THE ṬAWĀḤĪN AS-SUKKAR AND KHIRBAT ASH-SHAYKH 'ISA PROJECT PHASE I: THE SURVEYS

by

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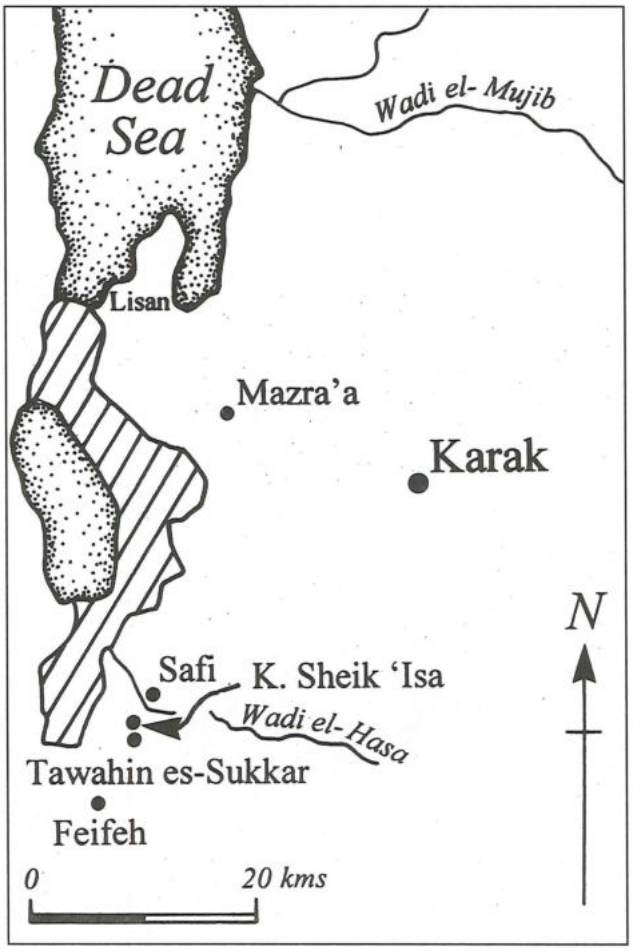
Introduction

A number of surveys, recent (MacDonald *et al* 1992; Politis 1998) and past (Mallon 1924; Glueck 1934-35), of the southern Ghawr Valley at the southern end of the Dead Sea have recorded the presence of establishments associated with the milling of sugar (probably sugar cane) and the processing of its extract. The most prominent and best preserved of them is Ṭawāḥīn as-Sukkar in Ghawr aṣ-Ṣāfī (Fig. 1), dating to the Mamluke period, perhaps earlier, and was first surveyed and planned in the early 1930s by Frank (1934). To the immediate north-west of Ṭawāḥīn as-Sukkar lies the mound of Khirbat ash-Shaykh 'Isa (Whitcomb 1992: 114) which may eventually be identified as Byzantine Zoara and/or Medieval Zughar; the site is known from the late sixth-early seventh century AD mosaic map in the Greek Orthodox church of St. George at Mādabā, where it is depicted as a walled city with ramparts surrounded by date palms. This paper reports a new project to record both sites, with particular emphasis on elucidating how the sugar processing installation at Ṭawāḥīn as-Sukkar may have functioned. The first stage, carried out in 1999, consisted of topographic and geophysical surveys, which followed on from an initial reconnaissance in 1997. The results of the surveys are presented here together with a preliminary scientific examination of some of the industrial waste from Ṭawāḥīn as-Sukkar.



1. Map of Dead Sea area.

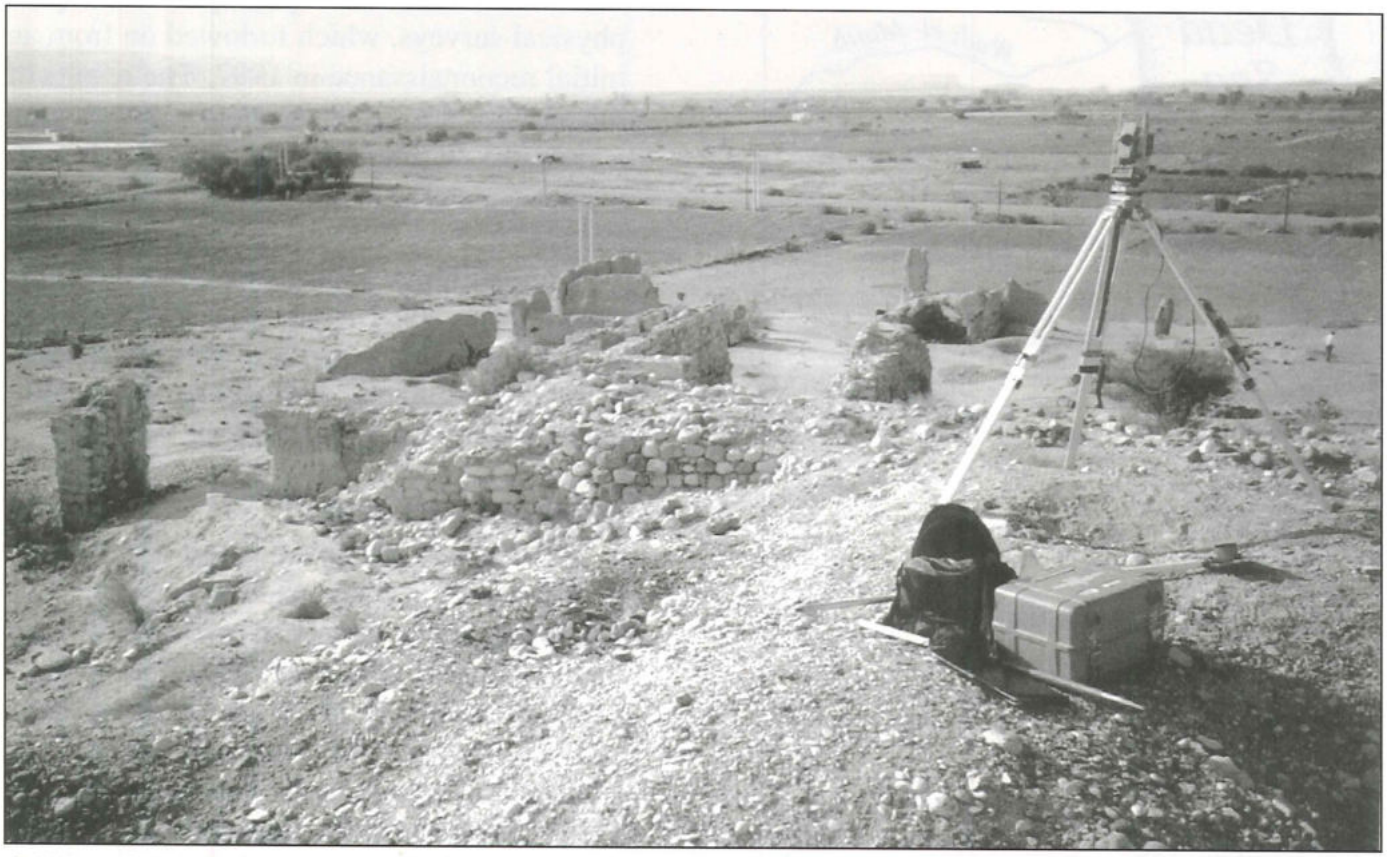
It is assumed throughout this paper that sugar from sugar cane was processed at aṭ-Ṭawāḥīn. This remains a working hypothesis until combined excavation and analytical data provide evidence to the contrary.

