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<b>Authors(s)</b>	Politis, Konstantinos D., Kelly, Amanda, Hull, Daniel, Foote, Rebecca
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# SURVEY AND EXCAVATIONS IN THE GHAWR AŞ-ŞĀFĪ 2004

*Konstantinos D. Politis, Amanda Kelly, Daniel Hull and Rebecca Foote*

## **Introduction**

Survey and excavations were conducted in the Ghawr aş-Şāfī during March and April 2004. The project was sponsored by the Hellenic Society for Near Eastern Studies and supported by the Palestine Exploration Fund in collaboration with the Department of Antiquities of Jordan. Additional support came from ARAMEX International Couriers. During the course of the season's work, the board of directors of the Jordan River Foundation accepted to officially sponsor the project's future activities.

## **Survey Objectives**

The present survey is an attempt to draw together the results of eight years of small-scale survey work and excavation in the Ghawr aş-Şāfī, so that the research objectives and logistics of a concerted, longer-term survey of the region can be assembled. Work so far has been summarised in a series of ADAJ articles (see especially Politis 1998, 1999 and Photo-Jones *et al.* 2002). These articles have already pointed out that the 'antiquities of the Ghawr aş-Şāfī represent some of the most important archaeological finds in Jordan and the southern Levant', due to their sheer quantity and chronological diversity (Politis 1998: 631-2). Some of the work which led to current knowledge in the ghawr was carried out during excavations at nearby Dayr 'Ayn 'Abāṭa. Following this, a rescue project was begun in 1996 as a result of widespread illicit excavation in the region. From January 2002, this work has focused in particular on the sites of Khirbat ash-Shaykh 'Īsā and Ṭawāḥin as-Sukkar.

All of these various elements have been aided substantially by a series of high resolution aerial photographs taken in 1992 by the Royal Jordanian Geographic Society, and obtained by Konstantinos D. Politis (permit reference 16.1/1/2/17, 1417/1/, 27/5/1996). These photographs continue to serve as an essential guide to survey in the region. For this reason, an important objective this year was to have them properly rectified and apply ground co-ordinates to them. In this way, the photographs can

be employed as a layer in a Geographical Information System (currently the ArcView 3.1 package). This task, along with the overall 'drawing together' of previous work, can be summarized as follows:

- To gain ground control points so that aerial photographs may be used both as a base map and a geo-referenced prospect ion tool, enabling potential sites to be located using GPS.
- To revisit certain areas of earlier reconnaissance in order to obtain GPS co-ordinates, assess their condition, and discuss the feasibility of future work.
- To geo-reference earlier survey maps, by obtaining GPS co-ordinates for certain ground control points. These maps may then be drawn into a larger, overall map.
- To map the current and ongoing excavation work.
- To assess the overall viability of a long-term research project in the area.

## **Co-ordinate System**

In common with other current surveys in the Levant, the Ghawr aş-Şāfī project faces a potential dilemma with regard to the co-ordinate system adopted for mapping the archaeology (see, for example, Philip 2002, Ur 2003). Conventional ground maps thus far, such as the aş-Şāfī map (Edition 1, Series K737, Sheet 3052 II) produced by the Jordanian Ministry of Economy from 1960s aerial photographs, have used the Palestine Belt Grid, Universal Transverse Mercator Zone 36, to produce a ground co-ordinate system. However, since 1997, maps produced by the Royal Jordanian Geographic Centre have used a different, Jordanian grid system. This series of maps, available in 1:50,000 and 1:25,000 series are undoubtedly more accurate than their predecessors. However, this series has yet to be completed, and not all of the sheets are available for the southern Dead Sea region. For this reason, all co-ordinates for archaeological sites are currently being recorded in longitude/latitude decimal degrees, using the WGS84 datum, by a Garmin GPS 12 channel receiver. These can then be re-projected to produce

Jordanian co-ordinates at a later date.

Another technical matter which was resolved this season related to the value of heights surveyed in previous seasons. Previously, an arbitrary temporary bench mark had been used throughout. Calibrating this height to a 'real' height above (or in this case below) sea level had proved difficult, since the nearest Jordanian national benchmark (in a building close to the former police post) has recently been destroyed. We were able to obtain a relatively accurate real value for this TBM using a Trimble 4600 LS differential GPS with the professional expertise of Joseph Severn of the Museum of London Archaeology Service.

