tial cairns in the terraced fields (WF 237, WF 241, WF 249), the latter especially dominant on a skyline position.

The predominant finds from the field-walking were Roman/Byzantine sherds, although lithics, glass, slag and copper ore were also recovered. Two pieces of a possible copper mould, a stamped Byzantine handle and several Roman coins were found. Brief preliminary reports are presented below on the lithics and pottery.

The lithic material within the field system (TEGR)

More than 3,500 pieces have been collected by the team to date, 3,078 of which were analyzed in the 1997 field season. Of this figure, 2,735 were struck chert artefacts from a total of 622 collection units (counting systematic pick-up and grab samples separately) within the field system. A sample of some representative pieces is illustrated in Fig. 12 and some preliminary observations on the material are offered below.

In terms of chronology, there is a 'background noise' of stray middle palaeolithic artefacts occurring singly within collections of other material. This middle palaeolithic element, falling within the date range 210,000–35,000 years ago, comprises chunky, flake-based, scrapers and denticulates. Regarding the Upper Palaeolithic, well-made, punch-struck blades are lacking in the collections but there is a consistent appearance of relatively large blades with broad, plain, striking platforms on medium-grained chert, which could be upper palaeolithic in date, though they could also fit into later industries. Blades and a blade core of probable upper palaeolithic date have been recovered by geomorphological survey from a section in the Wadi Ghuwayr (site 5029). Similarly, an epipalaeolithic blade and bladelet presence is probable, but consistent patterning within a single assemblage is lacking. There is a single crude lunate which could date from this time or the Natufian, though unfortunately the type also recurs in the Early Bronze Age. Amongst the microlithic tools, two trapezes could be any age from epipalaeolithic to early bronze age. A serrated bladelet and an obliquely blunted point would also fall into this range, although an early bronze age date is less likely than an earlier one as such types became scarce during the Early Bronze Age.

Type fossils with accurate chronological information regarding later prehistory (neolithic/chalcolithic/bronze age) are also rare. There are fan-shaped scrapers (Fig. 12:4), but these are not tabular and are made on tertiary flakes, which is not typical; such pieces have a late neolithic to early bronze age date range. Neolithic-type flake- and blade-based borers have been recovered from several units (Fig. 12: 5), whilst true Canaanite blades typical of the Early Bronze Age are absent; this absence could reflect the north/south division in Jordan, as such artefact types are much rarer in the south than the north, and possibly indeed absent. Pick fragments, of which two were found (Fig. 12: 1), have a chalcolithic to early bronze age date range and arch-backed blades from the collection (Fig. 12: 2) are likely to belong to the Early Bronze Age, though they, too, can occur in the Chalcolithic. The collection of sickle blades with gloss (Fig. 12: 6–8) shows cereal harvesting activities, which would again span a broad time range (from the Epipalaeolithic virtually until the present), but the various wear and damage characteristics of the pieces suggest they are unlikely to derive from recent threshing trolleys; a mid-Holocene date is likely. There is no evidence for the blades being reversed in their hafts and reused.

Raw materials are all locally-derived wadi cobbles and no special technology has been applied in reduction. Simple single platform and direction of flaking cores and informal cores dominate. The condition of the pieces collected confirms the high energy depositional environments to which pieces have been subjected and many post-depositional breaks are visible.

Reconnaissance survey outside the field system indicates that lithic material is denser on the low hills overlooking the fields than within the field system itself, and richer in materials. The collection and analysis of this material are likely to be an important aid in the interpretation of the lithic material gathered within the field system. The largest single collection made within the field system was *c.* 70 pieces, which is not large for a context with *in situ* knapping, but which might be indicative of settlement activity. Also, it has to be remembered that the survey here is investigating an area subject to high energy events characterized by substantial amounts of sediment transport and re-deposition: both micro-topography and human alteration of the landscape (the field wall systems) are likely to have had a profound effect on artefact distribution patterns. Nevertheless, there are a number of collection units which may be indicative of 'sites', or concentrations of activities, the most notable of which are indicated schematically in Figure 13. The concentration of material around the late neolithic/chalcolithic settlement of Tell Wadi Faynan (Najjar *et al.* 1990) is particularly striking, as is the spread of