Topographic Survey

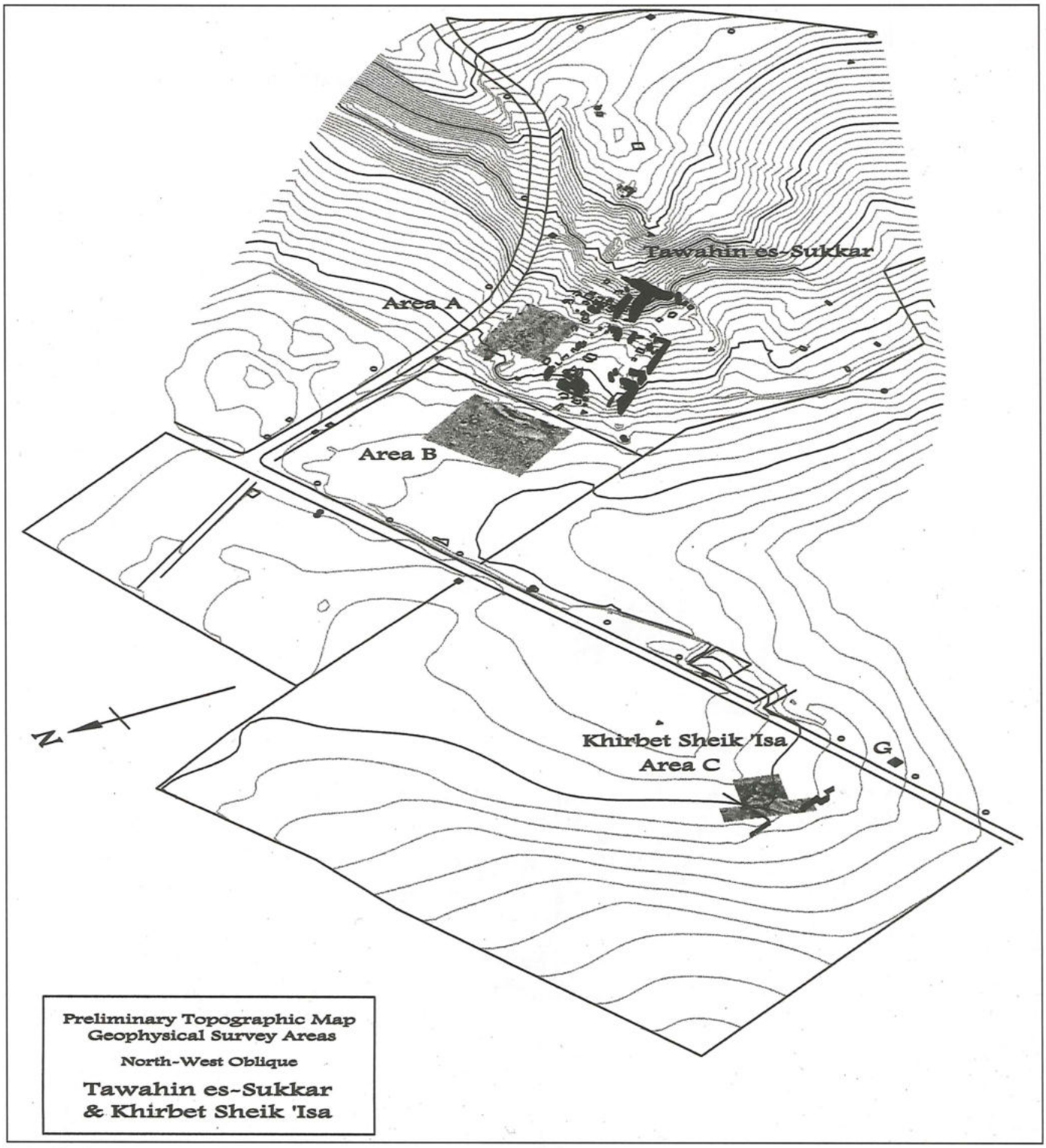
The descriptions given below arise directly from observations made in the course of the topographic survey (see Appendix for methods) with additional information coming from overhead aerial photographs taken in 1992 (Politis 1998: Fig. 6). Oblique aerial photographs from a helicopter taken by K.D. Politis in May 1999 (courtesy of the Royal Jordanian Air Force) will be presented in a later report. The first part of this section