### Preliminary Results

Work is still continuing on all of the survey objectives outlined above; yet, it is possible at this stage to illustrate some preliminary conclusions. (Fig. 1) These results both facilitated the accurate mapping of many important new discoveries while also demonstrating strong shifts in settlement patterns in the Ghawr aş-Şāfi from the late Iron Age to the present day. The site of Tulaylāt Qaşr Mūsā al-Ḥamid, first published in 1999, suggests a fairly large Iron Age II settlement towards the south-west of the Ghawr aş-Şāfi (Politis 1999). We now have accurate co-ordinates for this site, and can locate it on the aforementioned aerial photographs. Nabataean activity in the ghawr is more difficult to summarise since it appears to be more geographically diverse and less concentrated. Progress was made this year in mapping the location of a possible Nabataean inscription in the Wādī al-Ḥasā, as well as the course of a rock-cut channel leading from the wadi westwards into the ghawr itself. The fortress of Umm at-Ṭawābin was visited, and its condition noted. It has been generally assumed (mainly as a working hypothesis following previous survey in the ghawr) that the settlement focus for late Roman through to mid-'Islamic' occupation in the area was in the vicinity of Khirbat ash-Shaykh 'Īsā (Photos-Jones *et al.* 2002: 591). Certainly, current excavation work at this site has produced pottery approximately conforming to the later phases of this period, although this work is very much at a preliminary stage. Mid-to-late 'Islamic' period settlement shift to the site of al-Ameri seems likely given the date of surface sherds observed there. An important element of the 2004 survey season was establishing the location of the pre-1967 twentieth-century site of aş-Şāfi al-Qadim. Today, this site is represented an active Friday mosque (Fig. 2), surrounded by a series of bombed-out municipal structures of adobe brick

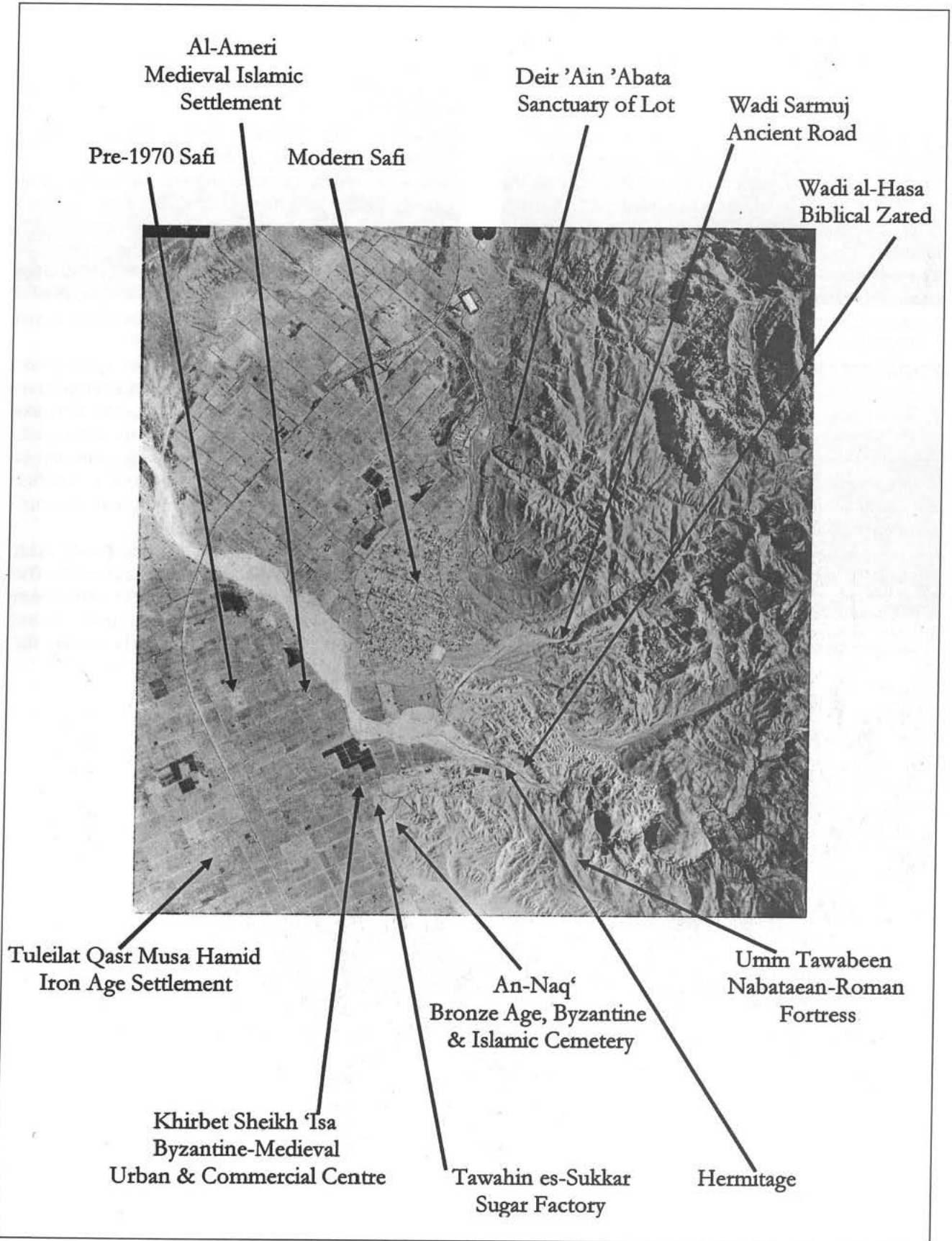
and concrete (Fig. 3). Although comparatively recent, the discovery of this site fills what had hitherto been a gap in our knowledge regarding the settlement shift in the region. Given the very modest size of aş-Şāfi al-Qadim compared with earlier settlement centres, it seems likely that by the late nineteenth and earlier twentieth centuries occupation was much more dispersed throughout the ghawr. Thus, aş-Şāfi al-Qadim probably housed only municipal structures such as a school, local council offices and a mosque, with the majority of settlement taking the form of nucleated farmsteads dispersed throughout the agricultural fields. It is important, therefore, that aş-Şāfi al-Qadim be fully planned and recorded in subsequent seasons.