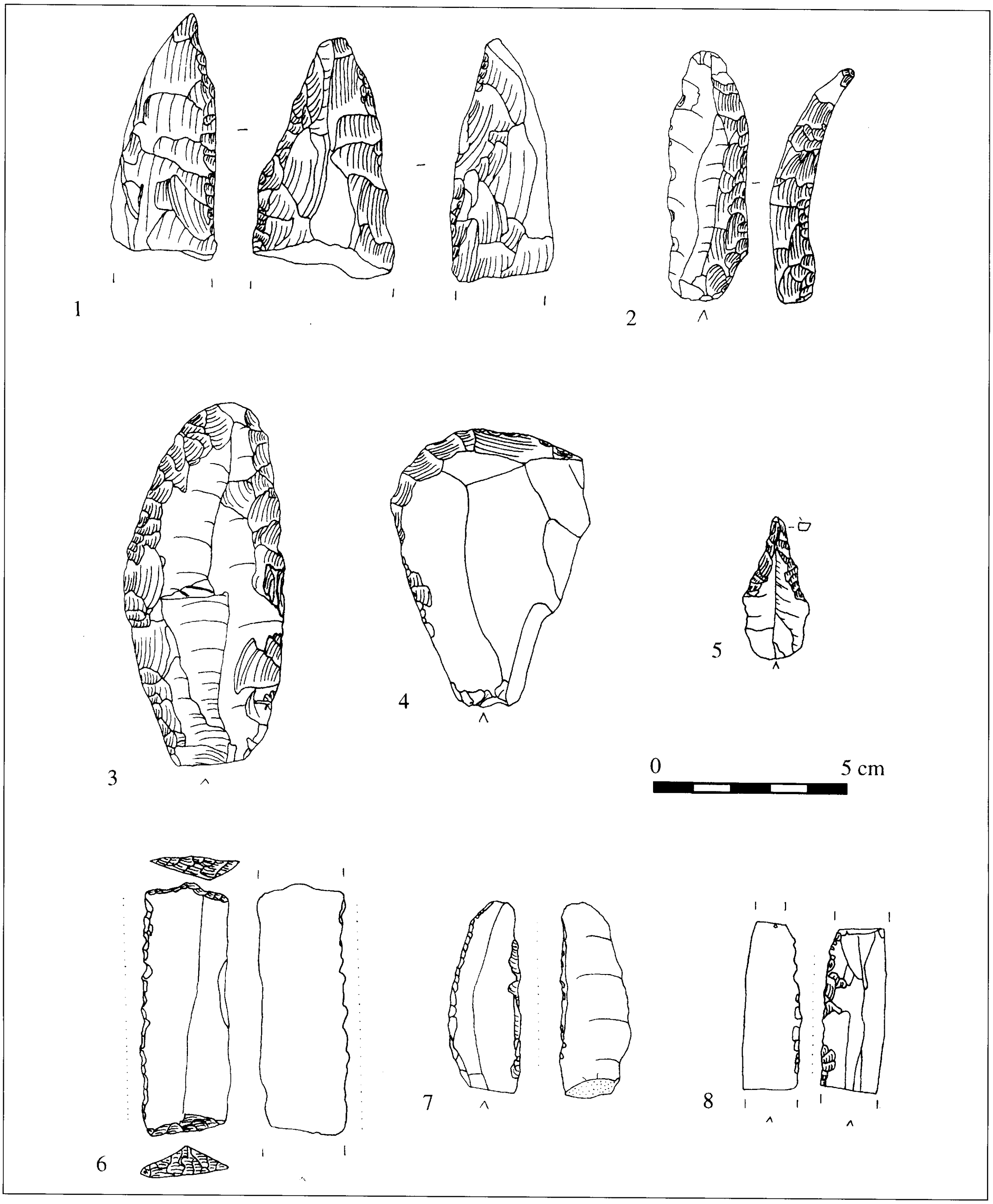

Figure 12. *Some chert artefacts from within the WF4 field system: 1. pick fragment (WF4.4.15); 2. arch-backed blade (WF4.5.2); 3. retouched flake knife (WF4.1.36); 4. fan-shaped scraper (WF4.6.60); 5. borer (WF4.7.1); 6. sickle blade with gloss (WF4.5.28); 7. sickle blade with gloss (WF4.6.25); 6. sickle blade with gloss (WF6.6.60). (Drawn by T. Reynolds).*

