as gazelle (Helms and Betts 1987). If we take the scene literally, the standing figure with raised hands in the lower centre could be preventing the escape of game already trapped in the lower kites (represented by the central oval shapes?), and the mounted rider above and to the right could be driving the other animals towards the corral – another hunting aid known ethnographically – shown at the top left.

On the WF20:F boulder (Figs 8.40, 8.41) there is a figure with raised arms riding a quadruped at the bottom right and what is probably another mounted figure to the left; at the centre of the panel is an inverted U as in WF20:B; at the top right are four human figures with arms raised as if dancing; and there is a long linear motif on the left upper section, to the left of the 'dancers'. As with WF20:B, these pictographs could be interpreted as depicting a hunt, the mounted rider at the bottom driving an ibex towards the open end of the kite and the 'dancers' frightening the animals to prevent their escape. In this interpretation, the linear feature at the top left could represent some kind of wall to help control the movements of the stampeding game.

On the WF1394 boulder nearby (Figs 8.42, 8.43), the motifs judged to be later in terms of patination include at least eight ibex along the upper section, most of them facing right but with a pair of ibex facing each other top right, and a lower row of eight or nine right-facing ibex, in the middle of which is a human figure with arms raised, probably holding a vertical stick- or weapon-like object in each hand and mounted on a quadruped; in front of this figure is what appears to be a running dog. Taken together, the pecked figures suggest a single 'scene' of associated people and animals, with a figure mounted on a horse or donkey, accompanied by a dog, pursuing ibex in a hunt. The impact of the image is enhanced by the curvature of the boulder, the far right 'reversed' ibex being on the curve of the boulder away from the 'vision' of the hunter.

Carved in the same style, with the same degree of patination, are what appear to be clear depictions of camels. WF20:H, for example (Figs 8.44, 8.45) appears to show a camel being ridden by a human with a raised arm, accompanied by a smaller (young?) camel below and possibly to the left. There is another large camel centre right with an exaggerated hump and probably not being ridden, with a possible small camel underneath it being led by a mounted human figure, possibly with an elongated ibex beside them. At centre left, to the left of the camel with the exaggerated hump, is another mounted human with arms raised and/or holding (?)weapons. There is a four-legged animal at the bottom of the group. All of the WF20:H motifs have a similar degree of colouring/patination.

WF20:R (Figs 8.46, 8.47), on an isolated small boulder below the terrace edge near the channel of the Shayqar,

Figure 8.46 *Tracing drawing of WF20:R pictograph, showing human and camel; see text for description. (Illustration: Lucy Farr.)*

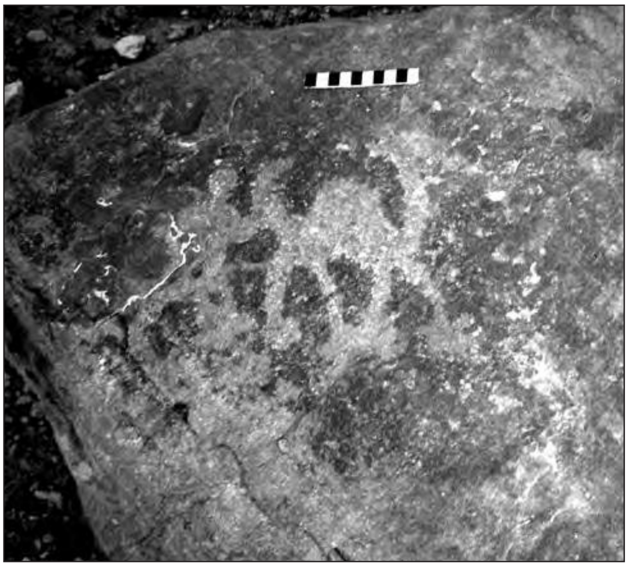


Figure 8.47 *WF20:R pictograph, looking southwest. Scale: 10 cm. (Photograph: Graeme Barker.)*

shows a human figure with a raised arm on the left and a camel to its right, facing right; the human and the camel appear to have been pecked out at the same time on the evidence of the conjoining of the upper arm of the human and the back of the camel.

Termini post quem dates can be ascribed to the depictions of donkeys, horses, and camels given our understanding of their domestication histories. Donkeys were being used in the Levant from Chalcolithic times (Ovadio 1992). Domesticated horses, and horse-riding, are generally thought to have reached the Near East from the Eurasian steppes by the third millennium BC, the same time as there are depictions of the domestic ass on Egyptian tomb paint-

Figure 8.48 *Pictograph WF1444, by EB1 enclosure WF1512, possibly showing an ibex hunt; see text for description. Scale: 10 cm. (Photograph: Graeme Barker.)*

ings (Clutton-Brock 1987: 91; Meadow and Uerpmann 1991). Most images from Egypt and Mesopotamia in the third millennium BC show donkeys, horses, or their hybrids as pack animals, or drawing carts and chariots, but they were also used for riding, though this is assumed not to have been widespread until the development of the true bit in the second millennium BC.

It is generally assumed that one-humped dromedary camels were first domesticated in Arabia and introduced to the Levant as domesticates (Köhler-Rollefson 1996). Pictographs in Arabia speculatively dated to the seventh–fifth millennia BC show dromedaries being hunted by men on foot armed with spears, but other pictographs showing horsemen touching camels with their spears, thought to indicate domesticated camels being claimed by raiders, are much later (MacDonald 1990). It is unclear when domesticated dromedaries became widespread in the Levant, but the consensus is that it was not until the later second millennium BC (MacDonald 2000). A complete camel scapula is reported from the copper mines of Timna in a fourteenth-century BC context (Rothenberg 1972), and there are Biblical references, thought to refer to the late second millennium BC, that tell of Midianite camel raiders 'without number' spilling out of their homelands in the Hisma and the coastal mountains of northern Arabia to prey on Israelites farmers (Judges 6: 4–5). According to Assyrian texts there were camel-herding Arab nomads (*Aribi*, *Arabu*, *Arbya*) in the northern Sinai and Syro-Arabian deserts by *c*.750 BC, and local Arab groups supplied dromedaries as water carriers to the Assyrian king Esarhaddon when he marched down the coast of Palestine to invade Egypt in 671 BC (Wapnish 1984: 179).

Ibex pictographs were also found on boulders built into some Nabataean and Roman domestic structures, but in every case the boulders appear to have been re-used, the pictographs therefore ante-dating the construction of the buildings. In the case of the single ibex on a boulder set into the enclosure wall of the domestic structure WF1417 (Fig. 8.16), however, the exposed section of the stone had developed a brown desert varnish, whereas the ibex had the typical orange patina of the main group of (assumed) Bronze Age pictographs described above. Excavation of the boulder showed that its buried part was rough, eroded by soil chemical processes, suggesting that the stone was placed in the ground as part of the wall and the ibex then pecked onto it. No pottery was found in association with the structure, but its construction morphology and location strongly suggest that it is EBA in date. In the same zone we found another pictograph, WF1444 (Fig. 8.48), on a boulder immediately beside the WF1512 enclosure dated by its surface pottery to EB1. It consisted of two ibex one above the other, a rough oval to their right, a small anthropomorphic figure and a four-legged animal to the left of the upper ibex and a half rectangle to the left of the lower ibex, all possible components of an ibex hunt (hunter, dog, linear kite, oval corral).

In the light of these associations, it seems reasonable to conclude that some of the pictographs showing ibex hunts with ridden equids could well be as early as the third millennium BC, though given the paucity of evidence for the riding of domesticated equids at that early date it may be that they are more likely to date from the second millennium BC onwards. The scenes of domesticated camels would seem unlikely to be earlier than the end of the second millennium BC. Of course all of these pictographs could be much later than this, but it is seems likely that some of them relate to the use of the Faynan area by mobile aceramic pastoralists through the third and second millennia BC. The same arguments apply to the pictographs in the Wadi Ghuwayr published by Pinkett and Mithen (2007). Whilst it would be extremely unwise to take the motifs as literal scenes of everyday life, the hunting and warrior scenes certainly chime with the male-focused ideologies of many pastoralist societies.

8.13 The Bronze Age landscapes and societies of Wadi Faynan

The discovery of a highly structured, indeed hierarchical, as well as densely occupied, landscape in the Wadi Faynan in the Early Bronze Age, especially in the EB1 phase, is one of the most striking results of the project. Of course the presence of pottery of a particular phase lasting several centuries does not imply that sites with that pottery were continuously occupied, or that they were contemporary with one another. However, whilst individual sites may well have been occupied for brief periods, there does appear to be a consistency in the overall patterning of Early Bronze Age settlement implying structured differentiation between arable, pastoral, and metallurgical activities in the different parts of the Faynan landscape.

On current evidence the most significant settlement complex in the wadi was at WF100, though as mentioned earlier, it is possible that a major EBA settlement is buried underneath the Khirbat Faynan mound given the numbers of EBA sherds that have been recovered over the decades from the flanks of the hill. Clearly the WF100 settlement was not an Arad-style fortified city with dense 'urban'-style housing within, but it was certainly a major and visually-prominent focus of habitation, with a substantial boundary wall enclosing a cluster of house-and-courtyard compounds and further paddocks and yards. The area of densest surface material covers 11 ha, a size of settlement for which Philip (2001: 182) suggests a likely population in the region of 1000–2500 people. It was the focus for a range of craft- as well as food-production activities. The latter included cereal cultivation, tree-crop agriculture, and animal husbandry – the faunal material from the excavations has only been cursorily studied to date but sheep, goat, cattle, donkey, and pig are all represented. Crafts included potting (perhaps of separate funerary and domestic wares: see below), making stone vessels, flint knapping, weaving (on the evidence of spindle whorls), and metallurgy. A suite of metallurgical activities was practised: copper ores were brought to the site, broken up, and smelted, and the resulting metal was fashioned into objects using moulds and hammering techniques. The implication is that there were powerful individuals or groups at WF100 controlling both the metal-extraction process and trade in copper and copper artefacts with the outside world.

The landscape immediately to the south of WF100 was the location for a complex suite of funerary monuments including elaborate kerbed burial cairns as well as simpler cairns, indicating marked differentiation in burial forms and social investment in parallel with the evidence for social differentiation at WF100. The prominent locations of many of the major monuments presumably acted as symbolic capital, legitimating the local community's rights to the land they controlled in terms of the presence of their ancestors. A series of discontinuous walls and associated structures hints at formal boundaries between the living and the dead, and controlled access to the latter.

Other farming communities were located alongside small tributary channels on either side of the main Faynan channel. Presumably they combined crop and animal husbandry, given the evidence of field systems, enclosures, and harvesting, grinding and (perhaps) shearing equipment, together with the pollen from WF100 indicating an agricultural landscape of olives, cereals, and pasture. They do not appear to have engaged in metal processing, however. Some of these communities had adjacent burial sites of various types of cairns of greater and lesser elaboration, but they lacked the major funerary monuments associated with WF100.

Although it is frequently postulated that floodwater farming and water storage were critical features of EBA agriculture in the southern Levant, the best evidence to date has been found inside the walled settlement of Jawa on the arid basalt plateau of eastern Jordan (Helms 1981: 151–80; Philip 2001: 174). The check dams, water diversion walls, and water-storage facilities identified in Wadi Faynan provide further strong evidence for its practice. The investment involved in constructing and maintaining these facilities implies significant changes in the ways in which labour was organized and deployed compared with during the Chalcolithic. Another implication is that water increasingly became a cultural commodity to be owned, controlled, and disbursed (Phillip 2003: 106). The introduction to the region at this time of the oxen- or donkey-drawn plough (Grigson 1995) represented a further intensification in the capitalization of agricultural technologies and the control of labour, as did the development of tree cropping.

At a distance from these cultivated landscapes, especially on the northern slopes of the mountain ridge bordering the north side of the main Faynan channel, were what appear to have been specialist pastoralist communities. The focus of their settlements consisted of quite substantial enclosures, to which were added a variety of smaller enclosures, yards, pens, and storage facilities. Further north still were numerous shaft-and-gallery mines. The copper ores extracted from them were part-processed there and transported to hilltop smelting locations around the Faynan basin, with further smelting and finishing taking place at the WF100 settlement (and at similar sites if they existed).

The similarities of the pottery at the Faynan EB1 sites suggest that all of these communities shared commonalities in culture and identity, and a key question concerns the extent to which the various mixes of arable, pastoral, and industrial activities were pursued as separate activities by distinct social and economic groups, or were articulated or coordinated in some manner. The balance of the evidence favours the latter. The first indicator of integration is the evidence for the geographical separation of the metal extraction and exploitation processes. Sites like the WF789 settlement (Fig. 8.39) constructed immediately below a hilltop smelting site without evidence for associated fields suggest that there may have been some specialist communities engaged in metallurgical processing, which cannot have been self sufficient, and the scale of the mines also indicates not just significant expertise and investment of labour but also the organization and control of the latter.

Integration is also implied by the results of a preliminary petrological analysis of pottery from a series of the EB1 settlement, funerary, and metallurgical sites (Edgar 2003). This analysis identified twelve fabric groups in the material on the basis of their inclusions: argillaceous, calcareous, chert/calcareous, chert/shale/argillaceous, coarse chert/silty matrix, granitic, coarse volcanic/shale, coarse volcanic, shale/grog, quartz sand, chert/grog, and fossiliferous limestone. The finer fabrics were generally reserved for vessels at funerary sites. The coarser fabrics dominated the collections from the domestic sites, being used especially for storage jars. Setting aside the fabric with grog (ground-up sherds) in it, all of the geological inclusions listed above can be found in the Fidan/Faynan region. Subtle differences in the forms and fabrics of the sites on either side of the Faynan channel indicate that much of the pottery was manufactured locally, that is, at or near the sites where it is found. However, WF100 emerged as the most likely centre of production for the large storage jars found at the other agricultural sites, hinting at a possible role of its community in the control and central storage of foodstuffs and the focus for some kind of redistribution systems with satellite agricultural communities. The specialist pastoralist groups living more independently on the edge of this system may have acquired the cereals that they processed with the grinding equipment we found at some of their sites by trading with adjacent agricultural communities, or they may have grown their own crops elsewhere, for example on the plateau edge of the Mountains of Edom if they practised the kind of transhumant systems of some of the bedouin today (Chapter 2).

The rationale for the use of grog in some vessels is unclear. Adding coarsely-ground fragments of sherds to clay as temper helps to prevent pots cracking during firing, but given that the grog in the Faynan material is found mixed in with other coarse inclusions such as chert and volcanic rock, it would not have been essential to use grog for this purpose. It may have been added for entirely different reasons. In some non-industrial societies today such as the Gurensi of Ghana, for example, the pottery of deceased people is smashed up and the sherds ground down as grog for new pots as a way of maintaining associations with the past whilst renewing life (Gosselain 1998). Against such an interpretation for the Faynan, though, is the fact that grog was not found in the sherds sampled from the funerary sites.

However, it is important not to exaggerate the scale of copper working and export, or of economic articulation, at this time. There was another significant copper-working settlement dating to EB1 at the end of the Faynan/Fidan complex, the site classified as Wadi Fidan 4 (Fig. 8.2). Like WF100 it was surrounded by what appear to have been smaller satellite sites. Detailed studies of its settlement architecture and artefactual distributions indicate that copper production at the site was relatively small scale, with part-time metal-workers carrying out their activities in restricted zones of what was otherwise a domestic agricultural village (Levy *et al*. 2001a,b). Similarly, forms and decoration in pottery styles at Faynan and Fidan sites were markedly local compared within the EB2 (Adams 2003; Wright *et al*. 1998). In short, though the EB1 landscape of Wadi Faynan appears to have been rather clearly structured in terms of where different activities were located, it seems likely that any degree of articulation was primarily a response to the needs by farmers and herders to develop risk-buffering strategies to deal with a marginal and unpredictable environment (Murone-Dunn 2005).

This structured agro-pastoral-industrial system continued into EB2 (3000–2700 BC) on a much reduced scale, but metal production appears to have intensified, with a more stable and productive copper ore being mined and processed in powerful wind-powered furnaces (Adams 2002; Craddock 2001; Hauptmann 2003). Although the pottery evidence indicates that the landscape was increasingly dominated by pastoralists, Faynan copper continued to be processed and traded out of the region. The latter has been identified, for example, in a series of axes and spearheads in an EB2 destruction deposit at the settlement of Pella in northern Jordan, though the presence of an axe of Cypriot copper and a chisel of Anatolian copper in the same hoard points to the range of trade networks competing to supply the region's urban centres (Philip *et al*. 2003). The focus of local power structures appears to have shifted at this time down-channel to Wadi Fidan, where the Jabal Hamrat Fidan Survey has found a network of small settlements and cemeteries grouped around the major strategically-located and defensible settlement of Khirbat Hamrat Ifdan (Fig. 8.2). The site of Barqa al-Hatiya, about 7 km southwest of Wadi Faynan, may also have played a role as a local trade centre at this time, for its pottery matches in its mineral composition pottery from the Negev and Jerusalem (Adams 2003).

During EB3 (2700–2200 BC), Khirbat Hamrat Ifdan was used for a variety of metallurgical processes, practised on a significant scale (Levy *et al*. 2002). Primary melting and casting were undertaken in the largest courtyard, where the excavators found hundreds of fragments of moulds employed in the casting of copper ingots and of artefacts such as axes, blades, chisels, and pins. Other courtyards and rooms were used for finishing the objects by hammering, grinding, and polishing. Lead isotope analysis of *c*.70 crescent-shaped bar ingots from southern Levantine sites, ingots of the kind made at Khirbat Hamrat Ifdan, indicates that they are probably made of Faynan copper. Although the site was still occupied in EB4 (2200–2000 BC), metallurgical activity then appears to have been on a far smaller scale and episodic, and occupation also ceased at the surrounding sites.

One factor in the decline in the exploitation of Faynan copper, with all its social and economic implications for the inhabitants of the region, might have been the shift in Egyptian trade links to Byblos and Cyprus, shifts which the power structures of the more urbanized settlement zones west of the Jordan valley were strong enough to weather. Another may have been the vulnerability of the agricultural system to even slight deteriorations in environment, whether climatically or humanly-induced. The increasing rates of soil erosion identified by the palynological and sedimentological studies of the WF24 and WF148 water catchments described earlier could have resulted from aridification removing the steppic vegetation cover, supporting arguments that a significant shift to aridification occurred throughout the region towards the end of the third millennium BC (Arz *et al*. 2006; Migowski *et al*. 2006; Parker *et al*. 2006; Rosen 1995); or it could reflect poor land-management techniques including stripping timber for smelting (like the burning recorded around the WF24 cistern); or, perhaps more likely, it reflects a combination of both factors.

In the Middle Bronze Age (2000–1550 BC), sophisticated urban forms and what appear to be state-level political structures developed in the better-watered regions of the southern Levant (Broshni and Gophna 1986). An elaborate settlement hierarchy can be discerned in the countryside of farms, hamlets, and villages that served local centres, the latter clustering around major regional centres such as Megiddo and Gezer. Such centres were the foci of administrators, priests, merchants, scribes, and professional military cadres equipped with the machinery of state-organized warfare (infantry, cavalry, chariots, siege engines, and so on). The elites maintained political and economic links with the more powerful neighbouring states: there were long-term emissaries from Babylon based at Hazor, for example (Ilan 1995: 307). There is then widespread evidence for settlement contraction and economic decline in the Late Bronze Age (1550–1200 BC), and for a loosening in socio-political integration, though surviving centres remained urban in character (Bunimovitz 1995). One view of these trends is that they can be linked to military campaigns by the Egyptians, for example the expulsion of the Hyksos from Egypt and the conquest of Canaan by the first pharaohs of the Eighteenth Dynasty, or to the demands for tribute by the Egyptian authorities controlling the coastal plain at this time (Bienkowski 1989). Another is that they primarily reflect a process of internal instability and conflict. In all likelihood both sets of processes, external and internal, were involved and inter-linked.

The nature of settlement in the more arid parts of the southern Levant during the Middle and Late Bronze Ages is much debated. One view is that the region continued to be inhabited by small-scale mobile populations that created an ephemeral archaeology that is difficult to recognize and date (Finkelstein 1995; Finkelstein and Perevolotsky 1990). Another is that, given the successful recognition in areas such as the Negev of 'pastoral archaeologies' in other periods (for the Early Bronze Age and Iron Ages, for example), the absence of evidence for Middle Bronze Age settlement suggests that there was a real decline in pastoral populations, with the arid zone perhaps being more or less abandoned (Rosen 1992b).

Wadi Faynan is typical of the region in the paucity of archaeological evidence obtained by the project for settlement dating to the second millennium BC. We found only a handful of sites with MBA and LBA pottery, the enclosure WF420 to the west of the WF406 EBA agricultural settlement and field system being one example. It is difficult to believe that pastoral populations living on the plateau did not avail themselves of seasonal grazing in Wadi Faynan at this time, but if they were, they do not appear to have built stone structures like their predecessors; or if they did (or if they made use of existing structures), they were certainly not pottery-using to any degree and so are invisible to the archaeological survey. However, given the discovery of the graves of apparently aceramic Iron Age people in Wadi Fidan buried with wooden bowls (Levy *et al*. 1999a,b), the near-absence of Middle and Late Bronze Age pottery in Wadi Faynan is not necessarily evidence for the absence of people. Indeed, Middle Bronze Age metallurgical activity at Khirbat Faynan is indicated by the basal sediments investigated by the trench we excavated behind the Khirbat Faynan barrage, dated to 3390±40 BP or 1867–1536 cal. BC (Beta-203402). The presence of significant burning, together with geochemical evidence for the presence of copper and lead, indicate the grading and smelting of copper ores from the lead-rich Dolomitic Limestone Shales at this locality. The evidence for metal-working activities here in the late second millennium BC is discussed in the next chapter. On balance, it seems likely that Wadi Faynan was characterized by predominantly pastoral use through much of the second millennium BC, though some people were still visiting its mountain rim from time to time to extract and process copper ores. The recent discovery of copper objects, prills, and casting discards at remote EBA campsites in the central Negev is a useful reminder that small-scale engagement in metallurgy (in the case of the Negev sites, in trade rather than production) can be part and parcel of the pastoral nomadic lifestyle (Segal and Rosen 2005).

9. The making of early states: the Iron Age and Nabataean periods

*David Mattingly, Paul Newson, John Grattan, Roberta Tomber, Graeme Barker, David Gilbertson, and Chris Hunt**

9.1 Introduction

The first millennium BC saw the rise of complex states in the Levant and the renewal of substantial metallurgical activity in Faynan. In this chapter we consider two phases of state formation, separated by a possibly significant period when mining and metal-working fell into abeyance. Both the Early Iron Age people of the region (1200–800 BC) and the early Nabataean society of the later centuries BC are believed to have had their roots in pastoral desert communities, who have left little tangible trace of their activities in the phases immediately preceding the emergence of the state. It is possible that similar processes of social evolution were involved here and this seems justification enough for placing these two distinct societies in the same chapter. It must be stressed at the outset that there is no evidence that there was any continuity from one society to the other; the Nabataeans may well represent a recolonization of the zone by a group migrating from the south.

9.2 Edom and the 'Edomites'

The uncertainties concerning the Late Bronze Age period in the Faynan area are compounded by equally controversial debates about the earliest Iron Age activity. One traditional view of the Early Iron Age in the Transjordan region highlights the synchronous emergence of a series of proto-states, Ammon, Moab, and Edom, to match the rise of Israel to the west. The Faynan district fell within the territory normally ascribed to Edom, the most southerly of the three Transjordan early states. However, the exact sequence and process of these evolutions are still imperfectly understood. In part this is because the Old Testament provides a distinct, but distorting, optic, in part also because archaeological work remains an underdeveloped resource (Bienkowski 1992b: 1; Finkelstein and Silberman 2001; Levy and Higham 2005, on the problems of traditional Biblical Archaeology). The biblical evidence is well summarized by Bartlett (1989; 1999), though from the ninth century onwards the Transjordanian states also had to deal successively with the neo-Assyrian and neo-Babylonian empires, enduring periods of tributary vassal status and, possibly, direct rule (Weippert 1987; cf. Bienkowski 1992b). Egyptian influence on the Red Sea and 'Arabah corridor was also significant (Kitchen 1992; Rothenberg 1988). The history of the Edomite kingdom must thus be constructed from a variety of external written sources to a greater or lesser extent antipathetic to it. Archaeology in this period is all too often used simply to support conclusions drawn from this written testimony, rather than being allowed to speak for itself. The simple correlation of Iron Age material in southern Jordan with the assumed ethnic label 'Edomite' is rarely questioned (LaBianca and Younker 1995; G. Mattingly 1992).

Although complex Iron Age chronologies are employed for many other parts of the Levant, in southern Jordan it is generally agreed that the following broad divisions are most appropriate: Iron I (1250–1000 BC), Iron II (1000–587 BC), and Iron III (587–332 BC). The Iron II period is sometimes subdivided into A, B, and C phases, but even this simple system is not without difficulties (see Herr and Najjar 2001 for the overall frameworks).

From various sources of evidence, the geographical scope of the Iron Age kingdoms can be defined in broad terms, although there was undoubtedly growth and shrinkage over time, often at the expense of one of the other Transjordanian territories (Fig. 9.1). The unity of the populations of these areas is perhaps too often taken for granted and the process of ethnogenesis represented by the emergence of the kingdoms attested in the Bible was arguably a more complex and long-term phenomenon. The kingdom of Ammon appears to have occupied the plateau lands to the east of the River Jordan, between the River Zarqa in the north and the northern limits of the Dead Sea to the south. Moab

* *Archaeology:* David Mattingly, Paul Newson, Roberta Tomber, Graeme Barker. *Geoarchaeology, palaeoecology, and geochemistry:* John Grattan, David Gilbertson, and Chris Hunt.

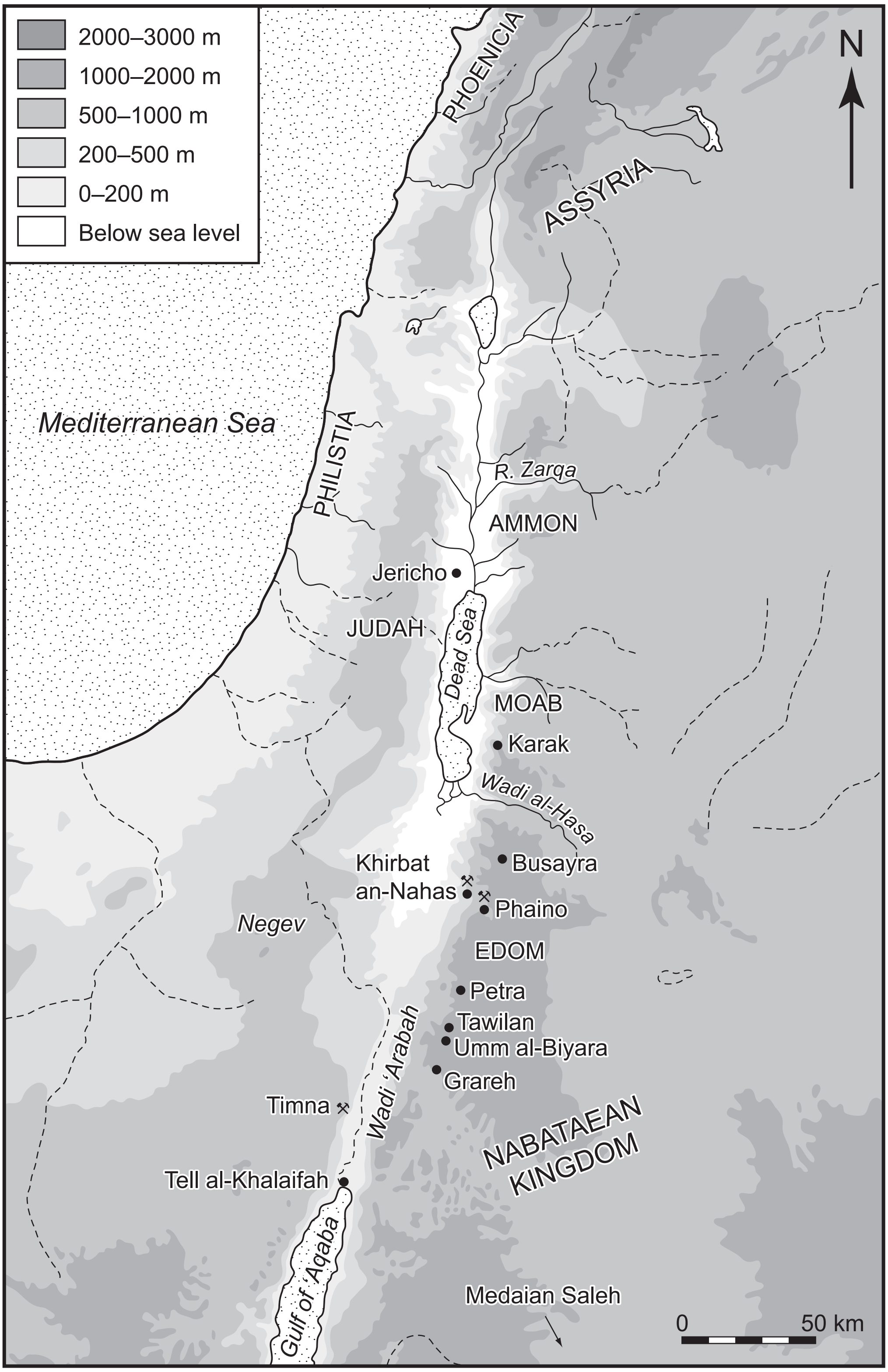


Figure 9.1 *Map of the southern Levant in the Iron Age, showing the approximate location of Ammon, Moab and Edom, and other sites mentioned in Chapter 9. (Illustration: Dora Kemp.)*

was probably centred on the region of the Wadi Mujib, but perhaps extended as far north as Madaba and Hesban and, more debateably, as far south as the Wadi al-Hasa (Routledge 2004: 41–57). The territory of Edom supposedly ran from the Wadi al-Hasa to the Wadi Hisma (Bienkowski 1992b: 1–2; cf. Bartlett 1989: 33–7). In the later Iron Age the territory also extended west across the Wadi 'Arabah corridor into the Negev. The agricultural plateau lands of Edom are the least well-watered of those in the Transjordanian region and are bordered to east, south and west by desert landscapes, with the result that throughout history there has been a significant pastoral component in their exploitation. Only a relatively small number of major 'Edomite' sites has been excavated, primarily in the south of their territorial zone (Tell al-Khalaifah, Umm al-Biyara, Tawilan and Grareh), with Busayra the major northern centre explored.

The large territorial and chronological range of Edom, coupled with the relative paucity of modern stratigraphic excavation, has made the identification and accurate dating of Moabite and Edomite pottery a highly controversial field (Bienkowski 1992a,b,c,d; Bienkowski and Adams 1999; Finkelstein 1992a,b; 1995; Hart 1987; 1992; Levy *et al.* 2003: 262–9; Oakeshott 1983). Nelson Glueck was the first archaeologist to collect and identify 'Edomite' pottery (1940: 73–6), though his assertions about its relative dating within the three Iron Age phases have inevitably been much disputed as further evidence has accrued (Sauer 1986b). Bienkowski (1992c) has argued on the basis of Crystal Bennett's Busayra excavations that none of the material thought by Glueck to relate to Iron I in fact predated the late eighth century BC. This highlights a fundamental problem encountered in archaeological research in southern Jordan, concerning the scarcity of sites with Late Bronze Age and Early Iron Age pottery (Bienkowski 1992b: 6). Finklestein's claims to the contrary still lack support from stratified contexts (1992a,b). Despite considerable survey efforts in recent decades, the numbers of sites that can be assigned to a Late Bronze Age or very earliest Iron Age date remain very small (Hart 1992: 94–7). For instance, the Edom survey along the plateau heartlands between Tafila and Khirbat ash-Shedeiyid south of Ma'an (Fig. 2.14) found no evidence of the Early Iron Age and virtually all pottery collected was assigned to the seventh–fifth centuries BC: 'before the seventh century BC there was little in the way of settlement on the plateau' (Hart 1987: 290). Only slightly more successful was the Wadi al-Hasa survey, six sites with Late Bronze Age or Early Iron Age activity being located on good agricultural land (MacDonald 1988: 166–70). Attempts to follow up this survey with excavation at selected sites identified as having potential Late Bronze Age and Iron I activity have failed to produce stratified material earlier than Iron II (Bienkowski and Adams 1999; Bienkowski *et al.* 1997). Nonetheless, from this evidence and from early collections of material from Wadi Faynan, it has become clear that there are differences in ceramics between the upland and lowland zones of Edom, perhaps cultural, perhaps chronological (Levy *et al.* 2003: 264).

Bienkowski's conclusion from the available evidence that 'Edom remained largely nomadic until the seventh century BC' (1992b: 8) implicitly does not recognize the existence of an Edomite state before the Iron IIC phase, a point also developed by Knauf (1992b: 50). Given the paucity of excavation on Edomite sites, is such a view entirely justified?

A particular problem of the Iron Age sites from the supposed Edomite heartlands on the Jordanian plateau east of the 'Arabah is that this has been a long-term favoured zone of farming and settlement. Many of the Iron Age sites have later phases of occupation in the Nabataean, Roman, Byzantine, and/or Islamic periods. There is no doubt that this later activity to some extent masks the traces of the earlier phases here and that we may be dealing with absence of evidence as much as evidence of absence. Another possible objection to the consensus view is that the heartlands of Edom are assumed from the very start to have been on the better-watered plateau region, though the population involved in making the transition is recognized to have been of a transhumant or nomadic pastoral background (Bienkowski 2001b; Bienkowski and van der Steen 2001; and see Chapter 8, §8.13). As Levy *et al.* (2001b: 159–65) have observed, the application of core-periphery models to the rise of early states in Transjordania needs to recognize that core-periphery zones were not static and that peripheries could become cores at critical junctures. What if the 'Arabah was the initial core of what was to become a fully-fledged Edomite state by the seventh century? (Levy *et al.* 2001b: 163 and Levy *et al*. 2005b make similar observations).

The Faynan area in fact offers an important supplementary body of data to the question of Iron Age state formation, in that the large-scale mobilization of labour and the use of specialized technologies of mining and smelting may justifiably be considered more commonly to have been features associated with states than nomadic societies. However, surprisingly little attention has been paid to the potential significance of copper production in the rise of the Edomite kingdom (Bartlett 1989; LaBianca and Younker 1995). The Southern Ghors and Northeast 'Arabah Survey traced some likely Iron I activity in the region of the Wadi Ghuwayb just north of Faynan (MacDonald 1992: 73–81). Initial radiocarbon dates published in the early 1990s from Iron Age mining sites in the Faynan region were already pushing back the date of renewed copper production earlier than might have been predicted by Bienkowski's thesis (1992b: 6) of a late development of the Edomite state (Hauptmann 2000: 66). The evidence now available from our survey in the Faynan region, coupled with the parallel work by Levy's team in Wadi Fidan and in Wadi al-Jariya and Wadi al-Ghuwayb (Levy *et al.* 2001b; 2003; 2005b), allows a substantial review of the question.

9.3 Copper mining and smelting

Since the pioneering survey work by Glueck (1935: 20–29, 32–5), the importance of Iron Age copper exploitation in the Faynan region has been well established. However, there

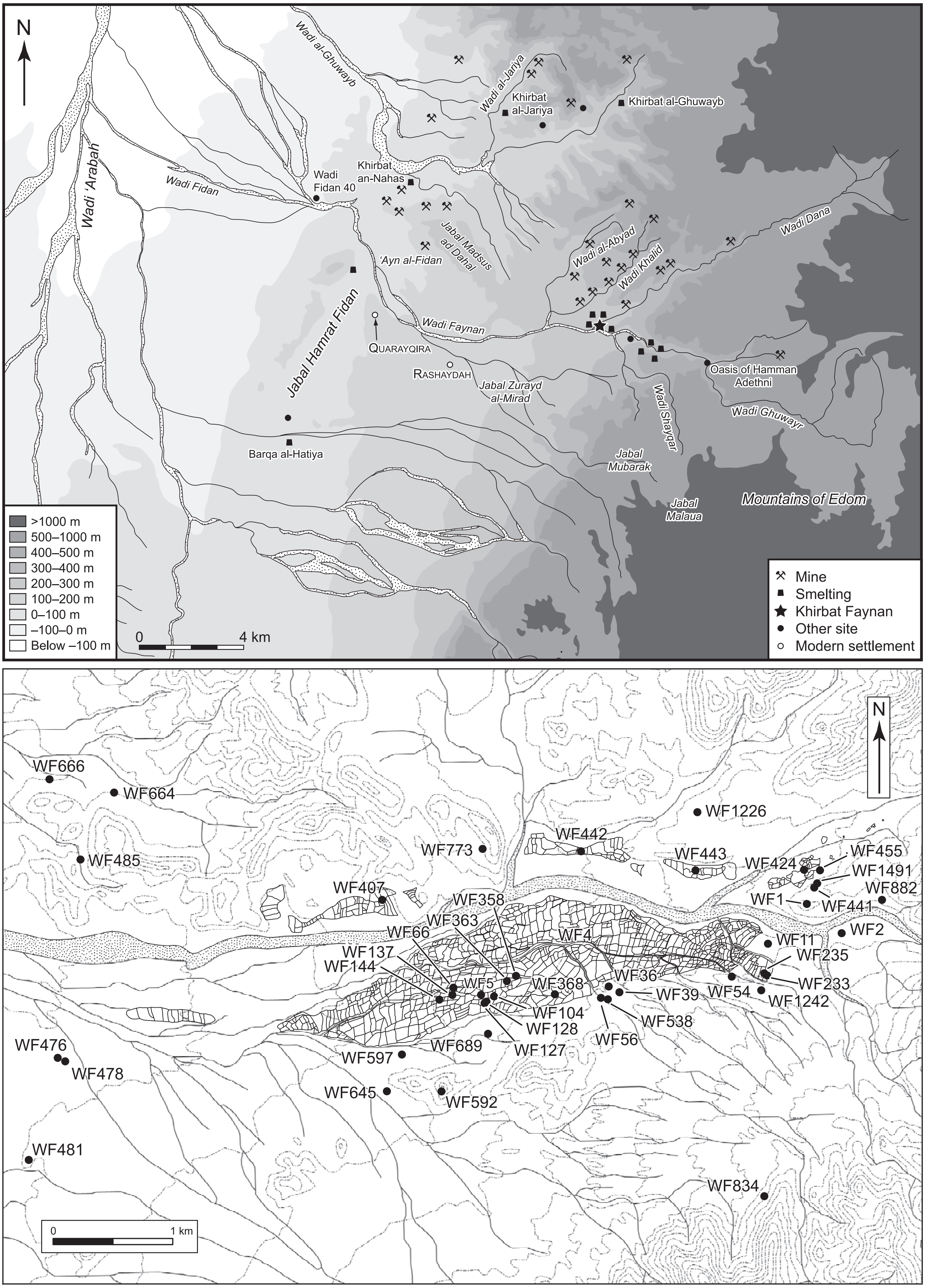


Figure 9.2 *Principal Iron Age and Nabataean sites in the Faynan region. (Illustration: above – Dora Kemp; below – Paul Newson.)*

has been much debate about the dating of production within the three Iron Age phases, with scepticism being expressed by many scholars that the restarting of copper production pre-dated the Iron II period, in line with the dating of the major Edomite sites on the plateau (Bienkowski 1992b; Hart 1992). Knauf and Lenzen (1987: 83–6) highlighted the mismatches between these pottery dates and the emerging archaeological evidence for mines and smelting sites in the Faynan region. The work of the Bochum Mining Museum has now made clear the huge scale of Iron Age activity (Hauptmann 2000: 62–100; 2007: 115–23, 127–33; Hauptmann *et al.* 1992: 20–30). Although it is not always possible to discriminate between Bronze Age and Iron Age mining from surface waste heaps (tailings), there were over 150 workings exploiting the DLS (Burj Dolomite Shale: Fig. 2.3) ores in the Faynan region. Subsequent radiocarbon dates from mines and metallurgical sites (Hauptmann 2000: 64–6; 2007: 89, 120) strongly support the existence of late Bronze Age and Iron I copper production, with the peak in production perhaps occurring early in the Iron II phase (tenth–ninth centuries BC). The dating evidence is discussed below in connection with new information from our project (Appendix 1). The recent surveys by Levy's team in the Wadis Fidan, al-Jariya and al-Ghuwayb (Fig. 9.2) have dramatically increased knowledge of the northern and northwestern part of the Faynan district (Levy *et al.* 2003; 2005a). In combination with the work of the Bochum team, they suggest a degree of centralization around major control/smelting sites and springs. Our work contributes importantly to this emerging picture.

Within a 20 × 15 km area centred on Wadi Faynan, there were probably in excess of 100 mines and at least five major Iron Age smelting sites (Fig. 9.2: Khirbat Faynan, Barqa al-Hatiya, Khirbat an-Nahas, Khirbat al-Jariya, Khirbat al-Ghuwayb). Hauptmann's estimates of the total copper slag represented by different phases of production put the Iron Age in first place in relation to other phases of metallurgical activity in Faynan, with 100,000–130,000 tonnes of slag, representing an estimated copper production of *c*.6500–13,000 tonnes (Hauptmann 2000: 97; Table 9.1).

Site	Archaeological evidence	Size of slag heaps (tonnes)
Barqa al-Hatiya	Small slag heap and settlement, location of mines uncertain	500–1000
Khirbat al-Ghuwayb	Furnaces, slag heaps, substantial mining settlement, mines within 2 km	10,000++
Khirbat al-Jariya	Furnaces, slag heaps, mining settlement, mines within 1 km	15,000–20,000
Khirbat an-Nahas	Furnaces, slag heaps, major fort, numerous buildings of large mining settlement, mines within 200 m of site	50,000–60,000
Khirbat Faynan	Furnaces, slag heaps (notably 5, 7, 14), enclosures and buildings, mines nearby in Wadi Khalid, Dana and al-Abyad	35,000++

Table 9.1 *Evidence of Iron Age metallurgy in the Wadi Faynan region.*

The major complexes of Iron Age mines appear to be just east and southwest of Khirbat an-Nahas, in the upper reaches of the Wadi al-Jariya around and east of Khirbat al-Jariya, in the Wadi al-Ghuwayb around Khirbat al-Ghuwayb, and near Khirbat Faynan in the Wadis Dana, Khalid, and al-Abyad (Hauptmann 2000: 63, 81–4, 87–9; 2007: 92–156; Levy *et al.* 2003: 268, 270). The miners appear uniformly to have targeted the copper-rich Dolomite

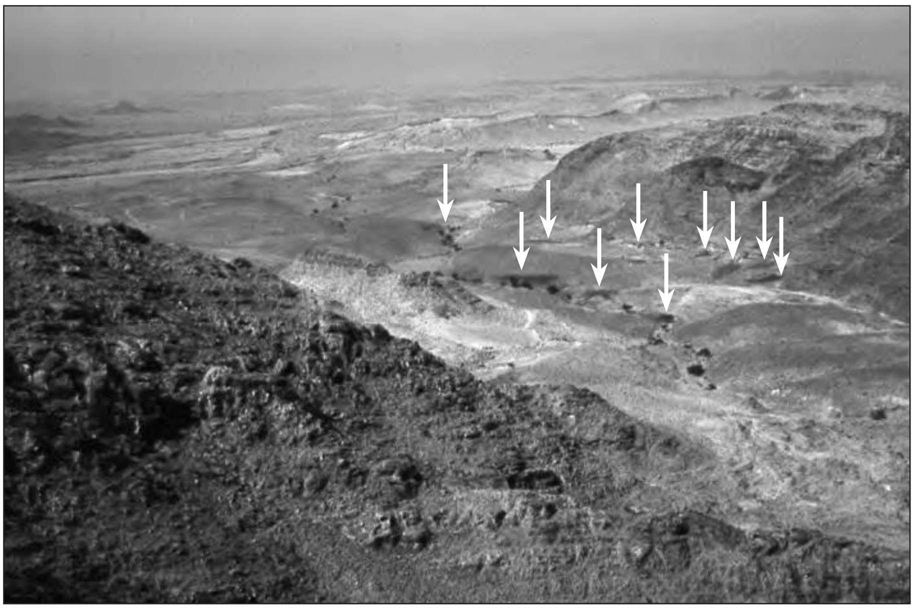


Figure 9.3 *Tailings (arrowed) marking Iron Age mine workings in the Wadi Khalid, looking west. (Photograph: David Mattingly.)*

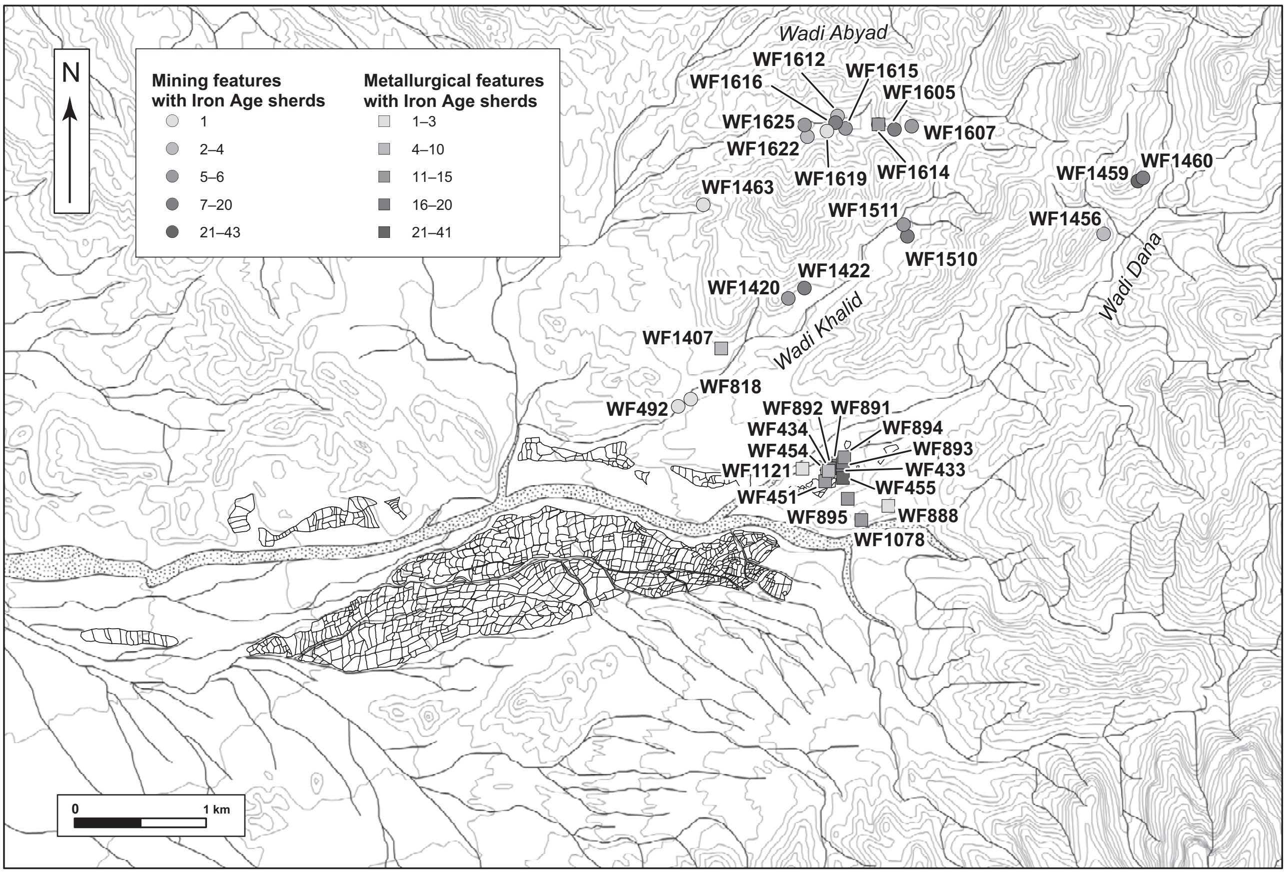


Figure 9.4 *Distribution of mines and smelting sites of Iron Age date, as recorded by the WFLS. (Illustration: Paul Newson.)*

Limestone Shale ('DLS') unit, though this only outcropped patchily in the vicinity of Khirbat an-Nahas and was better exposed in the higher mountain valleys. A total of over 50 mine workings was located in a minor tributary of the al-Jariya, ascending to the east of the main processing site (Hauptmann 2007: 131–2; Levy *et al.* 2003: 263, 270). Because of the relatively small amount of survey work yet carried out in the al-Jariya and al-Ghuwayb tributary systems, it is likely that much larger numbers of ancient workings await discovery there. The most common indicator is the presence of mine waste (tailings: e.g. Fig. 4.45) around their buried entrances, though some adits and shafts remain open (Fig. 9.3). The adits followed the 2–3 m thick DLS unit into the hillside at a strike of *c.*30° for at least 60 m (see Fig. 4.38).

In the Wadi Khalid, the area most explored by the Bochum team, there were at least 56 workings, most dated to the Bronze Age or Iron Age phases of exploitation, with another twenty in the Wadi al-Abyad and at least fourteen in the Wadi Dana, numbers confirmed by our reconnaissance of these valleys (Fig. 9.4). In the Wadi Khalid in particular, the Iron Age mines had to go deeper in consequence of the extent of Bronze Age mine works, which had been driven horizontally (or at shallow incline) into the rock following the mineral-rich DLS unit. These most accessible deposits were soon worked out and Iron Age mines had shafts up to 70 m deep in places in order to reach lenses of the DLS ores (Hauptmann 2007: 116–23; Hauptmann and Weisgerber 1987; 1992; Hauptmann *et al*. 1985; Khouri 1988: 124–7; Weisgerber 2006: 13–17)

Each of the areas of mines was accompanied by a primary processing/smelting site, though some smaller settlements and camps are also known, with some evidence of smelting. Of the main smelters, the site of Khirbat an-Nahas (the 'Copper Ruin') is visually the most striking and has the highest volume of slag associated with it (Kennedy and Bewley 2004; 118–19; Fig. 9.5). The extensive slag heaps are spread over 10 ha all around a large 'fort' and settlement (8.6 ha), eventually engulfing many of the buildings (for early reports, see Frank 1934: 298; Glueck 1935: 26–9; 1940: 67–73; Musil 1907 [1989]: 218; and for later studies, see Hauptmann 2000: 87–8, with fig. 64; 2007: 127–30; Levy *et al.* 2001b: 169; 2003: 268–71, with fig. 12; 2005b). Work by the Bochum Mining Museum team had already hinted at Early Iron Age origins of copper smelting here (Hauptmann 2000: 66, 87–8; Levy *et al.* 2005b: 132–6). Recent survey has established the existence of at least 100 separate buildings and 34 distinct slag mounds (Levy *et al.* 2003: 268). The enceinte of the 'fort' (*c.*73 m sq.) was constructed in good-quality masonry and still stands to a considerable height. Its main entrance faces northwest, away from the rest of the settlement, towards the Wadi al-Ghuwayb. There are traces of dense structures inside, but only the fort's impressive gate has

Figure 9.5 *Khirbat an-Nahas, aerial views, looking north (above), looking east (below). (Photographs: above - APA98/SL38.9, 20 May 1998 = Kennedy and Bewley 2004, 118, fig. 7.10A; below - APA98/SL38.12, 20 May 1998 = Kennedy and Bewley 2004, 119, fig. 7.10B.)*

as yet been excavated (Levy 2002; Levy *et al.* 2004b). The other rectangular buildings at the settlement were constructed in careful masonry and display a varied morphology, from large single room 'workshops' to complex multi-roomed units. At the centre of the site there was a 30 × 20 m tower-like complex, with a further three tower buildings on the northeastern edge of the site (Levy *et al.* 2003: 270–71). The recent excavations have identified a specialized processing structure (Building S), just to the east of the central building, where slag was broken up for the recovery of copper prills, with over 350 grinding slabs and hammers recorded.

Even more importantly, the new excavations by Levy and his team have produced a series of AMS dates linked to particular structures (Appendix 1). These primarily relate to the early Iron II phase (tenth–ninth centuries BC), which appears to have been the heyday of the site, though some finds and AMS dating of charcoal hint at a phase of copper production in the eleventh century or earlier (Levy 2002: 5; Levy *et al.* 2003: 264; 2004b; cf. also Higham *et al*. 2005). Further excavations and AMS datings at this key site are clearly a pre-requisite of research. There may well be a long sequence of development here, with the large fort built as early as the tenth century BC, hinting at a broader regional role for the site in the overall control of Iron Age copper production here.

Khirbat al-Jariya and Khirbat al-Ghuwayb were smaller sites than Khirbat an-Nahas and lack evidence of associated forts (for earlier reports, see Glueck 1935: 22–6 and pls 2–3; 1940: 74–6; Hauptmann 2000: 89; 2007: 131–2). Khirbat al-Jariya is 3.4 ha in extent, with traces of about 40 buildings built on either side of a steep-sided wadi (Levy *et al.* 2003: 270–72, 274, fig. 16). Smelting activity took place on both sides of the wadi, though the larger slag heaps are on the east bank, in the direction of the mines. The largest structure resembles the towers at Khirbat an-Nahas (Levy *et al.* 2003: 272). To judge from Glueck's plan and description, Khirbat al-Ghuwayb was of similar size and type (see also Weisgerber 2006: 20–21).

The Wadis al-Ghuwayb and al-Jariya are quite deeply incised and lack terrace surfaces suitable for wadi farming systems, such as are characteristic of the Wadi Faynan. Water is also very limited, with only a single spring known at 'Ayn al-Ghuwayb (close to Khirbat al-Ghuwayb). This is a significant difference between the northern and southern sectors of the Fidan/Faynan district. Apart from mine workings, major smelting sites, and associated cemeteries, the main types of site recorded in the northern region are campsites, of varied date from prehistory to the modern bedouin (Levy *et al.* 2003: 251–8). This suggests that the main part of the mining work force was accommodated either in temporary camps or travelled out from the main smelting centres. However, the availability of water in the Wadi Fidan, just a few kilometres to the southwest of Khirbat an-Nahas, created important links between the mining communities in the al-Jariya and al-Ghuwayb and further habitation and smelting sites in the Fidan.

The Wadi Fidan survey has located 24 sites with Iron Age activity, including the re-identification of a fortified settlement first discovered by Glueck (Adams 1992; Glueck 1935: 20–22; Levy *et al*. 1999b; 2001a,b). Apart from Glueck's fortified site (watchtower?) and a couple of small settlements, there is a handful of smelting sites and numerous funerary structures (Levy *et al.* 2001b: 180–81). Of particular importance has been the excavation of a large cemetery (Fidan 40), with an estimated total of several thousand burials (Levy *et al*. 1999a; 2005a). This had been initially assigned an Early Bronze Age date on the basis of surface morphology, but proved to be significantly later in date: an AMS date obtained on a pomegranate seed from one grave indicates a 1-sigma calibrated range of 1015–845 BC and a 2-sigma probability range of 1188–810 cal. BC (Levy *et al*. 1999a: 303; 2001b: 180; Beta-111366). One of the most striking aspects of this cemetery is that none of the initial batch of 62 graves excavated contained pottery vessels, though several wooden bowls were preserved. This hints at an explanation of the relative invisibility of Early Iron Age activity in southern Jordan, if the society was largely aceramic at this time (see also Chapter 8, §8.13).

A number of other Iron Age cemeteries has been identified on ceramic evidence, suggesting that the Wadi Fidan continued to be a centre of habitation during the phase of greatest metallurgy in the area just to the north. Although large-scale copper production at Khirbat Faynan (WF1) in the Iron Age has been definitively established by the dating of slag heaps 3–4, 5, 7, 14 (Hauptmann 2000: 64, 66; 2007: 97–108), the evidence of settlement and ceramics to accompany this was missing until our recent work, presumed buried beneath the ruins of the Khirbat. The dates obtained by Hauptmann at Khirbat Faynan were all from slag heap 5 and date to the Iron II and III periods only (1006–554 cal. BC, HD-10992; 748–383 cal. BC, HD-10580), whereas his samples from an-Nahas and al-Jariya also extended back to Iron I (1250–1000 BC).

9.4 Iron Age settlement in Wadi Faynan

Our survey has filled out knowledge of the scale and range of human activity in the Wadi Faynan basin during the late second and early first millennia BC. Whereas the densely nucleated settlements at an-Nahas, al-Jariya and al-Ghuwayb appear to represent isolated mining communities, with a focus on metal production, the WFLS evidence suggests a more extensive exploitation of the farming potential of the valley.

The systematic survey around Khirbat Faynan has elucidated the location and nature of Iron Age activity there. On the north side of the Khirbat, on the terrace surface immediately above the channel of the Wadi Dana, WF424 is an irregular 'field system' extending *c.*500 m east–west (Barker *et al.* 1999: 273–5). Morphologically this differs from the normal field units of the valley, in that it seemed to define a series of large interlinked enclosures, some with traces of other structures inside and a number containing

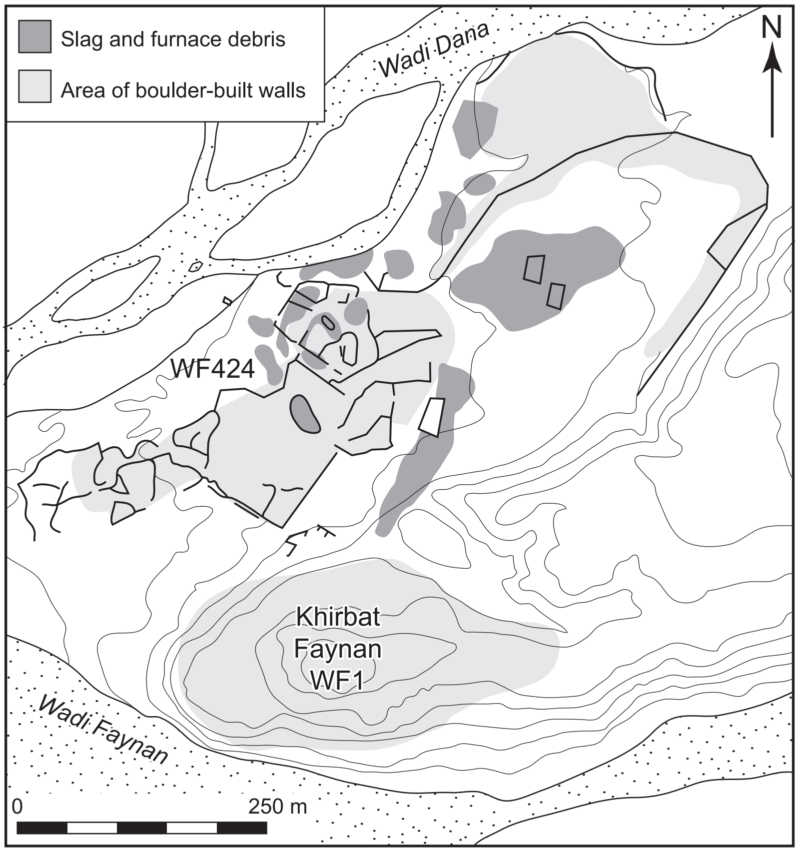


Figure 9.6 *WF424 Iron Age enclosures and smelting activity, showing their location relative to Khirbat Faynan. (Illustration: Dora Kemp, from Barker* et al. *1999, 273.)*

a substantial amount of slag and furnace debris (Fig. 9.6). Many of the 'field' units showed evidence of at least two phases of construction, the earlier being characterized by the use of large boulders (Fig 9.7). Moreover, in terms of shape and orientation to potential water flow, these 'fields' are also quite unlike the other wadi farming systems (see below). What we seem to have is a series of linked enclosures of non-agricultural use, containing other buildings. The area produced over 750 sherds of Iron Age pottery, by far the largest assemblage collected in the survey work, indicating the presence of a major settlement (Fig. 9.8). Some at least of the pottery appears to date before the seventh century BC. Part of a very substantial Iron Age settlement and smelting site thus appears to be free of later encumbrances on the north side of the Khirbat mound (see below, for further detail).

Figure 9.7 *Detail of construction of boulder walls in WF424, looking southwest. (Photograph: David Mattingly.)*

9.4.1 The mine workings

The other compelling element of the distribution of Iron Age sherds is their consistent presence at mine-workings in the Wadis Khalid and al-Abyad and at some of the elevated mining sites in the Dana valley. (The same pattern was recorded also by the Bochum team: Hauptmann and Weisgerber 1987: 426; Weisgerber 2006: 13–14). The characteristic large mine waste heaps indicate a considerable degree of primary ore dressing at the mines. The mine excavated by the Bochum team (WF1478: Fig. 4.38) showed that Iron Age workings were progressively backfilled with minewaste as the galleries were extended (Hauptmann 2007: 118–19). One particularly interesting feature recorded by the Bochum team in the Wadi Khalid was a triple shaft, comprising an original Iron II double shaft, supplemented in the early Roman period by a third shaft of rather more regular form (Fig. 9.9), interpreted as

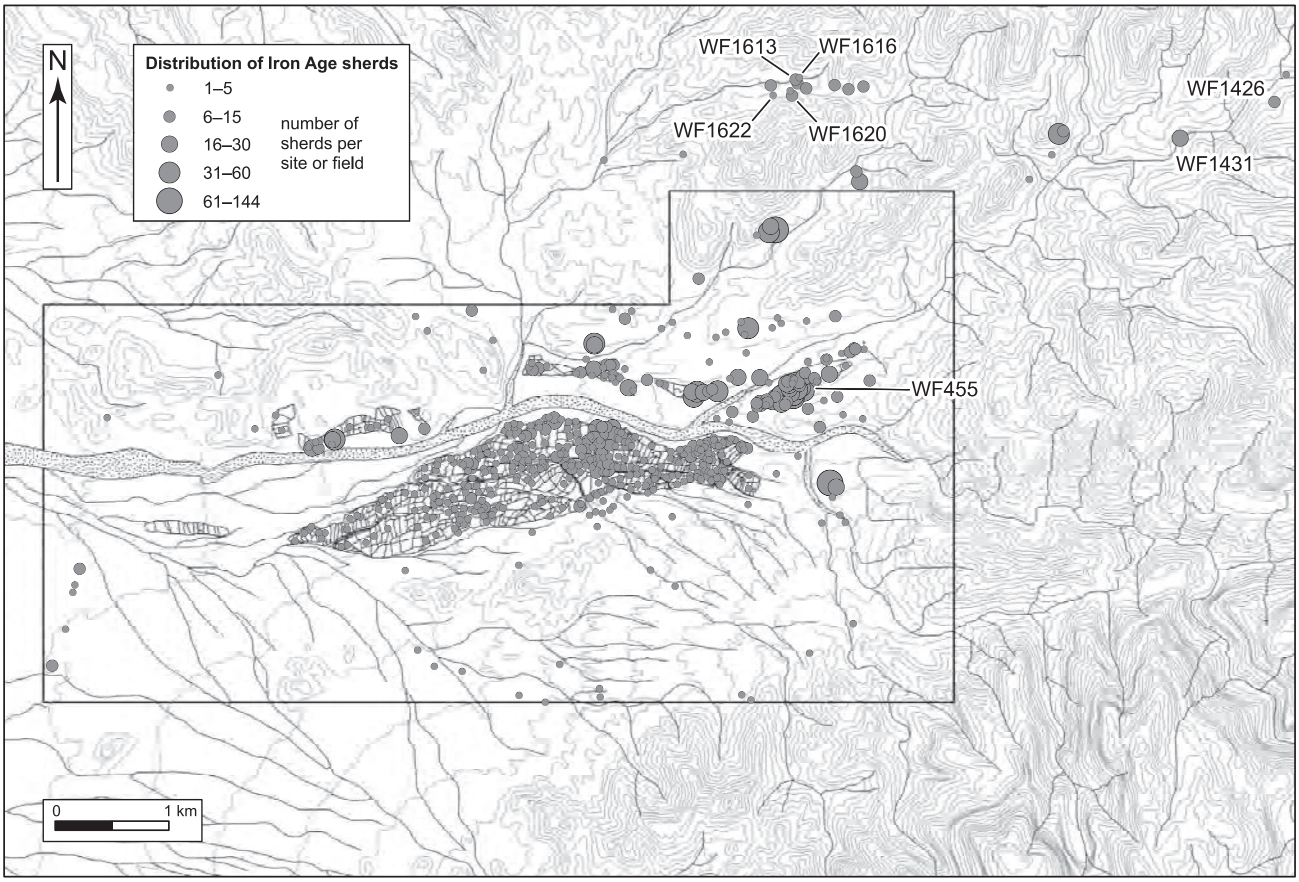


Figure 9.8 *Distribution of Iron Age pottery from sites and field units. (Illustration: Paul Newson.)*

Figure 9.9 *The triple mine shaft (WF1422) in Wadi Khalid, looking south. (Photograph: David Mattingly.)*

a late Nabataean or Roman prospection shaft (Hauptmann and Weisgerber 1987: 426). Some adits and shafts are still visible, but many other Iron Age features must remain cloaked in the mine waste heaps.

The mines in the lower courses of the Wadis Dana and Khalid did not have associated settlements and seem to have been worked directly from the main centre at Khirbat Faynan. However, in the more remote parts of these mining valleys, the evidence of mine waste and shafts was supplemented by complexes of rectangular buildings with associated Iron Age pottery (WF1613, WF1616, WF1620, WF1622 in the Wadi al-Abyad, and WF1431 in the Wadi Dana). In general,

Figure 9.10 *WF455, a gulley eroded through Iron Age slag-heaps and polluted sediments north of Khirbat Faynan, looking southwest. (Photograph: Graeme Barker.)*

smelting activity appears to have been focused on the major sites at lower altitudes, but WF1426 in the Wadi Dana appears to have been a small Iron Age smelting camp.

9.4.2 Smelting sites

Uncertainties arise in the study of smelting sites of the Iron Age–Nabataean period because in our field mapping there were no obvious visual methods for distinguishing between slags and polluted deposits of different antiquity, so we mapped them as the Atlal Member (Chapter 3). Indicators of age at some of them were provided by fragments of pottery found within them, and subsequent radiocarbon dating of contained charcoal fragments also proved useful to us, as for earlier workers (Appendix 1), but it is important to remember that in appropriate circumstances all such materials can be reworked into accumulating deposits, infiltrate, or be taken down by invertebrates into lower deposits, as discussed in Chapter 3. For example, an aggregation of charcoal fragments associated with indicators of smelting activity recovered by an Edelman corer in a borehole (WF5017 = WF5517) behind the barrage adjacent to Khirbat Faynan (Fig. 1.13) resulted in two identical radiocarbon dates of 2630±50 BP or 820–790 cal. BC (Beta-110840, Beta-110841), indicating that the beginning of industrial activity here was in the Iron Age, but a large fragment of charcoal recovered from the good exposure in a trench excavated the following season in the same deposits (Fig. 1.15) resulted in a Bronze Age date of 3390±40 BP or 1867–1536 cal. BC (Beta-203402). Section WF1491, an exposure below Khirbat Faynan through Hauptmann's 'slag heap 7' assigned by the Bochum team to the Iron Age was a complex aggradation of ash, slags, clays, and ceramic debris that yielded a Chalcolithic date at the base of 5690±40 BP or 4681–4450 cal. BC (Beta-203413) and a 'medieval' date at the top of 430±40 BP or cal. AD 1414–1624 (Beta-203412).

Nevertheless, the field evidence cited at the beginning of this section together with a series of AMS dates in combination indicate that the area to the north of Khirbat Faynan (WF424) represents a large and long-lived zone of Iron Age smelting activity. That activity appears to belong to at least two distinct technological phases, represented in a series of sections recorded by us. WF455 was a gully eroded down through the edge of Hauptmann's 'slag heap 7' just to the north of the Khirbat, within unit WF424. Two sections of the gully about 10 m apart were cleaned and sampled, both revealing a similar picture (Fig. 9.10). Section 1 was 1.3 m deep and had not bottomed the archaeological deposits, while Section 2 was 1 m deep, with possibly natural sand at the very base (context 108). The upper levels (contexts 01–02, 101–102) in both sections to a depth of 0.4–0.5 m featured large fragments of glassy tap-slag (average 10–20 cm across), with up to 80% of the matrix made up of slag. Below this level, there was a succession of thin layers of silty sands, with numerous inclusions of slag and charcoal and Iron Age pottery (contexts 03–10, 193–107, 109). At least one of these horizons in each section featured a dense concentration of slag fragments, though these were much smaller than the upper levels (*c*.3 cm).

In broad terms, the slag appears to belong to two phases of Iron Age production (Fig. 9.11). In the earlier period, the furnaces appear to have been quite thin walled and the slag was broken up into small lumps for the recovery of prills of copper. The higher level of slag at Khirbat Faynan, evidently dated to the Iron II period, comprised larger fragments and some large plates of distinctive tap slags, suggestive of a different furnace technology and more efficient separation of copper from slag in the furnace (Barker *et al.* 1999: 274, fig. 18 also illustrates the two types, though the later Iron Age tap slag is there labelled 'Roman', which it also resembles in appearance; cf. Hauptmann 2000: 101–40; 2007: 157–216 and Hauptmann *et al.* 1992: 20–27 on the chemistry of the

Figure 9.11 *The two different Iron Age slag types from section WF455: viscous tap slag (left) and earlier broken up and globular slag (right). Scale: 10 cm divisions. (Photograph: David Mattingly.)*

slags). There may have been further refinements in the Iron III phase, including new bellows settings. The six AMS dates we obtained from WF455, ranging from 1257–945 cal. BC to 1039–835 cal. BC (Table 9.2) correlate quite well with those recently obtained from Khirbat an-Nahas by Levy and his team, suggesting separate phases of copper production in Iron I (late twelfth–eleventh century BC) and early Iron II (tenth–ninth century BC) (Levy *et al*. 2005b; Higham *et al.* 2005).

9.4.3 Minor settlements

There are Iron Age (or probable Iron Age) sherds from quite a number of other mining-related and settlement sites as well as cemeteries in the Faynan landscape (Fig. 9.8). These predominantly cluster around Khirbat Faynan and the mining valleys to the north (Wadi al-Abyad, Wadi Khalid and Wadi Dana), and around the various field systems within the valley (see below). Because many of the locations from which Iron Age sherds were recovered also yielded sherds of Nabataean, Roman, and Byzantine date, we cannot certainly associate the ceramics with structural features that might prove diagnostic of Iron Age activity. This must remain a major desideratum for future work in the valley. The overall impression is that Iron Age activity was widespread in the landscape, but that the main foci lay in the eastern and northern parts of the valley, with sparser evidence to south and west. The best-preserved example of a probable Iron Age small settlement is WF1431, from the upper Dana valley (Fig. 9.12).

Context	Dates BP	Dates cal. BP (2σ)	Dates cal. BC (1σ)	Reference
Slag heap 9	2900±40	3210 (2.7%) 3180 3170 (92.7%) 2920	1257–945	Beta-203407
Slag heap 9	2890±40	3170 (92.6%) 2920 2910 (2.8%) 2880	1251–937	Beta-203406
Slag heap 9	2830±40	3080 (95.4%) 2840	1122–898	Beta-203409
Slag heap 9	2790±40	2990 (95.4%) 2780	1039–835	Beta-203408
Slag heap 9	2790±40	2990 (95.4%) 2780	1039–835	Beta-201410
Slag heap 9	2680±40	2860 (95.4%) 2740	906–796	Beta-203411

Table 9.2 *AMS dates obtained from WF455, an Iron Age smelting site at Khirbat Faynan.*

9.4.4 Field systems and farming

The density distribution of Iron Age sherds represents a very interesting stage in the development of the field groups which line the course of the Wadi Faynan (Fig. 9.13). The overall distribution of pottery recorded by the Wadi Faynan survey reveals a strong association with a number of the small field systems on the north side of the main Wadi Faynan channel (WF442, WF443), as well as with some sub-areas of the main Roman field system. The densest concentration of Iron Age sherds within a particular group of walls and enclosures is that of WF424, interpreted above as an area of settlement and metallurgical activity (Barker *et al.* 1999: 274–5). The next densest individual concentration comprises field group WF443, with sherds particularly concentrated within the lower fields of the eastern half of the system, as also applies with the concentrations in WF442. There are also high sherd densities at several points within WF4, with an emphasis on

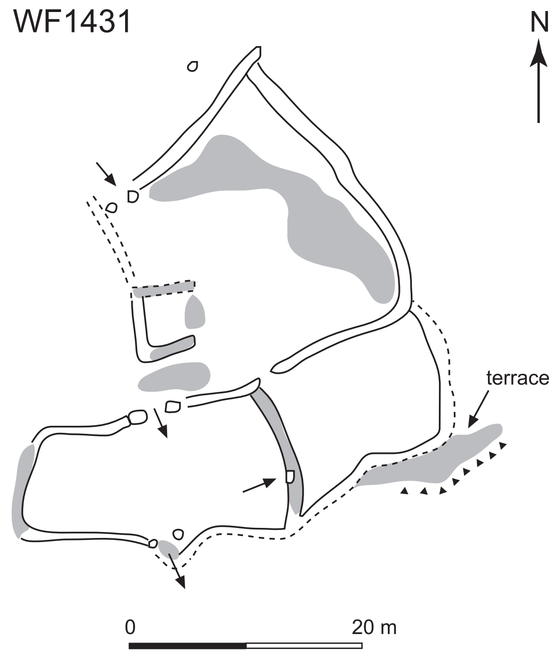


Figure 9.12 *Probable Iron Age building with enclosures (WF1431), Wadi Dana. (Illustration: Debbie Miles-Williams.)*

areas of terraced fields along the edges of the large level plain areas, parallel to the main wadi course (notably within Units WF4.3, WF4.7, WF4.9–10, and WF4.15). Such a distribution could reflect the survival of Iron Age field elements from extensive re-development in later periods or, alternatively, the presence of Iron Age settlements beneath the field system. Our survey generally indicates that Iron Age land use within the Wadi Faynan was centred within a few kilometres of Khirbat Faynan – we found little evidence either from sites or field groups in the south and west of the study area that might be related to this phase.

It seems likely that much of the Iron Age landscape in the region of WF4 has been obscured or hugely affected if not destroyed by the changing dynamics of the landscape. An indication of the extent to which the Iron Age fields or later Nabataean fields have been affected is the evidence collected for a number of buried wall sections recorded along the banks of deeply cutting tributary wadis in WF4.2 and WF4.11/12 (see for example Fig. 5.50). However, there is still a substantial amount of evidence pointing to a high level of Iron Age activity within the valley. Some of this evidence at least, particularly that of WF443 and WF4.7, reflects the increased organization of the agricultural environment, especially the development of simple floodwater farming techniques.

The WF442 and WF443 field systems provide the most convincing cases of Iron Age agricultural fields. The extent to which other areas of WF4 incorporate structures of Iron Age date is less clear, the most likely candidates being in Unit WF4.7 and parts of Unit WF4.3. In both these areas surface sherds from other periods were encountered, which prohibits a definite identification of particular structures to the Iron Age. However, the high density of Iron Age sherds centred on field WF4.9.5 and the western fields of WF4.7 would suggest that some Iron Age structures remain in these areas. Some of the parallel walls in WF4.9.5 are in parts constructed of large half-buried boulders, which might be of this age (Fig. 9.14).

A case can also be made for Iron Age use of the simple field groups WF773, WF834, WF882, and WF1226 in the vicinity of Khirbat Faynan (Fig. 9.2). Though the numbers of Iron Age sherds here are very few, their occurrence helps to underscore the intensity of the Iron Age presence around the Khirbat. Of further interest are the two Iron Age sherds found within the exposed wall section WF407 in field group WF406 (see Barker *et al.* 1999: 274; Fig. 5.48). Nevertheless, very few Iron Age sherds were discovered within this field group as a whole, suggesting a low level use of this part of the landscape and that most of the extant wall structures are pre- or post-Iron Age.

The contiguous fields of the eastern half of field group WF443 (fields 443.1–443.5 and 443.7–443.9) represent perhaps the clearest example of an Iron Age agricultural landscape that remains largely unaltered by later development (Fig. 9.14, lower). The structural evidence consists of a number of smallish irregular-shaped enclosures composed of walls of various constructions. In parts, some of the walls are constructed of orthostatic boulders, usually horizontally set and 0.4 m in diameter. The presence of orthostatic boulder walls is striking and may indicate a reuse of earlier Bronze Age field systems or (perhaps more likely given the sherd concentrations) the continued use of undressed stones for field boundaries.

Apart from a number of large gaps in the wall lines, which may have been significant in terms of access to the particular fields, no specific evidence for individual water-management structures was observed. Nonetheless, the layout and relative position of the fields in relation to the local topography and each other indicate a floodwater farming regime. The field morphology of the eastern half of WF443 comprises a single large enclosure subdivided by a series of small single-face terrace wall structures arranged

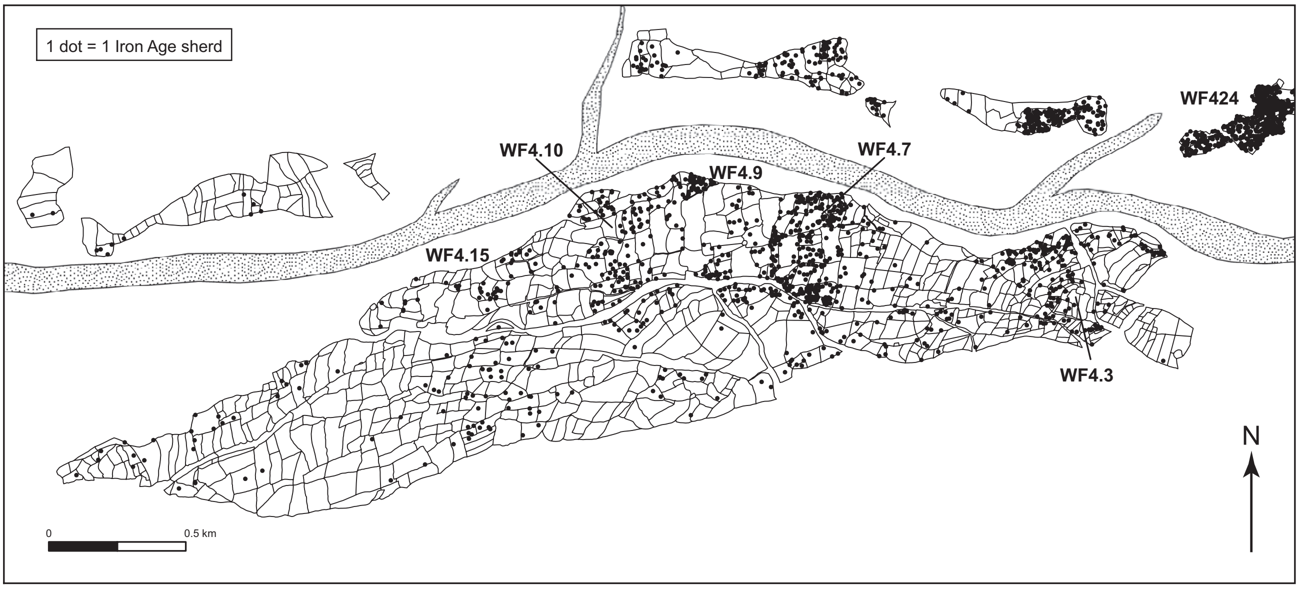


Figure 9.13 *Density of Iron Age sherds within the main field groups of Wadi Faynan. (Illustration: Paul Newson.)*

Figure 9.14 *Probable Iron Age field walls: (above) large boulder walls in Unit WF4.9, looking west; (below) the fields of WF443, a predominantly Iron Age system, looking northwest. (Photographs: above – David Mattingly, below – Paul Newson.)*

in line with the natural direction of surface flow. The general north–south orientation of these internal walls helps to form a series of simple linear barriers and field divisions at 90 degrees to the direction of water flow. The resultant fields are relatively small in area and gradually step down from the northeast to the southwest. A small tributary wadi today runs parallel and to the north of WF443, discharging run-off water into the main wadi, but it would have been directed through this small system in the past. A series of cross-wadi walls in WF443.6 was perhaps part of a system to control and then deflect surface run-off into the fields to the immediate south. There was a similar arrangement in the western half of WF443: a series of fields divided by linear terrace divisions, sometimes with orthostatic wall lengths forming part of the boundary wall and containing occasional cairns and graves, but very little pottery was recovered from the surface of these fields. What seems reasonably clear is that the Iron Age agricultural regime was based on fields that tended to be quite small in size, and involved more cohesive agricultural field systems compared with the walls and terraces of Bronze Age date, but using comparable methods of runoff farming. Modest-sized field systems were constructed in appropriate locations where there were small, manageable, wadi flows or surface run-off water could be controlled and dispersed.

Some degree of agricultural use of parts of the main field group WF4 also appears highly likely, but it is impossible on current evidence to disentangle the structural detail of this palimpsest landscape, given the dynamic evolution of the field system in later phases. WF4.7 may reflect the introduction for the first time of large-scale methods of floodwater management on the alluvial sediments of the Faynan beds. At any rate, the line of a large enclosing wall at the western edge of fields WF4.7.29–4.7.32 may have an Iron Age origin given the increased density of Iron Age sherds along its edge (Fig. 9.15).

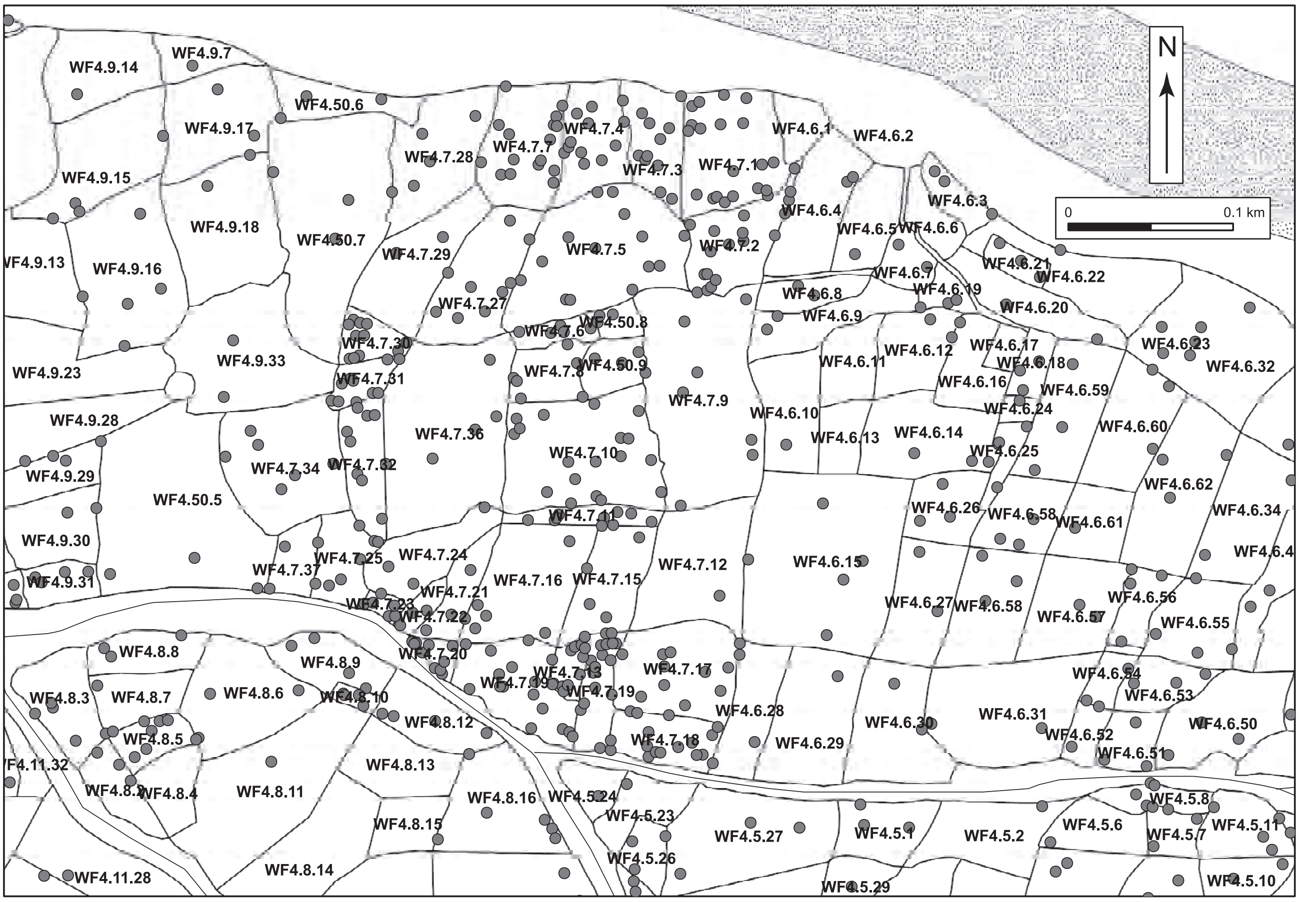


Figure 9.15 *Density of Iron Age sherds in WF4.7.29–WF4.7.32. (Numbers prefixed WF4.50 relate to field subdivisions identified in post-fieldwork analysis.) (Illustration: Paul Newson.)*

It seems that some Iron Age walls were serving as terraces in conventional run-off farming regimes similar to those of the later Nabataean and Roman/Byzantine systems. A few segments of walling appear to have had different functions, perhaps as overall boundary features or for stock control. Several of these field systems incorporate walls constructed using large river-rounded boulders. The field systems and enclosures and the settlement enclosure WF424 appear to reflect increasing sophistication compared with Bronze Age land use in the study area, in terms of the demarcation of land and zones for specific purposes such as crops, livestock, or industrial activities. The overall impression is that the Iron Age inhabitants of the Faynan valley were the first fully to master the art of run-off farming and constructed a series of discrete and complex field systems both on the northern side of the main wadi channel and on some parts of the terrace where the WF4 field system would later evolve.

9.5 Evidence of environmental change

The most detailed explorations of environmental change in the study area for this period are by Baierle *et al.* (1989), Engel (1992; 1993), Engel and Frey (1996) and Frey *et al*. (1991) (see also Chapter 3). These were based upon charcoal recovered from the metalliferous waste tips of the Faynan area. At Khirbat an-Nahas, Engel (1993) noted a distinct change in the type of wood used for smelting between the Bronze Age as described by Baierle *et al.* (1989) and Engel (1992), and the types they noted from charcoal attributed to the Iron Age. The types of timber used can be related to their altitudinal position in the region (Fig. 2.12). Whereas timber of high calorific value from upland taxa such as *Juniperus* and *Quercus* was used in the Bronze Age, the Iron Age was marked by charcoal from the smaller lowland and wadi shrubs such as *Tamarix*, *Retama, Haloxylon*, and *Acacia*, together with woody taxa of springs or irrigated land such as *Phoenix dactilyfera*. At the time of that research, it was uncertain whether a climatic change or fuel for industrial purposes produced the loss from the mountain front and lowlands of good fuel trees such as *Juniperus* and *Quercus*. Importantly, these authors concluded that, irrespective of the cause(s) of the losses of larger trees, large amounts of wood would have been available within walking distance of Khirbat an-Nahas from fast-growing lowland shrubs and that no transport of wood from further and higher localities was needed. These comments re-introduce the familiar polarity in arguments that stress an opposition between natural and human agents of environmental change in arid lands, issues discussed further in Chapters 10–13 (Chapter 1, §1.3).

Our analyses are built upon observations at a series of sites (Table 9.3).

9.5.1 Smelting slag: the Atlal Member

The deposits of black slag from past copper smelting in the region were designated as the Atlal Member (Mohamed 1999; Hunt *et al.* 2007b), and as described earlier range in date from the Chalcolithic to medieval periods. They vary from large piles of slag whose distribution can be determined from air photograph study (Kennedy and Bewley 2004: 214–15; Fig. 1.4) to many smaller patches of black slag that are not visible on the air photographs, such as at site WF5022 at Tell Wadi Faynan (Fig. 3.13).

9.5.2 Site WF5738/WF5739

Exposure WF5738/WF5739 is typical of the thick deposits of continuous black slag that were common between the Khirbat Faynan barrage and the modern braid-plain of the Wadi Dana (Kennedy and Bewley 2004: 215; Figs 3.1, 3.12, 3.13). Field mapping indicated a sheet of smelting waste, initially thickening and then thinning towards and onto the ancient braid-plain of the adjacent Wadi Dana. These deposits were investigated in a 1.5 m deep pit excavated into materials identified in the field as smelting waste overlying fluvial braid-plain deposits (Fig. 9.16 – lower). The stratigraphy and total concentrations of copper, lead, beryllium, arsenic, mercury, and thallium are also shown. No unambiguous evidence of age was found in the WF5739 exposure, but the adjacent site WF5738, with a similar stratigraphy, contained Iron Age sherds (Fig. 9.16 – upper). The highest concentrations of copper and lead that were found in these sediments had distinctive relationships with ash, as well as with slabs of black smelting slag.

Two other important patterns are evident. The first is the overall trend in the concentrations of metals. There is a stepped rise to peak concentrations at 0.5 m followed by a decline to 50 per cent of those peak concentrations immediately below the land surface. The lowest concentrations – albeit still evidencing dangerous levels of contamination – were in the ash and braid-plain deposits at the base of the excavation, suggesting some removal and perhaps dilution by fluvial and aeolian processes on the braid-plain. Metal concentrations were lowest in this Unit, and display a clear association with the observed sedimentary properties. Concentrations increase by a factor of at least two in the overlying ash-clay floor deposits of the geochemical zone. The presence of black copper slag is associated with a further rapid increase to concentrations of copper of *c*.130,000 ppm, lead of *c*.50,000 ppm, and thallium of *c*.150 ppm. Thallium is particularly associated with sulphide ores of copper, lead, and zinc that are known to be released into the environment during ore processing and smelting. The metal tends to be released as vapours and dusts before thallium re-condenses onto the surface of the airborne ash which falls back to the land surface. Once deposited, thallium tends to persist in the upper layers of soil, notably where there is fine-grained and organic material to which it bonds (Kazantzis 2000). Such associations with partially consumed ash and wood are found in this investigation, and there is also a relationship with the clay-lined surfaces.

The second trend concerns the proportions of copper to lead through the thickness of the deposit. Total concentrations of copper are sometimes twice those of lead in the lower part of the core. Above this level, total concentrations of lead notably exceed those of copper. The change in proportion is associated with a visible change in the evidence of ancient industrial activities: the presence or absence of black smelting slag. The distinctive pattern of concentrations and proportions of lead concentrations upward through the stratigraphic sequence might suggest that at this location one or more of the following took place: a decreasing degree of smelting; the progressive use of less metal-rich ores; and/or a progressively greater recovery of copper and loss of lead and thallium in the smelting process. Geomorphological processes that are likely at this site, such as sorting or post-depositional movement at the edge of the braid-plain, appear inadequate to explain this pattern and the magnitude of observed geochemical change. The distinctive middle layer (Unit 2 of ash with

Site	Slag heap and polluted sediments	Information available
WF1491/WF5741 – deposits and wall – inferred retaining wall immediately downslope of Khirbat Faynan barrage .	Representative exposure of copper smelting slag and ash; primarily Iron Age. Atlal Member; some Islamic metallurgy at top horizon.	Excavated pit; field description of stratigraphy; ICPMS; dating by field association and associated sherds to somewhere in Nabataean to Byzantine periods.
WF455 sections in side of gully cutting through slag deposits downslope from Khirbat Faynan barrage.	Section through two distinct horizons of Iron Age metallurgy.	Excavated section recorded; field description of stratigraphy; dating by AMS determinations.
Site	**Mine waste and slump**	**Information available**
WF5740 – mine 2, Wadi Khalid (Grattan *et al.* 2004).	Copper mine with slumped mining debris; evidence of post-mine-use, and slumped post-mine deposits; somewhere in Nabataean/ Byzantine periods (?).	Field description of stratigraphy, existing exposures; ICPMS of total concentrations (Grattan unpublished); stratigraphic association in the field.
Site	**Wadi infill sequence**	**Information available**
Wadi Faynan barrage-infill sediments at WF5017.	?uncertain provenance.	Borehole sampling; two radiocarbon dates to *c*.2.6 ka uncal. on re-worked charcoal.

Table 9.3 *Sites where Iron Age environmental impacts are recorded.*

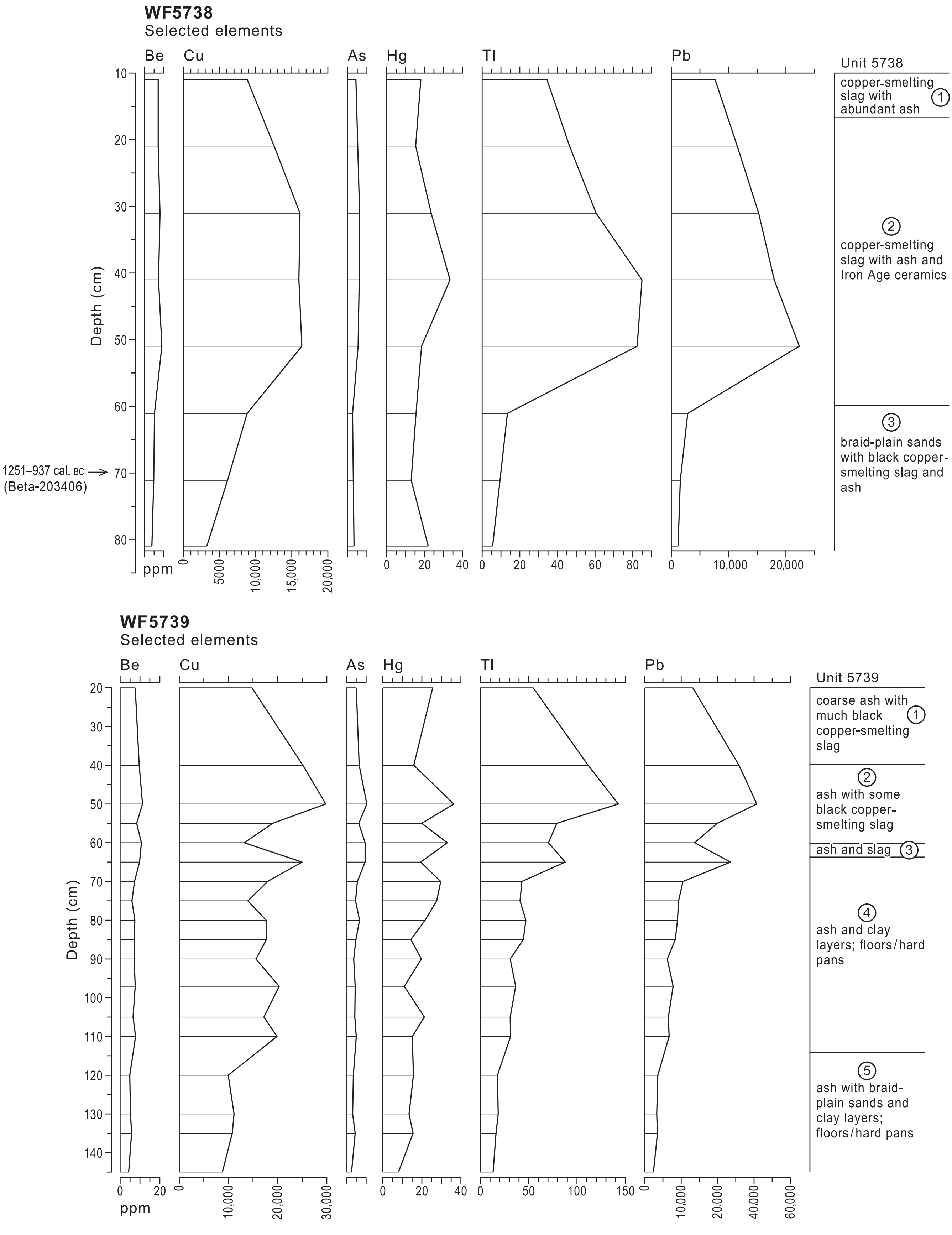


Figure 9.16 *WF5738 and WF5739: stratigraphy and selected geochemical analyses of sediments near Khirbat Faynan polluted with copper-smelting slag (Be = beryllium; Cu = copper; As = arsenic; Hg = mercury; Tl = thallium; Pb = lead). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

slag) at WF5741 (Fig. 9.17 – lower) displays similar trends in heavy metal concentrations and may date to the Iron Age–Roman period; however, in this case the available radiocarbon dates can only date the polluted materials that are below and above.

It is clear from these observations that there is no simple correlation in the smelting wastes at this site between the frequency of some obvious macroscopic indicators of ore processing or smelting (such as black slag, and grains of copper ore) and the overall magnitude of heavy metal pollution. Also, the exposure indicates that a fluvially-active wadi-floor braid-plain was present at about the elevation of the modern braid-plain during the early phases of the discard of these metalliferous wastes. In the exposure at WF5739, the thin (1–2 cm) layers of clay observed within Unit 4 did not have properties that suggested that they were the result of deposition by wind or water of fine-grained materials on slopes but appear to have been deliberately laid and compacted onto surfaces of ash or slag, perhaps with the intentions of stabilizing the surface to provide hard, constructed working surfaces. This interpretation would clearly merit further detailed investigation.

9.5.3 Mine WF5740 – infill waste and slump at entrance

Recent re-evaluations of the Wadi Khalid ores have resulted in many mine entrances being enlarged, with the result that many associated older superficial deposits and mine wastes have been removed. At WF5740, however, an undisturbed *c*.2 m-thick mine spoil sediment sequence had accumulated immediately inside a dry abandoned copper mine overlooking the Wadi Faynan, providing us with information on the sequence and sediment concentrations of copper and lead that had accumulated at its entrance (Fig. 9.17). The distinction between sediment types observed in the cave is reflected clearly in the metal concentrations. Copper concentrations in the post-mining abandonment infill deposits are typically about 1000–1500 ppm, with one sample at *c*.3500 ppm, and lead concentrations are typically in the range 800–2000 ppm, whereas the deposits interpreted as the slumped waste from times of active mining have copper concentrations ranging from *c*.6500 to *c*.16,000 ppm, whilst lead concentrations vary from *c*.3000 to *c*.5000 ppm. This evidence demonstrates clearly that the discarded mine waste was rich in both copper and lead, a general point for mines in the Burj Dolomite Shale (Hauptmann 2000). From the point of view of ancient skilled miners, the forced labourers and others, unless they worked with knowledge and appropriate regard to these metal concentrations, it is likely that there would have been significant deleterious effects upon their health and well-being (Chapter 13). A later influx of sediment with lower metal contents through wind, water, and animals is evident in the lower concentrations recorded in samples 1–5. There are no reasons to suspect substantial post-depositional bioturbation or mixing within this sequence, rather the opposite. The lower total metal concentrations in the uppermost post-mining infill deposits probably reflect the character of the infill sediments at deposition as much as contamination, through further slope wash and mixing with the mined waste previously in the mine and its entrance. Overall, the proportion of copper in the post-mining deposits declines more rapidly than that for lead which is relatively stable, a feature noted for the post-Byzantine loss of heavy metal pollutants around the Khirbat Faynan barrage (Chapter 11).

9.5.4 The Khirbat Faynan barrage site WF441

The infill deposits behind the Khirbat Faynan barrage WF441, sampled by excavation at WF5012 (= WF5512) and by borehole at WF5017 (= WF5517) (Figs 1.13, 1.15, 2.13), may also have been affected by ore-processing and smelting during in the Iron Age (Figs 10.39, 11.10, and Table 10.2). The two identical radiocarbon dates of 2630±50 BP or 910–594 cal. BC (Beta-110840; Beta-110841), based on charcoal fragments at two different depths recovered by Edelman corer in the borehole WF5017 at 2.4 m and 2.6 m respectively, may point to the complex history of ore-smelting and consequent intense pollution of pond-sediments during the Iron Age, as illustrated by Barker (2000: fig. 4.9). This activity clearly involved the use of fire, which led to the elevated levels of magnetic susceptibility recorded in the sedimentological studies of samples from borehole WF5017 (Fig. 3.5). On the other hand, as mentioned earlier, with the benefit of further information provided by new radiocarbon dates these *c*.2.6 kya dates appear to reflect the sampling by corer of charcoal re-worked into younger deposits, an explanation compatible with evidence presented in Chapter 10 from the investigations of good exposures produced by careful excavations at the adjacent site of WF5012 (= WF5512) (see Table 10.2).

9.6 Dating issues

There are now over 60 radiocarbon dates relating to the Late Bronze Age through Iron Age and Nabataean activity in the Faynan region (Appendix 1). There are potential objections to the interpretation of these AMS dates that we have tried to take into account in our analysis. As demonstrated in Chapter 3 and Pyatt *et al.* (2002a,b), for example, even the most polluted of slags are granular, and porous with an open fabric (Fig. 4.47); some contain burrows or fissures, and support some pollution-resistant plant and invertebrate life, and in times of intense storms, rainwater infiltrates into these surface materials. All these properties facilitate passive and active transport of charcoal both up and down through a stratigraphic sequence. Charcoal is often very durable and resistant to both decay and re-cycling, which allows the re-working and re-deposition of micro-charcoal (thermally-mature palynofacies). Some of the trees used for charcoal production may have been quite old when felled, and the dates of carbon absorption could be 50–100 years earlier than the date of the smelting activity. Kind *et al.* (2005: 190) make the same point

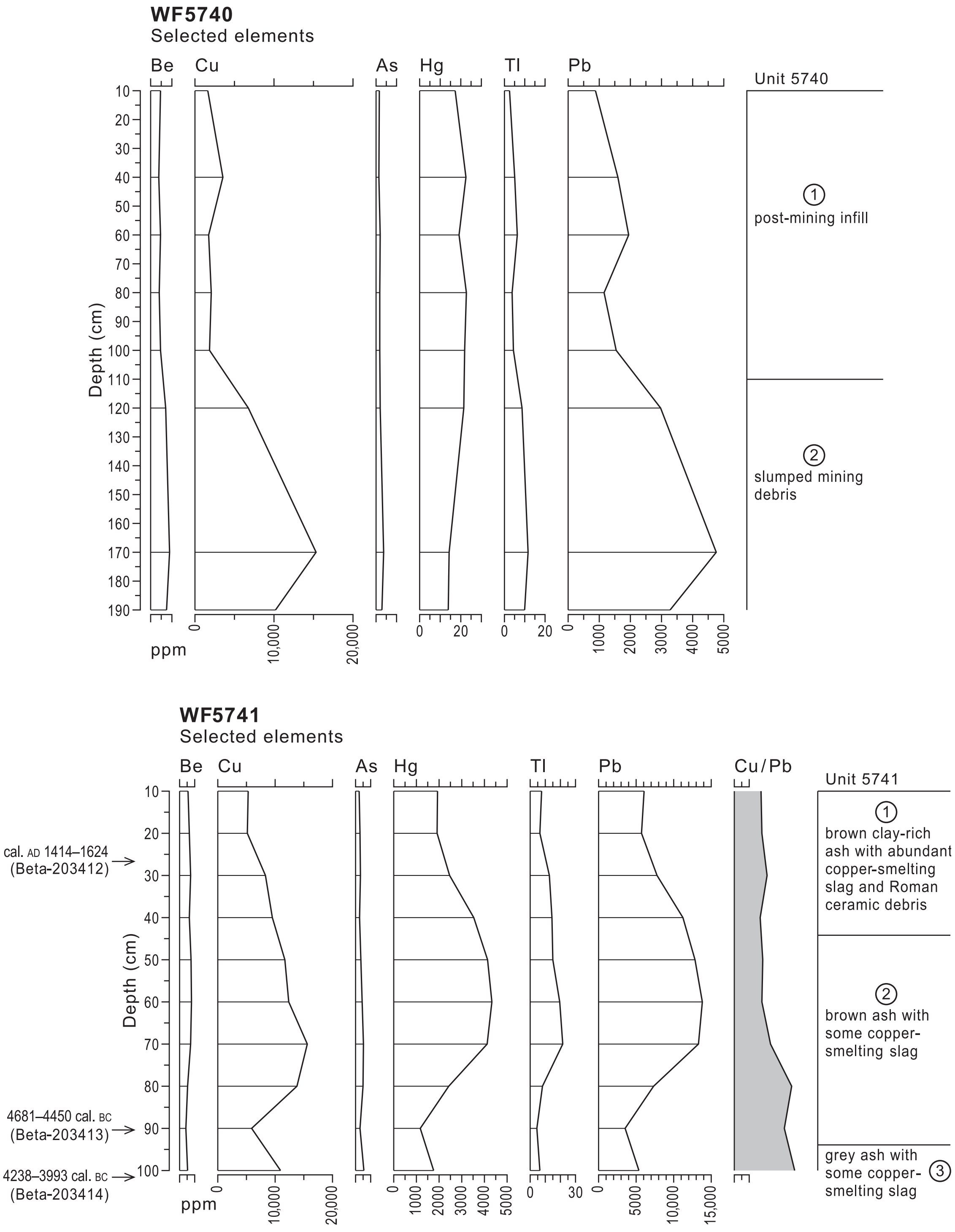


Figure 9.17 *Stratigraphy and selected geochemical analyses of sediments at (above, WF5740) the entrance to an Iron Age mine; and (below, WF5741) adjacent copper smelting slag (Be = beryllium; Cu = copper; As = arsenic; Hg = mercury; Tl = thallium; Pb = lead). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

concerning Roman activity to explain a mismatch between the coin list and AMS dates (for the impact of intensive wood-harvesting and the age structure of woody taxa, see Chapter 10). However, recent sampling at Khirbat an-Nahas has prioritized the outermost rings preserved on the smallest carbonized timber (Higham *et al.* 2005: 164–5), which should reduce the potential for large error. Moreover, even if we assume that the real dates of smelting activity corresponded with the later end of the calibrated bracket (or as much as a century after), there is still a mismatch between the activity at Faynan and the emergence of complex society on the Edomite plateau in the eighth–seventh centuries (the Iron IIC phase). Finds of Egyptian scarabs and 'Midianite' pottery at Khirbat an-Nahas and Barqa al-Hatiya also support a date there for initial activity in the thirteenth–eleventh century (Fritz 1994; Hauptmann 2007: 141–3; Levy 2002: 5). 'Midianite' pottery is now recorded in the Faynan valley (cf. Rothenberg and Glass 1983), so there appears to be independent confirmation of some Iron I renewal of mining and smelting activity.

The bulk of Iron Age pottery collected in the Faynan region hitherto has been dated to the Iron IIC phase, largely based on the sequences established from stratified sequences at sites such as Busayra, which lack the earlier phases (Bienkowski 1992d). The AMS dates from slag heaps and mine workings suggest that the expansion of copper working in the Faynan area may have begun near the end of Iron I or early in Iron II, and there is some evidence that may support this straightforward interpretation of the dates. As noted already, the latest evidence from Khirbat an-Nahas (Higham *et al.* 2005; Levy *et al.* 2005b) has isolated two main phases of production in the twelfth to eleventh centuries BC and the tenth to ninth centuries BC. The two identical AMS dates of 2630±50 BP or 910–594 cal. BC (Beta-110840/Beta-110841) obtained from pieces of charcoal found at a depth of 2.4/2.6 m in the sediments that built up behind the Khirbat Faynan barrage may correlate with the end of the high peak of Iron Age metallurgy, further evidence suggesting significant activity before Iron IIC. Hauptmann has pointed out similarities in the chemistry and typology of slags, smelting furnaces, and tuyères between the Faynan region and the Timna finds dated to the tenth–eighth centuries BC (Hauptmann and Weisgerber 1987: 423).

Further dating carried out in the context of our project, of materials from stratigraphic sections (WF455: Fig. 9.10) in the sides of gullies cutting through the deposits on the north side of the Khirbat Faynan (Hauptmann's slag heap 7), extends the range of Iron Age activity there too back to Iron I (for example, 2900±40 BP or 1257–945 cal. BC, Beta-203407) (Appendix 1). In addition, there are now several hints at some Late Bronze Age mining and smelting activity, even if this remains difficult to substantiate in terms of pottery finds. A mid second-millennium BC date from mine workings in the Wadi Khalid is suggestive (1602–1400 cal. BC, HD-14926), but is now supplemented by the early second-millennium BC date from a layer of slag at the very base of the deep section dug behind the barrage to the north of the Khirbat (1867–1536 cal. BC, Beta-203402). This raises the possibility that Khirbat Faynan is the key site for understanding the re-emergence of large-scale mining and smelting in the Late Bronze Age and Iron I period.

The AMS date from a large cemetery in the Wadi Fidan (Fidan 40), situated less than 5 km from the Khirbat an-Nahas smelting site, was obtained from a short-life fruit, but appears remarkably similar to the range of the bulk of the smelting dates, broadly late twelfth–ninth centuries BC (Levy *et al.* 1999a: 303). There is thus a high probability that the people buried at Fidan 40 were an important labour pool for the mining and smelting activity of the Early Iron Age. Some preliminary analyses of skeletal elements from this cemetery have revealed significant levels of copper and lead in the bones, almost certainly indicating involvement in mining or smelting of copper (Pyatt *et al.* 2005: 297, table 2). What is needed is further excavation at key sites like Khirbat Faynan and Khirbat an-Nahas to provide reliable stratigraphic sequences for the earlier Iron Age in southern Jordan. Even so, the Fidan 40 cemetery excavation suggests that the use of ceramics in late Iron I and early Iron II was very limited. Only through AMS dating and occasional diagnostic imports, such as 'Midianite' pottery, can we hope to establish a fuller picture of this pre-700 BC activity.

9.7 Ancient Edom and copper production in Wadi Faynan

An important starting point for this discussion is that, initially at any rate, 'Edom' simply had significance as a geographical or territorial term and implied no particular ethnic or political unity. In the Iron I period it seems inappropriate to talk of the existence of the Edomite kingdom or of a people known as the Edomites. Broadly similar issues and problems exist too in relation to the Moabite civilization (LaBianca and Younker 1995; Routledge 2004). The straightforward implication of the dearth of archaeological evidence of Late Bronze Age and Early Iron Age activity in southern Jordan is that settlement was mostly transient, based on tribal societies practising extensive pastoralism and leaving only vestigial traces (van der Steen 2004). However, the new evidence presented here suggests that there was some renewal of copper production in the Faynan region during the later second millennium BC or very early in the first millennium BC. The full extent of this remains difficult to trace because of the paucity of excavation and the near aceramic conditions of this phase. It is unclear at present whether these copper-mining initiatives were due to external forces or to the people to be known later as Edomites, or both at different moments.

The earliest use of the term 'Edom' dates to an Egyptian papyrus of the late thirteenth century BC, which refers to a region known as Edom, populated by pastoral clans of 'Shasu'. In the twelfth century, Ramesses III claimed to have destroyed the Shasu clans in a raid on their territory, also known as *Seir* (both texts discussed by Bienkowski 1994: 254; Levy *et al.* 2003: 248). The Shasu were evidently tent-dwelling pastoralists, encountered by Egyptians in the southern 'Arabah or Hijaz, where Pharaonic involvement in the copper mines at Timna created the potential for conflict with local pastoral groups. The extent to which these pastoral societies can be considered a 'tented kingdom' at so early a date remains debatable (cf. Kitchen 1992: 27). Egyptian initiative or influence on the Early Iron Age copper mining in Faynan is a possibility, supported by finds of a number of scarabs. However, close links have also been argued between the early pottery from Faynan and that from another copper processing/trading site at Khirbat al-Msash in the central Negev, perhaps reflecting the biblical claim that David had conquered and garrisoned Edom in the early tenth century (Knauf 1992b: 49; cf. Levy *et al.* 2005b: 157–60). Old Testament references to *Punon*/*Pinon* (summarized in Bartlett 1989: 50) perhaps concord with the interconnectedness of Judaea and Edom in the early first millennium BC. When Edom revolted against Israelite rule in the mid-ninth century, we get the first certain attestation of the existence of a kingdom of Edom (Bartlett 1989: 115–49). From the early eighth century, Edom was a tributary of Assyria, though Bienkowski has argued strongly against the possibility of direct rule by Assyrian officials or the imposition of a garrison (Bienkowski 1994: 255–6; 2000). The history of Edom thus must in part at least be understood in terms of its changing relations to external powers, who may have contributed to the processes of social and economic change (Knauf 1992b).

The period of Assyrian domination marks the archaeological highpoint of 'Edomite' civilization, with the expansion of permanent settlements on the plateau, with some emphasis on fortified strongholds (Lindner and Knauf 1997), though the major fort at Khirbat an-Nahas now clearly pre-dates this phase (Levy *et al.* 2005b: 160). However, in comparison with many other areas of the Levant, Iron Age Edom was never fully urbanized (Bienkowski 1995: 135). Busayra is the site that perhaps comes closest to conventional urban form, with the major buildings having similarities with Assyrian palace architecture. Most other identified sites are classifiable as villages, fortresses, or farms. What is much less clear at present is what existed in Edom prior to the emergence of these permanent settlement types. At any rate, the process of state formation in a society composed fundamentally of transhumant pastoralists may well have lagged significantly behind and been less far-reaching than that of the other Levantine Iron Age societies (see Herr and Najjar 2001; cf. Finkelstein and Na'aman 1994; van der Steen 2004). Yet even to the west of the Jordan river, it is increasingly clear that the key phase in early state formation occurred in the Iron IIA phase, now argued to span the tenth and ninth centuries BC (Herzog and Singer-Avitz 2004).