Communication routes into, and across, the Ghawr aş-Şāfi constitute an important element in understanding settlement patterns in the area. For this reason, a multi-period road in the Wādī Sarmūj, initially detected in 1999 (Ben-David 2001: 140-144), was revisited. The road was followed for at least 5km from close to the mouth of the wadi, up into the mountains of the interior. The road consisted of a delineated and variably metalled surface (Fig. 4) while also featured a series of associated bridges, temporary ancillary settlements and artefact scatters. Producing an accurate map of this feature and outlining a strategy for further survey work along its length will constitute one of our future objectives.

Another element of this season's work was to plot the location of cemetery sites in the region. These have already been described in some detail; in previous reports, and excavation work is ongoing (Politis 1998). Nevertheless, the basic plan of the multi-phase cemetery of an-Naq' has been started through the establishment of several survey stations in the area. Modern, visible features such as main roads and telegraph poles have been plotted, so that previous work in the area can now be accurately related to the aerial photograph base map. This work was carried out using a Topcon GTS-230 total station theodolite, kindly lent to us by the baladiyyat aş-Şāfi.

Further tombs were discovered, and their position mapped, in the Wādī Sarmūj. The general appearance and dimensions of these tombs, along with the occurrence of surface pottery, correlates with tombs of Middle Bronze Age II date similar to those identified and excavated at Dayr 'Ayn 'Abāṭa (Politis 1995: 484-488).

As well as survey work in the base of the ghawr itself, further prospection was carried out in the associated wadis which lead into the ghawr. In particular the Byzantine monastic hermitage on the



1. Annotated 1992 aerial photograph of the Ghawr aṣ-Ṣāfi (courtesy Royal Jordanian Geographic Society, Amman).



2. *Mihrab* and *Minbar* inside Friday mosque, aş-Şāfi al-Qadim (photo: K. D. Politis).



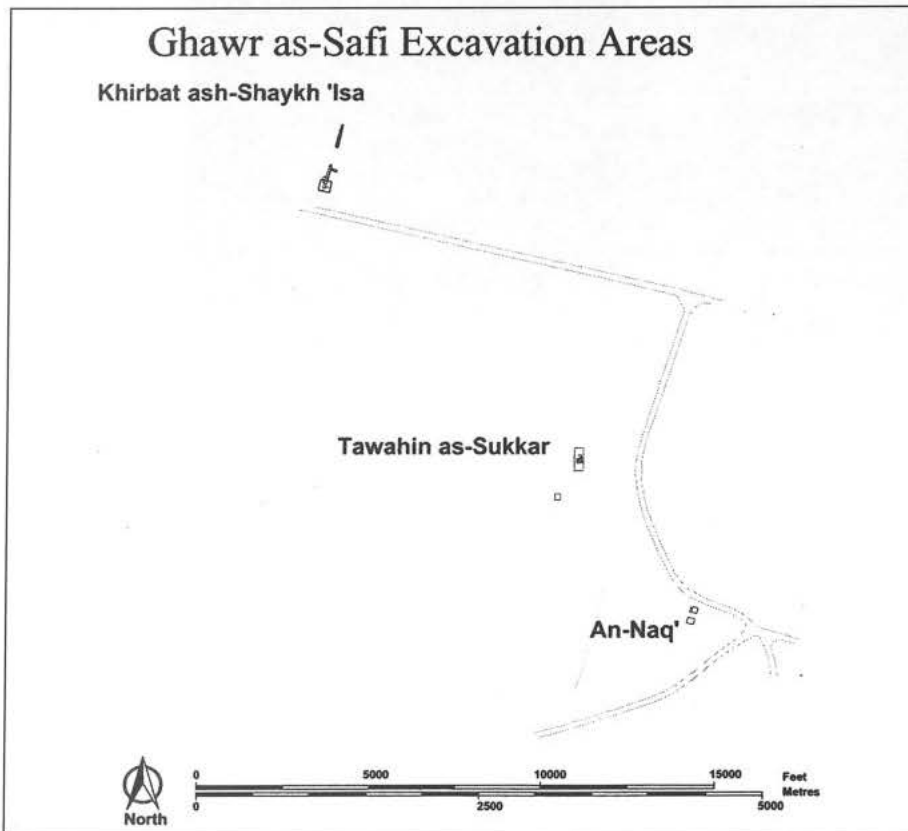
4. Ancient road at Wādi Sarmūj connecting the Ghawr aş-Şāfi with the Karak plateau (photo: K. D. Politis).