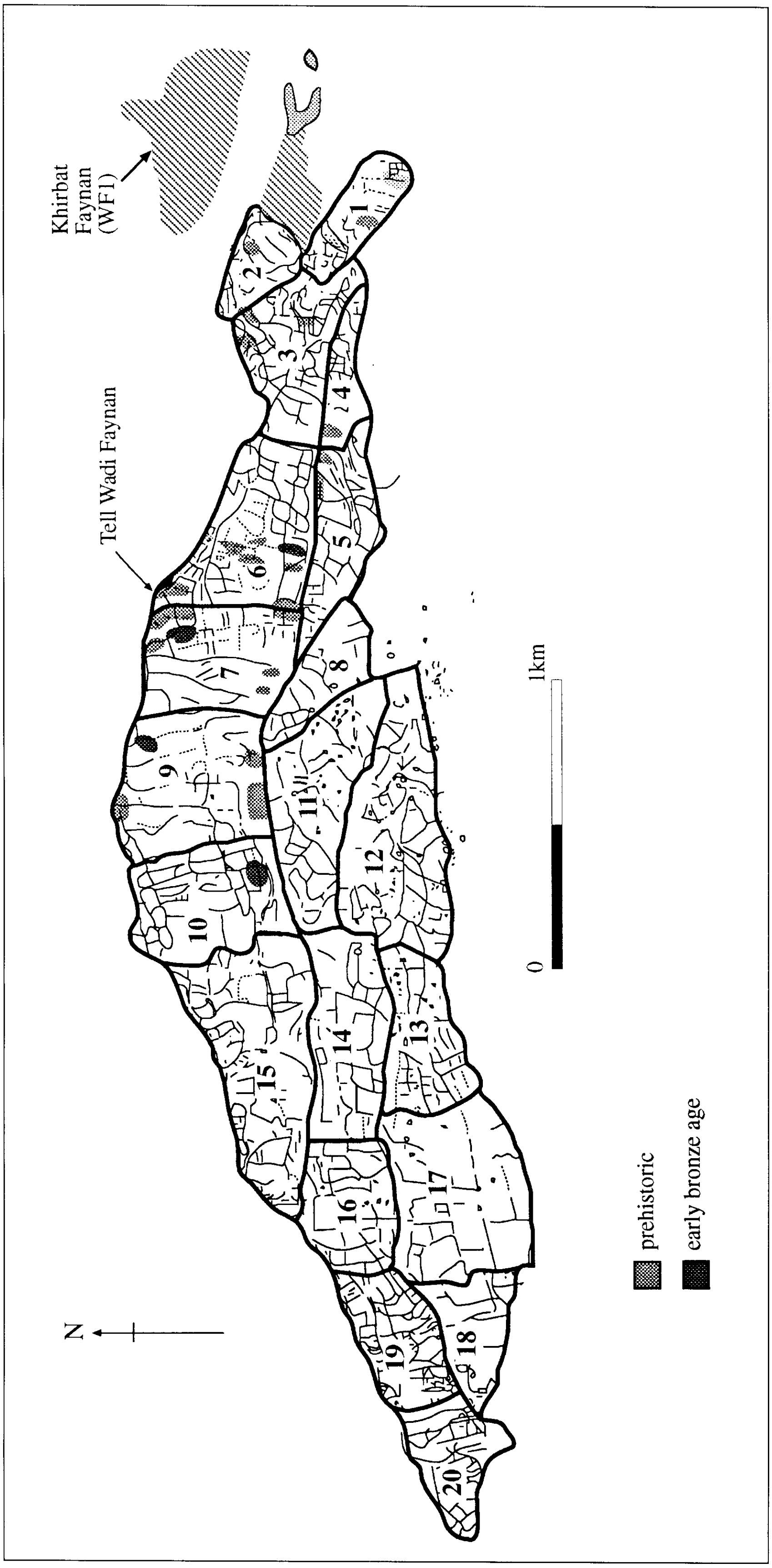

Figure 13. *Schematic map of significant concentrations of lithic artefacts noted in the 1997 field survey of units WF4.1–12. The material is divided into 'prehistoric' and 'early bronze age', the former probably dating mostly to the neolithic and chalcolithic periods.*