places aṭ-Ṭawāḥīn in its physical context, and this is followed by a brief statement about what changes have taken place during the present century at the site and its immediate environs. A first effort is then made to interpret the standing remains and some underground structures at Ṭawāḥīn as-Sukkar, and finally Khirbat ash-Shaykh 'Isa is described.

Ṭawāḥīn as-Sukkar (Figs. 2-3) lie at the northern, lower end of a narrow neck of land projecting northwards and descending into the plain; the location is prominent particularly when approached from the north and west. Within the site there is a marked slope traversing much of it from south to north, especially by the aqueducts, but little from east to west. Behind the site the land rises within 500m to a ridge forming the southern border of the plain. To the east the site looks out onto low, open ground leading to the 'suburb' of aṣ-Ṣāfī, an-Naqa', and to the west the ground falls away quite rapidly to agricultural land. The water supply to Ṭawāḥīn as-Sukkar, which has yet to be fully investigated would most probably have come from the south-east, that is from Wādī al-Ḥasa, along a channel that hugged the lower slope of the ridge. What is visible today is an abandoned, modern irrigation channel running across the southern part of the site (Fig. 4). A small Islamic and modern cemetery area is situated to the immediate west of the site where it is suspected the ground has been levelled, exaggerating the slope down from the site and creating a natural drainage 'feature'. But the most prominent feature of the terrain throughout to the south, south-west and south-east from the top of the ridge downwards to the plain is the honeycomb effect resulting from extensive (illicit) digging of tombs, most of them Early Bronze I but also Byzantine (Politis 1998: Fig. 5). There is also a cemetery at an-Naqa' to the immediate east of the site where Ara-



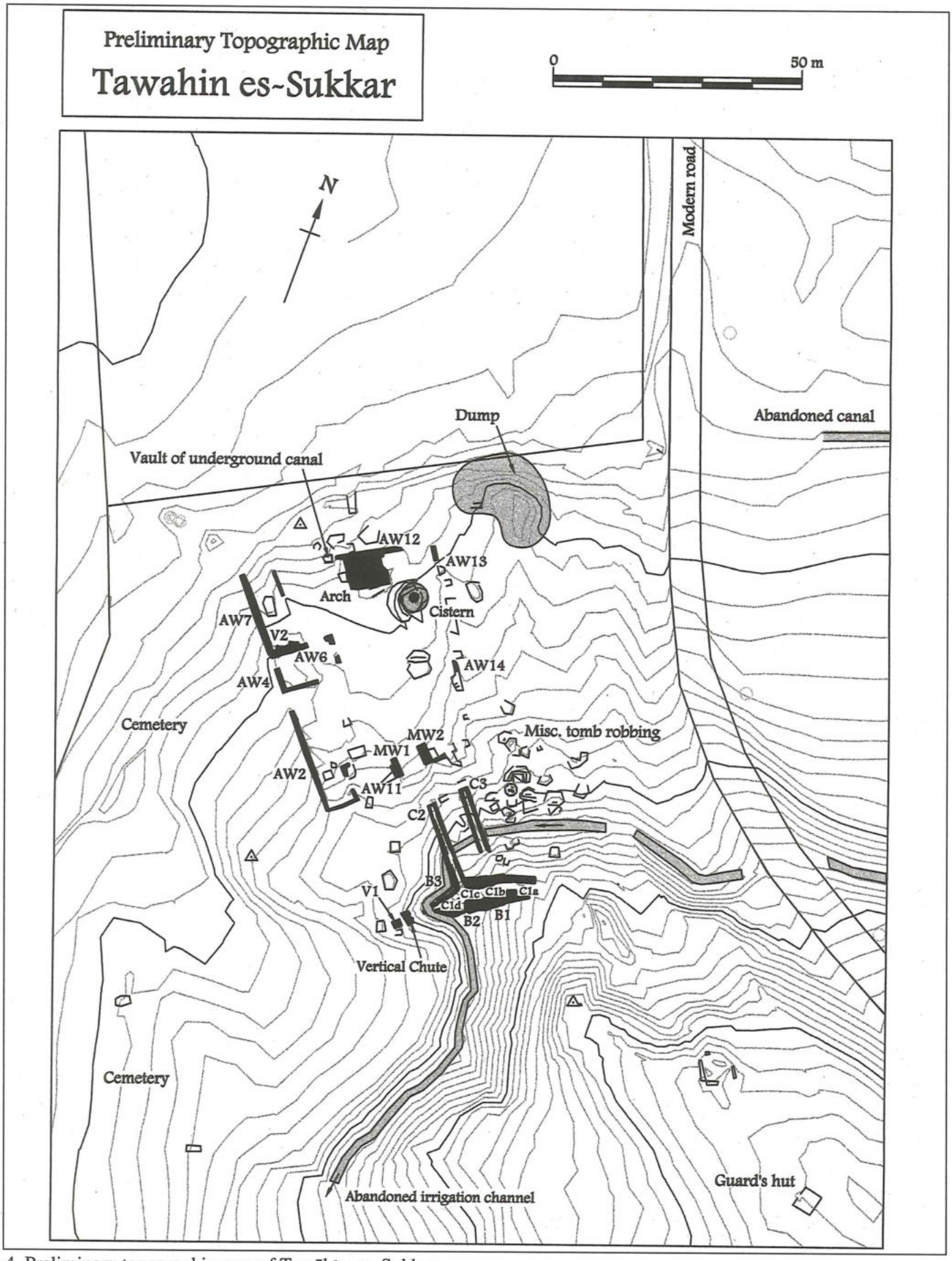
2. View of Ṭawāḥīn as-Sukkar in the foreground, looking NW to Khirbat ash-Shaykh 'Isa in the near distance and the Dead Sea in the far background.