3. Friday mosque and other municipal buildings at centre of aş-Şāfi al-Qadim (photo: K. D. Politis).

north slope of the Wādi al-Ḥasā (described by Politis 2001: 588) was revisited. It was found to have been robbed out further still, and traces of a fresco within the prayer niche almost totally destroyed. Detection and investigation of sites like this one is thus a pressing issue, since a network of further monastic sites of varying size throughout the surrounding hills is likely.

Finally, the excavations at Khirbat ash-Shaykh 'Īsā and Ṭawāḥin as-Sukkar were surveyed. The position of trenches and the features within them can now be plotted on the overall map of the Ghawr aş-Şāfi (Fig. 5). When overlaid onto the



5. Location map of 2004 excavation areas in the Ghawr aş-Şāfi.

aerial photograph for the area, it seems that the large building under excavation at Khirbat ash-Shaykh 'Īsā is in a location where there is substantially less of the thick, ashy deposit which covers most of the site. This may imply that this structure was domestic or municipal in nature, rather than industrial.

### Future Work

Having established what might be tentatively termed as a 'working model' for the patterns of settlement shift across the Ghawr aṣ-Ṣāfi the following research agenda is suggested for a more concerted programme of survey work commencing in 2005:

- To continue the task of linking the excavation work at Ṭawāḥīn as-Sukkar and Khirbat ash-Shaykh 'Īsā by conducting field walking both in between and around the two sites. This will serve not only to clarify the spatial relationship of the two, but also more accurately define the extent of the two for heritage management purposes. It is as yet unclear, for example, which zones of Khirbat ash-Shaykh 'Īsā may be termed 'industrial' and which 'domestic'.
- To clarify the patterns of settlement shift and contraction between the mid-Islamic period and the present day. It seems from preliminary observations that the urban focus may have moved from Khirbat ash-Shaykh 'Īsā to al-'Ameri in the late Islamic period, then subsequently, to aṣ-Ṣāfi al-Qadīm at some point in the early twentieth century. The scale, nature and date of these shifts remain ambiguous, however.
- To continue to map late Roman and Byzantine monastic activity throughout the region. This will require substantial survey work in the wadis and jabals leading into the Ghawr aṣ-Ṣāfi especially in the vicinity of Wādī al-Ḥasā, but also further north in the Wādī al-Sa'id and Wādī Sarmūj. This will involve understanding the nature of such sites also, as already a picture of considerable variation among monastic sites is emerging from larger communal centres to isolated hermitages and prayer niches.
- To understand the nature of resources and provision for human activity throughout the Ghawr aṣ-Ṣāfi. Water provision in the region is beginning to be understood, both in terms of supply for the Ṭawāḥīn as-Sukkar mill and also more general irrigation in the past. Sources of stone, timber, metal ores and other raw materials are also important for understanding the long-term settlement and industrial activities in the ghawr. Field systems may also be visible in the less

heavily farmed areas of the ghawr.

It is intended that these objectives be achieved by a combination of methods, each selected according to the needs of the site or sub-site and decided on in stages. In general the methodology will be to detect sites through a combination of aerial photography and local knowledge, gain an impression of their extent, date and nature through field walking (and geophysics where appropriate), map them and then decide on further strategy (in a similar way to that used by Philip in the Homs region of Syria, Philip 2002). In recent years, a high degree of threat from illicit excavation has been noted, which has tended to play a role in both site detection, but also subsequent rescue strategies (Politis 1998: 627). Future strategy in each case will consist of a careful balance between the research aims outlined above, and the perception of threat to the integrity of the site. In certain cases, interventions in the form of excavation will be made. However, it is not intended that such excavations will divert resources from the main foci of Khirbat ash-Shaykh 'Īsā and Ṭawāḥīn as-Sukkar.

## 2004 INVESTIGATIONS

### Excavations at an-Naq' Cemetery

#### *Aims and Objectives*

At an-Naq' (just east of Ṭawāḥīn as-Sukkar) two trenches, measuring 5m x 5m and oriented north-south, were opened in an area which was badly disturbed by tomb-robber activity (**Fig. 6**). The main objectives were to determine whether the area had any remaining undisturbed graves and attempt to date those remains.

#### *Findings*

The first trench (AN-I) yielded ten extended ar-



6. Graves in Trench I, An-Naq' from south (photo: K. D. Politis).

ticated burials. The graves were lined with unworked stone slabs and covered with large roughly-cut capstones. The graves were arranged on a north-south axis with the head to the south. In one instance the head was secured in place by pebbles positioned to either side skull. Only one skeleton was associated with any grave goods, consisting of two small Early Bronze Age pots placed beside the skull.