material on either side of the tributary wadi that forms the southern boundary of units 4.3, 4.6, 4.7, 4.9, and 4.10. Another feature of the distribution is the evidence for site or off-site activity roughly contemporaneous with the occupation of the major early bronze age settlement WF100 (Unit 4.13 in the field system divisions) being excavated by Dr Karen Wright's team. The preliminary study of the lithics collected within the field system thus indicates that this part of the Wadi Faynan was the focus of a variety of activities certainly from the Epipalaeolithic through to the later prehistoric periods (a middle palaeolithic presence is documented, but no *in situ* materials have been collected yet) and that, probably from the neolithic period onwards, both site and off-site activities extended over most of the area.

The pottery from the field system (RA)

The pottery from both the pickup and grab portions of the field survey was counted, weighed and catalogued. This pottery was then examined briefly to ascertain to what extent the material contained iron age and earlier material, and this was separated from the later Nabataean through late Islamic pottery. In 1997 the material from units 4.1-4.6 was processed – a larger finds team is anticipated for 1998. The pre-Nabataean pottery was examined for diagnostic pieces which would give an indication of a presence/absence of specific periods in the field systems.

The vast majority of all pottery in Units 4.1-4.6 is of Nabataean and later periods. In fact, the material seems to indicate a long period of use of this area, which includes all of the major post-Nabataean periods, up to the Ayyubid and Mamluk periods. Of specific interest was a single piece of green glazed Umayyad pottery, which is the first indication of this period to be found near Khirbat Faynan. Significant amounts of Nabataean pottery were evident in both the transect collections and grab samples, and included painted fine wares, with both floral and geometric motifs. The later Roman fine wares contained mould-made vessels and large amounts of rouletted and stamp-impressed pieces. By far the largest component in the later pottery was of the Byzantine period, which made up the bulk of the later assemblage.

The pre-Nabataean pottery was thinly distributed throughout the collections studied from Units 4.1 4.6 collections. No significant differences were found between the transect and grab collections. In total, some few hundred sherds of pre-Nabataean pottery were found in the collected samples, with the vast majority of this material being non-diagnostic body sherds. Separation of this material was hampered by the fact that hand-built wares occurred throughout the entire assemblage up to the present day, and on the whole the fabric of this hand-built pottery was very homogeneous, with the local sand from the region being used as temper, and being quite variable in firing (many often very poorly fired). In the absence of diagnostic aspects of the sherds, it was often impossible to ascertain with any certainty the date ranges of much of this material.

Of the diagnostic pottery of this group which was separated out, the vast majority falls into two periods chronologically: the Early Bronze Age; and the later Iron Age (probably the seventh–sixth centuries B.C.). The early bronze age material contained some of the heavily grit-tempered forms which are already well known from Site WF100, and also from Wadi Fidan 4, a settlement some 10 kilometres to the northwest. This material is most likely to be EB I in date, though this cannot be certain until further evidence is available. Alongside this pottery, however, was some later early bronze age pottery, most likely from EB III–IV, indicating continued use of the area throughout the Early Bronze Age. Comparative examples of pottery are known from the excavations at Khirbat Hamra Ifdan in the Wadi Fidan. In particular, later ledge handles and holemouth jar rims occur which are of a much finer fabric, and are potentially imports into the Faynan region. The presence of this material in areas close to Khirbat Faynan is not surprising, though, since EB II and later material is known from smelting sites on the terraces adjacent to Khirbat Faynan, and EB IV material is known from extensive cairn graves throughout the region.

Perhaps the most surprising corpus of material from Units 4.1–4.6 is the large amount of – probably – late iron age pottery. This pottery is dominated by a heavily grit-tempered fabric, with even firing. Diagnostic forms included a variety of small jar and bowl forms, as well as several rims from large storage pithoi of varied sizes (collared-rim jars). These collared-rim jars need to be studied further, in that some seem to be variant to known varieties. Two pieces of painted Edomite bowls were also found, indicating a clear dating of some of this iron age pottery.