The archaeological evidence for copper mining and production in the Faynan region in the early centuries of the first millennium BC shows that they were organized on an industrial scale, with centralized smelting facilities at a series of major sites. The large fort at Khirbat an-Nahas suggests that the production was protected by a military force, perhaps also required to oversee forced labour at the mines. Glueck (1935: 28) long ago speculated on the use of slave labour at the Iron Age mines and smelters, drawing on biblical references to the enslaving of defeated enemies by the Edomites and noting the tradition that David enslaved the people of Edom after his conquest of the region (Amos 1.6.9). The most recent review of the AMS dates from the fort suggests that it was constructed early in the Iron II phase (Higham *et al.* 2005; Levy *et al.* 2005b).

There has been a circularity of argument in the past in assigning the most dynamic phase of Iron Age copper production in the Faynan district to the Iron IIC period. Only from the seventh century was there a strong resurgence of ceramic production and use, so it is unsurprising that the bulk of the dateable ceramics found in the Faynan region relates to this phase (Bienkowski 1994: 256–7; Hart 1992: 96). As we have noted already, a substantial and well-organized population existed in the Fidan/Faynan valley at an earlier date, doing without pottery, but furnishing some of their burials with metal rings and bracelets (Levy *et al.* 1999a). The suite of AMS dates also hints at significant growth in smelting activity prior to 900 BC. Future excavations at Khirbat Faynan and Khirbat an-Nahas are likely to elucidate the sequence of Iron Age development significantly. As Knauf (1992b: 50) observed, the massive investment in agricultural expansion and in the embellishment of the main settlements on the Edom plateau required substantial capital and this most likely came from two sources: copper production and trade with Arabia. It is thus an interesting possibility that the evolution of copper production was a key driver in Edomite state formation, rather than that the creation of the kingdom led to the reopening of mines there (see Levy *et al.* 2001b: 163, for a similar observation). The growth of copper production may well have preceded the dynamic social changes on the plateau.

In any event, the fullest elaboration of the mining settlements and the supporting infrastructure of field systems and hydraulic works and significant technological advances in mining craft and smelting activity may well belong to the later Iron II phase. How far the intensive production also extended into the Iron III phase is again somewhat uncertain, but there was clearly some continuing activity, even if on a diminishing scale, under neo-Babylonian and Persian hegemony after the mid-sixth century BC (Bienkowski 2000; 2001a). There is no evidence to suggest that there was continuity between the Iron Age production and later Nabataean activity in the region (cf. Bartlett 1990) and the indicators available suggest a lengthy gap in copper production from around 400 BC, if not earlier.

9.8 Nabataean Faynan

The cultural identity of the Nabataeans is still controversial, though the possibility that they represent the direct descendants of the Edomites is now generally doubted (Schmid 2001: 367). It is most probable on linguistic and historical grounds that they were immigrants into the region from northwestern Saudi Arabia around 400 BC, though the first historical attestation is in 312 BC (Graf 1990). At present, archaeological evidence for early Nabataean society cannot offer conclusive support. Despite traditional theories of desert nomads, the archaeological record of later Nabataean civilization reveals a different picture of a complex, literate, society ruled by coin-issuing kings, with some substantial urban settlements, as at the capital Petra (Nehmé 1999; Schmid 2001; 2002). The Nabataeans had a distinctive tradition of monumental architecture, exemplified by the rock-cut tombs at Petra and Medain Saleh in Saudi Arabia (McKenzie 1990). They were expert hydraulic engineers and practised sophisticated run-off farming in the arid lands of the Jordanian plateau

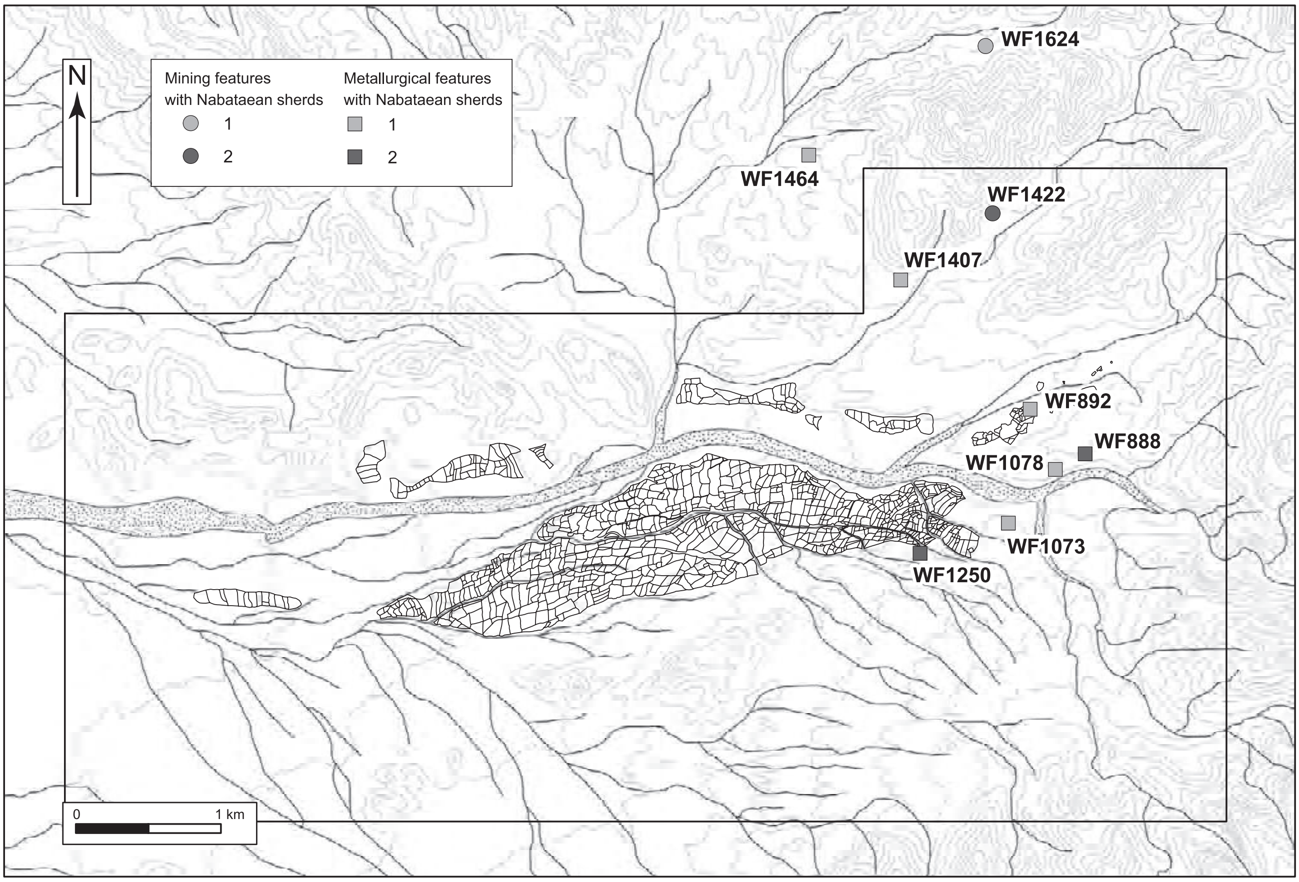


Figure 9.18 *Nabataean activity at copper-mining and smelting sites, as indicated by the distribution of pottery. (Illustration: Paul Newson.)*

and the pre-desert landscapes of the ‘Arabah and Negev (Oleson 1995). They also clearly had a controlling interest in the overland transport of incense, spices, and other exotic commodities from southern Arabia. From the early first century BC, the Nabataean kingdom repeatedly featured in the historical sources on the Levant, contesting military power with Hasmonean Judaea, the Seleucid kingdom, and the Roman empire. Recognized as a Roman client kingdom in the late first century BC, the territory was eventually annexed to form the province of Arabia in AD 106 (though resistance may have continued until AD 111).

One key question is the extent to which there was Nabataean mining and smelting activity as a precursor to the expanded Roman and Byzantine operations in Wadi Faynan described in the next chapter. The nature and extent of Nabataean-period activity in the Wadi Faynan remain rather unclear (Fig. 9.18). Some commentators have suggested that there was no Nabataean copper exploitation in the area, in part relying on the testimony of a second-century BC writer who claimed that the copper and iron mines of the mountains bordering Arabia were no longer worked in his time (Sartre 1993: 142, quoting the author of *Lettre d’Aristée*). Similarly, Strabo (*Geog.* 16.4.26) specifically stated that brass and iron were imported by the Nabataeans from other lands and that they practised only gold and silver working. However, we must be cautious in accepting the literal truth of these comments. Drawing on earlier sources, the first-century BC writer Diodorus described the first encounter between the successors of Alexander and the Nabataeans in 312 BC (19.94.1, 19.95.1–97.6). His stereotypical depiction of the Nabataeans as nomads and desert traders closely follows an established model employed by Greco-Roman writers in general when discussing ‘barbarian’ neighbours (see for example, Mattingly *et al.* 2003: 76–90 on the similar and demonstrably incorrect presentation of the Garamantes of the Libyan Sahara). While it appears likely that the ultimate origins of the Nabataean state lay with pastoral tribes of the desert margins, the ancient literary sources cannot be relied on to present an unbiased view.

Although Schmid (2001: 367) broadly accepts the account of the Nabataeans as nomads, on the grounds that there is little archaeological evidence that they were sedentary prior to the first century BC, there is clearly a danger that evidence reflecting the sedentarization and cultural sophistication of the people will from this perspective automatically be assumed to date after 100 BC. The fact that Nabataean pottery styles became much more diagnostic after that date makes them a key milestone in dating Nabataean sites, but although archaeologically elusive before that date, the Nabataeans were not completely invisible. On the other hand, it is true that the most rapid

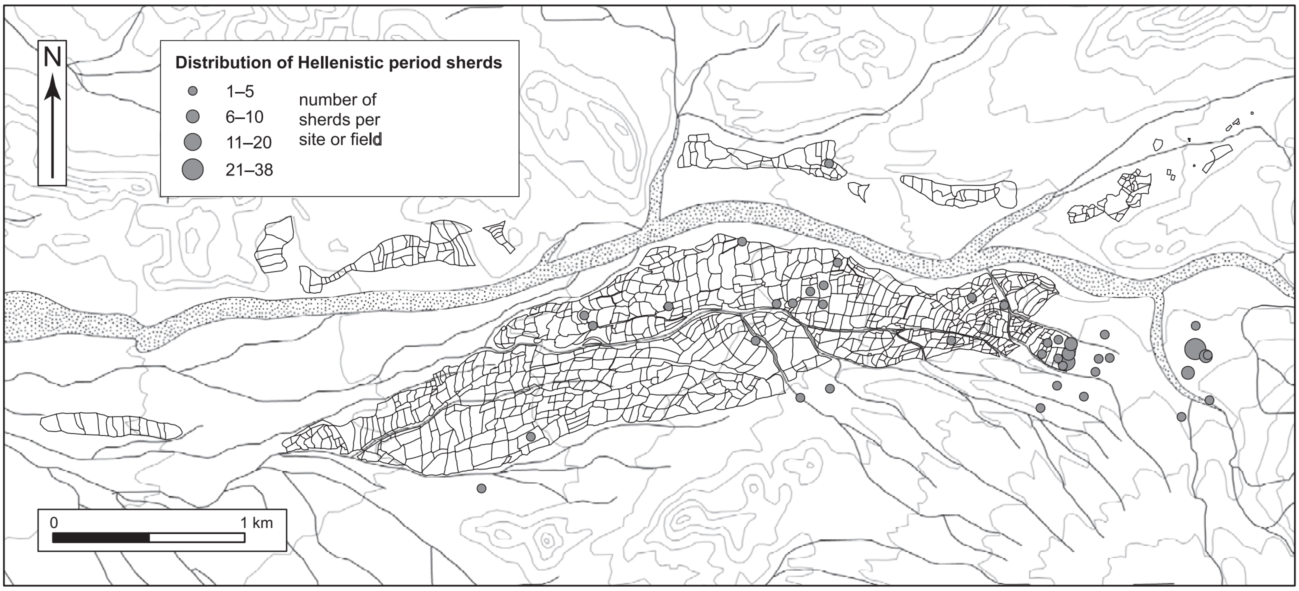


Figure 9.19 *Hellenistic pottery in the Wadi Faynan. (Illustration: Paul Newson.)*

and radical changes in Nabataean society reflected in the monumentalization of architecture, the production of coinage and sculpture in the round, and the appearance of high-quality painted pottery, can all be dated to the first century BC (Schmid 2001: 371–4). There is a strange parallelism here with the difficulty of documenting the initial stages of the rise of the Edomite Iron Age civilization in southern Jordan as discussed earlier in this chapter.

It is now clear from extensive excavations at Petra that Nabataean metallurgy was a good deal more sophisticated and that copper- and bronze-working were important components of this (Hammond 2000). Although Hauptmann's dating of charcoal from slag deposits (2000: 64–6) indicates a significant gap in the later first millennium BC, since not all the slag deposits at Khirbat Faynan have been systematically dated we cannot take this as conclusive support for the suggestion in the literary sources that the Nabataeans neglected the copper source on their doorstep.

9.8.1 Mining and smelting

Some Nabataean pottery from above the base of the Khirbat Faynan barrage section (WF5012) is suggestive of Nabataean metallurgy forming the foundation on which a huge Roman period pollution signature was built. A well-engineered shaft inserted next to an Iron Age double shaft in the Wadi Khalid is believed to date to either the late Nabataean or early Roman period and seems to represent technically proficient prospection work, evaluating the state of mineral deposits there. As discussed below, there is ceramic evidence for a substantial Nabataean presence at Khirbat Faynan and slight amounts of Nabataean material have been recovered at the other major Iron Age smelting sites Khirbat an-Nahas, al-Jariya, and al-Ghuwayb (Glueck 1935: 25, 34–5), perhaps indicating some small-scale activity elsewhere. Although it is clear that the huge scale of exploitation of the earlier Iron Age had not been maintained, these indications do suggest that some active measures were underway during the Nabataean period to re-exploit Faynan copper at least in a minor way.

9.8.2 Settlement

The evidence from the Faynan region indicates that there was both extensive Hellenistic (early Nabataean) and later Nabataean activity, as attested by coins and sherds on sites and more generally within the field system WF4 (Figs 9.19, 9.20) (Kind *et al.* 2005: 183–4; King *et al*. 1989: 201–4). ('Hellenistic' is used here to indicate the period 332–63 BC, while 'Nabataean' cannot easily be separated from 'early Roman' in terms of local ceramics and should be understood as covering 63 BC–AD 150.) There appears to have been growth over time, with the most extensive and impressive evidence for the later Nabataean–early Roman period (the first century BC and early second century AD). For the earlier Nabataean period ('Hellenistic'), occupation was strongly focused in the vicinity of Khirbat Faynan, with a few sherds suggesting activity at two points just south of WF4 (WF39, WF56 — for site locations see Fig. 9.2). WF597 was an isolated funerary structure *c*.1.5 km further to the west. Nonetheless, the early finds seem to represent permanent settlements. While the larger settlement suggested at Khirbat Faynan may have been associated with mining, the others appear to have been associated with farming systems, rather than the activities of nomadic pastoralists, a point of considerable importance to the debate about the nature of early Nabataean society. In the later Nabataean phase, pottery was much more widely distributed in the landscape and occurs on numerous sites spread through the valley, though in general it was far more abundant on the southern side of the Wadi Faynan in association with sites linked to the field system WF4 (Fig. 9.20).

Khirbat Faynan remained a key focus, with evidence of nucleated settlement there. Whereas the Iron Age activity

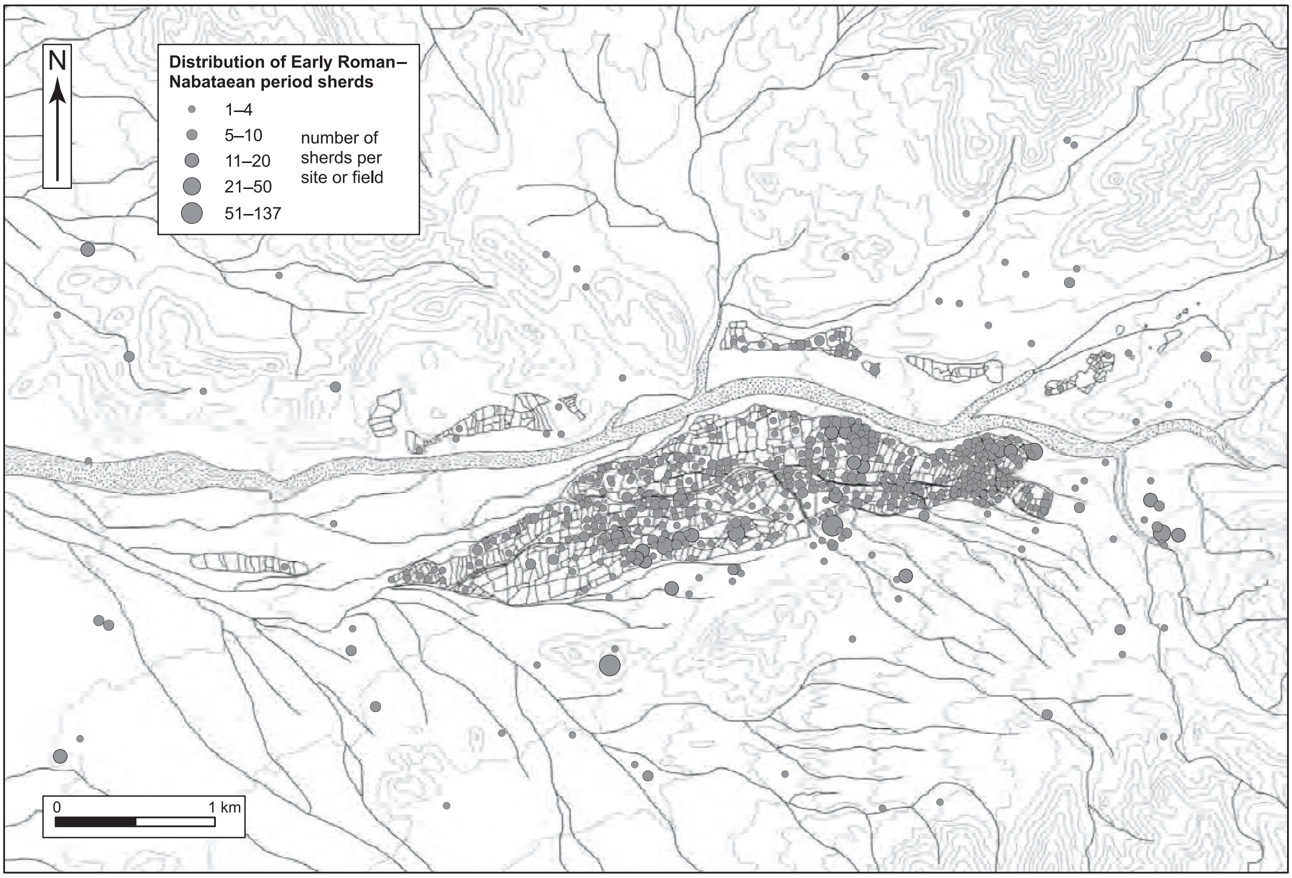


Figure 9.20 *Nabataean pottery in the Wadi Faynan. For locations of WF sites named in text, see Figure 9.2 (lower). (Illustration: Paul Newson.)*

had been focused along the south bank of the Wadi Dana, the Nabataean period marked the development of a significant settlement on the south bank of the Faynan opposite Khirbat Faynan (Fig. 9.21). There have also been previous collections of Nabataean sherds around WF1 on the north bank (Glueck 1935: 34; King *et al.* 1989: 201–4), but the extent and character of the occupation there are masked by the mass of later rubble. There are major concentrations of Nabataean material on both the east and west sides of the Wadi Shayqar, suggesting early origins of the nucleated settlement here (WF2/WF26 and WF11) (Coyne 1999). The available evidence thus suggests that a substantial tripartite settlement existed at Khirbat Faynan in the Nabataean period and that it underlay later Roman structures on the north bank of the Wadi Ghuwayr/Faynan and on east and west banks of the Wadi Shayqar to the south (the bulk of known Nabataean coins in Faynan has evidently been recovered from the WF2/WF11 area).

Although the Nabataean levels at Khirbat Faynan are buried beneath the later town, the impressive stonework and architecture of a Nabataean fortified site further down the wadi to the west (Tell al-Mirad, WF592) suggest that the activity in the valley was under some degree of supervision or surveillance (Figs 2.10, 9.22). This hilltop site on the south side of the valley commands outstanding views out to the Wadi ʻArabah to the west and eastwards up the valley to Khirbat Faynan and the mountain front beyond. The site comprises a series of fortified structures, built onto the natural summit and two ridges of a steeply scarped hill. Although very ruinous today, the main component appears to have been a small polygonal enceinte with well-faced walls at least 1 m thick. The summit was approached via a rock-cut staircase from the northwest (Fig. 9.23). The buildings constructed along two west–east ridges appear to have been designed to block any approach from the east flank, and the south side of the hill was reinforced by two substantial towers. The site is limited in size, but the character of the site is prestigious and its construction certainly required substantial investment. Military use of the site is suggested by its apparently defensive aspect, though a religious interpretation as a high holy place cannot be ruled out (cf. Atiat 2005; Kennedy and Bewley 2004: 128–31; Schmid 2001: 377–9 for 'temples' in similarly elevated locations). The profusion of fine Nabataean painted wares here indicates a site in close contact with the Nabataean heartlands. Both the substantial spread of material around Khirbat Faynan and this second high-status site suggest something more than pastoralists or subsistence farmers at work in the valley.

We have also identified several simpler domestic sites in the valley (WF36, WF233, WF368, WF476/WF478, WF481, WF538, WF645, WF689, WF1242). These sites comprised rectangular/polygonal enclosures with associ-

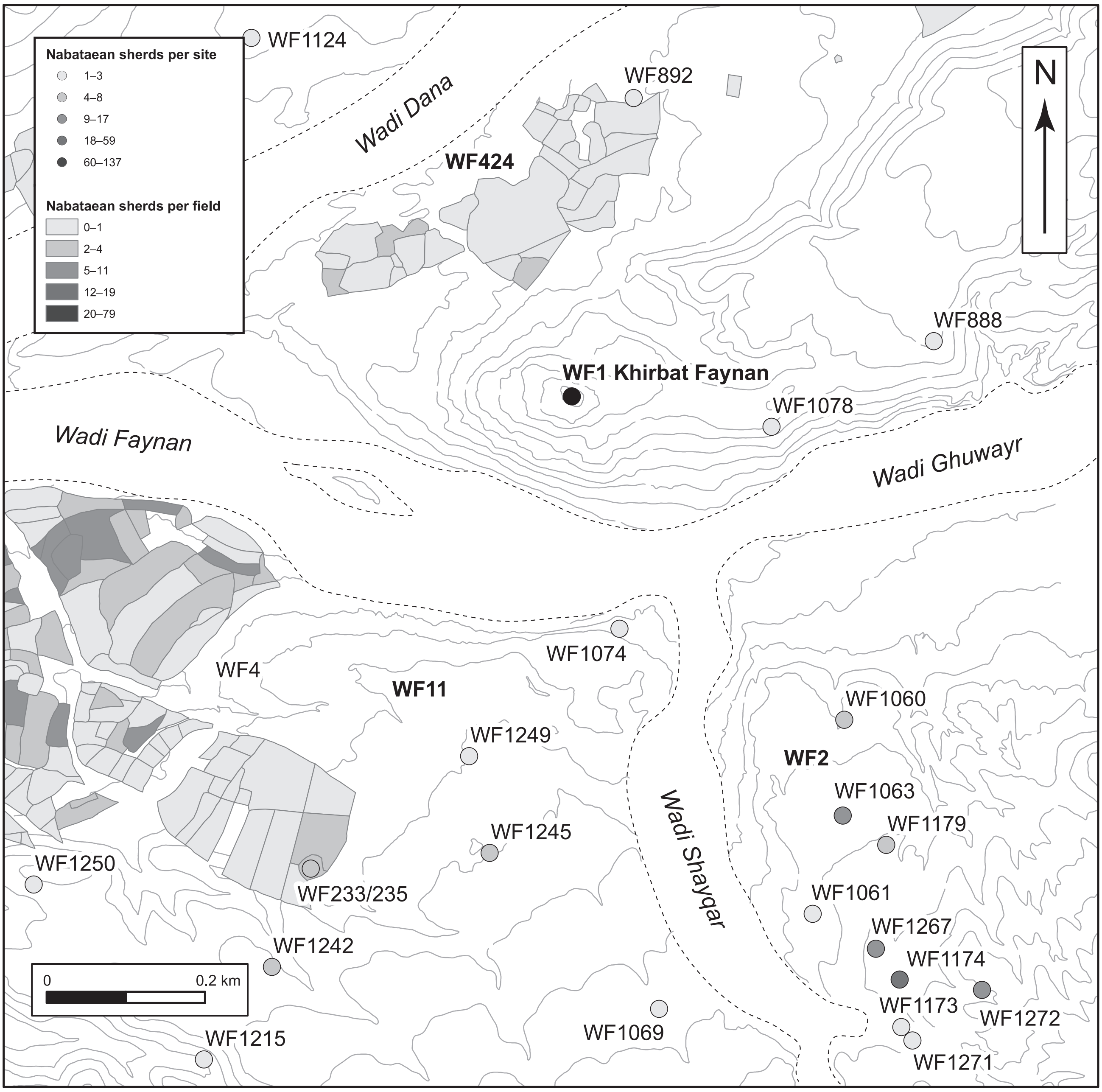
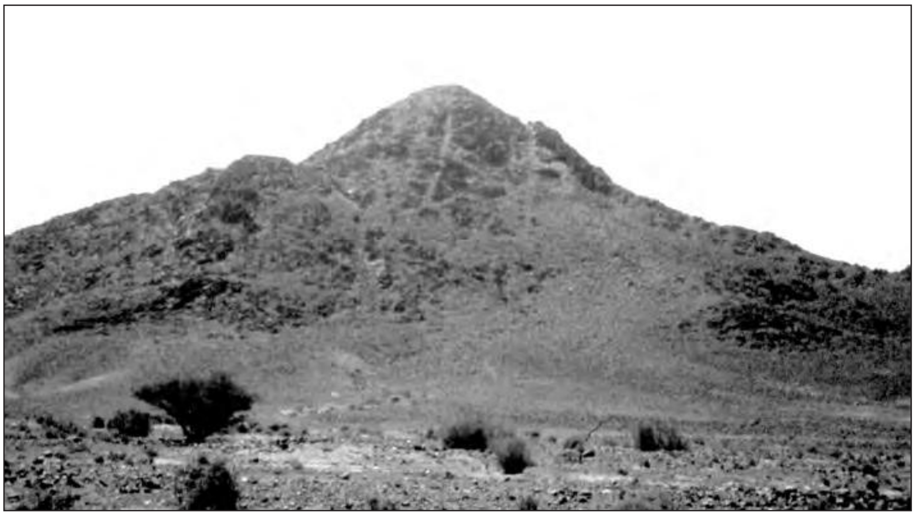


***Figure 9.21** Nabataean activity around Khirbat Faynan, as revealed by sherd distributions over area of major settlement complexes. (Illustration: Paul Newson.)*

ated rectangular building ranges; WF36 is a good example of the type (Fig. 9.24). Several of them appear to have been linked with an important phase in the overall evolution of the field system. WF235 (Fig. 9.25) and 368 are located within WF4 and WF36, WF538, WF645, WF689, and WF1242 all lie close to its southern margins at places where Nabataean sherds have been collected in neighbouring parts of the field system. On the other hand, WF476/WF478 and WF481 were located beyond the western end of the WF4 field system close to the limits of our survey by the modern village of Quarayqira, where shifting sand and modern cultivation have blurred the possible links with additional field systems.

9.8.3 Field systems and farming

One of the keys to understanding Nabataean and early Roman period farming regimes of the first century BC and later is the abundant evidence for dispersed settlement across the survey area. As noted already, indicative of this increased settlement distribution is a number of sites either just to the south or within the southern parts of the WF4 field system. These sites (namely WF35, WF36, WF54, WF358/WF363, WF538, WF689, WF1242) are complex in composition, often taking the form of a rectangular structure or structures in conjunction with enclosures. Their close spatial association with elements of the field group WF4 allows for their interpretation as farms and farmsteads.



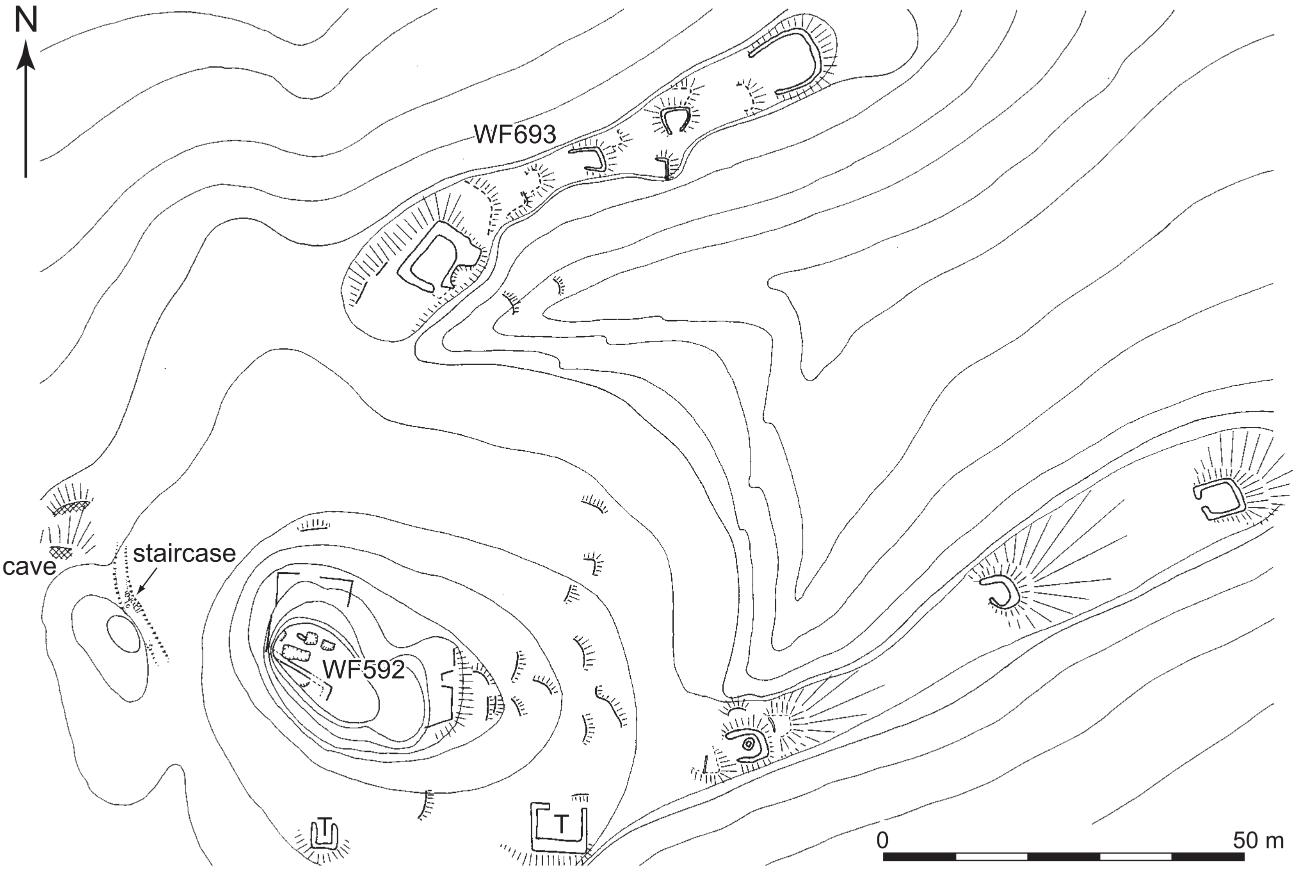


Figure 9.22 *The Tell al-Mirad, 'fort', WF592, general view of summit from below (looking south) and plan. T = tower. (Photograph: David Mattingly; Illustration: Oliver Creighton and Mike Hawkes.)*

Figure 9.23 Staircase to the summit of WF592, looking southeast. (Photograph: David Mattingly.)

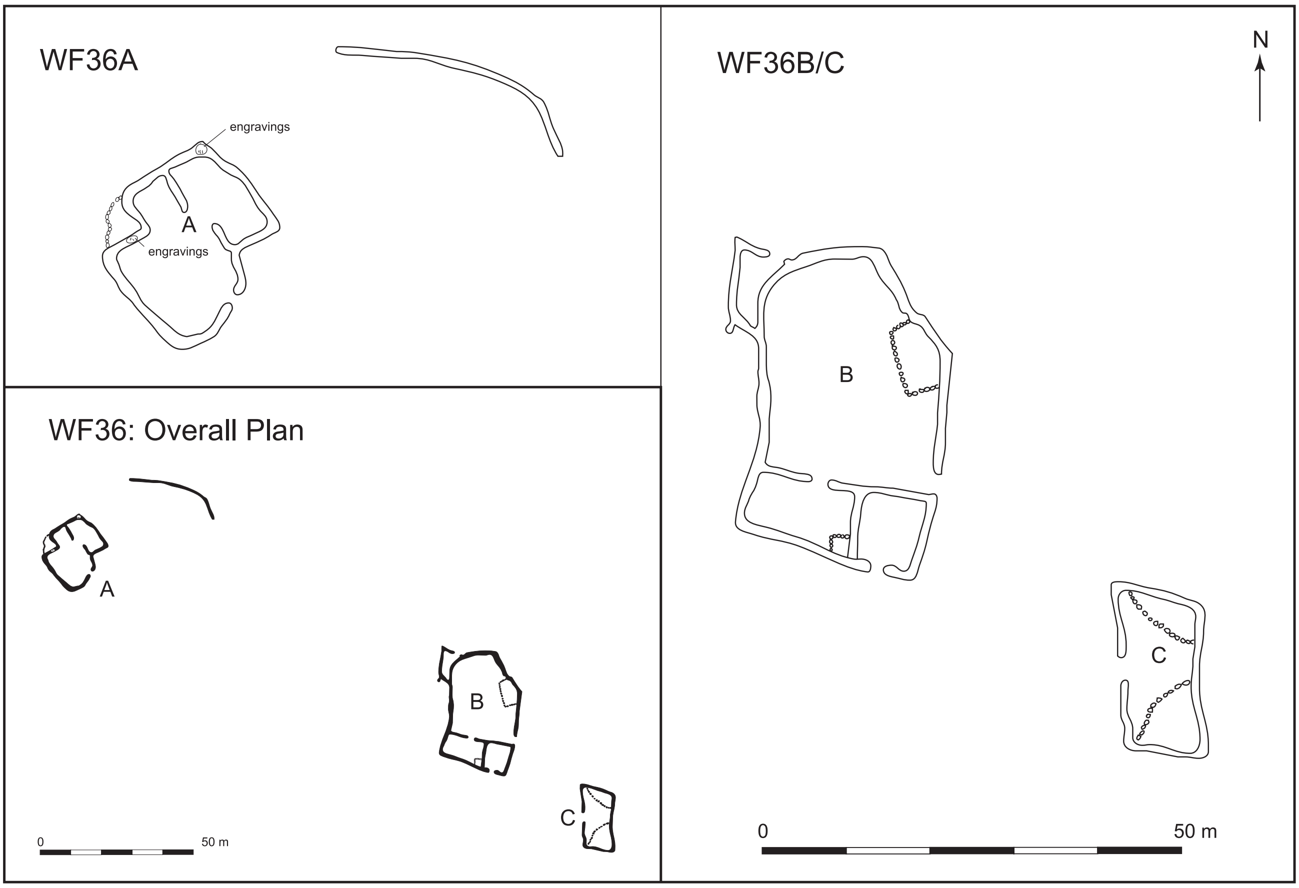


Figure 9.24 *WF36, a probable Nabataean farmstead. (Illustration: David Mattingly and Debbie Miles-Williams.)*

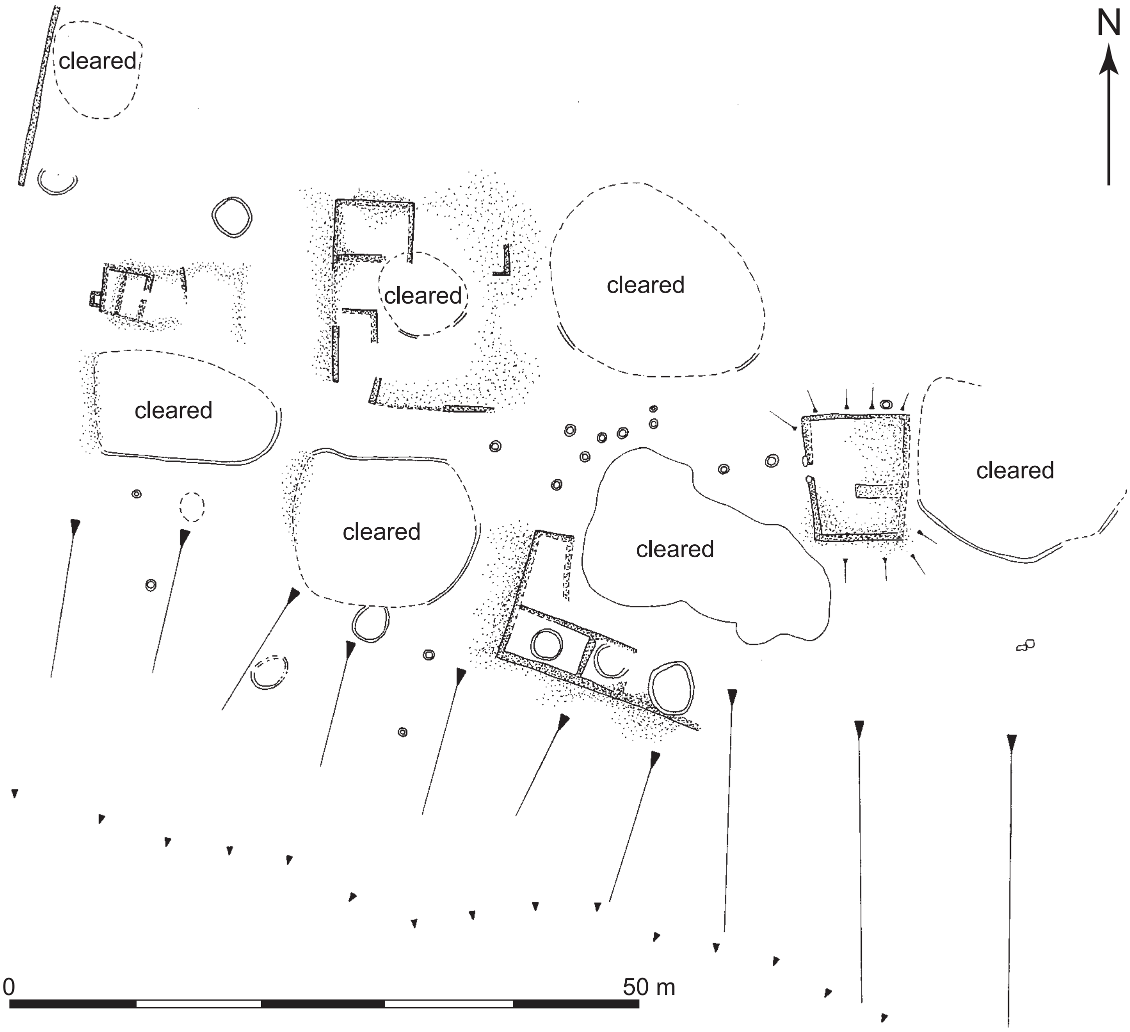


Figure 9.25 *WF235, a Classical-period farm in WF4.1.30 with possible Hellenistic/Nabataean origins on the evidence of sherd concentrations there. (Illustration: Mike Hawkes.)*

Within the field system WF4, several small rectangular or square buildings were recorded abutting, abutted by, or built into field walls (WF66, WF104, WF127, WF128, WF137, WF144). Most of them are situated in the area of fields lying directly to north of the Tell al-Mirad fort WF592 (Wright *et al.* 1998: 37–40). The most plausible interpretation of these is as agricultural buildings for purposes such as storing food or equipment, or as daytime field shelters for agricultural workers or for nightwatchmen (Fig. 9.26).

The relatively little early Hellenistic pottery (relating to the earlier phases of the Nabataean kingdom) is almost entirely limited to a few locations close to Khirbat Faynan and the eastern units of WF4 (Fig. 9.27; Table 9.4). Pottery of later Nabataean date is much more abundant (Fig. 9.28) and many more sites have produced material of this phase than for the Hellenistic phase. A few of the minor structures within WF4 have also been dated through excavation to the Nabataean period (Wright *et al.* 1998: 58). Although virtually all our Nabataean settlement is focused on the south bank of the Faynan, two unusual long 'rectangular' buildings with bowed side walls are known in the next valley to the north (WF664 and WF666, the latter associated with Nabataean pottery), isolated buildings perhaps linked to stock-raising rather than agriculture or mining. Other sites with Nabataean pottery on the north side of the valley include a Bronze Age enclosure (WF485) and a number of other locations where the small numbers of sherds make a link to Nabataean activity uncertain. The low occurrence of pottery in the northern field systems, with the exception of WF442, might hint at a more pastoral form of exploitation of this side of the valley. Excavation is required at some of these sites to test these hypotheses.

If we take the location of the various Nabataean rural structures into account, some suggestions can be made concerning agricultural activity and particularly the use of floodwater farming techniques. On the basis of the distribution of Nabataean pottery within the field system WF4 (Fig. 9.28), the sectors that appear most likely to have become fully developed during the Nabataean period are WF4.1–WF4.3, part of WF4.5–WF4.7, WF4.8, WF4.12, WF4.13–WF4.15, and part of WF4.16–WF4.17. Within this distribution area, the eastern areas of WF4 (generally WF4.1–WF4.6) reveal

Figure 9.26 *Small structure WF61 attached to the Nabataean terrace wall marking the northern edge of WF4.13. (Photograph: David Mattingly, looking northeast; Illustration from Wright* et al. *1998.)*

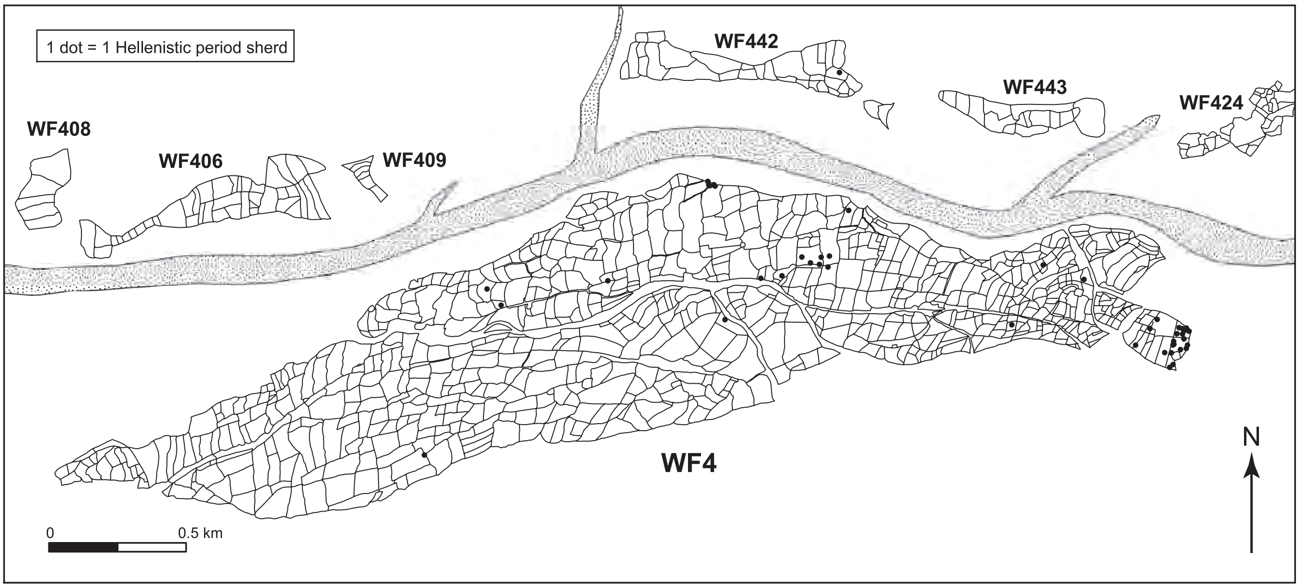


Figure 9.27 *Overall density of Hellenistic sherds in WF4 and associated field units. (Illustration: Paul Newson.)*

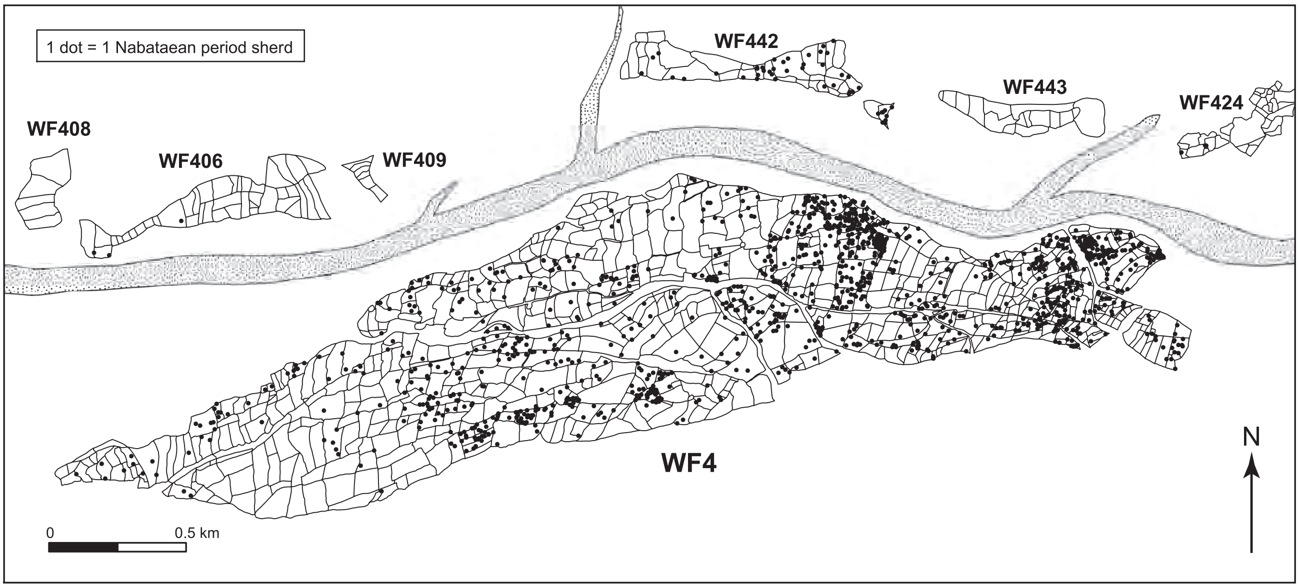


Figure 9.28 *Overall density of Nabataean sherds in WF4 and associated field units. (Illustration: Paul Newson.)*

a relatively rich density of sherds across most field units, whereas in the western units Hellenistic sherds are absent and Nabataean sherds tend to occur in a few small concentrations (that nevertheless often interlink). These different distributions may reflect the existence of a larger consolidated agricultural block close to Khirbat Faynan and a series of more isolated farms and associated wall/field systems lying to its west. The eastern area of WF4, particularly the core areas of units WF4.1–WF4.3 and WF4.6/4.7, appear to have been subject to an organized manuring regime, and are also characterized by systems of floodwater farming employing sophisticated channel diversion. The operation of such systems implies the systematic use of this core region by the inhabitants of Khirbat Faynan. The sherd distribution in the western units (within WF4.12–WF4.16) is smaller scale, often centred on the sites of assumed farmsteads. As there is evidence for ploughing in the units in the western part of WF4, indicated by plough marks to the tops of Bronze Age boulder walls in WF4.13 (Fig. 9.29), it seems clear that the field systems there are related to agricultural use, though it is possible that cultivation was of olives and vines on the steeper terraces of the field units along the southern margins of WF4, crops needing less manuring than cereals.

With the exception of the eastern portion of WF442, there is little evidence of Nabataean pottery associated with the minor field systems in the valley. As noted above, WF442 appears to have been Iron Age in origin, so the evidence for water-management structures here may be in part a

Unit	Iron Age	Hellenistic	Nabataean
4.1	4	21	59
4.2	38		223
4.3	148	2	297
4.4	17	1	54
4.5	29	1	109
4.6	46	2	467
4.7	334	9	217
4.8	52		75
4.9	119	4	82
4.10	117	1	62
4.11	26	1	30
4.12	14		89
4.13	24		95
4.14	27		81
4.15	53	2	78
4.16	1		15
4.17	4	1	15
4.18	5		2
4.19	16		33
4.20	6		7
Total	**1080**	**45**	**2090**

Table 9.4 *Numbers of sherds of Iron Age, Hellenistic, and Nabataean date within the WF4 field system.*

Figure 9.29 *Plough marks of probable Nabataean or Roman date within field unit WF4.13, marking the tops of Bronze Age walls. Scale: 1 m. (Photograph: David Mattingly.)*

Nabataean/early Roman period elaboration or adaptation of an earlier system.

Though a few Nabataean/early Roman farmsteads lie on the ridges beyond the southern edge of the WF4 field system, and are not linked physically to any fields (WF36 and WF5, for example), several zones of the central part of the WF4 field system such as WF4.12 and WF4.13 were centred on probable Nabataean/early Roman farmsteads. Site WF35/WF368, comprising well-built rectangular structures within large open enclosures, is a good candidate as a Nabataean/early Roman farmstead. The site lies in a prominent position on the summit of a long low terrace and has been subject to much reuse, most recently as a bedouin encampment, but appears to have been closely related to well-preserved systems of terraced fields, mostly of uniform size. The walls that surround these systems conform to the contours of the slope, producing a series of wide sweeping walls that extend from WF35 eastwards as far as WF358 (Fig. 5.42). Incorporated within these Nabataean farms were older EBA cairns and sections of orthostatic boulder walls probably of the same date, much as we found when we mapped WF4.13 (Figs 4.12, 9.30), and large orthostats are visible as the footings of several terrace walls (Fig. 9.31). The structure of the (presumed) Nabataean-age walls and the morphology of their fields served to maximize surface run-off and retain sediment. The rather stony nature of the ground may have made these fields more suitable for arboriculture than for the cultivation of cereals, perhaps the reason for the relative paucity of surface sherds in the fields except in those closest to the farms.

It seems that, as with other areas under Nabataean control, the Faynan region witnessed a surge in sedentary population associated with the use of floodwater farming and other agricultural techniques in the latter centuries BC (Bowersock 1983: 73; Evenari *et al.* 1982 [1971]). The association of Nabataean rural sites and advanced floodwater farming hydraulic systems is clear, though at this stage in its development the WF4 field system probably consisted of a series of discrete minor field systems or farm units rather than the single continuous entity we can discern in the Roman/Byzantine centuries (Fig. 10.32). Much of the pottery from our survey that can be assigned to the Nabataean period seems to be of the painted finewares of the first century AD, which Schmid suggests may imply an intense cultural *renovatio* under King Rabbel II (2001: 400–401, n.202). Whether the Nabataean farms of the Wadi Faynan represent such a florescence, or whether the apparent peak in first-century AD ceramics is a function of the particular visibility of these fine wares, are unclear, but could be tested in the future by excavation.

9.9 Historical implications

The coin list for the Wadi Faynan region includes 80 dated prior to the Roman annexation of AD 106, from a total of 1395 coins of all types (Kind *et al.* 2005). The majority (at least 44) consists of Nabataean issues but, in addition to a number of unidentified Hellenistic coins, there are six from the Ptolemaic kingdom including four from Cyprus, and six Hasmonean-Jewish coins. Interestingly, there are no Seleucid issues, suggesting that the external contacts in the

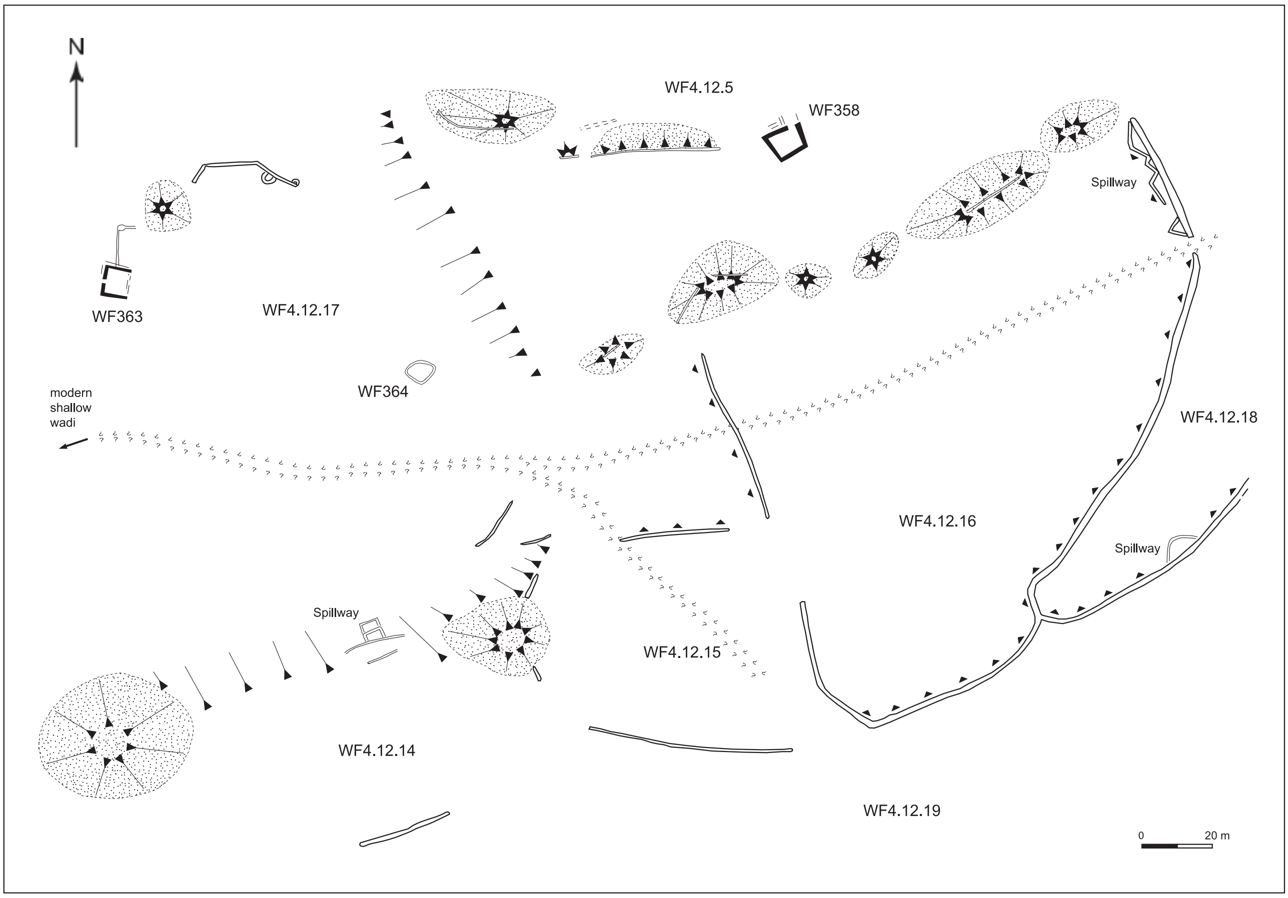


Figure 9.30 *Plan of WF364, and WF4.12.14–WF4.12.17. (Illustration: Paul Newson.)*

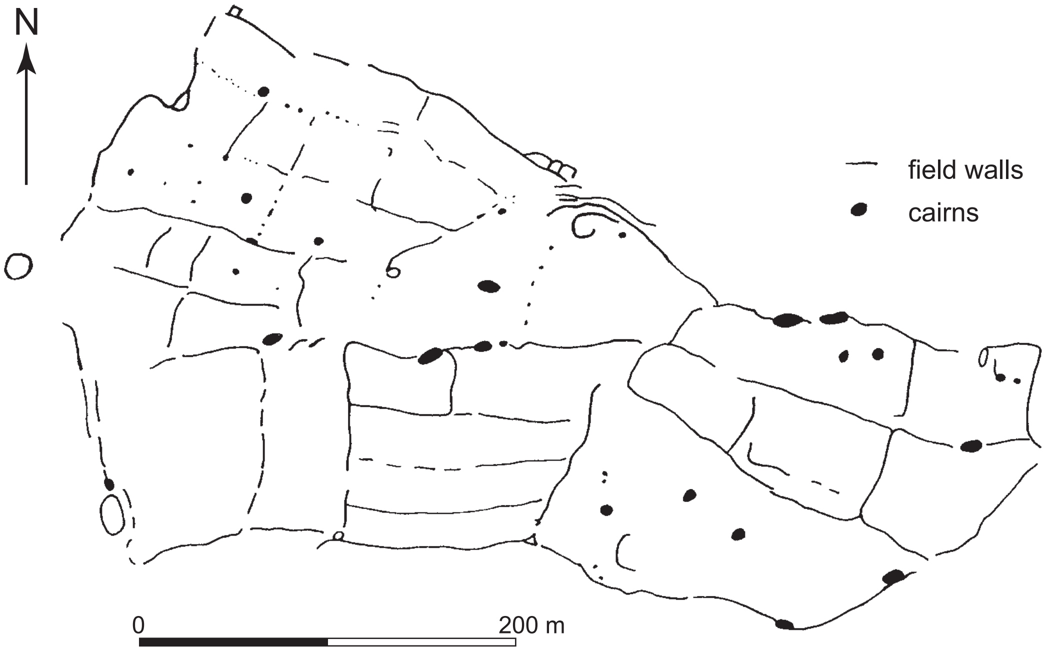


Figure 9.31 *Nabataean fields in Unit WF4.13. (Illustration: David Mattingly, in Barker* et al. *1999: fig. 10.)*

Figure 9.32 *A wall in Unit WF4.12 showing two phases of wall building: the lower is believed to be prehistoric, the upper Nabataean/early Roman. Scale: 50 cm divisions. (Photograph: Paul Newson.)*

Hellenistic period were primarily channelled towards the Ptolemaic kingdom. The predominance of Cypriot issues among the small sample of Ptolemaic coins may indicate contacts between the copper-mining specialists of Cyprus and the Wadi Faynan. There are three pre-annexation Roman coins, hinting at Roman interest in Faynan copper from the reign of Augustus onwards.

The Nabataean occupation of the study area appears to have focused on a substantial tri-partite nucleated settlement around the confluence of the Wadis Faynan/Ghuwayr, Shayqar, and Dana. The full extent and nature of this settlement are unclear (in the absence of excavation it is uncertain how much of the visible structural evidence could be Nabataean as opposed to Roman/Byzantine), but it appears to be different in character from the typical farmsteads of this phase, notably in terms of the quantity of Nabataean pottery and with the occurrence of coins. The only other site of architectural and material pretension was the Tell al-Mirad 'fort' (WF592: Fig. 9.22) a few kilometres to the southwest. Together, these two inter-visible sites would have dominated the wadi and are perhaps suggestive of direct political control from Petra. A chain of other fortified towers and posts can be traced along the Wadi 'Arabah and then up the easiest passes to Petra (Lindner 1987: 291–4), suggesting that Petra had a particular interest in exercising control down into the Wadi 'Arabah. In the case of Wadi Faynan, such control would seem more likely to have been associated with the renewed exploitation of its copper sources, even if on a very much reduced scale compared with earlier Iron Age mining, than with the small farmsteads that dotted the wadi floor. In this respect it may be significant that Nabataean bronze coins contain a very high percentage of copper, over 98 per cent in two analysed examples (Kind *et al*. 2005: 184). It will not be a surprise if future work can pinpoint its source as Wadi Faynan copper, and associate one or more of the numerous slag heaps with this phase. At the Roman conquest such resources will have been a prime target of interest and will likely have passed into the control of the Roman state, even if the active development of the mines was initially slow.

The putative Nabataean recommencement of copper mining and smelting at Khirbat Faynan, rather than in one of the other copper-rich valleys of the Faynan area, may have related to the greater potential of the Wadi Faynan for run-off water farming. Certainly some extensive areas of the WF4 field system seem to have been established at this time, integrating previous Bronze Age and Iron Age systems where they existed. A second and equally important factor was the existence of good springs in the Wadi Ghuwayr that could be utilized by the settlement at Khirbat Faynan. Finally, if there was renewed copper smelting at Faynan in the Nabataean period, this may well have provided additional motivation for the Roman annexation of the territory, which remains a somewhat murky episode in the *Realpolitik* of the empire (Freeman 1996).

10. A landscape of imperial power: Roman and Byzantine *Phaino*

David Mattingly, Paul Newson, Oliver Creighton, Roberta Tomber, John Grattan, Chris Hunt, David Gilbertson, Hwedi el-Rishi, and Brian Pyatt

10.1 Introduction

This chapter reviews the evidence for the later Classical era, concentrating on the Roman to Byzantine exploitation of the mineral wealth of Faynan. The Roman-period archaeology focuses on Khirbat Faynan and an impressive group of associated sites connected with the copper mines. A major point of debate concerns the status and organization of the Roman/Byzantine mining operations. The literary sources indicate that during the Great Persecution at the beginning of the fourth century AD a location named *Phaino* was under state control as an imperial mining operation (*metalla*) (see *inter alia*, Eusebius *De martyribus Palaestinae* 7.1–2; 8.1; 13.1, 4–10; *Ecclesiastical History* 8.13.5; Athanasius *Historia Arianorum* 60; *Collatio legum Mosaicarum et Romanarum* 15.3.7; Epiphanius *Haer.* 68.3.6, summarized by Sartre 1993: 139–42). It is generally agreed that this correlates with Wadi Faynan, and that *Phaino* was the ancient name for Khirbat Faynan (Lagrange 1898; 1900). Imperial control may have been established far earlier and have extended considerably later (with some later fourth-century references to schismatic Christians being sent there by Christian persecutors: Athanasius, *Historia Arianorum* 60), but our source evidence primarily concerns an extraordinary (and brief) period of persecution of Christians condemned to the mine workings (Gustafson 1994).

An important research question for our project was thus whether the surface archaeology could elucidate the sequence of development here and shed light on the practical administration of such sites. How were the mining and smelting operations staffed and how was the workforce supplied with food and other necessities? How did the mine interact with other people living in and exploiting the region, as pastoralists, wadi farmers, and so on? Another recurrent theme of this book concerns the impact of the metallurgical activity on environment and lifeways in the valley. The environmental evidence provides a consistent picture of the Roman/Byzantine period as a time of peak levels of heavy metal pollution from the smelting activity (see below).

Little is known of the site before it entered Bishop Eusebius's account of the Great Persecution in the early fourth century, but it was clearly at that date under Imperial control and being managed as part of the *res privata* of the emperor. It is plausible, though at present unprovable, that the copper mines had been taken into state ownership from the moment of the Roman annexation of the Nabataean kingdom in AD 106–111 – ore deposits were one of the key resources that drove imperial expansion (and helped pay for it). Tacitus, for instance, described the mineral resources of Britain as the 'spoils of victory' (*Agric*, 12.6: *Fert Britannia aurum et argentum et alia metalla, pretium victoriae*).

The Roman system for managing and exploiting mineral sources and outcrops of decorative stone was somewhat *ad hoc*, albeit informed by some guiding principles (see Hirt 2004 for the fullest recent review). Practice also changed over time, with private individuals much more important in Republican mining operations in Spain, for instance, but with an increasing bureaucracy of imperial officials overseeing mining districts in the Principate. In principle, from the time of Tiberius any significant mineral deposit and decorative stone source could come under imperial control (Suetonius, *Tiberius* 49.2). Although it had long been Roman practice to confiscate significant natural resources

* *Archaeology:* David Mattingly, Paul Newson, Oliver Creighton, Roberta Tomber. *Geoarchaeology, palaeoecology, and geochemistry:* John Grattan, Chris Hunt, David Gilbertson, and Brian Pyatt.

for the state, it is also apparent that not all mines and quarries were confiscated: in practice, it tended to be the precious metals, coloured marbles, granites, and the larger sources of copper and iron that were taken into imperial control. It is clear that there was no overall central directorate of mines and quarries (*contra* Cuvigny 1996), nor a standard blueprint for their operation although, interestingly, the same term (*metalla*) was used in the sources to describe both imperial mining and quarrying operations. Basic differences in the geology and nature of the extractive (and smelting) process also introduced significant variations in the operation of mines and quarries. The distinction between state property and imperial property was sometimes a grey area in operational terms, though they remained separately defined categories into Late Roman times. However, since the emperors appointed most of the officials to run both imperial and state *metalla*, there was overlap in terms of personnel and practices.

There were two main options in relation to the exploitation of the *metalla*: either to run them directly with imperial officials in charge of the day-to-day operations on the ground, or to lease the workings to contractors who paid a fee and a percentage of production, with officials overseeing arrangements from a distance. A hybrid variant, encountered at *Vipasca* in southwestern Iberia for instance, involved the presence of a key official (procurator of the mining district) at a central settlement, who regulated contracts with numerous contractors who undertook all manner of work on a monopoly basis, from mining and smelting to shoe-making or running the bathhouse (Domergue 1990).

A common misconception is that *metalla* were run largely as prison camps for convict/slave labour, a perspective that owes much to the accounts of the Christian sources. In reality, the highly technical nature of mining, quarrying, and smelting often demanded the presence of specialists. Moreover, the productivity of free labour in difficult living conditions often far exceeds that of forced labour gangs. It is no surprise to find ample evidence in Egypt and Dacia, for instance, for the employment of free labour alongside those condemned to the mines or quarries as punishment for serious crimes (Cuvigny 1996).

Nonetheless, convict labour was a component at many imperial mining and quarrying sites and was maintained through the regular operation of the provincial assize courts. Only the most senior magistrates, such as Provincial governors, had the right to condemn people to the mines for specified serious crimes, such as aggravated burglary, armed brigandage, pillaging of shipwrecks, despoiling boundary markers or irrigation works, violation of tombs, cattle or horse rustling, religious sacrilege and temple thefts, embezzlement of public money, or theft from the mines (*Digest*, 47.9.4.1–2; 47.12.1.1–4; 47.17.1–3; 47.18.1–2; 48.13.6 will give a flavour). There was a clear attempt here to provide a deterrent for certain categories of criminal or anti-social behaviour. Wealthy and high-status individuals accused of these crimes were generally excused the severest penalties of being condemned to *opus metalli* or (worse) *metallum*, so the majority of those sent to mines like *Phaino* in normal times were men of low status or slaves convicted of violent crimes (Hirt 2004: 73–7; Millar 1984: 137–40). The existence of two distinct categories of hard labour at the mines is interesting – apparently those sent for *opus metalli* were not as heavily chained, but the distinction may also have related to function at the mines. Some women were also condemned to the mines, normally under the separate category of *ministerium metallicorum* (*Digest*, 48.19.8.8). The meaning is obscure, but may well have related to secondary roles such as ore picking and ore dressing. Those condemned to the mines were routinely beaten, marked for ease of identification with tattoos or brands on the forehead, had their scalps half shaved, and were shackled with leg irons (Millar 1984: 128). We shall return to the question of the labour of the mines below, when we shall see that there is evidence of even more extreme mutilation and violence to the body during the Christian persecutions.

The Christian accounts of *Phaino* indicate that it was a large-scale mining operation, run by imperial officials and with soldiers either present at the mines or close at hand. They also highlight the threat that the evolution of Roman judicial deterrence posed for wider groups in society when their religious beliefs were criminalized – respectable and even upper class men and women were swept up in the Christian persecutions and it must be appreciated that they will have been quite different from the normal clientele of the forced labour gangs (Millar 1984: 147).

The starting point for our interpretation of the Roman and Byzantine evidence from Faynan is that it is a representative case of an imperial mining landscape, probably for much of its existence under direct imperial organization. A good comparative example of this type of situation concerns the extraordinary measures put into effect by Rome to exploit the granites and porphrys of the Eastern Egyptian desert, now revealed in full detail by the work of the Mons Claudianus and Mons Porphyrites projects (Maxfield 2001; Maxfield and Peacock 2001a,b; Peacock and Maxfield 1997). The scale, complexity, and expense of the enterprise there is revealed by the establishment and maintenance of quarries, slipways, and workshops, forts and fortlets, settlements for workers, animal feeding stations, wells, tracks and roads, and massive wheeled vehicles to transport columns up to 200 tonnes in weight across the desert to the Nile (see Maxfield 2001 for a succinct summary). The research has also highlighted the need to assemble and provision a very large and skilled workforce. The documentary records of the quarry sites, in the form of many ostraca on site and associated papyrological evidence, reveal a high level of organization of everything from orders for bread to the requisitioning of hundreds of draft animals (principally camels) from settlements along the Nile and in the Fayum (Adams 2001 details the complex arrangements made for requisitioning animals). They also demonstrate that most of the quarry

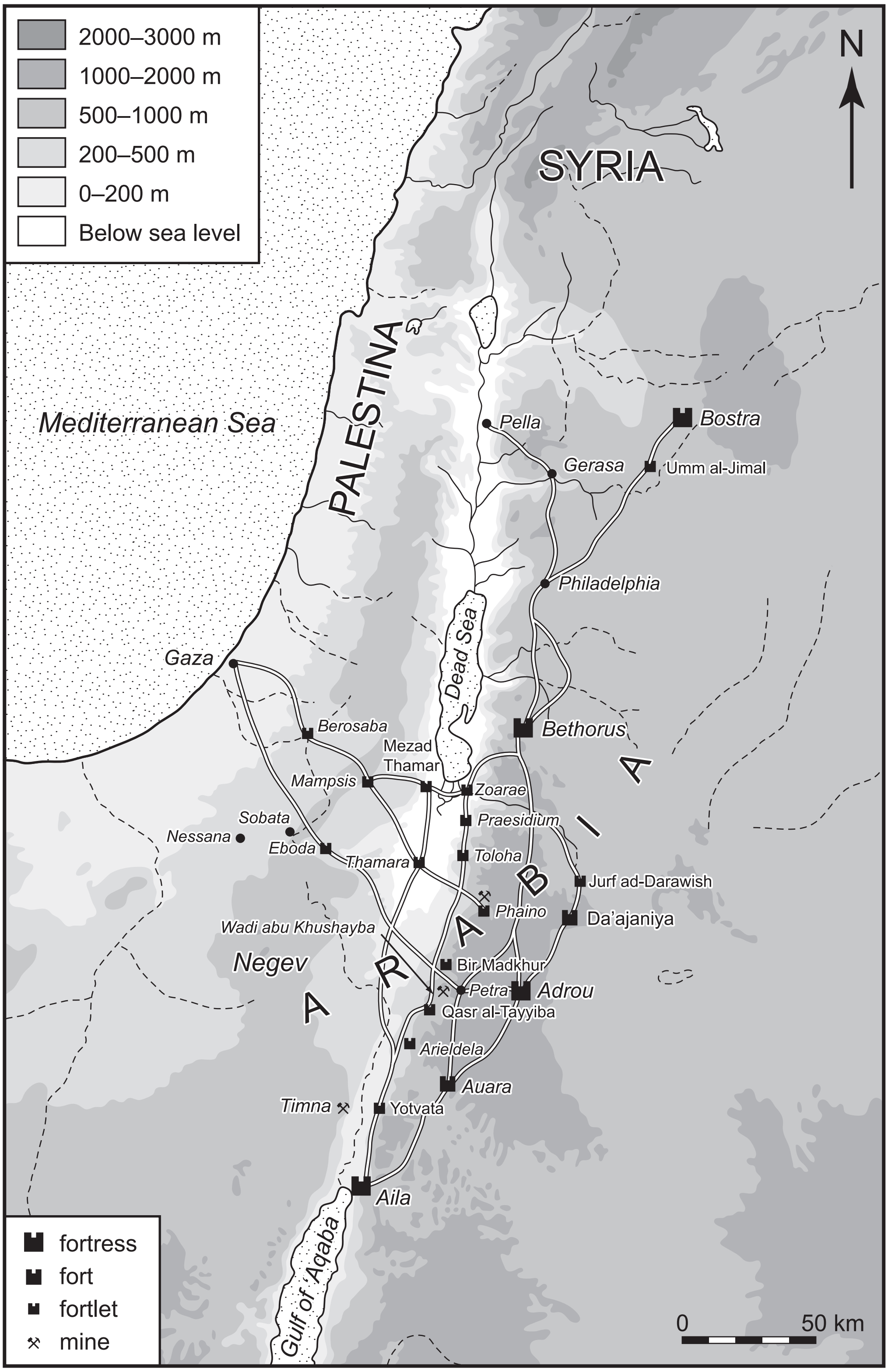


Figure 10.1 *Map of the Roman Levant, with principal sites mentioned in Chapter 10. Ancient names in italic. (Illustration: Dora Kemp and David Mattingly.)*

workers were paid wage earners rather than the slaves of popular imagination (Cuvigny 1996). The palaeobotanical studies of van der Veen (1998) have demonstrated that the diet of many of the people at the quarries was better than had been previously imagined (when a predominantly slave labour force was envisaged), the vast bulk of those foodstuffs being produced in the Nile valley several days journey to the west and imported. Fish bones indicate that some commodities were also obtained from the Red Sea ports on the coast to the east of the mines. The pottery assemblages are also revealing of the supply mechanisms of an imperial operation (Tomber 1996). What the Egyptian quarries highlight are the lengths and expense that the Roman State was prepared to go to in order to control the supply of both everyday necessities and of selected high-status commodities.

It is likely that the organization of the Faynan copper mines was not dissimilar in type if not in every detail. The scale of production, the relative isolation and the desert setting of the mines, all contribute to a situation that was broadly commensurate with the Egyptian case study described above. What we lack in Faynan is the wealth of everyday documentation (pottery ostraca and papyri) that has come from excavations in Egypt to supplement the limited primary source material and the surveyed remains. Nonetheless, the Faynan study presented here is a valuable addition to a limited number of detailed studies of Roman *metalla* (Domergue 1990; Orejas 2001; 2003; Sánchez-Palencia 2000, on the impressive Las Medulas evidence; Mackensen 2005; Rakob 1993 on the marble quarry at Chemtou).

The location of *Phaino* within the provincial and military infrastructure of Arabia and Palestine was a significant factor in the development and maintenance of the mines (for up-to-date mapping of the region at 1:1,000,000 scale, see Talbert 2000: maps 70–71; Tsafrir *et al.* 1994). The Wadi Faynan was initially included in the Roman province of *Arabia*, which was created out of the Nabataean kingdom with a capital at *Bostra* and with *Petra* as the major city in the south (Bowersock 1983; Freeman 2001: 433–44). When Arabia was subdivided into two parts in AD 295 or shortly after, the southern territory in which Faynan was placed became the new province of *Palestina Salutaris* (Millar 1993: 201–2). From the early fifth century this province, covering the Negev, the southern ʻArabah, and the plateau region as far north as Karak, was renamed as *Palestina Tertia* (Dauphin 1998).

Fundamentally, this remote desert location had communication and supply links with three key areas of Roman/Byzantine power (Fig. 10.1). A major road linking the site with the Mediterranean port of Gaza approached from the northwest across the Negev, via *Mampsis*. A north to south route linking the Dead Sea and the Red Sea passed a short distance to the west of the Faynan valley down the Wadi ʻArabah, with the Red Sea port at ʻAqaba the terminus. Roman garrisons based in the Wadi ʻArabah corridor probably supplied any troops out-posted at Faynan. The third route was the steep ascent up the Wadi Dana to the northeast of *Phaino*, to gain access to the plateau lands beyond the mountain escarpment. Further Roman roads ran north to south up this upland spine, connecting Faynan with Roman garrison posts and the major urban centres east of the River Jordan Valley. There was at least one alternative route up the escarpment towards the administrative centre of *Petra*, via Bir Madkhur, *c.*30 km south from Faynan.

The essential story of the Roman period in the Wadi Faynan region is thus that of an imperial power refashioning a landscape in order to exploit its resources. The nature of the Roman settlement and activity falls outside the norms of what one might expect of such a region. The political economics of an empire can be read in the landscape that resulted. The slag heaps at *Phaino* suggest that it was among the largest producers of copper in the Eastern Empire, second only to Cyprus, yet the site has often been overlooked in accounts of *Arabia* and *Palestina*. It is missing from both Ptolemy's geographical listing of significant places in the early second century AD and the late fourth-century *Notitia Dignitatum* that documents forts and significant imperial sites. Several modern studies of the region do not mention it at all (Ball 2000; Dauphin 1998; Safrai 1994; Sartre 1991). Yet this was clearly a long-lived mining operation, maintained in a very difficult desert environment long after the major mining centres of the Western Empire had declined in output (Edmondson 1989).

10.2 Roman copper exploitation in the Wadi ʻArabah region

A notable contrast between the Iron Age exploitation and the Roman/Byzantine activity is the apparent contraction to, and concentration of production at, the single main smelting site at *Phaino* in the latter phase. However, whilst *Phaino* appears to have been the largest Roman copper-smelting site in the Wadi ʻArabah, it was not the only one.

At the southern end of the ʻArabah corridor there was also some renewed mining activity in the Timna region (Fig. 2.1). Here, the huge scale of the early exploitation (Rothenberg 1999a) and the Egyptian control of the mines from the fourteenth down to the twelfth centuries BC, had substantially worked out the most accessible copper deposits. Nevertheless, Roman mining activity has been detected on the fringes of the Timna valley and in the Wadi Amram a few kilometres to the south, with a main smelting site at Beer Ora (Rothenberg 1999b: 162–3; Willies 1991). At Wadi Amram, only *c.*11 km from the Red Sea, Roman underground mining was characterized by a number of different techniques that produced dumps of pulverized mine waste at the surface (features also highly visible in the Faynan region). One extensive Roman mine network that has been mapped in detail comprised a complex system of narrow galleries and shafts (Rothenberg 1999b: 164–6, with fig. 24; Willies 1991: fig. 7). The working life of the nearby smelting site at Beer Ora, marked by three large slag heaps representing at least 5000 tonnes of tap slag, extended into the Early Islamic period. The associated buildings were built of slag blocks and of simple form (Rothenberg 1999b: 166–8).

There is also at least one mine working of typical Roman pillar and gallery form southwest of *Petra* near Sabra (Lindner 1987: 293; Meshel 2006: 230–36), part of a group of mine-workings on the route between *Petra* and the Wadi abu Khushayba area *c*.40 km south of Faynan (Fig. 10.1; Hauptmann 1986, 2000: 3, 21; Kind *et al*. 2005: 192). The abu Khushayba activity has been associated in one recent account with a reference in the *Onomasticon* of Eusebius (a listing of biblical place names, with brief commentary) to gold mining: 'mountains full of gold in the desert…lay beside the mines of *Phaino*n': text in Freeman-Grenville 2003: 64; discussed by Meshel 2006: 236–7). The core idea of parallel Roman exploitation of gold resources is quite plausible and supported by elevated trace elements of gold in deposits from Wadi abu Khushayba (Meshel 2006: 237) and from our own analyses in Wadi Faynan. Parallels can be found in the Eastern Egyptian desert, where there were gold mines close to and sharing infrastructural investment with the stone quarries (Maxfield 2001: 143–5).

However, while there is some evidence of additional Roman period mining and production elsewhere in the 'Arabah region, this appears to have been based on much smaller-scale operations than those encountered in the Wadi Faynan. It is unclear whether the secondary production sites were run as imperial *metalla* or simply sub-contracted to others.

10.3 The Roman army in southern Jordan

Throughout its existence, *Arabia* was a frontier province, with security dependent on a network of roads and control points (forts, fortlets, towers), especially in the arid margins of the cultivated belt (Graf 1997; Gregory 1995/1997; Kennedy 1996: 9–24; Kennedy 2000; Kennedy and Bewley 2004: 171–93; Parker 1987). Comparison with the Egyptian desert quarries might suggest the presence of a fort for a substantial garrison at such *metalla* sites (Maxfield 2001: 150–53). To date there is no evidence of a major fort at *Phaino*, but there are good candidates for smaller outposts (fortlets) that could have housed detachments of troops assigned to the mining administration. The ultimate source of these outposted troops may well have been larger garrison posts based in the Wadi 'Arabah or on one of several main routes across it (Karak–*Mampsis*–Gaza; *Petra*–*Eboda*–Gaza; *Phaino*–*Mampsis*–Gaza) that linked the Jordanian plateau to the Mediterranean across the Negev (Kennedy 2000: 193–4). At the southern end of the 'Arabah route was the ancient port of *Aila* ('Aqaba), site of a Late Roman garrison point for the *legio X Fretensis* (Eusebius, *Onom*. 6.17–21; *Notitia Dignitatum*, *Or.* 34.30) and this important site potentially could have been a military base earlier (Kennedy 2000: 194–5). The Roman fort/forts at *Aila* have as yet not been traced on the ground.

Most of the known sites of potentially Roman military character in the southern Wadi 'Arabah are relatively small scale: fortlets rather than forts capable of accommodating a unit of 500 men (Kennedy 2000: 197–204). The morphology of these sites is akin to the small *quadriburgi* of the Late Roman army, when units were much reduced in size and status. Although inscriptions from the fortlets themselves are currently lacking, it has been argued that the *Notitia Dignitatum* (*Or.* 34.26, 34.34, 34.35, 34.44) indicates the presence of the *cohors II Galatarum* at *Arieldela* (Gharandal?), perhaps correlating with a 37 m square fortlet with projecting towers; the *ala Constantiana* at *Toloha* (Qasr at-Talah, a 40 m square fortlet); the *ala II Felix Valentiana* at *Praesidium* (Qasr al-Faifah), where two sites are noted, one *c.*105 m square, the other 53 × 46 m); and the *equites sagittarii indigenae* at *Zoarae* (probably as-Safi, but no ancient fortifications preserved) (Kennedy 2000: 197–204). Whilst the precise identifications of sites mentioned in the *Notitia* are controversial, some of these attributions seem reasonable and their locations in the 'Arabah district are confirmed by other sources, such as the Late Roman edict from *Berosaba* (Beersheva) apparently naming garrison positions (Kennedy 2000: 24). There are further *quadiburgi* known at Bir Madkhur, Yotveta, Mezad Tamar, and the Negev towns of *Mampsis*, *Nessana*, and *Eboda*, while *Berosaba* was another Negev centre with a long military presence (Kennedy 2000: 209–12). There was also a significant military presence along the eastern desert fringe of the Jordanian plateau, notably linked to the great military road the *Via Nova Trajana* (Graf 1995). Troops based on this route could also have been seconded to the Faynan mines down the Dana gorge (Kennedy 2000: 144–73).

Thus the failure to identify a major Roman fort at Faynan itself should not occasion surprise. First, the general pattern of Late Roman garrisons in the 'Arabah region appears to have been based on a network of small outposts (and as we shall see there are indeed candidates for such structures at Faynan); and, second, the mines are set in a desert landscape traversed by roads with regular military control-points. Soldiers were close at hand when required, but the remote and closed-in location of the Faynan mines helped the mining authorities maintain order with minimal force, allowing troops to be deployed more widely in the region to oversee and protect the supply and export routes.

10.4 The Roman mining landscape around Faynan

There are several problems with forming our view of *Phaino* from the archaeological evidence (Fig. 10.2). One is that power is somewhat intangible in the archaeological record. There is a strong impression that this was a highly organized and controlled landscape, in which little could happen without official sanction, but it is impossible to demonstrate this incontrovertibly (though excavation at key sites may help in this regard). Another problem is that many of the most prominent features date to the very late Roman and Byzantine phases, obscuring evidence from the earlier Roman phases. The prime components of the Roman landscape of Faynan were a major settlement for

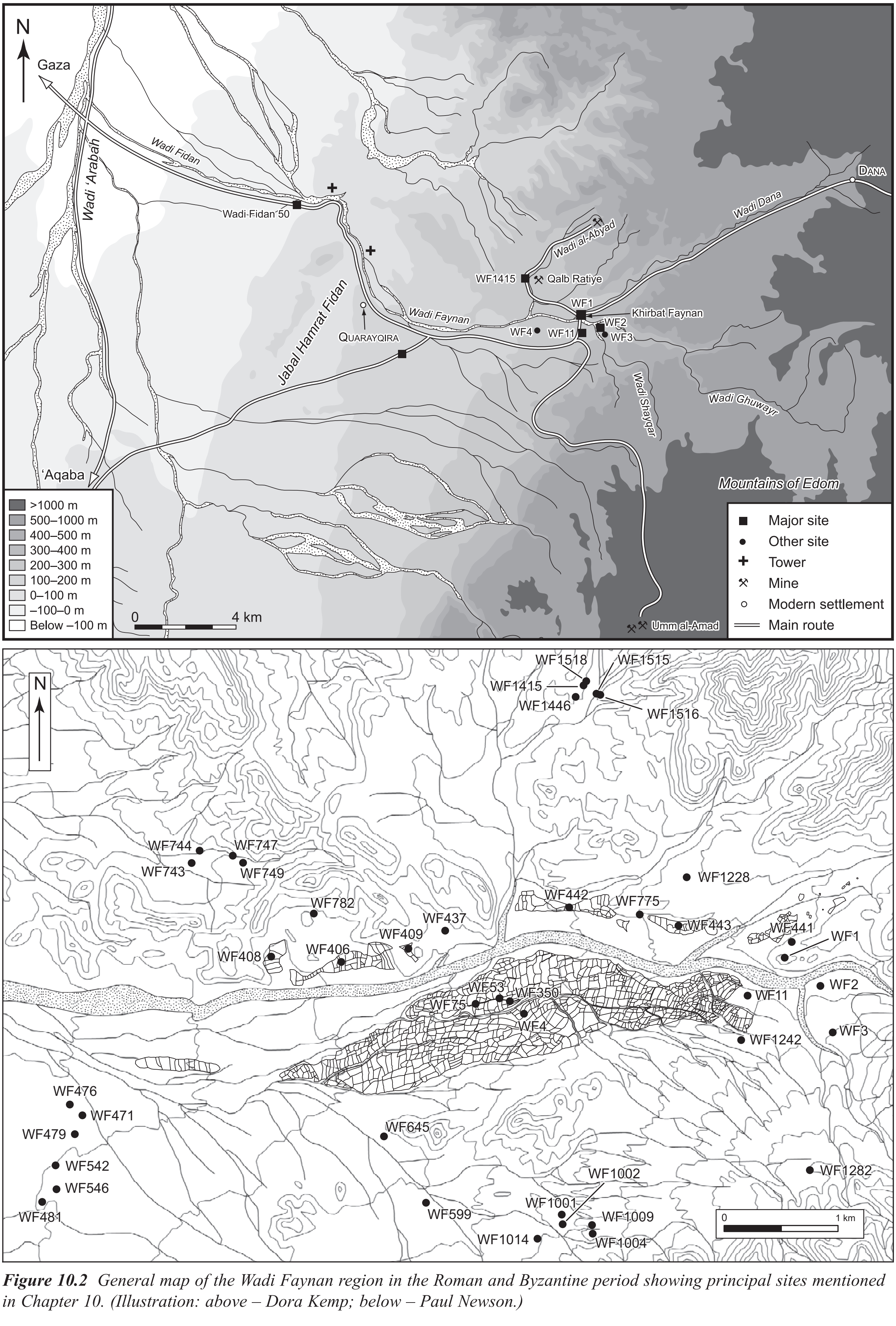


Figure 10.2 General map of the Wadi Faynan region in the Roman and Byzantine period showing principal sites mentioned in Chapter 10. (Illustration: above – Dora Kemp; below – Paul Newson.)

Figure 10.3 *The entrance to the main mine at Umm al-Amad, looking northeast. (Photograph: David Mattingly.)*

Figure 10.4 *The interior of the Umm al-Amad mine with its rows of rock arches, looking south. (Photograph: David Mattingly.)*

Figure 10.5 *Entrance to one of the Qalb Ratiye mines (WF1576), looking south. (Photograph: David Mattingly.)*

Figure 10.6 *Cramped gallery and shaft inside one of the Qalb Ratiye mines (WF1573), looking south. (Photograph: David Mattingly.)*

the administration of the mining district, where virtually all the smelting activity was also centralized, numerous mines and associated settlements, and the further evolution of the major field system WF4. We argue in this chapter that all these elements came under direct state control for some part of the period under review. In what follows, we define the 'Late Roman period' as AD 150–363, the 'Early Byzantine' as AD 363–502, and the 'later Byzantine' as AD 502–636, though the chronology derived primarily from ceramics is necessarily coarse. The close dating of many components of the landscape from surface assemblages of pottery is also difficult and to some extent the approach here has been to present an aggregate picture of Roman/Byzantine activity, although the evidence must incorporate some degree of change over time.

10.4.1 The mines

The mines in the Wadi Faynan have been studied in detail by Weisgerber, though to date only partially published (for instance, Weisgerber 1989; 1996; 2003; 2006: 17–25; cf. Meshel 2006: 233 for Umm al-Amad and 235 for abu Khushayba; Willies 1991 for a detailed survey of a Roman mine close to Timna). A general listing of the Bochum surveys of mining and smelting sites is provided by Hauptmann (2000: 62–100; 2007: 85–156). The basic forms of workings of Chalcolithic, Iron Age, and Roman/Byzantine date are believed to be distinguishable (Hauptmann 2000: 96–100), though the extent of reworking of old workings in subsequent periods will always be difficult to disentangle. About 55 separate workings have been identified in the Wadi (or Qalb) Ratiye area just north of Khirbat Faynan (Hauptmann 2000: 79–81; 2006: 128–9, 2007: 112–15; Hauptmann and Weisgerber 1987: 426–7; Hauptmann *et al.* 1985: 190–93 report Roman pottery of second- to third-century date). In addition, there were ten Roman mines in the nearby Wadi Abyad, one attested re-opening of a mine in the Wadi Khalid and at least four Roman workings *c.*12 km to the south at Umm al-Amad (Hauptmann 2007: 115–16, 144–5; Meshel 2006: 230–35). Smelting from all these mines appears to have been centralized at Khirbat Faynan itself. The scale of Roman copper production round WF1 appears to have been considerable, perhaps in excess of the 40–70,000 tonnes of slag and 2500–7000 tonnes copper estimated for this phase by Hauptmann (2000: 97).

The main Roman mines appear to have targeted low-grade MBS ores in the Qalb Ratiye/Abyad area, 2 km north of Khirbat Faynan (see Chapter 2 for the terminology and

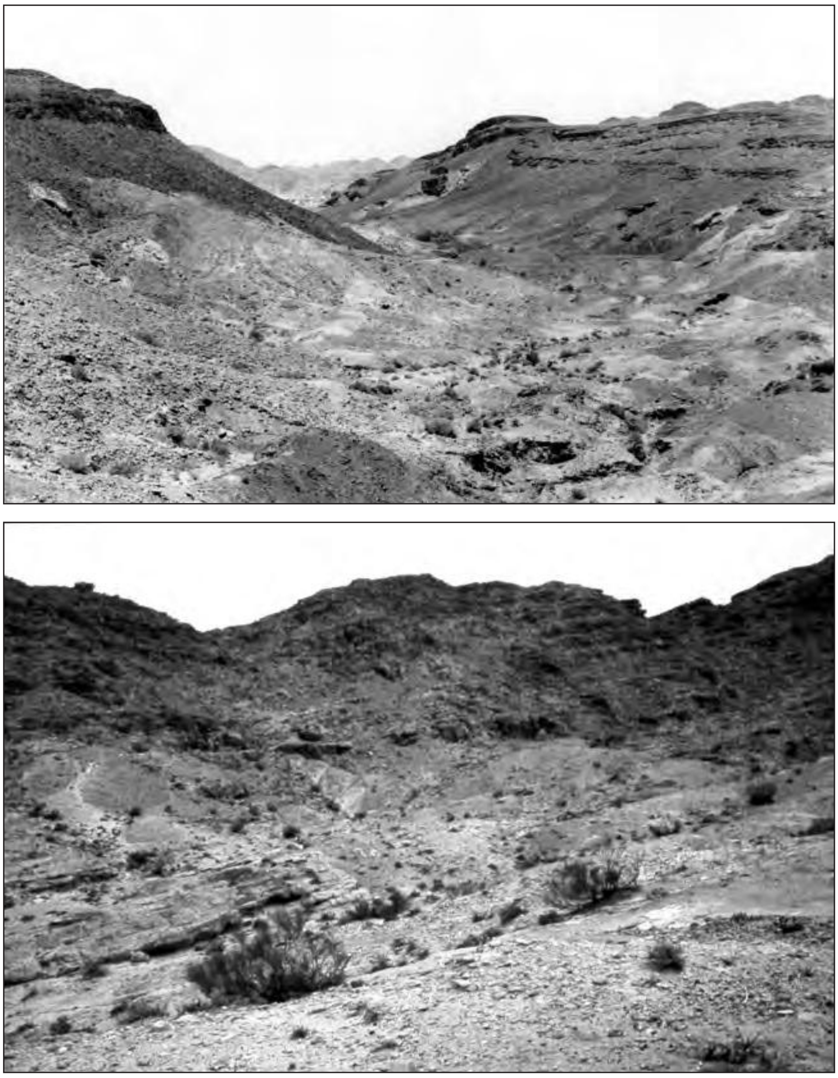


Figure 10.7 *General views of Qalb Ratiye, showing the presence of numerous mine waste heaps, (above) looking northwest, (below), looking southeast. (Photographs: David Mattingly.)*

geology of these ores). There is also evidence that the Upper Umm Ishrin Sandstone was exploited at Umm al-Amad, though whether for copper or gold is disputed (Meshel 2006). The higher-grade DLS ores previously exploited in the Bronze Age and Iron Age mining phases are believed by Hauptmann (2007: 155) to have been worked out by this date, leading to the switch. However, some Roman ceramics and coins have been noted around mines in the Wadis Dana, Khalid, and al-Abyad; when linked with the Nabataean/Roman date of the addition of a third shaft at the double-shaft Iron Age mine in the Wadi Khalid (Fig. 9.9), this strongly suggests that there was some additional reworking of the DLS ore beds (a point also conceded by Hauptmann 2007: 121). However, the distinctive pollution signature of the Roman-period smelting activity indicates that the Roman mining operations overall focused predominantly on the MBS ore-beds.

The indisputably Roman mines are generally characterized by horizontal (or gently sloping) adits and galleries connected by a network of vertical shafts (Hauptmann 2006: 129 for a plan of a typical example). These mines used a distinctive technique of leaving natural rock arches to support the roof of galleries, a feature that differentiates them from the earlier Bronze Age and Iron Age shafts and adits. Umm al-Amad ('Mother of the Pillars') had a uniquely large main gallery (120 × 55 m by up to 2.5 m high) supported on rows of undug rock arches (Hauptmann 2000: 94–5; 2007: 144–5; Meshel 2006: 233). However, the entrance to the mine is very low, requiring entry on all fours (Figs 10.3, 10.4). Other mine entrances in the Qalb Ratiye show similar characteristics, with low and narrow entry spaces that could be easily controlled by those supervising the workforce (Figs 10.5, 10.6). The implication would appear to be that some part of the mine labour was provided by convict gangs whose freedom to exit from the workings was closely circumscribed. Although some other large galleries are reported that were potentially large enough for the use of animals underground (Khouri

Figure 10.8 *The major Roman-period slag heap at Khirbat Faynan (WF11), looking east. (Photograph: David Mattingly.)*

1988: 126), the predominant characteristic of these Roman workings was of cramped, dangerous, low crawl spaces, where the minimum of parent rock was removed around the ore-bearing material (see Fig. 4.39 for a plan and elevation of a Roman mine in Qalb Ratiye).

10.4.2 Minewaste heaps

One of the most characteristic traces of the Roman mines comprises the surface dumps of finely crushed mine waste (Figs 4.45 lower, 10.7). Basic processing of copper ore was thus carried out at the mines, as the centralization of smelting at Khirbat Faynan made it essential to minimize the bulk and weight of material to be transported from mine to furnace (Hauptmann 2007: 114). However, there are clear traces at Khirbat Faynan that further ore preparation and processing took place there (see below), presumably designed to concentrate the furnace charge of low-grade ores as far as possible. It is likely that after crushing of the rock, ore dressing/ore-picking ('beneficiation') was carried out (cf. Willies 1991: 135–6, for analogous evidence from the southern 'Arabah). It is apparent from this that the mines required not only a large underground labour force to dig out the ore, but also a substantial surface workforce for the equally demanding work of ore crushing and beneficiation. The final stages of beneficiation were carried out close to the smelting furnaces, where water was available and where close supervision could be exercised, to limit the possibilities of theft of enriched ore.

10.4.3 Slag heaps and smelting activity

Smelting activity appears to have been concentrated exclusively at Khirbat Faynan, according to Hauptmann (2000: 66–70; 2007: 94–109) limited to the south side of the Wadi Ghuwayr in the WF11 area (his 'slag heap 1'), where a large horseshoe-shaped slag heap attests to very intensive metallurgy (Figs 1.4, 2.6, 10.8, 10.9). The Bochum team have recorded traces of a built road leading from the Umm al-Amad mine towards Khirbat Faynan (Hauptmann 2007: 94) and it may have been primarily the ores from the mines in that direction that were processed at WF11. In view of its greater proximity to the main mining area in the Qalb Ratiye, the south bank of the Wadi Dana, immediately to north of the Khirbat itself, is another potential area where Roman furnaces might be sought (cf. Fig. 3.1). AMS dates obtained so far have not confirmed Roman smelting in the latter area, but the furnace fragments and surface slag deposits are similar to those recognized as Roman at WF11 and geochemical analysis of the sediments behind the Roman barrage, described later in this chapter, indicates that ore-processing and smelting were taking place in the close vicinity. Therefore, there is a strong presumption (*contra* Hauptmann 2007: 96–109) that further work will confirm Roman-period slag deposits among the extensive smelting evidence to the north of the Khirbat.

There is a number of small Roman/Byzantine sites in the Wadi Fidan with undated metallurgical activity that could be contemporaneous with those of the Wadi Faynan, but in all cases such activity appears to have been comparatively small scale (Adams 1992: 178, 183; Levy *et al.* 2001b: 175–6).

10.4.4 The main centre: Khirbat Faynan (WF1/WF2/WF11)

As noted already, *Phaino* is almost certainly to be identified with the site of Khirbat Faynan, though with the proviso that the name probably extended to cover three separate areas of settlement and activity at the junction of the Wadis Ghuwayr/Faynan, Shayqar and Dana. If it was a town, *Phaino* was an unusual sort of town. It is certainly a large and complex site, with some high-status elements (for earlier reports, see Frank 1934: 217–25; Glueck 1935: 32–5; Hauptmann and Weisgerber 1987; 1992; Khouri 1988:

Figure 10.9 *Overall plan of archaeological features around Khirbat Faynan. (David Mattingly, after BIAAH/CBRL survey.)*

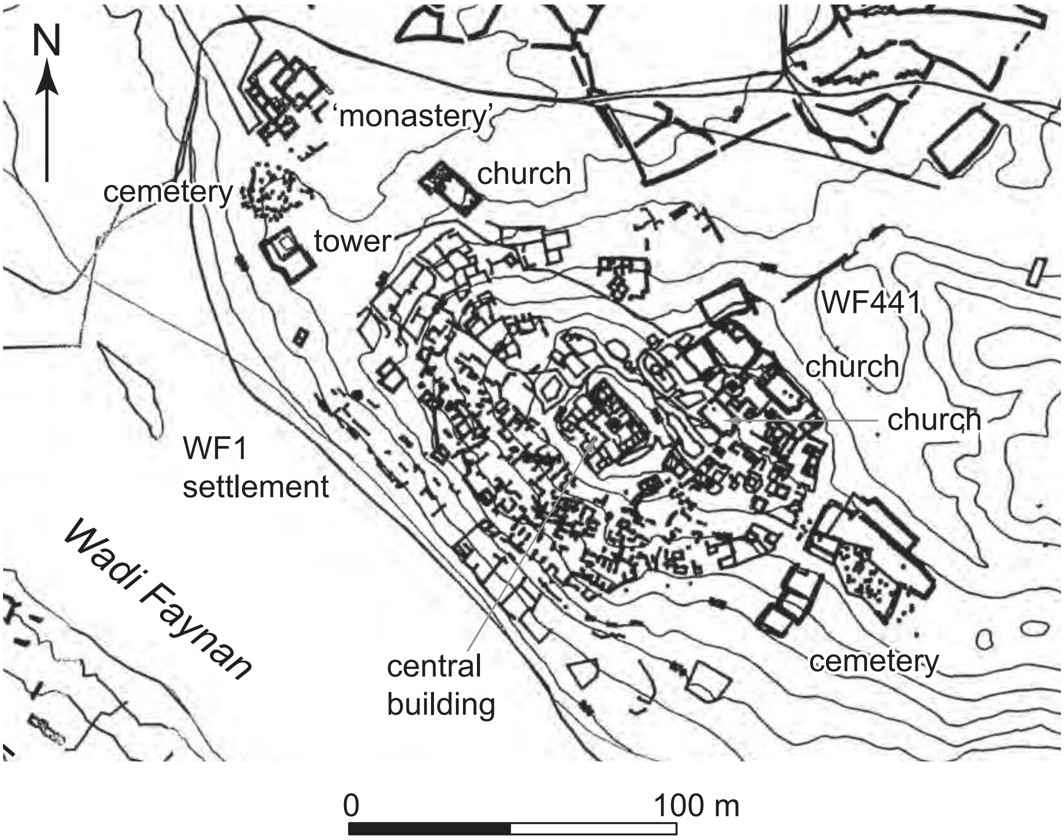


Figure 10.10 *Detail of core of WF1, Khirbat Faynan. See also Figure 3.12. (David Mattingly, after BIAAH/CBRL survey.)*

121–7; Musil 1907 [1989]: 293–8; Ruben *et al.* 1997). WF1 is the most visible feature in the landscape today, a veritable *tell* of collapsed stonework. Detailed survey by a BIAAH/CBRL team (Fig. 10.9) has revealed an oval core of densely packed structures (*c*.275 × 200 m) around a large rectangular building *c*.40 m square that sits on the highest part of the site (Barnes *et al.* 1995; Ruben *et al.* 1997; cf. Kennedy and Bewley 2004: 214–15 for dramatic aerial views Figs 1.4, 3.12). This has the appearance of a central administrative building and was the focal point of the site (Fig. 10.10). There may have been an overall defensive *enceinte* around the site, though in part at least this appears to have been formed from the exterior walls of the outer buildings, broken only by a limited number of streets or alleys leading to the interior. There was no street grid as such, though the alignment of the central building, the churches, and a number of other structures follows an approximately northwest to southeast orientation. Most of the structures that radiate around this central building appear to have been relatively simple in plan, though on the north side of the mound there were two churches (25 × 15 m and 23 × 14 m, with projecting apses to east) and several larger open areas. A further church (25 × 14 m) and a probable monastic building complex (29 × 18 m) lie to the west, slightly detached from the main settlement nucleus; the monastic building produced an inscription of *c.* AD 587/588 mentioning a bishop Theodore (Sartre 1993: no. 109). There is also a substantial (14 × 12.5 m) detached tower on the western fringe of the site. The visible traces, coupled with pottery and other dating evidence, reveal a sequence of activity at Khirbat Faynan that ran from the Early Bronze Age to some small-scale metal smelting in the Mamluk period (the thirteenth–sixteenth centuries). The structural evidence of the Nabataean and Early Roman phases is particularly difficult to reconstruct without further excavation.

There were two cemetery areas close to the core site, one on the west side, the other to the southeast, though these may contain post-Classical burials. There is a number of additional buildings and enclosures around WF1 on the north side of the Ghuwayr, and a further cemetery area beyond the north bank of the Dana to the northwest (WF1228 and related numbers).

Immediately north of the Khirbat, a substantial barrage wall (WF 441: 65 m long × 2 m wide) blocks the mouth of a small tributary of the Wadi Dana (Figs 1.13, 2.13). The nature and scale of pollution in the sediments that accumulated behind it (discussed below) make it most unlikely that this water was ever destined for human consumption, but was gathered for some industrial purpose, perhaps for ore washing close to suspected Roman smelting furnaces on the north side of the main wadi.

The associated settlements on the south side of the Wadi Ghuwayr divide into two zones to the east and west

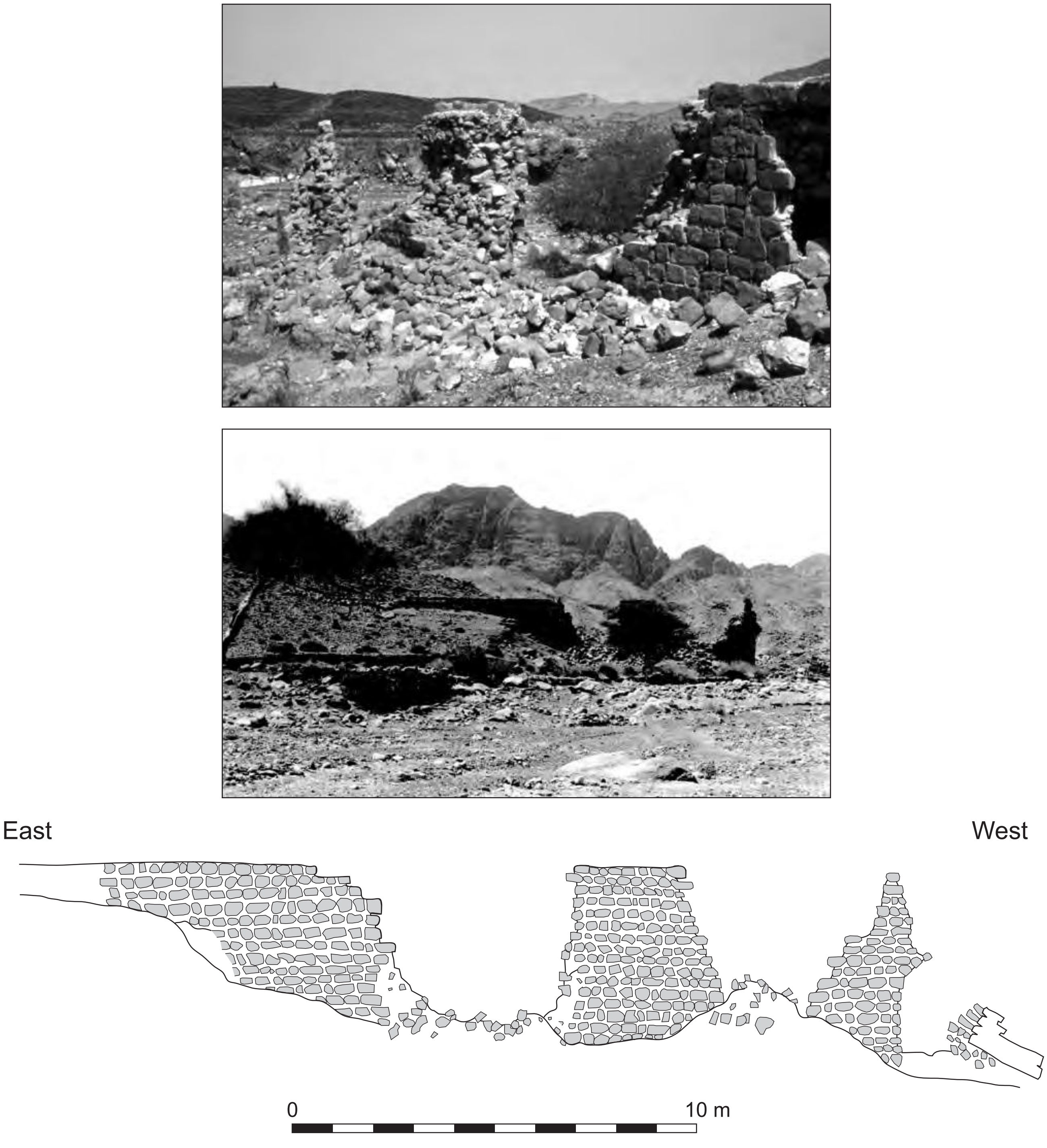


Figure 10.11 *The aqueduct bridge over the Wadi Shayqar, looking northwest (above) and south (below). (Photographs: Graeme Barker; Illustration: Dora Kemp, after Ruba Kana'an unpublished survey for BIAAH.)*

of the mouth of the Wadi Shayqar. WF2 comprises a flattish plateau area of *c.*230 × 200 m covered with traces of ancient buildings (Fig. 10.9). There were additional structures down the scarp to the north (including the likely site of a fifth church), though these are no longer visible at the surface. Occupation here seems to span the Early Nabataean (Hellenistic) to Byzantine periods, so the date of the visible structures must remain uncertain (cf. also Freeman and McEwan 1998). A Roman aqueduct passes along the north side of WF2 before crossing the Wadi Shayqar to the west on a 120 m long bridge (Fig. 10.11), now largely destroyed, and may well have provided water for the settlement via a branch channel.

The largest of the cemeteries at Khirbat Faynan (WF3) lies immediately to the southeast of this part of the settlement and it seems plausible that WF2 was an important secondary residential quarter throughout the Roman/Byzantine period. Immediately on the west side of the Wadi

Figure 10.12 *The Roman reservoir on the south bank of the Faynan, looking northwest. (Photograph: Graeme Barker.)*

Figure 10.13 *The Roman mill at Faynan, looking west. Arrow shows the position of the mill penstock tower. (Photograph: Graeme Barker.)*

Shayqar was the huge Roman slag heap and a second main area of Roman furnace activity (WF11). Slightly further northwest lay the large Roman reservoir (Fig. 10.12), fed by the aqueduct, at the heart of another dense area of buildings measuring *c.*250 × 200 m in extent. This area between the slag heap and the reservoir appears to have been quite industrial in character, with ore-processing and smelting activity, though the detail of this is elusive without excavation. The reservoir measures 31 × 22.4 m by at least 4 m deep, so with a capacity in excess of *c.*3000 cubic m (Barker *et al.* 1999: 280; cf. Ruben *et al*. 1997: 445). There is no evidence that the reservoir was ever covered and its proximity to the major smelting zone would have made the water very polluted (and visibly so) – a small spur from the aqueduct to an enclosed fountain would have constituted a more secure potable source. It is possible that the prime use of the reservoir was thus not for human consumption but linked to storage of water used in the processing or washing of ore (see below, for consideration of an alternative use in irrigation). At the extreme west end of the site was a water-powered mill, fed by a channel branching from the aqueduct that supplied the reservoir (Fig. 10.13). Although the mill was of the penstock type, more commonly encountered in post-Byzantine contexts, there seems no reason to doubt its Roman date here, especially as the mortar of aqueduct and mill channel are identical (McQuitty 1995; Wikander 2000; Wilson 1995 for watermills). The use of the mill is uncertain, though most previous accounts have presumed it was for grain. An interesting alternative would be to provide power for either rotary ore crushers or trip hammers used in ore-crushing (see Domergue *et al.* 1998 for the use of mechanized ore crushers; Lewis 1997). The latter function would be mechanically difficult in converting the direction of turn of a horizontal wheel to drive vertical stamping

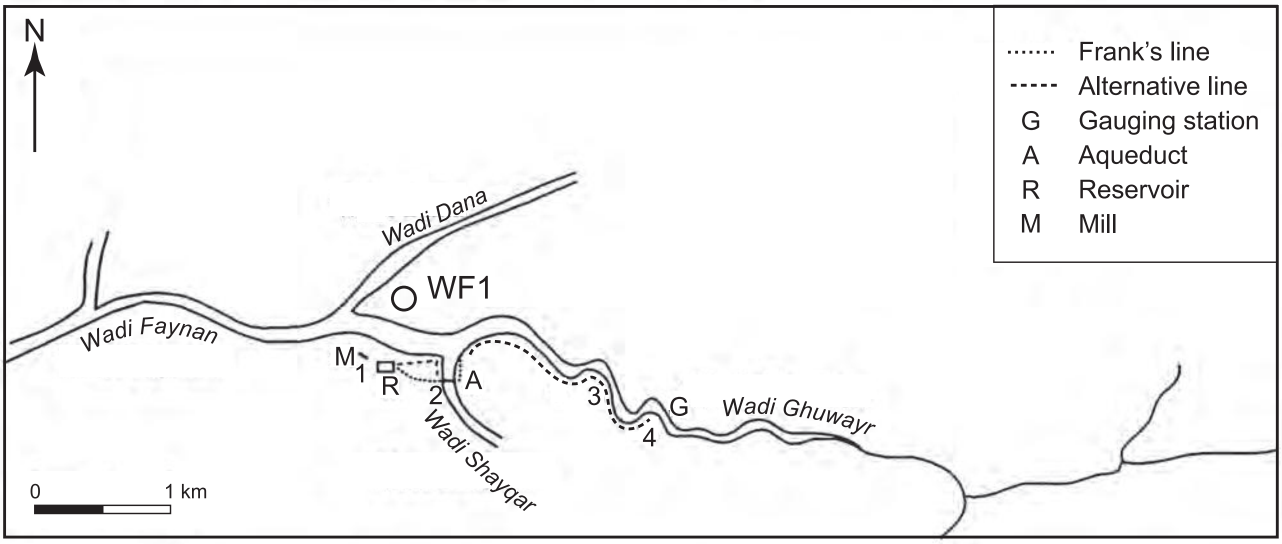


Figure 10.14 *Overall plan of the known course of the Faynan aqueducts along south side of Wadi Ghuwayr: 1 = mill channel (Fig. 4.33 left); 2 = bridge (Figs 4.33 centre, 10.11); 3 = channel (Fig. 5.39); 4 = channel (Fig. 4.33 right) (From Barker* et al. *1999: 227.)*

machinery, but rotary ore crushers are a possibility. The mill would repay further investigation. The fact that the surplus water was not used to irrigate the fields immediately in front of the mill (WF4.2), but was carried through them in a series of channels to discharge into the main wadi channel beyond suggests that water issuing from the mill was perceived as polluted (Barker *et al.*1999: 276–7).