The orientation and construction of these graves does not concur with those found during previous excavations at an-Naq' which belonged to the Early Bronze Age period (Papadopoulos *et al.* 2001: 191, fig. 2). Furthermore, the relocating of Early Bronze Age pots is reminiscent of an early Christian ritual recently observed at sites in the region (Politis 2001: 586-588).

In a second trench (AN-II) opened immediately to the south, no burials were found.

Although a relatively limited period of time was spent in this excavation area and the results were mixed (undisturbed burials but with virtually no grave goods), it was still maintained that this area should be the focus of future investigations.

### Excavations at Khirbat ash-Shaykh 'Īsā

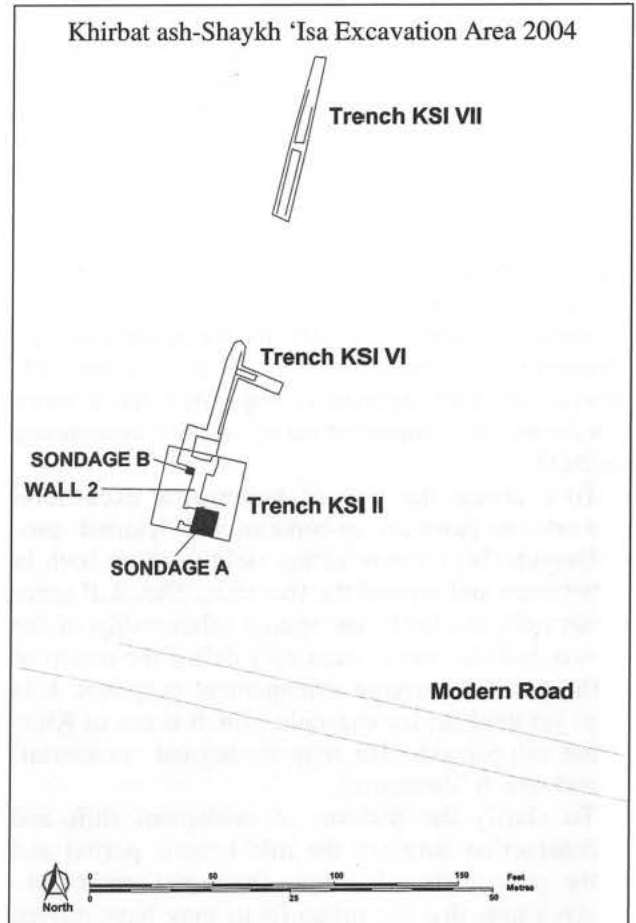
The ancient sites of Khirbat ash-Shaykh 'Īsā and Ṭawāḥin as-Sukkar are located approximately 150 metres apart at a distance of a 0.5km from the present location of the village of aṣ-Ṣafi (see Fig. 1).

#### *Aims and Objectives*

At Khirbat ash-Shaykh 'Īsā a trench (Trench II), measuring 10m x 10m, was laid out to investigate a monumental wall running north-south (Wall 2) with a westward projection (possibly a city wall tower), which had been revealed in 1995 by a bulldozer cut along its west face (see Waheeb 1995: 555) (Fig. 7). Prior to excavation the visible portion of the wall had considerable width of 1.60m and was constructed of large ashlar masonry and as such, was thought to represent the city wall of medieval Zughar (see Photos-Jones *et al.* 2002: 607). It was hoped to identify any historic activities either 'inside' or 'outside' the structure/city, to retrieve foundation pottery dating the wall and to identify any intersecting or parallel walls that might define habitation or industrial activity on the east side of the wall (i.e. Wall 2).

#### **Findings**

Excavation established that the height of Wall 2 from its foundation to the spring of an arched doorway, which pierced the wall, was



7. Location map of Khirbat ash-Shaykh 'Īsā excavation areas 2004.

3.34m (Fig. 8). Preliminary studies of the associated ceramics suggested Umayyad or Abbasid associations. The arched doorway measured 1.70m wide along the west face, widening to 2.22m on the east face. This width would not accommodate passing pack animals (barely one) and consequently, the doorway cannot represent the main gateway of



8. Upper part of springing of arched doorway (on right) and Sondage B (on left) at corner of Wall 2 and tower foundation, Trench II, Khirbat ash-Shaykh 'Īsā (photo: K. D. Politis).

the city. Nonetheless, the wall incorporates finely dressed ashlar blocks and its associated doorway could still constitute a minor pedestrian entrance.

A major rectangular projection in Wall 2 rested on substantial foundations (Fig. 9). A plastered area discovered to the west side of Wall 2 at its intersection with the projection seems to represent a dump. A large quantity of aqua glass found in the layer above context 11, may be representative of the same activity.