The iron age material collected from Units 4.1–4.6 concentrated in general in the upper fields at the eastern end of the system. One possibility is that the material represents a background scatter relating to (presumed) iron age settlement at Khirbat

Faynan, but given its location in the higher terrace fields it is possible that it is indicative of remnant iron age field systems in this part of the wadi. A combination of both scenarios is probable. In either event, the presence of iron age pottery here is further confirmation of the extensive iron age occupation of the region already known from smelting sites such as Khirbat al-Nahas, which most likely relate to the establishment of the kingdom of Edom in the later Iron Age.

Palynology of the Khirbat barrage reservoir sediments: initial results (COH, HAM)

During the 1996 fieldwork a core (5017) was taken from the sediments built up against the prominent barrage that has been constructed at the northern foot of the hill on which stands Khirbat Faynan, the 'reservoir infilling' marked in Fig. 1. The barrage would have prevented any water flowing down the narrow valley on the northern side of Khirbat Faynan from egressing into the Wadi Dana, and is probably associated with the smelting activities of the site, like the huge piles of smelting debris, the reservoir and aqueduct opposite the site on the southern side of the Wadi Shayqar dated fairly securely to the Roman period. Whilst there is evidence for prehistoric settlement at Khirbat Faynan, the similarities in construction of the barrage with the walls of the main field systems, and its context within the suite of structures around the site associated with smelting and water control, suggest that it is probably Nabataean, Roman or Byzantine in date. Initial radiocarbon dates confirm this, indicating a date for the basal deposits of *c.* 2500 B.P.

An initial set of samples taken from the core was subjected to pollen analysis using standard techniques (Hunt 1985). The sediments consisted of uniform sandy silts throughout the column. The palynomorphs (pollen, spores and other microfossils) were variably preserved and often very sparse. Initial assessment using fluorescence microscopy suggests that the samples are homogeneous in origin and not vertically mixed or subject to recycling.

Biogeographical background

The past and present biogeography of the research area can be understood best using an altitudinal transect. Consultation of the literature (Bottema and Bardoukah 1979; van Zeist and Bottema 1991) and field observations suggest division into three zones.

1. Forest Zone
A zone of dry forest once covered most of the mountains on the east side of the rift above about 800 m. This zone is now mostly cultivated or heavily grazed, but on some cliffs a *remanie* vegetation of juniper and pine is present. By comparison with woodlands further north, it is probable that pine, juniper, evergreen oak, olive, pistachio and other broadleaved trees were present in this zone in the past, but were eliminated by logging, agricultural clearance and overgrazing.

2. Steppe zone
Much of the middle and lower slopes of the Jordan rift, together with alluvial fans on the rift margin, were probably forest-steppe and steppe: a predominantly herbaceous vegetation dominated by grasses, *Artemisia* and *Plantago*, with isolated *Acacia* trees on the interfluves and other tree species, especially pistachios and oleanders, along watercourses. This type of vegetation is present at the coring site today, because of the high moisture availability in the reservoir fill. The same type of vegetation, substantially degraded, is also present on alluvial fans at the rift margin, where not too heavily overgrazed, again because of water availability. Oleanders and pistachio trees are still present in some wadi floors, including the Wadi Dana.

3. Desert zone
The floor of the rift today, and probably in the past, carries a sparse flora of chenopod bushes and woody plants like crack-pine (*Ephedra*). This type of vegetation is relatively grazing-resistant and has thus spread at the expense of the steppe flora. Much of the research area can now be included in this zone, though it is not clear whether this is because of the severe effects of overgrazing, or because of aridification, or some combination of the two.

Results and interpretation

The pollen diagram (Fig. 14) can be tentatively divided into three sections. (1) The lowest section (2·3–1·3 m.) is characterized by high counts for Chenopodiaceae and Lactucae, some Poaceae, *Artemisia*, and *Plantago*, a little cereal pollen and fairly sparse tree pollen including *Pinus*, *Quercus*, *Juniperus*, *Olea*, *Acacia* and *Pistacia*. Ephedra is more common from 1·8–1·3 m. than in the lowest part of the core. Algal microfossils are present. (2) From 1·3–0·3 m., the assemblages contain virtually no tree pollen, little grass pollen and very little pollen of steppe indicators such as *Artemisia* or *Plantago*. Assemblages are dominated by Lactucae and