In summary, WF11 appears to have been an industrial suburb of the *Phaino* settlement with a significant amount of ore processing and smelting taking place in and around the visible structures. The aqueduct, reservoir and mill cannot easily be disassociated from this, though it is possible that some of the labour force working the field system was also accommodated in this area and a conventional use of the mill for processing of cereals at a centralized facility cannot be excluded. The possibility that the large reservoir could have been part of a perennial irrigation system was considered carefully, but there is no evidence to show a connection between the outflow of the reservoir and the field system. The analysis of the long parallel wall channels within WF4 discussed later in this chapter suggests rather that these were fed by diverting floodwaters out of minor wadis and gullies running through the field system. This interpretation is consistent with the conclusion that the styles of stratification in the silts within these linear hollows indicate that the silts were laid down in a series of flood incidents, rather than as gradual and continuous accumulations.

The aqueduct has been traced for several kilometres up the Wadi Ghuwayr, though it has been scoured out entirely for long sections by the violent action of winter floods (Fig. 10.14). No less than three superimposed channels were observed in places, built or cut into the southern side of the valley, representing separate phases of hydraulic engineering (Fig. 5.39). The aqueduct bridge structure across the Wadi Shayqar also preserved evidence of two superimposed channels. The investment in the original construction and maintenance of the hydraulic features described here was evidently considerable and is indicative of the unusual nature of the site. There is also a possibility that there was a further aqueduct channel on the north side of the Ghuwayr. This eroded and degraded feature, observed by the project's geomorphologists but not corroborated by the archaeological team, follows the contours (Fig. 3.13 upper) along to southwest margin of the Khirbat. It cannot have delivered water over the much higher interfluve to the area impounded by the Khirbat Faynan barrage, especially since it is composed of a thick sequence of porous Pleistocene clastic deposits (Chapter 6). If there was no northern aqueduct line to WF1, considerable labour will have had to be expended manually carrying water across the wadi, to supplement what could have been stored in cisterns below the main site.

The combined area of the three zones of settlement at Khirbat Faynan covered *c.*15 ha, though of course we have no certainty of how much was actively in use at any one time and quite a large area within the settlement zones may have related to industrial rather than domestic activity. One possible advantage of the tripartite division of the settlement was that it may have facilitated the segregation of different parts of the community/workforce. Again, excavation is needed.

In the final Byzantine phases, the site may perhaps have functioned administratively as a town that was no longer under direct imperial control as a mining centre, though some mining-related activity may have continued. The lack of formal planning and of major public buildings, apart from churches, distinguishes the site from major towns in the Eastern Empire (Ball 2000: 149–206; Segal 1997). The best parallels for the form of the site may perhaps be

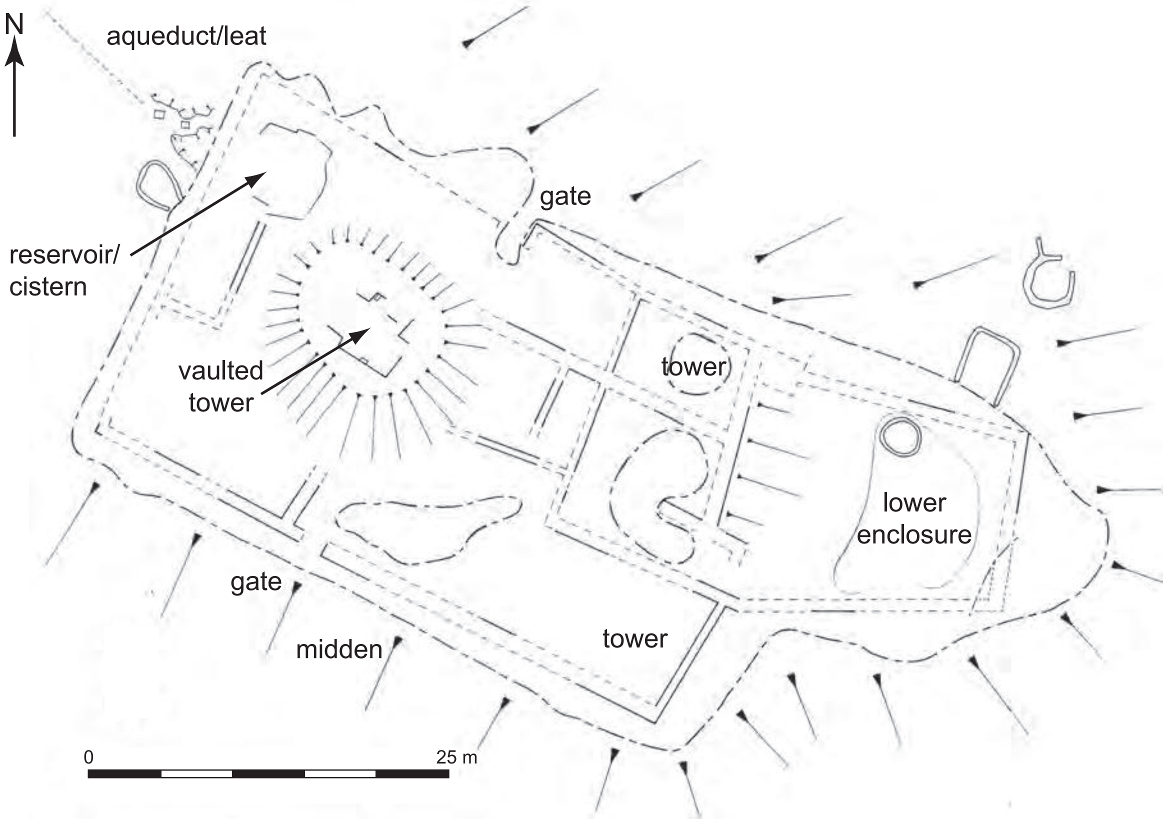


Figure 10.15 *Plan of Khirbat Ratiye (WF1415). (Illustration: Oliver Creighton and Mike Hawkes.)*

found in the desert towns and villages of the Negev, such as *Oboda* (Avdat), *Sobata* (Esbeita/Shivta), and *Mamphis* (Kurnub), with which it was connected by road (Negev 1988; 1997; Segal 1983; Sherevshevski 1991). Equally, the morphology of the site has some similarities with garrison settlements alongside major military bases, such as Umm al-Jimal or Umm ar-Resas (de Vries 1998; Kennedy and Bewley 2004: 200–201, 206–7).

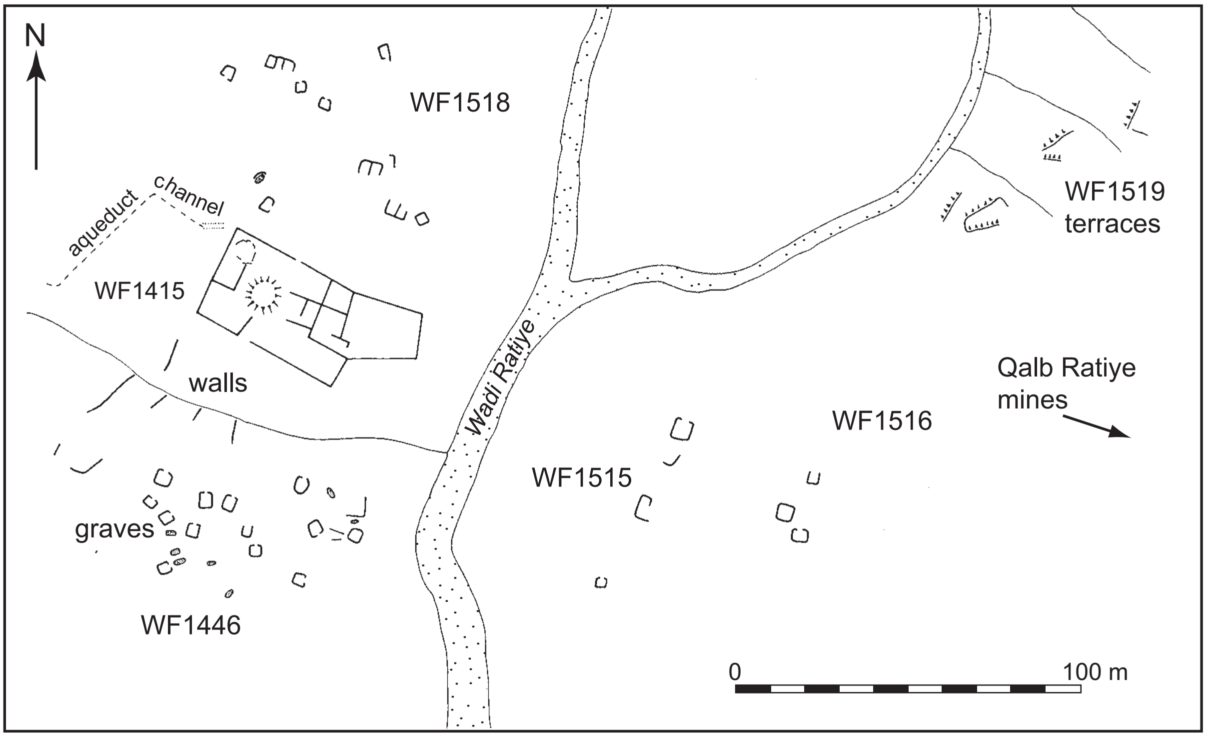
Gatier (1994: 24–30) argues that most of the Negev sites and Umm al-Jimal were no more than villages, as they are not specifically identified in written sources as urban centres and lack diagnostic features of towns. The key features of all these sites are that they lacked formal planning and road grids, and had no significant public buildings other than churches. For Gatier, a key urban discriminator in Late Antiquity was the presence of a bishopric at a particular site. Under this definition, *Elousa* (Khalasa) was the only town in the Negev; *Phaino* would also have qualified. The problem here is that in morphological terms there was little to distinguish small Byzantine towns from the larger 'villages' and some rural bishoprics certainly existed in *Arabia* (Watson 2001: 494). The large number of churches at Faynan in its latest phases was by no means unusual – Umm al-Jimal had fifteen and Umm ar-Resas has ten; nor can we equate large churches with cathedrals.

In the case of the garrison settlements and Khirbat Faynan, the dominant influence of the fort/administrative building is evident in the overall morphology of the site. Umm al-Jimal, like *Phaino*, had a large aqueduct-fed water reservoir at the core of the built-up area. However at *Phaino* the reservoir was separated from the main administrative building (WF1) by a main wadi channel. Although the core zone (WF1) of settlement on the north side of the wadi was densely nucleated and probably enclosed by a wall, the importance of the southeastern and southwestern areas of settlement is amply demonstrated by the direction of the aqueduct to these unenclosed areas. Overall, *Phaino* appears to be typical of a type of dependent small town (in this case relating to mining), growing over time and possibly achieving a measure of independence as an urban community in Late Antiquity, as suggested by the number of churches and the appointment of bishops.

10.4.5 The mining control site: Khirbat Ratiye

There seems no reason to doubt that Khirbat Faynan controlled the production of copper and the smelting works at Faynan. As the largest settlement it also probably served as the centre of administration for the overall operations of the mining district. However it was several kilometres from the densest concentration of Roman mines and it is no surprise to find another Roman/Byzantine prestige site positioned directly in front of the Qalb Ratiye, with clear views into the mining valley (see Fig. 10.2 for location). Khirbat Ratiye (WF1415) is a substantial (*c*.45 × 25 m) rectangular enclosed site, the architecture of which is reminiscent of Late Roman military construction in


Figure 10.16 *WF1415, Khirbat Ratiye: (left) detail of blockwork of outer wall, looking southeast; (right) general view of central tower-like building, looking west. (Photographs: David Mattingly.)*



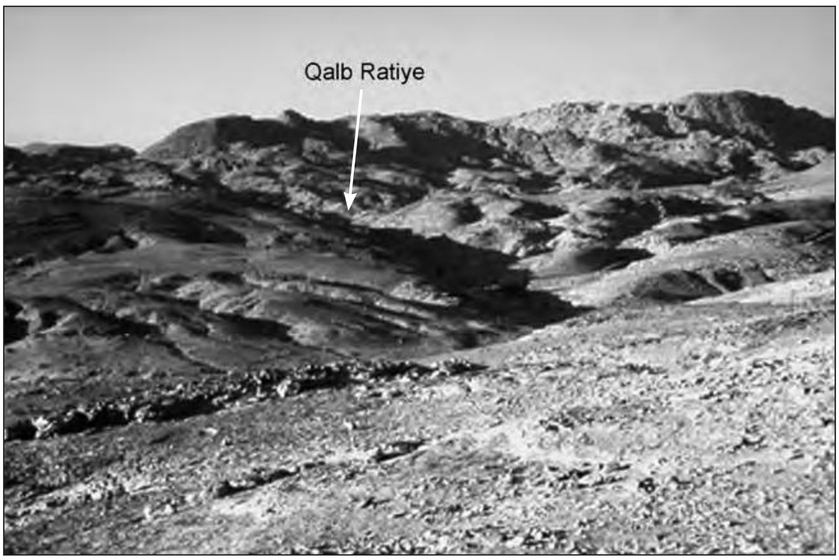


Figure 10.17 *WF1415 in its landscape setting: (above) showing associated minor settlements; (below) looking southeast into Qalb Ratiye. (Illustration: Oliver Creighton and Mike Hawkes; Photograph: David Mattingly.)*

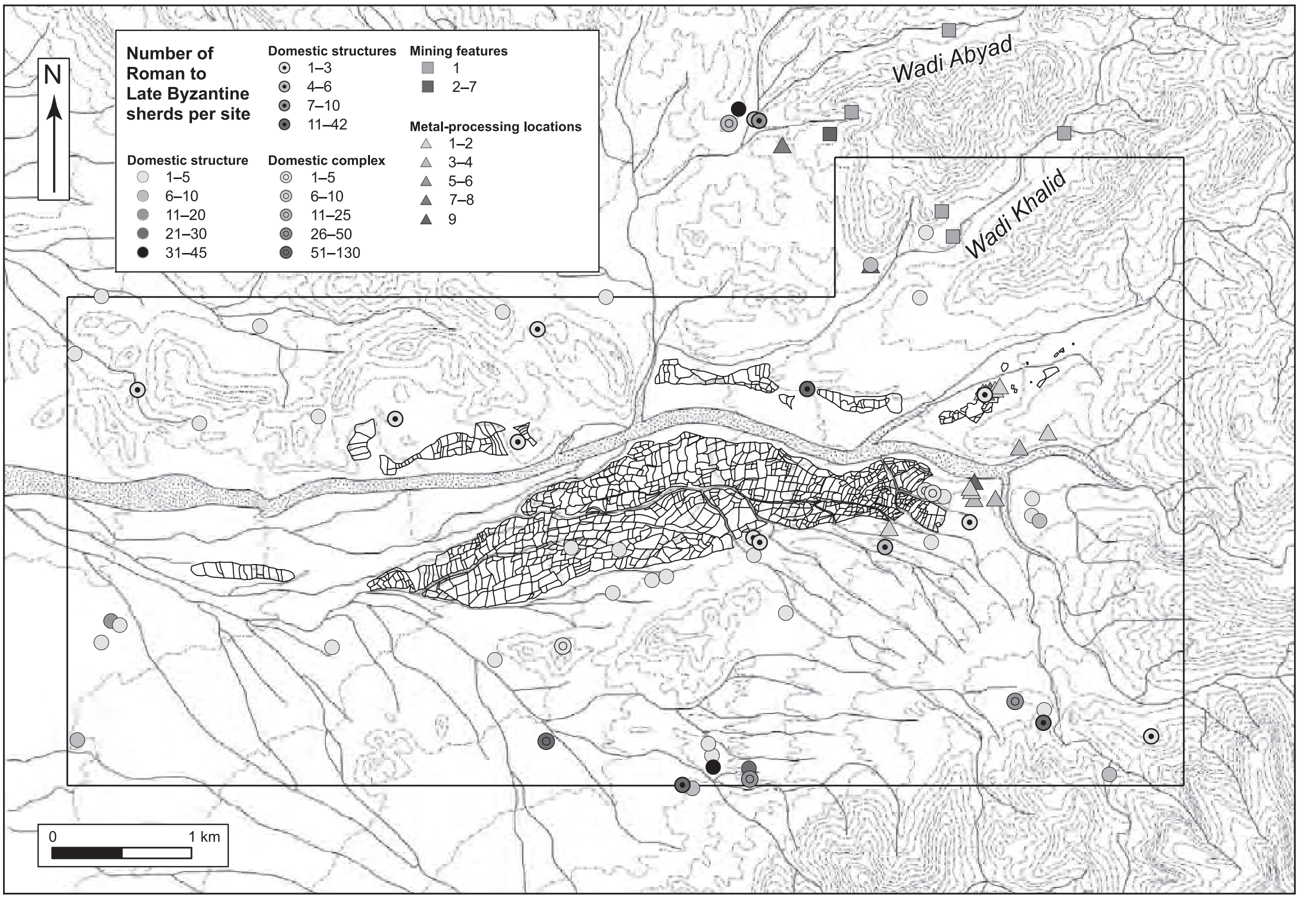


Figure 10.18 *Distribution of mining and smelting features and settlements of Roman/Byzantine date. (Illustration: Paul Newson.)*

Jordan (Fig. 10.15). It does not appear to have been previously recorded (there is for instance no reference to it in Hauptmann 2007: 112–15). The irregularities in the plan are a result of its maximizing the space available on a rocky promontory above the wadi floor. The outer *enceinte* wall was constructed in well-coursed large blockwork (Fig. 10.16). At its heart stood a 5 × 5 m tower-like structure, with a large reservoir behind fed by a floodwater catchment wall. Fragments of hypocaust and flue tile suggest the existence of a small bath suite here. Around the main building and on the facing slope to the east there were *c.*30 simple sub-rectangular buildings (generally 3–4 m sq.) of evidently contemporary date (WF1446, WF1518, WF1515/WF1516) (Fig. 10.17). There may also have been soldiers present here. Small-scale investigation of a midden located on the south side of the site yielded an assemblage of mainly Byzantine pottery and glass, along with fish bones from species (Lethrinidae, *Lethrinus* spp.) originating in the Red Sea. The finds indicate, on a small scale admittedly, the high status of the people accommodated in Khirbat Ratiye and, in a close parallel with Mons Claudianus, the importation of Red Sea fish to the *metalla*. The interpretation of this settlement as the control base of the mining supervisor and as accommodation for some of the mining workforce is highly plausible.

10.4.6 Other settlement complexes: mining-related villages

Survey work has identified a number of secondary settlements in the landscape away from the immediate vicinity of Khirbat Faynan, Khirbat Ratiye, and the WF4 field system (Fig. 10.18). Some of these lay close to the mountain front to the south of the Wadi Faynan. Two main building types have been identified, one represented by sub-rectangular or oval wall-footings defining single-roomed structures, the other comprising rectilinear multi-roomed structures with well-coursed, two-faced, walls and occasional well-worked door cases, thresholds, and lintels.

The first type is exemplified by WF599, a somewhat dispersed settlement of at least eleven sub-rectangular buildings, mostly single-roomed and in plan reminiscent of the structures observed around Khirbat Ratiye (Figs 10.19, 10.20). Several of these buildings had preserved traces of interior built features, interpreted as hearths and benches. The walls were mostly based on footings of rough river pebbles, with larger boulders at the corners and used as door frames. The superstructure may well have been constructed in less durable material such as mud brick, to judge from the relative absence of rubble on these sites. Other examples of this type of structure occur at WF1001, WF1446, WF1518, and WF1515/WF1516 (see Fig. 10.2 for locations).

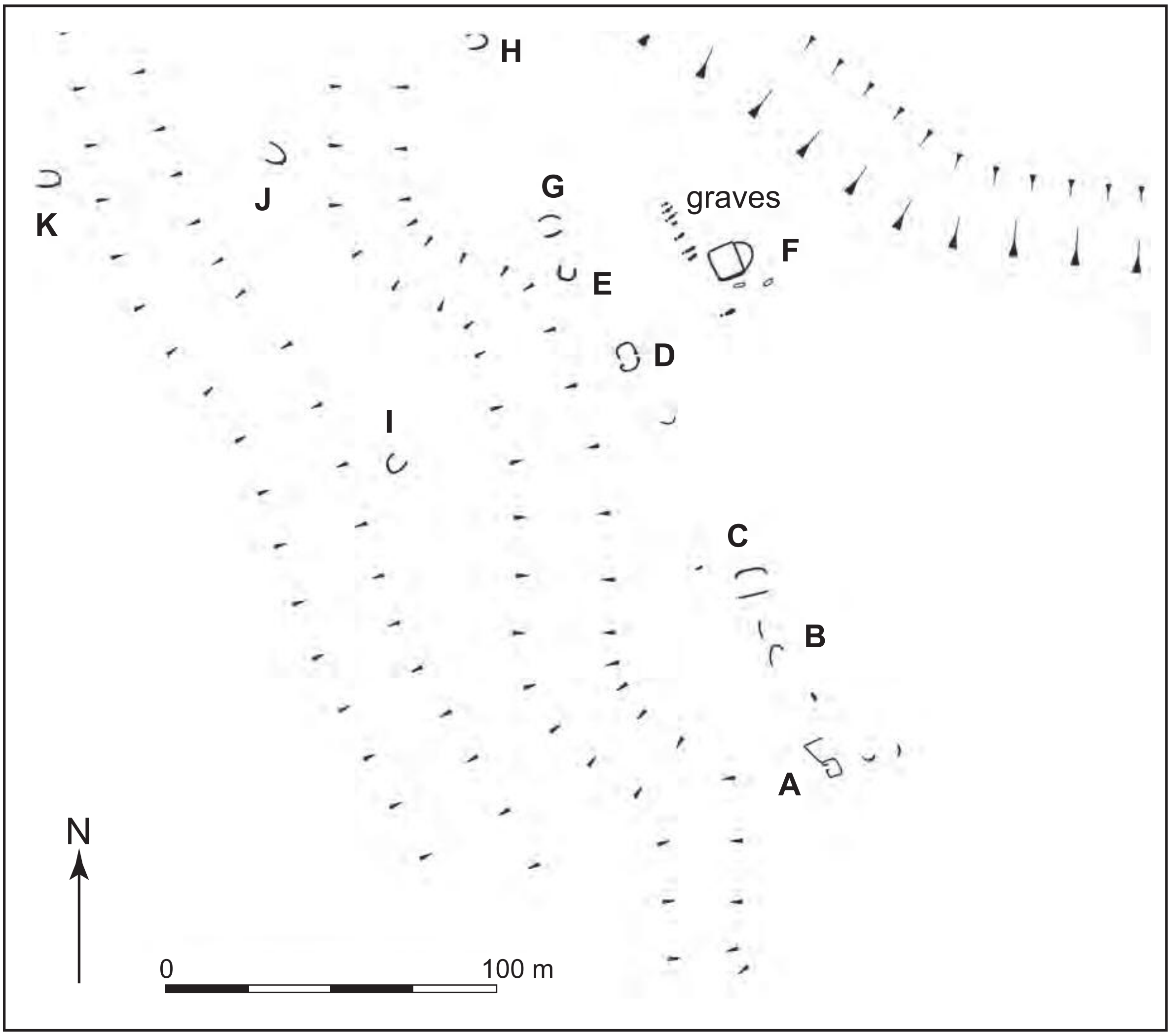


Figure 10.19 *WF599, a dispersed 'mining' settlement. (Illustration: Oliver Creighton and Mike Hawkes.)*

Figure 10.20 *WF599F, sub-rectangular building, looking northeast. (Photograph: David Mattingly.)*

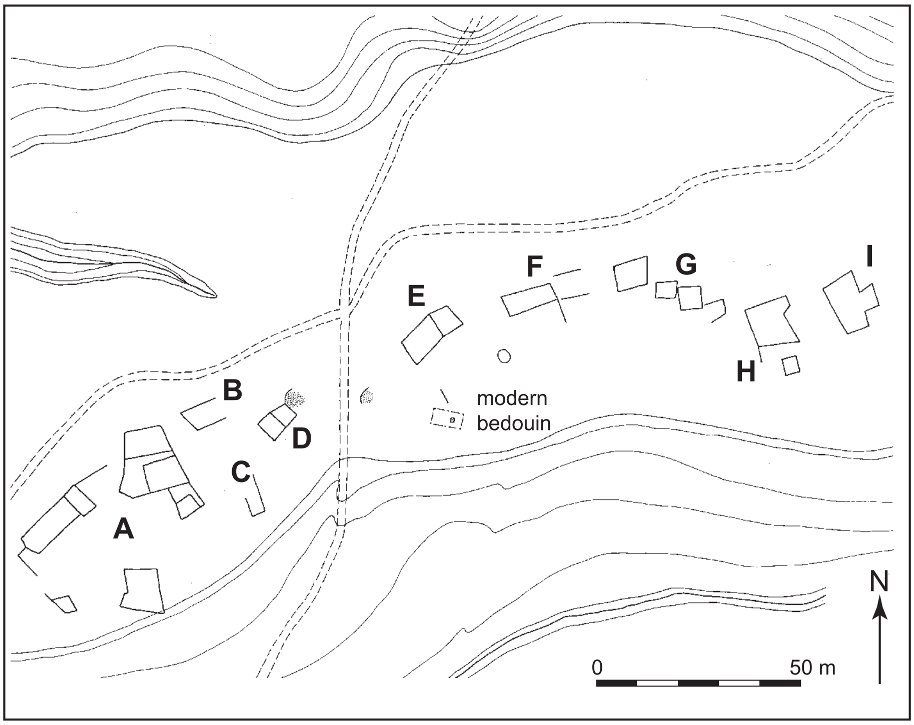


Figure 10.21 *WF1282, a Roman 'mining village' close to the mountain front at the southern edge of the Wadi Faynan basin. (Illustration: Oliver Creighton and Mike Hawkes.)*

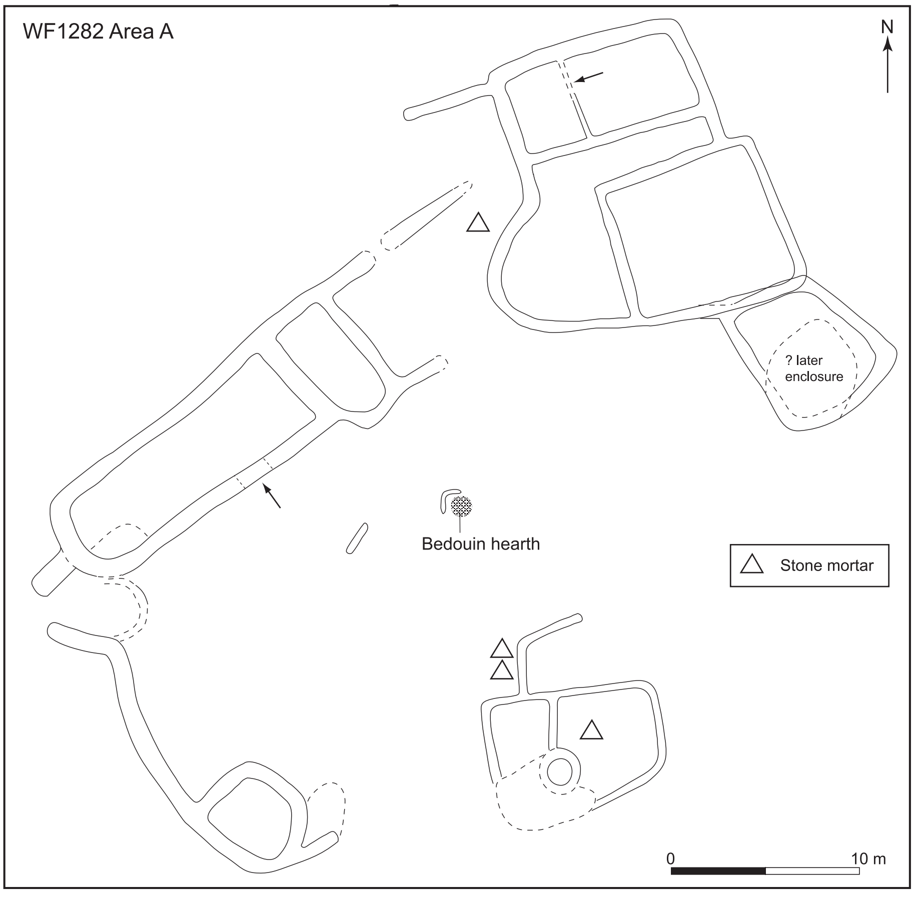


Figure 10.22 *Detail of building complex WF1282A within settlement illustrated in Figure 10.21. (Illustration: David Mattingly, Debbie Miles-Williams, and Dora Kemp.)*

The second class of site is well illustrated by WF1282 (= WF21), an elongated settlement at the mountain front near the headwaters of the Wadi Shayqar on the south side of the survey zone (Fig. 10.21). Spread across an area 220 × 40 m, the site comprises fifteen separate structures, mostly subdivided into several rooms, some of which appear to have been linked together around rough yard areas (for

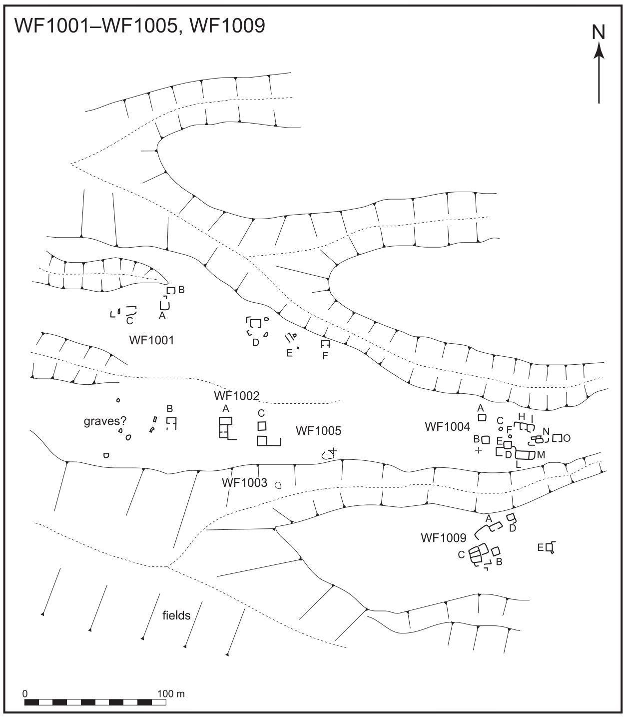


***Figure 10.23** Overall plan of settlements WF1001–WF1005, and WF1009. (Illustration: David Mattingly and Debbie Miles-Williams.)*

***Figure 10.25** Ashlar-quality door case from site WF645. (Photograph: David Mattingly.)*

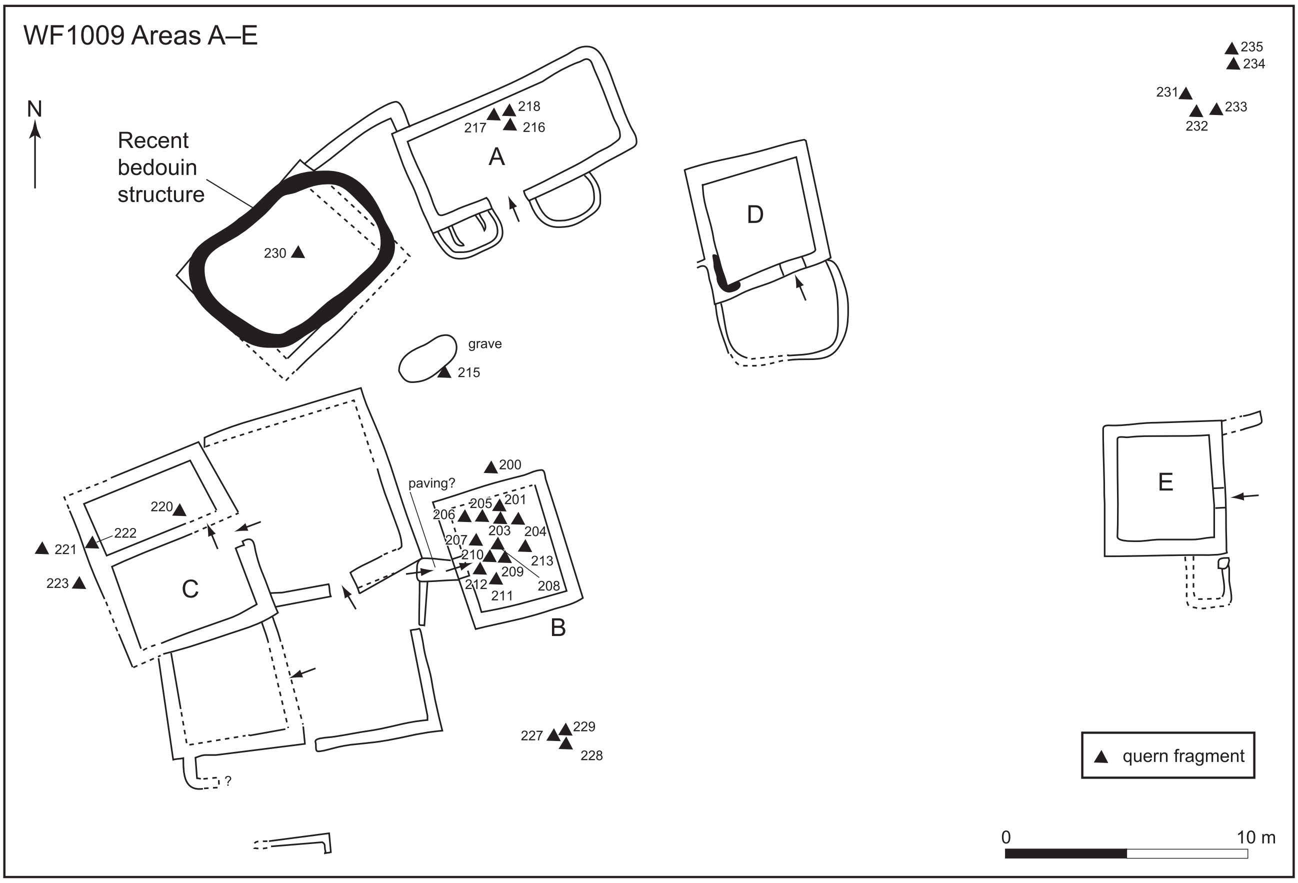


***Figure 10.24** Detailed plan of WF1009, showing location of fragments of quernstones. Quernstone fragment numbers refer to Small Find numbers (Appendix 8). (Illustration: Beatrice Prat, David Mattingly, and Debbie Miles-Williams.)*

example, complex A, Fig. 10.22). Several similar sites were located elsewhere in the vicinity of the mountain front on the south side of the valley (WF1002, WF1004, WF1009, WF1014). This group is interesting as the sites were all intervisible and combine structures of the two types in close proximity (Fig. 10.23). None of these mountain front settlements is well positioned in relation to cultivable grain land, but most of them produced large numbers of fragments of rotary querns (Figs 10.22, 10.24). As noted already, there are some high-quality architectural elements from these otherwise unpretentious settlements, including ashlar-quality doorcases (Fig. 10.25) and a piece of white marble from WF1282. The sub-rectangular buildings are paralleled by examples at the mining control site of Khirbat Ratiye and it seems likely that the examples just discussed also served part of the mining labour force. The better-built structures may in all probability also be interpreted as related to accommodation designed for higher-status workers and specialists.

The supply of these sites with good-quality quernstones (and by implication with the grain to process too) also fits in with the interpretation that these sites were tightly linked to the mining administration. The location of the sites at the mountain front is interesting and suggests that further Roman mines are still to be found in this direction to complement the two known mines at Umm al-Amad (the region has been little explored by the Bochum team because the DLS ores are not exposed in this direction). The mining settlements, if that is indeed what they are, are so placed to reduce the travel time to the mines in the mountain (it is at least a further 2–3 km from here down to Khirbat Faynan), but also to facilitate supervision and supply from the main administrative centre of *Phaino*. Excavation at one or more of these sites is highly desirable to confirm or refute this hypothesis. It is also possible that there were still active springs in the upper Wadi Shayqar in Roman times (the profusion of earlier rock art at the mountain front entrance of the wadi is suggestive of this possibility).

10.4.7 Small rural sites

The pattern of rural settlement from the Nabataean period does not in general seem to have endured. The bulk of the Nabataean farms associated with WF4 have not produced later Roman and Byzantine pottery, though within the field system some small structures were incorporated and maintained within the extended Roman field system (Wright *et al.* 1998: 37–40, indicating continuing Roman and possibly Byzantine use of Nabataean structures). As described in detail below, the field system reached its greatest extent in the Roman period when it appears to have been integrated into a single unit, compared with its probable earlier state as a series of closely adjacent, but essentially autonomous, small field systems (Chapter 9, §9.8.3). These factors strongly indicate a process of centralization of land-ownership and organization in the valley, with previously separate farming units now combined to form a single system. The abandonment of at least some of the farms before the Late Roman period seems clear from the pottery evidence, though we might have some expectation of continuation of farming structures in support of the more distant elements of the field system (as at WF645). Perhaps, though, the bulk of the farming labour force travelled out to the WF4 fields each day from the larger settlements around Khirbat Faynan. One of the surviving rural sites near the east end of WF4 is the complex site WF1242, where the main building was a substantially-built tower-like block, with a series of long narrow chambers at ground floor level (see Fig. 4.12). The building is reminiscent of the fortified farms (*gsur*) from the Libyan desert (Barker *et al*. 1996a: 127–33). In the context of Wadi Faynan, an interpretation as a fortified granary seems feasible.

One exception to the general rule that Nabataean sites were abandoned is the cluster of settlement evidence at the extreme west of the survey zone near Quarayqira village, where what may have been a medium-size settlement is partially buried under a sand-dune (WF471, WF476, WF479). Traffic entering the valley from the southwest round the southern end of the Jabal Hamrat Fidan will have passed in this direction, so a control station or minor staging post is a possible interpretation. There is some evidence also for continuing activity on a number of smaller sites in this area that have yielded Nabataean sherds (WF542, WF546, WF481).

The Jabal Hamrat Fidan Survey has also yielded a number of Roman sites, the two largest occurring at either end of the gorge-like section of the Wadi Fidan where it passes around the northern end of the Jabal Hamrat Fidan. The one at the western end lies just to the southwest of the point where the wadi breaks through the mountain and spreads out across the ‘Arabah plain. It is described as a ‘caravanserai’ (Levy *et al*. 2001b: 175, site 50) and is perfectly positioned as a control site for traffic entering and leaving the Faynan mining district. From there to Khirbat Faynan it would be the best part of a day’s journey on foot or accompanying slow pack animals. There is a possible watch-tower close by. The other main site relates to Byzantine reuse of the settlement plateau at Khirbat Hamrat Ifdan, marking the eastern end of the Fidan gorge, close to the main perennial spring. It seems likely that the Wadi Fidan was the major entry route into the Faynan valley for traffic from the north and the west and these sites could represent staging posts for convoys moving into or out of the valley.

10.4.8 Pastoral sites and minor structures

There are numerous incidences of a few Roman or Byzantine sherds occurring in association with minor features (the ‘Miscellaneous Structures’ of our classification described in Chapter 4, §4.10). Rosen’s work in the Negev (1993) has demonstrated the potential to recognize an archaeology of Roman-period pastoral camps. It is possible that some of the evidence from Faynan could be similarly interpreted (for example sites WF743, WF749), though caution is necessary in the absence of excavation, given the prevalence of post-Roman bedouin activity (see Chapters 11 and 12). Nonetheless, it is striking that this sort of evidence is primarily located on the northern side of the Wadi Faynan channel, in an area with little evidence of more substantial Roman settlements and away from the two main settlement foci of Khirbat Faynan and Khirbat Ratiye. It is possible that local pastoral groups may have been permitted access by the mining authorities to limited parts of the Faynan landscape. On the other hand, even on the northern side of the Faynan, there are many small-scale field systems, often comprising only a few poor terraces built across minor streams and these are often associated with Roman pottery.

10.4.9 Animal enclosures

It is clear that the mining and logistical operations at *Phaino* must have been heavily dependent on pack animals for importing supplies into the valley, moving raw materials, equipment, and foodstuffs within the valley, and transporting out the copper produced (see below). Just as in the Egyptian desert quarrying operations, this is likely to have been a well-organized and large-scale undertaking. To date we do not have evidence comparable with the Egyptian 'animal lines' associated with water sources, where enclosures with troughs were purpose-built to house the pack animals (Maxfield 2001: 161–3). However, many of the sites described above, including both the Khirbats, had enclosures where animals could have been securely stalled.

10.4.10 Cemeteries

Roman and Byzantine pottery is associated with a wide range of funerary features spread across the landscape. In the absence of excavation at most sites it is hard to evaluate whether these were genuinely Roman-period burials or whether the sherds represent some other activity at earlier funerary locations. However, there were major cemeteries close to Khirbat Faynan. To the east of WF1 there was a cemetery enclosure containing about 100 west–east aligned burials with uninscribed headstones, while to the west of the main site, close to the isolated tower and 'monastery', was an unenclosed cemetery of *c.*300 burials, some with crosses inscribed on the headstones. On the other side of the Wadi Dana was another multi-period cemetery area, now much robbed, that was certainly partly of Roman/Byzantine date (WF1228 and related numbers). The largest cemetery area associated with *Phaino*, the South Cemetery (WF3), was on the south side of the Wadi Faynan, covered an area of at least 3.5 ha, and contained a minimum of 1700 burials, predominantly oriented west–east (Findlater *et al*. 1998; Fig. 10.26). The date of this cemetery appears to span the fourth to seventh centuries AD. Some funerary inscriptions have been recovered here (Sartre 1993: 142–8), along with *c.*180 headstones engraved with crosses. Most burials were simple grave cuts, with stone slabs laid over the body. Some burials were more carefully demarcated at

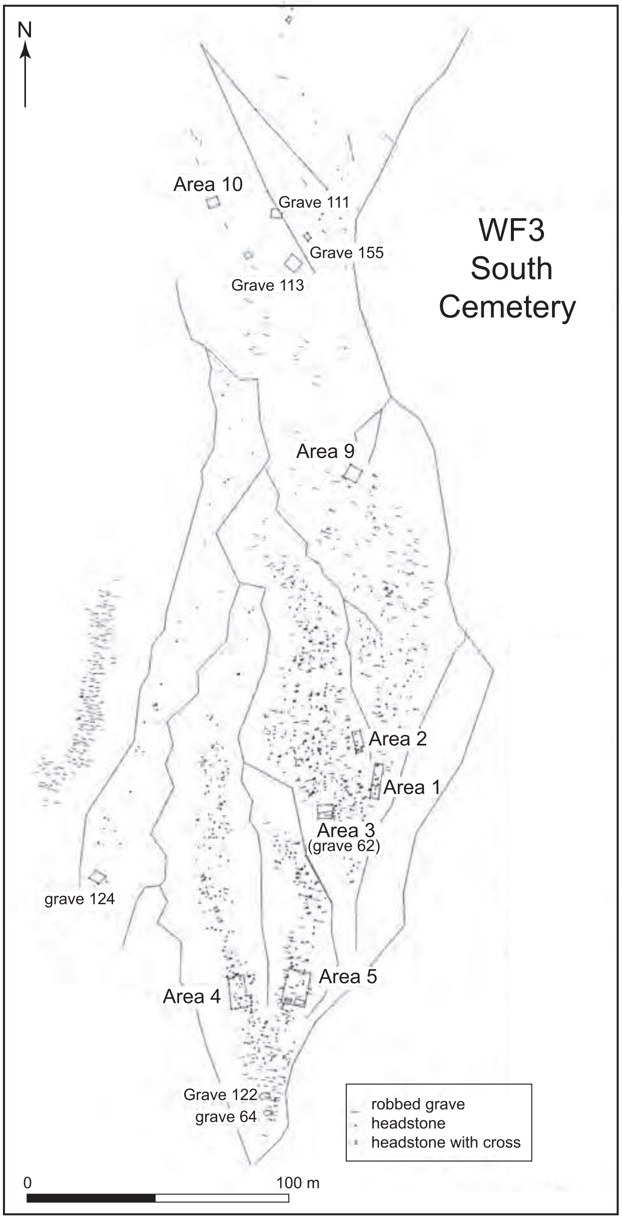


Figure 10.26 *Overall plan of the WF3 cemetery, after the BIAAH/CBRL survey and excavations (Findlater* et al. *1998).*

the surface, either with the grave cut outlined by stones, sometimes with earth and small chippings mounded up inside, or by built rectangular structures that appear to have been plaster-coated.

There was a number of other cemeteries of probable Roman date elsewhere in the valley, including quite a few in the Wadi Fidan (Levy *et al.* 2001b: 175–6). WF479 served the settlements at the western end of the valley and comprised west–east oriented burials in several lines, with headstones at the west end. Another cemetery of west–east burials with headstones, some with engraved symbols, was located north of the main Wadi Faynan (WF437), though some distance from the nearest settlement of any scale. Closer to WF1, but still on the northern side of the valley,

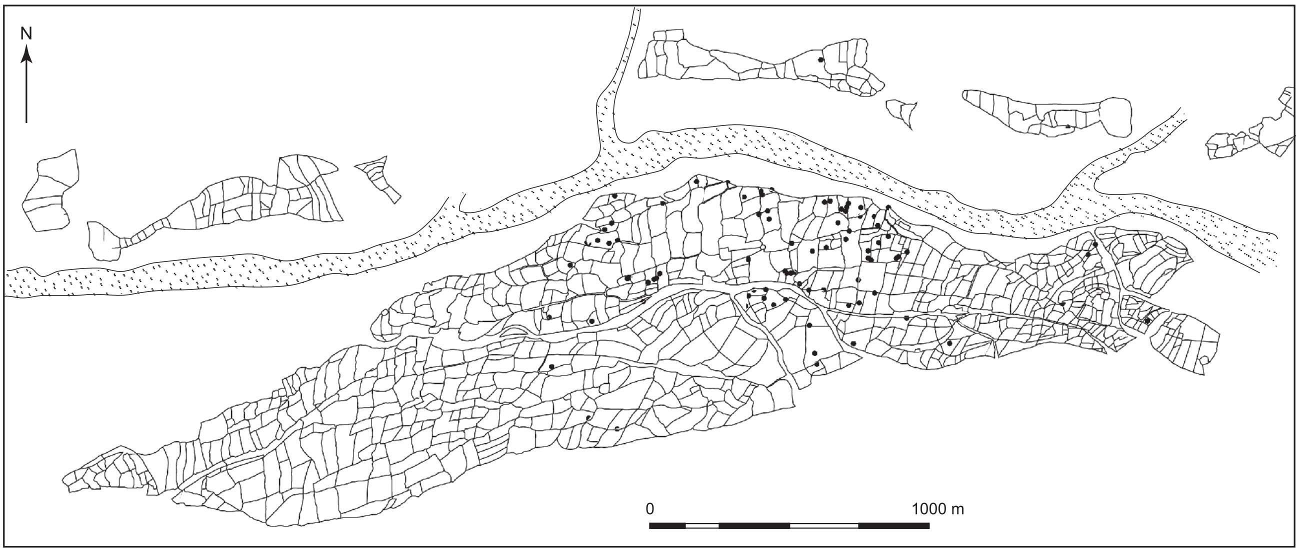


Figure 10.27 *Distribution of diagnostic Late Roman pottery in field system WF4. (Illustration: Paul Newson.)*

WF775 (Fig. 4.23) was a funerary area utilized in several phases, but with a significant Classical component. There are also lots of minor funerary structures, some isolated, some within clusters of varied mortuary features, that yielded a sherd or more of Roman pottery in the surface sherding. Without excavation attribution is very uncertain, but it is likely that funerary monuments took a variety of forms, from the orderly west–east Christian burials of WF3 to more randomly-organized cairns and cists.

10.4.11 The field system WF4 and related features

The WF4 field system reached its fully evolved state at some point during the Late Roman/Byzantine period (Fig. 10.32). What had hitherto been a series of smaller field units – perhaps not dissimilar in size and nature to those still extant on the northern side of the Faynan valley – now became joined together and enlarged to form a single bounded field group of *c.*800 fields. It must be stressed that there is nothing like this for complexity or scale in the other wadis of the Faynan district (Fidan, al-Jariya, al-Ghuwayb), as they lack the broad Holocene terrace surfaces that characterize the upper Faynan valley. Indeed, no other complex in terms of a single set of contiguous floodwater farming fields is known within the Levant as a whole. In total, WF4 covered an area of *c.*209 ha, divided into two main zones (Friedman 2004; Newson 2002). The northeastern or 'flatter' zone (106 ha – broadly equivalent to the Faynan deposits on Fig. 6.4) comprised a set of relatively level areas, while the southwestern or 'terraced' zone (103 ha – equivalent to the Asheiair and Shayqar deposits) was more significantly stepped, with a major series of terrace walls (Fig. 5.49). The morphology of the walls and other built features of the WF4 field systems also show some differences between the two areas.

The agricultural technology employed at Faynan was typical of the floodwater farming of the Negev and Jordanian pre-desert, evolving from sophisticated Nabataean systems (al-Muheisen 1986; 1992; Eadie and Oleson 1986; Evenari *et al.* 1982 [1971]; Mayerson 1961; Newson 2002; Oleson 1995; 2001). Research in the Negev has suggested two main phases of construction of such systems, in the Late Nabataean age and in the Byzantine period, when rural settlement in many areas of the Levant appears to have increased (Decker 2001; Foss 1995; LaBianca 1990; MacAdam 1994; Piccirillo 1985; Schick 1994). Several rural surveys in the more habitable regions of central southern Jordan reflect this basic pattern, with the Byzantine period standing out as one of peak levels of settlement, all the more so as there were significant numbers of nucleated villages in this phase (MacDonald 1988; 1992; Miller 1991). However, continuing issues with the classification and dating of many of the coarsewares of the southern Levant may have over-heightened the importance of diagnostic finewares relating to these two periods and lessened the chronological significance of sherds of other periods that have yet to be properly recognized. The Roman and Byzantine period in Faynan was undeniably a period of growth and intensification in the use of the WF4 field system. The distribution of the diagnostic sherd evidence for the Nabataean to Byzantine phases (Figs 9.28, 10.27, 10.28) is to some extent misleading, based on the fact that even small body sherds of the thin-walled vessels of the Nabataean/Early Roman period can be diagnostic whereas a large proportion of the general 'Classical' coarsewares (that are most probably of Roman or Byzantine) date have not been included in these maps. Our interpretation that the Late Roman/Byzantine phases marked the apogee of the field system is based in part on structural associations. Scatters of sherds from the Late Roman and Byzantine period have been noted in close association with the large channel networks whose fragmentary remains can be seen today dissecting the lower field units (for example within parts of units WF4.10 and WF4.14). The sherd distributions in the majority of the fields of these level units bordering the main course of the Wadi Faynan suggest that the Byzantine period marked the final phase of structural modifications to

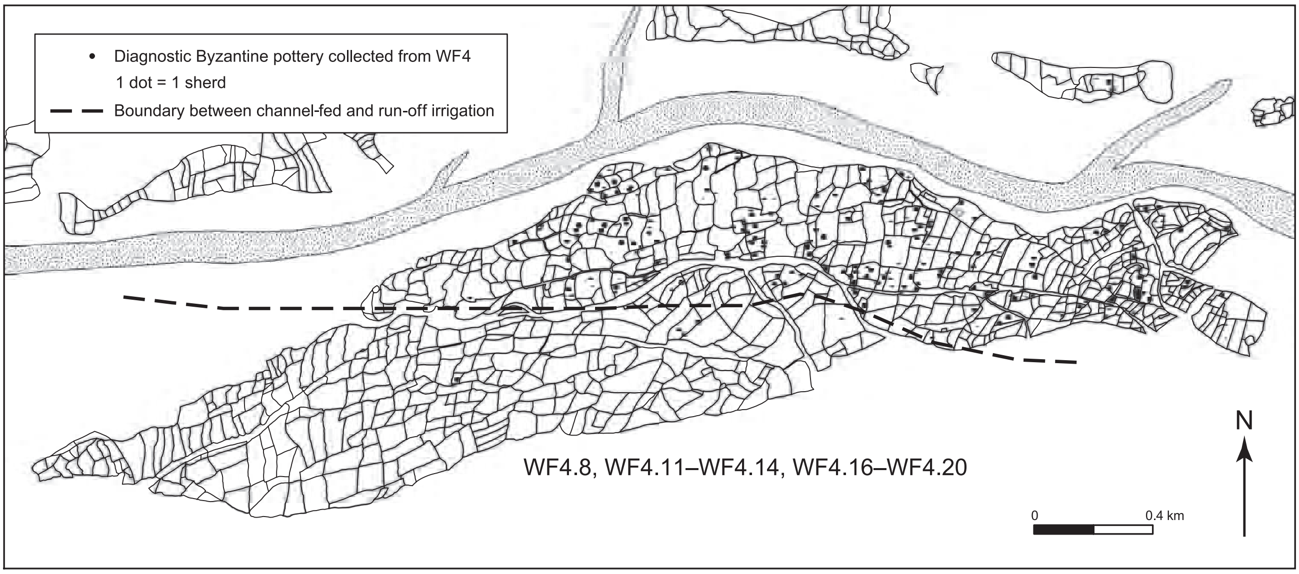


Figure 10.28 *Distribution of diagnostic Byzantine pottery in field system WF4. (Illustration: Paul Newson.)*

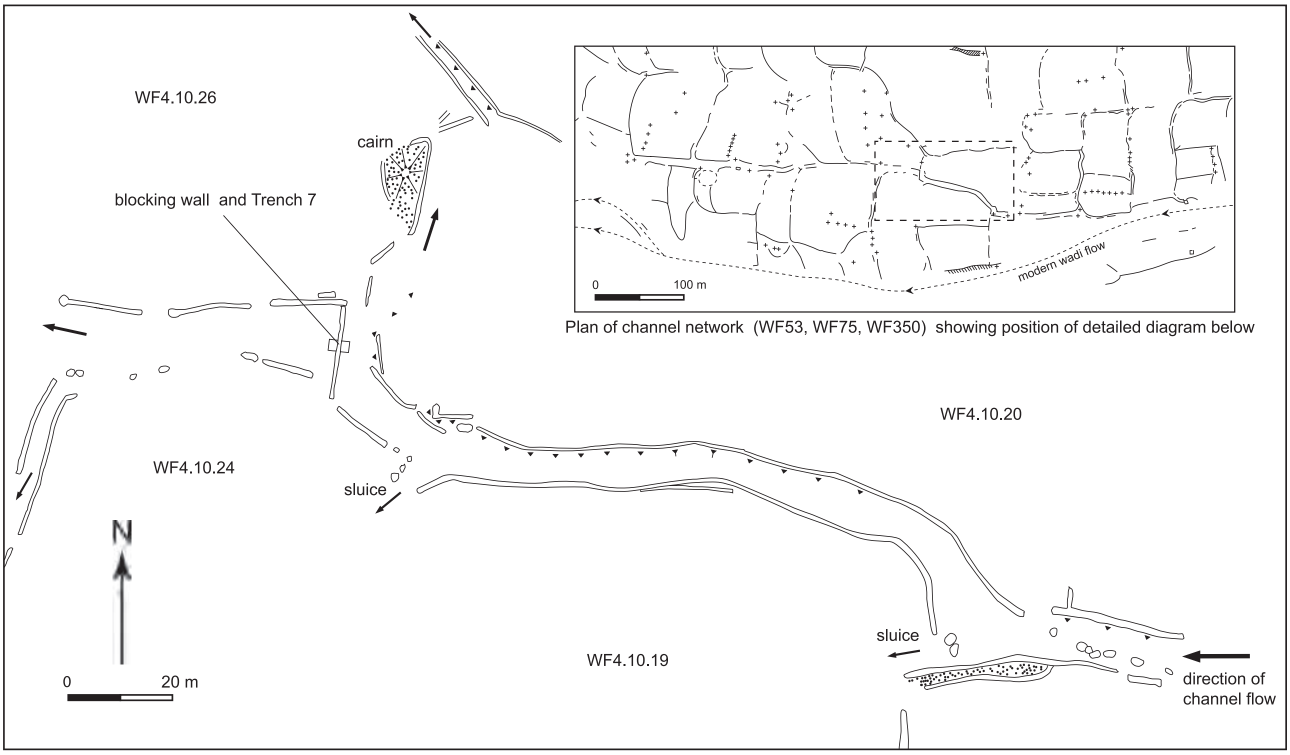


Figure 10.29 *The large channel system (WF53/WF75/WF350) in WF4.10 and WF4.15. (Illustration: Paul Newson.)*

these systems (Figs 10.27, 10.28). Our assumption is that much of this material derives from manuring activities (see below, §10.8 The logistics of supply).

Many parts of the lower and flatter (northern) field units were served by channel-edge structures made of lines of boulders. These were designed to distribute seasonal run-off from the tributary wadi systems and slopes flanking the system to the south across the relatively level expanse of land immediately adjacent to the deeply incised main Faynan braid-plain. The most complex of these networks, the main element of which is the large wide channel WF53–WF75–WF350, distributed water to the westernmost areas edging the Wadi Faynan (Units WF4.10 and WF4.15: Fig. 10.29). Besides this impressive complex, we mapped fragments of a number of other channels that served the lower field units (Figs 5.29–5.31). It is not clear if they formed a simultaneously operated system, but it would appear that the overall network of channels serving the core of the lower field units was utilized through most of the Late Roman/Byzantine period. What can clearly be demonstrated is the renewal and

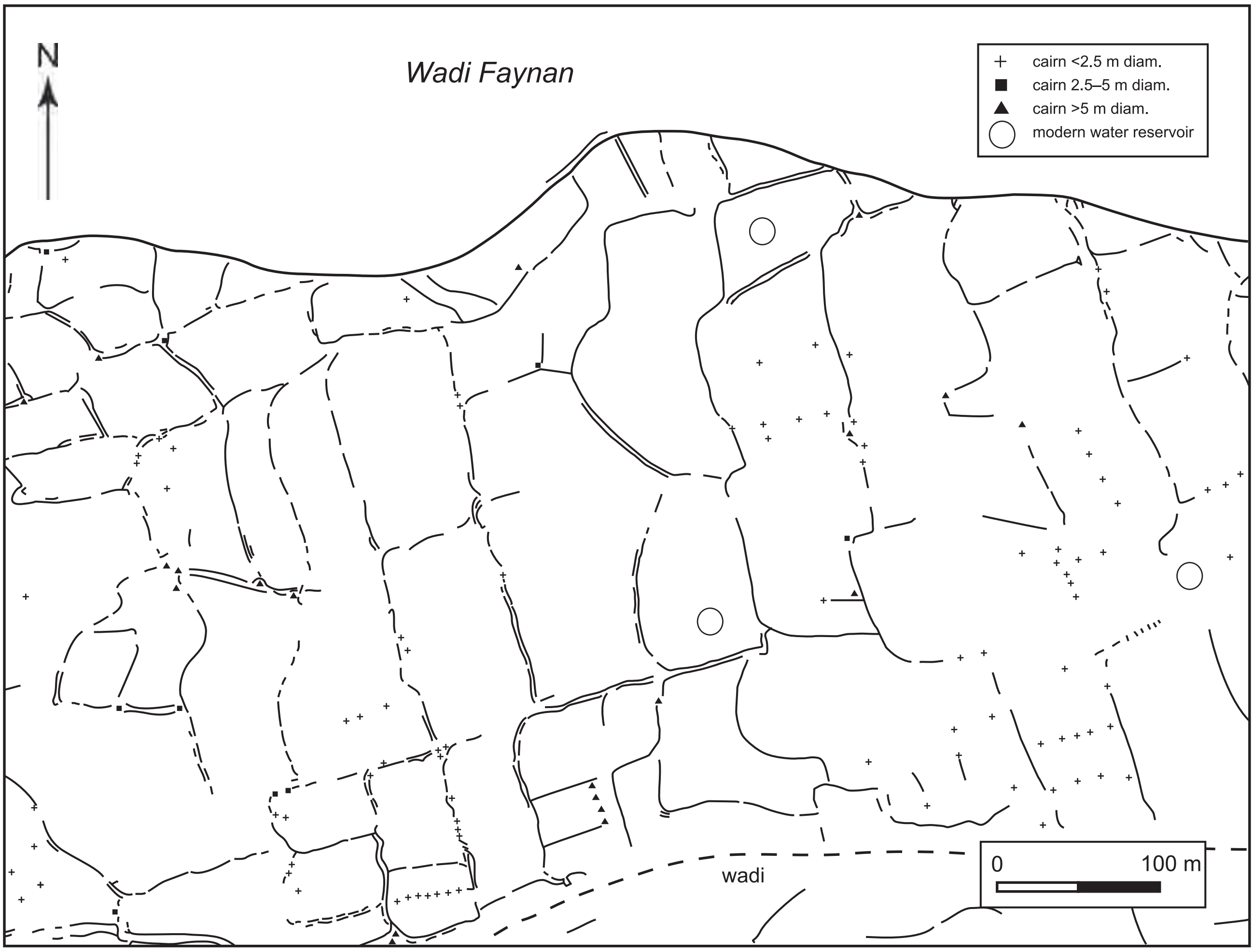


Figure 10.30 *Detail of field units WF4.9–WF4.10. (Illustration: Paul Newson.)*

Figure 10.31 *Detail of field units WF4.9–WF4.10, showing a parallel-wall channel in the centre and rectangular fields stepping down from east to west on either side. Looking east. (Illustration: Paul Newson.)*

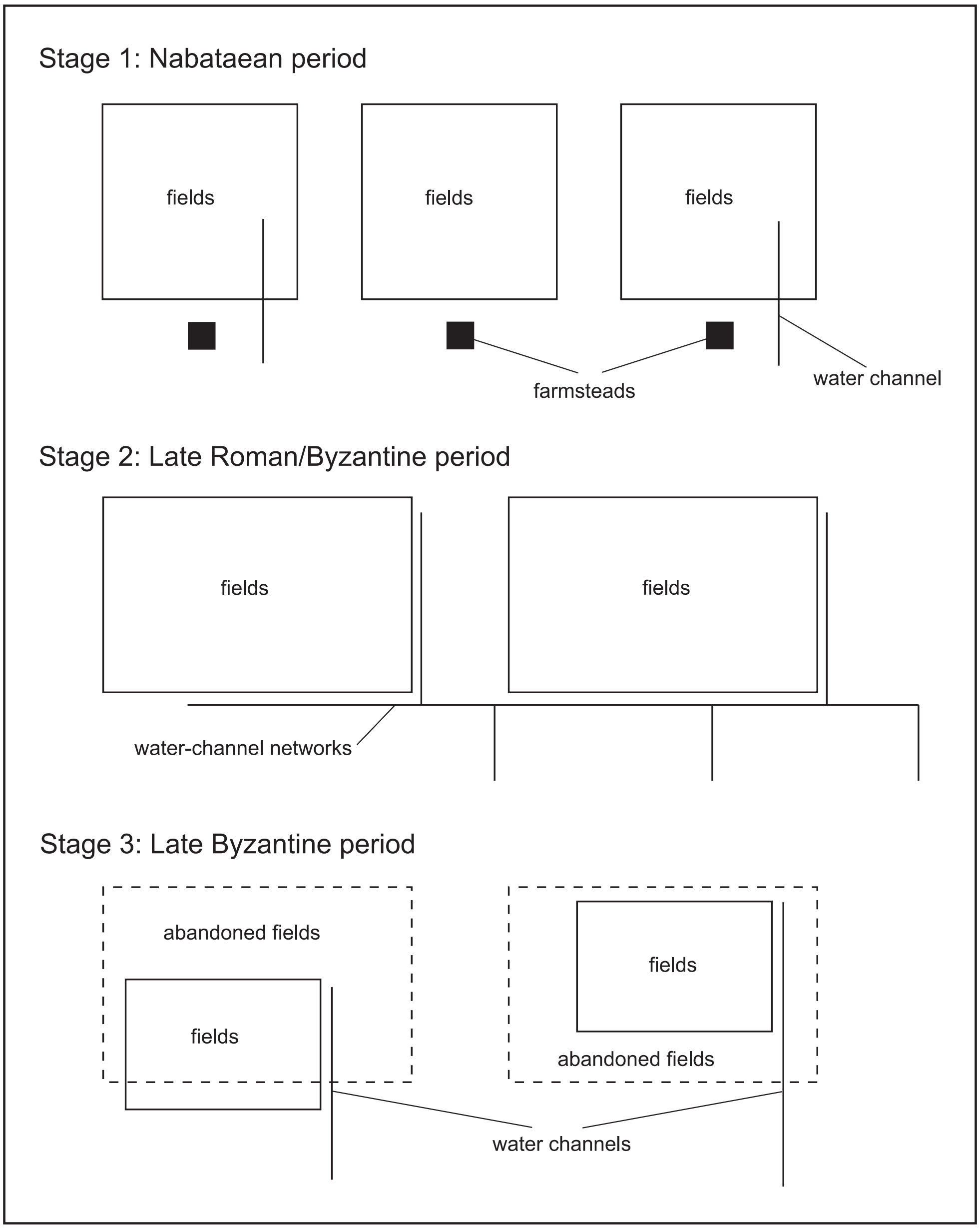


Figure 10.32 *A provisional model of the development of Nabataean-, Roman-, and Byzantine-period land use as represented by the WF4 field system. Stage 1: During the Nabataean and Early Roman periods, the agricultural systems covering most of the present WF4 site were characterized by a succession of discrete collections of fields maintained by individual farmsteads. These farms were placed at intervals along the southern edge of the agriculturally-useful region bordering the Wadi Faynan, examples being sites WF358 and WF368. Although much of the early field system evidence has been subsumed and altered by later developments, the small field system WF442 contains much evidence pertaining to this period and may represent a survival of such a field system. Water was distributed across the fields by simple run-off methods, enhanced by simple channels distributing floodwater flow. Stage 2: In the Late Roman period much of the area of WF4 was unified into large integrated field systems fed by comprehensive networks of channels distributing floodwater across large areas of fields. The individual farmhouses were abandoned and the whole system of fields, composed of conjoined but large and distinct field systems, had a central level of control placed upon it. Stage 3: By the Late Byzantine period some areas of fields had been abandoned, others added on a smaller scale. The fields that remained were subject to remodelling, and were fed by less-extensive channel networks. (Illustration: Paul Newson.)*

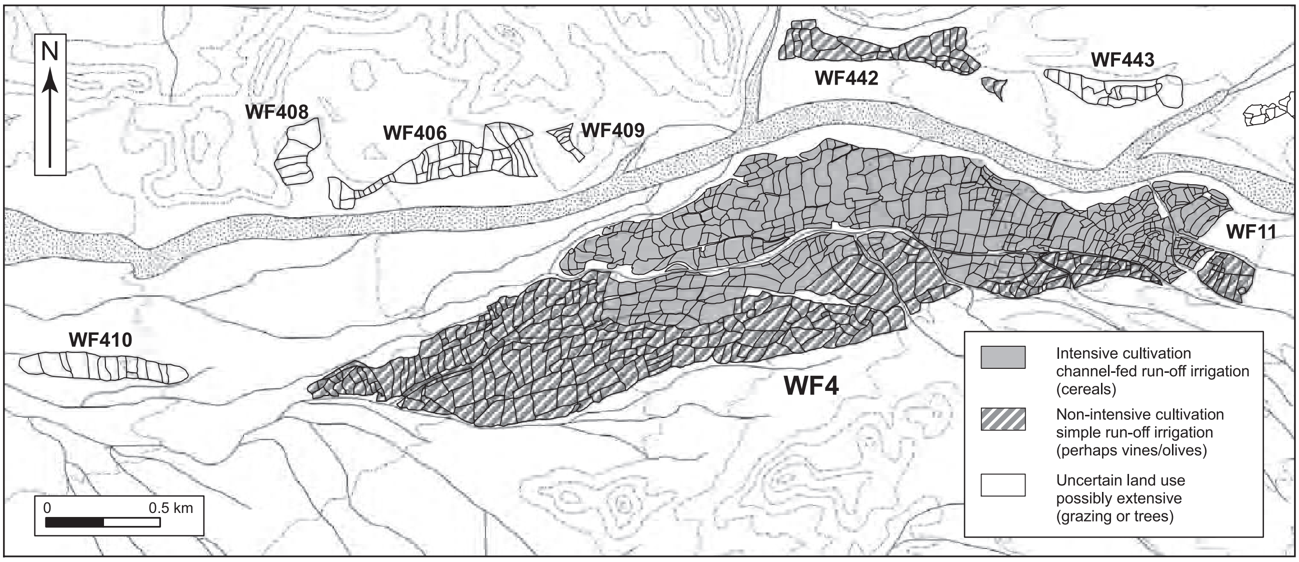


Figure 10.33 *Summary map of Roman and Byzantine land use. (Illustration: Paul Newson.)*

redevelopment of the channels at various times during the Roman to Byzantine periods. This was clearly demonstrated in Trench 2 in field WF4.6.47, which revealed signs of at least two periods of development (Chapter 5, §5.4.5; Fig. 5.36).

Linked with the construction and maintenance of these channels, many fields were remodelled, including extending their size, rebuilding their boundary walls, and adapting them for improved control of floodwaters. Good examples of such work are the fields and structures of Units WF4.9 and WF4.10, which have a high-density distribution of surface sherds of Byzantine date. The regular layout of a succession of large, level, rectilinear fields, flanked by smaller fields and fed by a trio of channels, can be clearly discerned (Figs 10.30, 10.31). Substantial rubble walls were observed in certain areas along the edges of the system, as well as low terrace walls fronting the large rectilinear fields, some still with the remains of inset stones at the base of the terraces. It seems likely that these marked the edges of secondary feeder channels.

The uneven distribution of Roman and Byzantine sherds across the WF4 field system (Figs 10.27, 10.28) reveals further aspects of its organization. Much of the northeastern zone (Units WF4.6, WF4.7, WF4.9, WF4.10, and WF4.15) had the highest densities of Late Roman and Byzantine pottery, a pattern interpreted as evidence of intensive manuring of fields used for staple annual crops, in particular cereals. The easternmost units (particularly Units WF4.1–WF4.3) also contained high densities of Late Roman to Byzantine sherds. The more varied topography here was exploited by a combination of channels and terrace sequences, the latter consisting of relatively high (*c.*1 m) terrace walls interspersed with simple spillway and sluice structures (see Chapter 5, §5.4.4). The close proximity of these Units to the main settlement at Khirbat Faynan accounts for their continuous and intensive use throughout the Classical period. The correlation between the sherd density and manuring seems particularly persuasive in this case. Accepting the manuring interpretation, the most likely crops grown on the areas with highest densities of Classical sherds would have been annual staples such as cereals. On more steeply terraced and stony units Roman/Byzantine pottery, though widely represented, was much less densely distributed, interpreted by us as implying less-intensive manuring rather than lack of use of these areas. Examples of such field units include Unit WF4.4, the upper parts of Unit WF4.5, and the lower terraced parts of Units WF4.8 and WF4.11. These more steeply terraced fields had less sophisticated run-off irrigation than the channel-fed systems of the northern part of WF4. They would have been well adapted to hardy perennial crops such as olives and vines needing less water and less intensive manuring than cereals (Fig. 10.33).

A number of units produced very little in the way of Late Roman to Byzantine sherds, notably WF4.12–WF4.14 and WF4.16–WF4.20 (Figs 10.27, 10.28). That development during the Late Roman to Byzantine period occurred in these areas is evidenced by the survival of a large faced wall to demarcate a terrace edge between Units WF4.13 and WF4.14, the construction of which absorbed the southern wall and entrance of an earlier Nabataean structure (Wright *et al.* 1998: 37–8), but apart from this there is little unequivocal evidence for Late Classical development within Unit WF4.13. The large terrace wall may have been built to serve as the bank for a channel leading to an area of less stony fields to the west of WF4.13, in Unit WF4.17, but it is perhaps more likely that it was built as a restraining bank to protect the lower fields of unit WF4.14. Centred on WF4.14 there is a small but significant collection of sherds dating to the Byzantine period, associated with fragmentary remains of channel-fed networks reminiscent of the channels in Units WF4.10 and WF4.15. The paucity of sherds in the southern and western units of WF4 might be because many fields here were abandoned (unlikely on various grounds), or that they were not being manured on anything like the scale of the northern and eastern fields (Fig. 10.33). If the latter, it is possible that they were being used for crops such as olives and vines, or for fodder crops or rough grazing. As already noted there is a fundamental difference in the irrigation regimes between the two broad areas of fields identified here, with simpler run-off systems on the steeper terrain to the south and complex channel systems on the flatter land to the north. However, it must be stressed that the evidence suggests that both areas of land were irrigated by seasonal floodwater, not by perennial flow.

There is limited evidence for the intensive use of the minor field groups on the northern side of the Wadi Faynan channel such as WF406, WF408, WF409, WF442, and WF443, the layout and construction of which mostly relate to earlier periods of land use as discussed in Chapters 8 and 9, though several diagnostic sherds of the Late Roman period were recovered from the fields of WF442. As with the western units of WF4, it is possible that these small field systems were used in the Late Roman/Byzantine period for extensive rather than intensive cropping. There is some evidence for small clusters of simple fields close to minor Classical sites, for example in the valleys north of Wadi Faynan (for example, WF744, WF747, WF782), but without excavation we can only speculate whether these relate to agricultural and/or pastoral activity in the Late Roman to Byzantine period, or succeeding periods, or both. If some of them do in fact to the Late Classical period, they could provide an intriguing hint at the breakdown of imperial control over the mining region as a whole.

10.5 Dating issues

The Bochum team made an extensive collection of 1395 coins during their work in the valley (Kind *et al.* 2005), mostly purchased from the local bedouin (perhaps unwittingly fuelling the pronounced rise in illegal excavations in the late twentieth century). The historical reconstruction made from this evidence by Kind *et al*. (2005: 188–92) must be handled with caution for a number of reasons.

First, the numbers of coins surviving from specific periods are often inversely proportional to their actual value. Low-value coins that were rendered worthless by major reforms of standards are often drastically over-represented, simply because they were not worth recycling and went into the domestic rubbish. Secondly, whilst the peak periods of coin loss were the fourth and fifth centuries AD (Kind *et al*. 2005: 170–81; Figs 10.34 and 10.35, which also includes the 42 coins found by our project), the significance of this must be carefully evaluated, in that it is a common feature of coin finds from all parts of the empire that issues of the Hellenistic/pre-Roman period and the early centuries AD are dramatically under-represented in the surviving site finds. The occurrence of even comparatively small numbers of coins of pre-fourth century date (31 date between AD 106 and AD 311) thus must be understood to represent a potentially significant degree of pre-Byzantine activity. This idea is possibly backed up by the AMS dates obtained (Appendix 1), which point to a consistently earlier date of activity than the peak of the coin finds (though the possible use of old timber for charcoal manufacture may be a factor). There is certainly some ceramic evidence from the early centuries AD from Faynan to support the idea that the origins of the mining operation could predate the first references to *Phaino* as a *metalla* in the late third century AD. Excavation is needed to provide clearer indices on the earliest phases of Roman activity.

The anomalous nature of the coin series can be seen in the extreme rarity of coins of the period AD 294–311 (only five in total), an unusual pattern for the period when *Phaino* was most prominently featured in the sources as an imperial *metalla* (Kind *et al*. 2005: 185–6). There was

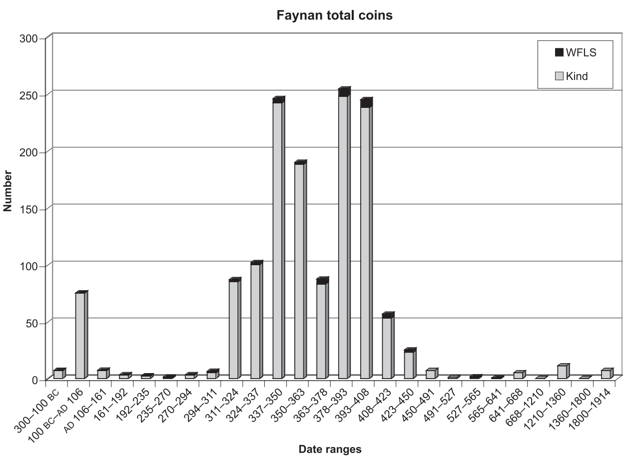


Figure 10.34 *Total coins from Wadi Faynan. The figures are taken from Kind* et al. *2005 and from the list of coins collected by the WFLS and include proportionately allocated examples, where identifications span more than a single reign or issue period.*

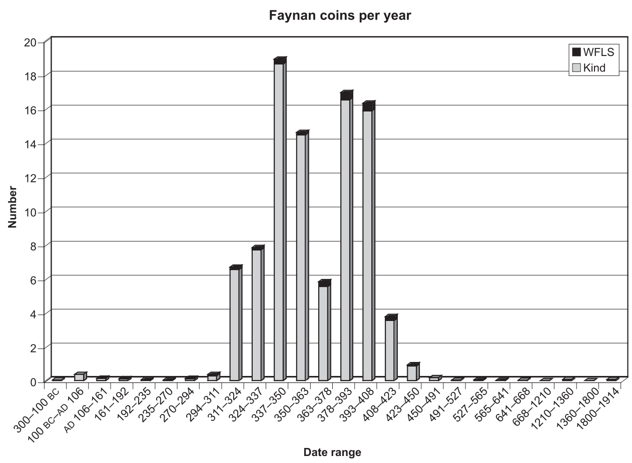


Figure 10.35 *Distribution of coins from the Wadi Faynan by year (dividing total number of coins in each period by length of period).*

also a clear drop-off after the mid-fifth century AD, though we know that activity on some scale continued at the site (only fourteen coins span AD 450–668). How might we read this evidence? First, it seems clear that the relative shortage of pre-Byzantine issues is not a reliable indicator of a lack of activity at the mines, though for a variety of reasons far less coinage of that period has survived in the archaeological record. It is possible that the form of mine administration at this time was less dependent on cash transactions and that the increase of the post-AD 311 period reflects some change in the nature of that organization. Kind *et al.* (2005: 189), for instance, explain the apparent sudden rise in coin use as due to a military garrison being installed for the first time at *Phaino* in the aftermath of the Great Persecution, though they indicate that there is an absence of independent corroboration of this either in the written sources or the archaeological evidence. The alternative view is that, as before, *Phaino* was run with the minimum possible military presence sent as detachments from units established on the main communication routes in the ʻArabah and towards the Negev. The provenance of most of these coins is unknown, but the likelihood is that the collection is heavily biased in favour of periods when coins were included in burials. The main source of coins is thus likely to have been the South Cemetery (WF3), which appears to be fourth century and later in date, with the possibility that the later Byzantine diminution in numbers of coins represents a change in funerary custom, with coins less frequently deposited in the grave after the late fourth century. Until we have excavations from the major settlements at Khirbat Faynan and Khirbat Ratiye it is hazardous to model their histories on such evidence.

It is possible that the nature of the organization of the mining settlement could have been overhauled following its near breakdown at the time of the executions in AD 311. One possibility is that, although the penal nature of the mining settlement continued (later Christian 'heretics' were condemned here in the mid fourth century: Athanasius, *Historia Arianorum* 60), a larger proportion of the labour force henceforth was salaried, allowing the substantial growth of the urban centre at Khirbat Faynan. The construction of several churches here cannot be precisely dated, but the settlement evidently achieved the status of a bishopric and centre of pilgrimage on account of its martyrs. Bishops of *Phaino* were mentioned in Church councils and synods of AD 431, AD 449, AD 518, and AD 536, and a Bishop Theodore is attested in an inscription building a church in AD 587–8 (Sartre 1993: 142 and 145–6, no. 109). This last piece of evidence also indicates that the history of the site extended long beyond the contraction in coin numbers after the mid-fifth century AD. Several sixth- to seventh-century geographical listings of significant places in *Palaestina Tertia* are also relevant (see Schick 1994: 143 for discussion). *Phaino* was not mentioned by Stephen of Byzantium, but Hierocles, evidently writing *c.*AD 535 and drawing on contemporary sources, did include it, as did George of Cyprus writing early in the seventh century AD. The power of the state may have been increasingly usurped by the power of the church by the later fifth and sixth centuries AD.

The assumption of Kind *et al* (2005: 192) that copper production was effectively over by the AD 360s seems unduly influenced by a historical reference dating to about AD 390 stating that 'the copper mines of *Phaino* had collapsed in our time' (Hieronimus, *Onomastikon*, cited in Klosterman 1904: 115). The coin evidence, on the contrary, might suggest a significant decline between AD 363 and AD 378, but with some recovery in the late fourth century. A large number of the skeletons from the fourth- to seventh-century South Cemetery had very high levels of heavy metals in their bones, suggesting continuing smelting activity and heavy pollution (Tables 10.5 and 10.6, discussed below). Another serious crisis for the mining activity may have been an epidemic in the AD 450s (Sartre 1993: nos 107–8), though clearly the community continued long thereafter and at present we cannot with any certainty pinpoint the end of copper production.

10.6 The labour force at the mines

It is important to put the use of slave and condemned labour in Roman mines into context, as the popular image derived from the sensational accounts of writers such as Eusebius is misleading in certain respects. One could easily conclude that slaves and condemned prisoners made up the vast bulk of the workforce at *Phaino* and that the severe and extreme measures taken against Christians sent there in the period AD 303–13 were a normal pattern of brutality at the mines. The reality was almost certainly rather different.

Millar's study (1984) of the legislation condemning people *ad metallum* is a valuable starting point for considering the nature of such punishment. The historical documentation, centred on two works of Eusebius of Caesarea (*Martyrs of Palestine* [*MP*] and *Ecclesiastical History* [*EH*]), paints an horrific picture of Roman judicial savagery against the Christians sent to *Phaino* (Sartre 1993: 139–42; Schick forthcoming, for detailed discussions of the sources; see also Garnsey 1968 on judicial savagery in the Roman empire). The events covered by Eusebius took place over a few years (AD 306–311), during which time extraordinary numbers were condemned to the mines. Far from being typical of the normal operation of the mining region, what Eusebius presents is a mining regime that was overwhelmed by the large numbers of people being sent there. The more extreme mutilations enacted on some of the Christian groups sent to *Phaino* (blinding in one eye, hamstringing, castration) may represent desperate measures to supervise these numbers (Mattingly forthcoming). However, the Christian martyr tradition at *Phaino* was based not on the overall maltreatment and deaths of Christians working at the mines, but on a specific purge that took place there over a few days in AD 311, when soldiers at the mines executed a number of the leading Christians, along with all those incapable of further physical work, and forcibly broke up the Christian community (Eusebius *MP* 13.1–10; *EH* 8.13.5).

It is likely that at no time did condemned people make up the entirety of the labour force and that normally they served hard labour alongside people who were paid good salaries (by ancient world standards) for doing specialized and often highly technical work. That is increasingly clear from mining and quarry sites elsewhere in the Roman world, where slaves and criminals are virtually unheard of in surviving documentation, but salaried staff are now well attested on ostraca, inscriptions, papyri, writing tablets, and so on (Cuvigny 1996). This was clearly the case at Mons Claudianus as we have described earlier (Maxfield 2001: 154–5). Two problems with slave and forced labour are that it required constant supervision and that it was difficult to motivate other than by brutality (which reduces the working life of many of its victims). Free labour can be encouraged by differential pay scales to work more diligently and with a higher degree of technical skill. Many aspects of mining and smelting involve a high level of knowledge and technique as well as brawn. Set against this is the fact that the Roman empire had a tradition of disposing of some of its condemned criminals and dissidents to the mines and quarries as disposable labour in dangerous and heavy work. The logical conclusion is that, as an imperially controlled mining centre, *Phaino* drew on a mixed pool of forced labour and free (perhaps migrant) workers. This view is supported by the failure of the survey work to produce evidence of major military garrison posts throughout the mining district. We know soldiers were there, but they appear to have been relatively few in number. A sudden increase in the forced labour pool at the mines would have had implications not only for supervision of the mine works but also for logistical supply. It is for these reasons that the influx of large numbers of unrepentant Christians would have presented problems for the mining authorities and created a situation that was rather abnormal.

10.7 Environment and people: the impacts of Roman mining

Until recently, there has been little definitive palaeoclimatic information for this period in this area, which is particularly unfortunate because of the obvious importance of the precipitation régime for most aspects of life within it (Chapters 2 and 3). Figure 10.36 presents some familiar interpretations of local palaeoclimate in the Classical period and also places them within the wider framework of deduced climatic change throughout the Holocene. The difficulty of deriving 'hard' palaeoclimatic information from the various deposits and landforms available in such arid lands has sometimes led to differences of interpretation or emphasis in their study. Fortunately, a detailed record of palaeoclimatic change has been proposed for the last 2500 years from studies of sediment cores taken from the floor of the Dead Sea by Heim *et al*. (1997). Against a background of general and widespread climatic aridity in the region since the middle Holocene, moister conditions were proposed in this region from about 2500 radiocarbon years ago until these gave way to a drier climate about 2250 years ago. The geomorphological studies of Frumkin *et al.* (1994; 1998) in the salt caves of Mount Sedom suggested a similar history, with the wetter episode commencing about 2200 calendar years ago and peaking about 1900–1800 years ago before declining gradually until a further arid episode at about 1500–1400 years ago. The evidence provided by the changing level of the Dead Sea led Klein (1986) to identify a particularly wet episode from about 2050 to 1950 calendar years BP. In a more regionally-based synthesis, Issar (1998) distinguished between comparatively warm and cool temperatures, and between precipitation levels. The period *c*.3000 BP to *c*.2200 BP was regarded as warm and dry, the period *c*.2000–1300 BP as mostly cold and humid, the period *c*.1700–1800 BP (the Roman–Byzantine transition) as warm, and the Byzantine period *c*.1800–1500 BP as cool and humid. Overall, although there are differences, these studies suggest at least a measure of agreement for the region to the northwest of the study area. Given the limited distances and climatic similarities between these areas, it is probable that the broad pattern of inferred climatic change also took place in the Faynan and that the Roman/Byzantine period was one of higher rainfall than the present (see also Bruins 1994; 2006; Frumkin 1997; Issar and Yakir 1997; Rubin 1989; Yair 1994).

Recent surveys of the relationships between settlement density and inferred climatic change in this region have linked larger populations, denser settlement, and enhanced agriculture from Iron Age to Byzantine times to a notably wetter climate (reviewed in Frumkin *et al.* 1998; Issar 1998). These arguments were based upon empirical observations, rather than through recourse to earlier ideas about the power of climatic controls upon people (cf. the climatic determinism of Huntington 1911). Nevertheless, in this area, as well as in other arid lands, there are many who have suspected that the capacity of people to manage scarce water supplies has been under-estimated, and/or that the frequency and geomorphological significance of extreme rain storms in such arid areas as the Faynan are misunderstood (see Bruins 1994; Ionides and Blake 1939 [1984]; Raikes 1967). Interestingly, Frumkin *et al.* (1998) noted that times of the greatest frequency of flash floods in the northern Negev did not correlate with times of peak aridity or wetness. In the Faynan area, it seems probable that the population numbers during these times mainly reflected industrial needs; the relationships between precipitation, water, agriculture and population are likely to have been different to those from non-mineralized areas.

Other aspects of the impacts of people and land use and their interactions in this area at this time remain largely unknown. Nevertheless, as important as climate and surface hydrology must be in such arid lands, it seems likely that the settlement, agriculture, ecology, and land use in the Wadi Faynan area during these times must also have been profoundly influenced by the series of developments in mining and smelting that took place in the area from the

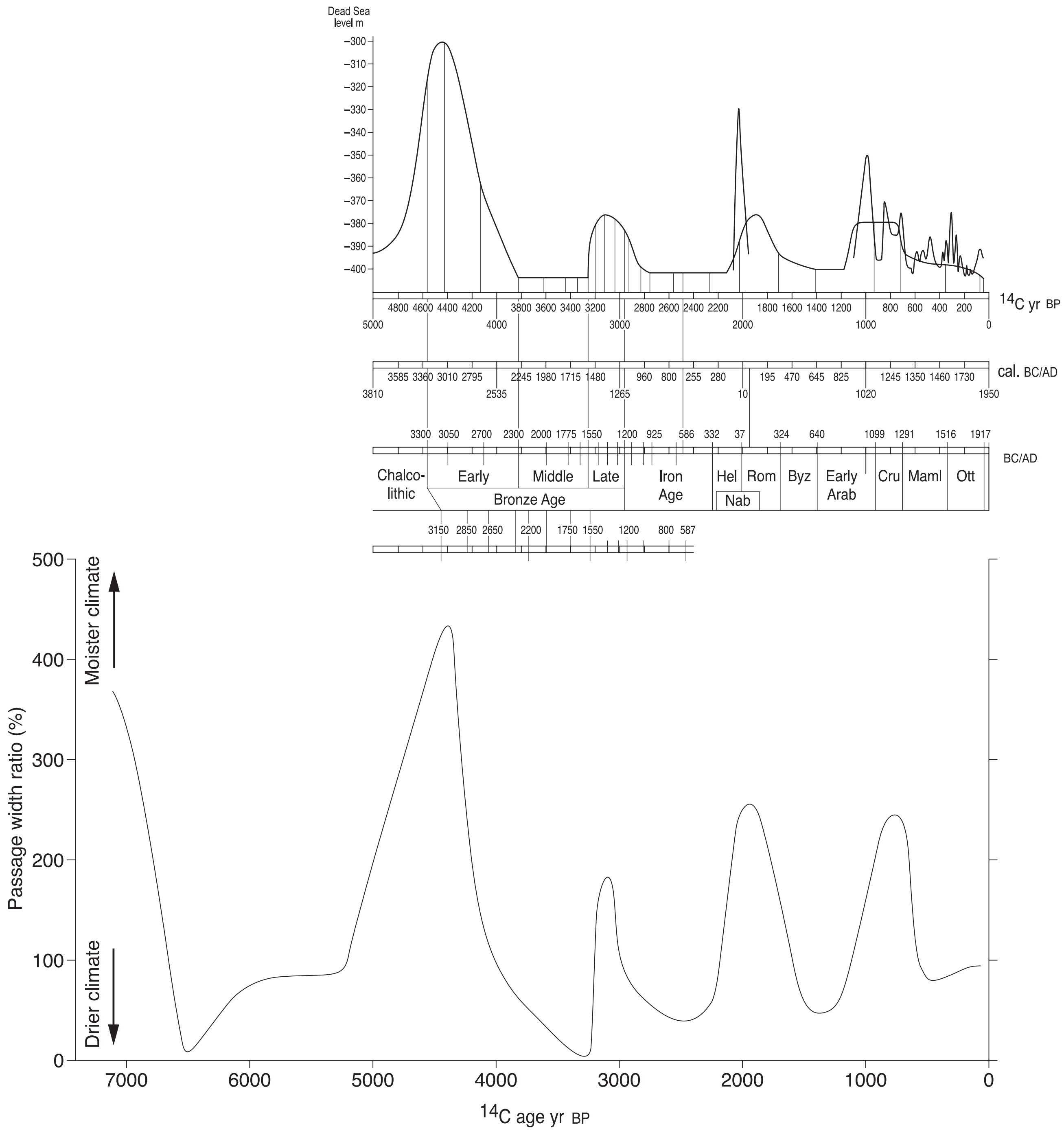


Figure 10.36 *Models of climatic change in the region setting the situation for Classical times in the context of the Holocene. (Hel = Hellenistic, Nab = Nabataean, Rom = Roman, Byz = Byzantine, Cru = Crusader, Maml = Mamluk, Ott = Ottoman.) (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Bruins 1994; Frumkin* et al. *1994; 1998; Issar 1998; Issar and Yakir 1997; Klein 1986.)*

Nabataean to the Byzantine periods, broadly from about 2500 to 1500 years ago. In this section we consider the environmental impacts of the mining activity and the short- and long-term effects of an increasingly polluted environment on the inhabitants of the valley. The sites, features, and deposits studied by our project, the most important of which are discussed below, are listed in Table 10.1 and located in Figure 3.1.

10.7.1 The Khirbat Faynan barrage (WF441)

As discussed in Chapter 3, the barrage (WF441) on the north side of Khirbat Faynan and the associated infill deposits behind it (WF5012, WF5017) are one of the most important sites for environmental research in the region. The barrage is substantial and enigmatic (Kennedy and Bewley 2004: 214; Figs 1.13, 2.13, 3.5, 4.36). Carefully constructed of large blocks of rock, it stretches at right

Site code and name	Summary of type of feature, site and deposit	Approaches and dating
	Barrage infill – anthropogenic, colluvial, pond, wind-blown	
WF5012 Khirbat Faynan barrage infill	Infill within basin up-drainage of barrage in wadi – 10 m from borehole at WF5017. Nabataean–Byzantine (?).	Excavated pit, field description, texture, magnetic susceptibility; palynomorphs; and ICPMS – total and bio-available concentrations by Condron (2000); contains Nabataean and Roman pottery; 1610±40 BP or cal. AD 349–547 (Beta-203399); 1870±40 BP or cal. AD 60–238 (Beta-203400); 1800±40 BP or cal. AD 92–339 (Beta-203401); 3390±40 BP or 1867–1536 cal. BC (Beta-203402), cross reference to two 14C dates from WF5017 of 2630±50 BP or 910–594 cal. BC now regarded as re-worked charcoal (Beta-110840, Beta-110841); biostratigraphic correlation indicates *c.*1350 BP at *c.*160 cm (Hunt *et al.* 2005; 2007b).
WF5017 Khirbat Faynan barrage infill	Infill within basin up-drainage of barrage in wadi – 10 m from WF5012. Nabataean–Byzantine, to modern	Eijkelkamp corer with Edelman 6 cm sampling head – in 10 cm samples; texture; pollen and palynomorphs and total concentrations ICPMS by Sykes (1997) via Grattan; dating by biostratigraphy, correlation with two ^{14}C dates of 2630±50 BP or 910–594 cal. BC (Beta-110840, Beta-110841); now regarded as re-worked charcoal; association in the field (Hunt *et al.* 2004; 2007b).
	Fluvial	
WF5025	Fluvial and colluvial sequence of Roman–Byzantine age, overlain by fluvial 'shocked gravels' of much younger age.	Natural exposure, pollen-biostratigraphic correlation with deposits in WF5017; field relationships; underlies radiocarbon date 390±50 BP or cal. AD 1435–1635 (Beta-115214).
WF5028 – confluence of Wadis Shayqar and Ghuwayr	Conduit infill – fluvial and colluvial. Nabataean–Byzantine.	Field relationships, existing exposures; total concentrations by Sykes (1997 via Grattan).
	Industrial wastes	
WF5053 – southwest of confluence of Wadis Shayqar and Faynan	Modern near-surface of silts in topographic hollow on surface of large mound of copper slag of Roman–Byzantine date, which is the Atlal Member.	Dating field relationships, existing exposures; total concentrations of Cu and Pb via AAS (Pyatt *et al.* 2005).
WF5022	Typical smaller area of slag – in the Atlal Member – at Tell Wadi Faynan associated with ancient field system.	Exposed face left by excavations of al-Najjar *et al.* (1990) who dated it by its pottery; detailed stratigraphic description and total concentrations by ICPMS.

Table 10.1 *Principal sites studied near the Khirbat Faynan that throw light on the earth surface processes, ancient pollution from ore mining, ore processing and smelting, and past land use and environments, in the Nabataean to Byzantine periods.*

angles across a shallow wadi and appears to be securely built onto wadi-sides to the north and south. Surface exposure and examination of a previously excavated pit indicate that it is faced on both sides by copper slag embedded against it. Its uppermost surface is significantly lower in the middle of the wadi than at its margins, but it is not clear if this is the original design, or the result of subsequent erosion by storm water or the passage of innumerable feet and hooves moving to and from the forage and shade beneath the extant *Acacia* trees growing on the ponded sediments. Today the barrage effectively impounds shallow water after heavy winter rain storms, which drains at its northern margin through a stone-built 'sluice' channel, apparently integral to the original construction (Fig. 3.5). Presumably this also happened in the past, in which case it seems possible that the sluice may have been equipped with a removable wooden barrier. Large and substantial barrages, some including sluices, are known across North Africa and southwest Asia, including in the arid regions of Jordan, their construction usually associated with the management of surface water and to a lesser extent sediment for agricultural or domestic purposes (Brunner and Haefner 1986; Evenari *et al.* 1982 [1971]; Gilbertson and Kennedy 1984; Gilbertson *et al.* 1984; Helms 1981; Kennedy 1995; Oleson 2001). In the case of the Khirbat Faynan barrage, though its adjacency to the settlement might suggest that its primary purpose was to store drinking water for people or animals, its massive construction appears significantly 'over-engineered' and excessively robust for that purpose given that the geomorphic properties of the catchment. The catchment is very small, often floored with porous Pleistocene deposits that have a lower capacity to yield surface run-off than the Palaeozoic bedrocks of the area. The southern boundary of the catchment is formed by the (modern rubble of) Khirbat Faynan. This interfluve continues to the southeast and is seen behind the *Acacia* in Figure 1.15 to be quite a number of metres above the catchment floor. The interfluve is significantly higher than the fragments of a possible degraded conduit (which is not an animal track) observed in the geomorphological surveys (e.g. Fig. 3.1). As a result, the barrage cannot have stored water transported to the area along the northern side of the Ghuwayr in the direction of the southern and lower margins of the Khirbat Faynan. Moreover, the large areas of metalliferous waste on its margins and within it (Fig. 3.12) would have seriously contaminated any water flowing into it, as indeed we found from our geochemical analyses of the sediments behind and below it (Figs 3.5, 3.11). A simpler explanation of the barrage is that it was designed to support industrial-metallurgical processes, perhaps related to ore washing, more than the impoundment of water.

The infill deposits up-wadi of the barrage were first examined using an Eijkelkamp corer with a 6 cm Edelman sampling head to a depth of 232 cm (WF5017 = WF5517; Fig. 3.5). Our understanding of the age and industrial significance of the barrage and the infill deposits has changed significantly during the course of the project as more radiocarbon dates and more detailed geochemical information were obtained. The initial dating and geochemical interpretation of these infill sediments (Barker 2002) was influenced by two radiocarbon dates obtained from disaggregated charcoal at two different depths in the core (WF5017), which gave the same radiocarbon date of 2630±50 BP or 910–594 cal. BC (Beta-110840, Beta-118041). The palynological and geochemical evidence derived from this core was useful and meaningful. The evidence pointed to a series of phases of intense metal pollution at the site which were broadly correlated with industrial ore-smelting in what was anticipated to be mainly in Classical times, but also reaching perhaps as far back as the Nabataean period or Iron Age. These pollution episodes were followed by a rapid fall-off in the input of heavy metals associated with the cessation of industrial activity, and then a long period in which the landscape surface slowly began to lose metal pollutants by natural processes. Due attention to issues of taphonomy emphasized the likelihood that charcoal had been re-worked at this location at various times in the past, just as re-working can be seen to be affecting charcoal, pottery, and clastic materials at the modern land surface. A cautious interpretation of these two identical radiocarbon dates (like the sherd fragments also found in the core WF5017) suggested that, whilst they can be taken to indicate some form of industrial activity in the locality in the first millennium BC, they probably represented charcoal that had been reworked and incorporated into younger sediments. These taphonomic issues became clearer when we excavated a 4 × 1 m pit in order to investigate the infill sequence with more precision. This excavation (WF5012, Fig. 1.15) reached to 2.8 m depth, where the surficial deposits were impenetrable, and samples were taken in 2 cm-thick spits for laboratory analysis (simple textural and mineral magnetic properties, together with % LOI [Loss on Ignition]), the laboratory determinations of the deposits corresponding well with the field observations throughout the sequence. The detailed evidence for the correlation of the cored deposits with the excavated deposits, combining lithological, pollen-biostratigraphic, geochemical, artefactual data, and four new radiocarbon dates from charcoal obtained from certain provenance during the excavation, and their antiquity, is provided by Grattan *et al.* (2007) and Hunt *et al.* (2004; 2007b). The new understanding, including the new and previous radiocarbon dates, was set out in Figure 3.11 in the wider context of the difficulties of establishing overall geoarchaeological sequences in this type of situation. The sequence observed in the excavated pit (WF5012) is summarized in Table 10.2.

Unexpectedly, a large fragment of charcoal within Lithofacies 6 at the base of the sequence gave a radiocarbon date of 3390±40 BP or 1867–1536 cal. BC (Beta-203402), suggesting that this distinctive pollution-rich deposit might be attributable to the Middle Bronze Age, or that this material had been reworked. Fragments of Nabataean and Byzantine sherds were found within the lower parts of Lithofacies 5. The sedimentary structures observed in both Lithofacies 6 and 5 demonstrated past mass-movement, which has a clear bearing upon the meaning of the radiocarbon date and its geochemical record. The new and previous radiocarbon dates (Beta-2034400–1) all indicate that the upper part of Lithofacies 5 and all of Lithofacies 4 appear to date to the latter stages of the Classical period. Lithofacies 2 and 1 are suggested at this and other sites to be attributable to sedimentation from *c.*1350 calendar years ago to the present, through a combination of geomorphic study, biostratigraphy, and radiocarbon dates (Chapters 3 and 12). As a result, this is the basic chronology adopted for the remainder of this and the following chapter, but we need to be mindful always of the difficulties and uncertainties of dating and interpretation in such dryland sand-dominated, clastic sequences.

10.7.1.1 Stratigraphy

The oldest deposits observed in the excavation were designated Lithofacies 6. The sedimentary properties and structures have the characteristics of colluvium with anthropogenic and mass-movement deposits associated with ancient ore processing that produced the ore particles, charcoal, and ash in a dry wadi floor environment. This suggests that Lithofacies 6 may have accumulated in the wadi basin before the Khirbat Faynan barrage was constructed and in the general absence of ponded water behind the barrage. The evidence indicates some form of fire-based ore processing, with smelting producing a small clinker. The geochemical signature of these deposits is quite distinct from the Roman–Byzantine deposits that overlie it, indicative of different ores being processed (see below).

The overlying Lithofacies 5 consisted of deposits that accumulated in a perennial standing-water environment that was also influenced by running water, at a location characterized by soil erosion, the crushing and sorting of copper ores, and (on the evidence of charcoal, ash, slag, and enhanced magnetic susceptibility) the intensive use of fire. The lower part of the lithofacies seems to represent a reworking of polluted ground in the vicinity, with the same geochemical character as Lithofacies 6 (perhaps the result of re-working of pre-Roman metalworking), but it does not seem to indicate active metallurgy. This part of Lithofacies 5 dates to approximately 1800±40 BP or cal. AD 92–339 (Beta-203401). There is no evidence of dryland conditions or temporary desiccation. The marked change in the local environment suggests that local rainfall was

WF5012 Lithofacies	Depth (cm)	Summary description and interpretation
4	156–205	Pale brown, fine, quartz and limestone sand; not copper ores; distinctive laminations; typically well-sorted; marked fining-upward laminae, with granite-derived grit and fine pebbles in lag deposits at the base of each laminae. Greater % sand than Lithofacies below; sometimes with brown hues. Roman potsherds at 1.95 m. No evidence of any of the following was found: ash, charcoal, copper slag, colluvial activity, local turbidity currents, mass-movement or sediment deformation, intra-sequence desiccation cracks, induration, or mineral deposition. *Interpretation*: run-off and storm deposits into a perennial pool behind the barrage-pool; moving water re-working of surface materials in the immediate area. Little or no industrial activity evident in the geochemical record above *c.*1.65 m; substantial pollution took place below this depth. *Dating*: Radiocarbon dates 1.74–1.76 m depth 1610±40 BP or cal . AD 349–547 (Beta-203399); 2.04–2.06 m 1870±40 BP or cal. AD 60–238 (Beta-203400). Biostratigraphic correlation indicates that the top of this deposit can be correlated with the period about 1350 years BP (Hunt *et al.* 2004; 2007b).
5	205–260	Fine sand, often with much clay, some silt; irregularly laminated with laminae between 1 and 3 mm thick; lenses of sorted sands, including lenses of sorted sand-sized, green copper ores; comminuted charcoal present throughout; some large clasts of charcoal but less comminuted charcoal than Lithofacies 6 beneath; cobbles and boulders common that have deformed underlying laminae producing distinctive 'bird's eye deformation-loading structures'; comparatively high % LOI and very high magnetic susceptibility. Nabataean potsherd at 2.35 m depth; Roman potsherd at 2.28 m. Between 240–260 cm the clay-rich sediment is deformed; overall poor sorting; occasional lenses of well-sorted, sand-sized grains of copper ore, slag and ash, colour varies: sand matrix – pale brown; ore sands – green; ash – grey. No evidence found of intra-sequence desiccation cracks, induration, or mineral precipitation. Infrequent pollen that are typically corroded. *Interpretation*: complex of individual mass flow deposits and local turbidity currents, and deposits of ponded-water and moving-water that accumulated rapidly at a wadi-floor location that was 'permanently wet' – often in shallow water. Frequent local use of hot fires producing ash and charcoal hereabouts and some smelting nearby; at the site there was mass-movement and deformation of wet sediment and fluvial re-working, with perennial water; where crushed ores had been crushed, graded, and size-sorted (perhaps using moving sorted in a flume or sluice), but not yet smelted. The high clay content and corroded pollen are derived by erosion from exposed surfaces and profiles. No evidence of dryland colluvial activity or dry wadi floor. Unpublished work by Gilbertson *et al*. suggests a hiatus exists at or immediately below 2.3 m depth, the materials beneath differing geochemically from those above this point. *Dating*: Radiocarbon date: *c.*2.24–2.26 m depth 1800±40 BP or cal. AD 92–339 (Beta-203401). Biostratigraphic and lithological comparisons with deposits in adjacent borehole WF5017 indicate correlation with two identical radiocarbon dates of 2630±50 years BP or 910–594 cal. BC (Beta-110840 and Beta-110841) which as a result are now regarded as charcoal re-worked into younger deposits (see Hunt *et al.* 2004; 2007b).
6	260–285	Diamicton; matrix supported; abundant sand-sized materials of different materials; some silt and clay; with numerous angular clasts of angular of slag-clinker; angular cobbles of limestone, no evidence of abrasion, grit and pebbles that are matrix supported; much comminuted charcoal but no charcoal clasts were seen; overall very poorly sorted; stratification not clear; rests upon a very hard, impenetrable layer of clay-sand that is located on a bedrock surface; black to dark brown colours. No evidence of intra-sequence desiccation cracks, induration, mineral deposition, slip planes, ponded or moving water. Comparatively raised % LOI and magnetic susceptibility. Pollen grains rare. *Interpretation*: product of ore-smelting involving fire, 'anthropogenic colluvium' and mass movement, with minor impact of deposits of airfall ash and silts from catchment, and overland flow, in a wadi floor that was dry, suggesting a hot and arid climate. The abundant sand-sized materials relate to disintegration of the bedrock and ore materials. *Dating*: Radiocarbon date 2.8 m depth 3390±40 BP or 1867–1536 cal. BC (Beta-203402). Sedimentological and pollen-biostratigraphic correlation with radiocarbon dates from adjacent borehole WF5017 also suggests an age older than 2630±50 radiocarbon years BP or 910–594 cal. BC (Beta-110840); these dates are now regarded as re-worked charcoal (see Hunt *et al.* 2004; 2007b).
Oldest		

Table 10.2 *Infill sequence at site WF5012 up-wadi of the Khirbat Faynan barrage.*

significantly higher and more regular than today, that the barrage had been constructed at this time ponding water and making the locality perennially water-logged or underwater, and that significant ore processing was being undertaken nearby.

Lithofacies 4 is substantially different from the two lithofacies beneath, being characterized by the distinctive laminations and good-sediment sorting of an aquatic depositional environment, with changing velocities of water entering the ponded area (on the evidence of lag deposits and fining-upward cycles). These conditions imply a wetter climate than today, but with higher water velocities than evidenced in Lithofacies 5 that may have been responsible for the greater proportion of sands, as opposed to silt and clay, being deposited. These fluvial-lacustrine deposits lack the indicators of mass-movement, colluvium, or ore-processing waste of the lower lithofacies, and though brown discolourations in the matrix imply some sort of industrial or agricultural activities nearby, there were no macroscopic indicators of fire, ore processing, or smelting. The radiocarbon dates suggest that these events are attributable to the Roman–Byzantine period: 1870±40 BP or cal. AD 60–238 (Beta-203400) and 1610±40 BP or cal. AD 349–547 (Beta-203399).

Lithofacies 3 is characterized by coarser sands that suggest a distinctive flood event that marks the end of lacustrine-fluvial depositional environments in the wadi (Table 3.4). There is a distinct stratigraphic and textural break between these deposits and those above (up to the present), which consist predominantly of aeolian silts and fine sands suggesting significant regional aridification, and lacking indicators of fire and/or industrial activity. It is younger than 1610±40 BP or cal. AD 349–547 (Beta-203399).

10.7.1.2 Palynology

The palynology, including palynomorphs, recovered from the borehole WF5017 is summarized in Figures 10.37 and 10.38, and the habitat changes inferred are illustrated in Figure 11.9. Following Mohamed (1999), the material is attributed to two pollen assemblage biozones, CLP (Chenopodiaceae-Lactuceae-Poaceae) and CPE (Chenopodiaceae-*Pinus-Ephedra*) (see Chapter 3, §3.4.2).

Fragmented charcoal at the base of the CLP biozone gave a radiocarbon date of 2630±50 BP or 910–594 cal. BC (Beta-110840 and Beta-110841), but the charcoal is thought to have been reworked into younger sediments (see above). The age of the top of the biozone has not been determined but is estimated to be approximately 2000 years BP (Mohamed 1999). The presence of significant quantities of pollen of Poaceae, Caryophyllaceae, and *Plantago*, and the members of the local desertic flora such as Chenopodiaceae and *Ephedra*, suggest a degraded, desiccated, steppe environment for the area, which is discordant with the previous conclusions of a notably wetter climate. The substantial numbers of Lactuceae, Asteraceae, and VAMs suggest significant erosion of surface- and near-surface materials in the surrounding area, contemporary with, and perhaps related to, land disturbance produced by the substantial metallurgical activity being undertaken locally in this period. Longer-distance inputs of a small number of grains from wooded vegetation on the plateau or high mountain front (Fig. 2.12) are indicated by the occasional grains of *Quercus*, *Pinus,* and *Juniperus*. Spores from aquatic algae also preserve in these sediments, indicating the presence of water at the site. Their frequencies correspond with variations in the abundance of pollen from waterside macrophytes, further demonstrating that water accumulated intermittently behind the barrage at this time, findings that are in keeping with the conclusions of the sedimentological studies. The palynofacies in biozone CLP included substantial numbers of thermally mature grains, pointing to the intensive use of fire. The distinctive changes in the numbers of thermally-mature grains might reflect variations in the scale and intensity of fires at the site, or perhaps merely the effects of other taphonomic processes. (Thermally-mature grains, like charcoal or pottery sherds, re-cycle in arid lands, but at present there is no further taphonomic information to assess the significance of this observation.) The modest numbers of VAMs provide a measure of soil erosion, indicating that this was significant, and much higher than in the subsequent pollen biozone C.

