REPORT ON THE FIRST SEASON OF THE BARQĀ LANDSCAPE SURVEY, SOUTH-WEST JORDAN

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The Barqā Landscape Survey, directed by Russell Adams (McMaster University, Canada) and co-directed by James Anderson (North Island College, Canada), undertook an archaeological survey of the Barqā Region of Faynān District, between 1 and 28 July 2009. The project was supported by a grant from the Social Sciences and Humanities Research Council of Canada, sponsored by McMaster University and affiliated with the Council for British Research in the Levant (CBRL).

Context of the Research

Over the last decade significant progress has been made in understanding the development and spread of early copper technology in ancient Western Asia. A major centre of this research has been in the Faynān region of southern Jordan, the oldest and largest industrial landscape of the ancient world. At Faynān a number of researchers have been actively investigating the technological development of metallurgy and the implications of these developments upon social evolution during later prehistory. The technological investigation into early mining and smelting was begun by Hauptmann, whose Early Metallurgy Project (1985-1993) formed the basis for subsequent investigations (Hauptmann 2000, 2007). The archaeological investigations of early metallurgical production sites was pioneered by Adams, first as the focus of a PhD thesis (1989-1993) (Adams 1999) and later expanded by the applicant as a collaborative project (1997-2002) (Levy and Adams *et al*. 2001).

To date these archaeological investigations have resulted in a small-scale survey focused upon the Wādī Fīdān drainage and extensive excavation of two major and highly visible sites in the same *wadi*. The first site dates to the developmental phase of metallurgy in the mid-fourth millennium BC (3600-3300 BC), and the second is a large production centre dating to the mid-third millennium BC (2600-2300 BC). The cumulative result of these investigations has been the development of a sequence for the evolution of early metallurgy spanning this period, which suggests a change from small-scale, village-level production (Adams and Genz 1995; Adams 1999), to highly-developed, large-scale, intensive production by the end of this period (Adams 1999, 2002; Levy and Adams *et al*. 2002). Intensive 'industrialized' production emerged at the beginning of the third millennium BC (*ca*. 2900 BC), at a time when other social changes were occurring in the Levant. Previous scholarship has noted a significant increase in the appearance of copper products at this time throughout the eastern Mediterranean, but recent work at Faynān in Jordan provides the first evidence of these processes from the perspective of the copper production sites (Adams 1999, 2002, 2003). At Faynān, the details from the excavations at these two sites have provided answers to many technical questions regarding copper production including the *chaine opératoire* and the social use of space within these sites, but they still remain isolated sites within the wider region. The relationship of these sites to other local copper production centers and the overall scale and intensity of metal production remains poorly understood.

Despite the quality of the archaeological evidence from the limited excavations in the Faynān region to date, significant underlying questions remain about the organization, scale and intensity of production of copper during the third millennium BC. The overall scale of these activities is hinted at by the preliminary results of the ancient mining surveys undertaken by Hauptmann (2000, 2007) which revealed extensive mining in the Faynān region during the third millennium BC. There is also evidence of slag deposits throughout the landscape in various locations, at several of the dedicated primary smelting sites that have been investigated at Khirbat Faynān and elsewhere in the region (Hauptmann 2000, 2007). To date, however, we lack a robust quantitative analysis of data which will allow us to determine the overall scale and distribution of production activities during the third millennium BC.

The best preserved and last remaining prehistoric landscape in the Faynān region lies to the south of the Wādī Faynān, in the region of Barqā, an area of approximately 100 square kilometers, along the edge of the 'Arabah rift valley. During the early 1990s Hauptmann's 'Early Metallurgy Project' conducted limited excavations in the Barqā region at the site of Barqā al-Hatiye (another highly visible site). Exposure there of a well preserved building, radiocarbon dated to the earliest phase of intensification of copper production (2900-2700 BC), suggests that the Barqā region will provide further evidence of this transitional phase of copper production (Fritz 1994a, 1994b; Adams 1999, 2003). The results of a very limited and undocumented reconnaissance revealed that the surrounding landscape was densely populated during the third millennium BC and contained numerous structures and features with archaeological finds similar to those found at the third millennium BC site at Khirbat Ḥamrat Ifdān, the largest and best preserved copper production centre in the Old World (Levy and Adams *et al.* 2002). This reconnaissance suggests that numerous metal processing activities took place in the Barqā region at this time, as evidenced by visible building remains, slags and extensive metallurgical production waste. The Barqā region is therefore a key zone for the understanding of copper production at Faynān, and may provide important data towards understanding the context of the intensification of copper production during the third millennium BC.

Theoretical Overview

To date there has been an overemphasis upon looking at the adoption and early spread of metals in society from the consumption end of the metallurgical cycle, largely through metal objects derived from 'elite' burials. The recent research at Faynān described above has begun to redress this imbalance, with research efforts focused upon the technological advances and intensification of copper production during the third millennium BC — a pivotal time in the advancement of both complexity in the region and in the adoption and spread of metallurgy. A great deal has been learned from surveys of mines, analysis of ancient smelting furnaces and associated ores and slags, and from limited excavations of large visible sites related to copper production. We have been able to 'fingerprint' the ores of the region through isotopic analysis and have begun to trace both copper ores and metal throughout the region and to understand the complex trading networks which developed to distribute these metals (Hauptmann 2000, 2007; Adams 2006). On the basis of this evidence it has been possible for the first time to develop a model for this phase of expansion of copper production, from the copper production zone, and to delineate specific changes in social processes and technologies that accompanied this expansion in the use of metals (Adams 1999, 2002). However, our model building is at best only preliminary, since most evidence to date has come from a limited number of large sites: These isolated excavations provide only a snapshot of events and processes without enough contextual evidence to prove that they are representative of copper production sites and activities across the Faynān landscape during the third millennium BC.

The evidence to date from excavated sites suggests that copper producing activities which had remained small-scale / low intensity operations throughout the fourth millennium BC suddenly and very rapidly changed during the early third millennium BC to large scale / high-intensity operations conducted by specialists. One possible reason for these changes and the resulting re-organization of production activities and scales of production may have been the increasing consumption of copper by emerging elites. Possible models for production range from some form of a hierarchical organization of production such as attached specialization (Costin 1991; Adams 1999, 2002) at one end of the spectrum to a heterarchical organization at the other (Crumley *et al*. 1995). To date, without the evidence that is available from the less visible sites in the region, the data are insufficient to fully support either of these models. In order to build up an accurate picture of these social and technological changes it is important to have a broad sample of data from production, habitation and other types of sites. The ability to provide this contextual background relies upon the collection of less visible and less easily accessible evidence in the landscape. Therefore, in order to advance our understanding of this phase of metallurgical development it is imperative to be able to understand the distribution of and relationship between all types and sizes of sites related to production and related activities across the landscape. The Barqā Landscape Survey (BLS) has been designed to fill this gap in our knowledge through investigation of the archaeological and environmental evidence for intensification of copper production across the broader landscape.

Objectives

To date, investigation of early metallurgy at Faynān has concentrated on mining and smelting sites (Hauptmann 2000, 2007) and upon limited evidence from only a few large and *highly visible sites* (Adams 1999, 2000, 2002, 2003; Levy and Adams *et al*. 2002). The Barqā Landscape Survey seeks to expand our understanding of the scale and intensity of copper production by documenting the *environmental impact* of copper production in the wider region from a variety of natural and archaeological contexts (cf. Grattan *et al*. 2003a, 2004, 2005, 2007). Our intention is to move the common research paradigm away from hypotheses which focus on site-based problems and solutions, and instead encourage hypotheses which explore critical aspects of human development which can be enlightened by a landscape-based approach (Wilkinson 2003).

Theoretical models for intensification and changes in the technology of copper production suggest that the processes which are observable in the larger production sites should be discernible in the wider landscape, with a number of production centers of similar (or differing) types (Adams 1999, 2002). The Barqā Landscape Survey seeks to test this model of intensification of production through an analysis of the less archaeologically visible production sites in the region, and to identify the nature and distribution of these sites in the landscape.

In order to arrive at a quantitative means of assessing the scale and intensity of copper production, it is essential to use a method which can provide numerous and demonstrable results of copper smelting and production activities. Archaeological survey and excavation alone is not enough to do this in a cost-effective way over a large area. We therefore propose to undertake an assessment of environmental pollution in areas which we can determine to be of the correct chronological time frame. The degree of pollution, as determined by sampling across the region, can be used to establish the scale and intensity of copper production.

Using a combination of archaeological survey, space-borne multi-spectral analysis, sampling excavations and geochemical mapping we are examining this early industrialization from the production residues and palaeoecological materials preserved across and within the ancient landscape. The geochemical analysis of dated contexts will inform us about the ore bodies being exploited at different periods, the efficiency of the smelting process and the impact of these activities on the environment. These chemical fingerprints will enable us to identify the magnitude and intensity of these activities at different periods and the organization of the landscape in support of them.

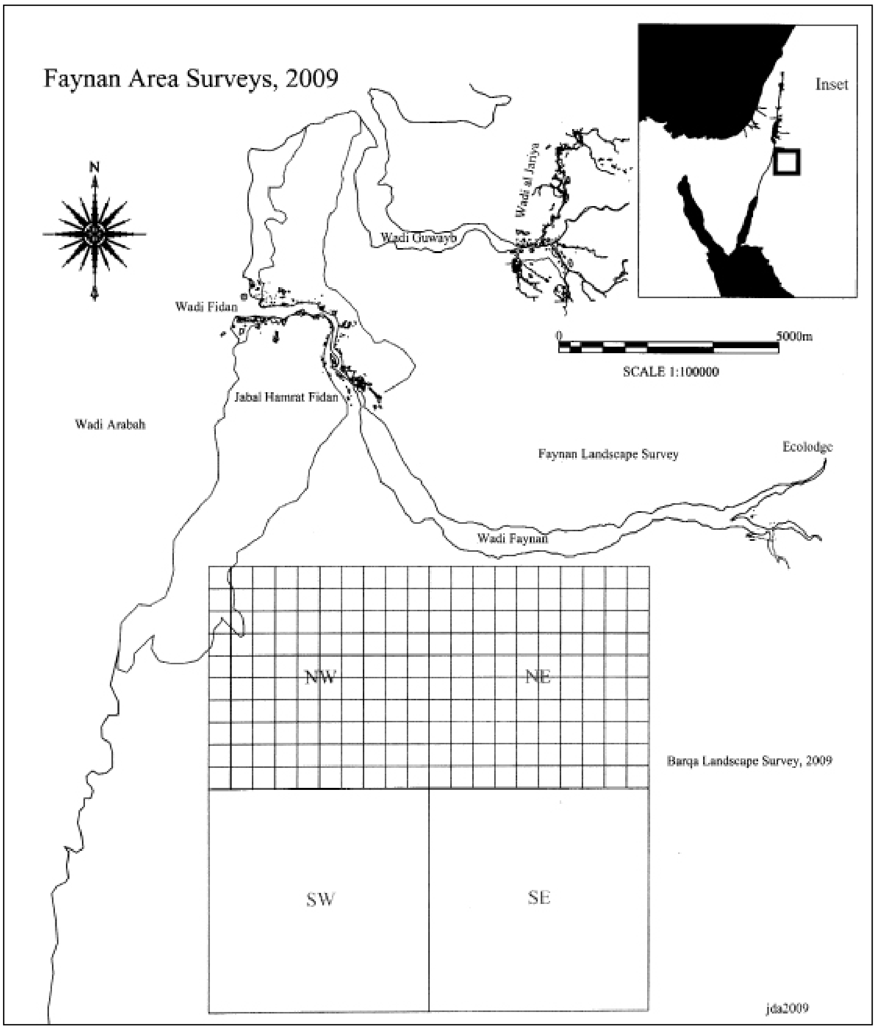
Similar research already has been undertaken successfully in the eastern Faynān basin (adjacent to the Barqā region), in order to explore and document the impact of Imperial Roman mining and smelting activities (Grattan *et al*. 2003b; Hunt *et al*. 2004; McClaren *et al*. 2004; Pyatt and Grattan 2002a, 2002b, 2005; Pyatt *et al*. 2000). This prior research has allowed us to develop techniques and methods with which to look at the prehistoric landscape in similar detail, and with equal success.