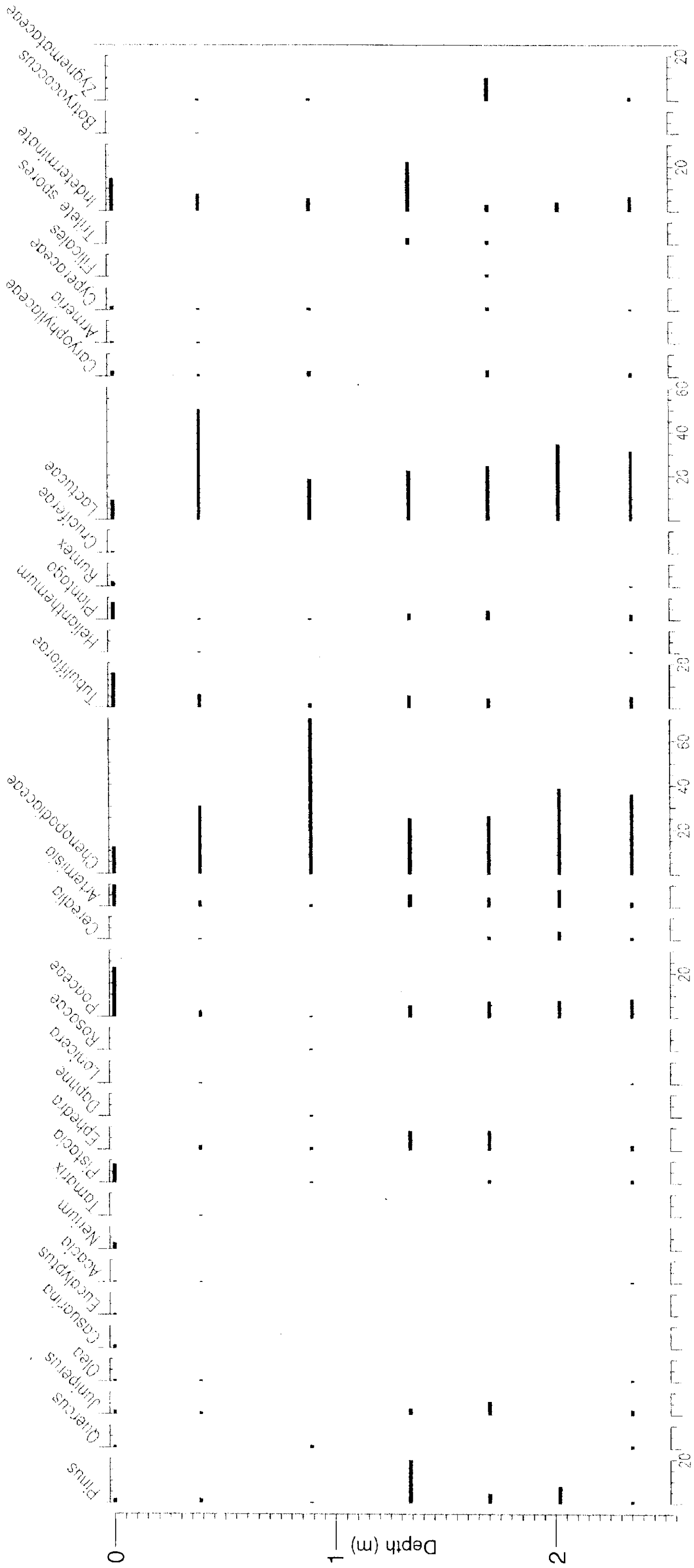

Figure 14. *Pollen diagram from sediments in the Khirbat Faynan barrage reservoir. Base of the diagram is radiocarbon-dated to c. 2500 years ago.*

Chenopodiaceae. Algal microfossils are present. (3) The surface sample shows a high count for grasses, *Plantago* and *Artemisia*, and some tree pollen, including the introduced Australian species *Eucalyptus* and *Casuarina*.

Interpretation must be tentative, because there are, as yet, few completed counts and the pollen sums are low. Nevertheless, some preliminary suggestions can be made. The lowest section of the core shows evidence for both steppic (Poaceae, *Artemisia*, *Plantago*, *Acacia*, *Pistacia*) and desert vegetation (Chenopodiaceae, *Ephedra*) near the site. The steppe vegetation was probably rather degraded, but low counts for *Acacia* and *Pistacia* (both low pollen producers) in the basal sample suggest that the demand for wood had at that stage not completely eliminated the local woody flora. The low counts for trees like pine, juniper, oak and olive are probably from trees growing on the plateau. The rise in the drought indicator *Ephedra* towards the end of this phase may point to aridification. The disappearance of cereals above 1·6 m. probably suggests the end of widespread arable farming near the Khirbat. The presence of algae such as the Zygnemataceae suggests at least seasonal standing water through this section.

