best understood at present is the impact of past metaliferous mining, where both primary waste materials and slags can be seen to have covered large areas of the landscape and to have entered into the river systems, where they now produce distinctive copper-rich terrace gravels. The primary constraints on progress are the absence of reliable knowledge of the antiquity of the deposits present and the absence of similar studies from adjacent areas with which comparisons can be drawn. Future fieldwork must widen the focus of study to establish whether or not the sequence established this year holds true further afield, and seek to establish an independent absolute chronology for the regional picture that emerges.

Our preliminary study of the nature and distribution of the Quaternary deposits present in the Wadi Faynan and its tributaries has revealed a complex history of events from c.150,000 years ago to the present, embracing environmental changes of great magnitude, and our study of the archaeology of the field system, along with the investigations of other archaeological teams, indicates the potential of the study area to yield an equally complex history of settlement and land use.

In the Late Pleistocene a period of erosion in the mountains and deposition at lower elevations led to the accumulation of alluvial fans and fluvial deposits nearly forty metres thick (which we have termed the Ghuwayr Beds) and at a later date by further fluvial deposits (the Shayqar Beds). The evidence for human occupation at this time recovered by the team consists of sporadic chipped stone artefacts, mostly of middle palaeolithic type, found within and on top of these two sets of deposits. However, reconnaissance survey in April 1996 by Bill Finlayson and Steve Mithen immediately prior to our own campaign discovered an epipalaeolithic (final palaeolithic) site (WF16) consisting of flints, quernstones and other groundstone artefacts on the interfluve between the Wadis Ghuwayr and Shayqar, possibly associated with circular and semi-circular platforms, and other smaller collections halfway up the Wadi Dana and on the plateau edge (Finlayson and Mithen 1996). The Epipalaeolithic in the Near East

Figure 12. Looking northeast towards the herring-bone fields in WF4.3, trapping overland water and gully flow and leading this water into the fields below. (Photograph: G. Barker).
is of course of critical interest as a key transitional stage to the emergence of agricultural communities, being characterized by social elaboration, the specialized exploitation of plant foods and herd animals, and a degree of sedentism especially at lower elevations, with upland sites usually interpreted as task-specific sites related to residential sites in the lowlands (Henry 1989; Kaufman 1992; Valla 1995).

Whilst detailed information on the nature of epipaleolithic settlement in the study area will only come from the detailed investigation of these sites that is planned, it is clear that a fully-fledged agricultural community was established here early in the Holocene, probably by the eighth millennium B.C. ‘Wadi Ghuyayr I’, the PPN site being excavated by the Jordanian Department of Antiquities, is of a date range similar to the well known village of Beidha a few hours walk away on the plateau near Petra (Kirkbride 1966), and has a similar range of structures and artefacts. The settlement was located at the point where the Wadi Ghuyayr egresses from a narrow defile to form a significant floodplain a kilometre up-wadi from the Khirbat Faynan confluence (Fig. 4), immediately by the spring that now irrigates the market gardens of the Faynan. Whilst the botanical and faunal data from the site are currently under study, the spring-side location is typical of many early farming settlements in the Near East, suggesting a reliance on naturally-irrigated land for crop farming and animal grazing (Bar-Yosef 1995).

Through the Holocene, the environment of the study area has been dominated by a series of mainly fluvial events: rivers have incised their floors, eroding the Ghuyayr and Shuygar Beds, as well as other pre-existing surficial deposits and bedrocks. Traces of these rivers exist up-wadi, in the form of terrace deposits of sediments and erosion surfaces, sometimes displaying significant cementation and calcitization, whilst in the confluence area, distinctive layers of fluvially-deposited boulders and gravels were laid down. The discovery within the Upper Faynan Beds of the presence of a more-or-less perennial stream adjacent to Tell Wadi Faynan, and associated with the site’s occupation in the sixth and fifth millennia B.C., presents a strikingly different picture from today, of a relatively rich and diverse aquatic landscape. Interestingly, the pottery and mortar from the site contained a mixture of reeds and grass as well as straw (Najjar et al. 1990, 41).

The excavations at Tell Wadi Faynan found traces of simple rectangular dry-stone buildings associated with storage pits, sickle blades, carbonized cereals and a faunal sample dominated by the bones of sheep or goat. We found traces of what may be a boulder wall in the river section fifty metres or so.
east of the settlement, within the same sedimentary horizon as the Tell Wadi Faynan settlement, so an important question to try to resolve in future years will be whether this community was growing its crops on moist backswamp soils, as Sherratt (1980) for example has argued for neolithic settlements in basin-edge locations such as Çatal Hüyük in Turkey and Nea Nikomedia in Greece, or whether people in the Wadi Faynan were now beginning to experiment with systems of floodwater farming using primitive diversion walls.