The base of the CPE biozone is estimated to be around 2000 BP and its top is defined at WF5025 by a date of 390±50 BP or cal. AD 1435–1635 (Beta-115214). There are

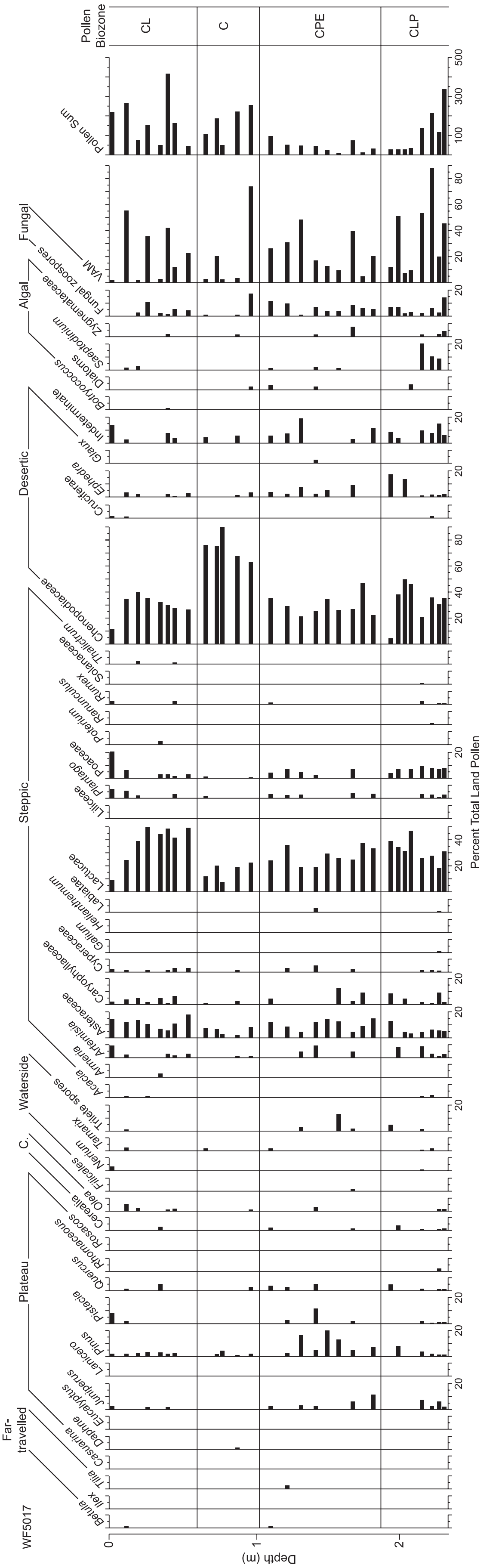


***Figure 10.37** The palynology of infill sediments in the borehole WF5017 in the small side-wadi behind the Khirbat Faynan barrage (WF441). The pollen taxa are grouped into broadly-defined habitat types; C = cultivated (see also Figs 2.13, 3.5, 10.38, 11.9). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

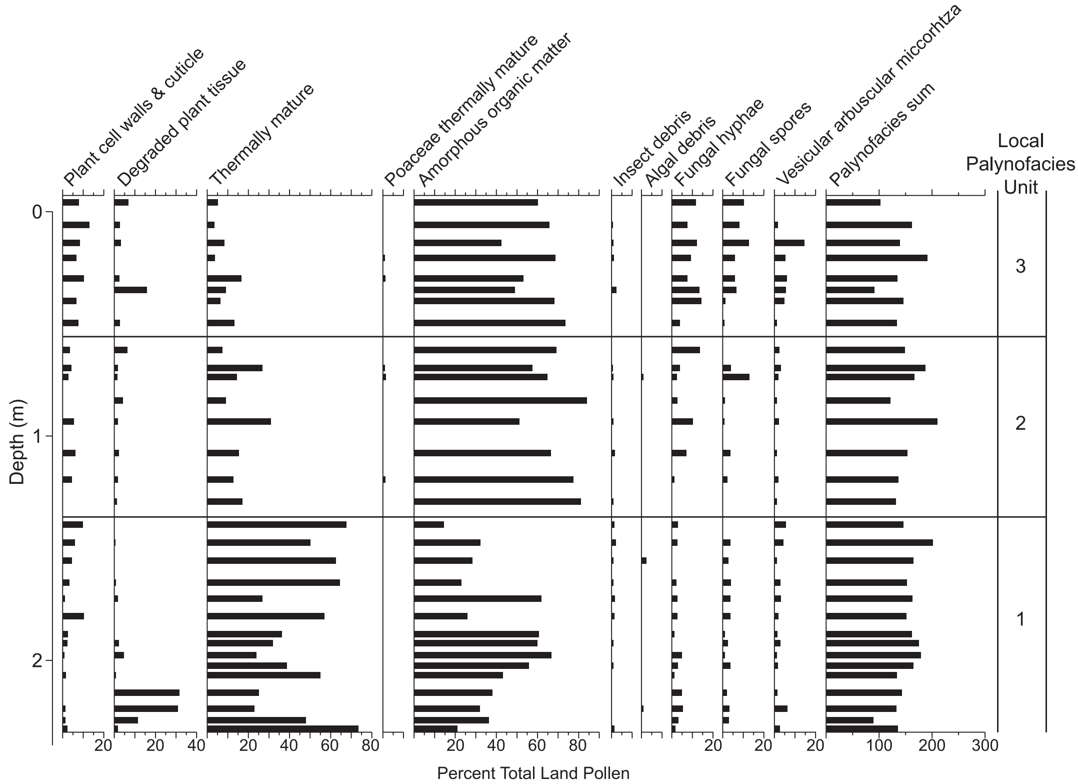


Figure 10.38 *Palynofacies in the infill sediments in the borehole WF5017 in the small side-wadi behind the Khirbat Faynan barrage (WF441) (see also Figs 2.13, 3.5, 10.37, 11.9). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

significant differences between this biozone and the earlier CLP biozone, pointing to the development of more arid conditions. The frequencies of Chenopodiaceae, Lactuceae, and Asteraceae, and *Ephedra*, *Plantago*, Caryophyllaceae, Liliaceae, *Glaux,* and *Rumex* suggest a degraded steppe environment, and there is continued palynofacies evidence for the erosion of surface and near-surface materials. Also present are algal spores and pollen of *Tamarix* and *Nerium*, taxa that are nowadays with permanent springs in the Faynan gorges (Fig. 2.8) or the moist areas of its braid-plain. The relatively high frequencies noted for *Pinus*, *Juniperus*, *Quercus,* and *Pistacia* are likely to reflect trees growing higher up on the mountain front or on the plateau. This type of 'exaggeration' of distinctive tree pollen in areas of low local pollen production is associated with desert environments (Horowitz 1992). The occurrence of *Olea* and cereal-type Gramineae is evidence that farming may have been taking place somewhere in the area. In the upper parts of the biozone at *c*.1450 calendar years ago there is a dramatic reduction in the numbers of thermally-mature grains, which remain consistently low in the overlying Biozone C, a decline suggesting the loss of the frequent and intense fires associated with smelting. The flora of Biozone C indicate a dry, degraded, desiccated steppe environment which experienced occasional intense rainstorms (Chapter 11).

10.7.1.3 Geochemistry

ICP-MS based studies of total major and minor metals were completed for sediments taken from both the excavation (WF5012) and from the adjacent borehole (WF5017); the results are summarized as Figure 10.39 and Table 10.3. The concentrations of copper, lead, strontium, and thallium are substantially higher, sometimes by several orders of magnitude, than those any other buried or surficial deposits studied to date in this region (Grattan unpublished; Sykes 1997; and see Chapter 3). Human agency must be the primary agency in their formation. The possible effects on the sediments of post-depositional processes such as the upward recycling of materials by tree roots and the downward movement by water percolation are estimated to be present but only of minor significance in terms of the total heavy metal load deposited in the original sediments (Grattan *et al.* 2007).

The stratigraphic discussion above indicates that Chemizone 4 may be wholly Bronze Age in date, though possibly the upper components are in part Iron Age and later. The dominance of lead over copper might represent the presence of crushed and graded ores of DLS lead-rich ores and smelting products from them, or the re-processing from previously smelted slag from which copper had already been removed by smelting, a process identified by Hauptmann (2000). The high concentrations of thallium at

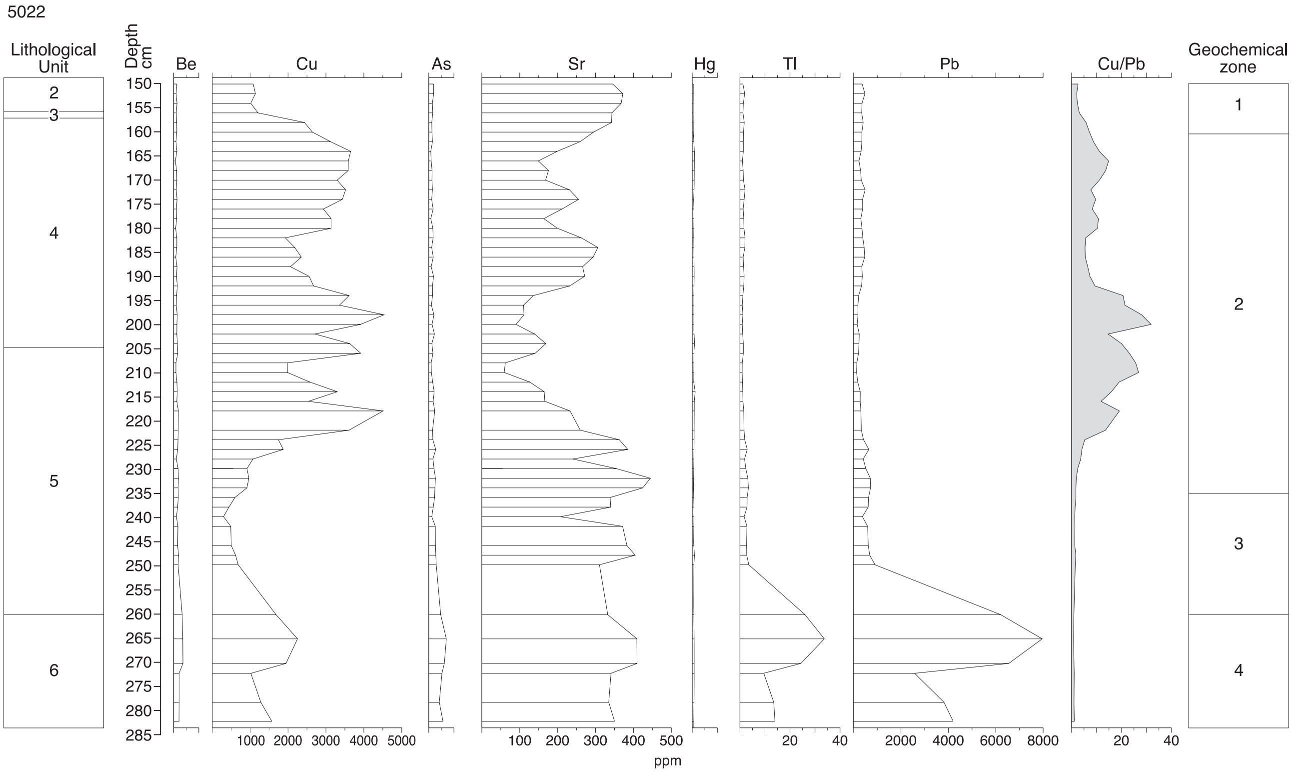


Figure 10.39 *Summary of the geochemistry (Chemizones 1–4) and lithologies (Lithofacies Units 2–6) of the infill sediments in the excavated trench WF5012 behind the Khirbat Faynan barrage (WF441) (Be = beryllium; Cu = copper; As = arsenic; Sr = strontium; Hg = mercury; Tl = thallium; Pb = lead). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

the top of this zone (which increase in Chemizone 3 above) could indicate the presence of thallium-rich ores or its local accumulation in ash or wood on surface deposits during smelting. High strontium concentrations point to a significant net input from one or both of two carbonate sources, the carbonate bedrocks of the locality and DLS ores.

Chemizone 3 corresponds with the lower part of Lithofacies 5 and may be Classical (Nabataean/Roman) in date. The relatively low concentrations of metals within this unit might reflect purely local, topographically-induced, changes, such as the effects of impounding water by the construction of the barrage, or the transfer of ore processing and smelting from the wadi floor to adjacent higher ground, but they appear more likely to reflect a general reduction in industrial activity at the locality. The reversal in the proportions of lead and copper at about 270 cm depth, associated with peak concentrations of thallium (used in this study as a partial surrogate of smelting-fires, as well as of original ore composition: see Chapters 2 and 3), is one of the most distinctive features of the geochemical sequence, with high levels of copper continuing throughout the rest of the sequence. Possible explanations include the re-use of materials from which lead had previously been extracted, technological changes increasing the release of copper, and differences between the geomorphological behaviour of copper and lead in fluvial environments (e.g. MacKenzie and Pulford 2002; Wray 1998), but by far the simplest explanation is a systematic and sustained shift to copper-rich lead-poor ores.

The distinctive fluctuations in the total concentrations of elements through Chemizone 2 cannot be interpreted simply as changes in the intensity of industrial activity, because they span Lithofacies 5 and 4 and Lithofacies 5 is interpreted as a period when the use of the barrage catchment was particularly intensive for ore processing and smelting. From about 207 cm to its base at 230 cm, Chemizone 2 occurs in mass-movement deposits with lenses of metal-rich sands that suggest concentrations in small streams, often with impounded water. As a result, the major fluctuations in geochemical signature between 230 cm and 207 cm may be no more than the chance effects of mass-movement and fluvial-lacustrine geomorphic processes. The deposits between 220 cm and 212 cm have the lowest concentrations of lead recorded throughout the entire sequence, including those of the modern day, and thallium concentrations are also comparatively low, suggesting the processing nearby of particularly copper-rich ores, or of materials from which lead and thallium had already been largely removed. Two sustained peaks of local metal pollution at *c.*200 cm and 170–185 cm, separated by a marked 'trough' at *c.*185–195 cm, are likely to reflect airfall and/or run-off from distinct episodes of industrial activity of different intensity, as they derive from Lithofacies 4 sediments, which were characterized by little evidence of mass-movement or fluvial re-working.

The rapid decline in metal concentrations from a peak at *c*.170 cm to the Lithofacies 3 gravels at *c*.159 cm probably represents the end of Roman/Byzantine metallurgical activity at the site. The upper parts of Chemizone 2 are attributed to the post-Byzantine period (Hunt *et al.* 2004; Grattan *et al*. 2007; and see Chapter 11).

10.7.1.4 Synthesis

In the Late Bronze Age and/or Iron Age, before *c*.2650 BP (Lithofacies 6; Chemizone C4), the barrage wadi was characterized by predominantly colluvial and mass-movement processes, in a generally hot and dry climate. The processing and smelting of copper ores (DLS ores especially), with substantial use of fire, disturbed and polluted the colluvial sediments. Two main episodes of activity produced concentrations of lead ranging from *c*.2400 to *c*.7825 ppm, of copper ranging from *c*.1000 to *c*.2230 ppm, and of thallium of *c*.25–33 ppm – creating a profoundly toxic working industrial environment. Subsequently (from before *c*.2650 BP to *c*.2000 BP), with the construction of the barrage (at a time of a substantially wetter climate), standing water resulted in fluvial and pond deposits with a dangerous metal burden resulting from the increasingly intensive processing, grading, and smelting of MBS ores on the margins of the basin (Lithofacies 5; Chemizone C3). After *c*.2000 BP, whilst trees grew on the distant high ground (Biozone CLP), the vegetation near the barrage was desertic and degraded steppic, though there is some evidence for olive cultivation. Clearly Roman/Byzantine industrial and associated agricultural activity had significant impacts on the landscape in a climate that was comparatively wet compared with today. Accelerated soil erosion and reworking similarly reflect the impacts of these geomorphic and industrial processes. The fires associated with the smelting at the site produced substantial quantities of thermally-mature pollen grains, charcoal, ash and discoloured sediment, and substantial pollution burdens from toxic metals were derived from the processing of relatively lead-poor copper ore sources. By the Byzantine period the local vegetation had become further degraded. The distinctive and relatively rapid decline in gross pollution evidenced in the WF5012 excavation and WF5017 borehole is assumed to mark the end of Roman/Byzantine industrial activity. Some time later the climate became more arid, the degraded steppe vegetation

Chemizone	Depth (cm)	Summary description and interpretation
C2	160–230	Four or more fluctuations in concentrations of copper and lead, whilst thallium is low, in an overall long-term decline in pollution input. Copper concentrations vary from *c*.1800 ppm to *c*.4500 ppm; lead concentrations are low, typically ≤200 ppm between 220–200 cm with minimum *c*.75 ppm, maximum 65 ppm. Strontium 200–450 ppm; thallium low *c*.1.5–2.5 ppm. Transitional change to Chemizone 3 below. *Interpretation*: An uncertain combination of the following: incorporation and sorting of residual polluted earth surface materials from the area by wind and perhaps overland flow into a perennial water body with abundant moving water in an area that from the time of about 165 cm depth experienced overall declining metal-processing activity; from metallurgy based nearby but not at this immediate wadi-floor location.
C3	230–260	Up-profile, copper declines to minimal *c*.470 ppm at 250 cm depth then increases to *c*.4500 ppm in concentrations of copper; lead concentrations at *c*.500 ppm and essentially stable with minor trough at 250 cm. Strontium *c*.50–300 ppm. Thallium typically <3.5 ppm, but 26 ppm at 250 cm. *Interpretation*: pollution from ore processing and smelting, fluctuates in intensity according to type and intensity of ore processing and smelting above *c*.2.25 m and dated to 'Roman–Byzantine' times. Below this level was much re-working and re-cycling by geomorphic processes of both metal-poor and metal-rich clays from adjacent surficial deposits and surrounding area; metals recycled by wind and water into a frequently perennially wet-ponded area impounded by the barrage.
C4	260–282	Two peaks and a trough in concentrations of lead which range from *c*.2400 to *c*.7825 ppm; and always significantly exceed those of copper in a range from *c*.1000 to *c*.2230 ppm. High concentrations of thallium with 9–13 ppm at base; maximum 25–33 ppm at top of zone. Strontium *c*.320–450 ppm. *Interpretation*: lead-rich copper ores accumulating on dry wadi floor, perhaps before, as well as during, copper smelting nearby – dating to the Bronze Age.
Oldest		

Table 10.3 *Description and interpretation of chemizones at WF5012 (= WF5512).*

Unit WF5022	Height above base of exposure (cm)	Description and interpretation
	Top of section	
1	155	Surface is a matrix-supported fine sand and silt, visibly wind-blown and water washed; with discontinuous clasts of mainly non-reworked copper slag (2–3 cm diameter) with fragments of pottery of Roman and Byzantine age. Thin layers of clay and lag deposits of pebbles resting on small surfaces. The copper slag essentially forms a local concentration of clinker waste – it represents past smelting at this particular site.
2	153–155	Surface crust, very pale grey-brown compact laminated silt clay, sometimes buff.
3	149–153	Silt, very pale grey-brown, ashy, friable, with Roman/Byzantine pottery, chert (flinty) chert, root pores, small peds which are irregular, weak, sometimes blocky, and rather disordered. Lower boundary transitional over 2–3 cm.
	Base of section	

Table 10.4 *Sequence of deposits at WF5022.*

continued losing all clear signs of the cultivation of crops or trees, and standing water became less frequent behind the barrage. The landscape was slowly cleared of toxic metals by natural bio-geomorphic processes, indicators of burning and burnt ground reduce, and soil erosion declined to significantly lower levels.

10.7.2 Fluvial deposits

WF5025 (Figs 3.1, 3.6, 3.7) situated on a low terrace adjacent to the floor of the modern Wadi Dana in one of its more confined sectors, was mapped as the Dana Beds by Barker *et al*. (1997) but is now classified as the Dana Wadi Beds (Hunt *et al.* 2004; McLaren *et al.* 2004). Unit 1 consists of 1.0 m of trough cross-bedded gravels, associated with palynological indicators of open eroding ground, degraded steppe and desert vegetation, and cereal cultivation. The flora can be correlated on biostratigraphic grounds with the CPE biozone in the Khirbat Faynan barrage infill sequence, suggesting a Roman–Byzantine age (Mohamed 1999). The sequence suggests that, during the deposition of Unit 1, in Roman–Byzantine times, as later, this wadi floor environment was a degraded treeless steppe adjacent to desert, with only occasional water and with no evidence of local industrial activity. Another relevant sediment sample (WF5028) was obtained from the conduit leading to the aqueduct that crosses the Wadi Shayqar en route to the major reservoir on the southern side of Wadi Faynan opposite Khirbat Faynan (Fig. 4.33). Geochemical analysis demonstrated significant contamination in copper and lead (copper 1792 ppm, lead 175 ppm), probably reflecting areas of smelting debris along the upstream route of the conduit.

Analysis of the sediments cored in the bare silt-filled hollow within the huge 'doughnut' of slag near the Khirbat Faynan reservoir, within the Atlal Member at WF5033 (Figs 1.4, 1.10; near WF5052, Fig. 3.1), found dangerous concentrations of copper and lead, the average of three samples being 11,961 mg/kg^{-1} of copper and 15,204 mg/kg^{-1} of lead (Pyatt *et al.* 2005).

The modern land surface at Tell Wadi Faynan is associated with walls of the WF4 field system assigned to the Roman–Byzantine period, and the upper 6 cm of the section exposed by the earlier excavations (al-Najjar *et al*. 1999; Fig. 1.9) can also be attributed to this period (WF5022). Although the ancient walls were designed to manage the overland flow of water, they also caused the deposition of aeolian sediments especially on their southern sides. Small concentrations of black copper-smelting slag occur on the land surface of these fields, and the frequency of small (*c*.1–3 m) pockets of smelted copper slag in the uppermost part of the WF5022 sequence (Units 1 and 2) indicates numerous brief episodes of local small-scale smelting (Fig. 3.4 and Table 10.4). The concentrations of copper in these sediments vary between 2166 and 3296 ppm, and of lead between 348 and 737 ppm, striking evidence of the toxicity of arable land in the WF4 field system in the Roman/Byzantine period.

10.7.3 Human skeletal remains

The skeletal remains of individuals from a series of graves in the South Cemetery (WF3) dating from the fourth–seventh centuries AD (Findlater *et al.* 1998; Karaki 1999) were the subject of geochemical studies by Grattan *et al.* (2002; 2003a; 2005) and Pyatt *et al.* (2005). The results are summarized in Tables 10.5 and 10.6. These data suggest that there are two distinctive human populations present, one with comparatively low concentrations of copper and lead and one with substantial heavy metal burdens. The latter evidently accumulated significant quantities of heavy metals, particularly lead, in life, indicating sustained exposure over a long period. The skeletons with low levels of metal pollutants might be people who had not lived long in the locality at the time of their death. Many of the examined skeletons exhibited osteological trauma, consistent with prolonged hard physical labour, again suggesting on-going mining and smelting operations. The heavy metal levels in the skeletal remains are thus unlikely to represent simply the residual effects of a polluted, but no longer active, industrial landscape (Grattan *et al.* 2002; 2007). Rather, the overall levels and the differential exposures suggest continuing engagement with metallurgy in the valley, with some individuals significantly more exposed than others to dangerous pollutants through work in the mines, in ore-processing, or at the furnaces.

The variations between the external and internal tissues in one skeleton (Table 10.6) could reflect some post-mortem transport from the surrounding sediments to the bones, but given the relative magnitudes, the observed pattern of enhanced concentrations is more likely to be the result of physiological properties of these bones and/or the proximity of these bone surfaces to tissues such as skin that may have greater contact with heavy metals (Pyatt *et al.* unpublished). It is not known if this individual was directly associated with any industrial activity in life. The insect pupae that form part of the decay chain do not appear to have accumulated heavy metals in comparison with the associated sediments and skeletal tissues. It seems clear from these results that the well-being of the population in the Wadi Faynan was profoundly compromised by the intensity of mining and smelting activity during the Roman/Byzantine periods.

The dense carpet of Classical sherds in the fields around Tell Wadi Faynan, as through much of the WF field system, together with the relative absence of major rubbish deposits around Khirbat Faynan itself, almost certainly indicate the sustained and large-scale collection of domestic and household waste from the major settlement and the manuring of the land with it. In Chapter 3 (§3.7) we noted the continuing effects of pollution on plant fertility, with seed production on wild barley plants showing a progressive decline with closer proximity to slag heaps (Fig. 3.15). Although perhaps not understood as a consequence of pollution, problems of diminished plant or soil fertility can hardly have gone unremarked amongst the people working the land in the Roman/Byzantine

Grave	Cu mg/g	Pb mg/kg
5	278.5	47.6
10	17.0	20.7
11	9.8	1.8
12	88.6	12.3
22	13.2	1.6
25	109.1	170.0
27	30.7	47.5
66	24.0	55.3
67	181	289.2
69	17.1	27.6
70	5.0	1.0
72	3.0	13.0
73	296.2	19.1
75	7.0	42.0
76	20.0	21.6
78	20.0	12.8
80	6.3	37.7
81	7.0	27.9
83	11.0	28.9
85	43.7	1.0
86	2.4	15.0
87	2.4	4.7
88	135.6	75.6
89	2.5	16.0
91	30.0	26.6
94	2.1	9.2
96	90.7	44.2
97	5.7	13.7
101	29.2	24.3
102	27.5	204.6
104	43.1	17.01
105	17.9	37.1
110	2.8	8.4
112	5.9	14.4
113	73.9	46.7
117	22.4	93.7
Mean	52.57	42.49
Max	296.2	289.2
Min	2.1	1.0

Table 10.5 *Concentrations of copper and lead (in mg/kg) in human skeletal bones excavated from graves of Byzantine age in the South Cemetery (WF3) near Khirbat Faynan. (After Grattan* et al. *2002.)*

Sample	Cu mg/kg	Pb mg/kg
Human femur – outer bone	197	196
Human femur – inner bone	177	170
Human cranium – outer bone	103	35
Human cranium – inner bone	47	24
Human rib adjacent to insect pupae	137	99
Insect pupae within thoracic cavity	30	11
Associated sediments	44	28

Table 10.6 *Concentrations of copper and lead (in mg/kg by AAS) of different skeletal parts of a single human skeleton and associated materials of Byzantine age from the South Cemetery (WF3) near Khirbat Faynan. (After Pyatt* et al. *unpublished.)*

period. Human and animal waste was known to improve soil and crop fertility in antiquity, and this was the obvious strategy for the ancient farmers of Faynan to adopt in response to declining yields. However, they cannot have appreciated that the unfortunate side-effect of this policy was to add to the farmland the fraction of heavy metal components excreted by themselves and their animals, as evidenced at Tell Wadi Faynan (Fig. 3.18 and Table 10.4). If manuring was perceived as a remedy to falling productivity, it was in fact almost certainly a factor in exacerbating it.

10.8 The logistics of supply

The logistical needs of the Faynan mining community were large and required significant investment to allow a large labour force to be maintained in the desert on a year-round basis. It was vital to make the most of available resources – hence the concentration of activity at *Phaino*, a site that could be provided with a reliable supply of water by the major aqueduct down the Wadi Ghuwayr (the surviving traces suggest that there were at least two or three phases of construction and modification to this system). One advantage of a running-water supply was that it was less susceptible to localized pollution, though the open nature of the reservoir (*if* that was the main collection point for domestic water) must have made it vulnerable to pollution as a result of the intense smelting activity close by. The suitability of the land west of Khirbat Faynan for run-off farming (the WF4 field system) was clearly another key factor in the latter's selection as the mining centre, because as much food as possible needed to be produced in the valley to reduce the burden of long-range transport of basic requirements. Its produce was needed to support the subsistence needs of a mixed population of agricultural workers, animal handlers, miners and specialist metallurgical workers, soldiers, and officials.

Calculations by Friedman (2004: 24–7) have suggested that the northern zone of fields could have grown enough grain to support a population of *c.*167–312 people in optimum conditions. These figures compare favourably with estimates made by Decker (2001: 168–82), based on predicted sowing and yield rates and the fact that a family of six people required *c.*1623 kg of wheat per year to fulfil its calorie needs. Using these estimates, the Faynan field system could in optimum conditions have provided the cereal needs of around 300 people. But since conditions at Faynan were far from optimum, with the combination of unreliable 'desert' rainfall (even allowing for the presumed 'wetter climate') and the effects of progressively building levels of pollution in the soil, the food yield may have been closer to the needs of 100–200 people. This suggests that, important as the farming activity in the Faynan was, at all times the mining operation and other inhabitants of the valley will have been dependent on the importation of additional foodstuffs. Depending on how large a population one envisages for the valley and on how nutritionally generous a diet was provided for mine workers, the logistical burden on the mine administration of transporting food may have been considerable.

The population at Khirbat Faynan may generally have numbered in hundreds rather than thousands, but if the overall labour force and transient workers (mule drivers and such like) totalled a thousand or so (Table 13.7), it would have been somewhat similar to that at Mons Claudianus in the Egyptian desert. Practically all the food had to be transported in the latter case, whereas is clear that about a third of the required food could have been produced within the Faynan valley. The rest would have needed to be transported, along with luxury items, pottery, personal goods, clothes, and so on. Wheeled transport would have been very difficult in the Faynan and ‘Arabah landscapes and pack animals were the most likely means of shifting goods in and out. Camels can carry *c.*150 kg and donkeys *c.*65 kg, so the numbers required will have been substantial. Adams (2001: 83) has calculated that 1800 camel loads per year were required to transport grain for Mons Claudianus, so (allowing for up to a third of the required food to have been grown locally in Faynan) perhaps 1200 camel journeys or 2800 donkey trips may have been needed annually at Faynan for food alone. Monthly supply convoys, as suggested by the Egyptian evidence (Adams 2001: 183), would imply a minimum complement of 100 camels or 233 donkeys at Faynan. Camels will have been better suited for the transport up and down the ‘Arabah and across the Negev, whereas donkeys will have coped better than camels with the steep ascents and descents to the plateau. A mix of these two main beasts of burden at the mines is likely.

As we have described earlier, the WF4 field system, partially developed as a series of farms in the Nabataean period, was dramatically expanded for cultivation in the Roman/Byzantine period (Fig. 10.32), its unified organization suggesting that the control of land was centralized within an imperial estate, with farming henceforth carried out by people housed for the most part in the main settlement at *Phaino*. There was a number of small rectangular buildings attached to walls within the field system, but it seems unlikely that these were intended for more than seasonal use (stores for equipment, water-management duties in the rainy season, crop watching, harvest duties, and so on.). Progressive additions to the field system increased its integral nature, its scale, and its hydraulic sophistication. The technology of the run-off and floodwater farming systems underpinning the construction of the WF4 field system were designed to combat the essential background aridity and sustain a level of agriculture normally reserved for a better-watered zone. Productivity was thus being artificially raised above the ‘normal carrying capacity’ of such a landscape, but in so marginal a zone its long-term maintenance was fragile, particularly if exacerbated by the likely effects of pollution on crop fertility as discussed in the previous section.

The import of foodstuffs and other goods not produced locally, the movement of ore from the mines to the smelters, the import of charcoal for the furnaces (discussed in the next section), and the export of copper (under suitable security arrangements), must have accounted for a considerable number of pack animals, probably mostly camels or donkeys. The fodder needs of these animals would have been an additional burden on the system, perhaps met by a combination of additional grain imports and by exploiting available grazing within the valley. If the landscape was extensively grazed by pack animals associated with the mines, this would have had implications for the access to this resource of contemporary pastoral groups.

10.9 Charcoal and fuel demands

The demands for wood and charcoal for industrial and domestic uses during this period are difficult to estimate. The many and complex uses of different parts and different species of trees in the Middle East are described in FAO (1962; 1995). These include construction, structural purposes, making implements, transport, provision of tannin and medical chemicals, food, shade, browse, forage and fodder, fibre, shade, shelter, habitat, through to tinder, fuel, and charcoal. In East African arid lands today, the amount of wood-fuel needed per person for cooking and similar domestic purposes is estimated to vary between 0.15 and 2.1 cubic metres per year, relativities that are also well known in the study region (Engel 1993). Dried young trees and thin branches form good tinder that burns hot and quickly. Older trees form more dense wood that provides sustained heat. The calorific value of the final product is significantly governed by its moisture content. The conversion of wood to charcoal can be as low as fifteen per cent, the key variables being the pre-drying of wood, the skill of the charcoal makers, and the type, age, and structure of the wood. *Acacia* in the study area is a wood of high specific gravity, with limited moisture content, and which dries rapidly after cutting. *Pinus* from the hills is a wood of notably lower specific gravity and higher natural moisture content. *Quercus* spp. are intermediate. Typical charcoal is 75 per cent carbon, with moisture at 7 per cent. In the absence of information on the likely demand and use, or the demography and dynamics of the past human population and of the woody taxa in the immediate area, it is impossible to turn these charcoal-conversion data into reliable or precise estimates of the scales of wood harvesting for domestic uses or of its impact on the ecology of the area. Nevertheless, the scale of settlement in Wadi Faynan in Roman/Byzantine times indicates that the demand must have been substantial in terms of its increasingly poorly vegetated environment.

The demand for domestic uses must have been notably smaller than that for industrial purposes. Focusing only on charcoal for smelting, the ratio of ore-charge to charcoal that is needed for successful smelting is likely to have varied between 1:1 by weight (for very efficient technology and rich ores) to 1:3 where there was much slag. Hence the translation from wood to charcoal may have been as low as fifteen per cent; which is multiplied by ratios in the range between 1:1 to 1:3 to identify the volume of original wood needed to extract metal (further details of these relationships are given in FAO 1962; Overstreet *et al.* 1982; Rothenburg 1972; Rothenburg *et al.* 1978; cf. also Rihll 2001). Copper slag that has been attributable to the Iron Age to Byzantine periods in the vicinity of Khirbat Faynan is estimated to be in the order of 170,000 tons, and Roman copper production estimated at 2500–7000 tonnes (Hauptmann 2000; 2007: 52–3, 147). Extrapolated on a 400-year production period, the average annual copper yield of the mines based on Hauptmann's figures would have been in the order of 6.25–17.5 tonnes per year. These figures, which are almost certainly an underestimate, imply that the amount of wood used between the Iron Age and the end of Byzantine production must be measured in millions of tonnes.

Comparisons with estimates from the famous ancient copper-mining area of Cyprus are instructive (Constantinou 1992). The ancient copper slag produced in Cyprus is estimated to be a million tons (producing *c.*40,000 tons of copper), that is approximately six times larger than that estimated for the Wadi Faynan mines. Three hundred kg of charcoal was estimated on that island to extract *c.*1 kg of copper from ore. For the production of one ton of charcoal from the Mediterranean pine-oak woodlands, somewhere between twelve and twenty cubic metres of wood was needed, depending upon the efficiency of charcoal manufacture. Hence, in crude terms, this use of wood in Cyprus required *c.*6,000,000 tons of charcoal, or *c.*1,200,000,000 cubic metres of pine wood. Constantinou noted that over the 3500-year history of copper mining and smelting, this demand for wood required that the entire timber over the 150,000 km^2 of Mediterranean woodland on the island would have had to be harvested no less than sixteen times to yield the estimated quantities.

Translation of these figures, in whole or small part, to the arid Faynan, where trees would have been relatively limited in numbers even in the better-watered gorges and lower mountain slopes, implies a colossal industrial demand for timber in what was a steppic, relatively biologically-unproductive, environment (Figs 1.2, 2.11, 2.12). The restriction to the use for smelting of smaller and fast-growing shrub taxa and palms of limited calorific value noted by Engel (1993) implies a wood-gathering task of major and recurrent importance that must have spread over and affected substantial areas of the main sources in gorges and the base of the mountains. The implied demand is so large that the deliberate management of timber over large areas might be envisaged. The efficient manufacture of high-quality charcoal must have been a critical undertaking. It is clear that, whereas in the Iron Age a wide array of trees and scrub grew locally, in Roman/Byzantine times charcoal for the furnaces was being brought in from the plateau above (Barker 2002: 501; Engel 1993; Engel and Frey 1996; Hauptmann 2007: 50–53). It is not surprising that the few tree pollen recovered in these industrial areas from sediments from the CLP and CPE biozones have been attributed to long-distance transport from the distant uplands (Chapter 3, §3.4.2). The 80–258 tonnes of charcoal that would have been required annually (at the 1:1 or 1:3 ratio to ore) would represent *c.*1200–4000 donkey loads.

10.10 A landscape of imperial power

With the imposition of Roman control on the region in the early second century AD, the entire zone of the Faynan mines was taken into state ownership at an early date and maintained as such long into the Byzantine period. This was a landscape under careful surveillance. Central authority over the district was exercised by Roman officials, perhaps backed by a few troops, based at *Phaino* (Khirbat Faynan) or Khirbat Ratiye (Fig. 10.40). Some of the labour for the mines is believed to have been provided by slaves or convicts, but many mining personnel and certainly the more specialist engineering and metallurgical roles will have depended on a salaried labour force, as in other imperial mining and quarrying operations. The different grades of workforce are likely to have been variously accommodated either at the main site of Khirbat Faynan, or at specialized mining settlements on the fringes of the valley. State/imperial ownership of the land around the mines allowed food production to be organized systematically within the run-off agriculture zone, possibly with an agricultural labour force also being maintained by the state. The distance of many of the mines from the centralized smelting facilities at *Phaino* will have required a large number of draught animals and animal handlers to be based at the site on a year-round basis to transport the ore from the mines to the furnaces, and to bring in supplies of fuel and additional foodstuffs. All this will have greatly added to the needs of the settlement for food and water provision.

The presence of clear evidence of perennial water behind the Khirbat Faynan barrage suggests a wetter climate than exists today. Palaeoecological evidence of agriculture is not strong, but the palynological data suggest that olives and perhaps cereals were cultivated somewhere in the area. Overall, though, there is considerable evidence of soil erosion (in the upstream gorge sections of the Wadi Dana, for example, braided conditions demonstrate levels of fluvial aggradations reaching to or above modern levels: Fig. 3.8) and the pollen and charcoal from the barrage sediments and from other sampled locations demonstrate that the vegetation of the Faynan valley was desertic or degraded steppic, indicating the considerable impact upon it of industrial and agricultural activity, the latter including the grazing needs of the substantial numbers of draught animals servicing the mining operation. The massive demand for charcoal meant that timber had to be gathered from a wide area beyond the valley.

The landscape was probably already damaged by earlier phases of metallurgy, but the Roman/Byzantine period produced peak levels of pollution, notably where ore washing and further processing were carried out and smelting activity was centralized. The latter were mainly around Khirbat Faynan extending across from the Wadi Dana to

Figure 10.40 *A landscape under surveillance? The view from the walls of Khirbat Ratiye (WF1415) into Qalb Ratiye (some mine entrances arrowed). (Photograph: M. Ruiz del Arbol.)*

the Wadi Shayqar, but there were 'hotspots' elsewhere. Our geochemical studies show that both the very large mounds of slag and also the many small sites through the region are extremely contaminated (Figs 3.13, 3.14). Unsurprisingly, sediments that accumulated in a mine entrance exhibited high levels of copper and, lead, but to a lesser degree than those evidenced at smelting and ore-processing sites (Figs 9.16, 9.17), whilst an upstream wadi-floor site in the gorge of the Wadi Dana displayed little evidence of pollution, reflecting the focus on activity downstream. The landscape was sufficiently open, windy, and dry for aeolian activity fed by east-to-west moving wind to transport contaminated materials from the Khirbat Faynan and elsewhere in small dunes accumulating downwind of walls in the major wall system of the Wadi Faynan. Biodiversity was reduced in many polluted areas, with crop productivity especially reduced within a kilometre or so of smelting sites (Fig. 3.15), and the disposal of manure and pottery-rich 'night soils' from Khirbat Faynan within the WF4 field system also elevated pollution concentrations dramatically.

Mining and smelting were dangerous and debilitating work, even for free workers. The summer heat and the risk of contagions in squalid nucleated centres were added hazards, especially for communities whose immune systems must have been damaged by the poison they lived in and breathed. As a result, the *Phaino* mines were a heavy net consumer of people. Two tombstones from the South Cemetery (WF3), evidently dating to AD 455–456, commemorated not only individual deaths, but some exceptional event that had led to 'the death of a third of the community' (Sartre 1993: nos 107 and 108). High levels of copper, lead, radon, and other harmful contaminants (Table 3.11) would have made this population even more vulnerable to any significant epidemic. The population tended to die young, and would have needed continuous reinforcement from outside the valley, whether in the form of convict labour or free workers attracted by the higher than average wages paid by such operations. It is an irony that far more Christians evidently died at Faynan after the Persecutions, when they chose voluntarily to go and live and work there, than during them.

The end of the industrial activity and gross pollution as evidenced in the sedimentary record are assumed to mark the end of Roman/Byzantine metallurgical activity. The process appears to have been relatively rapid, and was also associated with a local flood event. The surrounding landscape became slowly cleared of toxic metals by bio-geomorphic processes, as were the sedimentary legacies of burning and burnt ground, and rates of soil erosion declined. At some point the climate became more arid, the degraded steppe vegetation continued, and there are no palynological indicators of the cultivation of cereals or tree crops. Standing water became less and less frequent behind the Khirbat Faynan barrage. Biogeomorphic processes reduced the concentrations of copper more rapidly than of lead in the landscape, but areas of slag and ash, especially when below the surface, remained very contaminated. The natural landscape had become characterized by pollution and degradation.

The human landscape of Faynan in the Roman/Byzantine periods was above all one of power and imperialism. The mining district was set in a region bisected by military roads that were routinely under surveillance, and movement in and out was carefully controlled. The remoteness of the region, the limited water sources, and the hostility of the summer climate also acted as disincentives to anyone wishing to enter or leave the valley undetected. Convict labourers seeking to escape had to contend not only with their shackles and their highly visible tattoos and half-shaven heads but also, at the height of the Persecutions, with more serious mutilations. The architecture of the key control sites in the mining district at Khirbat Faynan and Khirbat Ratiye echoed the dominating role they played in everyday life. The unification of the WF4 fields into a single large system and the systematic collection of household waste for manuring the land (Figs 10.32, 10.33) equally reflect the strong centralizing tendencies of the mining administration.

What happened to the local people who lived and farmed in the valley at the start of the imperial mining experiment? They were no doubt primarily absorbed into its operations, as labour, as transporters of goods and suppliers of services. Were there transient pastoral groups also, who slipped in and out of the valley? It is possible, but given the large numbers of pack animals and stock required to feed the mining community, it is by no means certain that this was an area with spare grazing capacity. The authorities will almost certainly have discouraged casual visitors in any case. People operating within an imperial mining district did so by agreement and under some degree of supervision.

The landscape of Faynan and the traces of the pollution that Roman mining and smelting enacted within it provide eloquent testimony to the irrationality of imperial economics. The irrationality stems from the difficulty and expense of extracting copper from comparatively poor-grade ores, involving underground mining in a desert and mountainous region, which lacked adequate local fuel supplies for smelting or food resources for the mining community. Only an imperial state could have done this in defiance of normal economic logic and on the scale that the archaeological record reveals. It is a prime example of the operation of an imperial economy that was separate from normal provincial and interprovincial economies in the empire (Mattingly 2006a: 491–520; 2006b). The wonder is not that large-scale copper production took place here at all, but that it endured for so long against a background of worsening conditions. Here we may see a prime difference between the eastern empire and the western empire, as the western territories saw much earlier loss of mining capacity (Edmondson 1989). When copper mining ended at *Phaino*, at an unspecifiable moment in the later Byzantine period (and perhaps abruptly with the Arab conquest?), it was to be 700 years or more until copper mining on any significant scale was revived, and then only briefly.

11. The Islamic and Ottoman periods

*Paul Newson, David Mattingly, Patrick Daly, Roberta Tomber, Hwedi el-Rishi, David Gilbertson, John Grattan, Chris Hunt, Sue McLaren, and Brian Pyatt**

11.1 Introduction

During the long period from the coming of Islam up until the present, a period of over 1370 years, the landscape of the Wadi Faynan changed dramatically, with evident reductions in the scale of settlement activity compared with the preceding Classical period. With the ending of intensive mining and metallurgy, the local population had to use other survival strategies that were both better adapted to the constraints and opportunities of the local environment, and adjusted to the position of Wadi Faynan within the wider political-economic world. It is not clear if the area was ever completely devoid of settlement, a question explored further in the next chapter describing the ethnoarchaeology of the modern inhabitants of the area.

Until very recently, the pre-modern Islamic period of the southern Levant, and more specifically the part which constitutes present-day southern Jordan, was noticeably neglected by archaeologists and also, to a certain extent, by historians. Such neglect has been due to a lack of substantial documentary source evidence as well as to the absence of an appropriate body of archaeological data. This statement applies in particular to the Early and Middle Islamic periods. Although southern Jordan is mentioned in the accounts of various Arab geographers (notably al-Muqaddasi *c.*AD 985 and Idrisi *c.*AD 1154), there is little specific documentation with which to construct a coherent account of its development (al-Muqaddasi 1886; Schick 1997: 73). Indeed, throughout most of the Islamic period it seems that southern Jordan was perceived by the governing regimes as a peripheral region of marginal importance (Schick 1994: 133; Whitcomb 2001b: 503). Recent reviews of the literary evidence (Schick 1992; 1994; 1996; 1997; Walmsley 1987; 1997) have been prompted by an increasing awareness of the potential archaeological implications of data collected by intensive regional site surveys during the late 1980s and 1990s (e.g. King *et al.* 1987; 1989; MacDonald 1988; 1992; Miller 1991; Parker 1987; 2006).

A major focus of all this published archaeological work has been the identification, classification, and dating of the ceramic evidence on which reconstructions of settlement trends depend. Although much progress has been made in the last decade or so, significant problems remain in terms of identifying and classifying the material culture of these phases. These problems include: distinguishing between Late Byzantine and early Islamic wares, especially those of the Umayyad; identifying ‘Abbasid production (Whitcomb 2001b: 509); distinguishing between the ambiguous ceramic typologies of Fatimid and Seljuq Jordan (Walmsley 2001a: 525); and establishing coarseware typologies for the Ottoman period (McQuitty 2001). The lack of accurate dating of many categories of sherds means that politically-defined periods of the Islamic era, such as Fatimid, Seljuq, and the Crusader/Frankish interlude, remain virtually invisible in the regional archaeological record (Walmsley 2001a; cf. Fig. 2.16). As a result, many sherds collected by the Wadi Faynan Landscape Survey could only be assigned to general period designations following the example of Bienkowski (2006), MacDonald (2004), Parker (2006), and Whitcomb (1992; 2001a). The periodization we have used for the post-Byzantine pottery is shown in Table 11.1.

The seventh and eighth centuries AD witnessed a profound change in the political, economic, and social environment of southern Jordan. In the first half of the seventh century, eastern *Palestina Tertia,* which included the Faynan area, became the first Byzantine territory to fall to Muslim control (Donner 1981; Fiema 1992; Schick 1992: 111). Contrary to earlier ideas, however, it is far from clear

* *Archaeology:* Paul Newson, David Mattingly, Roberta Tomber, Patrick Daly. *Geomorphology, palaeoecology, and geochemistry:* Hwedi el-Rishi, Chris Hunt, John Grattan, David Gilbertson, Sue McLaren, Brian Pyatt.

Early Islamic	**AD 630–950**
Umayyad	AD 636–750
ʻAbbasid	AD 750–969
Middle Islamic	**AD 950–1400**
Fatimid	AD 969–1071
Seljuq/Zengid (Crusader)	AD 1071–1174
Ayyubid	AD 1174–1263
Mamluk	AD 1263–1516
Ottoman	**AD 1516–1918**
Modern	**AD 1918–**

Table 11.1 *Periodization used in the categorization of post-Byzantine pottery in the Wadi Faynan.*

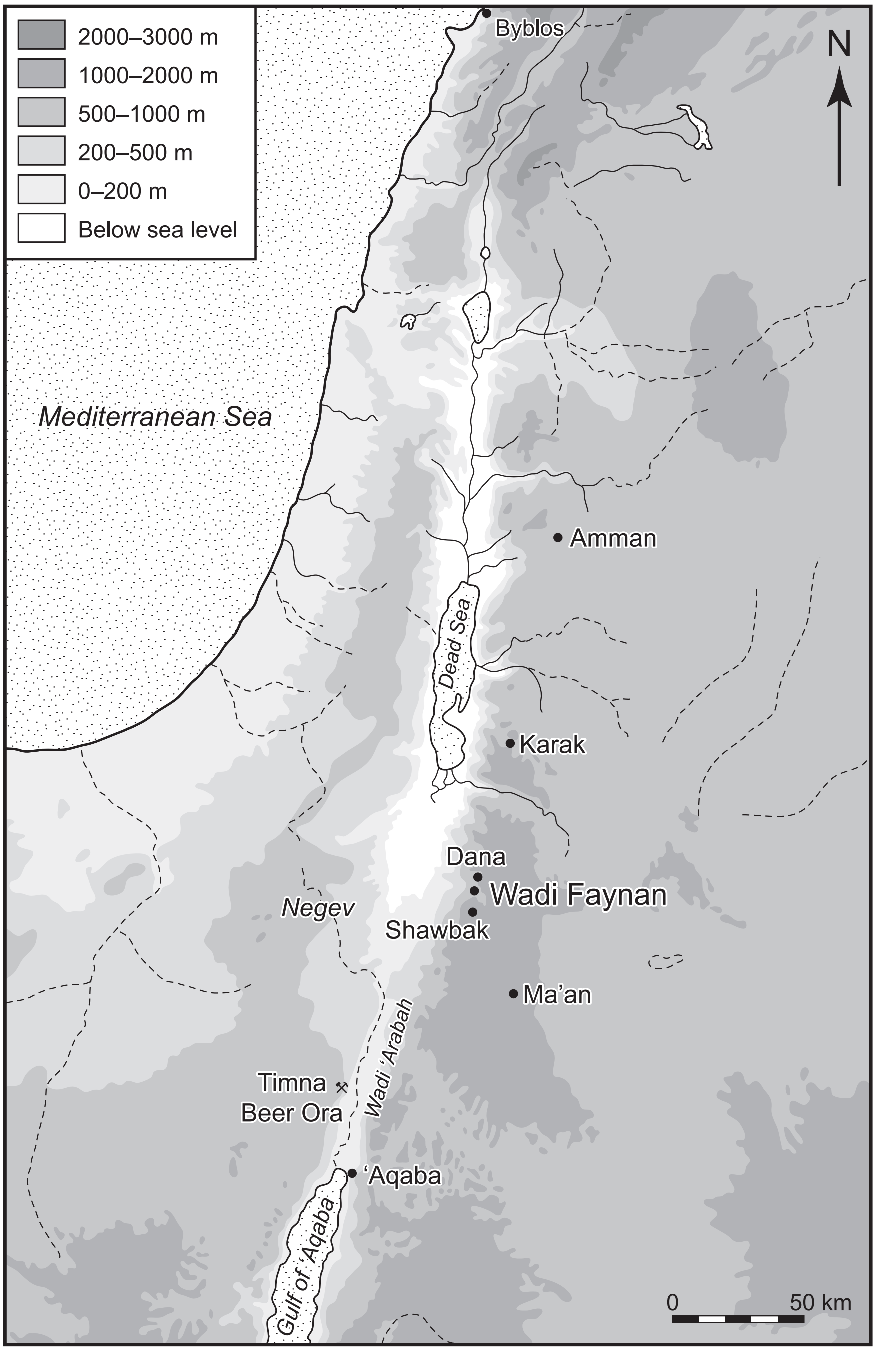


Figure 11.1 *The southern Levant, showing the principal regions and places outside the Wadi Faynan study area mentioned in Chapter 11. (Illustration: Dora Kemp.)*

that the Muslim conquest resulted in widespread destruction, or, initially, in any rapid cultural changes (Avner and Magness 1998: 39). The emerging evidence for southern Jordan is beginning to suggest a more gradual shift in settlement patterns during the Late Byzantine–Umayyad period. While some of the major settlements continued and even flourished, such as Ayla (al-Aqaba; ʻAqaba) and Zughar (Ghor es-Safi), others seem to have declined, and the city of Petra and perhaps the settlement at Khirbat Faynan may have been deserted (Fig. 11.1). A number of literary sources provides indirect evidence for the continued existence of Khirbat Faynan in the years prior to the Muslim takeover (see also Chapter 10). Faynan appears in a list of settlements noted as occupied in the early sixth century AD by Hierocles. This is confirmed by a note on the attendance of the *episkopos* John of Finān at the Council of Jerusalem in AD 536 (Honigmann 1939; Sartre 1993: 142; Schick 1994: 143). A later bishop of Finān, Theodore, is attested in a dedication inscription for the construction in AD 587–88 of the smaller of two churches whose vestiges lie to the immediate north of Khirbat Faynan (Sartre 1993: 145 no. 109; Schick 1994: 141; see also Fig. 10.10). The settlement then disappeared from the documentary record, with no mention of the site in the descriptions and lists of later Arab travellers and geographers until its reappearance in the work of Musil (1907 [1989]; Walmsley 1997).

While some important Byzantine-period settlements of central southern Jordan were in decline, recent excavations indicate that for other settlements, the Umayyad period was a time of continued development and prosperity. This is particularly true for the redeveloped and redefined port of Ayla, the fertile regions of the southern Ghor at the north end of the Wadi ʻArabah, and a number of key settlements on the plateau to the east of Wadi Faynan, including Gharandal, Udruh, and Ma'an (Fig. 2.14; Genequand 2003; Walmsley *et al.* 1999; Whitcomb 1994). Ayla's role as a pivotal Islamic entrepôt led to the resurgence of its hinterland as a centre for copper and gold mining and smelting activities (Avner and Magness 1998; Whitcomb 2006). The southern Ghor also continued as a focus of sedentary settlement and agricultural production throughout the early Islamic period (Politis 1998; Schick 1997; Walmsley 2001a). Recent work has also indicated that sedentary settlement was present on the plateau immediately to the east of the Faynan region from the late Byzantine to the Middle Islamic periods, with continued occupation of sites and the development of new sites in the vicinity of Gharandal, and the development of new agricultural estates at the key desert oasis of Ma'an (Genequand 2003; Walmsley 1998; Walmsley *et al.* 1999).

The apparent invisibility of pastoral groups in the archaeological record has prompted scholars to consider the location of potential temporary campsites and the issues concerned with the symbiotic relationship of pastoral to settled populations (Avni 1996; Banning 1986; Finkelstein 1995). Work in the southern Negev has highlighted the continued prevalence of pastoral populations on the fringes of sedentary areas throughout the Byzantine and into the early Islamic periods (Avni 1992; Rosen 1992a; Rosen and Avni 1997), and there are indications that the early Islamic period witnessed a renewed rural development during the Umayyad period in peripheral regions of both the Negev and beyond (Haiman 1995; Kennedy 1992; King 1992; Rosen 2000). Although some scholars have suggested that the taking of southern Jordan by the Muslims coincided with the arrival of several nomadic tribes from the Saudi Arabian peninsula, there is no direct evidence for this (Donner 1981). In fact, the gradual spread of these newer tribes, such as the Ghassānid confederation and others collectively known as 'Saracens', may have begun at some point during the late Byzantine period (Donner 1981: 43; Haiman 1995). Such nomadic pastoral groups may have restocked recently depleted areas of population. As Walmsley *et al.* (1999: 459) have noted, the comments in the literary sources on the dominance of the 'Arabs' (Bedouin) on the plateau (al-Jibal and ash-Shara) by the tenth century could indicate major developments in socio-political conditions.

The evidence relating to southern Jordan in the later Islamic periods, both literary and archaeological, is poor. The archaeological evidence for a number of transitional periods, such as from the Umayyad to the ʻAbbasid and from the Abbasid through to the Mamluk, has been interpreted as 'eras of decline' (Avner and Magness 1998: 39), but this may in part have been a function of the lack of precision in the dating of ceramic sherds, mentioned earlier. In the last decade or so, increased knowledge has caused a revision of ceramic typologies, narrowing the periods of supposed 'decline' between the ʻAbbasid and Mamluk periods (Walmsley 2001a; Whitcomb 2001b: 510). An indication that effective political control of the upper reaches of the Wadi ʻArabah was in abeyance is suggested by the unchallenged expeditions of the Frankish King Baldwin I to the southern Ghor and Wadi Musa (the region of Petra) in the early years of the twelfth century (Schick 1997: 78). Though Ghor es-Safi and Wadi Musa were undoubtedly occupied, the latter by pastoralists, either political control by the Fatimid or Seljuq regimes was low or the region was not considered strategically important enough to garrison with substantial numbers of troops (Schick 1997: 79). The absence of sizeable numbers of troops and the occupation of the former city of Petra by pastoralists both suggest that sedentary occupation in the region outside Ghor es-Safi was low (Schick 1997: 82), a finding with implications for the nature of settlement in the Wadi Faynan at this time.

As with previous Islamic periods, no direct mention of the Wadi Faynan region in the Fatimid and Seljuq periods (AD 970–1174) exists in the contemporary literature, though two permanent settlements at either end of the Wadi ʻArabah, Sughar (Ghor al-Safi) and Ayla (ʻAqaba), are mentioned (Schick 1997: 75–6). Recent archaeological explorations imply that throughout the middle Islamic period, particularly in the Mamluk and Ottoman periods, the production of sugar flourished in the town of Zughar (later Sughar and the present Ghor es-Safi) (Photos-Jones *et al.* 2002; Whitcomb 1992; 2006: 242). As we shall see, there is also evidence for a brief revival of copper production in the Faynan region in the Ayyubid/Mamluk period. As far as can be ascertained, the pattern of settlement throughout the Ottoman period remained relatively stable, in that the Ghor and plateau regions to the east of Faynan, such as Tafila and Shawbak, were occupied by sedentary populations, whereas everywhere else was the domain of bedouin pastoralists (Bailey 2006). The distinction between the settled regions of the southern Ghor and Shawbak plateau on the one hand, and the semi-nomadic/nomadic areas of the Wadi ʻArabah on the other, has continued until the present day.

11.2 Climate, environment, and human impacts

It is useful to begin this account of the climate and environment with the present day (see Chapter 2), since this provides a known-baseline with which the immediately preceding 'Ottoman' and 'Islamic' landscapes can be compared. A detailed long-term instrumental meteorological record exists for the southern Jordan Valley (Cohen and Stanhill 1996) and this indicates an increase of about 0.5°C in average annual temperatures over the previous fifty years, but without significant variations in overall total, or in the inter-annual variability of rainfall. Region-wide decreases in global irradiance were detected in this record and attributed to variations in atmospheric pollution in the region brought about by urbanization, industrialization, and land use. Looking back over the past century, with his

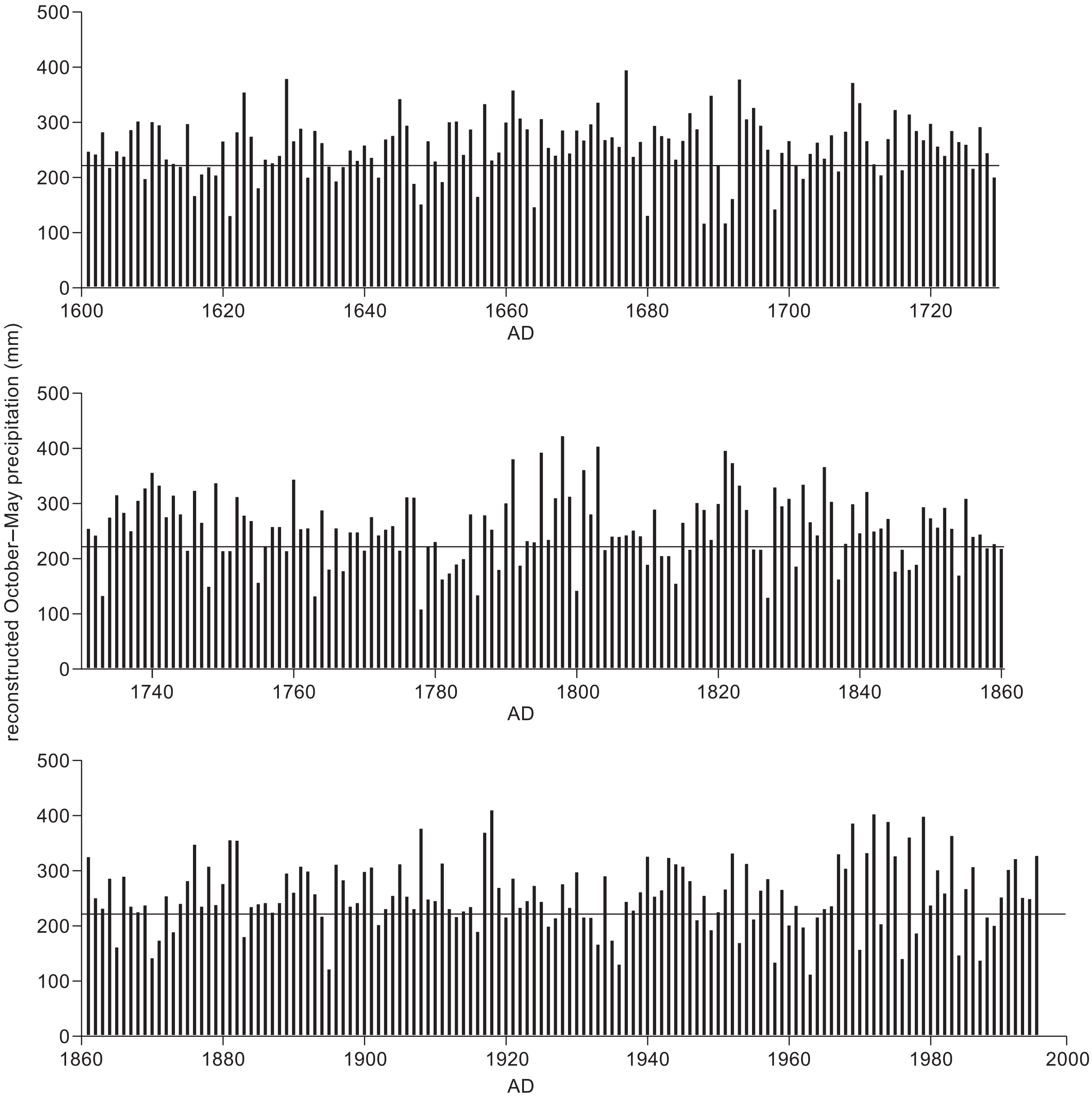


Figure 11.2 *Dendroclimatological reconstructions of October–May precipitation in southern Jordan between* AD *1600 and 2000, showing the average for this period. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Touchan and Hughes 1999.)*

detailed local knowledge from road-building in the area, Raikes (1980; 1985) estimated that annual rainfall around Wadi Faynan had varied from 50 mm in a notably wet year to 50 mm in a dry year, with a series of relatively wet years occurring in the 1870s and dry years in the 1890s. A dendroclimatological study of the trees of *Juniperus phoenicia* growing in the Dana Reserve and at Tor-al Iraq *c*.25 km to the southwest indicated the existence of 93 drought years (defined as below 80 per cent of mean precipitation in the period 1946–1995) in the period covered by the tree-ring chronology, AD 1469–1995, with an average interval between droughts of 4.2 years and a maximum interval of sixteen years (Touchan and Hughes 1999; Fig. 11.2). Fifty-five drought events lasted one year, seven had durations of two years, four continued for three years, and three persisted through four years. The maximum severity of the three-year drought evidenced by the tree-ring data between AD 1469 and 1680 is considerably greater than that suggested by the much shorter instrumental record. This evidence also indicates that winter precipitation between October and May exceeded *c*.300 mm in only thirteen years between 1600 and 1730, compared with 26 years between 1730 and 1860, and 31 years between 1860 and 1995. While these dendroclimatological reconstructions point to the episodic nature of the regional arid climate, they also emphasize the sustained presence of conditions more arid than occur at the present day during the seventeenth, eighteenth, and nineteenth centuries.

Bruins's (1994) more broadly-based and longer-term palaeoclimatic synthesis for the southern Levant is shown in

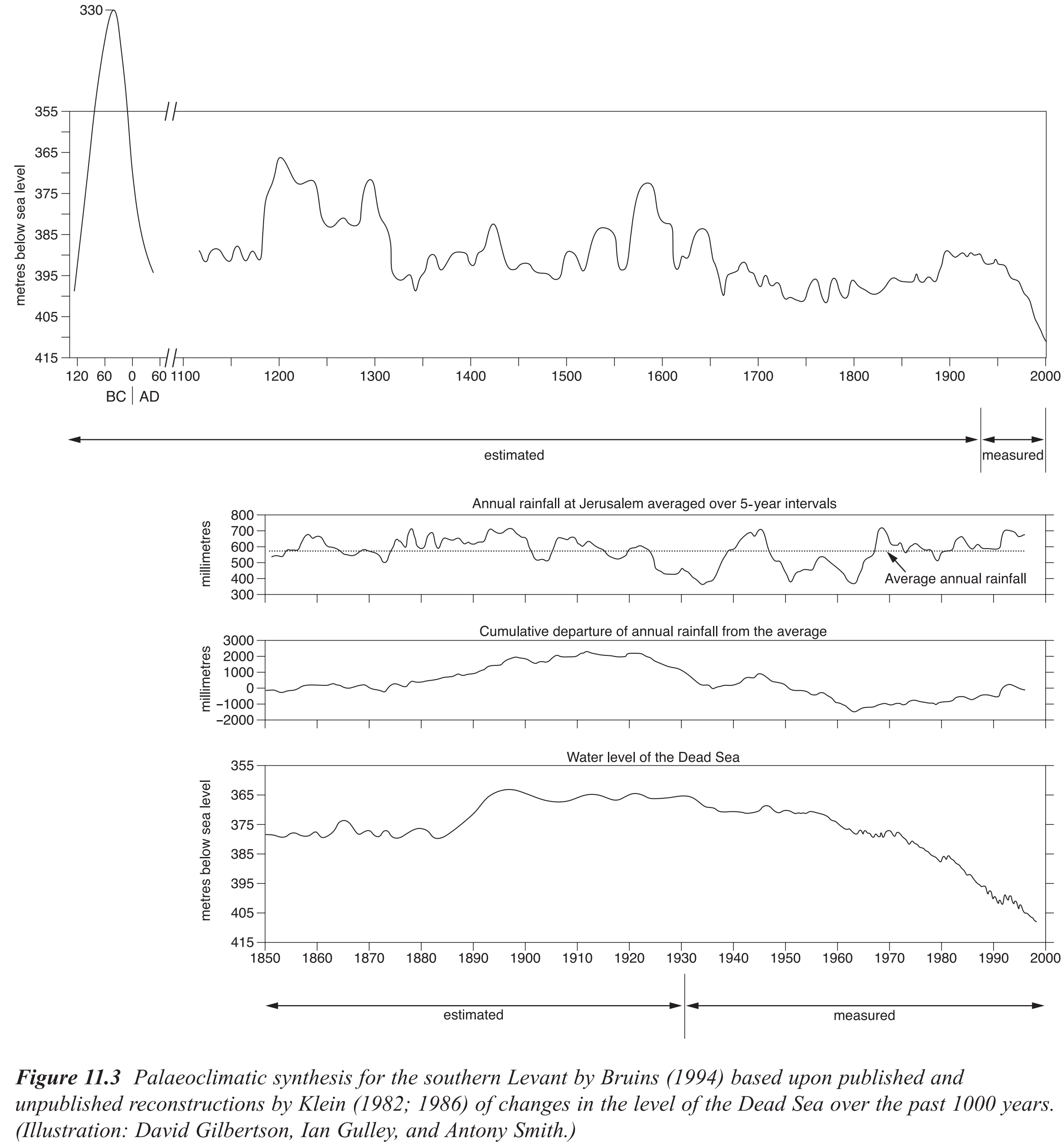


Figure 11.3 *Palaeoclimatic synthesis for the southern Levant by Bruins (1994) based upon published and unpublished reconstructions by Klein (1982; 1986) of changes in the level of the Dead Sea over the past 1000 years. (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

Figure 11.3. This includes published and unpublished reconstructions of aridity by Klein (1982; 1986) that were based on inferred changes in the level of the Dead Sea over the last 1000 years, together with the less-climatically sensitive, longer-term, hydro-geomorphological studies of salt caves in Mount Sedom (Frumkin *et al.* 1991; 1994). For those times before the effects of modern water consumption, both studies provide relatively straightforward proxy-indicators of the changing balance between regional precipitation and aridity, rather than records of human impact. These data indicate that the area around the Dead Sea during the late Byzantine period was relatively more arid than in Roman–Byzantine times. Comparatively dry conditions were inferred until *c.*AD 850 succeeded by a wetter climate between about AD 930 and 1060. A long run of wet weather was identified from about AD 1100 to 1300, followed by a period of time with distinctive fluctuations between sustained considerable aridity on one hand, and wetness on the other. In this region, the equivalent of the European Little Ice Age, that lasted from *c.*500 to *c.*100 years ago, was recognized as warm and dry by Issar (2003), but it appears to be notably arid in the reconstruction by Frumkin *et al.* (1994), Klein (1986), and the dendroclimatological reconstructions described previously. These conclusions are broadly similar to those derived from palaeoecological researches of late Holocene sea-floor sediments from the Dead Sea by Heim *et al.* (1997), who concluded that a relatively wet climate *c.*1500 years ago was followed by a gradual drying out and notable aridity, then another minor increase in wetness, before a sustained arid phase between *c.*300 and *c.*100 years ago which they equated with the coldest parts of the Little Ice Age as recognized in northwest Europe. The fluvial sediment sequences published by Hunt *et al.* (2004; 2007b) and McLaren *et al*. (2004) for the Faynan agree with this general model of environmental change (see Chapter 3; especially Fig. 3.8). The change from Ottoman to modern times in the Faynan, whilst important in its human history, was not associated with any climatic-environmental change or fluctuation.

11.2.1 Geomorphology

Deposits relevant to the centuries covered by this chapter are widespread in the study area. The most significant is the Dana Wadi Member, together with the upper components of each of the following: the Khirbat Member, the Atlal Member, and the Tell Loam Member (Figs 3.1, 6.4). Their principal features and dating evidence are summarized in Tables 11.2–11.4; and Figure 3.8. The shape of the radiocarbon calibration curve for this period of time means that the radiocarbon dates described in this chapter need to be treated with particular caution.

11.2.1.1 The Dana Wadi Beds and sequences in the gorges of the Wadis Dana and Ghuwayr

The floors of the wadis in the vicinity and down-wadi of the wadi-confluence near the Khirbat Faynan (Figs 2.5, 2.9, 5.3) contain a distinctive and complex set of inter-related fine-grained fluvio-aeolian and alluvial fan deposits of Late Holocene date with a characteristic morphological expression and stratigraphic relations (see Fig. 3.1; Table 11.3). These deposits were originally mapped as the 'Dana Beds' (Barker *et al.* 1997), but we realized that a Tertiary (geological) Unit has priority in the use of this name. Down-wadi of the confluence of the Dana, Ghuwayr and Shayqar these Beds comprise well- to moderately-sorted sands with occasional lenses and washouts of gravel, the assemblage having a distinct and stepped terrace landform (Figs 2.9, 11.5). Two morphostratigraphic members are

Formal name	Summary description and evidence of antiquity	WF sites	Possible age
Dana Wadi Member	Trough-cross-bedded sandy gravels or well-sorted fine sands in the Wadis Dana, Faynan, and lower Ghuwayr, with upper and lower components: braided-fluvial and/or wind-blown deposits. *Field relationships, archaeological associations, radiocarbon dates:* Dana Wadi Member at WF5025 overlies charcoal = 390±50 BP (Beta-115214); charcoal at WF5509 within the Dana Wadi Member = 110±50 BP (Beta-119600); wood overlying Dana Wadi Member at WF5520 = 100±50 BP (Beta-119620); charcoal+ beneath Dana Wadi Member at WF5511k = 1220±40 BP (Beta-1160).	WF5025 WF5509 WF5520* WF5617 WF5511k	Medieval to historical, *c.*650–100 years BP
Tell Loam Member	Laminated silts with calcareous nodules and layers; thin calcareous layers and shallow dunes with water-washed deposits; thin palaeosols; accumulated as shallow dunes beneath, on, and behind the walls and surfaces of WF4 (many of which were in use in Roman-Byzantine times – see Chapter 5) in the Wadi Faynan.	WF5021– WF5022 WF4	*c.*Roman/Byzantine to modern
Atlal Member	Copper- and lead-rich smelting slags, described in Chapters 8–10, variously from Bronze Age to Byzantine. At WF5741 = slag 7 of Hauptmann (2000), charcoal dated to Ayyubid/Mamluk period: 430±40 BP (Beta-203412).	Slag heap 7; WF5741	Ayyubid/Mamluk
Khirbat Member 0–158 cm depth	Massive or laminated sandy and lacustrine fine sands and silts, occasional gravel layers – fluvial; aeolian, pond-lacustrine deposits; impounded by the Khirbat Faynan barrage at WF5012–WF5017. Dated by excavation, archaeological associations, pollen-biostratigraphy, radiocarbon dates.	WF5012* WF5017* WF5051 WF5518	*c.*1600 years BP to present

Table 11.2 *Summary of the main lithological members that are, in part or whole, of post-Byzantine age that have been recognized in the Faynan area. * = upper part of sequence; + = lower part of sequence. (Definitions, locations, characteristics, dating evidence and further interpretations are given in Chapter 3; Barker* et al. *1997; 1998; 1999; 2000; Grattan* et al. *2007; Hunt* et al. *2004; 2007b; McLaren* et al. *2004; Mohamed 1999.) All radiocarbon dates are uncalibrated; for their calibration see Appendix 2.*

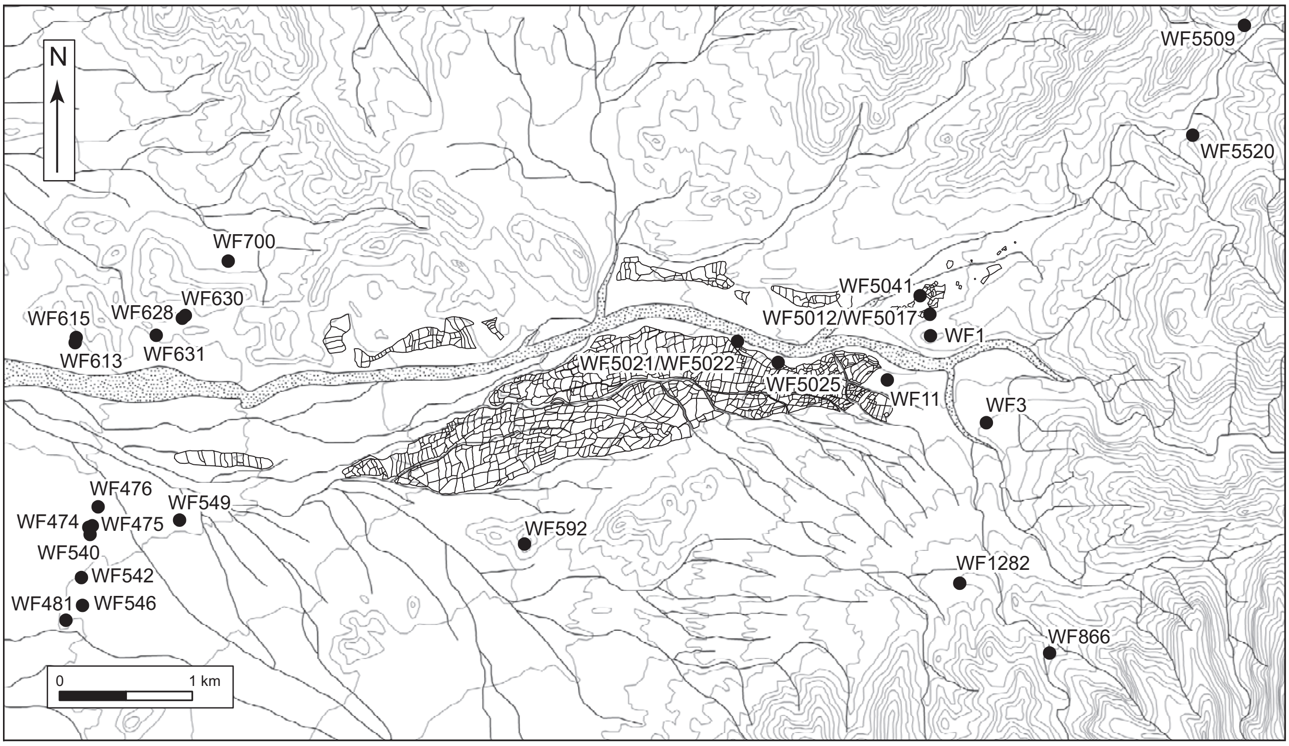


Figure 11.4 *The Wadi Faynan study area, showing the location of the principal geomorphological and archaeological sites discussed in Chapter 11. See also Figures 3.1 and 3.13. (Illustration: Paul Newson.)*

recognized as the Upper and Lower components of the Dana Wadi Beds (Table 11.3), following McLaren *et al*. (2004) and Hunt *et al*. (2004; 2007b). Field observation and the few radiocarbon dates available suggest that these features may represent a complex aggradation of fills and erosional surfaces and infills.

Examination of the distribution of the Dana Wadi Beds in Figures 3.1 and 6.4 shows that the most recent phase of incision at the wadi floor in the Faynan has resulted in the removal of much of the original distribution of these *c*.1–1.5 m thick 'terrace' deposits. Their fluvial origins are evident in the type of stratification recognized: trough cross-bedding. In places, the exposed surfaces of the sediment have become case-hardened. On occasion the deposits can be seen to be homogenized and contorted, features suspected to be the result of earthquake shock (Fig. 3.7). These materials are similar to those that accumulate on the modern wadi braid-plain and suggest occurrences of winter floods and flash-floods, with perhaps occasional wind-blow, as occur today. McLaren *et al*. (2004) hypothesized that the accumulation of two fluvial deposits summarized in Table 11.3 followed by subsequent wadi-floor incision might be the result of a geomorphological mechanism suggested by Bull (1991) that involves variations in precipitation and/or temperature and changes in surface ground conditions that prompted changes in run-off and fluvial incision.

The fluvial deposits of the Dana Wadi Member are securely dated to the very late Holocene. Near the confluence of the Wadi Dana with the Wadis Ghuwayr and Shayqar, there is a *c*.1.5 m thickness of trough cross-bedded sands and gravels that are attributed to the (undifferentiated) Dana Wadi Member, which provided organic material radiocarbon-dated to 390±50 years BP or cal. AD 1435–1635 (Beta-115214). Charcoal within the Lower Wadi Dana Member

Base of sequence		Upper Component (*c*.2–3 m above the modern wadi floor), Type site 30.631722°N, 035.491694°E, Lower Wadi Dana and Wadi Faynan (Fig. 3.1)
Unit	**Thickness (cm)**	**Summary description**
1	*c*.190	Boulder-rich clasts material fining upwards to medium gravel
2	*c*.20	Trough cross-bedded unconsolidated sand
3	*c*.50	Sandy gravel – distinctive buff to pinkish brown colour

Base of sequence		Lower Component (*c*.1–1.5 m above the modern wadi floor), Type site 30.614639°N, 035.533667°E, Wadi Ghuwayr
Unit	**Thickness (cm)**	**Summary description**
1	*c*.20	Coarse pebbles
2	*c*.20	Lenses of laminated sand
3	*c*.130	Imbricated cobbles and small boulders

Table 11.3 *Upper and Lower Components of the Dana Wadi Member.*

Figure 11.5 *Typical surface morphology of the Dana Wadi Beds, looking east from the summit of the Khirbat Faynan. The Dana Wadi Beds here in the lower part of the Wadi Ghuwayr are separated from the modern braid-plain by a low cliff (*c.*0.5–1.5 m high) that is emphasized in the middle ground by the occasional trees of Acacia. The surface expression of the Member is gently undulating to relatively flat. Its loose sandy texture and propensity to erode are shown by the higher reflectivity of its surface. The Member laps onto or butts against older deposits of Pleistocene age which form the hillslope. (Photograph: John Grattan.)*

Figure 11.6 *Complex sequence of gently sloping colluvial, alluvial, and fluvial deposits that are strongly eroded by gullies immediately above the modern gorge floor in the gorge section of the Wadi Dana near site WF5509. (Photograph: Chris Hunt.)*

fluvial deposits at WF5509 gave a radiocarbon date of 110±50 years BP or cal. AD 1673–1954 (Beta-119600). Wood in fluvial sands in an incision terrace cut into a late Holocene alluvial fan at WF5520 also yielded a radiocarbon date of 100±50 uncal. BP (Beta-119620). The overall length of time represented by the Dana Wadi Member is unknown: the sediments might have accumulated in a few years, decades or centuries. The most recent phase of incision (*c.*1.5–1 m in vertical extent) occurred during the nineteenth century; the remnant terrace-landform distribution shown in Figure 11.5 suggests the large surface area and significant volume of wadi floor materials that have been re-worked and removed from the previous wadi floor, to be re-deposited down-wadi since that process began.

Up-wadi of the confluence in the gorges of the Wadis Dana and Ghuwayr, the Dana Wadi Member becomes a more complex body of sediments. It comprises a number of distinctive lithofacies that include well-sorted bodies of fluvial cobbles, sands, gravels, and aeolian silts; trough cross-bedded sands and gravels of braided flows; slack-water muds and silts; and wedge-shaped bodies of talus, scree and ash entering from some side wadis. Sediment bodies also appear to have lost all of their original depositional sedimentary structures as a result of shock, perhaps earthquake shock.

Site WF5025 was described as a low terrace of the Dana Beds by Barker *et al.* (1997) and is of Late Holocene age (Fig. 3.7). The lowermost unit (Unit 1) is a 1 m thick accumulation of trough cross-bedded gravels with sand lenses suggesting braided flow conditions. Resting conformably on these is Unit 2, a thin layer of fine, well-sorted, laminated sands, 0.02 m thick, suggesting a stream-pool environment. A weathered and contorted sand body 0–0.9 m thick (Unit 2c) overlies these sands, materials which are in turn overlain by 0.3–1.5 m of 'shocked' gravels (Unit 3) and then a further thickness of 0.8 m of aeolian silts (Unit 4) that are sometimes sandy. Resting upon the terrace surface eroded across all the deposits is a number of cross-wadi walls. This location was always likely to have been relatively dry in the Holocene, despite occasional storms, so the distinctive lobes of disorganized, poorly sorted, 'shocked gravels' comprising Unit 3 are not necessarily the result of the most familiar cause, the rapid loading of wet sediments by heavy wet sediments: they might also be the result of earthquake-shock. Pollen assemblages were extracted at this site from sediments immediately below the find of charcoal. This charcoal provided a radiocarbon date of 390±50 uncal. BP or cal. AD 1435–1635 (Beta-115214). A pollen assemblage extracted immediately below this charcoal was attributed to the Chenopodiaceae-*Pinus-Ephedra* (CPE) Assemblage Biozone (see also Chapter 3).

Site WF5520 is typical of a number of low, terraced, landforms, together with alluvial fan deposits, exposed in the gorge-section of the Wadi Dana (Fig. 11.6). This site consists of an assemblage of deposits on the wadi floor that forms a 'gravel' terrace that passes laterally into an alluvial fan that is almost 4 m thick and which infills an entrant side-wadi. There is a number of 'incision terraces' through these deposits. The alluvial fan deposits have been resolved into five assemblages of lithological units which are all attributed to the Dana Wadi Beds. Upstream of the alluvial fans (Units 1, 4, 8, and perhaps 9), slack-water sands and silts (Units 3, 5, 6) that accumulated as the main wadi channel transported better-sorted sands and gravels (Units 2 and 5) were impeded by the encroaching alluvial fan forming the wadi-side. The alluvial fan and three incision terraces were sampled at this site. The oldest incision terrace here contains wood radiocarbon dated to 100±50 BP or cal. AD 1676–1954 (Beta-119602). The talus (Unit 10) at the base of the exposure is of uncertain age and origin. It is overlain with distinct unconformity by Units 1–9. The extent of fractured rock debris exposed at the surface at this location initially suggested this material might be waste from rock-breaking and crushing for metallurgical purposes, but it was later realized that these clastic deposits were probably a scree developed upon mineralized bedrocks. A pollen assemblage assigned to the Assemblage Biozone Chenopodiaceae-Lactuceae (CL – see Chapter 3) was recovered from sediments associated with the charcoal date.

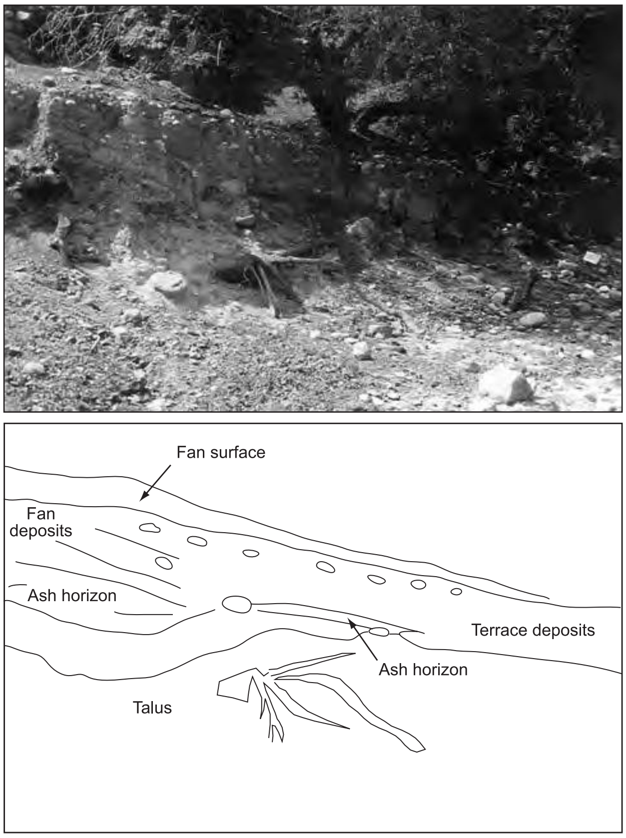


Figure 11.7 *Typical exposure of a low terrace/alluvial fan deposit in the Wadi Ghuwayr, about 4 m above the present wadi floor at WF5509. (Photograph: Hwedi el-Rishi.)*

Site WF5509 (Fig. 11.7) is a low terraced landform/alluvial fan deposit in the Wadi Ghuwayr, its surface lying about 4 m above the modern wadi floor. Three sedimentary units were recognized. The lowest consists of trough cross-bedded sandy gravels about 1.0–1.5 m thick and which indicate a fluvial origin. This gravel body is overlain by a wedge-shaped unit of obliquely-bedded sands, fine gravels, and ash variously derived from mass-movement and overland flows down the fan of a side wadi. This unit is in turn overlain by a layer of coarse cobble-rich gravels of fluvial origins introduced along the main wadi. Pollen attributable to pollen assemblage zone Chenopodiaceae Assemblage Biozone (C – see Chapter 3) was recovered from this deposit.

There is no information on either the precise period of time represented by any of these sedimentary units or of any of stratigraphic breaks between them. A minimalist view is that each deposit – whether colluvial, alluvial fan, or fluvial – could reflect no more that a single sustained wet storm event with a duration to be measured in minutes or hours. The absence of developed palaeosols suggests that the sediment surfaces were not exposed to the atmosphere for periods of time that were measurable in terms of decades. Overall, these deposits appear to date generally to the period from about AD 1400 to about 100 years ago. They demonstrate that through these centuries the main wadi floors saw episodes of flood and braided flow conditions that led to aggradation, then incision, then further aggradation. At about the same time, the gorge sections saw a variety of environments including permanent pools, some lush spring-fed oases (Fig. 2.8) and powerful stream flows and slumps of hill-slope materials. Along the wadi margins screes developed, with alluvial fans forming at entrant-side wadis; some mass-movements were relatively deep, others shallow. There may have been occasional earthquake-shocks. Over the last hundred years or so, the sequences formed in the main wadi floor deposits appear to resemble those of the present day, characterized by intermittent episodes of storm run-off, colluvial processes, aeolian processes in drier times, and probably the local impacts of people.

11.2.1.2 Tell Loam Member

Aeolian deposits of the Tell Loam Member, whose modern exposure is mainly of post-Byzantine age, are common to the west of the Khirbat Faynan and are widely exposed to the east of Tell Wadi Faynan, for example at WF5021–WF5025 (see also Figs 1.9, 1.12, 3.4, 3.8, 7.4) where they typically have been further sorted by overland flow and affected by episodes of soil development. The lower component of this Member, which was described in Chapters 3 and 8, occurs widely, especially as elongated dunes in the lee of the surface and buried walls of the WF4 field system.

11.2.1.3 Atlal Member

The Atlal Member comprises copper-smelting slag and charcoal components (Baierle *et al.* 1989; Engel 1992; 1993; Frey *et al*. 1991; Hauptmann 2000; Hunt *et al.* 2007b; Fig. 3.1). In the field, sediments at WF5041 (Hauptmann's slag pile 7) appeared indistinguishable from other much older slags in the vicinity of Khirbat Faynan, but an AMS date from charcoal was obtained of 430±40 BP (Beta-203412), suggesting that this particular slag deposit may be of Mamluk, or perhaps Ottoman, age. The local smelting of ores at approximately this time was also recognized by Hauptmann (2000).

11.2.1.4 Khirbat Faynan barrage infill deposits

The barrage-infill deposits of the post-Byzantine components of the Khirbat Member (Units 1–3) investigated in the initial borehole and then exposed in the excavation are described in Table 11.4, and their simple textural and mineral magnetic properties, together with %LOI (Loss-on-ignition), are illustrated in Figure 11.8. Samples were taken in 1 cm-thick slices at 2 cm vertical intervals from the excavated trench (WF5012 = WF5512: Fig. 1.15) and from the centres of 10 cm-thick Edelman corer samples at the adjacent borehole WF5017 = WF5517.

The sands and grits of Unit 3 shown in Figure 11.8 appear to represent a distinctive flood event marking the end of the period of predominately fluvial-lacustrine deposition associated with occasional wet and aquatic conditions. The event post-dates the end of Byzantine ore-smelting and processing activities identified through their geochemical signature in Lithofacies 4. The sharp boundary between Lithofacies 3 and 2 appears to represent a significant break in the sequence, although no evidence of weathering or soil-formation structures was detected. The silts or fine sands of Lithofacies 1 and 2 are interpreted on the basis of their textures as primarily aeolian, similar to those accumulating behind the barrage at the present time. The proportions of clays, silts, and sands show systematic

Lithofacies	Depth (cm)	Summary description and interpretation
1	0–86	Layers of clay and silt layers; sometimes distinctly organic with leaf remains; interbedded with layers of fine and medium sand, often well sorted; typically structure-less and homogeneous; individual layers bioturbated; pale brown; occasional roots; occasional large boulders; transitional lower boundary. *Interpretation*: wind-blown, water-washed, barrage-pool deposit of reworked sand with boulders from catchment. Boulders fallen from adjacent archaeological remains; clay-silt layers and organic debris represent intermittent periods of pond-sedimentation as occur at times of flood at the present day.
2	86–157	Clay, silt, and sands: sands are often well sorted in couplets of coarse to fine sands *c*.3 mm thick, but ranging from *c*.1 to 8 cm thickness; pale brown; slightly irregular, sharp, upper and lower boundaries. *Interpretation*: aeolian deposits with episodes of barrage-pool sedimentation at times of storm; some events with large sediment load.
3	157–158	Fine sand with grit, forming irregular laminae, pale brown. *Interpretation*: distinctive flood-lag deposit in the barrage-pool.
4–6	156–285	Byzantine–Roman(?) pool, colluvial and ore-processing deposits.

Table 11.4 *The sequence of infill deposits that accumulated behind the barrage immediately north of the Khirbat Faynan (excavation trench WF5012 = WF5512). Lithofacies 1–3 are attributed from the post-Byzantine period to the present day. Correlation and dating follow Mohamed (1999), Hunt* et al. *(2004; 2007b), and Grattan* et al. *(2007).*

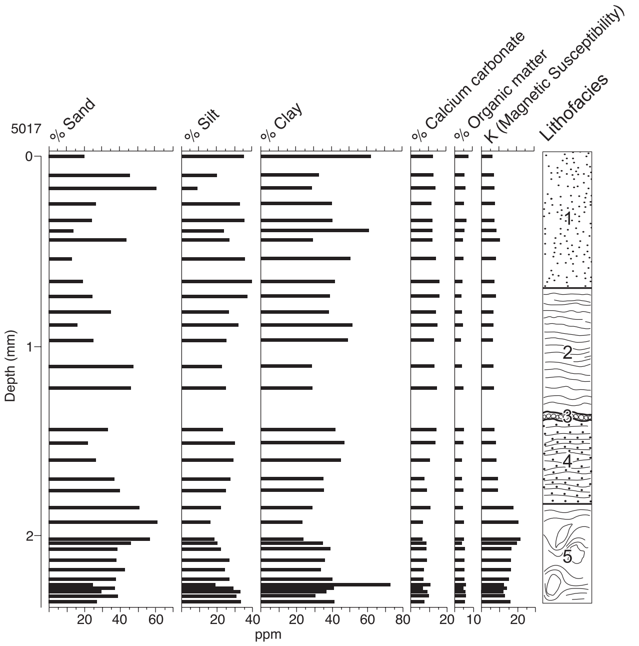


Figure 11.8 *Simple textural and mineral magnetic properties together with %LOI (Loss-on-ignition) with depth of the barrage infill deposits at Khirbat Faynan sampled by Edelman corer (WF5017). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

patterns of variation upwards, with minimal proportions of sand being recorded at the boundary between Lithofacies 2 and 1. The changing proportions of the fine-grained clay to silt suggest a maximum of aeolian activity at depths of about 0.6–0.7 m, followed by more frequent fluvial inputs indicated by the deposition of coarser particles in less well-sorted deposits. The repeated presence of layers of clay-silt in Lithofacies 1, sometimes with organic debris and couplets with fining upwards sequences, suggests the occasional presence of ponded water (as is often seen today). The occasional loss of sedimentary structure, the slightly increased frequencies of burrows, and intermittent layers of clay-silt and organic debris in Lithofacies 1 (as in parts of Lithofacies 3), indicate that the depositional and biological environment was sometimes wetter than typically occurred when Lithofacies 2 was accumulating.

The barrage infill sediments represent an unusual geomorphic environment: the location was evidently a deliberate trap that impounded water and sediment. Lateral sub-surface drainage is likely to have been impeded, and the enhanced soil moisture regime is likely to have always produced better tree growth and herbage than on the adjacent open hill sides or wadi floors. In the past, as now, this ameliorated habitat would have attracted animals, both wild and domestic, causing the introduction of significant quantities of dung as well as other biological wastes and debris. As a result, the barrage-infill sediments may reflect both moderated, ambient environmental fluctuations, as well as the intensity of agriculture and pastoralism, to a greater extent than typically has taken place at many surrounding (natural) depositional locations. It is notable that no indicators of burning or significant agricultural or industrial activity were observed in the post-Byzantine lithofacies (Figs 11.9, 11.10). The wider geomorphic and climatic relationships of these deposits were summarized in Figure 3.8.

11.2.2 Palaeoecology

Three pollen-assemblage biozones have been recognized in the post-Byzantine infill deposits behind the Khirbat Faynan barrage (Hunt *et al.* 2007b; Mohamed 1999).

The earliest post-Byzantine pollen assemblage zone occurs between depths 1.40 m and 1.05 m and is recognized as the Chenopodiaceae-*Pinus-Ephedra* (CPE) assemblage biozone (see Chapter 3). Its pollen floras are similar to the modern pollen rain, the high numbers of Chenopodiaceae, Lactuceae, and Asteraceae, together with some *Ephedra*, *Plantago*, Caryophyllaceae, Liliaceae, *Glaux,* and *Rumex,* all broadly consistent with a much degraded steppe environment of modern aspect (e.g. Figs 2.5, 2.6, 2.9). The relatively high frequency of plateau taxa such as *Pinus*, *Juniperus*, *Quercus,* and *Pistacia* may be the result of exaggeration by the low production rates of 'local' pollen, as is often the case in desertic environments (Horowitz 1992). Cultivated taxa, including *Olea* and cereals, are evidence of continued small-scale human activity and farming practice, including cereal cultivation. There are significant differences between the CPE biozone and the earlier CLP biozone attributed to the Iron Age–Byzantine period, the most significant difference being the decline of Poaceae and of the true steppe indicators such as *Poterium* in the CPE biozone. This is consistent with desiccation, but might also reflect the demise of the Roman–Byzantine integrated floodwater-farming system (Chapter 10). The fall in numbers of thermally mature grains suggests a reduction in the use of wood fires, presumably reflecting a reduction in ore-smelting, though other domestic and industrial uses are possible. The extent of erosion of adjacent soils as evidenced by the numbers of vesicular arbuscular myccorhyza (VAMs) increases slightly in the upper zone.

Assemblages of the later Chenopodiaceae Assemblage Biozone (C) were recovered from three locations: the Khirbat Faynan barrage infill at 0.60–1.05 m depth; the basal unit (Unit 5) of site WF5520, an alluvial fan deposit in the Wadi Dana; and WF5509 in the Wadi Ghuwayr. The high numbers of grains of Chenopodiaceae and relatively high frequency of Lactuceae, together with presence of *Ephedra* and Caryophyllaceae, suggest either a much degraded steppe environment and/or a steppe-desert environment (cf. El-Moslimany 1990). The presence of relatively large numbers of grains of *Pinus* and other plateau taxa may be a sign not of these plants increasing in abundance on the ground, but of the proportions of grains transported long-distance being exaggerated by a low production of local pollen. Overall this assemblage appears to reflect a significant decline in rainfall, though rainstorms prompted temporary pools sufficient to sustain algal and occasional waterside vegetation. The radiocarbon dates and the duration of sedimentation suggest

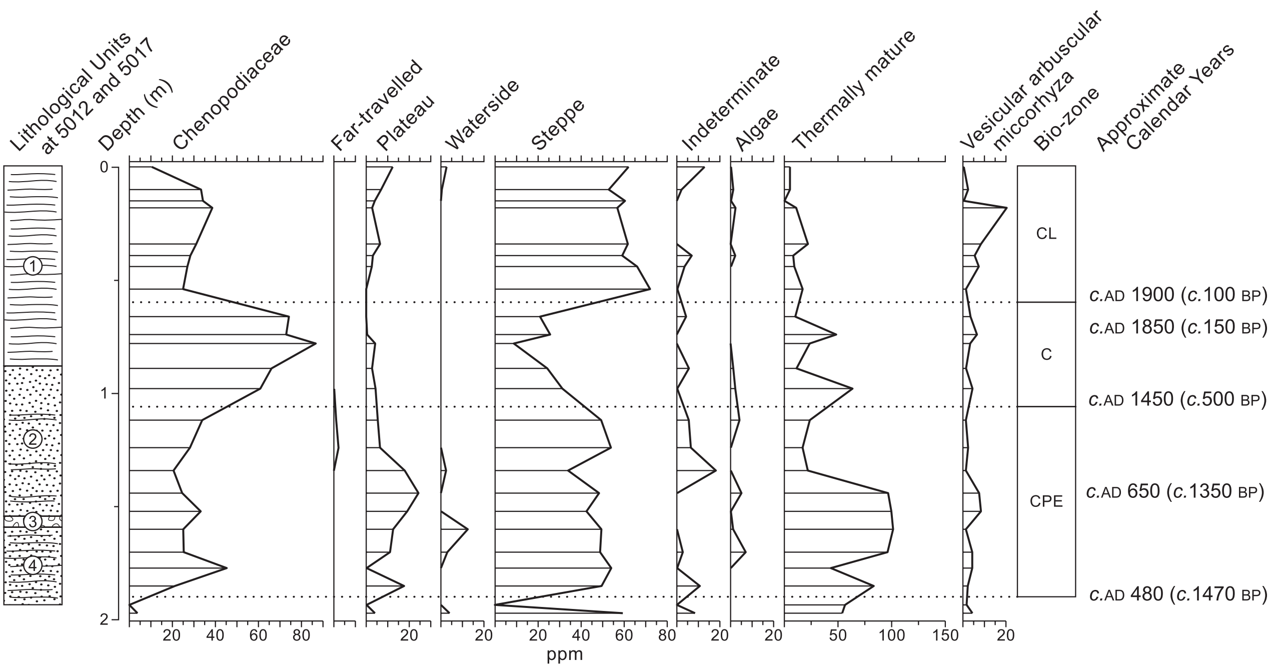


Figure 11.9 *Summary pollen and palynomorph distributions from the Khirbat Faynan barrage infill deposits sampled by Edelman corer at WF5017 (= WF5517). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith; data, correlations, and dating redrawn from Mohamed 1999; Hunt* et al. *2004; 2007b).*

that this biozone was broadly equivalent in time to that of the European 'Little Ice Age'. The progressive decline in thermally-mature grains and charcoal, already evidenced in the previous biozone, points to the progressive decrease in firing and smelting activity in the adjacent landscape, and the low numbers of VAMs point to an absence of soil erosion. There are very few or no indications of any cultivation of cereals or olives in the area.

The Chenopodiaceae-Lactuceae Assemblage Biozone (CL) was recovered from the barrage infill deposits at 0–0.55 m depth and from the alluvial fan deposits at WF5520 in the Wadi Dana. This essentially modern biozone is characterized by a rise of taxa such as Poaceae, *Artemisia*, *Plantago*, Liliaceae, and Caryophyllaceae, and a decline in Chenopodiaceae, a combination suggesting a degraded steppe but less desertic than that of biozone C, with more tree taxa. Grains of *Pinus*, Cupressaceae, *Olea*, *Quercus*, and *Juniperus* probably mostly derive from vegetation on the plateau. Far-travelled taxa such as *Acer*, probably from Europe, may reflect changes in ambient winds, with more winds coming from the northwest during the flowering season, while exotic genera of species from Australia or Island Southeast Asia reflect plantings from the 1930s onwards: she-oaks (*Casuarina*), for example, were planted on the plateau at Dana village (Fig. 2.24) for ornament and shade. Palynofacies evidence of fire in the catchment continues to decline, but a significant increase in the numbers of VAMs indicates increased soil erosion, probably as a result of the recent resurgence of grazing animals, as well as a very small scale cultivation of cereals and olives in the area.

This palynological evidence was introduced in the context of the entire Holocene and synthesized in Figures 3.9 and 3.17. This evidence suggests that the Roman/Byzantine environment, broadly similar to or perhaps slightly wetter than that of the present, was followed by climatically-driven aridity characterized by a progressive decline in the abundance of local indicators of wetness and of steppic vegetation and an increase in the representation of desert species, with little evidence for human activity in the landscape between about AD 1450 and 1900. The vegetation patterns established by 1900 can be readily understood in terms of the modern biogeography of the region. The period up to the present day has been characterized by essentially modern habitats and vegetation (Hunt *et al.* 2007b). In the provisional and skeletal palynological record (Fig. 11.9) there are no signs of some famous events, not so very distant, that have almost achieved mythic status, such as the widespread taking of timber from the plateau for construction and fuel for the Hijaz railway and its branch to Shawbak (Fig. 2.20). The recognition of the same biozone in both a gorge environment and in the open wadi environment of the Khirbat Faynan provides a further indication that vegetational changes were taking place across this diverse terrain. The palynological record of waterside and aquatic plants in the Khirbat barrage area is sporadic, suggesting the importance of episodic heavy rainfall events or particularly wet years. The longevity of such standing water is unclear, but its absence in the period inferred to be between 600 and 100 years ago is notable and corresponds closely with the dendroclimatological reconstructions shown in Figure 11.2.

11.2.3 Geochemistry

ICP-MS studies of total major and minor metals were completed for sediments taken from both the excavation (WF5012 = WF5512) and the adjacent borehole (WF5017 = WF5517) up-wadi of the Khirbat Faynan barrage (Grattan *et al*. 2007). Summary data for total concentrations for various key elements, including copper, lead, and thallium for the post-Byzantine deposits are presented in Table 11.5 and Figure 11.10. These materials overlie the sequence illustrated in Figure 10.39. The progressive decline in concentrations in copper and lead upwards through the post-Byzantine Chemizone 1 to the present surface appears to be the result of three types of geomorphic-biological processes: the re-working of remnant pollution by surface geomorphic processes (water flow and wind action); the progressive introduction of 'unpolluted materials' from elsewhere in the catchment, often by wind, effectively diluting the re-cycled polluted materials at the developing land surface; and, to a much lesser extent, the differential re-cycling of heavy metals from the lower deposits in the Khirbat Faynan Member through soil biota, tree roots, and so on as noted in a variety of contexts (see Korte *et al*. 1976; Pulford and Dickinson 2005).

The concentrations of copper and thallium at the land surface being reworked by earth-surface processes appear to have been diminishing over time from their peak in the Roman/Byzantine period. Lead, however, has been removed less rapidly from the landscape. This effect appears to be causing a proportional increase of lead in younger sediments in the barrage-infill deposits, as well as on the surface of the adjacent landscape. Such proportional changes in lead over time are known from intensely polluted site elsewhere: in temperate Britain; for example, the relatively low mobility of lead in historical, industrial, metal-rich smelting slags has been noted by Maskall *et al*. (1996). This is in contrast to the fate of copper in the environment at a number of abandoned 'modern' copper smelters. Developments around the Coniston Smelter at Sudbury, Ontario, Canada described by Gunn (1995) are especially relevant, even though at first consideration they are obviously located in a totally different part of the world. This smelter, which closed in 1972, was associated with soils that contained in excess of 12,000 ppm of copper, with run-off into the nearby Swan Lake enriched to over 25 ppm. The soils now yield 200–500 ppm Cu, and are predicted to return to 'normal' levels within the next 100 years. It is evident from the geochemical studies of slags and soils that such recovery is not taking place to the same degree or speed in Wadi Faynan. The fast recovery at Sudbury is associated with the frequency of base cations neutralizing the copper in soils as a result of their being released by weathering from carbonate-rich tills. Carbonate-rich rocks and surficial deposits are also abundant at and around the Khirbat Faynan and its barrage, but leaching rates are far slower than at Sudbury because of the arid climate. The evidence suggests that surface weathering and the leaching of copper (and by implication of other more dangerous heavy metals) will be very slow in the Wadi Faynan. Lead, by contrast, is relatively insoluble in this environment.

The analyses from the borehole samples at WF5017 are essentially similar to those taken in the excavated trench WF5012, with two possible exceptions to this general equivalence. These relate to the borehole-derived data of WF5017, where at Chemizone 1c there is a two- to three-fold increase in the heavy metal concentrations in two contiguous samples at *c*.80 and 90 cm, when compared with previous concentrations; and at Chemizone 1b at *c*.55 cm there is a *c*.25 per cent increase in copper concentrations compared with previous concentrations (Table 11.5; Fig. 11.10). These small peaks might represent the chance re-working into the deposits of much older fragments of ores or smelting debris. The absence of equivalent peaks in the more closely-spaced sampling units in the excavated trench WF5012 suggests that this could be the correct explanation. Alternatively, the AMS date of 530±40 BP (Beta-203412) from charcoal from copper slag pile 7, as well as the detection of smelting slag attributed to the Mamluk/Ayyubid periods by Hauptmann (2000), could indicate that the increase at 80–90 cm is a real reflection of ore smelting at the time. In which case, its absence in WF5012 reflects the evident patchiness of the sedimentary record. Overall, it is clear from these data that this particular part of the modern surface of the desert landscape is clearing itself only very slowly of its legacy of intense ancient metal-pollution; and that the rate of such clearance was initially comparatively fast but has slowed substantially since then.

Chemizone	Depth (cm)	Summary description and interpretation
WF5012 – excavation trench		
1	0–160	Typically copper less than 1000 ppm, lead typically 300–500 ppm; minimal fluctuations after an overall decline in concentrations upwards from the initial copper concentrations of *c*.2100 ppm at 159 cm, strontium 320–450 ppm and thallium *c*.1.5–2.5 ppm. Marked abrupt change to Chemizone 2 below (see Chapters 8–10). *Interpretation:* recycling by wind and run-off of natural and exposed smelting products.
WF5017 – borehole using Edelman corer		
1b	*c*.55	Copper 800 ppm
1c	*c*.80–90	Copper 1800 ppm

Table 11.5 *Chemizones recognized in the excavated trench WF5012 (= WF5512); and in centre of borehole samples 10 cm thick taken with an Edelman corer at WF5017 (= WF5517) on the basis of variations in key metals in the post-Byzantine infill deposits that accumulated up-wadi of the barrage immediately north of the Khirbat Faynan.*

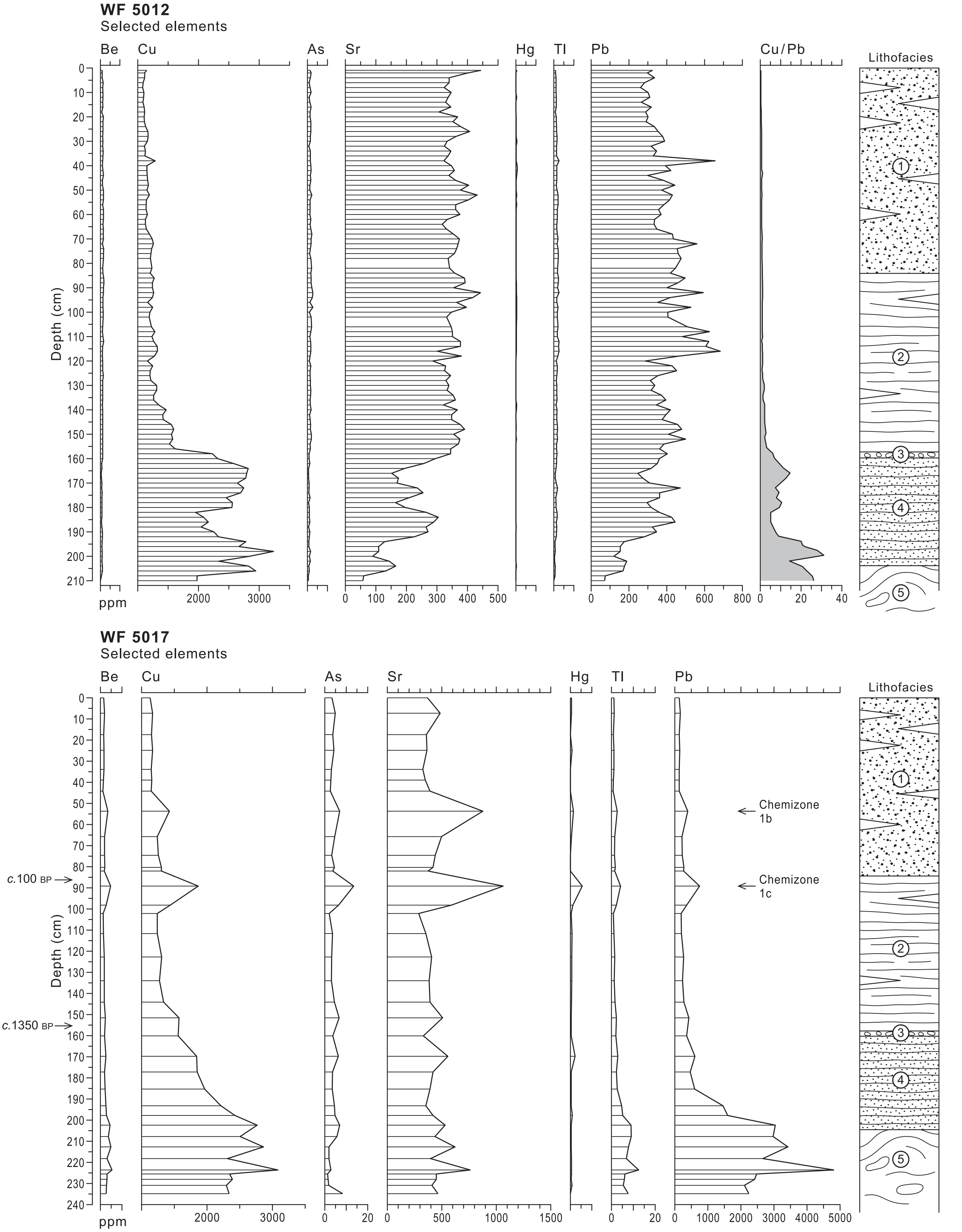


Figure 11.10 *Summary geochemical data (total concentrations in mg/kg by ICPMS) from the Khirbat Faynan barrage infill deposits sampled by excavation (WF5012 = WF5512, a continuous sequence of 2 cm-thick samples – upper diagram) and by Edelman corer (WF5017 = WF5517, single samples from centre of each 10 cm-thick borehole sample – lower diagram). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith.)*

11.3 Archaeology

The post-Classical ceramic evidence from the WFLS, together with data collected by earlier surveys, indicate a dramatic change in the use of the landscape during Islamic and Ottoman times compared with the preceding period. Early and mid Islamic pottery is rare, and though there were notably more sites found of Ottoman age, activity was still well below Classical levels (Figs 11.11, 11.12).

The pottery divides into two categories: sherds occurring as scatters across the landscape, and sherds clearly associated with particular types of structures. The former is by the far the larger of the two categories. Notable examples include site WF549, with 37 early Islamic sherds, and site WF700, with 102 middle Islamic sherds. Each of these collections represents a single pot-burst. In the case of WF700, this is a vessel of Handmade Geometrically Painted Ware (HMGPW), dated to between the thirteenth and sixteenth centuries, the Ayyubid–Mamluk periods (Walmsley 2001a: 527). Other collections of sherds from what are likely to be similar single-vessel pot-bursts were Ottoman in age. Most of the larger collections of sherds associated with structures were also Ottoman in date, particularly in the case of a number of sites on the southwest edge of the survey area (e.g. WF474, WF475, WF476, WF481, WF540, WF542, WF546). The sites with larger numbers of sherds (WF540, WF542 and WF546) consist of scatters of Ottoman-period sherds and other artefacts adjacent to simple rectangular structures (e.g.WF474, WF475, WF476, WF481), in combination indicating occupations at some point between the sixteenth and early twentieth centuries. That these sites are partially obscured by sand and also yielded sherds from earlier periods, particularly the early Roman period, further complicates the picture. Other multi-structure complexes (e.g. WF613 and WF615; WF628, WF630, and WF631; WF866; WF1282) have provided evidence for both earlier and later Ottoman occupations. The site of WF631 consisted simply of a number of small stone settings associated with nineteen Ottoman sherds; together with the adjacent sites WF628 and WF630, it might represent the reuse of earlier structures by Ottoman-period pastoralists, as a campsite and perhaps also for burials. Evidence for the re-use of earlier structures at locations with significant views such as WF1282 at the head of the Wadi Shayqar and WF866 may fall into the same category.

For the immediate post-Byzantine periods no specific structures can be linked with the pottery collected by the WFLS. Most of the material of earlier periods collected in the systematic surveys of the major field systems consisted of isolated sherds probably resulting from casual breakages, but they at least indicate the occasional presence of people in the Faynan landscape throughout the entire post-Classical period (Fig. 11.12). This evidence seems consistent with a shift from permanent mining-related settlements to the use of the valley by pastoral groups, leaving behind a materially-impoverished and vestigial archaeological record. There is no evident association between these sites and any of the older networks of walls and fields, suggesting minimal or no interest in their function.