The copper ores of the Faynān region are infused with lead — which is unusual — and, as a result, pollution and health problems stem from the release of lead and other associated suites of very dangerous metals (beryllium, cadmium, chromium, arsenic, nickel, mercury) whilst smelting copper. The Faynān evidence indicates that these metals accumulate and stay in biological systems causing substantial health problems. To date, geochemical analyses of Holocene sequences in this region suggest a model of increasing environmental degradation from the third millennium BC onwards. Through extensive sampling of a variety of sites and geographic locations identified through the survey and excavations, this project seeks to identify correlations between areas of maximum pollution intensity, metal extraction and smelting, and settlement and industrial patterns. This evidence is important in understanding the patterns of human activity, industry and natural processes in this region over the span of the third millennium BC, and is equally important in understanding continuing problems of environmental pollution up to the present time (Grattan 2003; Grattan *et al*. 2003a, 2005; Pyatt and Grattan 2005).

Geographical Context of the Barqā Landscape Survey and Survey methodology

The Barqā Landscape survey is orientated cardinally (True North) and has the following coordinates (WGS84 spheroid): NW corner: N 3389910.253 E 726438.631; NE corner: N 3389910.253 E 736438.454; SE corner: N 3379910.253 E 736438.454; SW corner: N 3379910.253 E 726438.454. The survey area comprises 100 square kilometers, divided into four quadrants (**Fig. 1**).

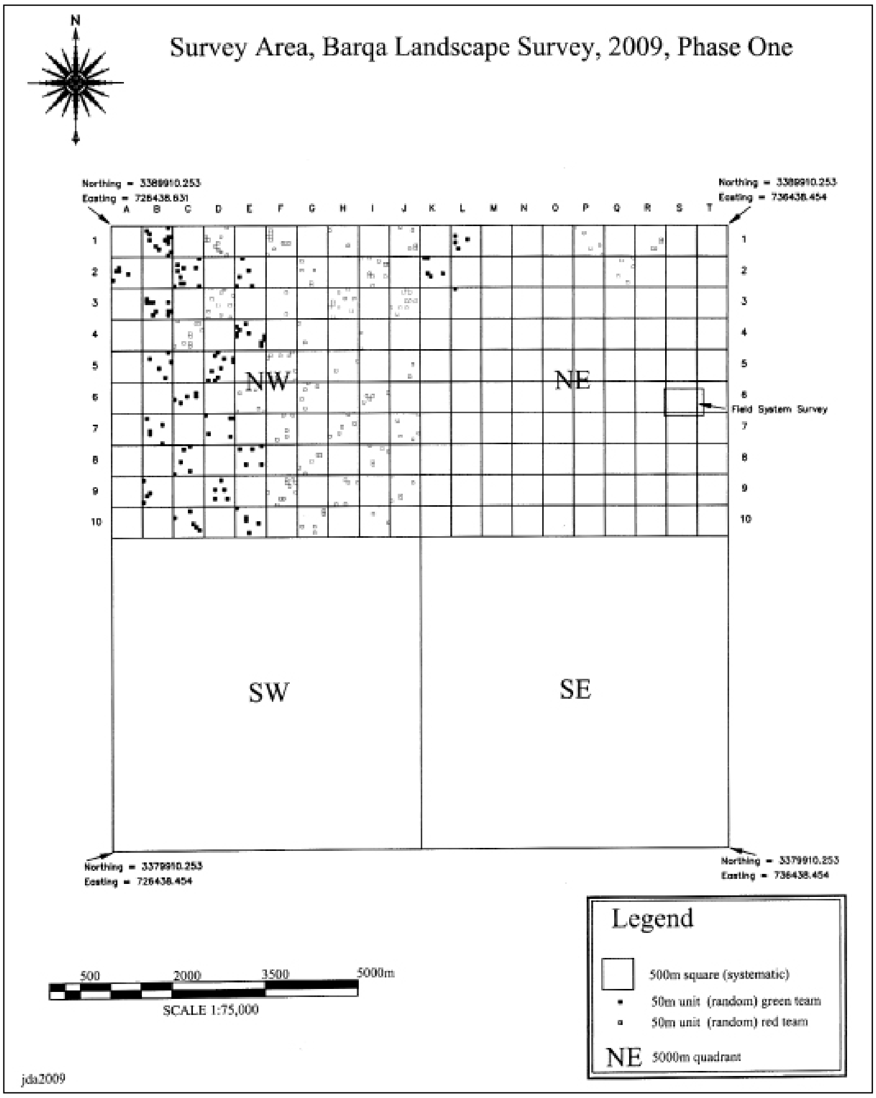
An initial control survey was conducted in the NW quadrant to establish highly accurate fixed points across that quadrant of the Barqā Landscape Survey area, against which to spatially reference the archaeological data that would be collected in subsequent phases. The co-ordinates of the first fixed point of the control survey were established with known points



1. Faynān area surveys 2009.

in Google Earth. The corners of four houses in the southernmost area of the town of Qurayqira were given placemarks with geodetic coordinates, and then saved in a kml file. These were then converted into Cartesian co-ordinates and entered into a data collector. Having found the four houses on the ground with the Magellan hand-held GPS, we conducted a four point resection with the total station of the house corners to establish the first control monument, RB 51, in three dimensional space. From RB51, RB 52 on the top of a nearby *jabal* was tied in with the total station. RB54 was then tied in from RB52, and so on until we reached RB63. From there we tied in our original station RB51, and compared the starting and terminal coordinates. As the relative precision of 1:11,000 was acceptable, we then adjusted the survey control net through a compass rule adjustment.

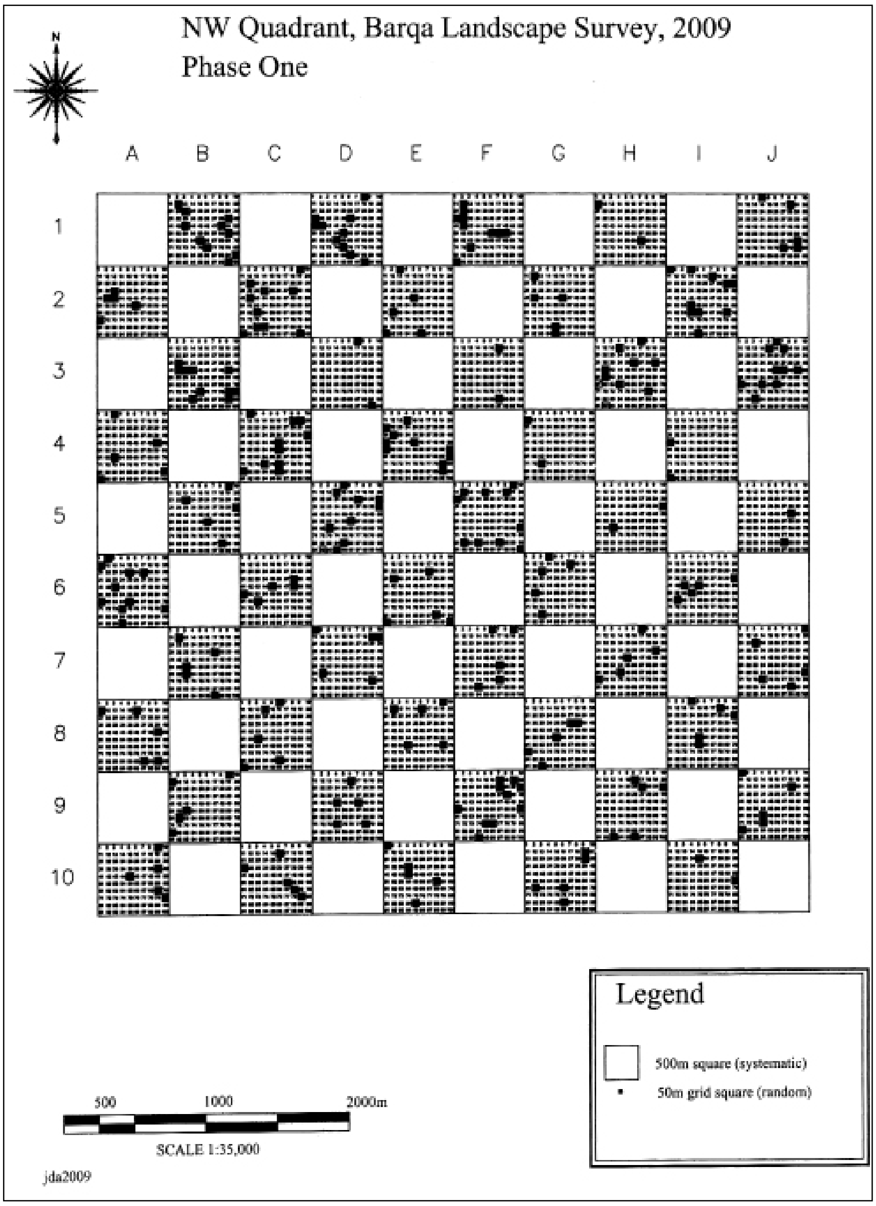
The survey work this year was primarily confined to an area of about 5 square kilometres in the NW quadrant of the survey zone (see **Fig. 1**). The project began with a systematic, random and stratified pedestrian survey (see **Fig. 2**) which recorded visible archaeology in the landscape, including architecture, pottery, flint and other artefacts. Each quadrant of the survey zone was divided into 500m squares, and every second of these was allocated for survey. These selected 500m squares were divided into one hundred 50m 'units', which were chosen at random. The number of 'units' to be surveyed in each 500m square was chosen based upon 'Areas of Interest' identified with the aid of Hyperion satellite



2. *Survey area, Barqā Landscape Survey 2009, Phase One.*

data and also by geographical landforms. Areas of interest identified by Hyperion satellite data were allocated ten 50m units, areas with large outcroppings of granite / dolomite, or obvious sand dunes were accorded two 50m units, and all others five 50m units (see **Fig. 3**).

