LEVANT 32 2000

Archaeology and Desertification in the Wadi Faynan: the Fourth (1999) Season of the Wadi Faynan Landscape Survey

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This report describes the fourth season of fieldwork by an interdisciplinary team of archaeologists and geographers working together to reconstruct the landscape history of the Wadi Faynan in southern Jordan. The particular focus of the project is the long-term history of inter-relationships between landscape and people, as a contribution to the study of processes of desertification and environmental degradation. The 1999 fieldwork contributed significantly towards the five objectives defined for the final two field seasons of the project in 1999 and 2000: to map the archaeology outside the ancient field systems flooring the wadi that have formed the principal focus of the archaeological survey in the previous seasons; to use ethnoarchaeological studies both to reconstruct modern and recent land use and also to yield archaeological signatures of land use to inform the analysis of the survey data; to complete the survey of ancient field systems and refine understanding of when and how they functioned; to complete the programme of geomorphological and palaeoecological fieldwork, and in particular to refine the chronology of climatic change and human impacts; and to complete the recording and classification of finds.

Introduction (GWB)

The Wadi Faynan Landscape Survey is a study of the landscape evolution of Wadi Faynan in southern Jordan over the past 10,000 years, as a contribution to understanding processes of desertification and environmental degradation in arid lands. The project plans five seasons of fieldwork, the fourth of which took place in April 1999, with an inter-disciplinary team of archaeologists, geographers and environmental biologists from the universities of Aberystwyth, Bournemouth, Bristol, Exeter, Huddersfield, Leicester, Northampton, Nottingham Trent and Oxford, together with researchers from institutions in Cambridge and London. Today, much of Wadi Faynan forms part of the Dana Nature Reserve of the Royal Society for the Conservation of Nature (RSCN) and is used mainly by nomadic Bedouin herders. However, the area is also known for its abundant archaeological remains that are *prima facie* evi-

dence for episodes of intensive settlement and sedentary farming in the past, very different from settlement and land use today, from villages of early farmers 10,000 years ago to major settlements of the Nabatean, Roman and Byzantine periods, the latter associated with relict field systems. Wadi Faynan is also rich in copper and lead ores, and there is plentiful archaeological evidence that the former have been mined and smelted for at least 5000 years. The study area is therefore a particularly attractive location for investigating the history of interactions between a desertic landscape and its human inhabitants, given the millennia of industrial and agro-pastoral activities that have characterized human settlement here.

The first three years of fieldwork and related laboratory studies by the team's geomorphologists and palaeoecologists have succeeded in establishing the outline sequence of landform changes and climatic fluctuations from the late Pleistocene to the present day (Barker *et al.* 1997, 1998, 1999). Our archaeological and hydrological studies have established the broad history of agricultural strategies, with a particular focus on the development of water-management techniques. The first farming by Neolithic people was practised in the early Holocene in a landscape significantly wetter and more vegetated than today. Simple systems of floodwater farming were probably first developed in the Early Bronze Age some 5500 years ago, coincident with the beginnings of aridification. These societies had also started to engage in systematic copper mining and smelting, trading the metal widely throughout the region. More sophisticated water-diversion techniques were used in the Iron Age, the period of the Edomite state in the early first millennium BC, when the scale of industrial activity was also greatly intensified. There were further refinements to farming and smelting in the Nabatean period. However, the most dramatic developments took place with the Roman annexation of the Nabatean kingdom in AD 106: mineral processing was organized on a massive (almost certainly state-controlled) scale, and the entire agricultural landscape appears to have been managed as a single integrated system, presumably to feed the administrative personnel and, in particular, the large workforce engaged in mining and mineral processing.

The project has also found strong evidence that these activities had a major impact on the landscape. Geochemical analyses have shown that heavy metals trapped within sediments are a record of changing levels of water and air pollution in the past caused by mining and smelting, which continue to impact on the landscape today (Gilbertson *et al.* 1999). Initial results indicate that pollution began on a small scale in the Early Bronze Age coincident with the beginnings of metallurgy in the Wadi Faynan, increased significantly in the Iron Age and again in Nabatean times, and then intensified dramatically in the Roman period. Industrial pollution declined to insignificant levels after the late Roman or Byzantine period, though there was another episode (small scale compared with Roman activity) later; the sediment layer with the evidence for this episode has not yet been dated, but the smelting technology implied by the mix of pollutants suggests that it may relate to Mamluk metallurgy. Pollen and other palaeoecological studies indicate that the steppic landscape that had developed by the fifth and fourth millennia BC degraded further in the third and second millennia, but it is not clear to what extent this process reflects climatic change (increasing aridity) or the activities of Bronze Age farmers, or both. However, the pollen record shows that vegetation was then massively degraded in Roman and Byzantine times, almost certainly reflecting human activity – presumably stripping the land of fuel-wood for smelting, farming the field system intensively, and pastoralism.