The late Byzantine and Islamic coins reported by the Bochum team (Kind *et al*. 2005: 179–83, 188–9) show a wide gap between the last Byzantine issues of the mid-seventh century AD and a number of Ayyubid and Mamluk issues of the thirteenth and fourteenth centuries (Fig. 10.35). The absence of any coins relating to the period AD 668–1210 (covering the Ummayad, ‘Abbasid, Fatimid, early Seljuq and Frankish phases) is striking and gives added weight to the general absence of diagnostic pottery of this period. With the most accessible copper ores worked out and mining concentrated in deep and dangerous underground galleries (Figs 10.3–10.6), perhaps with the naturally-regenerating local timber sources severely depleted or eradicated and with the immediate environment of the mining settlements heavily polluted (see Chapters 3 and 10), the sustainability of the Byzantine mining operation could well have been called into question even prior to Muslim invasions. Whether or not copper production had continued right up to the mid-seventh century Islamic conquest, the implications are surely that it did not endure in the subsequent centuries on any significant scale. The lithostratigraphic and geochemical evidence from the infill deposits at the Khirbat Faynan described previously is insufficiently precise to resolve this matter (Hunt *et al.* 2007b).

After a prolonged period in which the remaining population in the valley seems to have had little regular contact or trade with a wider world, there was a brief florescence in the thirteenth and fourteenth centuries AD. Previous surveys by King *et al*. (1989) and by the Bochum team (Hauptmann and Weisgerber 1992) recovered significant amounts of post-Classical sherds from several major sites within and immediately beyond the WFLS survey area. As in our own project, little early Islamic material was found, except for the occasional Fatimid-period sherd, but sherds from both the Ayyubid/Mamluk and Ottoman periods were collected in quite large numbers at a few sites. Mamluk sherds were collected in significant numbers within the general environs of Khirbat Faynan, including in the cemetery area to the north and at locations on the southern bank of Wadi Faynan (King *et al.* 1989: 203, 210). Another sizeable group of Mamluk material (41 sherds) was collected from Tell al-Mirad, the Nabataean fortress site classified as WF592 in our survey register (King *et al.* 1989: 204, 211; Fig. 9.22).

The Bochum work indicated a brief phase of renewed mining and smelting in the Ayyubid and Mamluk period on the evidence of distinctive slags and particular metallurgical signatures thought to be indicative of Mamluk smelting technologies. This evidence can be correlated with the identification of three smelting sites, the largest being al-Furn, a settlement *c.*6 km northwest of Khirbat Faynan and *c.*1.5 km east of Khirbat an-Nahas (Hauptmann 2000: 86–7; Hauptmann and Weisgerber 1992: 65; Hauptmann *et al.* 1985; Kind *et al.* 2005: 188; for location see Fig. 2.2). The

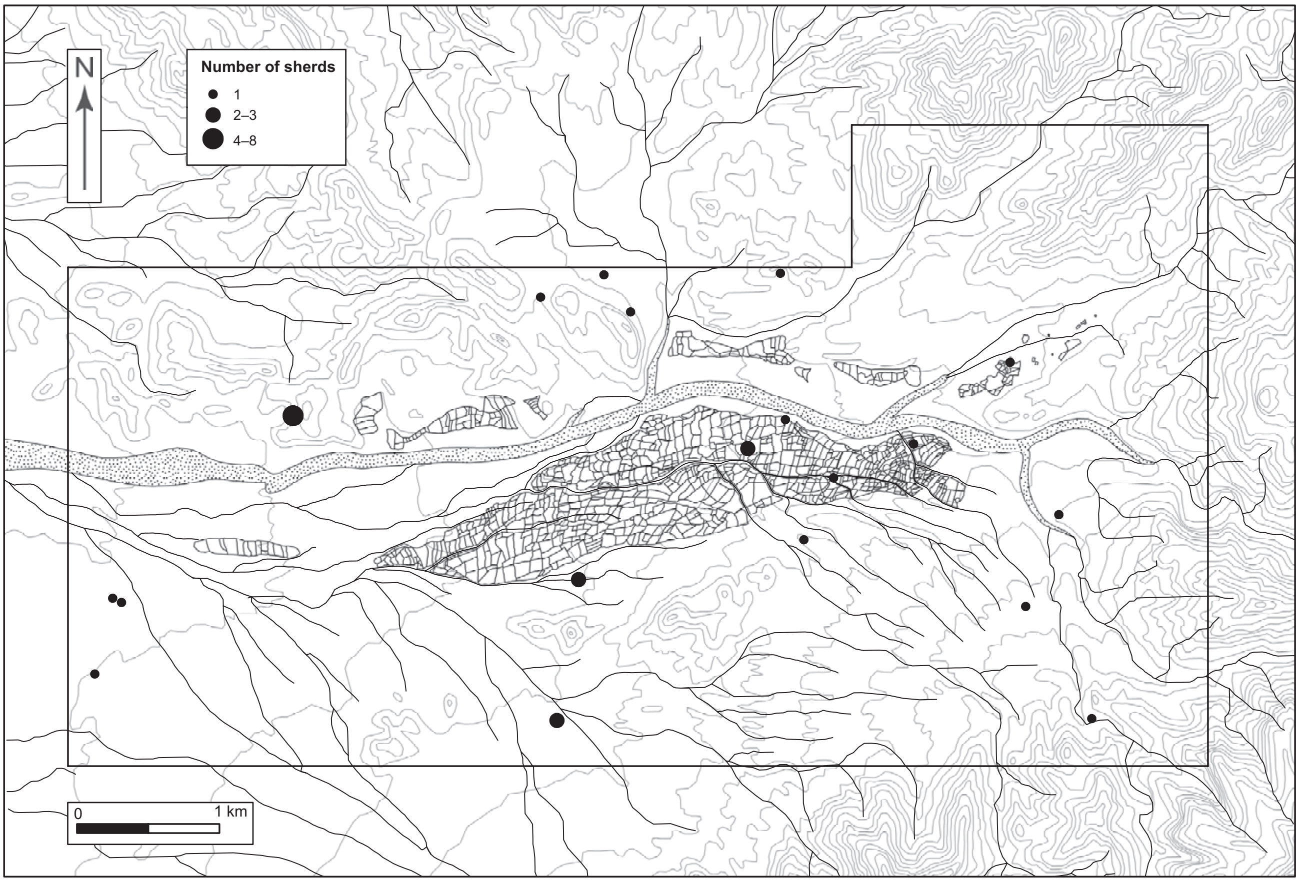


Figure 11.11 *The distribution of sites with sherd collections of clear Early or Middle Islamic date. (Illustration: Paul Newson.)*

site at al-Furn comprises a complex of fifteen well-built stone dwellings and a mosque (Hauptmann and Weisgerber 1992: 65). A central building and a number of other complexes have contemporary slag heaps adjacent (Fig. 11.13), which Hauptmann estimates at 1500 tonnes, representing a production of only 100–150 tonnes of copper (Hauptmann 2000: 98, 100). There is still much Islamic glazed ware pottery to be seen around these. Six Ayyubid coins were collected from here by the Bochum team (Kind *et al.* 2005: 188) spanning the period AD 1203–1235 and hinting at an Ayyubid date for the revival of copper working in the Faynan region, though this may have continued into the fourteenth century AD and the published accounts of the Bochum team often refer to the Islamic metallurgical activity as 'Mamluk' (Hauptmann *et al.* 1992: 8, 23).

The Bochum team have shown that the renewed interest in the Faynan ores during the Mamluk period was evident at Khirbat Faynan too (slag heaps 1 and 6) and postulated that activity might have included the renovation of the aqueduct channel and reservoir system which took water from the Wadi Ghuwayr to the settlement complex (Hauptmann and Weisgerber 1992: 65). King *et al*. collected equal numbers of Mamluk and Ottoman sherds (about twelve in each case) from the immediate vicinity of the reservoir, evidence that suggests some level of continued use of the reservoir system. Ottoman sherds have also been recovered in relatively large numbers (64) on the lower slopes of Khirbat Faynan and in the immediate vicinity, and in still larger quantities (170) from the eastern sector of the South Cemetery WF3 (Findlater *et al.* 1998; King *et al.* 1989: 204, 210). King proposed that the 'exploitation of the copper mines at Finan probably accounts for this later Islamic period use of the site' (King *et al*. 1989: 204). The best independent evidence for such smelting activities at Faynan is the date mentioned earlier of 530±40 BP (Beta-203412) from slag heap 7 (WF5041 = WF5741), though as we have seen there is also a post-Classical spike in the copper pollution registered in one of our sections behind the Khirbat Faynan barrage. Given the nature of the calibration curve at these times, on its own this radiocarbon date could suggest that the smelting of ores was taking place early in the Ottoman period – but at present we believe the balance of evidence points to the older Mamluk date.

It is not certain whether this Mamluk activity involved renewed mining or whether it was simply reprocessing the abundant slag deposits left behind by earlier phases of copper exploitation to extract residual copper. Further excavation is highly desirable at these Islamic metallurgical sites to make a fuller assessment. However, the physical appearance (Fig. 11.14) and the chemical composition of the slags believed by Hauptmann to be Islamic in date does differ from those of Roman or earlier phases and some may have related to iron processing (Hauptmann 2000: 232; Hauptmann *et al.* 1992: 23; Khouri 1988: 126). The substantial buildings at

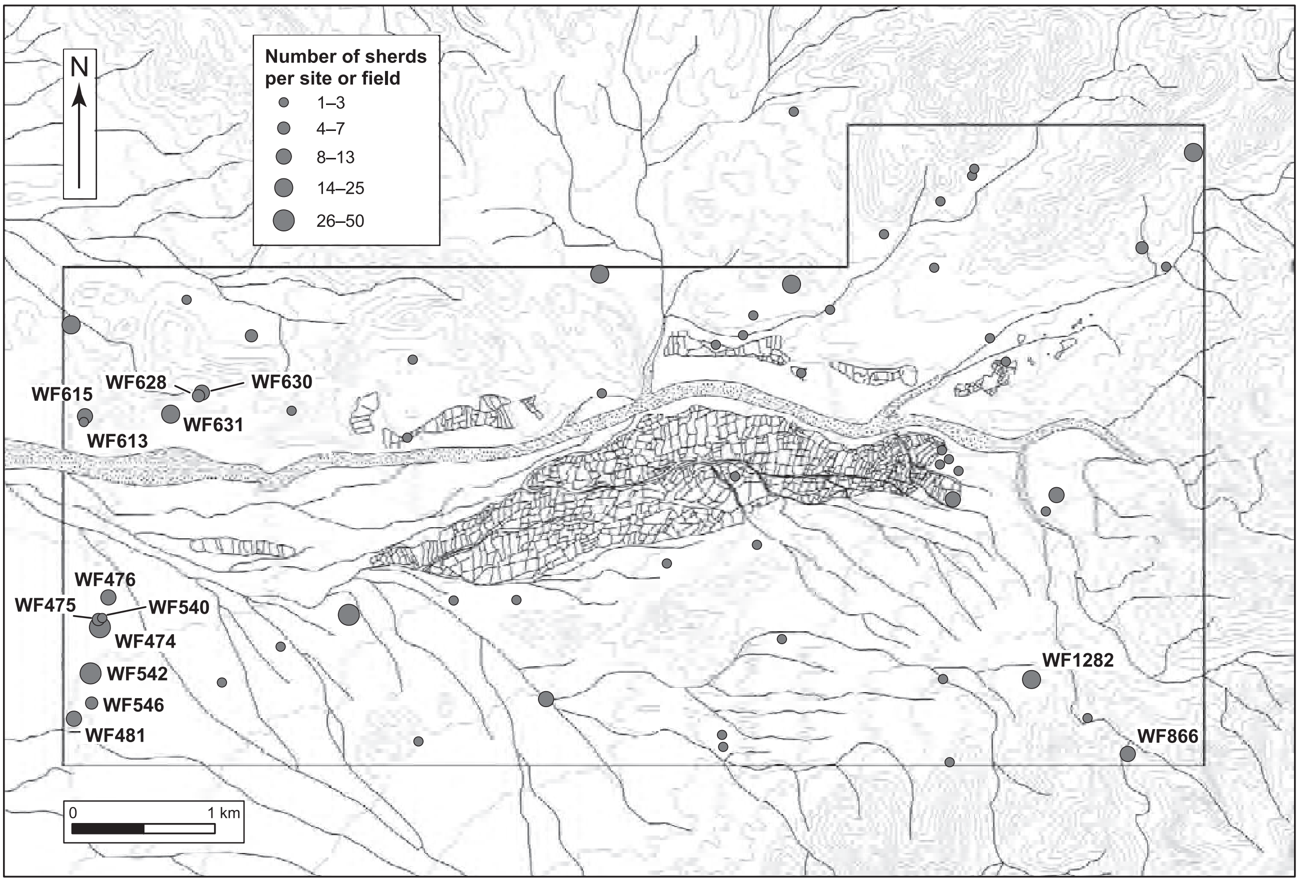


Figure 11.12 *The distribution of Ottoman period sherds across the survey area. (Illustration: Paul Newson.)*

al-Furn, along with the identification of Islamic slags on at least three of the slag heaps surrounding Khirbat Faynan (Hauptmann 2000: 68, slag heaps 1 to the south of the Wadi [= WF11], and 6 and 7 to the west and north of WF1) hint that this was a systematic and well-organized operation, with a life-span in decades at the very least. In this instance, as in the Roman period, the exploitation of the resource appears to have been the result of the interest and investment in a peripheral territory by a distant core polity.

There is an interesting correlation between the apparent renewal of permanent mining or smelting settlements in the Faynan region and Mamluk monetary policy. In the later fourteenth century the copper coinage (*fulus*) of the Mamluk ruling dynasty in Egypt was revised, with a much more abundant output to a new weight standard of higher purity copper coins (Schultz 1998). The initial development came in the reign of al-Nasir Hasan (Mamluk ruler 1347–51 and 1354–61) in AD 1357/58, with an issue of new copper coins to a changed weight standard (the *mithqal* or *c.*4 g compared with the previous copper issues of *c.*3 g weight). There is abundant numismatic evidence to illustrate this (Schultz 1998: 134–9). The new monetary system set the tone for the fifteenth century being an 'Age of Copper' in Mamluk territories (Schultz 1998: 128; though note that Schultz was unaware of the possible connection with exploitation of Faynan copper). A likely stimulus for the monetary reform in the late 1350s could thus have been a newly available source of copper, though, as noted already, the coin evidence from al-Furn suggests that the operation there may have started a century earlier. However, it is possible that the operation at Khirbat Faynan was exclusively of Mamluk date and raised substantially the copper output there to the benefit of the mints of Cairo and Alexandria, where the Mamluk *fulus* were produced. On the other hand, there are indications that by the end of the fourteenth century the Mamluk state was relying to some extent on imports of European-produced copper (Schulz 1998: 130, 143–5). If so, it is possible that the initial yield from the Faynan/al-Furn operations was not sustainable and that the metallurgical activity was abandoned after no more than 100–150 years. The lack of later Mamluk coinage at either site is potentially significant.

This apparently brief Islamic interlude of revived mining exploitation stands in stark contrast with the general pattern of economic activity in the Faynan valley in the post-Classical period. The evidence collected by the WFLS for Ottoman-period activity suggests that, compared with the Mamluk period, the use of the Wadi Faynan was linked more to pastoralism than to mining. There is no evident association between these sites and any of the older networks of walls and fields, suggesting minimal or no interest in their function (Fig. 11.11). As may also have been the case in the Middle and Late Bronze Age (Chapter 8, §8.13), it would not be surprising if Ottoman-period pastoralists engaged in mining on a small scale from time to time (Segal

Figure 11.13 *The Mamluk smelting site at al-Furn, main building and associated slag heap, looking north. (Photograph: David Mattingly.)*

Figure 11.14 *Detail of Mamluk slag at al-Furn. Scale: 10 cm. (Photograph: David Mattingly.)*

and Rosen 2005). Nonetheless, with the exception of the Ayyubid/Mamluk revival of an externally-sponsored mining regime in the valley, the evidence suggests the general pattern of life was pastoralist, transient, and archaeologically elusive. The low-level presence of material, especially at key campsite locations still favoured by the bedouin, is most likely to represent the dominance of pastoral lifestyles in the survey area through the post-Byzantine centuries (Banning and Köller-Rollefson 1992). Another activity which could have been responsible for (some of) the post-Byzantine surface pottery would have been trade caravans and Hajj pilgrims passing through the valley to and from Palestine, but it is known that the majority of the trade and pilgrim caravans passed either to the north through Ghor es-Safi (to and from Palestine) or to the south through ʻAqaba (to and from Egypt) (MacDonald 2006; Schick 1997). The archaeology of the present and recent bedouin communities, as discussed in detail in the next chapter, offers a way to develop a more sophisticated understanding of the archaeology of earlier generations of pastoral groups.

Pastoralists using the Wadi Faynan may have had a symbiotic relationship with sedentary farmers on the plateau (Banning 1986; Finkelstein 1995), utilizing the region in much the same way as bedouin have more recently, spending the summer on the higher plateau and the spring in the valley (see Chapter 2). The distribution of Ottoman-period ceramics would fit with such a scenario. The relative frequency of Ottoman material compared with the rest of the post-Classical assemblage may reflect taphonomic factors of survival or an increase in pastoral use of the landscape, or more likely a combination of both factors. The pastoral lifestyle would appear to have been extremely resilient with respect to the changes in climate and environment identified earlier in this chapter, and to have been responsive to economic and political influences, with the Mamluk and perhaps the Ottoman periods representing periods of economic growth in the context of stable political authority (McQuitty 2001). The paucity of settlement evidence for other periods correlates with periods of unsettled governance and economic isolation in southern Jordan, when the Faynan area returned to a 'default setting' of a marginal environment at the periphery of the core Islamic state (Johns 1994: 13).

11.4 Synthesis: life in an abandoned industrial landscape

There are no unequivocal indications in the new data that regional climate immediately after the Roman/Byzantine period differed in a profound manner from that during the earlier industrial episodes: there is a possibility that the climate at the beginning of this time, as in the preceding Roman/Byzantine period, may have been slightly wetter than prevails today. At this time, there was certainly a clear and rapid decline in burning by people, with some continuing small-scale cultivation of cereals and perhaps olives, with the cessation of all or most metallurgical activity and consequent pollution after the peaks in Classical times. Neither have any indications been found of any distinctive climatic episodes – notably hotter or colder, wetter or drier – in the period before AD 1400 that might correspond with the medieval climatic optimum of Europe, or those changes identified in the better known areas to the west (Fig. 11.2).

The disappearance of the settlement at the Faynan from the documentary record after the Muslim takeover, together with its subsequent lack of mention by later Arab travellers and geographers until its reappearance with Musil (1907 [1989]), all broadly correspond with the findings of our archaeological and palaeoecological studies. Nevertheless, it is also clear that some people were in the area. Similarly, the observed lack of political or other significance of the area appears to be also manifest in its archaeology. The density of sites of Islamic age evidently had declined dramatically compared with the preceding Classical times (Fig. 11.11). The vegetation and soils in this Faynan landscape may have altered locally as a result of the decline and cessation of industrial activity, resulting in a reduced pressure on the landscape producing vegetation broadly similar to that which prevails today. During the Islamic period, the decreased frequencies of VAMs and wider palynological evidence indicate lower rates of sub-surface soil erosion and a sparsely-occupied landscape in which the climate was becoming drier. Over time, the vegetation grew to be richer in grasses together with increasing frequencies of desertic components such as plants of the Chenopodiaceae. These local reconstructions, as much as the more regional palaeoclimatic reconstructions (Fig. 11.3), suggest that the climate was not sufficiently adverse to explain the general 'absence' of people in the records from Ummayid to Frankish times, remarked upon earlier. Other political-socio-economic factors must have been at work.

There is tenuous evidence at the Khirbat Faynan of enhanced metal pollution produced by the relatively small, brief, and localized episode of copper-smelting near the barrage site, as evidenced by the charcoal from copper smelting slag that dated to about 530 uncalibrated radiocarbon years before present. This episode is better recognized in the archaeological and historical records (see Grattan *et al.* 2007; Hauptmann 2000) and is tentatively attributed here to the economic demands of polities elsewhere during the Mamluk period. But the geochemical evidence suggests that this metallurgical activity was very small scale in the Wadi Faynan, especially when compared with the nature of ore-processing and smelting in preceding Classical and prehistoric times.

The period of time represented by Lithofacies 2 at the Khirbat Faynan infill sequence is approximately *c.* AD 1400 to *c.* AD 1850–1900, and hence it provided some deeper local insights into the Ottoman period in the Faynan (Tables 11.2, 11.4). The landscape is shown by our geomorphic, palynological and dendroclimatological evidence to have experienced substantial sustained aridity, punctuated by wetter episodes. Despite the loss of surface water and biological productivity, there was an increase in the density of sites with dated pottery sherds compared with the preceding Islamic period (Figs 11.11, 11.12). Even so, this surrogate measure of the intensity of human activity in the Ottoman period still suggests small local populations, with comparatively low levels of human activity and impact, with only minimal evidence of local cultivation. In practice, the overall impact of land use, or perhaps of smelting, upon the land surface appears to have been minimal: at least too small to be determined with precision by the methods used in this study. For both the Islamic and Ottoman periods, the implications of Figures 11.11 and 11.12 are that there was no especial interest in the functions of the older walls and field systems to manage overland flow, soils and agricultural produce. Presumably, sometime with the loss of agricultural need that came with the end of industrial-scale copper extraction, the wall-systems had largely or entirely fallen out of use by these times.

Although the primary productivity of *Juniperus phoenicia* growing in the Dana Reserve and at Tor al-Iraq to the southwest evidently responded to times of greater precipitation in the Ottoman period, there is no indication in the palynological studies of any associated (if brief) recovery in biodiversity, especially of woody taxa, taking place during these wetter episodes during the five centuries before 1900. Presumably, at least in part, this was the result of the overall greater aridity in climate. The extent of sub-surface soil erosion around the Khirbat Faynan diminished in this more arid episode, especially in comparison with the periods before and after, presumably the result of a comparative absence of human impacts via grazing animals, cultivation, or fuel-gathering, together with the infrequency of overland run-off.

Nevertheless, this more arid period evidently also encompassed some significant rain storms that on occasion caused small ephemeral pools to develop upstream of the Khirbat Faynan barrage, but unlike at the present day, this pool was not in receipt of significant quantities of biological debris. While there was a measure of parallelism in the palynological responses to climatic effects between an up-wadi gorge environment and the open wadis of the confluence, the effects of bedrock, topography, and the balance of geomorphic processes have brought about greater local variability in the geomorphological response. Little support exists in this new information to sustain the idea that there have been long-term 'regular cycles' of climatic change. During this period, sequences of widespread aggradations, incisions, and further aggradations took place in the wider wadi floors, with episodic braided flows, but the longevity of any of these geomorphic events is unclear: they may only reflect a series of major storms or wet years/decades as implied in the sixteenth- and seventeenth-century levels of the Dead Sea and the episodic changes indicated by the dendroclimatological reconstructions (Figs 10.36, 11.2, 11.3). The evidence for an overall arid climate interspersed with wet episodes correlates with that recognized in the Dead Sea by Heim *et al.* (1997) and the 'Little Ice Age' recognized from many sources in northwest Europe. This distinctive more 'arid' phase in the Wadi Faynan appears to have ended locally about 100 years ago, when the slightly wetter climate and less desertic and biologically-richer environment developed. The habitats of the present day became established and for which unequivocal indications of human activity in the landscape have been found in the geomorphic and palaeoecological records, including the planting of exotic species, small-scale cultivation, and the tending of animals. The impression created by the overall body of palaeoenvironmental data is of significant and overall progressive change taking place at *c*.550 years ago, and then a more sudden change at *c*.100 years ago, with numerous shorter events and phases within these trends.

In brief, climatic fluctuations rather than contemporary human impacts appear to have been the deciding influences that determined the characteristics of this desert landscape from the end of the Roman/Byzantine period to the end of the Ottoman period. The pastoral lifestyles involving small numbers of people that we think have dominated the Wadi Faynan through these centuries appear to have had little impact on the landscape compared with the settlement forms and activities that preceded them.

12. Ethnoarchaeology

Carol Palmer, Helen Smith, and Patrick Daly

12.1 Introduction

A recurrent question throughout the Wadi Faynan Landscape Survey concerns the extent to which a comparative absence of evidence of past human activity in this area reflects a real phenomenon, or merely reflects our inability to recognize and understand clues within the landscape. In brief, is there evidence of absence or an absence of evidence? This difficulty was evident, for example, in consideration of fluctuating population numbers during the Bronze Age (Chapter 8), and during the long period from the coming of Islam up until the present (Chapter 11). Within both of these periods, the landscape of the Wadi Faynan evidently changed dramatically, with some substantial reductions in the scale of settlement activity. But did it ever become completely empty of human activity? The apparent invisibility of pastoral groups in the archaeological record is well known and has prompted scholars to consider how to recognize the location of potential temporary campsites, together with issues concerned with the symbiotic relationship of pastoral to settled populations (Avni 1996; Banning 1986; Finkelstein 1995). This chapter approaches this problem by describing the material-culture patterning left by the modern occupants in parts of Wadi Faynan who have facilitated understanding of this patterning by giving valuable information about their own lives and those of their immediate forebears. As well as revealing important practical and social facets of the bedouin way of life, particularly in their use of space, this chapter also investigates what factors modify and moderate the archaeological record left behind. Ultimately, this chapter also documents the material culture associated with a distinguished way of life that is increasingly subject to the pressures and diversions of a new millennium (Chapter 13: Postscript).

12.2 The Bedouin Camp Survey

Ethnoarchaeological research elsewhere has demonstrated that recent pastoralists leave visible traces in the form of fixed campsite 'architecture' and durable artefactual and environmental remains (Avni 1992; Banning and Köhler-Rollefson 1983; 1986; 1992; Cribb 1991a,b; Hole 1979; Saidel 2000; Simms 1988; Simms and Russell 1996; 1997). The Bedouin Camp Survey reported here was undertaken to explore the nature and archaeological visibility of pastoral activity in Wadi Faynan in the recent past and to assess the possibility of identifying more ancient pastoral activity there. The survey also enabled the archaeologists working on the landscape survey to differentiate between the remains of modern bedouin from those of earlier periods.

The survey took place in the springs of 1999 and 2000, primarily undertaken in the field by Carol Palmer and Helen Smith, with GIS mapping of the results by Patrick Daly. During April 1999, a general survey was conducted to examine the location of tents in the landscape and to document main tent characteristics, including durable and non-durable architectural features. The winter of 1998–99 was particularly dry, so many families had packed up their winter campsites earlier than the previous year when spring conditions were good and families camped for longer in the area (Palmer 1999). The abundance of very recently abandoned campsites facilitated a clearer understanding of camp organization alongside visits to some eighteen camps that were still occupied where the inhabitants themselves were able to describe their homes to us, and we were able to observe routine activities. Eighty-one tent sites (WF900 to WF981, but excluding WF907 which was not a tent site, although it did represent bedouin activity) were visited in 1999, in addition to two additional sites which represent encampments originally recorded by the Wadi Faynan Landscape Survey team (WF860 and WF869), a total of 83 sites in all. Most of the tent sites recorded had been occupied in the last ten years, and in 75 cases it was possible to ascertain which tribe had lived there. Four sites represent older campsites of uncertain date.

For each tent site the position, orientation, spatial arrangement, and common key features were recorded. In addition, supplementary structures and features such as goat and kid pens, chicken coops, outside hearths, and a variety of features associated with the storage of fodder and household goods were recorded for each encampment. All sites were visited accompanied by a local informant, Jouma' 'Aly, a respected member of the 'Azazma (Fig.

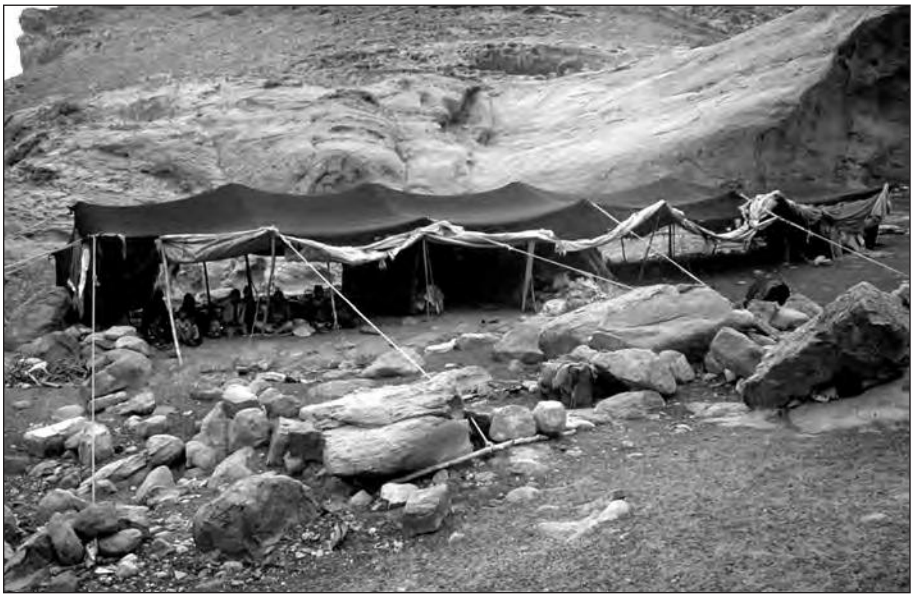


Figure 12.1 *Bedouin tent,* bayt al-sha'r*, in the Wadi Dana (WF918). (Photograph: Carol Palmer.)*

2.27), and lively discussions were often held with site occupants about the various key components of their current homes or former home locations. Where possible, some general details were noted about the inhabitants, including tribal affiliation, the number of family members living in the tent, estimated numbers of livestock held, and any family relationships between the occupants of tent clusters. Observations were also made of the various activities going on in and around tents as a way to understand site formation processes.

In southern Jordan, the work of Banning and Köhler-Rollefson (1983; 1986; 1992) among 'Ammarin camping in the Beidha area and Simms and Russell (Simms 1988; Simms and Russell 1996; 1997) among the B'dul of Petra is particularly relevant to this study. The Wadi Faynan bedouin camp survey built on these previous studies, but attempted to extend them by exploring seasonal and tribal variations in campsite organization, as well as the way in which campsites have changed within living memory. It also included detailed studies of selected sites to assess archaeological visibility through the distribution of artefacts and environmental evidence. GIS techniques were used to analyse the material remains of pastoral activity, both for the wider landscape and the individual site scales. GPS was used to locate all sites so that they could be incorporated within the overall WFLS site record.

12.3 Campsite architecture

The tent, *bayt al-sha'r*, or 'house of hair', is the central feature of an encampment and an important 'pillar' of bedouin life (Jabbur 1995: 241–56; Weir 1990 [1976]: 13–18; Fig. 12.1). In Arabic, the word *bayt*, house, is used equally for stone-built or fabric homes. The second component of the Arabic name, *sha'r*, refers to the black goat hair from which the tent is made. Although primarily associated with bedouin, villagers in southern Jordan also use goat hair tents to camp out with their goats and sheep, particularly during the spring and early summer during the milk-processing season (see Chapter 2). In the Wadi Faynan today, however, it is bedouin who occupy the tents found there.

The main components of a tent are the roof, the front and back 'walls', poles, and guy ropes. The roof and back wall are made of woven goat hair strips, *shugga*, sewn together. The number of strips used varies with the size of the tent, but seven strips are typical for the roof and two to three strips with alternate white horizontal cotton bands form the back wall. Although the *shugga* can be bought commercially, many women still weave their own strips, and each one represents many hours of labour from collecting the hair to spinning and, finally, weaving them (Fig. 12.2). Thus, women are very much the 'architects' and 'builders' of their homes (Crowfoot 1945: 34). Individual woven strips are replaced as they wear out, usually on an annual basis. Goat hair fabric is extremely durable and practical: it is waterproof and warm in winter, allowing smoke from internal fires to filter through the weave of the fabric, but provides shade and ventilation in summer. Although the black goat-hair fabric can be used in all seasons, in summer the heavy fabric is often today exchanged for lighter sacking, which is easier to transport. The front wall of the tent is now always made from lighter sacking fabric sewn together from empty fodder bags or purchased relatively inexpensively from towns.

Tents are described according to the number of 'centre' poles, or *wasat*, they possess. Two- and three-pole tents are most common in the Faynan area, although there is also a number of four-pole tents that are the homes of comparatively wealthier, more established, occupants. A

Figure 12.2 *Weaving a goat hair roof strip,* shugga*, Wadi Dana, 22 April 1999. (Photograph: Carol Palmer.)*

three-pole tent has three parallel rows of five poles (three 'centre' poles and one at each end), that is, fifteen supporting poles altogether. Each pole is 3–4 m apart, so a typical three-pole tent is 15–16 m in length and *c*.4 m wide.

Narrow woven goat-hair reinforcement bands, *tariga*, are stitched transversely across the tent roof and above the supporting poles to both protect the roof fabric from tearing and take the strain from the guy ropes. The guy rope and ends of the *tariga* are looped together over a stout stick. In a typical tent, the corner poles have two guy ropes to secure them in position, and the rest have one. The guy ropes are secured to the ground using either a metal peg or by tying the rope around a stick weighed down under rocks called *rugid*. The tent back and front walls are attached to the roof with wooden pins, *hilal*, or nails, *misamir*. In cold weather and at night both the front and back tent walls are kept down to keep in the warmth. On warm days, both the back and front walls can be rolled or propped up to allow cooling breezes to flow, but if the wind is strong, the walls are rolled down again to keep out the dust. In summer, the walls of the tent may be removed entirely, the roof acting as a shade.

A tent represents a flexible, pleasant, living environment. Internally, with the use of screens hung transversely, areas can be demarcated as public space, private and domestic space, and as areas for livestock. There is an element of flexibility and overlap between the spatial zones within and around tents and areas do change purpose, for example, between night and day and when visitors are present, but there are, overall, very strong, shared guiding principles in tent organization.

The most elaborate, often intricately woven, dividing screen in the tent, the *saha* or *mu'anad*, is always between the public or 'men's' section, the *shigg*, and the private, or 'women's' section, the *mahram*. The focus of the men's section is its central hearth, which can be a simple circular feature or a more elaborate rectangular one (discussed below). The *shigg* is used to entertain guests and prepare coffee. Hospitality is a key feature of a good and honourable life: a host must be available to guests, friendly and patient, and a fire should be lit immediately and a drink, above all coffee, prepared (Bailey 1991: 125). At night, the men of the household and any male guests sleep in the *shigg*. A spacious men's section to receive guests is a mark of an important household. Although described by local people as the men's section, when no guests are visiting, the whole family may sit, eat, and undertake tasks in the *shigg* (cf. Layne 1987: 358; 1994: 83–4). Not all tents have a 'men's', or public, section, but there is usually at least one tent in any group that does, and tents pitched alone will always possess one.

The women's section, *mahram*, is the family's private area where most daily cooking and food preparation are performed and where women and young children sleep at night. It may be a single unit or subdivided into a discrete kitchen and a sleeping compartment or compartments using further partition screens. In this society, the protection of female honour and modesty is paramount. Although the wife of an important man may, in the absence of her husband, extend hospitality to a male guest in the *shigg*, only close male relatives (technically, men whom by their degree of consanguinity the women cannot marry) are able to enter the *mahram*. The *shigg* is kept open during the day, while the front wall of the *mahram* is usually positioned in a way that prevents prying eyes from viewing the interior space. The final possible section of a tent is for housing animals in winter. Whole tents may also be used entirely as goat shelters.

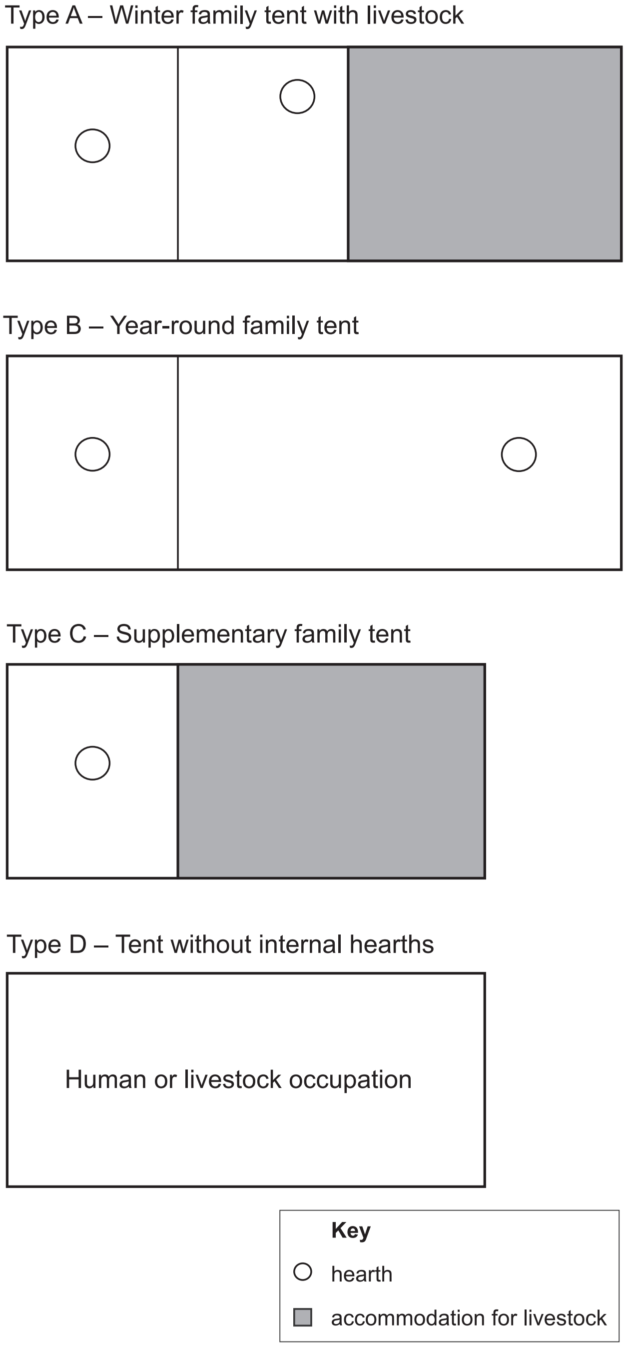


Figure 12.3 *Schematic representation of the tent forms discussed in the text. (Illustration: Carol Palmer.)*

One of the most important features of a bedouin tent is the hearth, which is also one of its more durable archaeological features (Simms and Russell 1996: 9.7; and see discussion below). It is mainly on the presence, number, and siting of hearths in an individual tent that tent types were grouped in the Wadi Faynan. The positioning of hearths reflects spatial organization within a tent. A schematic representation of the tent forms is given in Figure 12.3.

12.3.1 Type A – Winter family tent with livestock

This tent form is only found during rainy and cold periods, roughly November to April. Typically, a three-pole tent is used and one half of the tent is for human occupation, while the other is for sheltering animals at night. The half occupied by the family is further sub-divided into the *shigg*, the section used by guests and by men for the most part, and the *mahram*, the women's section. There is an internal hearth in both sections, but because half of the tent is occupied by animals, once the tent site is abandoned the hearths are situated relatively close together. This is the tent form described by Banning and Köhler-Rollefson (1992: 193–5) in their survey of camps in the Beidha area near Petra. Type A tents are not usually occupied for a long period on the same site because penning goats creates an unpleasant build-up of dung. Families using this tent form usually move two to three times during the winter period. The dung is normally allowed to decompose significantly before the site is reused, but may be burnt off between occupations in order to hasten this process.

12.3.2 Type B – Year-round family tent

This form of tent organization can be found year-round and it is mainly associated with larger tents, those with three poles or more. It has two hearths situated at either end of the tent; one in the men's section, the *shigg*, and the second in the kitchen area of the *mahram*, the women's section. Because livestock is not housed within this tent form and there is no consequent build-up of dung, it can be used on the same site for an extended period or the same site used repeatedly between years. The private or 'women's area' in these tents is larger and can be divided up into different women's activities areas: for example, the kitchen is demarcated from a woman's area.

12.3.3 Type C – Supplementary family tent

These tents possess a single hearth that is not normally used for hospitality purposes. These are usually smaller, two-pole tents. Livestock may be sheltered in this tent type when there is a dividing screen between the animal and human occupants. As human living space, it represents a private family area. This tent type is not found in isolation, but usually as part of a group with Types A or B, and is the tent form used by additional wives, widows, and recently married sons who have not yet established their own household.

12.3.4 Type D – Tent without internal hearths

Type D tents lack internal hearths, although hearths may be located just outside. In summer, more activities take place beyond the confines of the tent and most tents belonging to this category are summer tents. This type also includes tents set-up for celebrations and formal occasions such as weddings, as well as winter animal shelters. This is a highly ephemeral tent form in terms of post-abandonment visibility, particularly as the length of occupation is generally short. These tents can be of any size although in the Wadi Faynan summer tents tend to be small with one or two centre poles. Celebratory tents are much larger and can even combine more than one tent linked together on important occasions.

12.4 Campsite location

The Bedouin Camp Survey does not represent a study of all the campsites in the Wadi Faynan, but rather a detailed consideration of sites in the south and east of the survey area, in particular, and includes campsites that represent the main tribal groupings. Overwhelmingly, these camps represent very recent bedouin activity. Only four sites included in the survey were occupied beyond the living memory of local inhabitants, although many recently occupied sites were said to have been used regularly for many years. Campsites in other areas of the Wadi Faynan survey area were recognized and recorded by members of the archaeological survey team.

An important difference in the way that sites included in the Bedouin Camp Survey were recorded is that a site usually represents one individual tent, whereas the archaeological survey team recorded whole encampments as a single site, which can comprise one or more tents. This, in part, accounts for the extremely high concentration of campsites located in the lower Wadi Dana, the Wadi Shayqar, and along the 'madrassah' or school terrace-like surface near the RSCN camp, though these areas do represent foci of bedouin activity (see Chapter 6 – the gently sloping surface of the Madrasah Beds: Fig. 6.4). Because families may move tent site regularly, several sites were occupied by the same people. Sites WF949, WF950, WF951, and WF952, for example, represent relocations during the winter by the same family.

In terms of general factors affecting campsite location, sites are generally located near to water sources, such as in the lower Wadi Dana and Wadi Ghuwayr. In the Wadi Dana, water is piped from its main source in the springwater to the school via the Faynan camp (the base set up by the Natural Resources Authority and run by the RSCN and CBRL during the time of the survey) and there are several outlets along the way, which means that, effectively, families camping there have a piped water supply. Families camping in the Wadi Shayqar go to the Wadi Ghuwayr for their water, which is fetched daily on donkey-back usually by younger family members. The availability of perennial spring water means that local families can stay in the vicinity of the Wadi Faynan year-round, though the quantity and quality of the water deteriorate during the long, dry summer months.

Access to pasture is also vital for pastoral groups, although the contemporary availability of commodified fodder means that this is not as critical as it was in the past. However, the best milk for making milk products comes only from animals consuming fresh vegetation. The best grazing areas are in the mountains, and camps are situated within comparatively easy reach of the hilly terrain.

Fifty-seven campsites in the survey area are winter campsites and just eight were said to be exclusively summer sites, with one inhabited year-round. This emphasizes that Wadi Faynan is still mainly a winter camping ground. When men have full-time employment, often by association with the Faynan camp, their family may not stay with them during the summer, in which case they live with relatives or at the Faynan camp itself. On the other hand, due to the timing of the school year, women and children may live with relatives in the area until early summer, while the other family members go further upland with the livestock.

Figure 12.4 shows the upper part of the Wadi Shayqar and the distribution of winter and summer campsites there in relation to the local topography, as indicated by contour lines. Winter tents are located on raised terraces beside wadi beds, whereas summer tents are sited on ridge tops. The preference for camping in winter in sheltered locations, or 'canyons', was also noted for bedouin in the Beidha region (Banning and Köhler-Rollefson 1992: 187–9) and more broadly, for example by Avni (1992: 245). These locations provide protection from wind and rain as well as seclusion that, in the past, would have had a strategic value. Trees and shrubs are denser around wadis, so firewood is available and trees can be used to store household items beyond the reach of ever-hungry goats, as well as to tether animals, particularly donkeys, which are thereby afforded some shade. Some trees have edible fruits, such as *Ziziphus spina-christi*, and having such a tree nearby is considered an advantage. The gravel floors of the wadis provide a place to discard unsavoury rubbish, which is washed away during winter by rainstorms. They are also used as a toilet (also see Dickson 1959 [1949]: 81) and as a general dump for depositing foul garbage. Primary butchery usually takes place there: immediately below sites WF936–WF944 in the Wadi Shayqar, for example, there were goat lower limbs and discarded skins, as well as the remains of a decomposing donkey. By April or May, grazing resources are considerably depleted and many families move away. For those who stay, however, a shift is made to locations where advantage may be taken of any cooling breezes, and this is clear in the distribution of tents in the Wadi Shayqar.

Today, campsites are often close to tracks that are navigable by a vehicle. Most campsite moves, except perhaps the shortest when donkeys may be used, are performed with the aid of trucks, which have replaced camels (and mules) as the major form of transportation. Though not every household owns a truck, they are not only needed to shift camp, but also to bring in supplies, such as fodder, and to take people and their livestock to market, as well as for visiting relatives and allies. While hidden locations may have had a protective advantage in the past, camping near to main thoroughfares means that people are able to monitor the various comings and goings of Wadi Faynan life. Travelling tradesmen bring in goods along the tracks, people can follow the movements of neighbours, and there is always a great deal of interest in activities connected with the Faynan camp. With the development of the Dana Nature Reserve and recent archaeological interest, locals are quick to spot opportunities for casual employment,

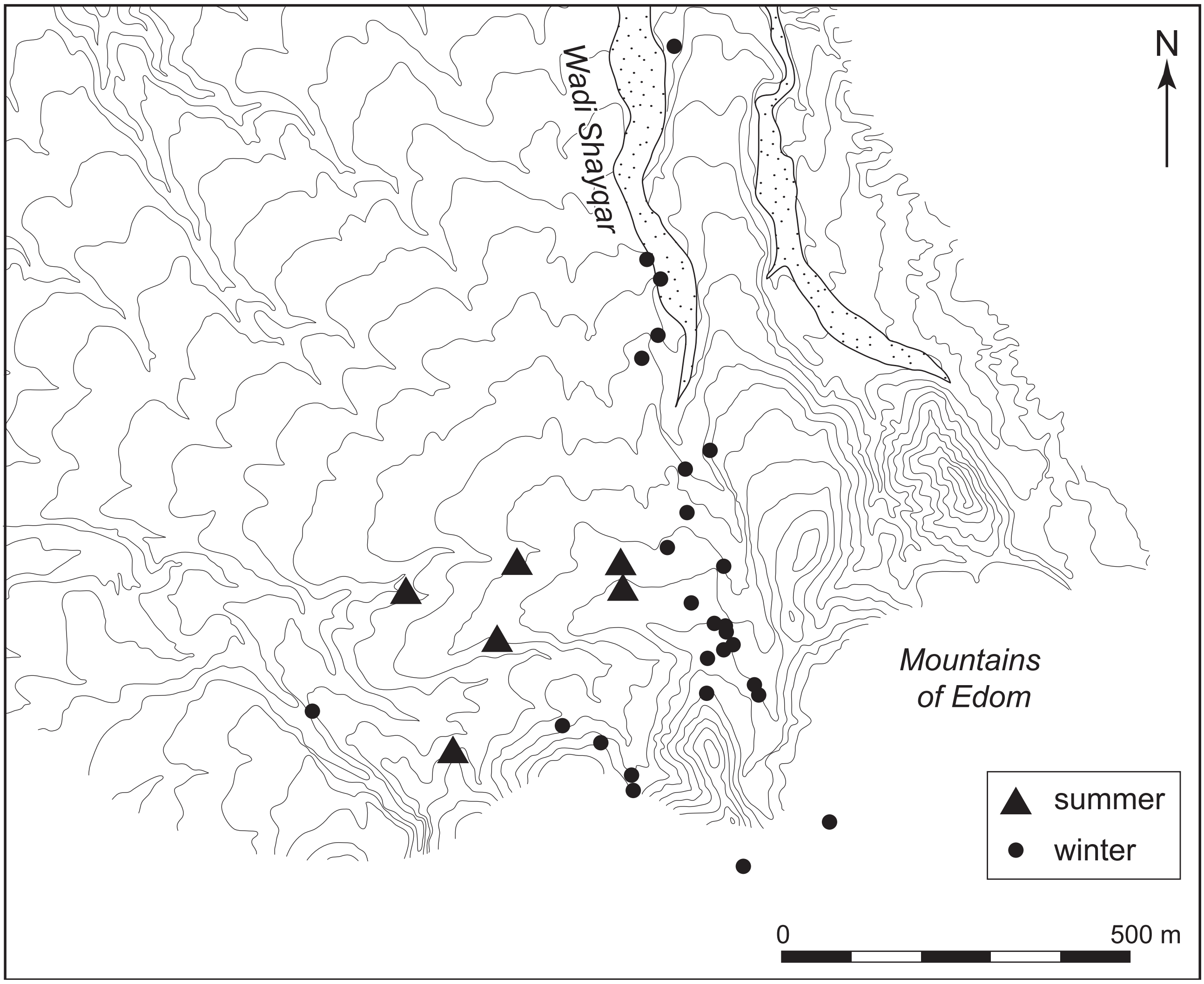


Figure 12.4 *The distribution of winter and summer campsites in the upper Wadi Shayqar. Winter campsites are situated along wadi terrace-surfaces and summer ones on the ridges above. The wider topographic and archaeological setting of this study area is shown in Figure 2.2. (Illustration: Patrick Daly and Dora Kemp.)*

which is highly valued. Even archaeological projects affect campsite location. At the time of the survey one member of the Rashaydah tribe was employed by the CBRL as a guard, and he located his camps where he felt he could perform his duties best. During the excavations in 1997 at WF100 (Wright *et al*. 1998), he and his family located his camp there (these are sites WF915–WF917).

Evidence of an abandoned campsite may attract local people to camp in the same spot again. The simple fact that the site was used before suggests a good location, and there is reduced work because the site will have been prepared to some degree. Good campsites may be visited repeatedly in the course of a lifetime.

12.5 Tent orientation

Where the line of the tent could be determined, 57 out of 73 (71 per cent) are pitched broadly towards the east (Fig. 12.5). Local people explained that tents are usually pitched with their face towards the rising sun, which brings both light and warmth into the tent in the morning, and the backs of the tents orientated against the prevailing wind that also brings rain in winter. This pattern of tent orientation has been observed for other parts of the region (Avni 1992; Dickson 1959 [1949]: 79; Jabbur 1995: 255; Layne 1994: 357).

It is likely that social factors are influential for those tents not facing broadly east. For occupied tents visited as part of the survey, the few that did face in a different direction were usually part of a family grouping. Here, tents are sited in a way that allows easy communication between people, with some consideration for privacy, not only among the family, but also between the family and potential visitors. In terms of a more 'functional' explanation for tent orientation, it may be that some wadi terrace-surfaces offer greater protection from the wind, which allows for variation in tent orientation.

There was no clear correlation between the siting of the men's section, used for entertaining guests, and tribal grouping. Some tribes in the region do have a preference for which end they use, for example Musil (1926) reports that the Rwala always place the men's section to the right, which Jabbur (1995: 254) considered true for Syrian bedouin generally, though perhaps not for the whole region. In the Wadi Faynan, however, the location of the men's section appears most influenced by accessibility from a track. This public section is usually the closest to the track, or easiest approach, so that, on approaching the tent, the guest does not pass the private family areas.

12.6 Tribal associations

The location of campsites and the tribal affiliation of the occupiers are shown in Figure 12.6. There are clear tribal groupings, with the numerical dominance of the 'Azazma evident (see also Table 12.1). There are two main clusters of 'Azazma occupation: in the lower Wadi Dana and in the Wadi Shayqar. The lower Wadi Dana has easy access to water and the facilities at the Faynan camp as well as, of course, the school. In the Wadi Dana and nearby Wadi Farra', the tents represent closely related groups; the senior male occupants of WF918, WF963, and WF967 are brothers. Their grown-up sons also camp nearby, and their tents include WF965 (eldest son of WF918), WF966, and WF968 (two tents for wives of WF967's eldest son). Because they own a large herd of goats, they move up to the Shawbak plateau during the winter months, though some of the group stay based in the Wadi Dana area, in part for the schooling of the children. The Wadi Shayqar is an excellent area in which to camp, possessing wonderful views over the surrounding landscape and immediate access to grazing in the mountains. A now well-established 'Azazma community lives here, some of whom camp there year-round, shifting tent sites regularly, while others move between this location and the mountainous area around Shawbak. 'Azazma camping in this area are not all close relatives.

Between the Faynan camp and the school there is a cluster of 'Ammarin tents, which represents a group of close-relatives. One influential brother from this group has been employed as an NRA guard at the Faynan camp for approximately 25 years. These campsites are re-occupied repeatedly, with some relatives only camping for the winter and others moving short distances between summer and winter tent sites. Another camp guard, from the Sa'idiyyin, camps year-round just east of the Faynan camp. The Rashaydah tribe camp away from all these groups, more centrally in the Wadi Faynan. A small Manaja' encampment (one family, but with two wives and, therefore, two tents) is also located further west. There were three tent sites in the west of the area, WF927, WF928, and WF929, which were not bedouin tents but accommodation for Egyptian workers involved with the recent Rashaydah irrigation project.

Table 12.1 shows tribal grouping compared with the tent type used, for sites where the type could be determined. There are some interesting patterns. The 'Azazma rarely use the Type B form, the year-round family tent, and most commonly use Type A, the winter family tent with livestock

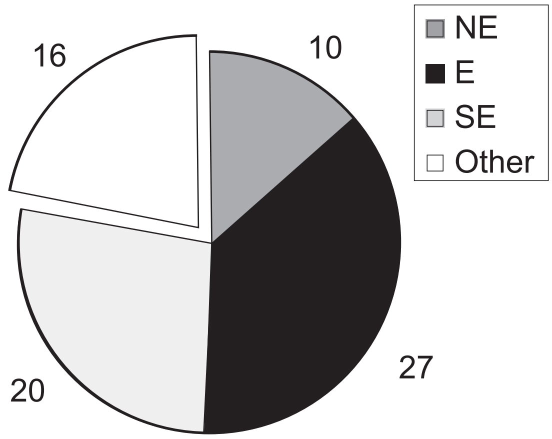


Figure 12.5 *Orientation of tents in the Bedouin Camp Survey.*

and Type C, the supplementary family tent, which often has a compartment for accommodating livestock. The 'Azazma also use the Type D form more regularly, either in winter for sheltering livestock or as a summer tent without internal hearths. Overall, these patterns reflect the importance of livestock to this group as they tend to have the largest herds. They arguably also reflect the generally lower status of this group within southern Jordanian society because many of their sites do not possess a men's section for receiving guests, though this is also indicative of tight family groupings or associations that exist within this community where they would share a men's section for receiving guests.

The Rashaydah never keep animals within the tent and do not use the Type A form. In the Wadi Faynan, this group generally has small numbers of livestock, deriving their main sources of income from employment or pensions. Moreover, members of the group consider keeping animals within their tents as unhygienic. The 'Ammarin use the first three tent types only. They tend both to have employment and keep livestock and, in summer when livestock do not require overnight sheltering, they use the Type B form and stress the importance of having a men's area at all times where guests can be received formally. All the tents identified as belonging to the Sa'idiyyin group had a men's section and they used both Type A and B forms. The tent belonging to the Sa'idiyyin Faynan camp guard is of Type B and is occupied continually. The Manaja' only had one encampment in which lived a man with two wives as

	Tent type				
Tribal grouping	**A**	**B**	**C**	**D**	**Total number of tent sites**
'Azazma	11	1	27	7	**46**
Rashaydah		9			**9**
'Ammarin	2	5	1		**8**
Sa'idiyyin	2	4			**6**
Manaja		1	1		2
Total	**15**	**20**	**29**	**7**	**71**

Table 12.1 *Tribal grouping compared with the tent type used in the Wadi Faynan.*

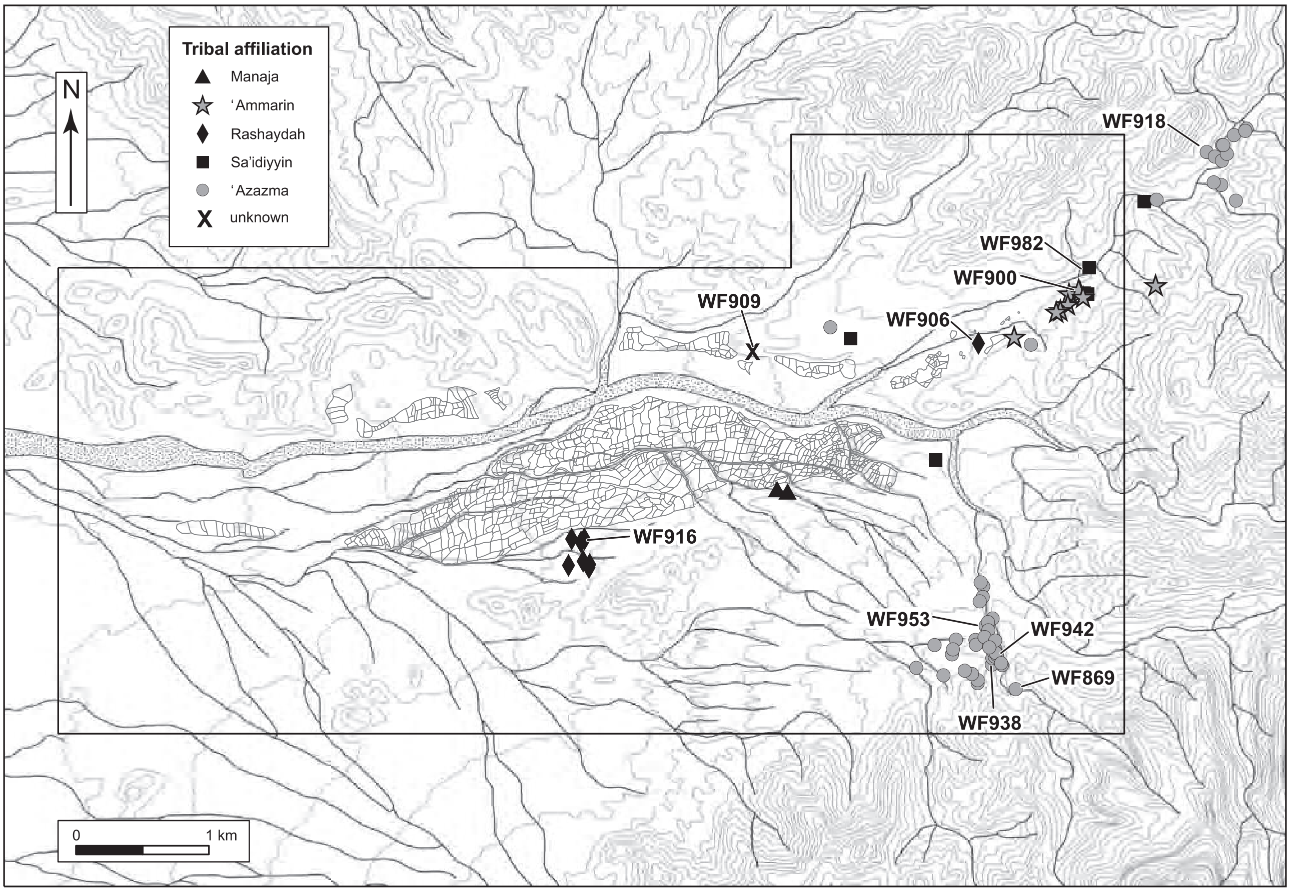


Figure 12.6 *Location of campsites in the Bedouin Camp Survey coded according to the tribal affiliation of the occupiers. (Illustration: Paul Newson.)*

noted above. One tent had a men's section and the second, where the second wife lived, did not.

12.7 Durable campsite architecture

Old abandoned campsites are fondly referred to in Arabic poetry and were also evident to early European travellers (Banning and Köhler-Rollefson 1992: 181–2; Musil 1928). Recently abandoned camps are easily identified by spreads of dung and other debris such as empty sacks, cans, and plastic shoes, but there are also stone architectural and other features, which have the potential to survive in the landscape. Importantly, many features indicate seasonal use, and some appear to be used by some tribes and not by others.

12.7.1 Hearths

Hearths are foci of social life (cf. Fewster 1999: 185). Within a tent, hearths denote different activity areas and their positioning has already been used to differentiate between different tent types. Hearths found in different sections differ in their construction. The 'hospitality hearth' found in the men's section, the *shigg*, has the potential to be the largest and most elaborate. It may be rectangular or circular, but rectangular hearths are usually the most grand, lined with stone and sometimes with an adjacent raised platform made from stone or sediment at one end (Fig. 12.7). These rectangular stone-lined hearths are strongly associated with coffee preparation, which is an important component of local hospitality (Layne 1987: 358; Palmer 2002: 190; Weir 1990 [1976]: 21–2). Households constructing these stone-lined rectangular hearths are likely to receive a larger number of guests and, in the Wadi Faynan, it is the tribes which claim social dominance and a long history of association with the area, particularly the Rashaydah and the 'Ammarin, that use this arrangement. Jabbur (1995: 255) notes about Syrian bedouin that from the fireplace in the men's section, 'one stopping later at the traces of the tents will judge the generosity of the shaykh and his standing among the shaykhs of the tribes: the broader and larger the heap of ashes is, the more generosity and expense it indicates'. There has been a change in construction of the men's hearth recently as movable rectangular iron braziers sunk into the ground may be used. They are impressive when installed and usually possessed by households of relatively high social standing, but they leave fewer traces once the encampment has moved.

Hearths in the men's section can also be relatively modest, simple circular hospitality hearths that are not stone-lined. All the 'Azazma hospitality hearths observed were of this form. Circular hearths are also found in single hearth tents (Type C) where there is no *shigg* and only the

Figure 12.7 Rectangular, stone-lined 'hospitality hearth' associated with WF916. Note the fine wadi gravel spread on the floor in the 'men's section' of this former tent site. Scale: 1 m. (Photograph: Carol Palmer.)

family sits around and uses the hearth. The use of relatively simple hospitality hearths by the 'Azazma might indicate a different tradition, but it is likely that it is also indicative of their generally lower social standing.

Hearths used primarily for cooking in the women's section, the *mahram*, are circular and traditionally distinguished by the use of three fire-blackened stones, called *ladaiya* or *hafayiz* in the local dialects (cf. Banning and Köhler-Rollefson 1986: 162; Layne 1994: 88) which are used for propping up a pan, a *saj* (bread-baking tin), or a teapot. Today, iron tripod stands can be used instead of stones, especially for use with teapots and smaller pans, but the *saj* used for cooking bread is almost always still set on stones (see Fig. 2.22).

In summer in the Wadi Faynan, exterior hearths are often used for the routine preparation of food and drink, when tent occupants usually wish to keep shaded areas as cool as possible. In winter or in summer, large outside hearths are used to prepare *mansaf* (Palmer 2002: 189–90; Fig. 2.21), the local feast dish, where large pans of meat and yoghurt, propped up on three fire-blackened stones, are boiled together. Some households also process milk outside the tent because of the strong smells; an outside hearth may accompany this activity.

Hearths are distinctive features which appear to have some durability in the landscape, particularly when they are stone-lined. Where not stone-lined, the edge of a hearth may be consolidated using water, although a hardened surface edge develops with occupation and associated cleaning and cooking activities.

12.7.2 Interior surfaces or 'floors'

The tent platform, or surface covered by the tent, is normally cleared of stones, though tent sites occupied for a short time (for example, wedding party tents) and summer tents usually have little prior preparation. As well as clearing away rock-strewn surfaces, the living surfaces may be levelled where necessary and to varying degrees. In the main, however, 'floors' take shape through use and repeated cleaning activities during occupation. The most common method used to clean the interior of tents and reduce dust is to sprinkle areas with water and sweep with brushwood. The repeated action of wetting and sweeping causes a thin hard crust to form. This is most strongly developed in kitchen areas, where food preparation and washing activities take place. Rubbish from sweeping is swept beyond the immediate tent area (cf. Simms 1988) or into hearths. It has already been noted that a thick crust may form on the edge of a hearth as the result of accumulated cooking and cleaning activities. In the men's section, particularly around elaborate hearths such as those used by the Rashaydah and some of the 'Ammarin, the floor was not swept regularly and, instead, fine wadi gravel was spread to reduce dust and keep the floor appearing tidy.

12.7.3 Platforms

Stone platforms, creating a raised surface, are constructed for a range of purposes. They are used as places to store bedding and other household effects, to sleep on, for milk-processing, and, in the past, for laying out skin water bags to keep them cool. These stone platforms, on a long abandoned site, can be superficially similar to ancient features, such as Bronze Age burial tombs.

Sleeping platforms, *mnam*, are stone-rimmed features, infilled with sediment and, when in use, topped with soft vegetation such as *ratam*, *Retama raetam*, or fragrant *shih*, *Artemisia herba-alba* (syn. *A. sieberi*), before placing the bedding on top. Sleeping platforms in the Wadi Faynan are usually fairly low features, usually just a single, roughly rectangular, outline of stones, but in the highlands, they may be several courses high – up to *c*.0.75 m (Fig. 12.8). Once out-of-use, the sedimentary infilling of these features appears to erode away quickly, but the stones remain and two of the older sites recorded in the Bedouin Camp Survey, WF975 and WF976, were identified on the presence of sleeping platforms alone. Some sleeping platforms had a double (or more) row of outlining stones on one end, explained by local people as either for storing folded bedding during the daytime or as a 'pillow', a raised area for the head.

Stone platforms for storing bedding and other household effects including food stores are made from more-or-less even-sized slabs or consist of an outline of larger stones with smaller ones in the centre. Platforms may be circular, oblong, or rectangular, and vary in size. Those platforms that are used in milk-processing, so-called *laban* platforms, are important because they indicate that a camp was occupied during the milking period, sometime between March and May depending upon the availability of good grazing. These platforms are used to rest and store skin bags that are filled with fermenting milk or *laban* (see

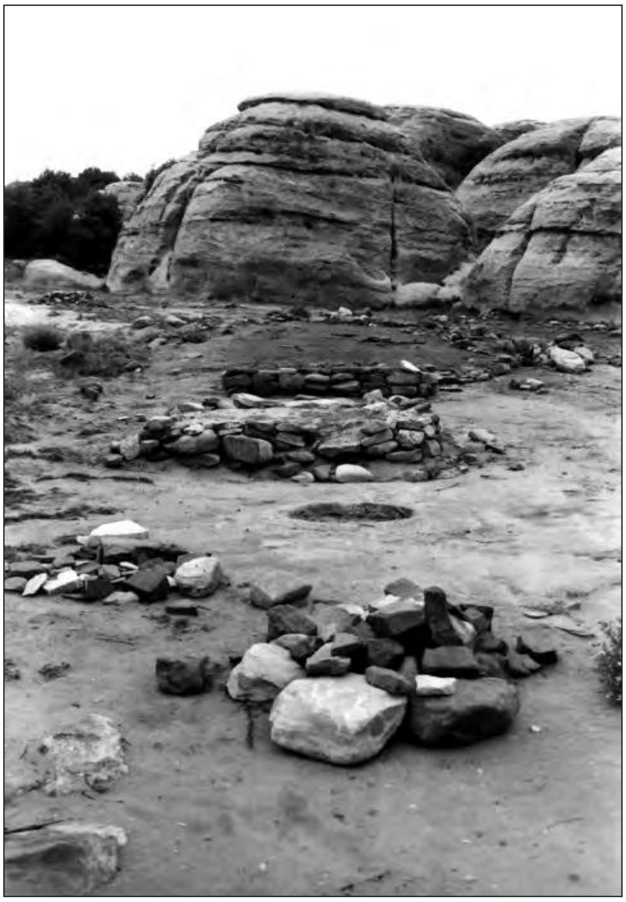


Figure 12.8 *Pastoral campsite with two sleeping platforms (centre) in the al-Barra area of the Dana Nature Reserve. This campsite is annually occupied in winter by villagers from Dana. Note the hearth to the front and the spread of animal dung to the rear. (Photograph: Carol Palmer.)*

Figure 12.9 *Stone* laban *platform from a recently abandoned site, WF906. Note the rotary quern on the left, traditionally a common component of bedouin material culture. (Photograph: Carol Palmer.)*

Palmer 2002: 184, fig. 10). In the past, as with sleeping platforms, soft vegetation could be placed between the stones and the skin bags, but now nylon sacking is commonly used. The size of a *laban* platform varies according to the number of skin bags in use. The smallest observed was circular and *c.*0.5 m in diameter (Fig. 12.9) for a single skin bag, but larger platforms tend to be rectangular. *Laban* platforms are quite specific seasonal indicators, but platforms are constructed for a number of uses so not all platforms indicate milk-processing. The location of the platform may help interpretation: *laban* platforms are usually situated in the kitchen area of a tent, just under the tent eaves of the short side, where the skin bags can be kept in the shade and relatively cool. Platforms for storing bedding are situated behind the dividing screen between men's and women's sections. Today, however, some households conduct milk-processing outside in separate shaded area due to the strong smell and flies it attracts. Stone platforms are now constructed less often than in the past because people have cheap plastic matting as well as plastic bags and nylon sacking upon which they can place household items and bedding. Water is now stored in metal and plastic containers, instead of skins, so platforms for keeping water skins cool are no longer required.

12.7.4 Tent outlines in stone

Large stones are used to secure tent eaves to the ground, and around a recently abandoned winter campsite they are usually clearly visible. These stones are concentrated to the rear of a tent (the direction from which the wind normally comes), with a few towards the front used to keep the front flap secured down at night and during bad weather. Summer tents usually have many fewer, if any, stones delineating the former borders of the tent. During tent dismantlement, the stones often become scattered. As well as lines of stones around the exterior of a tent, there can also be lines of stones used to hold down dividers between different sections of the tent, usually particularly clear between animal and human living sections. Over time, both interior and exterior lines of stones appear to become less distinct, being picked up and used by other households or, potentially, moved during rainstorms.

12.7.5 Rope stones

Rope stones or cairns, unlike stones used to secure tent edges, appear to have greater durability in the landscape. In the rocky landscape of the Wadi Faynan, instead of using pegs, some families tie tent guy ropes to strong sticks and weight these down under heavy boulders (Fig. 12.1). It is noticeable that goats like to sit by these and also walk restlessly up and down, scratching their backs against the guys, forming short tracks along the ground.

12.7.6 Gullies

Gullies are excavated along the perimeter of winter tents to direct water drips from the roof and run-off from sloping land away from the interior of the tent. Gullies are usually dug along one long and one short side of the tent. They are normally cut across the face of the tent to catch the

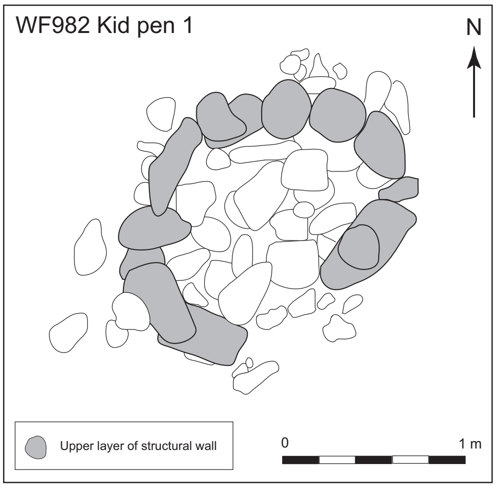


Figure 12.10 Kid pen associated with WF982. (Illustration: Lucy Farr and Helen Smith.)

Figure 12.11 Open-air mosque associated with WF916. In this case, stones have been cleared to form the mosque. The mihrab*, in the direction of Mecca, is clearly visible, looking southwest. (Photograph: Carol Palmer.)*

drips from the roof, but may be situated along the rear if the back of the tent is at the bottom of a slope. As well as large gullies associated with rainfall, small interior gullies may be evident in kitchen areas, which form through routine cooking and cleaning activities. Gullies are clearly evident immediately after abandonment (Figs 12.13, 12.14), but appear to infill rapidly with sediment over a short period of time.

12.7.7 Ash dumps

The ash from hearths is cleaned out regularly, most often daily, and placed on an ash dump, which is normally situated to the rear or side of the tent, usually down a convenient slope.

12.7.8 Kid pens

Very young kids, a week to one month old, are sheltered and protected at night in kid pens: small, *c.*1–1.5 m stone circular structures (Fig. 12.10). In use, they have a roof made from branches or other materials (sacks, plastic or fabric) that is weighted down at night with stones. Inside is a layer of soft bedding, usually fallen dried *ratam* twigs collected from the base of bushes, with ash underneath to soak up urine. Ten to fifteen small kids may be kept in these structures at night. Kid pens are often built into cliffs, where there is greater shelter, but are also commonly free-standing structures. Kid pens indicate winter conditions from the time when the first kids are born and the weather conditions still bad. They are, therefore, specific seasonal indicators.

12.7.9 Wild animal 'alarms'

Locals talk energetically of wild animals, *wuhush*, that come at night to steal livestock. In order to scare them away, *rayab*, or 'alarms' are set-up around the edge of the campsite. The simplest alarm is a stick, propped upright in a pile of stones, with flapping material at the top. Sometimes a loose fence-like construction running around the camp boundary is made with a series of low sticks connected at the top by rope (or plastic piping). Material is tied along the rope to flap in the wind and deter wild animals. Where cairns are constructed to support these features, they are evident after the abandonment of a campsite.

12.7.10 Chicken coops

Many bedouin households keep chickens that are sheltered at night in improvised coops made from stone, metal, and plastic. Chickens are a relatively recent addition to bedouin life and Simms and Russell (1996) note that chicken keeping by B'dul bedouin of the Petra area only occurred within the last 50 years, chickens being previously viewed as part of a settled life. Banning and Köhler-Rollefson (1992: 200) also note that chickens are a 'recent addition to the 'Ammarin menagerie'.

12.7.11 Mosques

Outdoor mosques were noted at three sites: WF900, WF916, and WF930. Open mosques are simple features: a rectangle arrangement of small single stones, set in an area otherwise cleared from stones and other debris, with a niche, *mihrab*, along the long southern end facing in the direction of Mecca (Fig. 12.11). They are most often constructed during Ramadan.

12.7.12 Ovens

A recent innovation in the Wadi Faynan is the construction of fixed ovens, *tawabin* (plural). A *tabun* (singular) (Palmer 2002, fig. 5) is a domed clay installation where bread is baked on the oven base, usually consisting of wadi pebbles in southern Jordan (McQuitty 1993–94). The main source of fuel used is dung, and the oven is kept warm throughout the day under a smouldering heap of dung ash. Two sites had associated *tawabin*, WF901 and WF903, and there was also a ruinous *tabun*-like feature found within 100 m of WF952, though not recorded as part of the site. Local people said they had tried to construct a *tabun*, but it had not been entirely successful. Bedouin normally cook bread using a *saj*, not a *tabun,* and their presence in the Wadi Faynan suggests increasing sedentarization – camping longer in one place – and the declining availability of firewood. Two families (WF900 and WF901) also constructed small oven-like installations made from metal and stones (or concrete bricks) for roasting or grilling meat. A traditional way to prepare meat is in a roasting pit, called a *zarb*, and some families said they had recently used an old oil drum for the same purpose.

12.7.13 Storage structures

Household items and food and fodder are stored outside the tent as well as inside it. Natural features around the campsite are used to cache objects; items are hung-up in bags in trees and pushed inside crevices in cliffs that are then blocked in with stones. At the top of the Wadi Shayqar, roofed, single-room stone structures (Fig. 12.12) were constructed from stone blocks from an ancient site there, principally to store fodder, barley, and bran, when subsidized fodder became an important part of the local goat-rearing economy. Today, large sheets of iron mesh are used to construct various moveable features, including stores of household goods, food and fodder, goat and kid pens, and 'supplementary rooms'.

12.7.14 Supplementary 'rooms'

A relatively recent innovation is the erection of temporary structures made from plastic piping (the materials derive from the recent irrigation project), iron grilles, and plastic sheeting. These are mostly supplementary sleeping quarters (e.g. WF925) and store rooms. After abandonment, they are visible by shallow post-holes and gullies around their perimeter.

Figure 12.12 *Storage structure built from archaeological remains, near WF938, Wadi Shayqar. (Photograph: Carol Palmer.)*

12.8 Contrasts in campsite organization and architecture

Two campsites are described here in greater detail to illustrate some of the differences between tribal groupings and to highlight recent changes in material culture that are affecting campsite organization, especially where campsites are becoming occupied repeatedly and for longer periods.

12.8.1 WF953

WF953 is located in one of a number of favourite winter camping spots used by the 'Azazma in the Wadi Shayqar. Jouma' 'Aly, our principal informant, occupied this site with his wife, eight children and elderly paternal grandfather during late winter and early spring 1999 (Fig. 12.13). At the time the site was occupied they were managing approximately 150 goats, although herding is not their only source of income. The entire camp consisted of two tents: WF953, used for human and animal occupation, and WF954, which was used to shelter goats. WF954 had been used the previous year as the living quarters for the family and another tent site, WF955, approximately 5 m to the south, was used as the 'goat tent'. This emphasizes the way that tent sites are re-used, in part because limited site preparation is required. WF953, WF954, and WF955 are positioned on a narrow terrace and, when occupied, the 'faces' of the tents were towards the east and a rocky slope. To the west, just 4–5 m from the back of the tents, the slope descends steeply down to the wadi floor.

WF953 conforms to the Type A form of tent organization, a winter tent with livestock (Fig. 12.14). Once the tent was dismantled, the site was easily distinguishable by a thick dung spread where the animals had been housed at night. The human living areas were to the north, and this area was relatively smooth and stone-free. Different parts of this area had been swept to different intensities, with most activity in the vicinity of the hearths. There are three hearths associated with the 1999 encampment, two interior and one external. The northernmost hearth, at the centre of the former *shigg*, was a circular excavated hearth, not lined with stones. The family had provision to receive guests, but did not expect to receive important guests on a regular basis, so the *shigg* was relatively modest in design and coffee was not normally prepared there. The *shigg* hearth was mainly used to prepare tea for guests and was also used occasionally for family cooking when a triangular metal stand propped up the tea or cooking pots. The second interior hearth, in the *mahram*, was situated directly against the screen with the animal section somewhat off-set to the eastern side of the tent, which is the usual positioning for this hearth in this tent form. This hearth is where bread had been routinely cooked, and it had three stones around its perimeter. The final hearth is situated externally, to the east of the dung-covered area and is large with three fire-blackened stones around it. The family said that this hearth had been used to cook a *mansaf*, the traditional celebratory and feast dish (Fig. 2.21), when the brother, who normally lives some distance away, had visited.

Figure 12.13 *Recently dismantled winter tent site WF953, looking south. Scale: 1 m. (Photograph: Carol Palmer.)*

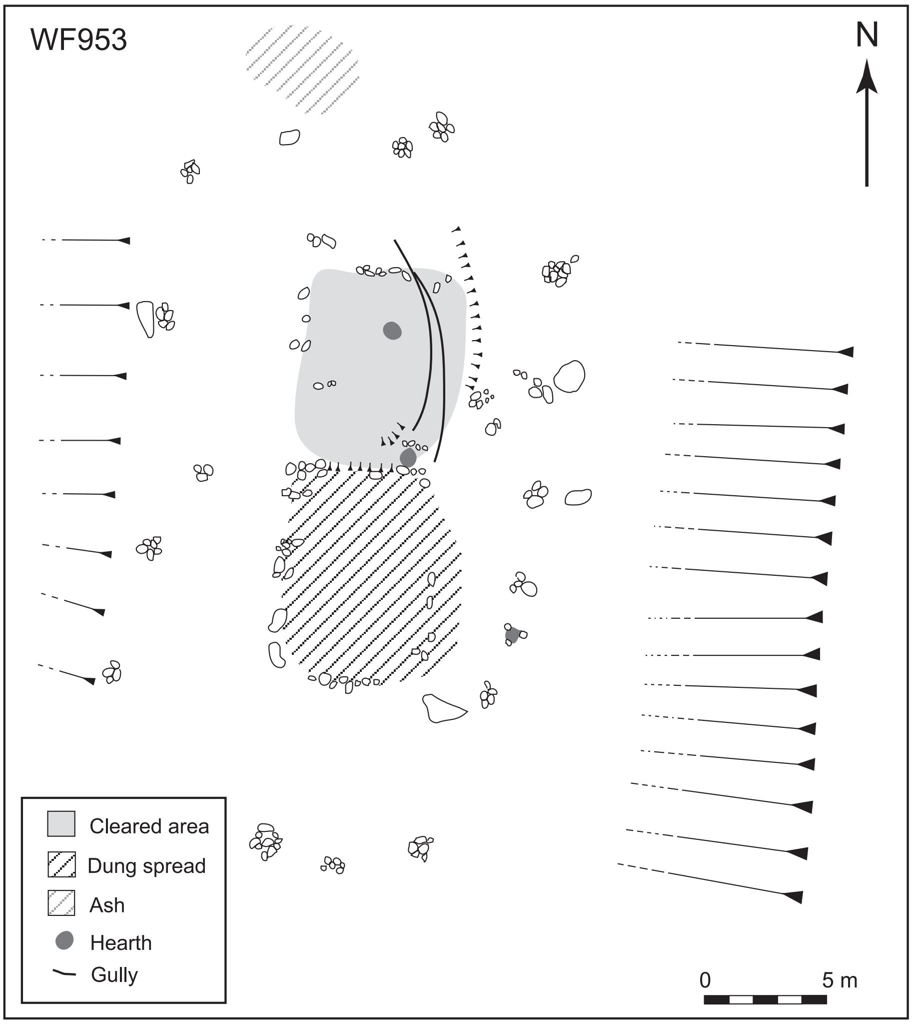


Figure 12.14 *Site plan of WF953. (Illustration: Lucy Farr and Helen Smith.)*

There are fifteen small cairns surrounding the tent, *c*.4–7 m away from the former tent perimeter (excluding the small pile of stones immediately to the south of the depression). These cairns are *rujid*, or stones securing the guy ropes of the tent. As this tent was a three-pole tent, it had sixteen guy ropes, the final *rujid* being the single rock indicated to the northwest of the tent area. The ash dump is to the northwest.

Supplementary features associated with WF953 include a chicken hut and a wild animal ‘alarm’, sticks supported by cairns that had flapping material at the upper end. There was also a small cleared area on the upper slope where the dogs were kept tied. WF953 does not possess a kid pen, although the site was occupied during the time of year when they are born. This was because the family was able to keep them within the animal section of their tent, separated from their mothers by an internal structure made from iron grilles.

12.8.2 WF900

The second case study and associated features, WF900, is also a winter camp, but it takes the Type B form (Fig. 12.15). This case study was chosen in part because of the extensive demarcation of different activity areas and common use of modern material culture. WF900 is associated with a number of other tent sites around the Wadi Faynan camp, beside the main track leading to the camp. This area is occupied by closely related members of the ‘Ammarin tribe. WF900 and associated sites have been re-occupied each winter for a number of years, each year developing new features with subsequent re-occupations. The group that camp here, unlike the Wadi Shayqar group, have the benefit of the piped water supply that runs from the lower Wadi Dana to the school.

The owner of WF900 is a mature divorced woman with married children who have households elsewhere. Her brother has been an NRA guard at the Faynan camp for 25 years. She is often visited by family members, both those living nearby and further afield. The location of her tent, situated as it is among tents belonging to close relatives, is important. She does not camp independently – when she moves away she always camps or lives with close family members. She has respect as an individual and possesses many skills: she is an accomplished weaver and is noted for her organization and neatness. During the 1998/1999 winter she cared for a group of ten goats, penned separately, in a small corral well away from main living areas.

The whole area of the camp, up to the steep wadi edge, is cleared of stones, unlike WF953, where stones were cleared only from the immediate tent area. Using small

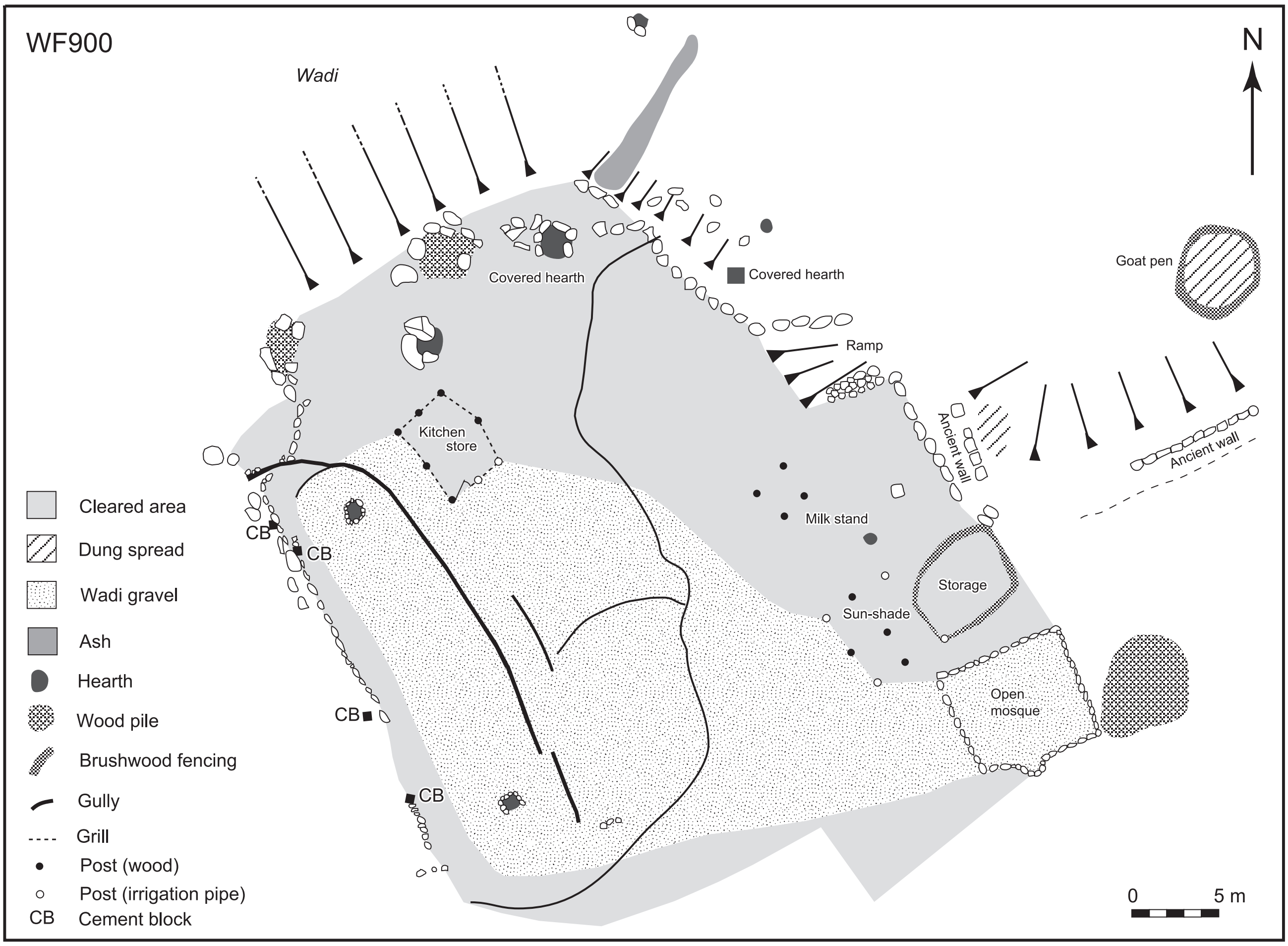


Figure 12.15 Site plan of WF900. (Illustration: Lucy Farr and Helen Smith.)

evenly-sized pebbles she has created a boundary around the camp and, in parts, the boundary takes advantage of a pre-existing ancient wall. There is a shallow gully and associated tributary stretching across the cleared area from the southwest corner to the northeast. Across a large area of the camp, wadi gravel is spread and is particularly thick in the area where the tent itself was pitched, where it was used to help keep the dust down. This camp was recently vacated and the *Eid al-Adha* had just occurred (28 March 1999), and it is likely that the gravel was renewed for that special occasion, especially as the gravel extends to the open mosque, distinguishable by its niche, *mihrab*, and situated in the extreme southeastern corner of the cleared area (Fig. 12.16).

The tent used on this site is a long 'four-pole' tent. *Rujid*, stone clusters as used at WF953 to secure guy ropes, are not in evidence. Instead, metal rods were used in addition to four cement building blocks, which are located to the west of the tent and around which the guy ropes were previously secured. The tent was pitched along a north–south axis, as at WF953, with the 'face' of the tent towards the east where there is a clear gully. There was also a line of stones still clearly visible holding down the back wall of the tent. The guest area, the *shigg*, was to the south and the 'kitchen' to the north. Although the owner is female, as an established individual she maintains a separate section for receiving guests. Indeed, the south end has a square hearth, stone-lined on three sides, like those associated with 'men's sections' and the preparation of coffee. The whole of the kitchen area was covered with gravel when it was studied, the only site observed with gravel in the kitchen area. Interestingly, the kitchen hearth is stone-lined in a similar way to the men's hearth and does not have the usual three fire-blackened stones. The owner also did a lot of cooking outside the tent: there are four external hearths, three to the north, including two covered hearths, and a small hearth next to the milk stand. In addition, she also had a gas stove. The central area in the middle of the tent was used as a secluded area for sitting and sleeping.

The camp has several supplementary structures, which were still standing at the time of the survey. These include a kitchen store, a sun-shade and attached store, a milk stand, and an open mosque, already mentioned, as well as a number of smaller features. The kitchen store is situated immediately to the east of the 'kitchen' and constructed from eight main upright poles with iron grilles for 'walls'. There is a door, made from wooden boards, in the south-west corner. Six of the posts are wooden, while two make use of lengths of thick black irrigation pipe. The whole structure is roofed using horizontal wooden supports and reed canes from either *Arundo donax*, giant reed, or *Phragmites australis*, common reed, both available from the Wadi Ghuwayr and Hamman Adethni. Throughout the structure posts, metal grilles, uprights, and roofing material are secured in place using thin irrigation pipe for rope. While it was surveyed, the kitchen store contained a bench, a large pan, and a rotary quern. It was safe to store this material in open view while the occupant was away because relatives were still living nearby. While the tent was occupied the gas stove was also here, but this had been removed.

The sun-shade and attached store were positioned approximately 20 m east of the southern end of the tent. The sun-shade is constructed from four corner uprights made from thick black irrigation pipe, three thinner wooden uprights between the corner posts on the northern, western, and southern sides, and a central post. The two western-facing corner posts are embellished with upright giant reeds, complete with their fruiting heads (Fig. 12.16). Black irrigation pipe and pieces of nylon sacking were

Figure 12.16 *Sun-shade and store at WF900, embellished with giant reeds. Some of the stones outlining the open mosque are visible to the right, looking southeast. Scale: 1 m. (Photograph: Carol Palmer.)*

stretched across the structure, forming a retaining barrier to prevent animals straying inside. Attached to the sun-shade was a small brushwood enclosure, which also includes a flattened oil drum and thin irrigation pipe in its construction. Inside were miscellaneous stored items covered with black plastic sheeting.

There was a milk stand positioned 6 m northwest of the sun-shade and store. Milk stands represent an innovation used by other members of the ‘Ammarin for milk-processing. It was constructed from four upright wooden posts with a roof and shelf below. There is a hearth nearby. Milk-processing is a pungent process and the separation of this activity away from the tent is an example of specialization of activity areas. While it was surveyed, however, the milk stand was being used as a store for weaving materials. In addition to items stored within the remaining standing structure at the site, there were also three piles of firewood associated with it, one next to the open mosque and two piled up on large rocks along the northern boundary of the camp.

Other features associated with the campsite are supplementary hearths, both within the cleared area and beyond, mentioned previously. One covered hearth is inside the cleared area and the other outside, used to roast meat. An old square metal container, to the south of the track, was used as a chicken coop.

12.8.3 Social differences and changing trends in camp architecture

The two campsites illustrate the different status of the inhabitants and their occupations. Although a woman, the owner of WF900 has a larger tent and more impressive hearth in the so-called *shigg*. WF900 has been occupied repeatedly for several winters and the site has several supplementary features. Supplementary features tend to correspond with more prosperous groups and those who are becoming more settled. Overall, WF900 shows greater specialization in the use of space, with the demarcation of additional rooms and more care marking off different activity areas. This is similar to trends observed when bedouin move to permanent housing (Bienkowski and Chlebik 1991: 168–77; Layne 1994: 89), where the use of space tends to be more specialized and also includes sexually segregated areas.

The extent of site preparation – levelling and clearing – was more extensive at WF900 than WF953, where only the human living quarters within the tent were cleared. With length of occupation, the extent of sweeping and clearing rubbish away from the immediate tent area appears to expand. The tent at WF953 could not be lived in for a long period of time because livestock was accommodated within it, whereas goats are accommodated separately at WF900.

At WF900 modern material culture is used extensively to construct supplementary structures and features. These new materials are either purchased from outside or derive from the recent irrigation project in the Wadi Faynan and building at the Faynan camp. The recent introduction of iron grilles has provided a way to create flexible temporary structures, which can be used equally well for stalling animals (keeping goats in), creating stores (keeping goats out), isolating special areas for certain activities such as milk-processing, and to make extra rooms. Other new building materials include large stout irrigation piping that can be used as poles, smaller black plastic irrigation piping that is used like rope, metal rods, concrete and building blocks. This modern material culture reduces the need for stone features.

At WF953 metal grilles were used to secure young animals at night, rather than building a stone kid pen. Among more wealthy households, movable metal tent pegs or rods – invisible once removed – are often used to secure guy ropes instead of rocks. Interestingly, earlier in the twentieth century Jabbur (1995: 243) associated the use of rope stones with poverty, and the use of modern material culture today usually indicates greater wealth and integration with the broader Jordanian economy. Plastic or sacking can be laid on the ground to protect household stores and bedding so people do not need to build stone platforms for this purpose. Water is now carried and stored in plastic or metal containers, which are not stored on platforms as the skin bags used to be. At WF900, a four-posted wooden structure was used for milk-processing instead of a stone platform. It was noted previously that the use of rectangular metal hearth-linings in the *shigg* are also similarly decreasing site visibility. Triangular metal tripods can replace the three fire-blackened stones that surround a kitchen hearth. Gas hobs for cooking are being adopted among wealthier households; although expensive, they do not require firewood, which is in very restricted supply. Traditional bedouin bread cannot be prepared on these, however, and the owner of WF900 continued to prepare her bread on her kitchen hearth. In short, the increasing availability of iron, plastic, and sacking items has changed architectural forms, reducing the necessity for stone structures, features which tend to have the longest visibility in the landscape.

12.9 Artefacts and activities around tent sites

In 2000, four abandoned campsites were studied in greater detail to examine discard practices, differences between material culture discard based upon seasonality, as well as how post-discard processes modify the material culture assemblages over time (Palmer and Daly 2006). The sites were chosen because they had been left abandoned for variable periods of time: WF942 was abandoned just a few weeks previously, WF869 three to four years ago, WF982 approximately fifteen years ago, and WF909 was occupied beyond living memory.

12.9.1 WF942

WF942 (Fig. 12.17) is a tent site belonging to the ‘Azazma group who camp in and around the Wadi Shayqar. WF942 is one of a group of winter tent sites, WF936–WF944, located on a narrow wadi terrace-surface. Although there

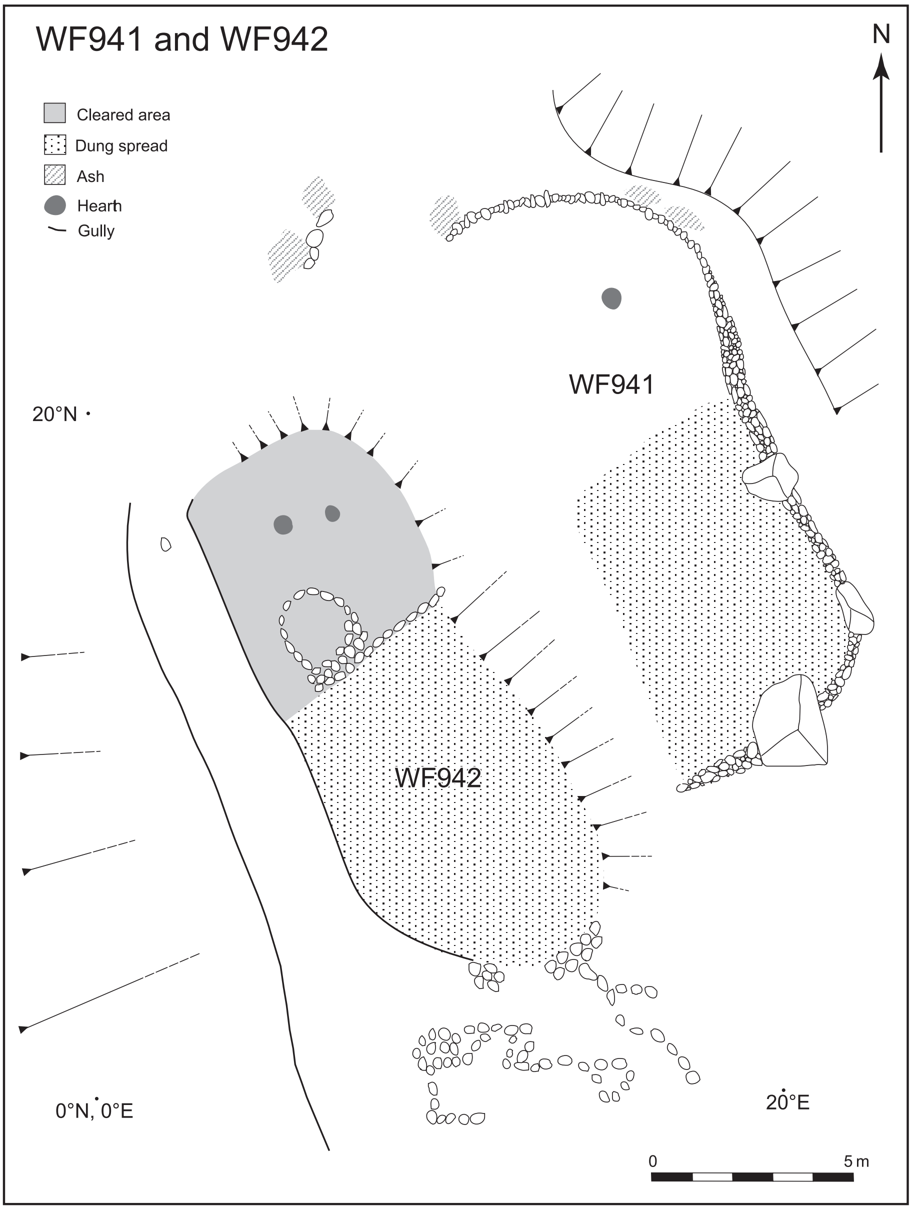


Figure 12.17 *Site plan of WF941 and WF942. Note the use of walling (and also clearance). WF942 is to the west, with a sleeping platform and line of stones between the human and animal living areas, and WF941 to the east. (Illustration: Lucy Farr and Helen Smith.)*

are several tent sites, in recent years just two family units have lived here (a father and married son), and the sites represent repeated winter re-occupations. WF942 was occupied for approximately one month and abandoned just a few weeks before the survey. To the west and north of WF942, there is a slope rising up towards a ridge where more campsites are located; to the east there is another tent platform, WF941, and a rubble wall (built from stone cleared from the camping areas), before an immediate drop to the wadi bottom below. When erected, the tent faced east, towards the wadi, with the back against the slope, where drainage gullies are situated. Both livestock and people lived together in WF942, and the southern half of the tent platform was covered in a thick layer of dung. The tent platform itself was well prepared, cleared of stones, and evenly levelled. In the family's living quarters, two hearths are visible, but they were said not to be contemporary; only one was in use during its most recent occupation. Both hearths are simple circular excavated features. This tent represents a Type C form where there is no division between men's and women's (public and family) areas. The ring of stones in the bottom left-hand corner of the family's living quarters represents a sleeping platform and the line of stones close to it divides human from animal living quarters. Another tent platform, WF940, is immediately to the south of WF942.

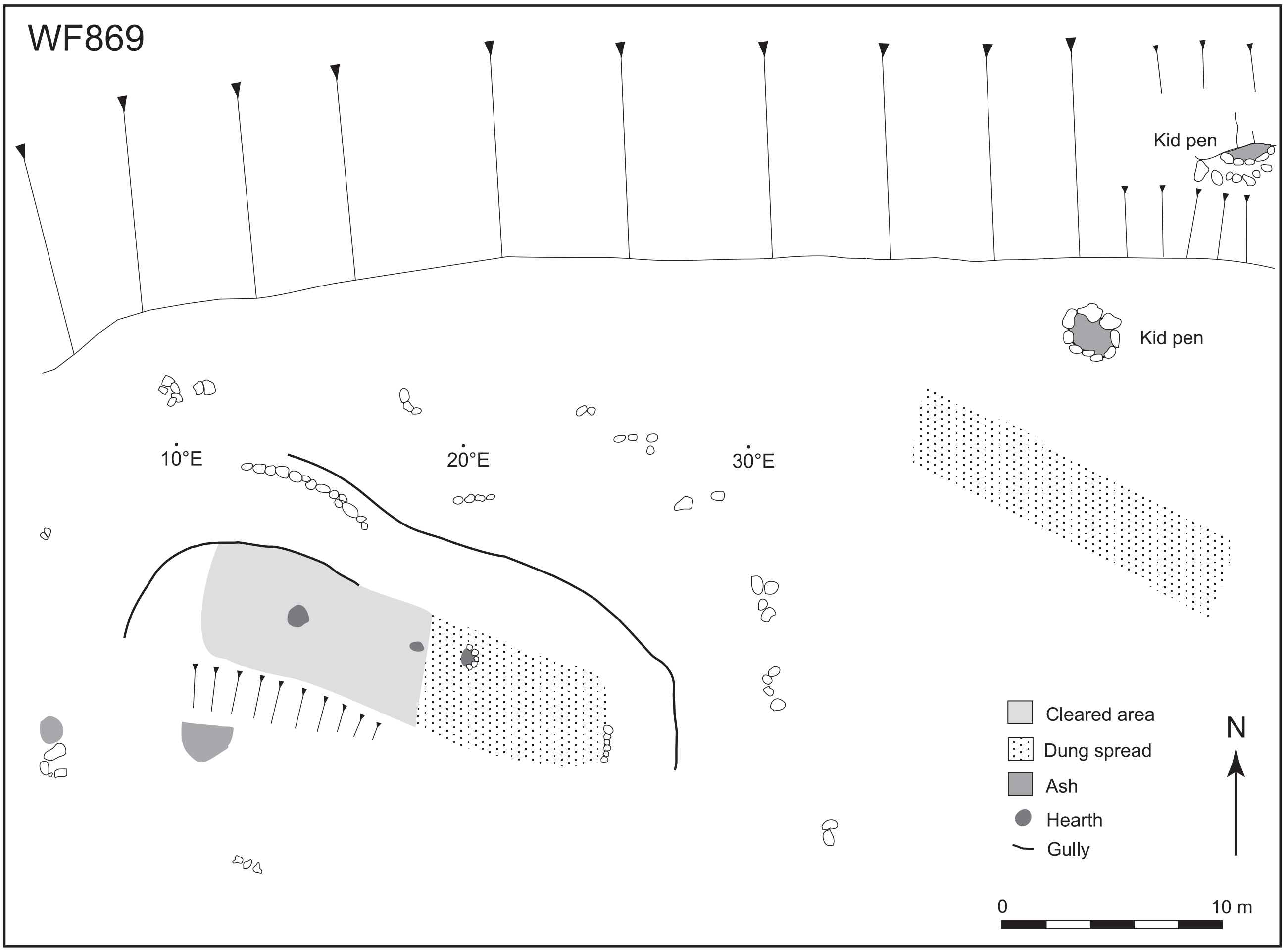


Figure 12.18 *Site plan of WF869. There are two tent platforms: one used for human and animal accommodation (Type A) and one for animal only, as indicated by a rectangular spread of dung with kid pens nearby. (Illustration: Lucy Farr and Helen Smith.)*

12.9.2 WF869

WF869 (Fig. 12.18) was another campsite occupied by Jouma' 'Aly, our principal informant, and his family who are from the 'Azazma. The whole campsite is arranged in a similar way to WF953. There were two tents erected here, WF869, and a second *c.*20 m to the northwest used solely to accommodate goats (not included in the artefact distribution study). Like WF942, WF869 is situated on a wadi terrace-surface, but the terrace is a larger, more open, area with the wadi bottom *c.*200 m to the south. The area of the tent platform site was levelled, particularly in the human living area, with a banking-up of sediment towards the rear and gullies positioned to the front to divert rainwater and run-off. The arrangement is the same as WF953: it is a Type A site, a winter tent site with half the tent occupied by animals and the other half by the family. Unlike in WF942, the human living area is divided into men's and women's sections so there are two internal hearths, one towards the centre of the men's section and one in the women's section towards the front and adjacent to the screen that divided off the animals' living section. As at WF953, the men's hearth is simple and circular and the kitchen hearth surrounded by fire-blackened stones. A large hearth in the goat section of the tent had been used to cook a *mansaf* when a brother visited from town. Jouma' 'Aly's family did not construct a sleeping platform as at WF942. Rope stones, small piles of stones up to 8 m away from the tent platform, are clearly visible. The campsite was once used as a regular camping ground for the family, but has now been abandoned due to its inaccessibility by vehicle.

Jouma' 'Aly said that the area had been used as a camping ground by bedouin for a long period and that it was this older activity that had attracted him to camp there in the first place. The area of the main tent site was partly cleared and required comparatively little modification to make it habitable again. There was also artefactual evidence for older bedouin activity at this site: a fragment from a rotary quern and a fragment from a silver amulet were found.

12.9.3 WF982

WF982 (Fig. 12.19) is located very close to the Faynan camp and was known to have been occupied last approxi-

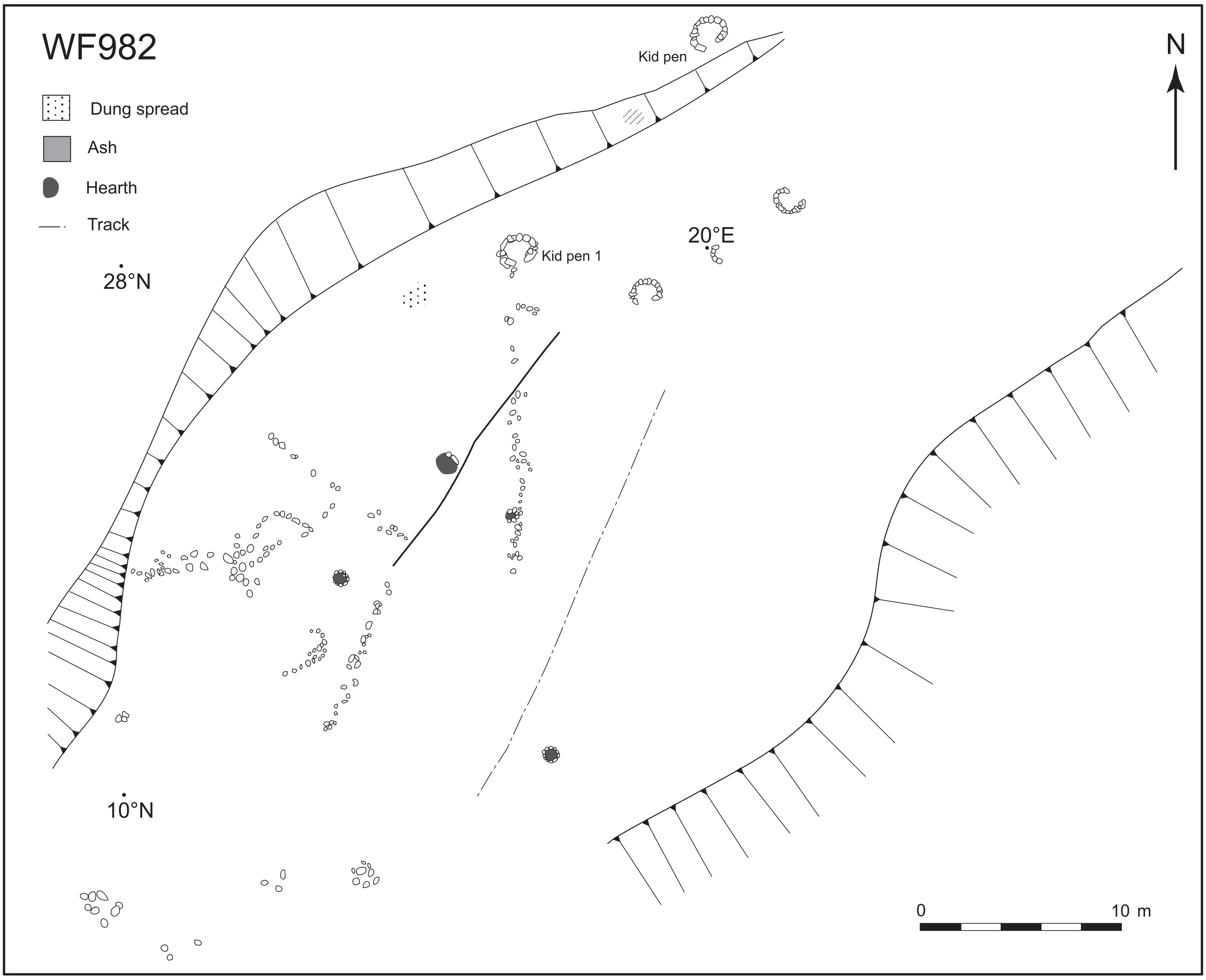


Figure 12.19 *Site plan of WF982. (Illustration: Lucy Farr and Helen Smith.)*

mately fifteen years ago by a member of the Sa'idiyyin group. It is not clear how long WF982 was occupied at that time, or for how many winters it may have been occupied prior to that, but it is likely that the site was occupied on repeated occasions. This tent, like WF869, possessed two hearths indicating men's and women's sections, the positioning of the hearths suggesting that the front of the tent was towards the southeast and the Wadi Faynan. There were no remnants of goat dung on the tent platform itself. The ash dump is located to the northeast, beyond the mapped area, close to the kid pens (Fig. 12.10), which indicate winter use of the campsite.

12.9.4 WF909

WF909 (Fig. 12.20) consists of a number of clear architectural features: sleeping platforms and other platforms of differing dimensions, as well as hearths and rope stones. The large number of platforms suggests use in springtime when plenty of milk was available for processing into storable products. There are at least three hearths present, identified by the placement of three fire-cracked stones and, when the surface was scraped, the presence of ash. It is difficult to distinguish individual tents in this grouping, and it is likely that the site represents re-occupations and re-alignments. The stone features do not clearly conform with the tent types outlined. There is an unusual enigmatic feature, a large circular cleared area to the east of the platforms and hearths. This was interpreted by local people variously as an animal corral, something children might have created or, even, as the site of a foreign traveller's tent. Early travellers, including Musil (1907 [1989]) and Glueck (1935), did pass through the Wadi Faynan documenting the archaeological monuments.

12.9.5 Artefact distribution at the sites

Artefacts lying on the surface of sites WF942, WF869 and WF982 were recorded on a metre-by-metre basis (Fig. 12.21) according to material (e.g. glass, metal, bone) and size classes (<2 cm, 2–5 cm, and >5 cm). Where known, the function of artefacts was recorded, for example, a sardine tin or particular component of the tent. A full listing of artefacts recorded is given in Table 12.2. All recording

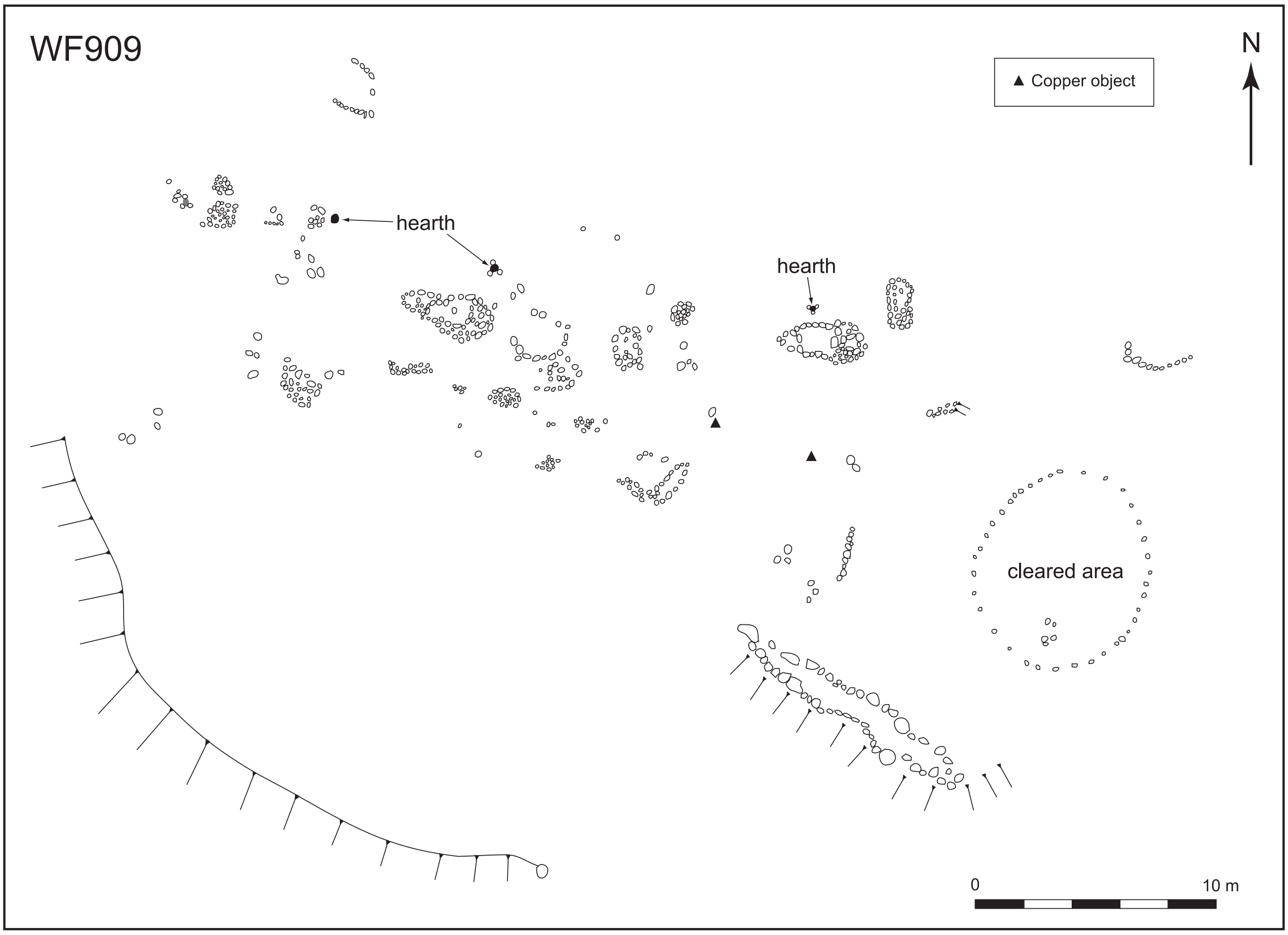


Figure 12.20 *Site plan of WF909. (Illustration: Lucy Farr and Helen Smith.)*

Figure 12.21 *Recording artefact distribution at WF982, looking south. (Photograph: Carol Palmer.)*

in the field was done on paper, with artefactual data later superimposed on outlines of the site plans to create digital models (see Palmer and Daly 2006 for further methodological details). WF909 was planned but a digital model not created because artefact density was so low that it was possible to plot finds manually in the field.