The survey was divided into two teams, Red and Green, consisting of about 8 people, led by a survey leader and an assistant. Team Green was accorded the squares in the western half of the NW quadrant, and Team Red the eastern half. Each team used hand-held GPS units which were uploaded daily with the NW and NE corner of each 50m unit to be surveyed. Each team would find the NW corner of the 50m unit to be surveyed with the aid of the hand-held GPS and, using a compass set due south (accounting for a 3° 56' declination), the team leader would align the team from north to south. The team leader would then orient the team towards the next (NE) waypoint. Each member of the team then would move directly east over the 50m unit, scanning the ground in front and to either side for artefacts lying on the surface. These artefacts would be collected and accorded to the 50m unit, unless they belonged to a specific site (see below). Each team would designate one member to write tags and bag artefacts from the



3. NW quadrant, Barqā Landscape Survey 2009, Phase One.

unit being surveyed.

When a site was identified, the centre point was given a *waypoint*, the dimensions measured with a tape measure, and a photograph taken. All of the artefacts collected from the surface then would be attributed to the identified site.

Once the survey team arrived back at the 'clean' lab, the site waypoints would be downloaded from the handheld GPS receivers and entered into the GIS (see below). The artefacts collected on the survey would be submitted to the 'dirty' lab for processing and analysis.

Once Phase 1 of the survey methodology had been completed, Phase 2 comprised a more intensive survey of areas that had produced the most artefacts and sites in the NW quadrant. The area around the 'Barqā houses' excavated in 1990 and 1993 (Fritz 1994a, 1994b; Flender n.d.) produced the most artefacts, and it was around this area that an intensive (full coverage) survey was undertaken (see **Fig. 4**).

GIS Methodology

The GIS analyses performed during this field campaign were based on a combination of spatial data (survey grids and sampling areas, collection and analysis points, and sites) and tabular data (site records, ceramic analyses, XRF data, etc.). These various data were housed in several specific geodatabases and manipulated via Microsoft Access (see **Fig. 5**).

Spatial data consisted mainly of data generated by the survey teams (see above) using handheld GPS units (Garmin Etrex Vista and Magellan Triton 400) and control data from the total station survey, stored in AutoCAD formats. AutoCAD maps and corresponding data, such as the survey grid and control points prepared during Phase 1 of the survey, were brought into the GIS and transformed into geodatabase formats. During the pedestrian surveys of Phases 2 and 3, GPS waypoints were taken when survey teams located archaeological sites, significant landscape features, modern fields, or when specific non-site collection areas were recorded (for example along the north slope of Barqā hill). All new GPS points were downloaded daily from the handheld units, using MapSource 6.15.6 and Vantage Point 1.60 software packages, and incorporated into the appropriate geodatabase. Sites and collection areas became part of the Survey 2009 geodatabase in both point (center point) and polygon (boundary) form. Waypoints corresponding to XRF reading locations became part of the pollution study geodatabase, and landscape features became part of a control geodatabase.

In addition to the spatial data, these various databases also house the tabular data generated by this field campaign in Microsoft Access tables. Site record forms were entered daily into a master table designed to store this information. Other information was entered as needed or once analysis had been completed.

By combining the spatial and tabular data in various ways within Access, and then marrying these results back into the visual component of the GIS, we are able to analyze data quickly and comprehensively. The tabular and spatial data were combined by building a series of queries within the geodatabase using Access, joining the quantifiable table data and spatial locations through unique identifier fields such as survey unit or site number. We have also used Access queries to re-combine and select specific categories of data relevant to the research hypotheses. By keeping the unique identifier of each piece of spatial data involved in the joins, the results of each query were easily made visible in the GIS software. We have thus used the analytical power of Access and the visualization power of GIS software to effectively attribute spatial information to tabular data and *vice versa*.

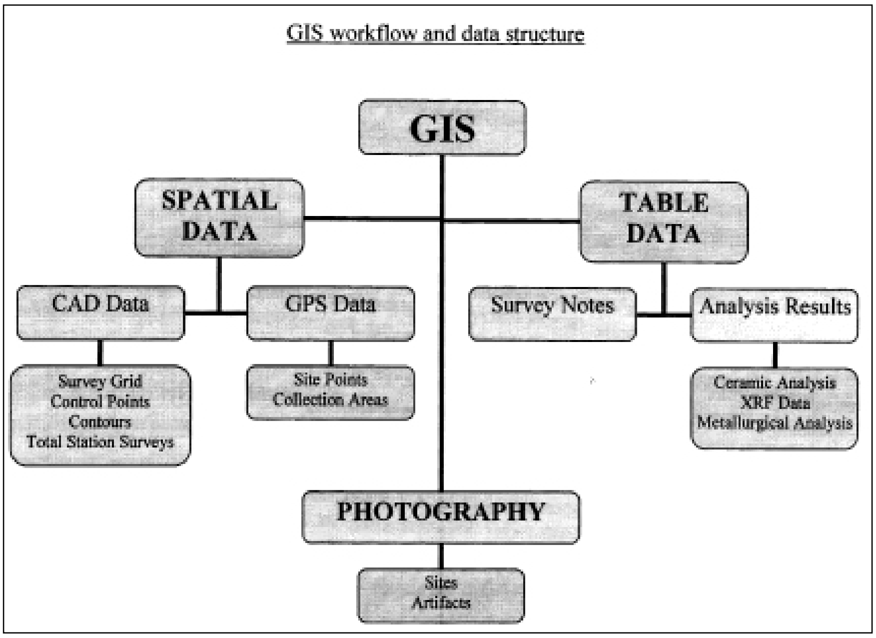
Particularly for the pollution study and XRF data, the ability to visualize results daily within the GIS allowed for in-field testing and modification of research hypotheses. For the pedestrian survey, the use of GIS allowed us to update survey phases to more effectively utilize project time and resources.

Results of Season One of the Barqā Landscape Survey

Environmental Studies

The focus of the environmental research in the 2009 season was to establish baseline parameters whereby phases of chemical enrichment and environmental impact of ore processing activities could be confidently identified. Our research design was based extensively on prior knowledge of the nature of the metals cycling in the local environment, developed over 15 years of research in Jordan (cf. Grattan *et al.* 2003,

4. Barqā House area site survey, Phases One and Two.



5. *GIS workflow and data structure.*

2005; Pyatt and Grattan 2005). Our research focused primarily on mapping the lateral extent of the metal working signature from known locales such as the Barqā smelting site, and by exploiting vertical sedimentary exposures in the survey area we were able to identify ancient land surfaces and assess their palaeoenvironmental potential. Our research was enhanced by the first archaeological use of a NITON hand held XRF instrument. This allowed us to accurately determine the geochemical content of sediments *in situ*, without the need to excavate or collect samples. In this brief field season we analysed over 1400 samples and were able to develop our research and sampling methodology constantly, informed by the results of our testing and sampling regime.

Baseline Sampling

To establish the pre-metal working geochemical signature, the Faynān Gravels, a Pleistocene fluvial unit exposed in the modern Wādī Faynān and mapped by Hunt *et al.* (2005, 2007), was analysed. These sediments were found to contain mainly strontium, rubidium and iron, which are ubiquitous indicators of natural erosion (Grattan *et al.* 2007) and no detectable concentrations of copper, zinc, manganese, arsenic, lead, antimony or tin, which suggests that where these metals are detected in association with each other in the survey area, they may indicate metal processing activity and not the fortuitous accident of natural erosion and deposition.

Firepits Exposed in a Pipeline Trench Adjacent to Barqā Hill

A reconnaissance was made of a long trench (Lat 30.595878° Long 35.378344°) dug by the Aqaba Development Authority to carry a new water pipeline. The section exposed within the trench consisted of an upper layer of chert scree, approximately 5cm thick, which sealed wind blown sand exposed to a depth of at least 1m. Within this trench, several firepits were identified within the blown sand between 30-50cm below the surface. No cultural material was found *in situ*, but within the spoil cast up by the excavation of the trench several Neolithic flakes were found. XRF analysis on the windblown sands and the firepits indicated the normal presence of strontium, rubidium and iron, and the absence of any chemical signature indicative of industrial activity. At this point in time, we may infer that the environment was uncontaminated by industrial activity and that ore bearing strata in the region were undisturbed.

Palm Tree Pit

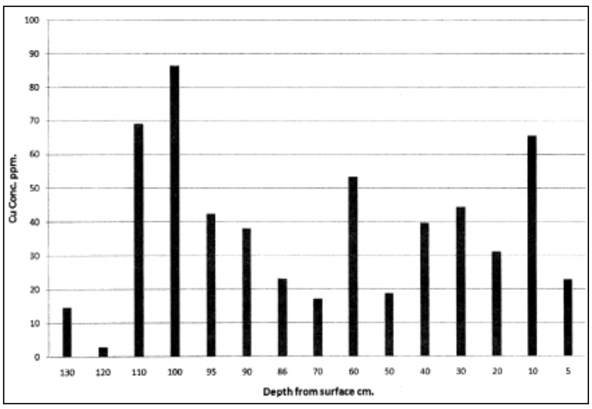
Three palm trees grow in the middle of a very shallow hollow (Lat 30.603808° Long 35.379978°) that is relatively rich in archaeological remains. It is the current topographic low in the area. The adjacent low angle surfaces also support small 'cockpit dunes', with a higher content of silt. The surfaces are crossed by linear dunes of red-brown sands. The hollow had been excavated for unknown purposes by a backhoe, with the spoil left adjacent to the site. The spoil was a grey sediment, perhaps from an anaerobic environment, as might occur at an oasis. Evidence of metal working activity in the past was detected in two palaeosols identified in a water prospection trench dug within a grove of palm trees located 182 meters downslope to the north-west of House 2, Barqā Ridge. Each of the palaeosols was modestly enriched in copper (**Fig. 6**), which confirms the potential for test pitting and associated pollution studies next season. The concentrations of copper in the palaeosols are similar to the concentrations of copper below 50cm depth (see 'Barqā settlement gully' below) and indicate that these may be contemporaneous events.

The oasis pool may have occupied this location for much of Antiquity, perhaps filling the topographic low in which it is currently located, and may have been a major focal point for people in the past, as it is now. Many of the low angle surfaces in the vicinity seem to lead down to it. The condition of the modern date palms will provide an indication of the future well-being of the aquifer, which is close to the ground surface hereabouts.