The discovery of an intact sugar pot cone in Sondage A (opened within the 10m x 10m trench on the east side of Wall 2) not only provides the first complete example at the site, but also bears out a close relationship between Khirbat ash-Shaykh 'Īsā and the Ṭawāḥin as-Sukkar. Recovery of fine examples of re-constructable glazed pots and a variety of other glazed sherds excavated in every context demonstrate the high level of material culture at the site (Fig. 10).



9. Depth of Sondage B at corner of Wall 2 and tower showing foundations, Trench II, Khirbat ash-Shaykh 'Īsā (photo: K. D. Politis).



10. Re-assembled glazed bowls dating from 12th –14th centuries AD from Layer 1(b), Trench II, Khirbat ash-Shaykh 'Īsā (photo: T. Springett).

## Excavations at Ṭawāḥin as-Sukkar

### *Aims and Objectives*

1. To establish the full extent of the mill chamber associated with the easternmost leat.
2. To reach the foundation layers at the base of the northern wall of the mill chamber.
3. To reach the foundation layers at the base of the northern wall of the mill chamber.
4. To establish the source of water for the mill and examine how this water was conducted to Ṭawāḥin as-Sukkar.
5. To establish the typology of the mill.
6. To determine the chronological relationship between Ṭawāḥin as-Sukkar and Khirbat ash-Shaykh 'Īsā.

### Structural Description of Ṭawāḥin as-Sukkar

The standing architecture at Ṭawāḥin as-Sukkar consists of two parallel edge-runner water-mills (with oblique penstocks) operated using high-powered water jets (Fig. 11) and a third water-mill (with a vertical penstock) to the west (Fig. 12). The third mill at Ṭawāḥin as-Sukkar, with the vertical penstock, is relatively smaller than the edge-runner examples (generating a smaller head), last in sequence to be fed by the aqueduct and, consequently, possibly of secondary importance to the parallel arrangement.

The substructure walls of the two parallel leats still stand to heights of about 4m in places. The channels are still visible along the tops of both leats where they are defined by finely-cut sandstone blocks. The substructure walls are constructed using a mortared-rubble core faced with rough courses of natural stones of similar size and shape. The stones are mainly water-rolled and must have been collected from the nearby wadi. Smaller water-rolled stones are used for packing between the larger examples. Each of the parallel leats incorporates a single arch with a height of approximately 2m. On approaching the mill-house installation the leats



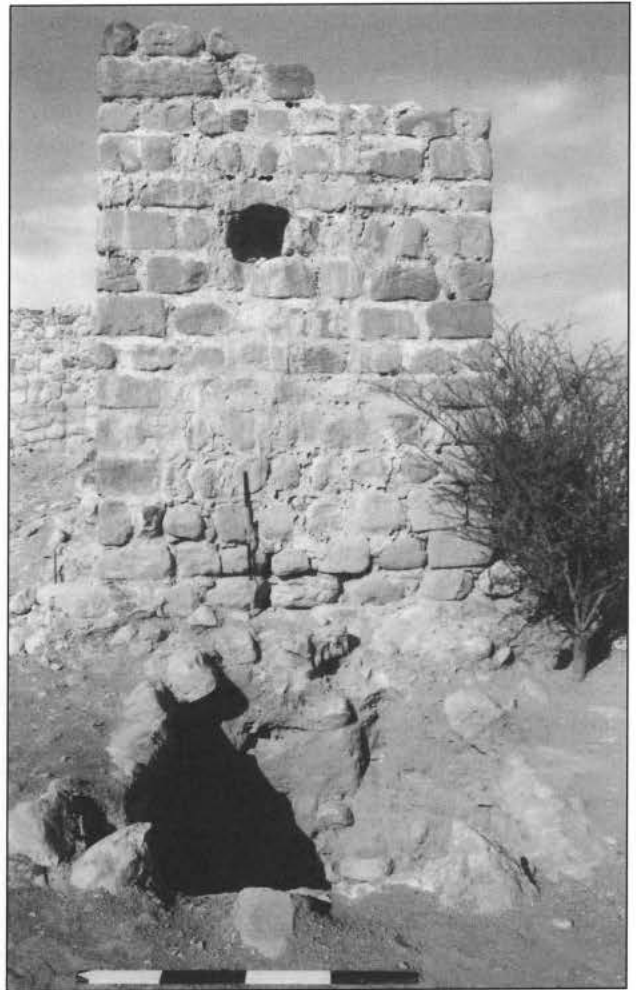


11. View of two parallel oblique penstocks from north-eastern edge-runner water mill chamber in Trench VI, Ṭawāḥin as-Sukkar (photo: K. D. Politis).

descend sharply (yet obliquely) while the channel width tapers. Both channels are lined with series of U-shaped sandstone troughs along this sharp descent into the installation. Although it is conceivable that the water could be stopped at the base of the chute by a sluice (as previously suggested by Photos-Jones *et al.* 2002: 602), it is more likely that the water flow would have been cut off (and thus controlled) along the main branch of the channel behind the parallel leats so that it could be diverted to whichever mill-house was in operation. Such an arrangement has been outlined by Jones *et al.* who refer to four distinct segments along the main aqueduct branch behind the parallel leats (2000: 527). These channel divisions were supported by substantial buttressing and possibly facilitated sluice devices at this point.