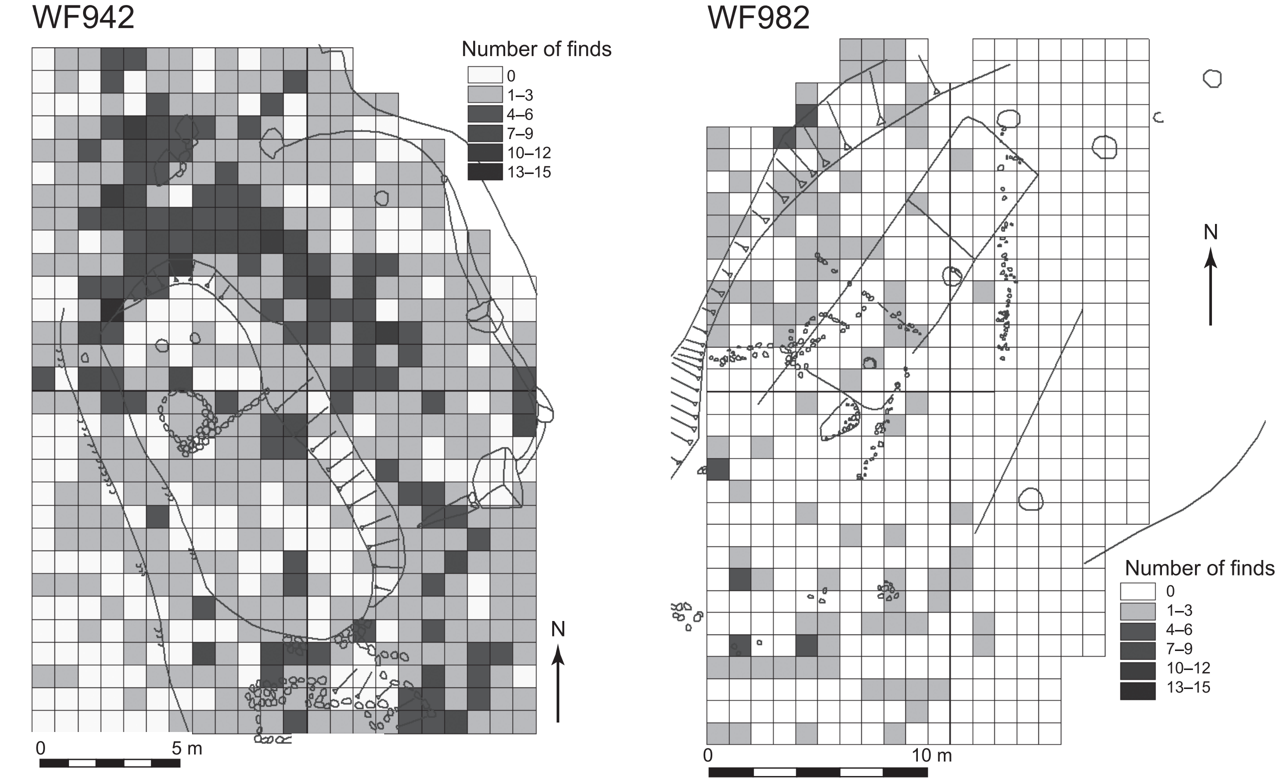
The majority of the materials discarded around the first three tent sites consists of disposable modern consumables and fabrics. Figure 12.22 shows the distribution of all items, including cheese foil wrappers, plastic food containers, sardine tins, fabric, bone, discarded tent fabric and rope, bone as well as plant remains (chiefly large charcoal fragments). At WF942 debris is widely dispersed but particularly concentrated towards the north and west, between the family living quarters and the ash dump. At WF869, debris is again widely dispersed, but in highest concentrations to the rear of the tent, immediately downslope from the tent platform. At WF982, debris is less dense, but there are similar concentrations near what was the back of the tent, in a small depression, and towards the south. There are generally lower densities of material associated with the tent platform. At WF869 there is often a slightly higher density of debris trapped or in the vicinity of rope stones.

Organic components
charcoal <2 cm; 2–5 cm; >5 cm
uncharred/charred *Phoenix dactylifera* (date) stone <2 cm
uncharred/charred *Ziziphus spina-christi* seed <2 cm
goat bone <2 cm; 2–5 cm; >5 cm
articulated lower goat limb >5 cm
goat tooth <2 cm
goat hoof 2–5 cm
goat horn 2–5 cm; >5 cm
goat hair <2 cm; 2–5 cm; >5 cm
goat skin 2–5 cm; >5 cm
chicken bone <2 cm; 2–5 cm; >5 cm
donkey bone >5 cm
unidentified bone fragment <2 cm; 2–5 cm; >5 cm
Glass
bottle fragments <2 cm; 2–5 cm; >5 cm
mirror fragments 2–5 cm
bracelet fragment (ancient) <2 cm
Plastic
bottle >5 cm
lid <2 cm; 2–5 cm; >5 cm
bag <2 cm; 2–5 cm; >5 cm
handbag handle >5 cm
button <2 cm
irrigation piping <2 cm; 2–5 cm; >5 cm
flute (from plastic piping) >5 cm
comb 2–5 cm; >5 cm
watch strap >5 cm
toy <2 cm; 2–5 cm; >5 cm
bead <2 cm
cup >5 cm
music cassette >5 cm
fragment <2 cm; 2–5 cm; >5 cm
sweet wrapper <2 cm; 2–5 cm
food wrapper (biscuit, crisp etc.) >5 cm
pill packet <2 cm; 2–5 cm; >5 cm
cling film >5 cm
Rubber
shoe fragment <2 cm; 2–5 cm; >5 cm
shoe altered as toy >5 cm
rubber (from a *rowayah*, a water carrier)
fragment <2 cm; 2–5 cm; >5 cm
washer 2–5 cm
band <2 cm; >5 cm
Metal objects
gun cartridge >5 cm
knife >5 cm
iron dagger sheath >5 cm
broken shears >5 cm
amulet (old bedouin jewellery) 2–5 cm
wire (mostly electrical) <2 cm; 2–5 cm; >5 cm
tent peg/iron >5 cm
nail <2 cm; 2–5 cm; >5 cm
key >5 cm
coin <2 cm
fragment from paraffin lamp >5 cm
stud <2 cm
copper rod >5 cm
necklace chain 2–5 cm
oil drum lid >5 cm
kettle handle >5 cm
miscellaneous object <2 cm; 2–5 cm; >5 cm
iron fragment 2–5 cm; >5 cm
sardine tin 2–5 cm; >5 cm
sardine lid 2–5 cm; >5 cm
other food tin 2–5 cm; >5 cm
other tin lid 2–5 cm; >5 cm
bottle cap <2 cm; 2–5 cm
tube of cream 2–5 cm; >5 cm
spray can >5 cm
zip frag <2 cm; >5 cm
windscreen wiper fragment <2 cm; >5 cm
razor <2 cm; 2–5 cm; >5 cm
staple <2 cm
ring-can pull 2–5 cm
Fabric, rope, and twine
fabric (clothing) fragment <2 cm; 2–5 cm; >5 cm
fabric (clothing) rope >5 cm
sock >5 cm
goat hair tent fabric 2–5 cm; >5 cm
cotton stuffing <2 cm; 2–5 cm; >5 cm
cotton thread <2 cm; 2–5 cm; >5 cm
wool stuffing 2–5 cm; >5 cm
wool, yarn <2 cm; 2–5 cm; >5 cm
wool, knitted 2–5 cm; >5 cm
wool, woven 2–5 cm; >5 cm
hessian sacking 2–5 cm; >5 cm
nylon sacking <2 cm; 2–5 cm; >5 cm
jute rope (around rope stone) >5 cm
jute rope <2 cm; 2–5 cm; >5 cm
plastic twine <2 cm; 2–5 cm; >5 cm
plastic rope <2 cm; 2–5 cm; >5 cm
goat hair twine 2–5 cm; >5 cm
string <2 cm; 2–5 cm; >5 cm
shoelace >5 cm
Wood (worked), cardboard, and paper
paper <2 cm; 2–5 cm; >5 cm
cardboard box fragment 2–5 cm; >5 cm
match 2–5 cm; >5 cm
lolly stick 2–5 cm
worked wood >5 cm
tent pole positioner (*wawiyah*) >5 cm
spinning whorl (broken) >5 cm
Stone
flint 2–5 cm
rotary quern fragment >5 cm
Pottery
glazed pottery <2 cm; 2–5 cm
Miscellaneous materials
foil (food wrapping) <2 cm; 2–5 cm; >5 cm
polystyrene box fragment <2 cm; 2–5 cm; >5 cm
battery <2 cm; 2–5 cm; >5 cm
torch light bulb <2 cm
pencil 2–5 cm; >5 cm
plastic pen >5 cm
metal from a pen <2 cm
sponge 2–5 cm
plaster/band-aid >5 cm
roof tile >5 cm

Table 12.2 *List of the artefacts recorded in 2000 at four abandoned campsites. Materials are grouped by constituent material (see Bradley 1992) except 'fabric, twine, and rope' and 'miscellaneous materials'.*

There is a marked decline in artefact density through time. WF942, the most recently occupied campsite, has the densest spread of debris: across the 612 m^2 surveyed, average artefact density is 1.94 per m^2 (excluding charcoal fragments). Artefact density is lowest at WF982, occupied approximately 15 years ago: 0.39 artefacts per m^2 for the 588 m^2 surveyed. At WF869, occupied three to four years previously, over the 752 m^2 surveyed, average artefact density is 1.38 artefacts/m^2. The summary density of the main categories of material discarded at the three sites is shown in Figure 12.23 (see also see Palmer and Daly 2006: figs 5.6–5.10).

WF942 has a high density of fabric (old clothing and fragments), tent fabric and sacking pieces, as well as rope and twine. This reflects the very recent occupation of the site and, perhaps, that the tent was not in very good repair. Many of the fabric pieces were knotted, either to form rope or tethers for goats. WF869 has a higher density of glass, plastics, food cans, which mostly represent discarded food containers. WF869 was occupied by more people than WF942 – a family of eight compared with a family of five – and also occupied for a longer period of time, and this is reflected in the higher number of food-related items. The relatively high frequency of glass fragments at WF869



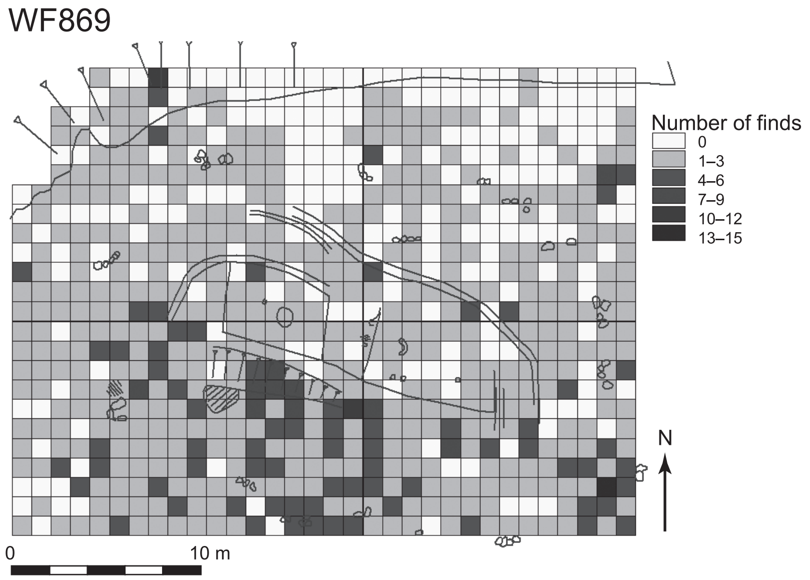


Figure 12.22 *Distribution of all finds at WF942, WF869, and WF982. (Illustration: Patrick Daly.)*

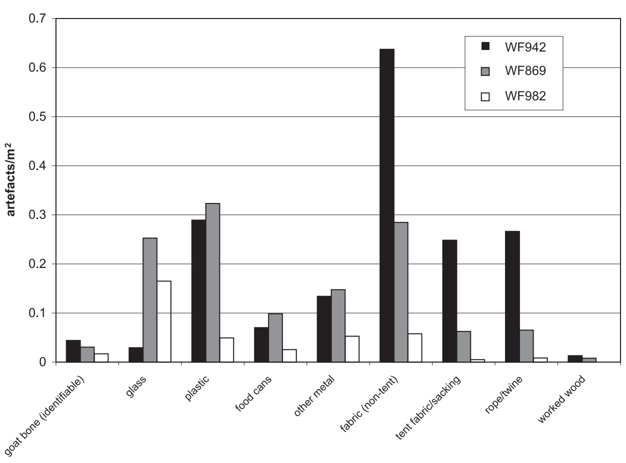


Figure 12.23 *Density of artefacts/m² by category at WF942, WF869, and WF982.*

Figure 12.24 *Campsite debris at WF942, including a healed fractured goat metapodial, sardine tins, pieces of fabric knotted together, and twine, all discarded in a mass of goat dung pellets. Scale: 40 cm. (Photograph: Carol Palmer.)*

is partly explained by the presence of a recently broken glass bottle associated with the track that runs across the southeast of the area.

Identifiable goat bone is comparatively rare at all the sites and is often found as whole bones (Fig. 12.24) and horns, rather than fragments; that is, they represent discard from primary butchery activity. At WF942 there were eight articulated goat limbs (see, for example, Palmer and Daly 2006, fig. 5.7). It is likely that these bones do not derive from the time when WF942 was occupied, but were discarded there afterwards by another household from further up the wadi. Goat limb elements and goatskins were also present in the wadi below the site, along with a stinking, decaying carcass of a donkey, most likely deposited there after the family left.

Children have an impact on the distribution of rubbish, creating toys from any useful debris, and leaving them behind, once broken, in the rubbish areas after play. A number of sardine tins at WF869 showed evidence of modification to turn them into toy trucks. Other activities represented at WF869 include evidence for spinning goat hair from the presence of a broken wooden spindle whorl.

Although WF909 was examined intensively, only two copper fragments, probably from old-style cooking pots, were found (Fig. 12.20). Given the placement of the sleeping platforms and hearths, these do appear to have been discarded at what would have been the back of the tents. The use of copper utensils suggests that the site dates, at the latest, to the mid-twentieth century. In addition to examining surface finds, a fine layer of sediment, immediately around the hearths and nearby platforms, was cleared (Fig. 12.25), but no further finds were made. Excavation and sieving across a wider area might have revealed further finds.

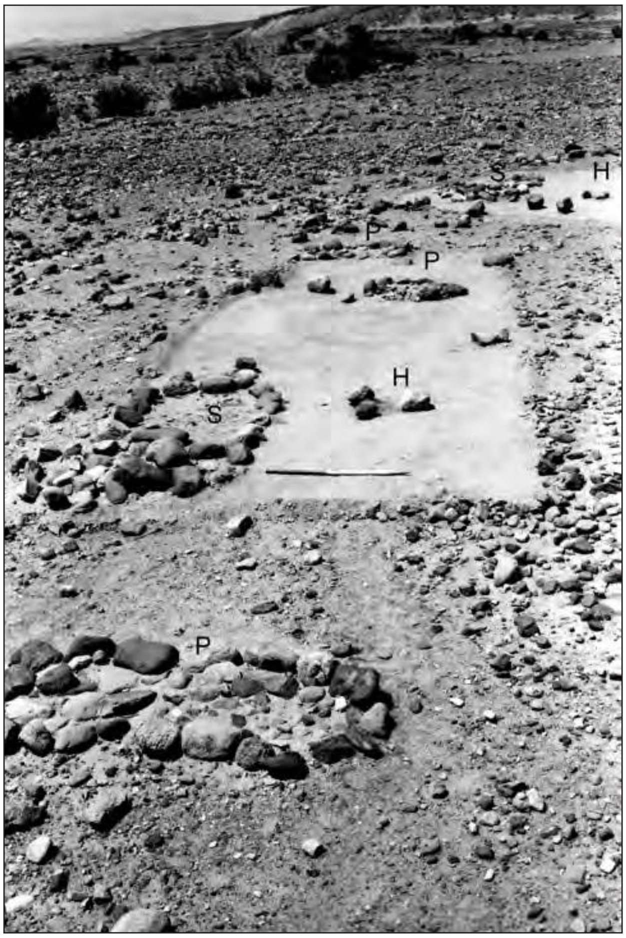


Figure 12.25 *WF909 after light cleaning, looking west. H = hearth, S = sleeping platform and P = platform. Scale: 1 m. (Photograph: Carol Palmer.)*

12.9.6 Trends in the overall patterning of artefacts

Modern consumer goods, especially packaged foods, have increased the visibility of recently abandoned campsites. The human population appears to depend as much on bought food goods as the livestock do on purchased fodder, which marks a notable change in the local economy. There have been considerable recent changes in diet (Heine 1994; Palmer 2002), which are clearly reflected in the disposable material culture. Sardine tins, bottles, and plastic containers have joined accumulations of dung as very clear indicators of recent bedouin activity.

Routine daily activities at the bedouin sites are reflected in the patterning of artefacts, with human living areas swept clean of debris and items of rubbish discarded just outside the tent. Similar patterning has been noted in the distribution of artefacts at B'dul and Sa'idiyyin encampments in the Petra area (Simms 1988; Simms and Russell 1996). Living areas tend to have low levels of remains with refuse concentrated to the rear of the tent and particularly around ash dumps (also see Cribb 1991b). Refuse location is therefore not an indicator of activity location (Simms 1988: 207).

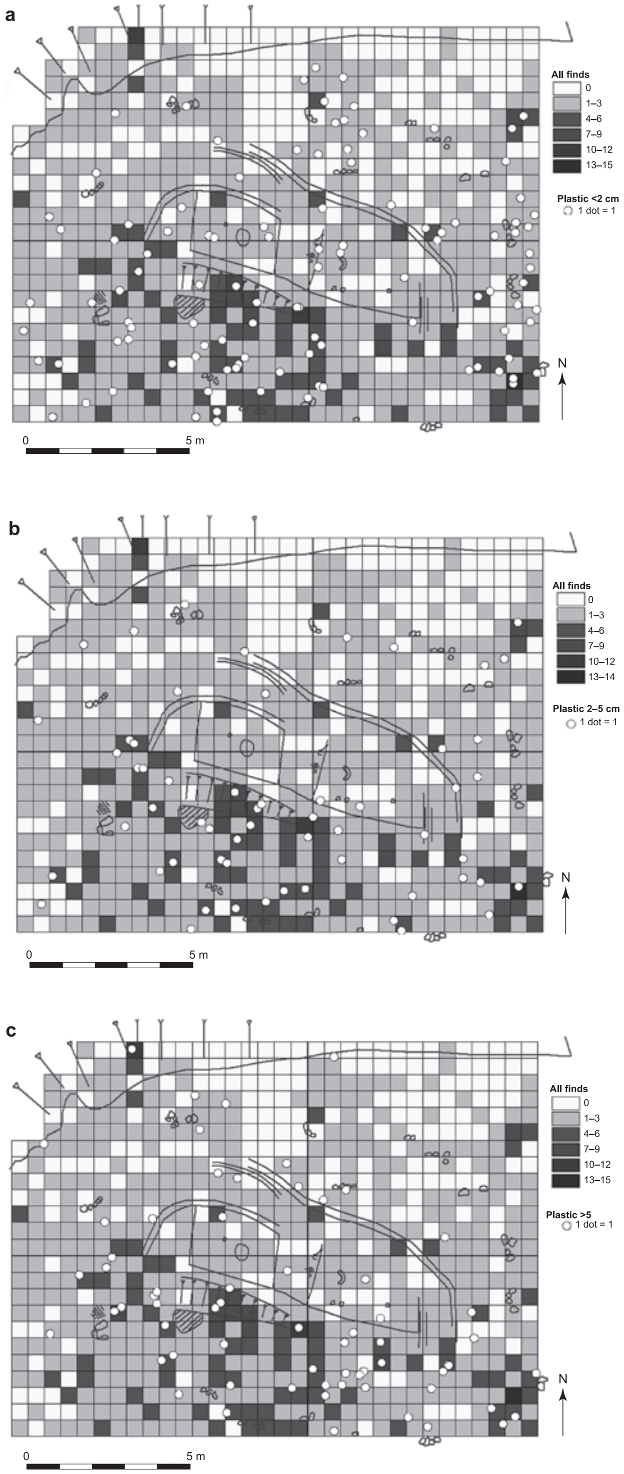


Figure 12.26 *Distribution of all finds at WF869, with overlay of find spots of (a) plastic <2 cm, (b) plastic 2–5 cm and (c) plastic >5 cm. (Illustrations: Patrick Daly.)*

In comparison with WF942 and WF869, Qublan's tent, the tent site Simms (1988) surveyed at Petra, has a much larger cleared area around the tent and, in general, there is a higher density of artefacts in the areas where rubbish concentrates, ranging between 10 and 50 items/m², with an average of 15/m² in the swept zone just outside the tent ('zone 2'). At WF942 and WF869, 14–15 items/m² were the maximum recorded across the whole site. However, similar densities to those at Wadi Faynan are recorded by Banning and Köhler-Rollefson (1992: 195–8) and when Simms and Russell (1996) surveyed a further ten, mostly winter, tent sites they noted that overall densities were much lower and rubbish deposited closer to the tent platform than at Qublan's tent. The difference appears to be due to the fact that Qublan's tent was occupied for a much longer period – six months – and during summer when more activities tend to take place outside, a trend that has been observed throughout the region (Cribb 1991b: 377; Layne 1987).

Simms (1988) and Simms and Russell (1996: 9.13) observed that long-term sweeping, beginning about one month after the start of occupation, results in secondary sorting of rubbish across pastoral sites. The sorting by size category around tent platforms they observed was not clearly determinable in Wadi Faynan due to the sites' short winter occupation. However, at WF869, the effect of sweeping inside the tent is visible; for example, in the distribution of plastic artefacts (mostly, but not all, food related containers, see Table 12.2) of different sizes. There are no fragments in the size category 2–5 cm in the living areas (Fig. 12.26a), with just a few smaller pieces, under 2 cm (Fig. 12.26b). The larger plastic items, >5 cm (Fig. 12.26c), inside the tent mostly derive from post-abandonment. Overall, the tent sites examined here represent palimpsests of multiple short-term occupations rather than long-term occupations.

The remarkably low frequency of bones at pastoral sites was also noted previously by Banning and Köhler-Rollefson (1992: 198–200) and Simms (1988: 207), who attribute this to scavenging by dogs. Furthermore, meat is not regularly consumed and is only eaten on special occasions – during feasts, weddings, and when guests visit. The traditional diet, before the arrival of modern packaged foods and sardines, was predominantly based on milk products and cereals, supplemented by the collection of some wild foods.

Even with modern, relatively durable, disposable material culture, there appears to be a remarkable fall-off of visibility of these items within a relatively short time. Organic components, such as fabrics and worked wood, might be expected to disappear quickly, but it appears that even more durable disposable items are quickly dispersed over time, as at WF982. Simms and Russell (1996) returned to Qublan's tent site two, four, and eight years later and remapped artefact distribution. They found that artefact density reduced considerably; for example, two years later, artefact density across the tent floor ('zone 1') decreased from an average of 5 to 1.4 items/m², with many light and perishable items gone. In addition, the site was greatly affected by the wind, with surface deflation in some areas and deposition in others, processes that also varied in intensity from year to year. In Wadi Faynan, as well as aeolian influences affecting the visibility and distribution of artefacts and sediments,

Figure 12.27 Cave in the Wadi Burwas formerly used by local bedouin. (Photograph: Carol Palmer.)

run-off from heavy rainfall is likely to reduce surface artefact density, both dispersing items and burying them.

12.10 Bedouin material culture in the recent past

During the late nineteenth and early twentieth centuries, travellers and ethnographers were fascinated by the rich heritage of poetry and complex codes of conduct of the bedouin, which contrasted with what they viewed as the relative paucity of their material culture. Tent furnishings and equipment are described in some detail by Dalman (1964 [1939]: 44–52) and Musil (1928: 64–72). All the furnishings and equipment were portable and most are highly perishable. These were carried from encampment to encampment and discarded only if beyond repair, reuse, or recycling into some other object. These observations on bedouin material culture have long contributed to the debate on the visibility, or rather invisibility, of pastoral campsites. A few items of bedouin material culture were, however, both disposable and durable.

Bedouin did employ more pottery vessels (other than coffee cups) in the recent past, including water jugs for pouring water with which to wash, for example. Coarse hand-made ceramics used as cooking and storage vessels, dating between the sixteenth and nineteenth centuries, were recovered from excavations at the bedouin rock-shelter of Tor Imdai in the Wadi Siyagh below Petra, south of the Wadi Faynan (Simms and Russell 1997: 468). At the same site, stone whetstones, flint flakes and blades, flint strikers and gun flints were also found. Cribb (1991a: 75) noted that the availability of new materials, particularly aluminium and enamel, has greatly reduced the use of pottery at both sedentary and nomadic sites (see also Banning and Köhler-Rollefson 1992: 195). Plastic utensils are used today in place of pottery, metal, wooden objects, and water skins. Matches have replaced flint strikers, and flint flakes and blades are no longer in regular use due to the availability and relative cheapness of mass-produced metal knives.

Items of personal attire, jewellery for women (amulets, bracelets and beads) and weapons for men (rifles and knives), are commonly seen today. Broken, lost, or discarded objects like these may be expected on sites, as at WF869 where a broken amulet fragment was found. At Tor Imdai, rifle cartridges and fragments from glass bracelets were recovered (Simms and Russell 1997: 468). Rifle cartridges were also found at the sites surveyed at Wadi Faynan.

12.11 Other evidence of bedouin activity around the Wadi Faynan

Bedouin use rock-shelters and caves as accommodation, to shelter animals and as stores. In the Wadi Dana, many tent sites are located close to low, sheltering cliffs such as WF918 (Fig. 12.1). When local people moved by mule and camel between camping locations, caves and rock-shelters were regularly used as temporary shelters. Figure 12.27 shows a cave from the Wadi Burwas said to have been used as temporary winter accommodation. Today, caves tend to be used most frequently by shepherds or, more accurately, by their animals, as attested by the thick accumulations of dung usually present. 'Caves' also include accessible mine entrances; for example, there is a thick accumulation of dung at the entrance to the ancient copper mine, Umm al-Amad (Fig. 10.3).

Today, three fire-blackened stones are regular features across the landscape, often found near trees or along sandy wadi beds. Shepherds carry a teapot, glasses, tea, and plenty of sugar with them to make regular glasses of sweet tea. However, tea is a relatively new addition to the regular bedouin diet, from within the past 100 years. Fires are also

Figure 12.28 *Ancient water-catchment system in the Wadi Khalid used for cultivation by local bedouin, WF907, looking northeast. (Photograph: Carol Palmer.)*

made to make a special type of bread, *gurus al-nar*, in the embers (Palmer 2002: 179). This bread is exclusively made by men, usually when they are on a journey or picnic.

In the past, grain and storable food items were also hidden in secret locations, in isolated caves and niches, as well as underground. Food-hiding behaviour is not common today due to the availability of food in local stores and government subsidized supplies, but was more common when food was in scarcer supply and towns were further away than a day's journey by truck or bus. Simms and Russell record food-hiding behaviour among the B'dul around Petra, which, from local accounts, they particularly associate with times of scarcity (Simms and Russell 1996). There, the threat to the supplies was not so much from outside groups, but from within the community.

Bedouin graves are present in the Wadi Faynan, the bedouin previously often burying their dead around ancient features, notably around the Byzantine churches at the foot of Khirbat Faynan. Graves are mounded up and usually encircled with small stones, with larger stones at the foot and head of the graves. Bedouin graves may today be marked with a written-out name, or, alternatively, a tribal mark, a *wasm*. According to local Islamic custom, the body within the grave is laid on the right side with the head raised slightly on a stone or earth and the face directed towards Mecca (al-Qibla).

The recent venture into irrigation agriculture by the Rashaydah by piping spring-water via a system of plastic piping from the Wadi Ghuwayr to the ancient wall and field system in order to irrigate tomatoes and melons grown under black plastic sheeting represents a very modern agricultural enterprise. On a smaller scale, the bedouin also used some of the ancient water-harvesting systems of the area to cultivate crops, even renovating them to some degree. WF907, in the Wadi Khalid, north of the Wadi Faynan, is an example of this (Fig. 12.28). Here, *c.*15 stepped ancient terrace fields sit in a shallow wadi basin. The terraces of the larger upper fields have been renovated and were used to cultivate local tobacco, *heeshee*, in good rainfall years, by our informant Jouma' 'Aly and his father, a practice that was stopped when the RSCN Reserve was established. *Heeshee*, like tomatoes and melons, is a profitable cash crop, but requires less water to cultivate it. The cultivation of *heeshee* appears to be widespread in similar arid situations in wadi systems along the Wadi 'Arabah where water-harvesting is possible, and where it is often based on ancient field systems (e.g. Palmer 2001: 624).

12.12 Conclusion

The Bedouin Camp Survey demonstrates that traditional bedouin life, character, and values are strongly reflected in the organization of campsites, but this life is changing (see Chapters 2 and 13). The survey also indicates the continuing importance of tribal associations to the people of Wadi Faynan, as shown by the location of sites in the wadi, and that tent forms, their organization and situation, for example, along wadi courses and near to water supplies, continue to follow enduring practice. However, the location of sites is seen to be increasingly affected by more modern considerations, such as vehicle access and work opportunities. For all tribal groups, the growth of state infrastructure and markets is fundamentally changing local lives, and this is visible in camp architecture and the debris deposited there.

The Bedouin Camp Survey shows that mobile people maintain very strong concepts of spatial organization, reflecting fundamental values of the society, and this is played out each time a camp is established or re-established. Families also constantly camp in locations with which they have become deeply familiar.

Although traditional tent organization has been maintained, the availability of modern materials, including plastic pipes from the Rashaydah irrigation scheme, enables households to separate activities that once each had a particular space within the tent to another location nearby, for example, for activities such as milk-processing, storage of fodder and supplies, as well as to create separate sleeping compartments for particular family members. Long-term occupation and re-occupation also mean that it is necessary to separate animal from human accommodation in winter. The longer a family has lived at, or re-occupied, a location, as at WF900, the more additional accessory features and specialized activity areas develop. The availability of modern materials such as plastic matting and sacking is, however, reducing the necessity to build platforms and stone features that have long-term durability and immediate visibility in the landscape. These features are the most reliable evidence for identifying abandoned campsites.

Older campsites, as at WF909, have very little visible material culture. The availability and use of modern packaged foods have increased the visibility of recently abandoned campsites, but the artefactual study suggests that this material is almost as prone to dispersal over time as traditional forms of material culture. Campsites usually represent palimpsests, so artefacts are likely to represent several occupations over the course of many years, a finding with significant implications for earlier pastoral sites. The reuse of campsites, though, makes it difficult to assess the age and length of the occupation of camps. It also means the destruction and modification of older sites below modern ones. The antiquity of the goat-hair tent, *bayt al-sha'r*, in the form known in the nineteenth and twentieth century, and documented here, however, is therefore still a fascinating, better defined, and perhaps more tractable question given the results of the present study.

13. Archaeology and desertification: the landscapes of the Wadi Faynan

David Gilbertson, Graeme Barker, David Mattingly, Carol Palmer, John Grattan, and Brian Pyatt

> By definition, desertification is about dryland ecology and capability. At the heart of desertification lies ecology, including the meteorological dimensions, grounded in the web of social relations that ties, for example, pastoral and/or farming households together, and links them to larger entities, namely markets, access to assets, land tenure and the state … Processes of desertification are of great antiquity, and the study of ancient desertification can be important *per se*, for example, potentially to derive generic principles for the co-evolution of human societies with their natural environments. (Geist 2005: 3–4)

13.1 Introduction

In Chapter 1 we introduced the key themes that shaped the conception and development of the research framework we have described in the preceding chapters. First and foremost we wanted the Wadi Faynan Landscape Survey to contribute to *understanding desertification and aridification*, notably the respective roles of people and climate in the past in shaping present-day arid and desertic landscapes. With the benefit of its long timescales, archaeology should be able to contribute importantly to understanding desertification, a particularly vital topic given the potentially dire impact of global warming on the almost one-third of the world's population who dwell in arid lands (Breckle *et al.* 2002; Dregne 2002; Le Houérou 2002; Warren 2002). How did the socio-economic and biophysical sphere interact in different environmental and historical circumstances? How did past societies respond to changing opportunities and hazards? Why did they take the choices they took? A related focus of interest was *landscape degradation and well-being* viewed from the long-term historical perspective that archaeology allows. Has there been (as so often supposed) a simple cause-and-effect relation between human actions and environmental circumstances? In what situations – climatic, demographic, socio-economic – were arid lands degraded in ways in which they were able to recover, and in what circumstances were they damaged irreversibly? The third core interest was *understanding marginality*, in particular how past peoples living in arid zones have interacted with the populations of adjacent better-watered zones, in terms of core-periphery relations. Has the 'desert' always been peripheral to the 'sown' in terms of social and economic interactions and power structures? Related to this is a consideration of social *scale and complexity* across time. The chronological summary chapters have demonstrated huge variability in the social organization of the inhabitants of the Faynan district through time. At one extreme we have low-intensity pastoral exploitation by tent-dwelling bedouin, at another we have an urban-focused and highly centralized society linked to an imperial regime. Putting numbers on the human populations at different times is always hazardous in survey archaeology – especially in a marginal landscape where the spatial boundaries of the societies have varied across time. Some of these populations are also much more readily visible archaeologically than others. Nonetheless, some attempt must be made to consider the long-term trends in regional demography and the extent to which population levels at times rose above previous carrying capacity of the landscape. Underpinning all of the above is our final overarching interest in *arid-zone archaeological methodologies*, in particular the much-debated problem of distinguishing between absence of evidence, and evidence of absence, in the case of mobile pastoralists or other groups leaving ephemeral kinds of archaeology, or none at all.

As we described in Chapter 1, the Wadi Faynan appeared to be an ideal landscape in which to investigate such questions. First, it is part of a notably arid and desertic region, the trench of the Wadi 'Arabah, but it also forms part of a mountain front of a much better-watered zone, the Mountains of Edom, where rainfall of more than 200 mm a year supports a Mediterranean-style agriculture. Second, previous archaeological studies indicated that there was a rich prehistoric and Classical archaeology of stone-built habitation and funerary monuments and other structures that appeared to be *prima facie* evidence for a succession of phases of intensive, possibly sedentary, settlement associated (on the evidence of what appeared to be fields) with agricultural systems very different from the present-day settlement forms dominated by tented pastoralists. Third, earlier work, especially by the Bochum Mining Museum, had demonstrated the likely importance of the Wadi Faynan for urban societies given its rich copper ores and the evidence for their exploitation with a variety of different technologies and at different levels of intensity by past societies (Hauptmann 2000). This raises questions concerning the varied environmental impacts caused by the different *socio-political organizations and scales* of mining activity. Were the impacts wrought by complex states and imperial societies proportionally larger than those of more fragmented social groupings, irrespective of the absolute numbers of people living in the valley? In this final chapter we reflect on the findings of the Wadi Faynan Landscape Survey regarding these questions, and their implications for arid-land archaeological studies generally as well as specifically for the future of the Wadi Faynan and the people who dwell in it.

13.2 Desertification: research issues and analytical problems

Numerous studies of past societies and landscapes have identified desertification as the primary culprit of 'civilization collapse', but the likelihood that these models are far too simplistic is indicated by the emphasis of modern ecological theory on the complexity of modern relations between dryland environments, climate, and people. Policy-orientated studies of desertification processes have emphasized concepts of multiple causality, synergy, and feedback, and nested process-response models (Geist 2005; Geist and Lambin 2004; Reynolds and Stafford-Smith 2002; Thomas and Middleton 1994). The global meta-analysis of the causes of twentieth-century 'desertification' by Geist and Lambin (2004) identifies recurrent groupings of causes that appear to exist in the multiplicity of processes and attempts to distinguish between proximate (immediate/trigger) and underlying (predisposing/maintaining) factors (Tables 13.1, 13.2; Fig. 13.1). Their findings show that unequivocal, climate-driven, 'desertification' was identified frequently, but less frequently as a single cause of desertification than might be commonly supposed, especially as the human situation became more complex.

Nested process-response models lie at the heart of much contemporary research into desertification, as illustrated succinctly in Figure 13.2, which simplifies linkages

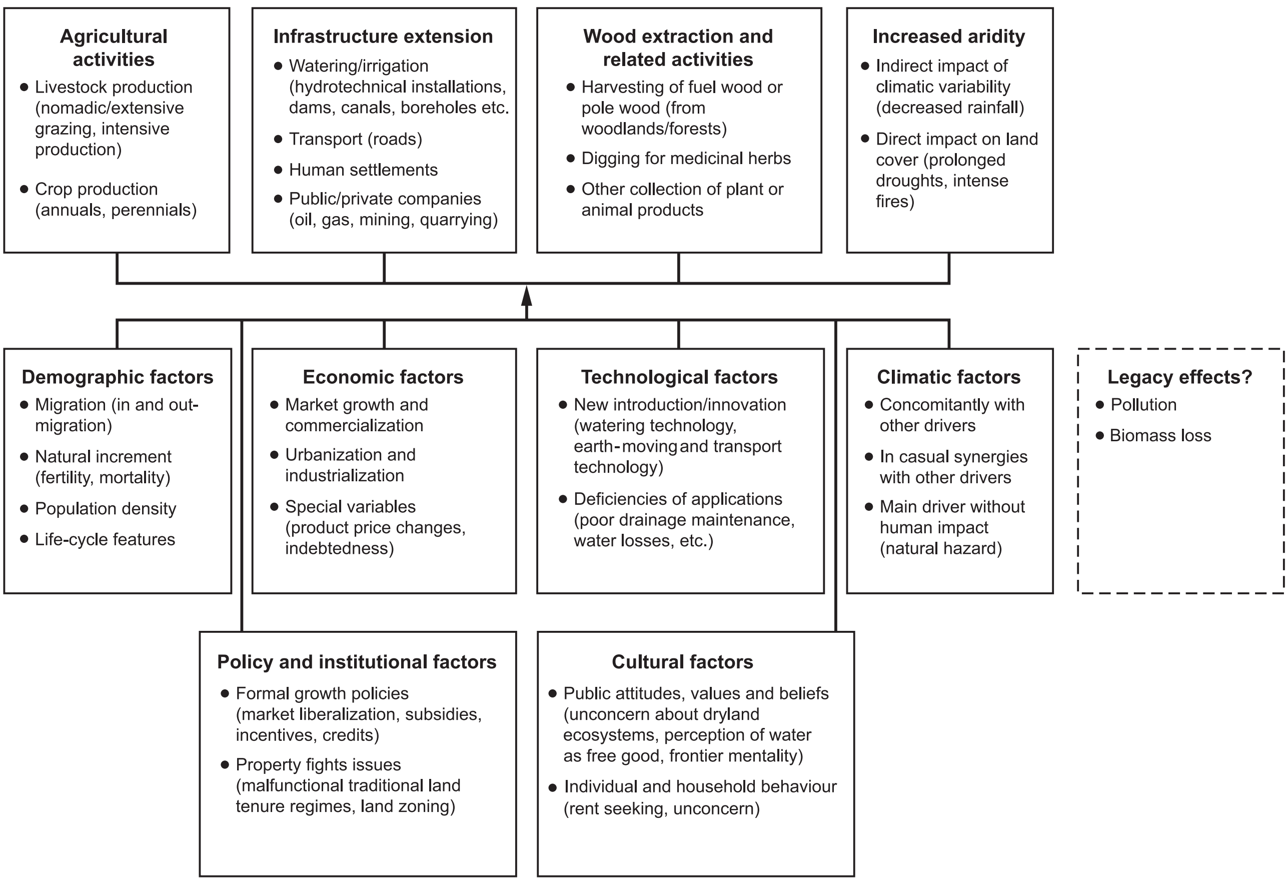


Figure 13.1 *Recurrent groupings of reported causes of modern desertification identified by the meta-analysis of Geist and Lambin (2004), with the addition of a further group entitled 'Legacy Effects' suggested by the findings of this project.*

Proximate causes of desertification	Africa (n = 42)	World-wide (n = 132)
Agricultural activities or agrarian land uses; livestock production, including nomadic grazing	86	95
Increased aridity including changes in precipitation; warmer or drier; more storms, prolonged droughts, direct influence of sunlight	93	86
Infrastructure extension including changes in water technology, irrigation, human settlements, mining, quarrying, transport, pollution	48	55
Wood extraction from forests or woodland	40	45

Table 13.1 *The relative frequencies (%) of the proximate causes of modern desertification in Africa and world-wide. (After Geist and Lambin 2004.)*

between the primary causal-mechanisms responsible for desertification into two inter-related feedback systems, societal and biophysical, both of which impact on and are influenced by key land surface properties shown as 'vegetation cover' and 'soil degradation'. In practice, analysing desertification may require the more detailed systems approach illustrated as Figure 13.3, which emphasizes the importance of complex variations in the rate and recurrence of the various processes. Although both positive and negative feedbacks can occur widely and in many forms, amongst the most commonly cited in the archaeological literature are the deleterious self-reinforcing feedbacks such as interactions between wood gathering and erosion, multiplier effects in the economy, and increasing population resulting in over-exploitation or improved land–crop–animal productivity (Gilbertson 1996; Mortimore 1998; Thomas and Middleton 1994; Table 13.1). Such systems-based analytical approaches present profound challenges to traditional styles of archaeological or historical investigations of past desertification processes that have focused upon only one or two possible agents of change.

The edited volume by Hassan (2002) examined lessons that might be derived from exploring long-term food-security in the face of recurrent drought in Africa over archaeological timescales, in an endeavour to situate 'archaeology within the domain of contemporary human affairs' (Hassan 2002: 1). The first major finding was that abrupt and severe meteorological/climatic events have occurred relatively frequently, but may or may not have triggered human responses. The second was that human responses, when they could be identified, could be immensely variable, including for example population movements or dispersal, modifications of social organization, technological or economic innovations, changes in ritual or ideological practices, and changes in exchange of information, food, or other goods. The third was that human responses were often very difficult to identify, let alone understand in terms of perception and decision-making in the past.

	Africa (n = 42)	World-wide (n = 132)
Single factor causes		
Climate	14	5
Institutional		4
Economy		
Technology		
Culture		
Population		
Two factors in combination		
Pop-clim	24	6
Tech-clim		7
Econ-tech		2
Econ-inst	5	2
Cult-clim		1
Three factors in combination		
Tech-inst-clim	10	3
Pop-tech-inst	3	
Pop-econ-clim	5	2
Econ-tech-clim	2	2
Tech-cult-clim	5	2
Pop-cult-clim		2
Four factors in combination		
Econ-tech-inst-clim		5
Pop-econ-inst-clim	2	3
Tech-inst-cult-clim	5	2
Pop-tech-inst-clim	7	4
Pop-econ-cult-clim		2
Econ-tech-cult-clim		1
Pop-econ-tech-clim		1
Pop-econ-tech-inst		1
Five factors in combination		
Econ-tech-inst-cult-clim	12	11
Pop-econ-tech-inst-clim	2	9
Pop-econ-inst-cult-clim	2	4
Pop-econ-tech-inst-cult	2	3
Pop-econ-tech-cult-clim		2
Six factors in combination		
Pop-econ-tech-cult-clim-inst	2	17

Table 13.2 *The relative frequencies (%) of single factors, or combinations of factors, identified as causing modern desertification in Africa and world-wide, with factors listed in order of priority. Abbreviations: clim = climatic; inst = institutional; econ = economic; tech = technological; cult = cultural. (After Geist and Lambin 2004.)*

Overall, our survey supports these views, re-emphasizing to us that investigating desertification in historical-archaeological terms demands that we pose a series of inter-related questions. What actually happened? Were there persistent droughts? How reliable and representative are the lines of evidence? What did people actually do? What did they think? What mattered to people? If so, to whom, where, when, why? As Butzer (1997) observed, in studies of the archaeological past in arid lands there is an unfortunate tendency to search for and discover 'catastrophe' when there may only have been change. A critical challenge in investigating ancient desertification is the attainable

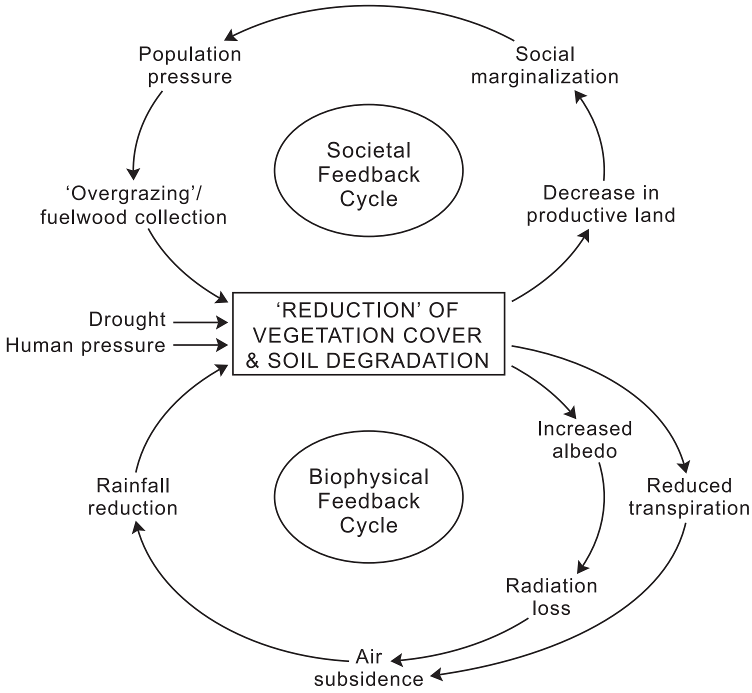


Figure 13.2 *Social and biophysical desertification feedback cycles (based on Thomas and Middleton 1994, and Scoging 1991) which emphasize deterioration in the landscape system.*

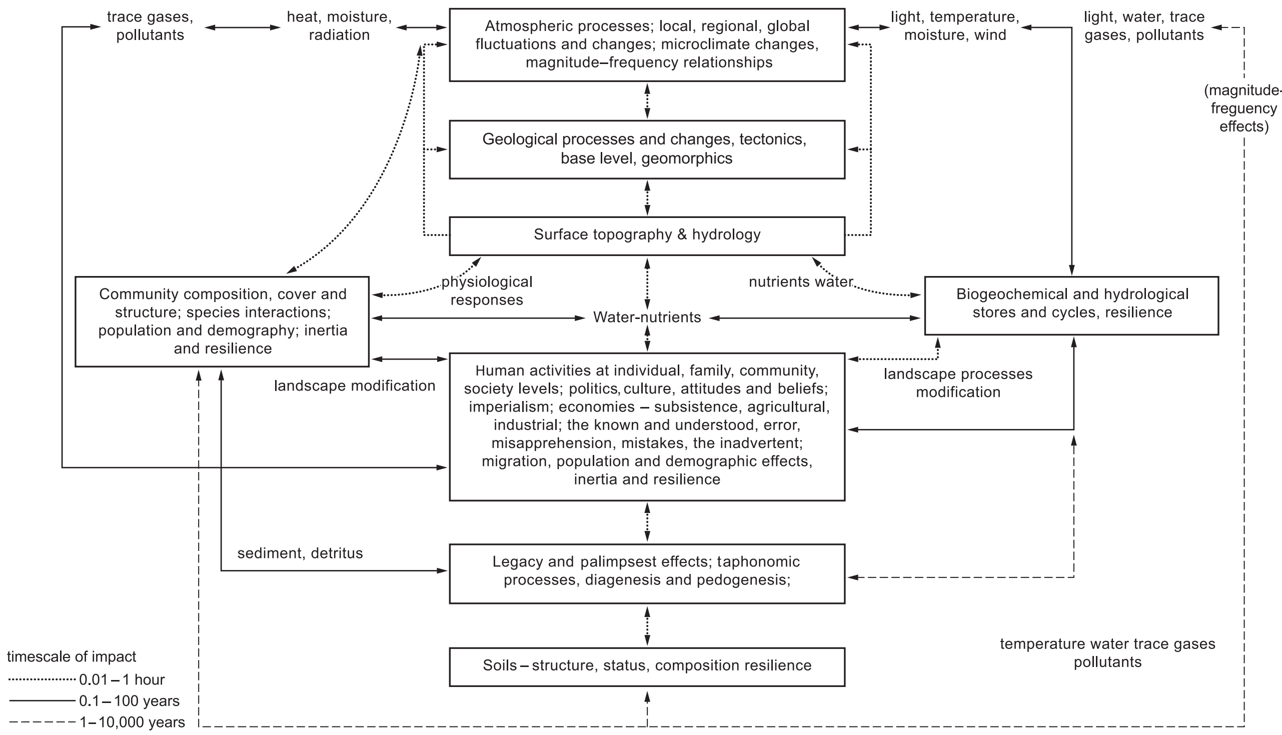


Figure 13.3 *Interactions between processes at the land surface and in the hydrosphere-atmosphere at various timescales, emphasizing human and archaeological dimensions; the nature of the evidence base; that processes and events also behave, vary and interact differently over long timescales including the types of archaeological investigation and 'legacy effects' identified in this research; and facilitating research with a variety of analytical frameworks, paradigms and objectives. (Substantially modified from Hutjes* et al. *1998, 4.)*

precision and accuracy in correlation and dating, properties that may involve chronological uncertainties of tens or hundreds or even thousands of years, making it difficult to separate cause and effect. Could observed archaeological associations of 'cause' and 'effect' be just the result of chance and coincidence? Can a supposed outcome be discounted because it can be argued to have pre-dated a supposed cause?

Such problems are demonstrated in the report of Ionides and Blake (1939) that included the Faynan region. This showed that, even where equivalence exists in time and 'probable cause' exists between two events, misunderstandings about cause and effect can occur, not least as a result of perception or prejudice. The observation of bedouin with animal herds in a Jordanian desert landscape which displayed evidence of soil erosion should not, they argued, be immediately read as implying either cause (observed nomadic grazing) or effect (observed soil erosion). Soil erosion and re-deposition can and do occur all the time in arid lands; it is the comparative rate, duration, and distribution that matter. Indeed, Ionides and Blake concluded that the particular desert landscape they observed being grazed by bedouin herds was actually recovering from an earlier period of soil erosion caused by previous drought and earlier human activities. Overall, our new palaeoecological and archaeological enquiries support these views, and more specifically those recently proposed by Rosen (2006) for the adjacent regions of the Negev, that over the last 5000–6000 years communities of pastoral nomads such as bedouin were not the 'fathers and sons of the desert' as sometime asserted; neither were they the 'only' nor the 'ultimate cause of desertification' in this region.

In the Wadi Faynan study, therefore, we attempted to identify unequivocally the situation before, during, and after supposed impacts, whilst always being mindful of the many limitations and distortions in our windows onto the past. We tried to separate one possible agency from another: for example, not to assume that an effect noted only on past vegetation necessarily reflected the impacts of climate-induced aridification. But clearly, overall, we have insufficient information in the Faynan to separate out reliably in any quantititative manner the relative effects of any particular variables. The approach we adopted was to base inferences on knowledge of processes in the modern landscape, and to compare and contrast parallel lines of evidence. One outcome is illustrated in the reconstruction of a wetter Roman–Byzantine climate from the evidence of sediments, pollen, and charcoal (Chapters 3 and 10).

Unfortunately, as the preceding chapters make clear, the evidence available to us from the five short reconnaissance-level field seasons rarely provided the resolution needed to determine the original course of events with precision. Exposures were limited, the numbers of OSL and radiocarbon dates are modest, and geomorphic-palaeoecological evidence is patchy for many crucial periods of human activity. Despite the apparent power and novelty of some of the analytical approaches used in this study, it remains the case that many aspects of the interpretations of 'cause and effect', or of non-associations between events, depend on judgements based on limited field observations, or on reference to published information from rather different contexts elsewhere. The result is that many of the interpretations proposed in this volume must remain qualitative initial estimates. We still know little of the magnitude and frequency of modern geomorphic events in the study area, or of the short- to medium-term ecological dynamics of the vegetation or animal life (Chapter 2).

For all periods of settlement we can only speculate about demographic levels in relation to the changing capacity of the region to sustain these populations, though these are likely to be essential components of desertification histories. The archaeological field survey had to recognize the dominance of stone in the visible archaeological record, despite the fact that past societies must have made substantial and constant use of organic materials, as shown in the studies of adjacent area by Levy. The difficulties of dating stone structures (particularly small buildings and cairns, as well as 'field' walls) by adjacent artefactual evidence, rather than by stratified excavated material, were emphasized in Chapters 4 and 5 and form an important caveat in relation to the settlement histories discussed in Chapters 6–11. Nonetheless, we would also stress the incredible richness of the surface archaeological record in our area of the Faynan – the 1500 'sites' in just over 30 sq. km is a reflection of preservation in the desert landscape, rather than absolute intensity of activity.

The modern landscape has been shown to be a palimpsest in which the legacies of earlier events continue to manifest themselves through re-working or re-burial in the landscape through natural and human processes (Chapter 3; Grattan *et al.* 2007). Given processes such as erosion, transportation, and deposition by wind, water and mass-movement, the observed distributions and frequencies of recorded archaeological remains are understood to reflect a combination of the reconnaissance level of survey, the survival of deposits, and the patterns of exposure. This is particularly so in the case of our evidence for Palaeolithic settlement, with the exception of the Upper Palaeolithic and Epipalaeolithic for which an absence of evidence may be evidence of absence, though this inference also relates to questions of archaeological visibility (Chapter 6). Within the Holocene, the situation is more complex. The stream-side location identified at Tell Wadi Faynan (Chapter 7) suggests that similar locations may well have been selected by Neolithic people elsewhere in the study area, but they either remain buried and invisible to modern surface survey, or have since been eroded, whilst contemporary Neolithic sites higher up above the wadi channels (such as WF5015 in the Wadi Dana) may be hidden by aeolian and colluvial deposits (in the case of WF5015, to be revealed by the creation of 4WD vehicle routes). Over large areas of the alluvial fans and wadi hillsides, however, the remaining sediment-soil covers on the alluvial fans and slope deposits were sufficiently thin to suggest that field mapping of the present surface palimpsest has correctly established the original distributions of sites and finds. Whilst the distribution of large and small slag heaps was determined with some confidence, it only became clear from coring and trial pits in the lower Wadi Dana that detailed knowledge of their lithostratigraphy and dating was needed to establish their age and significance (Chapters 3, 8–11). Understanding their antiquity was also complicated by field observations that charcoal and pottery fragments could be re-worked within them. It is likely that their nature and antiquity are more complex than that described in the preceding chapters.

Some questions concerning the abruptness of industrial, population, climatic, or other ecological changes can be answered with appropriate precision, whilst others cannot. The changing concentrations of heavy metals in the infill sediments behind the Khirbat Faynan barrage, for example, appear to be reasonable guides to changes in anthropogenic pollution generation and re-working over time at the land surface (Chapters 10 and 11), whereas much of the field evidence could only be dated by ceramic types or biostratigraphy, poor guides to the abruptness or otherwise of change. Issues of abruptness are also obscured in the fluvial sequences. At some wadi floor sites, erosion has truncated sediment bodies and created sharp boundaries between them that need further examination. Failure to note such contacts could have led to false assertions of abrupt shifts in climate or human activity. Rapid shifts of climate have clearly occurred, but in most cases we do not know the rate of change. There remain further uncertainties about the lengths of time represented by the various bodies of sediments: do they represent sedimentation lasting minutes, days, months, years, decades, or centuries? Such difficulties lie at the heart of correlation and dating at one of the most important sequences found in the survey, the Late Neolithic to Byzantine-age aeolian-colluvial sequences at Tell Wadi Faynan (WF5021), where the field evidence suggests that a rapid and profound change in climate towards aridity took place. Here as elsewhere, OSL studies are needed to identify the periods of time represented by thin bodies of fine-grained sediment separated by episodes of erosion and soil development.

The related issue of the magnitude and frequency of geomorphic processes is similarly important. Raikes (1967 [1984]; 1985), from his experience in the adjacent Wadi ʻArabah, like others elsewhere, indicated that the sedimentary evidence of very unusual, very severe, storms (in common with other high-magnitude low-frequency events) tends to be represented disproportionately well in the visible geomorphological record. Our field studies indicate that this property may apply to anthropogenic deposits as much as to natural aggradations in the Wadi Faynan. For example, there was little field evidence in the exposures in the sediment and slags of the floodplain of the Wadi Dana to indicate whether the discard took place over a few minutes, hours, or much longer periods of time. We had to use our judgment and experience of sedimentary properties to identify the significance of the erosional and depositional features detected and then extrapolate this information with some caution to our interpretations of the older deposits and landforms.

Analytical advances enabled dangerous combinations of anthropogenic metal pollution to be explored which previously have been suspected but often ignored. The significance of the poisonous metal thallium is a good example. The surface concentrations of smelting slags, interpreted as a good guide to polluted ground, in fact had only a partial relationship to very high concentrations of this dangerous heavy metal (Chapter 3). Noxious thallium fumes released during smelting would have entered lungs and contaminated exposed skin, food, and water of people already weakened by complex previous exposures. Many combustion gases as well as vapours and particulates of other metals (including antimony, arsenic, bismuth, cadmium, mercury, nickel, and thorium) would similarly have been liberated during ore treatment and smelting. Their abundance demonstrates the likely importance of synergies between them for ancient health and well-being.

We must remember, however, that some of the most powerful local influences on past lifeways are difficult or impossible to detect in the geoarchaeological record. Diseases of plants and animals, human plague and similar diseases of soft tissues, documented for the region in the historical period (Ghawanmeh 1986), are obvious examples of this category. Less obvious is the impact of radon gas, perhaps compounded by exposure in metal-rich dust within closed closed-working spaces as occur in mines and adits today (Chapter 3). At least in this case, it was possible to monitor the modern environment and extrapolate from epidemiological literature to reach conclusions about the potential health problems that might have affected people who spent much time underground such as overseers and professional miners (Grattan *et al*. 2004).

13.3. Pleistocene environments and human occupation

The environmental and human history of the Wadi Faynan over the past half million years of the Pleistocene, as reconstructed by the project's evidence of geomorphology, palaeoecology, and archaeology, is summarized in Table 13.3. The earliest secure evidence for human occupation in the Wadi Faynan (Chapter 6) is a series of Acheulean stone artefacts, though they cannot be assigned to precise periods within the time period *c*.450,000–150,000 BP. The one found *in situ* at WF5063 in the Wadi Dana (Fig. 6.14), a pebble-butted biface made with a soft hammer technique, was associated with fine-grained fluvial-colluvial deposits suggesting (perennially) relatively wetter conditions than prevail today at the time when the artefact became incorporated in the sediment body. Comparison of this find with those which are better known elsewhere suggests that the original find sites are preferentially concentrated at or near the escarpment of the mountain front and the wadis that breach it, in part because deposits of appropriate age

Approximate age	Environment in the Wadi Faynan	Anthropology, history, and archaeology
oldest	High magnitude intermittent phases of fluvial incision and aggradation; low frequency floods. Probably a minimal record of many complex processes and changes that took place.	Quabbah Member – no evidence of human activity
Early Quaternary		
c.225 kya Pleistocene	Evidence of wetter phases with alluvial fan development, slope activity. Fluvial incision and aggradation. River sediments reflect slightly wetter conditions. Probably a minimal record of many complex processes and changes that took place.	
c.109 kya?	Slightly wetter than today; colluvial and fluvial processes noted. Probably a minimal record of many and complex processes and changes that took place in an overall sequence from dry to moister than today (such conditions associated with more widespread presence of woodland, marsh, ponds along rivers and similar favoured places) and then more arid conditions.	Bifaces/biface fragments upon, and one Acheulean handaxe *in situ* within, Fas Yad Member that by comparison with relevant sites elsewhere might date anywhere between 450 kya and 150 kya. Sites at edges of escarpment?
c.80–60 kya	Relatively wetter and drier than today. Fluvial deposition and down-cutting? Probably a minimal record of many complex processes and changes that took place.	Middle Palaeolithic tools at >50 kya on Fass Yad Member? Sites at edges of escarpment?
c.55–45 kya	Increasingly more arid?	Middle Palaeolithic tools at >50 kya on Fass Yad Member?
c.45–20 kya		Upper Palaeolithic *c*.45–20 kya – large blades and blade core. Perhaps Faynan area was site of transitional camps for people engaged in seasonal transhumance moving between lakes and streams of Wadi 'Arabah and plateau steppelands? Perhaps sometimes fishing, fowling, and collecting forest foods and wild cereal, and other grasses, hunting gazelle and small game?
c.20–10.3 kya, more arid at *c*.19 kya, *c*.15 kya, *c*.13.7–13.6 kya	Fluctuating climate – notably arid with distinctive sand dunes of Quarayqira (= Gregora) Member at 13.4 kya, but at other times with wetter flood episodes evidenced in the lower parts of the Faynan Member. Precise nature of vegetation and habitats unclear. Fluvial activity of Faynan Member.	Epipalaeolithic Minimal evidence in immediate study area (but see Finlayson and Mithen 2007)
youngest		

Table 13.3 *Summary of knowledge concerning Palaeolithic activities and Pleistocene environments in the study area identified from this survey. Tectonic events are likely to have been significant, but details are unknown. In the period before* c.*10 kya, there were relatively few archaeological finds to facilitate precise and reliable correlations between artefacts and Pleistocene deposits or landforms.*

have been located there, but also because plateau-edge intercept locations were probably preferred by the human groups using them.

Middle Palaeolithic stone tools (*c*.150,000–45,000 BP) were more frequent and more widely represented than those attributed to the preceding Acheulean, suggesting a real intensification in the use of the landscape. The geomorphological evidence from Wadi Faynan, as elsewhere in the region, indicates an initially cool and dry climate, though moister than today, favouring steppe/desert with woodland along rivers, which in time became drier. Whether the spreads of lithic debris we found were the result of residential patterns of mobility located in the Wadi 'Arabah, or logistical patterns of seasonal movement linking short-term camps in the Faynan with longer-term occupation in the adjacent mountains (both models have been proposed in the region), or both, is impossible to tell. Remains of both Neanderthals and modern humans have been found dating to this period west of the Rift Valley of the 'Arabah, and both are known to have used Levantine Mousterian industries.

The Upper Palaeolithic (*c*.45,000–20,000 BP) and Epipalaeolithic (*c*.20,000–10,300 BP) proved even more elusive, a problem stemming, in part, from uncertainties defining the technological characteristics of these periods. Upper Palaeolithic remains in the study area are best known from limited finds in the Wadi Ghuwayr, when the Wadi Faynan may have been a stop-off location for groups moving between the lakes and streams of the Wadi 'Arabah and the plateau steppelands. Such activities may have been disrupted by the distinctive episodes of profound aridity that we identified, but elsewhere in the region there is abundant evidence that the Epipalaeolithic, the period from the Last Glacial Maximum to the Pleistocene/Holocene transition occupied by people using Kebaran and then Natufian material culture, was characterized by subsistence intensification, social

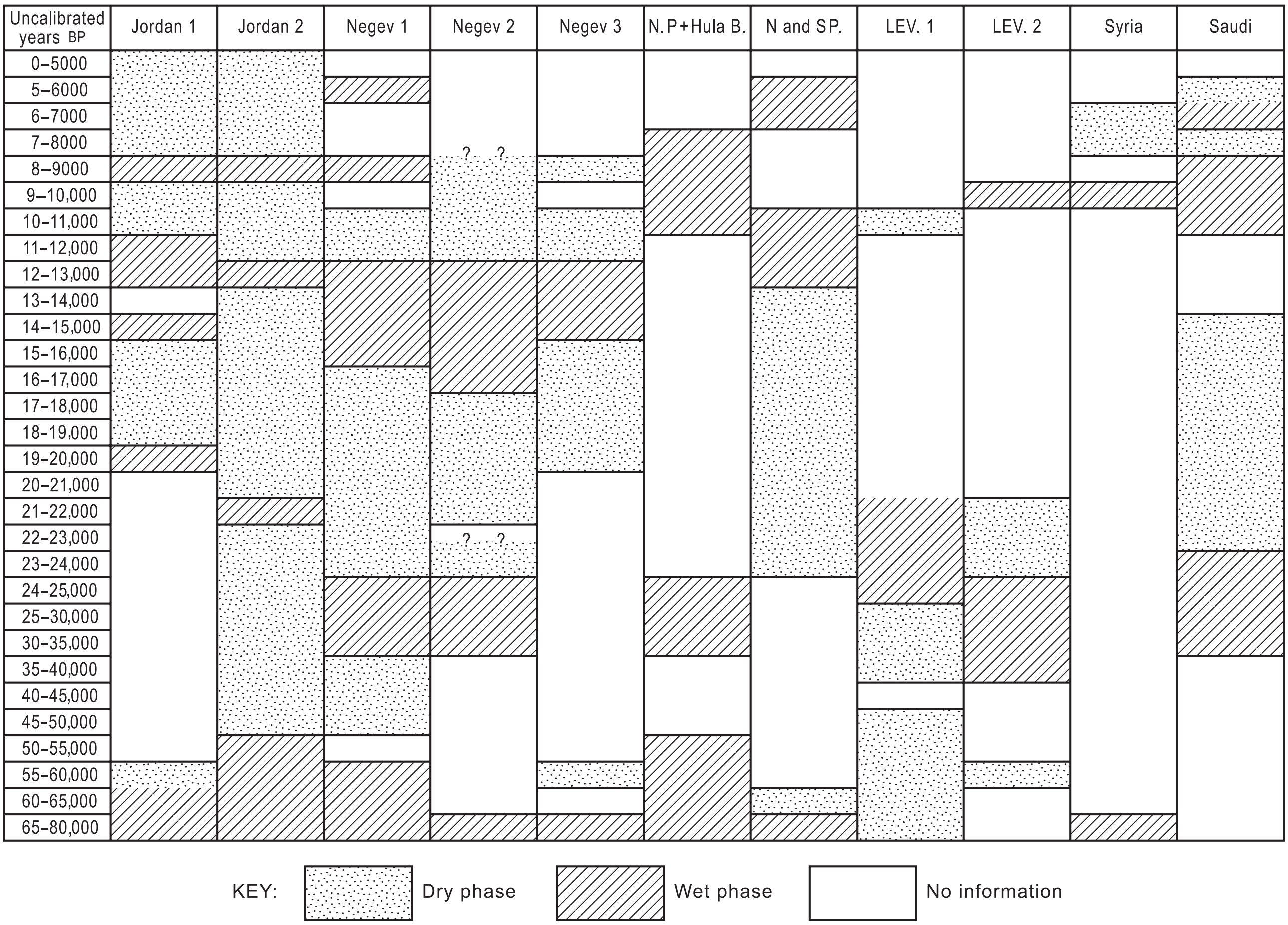


Figure 13.4 *Regional-scale comparison between selected inferred climatic changes across Southwest Asia over the past 80,000 years. (Information presented here is based on reviewing the work of the following authors. Jordan 1, 2 and 3: Henry (1979; 1982; 1986; 1995a); McNicoll* et al. *(1984); Copeland and Vita-Finzi (1978); Zeuner* et al. *(1957); Marks (1981a); Goldberg (1981); Garrard* et al. *(1986; 1987; 1988); Garrard and Byrd (1992). North and south Palestine and North Palestine Hula Basin: Bar-Yosef and Vandermeersch (1981); Farrand (1979); Jelinek (1981); Goldberg (1981); Marks (1977); Bottema and van Zeist (1981); van Zeist and Bottema (1982); Horowitz (1979); Rosen (1995). Syria: Sakaguchi (1978); Leroi-Gourhan (1981); Bottema (1989). Levant 1 and 2: Goldberg (1981; 1986); Horowitz (1979); Tchernov (1981); Noy* et al. *(1980); Henry (1986); Bar-Yosef and Tchernov (1966). Negev 1, 2 and 3: Schwartz* et al. *(1979); Marks (1977); Goldberg (1981; 1986); Henry and Leroi-Gourhan (1976); Henry (1981; 1982; 1983); Henry* et al. *(1981); Tchernov (1981); Bottema and van Zeist (1981). (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Mohamed 1999.)*

elaboration, and sedentism presaging the beginnings of plant cultivation and animal husbandry in the Early Holocene (Barker 2006).

Overall, the project succeeded in establishing an outline litho- and morpho-stratigraphy for the last half million years of the Pleistocene, together with the beginnings of an OSL-based chronostratigraphy, with evidence that the study area experienced profound climatic, geomorphic, and ecological changes that brought about dramatic landscape changes. For the last *c*.100,000 years this sequence is in broad accord with evidence from the wider region (Fig. 13.4). However, the evidence is demonstrably patchy and discontinuous and is not capable of sustaining detailed discussion about the significance of past climates, and climatic change, for the human populations living in (or passing through) the study area, nor about the importance of rapid habitat change for human settlement, nor about the magnitudes of impacts of human activities upon ecosystems.

13.4 People and environment in the Holocene: disaggregating desertification

With the Holocene, the quantity and quality of the evidence for environmental change and human history increase dramatically (Table 13.4), allowing us to attempt to understand the landscape history of the Wadi Faynan in terms of several distinctive themes highlighted by the current work on present-day desertification processes and their potential interactions discussed earlier.

13.4.1 Past climates and their impacts

A generalized palaeoclimatic history for the Holocene deduced for the Faynan area was set out in Chapter 3

Approximate age – uncalibrated BP	**Environment in the Wadi Faynan**	**Nature and intensity of copper mining/smelting and pollution outcomes**	**Anthropology, history and archaeology**
oldest			
In parts of the period *c*.9.6–7.5 kya; Pre-Pottery Neolithic (eighth–seventh millennia BC)	Trees and shrubs (*Quercus*, *Ostrya carpinifolia*, *Juniperus*, *Pinus*, *Tamarix*, with steppe and grasslands, perhaps affected by grazing) grow in wetter climate than prevails today which progressively desiccates, before wetter conditions in late Neolithic. Meandering perennial streams with riparian vegetation extending down the Wadi Faynan replaced more powerful flows of upper part of the Faynan Member?	The first use of local copper ores in the Wadi Ghuwayr. 'Greenstone' beads, and green powder for cosmetic purposes from Faynan became popular throughout Jordan and Palestine. Negligible pollution anticipated – no evidence.	Neolithic site adjacent to a perennial stream with riparian vegetation in the Wadi Faynan.
Parts of *c*.7.5–6 kya Late Neolithic (sixth–fifth millennia BC)	A wetter climate with perhaps $\geq$ *c*.150 mm a^{-1}, rainfall which supports a perennial river perhaps with riparian woodland in the Wadi Faynan. Deposits of epsilon cross-bedded sands and silts with anthropogenic wastes that form the upper part of the Faynan Member. Trees and shrubs (*Quercus*, *Ostrya carpinifolia*, *Juniperus*, *Pinus* (?), *Tamarix*, perhaps at stream sides, elsewhere with steppe vegetation including *Ephedra*, perhaps also grasslands). However there was a distinctive regional climatic aridification, when the lowland landscape changed to steppe with some *Pinus* and *Pistacia*. Possibly fluvial incision began with the adoption of braided conditions leading to the loss of postulated Neolithic and older remains along the lines of the modern wadi floors. Cultivation and pastoral farming present. Aeolian processes became important depositing dunes of silt and sand with carbonate induration which form the basal part of the Tell Loam Member.	Copper ores and some 'greenstone' beads at Tell Wadi Faynan, reflecting the use of copper, but not deliberate smelting of ores. Ores from Umm 'Ishrin Sandstone (sometimes with significant lead) used from exposures in wadis and mountain front. Occasional small pockets of significant anthropogenic pollution in copper, and particularly of lead and thallium, associated with discarded ash (WF5021) on (perennial) stream bank, with minimal pene-contemporaneous recycling.	Neolithic site adjacent to a perennial stream with riparian vegetation in the Wadi Faynan.
c.5.5 kya; Chalcolithic	Marked climatic aridification continues, with perennial water confined to spring-fed run-off water in the wadis. Wind-blown water-washed silts, sands with carbonate induration and ped development on low rise on the Tell Wadi Faynan produces Tell Loam Member (WF5022). A grass-dominated steppe with no evidence of trees may have occurred at this time or slightly later. Essentially the modern pattern of climate, with its occasional winter storms and floods. Braid-plains incise, causing the older Holocene fluvial deposits to be buried, eroded, or abandoned in wadi-cliff edges.	At settlements in Jordan and Palestine, evidence of pyro-metallurgical activities in the second half of the fourth millennium BC indicating 'household metallurgy' – small-scale operations. Small pieces of Chalcolithic (?) slag and copper prills at Tell Wadi Faynan; small-scale mining and metal-working took place in the region of the Faynan. Small-scale local pollution, with corresponding pene-contemporaneous re-cycling. Probable minor re-cycling and/or dilution in carbonate, as a result of wind and surface wash in an increasingly open arid environment.	Chalcolithic site adjacent to a perennial stream with riparian vegetation in the Wadi Faynan.
Parts of *c*.5.55–3.95 kya; Early Bronze Age	A grass-dominated steppe with no evidence of trees may have occurred at this time. Essentially the modern climate and geomorphic regime: represented by the Tell Loam Member of WF5022. Braided planforms continue along wadi floors. First evidence of water storage and floodwater farming.	The first extensive mining and pyro-metallurgical activities; high-grade, copper-manganese ores exploited from widespread but thin, secondary enrichment – including malachite and chryscolla – in Numayr Dolomite Limestone and elsewhere in Burj Dolomite Limestone-Shale. Mines in Wadis Khalid and Dana. Mining and pyrotechnology improve. Large-scale copper 'manufactory' at Khirbat Hamrat Ifdan (*c*.4150–4650 calendar years BP). High purity copper exported across the Levant. Significant local pollution, relatively low in lead, with corresponding pene-contemporaneous recycling of heavy metals.	Abundant EBA settlement in the Wadi Faynan.
Parts of *c*.3.95–3.45 kya; Middle Bronze Age	Essentially the modern climate and geomorphic regime: represented by the Tell Loam Member of WF5022; but strong sustained drought evidenced to the west; braided planforms continued along wadi floors perhaps with significant down-cutting – fluvial incision by storm waters. A grass-dominated steppe with no evidence of trees may have occurred at this time.	Relatively little ore extraction or processing. Minimal pollution signature, only minor recycling.	Little archaeological evidence for settlement in the Wadi Faynan, but aceramic Iron Age burials in Wadi Fidan suggest aceramic pastoral populations may be using Wadi Faynan.
Parts of *c*.3.45–2.85 kya; Late Bronze Age to Early Iron Age	Trapping and management using walls of winter floodwaters to sustain run-off farming take place; development of the major network of walls to manage water and provide crops and animal products east of Khirbat Faynan. A grass-dominated steppe with no evidence of trees may have occurred at this time. Fluvial incision (?) by storm waters; braided planforms continued along wadi floors, occasionally with fluvial deposition extending into smelting wastes in the lower Wadi Dana – essentially the modern climate and geomorphic regime: represented by the Tell Loam Member of WF5022.	Renaissance of metal production? Progressive increase in copper pollution, a proportionately larger increase in lead pollution (WF5022 zone 2d), followed by minor reduction in heavy metal pollution (WF5022 zone 2c); uncertain – inferred decline in input by wind of carbonate minerals.	

Table 13.4 *Summary of information on the inter-relationships between people, their activities, past environmental conditions, the scale of mining, metallurgy, and their pollution outcomes in the Faynan survey. (After Chapters 6–11 and the authors therein.)*

Approximate age – uncalibrated BP	**Environment in the Wadi Faynan**	**Nature and intensity of copper mining/smelting and pollution outcomes**	**Anthropology, history and archaeology**
Parts of *c*.2.85–2.55 kya; Iron Age IIB and IIC, first millennium BC	A grass-dominated steppe with no evidence of trees may have occurred at this time. Braided planforms continued along wadi floors – essentially the modern climate and geomorphic regime: represented by the Tell Loam Member of WF5022, and wadi floor and barrage infill deposits at WF5012 and WF5017.	Second main period of copper production in region. Innovations in mining and smelting occur, together with further substantial expansions of copper mining and smelting. Original outcrops of high-grade copper ores in Burj Dolomite Limestones Shale become exhausted. Mining reverts to the Umm ‘Ishrin Sandstone, which contains less lead, with re-processing of earlier prehistoric slag. Metallurgical activities on a new industrial scale. Mining and smelting, well-organized and on a sophisticated scale with improved geological understanding. Exploitation of deep mineralization by shafts 60 m deep. Faynan region has largest copper production of the entire Near East beside Cyprus. 100,000 tons of black, copper slag, still often unvegetated, left at the Khirbat Faynan and Khirbat an-Nahas. Sustained increase in copper pollution; with significant pollution from lead that fluctuates slightly in intensity. Substantial metal pollution, relatively lead-rich anticipated, with corresponding extensive penecontemporaneous recycling.	Major metal-working centres at e.g. Khirbat an-Nahas and Khirbat Faynan; small ?agricultural settlements; diversion-wall floodwater farming.
Parts of *c*.2.55 kya to *c*.1450 calendar years ago; Nabataean and Roman–Byzantine periods	A steppic and desertic vegetation and geomorphic regime, with a wetter climate; perhaps but not certainly local exhaustion of wood supplies. Wood-management or harvesting strategies in place? Extensive pressures on wooded vegetation for fuel and for cultivation and grazing may have caused the vegetation to remain open and steppic. Braided planforms continued along wadi floors, occasionally with fluvial deposition extending into smelting wastes in the lower Wadi Dana. Lower parts of barrage infill deposits at Khirbat Faynan (WF5012, WF5017, and ash-rich smelting waste (e.g. WF5738, WF5741).	Extensive use of shafts and deeper underground passages in magnesium-rich ores in Umm ‘Ishrin Sandstone – together with new methods of smelting, countered the local exhaustion of the thin seams of DLS. Large-scale mining and smelting from the first century BC to fifth century AD; much exploitation in the third and fourth centuries AD. At Umm al-Amad, mines first worked 2500–3000 years earlier, are significantly re-used; old mines serve as entrances for the new larger underground mines driven through shafts with deep connected underground passages. 1.5 m-high galleries interpreted as indicating animals transport the ore inside the mines as well as from the mines to the central smelting works at Khirbat Faynan. Spring and stream water was supplied to the Khirbat Faynan by a series of aqueducts and stored in a large reservoir. 50–70,000 tons of copper slag at Wadi Faynan (WF5052, WF5053). Metal working with professional mine engineers and forced labourers. Substantial and dangerous concentrations of copper and lead, initially rich in lead, with change from relatively lead-poor to lead-rich pollution in wastes reaching >40 k ppm Pb; 16 k ppm Cu, and substantial 90 ppm Tl where there are ash and charcoal from smelting (WF5738, WF5741); transition from relatively rich to lead-poor pollution at dangerous, poisonous and toxic levels, with substantial pollution in crushed ores in colluvium, then in impounded water by smelting areas. Disposal of massively contaminated wastes from smelting as piles and onto braid-plain where rapid geomorphic removal and/or dilution down-wadi occur (WF5731 – Unit 3), with significant geomorphic re-recycling indicated by fluvial deposits producing heterogeneity and undated wind-induced distance-decay effects to south (SP8-2); copper and lead appear to behave differently. Many smaller sites (SP1, 6, 18, 31, 32–5) characterized by intense local pollution with copper and lead and associated suites of dangerous volatile metals sporadically preserved with ash-charcoal (WF5022 zone1).	In Byzantine period, Khirbat Faynan became an even more significant location: it became the Seat of a Bishopric, with three other churches.
c.1450–650 calendar years BP; Early Arab period	Steppic and desertic vegetation and geomorphic regime, in climate similar to that of the present day, but which became increasingly arid. Represented by barrage infill deposits at WF5012 and WF5017, and Upper and Lower Dana Wadi Members. Wadi floors are braid-plains with aeolian and fluvial storm deposition.	Mining and smelting activity around Faynan decline rapidly after the Roman-Byzantine period. After AD 500 the Faynan ceases to be a major copper supplier in the Levant. Initial rapid decline in concentrations of copper and lead, and associated metals after peak of Byzantine activity, followed by progressive reduction over *c*.1300 years to present, during periods in which the geomorphic environments altered with one sustained episode of aridity; input of strontium increases; lead reduces in concentration in surface deposits much less rapidly than copper. Small-scale smelting during the early medieval Islamic periods at al-Furn, Faynan, Ain Fidan and probably in the Wadi Dana leaving a patchy trace. In late Ayyubid/early Mamluk period, in the thirteenth century AD, possibility that in addition to copper, lead was deliberately smelted	Predominantly seasonal use of Wadi Faynan.

Table 13.4 *(cont.)*

Approximate age – uncalibrated BP	Environment in the Wadi Faynan	Nature and intensity of copper mining/smelting and pollution outcomes	Anthropology, history and archaeology
c.650 calendar years ago to present	Steppic and desertic vegetation become fully desertic with marked aridification that lasts from about *c*.550 to *c*.100 calendar years ago and is correlated with the European Little Ice Age. Wadi floors are braidplains with aeolian and fluvial storm deposition leaving distinct terrace landforms, which are exposed by subsequent or related incision. After this arid period, a slightly wetter climate occurred, producing the modern conditions. There was a slight increase in the number of trees and shrubs, with wind-blown silts observed to enter the global atmosphere. The modern land-surface is a complex palimpsest.	No metallurgical activity: re-cycling of surface deposits anticipated. Modern survey of ore resources by the Natural Resources Agency. Recycling of copper and lead continues at comparatively low rate through biological processes to a few hundred ppm; fluvial and aeolian processes on wadi floor produce great heterogeneity in heavy metal burdens; mix of aeolian and overland flow, recent ploughing and clearance, the surface heavy metal loads beyond the land around the Khirbat Faynan and the wadi-floor are also heterogeneous. Copper was removed from the circulation of heavy metals at the land surface by natural processes more rapidly than lead. The overall rate of loss by such biogeochemical-biogeophysical processes over the last 1500 years has been comparatively small in comparison to the magnitude of the pollution legacy.	Pastoral/seasonal use of Wadi Faynan.

Table 13.4 *(cont.)*

(summarized in Table 3.3 and Fig. 3.17). It depended on the use of modern biogeographical information, adjusted to accommodate local pollen taphonomic studies, as well as independent geomorphic and charcoal evidence of the existence of perennial surface water or at other times, more arid conditions. Whilst we have confidence in its general characteristics, examination of the details of the sites set out in Chapters 7–11 indicates that it can only be regarded as a first approximation. However, as described in those chapters, one of the most remarkable aspects of the archaeological and palaeoecological conclusions from the project is that there are many parallels with other palaeoclimatic evidence gathered in adjacent areas of Southwest Asia (Fig. 13.4), and with an even wider geographical synthesis of Holocene climates (Roberts *et al*. 2004). Interestingly, this parallelism is found not only in similarities between the broad course of palaeoclimatic events but also in the consistencies or apparent inconsistencies between the various lines of evidence – patterns which are likely to be significant.

The time resolution of the various surveys limits the extent to which important comparisons can be made between the various regions. For example, our data are not sufficiently precise to support the first key palaeoclimatic conclusion by Roberts *et al*. (2004), based on the frequency of short-duration 'see-saw' climatic effects evident in instrumental and tree-ring records, that wetter periods in the western Mediterranean were associated with drier periods in the east, all ultimately attributed to North Atlantic Oscillation (NAO) fluctuations. Nevertheless, there is much coherence between the palaeoclimatic records derived throughout the entire region and the climatic evidence identified in Wadi Faynan for five significant climatic episodes in the Holocene: (1) a significantly wetter Early Holocene; (2) Early Bronze Age substantial aridity; (3) the wetter Roman/Byzantine period; (4) a period of significant aridity with occasional wetter episodes *c*.600–100 BP; (5) the relatively moister, but nevertheless still arid, twentieth century. We found no evidence in the Wadi Faynan to suggest that any of these distinctive changes in degrees of aridity are the result of anything other than changes in the regional climate, notably in precipitation; fluctuations in temperature remain obscure. Within this history, several climatic events are particularly distinctive and widely recorded throughout Southwest Asia, the Mediterranean, and North Africa.

The first event is the significantly wetter climate of the Early Holocene, resulting in a landscape that differed in a fundamental manner from all those that followed (Hunt *et al*. 2007b; Mohamed 1999; Roberts *et al*. 2004). On the evidence of the geomorphology and palaeoecology of the study area, this climate caused biologically-richer woodland vegetation to extend westwards from the mountain front escarpment as riparian woodland bordering perennial meandering streams into locations that are now desert (Chapter 7). The greater extent of regional forest biomass was attributed by Roberts *et al.* (2004) to the reduced intensity of summer drought, but in the Wadi Faynan we found no unequivocal evidence to show whether or not greater wetness was associated with higher annual temperatures.

The second event is the sustained and marked aridification marked by the loss of species diversity, productivity, and biomass that may have started 6000–5000 years ago, within the Early Bronze Age, but which is apparent at the Tell Wadi Faynan exposure in terms of increasing aeolian deposition and thin palaeosols by the end of the third millennium BC (Chapter 8). The regional evidence indicates oscillating but declining levels of precipitation between *c*.5000 and 3000–2000 years ago (Roberts *et al*. 2004). The exact correlation of these inferred oscillations with the climatic developments in the Faynan is not clear. The local evidence is not at odds with the regional model, but the timing, strength, abruptness, or longevity of aridification here remain unknown because we cannot assess whether hiatuses in exposures reflect local episodes of erosion, truncation, or re-working, or abrupt, regional-scale, climatically-driven events. Targeted OSL dating is needed. This substantial climatic shift caused steppic and perhaps desertic taxa to spread to or close to the base of the mountain front, and aeolian-dominated processes replaced perennial fluvial processes on the floodplain. At the end of the Early Bronze Age there was also a decline in occupation in the Wadi Faynan (or at least, a decline in visible evidence for settlement) and in industrial activity according to their pollution signatures. There is no evidence that this aridification was the result, in part or whole, of human activities; rather, the opposite is the

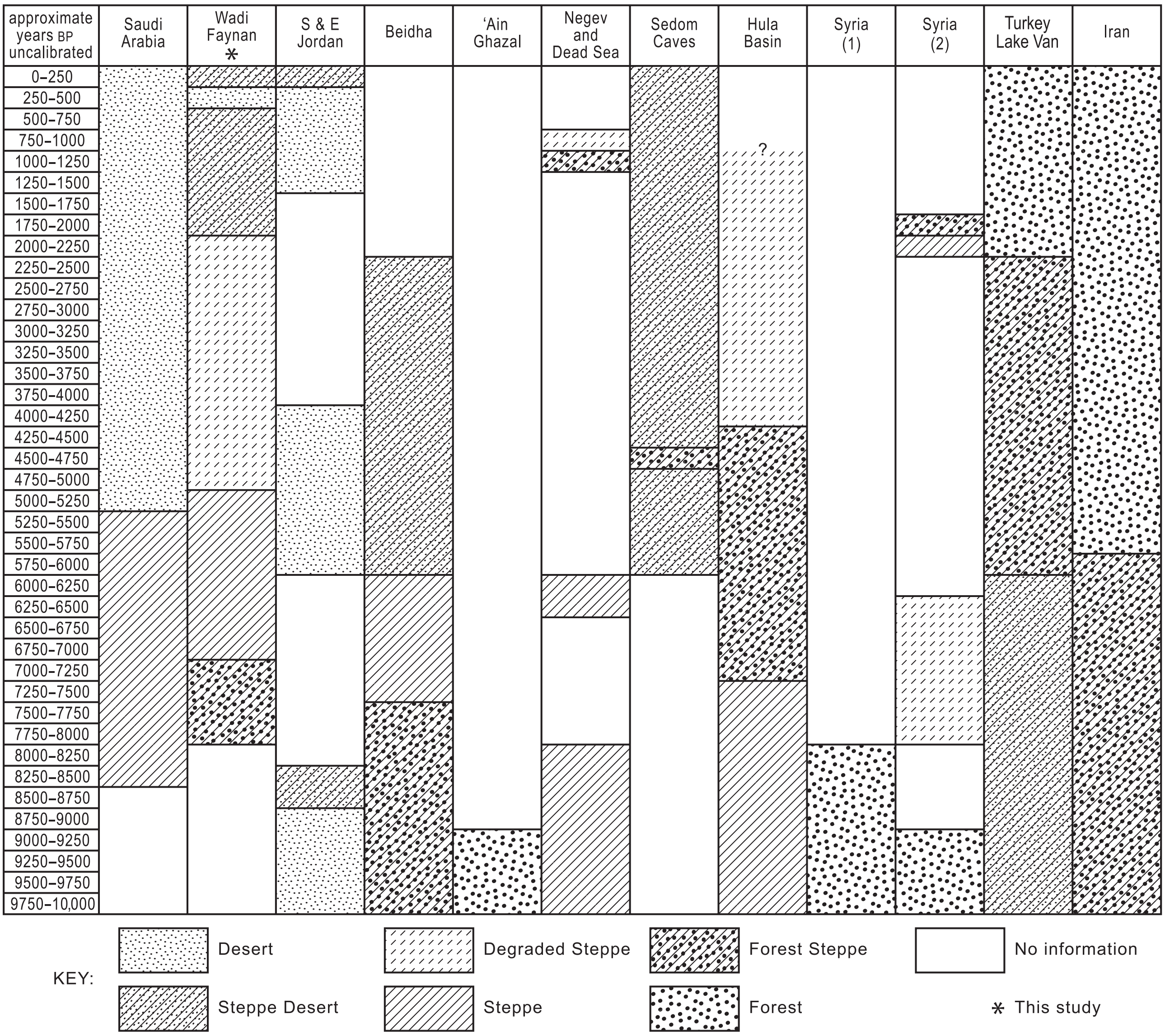


Figure 13.5 *Regional-scale comparison between selected inferred vegetation changes in Southwest Asia over the last 10,000 years. (For references on which this information is based see caption to Fig. 13.4.) (Illustration: David Gilbertson, Ian Gulley, and Antony Smith, after Hunt* et al. *2007b; Mohamed 1999.)*

case. The extent to which aridification as opposed to other socio-economic-political factors was the primary 'driver' of settlement changes is subject to active debate (Chapter 8), but it seems more productive to examine these matters in terms of synergies and feedbacks rather than opposed alternatives. Whatever its precise antiquity, the onset of greater aridity changed the character of the Wadi Faynan irreversibly, bringing about the landscape that has survived to the present, of arid steppes, grasslands, and desert incised by channels and braid-plains.

There is unequivocal geomorphic and palynological evidence that aridification driven by a changing regional climate also took place after about 600 years ago (Chapter 11). Desertic conditions again reached to the foot of the mountain front, but in this case they affected a landscape already substantially abandoned by people and industrial activity after the peaks in Classical times. Evidence of the possible associations between aridification and human settlement is therefore more ambiguous than in the Mid Holocene: at the regional scale a sustained climate-driven 'desertification' probably did take place equivalent to the European Little Ice Age, but it probably had rather limited human consequences in a relatively empty Wadi Faynan of limited biological productivity. The details of its relationships to a brief episode noted of 'medieval' metal smelting and pollution at Khirbat Faynan are unclear.

The evidence from the Faynan, though, certainly indicates that 'desertification' driven by regional climatic aridification was not one-directional, but has also been reversed. An example is the modest vegetation and geomorphic changes that accompanied wetter climates over the last century, a time which was also one of comparatively

Period	Timescale (years)	Maximum slag (tonnes)	Maximum copper production (tonnes)	Average copper per year (tonnes)	Maximum total charcoal (tonnes)	Charcoal per year (tonnes)
Early Bronze Age	1000	5000	500	0.5	45,000	45
Iron Age	800	130,000	13,000	16.25	800,000	1000
Roman/Byzantine	400	70,000	7000	17.5	560,000	1400

Table 13.5 *Copper production and charcoal requirements compared (all figures from Hauptmann 2007: 52–3, 147). Our calculations in Chapter 10 suggest that the total charcoal consumption could have been even higher.*

limited human impact on the landscape (Chapter 11). The general impression of the modern and palaeoecological evidence (Chapters 2 and 3) is that recovery from profound drought may have been more protracted after the major episode of pollution in Roman/Byzantine times compared with changes after earlier droughts.

13.4.2 Human impacts on vegetation

As elsewhere in the region, the study area provides evidence of many local, small-scale, anthropogenic disturbances to soils and vegetation cover during the Early Holocene, probably as a result of the effects of grazing animals but perhaps also from the harvesting of wild grasses during simple cultivation (Hunt *et al*. 2004; Chapter 7). These impacts would not have had irreversible ecological consequences, or posed a serious threat to settlement. (Small-scale impacts may well have occurred too in later periods, but if so they have been subsumed within the greater impacts that were to follow.) The beginnings of the practice of floodwater farming in the Early Bronze Age appear to coincide with further evidence for industrial- and agriculturally-driven impacts on the vegetation and soils (Chapter 8). Studies of pollen from small water-collecting sites, and of charcoal from slag heaps, demonstrate that timber trees progressively became less common through the second and first millennia BC, leading to an almost complete absence in the palaeoecological record by the Classical period. Hauptmann's estimates of timber consumption in the three major phases of mining are summarized in Table 13.5. Given the potential inaccuracies in these figures, the interpretation cannot be pushed too far, but it is interesting nonetheless that the Roman/Byzantine annual copper output and charcoal consumption figures are broadly similar to those of the Iron Age, whereas the Iron Age has hitherto tended to be highlighted as the peak period of production and impacts (Hauptmann 2007: 153–6).

In the Bronze Age, timbers of high calorific value from taxa such as *Juniperus* and *Quercus* were in use, whereas by the Iron Age, charcoal was dominated by wood from smaller lowland and wadi shrubs such as *Tamarix, Retama, Haloxylon,* and *Acacia,* together with timber of taxa such as date palm from springs or irrigated land. The ensuing loss from the lowlands of good fuel trees such as *Juniperus* and *Quercus* reflects the massive exploitation and procurement needed to support the metal-extracting industry in the Iron Age and Roman periods, rather than climatic change. Wood-gathering on a major scale must have drastically diminished the main timber sources in the gorges and accessible slopes of the mountains, with substantial effects on other plant and animal life and on soil stability. It is difficult to imagine that at the periods of most intense industrial activity adequate quantities of appropriate good timber wood could have been recovered within a day's walking distance in this terrain, as previously suggested in the original charcoal-based research (Engel 1992; 1993; Engel and Frey 1996). Our calculations of the amount of timber needed by the mining and smelting operations of the Roman/Byzantine period (Chapter 10, §10.9) imply the deliberate production and management of wood over large areas; it is not surprising that the few tree pollen recovered in the industrial areas of the Wadi Faynan have been attributed to long-distance transport from distant uplands. The average annual Roman/Byzantine consumption figure of charcoal derived from Hauptmann's estimates would represent the felling of approximately 17,000–18,000 cubic metres of timber. The absence of an increase in tree pollen in the sediments behind the Khirbat Faynan barrage in Byzantine times, a period of greater precipitation, is also readily understood in terms of this massive demand for wood. The impact of Iron Age/Roman/Byzantine mining and smelting on local biomass, biodiversity, wildlife, and soils was clearly profound; this might best be considered not in the neutral language of 'human impact' or 'biological change', but as a sustained local ecological catastrophe whose consequences are still with us today.

The fact that tree- and shrub-rich habitats exist nowadays in many places on the mountain front and in the gorges (Chapter 2) is evidence that, after an industrial-scale ecological onslaught that lasted well over 1000 years, some vegetation has managed to survive, and then to recover, over the past 1500 years. Such resilience appears to be a distinctive property of arid-land vegetation (Gilbertson 1996; Noye-Meir 1978; 1985). On a global scale, desertification today is typically associated with wood extraction only when the latter is combined with agriculture and increasing aridity (Geist and Lambin 2004). In the case of the Wadi Faynan, the slightly wetter climate and limited land use of the past century ought to have boosted the production of airborne tree pollen and aided the recovery of woody taxa, but these did not happen.

13.4.3 Human activity and the management of water and soils

Deliberate water management in the Wadi Faynan between the Early Bronze Age and the Roman/Byzantine period is clearly evidenced by the progressive, if episodic, development of wall networks, both to manage water and to create cultivable land (Chapters 8–10). In the Negev, Rosen (1995) suggested that such activity represented sustained attempts to improve or buffer cereal cultivation in the face of environmental challenge. By analogy with ancient wall systems in North Africa and elsewhere in Southwest Asia, it seems likely that the many enclosed fields constructed on the relatively permeable deposits of the Faynan and irrigated by seasonal floodwaters were significantly richer and more productive in plants and animals than non-irrigated land, their fertility perhaps further enhanced by the deliberate management of timber-yielding shrubs and trees, and the enhanced propagation and survival of woody species against walls (Gilbertson 1996). The dense spreads of (especially) Roman and Byzantine sherds and other cultural debris in the Wadi Faynan fields are taken to be evidence of further attempts to enrich the soil by manuring. The wall networks concentrated storm-water run-off in enclosed arable or pastoral land, impeded run-off, and promoted infiltration, especially where the fields were located on the widespread, relatively porous, Pleistocene deposits.

In the Roman/Byzantine period, too, critical importance was given to the delivery of spring water via conduits and aqueducts to the Khirbat Faynan community and its industrial zones and their industrial activities. This running water, though, was not always safeguarded from toxic waste: the water flowing down the primary feeder conduit to the main reservoir (WF11), for example, must have been badly polluted by the smelting residues dumped around and sometimes directly on top of it (Fig. 1.4), and the sediments that accumulated behind the Khirbat Faynan barrage during Roman/Byzantine times are so toxic (Chapters 10 and 11) that it seems unlikely that any standing water collected behind the barrage could have sustained human, plant, or animal life. It is possible that the water supplies were mainly or totally used for industrial purposes, or that there was a total ignorance of or disregard for the consequences of drinking polluted water. Perhaps potable water, as now, was obtained directly from the excellent springs in the gorges of the Dana and Ghuwayr.

The palynological, palynofacies (VAMs and microcharcoal), charcoal, and geochemical evidence from around Khirbat Faynan indicates that significant soil erosion began in the Early Bronze Age and intensified dramatically between the Iron Age and Byzantine periods. Indicators of erosion are largely missing from the comparatively brief episodes of aridity that developed in the later phases of the Bronze Age (in the second millennium BC), as well as for the period from 600 to 100 years ago, implying an absence of erosion-producing human activities that correlates with the periods for which there is a paucity of archaeological evidence for settlement (Chapters 8 and 11).

13.4.4 Geomorphic systems

Changes in the prevailing fluvial geomorphological systems can be shown to relate variously to both climatic and human impacts. The wetter climate of the Early Holocene was characterized by small-scale erosion of colluvial and loessic sediments on slopes and the development of alluvial fans and various types of wadi infill deposits. The transition in the Faynan channel from a meandering to a braided planform with associated incision seen at Tell Wadi Faynan after the Late Neolithic/Chalcolithic occupation is matched by well-documented and similar findings elsewhere in the region, and is attributable to regional climatic change (see above). There is insufficient evidence to establish any clear associations between the intensity of industrial activity from Bronze Age to Classical times around Khirbat Faynan and the episodes of fluvial aggradation and deposition noted in the lower Wadi Dana, though such associations are likely, with direct effects such as changes in flood magnitude–frequency and erosion–deposition. Overall, however, the project's data demonstrate that, despite the evident power of industrial and agricultural forces on the land surface, climatic controls were the dominant force affecting the behaviour of the Wadi Faynan's fluvial systems (Hunt *et al*. 2007b). In the post-Byzantine period, it was distinctive episodes of aridity rather than human activity that prompted episodes of further incision and aggradation on the braid-plain, giving rise to the distinctive landforms and deposits of the Dana Wadi Beds. In some locations, away from areas of obvious erosion, fine-grained aeolian deposits have provided a semi-continuous thin soil cover. Within sedimentary basins such as the Khirbat Faynan barrage infill or on the modern braid-plains of the wadis, substantial quantities of the heavy metals introduced by mining and smelting continue to be re-worked and recycled today, but the rate of removal is slow in comparison with the legacy left by earlier industrial activity. Fluvial processes on the braid-plains have created more complex patterns of residual heavy metal concentrations. Human-induced or -mediated processes continue to influence the rate and patterns of heavy metal circulation in the area (Chapter 3), whilst aeolian processes must remove an unknown but significant quantity of polluted dust into the atmosphere.

13.4.5 Heavy metal pollution, biological productivity, and human health

Investigations of human health and well-being in relation to desertification typically relate to matters of malnutrition, famine, minimal access to good water, losses of crops and livestock, dearth of firewood, and sickness and distress consequent upon them. Such problems probably arose many times for the ancient populations of the Wadi Faynan, but the relative ease with which people with their herds could escape to the springs and the better watered-uplands probably provided some relief and mitigation (Chapter 2). Different aspects of human health and well-being have been discovered in this study.

The project's geochemical studies demonstrate that the landscape in the immediate vicinity of the Faynan mines and smelting sites was substantially damaged by the release of heavy metals by ore processing, especially between the

Material	Copper concentration (mg/kg)
Bread	364
Dung	150
Floor	1800–2040
Fuel: *Acacia*	166
Oleander (*Nerium*) (use unclear)	159
Shop-bought flour	13

Table 13.6 *Copper pollution in the domestic life of bedouin in the Wadi Faynan. (Modified from Pyatt* et al. *2002b and subsequently summarized by Grattan* et al. *2003b.)*

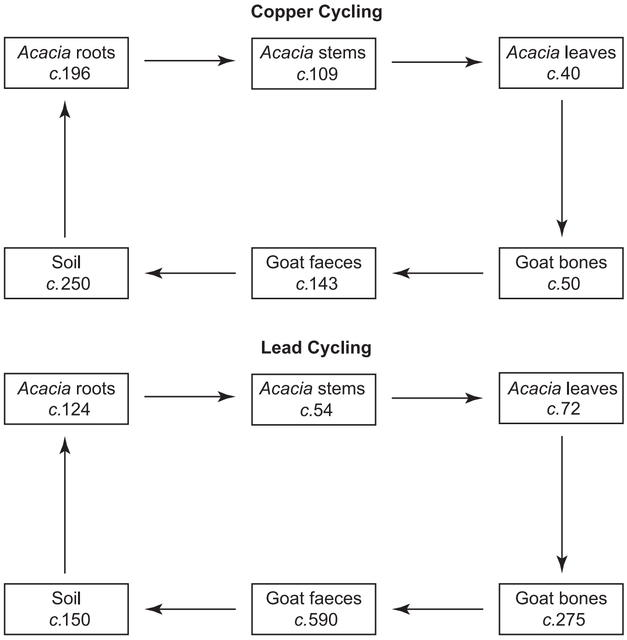


Figure 13.6 *Pollution pathways, concentration mechanisms and sinks for copper (above) and lead (below) in mg/kg, in present-day domestic organisms in Wadi Faynan. The* Acacia *spp. data is from a control site in all cases. (Derived from some of the data published by Pyatt* et al. *2000 and presented more fully in Chapter 3. Data summarized additionally from Grattan,* et al. *2003a.)*

Iron Age and Byzantine periods. In places the land was totally poisoned: the concentrations of copper and lead in the Roman/Byzantine sediments behind the Khirbat Faynan barrage exceed those found at the world's primary site of sustained copper smelting in the nineteenth century, in the Lower Swansea Valley, South Wales (Bromley and Humphrys 1979). Plant productivity, including that of domesticated cereals, is likely to have been reduced by more than the 50 per cent in the vicinity of smelting or polluted ground in comparison with more pristine ground several kilometres distant (Fig. 3.15, Tables 3.8, 3.9). Spreading manure and 'night soil' to fertilize affected land, and grazing livestock on it, would have helped recycle and then spread elevated lead and copper concentrations. The ancient industrial history of the Wadi Faynan continues to impact significantly on the present-day inhabitants. Likely pathways and sinks of noxious metals in the area were listed in Figure 3.15; actual reconnaissance data on such pathways and sinks for copper in domestic life of modern Bedouin camps are given in Table 13.6, which is summarized from Grattan *et al*. (2003b). These measurements suggest that heavy metals continue to enter domestic life through a number of biogeochemical pathways (Fig. 13.6).

The nature of the tents is clearly important (Figs 12.1, 12.3). Tents made of goat-hair or similar semi-permeable materials retard air-flow and can be seen to cause metal-bearing dusts to accumulate upon, about, and within them, to be recycled when the fabric is disturbed. Likewise, exposed cooking and storage vessels, domestic utensils, implements, carpets, furnishings, hair, clothing, animal skins, and all the other necessities of life are vulnerable to contamination by metal-rich dust. The concentrations of copper that have accumulated in the tent-sediments that are adjacent to spoil sites are substantial, in the same order of magnitude as those detected in the adjacent spoil (the background concentrations in the underlying Pleistocene deposits being in the order of 1–60 mg/kg). Although the greatest pollution was not detected in a tent pitched directly upon smelting slag, the lowest concentrations were detected in those tent-sediments that were furthest from the spoils.

Wood of *Acacia* gathered near a tent and being used as fuel had substantially raised metal content in comparison with controls taken 5 km distant to the east in the mountains. The effects of burning such metal-rich wood and dung, together with dust contamination of cooking and storage utensils, are suggested in two components of these data. The first is the notably higher concentrations of copper detected in the tent floor sediments detected in the womens' area of the tents, and at the hearth sites where cooking takes place, reaching *c*.2440 mg/kg at the hearth site in one tent. Second is the copper content of bread made within the tent where dough had been manipulated on wooden working surfaces that were exposed to the air and then baked: copper concentrations in this locally-prepared bread reached *c*.18 times those of flour available in local stores or in bread made in Amman.

These data correlate with the main conclusions of other research on modern communities where there is active mining of metalliferous ores. These investigations indicate that in everyday life, both at home and in administrative areas, metal pollutants spread as dust and concentrate in significant quantities through families and on to other people whose lives were removed from the main areas of metal concentration (Grattan *et al*. 2003a,b; Jha *et al.* 2001; Lipsztein *et al*. 2001; Pelig-Ba *et al*. 2001). The documented means of transfer observed within such modern communities, typically with more permanent solid buildings than in the Faynan study, may be via direct skin contact with carpets, clothing, cosmetics, animal skins, and crops; through hand contact with mouths; by the preparation and ingestion of metals within and upon plant and animal foods; carrying and storing water and food in open containers; drinking water; through inhalation of air in domestic spaces; and through more direct contact with air-fall pollutants in stored drinking water or overland flow.

It is clear that the bedouin living in Wadi Faynan are exposed to high concentrations of metal within their domestic environments. Despite appearances to the contrary, they are in fact living in an environment which contains occasionally profound levels of industrial contamination. Living in such an environment from birth may pose real problems for human health; constant exposure may overwhelm the body's excretory processes and lead to accumulation within important organs, compromising their function and in the long-term increasing the risk of failure and serious illness.

The concentrations of heavy metal detected in the environment suggest that the bedouin of Wadi Faynan are likely to be vulnerable to a range of illnesses related to the intensity of individual exposure (see Chapter 3, §3.5). Most serious for the bedouin of Wadi Faynan is the range of pathways by which this study suggests they are exposed: the floor dusts in their dwellings, the meat and dairy products of their livestock, the fuel they burn, and the dust they involuntarily ingest are all potential sources of heavy metals (Fig. 3.15 and above). These issues are serious but in the absence of detailed physiological and medical examinations of the bedouin there is little detailed knowledge of the impact of these conditions on modern health. As a result of this work, obviously polluted campsites have been identified and the local population has been advised to discontinue their use. However, it appears that traditional practices may lead to a concentration of metals in the campsites through time, mainly through the concentration of organic material enriched in metals absorbed from the environment. For the future it will be useful to assess the degree to which metals have accumulated in the many ancient campsites identified in this study.

The metal loadings in various plants, animals, water, foods, and material culture of the present-day bedouin, combined with epidemiological research elsewhere, suggest that the health and well-being of many longer-term occupants in the area would have been compromised during times of intense metallurgical activity (the Iron Age to Byzantine periods), whilst such difficulties may also have affected earlier and later populations to a lesser degree (Grattan *et al.* 2003a,b; Chapter 3). The list of possible debilitating conditions resulting from sustained exposure to copper and lead includes headache, loss of appetite, nausea, vomiting, diarrhoea, fatigue, abdominal cramps, constipation, confusion, convulsions, coma, Wilson's disease, motor nerve paralysis, anæmia, blood disorders, brain damage, Parkinson's disease, the destabilization of nucleic acids, bone disorders, and various tumours, and cancers (Grattan *et al*. 2002; Pyatt and Grattan 2001). To this litany of misfortune we can probably add further complications for professional miners, smelters, and overseers working in the Faynan metal industry exposed to particles in smoke, aerosols, and gases, and to radon gas liberated and concentrated in mines and shafts with limited ventilation (Chapter 3). The skeletons analysed from the Roman/Byzantine South Cemetery (Chapter 10) demonstrate that some individuals in the Wadi Faynan population had little exposure to metals (whether because they were in 'reserved occupations' or died quickly is not clear) but many had evidence of lengthy and dangerous exposure to pollutants. Evidently gross pollution is not a property unique to the modern industrial world – it was taking place in antiquity. In contrast, archaeological evidence of the notorious if mercifully brief episodes of grotesque inhumanity described at *Phaino* by Bishop Eusebius remains unidentified by us at Faynan. Similarly, whilst our new geoarchaeological evidence has facilitated informed guesses about the extent of misery, pain, degradation, and inhumanity experienced by some (but not all) components of the human and natural worlds in the Faynan, the evidence of the many other possible events that could have taken place hereabouts remains largely hidden from us: for example, civil strife or hostilities induced by the desire for metals, or household-distress associated with distant variations in the demand for them.

13.4.6 The singularity of the history of desertification in the Faynan

Whilst the Holocene prehistory and history of the Wadi Faynan landscape share numerous similarities with many other locations across Southwest Asia and the Mediterranean, our project has also highlighted their singularity. Of primary importance in this respect have been the patterns and processes of the mining, smelting, and export of the unusual and rich assemblages of metals that occur in the mineralized Palaeozoic bedrocks, and the intensity, magnitude and great longevity of the direct and indirect impacts on the landscape that resulted from their exploitation. The topography of the Faynan landscape, with metal-rich ores exposed in spectacular wadis eroded into the rugged terrain of the mountain front, and where ground water was locally available, were also factors that strongly influenced the character of past developments and the modern legacy. The particular location of the Wadi Faynan at the junction between the hyper-arid desert of the Wadi 'Arabah and the Mountains of Edom evidently variously enhanced or lessened the effects of significant variations in climate, some of which seem to have been relatively slow and others relatively abrupt. The small size of the study area makes comparisons difficult with most studies of contemporary desertification. In analytical terms, we have far more (plausible) causal variables than we have experimental outcomes to evaluate them. But counter to this is the considerable timescale of the landscape history described in this volume. The study has demonstrated the importance of social-economic-political developments over 5000–6000 years for both the economy and the ecology of the Wadi Faynan. The main local pollution events date from the Bronze Age to Classical periods, but the local narratives to which they contributed were also part of economic, social, and political histories that linked the Wadi Faynan with distant regions (see below: §13.6 Cores and peripheries). The effective abandonment of the region for nearly 1500 years after Classical times demonstrates both the unsustainably high cost of exploitation and the very slow rate of natural recovery of its intensively polluted ecosystems and the longevity of its industrial legacy.