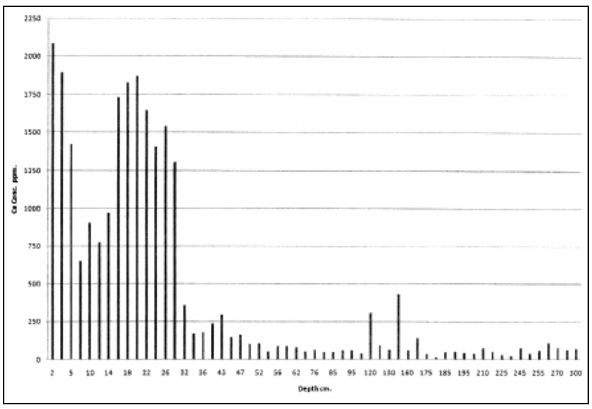
Barqā Settlement Gully

Between the Barqā Smelting Hill and the main settlement site lies a narrow *wadi* (Lat 30.600185° Long 35.381156°). Exposed in the *wadi* is a body of sediment which has been provisionally identified as a flood loam, overtopped by blown sands. Our field observations suggest that this deposit is formed from two major floods in a desertic environment in which there was much silt and sand to be eroded. The later stages of each flood caused the surface of the flood deposit to be reworked. Sand dunes then accumulated over the flood deposits. The dune surface eroded, with an east-flowing stream carving out a linear gully parallel to the ridge of Barqā Smelting Hill and the original sand dune, whilst deflation occurred on the industrial dune surface. Many detailed issues of chronology and palaeoenvironment require further analyses. The surface of the sand dune unit consists of copper ore, copper prills, pottery and crushed slag fragments. The exposure was analysed to determine the history of metal working in this location, specifically whether the obvious metal processing debris visible in the uppermost horizon was the only evidence of metal working.

It is clear from **Fig. 7** that a considerable history of copper processing is present. Between 300 and 76cm depth, copper is present at concentrations generally below 125 ppm. This suggests that copper was present and being distributed across this landscape, but that the activity was small scale and probably not in the immediate vicinity. As noted above, these concentrations are similar to those seen in the palaeosols identified in the palm tree pit (see above). From 76 to 32cm depth, it can be seen that the concentration of copper cycling in the environment generally increases until a profound increase in the copper values to well over 1000 ppm at 30cm. Our current interpretation is that this indicates a significant increase in the scale of copper smelt-



6. *Depth vs Copper Concentration, PPM Histogram I.*



7. *Depth vs Copper Concentration, PPM Histogram II.*

ing activity and that this activity probably took place close by. It is interesting to note, however, that there is no archaeological evidence for this activity in the sediment; this activity phase is identified only by the geochemical signal. This intense phase of activity appears to reduce somewhat between 14 and 5cm depth, when the 5cm thick surface deposit is encountered. In this deposit, archaeological material, slag, ash, pottery, copper prills and ore are encountered for the first time; these can be attributed to the Early Bronze Age, or roughly the early third millennium BC. In-field analysis of the copper content of sherds lying on this archaeological surface revealed copper values of between 32 and 165 ppm. The metalworking history indicated in this *wadi* gully reveals a hitherto unanticipated depth to the story and confirms the value of palaeoenvironmentally focussed geochemical reconnaissance studies.

Barqā Smelting Hill — Lateral Pollution Dispersal Study

Earlier research by Grattan *et al.*, at Khirbat Faynān (Grattan *et al.* 2007) has identified significant dispersal of pollutants from the copper smelting activity at this site. Guided by this experience, the dispersal of copper from the main smelting site at Barqā hill was investigated. Several transects were walked with analyses of the sediment chemistry being conducted every 50m. Much of the north facing slope of Barqā hill is profoundly contaminated by copper and other heavy metals, such as cadmium, and manganese. In contrast the south facing flanks are uncontaminated, with the exception of two gullies which drain south from the smelting carpet on the summit ridge. To the north of Barqā hill, metal contamination reaches just beyond the ridge where Barqā Houses 1 and 2 lie, but peters out quite quickly beyond these to the topographic low occupied by the palm trees discussed above. To the north-west it was possible to identify the Bronze Age settlement on the basis of its significant metal content, whilst it is worth noting that the adjacent Iron Age settlement is largely uncontaminated. This may confirm suggestions that Barqā was not being used as a smelting or processing site during the Iron Age; it may also indicate that a Bronze Age settlement underlies the Iron Age material.

Summary

These explorations represent the first ever use of a Niton hand held XRF in geoarchaeological research. We have established that the pre-metal working environment was essentially pristine, with no heavy metals cycling. This picture changes profoundly from at least the Early Bronze Age with copper, lead, cadmium, manganese, antimony and nickel released into the environment at this time and continuing to cycle throughout the environment until the present day.

Archaeological Survey Results

Results of the Pedestrian Survey

The pedestrian transects of random 50 x 50m survey units during Phase 1 of the survey helped to define a total of 107 sites, most of which were concentrated in the NW quadrant. The survey teams located a wide variety of site types, including concentrations of flint and pottery, architectural, funerary and industrial sites. The definition of site perimeters was undertaken every time a site was found, and these were mapped using the hand-held GPS units. When, during the survey, no archaeological sites were found or defined, background collections of artefacts were bagged for each 50 x 50m unit. The collections of archaeological materials were therefore logged as "site" or "unit" collections for further processing.

Each archaeological site defined by the survey teams was logged on a site sheet and standardized information was recorded about each site, including: GPS waypoint, site dimensions, site type, wall construction information, types of archaeological materials collected, aspect, slope, position on slope, geomorphology, drainage, preservation, details of photographs taken and a general description of the site with a sketch plan where possible.

Once in the 'dirty' lab, archaeological materials were logged into the Master Survey Register. Metallurgical finds were categorized, weighed and counted, and flint and pottery were washed and re-bagged. In the absence this season of a flint specialist, the flint was prepared for storage and processing next season.

The pottery from "sites" was weighed, counted and sorted into diagnostic and non-diagnostic categories and analyzed to provide MNI data by period and pottery form. The "unit" pottery was similarly analyzed to provide background readings of the survey units by period. Information from both "sites" and "units" was entered into a Microsoft Access database, and this tabular information was used by the GIS Analyst to provide visual maps of the distribution of the pottery collections by period (**Figs. 8-11**). The latter was particularly helpful for Phase 2 of the survey, during which an intensive, full coverage survey was undertaken of the region directly north of the Barqā Smelting Hill (**Fig. 4**). The ongoing analysis of the ceramics through the GIS program allowed real-time analysis of the location of archaeological periods in the landscape. Although the primary focus of this research program has been the Bronze Age landscape and pollution intensities associated with it, the pedestrian archaeological survey also recorded a wide range of periods including the Early Bronze Age, Iron Age and Roman periods as well as a pre-Holocene occupation of the Barqā region.

The Early Bronze Age Landscape North of Barqā Smelting Hill

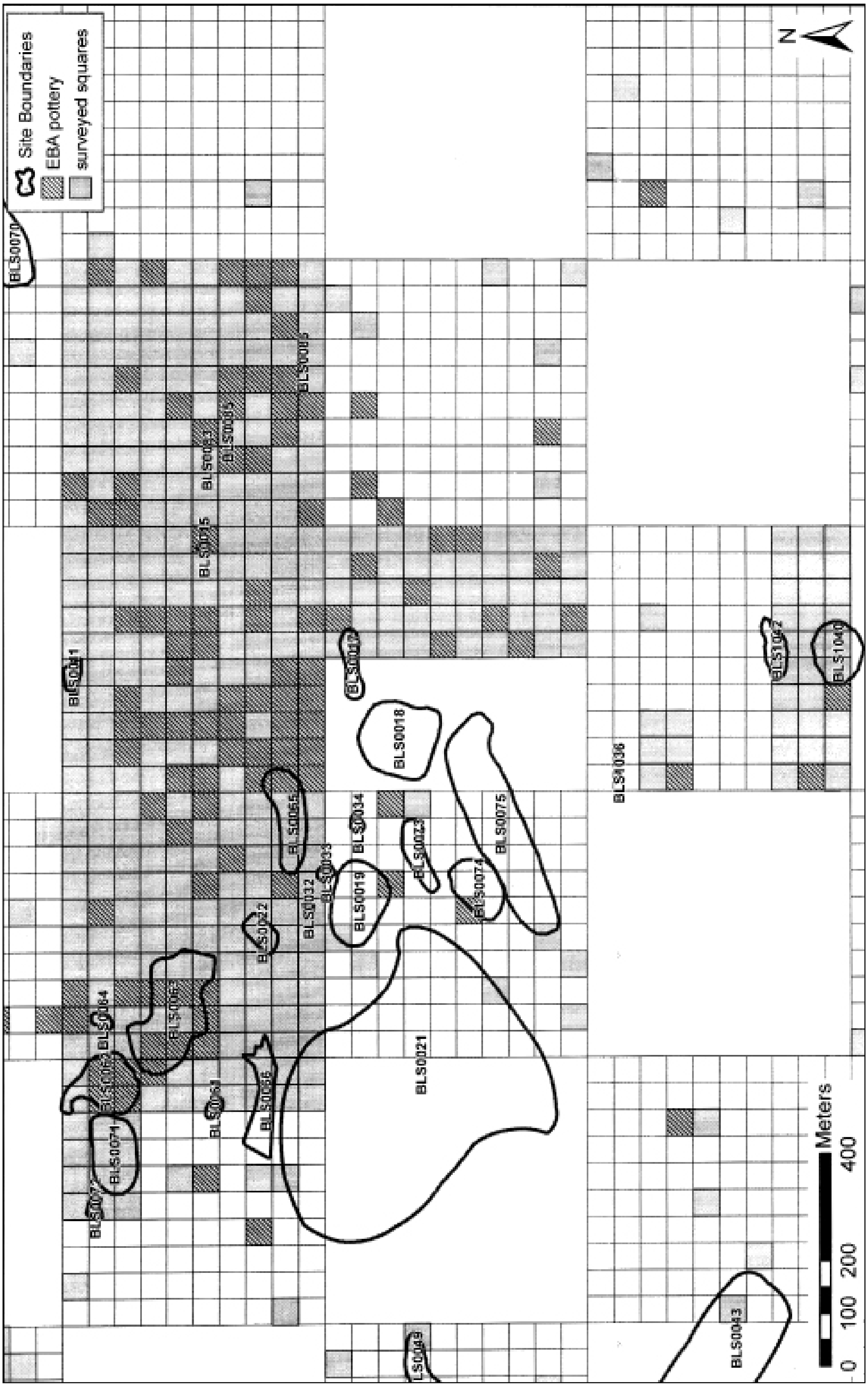
The presence of Early Bronze activities in the Barqā region has been known since the work of Hauptmann and Fritz in 1990, when a prominent hill with evidence of smelting and large amounts of slag was investigated (the Barqā Smelting Hill site), and an adjacent structure on the flint knoll just to the north of this hill was excavated to reveal a well preserved, burnt structure dating to the Early Bronze Age II. Other smaller 'cuts' were excavated by the German Mining Museum team in the immediate vicinity, but never published. Barqā House 1 (according to Hauptmann's site numbering) has been published by Fritz (1994a, 1994b), and later a more detailed analysis has been published by Adams (1999, 2003). The site is unique, not only owing to its prominent location near to the Smelting Hill, but also for its unusual architecture and surrounding wall, and the possibility that it may have served a cultic function.