In the light of these preliminary findings, five major tasks were defined for the 1999 fieldwork season. The principal archaeological objective was to undertake survey outside the field system, as the focus of the archaeological survey in the first three seasons was entirely on the ancient fields (in part because the field walls were being damaged by agricultural development at the time the project began). The survey was directed by Professor D.J. Mattingly and Dr O.H. Creighton. This work was to be supported by ethnoarchaeological studies of modern settlement forms in the study area. Preliminary fieldwork by Dr C. Palmer in 1998 (Palmer 1999) established the principal Bedouin groups and present-day economic systems in the study area. The objectives for the 1999 fieldwork were to enhance these data, in particular by establishing the extent to which Bedouin societies have changed over the past generation, and secondly, in collaboration with Dr H. Smith, to attempt to establish the 'archaeological signatures' of pastoral and arable land use to aid the interpretation of the survey evidence for past settlement systems. The third objective was to complete the survey of the small field systems on the northern side of Wadi Faynan, and to conduct further research within the main field system (denoted as WF4 in the survey register) to refine understanding of its chronology, hydraulic characteristics, and relationship to the variety of domestic and funerary structures found within it. This study was the particular responsibility of P. Newson and P. Daly, who are collaborating in the development of the Geographical Information Systems (GIS) analysis of the field system data. The geomorphological and eco-

logical team, coordinated by Professor D.D. Gilbertson, aimed to advance the geomorphological survey (Dr S.J. McLaren), collect further samples for pollen analysis (Dr C.O. Hunt), sample sediments in geomorphological facies and in sediments associated with archaeological features for Optically Stimulated Luminescence (OSL) dating (A.J. Truscott), and to continue the sampling of modern sediments, fauna, flora and skeletal material to assess the nature and extent of pollution away from the 'hotspots' sampled in 1998 (Dr F.B. Pyatt). Finally, the finds team (Dr R. Adams, Dr T.E.G. Reynolds, Dr R. Tomber, Ms H. Parton) aimed to continue and if possible complete the primary recording and classification of the surface finds collected by the survey teams in the 1996–1999 field seasons.

In the following report, we discuss these objectives in turn, describing the methodologies where new techniques have been used that have not been described in our previous reports, and offering preliminary observations on the first results that have emerged from the fieldwork.

Archaeological field survey outside the ancient field systems (OHC, DJM)

Aims of the 1999 season and definition of the study area

Previous archaeological fieldwork has focussed on the detailed exploration of the main field system (WF4) and on the classification of its wall systems (Barker *et al.* 1997, 26–38; 1998, 8–14; 1999, 272–82). The methods employed have been described in previous reports (Barker *et al.* 1997, 27–30; 1998, 9–10): the systematic collection and counting of artefacts in each individually-numbered field of the system (*c.* 900 fields in total) and the detailed recording of constructional details of wall types and of other structures within or adjacent to the fields. By the end of the 1998 season, the preliminary recording of WF4 was completed, along with similar survey of a number of satellite field units (WF9/406 and WF14/410 on the northern side of Wadi Faynan, and WF424 near Khirbat Faynan: see Barker *et al.* 1999, 272–82).

The next phase of the project was designed to frame these data within a broader landscape context, through extensive fieldwalking and recording of a block of terrain around the ancient field systems. This wider landscape survey has formed the major archaeological component of the 1999 season. Fieldwork in previous seasons has demonstrated field system WF4 to be a complex palimpsest of occupation, with many sites characterized by high levels of reuse and adaptation. Consequently, it was envisaged that an extensive programme of archaeological survey beyond field system WF4, where sites tend to remain less disturbed, would further our understanding of site morphology and chronology in the Wadi Faynan as a whole.

The study area comprises a rectangle superimposed on the photogrammetric map of the wadi produced by Leoni Blank (University College London). The original irregular outline of the photogrammetric image has been set in a rectangular frame ($3{\cdot}5 \times 8$ km.), with an additional $1 \times 2{\cdot}5$ km. along the north-east margin to incorporate the main zone of ancient mines and the RSCN/CBRL camp (Fig.1). The total area covered by the grid is 30·5 sq. km. The survey area thus designated provides an envelope around the WF4 field system that spans the Wadi Faynan watershed. The western limits of the survey area lie close to the outskirts of the modern settlement of Qriqora. The eastern limits encompass the lower Wadi Dana up to the RSCN/CBRL base camp and the Wadi Ghuwayr to its egress point from the mountains just beyond the PPNA (Pre-Pottery Neolithic A) site WF16 (Finlayson and Mithen 1999) and the PPNB (Pre-Pottery Neolithic B) site Ghuwayr I (Simmons and al-Najjar 1996). The northern limits cross over the watershed between tributaries flowing south into the Faynan and other minor wadis flowing west to link with the Faynan/Fidan beyond Qriqora. The southern boundary lies in or close to the mountain front in that direction.