The middle section, from 1·3–0·3 m., shows the appearance of a very degraded, desertic vegetation around the site. The continued presence of algal microfossils points to there still being seasonal standing water on the site. The flora shown by the surface sample is somewhat misleading, since it reflects only the fact that a steppic flora has recently established itself in the old reservoir basin, now that it is virtually full of sediment and the seasonal inundation is very short. The regional vegetation is very sparse and dominated by Chenopodiaceae.

These preliminary findings are of some importance, since they suggest that a considerable environmental change has occurred in the study area during the past 2500 years. The vegetation shortly after the commencement of filling of the reservoir was to an extent degraded, but seems to have been relatively stable for a considerable period. There is some evidence for aridification in the higher counts for *Ephedra* around 1·3–1·8 m. This is accompanied by the virtual ending of cereal cultivation and followed by a collapse of the steppic component of the local vegetation. This may have been a consequence of climate change and considerable aridification, but it might also be the consequence of a shift to pastoral agriculture as the key subsistence mode, centuries of overgrazing and the cumulative loss of soil and vegetation from the slopes around the site. The flora of this interval is analogous to the modern pollen rain in the Dead Sea (Rossignol 1969) and an assemblage from a 'medieval' (essentially either Roman or post– Roman) fill in the Wadi Kafrain, just north of the Dead Sea, reported by Vita-Finzi and Dimbleby (1971). Further research is needed to clarify the cause of this environmental change.

Discussion and conclusion (GWB, DJM)

The 1997 fieldwork has added considerable detail to the preliminary sequence of landscape development outlined in the team's first report (Barker *et al.* 1997), and over half of the major field system (WF4) has now been recorded in terms of wall layout and construction, hydrological characteristics, and surface archaeology.

The geomorphological fieldwork has provided further understanding of the sedimentary fills of the survey area, and underlined the likely importance of tectonic activity as a controlling environmental process. Human populations exploiting the Wadi Faynan system have had to adapt to the fact that closely adjacent wadis could be accumulating or discharging material at different rates.

The lithic artefacts collected within the field system indicate that the locality was visited by prehistoric people certainly from the epipalaeolithic period 10,000 years ago through to the later prehistoric periods. Preliminary survey by Dr Mithen's team in 1996 indicates that the foci of settlement for epipalaeolithic groups at the threshold of agriculture were the springs in the upper sections of the Wadis Ghuwayr and Dana. By the eighth millennium B.C. the Wadi Ghuwayr spring was the base for a fully fledged agricultural community ('Wadi Ghuwayr 1': Simmons and Najjar 1996); the location is typical of many early farming sites in the Near East – presumably because the spring provided naturally-irrigated land for cereal fields and animal pasture (Bar-Yosef 1995). By the sixth and fifth millennia B.C., however, there was a later neolithic and chalcolithic settlement about a kilometre west of the Dana-Ghuwayr confluence at Tell Wadi Faynan (Najjar *et al.* 1990). This settlement was situated within what we have defined as the Faynan Beds, and as we reported last year, our geomorphological investigations indicate that this settlement was located in a relatively rich and diverse aquatic landscape that was very different from the modern desertic landscape – there was a more or less perennial stream by the site, and the likelihood is that farmers were able to grow their crops beside it much like the first farmers had been doing at the Wadi Ghuwayr spring. Whilst the interpretation of our distributions of surface lithic material is problematical given the high-energy depositional environments in which they are located, the concentrations of material around Tell Wadi Faynan and along the main tributary wadi to the south that runs parallel with the main wadi (Fig. 13) suggest that neolithic and chalcolithic farmers practised off-site activities such as pastoralism and hunting around their settlements on the wadi floor as well as growing their crops by the watercourses.