3. Preliminary topographic map - NW oblique - of Ṭawāḥīn as-Sukkar and Khirbat ash-Shaykh 'Isa.

maic inscribed tombstones have been found (Politis 1998: Figs. 4 and 5).

Examination of maps and aerial photographs taken in 1961 and 1992 (Politis 1998: Fig. 6) makes clear that the appearance of the natural landscape in the immediate environs of Ṭawāḥīn as-Sukkar has altered during the course of the last half century. The former aerial photograph shows, for instance, roads/tracks that are not visible today: one that cuts westward across the northern extremity of the site and then turns abruptly to the south, another that runs across the field between Ṭawāḥīn as-Sukkar



4. Preliminary topographic map of Ṭawāḥīn as-Sukkar.

and today's main east-west road, and a third to the north of Ṭawāḥīn as-Sukkar and east of Khirbat ash-Shaykh 'Isa that most likely belongs to the British Mandate period. Between the first two of these roads and roughly parallel to them is the course of an abandoned canal leading to a small reservoir to the west of the site. There is an overhead power line clipping the NW extremity of the site and traversing the lower field in a SW-NE direction. Changes have inevitably occurred to the field systems; during the 1980s underground irrigation pipes were installed.

Considering the site on its own (Fig. 4), there are four important points to make at the outset: (a) Ṭawāḥīn as-Sukkar comprised (at least) two principal 'industrial' areas, the one that is most visible today involving the crushing/grinding of the sugar cane, and the other, only indirectly visible today in the form of the waste dump, which was where the sugar refining took place; (b) the striking visual dichotomy of stone-built structures and mud brick (adobe) walls; (c) phasing is evident in some of the former structures, and (d) since the site has not received previous attention in the form of either excavation or cleaning/restoration, it is partly and unevenly buried in both wind-blown sand and at the southern end by collapsed walling. As a consequence, the original ground surface is not generally identifiable. Adobe walls are not only prominent but along the site's western flank they are impressive, standing up to nearly 5m in places. But elsewhere, such as the centre and the eastern side, there is very little extant adobe walling, only surface evidence of its collapse. Much of this walling seems to stand alone (whether on natural or otherwise; see below), but there are some instances, in particular around the arch at the northern end, of the stone structure acting as a foundation or support for the adobe. Pending the results of excavation, the present authors currently believe that the adobe may post-date the sugar factory, although this need not be the case at the neighbouring contemporary sugar mills (see below).

That now leaves the extant stone-built structures above and below ground. The majority of these form the basis of the sugar installation, but there are others, notably the arch, that on the basis of building style and function seem to be incompatible with the installation itself and pre-date it. It is convenient now to proceed with the aid of Fig. 4 to a description of these structures and a tentative identification of their function, beginning at the southern end. Water was brought to the mill along at least one channel: Channel (C) 1 which was well built and is today in good condition seems to have had four distinct contiguous segments, shown as C1a-1d; it is also evident that the last segment, C1d, required considerable support in the form of two substantial buttresses B1 and B2 to the south and B3 to the north. The chronological relationship of C1a-C1d is as yet uncertain. There may have been a sluice device in C1d, separating the flow of water to C2 from that to the substantial structure housing the Vertical Chute; some 3m height of this chute, whose plaster coating and layers of water scale remain intact, is visible before it connects at the bottom to a basin and thence through a channel to vaulted structure V1. Cleaning/excavation will be required to ascertain the presence of a possible second channel parallel to C1 that fed C3. The two parallel Channels C2 and C3 (Fig. 5), the most striking structures at the site, were constructed as aqueducts each with a single arch leading to the north by a chute angled, in the case of C3, at ca. 45° and made up of joining, apparently unplastered cut-stone units, some eight of which survive *in situ*. An abandoned, modern irrigation channel, shown in Fig. 4 with its direction of water flow, occurs on the southern side of the site.

Moving northwards are the solidly constructed mill walls, MW1 and 2, nearly parallel to, but offset from, C2 and C3. The millstones, similar to those at the con-

5. Mill wall 2 (foreground) and Channels C2 and C3 at the aṭ-Ṭawāḥīn .

temporary sugar factories at Feifeh (with grindstone *in situ*) and al-Mazra'a (Fig. 1) were presumably located here. There are two rectangular holes on the inner side of each of these walls, the separation between these holes being less than 1m. Abutting the southern end of MW1 at right angles to it is a very short stretch of adobe wall (AB11) and a stone wall in the case of MW2. Before the arch, there is the underground vaulted structure V2 aligned with and apparently abutting AW6; the adobe beneath the vault appears to be a direct continuation of that above except that part of it (to the west) has been darkened by systematic burning or firing. To the east of this vault is a possible (underground) circular cistern. The arch, which aligns with neither MW 1 and 2 nor C2 and C3, has fine lower masonry blocks, suggesting a possible Byzantine date and thus pre-dating the sugar factory. Incorporated into the arch is much adobe wall (AW12). A section of vaulted roof is visible on the ground surface a few metres west of the arch, and in 1997 it was possible to enter this structure consisting of an impressive underground canal, a little over 1m wide and some 20m long running southward; in March 1999 half of it had collapsed. Among the many sections of adobe walls at the north-western and western sides of the site are some, notably AW2, 4 and 7, that were built on stone foundations; other walls may have been similarly built but the foundations are not visible.