By the later fifth millennium B.C. the Tell Wadi Faynan community was extracting malachite copper ore on a small scale from the local sandstones, and smelting it on site, creating quantities of iron-silicate slag (Najjar et al. 1990). This development accords with the evidence from the region as a whole, that the systematic exploitation of copper ores began in the Chalcolithic and then greatly expanded in the third millennium B.C. during the Early Bronze Age, accompanied by technological improvements allowing the large-scale use of low grade ores (Adams 1991; Adams and Genz 1995; Hauptmann 1989 and 1992; Hauptmann et al. 1992; Rothenberg 1972). The social and economic context of these transformations, for example the nature of the control of the ores and of the trade in their products, and of the impact of the expansion of copper mining on local economic and social organization, are much debated (Finkelstein 1995; Joffe 1993), and form the principal research focus for Dr Wright’s investigation of site WF100.

Whilst her initial fieldwork at the site is being reported separately, the principal result was an appreciation of the remarkable size of the settlement: the boundary walls of WF4.13 measure approximately 400 by 200 metres, and the area within is carpeted with chalcolithic and early bronze age pottery, together with other diagnostic artefacts of the periods such as ‘Canaanite’ blades and fragments of basalt bowls. Some of the enclosure walls are certainly later, presumably of Nabataean/Roman/Byzantine date, but others, including sections with turret- or bastion-like structures attached to them somewhat akin to the towers at contemporary settlements such as Arad (Amiran et al. 1978), may also be associated with the early bronze age settlement. As noted earlier, habitation traces of

Figure 14. The water catchment structure WF24, on the basis of surface material likely to be of chalcolithic and/or early bronze age date. (Photograph: G. Barker)
these critical periods were also noted elsewhere within the field system.

Whilst our understanding of the land use systems that supported the chalcolithic and bronze age settlement transformations in the study area will certainly require excavation of sites such as WF100, it is noteworthy that our survey identified a series of circular or oval silt-filled structures on the low-angle fans along the southern edge of the floodplain that may have been used for water catchment and/or storage at this time. WF24, for example, located within WF4.11, consisted of a circular depression some fifteen metres in diameter bordered by a rough dry-stone wall (Fig. 14). Immediately to its south, upslope, was a single boulder wall (5059) constructed along the slope to lead any surface runoff into a small (three by two metre) rectangular structure (5059) and thence into the main catchment. The pottery around these structures was entirely hand-made, the shapes and decoration broadly indicative of a chalcolithic/early bronze age date, and was associated with other typical finds such as the fragment of a pierced stone weight, a tabular flint scraper, a sickle blade and borers. The silts were cored, and are currently being analyzed. Other similar catchments were noted to the south of WF4.8 (WF39) and of WF4.18 (WF40). Although direct information regarding chalcolithic and early bronze age cultivation systems in the region is still extremely poor, there are some archaeological indications from the Negev that the settlement transformations at this time were associated with the development of simple floodwater farming systems (Cohen and Dever 1980, 42; Levy 1995, 230), and the thesis is supported now by phytolith evidence in cereal crops (Rosen 1992).

Our initial study of the field system has demonstrated the likely longevity and complexity of its history, with indications of piecemeal development of the main suite of walls. This hypothesis is supported by the occurrence of a number of Nabataean–Roman farmsteads on the slopes immediately south of the field system (such as WF35 and WF36), and burial cairns of similar ages around these farms and within the enclosed areas, and also by the variability in the distributions of Nabataean, Roman and Byzantine pottery indicated by our initial studies of the abundant surface material. The fact that water catchment was only one element in the system also emphasizes the fact that we are not dealing with a unitary system laid out to some grand design, as does the relationship of the field system to the Dana Beds, which in part seem to be contemporary with the construction and use of fields (as with the con-
struction of the aqueduct) but elsewhere clearly post-date them. Evidence for re-plastering the conduits to the Khirbat Faynan water mill, with the upper level consisting of an *opus signinum* and the lower level of a coarse lime plaster, and of re-plastering the inlet conduit to the reservoir, is another indicator of the likelihood of a development sequence of water management associated with the field system (Appendix).

In this respect, it is noteworthy that the scale of mining activity in the Wadi Faynan through the Nabataean, Roman and Byzantine periods also seems to have been highly variable through time: charcoal analysis from the major smelting site of Khirbat an-Nahas indicated that in the earlier centuries of the first millennium B.C. the activity was relatively small scale, with little impact on the environment – people were able to gather sufficient fuel wood for the smelting within walking distance of the site without significant damage to the local ecology (Engel 1993). The Roman period, however, was characterized by a massive expansion in exploitation (Hauptmann 1992). It is hoped that the samples taken from the sedimentary sequences examined by the project's geomorphologists will provide a further indicator of the changing scales of land use and mining activity through these periods. Certainly the use of the field system seems to have been associated with the widespread deposition of loamy deposits by wind and water, whilst its eventual abandonment may in part be related to the lowering of the water table as the river incised itself into the wadi floor after the deposition of the Dana Beds.