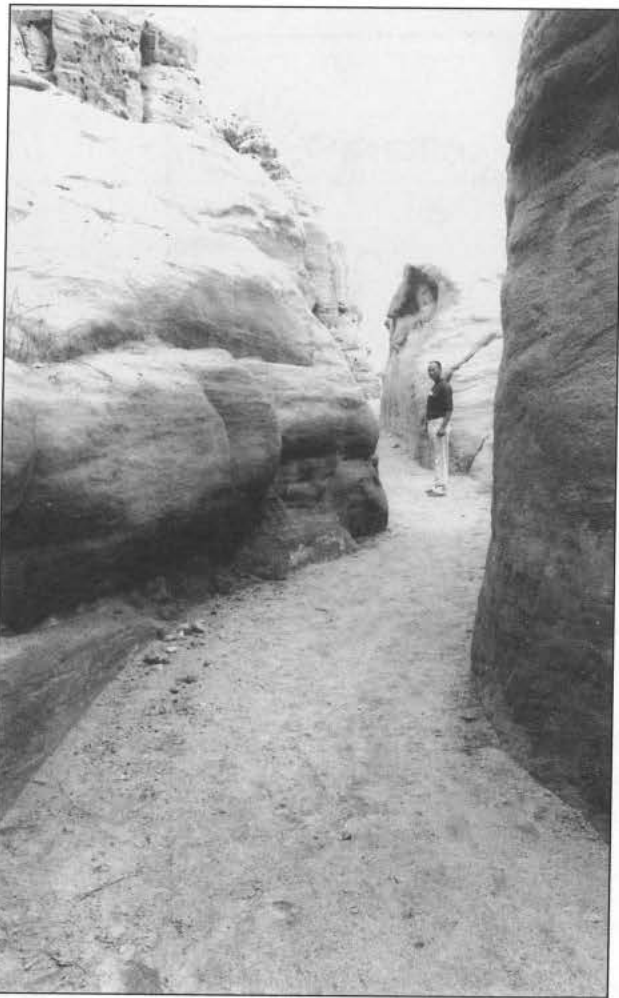
### The Aqueduct

All three mills within the complex were fed by a



12. Vertical penstock of western mill at Ṭawāḥin as-Sukkar (photo: K. D. Politis).

substantial contour-line gravity-flow aqueduct which tapped the Wādī al-Ḥasā and descended along the south-western contour of the wadi mouth, using gravity flow to reach the mill. High in the mouth of the wadi a considerable stone-carved conduit was discovered during the 2003 season of work (Politis 2004) with a stone-carved *specus* measuring 1.5m-2m in width (Fig. 13). An inscription directly south of this tract of channel may mark the point at which the water was tapped, perhaps with the use of a dam which has since been washed away. The width of the aqueduct's channel, directly behind the parallel leats, is 1.35m while the channel widths of the parallel branches are 0.95m. The considerable dimensions of the channel itself (both in the wadi and directly behind the milling installation), the presence of three large water-mills and evidence supporting a high degree of industrial activity at the site all suggest that a substantial amount of water was necessary for the installation



13. Stone-carved conduit on the south-western side of the mouth of the Wādī al-Ḥasā (photo: K. D. Politis).

to operate at its full potential<sup>1</sup>.

Sinter build-up, a calcareous encrustation which generally grew at a rate of 1mm a year (at least in Roman aqueducts, see Kessener 2000: 111), is evident in places along the substructure walls of the leats and on the soffits of the voussoirs of the western arch. This evidence either reflects a degree of leakage during the operation of the mill or, more likely, marks the point at which the mill fell into permanent disrepair.

The vast amount of water directed towards the site was also used to irrigate the surrounding countryside where presumably cane was cultivated (see Greene 2002: 760). The vault of an underground channel was visible at the northern extent of the complex in 1997 (Jones *et al.* 2000: 528). The channel was over one metre wide and over 20 me-

tres long running on a north-south axis.

### The Eastern Mill House

#### Trench VI

At Ṭawāḥin as-Sukkar an extension trench (measuring 10m x 10m) was opened to the north of the main trench excavated in 2002 (Trench VI). The area was investigated to establish the extent of the eastern of the parallel mill houses and to confirm how the vaulted room below the main mill chamber (of the eastern mill house) was accessed (Fig. 14).

#### A. The Main Mill Chamber (of the Eastern Mill House)

The northern extent of the millstone chamber was completely cleared yielding a substantial room with dimensions 6.90m (north-south) x 4.80m (east-west).