The photogrammetric map was realigned with a new grid based on UTM (Universal Transerve Mercator) co-ordinates. The UTM grid is aligned north/south and can thus be related readily to Jordanian national cartography. Within the grid, Global Positioning System (GPS) technology enabled the accurate geo-referencing of archaeological sites, and formed a key component of the survey programme. The hand-held Garmin 12 GPS units we used provide continuous readout of position in UTM co-ordinates and have a tolerable estimated position error – generally under 30 m., and commonly better than that in practice. The UTM grid was established by taking a series of GPS readings across the landscape at points that were easily identifiable on the ground. These were then mapped on a grid of 500×500 m. squares and overlain on the photogrammetric map and adjusted until the best fit was achieved (the arbitrary grid of the original map was found to be 29° from true north). The resulting map provides an adequate basis for the mapping of archaeological features, whilst acknowledging the inbuilt margins of error in hand-held GPS units.

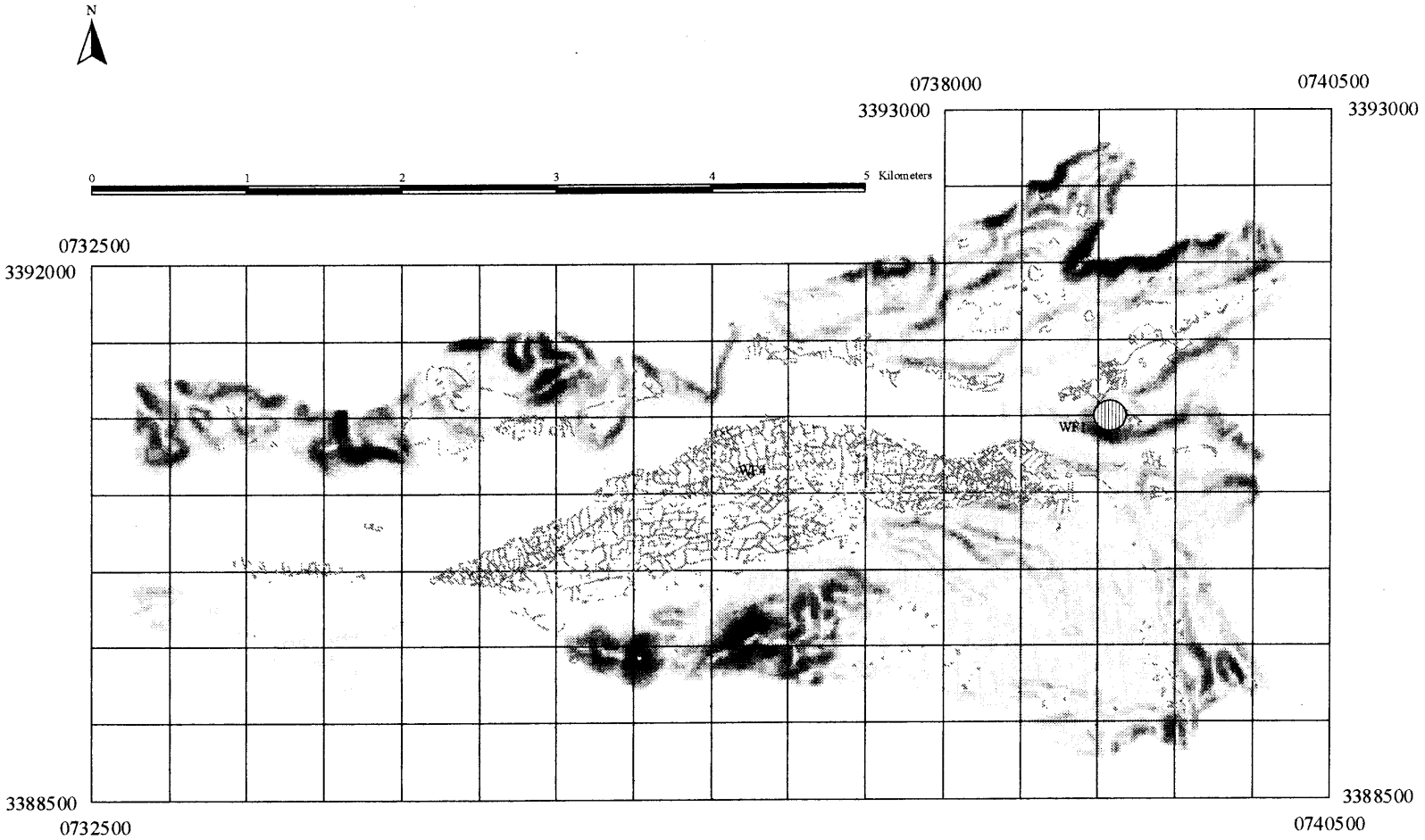

Figure 1. *The survey area of the Wadi Faynan Landscape Survey, showing the ancient field systems and the survey grid of 500 × 500 m. squares aligned on UTM coordinates. The topography shown is from the photogrammetric map, the boundaries of which do not extend as far as the boundaries of the survey area.*

A more accurate mapping programme (DGPS) would have been far more expensive to achieve, with four teams recording data at any time; we decided that the lack of centimetre precision was less important than overall coverage of the selected study area, which the recording system we selected would allow. The 500 × 500 m. squares in the designated survey area totalled 122. Each square was defined by the UTM co-ordinates and numbered according to its UTM Easting and Northing co-ordinates. For instance, the most north-westerly square is numbered 325/915, with its full UTM co-ordinates being 36 R 0732500/3391500.