Aside from noting that there was evidence of copper processing in the gully between the Smelting Hill and the Early Bronze Age building, Hauptmann and his team paid comparatively little attention to the surrounding landscape at Barqā. The survey results of the 2009 season of the Barqā Landscape Survey contextualize the work carried out by Hauptmann and show quite clearly that Barqā House 1 is not an isolated structure, but that there are concentrations of material, especially pottery and archaeometallurgical finds, which attest to a much larger Early Bronze Age landscape north of the Smelting Hill and House 1 (**Fig. 8**). This is confirmed also by the pollution sampling around Barqā, as well as in the gully and the date palm pit (discussed above). One of the interesting aspects of this landscape is that it seems intermittent, but this may in fact be a function of later Iron Age occupations overlying it, as in the case of BLS Site 21 (see below), as well as recent dune activity which seems to be more recent than anticipated.

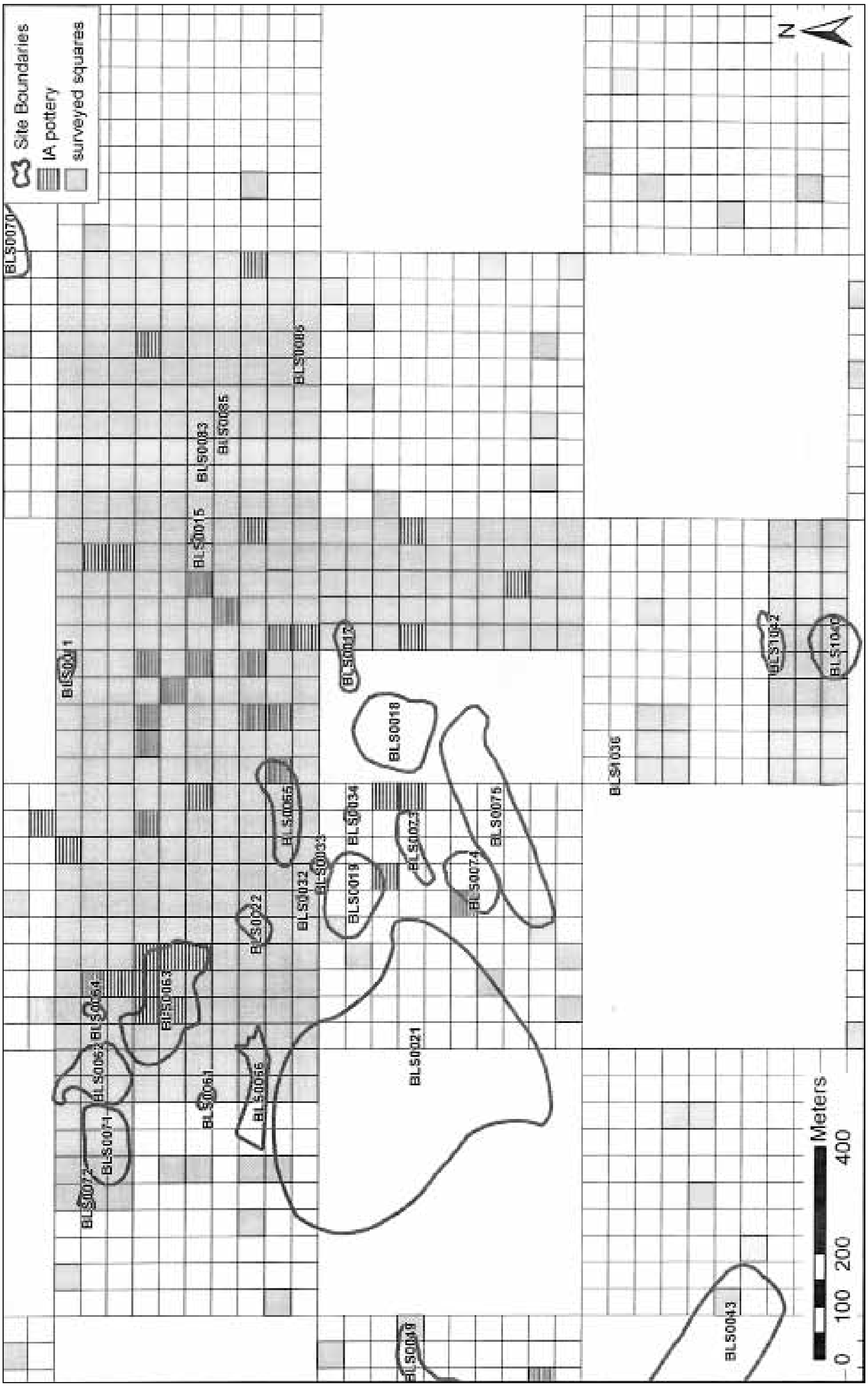
The Iron Age Landscape North of Barqā Smelting Hill

Like the Early Bronze Age, the Iron Age has been known since the 1990 excavations of Hauptmann and Fritz at Barqā House 2. House 2 is a large, multi-room structure, which is likely domestic in nature. The site was notable since the excavations produced both Midianite pottery and one radiocarbon date from the late tenth century BC. Unlike the Bronze Age, however, Hauptman's survey recorded a number of other buildings to the west and north-west of House 2. Although these were mapped, they were not surveyed and no collections were made (**Fig. 12**).

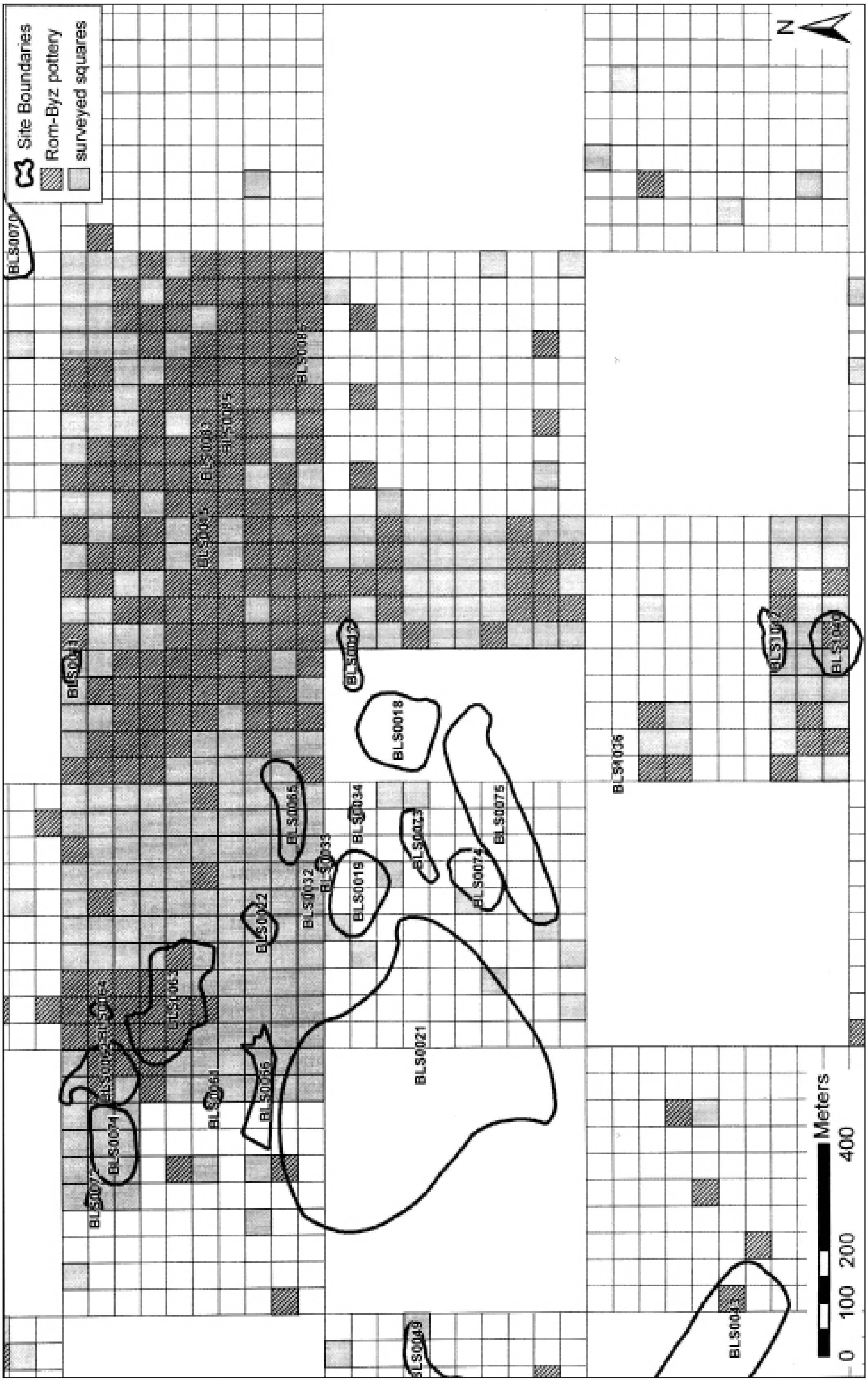
The Barqā Landscape Survey recorded several large sites with significant amounts of Iron Age pottery. The most notable of these was Site 21, which covers an area of approximately 300 x 400m and which has obvious wall lines of buildings, numerous stone-built tombs and a large quantity of diagnostic Iron Age pottery (**Fig. 4**). Mixed in with the Iron Age pottery, however, were concentrations of Early Bronze Age pottery, suggesting that the Iron Age site may overlay an earlier Bronze Age landscape. Site 21 and other evidence of Iron Age ceramics in the vicinity of the other buildings to the north-west of House 2 suggest that this area was densely occupied during the Iron Age (**Fig. 9**). Of interest, however, is the fact that little metallurgical evidence was found in conjunction with the Iron Age ceramics, suggesting perhaps that the Iron Age landscape here was not primarily a metallurgical production zone at that time, as also suggested by the pollution analysis.