A distinct feature of the site, also observed at Feifeh and Mazra'a, lying between AW 13 and 14 and the road running along the eastern side of the site is a dump composed of grey, compacted cindery ash with much inter-mixed charcoal (see section IV). This material, which spreads at least 20m to the east and south, should represent the waste from the refinery sector situated most likely at the northern end of the site.

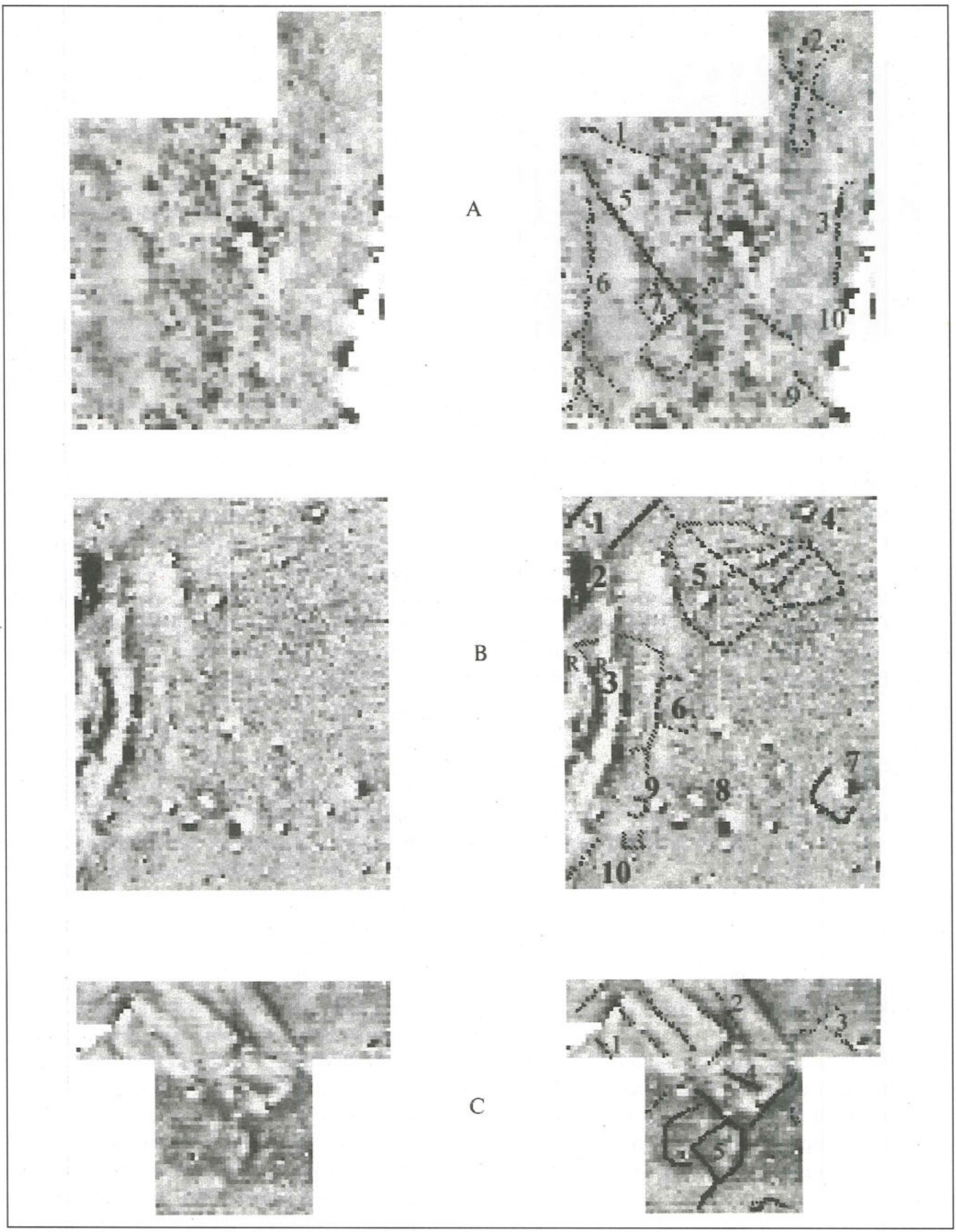
Khirbat ash-Shaykh 'Isa (Fig. 3) lies in a field across the main road from aṭ- Ṭawāḥīn to the north-west, forming a mound which is of little prominence today because of the destructive effects of agricultural activity. The presence of dark soil over the site, clearly visible in the available air photographs allows one to estimate the site's physical extent (Politis 1998: Fig. 6). There is a remarkable amount of surface finds from pottery to glass, mosaic tesserae and architectural stone, as the most recent investigator has noted (Politis 1998: 630). A section of the probable town wall (shown on Figs. 3 and 6d) and a possible gateway on the southern side (marked G in Fig. 3) have been exposed.