The 1999 field season employed two complementary techniques designed to sample the archaeological landscape: line-walking and grid square survey.

Line-walking

The first stage was the systematic examination of a series of north/south transects across the entire study area. These transects were based on the Easting grid lines at intervals of 500 m. (e.g. UTM co-ordinates 36 R 0732500, 0733000, 0733500, and so on). The lines could be easily located using the GPS units and through a combination of compass and GPS readings were relatively easy to navigate (though the terrain was in places very demanding!). The line-walking had three aims: to provide indications of the spread of off-site material across the landscape and insights into off-site activity; to test the hypothesis that the very high densities of material recorded within the WF4 field system were exceptional in comparison with the normal 'background noise' within the Faynan basin; and to preview the nature of the archaeology and the landscape encompassed within the grid squares.

The UTM grid provided a practical basis for carrying out this task, and sixteen transects were walked (making a total length of 61 km.), each defined as a 2-m. wide corridor. The total area covered by the transects was thus 122,000 sq. m. The line-walking teams normally comprised two people, one navigating, the other collecting all archaeological materials encountered (primarily pottery and lithics, but occasionally slag and other artefacts). Each line was divided into a series of 250-m. long segments (stints), again defined by GPS co-ordinate read-outs; finds were bagged in relation to these stints. For instance, finds from the first 250 m. of the most westerly line would be recorded as coming from line 0732500, stint 3388500–750. Sites encountered in the line of the transect (whether defined by structures or as distinct artefact concentrations) were numbered and their position recorded for later revisit by the grid square teams. Finds were processed using the same form as devised for the finds from the field systems, with the number and weight of artefacts collected being recorded along with the length of the stint, so that density values could be calculated. The area of the WF4 field system and the outlying small field systems already recorded were excluded from the line-walking stints and, where such features were crossed by the lines, collection ceased until the far side of the fields was reached. Since such excluded areas were deducted from stint lengths, some recorded stints are significantly shorter than 250 m. This systematic approach to the distribution of material across the landscape allows us to compare densities within the field system with those across a range of terrain types outside it.

Analysis of the data collected is at an early stage, but it is already clear that overall densities of artefacts in the landscape outside the main field systems are very low, typically 0·2–0·4 sherds of pottery and/or struck lithic artefacts per hectare. These values stand in sharp contrast to the extraordinary densities of material recovered from many of the individual fields in WF4, where figures are typically in the region of tens or even hundreds of sherds per hectare. The exceptional density of material within the WF4 field system is thus confirmed. It still remains to be established whether the concentration within WF4 is due to manuring regimes or whether it correlates with proximity to settlement and structures, or to combinations of processes. It is probable that the explanation will differ for the various periods represented, though manuring is probably the main factor that has caused the very high densities of pottery and other artefacts surviving from the Roman/Byzantine phases. Given that the main population focus in the Roman/Byzantine phases appears to have been the major settlement of Khirbat Faynan (WF1) at the eastern end of the WF4 field system, the near-exclusive distribution of artefacts of these phases within the WF4 field system (both close to and far from WF1) indicates extensive and long-maintained rubbish disposal there. Presumably the Roman-Byzantine artefacts can be taken as a proxy marker for a wide range of domestic waste, much of it organic and of potential use as fertiliser such as animal and human faeces, that was systematically collected and spread across the fields. The key to understanding this behaviour probably lies in the geochemical and pollution studies reported by Gilbertson *et al.* (1999). Intensive manuring of the field system, even at considerable distances from the major settlement site as our archaeological evidence implies, may well indicate attempts to combat declining soil fertility and crop

productivity caused by the progressive pollution of cultivable soils as a result of intense copper smelting in and around the valley.

The low-density background distribution of artefacts outside the field system is relatively stable in all landforms: sporadic sherds or lithic material (predominantly waste flakes) are as likely to be encountered halfway up a mountain slope as on relatively flat boulder-strewn areas. Movement of artefacts across the landscape through natural processes such as erosion appears to be of minor importance – there is a very slight halo of artefacts around the main field system WF4 and a number of other sites. On the other hand, there is a strong correlation between higher density values recorded in the line-walking and the proximity of major sites and structures.

Recording the archaeology of the grid squares

Systematic recording of archaeological sites within the study area formed the second major element of fieldwork during the 1999 season. The 500 × 500 m. grid squares based on the UTM grid formed the basis for survey by small teams, generally comprising 2–3 people, using GPS units to determine co-ordinates of the limits of the assigned square and to log the position of all archaeological features encountered. The varied nature of the terrain, from flat braided wadi plains to steep, occasionally vertical, escarpments, militated against complete consistency in approach. However, the objective was for teams to search the entirety of each square for traces of human activity. Depending on the nature of the terrain, this might be achieved by systematic walking back and forward until the square was entirely traversed. Alternatively, in more rugged terrain, the approach generally focussed on the gentler slopes, ridges and level ground, though with steeper escarpments sampled by the line-walking and by random ascents during the recording of each square. Visual reconnaissance from elevated positions facilitated identification of ancient structures in many squares.