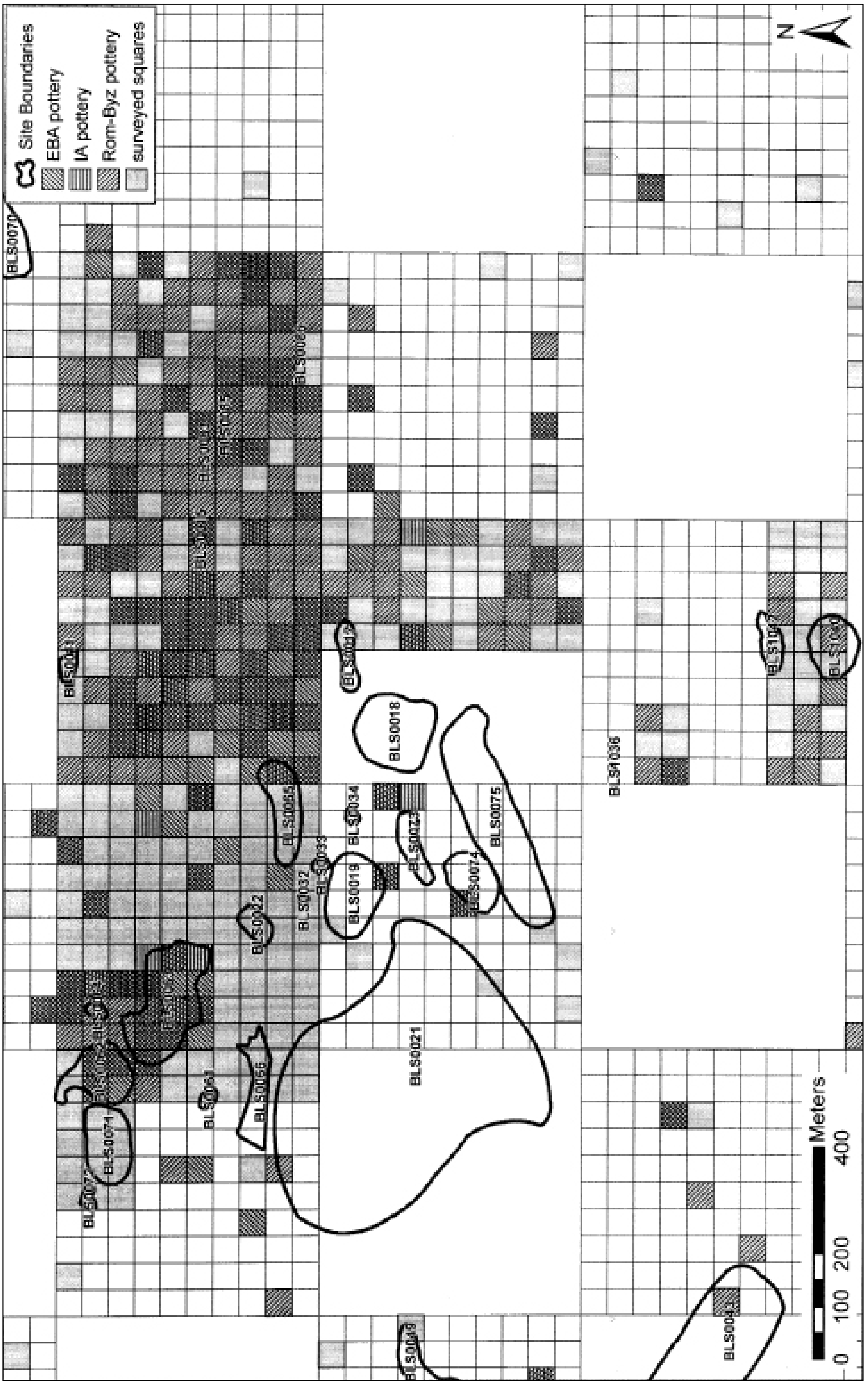
8. Barqā archaeological site environs: EBA pottery.



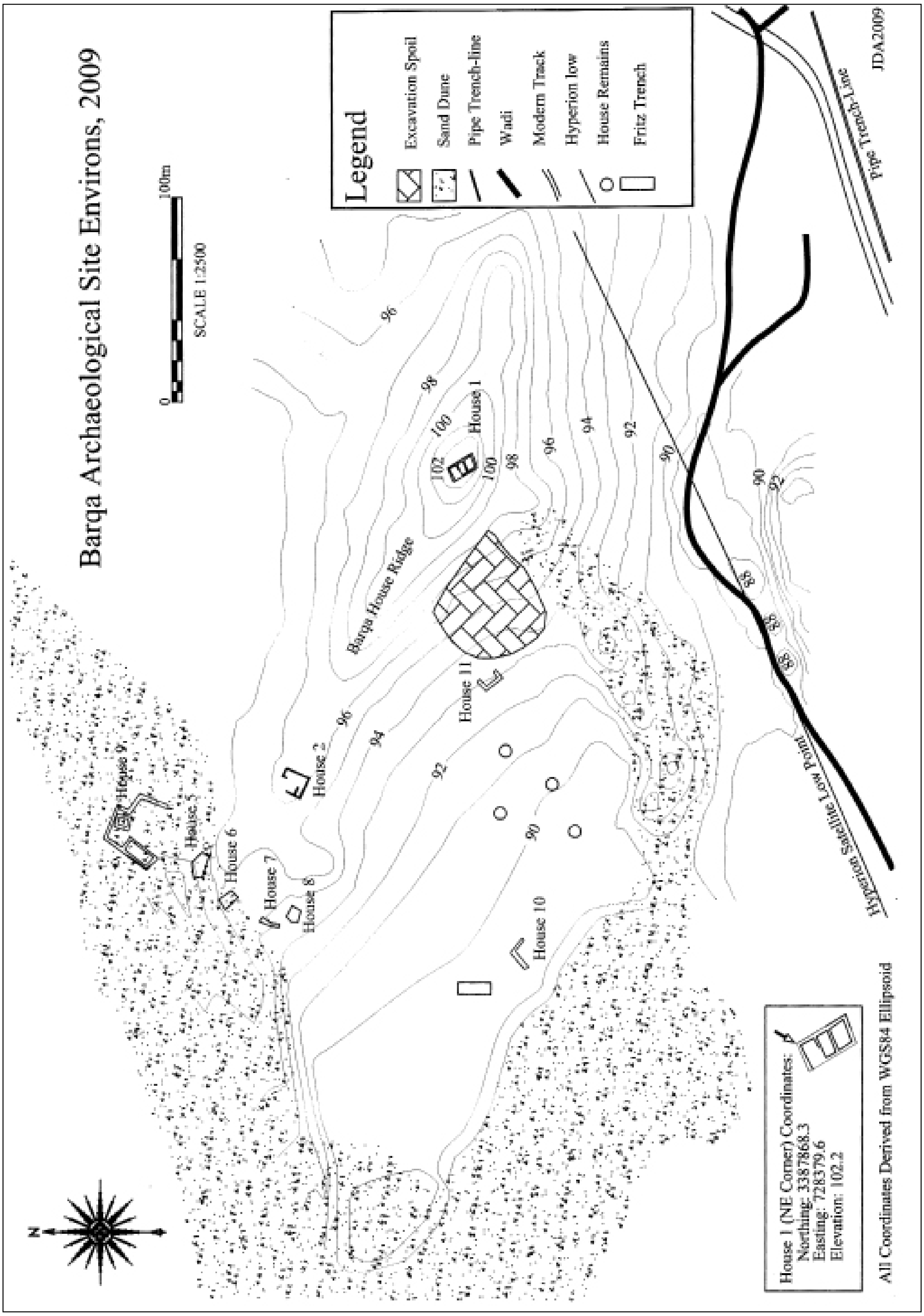
9. Barqā archaeological site environs: IA pottery.



10. Barqā archaeological site environs: Roman - Byzantine pottery.



11. Barqā archaeological site environs: EBA, IA and Roman - Byzantine.



12. Barqā archaeological site environs 2009.

The Roman Landscape North of Barqā *Smelting Hill and Sites 87 and 67 in the NE Quadrant*

The survey of the NW quadrant of the survey area yielded significant quantities of Roman / Byzantine pottery, spread over discreet "sites" as well as survey "units" (**Fig. 10**). Although not surprising given the extent of Roman and Byzantine occupation at Faynān, it constitutes further evidence for the extensive nature of Late Antique occupation of the region. The widespread nature of Roman / Byzantine pottery in the Phase 2 total survey coverage area, suggests that this area, much like the Faynān basin further north, was cultivated at this time. The small and extremely fragmented nature of the pottery sherds found throughout this area, perhaps evidence for spreading manure, also supports this supposition.

The largest Roman site found in the survey area was discovered during examination of Google Earth imagery. Overviews of the area highlighted several interesting sites with clustered buildings, stone circles and various other architectural features. Site 87 in the NE quadrant was by far the largest of these and was very obviously a large, complex field system, not unlike that along Wādī Faynān, albeit on a smaller scale (**Fig. 13**). An initial reconnaissance on 1 July revealed large walls and an elaborate hydraulic system; pedestrian survey began in this area on 3 July 2009.

Survey Methodology

The Google Earth imagery was geo-referenced in AutoCAD into the WGS84 reference ellipsoid, and 'wall systems' were identified and labelled chronologically, beginning in the north-east and moving to the south-west. The first draft of the wall system was produced in AutoCAD. Using the first generation map as a guide, the field walkers then identified many walls and features not apparent on the Google Earth imagery. The artefacts were labelled according to the field units on the map (**Fig. 13**). The edits made in the field were incorporated into Google Earth as far as was possible.

A total station survey was conducted to incorporate those features identified on the ground and not visible on Google Earth. Using corners of features visible on Google Earth, a 3 point resection established the 3-dimensional co-ordinates of a survey monument. Once done, three 'intakes' were tied in, as well as five cross-sections, as well as graveyards and wall features in the south-east corner of the wall system. All of these features were incorporated into Figure 13, and the intakes and cross sections drawn as separate figures (**Fig. 14**).

The Mechanics of the Roman-Period Field System at Site 87

Long, Roman-period walls were constructed to direct water from the adjacent *wadi* through three intakes in the extreme north-east area of the overall wall system (**Fig. 13**). Once into the system, an elaborate system of walls directed the course of water to areas directly in front of 'field systems'. Although there is much infilling across Intakes 1, 2 and 3, their requisite cross-sections reveal narrow openings that may have been controlled by sluices. Intake 1 permitted water to run in a channel between the wall systems in the southern part of this area, and Cross Section 4 profiles this channel. Intake 2 allowed water through a channel directly to the north of the Intake 1 channel. The field complex is characterized by short walls enclosing, for the most part on four sides, discrete units identified as field terraces. For the purpose of the pedestrian survey, each of these was given its own number in order to record finds in each area, ranging from 1 to 86.

Site 67 Building Complex

A building complex in the north-central part of the wall system appears to be situated just north of a point at which water was directed along two discrete channels, one flowing west and the other south-west. This series of connected buildings and the area immediately around them had by far the largest concentrations of pottery (**Fig. 13**).