Geophysical Survey

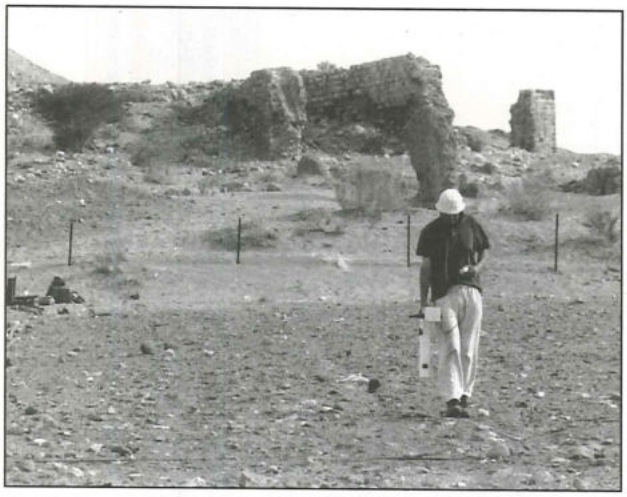
The purpose of the geophysical survey, employing in the main the fluxgate gradiometer (Fig.7), described in the Appendix, was to provide a rapid assessment of the near-surface structures/features that might exist in two areas immediately adjacent to aṭ-Ṭawāḥīn where the standing structures are few or absent. A similar exercise was carried out at the western end of Khirbat ash-Shaykh 'Isa specifically to detect building remains. The results in Fig. 6 consist of the magnetic map of each area (left) and its interpretation (right).

Ṭawāḥīn as-Sukkar

In *Area A* (Fig. 3), on the east side of the



6. Magnetic survey graphic (left) and its interpretation plan (right) of (a) Area A, (b) Area B, and (c) Area C. Dark areas represent negative magnetic anomalies.



7. Fluxgate gradiometer survey in progress in Area B with aṭ-Ṭawāḥīn in the background.

site and adjacent to the waste dump, the ground surface consisted of dark, compacted ash-cinder and loose sand. The graph of the magnetic data (Fig. 6a) shows a complex picture dominated by a broad rather noisy band running approximately north-south with one bi-polar feature roughly in the centre (4) that may represent a fragmentary furnace. Elsewhere there are weak, negative and generally linear anomalies that may be either (adobe) walls or tracks/paths:

1 merges into the noisy area in the centre.
2 cannot be interpreted at present.
5 finds alignments with 8 and 9 and probably elsewhere. It also includes enclosed structures around 7.
6 seems to align with the main layout of the installation; it may branch off at right angles at the southern end. 3 is tenuous but may be parallel to it.
10 is due to the modern power cable.

Collectively, there is the impression that these features are not contemporary but rather represent a palimpsest of activities, some of them perhaps modern. Which of them relates to the sugar installation remains to be determined.

One area in the centre of the site (not shown on Fig. 3), lying entirely in sand, was scanned from MW 1 and 3 northwards to the arch. Since changes in magnetic intensity were detected close to the mill walls, two (5x10m) grids were laid out and systematically surveyed: two small bipolar anomalies were found, but their significance is as yet uncertain.

In *Area B* in the field below the site to its north (Figs. 3 and 7) ten 10x20m grids were surveyed, the five closer to the site overlying the main ceramic scatter consisting of sugar vessel fragments and furnace debris. The results in Fig. 6b are of some complexity: there are both, clearly visible anomalies and others which are weaker and more speculative. Beginning at the western end, two wall-like, parallel features form 1, while 2 is a large, bipolar anomaly which could be a furnace remnant. The principal anomaly in this area, 3, is positive, slightly curved and bordered by two negative anomalies; one interpretation of 3 would be that it is the water canal observed in the 1961 aerial photograph (see above) whose extension is visible today to the east (Fig. 4). If this view is correct, it has probably damaged a number of earlier structures; for instance, it seems to have truncated a very weak positive anomaly traversing 3 at almost right angles, this anomaly proceeding to take on a sub-rectangular shape and bordering 6 (see below). 4 is a 'hotspot' of uncertain significance. Several very weak anomalies constitute 5, all of them perhaps adobe walls, one of which is of interest in the way it is at right angles to 1. The others form a distinctly less well ordered overall shape and moreover, on the south side they abut three 'hotspots'. 6 is another weak feature, sub-rectangular in shape, whereas 7 is apparently more square shaped with a 'hotspot' within it. A series of four 'hotspots' make up 8, and 9 is a small almost semi-circular structure with one of similar shape but different orientation to the east across a narrow N-S band of positive intensity. Finally, 10 is a stretch of ?wall which seems to have a parallel direction to 1. In sum, the situation is similar to that in Area

A, that is a range of features, ancient and modern, located in the field, perhaps only few of them, for instance the 'hotspots', relating to the sugar installation itself.

Upon completion of the magnetometer survey, two parallel 10m traverses (1m apart) crossing magnetic anomaly 3 were surveyed with resistivity (see Appendix). This operation, requiring the metal probes to be driven very firmly into the ground, was both time consuming and tiring, but the results were encouraging; high resistance values were obtained at R and R' in Fig. 6b, the latter coinciding with the negative magnetic anomaly.