When the field teams encountered structural evidence or a distinctive concentration of artefacts, the location was assigned a number in the WF site sequence, GPS co-ordinates were logged, and the position of the site mapped on tiles prepared at a 1:2000 scale from the photogrammetric map. Where survey extended beyond the limits of the photogrammetric map, the principal features of the topography (scarps, wadis and so on) were also mapped on the tile. Artefact collection was often in the form of a grab sample, but whenever possible by systematic transects across structures or artefact scatters, the latter to provide data on artefact density comparable with that gathered by the field system survey and the line-walking. A *pro forma* site record sheet was filled out for each unit identified, including sketch plans of the structures and details of photographs taken.

Survey work commenced at the western end of the system and moved progressively eastwards, both north (partly within the Dana reserve) and south of the Wadi Faynan. All 122 grid squares were completed in the season, with a total of over 1000 unit numbers being assigned (Fig. 2). The nature of these 'sites' varied considerably, and included: domestic structures and enclosures; field walls; cemeteries and individual funerary monuments; lithic scatters and pottery scatters not associated with structures; mining- and smelting-related features; pictographs and inscriptions; Bedouin encampments and associated features (see Ethnoarchaeology below); and stone settings and indistinct features of indubitably human origin but uncertain interpretation. The overall density of these 'sites' is variable, but few sectors of the map, with the exception of the broad main channel of the Wadi Faynan, were blank or sparsely covered. The respective distributions of rectangular and circular/oval structures are shown schematically in Figures 3 and 4. Classifying, dating and interpreting such evidence will be a challenging task, but the overall impression from the initial studies of structure typologies and artefacts is that the landscapes around the Wadi Faynan have been affected by a palimpsest of human activity just as complex as that of the ancient field systems. As an indication of the wealth and complexity of the archaeology mapped in 1999 outside the field system, the final part of this section of the report presents some preliminary observations on one segment of the gridded area, the strip of land on the north of the Wadi Faynan between UTM Eastings 0732500–0736500 and Northings 3390500–3392000.

Between Faynan and Fidan

The north-western sector of our survey zone comprises a series of prominent hills forming a watershed between minor tributary wadis trending south into the Wadi Faynan and other streams running westwards and north-westwards to join the wadi after it has become the Fidan to the north of the modern settlement of Qriqora. The hills comprise tilted and folded limestone strata, with some of the wadis being quite deeply incised, producing some steep-sided narrow valleys. Deposits of yellowish dry clay were identified in some of these valleys, and some showed traces of past exploitation as clay