The processes of desertification in the Wadi Faynan have been shown to be of great antiquity. As a result, a further lesson from the project is that it provides a perspective upon Geist's (2005: 3–4) observation that such 'time-depth' can provide an example from which to 'derive generic principles of the co-evolution of relationships between human society and natural environments'. In this particular region, where the environment has been placed under profound and sustained pressure over timescales to be measured in centuries or millennia, perhaps the lesson from the new information is that there has been no such 'co-evolution'. At a wider geographical scale, the dominance of both climatic and industrial causes of desertification as determined in the Wadi Faynan was recorded by Geist and Lambin (2004) for only seven per cent of all situations reported around the world. This proportion becomes even smaller as more complex combinations of causal factors are included in Table 13.2. If the pathways and causes of desertification recognized in this Faynan study are included in the lexicon of desertification, a universal pathway of desertification can never be recognized. In the case of the Wadi Faynan, neither local human population numbers, nor the overall adverse environmental impacts of their activities, nor fluctuations in aridity, ultimately proved the key property influencing the most evident archaeology, palaeoecology, and productivity of the area: in the broadest of terms, its status was caused and sustained by economic-social-political drivers located tens, hundreds, or thousands of miles distant, the theme of the following section. Such thinking about desertification in ecosystematic terms moves us on from the traditional climate:people dichotomy to something that is more closely related to reality: a complex intermeshing of natural and cultural processes and values. The time-depth provided by the Wadi Faynan Landscape Survey provides an important perspective on the complexity of desertification, which we have to understand if we are to improve the well-being of the arid environments of the modern world and the people who dwell in them.

13.5 Scale and complexity

How many people were there in the Faynan region in different periods? The question is a fundamental one in landscape archaeology, with its common focus on reconstructing changing patterns of human occupation. For this study, it is a particularly difficult one to answer because of problems of archaeological visibility, because the chronological phases are of very different lengths, and because we did not in fact attempt a regional survey in the manner of the Kerak plateau survey (Miller 1991) or the Southern Ghors and Northeast 'Arabah Survey (MacDonald 1992). Modelling out from a 30.5 sq. km sample to the broader landscape of *c.*700 sq. km (as represented in Figure 1.3) is potentially problematic. Indeed, in certain phases of human activity it is clear that the density of 'sites' in the central Faynan valley is highly atypical of the surrounding desert region due to the unique congruence of springs, cultivable land, and copper ore deposits. Some data are available on immediately adjacent areas, notably through the surveys of Finlayson and Mithen (2007), Levy (Adams and Levy 1999; Levy *et al.* 2001b; 2003) and the Bochum Mining Museum (Hauptmann 2007), but these are as yet only partially published. Bienkowski (2006: 11–16) has published an overview of settlement patterns in the Wadi 'Arabah region as a whole, though acknowledging that the current distribution maps reflect current knowledge as much as ancient realities. Nonetheless, some order-of-magnitude figures can be generated from the available survey results regarding the changing demographic patterns in the Faynan valley, for testing against more refined data in future (Table 13.7).

For the immense span of the Palaeolithic periods there is no evidence to suggest that the numbers of people visiting the valley at any time were more than a handful (see Chapter 6).

The half-dozen known Neolithic sites (Fig. 7.2), from a period that in total spans almost 5000 years, are likely to represent only a percentage of the original total, given the evidence for significant landscape change since the Neolithic. The Neolithic deposits at WF5015 in the Wadi Dana and at Tell Wadi Faynan in the main Faynan channel, for example, were both deeply buried below alluvium, their occupations exposed by channel erosion. Also, as discussed by Finlayson and Mithen (2007: 484–6), the evidence for all-year-round sedentary occupation at WF16, the earliest (PPNA) site, is equivocal, though the balance of the evidence suggests repeated occupation for several months a year – we can probably only start to use the term 'village' with the appearance of PPNB sites such as Ghwair I. Estimating the likely population at the Neolithic sites in the Faynan and Fidan using one of the common measures such as Narroll's (1962) formula of 10 m^2 floor space per individual is impossible given the small size of the excavations relative to the known or suspected size of the settlements. Although the occupation zones of a few major Early Neolithic sites in the region such as Abu Hureyra (Syria) and Çatalhöyük (Turkey), cover several hectares, most contemporary Neolithic sites are under 3 ha in size. At Çatalhöyük, a very large (13.6 ha) site and certainly the most complex in terms of known structures, Cessford (2005) compares calculations from the Narroll formula and other formulae to arrive at an estimate of a Neolithic population at the site of between 3500 and 8000 people, whereas Peltenburg (2004: 84) cites an estimate for the small settlement of Khirokitia (Cyprus) of 300–600 people. In this context we suggest (Table 13.7) a Neolithic population for the Faynan of around 100 people or fewer

Period	Small	Medium	Large	Major	Calculated population	Suggested range
Palaeolithic	N/a	N/a	N/a	N/a	N/a	<20?
PPNA	2				N/a	50–100?
PPNB	? (2)		1 (1)		220	> 200
Pottery Neolithic	?		1		N/a	>100
Chalcolithic	1 (2)		(1)		130	<150
EBA 1–4	70 (13)	27 (2)	(2)	1 (2)	2510	1000–2500+
Middle Bronze Age	1?				N/a	<50
Late Bronze Age	?				N/a	<50
Iron 1	?		1	(2)	N/a	>200
Iron 2	30 (8)	18 (3)	(1)	1 (4)	2400	1000–2500
Hellenistic	7	2			110	<100
Nabataean	31	15	1		710	500–700
Roman	20 (12)	13	(3)	2	1480	1500(+)
Byzantine	31 (12)	21	(3)	2	1750	1500–1750
Early Islamic	2	1			40	<100
Mamluk	?		1 (1)		200	<300
Ottoman	22 (13)	2			390	<100
Recent (bedouin)	158 (12)				1700	<200

Table 13.7 *Hypothetical demographic trends in the Wadi Faynan. Site numbers are from the WFLS with additional numbers in parentheses from other surveys in the vicinity. Only occupation sites are included, with 'small' indicating sites of <0.5 ha, 'medium' <1 ha, 'large' >1 ha, and 'major' >3 ha. In calculating the order of magnitude of overall population figures, the following notional site averages have been applied: small = 10 people, medium = 20, large = 100, major = 300. These estimates are smaller than the formula proposed by Narroll (1962) of 1 person per 10 m^2 per floor area of building, reflecting the fact that the measured size of many Faynan sites included large areas of courtyards, pens, and other non-inhabited space. There is no certainty about the relative contemporaneity of occupation of sites within the broad period divisions – this is particularly a factor in the case of transient occupation sites such as bedouin encampments.*

in the PPNA, perhaps double that in the PPNB, and around the 100 figure again in the Pottery Neolithic. These may be under-estimates, but perhaps not by a considerable factor.

Comparatively few unequivocally Chalcolithic sites have been identified in the region, in part a problem of diagnostic material, though at least one large settlement existed in the Wadi Fidan (JHF 51) (Hauptmann 2007: 136–40; Levy *et al*. 2001b: 167–8). The AMS dates from Khirbat Faynan and Tell Wadi Faynan attest to Chalcolithic activity there, even if artefacts and structural evidence are elusive. Hauptmann (2007: 114) identifies putative Chalcolithic mining in the Qalb Ratiye area. Despite the attested export of Faynan ores to the Negev, the overall scale of Chalcolithic activity in the Faynan appears quite small, perhaps involving fewer than 150 people in the valley. Again, this may be an underestimate, but it is difficult to argue for a population in the several hundreds.

We are on more certain ground when it comes to the Early Bronze Age. WF100 is a large nucleated centre – at *c.*11 ha arguably the largest such site in the 'Arabah region (Hauptmann 2007: 110; Wright *et al.* 1998; Fig. 8.8). As mentioned in Chapter 8, a population of 1000–2500 is suggested by Philip (2001: 182) for EBA nucleated centres of this size, but given the small size of the excavation and the evidence for what appear to be field and pen walls within the settlement zone (Fig. 8.12) such a figure seems likely to be a considerable overestimate. Several other large to major sites in the Faynan, Fidan, and neighbouring wadis reflect a degree of population clustering – perhaps in part connected with mining and smelting activities. The most extensively excavated of these is the 3.25 ha Khirbat Hamrat Ifdan in the Wadi Fidan (Levy *et al.* 2002). This site produced a hoard of ingots and ingot moulds (the latter also paralleled at another large site, Barqa al-Hatiya) of EBA III date reflecting export of copper from the region. Barqa al-Hatiya and Khirbat Hamrat Ifdan effectively controlled the routes into and out of the valley around the north and south ends of the Jabal Hamrat Fidan range. A further large or major site is suspected underneath Khirbat Faynan on the basis of the extensive evidence of EBA smelting sites close by (Hauptmann 2007: 104–8). As we have seen in Chapter 8, there were also numerous small to medium sites of EBA date (*c.*100 in our 30.5 sq. km area alone). While we cannot prove contemporaneity of all these settlements, it does look as though a hierarchical organization of settlement had emerged at this time and that the overall population of the valley must have exceeded 1000 people, and could have been well over 2500 people at its peak. The Middle and Later Bronze Age periods are archaeologically more or less invisible in terms of settlements and artefacts, though the AMS dates are suggestive of some continuing activity at this time. However, in comparison with the Early Bronze Age it certainly appears that there was a substantial reduction in population and activity in the valley.

The Iron II period marks the next peak of settlement, with a series of major mining/smelting nucleated settlements (Khirbat Faynan, Khirbat an-Nahas, Khirbat al-Jariya) and at least two further substantial smelting sites (Khirbat al-Ghuwayb, Barqa al-Hatiya). Although the evidence for the Iron I phase remains sketchy, it is increasingly clear that copper production was already organized on a substantial scale prior to the more readily discernible Iron II phase. Population can only be modelled effectively for the latter phase. Each of the five main sites could have had a population of several hundred people. In addition, the Iron Age cemetery at Wadi Fidan 40 comprised at least 1000 burials possibly relating to another major settlement close to the mining area. Iron Age pottery has been found on quite a few isolated farms and small settlements in the main valley (though often in small quantities on sites of certain later occupation) and some parts of the Faynan field system were certainly in operation now. There were also further small settlements by some mines in the mountain areas (Wadi Dana and Wadi al-Abyad). Hauptmann (2007) has identified from surface traces and morphological characteristics a minimum of over 100 mines as dating to the Iron Age. An overall peak population in excess of 1500 seems plausible, though it would probably have required quite extensive supplies imported from outside the region to sustain it. The peak population in the Iron II phase could thus have exceeded 2000, pushing well beyond the carrying capacity of the locality.

There is comparatively little evidence of early Hellenistic settlement, seemingly representing a small number of farms and perhaps some larger-scale settlement around WF2. The overall population is unlikely to have exceeded 100. The Nabataean to early Roman activity is marked by quite numerous pottery but few settlements of significant scale. With the exception of the immediate environs of Khirbat Faynan and the Tell al-Mirad 'fort', most of the Nabataean sites appear to have been smallish farms associated with the WF4 field system. The population could perhaps have numbered 500–700, depending on the scale of contemporary activity in the Wadi al-Jariya and Wadi al-Ghuwayb.

The later Roman and Byzantine phases focused on the large site of *Phaino* (made up of three separate settlement areas: WF1, WF2 and WF11). Although quite extensive in area, the industrial nature of the site, coupled with its role as the logistical centre of the mining, smelting, and farming communities, means that it is difficult to estimate how much of the *c.*15 ha area comprised domestic habitations. The limited carrying capacity of the field system (estimated as enough to feed *c.*300 people), would suggest that the total population at *Phaino* itself was probably under 600. This estimate is supported by the relatively small size (1700+ burials) of the main Byzantine cemetery (WF3). There were of course additional settlements in the surrounding landscape, including another major site close to the Ratiye mines that might have accommodated 100 people between the 'elite' control fortlet and the one-room hovels clustered round it. Several other sites might be classified as villages or hamlets, with potential populations numbering up to 50 or so (including an extensive settlement at the western entry point into the Fidan), with between 50–60 small to medium settlements dated to either the late Roman or Byzantine phases (or both). Hauptmann (2007: 112–23, 144–5) has identified a total of 70 mines as showing evidence of Roman/Byzantine exploitation, *c.*55 in the Qalb Ratiye alone. In addition to the resident population close to the mines and smelting centre at *Phaino*, there were no doubt more transient groups involved with the supply of a range of commodities and the transport of material out of the valley. There are traces here and there of a Roman pastoralist presence also, though archaeologically elusive. The total Roman/Byzantine population in the valley could thus have numbered 1500–1700, but is not likely to have been much higher primarily for reasons relating to supply.

The immediately post-Classical phases are again archaeologically indistinct, though it is likely that many of the late Byzantine pottery forms and fabrics continued in production into the early Islamic phase (Tomber pers. comm.). It seems unlikely that copper mining and smelting continued in any organized fashion and the Mamluk revitalization of copper production appears to have been short-lived. The nature of Mamluk occupation at Khirbat Faynan is uncertain and probably involved the renovation and reoccupation of earlier structures. At least three slag heaps around the Khirbat have yielded Mamluk dates, including one close to the mill on the south side of the Wadi, one by the monastery (Hauptmann 2007: 97 - Faynan 2; 103 - Faynan 6) and one by the barrage. The other Mamluk site of al-Furn (Nuqayb al-'Usmayir), *c.*1 km east of Khirbat an-Nahas, comprised a small village of *c.*15–20 buildings (including a mosque) associated with a main building complex against which *c.*1000 tonnes of slag had accumulated (Glueck 1935: 30–32 and pl. 5; Hauptmann 2007: 126–7). There are undated traces of mining activity close to the settlement. If the operation based at Khirbat Faynan was of similar size, it is improbable that the total labour force in this phase exceeded 200, to which must probably be added a small (possibly seasonal) pastoral component.

The pastoral communities of the Ottoman and recent periods have left traces of numerous campsites, but the number of sites in use at any one time was probably very low. What we have is a spatially extensive accumulation of short-term settlements, often occupied for a few months of the year only. The bedouin use of the valley does not seem generally to have exceeded a few dozen people at any one time, exploiting winter grazing in the valley either from the escarpment centres of Dana or Showbak or from across the ‘Arabah in the Negev. Only in the last few decades, with the establishment of the village of Quarayqira and the influx of Palestinian refugees, has the intensity (and competitiveness) of use increased (see Chapters 2, 12 and Postscript).

The climatic evidence provided by the relative level of the Dead Sea suggests that there were four phases of higher rainfall in the Levant after the Chalcolithic arid phase that marked the end of the early Holocene wet phase (Hauptmann 2007: 46–7). The first three of these broadly correspond with the EBA, IA and Roman/Byzantine peaks in activity/population, while the fourth incident includes the Mamluk reactivation of mining activity. This is not to argue that human activity in these periods was determined by potentially more favourable conditions, but, at any rate, it is evident that the sustainability of such operations at or above the carrying capacity of the land will have been made more feasible if rainfall was even slightly higher than the norm. The EBA, IA, and Roman/Byzantine phases were also periods of peak environmental degradation – attributable in part to the intensive industrial activities of the mining communities and to the added pressures of higher numbers in a fragile environment.

13.6 Cores and peripheries

A critical theme of this study has been the changing nature and scale of core-periphery relations in which the Wadi Faynan has shared, and the ‘boom and bust’ nature of its settlement histories. The relations between the ‘Faynan periphery’ of local people beginning to exploit copper in the Chalcolithic and the Negev chiefdoms who acquired Faynan copper remain unclear. Early Bronze Age elites, including perhaps pastoral-based societies in Early Bronze Age 2, may have played a central role in supplying the metal needs of the Levantine urban zone (focused on the highlands of present-day Israel, Palestine, and Jordan), until Egypt’s trade links – including to obtain copper – shifted to Cyprus. Subsequently it appears that pastoral-based societies continued to use the Faynan copper ores through the course of the second millennium BC, but largely for their local needs. In contrast, the expansion of copper mining to an industrial scale during the first half of the first millennium BC may have been an important driver of the development of the Edomite kingdom, in which Faynan was perhaps initially as much core as periphery. The accrued wealth was in our view influential in stimulating the evolution of a fully-fledged Edomite state and raising it to a level of prominence where it may have attracted Assyrian expansionism. The region then returned to peripheral status, before the process of state formation and imperial take-over repeated itself. The scale of industrial activity at Faynan in the ensuing Nabataean kingdom is unclear, but mining was evidently renewed and surveillance structures were put in place to control it. This activity may have provided some of the motivation for the eventual Roman annexation of the territory, which remains a somewhat murky episode in the *Realpolitik* of the empire (Freeman 1996). Certainly the subsequent exploitation of metals from the Jordanian desert region represents in a microcosm key elements of the *modus operandi* of an imperial regime: an imperial landscape of control and exploitation, an operation that defied normal rules of economic rationality in the service of a super-state. The ecological and human consequences in the Wadi Faynan were profound in antiquity and are still with us to the present day, parts of this sector of the periphery being left almost uninhabitable as a result of the ‘core’ state’s approaches to exploiting the area’s resources.

The scale of the states that exploited the Faynan’s mineral wealth thus changed over time. Relatively small-scale copper production and trade were managed by well-organized Early Bronze Age societies spanning across to the Negev. More substantial regional copper output was achieved by the local Iron Age polity, whether under the controlling influence of powerful neighbours or independently. After an apparent gap in production in the late Iron Age, copper production seems to have revived under a new localized polity, the Nabataean kingdom, before the Nabataean territory was annexed by Rome and its chief resources taken into state control. The Roman/Byzantine copper production was notable for the intensity of its environmental effects around the sole major smelting site at Khirbat Faynan. The sustained and large-scale Iron Age and Roman/Byzantine copper production had large effects on the environment that must have significantly added to the difficulties of extracting and processing minerals. While some of the environmental damage could be repaired over time and surficial levels of pollution reduced by biological and geomorphic processes, it is nonetheless clear that there remains a substantial legacy in the modern environment. The extent to which the heavy metal pollutants remain present in the modern vegetation and livestock, or can be mobilized with dust particles blown up from surface exposures, was a major surprise in the research. There are salutary lessons to be learned from this about the disproportional scale of residual impacts that larger states and empires can produce in this sort of situation.

13.7 Arid-zone archaeology

The methodologies developed by the WFLS were discussed in Chapter 1 and their efficacy we hope has been demonstrated in the ensuing chapters. A particular and distinctive contribution to arid-zone archaeology concerns the elucidation of the activity of pastoral communities in such landscapes, both in the present and recent past (Chapters 2 and 11) and in more remote time periods. The melding of traditional field survey recording techniques with ethnographic research on the archaeology of the recent bedouin campsites opened a window on the interpretation of the vestigial traces that such settlements leave behind.

A second strength of our archaeological fieldwork has been its systematic and methodological nature, applying standard methods to different parts of the landscape and producing robust and comparable data sets. The density of 'sites' recorded in our core survey block is testimony not only to the extraordinary proliferation and preservation of archaeology there, but also to the intensity of our search. The project has built on the previous experience of the core team in working in an interdisciplinary way on similar landscapes in Libya (Barker *et al*. 1996a,b). Methodologically, the WFLS had many differences to the UNESCO Libyan Valleys Survey, not least because of advances in technologies (GIS, GPS, etc.) and in dating and analytical methods. However, a core strength that unites both projects was the interactive engagement in the fieldwork of archaeologists and a wide array of specialists in geography, geomorphology, climate, palaeobotany and, in the case if the WFLS, pollution studies.

One of the key advantages in bringing archaeologists and environmental scientists into the field together is that their shared thinking can then feed into the further refinement of the field methodologies. We would make a virtue of the fact that we did not have all the answers and often not even the 'right' questions on starting the project, but were prepared to modify methods with experience and to be flexible and to innovate in response to our combined observations as the work progressed. As outlined in Chapter 1, the field programme evolved in many positive directions over the course of the project. Chance had its part to play in dictating what would eventually prove to be the most significant research lines, but the overall research design of the project provided a structure for such deliberations. The fieldwork involved a continuing dialogue between participants that for all of us transformed our perceptions of the landscape and its archaeology.

In all such projects it is important to define limits and to know when to stop. Further research, and especially follow-up excavation at key locations and sites, will undoubtedly refine the picture presented in this book. Some of our hypotheses will no doubt be disproved by future more detailed studies. But with the research goals set and in the context of research careers, we believe that ample data were produced by our five seasons of work to support this baseline account of the intertwined histories of environment and human activity from prehistoric times to the present day. Despite all the caveats about the nature of the record and lacunae in the data, this is a rich resource for studying past human–environment relations. Although necessarily coarse-grained, the diachronic approach to the changing landscapes of Wadi Faynan has allowed a very different perspective compared with other studies of the Wadi that have focused on a single period of its archaeology.

13.8 Conclusion

In the Wadi Faynan over the last ten thousand years the interactions between climate, climatic change, biodiversity, agriculture, economic, and political activities have been manifestly complex. The relationships between the health and well-being of people, past and present, their habitats and lifeways, are best considered in terms of complex pathways and systems with synergies and feedbacks that operated at many different geographical scales, rates and intensities; and of underlying causes and immediate triggers rather than simple cause-and-effect models. The richness and variability of the palaeoclimatic, archaeological, and palaeoecological history of the area were almost certainly far greater than we have been able to determine as a result of the result of the patchiness of the surviving evidence in both space and time, the patchiness and invisibility of much of its original human and natural histories, and the limitations of our present capacity to discover, date, and correlate.

Climatic, geomorphic, and palaeoecological variations during the Pleistocene have been profound, bringing about changes in the topography of the mountain front and gorges that are on a much larger scale than anything observed in the Holocene. Palaeolithic people clearly were present along the mountain front in the Faynan, but there are few clear signs of their numbers of activities. At times the limited evidence suggests that they may have been largely absent; their relationships with the changing environments are unclear. Human populations in the Late Palaeolithic and Pre-Pottery Neolithic people engaging in hunting and gathering and later in what eventually came to be agriculture appear to have been larger in numbers. The magnitudes of biological and geomorphic changes in the Wadi Faynan brought about by climatic shifts in the period from *c*.20,000 to 10,000 years ago were much greater than anything that was to be experienced in the Wadi from *c*.10,000 years ago to the present. But serving as nuclei throughout the Late Quaternary up to and including the present day has been the sustained presence in the gorges of excellent water from many significant groundwater-fed springs and the stream water flowing from the higher and wetter table lands; these have underpinned all plant, animal, and human life.

The overall character of the human and natural landscape of the Faynan as we see it today can probably be dated back to a notable aridification that took place here and elsewhere in the region during the Early Bronze Age. The productivity and biological character of the resulting spectrum of habitats at that time ranged from hyper-desert in the lowlands of the Wadi 'Arabah through steppe and grasslands to moister forests and spring-fed oases on the mountain fronts and in the gorges. The Wadi Faynan came to be profoundly and systematically influenced from the Early Bronze Age by the episodic development of ever larger mining for copper, for smelting, production and waste disposal, transport and export, and the resources of food, water, shelter and transport needed to carry out this work. Even as far back as the Neolithic the bright green ores of the mineralized bedrocks attracted human attention. Metallurgical activities began to have notable environmental impacts also in the Early Bronze Age, but reached industrial levels during the Late Bronze Age–Iron Age, with the most intense and far-reaching industrial and agricultural activities taking place during the Roman–Byzantine period in a climate that was dry, but wetter than occurs today. There is a good overall relationship between the scale of mining observed in the frequency and sizes of mines and adits, the intensity of metal-polluted sediments, the likelihood of ill-health or pre-mature death, and the extent to which land was farmed and irrigated by the management of storm-water.

Attempts to improve agricultural productivity using local fertilizers or night soil to sustain the human population as well as draft animals may have been partially counter-productive. Overall, the biological, human, and socio-economic consequences of these activities came primarily to reflect the demands of Imperial-scale economies located far distant. Material support of the Faynan community almost certainly led to substantial import of food, labour, expertise, animals, and charcoal, amongst many other things. Even so, it is difficult to imagine how the supply of essential wood was maintained without some form of vegetation management in the area.

The loss of all this intense metallurgical industry with its associated substantial human population, trade, and agriculture during the Late Byzantine period initiated the relatively empty human landscape that is evident today. The habitats of the modern landscape reflect a very slow and only partial recovery from the degradations of prehistory and Classical times. The rate of ecological recovery was further reduced by a long phase of overall aridity from about 600 to 100 years ago, the impaired processes of revival being accompanied by a near absence of people during much of that time. The modern landscape reflects recovery aided by the slightly wetter climate of the twentieth century, and most recently the concerted attempts to improve biodiversity and biological productivity that are now beginning to have significant consequences for the inhabitants of the Wadi Faynan (see §13.9, Postscript).

The history of the Wadi Faynan is more than one of fragility or sensitivity of people and landscape in the face of a litany of problems – environmental degradation, metal-pollution, loss of woody species, soil erosion, the impact of distant power and exploitation, widespread impaired well-being, poor health, or premature death – outcomes that were all ultimately the result of sustained intensive exploitation of ore resources over millennia in what was, from the Early Bronze Age onwards, a dry and marginal land. It is also a story of resilience – resilience of both the landscape and its human inhabitants. In many ways these emergent themes in the natural and human history of the Wadi Faynan resemble those identified in many other areas of Southwest Asia and North Africa, but the particular 8000-year history of copper mining, smelting, and abandonment that the Faynan probably shares with other ore-fields in the Wadi ʻArabah renders the arid lands of these orefields different. Much of its long and complex history of desertification and recovery in the Faynan is singular, even extraordinary.

The modern landscape is a complex palimpsest of multiple episodes of aridification, desertification, and partial recoveries; of episodes of changing technologies; of human and economic impacts with different intensities and at different scales. The archaeology of its most recent inhabitants of bedouin herders is rich and complex, but it is unlikely that the richness of their histories could have been realized from these archaeological remains without the personal memories and oral tradition so generously passed on to the project. Depending upon the choices made, the many legacies of the past could prove to be either blight or a boon for the future well-being of the Wadi Faynan and its inhabitants.

13.9 Postscript: the Wadi Faynan today and in the future (CP)

In the time since the CBRL initiated its work in the Wadi Faynan, there have been profound changes in the Faynan area. The biggest change is the rapid sedentarization of the bedouin there. Most notably, the Rashaydah have established a village at the foot of Wadi Faynan, making concrete a long-held territorial claim (Fig. 13.7). The ʻAmmarin and Saʻidiyyin settlement of Quarayqira has expanded, and the ʻAzazma village to the north at Ghuwaybah along the Wadi ʻArabah road has developed from its original cluster of tents. In addition, the Faynan campsite is no longer a campsite, but a ʻWilderness Lodge', a large hotel (Fig. 13.8). This reflects a shift in policy by the RSCN to develop more socio-economic opportunities for the people of the western Dana Reserve (Johnson and Abul Hawa 2002), as well as part of an effort to avert the threat of modern copper exploitation by visibly investing in the ecological value of Faynan. In addition to the school along the Faynan track leading to the Lodge, there is now a small mosque. Road building has continued apace and, most recently, the Nimalah track from Beidha, near Petra, to Quarayqira has been considerably improved and asphalted and is now negotiable in a small car, reducing travelling from Shawbak to about one hour or so.

The cultivation of the ancient field system at Faynan by the Rashaydah that, in part, prompted the Wadi Faynan Landscape Survey (Fig. 1.7) was an attempt to establish a village at Faynan. The Pasha (Fig. 2.23), from the Rashaydah, played a large role in this, and he recounted (pers. comm. 2006) that this was his original intention. In this he was supported by the Rashaydah elders, many of whom were retired military men, and especially by Sheikh Ahmed. The settlement in the uplands of the Shawbak area, Howalah, had become too small for the expanding population, so a new village was required along with new employment opportunities. This idea also fell in line with the policy of the ʻAqabah Regional Authority to develop the Wadi ʻArabah in general. Although the original agricultural project the Pasha began was suspended due to territorial disputes, an agricultural co-operative was established in 2003 and farming recommenced in 2004.

The agricultural project was the first step in founding the new village. By the final (April 2000) season of the WFLS fieldwork, events had moved on rapidly: the village housing grid was laid out, and the road leading to it considerably

Figure 13.7 *The new Rashaydah village in the Wadi Faynan, April 2006. (Photograph: Carol Palmer.)*

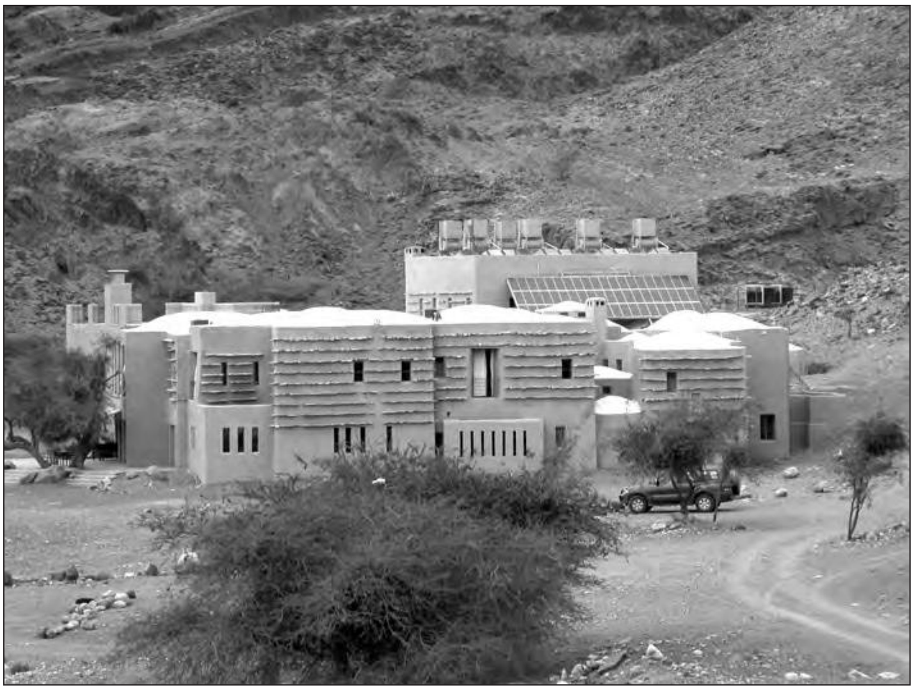


Figure 13.8 *The RCSN's 'Wilderness Lodge', on the site of the former Faynan camp, April 2006. (Photograph: Carol Palmer.)*

improved by bull-dozing. The Rashaydah obtained agreement from the 'Aqabah Regional Authority for a village of *c.*200 families. The total size of the gridded area was *c.*500 dunums, with each plot measuring 1.25 dunums. By April 2001, Abu Fawaz, the CBRL guard, had pitched his tent, *bayt sha'r*, on his plot and was starting to construct a room from concrete. One of the Jordanian archaeologists who had excavated in Faynan, Dr Mohammad al-Najjar, had bought a plot and was building too. By the time of this author's next visit in April 2004, there was electricity, water, an asphalted road, a school, and a tourist centre (Fig. 13.9). A deep well had been sunk into the wadi and a large reservoir built behind the school to store water. The development of the village had been considerably advanced by the gift of sixteen houses following a visit by King Abdullah II, which was quickly followed up by the gift of a further nineteen. By April 2006, the village was appearing even more developed with small, maturing, gardens around the neat, recently constructed, houses and fewer bedouin tents pitched alongside. A mosque was also under construction – another gift from King Abdullah II. The agricultural scheme in the ancient field system had been expanded to 100–150 dunums and members of the co-operative were busy cultivating watermelon, tomatoes, and cucumbers.

In 1998, the Rashaydah registered a tourism co-operative for Faynan, effectively and shrewdly giving themselves primary rights to tourist development there. Alison McQuitty, former BIAAH Director, went on to develop a tourism company, 'Idrissi', offering as part of their portfolio walking trips guided by members of the Rashaydah Faynan

Figure 13.9 *The new tourist centre in the Wadi Faynan, April 2004. (Photograph: Carol Palmer.)*

Figure 13.10 *Young bedouin woman working on the RSCN goat-leather project. (Photograph: Carol Palmer.)*

co-operative. In 2006, the Rashaydah had just agreed to rent their tourist centre to the Dana Reserve and were negotiating rates and numbers of cars from their tribe that would be allowed to transport tourists to the RSCN Wilderness Lodge on the former Faynan campsite. The highly charged negotiations witnessed by this author appeared strongly reminiscent of nineteenth-century protection levies paid by Hajj pilgrims, with some of the Rashaydah wanting to claim exclusive rights! However, a compromise appeared possible, and some sharing of the benefits of transport to the Lodge with other tribes was in prospect. In general, the Rashaydah spoke highly of the management of the Reserve, contrary to early encounters when they felt overwhelmingly angry and excluded.

The RSCN's early re-orientation to pair conservation with developing socio-economic opportunities for local people, rather than adopting a culture of exclusion, has also developed since the early years of the WFLS. The initial, somewhat negative, policy towards the 'Azazma – the post-1948 refugee community from the Negev most dependent on livestock with the fewest other economic alternatives (Chapter 2, §2.2.6.5) – has completely shifted; the new manager of the Wilderness Lodge, for example, is from this group. The construction of the substantial Wilderness Lodge itself, designed by the well-known architect and artist Amar Khammash, mixing architectural styles from Africa and the Arab world, marks a considerable investment in the western Reserve. Early efforts were concentrated in the uplands and to the east around Dana, and the Ata'ata, villagers from Dana and Qadisiyya, arguably benefited most. A number of new projects in the western Reserve has attempted to redress this imbalance, especially as people here generally had the most livestock and thus were perceived to be the greatest threat to nature conservation. The signing of the 'Dana Declaration on Mobile Peoples and

Conservation' (http://www.danadeclaration.org/) during an international conference hosted by the RSCN at Dana and organized by the Refugees Study Centre, Queen Elizabeth House, University of Oxford, in 2002 formally marked the change in the RSCN's orientation towards working in partnership with local people. In May 2006, Abu Mustafa from the 'Ammarin, RSCN Dana Reserve Ranger and former forestry guard, was chosen as a representative to attend the Fifth United Nations Permanent Forum on Indigenous Issues in New York.

On a more local level, the goat-fattening scheme at Faynan originally piloted by Alan Rowe as part of his study of the 'Azazma (1997) was initially continued (Johnson and Abul Hawa 2002), but eventually suspended because the RSCN ultimately felt uncomfortable encouraging local people to raise goats, even though the original intention had been to obtain agreements from participating people to fatten goats in pens on feeds (mostly agricultural residues) in exchange for reduction in herd sizes. However, a goat-leather project involving local bedouin women (Fig. 13.10), meant to give 'added value' to goats (and therefore encourage reduction in livestock numbers), has continued. The decorative items sold, aimed at the tourist market, have been very successful, like the silver workshop run by local village women producing hand-crafted silver items at Dana. In addition, both projects provide women with an external income and companionship for however long they are involved. In general, these activities have helped to promote a positive attitude towards the Reserve and nature conservation that, under ideal circumstances, also has the potential to be passed on to workers' children.

It is not clear whether or not livestock numbers have reduced in the Reserve in line with RSCN aims. Part of the reduction strategy depends on the availability of other economic opportunities, some being provided by the RSCN, but broader economic trends also play a part. The area is definitely more accessible and less remote than in the mid-1990s as the road system has developed and following the growth of settlement promoted by the 'Aqabah Regional Authority. In addition, there is now a bedouin market at Quarayqira, so people do not have to travel to Husseiniyya to purchase or market goods. One key outside factor promoting livestock-holding until 1996 was a subsidy on fodder. The loss of the subsidy has tended to encourage local people to seek supplementary or alternative employment and the availability of schooling in Faynan gives new generations the opportunity to explore different economic opportunities. Employment, especially accompanied by retirement pensions, rather than pastoralism, is highly sought. The 'Azazma, in particular, still maintain large herds, but there is the increased feeling that salaried employment is more desirable than livestock herding, a trend first noted by Rowe (1997). Overall, livestock numbers still appear most affected by the availability of good grazing. In good years, such as in 2004, 2005, and even 2006, though the rains were late, the herd sizes of most of my informants continued to be held at similar levels. The growth of the port of 'Aqabah, with plans to develop it following a Dubai model – as advertised on bill-boards across Jordan in April 2006 – potentially offers a very different future. Already, Wadi Faynan and Dana (including the campsite at Rummana) are very much 'on the map' as additional tourist attractions to Petra and Wadi Rum for visitors to southern Jordan.

With increased sedentarization and the accessibility of goods, many aspects of 'traditional' bedouin life are disappearing in Wadi Faynan. In 1998 and 1999, for example, it was not uncommon for women to collect, spin, and weave *shugga*, the goat hair strips that, sewn together, form the classic black goat hair tent, *bayt sha'r* (Fig. 12.2). This was in contrast to much of the rest of Jordan where *shugga* were often purchased, the female labour being much more valuably used in other activities. By 2006, the wife of Jouma' 'Aly, a skilled weaver, had given up weaving for the same reasons: at 45 Jordanian dinars a strip, it was no longer economic to weave. This also reflects the decreasing economic isolation of Wadi Faynan and increased access to transportation. Pastoral lifeways in Wadi Faynan are changing, as they have for hundreds, indeed thousands, of years. Like the rest of the evolving and emerging landscape of which they are an integral part, their future is uncertain. With world copper prices growing increasingly high, there remains a prospect that copper mining will, once again, return to Faynan.

SUMMARIES

Archaeology and desertification: English summary

Graeme Barker and David Mattingly

The Wadi Faynan is a harshly beautiful and desertic landscape in southern Jordan, situated between the lowland hyper-arid deserts of the Wadi ʻArabah to the west and the rugged and wetter Mountains of Edom to the east. *Archaeology and Desertification* presents the results of the Wadi Faynan Landscape Survey, an interdisciplinary study of landscape change undertaken in the Wadi Faynan between 1996 and 2000 by a team of archaeologists and geographers. The objective of the project was to contribute to present-day desertification debates by providing a long-term perspective on the relationship between environmental change and human history. We embarked on the project because the abundant archaeological remains already known in the Wadi Faynan – settlements, cemeteries, 'field systems', and mining residues – indicated that its past had been characterized by episodes of settlement and land use very different from those of today. The principal archaeological site, Khirbat Faynan, was known to date to the Roman–Byzantine centuries and was commonly identified with the settlement of *Phaino* known to be a major centre of a copper- and lead-mining industry at that time. Hence the Wadi Faynan seemed an ideal location for investigating the long-term 'archaeological history' of interactions between a desertic landscape and its human inhabitants.

The book is divided into two main sections. The first part (Part I, Research Themes, Methods, and Background, Chapters 1–5) describes the approaches used by the project, and discusses the results of particular techniques applied – archaeological, geomorphological, palaeoecological, and geochemical (Chapters 1–5). The second part (Part II, Chronological Syntheses) integrates the results of these various approaches in order to construct a period-by-period assessment of the data from the Pleistocene to the present-day (Chapters 6–12), with a final chapter (13) reviewing the entire data set in terms of understanding human strategies to desert settlement and the implications of the Faynan study for debates about desertification, present as well as past.

In Chapter 1 ('The Wadi Faynan Landscape Survey: research themes and project development') we introduce the key themes of the project and how they shaped its development. First and foremost we wanted the Wadi Faynan Landscape Survey to contribute to *understanding desertification and aridification*, notably the respective roles of people and climate in the past in shaping present-day arid and desertic landscapes. A related focus of interest was *landscape degradation and well-being* viewed from the long-term historical perspective that archaeology allows. In what situations – climatic, demographic, socio-economic – were arid lands degraded in ways in which they were able to recover, and in what circumstances were they damaged irreversibly? The third core interest was *understanding marginality*, in particular how past peoples living in arid zones have interacted with the agricultural populations of adjacent better-watered zones, in terms of core-periphery relations. The fourth interest was in *arid-zone archaeological methodologies*, for example the much-debated problem of distinguishing between absence of evidence, and evidence of absence, in particular relating to the archaeology of pastoralism.

The major strengths of a landscape archaeology study such as the Wadi Faynan Landscape Survey are the spatial and chronological scales of the data accumulated, and their multi-disciplinary nature. The major weakness of such a project is the lack of detailed and tightly-dated information that only major excavations can provide, about particular activities and environments at particular locations at particular moments in the past. Any holistic study of landscape development of course needs both approaches. In this respect we were extremely fortunate in being able to compare our data with, and relate our results to, the significant amount of excavation work undertaken and being undertaken by other teams in the Wadis Faynan and Fidan of sites relating to most of the major periods of settlement in the past. For the prehistoric periods, for example, these include, in the Wadi Faynan, the PPNA settlement of WF16 (Finlayson and Mithen 2007), the adjacent PPNB settlement Ghwair I (Simmons and Najjar 2006), the Pottery Neolithic/Chalcolithic settlement of Tell Wadi Faynan (al-Najjar *et al*. 1990), and Early Bronze Age WF100 (Wright *et al*. 1998), and a series of settlement and cemetery excavations in the Wadi Fidan, which forms the lower section of the Wadi Faynan (e.g. Adams 2000; Adams and Genz 1995; Levy 2004; 2006; Levy and Higham 2005; Levy *et al*. 1999a; 2001a,b; 2003; 2004a,b; 2005a; Muniz 2006). Another enormously important contribution has been the ongoing programme of research by the Bochum Mining Museum on ancient mining and smelting (Hauptmann 2000; 2007).

Chapter 2 ('The Wadi Faynan today: landscape, environment, and people') sets the scene in terms of describing the present-day landscape, natural and cultural, of the study area. The first part of the chapter presents the natural environment: the climate, topography, geology and mineralization, the soils and surface sediments, vegetation and fauna. The second part describes the present-day bedouin using the wadi (Rashaydah, Sa'idiyyin, Manaja', 'Azazma, 'Ata'ata, Shawabka), their histories, what is known of traditional patterns of life in recent centuries, and how those patterns are responding to modern-day pressures and opportunities.

Chapter 3 ('The past and present landscapes of the Wadi Faynan: geoarchaeological approaches and frameworks') explains the fieldwork strategies and methodologies employed by the geoarchaeological team to document and date the development of the Wadi Faynan landscape and to detect the various influences of climate and people on that process. Though the limitations of the geoarchaeological methodologies employed are stressed, the team was able to recognize a series of fluvial, alluvial-fan, aeolian, and anthropogenic deposits of late Pleistocene and Holocene age, from the Ghuwayr Beds over 225,000 years old to sediments forming in recent centuries (Tables 3.2 and 3.3). Analyses of pollen, palynofacies, and macrofossils enabled the team to assemble an outline palaeoecological framework for the Holocene (Table 3.5 and Fig. 3.9), and an outline framework of changes in local environment, especially in precipitation (Fig. 3.17). Another distinctive feature of the project's methodologies was the extensive use of geochemical techniques to investigate suites of metals within sediments, an approach which enabled the project to detect the changing nature and scale of metal smelting through time in terms of the pollution effects on the landscape (Fig. 3.18), as a complement to the work on the ancient mines and smelting sites of the Wadi Faynan by the Bochum team.

Chapter 4 ('Recording and classifying the archaeological record') describes how the project went about recording, describing, and classifying the *c*.1500 archaeological sites, mostly stone structures, that it discovered by systematic archaeological survey of the study area. Whilst acknowledging the impossibility of total objectivity in field recording, the field survey strategy attempted first to characterize the morphology – or shape and style – of all visible archaeological structures in as objectively descriptive terms as possible, and then to develop a scheme of classification on the basis of these observations. The typology of site morphology developed for the survey, and which is used in the Survey Gazetteer (Appendix 3), is summarized in Table 4.1. The scheme uses two tiers of classification: major categories (e.g. hydraulic feature), and sub-categories (e.g. aqueduct bridge). The chapter reviews the evidence for these various categories, illustrating the different types of structure, and discusses the major trends in distribution of the different classes of site and the dating evidence for them (summarized in Fig. 4.1).

The last chapter in Part I (Chapter 5. 'The Wadi Faynan field systems' describes our approaches to recording, classifying, dating, and interpreting the stone lines as the walls of ancient 'field systems' in the Wadi Faynan. These 'field systems' have been described by many previous visitors (e.g. Glueck 1935), but had never been studied systematically. The largest of them, lying along the southern bank of the Wadi Faynan, had been designated WF4 by the original BIAAH survey team (Barnes *et al*. 1995). This was divided into 20 units by the project to aid its systematic recording, the boundaries of the units determined by major topographical features such as the tributary wadis that dissect the system (Fig. 1.11). Ten different wall categories were defined (Table 5.2). A 'GIS' (Geographical Information System) was constructed to integrate the various data we collected, in particular to assess the relationships between the distribution of different wall types and other structures such as 'sluices', 'spillways', and 'channels', and the distributions of artefacts of different chronological periods collected in the fields enclosed by the walls. The principal conclusion from the analysis is that the field systems, WF4 in particular, represent complex 'palimpsest landscapes' rather than a single phase of construction, and document the development of systems of 'floodwater farming' (the trapping, controlling, and distribution of surface water flowing down wadi channels after flash floods) from the Bronze Age to the present day. The major phase of the WF4 field system, though, when a series of long irrigation channels marked by 'parallel walls' (Figs 5.34, 5.35) was constructed that appear to represent a coordinated approach to water control (Fig. 5.29), dates to the Roman–Byzantine centuries, contemporary with the major phase of settlement at Khirbat Faynan.

Chapter 6 ('Pleistocene environments and human settlement') sets out the evidence for the several distinct and major phases of geomorphic evolution identified by the project as dating to the Pleistocene (Fig. 6.4 and Table 6.1), documenting a dynamic environment shaped by tectonic activity, climatic change, and geological complexity. On the evidence of both our survey and that of the Dana-Faynan-Ghuwayr Early Prehistory project (Finlayson and Mithen 2007), this landscape was periodically exploited during the Pleistocene (e.g. Figs 6.17, 6.19), with low-intensity hunting and gathering activity. In many phases, the uplands were more arid than today and lowlands such as Wadi Faynan were better watered. The likelihood is that Wadi Faynan was mostly occupied on a seasonal basis by Palaeolithic groups moving between the Jordanian uplands and the lowlands. It appears that it was only with the end of the Pleistocene that the Wadi Faynan can probably be regarded as permanently settled.

Chapter 7 ('Early Holocene environments and early farming, *c*.11,000–7000 cal. BP, *c*.9500–5000 cal. BC') describes the evidence collected by the project, integrated with the results of the excavations mentioned earlier, for the changing nature of the landscape in the opening millennia of the Holocene and the changing character of human settlement through those millennia. With the development of moister climates at the beginning of the Holocene *c*.9500 BC, people started to camp near the springs at the foot of the mountain front for several months of the year, and perhaps even on an all-year-round basis. At WF16 (Finlayson and Mithen 2007; Fig. 7.10) they gathered wild plants including cereals, and may have started to manage and control goats as well as hunting them. A thousand years later, PPNB communities at Ghwair I (Figs 7.13, 7.14) and Wadi Fidan I were characterized by a developed commitment to agriculture. Though some scholars have argued that a climatic shift to aridity caused a move to pastoral nomadism in the PPNC, our geomorphological and palaeoecological evidence indicates that the Faynan landscape was equally favourable to agricultural settlement at the time of the occupation of Ghwair I *c*.7500 cal. BC and of Tell Wadi Faynan *c*.5500 BC, in terms of having in both periods perennial streams where now there are largely dry torrent beds, and extensive steppe land and clumps of Mediterranean woodland where now there is little or no vegetation except after the rains. The pollen record suggests the possibility of patches of small-scale cereal land in both instances.

As described at the beginning of Chapter 8, 'Chalcolithic (*c*.5000–3600 cal. BC) and Bronze Age (*c*.3600–1200 cal. BC) settlement: metallurgy and social complexity', the fourth, third, and second millennia BC were periods of extraordinary social change throughout the Levant, characterized especially by the development of hierarchical societies in the Chalcolithic (*c*.5000–3600 BC) and the rise, and in places subsequent collapse, of urbanism in the Bronze Age (*c*.3600–1200 BC). Wadi Faynan, on the margins of the settled landscape but rich in mineral wealth, was clearly exposed to the effects of these transformations. We found no evidence for major Chalcolithic settlements, but our geochemical studies indicate that there were Chalcolithic communities living in the Wadi Faynan engaged in the extraction and processing of copper ores. We then found evidence for a highly structured, indeed hierarchical, as well as densely occupied landscape in the Early Bronze Age, with evidence for marked differentiation between arable, pastoral, and metallurgical activities in the different parts of the Wadi Faynan (Figs 8.5, 8.27, 8.36). Simple floodwater farming systems were developed in response to increasing aridity. The decline in the exploitation of Faynan copper in the second half of the third millennium BC probably reflects both shifts in Egyptian trade and the vulnerability of the agricultural system to deteriorations in environment, probably both climatically and humanly induced. The landscape was characterized by predominantly pastoral use through the course of the second millennium BC, though some people were still visiting its mountain rim from time to time to extract and process copper ores.

As we describe in Chapter 9 ('The making of early states: the Iron Age and Nabataean periods'), with the development of the Iron Age proto-states of Edom, Moab, and Ammon in the southern Levant in the early first millennium BC, copper mining and production in the Faynan region was organized on an industrial scale. The large fort at Khirbat an-Nahas (Fig. 9.5) suggests that the production was protected by military force. We argue that the evolution of copper production in the Wadi Faynan may have been a key driver in Edomite state formation, rather than that the creation of the kingdom led to the reopening of mines there. The archaeological record of later Nabataean civilization, traditionally viewed as a desert nomadic culture, reveals instead a complex, literate, society ruled by coin-issuing kings, with some substantial urban settlements such as Petra. Some scholars have suggested that the Nabataeans did not exploit Faynan copper, our archaeological survey and geochemical evidence combine to indicate that Faynan copper was being mined, albeit on a smaller scale than in the earlier Iron Age (Fig. 9.18). There were numerous farms and farmsteads in the valley (e.g. Fig. 9.24), associated with sophisticated small-scale floodwater farming systems. A substantial nucleated settlement at Khirbat Faynan and a secondary (intervisible) hill-top fort, Tell al-Mirad (Fig. 9.22), indicate that these, like the mining operations, were under direct political control by the authorities at Petra.

With the imposition of Roman control on the region at the beginning of the second century AD, Khirbat Faynan, ancient *Phaino* (Fig. 10.10), developed as the control site for an imperial mining operation (*metalla*), a major state operation imposed on the landscape (Chapter 10, 'A landscape of imperial power: Roman and Byzantine *Phaino*'). The selection of the Wadi Faynan as the Roman mining centre was undoubtedly connected with the fact that there was a good water supply in the Wadi Ghuwayr and the largest expanse of potentially cultivable land in the Wadi 'Arabah region. Our analysis of the WF4 field system indicates that the control of land was now centralized and unified, with farming carried out by people based at *Phaino* (Figs 10.32, 10.33). Progressive additions to the field system increased its integral nature, its scale, and its hydraulic sophistication – an elaborate irrigation system of water conduits was constructed (Fig. 10.29). Productivity was artificially raised above the normal carrying capacity of the arid Faynan landscape to feed the greatly enlarged population. By the Late Roman/Byzantine period, however, this landscape was severely compromised by the scale of industrial and agricultural activity. The production of copper required large quantities of charcoal and timber, that had to be brought in from the plateau above because the local environment had been stripped of suitable vegetation. The intense smelting activity around Khirbat Faynan produced a dense pall of airborne pollution that affected plants, animals, and people. Fertilizing the fields with domestic and household waste from Khirbat Faynan exacerbated the situation, increasing the pollutants in the soil and thus in the crops grown on the land.

Whether or not copper production had continued right up to the mid-seventh century Islamic conquest, it certainly did not endure in the subsequent centuries on any significant scale. The post-Classical ceramic evidence presents many dating problems, but, together with data collected by earlier surveys, indicates a dramatic change in the use of the landscape (Chapter 11, 'The Islamic and Ottoman periods'). The absence of any coins relating to the period AD 668–1210 (covering the Ummayad, Abbasid, Fatimid, early Seljuq and Frankish phases) and the general absence of diagnostic pottery are consistent with a shift to the use of the valley by pastoral groups, leaving behind a materially-impoverished and vestigial archaeological record (Fig. 11.11). There was a brief period of renewed interest in the Faynan ores during the Mamluk period (Fig. 11.8), though is not certain whether this activity involved renewed mining or simply the reprocessing of the abundant slag deposits left behind by earlier phases of copper exploitation. This brief interlude was followed by centuries of pastoral-dominated land use in the Ottoman period, as the Faynan area returned to a 'default setting' of a marginal environment at the periphery of the core Islamic state (Fig. 11.12). The geoarchaeological and palaeoecological evidence indicates an overall arid climate interspersed with wet episodes, with a slightly wetter and biologically-richer environment developing about 100 years ago. climate slightly wetter than prevails today at this time.

An ethnoarchaeological survey of bedouin tent-sites in the Wadi Faynan was undertaken in 1999 and 2000 in order to document the 'archaeological visibility' of pastoral activity today and in the recent past, to help the archaeologists develop criteria for identifying pastoral activity in the past (Chapter 12, 'Ethnoarchaeology). For each tent site the position, orientation, spatial arrangement, and common key features were recorded, together with supplementary structures such as goat and kid pens, chicken coops, outside hearths, and a variety of features associated with the storage of fodder and household goods (e.g. Figs 12.14, 12.15). All sites were visited accompanied by a local informant. The availability of modern material culture has greatly increased the visibility of recently abandoned bedouin camps (Fig. 12.23), but this material is seemingly almost as prone to dispersal over time as more traditional forms of material culture. Campsite architectural features provide the clearest evidence of recent pastoral activity and artefacts found in association with these features provide good evidence of activity, but the survey also showed that campsites usually represent palimpsests, so artefacts may represent several occupations over the course of many years, a finding with significant implications for earlier pastoral sites. For all bedouin groups, the growth of state infrastructure, including roads, schools, and medical facilities, as well as the opportunity to work for money and buy modern consumables is fundamentally changing local land use and campsite organization, but it is noteworthy that many traditional norms have been maintained, such as the exploitation of specific environmental niches, clustering based upon tribal affiliation, and the spatial organization within occupied tents.

As we conclude in Chapter 13 ('Archaeology and desertification: the landscape of the Wadi Faynan'), the landscape history of the Wadi Faynan is clearly a complex palimpsest of multiple episodes of aridification, desertification, and partial recoveries; of episodes of changing technologies; of human and economic impacts with different intensities and at different scales. It is a story of fragility and sensitivity of people and landscape in the face of a litany of problems, but it is also a story of resilience of the landscape and its human inhabitants. Over the last 10,000 years the interactions between climate, climatic change, biodiversity, agriculture, economic, and political activities have been manifestly complex. The richness of the project's palaeoclimatic, archaeological, and palaeoecological data provides no simple cause-and-effect models but rather an environmental/cultural history of complex pathways, synergies, and feedbacks operating at many different geographical scales, rates, and intensities. The industrial history of the Wadi Faynan continues to impact on the present-day bedouin, our geochemical analyses of bread, hearth ash, and animal dung indicating that heavy metals are continuing to enter domestic life, with women and children being somewhat more exposed to this hazard than men (Fig. 13.6).

The project's findings on the complexity of past and present people:environment relations in the Wadi Faynan affirm the power of interdisciplinary landscape archaeology to contribute significantly to the desertification debate. With global warming likely to threaten the lives of millions of people in the semi-arid and arid lands that comprise over a third of the planet through the course of this century, with potentially dire consequences for adjacent populations in better-watered regions, understanding the complexity of past responses to aridification has never been more urgent.

والمستوطنات. ويجدر الذكر هنا أن الكثير من النماذج والمعايير التقليدية تم الحفاظ عليها مثل استغلال حنايا ومواضع بيئية معينة، وتجمعات مبنية على أساس الإنتساب والإنتماء القبلي، وكذلك الترتيبات والتقسيمات الحيزية والمكانية في داخل الخيم المأهولة.

نستعرض في الفصل الختامي 13 ("علم الآثار والتصحّر: منطقة وادي فينان")، تاريخ منطقة وادي فينان الذي يمثل بكل وضوح عدة مراحل معقدة لفترات جفاف متتالية وتصحّر تخللتها بعض مراحل التحسن، وسلسلة من التقنيات المتغيرة، وتأثيرات بشرية واقتصادية بكثافات ودرجات متفاوتة. إنها لقصة تتكلم عن هشاشة وحساسية أناس ومنطقة واجها سلسلة من المصاعب والعوائق، وهي في الوقت ذاته قصة تعبرعن صمود منطقة وأهلها وقدرتهما على التأقلم مع الظروف الصعبة. وعلى مدى العشرة الاف سنة الماضية كان التفاعل بين المناخ والتغيرات المناخية والتنوع الحيوي والزراعة والإقتصاد والأنشطة السياسية واضح التعقيد. إن غنى وتوفر البيانات الباليواقليمية (علم المناخ القديم) والآثارية والباليوإكولوجية (علم البيئة القديمة) للمشروع، لا توفر لنا نماذج بسيطة أو سهلة فيما يخص موضوع المسبب والنتيجة، ولكن بالأحرى تاريخ بيئي ثقافي معقد السّبل والتداوب والتغذية الإسترجاعية كلها تعمل بمعايير ودرجات وكثافات متباينة جغرافياً. ومازال تاريخ وادي فينان الصناعي يؤثر على حياة بدو اليوم. فقد أشارت تحاليلنا الجيوكيميائية التي أُجريت على الخبز ورماد المواقد وروث الحيوانات إلى أن المعادن الثقيلة تستمر في الدخول إلى الحياة المنزلية، وبطريقة ما تتعرض النساء والأطفال بصورة أكبر إلى هذا الخطر مما يتعرض له الرجال (شكل13،6).

إن استنتاجات المشروع فيما يخص العلاقات المعقدة ما بين الناس وبيئتهم في الحاضر والماضي في وادي فينان، تثبت قدرة وجدارة علم آثار المواقع كثير التخصص في مساهمته البارزة في مناقشات موضوع التصحّر. وبوجود الخطر الناجم عن إرتفاع درجات الحرارة على الكرة الأرضية، والذي من المحتمل أن يهدد حياة الملايين من الناس في المناطق شبه الجافة والجافة التي تشكل ثلث حجم الكوكب خلال هذا القرن، ومع توقع حدوث عواقب صعبة لدى سكان المناطق المجاورة ذات ظروف مائية أفضل، فإن فهمنا لمسألة ردود فعل الماضي على حدوث التقحّل والجفاف لم يكن أبداً أمس حاجة إليه عما هو الحال عليه اليوم.

البيئة المحلية جُرّدت من الحياة النباتية المناسبة. كما أن عمليات الصّهرالمكثفة حول خربة فينان أنتجت طبقة جوّية ملوثة كثيفة، بحيث أنها تركت أثرها السلبي على النباتات والحيوانات والناس (شكل 10، 40). ومما زاد الأمر سوءاً وتفاقماً عمليات تخصيب الحقول بفضلات ونفايات خربة فينان المنزلية (شكل 10، 27). وهكذا تزايد عدد ملوثات التربة والمحاصيل الزراعية التي كانت تنمو على هذه الأرض.

ولا نعرف تمام المعرفة اذا كانت عمليات انتاج النحاس قد استمرت إلى منتصف القرن السابع في الفتوحات الإسلامية، ولكننا نعرف بكل تأكيد أن انتاج النحاس لم يدم ولم يصمد في القرون اللاحقة بصورة بارزة. وُتقدم الشواهد الخزفية اللاحقة للفترات الكلاسيكية مشاكلاً تأريخية كثيرة، ولكن بعد الإستعانة بالبيانات المتراكمة عن طريق مسوحات سابقة، فقد أظهرت تغيراً مفاجئاً فيما كان يخص استخدامات واستعمالات المنطقة (فصل 11، "العصور الإسلامية والعثمانية"). إن غياب المسكوكات المتعلقة بالفترة الزمنية 668 – 1210م (وتشمل الفترات الأموية والعباسية والفاطمية والسلجوقية المبكرة والصليبية)، والغياب العام للفخارالمميز لهذه الفترات، هي أمورمتلازمة ومتزامنة مع حدوث التحول في استعمال الوادي من قِبل جماعات رعوية تركت وراءها سجلاً آثارياً يفتقر إلى المخلفات الآثارية وغير ذي قيمة (شكل 11، 11). كانت هناك فترة قصيرة تعكس إهتماماً مجدداً في مواد فينان الخام خلال الفترة المملوكية (شكل 11،13)، ولكنه أمرغير مؤكد إذا ما شملت هذه النشاطات تجديد عمليات استخراج التعدين أم بكل بساطة فقط إعادة معالجة الخبث الذي كان متواجداً بكميات متوفرة والذي خلفته مراحل استخراج المعادن السابقة. وقد لحقت هذه الفترة الفاصلة القصيرة قرون تمثل سيادة عمليات الرعي في هذه الأراضي في العصر العثماني عندما عادت منطقة فينان إلى وضعها الأساسي بصفتها بيئة هامشية تمثل المنطقة المحيطة بمركز الدولة الإسلامية (شكل 11، 12). وتشير الشواهد الجيوآثارية والدراسات البيئية القديمة إلى سيادة مناخ جاف بشكل عام تخللتها بعض الفترات الرطبة. وتطورت بيئة أكثر رطوبة بنسبة ضئيلة وأغنى بيولوجياً من قبل حوالي 100 سنة.

وقد أجريت مسوحات إثنوآثارية (عرقية آثارية) في مواقع مخيمات البدو في وادي فينان في عامي 1999 و2000 من أجل توثيق "الوضوح الآثاري" للنشاطات الرعوية في يومنا هذا وفي الماضي القريب، وذلك لمساعدة علماء الآثار في تطوير معيار للتعرّف على الأنشطة الرعوية في الماضي (فصل 12و "علوم الإثنوآثارية"). فقد تم تسجيل موضع واتجاه والتقسيمات والترتيبات الحيزية والخصائص والملامح الرئيسة العامة لجميع مواقع هذه الخيم. بالإضافة إلى بنيات وإنشاءات مكمّلة مثل حظائر الماعز وغرف الأطفال وأخمام الدجاج والمواقد الخارجية ومجموعات أخرى من البنيات التي لها علاقة بتخزين الطعام والبضاعة المنزلية (مثلاً شكل 12، 14 و 12، 15). فكل هذه المواقع تم زيارتها باصطحاب شخص محليّ يقدم المعلومات. وقد زادت مُتاحية المعثورات واللقي والمخلفات الأثرية العصرية بنسبة كبيرة من وضوح مخيمات و مستوطنات البدو المهجورة حديثاً (شكل 12، 23). ولكن هذه المخلفات على ما يبدو عرضة للتشتت والتبدد على مرّ الزمن، كما هو الحال في الأنماط الأكثر تقليدية للمعثورات والمخلفات. إن الخصائص والملامح المعمارية لمواقع المخيمات والمستوطنات تزودنا بأوضح شواهد للأنشطة الرعوية الحديثة. كما أن المشغولات (الأدوات المصنوعة يدوياً) والتي عثرعليها ولها صلة بهذه الخصائص تعتبر أدلة جيدة للكشف عن أنواع النشاطات التي كانت تُزاول. ولكنه أيضاً تبين من المسوحات أن المواقع كانت مسرحاً لعدة مراحل. فيحتمل أن تمثل المشغولات عدداً من فترات الإستيطان على مدى عدد من السنوات، وهذا استنتاج هام فيما يخص المواقع الرعوية السابقة. وبخصوص جميع التجمعات البدوية، فإن نموّ البنية التحتية للدولة بما فيها من طرقات ومدارس ومرافق طبية، بالإضافة إلى فرص العمل من أجل النقود وشراء البضائع العصرية، كل هذه الأمور تقوم بتغيير جذري في طريقة استعمال واستغلال الأراضي المحلية وتنظيم مواقع المخيمات

مستوطنات العصر النحاسي، ولكن دراساتنا الجيوكيميائية تبين وجود مجتمعات تعود إلى العصر النحاسي والتي عاشت في وادي فينان وعملت في استخراج ومعالجة معدن النحاس الخام. ثم عثرنا على شواهد تشير إلى منطقة ذات بنية كبيرة وبكل تأكيد من ناحية التسلسل الهرمي أو الطبقية الإجتماعية. وقد كانت مأهولة بكثافة في العصر الحجري البرونزي المبكر. وتوفرت أدلة على عملية التفريق الواضح بين ما هو صالح للزراعة وما هو رعوي أو موقع يخص أعمال التعدين في مختلف أنحاء وادي فينان (شكل 8، 5 و 8، 27 و 8، 36). فقد تم تطوير النظام البسيط للزراعة باستعمال مياه الفيضانات استجابة إلى تزايد الجفاف. وربما يعكس الإنخفاض في عمليات استخراج واستغلال نحاس وادي فينان، في النصف الثاني للألفية الثالثة ق.م.، تحوّل في التجارة المصرية وضعف النظام الزراعي وتدهور حالة البيئة. ولربما يعزى لأسباب مناخية وبشرية معاً. ووصفت المنطقة بغالبية استعمالها لأغراض رعوية خلال الألفية الثانية ق.م. مع أن بعض الناس كانوا ما زالوا يزورون حافة الجبل من حين إلى آخر لاستخراج ومعالجة معدن خام النحاس.

نوضح في الفصل 9 ("تشكيل الولايات أو الدويلات الأولى: العصر الحديدي والفترات النبطية")، ومع تطور الولايات أو الدويلات الأولى لادوم ومؤاب وعمون في الجزء الجنوبي من سورية الطبيعية في الألفية الأولى المبكرة ق.م.، تمّ تعدين وصناعة النحاس في منطقة فينان على مستوى صناعي. ويوحي الحصن الكبير في خربة النحاس (شكل 9، 5) بأن صناعة النحاس كانت محمية من قِبل قوة عسكرية. ونتجادل هنا في موضوع تطور صناعة النحاس في وادي فينان وترجيح فكرة كونه السبب الرئيسي في ادوم وراء تشكيل الدويلة، وليس أن تشكيل المملكة كان السبب وراء إعادة فتح المناجم. إن السجل الأثري للحضارة النبطية اللاحقة، والتي كان فيها الإعتقاد السائد أنها ذات ثقافة بدوية صحراوية، كشف هذا السجل لنا عن مجتمع معقد التركيب ومثقف حُكم من قِبل ملوك قاموا بسك العملات، وأيضاً وجود بعض الإستيطانات المدنية الهامة مثل البتراء. وقد اقترح بعض العلماء أن النبطيين لم يقوموا باستغلال النحاس في فينان، ولكن مسوحاتنا الأثرية والشواهد الجيوكيميائية تتفقان على أن نحاس فينان تم تعدينه، ولو بصورة أصغر مما كان التعدين عليه في العصر الحديدي المبكر (شكل 9، 18). وكان هناك عدد من المزارع والمنشآت الزراعية في الوادي (مثلاً شكل 9، 24) مرتبطة بأنظمة صغيرة ومعقدة للزراعة بمياه الفيضانات. فإن مستوطنة مهمة في خربة فينان وكذلك حصن ثانوي على قمة التل، تل المرَد (شكل 9، 22)، كلاهما أدلة على أن هذه، وكما هو الحال في عمليات التعدين، كانت تحت سيطرة سياسية مباشرة من قِبل السلطات في البتراء.

ومع فرض الرومان سيطرتهم على المنطقة في بداية القرن الثاني ميلادي، تطورت خربة فينان، قديماً فاينو (شكل 10، 10)، إلى موقع السيطرة والتحكم فيما يخص عمليات التعدين الخاصة بالإمبراطورية (ميتالا). وهي فعالية أو عملية رسمية رئيسة فرضت نفسها على المنطقة (فصل 10، "منطقة نفوذ إمبراطوري: فينان الرومانية والبيزنطية"). ويعزى سبب اختيار وادي فينان كمركز التعدين الروماني بلا شك إلى وجود مصدر جيد للمياه في وادي الغوير ووجود أكبر أراضي قابلة للزراعة في منطقة وادي عربة. إن تحاليلنا لنظام مياه وادي فينان 4 تشير إلى أن السيطرة على الأراضي كانت هنا مركزية وموحدة، وقام أناس متمركزين في فاينو بالعمليات الزراعية (شكل 10، 32 و 10، 33). كما أن قامت العمليات المتطورة التي تم إضافتها إلى النظام الحقلي برفع مستوى طبيعته المتكاملة ومستواه وتعقيداته الهيدروليكية. فقد تم تشكيل وبناء نظام ريّ مُتقن من قنوات المياه (شكل 10، 29). وهكذا كانت القوة الإنتاجية تفوق الطاقة التحملية لمناطق وادي فينان القاحلة وبشكل اصطناعي، وذلك من أجل توفير الطعام والغذاء لعدد السكان المتزايد. وعلى كل حال فإنه في الفترات الرومانية البيزنطية المتأخرة، تم إجهاد هذه المنطقة بشدة بوساطة كثرة الأنشطة الصناعية والزراعية. وتطلب انتاج النحاس كميات هائلة من الفحم والخشب، والتي توجّب جلبها من النّجد والسهول في المناطق المرتفعة، لأن

الموازية" (شكل 5، 34 و 5، 35) بدت أنها تمثل أسلوب متناسق لعملية السيطرة على المياه (شكل 5، 29)، لكنها تؤرخ فعلياً إلى القرون الرومانية البيزنطية المعاصرة لمرحلة الإستيطان الرئيسة في خربة فينان.

الفصل 6 ("البيئات البلايستوسينية والمستوطنات البشرية") هذا الفصل يُثبت الشواهد لعدد من المراحل المميزة والأساسية من التطور والتحول الجيومورفي والذي أرخه المشروع إلى العصر البلايستوسيني (شكل 6، 4 و لوحة 6، 1)، حيث تم توثيق بيئة ديناميكية شُكلت عن طريق نشاطات تكتونية وتغيرات مناخية وتعقيدات جيولوجية. وحسب شواهد مسوحاتنا ومسوحات مشروع ضانا – فينان - الغويرما قبل التاريخ المبكر(فنلايسون ومايذن 2007)، تم استغلال هذه المنطقة بشكل متكرر خلال عصر البلايستوسين (مثال على ذلك شكل 6، 17 و 6، 19) عن طريق نشاطات الصيد القليلة وجمع الطعام. وقد كانت الأراضي المرتفعة في الكثير من المراحل أكثر جفافاً مما هي عليه اليوم، بينما كانت الأراضي المنخفضة مروية بشكل أفضل. ويرجح ان وادي فينان كان مأهولاً فصلياً بشكل عام من قِبل مجموعات من العصر الحجري القديم، تتنقل ما بين أراضي الأردن المرتفعة منها والمنخفضة. ويبدو أن وادي فينان يمكن اعتباره مأهولاً بشكل دائم فقط مع نهاية عصر البلايستوسين.

الفصل 7 ("البيئات الهولوسينية المبكرة والزراعة المبكرة حوالي 11000 – 7000 مقوّم كربونياً ق.م. وحوالي 9500 – 5000 مقوّم كربونياً ق.م.) هنا يتم وصف الشواهد والأدلة التي قام المشروع بجمعها ودمجها مع نتائج الحفريات المذكورة سابقاً بخصوص تغير طبيعة المنطقة في بداية الألفيات الهولوسينية وتغير طبيعة الإستيطانات البشرية خلال تلك الألفيات. ومع تطور بيئات مناخية أكثر رطوبة في بدايات الهولوسين في حوالي 9500 ق.م.، بدأ الناس يخيمون بجوار الينابيع في سفح واجهة الجبل لعدة شهور في السنة، ولربما حتى على مدار العام الكامل. وفي وادي فينان 16 (فنلايسون ومايذن 2007، شكل 7، 10) قام الناس بجمع النباتات البرية ومن ضمنها الحبوب، وربما بدأوا بترويض وبالسيطرة على الماعز إلى جانب صيدها. وبعد مضي ألف عام تم تمييز مجتمعات العصر الحجري الحديث ما قبل الفخار "ب" في الغوير 1 (شكل 7، 13 و 7، 14) وفي وادي فينان 1 بالتزام متقدم تجاه الزراعة. ومع أن بعض العلماء تجادلوا في حصول تحوّل مناخي إلى الجفاف، مما تسبب في تشكيل البداوة الرعوية في العصر الحجري الحديث ما قبل الفخار "سي"، إلاّ أن شواهدنا الجيومورفولوجية ودراسات البيئة القديمة أشارت إلى أن منطقة وادي فينان كانت تفضل بنفس الدرجة التي تم فيها تفضيل المستوطنات الزراعية في الفترة التي سُكنت فيها الغوير1في حوالي 7500 مقوّم كربونياً ق.م. بالإضافة إلى تل وادي فينان في حوالي 5500 ق.م، وذلك بما يخص وجود التيارات المائية بشكل دائم في الفترتين، حيث توجد الآن فقط طبقات سيل معظمها جافة. كما كانت هناك سهوب شاسعة وبقع من الغابات المتوسطية. أما الآن فلا توجد هناك حياة نباتية باستثناء الفترة التي تلحق المطر. وتقترح السجلات والدراسات اللقاحية إحتمالية وجود رقع أرضية من الحبوب بصورة قليلة في الحالتين.

وكما هو مذكورفي بداية الفصل 8، "مستوطنات العصر النحاسي (حوالي 5000 - 3600 مقوّم كربونياً ق.م.) والعصر البرونزي (حوالي 3600 – 1200 مقوّم كربونياً ق.م.): علوم المعادن والتعقيدات الإجتماعية"، فإن الألفية الرابعة والثالثة والثانية ق.م. كانت فترات تغير وتحول اجتماعي استثنائي في كل منطقة سورية الطبيعية. وقد تم تمييزها ووصفها بشكل خاص بتطور التسلسل الهرمي أو الطبقية الإجتماعية لمجتمعاتها في العصر النحاسي (حوالي 5000 – 3600 ق.م.)، وبالنهوض وانهيارالحياة المدنية فيها في العصر البرونزي (حوالي 3600 – 1200 ق.م.) أحياناً أخرى. وقد تعرض وادي فينان، والذي تواجد على هوامش المنطقة المأهولة ولكن ثري بثروته المعدنية، بوضوح لتأثيرات هذه التحولات والتغييرات. ولم نعثرعلى أية أدلة أو شواهد تشير إلى تواجد

استنفادها، إلاّ أن الفريق تمكن من التعرف على سلسلة من الترسبات النهرية والمراوح الطميّة والمنسوبية والأنثروبولوجية؟ التي تعود إلى عصر البلايستوسين المتأخر وعصر الهولوسين (الحديث)، منها ما عثر عليها في طبقات الغوير التي تعود إلى قبل ما يزيد عن 225 ألف عام ولغاية ترسبات تشكلت في القرون الحديثة (لوحة 3، 2 و 3، 3). وقد مكنت التحاليل التي أجريت على حبوب الطلع والبقايا العضوية الأخرى في التربة والمستحاثات الكبيرة الفريق من تكوين إطار بيئي قديم لعصر الهولوسين (لوحة 3، 5 وشكل 3، 9). كما تمكنوا من عمل إطار للتغيرات في البيئة المحلية، ولاسيما فيما يخص الترسبات (شكل 3، 17). ووجدت ميزة أخرى للاسلوب البحثي لهذا المشروع وهو الاستخدام المكثف للتقنيات الجيوكيميائية للكشف عن مجموعات معدنية تحوي ترسبات، وهو أسلوب مكن المشروع من الكشف عن الطبيعة المتغيرة ودرجة عمليات صهر المعادن خلال الأزمان بما يخص آثار التلوث على المنطقة (شكل 3، 18)، وذلك كتتمة للأعمال التي أجريت على المناجم القديمة ومواقع الصّهر في وادي فينان من قِبل فريق بوخوم.

فصل 4 ("تسجيل وتصنيف السجل الأثري") وهنا يتم شرح عملية وطريقة تسجيل ووصف وتصنيف المواقع الأثرية التي يبلغ عددها حوالي 1500 موقع، معظمها مبني من الحجارة والتي تم كشف النقاب عنها بوساطة مسوحات أثرية منظمة للمنطقة المدروسة. ومع الأخذ بعين الإعتبار استحالة الموضوعية التامة في عمليات التسجيل الميداني، إلا أن استراتيجية المسوحات الأثرية حاولت اولاً تصوير ووصف مورفولوجية - أو شكل وأسلوب - جميع البنيات والتراكيب الأثرية المرئية بمصطلحات موضوعية قدر الإمكان ومن ثم تطوير خطة تصنيف مبنية على أساس هذه الملاحظات. إن علم النماذج لمورفولوجية المواقع تطور في عمليات المسح والذي تم استخدامه في معجم المسوحات (ملحق 3) واختصارها في لوحة 4، 1. هذه الخطة تستعمل صفين من التصنيف: صف الفئات الرئيسة (على سبيل المثال الميزات الهيدروليكية)، وصف الفئات الفرعية (وعلى سبيل المثال جسور القنوات). يستعرض هذا الفصل الشواهد على هذه الفئات المتنوعة، وذلك بتوضيح الأشكال والأنواع المختلفة للبنيات، ويناقش الإتجاهات الرئيسة في توزيع الأصناف المختلفة للمواقع وشواهدها التأريخية (ملخص في الشكل 4، 1).

أما الفصل الأخير في جزء 1 (فصل 5. "أنظمة وادي فينان الميدانية") هنا يتم وصف أساليب وطرق التسجيل والتدوين والتصنيف والتأريخ وترجمة صفوف الحجارة بصفتها جدران الأنظمة الحقلية القديمة في وادي فينان. وقد تم وصف هذه الأنظمة الحقلية من قبل الكثير من الزوار السابقين (مثل كلوك 1935)، ولكنها لم تُدرس أبداً بطريقة نظامية. أعظمها حجماً متواجدة على مدى ضفاف وادي فينان الجنوبية، وقد تم تدريجها تحت وادي فينان 4 من قِبل الفريق الأساسي لمسوحات المعهد البريطاني للآثار والتاريخ/عمّان (بارنز وغيره 1995). وقام المشروع بتقسيمها إلى 20 وحدة لتسهيل عملية تسجيلها بالطريقة النظامية. إن حدود هذه الوحدات تم تحديدها بوساطة خصائص وصفات طوبوغرافية أساسية مثل الوديان التابعة التي تجزىء النظام (شكل 1، 11). فقد تم تعريف عشر فئات جدارية مختلفة (لوحة 5، 2). كما أنه تم اختراع وصنع نظام معلوماتي جغرافي لدمج جميع البيانات التي جمعناها، وبالأخص لتقييم العلاقات ما بين توزيع الأنماط الجدارية المختلفة والبنيات الأخرى مثل الصِّمامات والقنوات والمجاري، وبين توزيع المشغولات (الأدوات المصنوعة يدوياً) العائدة إلى فترات تاريخية متباينة، والتي تم جمعها في الميدان داخل الجدران. الإستنتاج النهائي والرئيسي من التحاليل هو أن الأنظمة الميدانية، وبشكل خاص وادي فينان 4 يمثل "منطقة ذات مراحل بنائية متعددة"، وليس ذات مرحلة بنائية واحدة، بالإضافة إلى توثيق تطور أنظمة "الزراعة عن طريق مياه الفيضانات" (حجز وتوزيع والسيطرة على المياه السطحية التي تتدفق إلى قنوات الأودية بعد حدوث فيضانات محلية)، وذلك من العصر البرونزي إلى يومنا هذا. ومع أن المرحلة الأساسية للنظام الميداني لوادي فينان 4 عندما تم بناء مجموعة من القنوات الطويلة والمعلّمة "بالجدران

كان هناك موضوع اهتمام آخر وهو موضوع التعرية وتدهور حالة الأرض أو صلاحيتها من منظور تاريخي طويل الأمد من ضمن ما تسمح به الدراسات الأثرية. نسأل في اي ظروف مناخية وديموغرافية واجتماعية اقتصادية تم فيها تدهور حالة الأراضي القاحلة ولكنها استطاعت اصلاح وانقاذ نفسها فيها. وفي أي حالات كانت فيها عمليات التدهور قوية إلى درجة لم تستطع ذلك؟ الإهتمام الجوهري الثالث كان يكمن في فهم موضوع الهامشية، ولاسيما كيفية تفاعل الناس الذين عاشوا في مناطق جافة وقاحلة في الماضي مع جيرانهم سكان المناطق الزراعية الأكثر مياهاً، وذلك فيما يخص العلاقات المركزية المحيطية (المركز بمحيطه). الإهتمام الرابع كان يتناول موضوع أساليب البحث الأثري في المناطق القاحلة، وعلى سبيل المثال موضوع ومشكلة المقدرة على التمييز بين غياب الدليل من جهة والدليل على الغياب من جهة أخرى وبشكل خاص ما يتعلق بعلم آثار الرعوية.

إن نقاط القوة الرئيسة في أبحاث علم آثار المواقع مثل مسح موقع وادي فينان تكمن في معاييرالحيّز والكرونولوجيا للبيانات والمعلومات المتراكمة وطبيعة علاقتها بعدد من الفروع والتخصصات الدراسية. ولكن نقطة ضعف مشروع كهذا تكمن في غياب وعدم دقة تأريخ المعلومات والبيانات المفصلة، والتي يمكن فقط تزويدنا بها عن طريق مشاريع التنقيبات الأثرية المنظمة الكبيرة والمهمة . وذلك بخصوص أنشطة معينة وبيئات في مواقع معينة وفي لحظات معينة في الماضي. وبطبيعة الحال، فإن أية دراسة شاملة تخص تطور المواقع تحتاج لاستخدام الطريقتين معاً. وهنا كنا محظوظين جداً لتمكننا من مقارنة بياناتنا وربط نتائجنا مع أعمال الحفريات الكثيرة التي أجريت ومازالت تجرى من قِبل فِرق أخرى في وادي فينان ووادي فيدان، وهي من المواقع المرتبطة بمعظم فترات الاستيطان الرئيسة في الماضي. وعلى سبيل المثال وفيما يخص فترات ما قبل التأريخ نجد في وادي فينان ما يلي: استيطان يعود إلى العصر الحجري الحديث ما قبل الفخار" أ" لوادي فينان 16 (فنلايسون ومايذن 2007)، وبجوار الموقع المذكور نجد استيطان غوير 1 يعود إلى العصر الحجري الحديث ما قبل الفخار "ب" (سيمونز والنجّار 2006)، ومستوطنة العصر الحجري الحديث الفخاري/النحاسي في تل وادي فينان (النجّار وغيره 1990)، وموقع وادي فينان 100 الذي يعود إلى العصر البرونزي المبكر (رايت وغيرها 1998)، بالإضافة إلى سلسلة من حفريات المستوطنات والمقابر في موقع وادي فيدان الذي يشكل الجزء الأدنى لموقع وادي فينان (مثل آدامز 2000، آدامز وجينز 1995، ليفي 2004، 2006، ليفي وهايام 2005، ليفي وغيره 1999، 2001أ، 2001ب، 2003، 2004 أ، 2004ب، 2005، مونيز 2006).

ويجدر بنا ذكر مساهمة أخرى عظيمة الأهمية ألا وهي برنامج الأبحاث الجاري من طرف متحف تعدين بوخوم، والذي يخص عمليات التعدين والصّهر قديماً (هاوبتمان 2000و 2007).

الفصل 2 ("وادي فينان اليوم: أرضه وبيئته وأهله") الدراسات هنا تتناول وصف منطقة وأرض وطبيعة وثقافة المنطقة في يومنا هذا. الجزء الأول لهذا الفصل يستعرض البيئة الطبيعية: المناخ، الطبوغرافيا، الجيولوجيا والتعدين، التربة والترسبات السطحية، الحياة النباتية والحيوانات. الجزء الثاني يقوم بوصف البدو في يومنا هذا، وذلك بالإستعانة بالوديان التالية(الرشايدة والسعيديين والمناجعة والعزازمة والعطاعطة والشوابكة)، تاريخهم وما هو معروف عن أنماط حياتهم التقليدية في القرون الحديثة، والبحث في كيفية تفاعل وتجاوب هذه الأنماط مع ضغوط الحياة الحديثة وفرصها.

الفصل 3 ("منطقة وأراضي وادي فينان في الماضي وفي الحاضر: أساليب جيوآثارية وبنيات/إطارات") يوضح ويشرح فيه استراتيجية الأعمال الميدانية والميثولجيات واساليب البحث المتبعة من قِبل الفريق الجيوآثاري لتوثيق وتأريخ تطورات منطقة وادي فينان وللكشف عن التـأثيرات المناخية المختلفة وتأثير الناس على هذه العملية. ومع أن إمكانيات وحدود الأساليب الجيوآثارية هنا تم

Archaeology and desertification: Arabic summary

Graeme Barker and David Mattingly

علم الآثار والتصحّر: مسوحات منطقة وادي فينان

غريم باركر و ديفيد ماتنغلي

إن وادي فينان منطقة صحراوية ذات جمال قاس تقع في جنوب الأردن بين صحراء وادي عربة القاحلة ذات الأراضي المنخفضة غرباً وبين جبال ادوم الوعرة والأكثر رطوبة شرقاً. يمثل كتاب علم الآثار والتصحّر نتائج مسوحات منطقة وادي فينان، فهو يقدم دراسات تشمل كافة التخصصات فيما يتعلق بالتغيرات التي حصلت في منطقة وادي فينان والتي تمت ما بين عام 1996 وعام 2000 على يد فريق من خبراء الآثار والجغرافيا. وقد كان هدف هذا المشروع المساهمة في المناقشات الدائرة حول التصحر في يومنا هذا، وذلك من خلال تزويدنا بمنظور بعيد الأمد عن العلاقات ما بين التغير البيئي وتاريخ البشر. وقد تناولنا هذا الموضوع لأن الآثار المتوفرة التي تم التعرف عليها سابقاً في مستوطنات وادي فينان ومقابره "وأنظمة حقوله" وبقايا عمليات التعدين، تشير إلى أن ماضيه تم تشخيصه بعدّة مراحل استيطان واستخدام للأراضي بطرق مختلفة لما عليه الوضع اليوم. إن خربة فينان وهي الموقع الأثري الرئيسي، كان معروفاً في القرون الرومانية البيزنطية، وتمّت الإشارة إليه بـِ فينو، حيث كان معروفاً بكونه مركزاً رئيساً لتصنيع النحاس في ذلك الوقت. ولهذا السبب بدا لنا وادي فينان موقعاً مثالياً لدراسة "التاريخ الآثاري" على المدى الطويل والبعيد فيما يخص العلاقة ما بين منطقة صحراوية وسكانها من البشر.

الكتاب مقسم إلى جزئين رئيسيين. الجزء الأول (الجزء 1، ويتضمن الفصول من 1-5 ويصف أسلوب المشروع المتبع عن نتائج التقنيات المعينة التي تم الإستعانة بها في المشروع من الناحية الأثرية والجيومورفولوجية وعلوم البيئة القديمة والجيوكيميائية. والجزء الثاني (الجزء 2، الترتيب الكرونولوجي) فيه تدمج وتوحّد نتائج جميع هذه الأساليب المختلفة من أجل بناء معايير يجري في ضوئها تقييم كل فترة على حدة ولكل البيانات المتوفرة من عصر البلايستوسين وحتى يومنا هذا (فصل 6- 12). أمّا الفصل الأخير (13) فيقوم باستعراض جميع المعلومات والبيانات الموضوعة بخصوص فهمنا لاستراتيجية البشر في المستوطنات الصحراوية ودور دراسات وأبحاث منطقة فينان بمواضيع حول التصحر في الحاضر والماضي.

في الجزء 1 ("مسح منطقة وادي فينان: مواضيع البحث وتطور المشروع") قمنا بتقديم وعرض مواضيع المشروع الرئيسة وكيف قامت بتشكيل تطوراته. فقد كان هدفنا الرئيسي أوّلاً هو مساهمة نتائج مسح منطقة وادي فينان في فهمنا لعملية التصحّر والجفاف، ولاسيما دور كل من الناس والمناخ في الماضي في تكوين وتشكيل المناطق الجافة والصحراوية في يومنا الحاضر.

APPENDICES

Appendix 1. Published radiocarbon dates from the Faynan region

Chris Hunt, David Mattingly, Graeme Barker, and David Gilbertson

The dates have been calibrated (or recalibrated) using CALIB (http://calib.qub.ac.uk/). The lower and upper ranges of the calibrated dates are quoted to both 2 σ in years BP and 2 σ in years BC/AD to facilitate comparison with the evidence presented elsewhere. Also presented is the median probability of each calibrated date in years BP and BC/AD. Abbreviations for previous publication of dates in the tables below are as follows: Finlayson = Finlayson and Mithen 2007: 461; Hauptmann a = Hauptmann 2000: 65–6; Hauptmann b = Hauptmann 2007: 88–9; Higham = Higham *et al.* 2005: 166–7; Hunt = Hunt *et al*. 2007b: 1333–4 (for previous publication of the Wadi Faynan Landscape Survey dates); Levy a = Levy *et al.* 1999a: 303; Levy b = Levy *et al.* 2001b: 169; Levy c = Levy *et al.* 2005b: 135; Simmons = Simmons and Najjar 2006: 80; WFLS = Wadi Faynan Landscape Survey unpublished.

The dates show distinct clustering, with peaks between 12,000–9000 BP (Early Neolithic), 7500–6000 BP (Late Neolithic), 5500–4000 BP (Chalcolithic/Early Bronze Age), 3500–2500 BP (Late Bronze Age–Nabatean), and 2000–1500 BP (Roman), of which the largest peak is Late Bronze Age–Nabatean (Fig. A1.1). They have been divided below into these broad chronological groups, though there is sometimes overlap at the boundaries. This pattern must partly reflect the interests of investigators, but is also likely to reflect real differences in the intensity of human activity, with periods of expansion and intense activity separated by periods when activity was less intense.

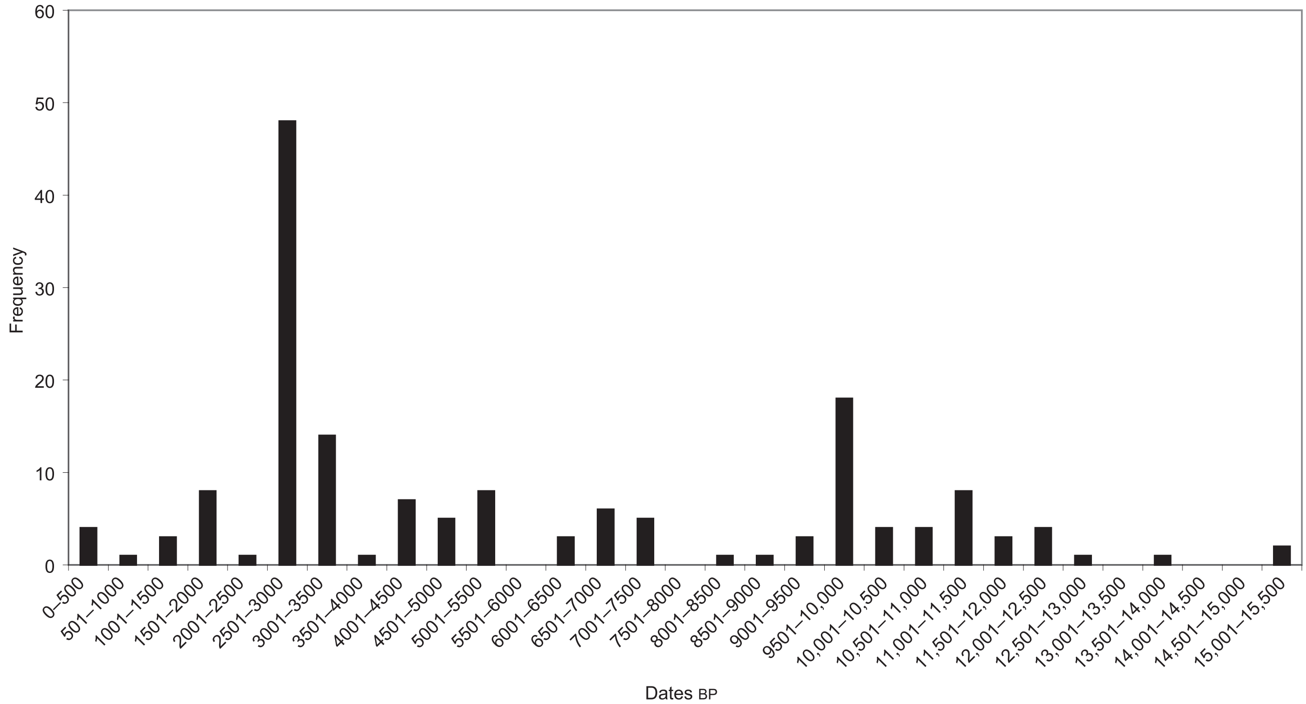


Figure A1.1 *Frequency of published radiocarbon dates from the Faynan region.*

Table A1.1 *Neolithic and pre-Neolithic radiocarbon dates from the Faynan region (n.b. there is some overlap with Table A1.2 below, of Chalcolithic dates).*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC	Median probability BC	Upper cal. range BC	Reference
WF16	110	Beta-120204	13,010	50	15,092	15,363	15,693	13,744	13,413	13,143	Finlayson
WF16	112	Beta-120208	12,830	50	14,929	15,148	15,417	13,468	13,198	12,980	Finlayson
WF16	114	Beta-120209	11,830	50	13,543	13,701	13,819	11,870	11,751	11,594	Finlayson
WF16	130	Beta-192521	10,500	40	12,242	12,514	12,691	10,742	10,564	10,293	Finlayson
WF16	243	Beta-192527	10,440	40	12,134	12,377	12,624	10,675	10,427	10,185	Finlayson
WF16	241	Beta-192526	10,420	40	12,110	12,313	12,601	10,652	10,363	10,161	Finlayson
WF16	239	Beta-192525	10,350	40	12,044	12,206	12,386	10,437	10,256	10,095	Finlayson
WF16	332	Beta-192530	10,340	40	12,034	12,184	12,384	10,435	10,234	10,085	Finlayson
WF16	332	Beta-135111	10,220	50	11,751	11,941	12,130	10,181	9991	9802	Finlayson
WF16	210	Beta-120210	10,190	50	11,647	11,891	12,077	10,128	9941	9698	Finlayson
WF16	232	Beta-192524	10,150	40	11,621	11,830	12,025	10,076	9880	9672	Finlayson
WF16	327	Beta-192531	9950	40	11,246	11,356	11,604	9655	9406	9297	Finlayson
WF16	151	Beta-192523	9920	40	11,229	11,312	11,599	9650	9362	9280	Finlayson
WF16	126	Beta-192520	9900	40	11,216	11,292	11,401	9452	9342	9267	Finlayson
WF16	211	Beta-120211	9890	50	11,202	11,292	11,597	9648	9342	9253	Finlayson
WF16	148	Beta-192522	9880	40	11,212	11,271	11,390	9441	9321	9263	Finlayson
WF16	330	Beta-192529	9870	40	11,206	11,262	11,386	9437	9312	9257	Finlayson
Ghwair I WF38	II/I	ISGS-4366	9710	50	10,809	11,149	11,236	9287	9199	8860	Simmons
WF16	111	Beta-120205	9690	50	10,794	11,123	11,225	9276	9173	8845	Finlayson
WF16	239	Beta-208671	9560	40	10,729	10,932	11,092	9143	8982	8780	Finlayson
WF16	238	Beta-208672	9430	40	10,566	10,661	10,759	8810	8711	8617	Finlayson
WF16	111	Beta-120206	9420	50	10,509	10,651	10,773	8824	8701	8560	Finlayson
WF16	112	Beta-120207	9400	50	10,507	10,631	10,747	8798	8681	8558	Finlayson
WF16	329	Beta-135110	9180	50	10,238	10,344	10,493	8544	8394	8289	Finlayson
Wadi Fidan 11	(depth 0.25 m)	HD-12333	9157	112	9952	10,352	10,659	8710	8402	8003	Hauptmann a
WF16	310 [4]	Beta-209010	9140	40	10,226	10,288	10,412	8463	8338	8277	Finlayson
Ghwair I WF38	II/II?	DRI-3253	9027	116	9745	10,161	10,495	8546	8211	7796	Simmons
Ghwair I WF38	I/II	DRI-3252	8880	117	9608	9960	10,231	8282	8010	7659	Simmons
Ghwair I WF38	I/II	ISGS-4330	8870	70	9704	9982	10,190	8241	8032	7755	Simmons
Ghwair I WF38	I/I	HD-17219–HD-17541	8812	61	9632	9864	10,159	8210	7914	7683	Simmons
Ghwair I WF38	I/II	DRI-3251	8806	52	9633	9847	10,154	8205	7897	7684	Simmons
Ghwair I WF38	III/II?	DRI-3253	8755	311	9024	9838	10,641	8692	7888	7075	Simmons
Ghwair I WF38	II/II?	DRI-3256	8754	52	9552	9748	10,114	8165	7798	7603	Simmons
Ghwair I WF38	II/I	ISGS-4364	8690	70	9536	9665	9899	7950	7715	7587	Simmons
Ghwair I WF38	I/II	DRI-3254	8659	178	9306	9722	10,199	8250	7772	7357	Simmons
Ghwair I WF38	I/III	HD-17220–HD-17550	8627	46	9528	9588	9689	7740	7638	7579	Simmons
Ghwair I WF38	IV/II?	ISGS-4333	8620	70	9477	9600	9882	7933	7650	7528	Simmons
Ghwair I WF38	I/III	Beta-140758	8620	50	9520	9585	9698	7749	7635	7571	Simmons
Ghwair I WF38	I/III	Beta-140759	8610	50	9500	9576	9689	7740	7626	7551	Simmons
Ghwair I WF38	II/II?	ISGS-4325	8590	70	9466	9567	9736	7787	7617	7517	Simmons
Ghwair I WF38	II/III?	ISGS-4332	8570	70	9449	9544	9696	7747	7594	7500	Simmons
Ghwair I WF38	VI/II?	ISGS-4364	8570	100	9326	9562	9889	7940	7612	7377	Simmons
Ghwair I WF38	IV/II?	ISGS-4365	8530	100	9285	9518	9765	7816	7568	7336	Simmons
Ghwair I WF38	IV/II?	HD-17221–HD-17359	8528	89	9304	9515	9699	7750	7565	7355	Simmons
Ghwair I WF38	IV/II?	ISGS-4331	8510	70	9322	9504	9625	7676	7554	7373	Simmons
Ghwair I WF38	I/III	Beta-140757	8390	50	9290	9422	9517	7568	7472	7341	Simmons
Wadi Fidan 8	Trench 6.11	HD-13530	8272	324	8422	9206	10,128	8179	7256	6473	Hauptmann b
Wadi Fidan 8	Trench 3	HD-13777	8220	117	8783	9196	9488	7539	7246	6834	Hauptmann b
Wadi Fidan 11	East slope (depth 0.2 m)	HD-12334	7768	74	8402	8547	8760	6811	6597	6453	Hauptmann b
Wadi Dana WF5015	Neolithic pit fill	Beta-111121	7240	90	7868	8068	8302	6353	6118	5919	Hunt
Tell Wadi Faynan WF25	Wadi cliff section (depth 4 m)	HD-10567	6408	114	7025	7327	7561	5612	5377	5076	Hauptmann a
Tell Wadi Faynan WF25	Wadi cliff section (depth 2.5 m)	HD-12335	6370	40	7180	7306	7420	5471	5356	5231	Hauptmann a
Tell Wadi Faynan WF25	Wadi section WF5021G	Beta-205964	6200	40	6994	7092	7245	5296	5142	5045	Hunt

Table A1.2 *Chalcolithic and Early Bronze Age radiocarbon dates from the Faynan region.*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC	Median probability BC	Upper cal. range BC	Reference
Tell Wadi Faynan WF25	Sq B, locus 6 (depth 0.8 m)	HD-13775	6132	50	6892	7030	7164	5215	5080	4943	Hauptmann a
Tell Wadi Faynan WF25	Sq Fa (depth 0.2 m)	HD-12338	6105	68	6796	6987	7164	5215	5037	4847	Hauptmann a
Wadi Fidan 8	A, 8/7, locus 7	HD-17471	6082	44	6797	6947	7156	5207	4997	4848	Hauptmann a
Tell Wadi Faynan WF25	Sq A, locus 23 (depth 1.4 m)	HD-12337	5740	35	6448	6538	6637	4688	4588	4499	Hauptmann a
Khirbat Faynan WF5741	Base layer of slag heap 7 = WF1491 (depth 0.9 m)	Beta-203413	5690	40	6399	6473	6630	4681	4523	4450	Hunt
Tell Wadi Faynan WF25	Sq A, locus 8 (depth 1.05 m)	HD-12336	5375	30	6018	6197	6280	4331	4247	4069	Hauptmann a
Khirbat Faynan WF5741	Base layer of slag heap 7 = WF1491 (depth 0.9 m)	Beta-203414	5290	40	5942	6078	6187	4238	4128	3993	Hunt
Wadi Fidan 4	Area D, locus 9	HD-16327	4718	25	5325	5458	5580	3631	3508	3376	Levy b
Wadi Fidan 4	Area D, locus 14	HD-16380	4702	37	5320	5412	5580	3631	3462	3371	Levy b
Wadi Fidan 4	Area A, locus 50	HD-13776	4684	50	5313	5412	5580	3631	3462	3364	Levy b
Wadi Fidan 4	Area A, locus 5	HD-16379	4576	44	5052	5269	5447	3498	3319	3103	Levy b
WF16	323	Beta-192528	4490	40	4978	5163	5299	3350	3213	3029	Finlayson
WF16	323	Beta-209011	4490	40	4978	5163	5299	3350	3213	3029	Finlayson
WF8	320	Beta-135112	4440	50	4873	5059	5285	3336	3109	2924	Finlayson
Wadi Fidan 4	Area A, locus 22	HD-16378	4422	51	4864	5021	5282	3333	3071	2915	Levy b
Barqa al-Hatiya	House BH 1, 27/91, locus 13	HD-13975	4376	57	4840	4957	5275	3326	3007	2891	Hauptmann a
Barqa al-Hatiya	House BH 1, 8/90, locus 3	HD-13976	4267	43	4650	4842	4961	3012	2892	2701	Hauptmann a
Khirbat Faynan WF648	Slag heap 9 (depth 0.5 m)	HD-10577	4140	109	4359	4662	4960	3011	2712	2410	Hauptmann a
Wadi Ghuwayr 4	Slag heap (depth 0.5 m)	HD-10573	4059	55	4419	4559	4813	2864	2609	2470	Hauptmann a
Khirbat Hamrat Ifdan (Wadi Fidan 120)	Trench 1, locus 114	HD-16533	4044	40	4419	4520	4797	2848	2570	2470	Hauptmann a
Khirbat Faynan WF648	Slag heap 9 Furnace 7/8	HD-10993	3981	50	4257	4456	4776	2827	2506	2308	Hauptmann a
Khirbat Faynan WF648	Slag heap 9 Furnace 25	HD-10994	3973	85	4155	4436	4806	2857	2486	2206	Hauptmann a
Ras an-Naqab	Slag heap (depth 0.3 m)	HD-10574	3971	67	4162	4434	4785	2836	2484	2213	Hauptmann a
Khirbat Faynan	Slag heap 16 (depth 0.3 m)	HD-10579	3923	61	4157	4354	4522	2573	2404	2208	Hauptmann a
Wadi Ghuwayr 3	Slag heap (depth 0.5 m)	HD-16529	3919	26	4253	4358	4424	2475	2408	2304	Hauptmann a
Khirbat Hamrat Ifdan (Wadi Fidan 120)	Trench 2, locus 209	HD-16534	3914	45	4162	4346	4513	2564	2396	2213	Hauptmann a
Khirbat Faynan WF648	Slag heap 9 Furnace 24	HD-10584	3812	77	3985	4212	4418	2469	2262	2036	Hauptmann a

Table A1.3 *Radiocarbon dates of Late Bronze Age, Iron Age and Nabataean activity in the Faynan region.*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC	Median probability BC	Upper cal. range BC	Reference
Khirbat Faynan WF5012	Barrage section, slag deposit at *c.* 2.8 m depth	Beta-203402	3390	40	3485	3636	3816	1867	1686	1536	Hunt
Wadi Khalid WF1548	Mine workings 42 = WF1548, backfill 17 m inside entrance	HD-14926	3197	39	3349	3419	3551	1602	1469	1400	Hauptmann a
Wadi Dana WF1580	Mine workings 13 = WF1580, waste dump in front of entrance (0.6 m deep)	HD-10578	2949	63	2929	3118	3330	1381	1168	980	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.89 B.1840 Red sediment below indus. (Area A3)	GrA-25318	2920	35	2959	3070	3207	1258	1120	1010	Levy c
Khirbat al-Jariya (WAJ 540)	Slag heap KJ24	HD-16351	2915	30	2961	3059	3201	1252	1109	1012	Hauptmann a

Table A1.3 *(cont.)*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC	Median probability BC	Upper cal. range BC	Reference
Khirbat an-Nahas (WAG 62)	L.21 B.1458 (Area A2A)	GrA-25334	2910	50	2887	3058	3214	1265	1108	938	Levy c
Khirbat an-Nahas (WAG 62)	Slag heap KN 2, 0.9 m deep	HD-14057	2906	39	2929	3049	3207	1258	1099	980	Hauptmann a
Khirbat Faynan WF5739	Slag heap 7 = WF455	Beta-203407	2900	40	2894	3041	3206	1257	1091	945	Hunt
Khirbat an-Nahas (WAG 62)	L356 Cooking installation; basal layer (Area S4)	OxA-12169	2899	27	2953	3034	3156	1207	1084	1004	Higham
Khirbat an-Nahas (WAG 62)	Slag heap KN 3, 1.25 m deep	HD-14336	2898	36	2927	3036	3202	1253	1086	978	Hauptmann a
Khirbat Faynan WF5738	Slag heap 7 = WF455	Beta-203406	2890	40	2886	3027	3200	1251	1077	937	Hunt
Khirbat al-Jariya (WAJ 540)	Slag heap, depth 0.3 m	HD-10990	2886	56	2868	3026	3208	1259	1076	919	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.89B.1911 (Area A3)	GrA-25354	2880	50	2870	3015	3202	1253	1065	921	Levy c
Khirbat an-Nahas (WAG 62)	Slag heap KN Eisen 2, 0.2 m deep	HD-14302	2880	28	2889	3009	3139	1190	1059	940	Hauptmann a
Khirbat an-Nahas (WAG 62)	Slag heap KN Eisen 5, 1.20 m deep	HD-14308	2876	38	2877	3005	3143	1194	1055	928	Hauptmann a
Khirbat an-Nahas (WAG 62)	Slag heap KN Eisen 6, 1.75 m deep	HD-14113	2864	46	2860	2989	3156	1207	1039	911	Hauptmann a
Khirbat al-Jariya (WAJ 540)	Slag heap KJ27, base at 0.75 m deep	HD-16530	2839	22	2866	2942	3020	1071	992	917	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.344 B.7621 Slag Layer/ Surface (SU) below RM 3 (Area S3)	GrA-25347	2830	45	2798	2939	3075	1126	989	849	Levy c
Khirbat Faynan WF5739	Slag heap 7 = WF455	Beta-203409	2830	40	2847	2936	3071	1122	986	898	Hunt
Khirbat an-Nahas (WAG 62)	L341 Earliest industrial slag layer; under building foundations (Area S3)	OxA-12342	2830	27	2855	2932	3055	1106	982	906	Higham
Khirbat an-Nahas (WAG 62)	L95 Ashy layer below surface over bedrock (Area A4A)	OxA-12365	2825	32	2850	2928	3060	1111	978	901	Higham
Khirbat an-Nahas (WAG 62)	L.342 B.7660 Slag layer (SL) below RM 1 (Area S3)	GrA-25353	2820	50	2792	2928	3071	1122	978	843	Levy c
Khirbat an-Nahas (WAG 62)	L.301B.6103 (Area S2A)	*Antiquity* 78	2820	35	2845	2923	3062	1113	973	896	Levy c
Khirbat an-Nahas (WAG 62)	L.74 B.1642 (Area A2B)	GrA-25316	2815	40	2795	2919	3061	1112	969	846	Levy c
Wadi Fidan 40	Cemetery	Beta-111366	2800	70	2759	2913	3137	1188	963	810	Levy a
Khirbat an-Nahas (WAG 62)	L.353 B.7738 Surface (SU) below RM 1 (Area S4)	GrA-25352	2800	45	2781	2904	3058	1109	954	832	Levy c
Khirbat an-Nahas (WAG 62)	L.317 B.6508 (Area S1)	GrA-25342	2795	45	2777	2898	3055	1106	948	828	Levy c
Khirbat an-Nahas (WAG 62)	L.347 B.7659 Fill above Surface (FS) (Area S4)	GrA-25349	2790	45	2779	2892	2999	1050	942	830	Levy c
Khirbat Faynan WF5739	Slag heap 7 = WF455	Beta-203408	2790	40	2784	2891	2988	1039	941	835	Hunt
Khirbat Faynan WF5739	Slag heap 7 = WF455	Beta-203410	2790	40	2784	2891	2988	1039	941	835	Hunt
Khirbat an-Nahas (WAG 62)	L94 Surface connected to original gate structure (Area A3)	OxA-12366	2783	31	2792	2882	2955	1006	932	843	Higham
Khirbat an-Nahas (WAG 62)	L.338 B.7418 Surface (SU) inside structure RM 2 (Area S2B)	GrA-25345	2780	45	2775	2879	2989	1040	929	826	Levy c
Khirbat an-Nahas (WAG 62)	L.336 B.7524 Silty sediment (SD) outside structure (Area S2B)	GrA-25344	2770	45	2767	2867	2964	1015	917	818	Levy c
Khirbat an-Nahas (WAG 62)	L.346 B.7667 Silty sed. (SD) above surface (Area S4)	GrA-25348	2770	45	2767	2867	2964	1015	917	818	Levy c

Table A1.3 *(cont.)*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC	Median probability BC	Upper cal. range BC	Reference
Khirbat an-Nahas (WAG 62)	Slag heap KN 1	HD-14107	2755	82	2739	2870	3077	1128	920	790	Hauptmann a
Khirbat an-Nahas (WAG 62)	L36 Main occupation phase of building (Area S2B)	OxA-12168	2747	26	2775	2831	2921	972	881	826	Higham
Barqa al-Hatiya	House BH 2, locus 108	HD-13977	2743	23	2776	2826	2917	968	876	827	Hauptmann a
Khirbat an-Nahas (WAG 62)	Slag heap, wadi edge section	HD-10575	2738	52	2756	2836	2947	998	886	807	Hauptmann a
Khirbat an-Nahas (WAG 62)	Slag heap NW, 0.3 m deep	HD-10991	2735	46	2755	2830	2942	993	880	806	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.317 B.6389 Silty sed. (SD) bel. and w/ collapse RM 2(Area S1)	GrA-25326	2735	35	2760	2825	2922	973	875	811	Levy c
Khirbat Faynan E of WF1	Slag heap 5 (storage jar, locus 3)	HD-10581	2726	102	2510	2851	3159	1210	901	561	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.340 B.7594 Silty Sed. (SD) below and w/ collapse (Area S2A)	GrA-25343	2720	45	2751	2820	2923	974	870	802	Levy c
Khirbat an-Nahas (WAG 62)	L. 263 B.5770 Ash fill (AS) Large amounts of slag (Area S1)	GrA-25324	2720	35	2755	2816	2916	967	866	806	Levy c
Khirbat an-Nahas (WAG 62)	L61 Installation with human remains, outside gate (Area A2A)	OxA-12368	2719	31	2759	2815	2867	918	865	810	Higham
Khirbat an-Nahas (WAG 62)	L.322 B.6943 Silty sed. (SD) outside structure (Area S2A)	GrA-25332	2715	40	2752	2815	2918	969	865	803	Levy c
Khirbat an-Nahas (WAG 62)	L.21 B.1069 Ash and slag layer (Area A2A)	GrA-25311	2710	35	2754	2810	2867	918	860	805	Levy c
Khirbat an-Nahas (WAG 62)	L.58 B.1409 Hard reddish surface/ S prb/u. L.57, 56 (Area A4A)	GrA-25320	2710	35	2754	2810	2867	918	860	805	Levy c
Khirbat an-Nahas (WAG 62)	L.74 B.1655 (Area A2B)	GrA-25315	2705	40	2750	2808	2873	924	858	801	Levy c
Khirbat an-Nahas (WAG 62)	L.301B.6041 (Area S2A)	GrA-25329	2705	40	2750	2808	2873	924	858	801	Levy c
Khirbat an-Nahas (WAG 62)	L.74 B.1659 Copper ind. Waste (Area A2B)	GrA-25314	2705	35	2753	2806	2863	914	856	804	Levy c
Khirbat an-Nahas (WAG 62)	House 1	HD-13978	2704	52	2743	2813	2924	975	863	794	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.312 B.6709 Silty sed. (SD) bel. and w/ collapse RM 3 (Area S1)	GrA-25325	2700	35	2752	2802	2859	910	852	803	Levy c
Khirbat an-Nahas (WAG 62)	L92 Massive smelting inside chamber (Area A2B)	OxA-12367	2689	31	2752	2790	2849	900	840	803	Higham
Khirbat an-Nahas (WAG 62)	L331 Reuse of Room 2 (Area S2A)	OxA-12274	2682	34	2749	2786	2849	900	836	800	Higham
Khirbat Faynan WF5739	Slag heap 7 = WF455	Beta-203411	2680	40	2745	2788	2855	906	838	796	Hunt
Khirbat an-Nahas (WAG 62)	L.94 B.1944 Reddish-brown layer (surface?) NE cham (Area A3)	GrA-25322	2680	40	2745	2788	2855	906	838	796	Levy c
Khirbat an-Nahas (WAG 62)	L.21 B.1419 (Area A2A)	GrA-25312	2670	35	2746	2778	2846	897	828	797	Levy c
Khirbat an-Nahas (WAG 62)	L.317B.6383 (Area S1)	GrA-25328	2670	35	2746	2778	2846	897	828	797	Levy c
Khirbat Faynan E of WF1	Slag heap 5, 0.3 m deep	HD-10992	2664	74	2503	2786	2955	1006	836	554	Hauptmann a
Khirbat an-Nahas (WAG 62)	L.53 B.1332 Solid ash layer/ E probe (Area A3)	GrA-25321	2660	40	2739	2774	2849	900	824	790	Levy c
Khirbat Faynan E of WF1	Slag heap 5, furnace locus 2	HD-10582	2647	47	2625	2769	2857	908	819	676	Hauptmann a
Khirbat Faynan WF5017	Barrage section, 2.40 m depth	Beta-110840	2630	50	2543	2757	2859	910	807	594	Hunt
Khirbat Faynan WF5017	Barrage section, 2.60 m depth	Beta-110841	2630	50	2543	2757	2859	910	807	594	Hunt
Khirbat Faynan E of WF1	Slag heap 5, S furnace, locus 4	HD-10580	2380	45	2332	2426	2697	748	476	383	Hauptmann a (HD-10580)

Table A1.4 *Roman and Byzantine period radiocarbon dates from the Faynan region.*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range BC/AD	Median probability BC/AD	Upper cal. range BC /AD	Reference
Khirbat Faynan WF11	Slag heap 1, section L3 0.45 m deep	HD-14307	2031	50	1882	1990	2120	171 BC	40 BC	AD 68	Hauptmann a
Khirbat Faynan WF11	Slag heap 1, section 3, 0.3 m deep	HD-14378	1991	72	1741	1950	2143	194 BC	AD 1	AD 209	Hauptmann a
Khirbat Faynan WF5012	Barrage section, 2.04–2.06 m deep	Beta-203400	1870	40	1712	1809	1890	AD 60	AD 142	AD 238	Hunt
Khirbat Faynan WF11	Slag heap 1, section 15, 4.7 m deep	HD-14380	1828	34	1637	1768	1865	AD 85	AD 183	AD 313	Hauptmann a
Khirbat Faynan WF11	Slag heap 1, section 12, 3.2 m deep	HD-14066	1822	31	1633	1764	1861	AD 89	AD 187	AD 317	Hauptmann a
Khirbat Faynan WF11	Slag heap 1, section L9, 1.25 m deep	HD-14306	1801	34	1620	1737	1673	AD 128	AD 214	AD 330	Hauptmann a
Khirbat Faynan WF5012	Barrage section, 2.24–2.26 m	Beta-203401	1800	40	1611	1735	1825	AD 92	AD 216	AD 339	Hunt
Khirbat Faynan WF11	Slag heap 1, section R2, 0.6 m deep	HD-14097	1790	40	1575	1719	1576	AD 127	AD 232	AD 375	Hauptmann a
Khirbat Faynan WF5012	Barrage section, 1.74–1.76 m	Beta-203399	1610	40	1403	1488	1571	AD 349	AD 463	AD 547	Hunt

Table A1.5 *Islamic and Mamluk period radiocarbon dates from the Faynan region.*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range AD	Median probability AD	Upper cal. range AD	Reference
Wadi Ghuwayr WF5511	Hammam Member	Beta-119620	1220	40	1058	1149	1265	685	802	892	Hunt
Wadi Ghuwayr WF5511	Terrace section	Beta-203398	1210	40	1014	1137	1025	687	814	936	WFLS
Wadi Dana WF5025	Terrace section	Beta-115214	390	50	315	439	413	1435	1512	1635	Hunt
Khirbat Faynan WF5041	Slag heap 7 (top layer in section WF1491	Beta-203412	430	40	326	491	536	1414	1460	1624	Hunt
Wadi Dana WF5710	Terrace section	Beta-203403	660	40	553	615	611	1274	1336	1397	Hunt

Table A1.6 *'Sub-recent' radiocarbon dates from the Faynan region.*

Site	Context	Lab code	14C age	St. dev.	Lower cal. range BP	Median probability BP	Upper cal. range BP	Lower cal. range AD	Median probability AD	Upper cal. range AD	Reference
Wadi Ghuwayr WF5509	Terrace section	Beta-119600	110	50	–4	123	277	1673	1828	1954	Hunt
Wadi Dana WF5520	Terrace section	Beta-119602	100	50	–4	119	274	1676	1832	1954	Hunt

Appendix 2. Classical and Islamic pottery

Roberta Tomber

A2.1 Introduction

The first objective of the study of Hellenistic and later pottery from the Wadi Faynan survey was to establish a chronology from which to interpret the field data. Initial classification and analysis of the pottery therefore concentrated on the identification of ceramic markers (both imported wares and well-known local types) that could be consistently used to characterize the different chronological horizons. The level of precision that could be expected from these data was determined by both the nature of the assemblages, in particular their formation processes, and the current knowledge of Classical and later pottery in southern Jordan.