Beyond the field system, it is clear from the little reconnaissance survey that we undertook, for example on the upper slopes on either side of the Wadi Shayqar, that there is a rich suite of archaeological remains including lithic scatters, terrace walls, domestic structures and graves, as well as numerous examples of boulders decorated with pictographs with human, animal and abstract motifs. A number of structures containing a room or rooms and a pen or enclosure were located, some with Roman and Byzantine pottery, others clearly very recent in date, and we also found a number of tent footings of (recently?) abandoned Bedouin camps. Classifying

![Figure 16. A modern irrigation reservoir in the Wadi Faynan. The water is piped down from the Wadi Ghuwayr spring (on the right, at the foot of the hills in the distance) into such reservoirs, and then pumped onto the surrounding fields. (Photograph: G. Barker).](image-url)
and dating this archaeology is likely to be extremely difficult, but the potential clearly exists in the archaeology 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 by the Wadi Ghuwayr spring to the present day.

The recent introduction of irrigated agriculture for water-dependent crops such as tomatoes, water melons, courgettes and cucumbers poses a very real threat to the remarkable archaeological landscapes of the Wadi Faynan. At the present moment there are thirteen water reservoirs in use or near completion (almost all built in the past two years), and the cultivated area covers about a third of the field system (Figs. 15 and 16). The area taken back into cultivation is thus growing rapidly, sometimes preceded by the destruction of the extant ancient walls and other structures, sometimes by bulldozing simply the surface material. Even ploughing of the fields has an impact on the archaeology, however, remixing and reburying the surface artefacts. It is clear that within a few more years there will have been a significant loss of information on the ancient settlement and farming systems of the Wadi Faynan. For this reason, the intensive field-walking and structural survey of the field system area have to be the main priority for future work, with the study of the abundant archaeological remains outside the system - themselves also under threat especially from tomb robbing - the second urgent priority.

Whilst the problems of modern destruction are profound, the scale of the archaeological record immense, and chronological resolution likely to be especially daunting, there is every reason to expect that the continuation of a carefully integrated programme of geo-archaeological fieldwork in the Wadi Faynan will provide a complex and detailed landscape history that will add considerably to our understanding of the human history of Jordan and of the region as a whole.

Appendix: mortar/plaster samples from the Wadi Faynan (GCM)

Samples of mortar/plaster were collected in 1995 from three locations in the Wadi Faynan: the inlet channel into the water mill (sample A1, upper; sample A2, lower); the outlet channel from the reservoir (B); and the inlet channel to the reservoir (C). The samples were analyzed microscopically and chemically to determine their structure and composition. They were all lime-based, with varying aggregates, and can be described as follows:

A1. Pink fired clay and lime plaster, 7–10 millimetres, over A2, a flat coarse white lime plaster with gravel and traces of grass or straw and chalk or lime lumps, 22 millimetres thick. The flat interface suggests that the pink plaster is a secondary phase. The fired clay is probably crushed tile, brick, or pottery.

B. Coarse white lime mortar with gravel and charcoal, about 28 millimetres thick.

C. Roughly faced white lime mortar or plaster, 22 millimetres thick, with gravel, chalk, charcoal, and traces of an over-layer of crushed tile (?) plaster.

Chemical separation with dilute hydrochloric acid left residues which were identified and graded. They were composed of basalt-type rocks with quartzite, quartz, sandstone and some flint or chert. Sample A1 had an upper layer composed almost entirely of crushed ceramic material with some quartz sand which may also have come from the ceramic. The charcoal was probably a lime-burning residue. The table below summarizes the particle size distribution analysis.

### Table 2. Wadi Faynan mortar/plaster samples: particle size distribution analysis.

<table>
<thead>
<tr>
<th>Sample</th>
<th>'gravel'</th>
<th>'sand'</th>
<th>'silt'</th>
<th>soluble % comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;2 mm.</td>
<td>&lt;0.15-2 mm.</td>
<td>&lt;0.015 mm.</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>3</td>
<td>63</td>
<td>34</td>
<td>69 upper, brick/tile lower</td>
</tr>
<tr>
<td>A2</td>
<td>83</td>
<td>12</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>B</td>
<td>67</td>
<td>25</td>
<td>8</td>
<td>43</td>
</tr>
<tr>
<td>C</td>
<td>55</td>
<td>30</td>
<td>15</td>
<td>48</td>
</tr>
</tbody>
</table>

The soluble value approximates to the lime content, but here it may be slightly high due to the presence of chalk or limestone, although this may in fact be unburnt lime.

The results show that the coarse mortar layers are fairly similar in composition, although the particle size grades are not. This may be partly due to the very small sample size and numbers. The very high lime content for the ceramic-based material is of interest, though. It does appear to be very similar to classic Roman *opus signinum* brick- or tile-based mortar used for water-resisting structures. This also had a higher lime content than ordinary mortars and plasters.

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Bibliography