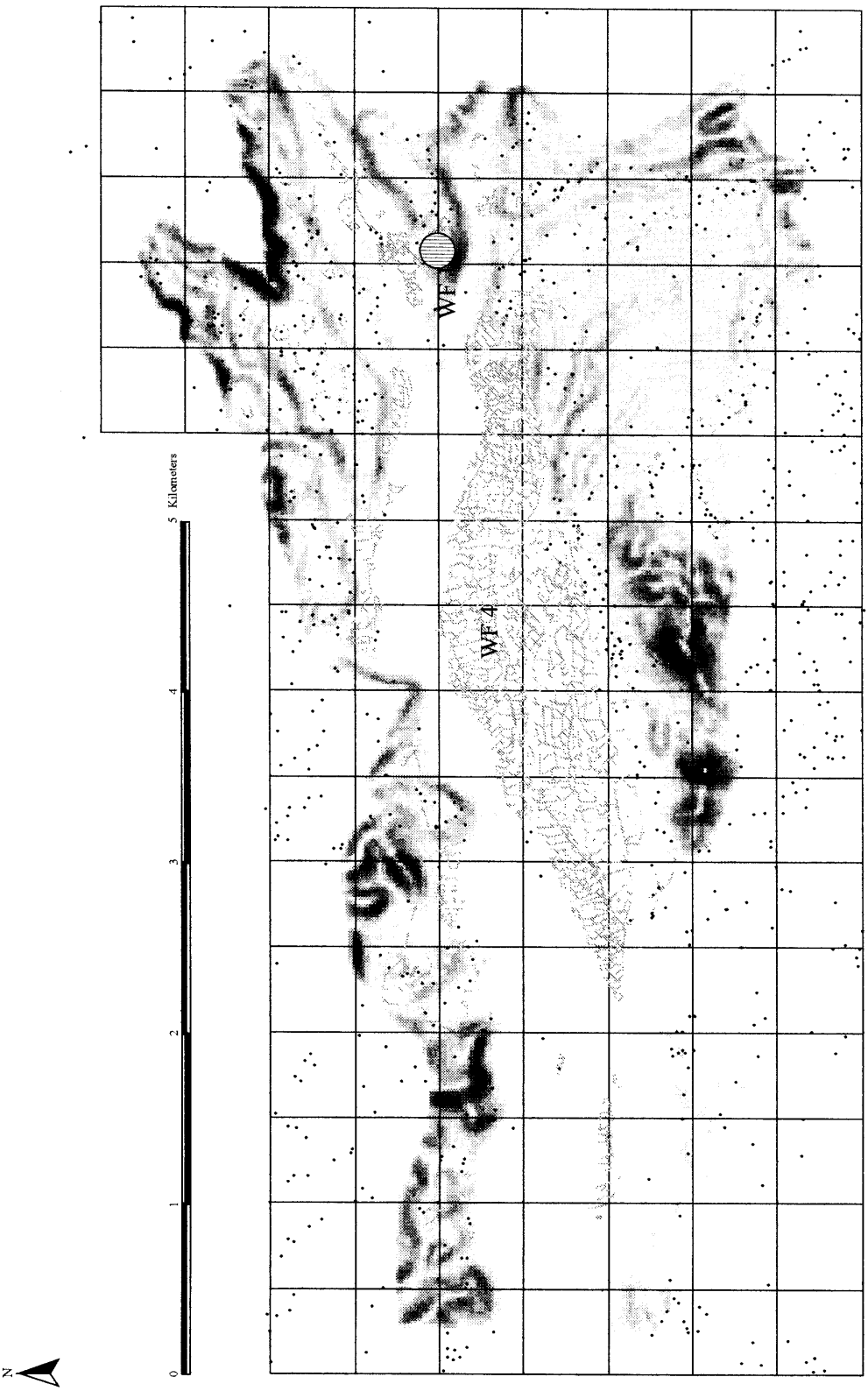

Figure 2. *The survey area of the Wadi Faynan Landscape Survey, showing the ancient field systems and the archaeological sites recorded in the 1999 survey; see text for the discussion of the varied nature of these sites. The topography shown is from the photogrammetric map, the boundaries of which do not extend as far as the boundaries of the survey area.*

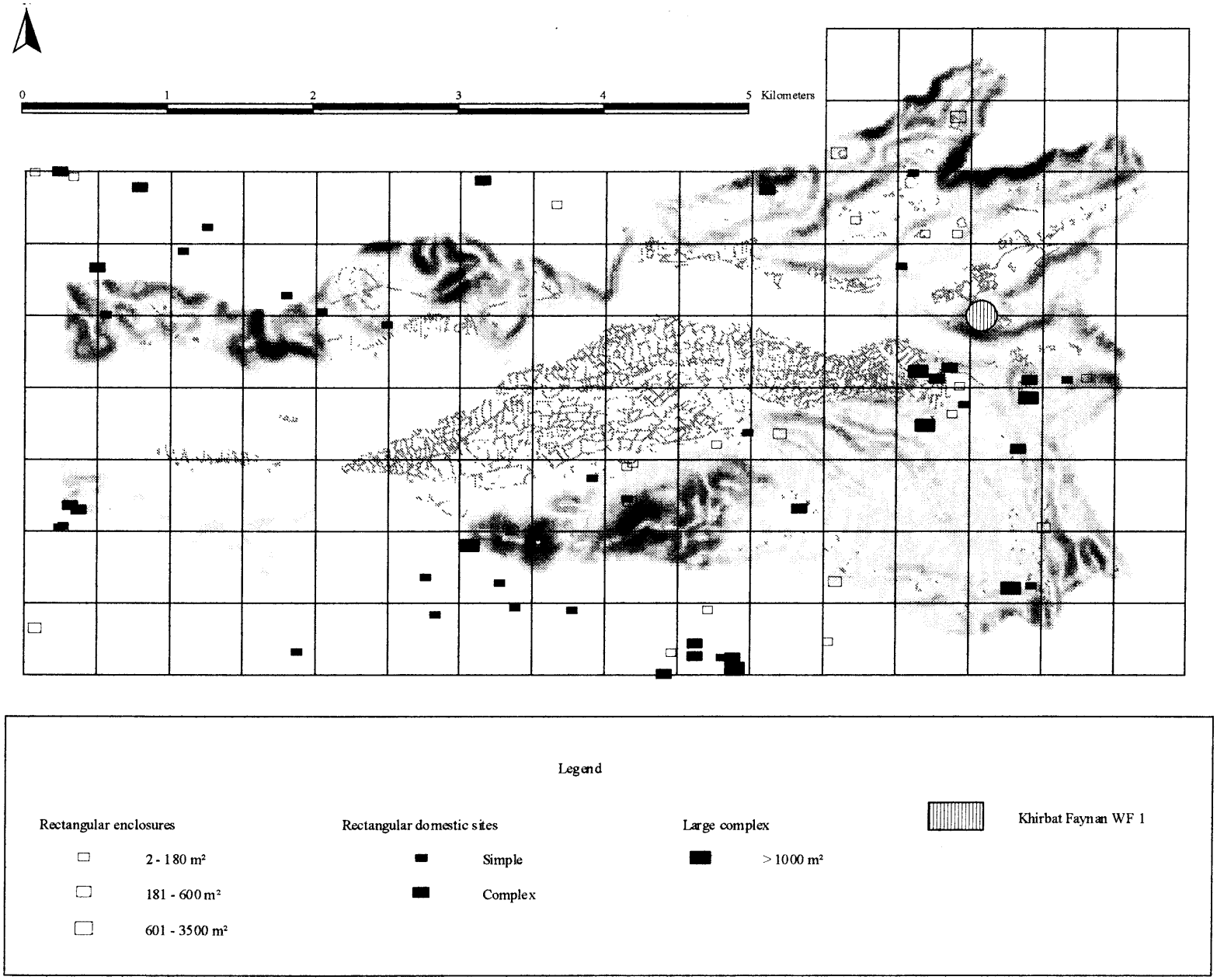

Figure 3. *The survey area of the Wadi Faynan Landscape Survey, showing the ancient field systems and the distribution of various categories of rectangular enclosures. The topography shown is from the photogrammetric map, the boundaries of which do not extend as far as the boundaries of the survey area.*