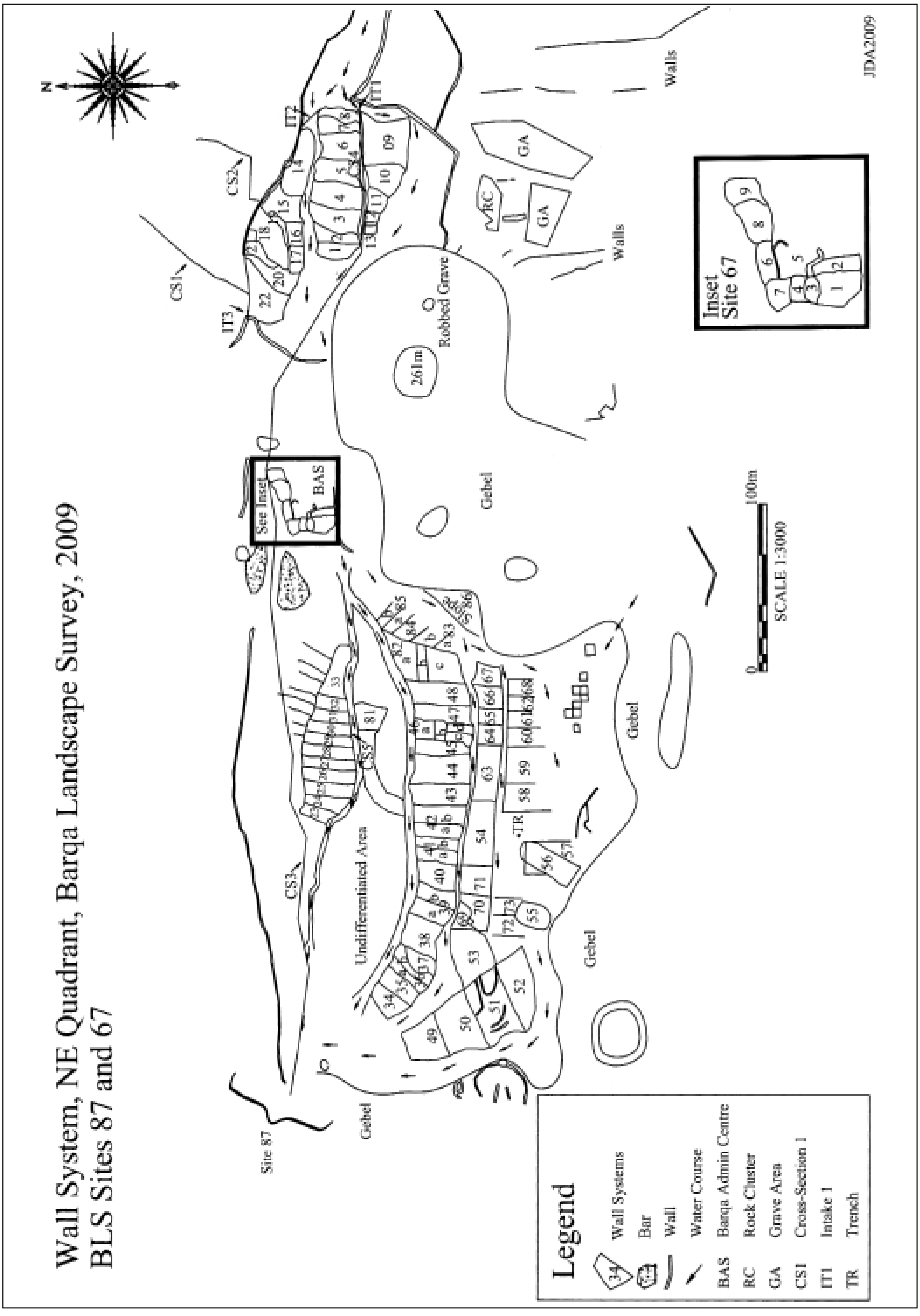
West Aspect Channels

1. North area in west quadrant

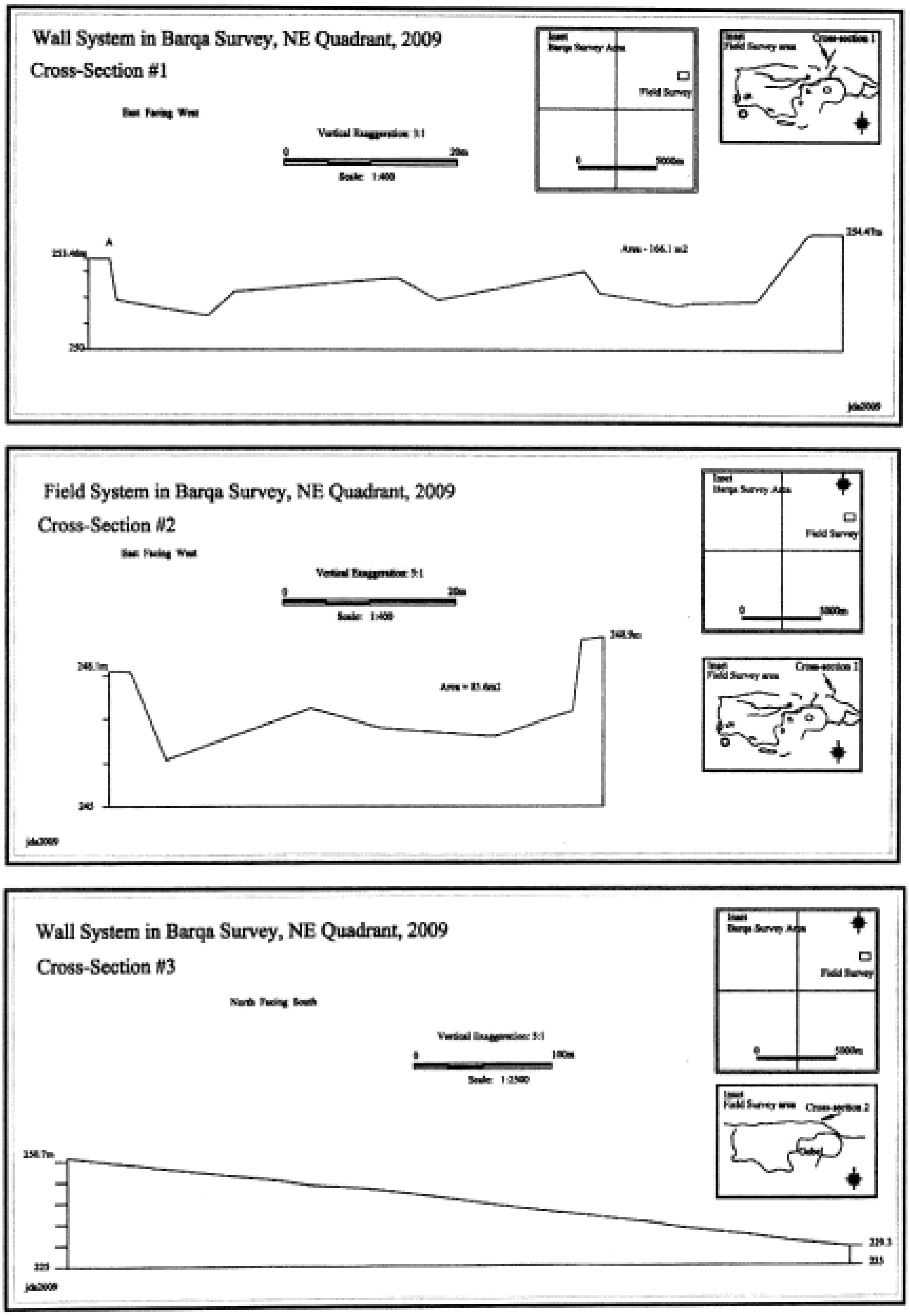
The first channel runs north and splits into a northern and southern channel. The northern channel runs north of Wall System 81 and the southern channel south of Wall System 81. Both of these channels empty into an area at the extreme north-west of the wall system area.

2. South area in west quadrant

The second main channel runs to the south of



13. Wall system, NE quadrant, Barqā Landscape Survey 2009, BLS Sites 87 and 67.



BLS Site 87 Cross Sections

14. BLS Site 87 cross sections.

the BAS building and splits into three channels. From north to south, one channel runs north of Wall System 67, a second runs north of Wall System 68 and a third runs south of Wall System 68. All of these channels coalesce in the extreme north-west area of the wall system.

Cross Sections 1 and 2

These cross sections profile the *wadi* channel immediately north of the NE part of the wall system. There was found to be much infilling of this *wadi* with material ranging from gravel to cobble-sized stones (**Fig. 14**).

Cross Section 3

This cross section gives a north-facing view of the entire water flow of the wall system area. The drop from east to west is 3.8% and is consistent throughout (**Fig. 14**).

Summary

An elaborate hydraulic system at this site consisted of long walls directing the course of flowing water from the adjacent *wadi* into 'intakes', which siphoned water through discrete water channels and into 'field systems' delineated by shorter walls. This system was designed not only to exploit a water source, but also to direct it through a system that would maximize its use, perhaps retaining it for future use through a system of dams and perhaps reservoirs.