In the last report we suggested that a series of circular depressions on the edge of the WF4 field system might be primitive water catchment structures of chalcolithic/early bronze age date (Barker *et al.* 1997, 35-36). These structures are mainly located just within or just outside WF4.8, WF4.11 and WF4.12, in an area of cairns and simple terrace walls, the latter especially on the upper slopes outside the main field system. The pottery from this part of the survey area was not examined in 1997, so the field systems here are not being discussed in this report, but the indications are that the complex of circular catchments, cairns and terrace walls is associated with late prehistoric pottery and lithics. These structures bear resemblances to the microcatchment water-control systems and simple terrace walls found by Levy at Shiqmim in the Negev (Levy 1987). Whilst at this stage we can only offer a very tentative interpretation of the Wadi Faynan evidence, our hypothesis is that the social transformations of the chalcolithic period were associated not only with the systematic exploitation of copper ores but also with new systems of land use characterized by the deliberate management and storage of surface floodwaters. Although the regional climatic evidence for this period of the Holocene is partial, and sometimes mutually incompatible, the consensus is that significant aridity was developing by 5000–3500 B.C.; chalcolithic floodwater farming was presumably developed in response to this, though in the context of the new social structures.

Although the field-walking suggests that the principal use of the WF4 field system was in the Nabataean and Roman periods, there is increasing evidence for variability within the system. The upper slopes formed by the Shayqar Beds were exploited by major diversion walls in Unit 4.4 and Unit 4.5 that captured the floodwater at its egress from the hills, carried it westwards at the major break of slope, and filtered it through the walls at controlled points (simple sluices and slipways) down to the terraced fields below. Alternatively, in Unit 4.3, the water was diverted down a channel formed by two parallel walls which fed the fields on either side. The latter system was also used in the lower fields situated on the more gradual slopes formed by the Faynan Beds and Dana Beds. Unit 4.2 appears to have been designed especially to 're-cycle' water from the Roman mill.

The 1997 fieldwork also produced several indicators of development and change in the field system. The uppermost fields of Units 4.3 and 4.4 today are on either side of a deeply-cut wadi (F/G in Figure 4), but their alignments suggest that they were laid out at first as single fields – presumably most water was being diverted westwards down the outer wall of Unit 4.4. Then, as the wadi started to cut down, attempts were made to keep the water within the fields and prevent it from flowing down into the channel by constructing substantial walls along its edge; furthermore, one of these produced clear evidence for enlargement and reinforcement in a second phase of construction (WF239). In Unit 4.5 (Fig. 9), the wadi that is diverted westwards at point N by the outer wall of the unit cuts through – and thus renders ineffective – the parallel channel WF288 constructed to divert water into the lower part of the unit from the wadi at the northern boundary, from point O, so it seems highly unlikely that the upper diversion wall (and its terrace system) and the lower parallel-wall system WF288 (and the system of fields it feeds) were contemporary. A decorated Roman sherd from sediment under one of the walls of the parallel-wall system WF288 at the point where the upper wadi cuts through it (WF259) provides a possible *terminus post quem* for the lower diversion system. In addition to the surprising evidence of the field-walking for the frequency of late iron age pottery in the upper fields, Nabataean pottery and slag were found in the fill of one of the upper terrace walls of Unit 4.3.

The indications so far, therefore, are that the first major phase of extensive floodwater farming concentrated on simple diversion barrages and terracing on the upper slopes and that it probably dates at least to the Nabataean period and may be earlier still. There are many similarities with the floodwater diversion systems recorded by Evenari *et al.* (1971) in the Negev. As wadi down-cutting made these systems less effective, efforts concentrated increasingly (in the Roman period?) on capturing the water at lower elevations and spreading it across the lower slopes by means of parallel-wall channels. Evidence for the latest phase of wall-building may be represented by the fragments of walls that survive on the lower terrace of Unit 4.3, the Dana Beds, which seem to have been forming from the Roman period onwards on the evidence of the association of the Roman aqueduct with a sand facies of this unit (Barker *et al.* 1997, 27).

The beginning of the major phase of wall building is probably more or less contemporary with the beginning of sedimentary accumulation behind the barrage at Khirbat Faynan *c.* 2500 B.P. The preliminary pollen analysis from these sediments indicates a relatively stable steppic landscape for a considerable period, followed by a much more desertic landscape in which cereal cultivation was minimal. 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.

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