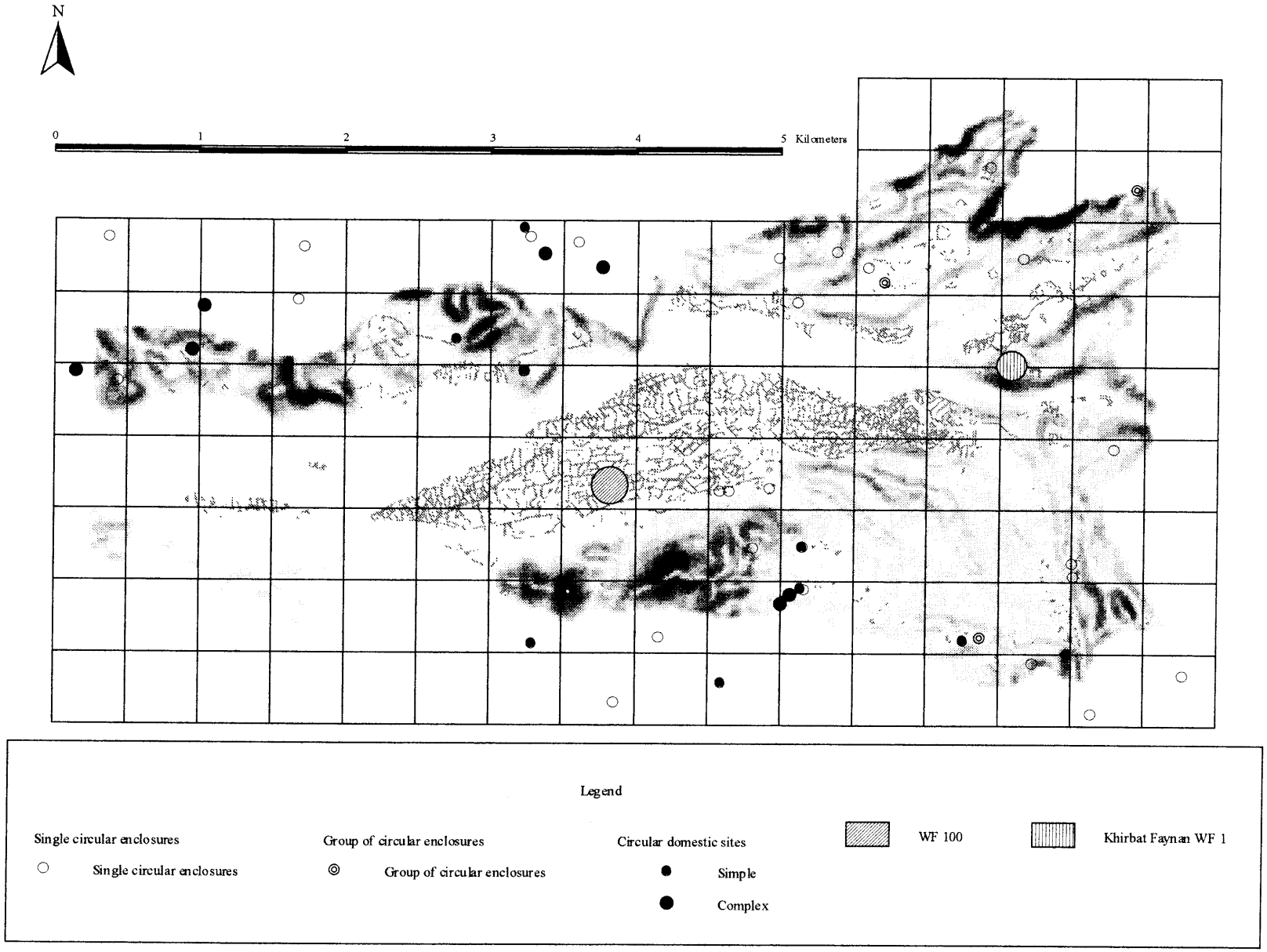

Figure 4. *The survey area of the Wadi Faynan Landscape Survey, showing the ancient field systems and the distribution of circular/oval structures. The topography shown is from the photogrammetric map, the boundaries of which do not extend as far as the boundaries of the survey area.*

sources. Many ridges are very sharp and escarpments are generally steep and scree-covered. The higher peaks rise in a short distance to heights of several hundred metres above the level of the main wadi floor. There are cairns and a variety of other possible funerary monuments on some of the peaks and ridges, along with occasional lithic scatters – particularly on cols and slight terraces. For the most part the steep slopes are devoid of sites, though sporadic artefacts were recorded. Structures (domestic sites and enclosures) are preferentially located at lower elevations, either at or close to the base of slopes or on low terraces. Along the northern edge of the grid, where the wadis flowing towards the Fidan open out into a plain, most of the settlement seems to be located close to the foot of the hills. However, a small number of ancient encampments and associated field systems was situated on low terraces directly adjacent to the wadi channels. On the southern side of the hills, the level terraces alongside the northern side of the Wadi Faynan have evidently been intensively exploited over time, with much evidence of prehistoric (Bronze Age) activity and field systems (see Barker *et al.* 1999, 275–77 for a description of these).