Khirbat ash-Shaykh 'Isa

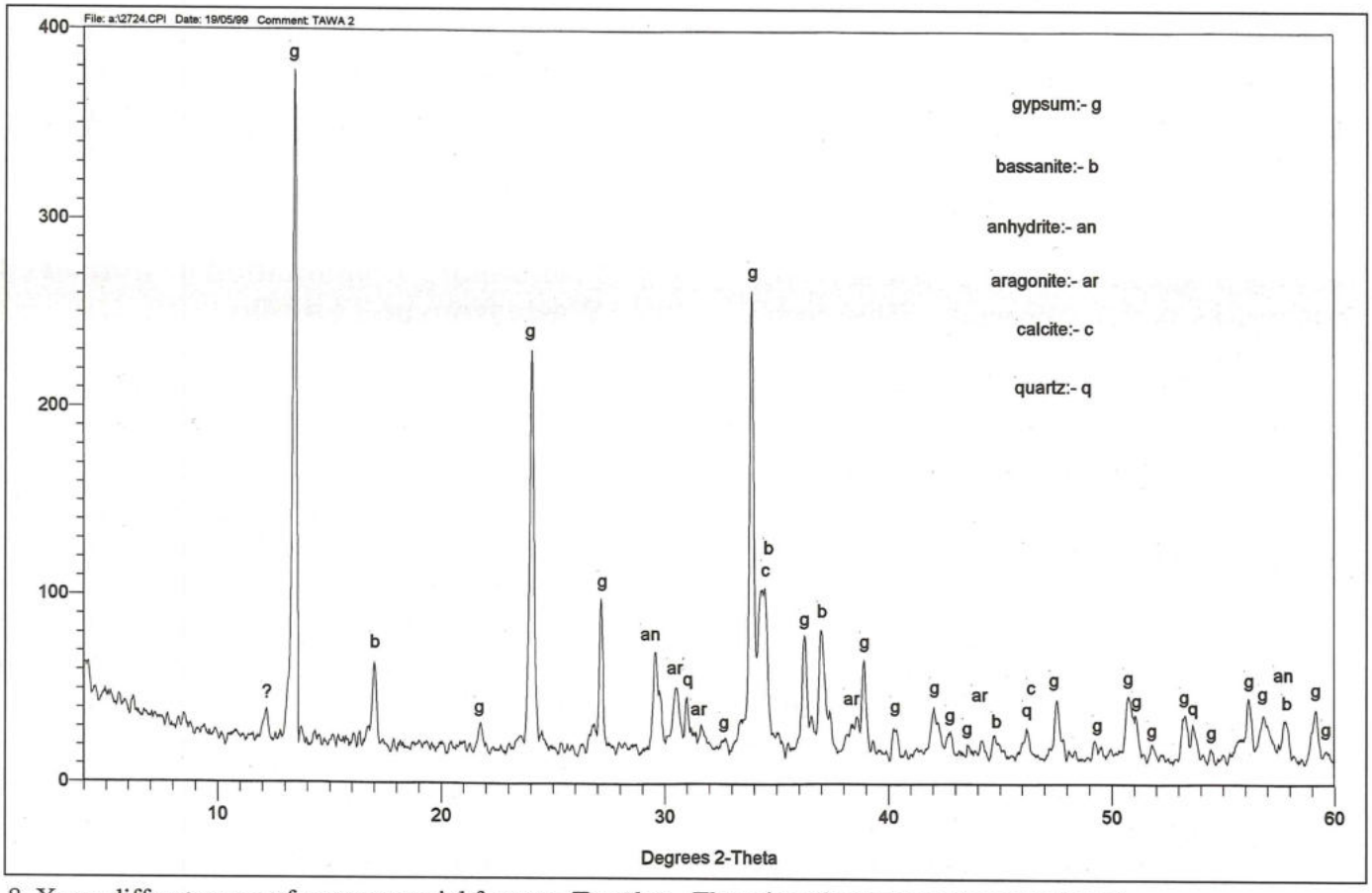
Time permitted only a small survey (*Area C*) at the western end of the settlement where an impressive stretch of the town wall close to the ground surface was recently exposed, as already mentioned. Survey conditions were good in the sense that the terrain was almost flat and there were few obstacles apart from a small Bedouin encampment. Within the area surveyed (see Fig. 3) there was a notable concentration of ceramic and industrial waste material. Furthermore, three types of top soil were noted, all of them dry and sandy: (a) white, almost powdery, (b) dark, probably burnt, and (c) brownish, perhaps arising from admixture of (b) with animal manure around the encampment. As Fig. 6c makes clear, some features are detected very clearly, as is their N-S and E-W orientation. The continuation of the excavated N-S wall is picked up; there is as well an E-W wall, part of which is visible on the ground surface, meeting a wall at right angles to it, and there is a right-angled branch from that (3). A rectangular structure is formed by 1 with two internal walls. 2 runs at a distinct angle to this structure but seems to join one of its corners. There is a short stretch of wall at 4 which is adjacent to a 'hot spot', and two apparently enclosed, irregularly-shaped structures, 5; a short stretch of wall is just picked up at the eastern edge of the surveyed area. In view of the wealth of detail obtained in Area C, the survey's continuation will be a priority in the second phase of the project.

Preliminary Examination of Industrial Waste from aṭ-Ṭawāḥīn

A small sample of industrial waste was collected from the eastern sector of the site associated with the spread of the ashy layer and cinder-rich material mixed with charcoal. One sample of cinder, off-white in colour, light in weight and very vesicular, was subjected to mineralogical analysis by X-ray diffraction. The peaks identified (Fig. 8) were those of gypsum ($CaSO_4.0.5H_2O$) and anhydrite ($CaSO_4$), as well as calcium carbonate as both calcite and aragonite. Quartz was also present as well as bassanite which constituted the second major component after gypsum. The composition of this cindery material is highly unusual since the gypsum is most likely produced artificially, probably as a waste product of the sugar refining stage or even the further processing of sugar ?cane waste after milling. Furthermore, the cindery material contains an organic component, in addition to the inorganic content just described.