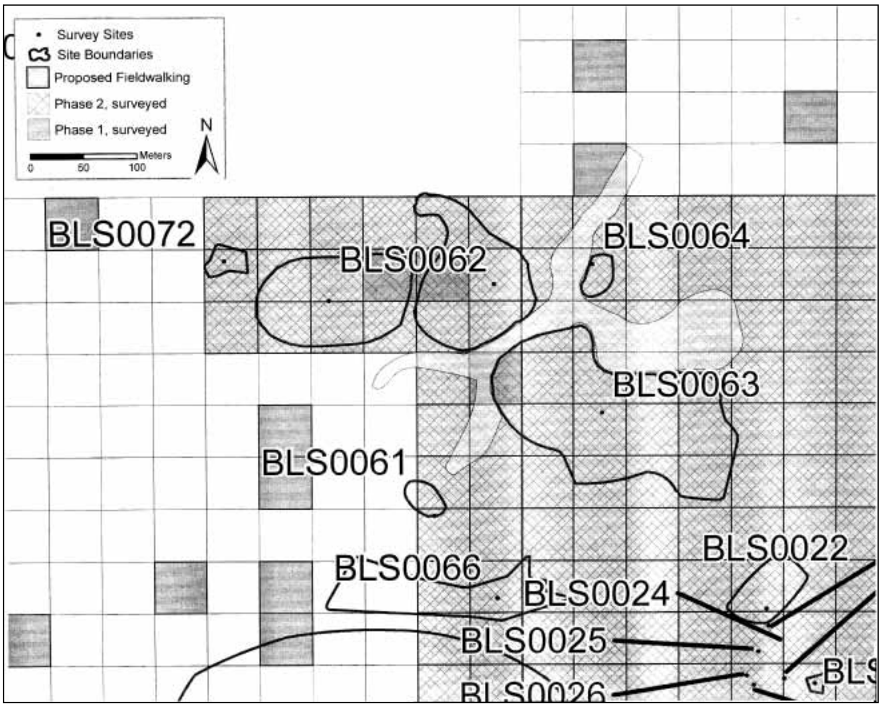
The Late Pleistocene Landscape North of Barqā Smelting Hill

Perhaps the most unexpected outcome of the Barqā survey was the discovery of a series of sites north of the Barqā Smelting Hill which were extremely dense in surface finds of flint tools and debitage. These sites, which include BLS Sites 61, 62, 63 and 66, were all extremely similar in character and, although the flint appears on initial inspection to vary in density of artefacts within and between sites, they all have a wide range of tool types which are, in general terms, comparable (**Fig. 15**). Team Green spent a significant amount of time defining the boundaries of each site, and the end result appears to be that, for the most part, the 'boundaries' between sites take the form either of large sand dunes, as in the case between Sites 62 and 63, or shallow sand fields, as in the case between Sites 61, 63 and 66. As a result, one possibility is that the sites are connected and partially overlain by later sand dunes and sand fields. If this is the case, the site may be as large as 12-16 hectares, making it one of the largest prehistoric sites in the Wādī 'Arabah. Collections from these sites were examined by two independent experts who both suggested that the sites are likely Early to Middle Epipalaolithic in date (22,000-15,000 BP), a period as yet not known from other surveys in the Faynān district. Certain sites appear to have a significant frequency of microlithic tools, including some which may indicate Natufian occupation, thereby suggesting a long history of occupation at these sites.

In an attempt to counter any bias towards under-recovery of microliths during the pedestrian pickup, it was decided to do a random total collection from the surface of 5 squares in Square D4, Unit 42. The five 1 x 1m squares were scraped clean of surface flint to a depth of 1cm; this was bagged, then subsequently sieved and wet sieved in the 'dirty' lab. These collections yielded a much higher proportion of microliths, which await further analysis in the coming year.

The horizontal distribution of these sites is best explained by the reconstruction of palaeochannels from radar images, which suggest that they occur on what appears to be a gentle slope down to what was likely a permanent, slowly moving stream directly south of the site. This palaeochannel is the same modern drainage in which the date palm pit is located, suggesting that ground water still flows through this area. The reconstruction of the Pleistocene environment will be the subject of future investigations next year, but the working hypothesis is that these Epipaleolithic sites were most likely situated in a lush, savannah-like environment, which had plentiful water, plant and perhaps animal resources. The sites are unlikely to all be contemporary, but likely represent long-term, annual, perhaps seasonal re-use of the site. The very significant amount of debitage is suggestive of intensive tool manufacturing at the site, and the variety between different parts of the site may reflect chronological variation.

Finally, a modern small pit (purpose unknown) in Site 63 yielded a small profile of part of the site, thereby permitting an initial reconstruction of site depth, chronological phasing



15. Pleistocene site locations and Phase 1 and 2 surveys.

and characterization of soil deposits. This is, of course, a fortuitous event, but one which will also necessitate further comparison with other parts of these sites in order to check this year's results.

Analysis of the Indurated Surfaces Beneath the Extensive Flint Scatters of BLS Sites 61, 62, 63 and 66

An extensive carpet of worked flint, preliminarily dated to the Middle Epipalaeolithic was identified (see below). It is clear in the field that modern linear dunes are rolling over this group of sites, but that the flint carpet has protected the archaeological surface and prevented its erosion. The indurated layer is composed of fine sand and silt, which does not appear to have been significantly disturbed by the people working upon it. The indurated layer of sediment below the flint working debris was interpreted as being the contemporary surface and was extensively analysed using the Niton XRF. In all these analyses strontium, rubidium and iron were identified, but no chemical signature for metalworking could be identified.

As described above, a pre-existing pit (Waypoint 743) cut into the ground surface within the area of Site 63 provided an opportunity to examine the topography and lithostratigraphy in detail.

Topography of the Location

There are three components:

1. A low angle surface, dipping SW at ~7-8° for at least 200-300m, which leads down to the topographically low level that is the location of the palm trees. This surface is littered with primary and secondary flakes made of chert, creating a carpet of debitage. There is at least 1 small blade per 5 cm^2; many areas have a much denser coverage. Occasionally, there is some pottery attributed to the Bronze Age. No smelting slag was found. Nowadays, sand blows across this surface, sometimes forming a very thin sheet, but it does not settle.
2. Small cockpit dunes supporting one shrub of saltbush every 10-20m. These are variable in shape (a mixture of 'egg-shaped' and 'cone-shaped'), and typically 2-3m long and 1m wide. The sand on the top edges of these small features is mobile.
3. Linear dunes in excess of 100m length, typically much longer, 10-20m wide and 5-10m high. Google Earth imagery shows that these linear dunes are more or less parallel. The sand on the dune surfaces is mobile.

The topographic relationships between these landforms show that the low angle surface is oldest, and that it was subsequently covered by the linear sand dunes and cockpit dunes. The age relationships between the small cockpit dunes and the linear dunes are unclear, but the linear dunes appear to be fed with sand in much greater quantities and from further afield than the cockpit dunes, which appear to be made up of silt and fine sand eroded from the low angle surface.

Two lithostratigraphic units, here termed lithofacies, were visible in a small exposure left by an earlier pit. These indicated the nature and stratigraphic relationships of the cockpit dune and the low angle surface.

Lithostratigraphy

Cockpit dune lithofacies

Description: 0-50cm, thinner towards edge of dune. Fine sand and silt, fairly well sorted; these form couplets of *laminae* that are more silt-rich and better-sorted fine sands, each 1-3mm thick. The silt-rich material can be slightly indurated. Twenty six such couplets outcropped in the exposure. These are sometimes flat-bedded in the centre of the dune, but increase in dip to ~35° on the steeper slope of the dune before gradually decreasing slope to ~0° at the edge of the dune, where its thickness thins to zero. The strike of these couplets varies around the dune. The colour of the dune has not been determined by reference to a formal guide. In the prevailing light at the exposure, the colour appeared grey-yellow. The lithofacies was penetrated by saltbush roots, 1 root of 0.5cm width per 100cm^2 of exposure; there was no other evidence of bioturbation, or of any other biological or archaeological remains. The base of the lithofacies was always sharp, undulating over 1-5cm. Parts of the dune surface are eroding. The topography is described above. The assumption is that these cockpit dunes are relatively young and transient features in the landscape, but the only currently available evidence for this is that they overlay the materials in the lithofacies below.

Interpretation: these are small dunes accumulating around saltbush, the fine sand and silt deriving from adjacent surfaces.

Pit Lithofacies

Description: thickness greater than 20cm. There are two visible components.

Upper component: Pit Silt Layer, 1-3mm thick. Well sorted silt or very fine sand forming a distinctive layer throughout the exposure. This layer also appears to be the surface of the low-angle surface that led towards the palm trees. It appeared grey in the prevailing light, was perhaps indurated, and was harder and protruded slightly from the exposed face. The upper surface of this layer was visible beneath the cockpit dune lithofacies, where it was sharp. The base of this layer was also sharp and undulated gently over 1-3cm, parallel to the upper surface. The relationships between this layer and the many flint artefacts present suggest to these observers that it either was, or was stratigraphically very close to, the stratigraphic source of many of those artefacts. The exposure revealed no evidence of bioturbation, nor of desiccation cracks or other disturbance.

Interpretation of upper component: a layer of silt that was deposited by the wind across the site. Duration: likely to have been brief. Age relationship: older than the base of overlying cockpit dune.

Lower component: Pit Sands, thickness >20cm. Sand with two fractions: sorted fine sand, which appeared yellow in the prevailing light, and a smaller component of coarser sand, 1+ mm with light coloured fragments and darker grains. Overall, it appeared to be a pale red / brown, possibly from weathering or rubification. Weak, poorly developed lamination sometimes locally present; individual laminae ~1 mm. Overall, in the exposure the stratum appeared relatively homogeneous, perhaps even structureless in places. Lower boundary unseen. No evidence seen in exposure of bioturbation, desiccation, pits or reworking; no charcoal was found. Very characteristic was a layer of flint artefacts, ranging in size from 2mm to 2cm, that formed a layer 3-4cm beneath the ground surface. These were flat-bedded and displayed no evidence of disturbance or reworking. Occasional saltbush roots penetrated this layer, situated beneath the cockpit dune. The layer is older than the Cockpit Dune lithofacies and equivalent in age to the two (?) layers of flint artefacts (surface / near surface, and ~3-4cm beneath surface) that appeared in this exposure.

Interpretation of lower component: upper surface of a sand sheet that led gently down to the level of the palm trees, upon which people worked flint on at least two occasions, without materially disturbing the aggrading sand surface. Subsequently, these sands weathered slightly.

Summary

The earliest observed deposit was the upper surface of a sand sheet that led gently down to the level of the palm trees, upon which people worked flint on at least two occasions, without materially disturbing the aggrading sand surface; during this time sand blew across the site. Subsequently, a thin layer of silt blew over the site; again this accumulation was associated with people. The landscape included dunes and windblown deposits; presumably it was arid, but it is not clear how arid. Subsequently, these sands weathered slightly.

At a currently unknown point in time, linear dunes accumulated across parts of this low angle plain, upon which occasional pottery fragments were dropped in Bronze Age and Roman times. Subsequently, fine grained materials, seemingly richer in silt, collected episodically to form the cockpit dunes around salt bushes.

Finally, it should be noted that this site, and other adjacent Pleistocene sites, require micromorphological study, OSL dating of the dunes, sedimentological study and radiometric dating, as well as other detailed studies. As these sites may represent key events and locations within the regional environment, a reconstruction of the ancient landscape is a priority for the second season of the Barqā Landscape Survey.

Barqā Landscape Survey: Summary and Plans for the Second Season

The first season of the project has been particularly successful, resulting in the collection of a large sample of data from both the pedestrian archaeological survey and the pollution analysis. The project is now in a position to benefit from this season's results and to continue with the detailed pollution analysis planned for the second season. Several unexpected outcomes, such as the discovery of large numbers of Iron Age sites, as well as the Late Pleistocene sites and flint scatters, will require minor adjustments to next season's plans since both of these are important enough to investigate further.

The second season will therefore broaden its approach to look at: (1) long-term environmental changes, (2) Holocene landform changes and (3) the extent and characterization of both the Bronze and Iron Age landscapes north of the Barqā Smelting Hill. Also planned for the forthcoming season is a detailed analysis of the prehistoric flint recovered during the survey and a detailed analysis of the Roman / Byzantine pottery by an appropriate specialist.

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