In all sectors of this landscape there is considerable evidence of prehistoric activity, which in advance of full analysis of the artefacts collected we believe to be primarily Early Bronze Age in date. A large number of circular or oval sites associated with prehistoric pottery and lithics was recorded, some on the southern terraces, others in the valleys and pathways through the hills, with a large concentration along the northern fringe of the hills. These sites typically consist of a main enclosure 10–15 m. in diameter with one or more rooms around the circumference, either attached to or integral with the construction of the enclosure. On the southern terraces, these sites are sometimes associated with simple terrace and floodwater farming systems, but in the other areas circular enclosures, sometimes with a few oval rooms attached, lack associated field systems (Fig. 5) – did they have a more pastoral function than the structures associated with field

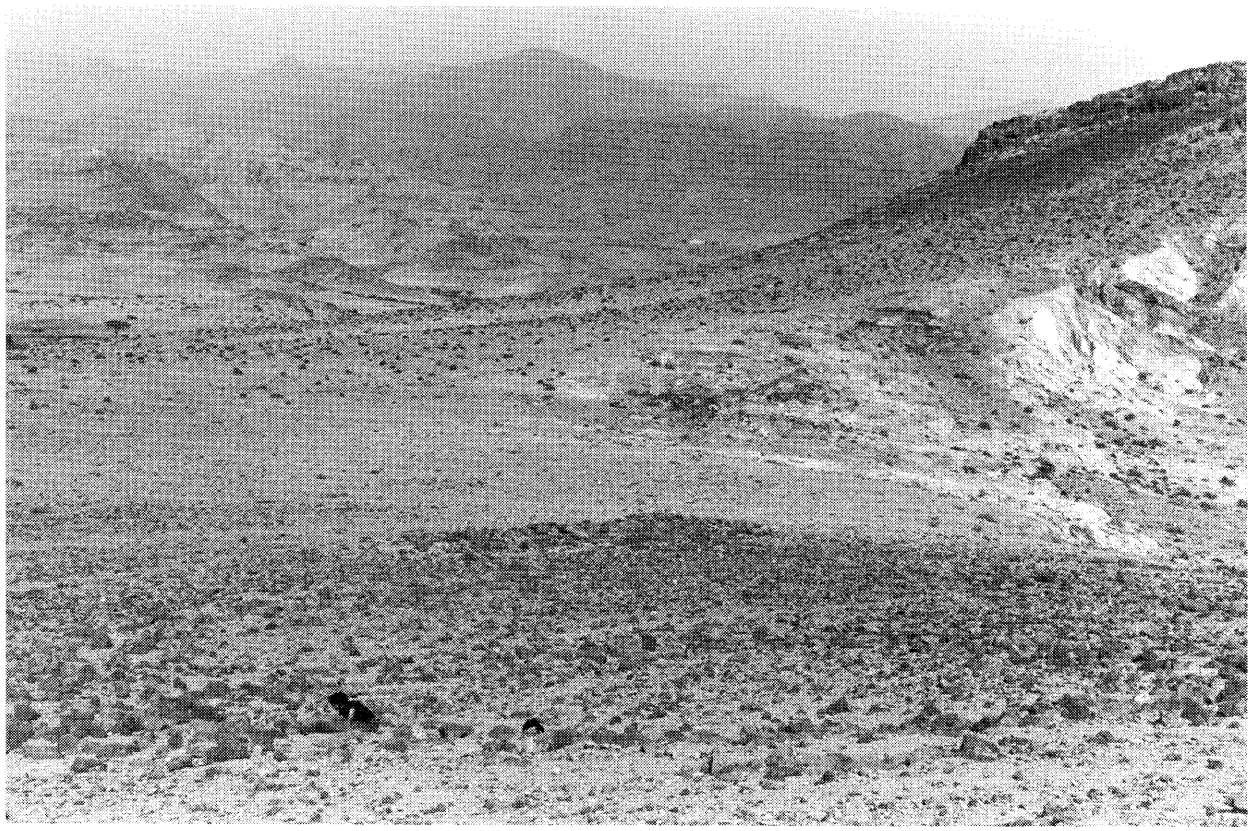

Figure 5. *Site WF792, a flimsily-built circular enclosure formed by a single wall of uprights, probably of Early Bronze Age date according to surface artefacts – a site geared to pastoralism? The enclosure spans the foreground, from the crouching figure on the left to the right-hand side of the picture. Looking north-east. (Photograph: G. Barker).*