Conclusions

In laying a foundation for further exploration of both aṭ- Ṭawāḥīn and Khirbat ash-Shaykh 'Isa, the topographic survey has provided a visual representation of the relationship between the two sites' setting, as well as allowing a first interpretation to be made of the standing structures at the former site. In view of the preliminary analytical data, a complementary characterisation of the industry at aṭ- Ṭawāḥīn in terms of the industrial waste *per se* looks as if it will be possible. We acknowledge that, while sugar processing was the original function of the installation, it may have had other functions during its lifetime; R. Abudelou (pers.



8. X-ray diffractogram of waste material from aṭ- Ṭawāḥīn. The mineral components are indicated.

comm.) has suggested, for instance, that perhaps wheat flour was the product of the mills in the installation's last phase. The geophysical survey has detected a wealth of buried features probably belonging to differing periods of time in the immediate vicinity of aṭ- Ṭawāḥīn whose significance will have to be tested by excavation. As for Khirbat ash-Shaykh 'Isa, the quality of the results of the admittedly limited survey bodes well for a survey of the whole mound.

Acknowledgments

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References

Frank, F.
1936 Aus der Araba I Reiseberichte. *ZDPV* 57.

Glueck, N.
1935 Explorations in Eastern Palestine II. *AASOR* XV for 1934-35: 7-9.

King, G.
1987 Survey of the Byzantine and Islamic Sites in Jordan, Third Season Preliminary Report (1982): The Southern Ghor. *ADAJ* 31: 439-459.

MacDonald, B.
1992 *The Southern Ghors and North East Arabah Archaeological Survey*. Sheffield Monograph 5.

Mallon, A.A.
1924 Voyage d'exploration au sud est de la Mer Morte. *Biblica* 5: 413-455.

Politis, K.D.
1998 Survey and Rescue Collections in the Ghawr aṣ-Ṣāfī. *ADAJ* 42: 627-633.

Whitcomb, D.
1992 The Islamic period as seen from selected sites. Pp. 113-125 in B. MacDonald (ed.), *The Southern Ghors and North East Arabah Archaeologyical Survey*. Sheffield Monograph 5

Appendix

The topographic survey comprised the systematic capture of height and feature points of aṭ-Ṭawāḥīn, Khirbat ash-Shaykh 'Isa and environs. In addition, some of the land in between the two sites was surveyed in order to join the coverage. Due to the open nature of the site, most of the survey was conducted with a Total Station (see below) situated on the high ground between the guards' hut and aṭ- Ṭawāḥīn. However, for features that were blind to, or too distant from this station, observations were made from other radiated stations. These numbered five in total, one of which was in the area of Khirbat ash-Shaykh 'Isa.

The features recorded were coded according to type and context; point and/or string. The broad categories of code were: spot heights, top and bottom of banks, man-made features, modern disturbances (digging) and significantly, the segments of upstanding walling and architecture. These building components were initially recorded at their foot (to facilitate ground contour modelling) and subsequently at the upper corner points. This procedure will enable 3-D representation at later stages of processing. The geophysical survey grids were recorded so that not only the positions but also the scaling and rotations of the geophysics graphics could be controlled. Figure. 3 demonstrates how the attached graphics provide an aid to interpretation.

The building segments proved the most difficult to capture, since careful attention to coding, stringing and intervisibility had to be maintained. Three further methods were used to augment the instrument survey: hand measurements, the use of a small 'retro-prism' for the more intricate parts of the site, and photography. Photographs were taken, where possible, 'straight on' and as such were virtually rectified so that they can then be used in any digital rendering or metric construction of building parts. Polaroid photography was used to provide on-site templates, primarily to show the exact location of observations to the upper reaches of the walls.

During the survey, observations were made to local control. This will enable the survey to be brought into the Jordanian grid. Near station 1 (in a former police post) was found the remains of a

triangulation pillar which represents Jordan's 'second order of control', that is a network of secondary triangulation of the country. Although damaged, observation of its elevation enabled absolute height to be introduced to the site survey (+/- 2m). Further observations to steel angle pegs adjacent to the road provided control in Easting and Northing of the Jordanian grid, enabling a subsequent transformation to be made. The co-ordinates of the pegs were obtained from recent Cadastral (Land Registry) mapping of the region. The elevation of the triangulation pillar was taken from the local 1:10 000 map.

A Sokkia Set 5 Total Station theodolite was used in the topographic survey, logging to a Psion LZ64 data-logger loaded with SDR software. This was down-loaded daily into a lap-top PC running Leica LisCAD Survey Engineering Environment software, with which most of the processing took place. In the final stages, the data was imported into AutoCAD (release 14).

Most of the *geophysical survey* was carried out with a fluxgate gradiometer (Geoscan FM36), a type of magnetometer well suited to the detection of many types of archaeological structure, and especially those that have been burnt or fired. It senses to a depth of ca. 0.5m. Readings were taken at 0.5m intervals along 10 or 20m lines spaced 0.5m apart within a grid (except in one central area which was scanned), and the results were then processed with Geoscan's Geoplot 2 program (using typically the despike, edge match and deslope functions). The resultant graphics shown in Figs. 3 and 6a-c are shade plots in which dark and light areas represent *negative* and *positive* magnetic anomalies respectively. Owing to the extent of detail observed in the plots, many of the features have been highlighted and numbered in the interpretation plans of each area (Fig. 6a-c). Frequent mention is made to the occurrence of localised bi-polar magnetic anomalies, called 'hotspots'; while some of these are probably associated with near-surface iron rubbish, the larger ones may be more consistent with the presence of fragmentary thermoremanent structures, such as furnaces. Electrical resistivity (Geoscan RM4) using the Wenner probe array (probe separation 1m, sampling interval 0.5m) was limited to one area only (B) mainly because of the difficulty of obtaining reliable electrical contact in the dry, sandy soil.