There are some inherent limitations in the interpretation of surface ceramics from any multi-period landscape. The two most obvious are the lack of closed assemblages and the continuity of resource exploitation that results in the production of similar clay fabrics over a long period of time, excluding a refined date for non-diagnostic body sherds. Quantitatively, most of the pottery was collected from the WF4 field system. Owing to the intensity and nature of the field usage, together with water erosion within the wadi system itself, most of the assemblages are mixed in date, frequently containing pottery ranging from the prehistoric through to the Early Islamic periods.

The interpretation of surface collections relies upon linkage to well-stratified and dated excavated assemblages. While much Classical and later pottery has been published from Jordan, historically most has been from the north. The consensus amongst pottery specialists working in Jordan (IFAPO round table, see below) is that the regional nature of Jordanian pottery production limits comparison, with a tendency for the same types to be produced in different fabrics at different times throughout Jordan, thus restricting direct chronological comparisons between northern and southern Jordan (Bienkowski and Adams 1999: 160 and also for additional discussion on the problem of publishing Roman pottery from survey: Melkawi *et al*. 1994: 453–4). This is perhaps most graphically illustrated by the distribution of Jerash bowls, which are largely restricted to central and northern Jordan (Parker 1998: 388 notes two possible sherds of them from ‘Aqaba, which if verified provide the first examples south of the al-Kerak plateau; Watson 1989).

Much of the work undertaken in southern Jordan has been survey which, although providing comparanda, suffers from chronological inexactitude. Relevant surveys include: Kerak (Miller 1991, although the dating of some pottery types differs from current interpretations, see Bienkowski and Adams 1999: 170 for comments), Southern Ghors and northeast ‘Arabah (MacDonald 1992), Petra region (‘Amr *et al*. 1998), ‘Aqaba (Meloy 1991), Ras an-Naqab–‘Aqaba highway (Bisheh *et al.* 1993) and at Wadi Faynan itself (Coyne 1999). Nevertheless, much progress has recently been made in the study of southern Jordanian pottery through major publications of excavations at Petra (e.g. Bignasca *et al.* 1996; Fellmann Brogli 1996; Schmid 1996; 2000) and Ayn ez-Zâra (Clamer 1997; Clamer and Magness 1997), as well as smaller, sometimes preliminary, reports from ‘Aqaba, Gharandal, Humeiyma, and Deir ayn Abbata, providing parallels for Wadi Faynan. From this body of excavated data it has been possible to identify well-dated ceramic markers and in this way construct a chronological framework for the Faynan survey material. Publication of additional excavated assemblages from the sites mentioned above, but ideally from the deeply stratified levels in Wadi Faynan itself, would no doubt allow much refinement to the dating schema presented below.

A2.2 Method

The pottery was recorded in a standard hierarchical system commonly adopted for Classical sites in the Mediterranean and Near East. Thus, classification was based on ware type (amphorae, fine, cooking, table or where uncertain coarse wares), followed by fabric and form types. For local and regional pottery, fabric and form series were created with specific reference to the site; for imported types, fabric and forms series utilized pre-existing and commonly accepted *corpora*. Count data were recorded for each fabric and form combination to provide a gauge

Period	Wadi Faynan	Homès-Fredericq and Hennessy 1989	Kennedy 2000	Parker 1987	Whitcomb 1992
Hellenistic		332–63 BC	300–64 BC		
Late Hellenistic	150–50 BC				
Nabataean		312 BC–AD 106	300 BC–AD 106		
Early Roman		63 BC–AD 106	64 BC–AD 135		
Nabataean/Early Roman	50 BC–AD 150			63 BC–AD 135	
Late Roman	AD 150–363	AD 106–324	AD 135–324	AD 284–363	
Early Byzantine	AD 363–502	AD 324–491	AD 324–491	AD 363–502	
Late Byzantine	AD 502–636	AD 491–634	AD 491–640	AD 502–551	
Early Islamic	AD 636–1071	AD 661–1099	AD 640–1174		AD 600–1000
Middle Islamic					AD 1000–1400
Late Islamic			AD 1174–1918		AD 1400–1800
Later Islamic	AD 1071–1516				
Ottoman	AD 1516–1918	AD 1515–1918	AD 1516–1918		

Table A2.1 *Chronological periodization employed in the Wadi Faynan Landscape Survey pottery studies, compared with other regional projects.*

of the relative quantities of types present individually for each field/unit or site. Weight data were recorded by fabric, although this was not subsequently used in the analysis. Pick and grab samples were distinguished in the quantified records.

Owing to the methodological limitations described above, the creation of ceramic phase groups or dating horizons relied primarily upon comparison with excavated (rather than surface) assemblages from southern Jordan. Much insight into unpublished assemblages from Jordan was made available at a round table on ceramics hosted by IFAPO in August 2000 (particularly Khairieh ‘Amr, Ben Dolinka, Yvonne Gerber, Ina Kehrlberg and Bethany Walker), which has been integrated into the final ceramic horizon groups. Outside of this forum, Tony Grey and Tom Parker also provided much helpful advice on the pottery of southern Jordan. Because their views on dating may have changed substantially since 2000, their comments are indicated only as ‘pers. comm.’ and not attributed to the individual specialist.

The dates implemented here for the ceramic horizons differ somewhat from those frequently used in Jordan (see Table A2.1). They were defined to reflect distinctive junctures in the ceramic assemblage in order to achieve the clearest picture of activity in the study area. However, the long currency for many fabric and form types has meant that precision is frequently lacking. Small sherd size was also a factor, making assignation to types difficult. A total of 24,545 sherds weighing 250,150 g was collected, making the average sherd size just over 10 g each. While as an average this is not particularly small, in this instance average size does not accurately reflect the balance towards small sherds. In many cases it was possible to distinguish only between ‘Prehistoric’ and ‘Classical/Islamic’ (coded in the data base as ‘Classical’) pottery.

Similar methodological problems, however, would have arisen regardless of the definition of the chronological horizons. There was no way of ‘slicing’ the horizons so that the ceramic types would be exclusive to a given period, because of the variables already discussed: continuity in resource exploitation and ceramic production; imprecise dating of types; the nature of surface collection; and small sherd size. Some adjustment was also required when integrating imported types in order to align Levantine chronology with horizons adopted elsewhere in the Mediterranean.

Only those types selected as ceramic markers are illustrated here, but a complete form typology with suggested dates derived from external parallels and their relative quantity within Faynan are presented on the CD. Within regional pottery studies there is a tendency to publish repeatedly a limited number of vessel types which are well-known and dated: for this reason many fragmentary and undated vessel types are represented on the CD as a baseline for future studies.

Comparanda are based on published assemblages, primarily for the south but from further afield in the cases of very common or unique types; similarly these are restricted to sherds with fairly extensive profiles. Dating is based not necessarily on earliest and latest single occurrences, but on the main currency for the type: many types are long-lived with a good deal of overlap between the horizons. These results have served to demonstrate the extensive continuity in tradition, between all periods, particularly between the Late Roman and Early Byzantine periods, and the Late Byzantine and Early Islamic periods. Pottery from the second half of the second century and third century AD is generally poorly published, although recent material from Ez-Zantur, Petra, suggest that this gap can be filled (Gerber 2001a).

A2.3 Pottery classification

A2.3.1 Pottery ware types

Four main ware types were defined: *Amphorae*: large vessels used for the transportation of foodstuffs. *Finewares*: decorated table vessels, particularly bowls, dishes and cups. *Cooking wares*: vessels for use over fire, particularly cooking pots and casseroles. *Table wares*: vessels for use at the table or for domestic storage, particularly jars, bowls and dishes. *Coarse wares*: poorly identified vessels that could belong to cooking or table wares.

A2.3.2 Fabric types

The definitions of fabric groups are based on macroscopic description of colour (free descriptive terms and Munsell values for the most typical colours) and inclusions, rather than microscope criteria. This provided a quick and therefore workable method by which to classify the survey pottery, the majority of which consisted of undiagnostic body sherds. Apart from ʻAqaba ware, none of the groups thought to be local or regional (i.e. Jordanian) in origin can be equated with a single production site, and there is scope for refinement in their definition. Nevertheless, the oxidized fabrics (particularly Orange Oxidized 1 and 3) appear similar to wares found at Petra and a shared source is likely (pers. comm.).

Descriptions of the main fabrics follow. Unless otherwise specified, the fabrics were used for the manufacture of wheelmade vessels. A number of vessels did not fall into the defined groups and these fabrics are described individually in the form catalogue. In addition to local or regional fabrics, a number of Roman and Byzantine imported wares, belonging to well-published types, was present and the main citation for them is given below.

Quantity is indicated for imported Roman/Byzantine fabrics and Late ʻAqaba ware: for all others quantity is provided in the CD catalogue.

A2.3.3 Oxidized wares

A2.3.3.1 Orange Oxidized ware 1

This group incorporates those fabrics dominated by quartz inclusions. It displays a wide range of variability in terms of both quantity and size of inclusions, representing numerous production centres throughout time. In addition to quartz, differing quantities of limestone and clay pellets (normally red-brown) are present in variants. The most common fabric in this group has a clean matrix with moderate to common well-sorted quartz up to *c*.0.5–1.0 mm. In the catalogue some variants are noted: coarse refers to a fabric where inclusions are usually 1.0 mm in size, fine to the smallest size range; moderate refers to a fabric with more abundant inclusions belonging to the smaller size range. It is typically orange (2.5YR 6/8–5/8) throughout, although examples exist with surfaces of cream or cream-yellow (10YR 8/3) and dark, especially grey-brown (10YR 5/1–5/2), but not true black. Sherds with a reduced core are also known, and are usually grey (5/N–4/N) to brown-grey (10YR 4/1) or grey-green (2.5Y 6/2) in colour. A small group of vessels is reduced throughout, but it is not certain whether these are intentionally reduced or mis-fired so they have been included here with the oxidized wares. Those with a darkened surface are frequently associated with the coarse variant and have a correspondingly pimply surface; the fabric is present during both the Nabataean and Early Islamic periods (pers. comm.). Vessels assigned to this fabric are normally wheelmade, although there are some exceptions. While the handmade wares need not be Classical in date, the bright orange appearance of many of them is more suggestive of the Roman and Byzantine periods than, at least, of the prehistoric. The entire range of vessel forms was produced in this fabric.

A2.3.3.2 Orange Oxidized ware 2

This is another sandy fabric, also with well-sorted quartz and a clean clay matrix. It is distinguished from Orange Oxidized ware 1 by its dense, heavy appearance resulting from a greater quantity of small quartz, normally < 0.5 mm. It is also lighter in colour, frequently dull orange-brown (7.5YR 6/3), although sometimes with red (10R 6/6) or orange (2.5YR 6/6) margins or core. It is Late Byzantine and Early Islamic in date, and is particularly associated with basins.

A2.3.3.3 Orange Oxidized ware 3

This is a broad grouping used to incorporate all fabrics with a fine, silty clay matrix and few visible inclusions, Those inclusions, which are just visible to the naked eye (*c*.<0.3 mm), normally comprise red-brown iron rich ?clay pellets and white ?limestone fragments, although the coarser examples may also contain visible quartz. Most sherds are orange, but slightly paler in colour (2.5YR 7/6–7/8) than Orange Oxidized ware 1. Many are also distinguished by having a pale grey (6/N–6/10Y) core, and this is particularly notable on vessels which have silky surfaces. Like Orange Oxidized ware 1 it incorporates a variety of production centres of differing dates. The fabric was used for the production of fine, cooking and table wares. Included amongst this fabric are Nabataean thin-walled wares, which are distinguished in the published catalogue only as Nabataean Fineware. For the fineware vessels the fabric tends to be orange-brown (2.5YR 6/6–6/8), sometimes with a reduced core, either pale grey as above or grey-green (2.5Y 6/1–6/2). The painted decoration is normally red-brown, ranging from 10R 4/4 to 10R 5/8, depending on the thickness of the paint and firing conditions. Occasionally the paint appears black in colour.

A2.3.3.4 Hellenistic Oxidized ware

This is a variant of Orange Oxidized ware 1 with patchy, darkened surfaces and sparse quartz inclusions. The fabric tends to be slightly paler than Oxidized ware 1 (2.5YR 7/6–7/8; 2.5YR 6/6–6/8) with reddish-brown (2.5YR 5/1; 10R 4/1) surfaces, although they may be nearer to black. The quartz can be ill-sorted, <1.0 mm, and variable in quantity although normally sparse. Similar fabrics can be identified from the north and south of Jordan, but no source is suggested. This fabric was used primarily for the manufacture of bowls and dishes.

A2.3.3.5 Red Oxidized ware

This is a readily identifiable fabric, in terms of both inclusions and colour. The clay is clean and dense, containing abundant well-sorted quartz inclusions to *c*.1.0 mm, although in some samples silt-sized inclusions are also visible. In colour it is universally red or red-brown (10R 4/8; 2.5YR 5/8–4/8) throughout. Apparently first present in the Late Roman period, it is characteristic of the Byzantine and Early Islamic periods, when it was used almost exclusively for the manufacture of cooking wares. Similar wares seem to have a widespread north–south distribution, and it is not known how many sources are involved. The ware has, however, been recorded from production sites in the ‘Aqaba area (‘Amr and Schick 2001: 114). During the Early Islamic period the fabric tends to have slightly more inclusions, resulting in a more granular texture with darker surfaces (10R 4/4) and break (2.5YR 4/6) (cf. Fig. A2.10, no. 93). It was not possible to separate this later variant during bulk sorting, but rare chronological evolution may be matched in the forms.

A2.3.3.6 Coarse Oxidized ware
This is a very coarse and variable fabric, normally handmade but sometimes wheelmade or at least wheel-finished. It is defined primarily by the presence of large (up to *c*.3.0 mm), ill-sorted, flat white and red pellets, likely derived from the Nubian sandstone. Coarse (to 1.0 mm) quartz also occurs in variable quantities. It is difficult to separate body sherds from the prehistoric fabrics unless ribbed or otherwise decorated. Most vessels are oxidized in a wide range of colours, primarily orange (2.5YR 6/6–6/8; 2.5YR 5/6–5/8), but sometimes more red (10R 5/6) and occasionally with dark (2.5YR 5/1) surfaces. The fabric itself cannot be dated, although rare forms are more sensitive and appear to cluster from the Late Roman periods onwards. Cooking pots and basins are the most common forms produced in this fabric.

A2.3.4 Cream wares
Included here are white or near-white firing fabrics normally classified as ‘Islamic Cream ware’ (ICW), associated with thin-walled jugs, jars and lids with incised/pared, moulded and applied decoration that date from the Abassid period (Walmsley 2001b). Although certain jug forms found at Faynan suggest that cream wares may have begun in the Roman or at least Late Roman period, their quantitative significance dates from the Early Islamic period. Distinct from these are Nabataean cream wares, identified from Wadi Faynan by undulating wavy combing. From this it was possible to extrapolate some undecorated sherds in an identical fabric. ‘Aqaba ware is also described here as technologically it falls into a similar category of iron-free wares.

A2.3.4.1 Cream ware 1
This is a buff or pale orange (5YR 7/4) coloured fabric with a cream-yellow (10YR 8/3) surfaces. It is characterized by a dense, clean matrix containing sparse ill-sorted quartz to *c*.0.5 mm and some ?calcareous and red iron-rich inclusions of a similar size range. The fabric can be difficult to distinguish from Orange Oxidized ware 1 when it has a white-slipped surface, but it is generally paler with less distinction between the fabric and surface colour. Although associated with table or plain wares there are only rare fragmentary rim sherds represented in this fabric. It is considered late (see above), although apart from a few sherds with combed decoration there is little dating evidence.

A2.3.4.2 Cream ware 2
This fabric is rich in calcium carbonate and is marl clay. It has a fine, granular matrix with few visible inclusions and rare larger aplastic fragments of quartz, limestone and iron-rich inclusions, <1.0 mm and usually less than <0.5 mm. It is distinguished from Cream ware 1 by a silty matrix, and its colour, which is normally pale green (2.5Y 8/3–7/3). Table or plain wares were produced in this fabric.

A2.3.4.3 Nabataean Cream ware
This fabric is distinguished from Cream ware 2 by having a slightly cleaner, denser fabric with occasional quartz inclusions <0.5 mm. It is pale pink (7.5R 7/6) with a cream (7.5YR 8/4) outside surface. The fabric is rare at Faynan and is represented by Figure A2.2, no. 24 with wavy undulating combing.

A2.3.4.4 ‘Aqaba ware
This cream or pale fabric, frequently with a pink or green core, is distinguished by the presence of large flakes of gold (biotite) mica and angular granitic rock inclusions, both of which are visible in the hand specimen. Here the ware is divided into Early and Late ‘Aqaba ware. Late ‘Aqaba ware was first recognized at seventh-century kilns excavated by Whitcomb (Melkawi *et al*. 1994), but the distribution of the type now makes it clear that kilns producing this ware were in operation at ‘Aqaba between the fourth and seventh centuries (Tomber 2004). The fabric is distinguished by very dense, hard-fired and thick walls. In contrast, the Early ‘Aqaba ware, dating to the first and second centuries, is known only from kiln waste rather than kilns (Parker 2000: 375). The fabric comprises the same inclusions as the late variant, but it has thinner walls and is softer (see Dolinka 2003: 64 for a detailed fabric description). The illustrated Faynan sherd (Fig. A2.3, no. 28) is dull orange (2.5YR 6/6) with cream (10YR 8/3) surfaces. The general impression to this writer, based on only a small sample, is that the earlier fabric has a sandier matrix and a greater number of inclusions than Late ‘Aqaba ware. Early ‘Aqaba ware is represented by a ribbed neck jar, Late ‘Aqaba ware by amphorae and basins (312 sherds, mostly body sherds).

A2.3.5 Other wares
A2.3.5.1 Handmade Geometric Painted ware
This fabric is represented by one Mamluk vessel. It comprises poorly mixed clay with numerous cream-coloured, sub-angular to angular pellets up to 2.0 mm in size, although typically up to 1.0 mm; rare small rounded red pellets measuring *c*.<0.5 mm are also visible. In colour the vessel is pale orange (2.5YR 7/6) on the inside surface and margin, and cream (7.5YR 8/3) on the outside surface; the internal break and margin is slightly more green (2.5Y 8/2). Painted decoration is dark red (10R 4/2).

A2.3.5.2 Islamic Handmade ware
A handmade fabric, it is highly variable but united by intensely vesicular (and therefore light) clay with thin elongate voids visible in both the break and on the surfaces. Some similar-shaped inclusions are white (or voids in-filled with a white substance?), suggesting that these inclusions and the voids are chaff. Other inclusions are ill-sorted coarse quartz and ?chaff to *c*.2.0 mm. Most sherds have a thick black to grey (4/N–3/N) core; surfaces are frequently mottled, grey or pale brown (7.5YR 6/3–4/3) to dull orange-brown (5YR 6/6; 5YR 6/4). Two sherds have a red-painted outside surface (2.5YR 5/6) with a darker pattern (10R 3/2). The fabric was first identified by comparison with pottery seen on the surface at al-Furn and is regarded as Mamluk in date. The Faynan vessels are probably twelfth century or later with the type in general continuing into the Ottoman period (Walmsley and Grey 2001: 158; also see below). Bowls and jars are the most common forms in this fabric at Faynan, with the lug handle particularly characteristic.

A2.3.5.3 Sandy Grey ware
This fabric is sandy, containing variable amounts of moderately well-sorted quartz (<0.5 mm) in a silty matrix. It ranges from medium (4/N) to pale (5/N) grey with medium grey surfaces. Although rare, a small range of bowls, beakers and jars has been identified in a reduced fabric. The tradition may belong to the Islamic (Schaefer 1986) and particularly the later Islamic period (Schaefer 1989), although firm parallels are lacking and the type cannot be precisely dated.

A2.3.6 Imported finewares

A2.3.6.1 Eastern Sigillata A (ESA)
Fabric and forms are described by Hayes (1985: 9–48) with a source in Syria-Palestine discussed by Slane (1997: 272). Occurrences: 24 sherds.

A2.3.6.2 African Red Slip ware (ARS)
Fabric and forms are described by Hayes (1972). Occurrences: 364 sherds.

A2.3.6.3 Phocaean Red Slip ware (PRS)
Fabric and forms are described by Hayes (1972), with more recent work by Vaarg (2001). Occurrences: 125 sherds.

A2.3.6.4 Cypriot Red Slip ware (CRS)
Fabric and forms are described by Hayes (1972). Occurrences: 54 sherds.

A2.3.6.5 Egyptian Red Slip A ware (ERSA)
Egyptian Red Slip A ware from Aswan. Fabric and forms are described by Hayes (1972) and Gempeler (1992). Occurrences: 2 sherds.

A2.3.6.6 Egyptian Red Slip B ware (ERSB)
Egyptian Red Slip B ware from Nile silt. Fabric and forms are described by Hayes (1972), with numerous illustrations in Faiers (2005: 81–93). Occurrences: 4 sherds.

A2.3.7 Imported coarse wares

A2.3.7.1 Egyptian coarse wares
Egyptian coarse wares made from Nile silt (including LR Amphora 7). Occurrences: 61 sherds (5 amphorae).

A2.3.7.2 Late Roman Amphora 1 (LR Amphora 1)
LR Amphora 1 from the coast of Cilicia or Cyprus (Empereur and Picon 1989: 236–9; Peacock and Williams 1986: Class 44, 185–7; Riley 1981: 120). Occurrences: 7 sherds.

A2.3.7.3 Late Roman Amphora 2 (LR Amphora 2)
Late Roman Amphora 2 from the Peloponnese, Argolid, and Chios (Opait 2004: 10–12; Peacock and Williams 1986: Class 43,182–4; Riley 1981: 122). Occurrences: 1 sherd.

A2.3.7.4 Late Roman Amphora 3 (LR Amphora 3)
Late Roman Amphora 3 from Western Asia Minor (Peacock and Williams 1986: Class 45, 188–90; Riley 1981: 118). Occurrences: 5 sherds.

A2.3.7.5 Late Roman Amphora 4 (LR Amphora 4)
Late Roman Amphora 4 or Gaza amphora (Majcherek 1995; Peacock and Williams 1986: Class 48–9, 196–9; Riley 1981: 120). Occurrences: 17 sherds.

A2.3.7.6 North African Cylindrical amphora
North African Cylindrical amphorae from modern-day Tunisia. For general form and fabric descriptions see Peacock and Williams (1986: 153–64) Class 33 (Africana I, *Piccolo*), Class 34 (Africana II, *Grande*) and Class 35; for a recent overview see Bonifay (2004). Occurrences: 7 sherds.

A2.3.7.7 Black sand fabrics
Black Sand amphora fabrics rich in black, volcanic minerals. Occurrences: 4 sherds, two likely to be Roman, of unknown source.

A2.3.7.8 Syrian mortaria
Syrian mortaria produced at and in the vicinity of Ras el-Basit (Hayes 1967). Occurrences: 1 sherd.

A2.3.8 Islamic glazed and painted wares

A2.3.8.1 ?Abbasid Iraqi Splash ware
?Abbasid Iraqi Splash ware (pers. comm.). Occurrences: 2 sherds.

A2.3.8.2 Ayyubid ?Syrian underglazed painted ware
Ayyubid ?Syrian underglazed painted ware (pers. comm.). Occurrences: 1 sherd.

A2.3.8.3 Slip painted ware
Slip painted ware, thirteenth or fourteenth century (pers. comm.). Occurrences: 1 sherd.

A2.4 Chronological summary

A2.4.1 Late Hellenistic (c.130/50–50 BC)

At Wadi Faynan only a small amount of Late Hellenistic pottery can be positively identified. The dates for this horizon are derived from the Phase 1 fineware types identified by Schmid at Ez-Zantur, Petra (Schmid 1995, summarized on fig. 8; Schmid 1996; 1997; 2000; Stucky *et al*. 1994). During this period there appears to be a degree of uniformity between the north and south of Jordan, with similar vessels present at Petra (Schmid 1995; 1996; 1997; 2000), and further north at Pella (McNicoll 1992: e.g. pl. 75, nos 1–5, pl. 77, nos 1–9) and Amman (Greene and ‘Amr 1992: fig. 4, nos 7–8).

Platters or bowls characterized by an irregular red or red-brown slip are typical (nos 2–6), with jars (no. 1; see Stucky *et al*. 1994: fig. 15g–k) less frequently present. At Wadi Faynan these vessels are normally in Hellenistic Oxidized ware, sometimes Orange Oxidized wares 1 and 3.

Eastern Sigillata A is the only imported ware that may belong to this period. Represented by body sherds alone, frequently from closed vessels, it cannot be precisely dated, but at Petra a range of ESA forms are found in association with Phase 1 finewares (Schmid 1995: 640).

A2.4.1.1 Catalogue (Fig. A2.1)

1. Jar with enlarged bead rim and enlarged neck. Orientation uncertain. Orange Oxidized ware 1. Orange throughout. 4.4.10 P.

2. Dish or platter with footring base and over-hanging rim. Two rims, one base and one sherd, joining. Hellenistic Oxidized ware. Orange with red-brown surface inside and on the base underside; darkened on the outside wall and unevenly inside just beyond the rim. 1066 G.

3. Dish or platter with slightly dropped, flattened rim. Hellenistic Oxidized ware. Dull, light orange with darkened rim top and outside surface, brown-black. 442.14 G.

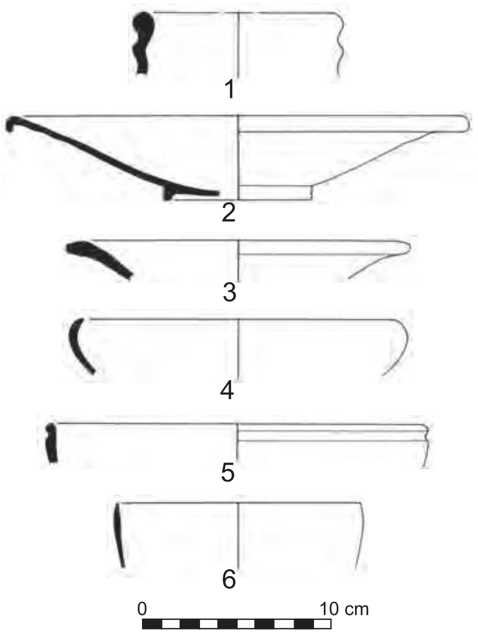


Figure A2.1 *Late Hellenistic pottery.*

4. Bowl or shallow dish with plain, in-turned rim. Orange Oxidized ware 3. Orange with pale grey core. 4.5.41 G.

5. Bowl or dish with well-defined bead rim. Hellenistic Oxidized ware. Light orange with darkened outside surface, grey-brown. 1063 G.

6. Small bowl with plain rim, slightly out-splayed. Orange Oxidized ware 3. Orange, originally with a black outside surface. 4.6.31 P.

A2.4.2 Nabataean and Early Roman (50 BC–AD 150)

Strictly speaking the terminus for the Nabataean period is AD 106, but this phase is defined in order to include vessels of the same chronological period that may be culturally defined as either Nabataean or Roman in origin. Some authors (e.g. Kennedy 2000; Miller 1991; Parker 1987) bring the Early Roman period to a close at AD 135 with the Bar Kochba Revolt; here AD 150 is adopted as a terminus date since ‘mid-second century’ is frequently applied to pottery types.

Our understanding of Nabataean pottery, both fine and coarse wares, has greatly increased since Zeitler’s 1990 (p. 392) statement that ‘The chronological succession of the Nabataean pottery remains a secret’, an advancement largely due to the publication of excavated assemblages from Petra. This ceramic horizon incorporates fineware Phases 2–3 (Schmid 1995; 1996; 1997; 2000) with corresponding coarse wares (Gerber 1997; 2001b; Stucky *et al.* 1994) from Ez-Zantur, Petra; other assemblages published from Petra include those by Parr (1970), and more recently Zeitler (1990), Lindner and Gunsam (1995), Bestock (1999) and Bikai and Perry (2001).

Two large assemblages of pottery, dating from the late first century BC through the first quarter or half of the first century AD, and to the second half of the first century AD, are published from Ayn es-Zâra (Clamer 1997), where the absence of classic Nabataean cooking pots and painted vessels, for example, is striking (see also ‘Amr 1992: 221; Gerber 1988: 88 for comments). Other excavated sites in southern Jordan with dated deposits include Ed-Sadeh (Zeitler 1988), Khirbat Edh-Dharih (Villeneuve 1990) and Khirbat Dubab (Bienkowski and Adams 1999). From Judea the large published assemblage from Odoba, once but no longer thought to be a production site for Nabataean pottery, provides comparative data (Negev 1986).

In terms of the ceramic evidence, the Nabataean period sees intensification of activity in Wadi Faynan from the preceeding period. While this is considered a real trend, it also reflects the advanced state of knowledge of Nabataean wares and the greater ease of identification, particularly for the thin-walled painted sherds that can be classified from small fragments. These finewares also provide the most refined dating evidence for this horizon, with their Phase 2 dated *c*.50 BC–AD 20 and Phase 3 *c*.AD 20–100+. Phase 3 is divided into decorative sub-groups, of which 3a–c are relevant here and date as follows: 3a *c*. AD 20–70/80; 3b *c*. AD 70/80–*c*.100; 3c *c*.AD 100+ (Schmid 1997: 413). Petra appears to be the main production centre for both the fine and coarse wares (‘Amr 1991; ‘Amr and al-Momani 1999; Zayadine 1982).

The distribution of Nabataean wares throughout Jordan and further afield has been a matter of debate, particularly for the painted finewares, as these are the easiest and more reliable to track. Writing in 1942 Glueck drew a northern limit for Nabataean painted wares at what he termed the 'Madaba-Dead sea line' (Glueck 1942: 3). Recent finds from the Hauran (Dentzer 1985) fall outside this area, although there is no consensus on whether they dispute Glueck's boundary ('Amr 1987: 5–6) or should be seen as exceptions (Dolinka 2003: 56). Here the painted wares are interpreted as clustering on Nabataean sites, rather than being evenly distributed throughout the region.

The balance of the painted finewares from Wadi Faynan belong to Phase 3 (nos 7–20) and this is reinforced by the common presence of rouletted decoration (nos 14–18; published parallels to no. 17 are lacking but the sherd is identified as a Nabataean form, pers. comm.), which is essentially restricted to this phase (Schmid 1995: 641; see rare examples from Phase 2, e.g. Schmid 2001: fig. 11.3, no. 6; see also Khairy 1982). Other Nabataean fineware types include juglets and beakers (nos 21–3; Hammond 1973: nos 4, 9; Khairy 1982: nos 22, 74–5; Zayadine 1982: pl. cxl 37–8), and the base no. 20 with cut-away decoration, which is found on bowls represented by no. 19 (see Bestock 1999: fig. 8; Bikai and Perry 2001: fig. 5, no. 10, fig. 8, nos 6–7). Nos 21 and 19/20 are both present in tombs dating to the first century AD (Bikai and Perry 2001: fig. 5, nos 10, 19–20, fig. 8, nos 6–7, 14). The lack of illustrated Phase 2 vessels does not indicate a hiatus in the Nabataean sequence but more a methodological problem in distinguishing the carinated bowls from Phases 2 and 3. A number of carinated bowls in a form similar to no. 7 etc. with white slip on the rim probably belong to Phase 2 (Stucky *et al.* 1994: 281), although they are drastically less common at Faynan than the unslipped ones and none is illustrated here.

Nabataean coarse wares include particularly the cooking pots nos 30–31. No. 30 is the classic Nabataean cooking pot normally dated from the mid-first to early second (e.g. Gerber 1997: fig. 4e; Stucky *et al*. 1994: fig. 16a;) or mid-second century AD ('Amr and al-Momani 1999: Kiln VII, fig. 14, nos 15–17). No. 31 (near Negev 1986: no. 957) is a slight variant.

Cooking pots with tall necks, undulating rims and ribbed walls, as no. 32, are also considered classic Nabataean indicators (see for example Dolinka 2003: 118–19), but they are common in Roman deposits throughout the Levant and eastern Mediterranean. In Transjordan, the vessel type originates during this period and flourishes into at least the Late Roman (see Gerber 2001a), with much of their development relating to changes in fabric and typological nuances, such as wall thickness. Dating of these cooking pots is therefore more reliable when based on a large assemblage rather than single vessels. Another cooking pot or jar which recurs during this period is no. 29 with short neck and thumbed rim (Negev 1986: nos 980–82). Additional indicators are jars or cooking pots, no. 25 (Negev 1986: nos 1023–5; Stucky *et al*. 1994: fig. 16g) and no. 26, the latter of which can be seen as a development of the more rounded Late Hellenistic no. 1 (pers comm.). Here the vessel is in the common Orange Oxidized ware 1, rather than the Hellenistic Oxidized ware with darkened outside surface.

A series of casseroles and bowls (nos 34–7) can be paralleled from early second–century AD deposits at Petra (Stucky *et al*. 1994: fig. 16l–o). Like the cooking pots, some of these vessels also have a long sequence. For example, bowls similar to no. 34 are first introduced during this horizon but continue throughout the Late Roman period (e.g. Parker 1987: fig. 95, no. 43). The flat rimmed bowl, no. 33 (Bienkowski and Adams 1999: fig. 8, no. 12; Negev 1986: near nos 755, 772;), is similar in date and it too is likely to continue into the Late Roman period (pers. comm.).

Although cream-coloured fabrics have been associated particularly with the Early Islamic period they are known from Nabataean times. At Wadi Faynan, two cream-coloured fabrics are present during this period. The first is Nabataean Cream ware, although considered Parthian rather than Nabataean in inspiration (Gerber 1998: 88). At Faynan it is represented by several sherds with the distinctive undulating combed decoration typical of this period (no. 24) ('Amr 1992: fig. 3; Clamer 1997: e.g. pls 9–10). It is present at Petra ('Amr 1992) during this period and in the second half of the first century at Ayn es-Zâra (Clamer 1997). The second, Early 'Aqaba ware, was manufactured from the late first century BC to at least the mid-second century AD (Dolinka 2003: 64; see also Late 'Aqaba ware, below). This category was kindly identified by Ben Dolinka who examined the pottery from WF4.7 and WF4.9 after it was recorded by this writer, resulting in the classification of 11 sherds of Early 'Aqaba ware. In contrast, approximately 10 times as many sherds of the Late 'Aqaba ware were recovered from these same units. Based on this evidence alone, contact between Faynan and 'Aqaba appears less intense during the Nabataean and Early Roman period than during the Byzantine and later. However, other factors to take into consideration include the level of ceramic production and the intensity of its export, which is likely to be much greater for the late period. The most distinctive early form produced at 'Aqaba is a lid-seat jar represented by the somewhat typologically atypical no. 28 (cf. Dolinka 2003: 128), but its production was not restricted to 'Aqaba as seen by no. 27 in a non-'Aqaba fabric. Like their later counterparts, the Early 'Aqaba ware jar may have been used to transport foodstuffs; both date wine and fish products have been suggested as possible contents (Dolinka 2003: 95–6).

Imported wares belonging to this period are rare, but may include the *Africano I* amphorae from Tunisia (although continuing into the Late Roman period). Other imports include four sherds of Black sand fabric, none of which need to belong to the classic Early Roman Campanian fabric.

Site 592 provided the largest and most homogeneous collection of Nabataean pottery in the survey area, with sherds from fineware Phases 2–3 dating the site to the first and probably into the early second centuries AD.

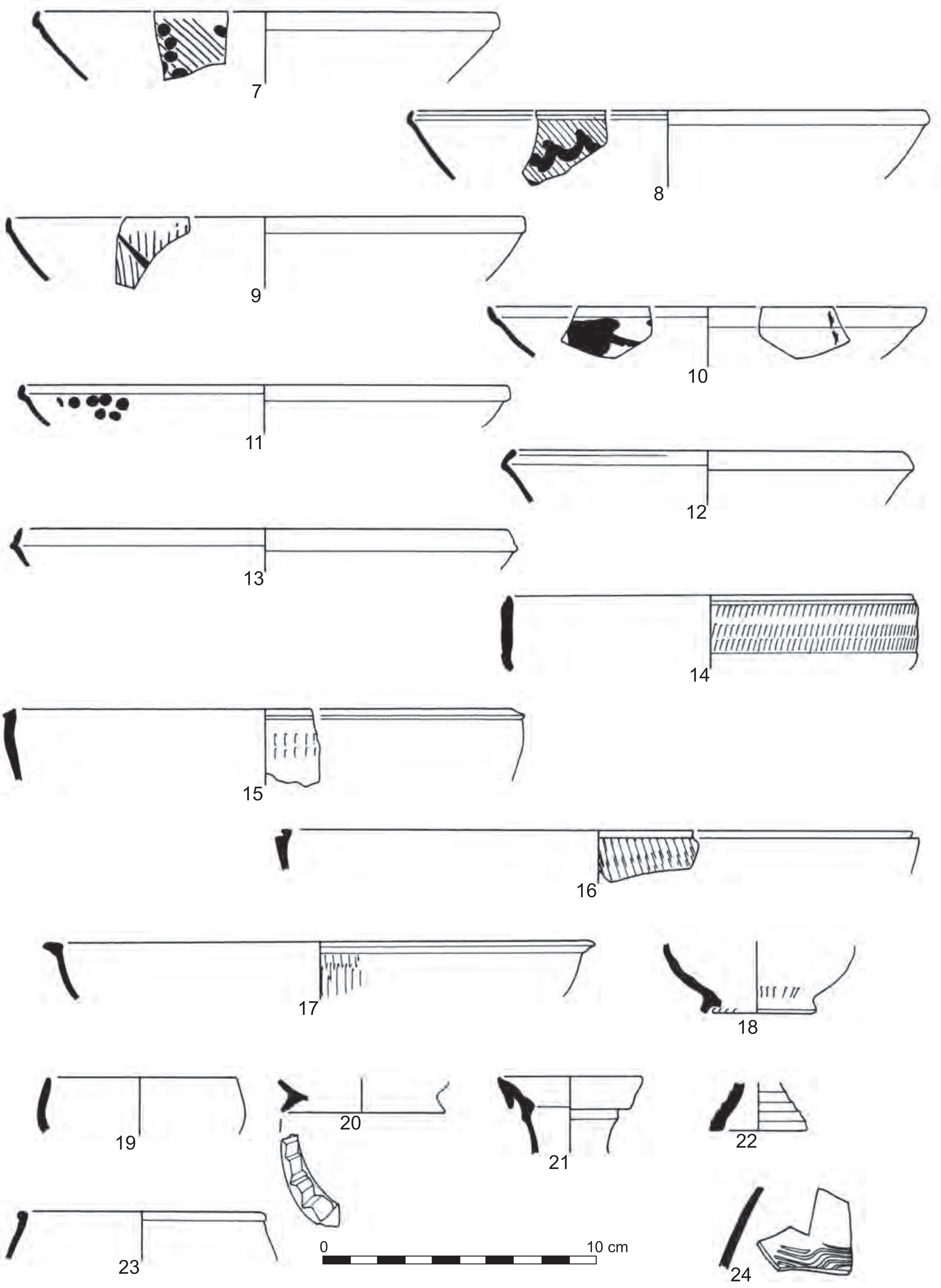


Figure A2.2 *Nabataean and Early Roman pottery.*

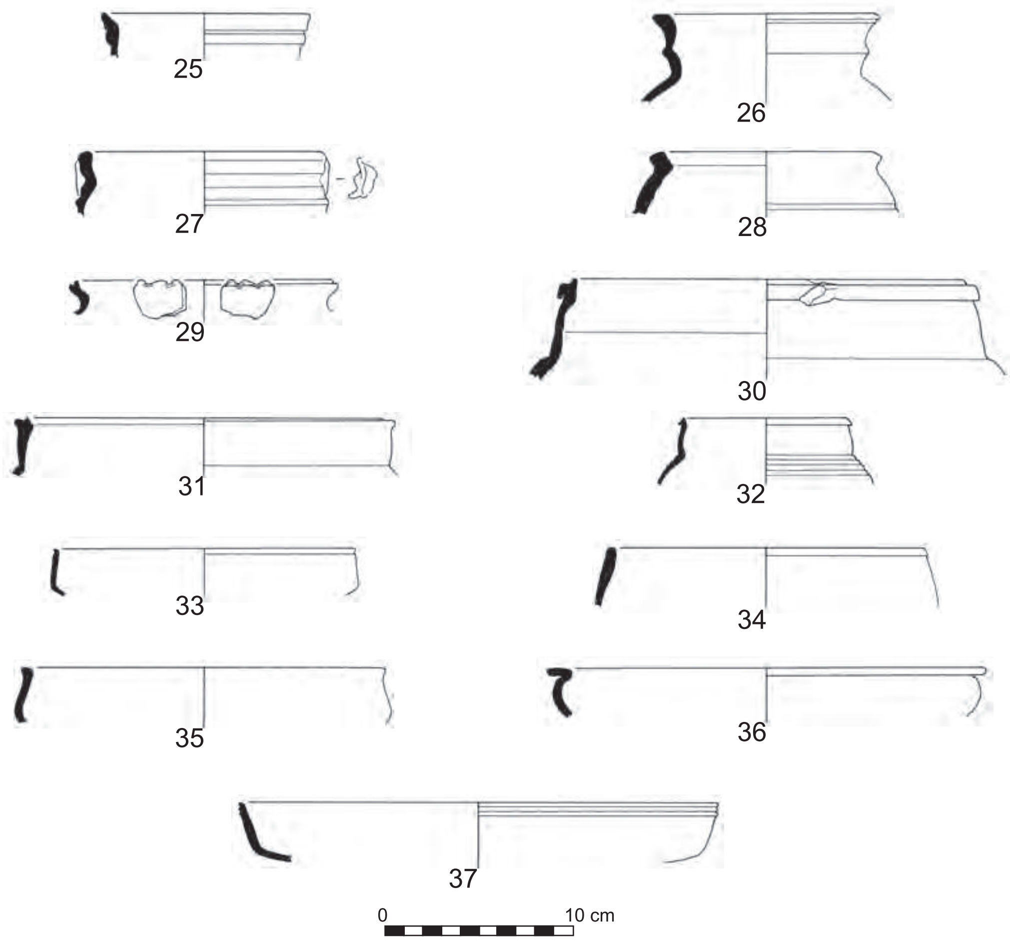


Figure A2.3 *Nabataean and Early Roman pottery.*

A2.4.2.1 Catalogue (Figs A2.2, A2.3)

Nabataean finewares Phase 3b

7. Small bowl with rounded, in-turned rim. Orange Oxidized ware 3. Orange with red-brown paint. Concreted. 442.14 G.

8. Small bowl with slightly in-turned rim. Orange Oxidized ware 3. Orange-brown throughout with red-brown paint; the outside may have been slipped with white, at least on the rim. 592 G.

9. Small bowl with rounded, in-turned rim. Orange Oxidized ware 3. Red-orange with intermittent grey core; red-brown paint. 592 G.

Nabataean finewares Phase 3c

10. Small bowl with internal bead rim. Orange Oxidized ware 3. Orange throughout; purple paint. Concreted. 592 G.

11. Small bowl with in-turned rim. Orange Oxidized ware 3. Orange throughout; purple paint. 592 G.

Nabataean finewares Phase 3

12. Small bowl with in-turned rim. Orange Oxidized ware 1. Dull orange-brown, darkened grey-brown on the outside rim. 4.2.17 P.

13. Small bowl with upright, reeded rim. Orange Oxidized ware 3. Dull red-brown with grey core. 481.

14. Carinated bowl with upright, grooved rim; rouletted wall. Orange Oxidized ware 3/1. Orange-brown with very pale grey-green internal margin. 4.14.11 G.

15. Small bowl with up-turned, lipped rim and ledged shoulder; rouletted walls. Orange Oxidized ware 3. Red-orange with grey core. 4.14.6 G.

16. Small bowl with flattened bead rim and ledged shoulder; rouletted walls. Orange Oxidized ware 3. Red-orange throughout. 4.12.38 P.

17. Small bowl with flat rim, moulded on the underside; rouletted walls. Miscellaneous wheelmade fabric. Dense, hard-fired clay with some silt-sized quartz and darker inclusions. Buff (5YR 7/4) throughout; small patches of brown (5YR 4/3) slip under the rim. 4.3.82 P.

18. Footring base with rounded walls; rouletted on the base underside and lower outside wall. Orange Oxidized ware 3. Orange throughout. 4.15.63 G.

19. Small bowl with plain, slightly in-turned rim. Orange Oxidized ware 1/3. Dull orange with discoloured surfaces. 4.8.7 P.

20. Footring base with excised decoration under the foot, belonging to the same vessel type as no. 19. Orange Oxidized ware 3. Orange to orange-brown throughout. 4.6.28 P.

Nabataean finewares unphased

21. Juglet with triangular-shaped rim, undercut externally and bevelled internally. Orange Oxidized ware 3. Orange-brown throughout. 442.13 G.

22. High pedestal base with ribbed pedestal. Orange Oxidized ware 3. Pale orange with pale grey core. 114 G.

23. Small beaker with wide girth and bead rim. The type is also found in conjunction with rouletting, so may belong to Phase 3 (Khairy 1982: nos 20–22). Orange Oxidized ware 3. Medium grey with orange surfaces. 4.2.7 P.

Cream fineware

24. Jar or jug with wavy incised decoration. Two body sherds, joining. Cream ware 2. Pale pink with cream outside surface. 592 G.

Jars and cooking pots

25. Jar with internally bevelled rim and ribbed walls. Orange Oxidized ware 1. Orange-red with grey-brown outside margin, surface and rim top. 4.2.17 P.

26. Jar with everted rim, flattened on top, and neck bulge. Orange Oxidized ware 1. Orange with brown surfaces. 4.1.36 G.

27. Double-handed jar with upright, concave rim and ribbed, wide-girth walls; a handle smear is visible on the rim and shoulder. Orange Oxidized ware 1, moderate. Orange with cream-orange outside surface. 4.7.32 P.

28. Similar to no. 27, but with slightly thicker walls. Early ʻAqaba ware. Dull orange with cream surfaces. 4.7.28 P.

29. Jar or cooking pot with sharply everted, double-lip rim; thumbing on the upper lip and lid-seat. Orange Oxidized ware 3. Orange throughout. 4.8.11 G.

30. Handled cooking pot with flanged rim, long neck, sharply defined shoulder and broad girth; a handle scar is visible on the rim flange. Orange Oxidized ware 1 variant with common red-brown iron-rich inclusions and common brown pellets to *c*. 2.0 mm visible on the surface. Brown-red with brown core and abraded tan-brown surfaces. 4.15.57 P.

31. Cooking pot with near-level oriented split rim, shallow lid-seat and long, slightly bowed neck. Orange Oxidized ware 1. Orange throughout with a cream-yellow slip outside. 4.12.23 G.

32. Cooking pot with undulating rim, long slightly bowed neck and ribbed wall. Orange Oxidized ware 3 with common small white inclusions (limestone or chaff). Orange with patchy cream-coloured outside skin. 592 G.

Bowls and casseroles

33. Small carinated bowl with sharply defined bead rim. Orange Oxidized ware 1. Orange with medium-grey core. 442.21 P.

34. Small bowl with wide girth and slightly squared-off bead rim. Orange Oxidized ware 1, dense clay. Red-orange throughout. 4.3.1 P.

35. Small bowl rounded towards base with rounded bead rim. Orange Oxidized ware 3. Pale orange with cream rim top and outer surface. 4.7.5 G.

36. Small bowl with flatly oriented rim and rounded walls. Orange Oxidized ware 1. Orange throughout with cream-coloured surface outside and on the outer half of the rim top. 4.5.31 G.

37. Carinated dish or casserole with moulded rim. Orange Oxidized ware 3. Grey with orange outer margin and orange surfaces. 4.6.29 P.

A2.4.3 Late Roman (AD 150–363)

The dating for this horizon differs from that conventionally adopted in the Jordanian chronology. By taking the earthquake horizon of AD 363 as the terminal juncture, an attempt was made to separate out those ceramic types restricted or at least more typical of the Late Roman period from Early Byzantine ones. For comparative purposes the key Late Roman excavated assemblage is Late Roman Phase I from Ez-Zantur (EZI), Petra dated between the early fourth century and AD 363 (Fellmann Brogli 1996; see also Gerber 2001a; Gerber and Fellmann Brogli 1995; Kolb *et al*. 1998; Stucky *et al*. 1990). However, there are few forms from EZI that can be distinguished from the succeeding phase EZII that is dated from the late fourth to the early fifth century AD (Fellmann Brogli 1996: 241) and the striking quantitative differences between the phases (Fellmann Brogli 1996: 237, Abb. 727) relate more to the greater absolute quantity in EZII than reflecting meaningful increases in types through time (Gerber, in Kolb *et al*. 1998: 275, no. 23).

While this phase begins at AD 150, in reality there are very few forms or assemblages that are assigned to a date before the fourth century. Gerber's (2001a) recent work draws attention to the continuity in form between the first and fourth centuries, particularly variants dating to the second and third centuries, and therefore has important implications for ceramic studies. ʻAmr (2004) has also demonstrated the continuity in pottery from the Nabataean period to the sixth century.

Continuity can be seen from the Nabataean/Early Roman phase in cooking pots with undulating rims. No. 41 is likely to belong to this phase, as is no. 42. The small bowl, no. 49 (Parker 1987: fig. 95, no. 43) is in the same family as the earlier no. 34, but here is in a coarser fabric and has thicker walls. Although lacking published parallels from southern Jordan, one vessel form that may be restricted to the third century or earlier is the wide-mouthed bowl or jar no. 48 (pers. comm.).

Distinctive and important additions that are quantitatively significant at Wadi Faynan also occur. These include the double-lip jug (nos 38–9; Fellmann Brogli 1996: 241, A22a), which is present at Ez-Zantur I and although it continues at Ez-Zantur II is considered particularly characteristic here. The split-lip cooking pot is another diagnostic form common from the third century (e.g. Parker 1987: fig. 94, nos 33–5), first present at Ez-Zantur I and continuing as a significant marker at Ez-Zantur II (nos 45–7; Fellmann Brogli 1996: A2a–b, Abb. 727).

Lids and casseroles (nos 52–3; Fellmann Brogli 1996: C6, D1) are common throughout Jordan and further afield (e.g. Magness 1993: 211–12, 215, Casserole Form 1 and Lids; Parker 1987: fig. 96, nos 52–5, fig. 97) and they continue not only throughout the Byzantine but into the Early Islamic period. Ribbed casseroles (no. 52) are present in both EZI and EZII (Fellmann Brogli 1996: 237, C6a and C6b, *contra* Abb. 727). Plain examples of the corresponding lids are present from EZI (Fellmann Brogli 1996: 237, D1a). According to Abb. 727 the ribbed examples (D1b) begin only in EZII, but numbers are small and their distribution is not mentioned explicitly in the text as a chronological indicator; certainly in Jerusalem ribbed vessels occur from the late third or early fourth century (Magness 1993: 211). Cooking pot no. 43 is also present in both Ez-Zantur I and II (Fellmann Brogli 1996: Abb. 727, A5a), while another in the same family, no. 44, can be paralleled in mid-fourth century deposits at Humeima

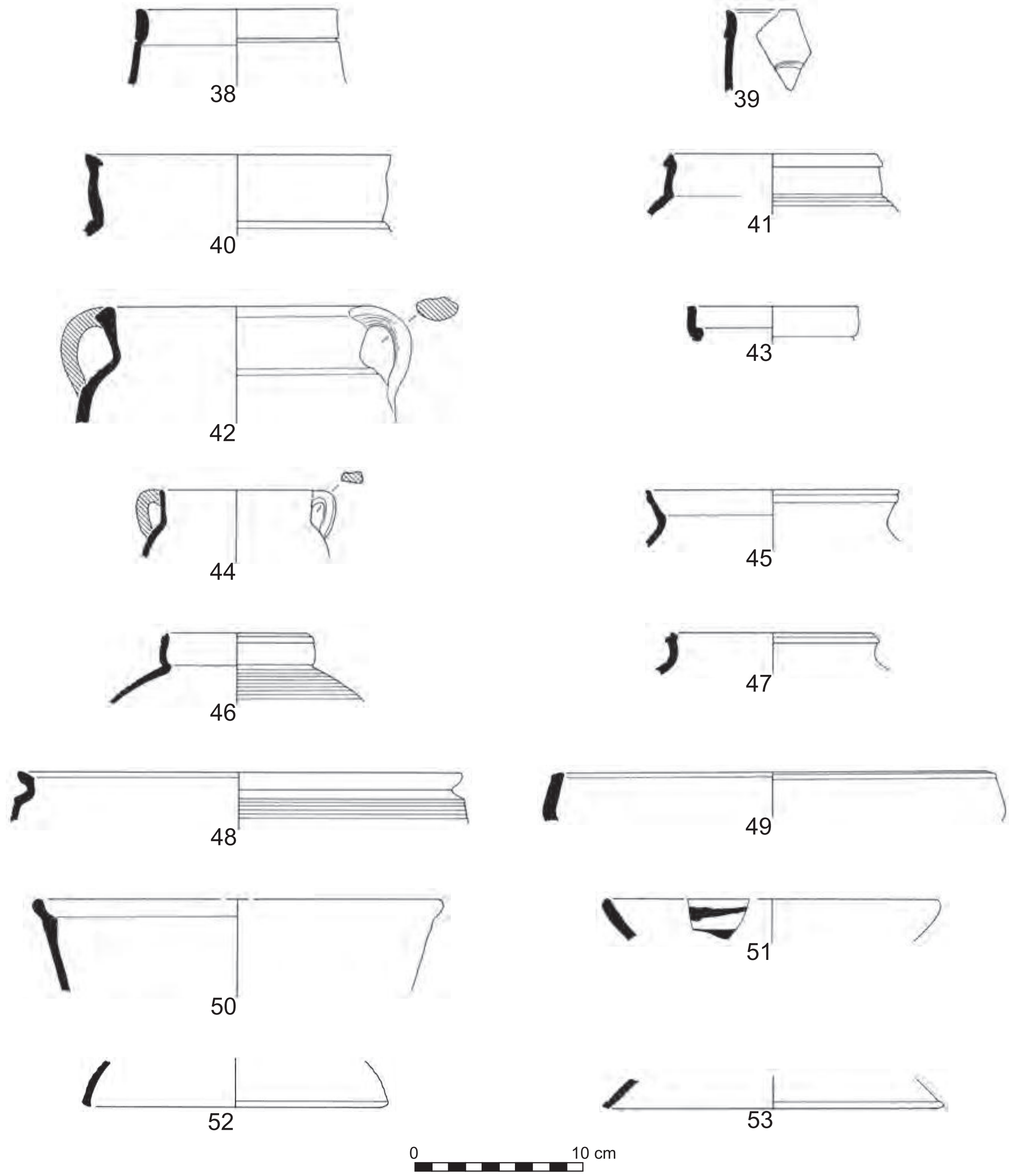


Figure A2.4 *Late Roman pottery.*

(Oleson *et al*. 1995: fig. 7, no. 6). Also at Ez-Zantur a similar vessel, with ribbed walls, contained a coin hoard dating to the mid-fourth century (Gerber and Fellmann Brogli 1995: 649–51, fig. 9, no. 5).

Other characteristic table ware forms, which continue into the Byzantine period, include the jar or jug (no. 40; Fellmann Brogli 1996: A12a), lid-seated bowl (no. 50; Fellmann Brogli 1996: C1a) and painted dish (no. 51; Fellmann Brogli 1996: 240, Abb. 844–9; see also ‘Amr 2004).

A number of African Red Slip ware forms whose conventional dates are restricted or fall primarily within the Late Roman period include Hayes's (1972) Forms 31, 32/58, 44, 45C, 50, 57/8 and 58. This period also sees the introduction of Cypriot Red Slip ware (Hayes 1972), rare at Faynan, which is more typical of the Byzantine period, but here represented by Hayes's Form 1. Another import identified at Wadi Faynan falling within this period is the late third- and early fourth-century Syrian mortarium (Hayes 1967).

A2.4.3.1 Catalogue (Fig. A2.4)

Jugs

38. Jug with long, undulating rim. Two rims. Orange Oxidized ware 1. Orange throughout. Slightly concreted. 4.6.14 G.

39. Jar or jug with upright, undulating rim; decorated with wavy incising on the wall. Orange Oxidized ware 1, moderate. Overfired or discoloured to grey throughout with pale brown to slightly orange surfaces. 4.10.37 G.

40. Jug or jar with inturned, undercut rim, long neck, and sharply splayed, ribbed shoulder. Orange Oxidized ware 1. Orange throughout with brown outside surface and rim top. 4.2.24 G.

Jars and cooking pots

41. Cooking pot with triangular-shaped, slightly undulating rim, shallow lid seat, long well-defined neck and shallowly ribbed walls. Orange Oxidized ware 1, coarse. Orange-red with grey-brown outside surface. 592 G.

42. Handled, globular cooking pot with enlarged rim, long, angled neck and ribbed shoulder; a handle joined to the rim and shoulder obscures the rim profile. Orange Oxidized ware 1. Orange with grey-brown rim top and outside surface. 4.1.36 G.

43. Cooking pot with upright, lipped rim and deep lid-seat. Orange Oxidized ware 1. Grey-brown with duller surfaces. 4.3.49 P.

44. Handled jar or cooking pot with upright, plain rim; a squared-off handle is joined to the rim and shoulder at a slight angle. Orange Oxidized ware 1, coarse. Orange with cream-brown rim top and outside surface. 1427 G.

45. Cooking pot with sharply everted neck, internally ledged, and double-lip rim, the lower lip flattened. Orange Oxidized ware 1, coarse. Orange throughout, slightly darkened in part on the outside. Possibly restricted to the third century AD (pers. comm.). 4.2.10 G.

46. Cooking pot with double-lip rim, the lower lip flattened, well-defined, long neck and ribbed walls. Orange Oxidized ware 1. Orange with grey-green core with slightly discoloured, to brown-grey, outside surface. 1071 G.

47. Cooking pot with double-lip rim, the lower lip downward pointing, and curved neck. Orange Oxidized ware 1. Orange-red with grey-brown outside surfaces and in part inside rim. 4.6.30 P.

Bowls and dishes

48. Jar or wide-mouthed bowl with carinated shoulder and out-turned rim, internally bevelled; narrowly-ribbed walls. Orange Oxidized ware 1, coarse. Orange-red throughout. 4.5.8 P.

49. Carinated shallow bowl with externally bevelled rim. Orange Oxidized ware 1. Orange with slightly darkened core. 4.6.28 G.

50. Bowl with internally angled walls, enlarged rim and lid seat. Orange Oxidized ware 1, moderate. Orange with thick grey inside margin and white slip outside. 4.4.7 P.

51. Dish with plain, out-splayed rim. Orange Oxidized ware 1. Orange; grey-brown (2.5Y 5/1) paint. 4.3.106 P.

Casseroles and lids

52. Casserole (or possibly a lid) with externally bevelled, in-turned rim and ribbed, rounded walls. Orange Oxidized ware 1. Orange-red throughout. 4.6.24.

53. Shallow casserole lid with squared-off and grooved rim. Orange Oxidized ware 1, moderate. Orange throughout with brown outside surface. 4.19.35 G.

A2.4.4 Byzantine

This period has been sub-divided into Early and Late Byzantine. Essentially, the Early Byzantine dates to the fifth century and sees a continuation of many of the forms first identified in the Late Roman period, while the Late Byzantine period dates to the sixth century and marks the introduction of types that remain important into the Early Islamic period. Although the distinction in ceramics between the north and south of Jordan persists (Melkawi *et al*. 1993: 453) it seems that during the Byzantine and Early Islamic periods at Faynan some similarities can be seen not only throughout Transjordan but further afield, and that Wadi Faynan is now part of a much wider zone of material culture.

During the Byzantine period a number of imported types common throughout the eastern Mediterranean is present in small numbers. Amphorae in particular are poorly represented, comprising rare vessels from Cilicia or Cyprus (LR Amphora 1), Western Asia Minor (LR Amphora 3), Egypt (nos 54–5; LR Amphora 7) and Gaza (LR Amphora 4). Palestinian baggy jars (e.g. LR Amphorae 5 and 6), commonly illustrated from the north of Jordan and at some sites in the south such as Humeima (‘Amr and Schick 2001: fig. 4), are absent at Faynan and this serves to emphasize the insular nature of pottery supply to the site. Imported red-slipped wares are more frequent than amphorae, with vessels from Phocaea (PRS) and Egypt (ERS) joining those already present from Tunisia (ARS) and, rarely, Cyprus (CRS).

The late ‘Aqaba products occur in some quantity (no. 56; Fellmann Brogli 1996: A25e). Two seventh-century kilns producing coarse wares and amphorae were excavated at ‘Aqaba, with the forms clearly drawing on Late Byzantine prototypes (Melkawi *et al*. 1994). Whitcomb describes the assemblages as ‘part of a Late Byzantine Palestinian corpus’ (Melkawi *et al*. 1994: 463). The widespread distribution of the Ayla amphora, thought to have been used for the transport of fish products (Whitcomb 2001a), has enabled a better understanding of its initial date. At Berenike on the Egyptian Red Sea it occurs in deposits as early as the fourth century (Hayes 1996; Tomber 1998), and by at least the fifth century at Abu Sha’ar (Riley 1989). As a result, here the fabric as a whole has been dated as Byzantine/Early

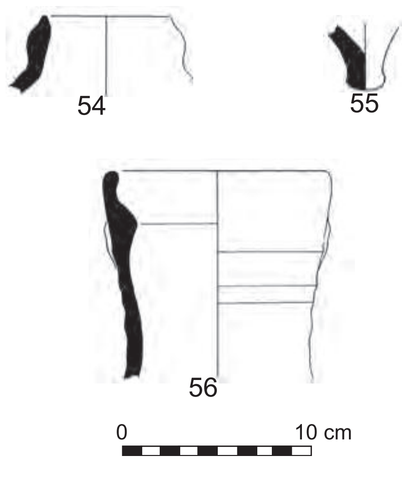


Figure A2.5 *Byzantine pottery.*

Islamic, although certain forms are more typical of the Late Byzantine period onwards (see below no. 80).

A large assemblage of pottery from Deir 'Ayn 'Abata (Politis *et al*. in press; see MacDonald and Politis 1988 for selected Byzantine pottery; Joyner and Politis 2000) spans from the fourth through eleventh centuries AD and shares types with the Faynan corpus.

A2.4.4.1 Catalogue for Byzantine imported amphorae (Fig. A2.5)

54. Amphora with upright bead rim, grooved on top. Egyptian, sandy fabric with organic inclusions. Orange-brown (2.5YR 5/6) with pink (7.5R 5/6) core and duller (2.5YR 6/4) outside surface. 564 P.

55. Small amphora base with solid knob and flared walls. Egyptian silt fabric. Orange-brown (2.5YR 5/8) with slightly duller (2.5YR 5/6) surfaces. 4.2.13 G.

56. Amphora with upright, lid-seat rim and ribbed wall; a handle smear is extant above the ribbing. Late 'Aqaba ware. Pink-buff. Slightly concreted surfaces. 1446 G.

A2.4.5 Early Byzantine (AD 363–502)

Because of the blurring in ceramic types found in Late Roman I and II at Ez-Zantur, Petra (see above), EZII dated from the last quarter of the fourth century to AD 419 (Fellmann Brogli 1996) does not provide firm evidence for the introduction of new types during this period. It does, however, demonstrate the continuity of many forms first identified during the Late Roman period. A second site, Ayn ez-Zâra on the Dead Sea, has an assemblage dated to the second half of the fourth and fifth centuries considered typical of Transjordan (Clamer and Magness 1997: 89), with the closest affinities to Faynan in the cooking vessels.

The phase sees the introduction of the distinctive, readily identifiable and prolific Red Oxidized ware, particularly associated with cooking wares, which continues through the Late Byzantine and into the Early Islamic period. A small number of sherds have been recorded from production sites in 'Aqaba ('Amr and Schick 2001: 114), so the possibility exists for an 'Aqaba source. With a wide distribution and fabric variants throughout Jordan, numerous workshops are likely to be involved and it has been variously dated, but on balance seems most appropriately placed here. For example, in central Jordan it begins in the sixth century (Parker 1987: 543), while at Deir 'Ayn 'Abata sometime in the fourth century (Joyner and Politis 2000). Magness notes a potentially similar fabric from the late third or fourth century at Jerusalem, although some of her forms (Cooking pot 4B) that at Faynan are restricted to Red Oxidized ware only occur from the fifth century at Jerusalem (Magness 1993: 211, 219). Gerber describes a dark red and coarse fabric present from the late fourth century at Ez-Zantur (Gerber, in Kolb 1998: 275). A selection of vessels in Red Oxidized ware is illustrated here by nos 63–4 (Magness 1993: 219–20, Cooking pot 4B; Parker 1987: fig. 113, nos 182–3) and nos 69–71, (Parker 1987: fig. 114, nos 186–7). Cooking vessels such as nos 41–2 and 45–7 in other fabrics, particularly Orange Oxidized ware 1, continue (cf. Clamer and Magness 1997: pl. 18, 10–12 and 15), although nos 41–2 may have ceased production by the end of the fourth century.

African Red Slip ware continues to be important. Although many of these forms began in the Late Roman period they are more typical of the Early Byzantine and comprise Hayes's (1972) Forms 52, 59, 61A, 61B, 67, 68, 71, 91. Associated with these forms are stamps in Style A (nos 57–61). Cypriot Red Slip ware, possibly Hayes's (1972) Form 1, produced from the late fourth century, is another diagnostic form. Equally, this period seems the introduction of Phocaean Red Slip (PRS), here represented by the bowl Hayes's (1972) Form 1D and, from the mid-fifth century, the introduction of the common bowl Form 3. No. 62 is an Egyptian vessel, although the fabric is somewhat coarser than usual. As part of the trend of imported red-slipped wares, a range of local bowls imitating PRS and ARS, illustrated by nos 65–7, can be identified. Coarse ware ribbed bowls, such as no. 68 (cf. 'Amr *et al*. 1998: fig. 22, no. 7), are also characteristic.

A2.4.5.1 Catalogue (Figs A2.6, A2.7)

Finewares

57. ARS. Flat base. Stamped with radiating palmettes (2) with rosettes (3) between their tips enclosed within two concentric grooves. 4.15.5 G.

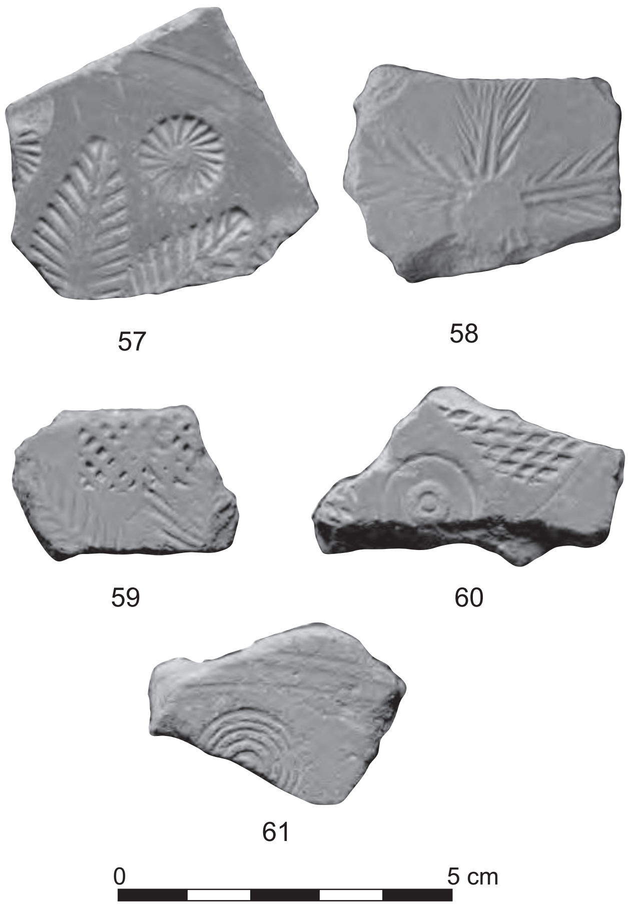


Figure A2.6 *Early Byzantine pottery.*

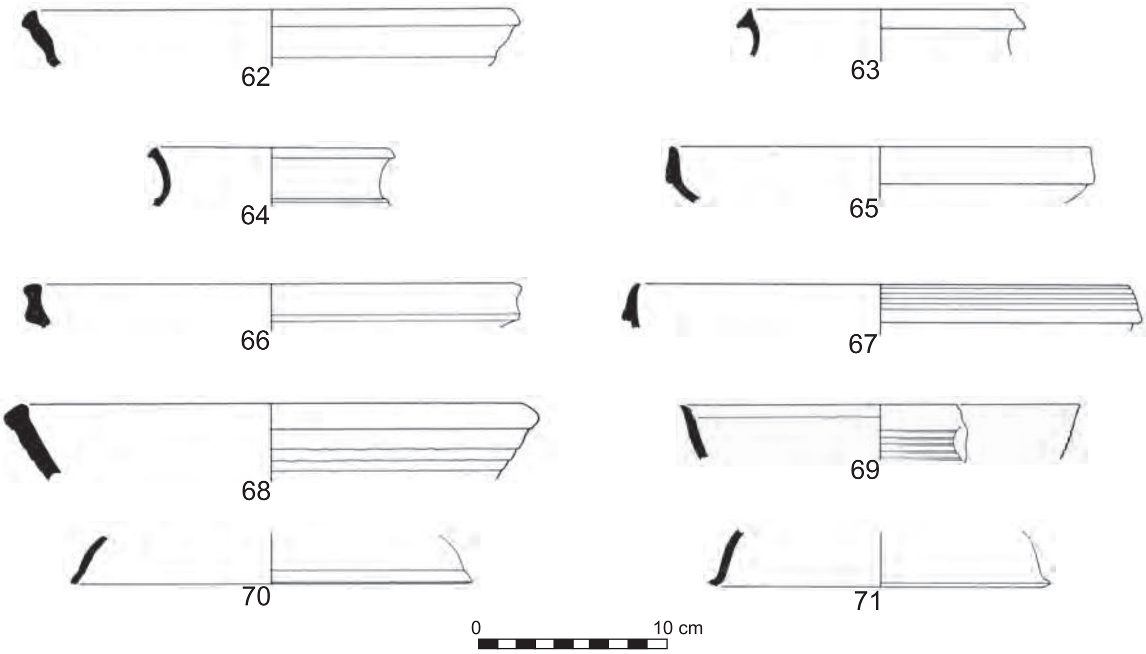


Figure A2.7 *Early Byzantine pottery.*

58. ARS. Flat base. Stamped with palmettes (5) radiating from a central circle. 4.5.11 G.

59. ARS. Flat base. Stamped with radiating palmettes (2) with square grilles (2) between their tips. 4.10.30 G.

60. ARS. Flat base. Stamped with concentric circles flanked by grilles (2) enclosed within a groove. 4.5.28 P.

61. ARS. Flat base. Stamped with concentric circles enclosed within two concentric grooves. 4.7.9 G.

62. ERS B. Dish or platter with out-turned, stepped wall and rounded lip, similar to Hayes (1972) ARS Form 67. Coarse fabric variant, fine, sandy matrix with common well-sorted limestone inclusions, <0.5 mm. Dark red (10R 4/4) with purple-grey (10R 3/1) margins and glossy dark red slip inside, probably originally all over. 1350 G.

Cooking pots

63. Cooking pot with triangular-shaped rim, slightly concave internally and moulded under the rim. Red Oxidized ware. Red with purple reduced core. 4.2.11 P.

64. Cooking pot with triangular-shaped rim, lipped internally, and ribbed walls, although only the first rib is extant. Red Oxidized ware. Red-brown throughout with some concretions on the outside surface. 424.3.18 P.

Bowls and dishes

65. Bowl with upright rim and residual flange, imitating PRS Form 3 (Hayes 1972). Orange Oxidized ware 1, coarse. Orange throughout with medium grey surfaces inside, on the rim and slightly below outside. 1379 G.

66. Bowl with bead rim and short, stubby flange imitating PRS Form 3 (Hayes 1972). Orientation uncertain. Orange Oxidized ware 1, very coarse. Orange throughout. 4.2.14 P.

67. Bowl with grooved, collared rim, similar to ARS Form 86 (Hayes 1972). Miscellaneous wheelmade fabric. Fine, slightly sandy matrix with common limestone inclusions, <0.5 mm. Red-brown (2.5YR 6/6) with slight brown-green (2.5YR 5/1) core. 4.6.15 P.

Basin

68. Bowl or basin with up-turned lip and ribbed wall. Orange Oxidized ware 1, moderate. Medium grey with orange surfaces. 4.11.20 G.

Casseroles and lids

69. Casserole with internally bevelled rim and ribbed walls. Red Oxidized ware. Red-brown with black outside surface. 599J G.

70. Deep cooking ware lid with flatly oriented rim. Red Oxidized ware. Red-brown throughout. 424.3.18 P.

71. Deep cooking ware lid with grooved lip. Red Oxidized ware. Orange-red with red internal margin and similarly coloured surfaces. WF288, Trench 1, Layer 5.

A.2.4.6 Late Byzantine (AD 502–636)

There are only a few published assemblages from southern Jordan that are restricted to his period, but these include a sixth- and seventh-century assemblage from Khirbat edh-Dharih (Waliszewski 2001) and a mid-seventh-century one from Humeima (‘Amr and Schick 2001).

The most significant marker of this period is the introduction of straight and wavy combed decoration, which continues throughout the Early Islamic period. This motif is found on many bowls and basins decorating both the walls and the rim top, including no. 82 (similar to Smith *et al*. 1992: fig. 116, no. 6; Tushington 1985: fig. 31, no. 34), no. 83, nos 84–5 (Magness 1993: 206–7, Basin 2A; Tushington 1985: fig. 27, no. 10) and no. 86 (Tushington 1985: fig. 30, no. 8). The cooking or coarse ware lid no. 87 (Walmsley *et al*. 1993: fig. 20, no. 5) and jar no. 75 are also decorated with bands of combing. Basin no. 81 (Magness 1993: 209, Basin 3) appears to be decorated with combing, but it is narrow ribbing.

A new, diagnostic fabric, Orange Oxidized ware 2, is frequently used in the manufacture of these basins (nos 81, 83–5), and by inference it too is dated to the Late Byzantine and Early Islamic periods. The impressed, palm-shape is introduced during this period (no. 79; Waliszewski 2001: 97). Unpublished examples are known from Petra and the Dana Archaeological Survey, while from Gharandale they occur in a terminal Late Byzantine/Early Islamic context (Walmsley and Grey 2001: 152, fig. 8, no. 5). This motif sometimes occurs in association with Orange Oxidized ware 2, but more frequently with Orange Oxidized ware 1 or other wheelmade fabrics.

Of the Late ‘Aqaba ware, the amphorae continue and a basin type, found in all levels at the production site (no. 80; Melkawi *et al*. 1994: 463, fig. 8k), is present. Other forms spanning the Late Byzantine and Early Islamic periods include the ubiquitous storage jar, mostly in Orange Oxidized ware 1 illustrated by nos 76–8 (e.g. ‘Amr and Schick 2001: figs 6–7; Parker 1987: fig. 120, nos 220–22). Although diagnostic the form is rare at Faynan.

Fine Byzantine ware (Magness 1993: 166–71, 193–4, Form 1A) is a regional ware moderately widespread in the Levant and represented at Faynan by two vessels, including no. 74. This form was current between the mid-sixth and late seventh or early eighth century in Jerusalem, which is likely to be the centre for its production (Magness 1993). Imported red-slipped wares are also present. Phocaean Red Slip, Hayes’s (1972) Form 10C, is particularly common, although Form 3 is still quantitatively important. Cypriot Red Slip is represented by Hayes’s Forms 9 and 10. African Red Slip ware is not common, but new forms include Hayes’s 107, 104C and 105, while those dating to the late fifth but more typical of the sixth century include Hayes’s Forms 99, 103, 104B and 93. Stamped sherds, which could belong to these vessel forms, are also present (nos 72–3). As at Humeima (‘Amr and Schick 2001: 114) the Late Byzantine/Early Islamic ‘white on red’ painted decoration, characteristic in the north, is absent.

Red Oxidized ware remains an important component of the assemblage, with the casserole and jar forms illustrated for the Early Byzantine period continuing here (e.g. ‘Amr and Schick 2001: fig. 9, nos 20–26). Earlier cooking ware vessels, such as nos 41–2 and 45–7, are no longer in use.

A2.4.6.1 Catalogue (Figs A2.8, A2.9)

Finewares

72. ARS. Flat base. Stamped ?amphora. 4.10.34 P.

73. PRS? Flat base. Figurative stamp, possibly including a ?bird. 4.10.21 P.

74. Cup with plain slightly in-splayed rim, decorated on the outer wall with a burnished wavy line. Fine Byzantine ware. Dull orange with irregular brown outside surface. 599 G.

Jar

75. Jar with internally bevelled, undercut rim and ribbed shoulder; decorated on the neck with wavy incising. Orange Oxidized ware 1. Orange-red throughout. 4.5.3 P.

Storage jars

76. Storage jar with chunky rim, lipped externally. Orange Oxidized ware 1/2. Medium grey with pale brown surfaces. 1415 G.

77. Storage jar with narrowly ribbed walls and internally bevelled and undercut rim. Orange Oxidized ware 1. Dull orange with intermittent pale grey core. Concreted surfaces. 4.7.35 P.

78. Storage jar with upright tapered rim, bevelled internally, and ribbed walls. Orange Oxidized ware 1, moderate. Orange-red with intermittent pale brown core and remnants of white slip outside. 4.1.14 G.

79. Body sherd from a large storage jar (cf. Schick *et al*. 1993: pl. III, no. 2) with impressed palm motif. Miscellaneous wheelmade fabric. No fabric description.

Bowls and basins

80. Basin with abraded flange and prominent rim, tapered in section; enlarged bulge under the flange, possibly the beginning of ribbing. Late ‘Aqaba ware. Orange with cream outside surface and rim. 4.6.27 G.

81. Large, flanged basin with plain rim bevelled internally and narrowly ribbed lower wall. Orange Oxidized ware 2. Pale brown with pale grey core. 4.6.14 G.

82. Basin with chunky rim, oriented on the outside surface and with an internal lip; the rim top is decorated with an incised wavy line. Orange Oxidized ware 1 variant with common red-brown pellets. Pale pink throughout. 4.6.15 G.

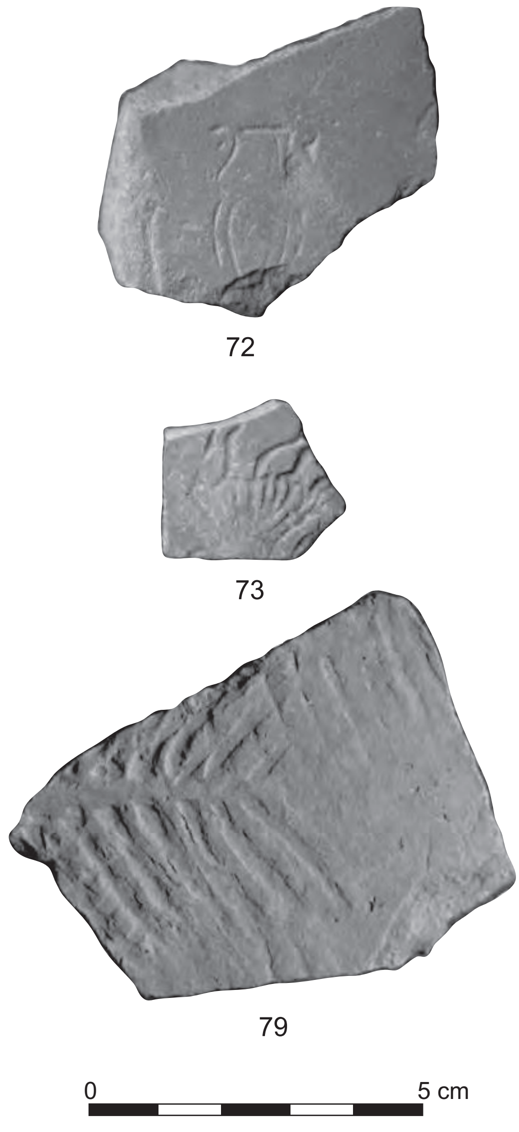


Figure A2.8 *Late Byzantine pottery.*

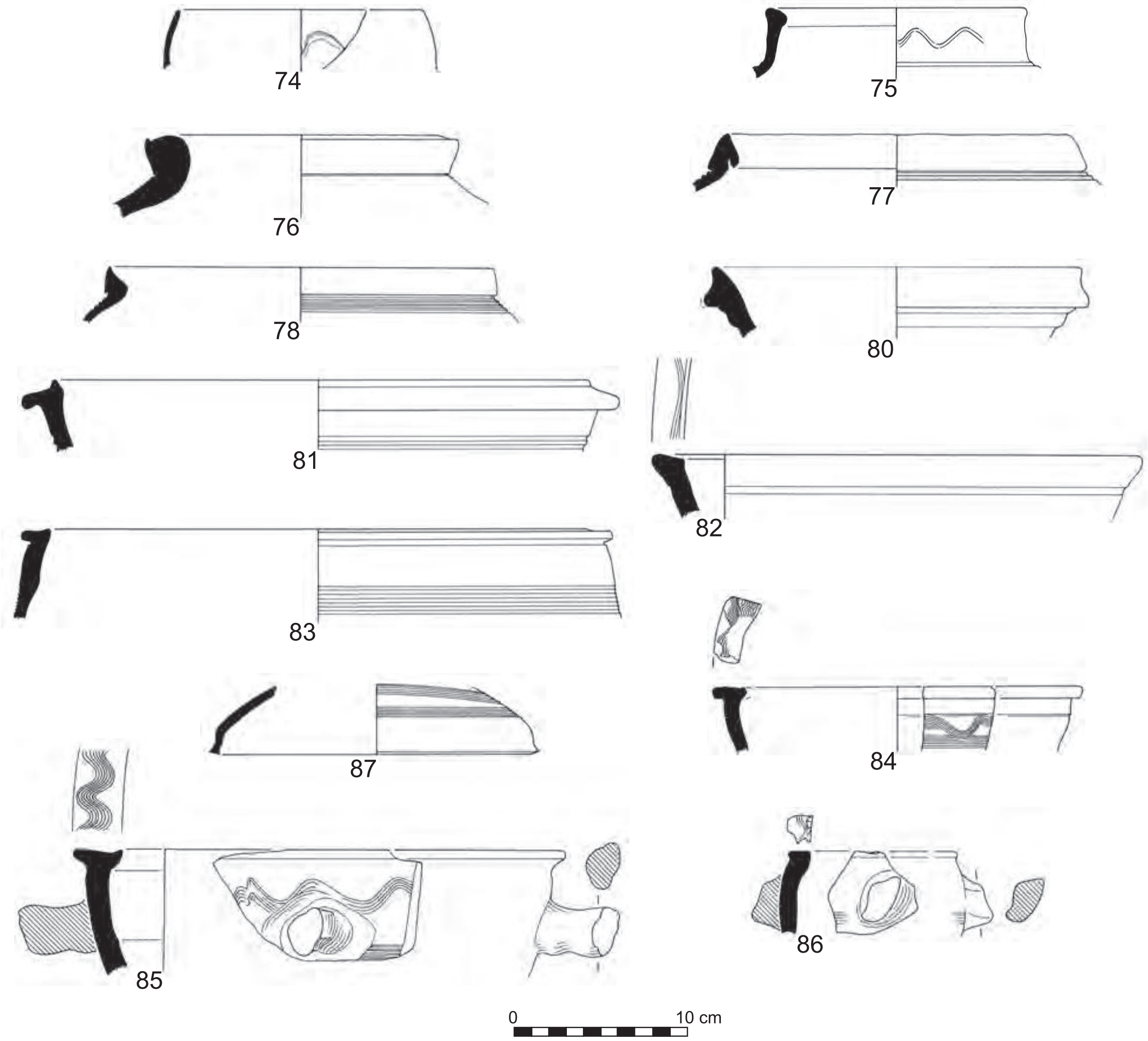


Figure A2.9 *Late Byzantine pottery.*

83. Basin with wide girth, slightly undulating flattened rim and horizontally combed wall. Orange Oxidized ware 2. Buff with pale red surfaces, abraded in part. 4.9.13 G.

84. Basin with nearly flat, flanged rim and abraded internal bead lip, unlikely to have been much larger than the extant bead; the rim top is decorated with wavy combing and the walls with horizontal bands of straight and wavy combing below a girth groove. Orange Oxidized ware 2. Pale brown with grey-green core and slightly oranger margins. Concreted in part on the outer wall. 4.8.18 G.

85. Basin with horizontal handle and grooved, flattened rim decorated with wavy combing on the rim top; horizontal wavy and straight combing on the walls. Orange Oxidized ware 2. Pale brown inner and pale orange outer margins and surfaces. 4.7.11 G.

86. Basin with horizontal handle and flat rim, decorated with wavy combing on the rim top; horizontal combing on the wall. Orange Oxidized ware 1, moderate. Pale orange with slightly lighter inside surface and reddened, wiped outside surface. 424.2.3 G.

Lid

87. Cooking ware lid with lipped rim and curved walls, decorated with two extant bands of combing. Five rims. Miscellaneous wheelmade fabric. Very hard fired, inclusionless fabric. Pale brown (5YR 6/1) with pale grey (6/N) inner margin, brown-grey (7.5YR 5/1) inner surface, with dark brown-grey (7.5YR 4/1) outside surface, likely slipped. 1415 G.

A2.4.7 Early Islamic (AD 636–1000)

This ceramic horizon includes pottery primarily of the Umayyad (AD 661–750) and Abbasid (AD 750–969) periods, but since some of these traditions continue into the Fatamid (AD 969–1174) the horizon has been extended to include earliest Fatamid; it is also defined so that the handmade Islamic wares – generally starting in the eleventh century – are limited to the succeeding horizon. Comparative assemblages of this date from southern Jordan include a late eighth/early ninth century group from Gharandal (Walmsley *et al*. 1999; Walmsley and Grey 2001) and Umayyad (Whitcomb 1989a) and early Fatimid (Whitcomb 1988) levels at ‘Aqaba.

Many of the fabrics, forms and decorative techniques current in the Late Byzantine period continue here, including combing, particularly on basins, storage jars, cooking pots and casseroles. There are, however, a number of additions to the assemblage including the main currency of cream wares, as distinct from the Nabataean cream wares described earlier. Although certain jug forms found at Faynan suggest that cream wares may have begun in the Roman or at least Late Roman period, their quantitative significance dates from the Early Islamic period. 'Islamic Cream ware' (ICW), associated with thin-walled jugs, jars and lids with incised/pared, moulded and applied decoration, dates from the Abassid period (Walmsley 2001). It is noteworthy that such finely potted vessels in the classic ICW are rare at Faynan (no. 89), as are moulded and applied decoration. As for earlier periods, the repertoire emphasizes the functional nature of the assemblage. Chunkier cream wares and cream-surfaced wares were used to produce basins and jars at 'Aqaba during the Early Umayyad period (Whitcomb 1989a: 169), but there the combed basins in cream ware are, like the finer ICW, considered Abbasid in date (Whitcomb 1989b: fig. 3).

Forms illustrated in cream fabrics include a jar with high neck (no. 95), jars with combed decoration (no. 91, nr. McNicoll *et al*. 1982: pl. 148, 1; no. 90 with a cream surface) and lid (no. 104). Vessels similar to no. 104 are sometimes published as bowls (Uscatescu 1996: fig. 111), and in some cases it was difficult to distinguish whether the Faynan vessels were intended as bowls or lids, although both are present (no. 98).

A decorative motif new to the Early Islamic period is the excised technique, described as cut, chiselled or gouged, on handmade vessels. The decoration on no. 96 (Sauer 1982: fig. 5, top row fourth from left; Sauer 1986b: fig. 5 bottom row third from right;) is fairly typical of this technique, while no. 99 is similar to an Abbasid sherd from Hesban (Sauer 1982: fig. 5, top row second and third from right). Sauer (1982: 332–3) describes all the small cut-ware vessels as handmade and also notes that the Abbasid ones are more crudely made than those in the Umayyad period. Although the Faynan forms are not exactly paralleled elsewhere, and the decoration on the Faynan vessels is cruder, the technique (nos 100–101) is similar to examples seen from Pella and Hesban and dating to the Umayyad and Abbasid periods (McNicoll *et al*. 1982: pl. 149, nos 2, 3, 7). Of all these vessels, only no. 99 is obviously handmade or moulded.

In addition to cut decoration, the top of the rim of no. 100 has been pinched (cf. Smith and Day 1989: pl. 55, 14). Other examples of thumbing, possibly on applied strips as seen on no. 97, occur from the Late Roman period but the small bowls illustrated here seem to be characteristic of the Umayyad production at Jerash (Schaefer 1986: fig. 10, nos 7–8). Combed decoration continues from the Late Byzantine and many of the basins seen for that period are still in use; the addition of one with a rounded or dropped rim, sometimes combed, is distinctive during the eighth and ninth centuries (nos 102–3; Sauer 1986b: fig. 7; Walmsley 1995: fig. 8, nos 8, 10; Walmsley *et al*. 1993: fig. 23, no. 5). The jar, no. 92, is unusual at Faynan, but common in northern Jordan in having painted decoration on the rim top.

Red Oxidized ware remains important for cooking wares. While there are typlogical changes to the casseroles through time (Magness 1993: 211), the small fragments collected at Wadi Faynan did not allow distinctions to be isolated. The earlier cooking pots (nos 63–4) also continue (Magness 1993: 219). There are no exact published parallels for the type illustrated by no. 93 with its distinctive flattened bead rim, long curving neck and ribbed walls. Perhaps the closest fit is from 'Aqaba (Whitcomb 1989a: fig. 4i), putting it in the Early Umayyad period. The consensus of the IFAPO round table was that the type continued through the Late Umayyad/Early Abbasid period.

Other forms can be paralleled to ones illustrated by Kareem (1987) from the Late Byzantine to Fatamid period in the Jordan Valley. These include a ribbed lid (no. 105; Kareem 1987: pls 95–6) and a jar (no. 94; Kareem 1987: pl. 83, no. 9, pl. 84, no. 3) belonging to the general category of baggy jars, but not in a Palestinian fabric.

The utilitarian nature of the Faynan assemblage for this period is perhaps most dramatically illustrated by the small quantity of glazed pottery. Four sherds were collected from the Faynan main site, two of which were identified as belonging to this period (pers. comm.). These comprise the base of what is possibly Abbasid Iraqi Splash ware (no. 88), as well as unillustrated fragment from a glazed jar of the same date from 849 G.

A2.4.7.1 Catalogue (Fig. A2.10)

Glazed ware

88. ?Abbasid Iraqi Splash ware. Base decorated with turquoise (5/5G) border and brown/purple (7.5R 5/1) roundels. Calcareous clay with common, well-sorted quartz to *c*.<1.0 mm. Cream (10YR 8/3) throughout. 475 G.

Jug

89. Filter or jug with plain upright rim; decorated with horizontal combing. Cream ware 1. Pale orange with creamy-white surfaces. 4.6.64 G.

Jars and cooking pots

90. Globular jar with upright rim; horizontal combing on the rim and shoulder. Miscellaneous wheelmade fabric. Fine matrix with occasional quartz, limestone and red-brown inclusions to *c*.0.5 mm. Dull red (7.5YR 6/6) with pink-cream (5YR 8/6) slip outside. 4.5.26 G.

91. Jar with enlarged, slightly everted rim and well-defined shoulder; decorated with poorly impressed wavy horizontal combing on the neck. Cream ware 2. Cream-green with cream-pink surfaces. 4.5.9 G.

92. Jar with flattened bead rim, oriented on the top; decorated with horizontal wavy combing on the wall. The rim top is painted purple-red (7.5R 5/4-4/3). Orange Oxidized ware 1. Orange throughout. 4.6.57P.

93. Cooking pot with everted rim, beaded lip and ribbed neck and walls. Red Oxidized ware. Red-brown with slighter redder surfaces. 1009F G.

94. Double-handled jar with tall neck and plain rim; a flattened handle is joined to the base of the neck. Two rims, joining. Miscellaneous wheelmade fabric. Silty matrix with occasional ill-sorted inclusions or poorly mixed clay, ?limestone and dark ?rock fragments to *c*.2.0 mm. Dull red (2.5YR 6/6) with irregular medium grey (5/N) core and dark grey-cream (10YR 7/2) slipped and wiped outside surface. 1242 G.

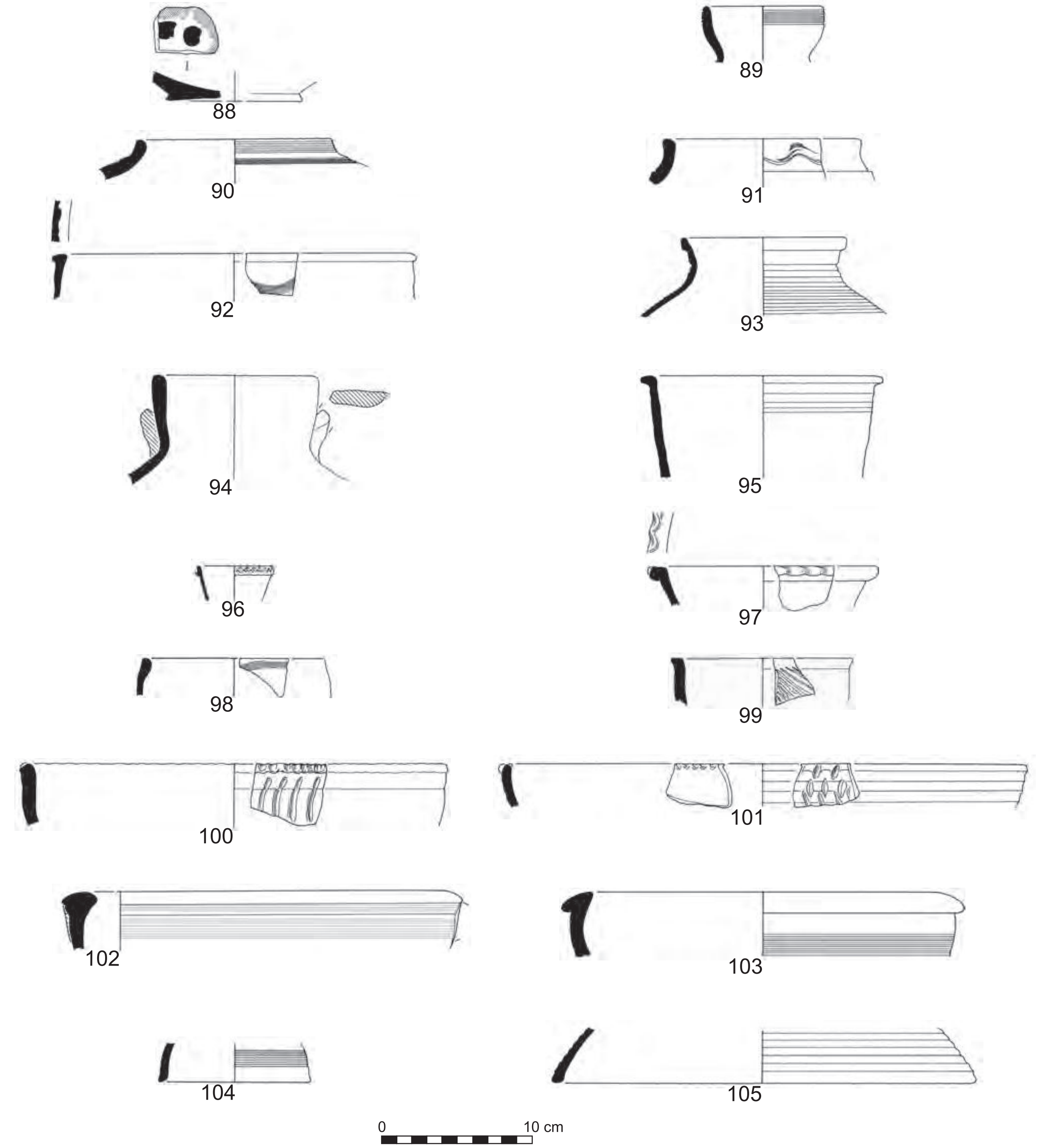


Figure A2.10 *Early Islamic pottery.*

95. Jar with tall, partly ribbed neck and flat, out-turned rim. Cream ware 2. Pale green throughout with burnt, discoloured surfaces. 1315 G.

Cup

96. Small cup with triangular-shaped incisions on the rim. Orange Oxidized ware 2, moderate. Orange throughout. 4.15.20 G.

Bowls and basins

97. Bowl or small basin with flatly oriented club rim; rim thumbed on the outside, possibly onto a small applied strip. Orange Oxidized ware 1, moderate. Orange-red throughout. 4.6.64 G.

98. Bowl with plain rim, enlarged internally; decorated with horizontal wavy combing on the rim, a single incision near the break suggests the beginning of a second band of combing. Cream ware 2. Cream throughout. 4.6.57 P.

99. Small bowl with flatly oriented rim; diagonal cut decoration on the wall. Diameter uncertain. Miscellaneous fabric, handmade or mould-made. Fine, dense fabric with some clay pellets or unmixed clay <1.0 mm.

Medium grey (5/N) with dull orange-brown (2.5YR 6/6) surfaces. 4.7.1 G.

100. Basin with enlarged rim, thumbed on the rim top; vertical cut decoration on the wall. Orange Oxidized ware 1. Orange throughout. 4.15.62 G.

101. Bowl with in-turned rim, pinched or incised on the inside; three rows of vertical or diagonal cuts on the outside of the rim and wall. Orange Oxidized ware 1, moderate. Orange throughout with red-orange outside surface. Concreted. 4.15.48 P.

102. Basin with rounded rim and horizontal combing directly beneath the rim; handle smear on the rim and shoulder. Orange Oxidized ware 1/2. Brown with orange sandwich in the break and pale brown-buff outside wall and in part on the rim top. 1351 G.

103. Basin with ovoid bead rim, dropped externally; decorated with a band of horizontal combing on the wall. Orange Oxidized ware 2. Yellow-brown with orange sandwiches and surfaces as break. 4.10.29 P.

Lids
104. Deep lid with internally bevelled rim; decorated with horizontal combing on the girth. Cream ware 1/2. Pale pink with cream outer margin, green inner margin and cream surfaces. 4.6.61 P.

105. Domed lid with enlarged rim and ribbed walls. Orange Oxidized ware 1, dense clay. Grey with mottled dull orange surfaces on the rim top and inside surface. 4.6.4 G.

A2.4.8 Later Islamic and Ottoman (AD 1000–1918)

From the eleventh, or possibly the late tenth, century handmade coarse wares become a diagnostic feature of assemblages in Transjordan. The most comprehensive discussion of these wares in southern Jordan is by Grey in the Gharandal report (Walmsley and Grey 2001), who has subdivided them into two main groups: Early Plain Handmade ware (eleventh/twelfth) and Plain Handmade Coarse ware (twelfth to modern), both of which also occur with painted decoration. Elsewhere in southern Jordan they are published from late tenth or early eleventh contexts at ‘Aqaba (Whitcomb 1988: 212), and twelfth century and later contexts at al-Wu‘ayra (Petra) (Brown 1987; Tonghini and Vanni Desideiri 2001; Vannini and Tonghini 1997; Vannini and Vanni Desideiri 1995), Shawbak (Brown 1988) and Kerak (Brown 1989).

Although both types share an organic-tempered fabric, Grey (Walmsley and Grey 2001: 158) notes that at Gharandal the early fabric is primarily chaff-tempered and characterized by a light-coloured surface, while the later one has chaff in combination with other inclusions (particularly large quartz) and is associated with a thick dark core. The handmade wares described from al-Wu‘ayra from the first half of the twelfth century correspond to Grey’s late group (Tonghini and Vanni Desideiri 2001: 708–10).

Typologically, Grey suggests that smaller vessels were produced in the earlier fabric, with larger vessels and the up-turned lug or ‘elephant ear’ handles typical of the later series (Walmsley and Grey 2001: 158). The fabric type and forms as described were seen in abundance on the surface of the site at al-Furn, near Faynan and generally regarded as Mamluk – a date reinforced by the presence of two Mamluk glazed sherds (pers. comm.).

The predominance of lug handles, such as no. 111, at Faynan suggests that most of our vessels date from at least the twelfth century, with an undefined terminus since their production continued into the Ottoman (Brown 1992: *passim*) and even modern period. However, the recognition of Ottoman vessels is problematic, largely dependent upon stratigraphic means since it is difficult to distinguish them from earlier ones on typological grounds (McQuitty 2001: 577). Another recurring type is the open shape, no. 110, also present at al-Wu‘ayra (Vannini and Vanni Desideiri 1995: fig. 19, no. 9). Amongst the Faynan material, the handled jar (no. 108) and possibly the hole-mouth jar (no. 109) may belong typologically to the earlier group (Walmsley and Grey 2001: fig. 9, nos 6–10), but the remainder should date from the twelfth century onwards.

Handmade wares with painted decoration are represented at Faynan by two different styles. The first is an organic fabric with red painted decoration (no. 112). Grey (Walmsley and Grey 2001: 158) describes a red free-style painted decoration on his late handmade ware, to which our sherd might belong.

The second (no. 107) belongs to what is traditionally termed ‘Handmade Geometric Painted ware’ (HMGPW), referred to by Grey (Walmsley and Grey 2001: 159) as Handmade Painted Coarse ware. Particularly characteristic of the Mamluk period, HMGPW probably continues into the seventeenth (Walmsley 2001: 549–52) or even nineteenth century (McQuitty 2001: 578). Walmsley (2001: 550) has noted that between the eleventh and thirteenth centuries the fabrics and forms of handmade wares display variability on a local scale, but by the fourteenth century there is greater standardization over regions as exemplified by HMGPW (see also Abu-Jaber and al Saa’d 2000 for petrological analysis of HMGPW from Khirbat Faris).

Two glazed Islamic sherds falling into this time frame were collected from the Wadi Faynan survey: these comprise an underglazed, painted Ayyubid sherd, possibly of Syrian manufacture (4.3.21 G) and a fragment of a thirteenth-/fourteenth-century slip painted bowl (1350 G) (pers. comm.).

Another fabric group, Sandy Grey ware, may belong to this horizon. In northern Jordan and southern Palestine, grey wares are well-known from the Umayyad period, with a kiln excavated at Jerash (Schaefer 1986). In medieval times, extending into the modern period, grey wares are typical of the Gaza strip, the southern coastal plain and possibly the fringes of southern Palestine (Schaefer 1989: 42). However, the forms represented at Faynan differ from those commonly associated with grey wares so it is not clear whether the vessels belong to the same tradition. Our sherds occur in at least three different locations: one of these (849) is found in association with the sherd of Abbasid Glazed ware, Islamic Handmade ware sherds and Red Oxidized ware. The other two locations (609 and 699) contained only sparse pottery, not including other Islamic sherds.

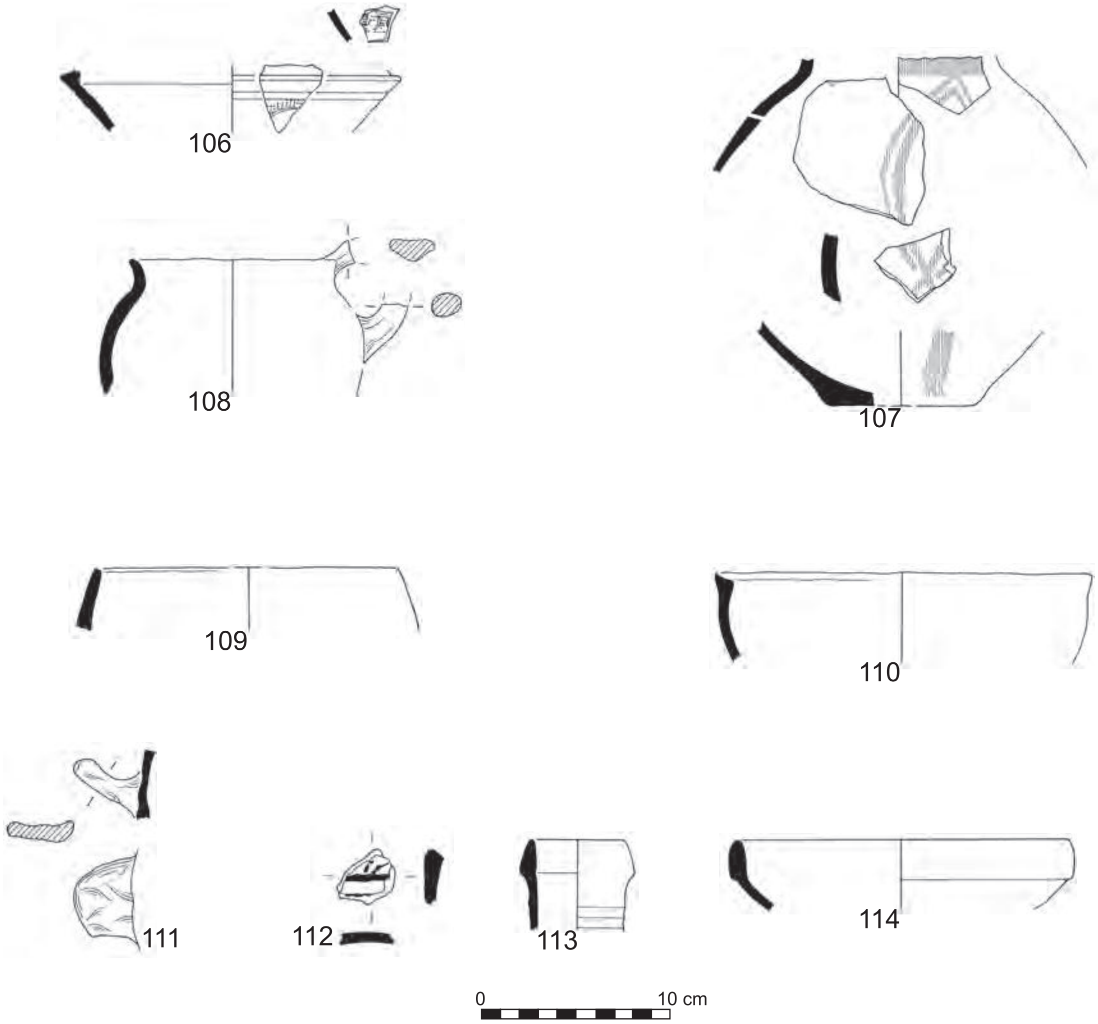


Figure A2.11 *Later Islamic and Ottoman pottery.*

Finally a cream ware vessel, no. 106, has the distinct 'pricked' decoration associated with the Mamluk period (Walmsley and Grey 2001: 153).

A2.4.8.1 Catalogue (Fig. A2.11)

Cream ware

106. Two sherds, non-joining, from a large carinated vessel. Ribbed wall with incised and punctate decoration. Cream ware 2. Cream-green with burnished outside surface. 4.7.32 P.

Handmade Geometric Painted ware

107. Globular jar with flattish-base. Four non-joining sherds illustrated out of a total of 102 sherds. Pale orange on the inside surface and margin and cream on the outside surface with a slightly greenish internal break and margin. 700 G.

Islamic Handmade ware

108. ?Single-handled, globular jar with plain, everted rim; a handle round in section is joined to the rim and girth. Three rims, two joining, and one handle. Islamic Handmade ware with occasional ?shell inclusions. Mottled orange-brown to brown outside; inside orange with dark grey core. 824 G.

109. Hole-mouth jar with squared-off rim. Orange-red with thick black core. 849 G.

110. Bowl or casserole with lid-seat rim. Four rims, two joining. Brown with thick black to dark grey core. 562 G.

111. Lug handle. Mottled brown to grey with black core and orange margins. 869 G.

112. Body sherd from a globular jar. Dark grey with orange outside surface, burnished or slipped to red with dark red-brown painted decoration. 4.2.8 P.

Sandy Grey ware

113. Beaker with upright, triangular-shaped rim and ribbed walls. Four rims, two each joining. Pale grey with slightly brown margins and dark grey surfaces. 699 G.

114. Bowl with ovoid-shaped, collared rim. One rim, six sherds. Pale grey with dark grey outside surface. 609 G.

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NB: Arabic, French, and Dutch names such as al-Najjar, Le Roux, and van der Steen, are listed alphabetically by the first letter of their main name, i.e. under 'N', 'R' and 'S' respectively.

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