The centre of the room was occupied by a substantial base stone (with a diameter of 3.10m). The upper millstone has fallen over the north-eastern lip of this base stone but would have originally sat on edge and rotated over the floor of the base stone with the aid of wooden beams and a collar stone which would have secured it in place. The floor of the entire room was originally paved with flagstones which mostly now survive in situ in the south-eastern corner of the room. Isolated examples survive at the base of the eastern and western walls of the room. Numerous fragments of fallen paving slabs were found in a thick layer abutting the lower tiers of the northern façade of the overall installation. These paving slabs must have fallen from this room (i.e. the millstone chamber), possibly dislodged by the collapse of substantial adobe brick walls onto the flooring of the northern section of the room.

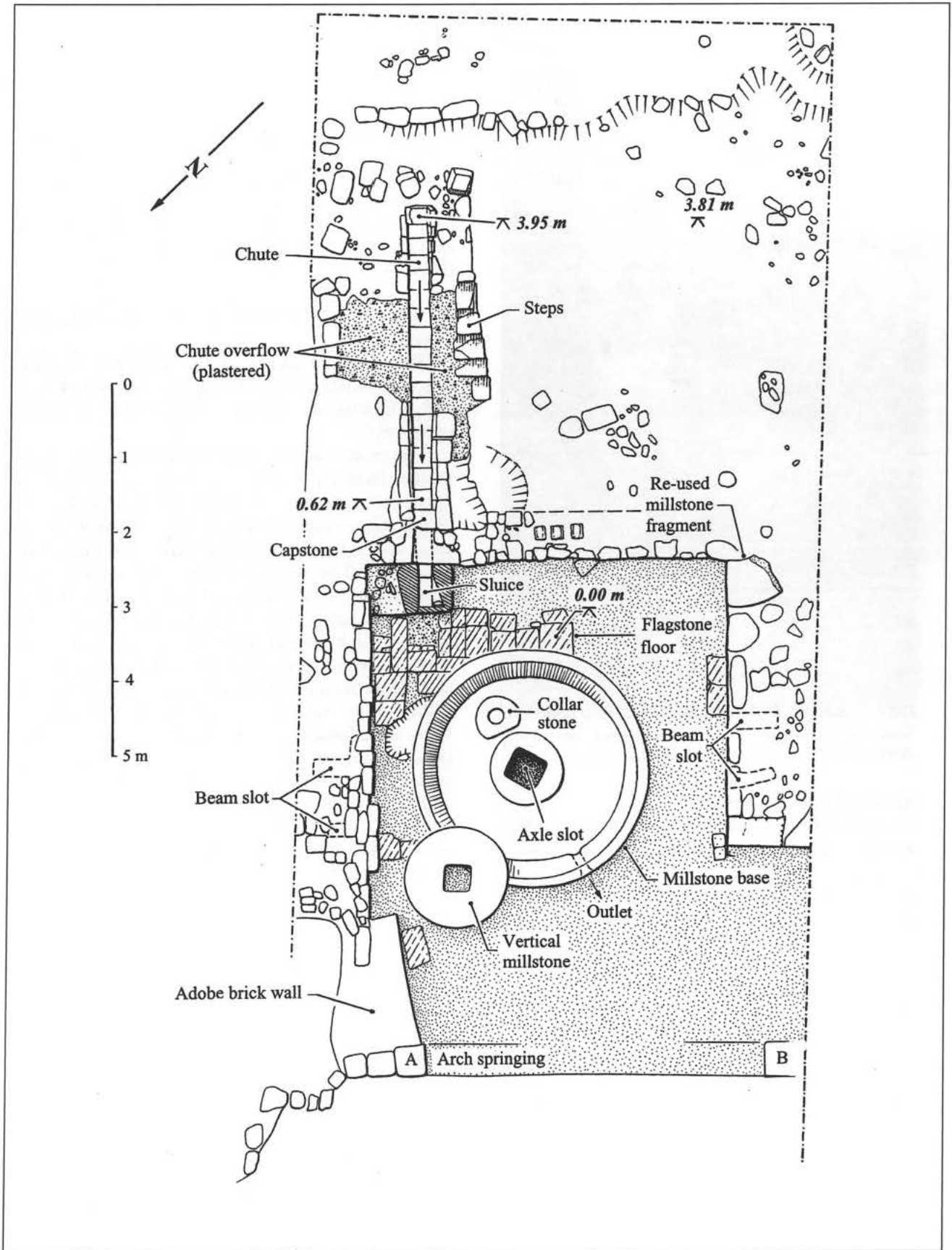
#### B. The Vaulted Chamber Below the Main Mill

Directly below the lower or base millstone a vaulted chamber, which would originally have held the wheel emplacement, was investigated. The chamber was filled with sand to a level covering the spring of its barrel-vaulted roof. The voussoirs of the barrel vault consisted of finely-cut dressed blocks of both limestone and sandstone. An arched doorway discovered in the northern wall facilitated access to the area (Fig. 15).

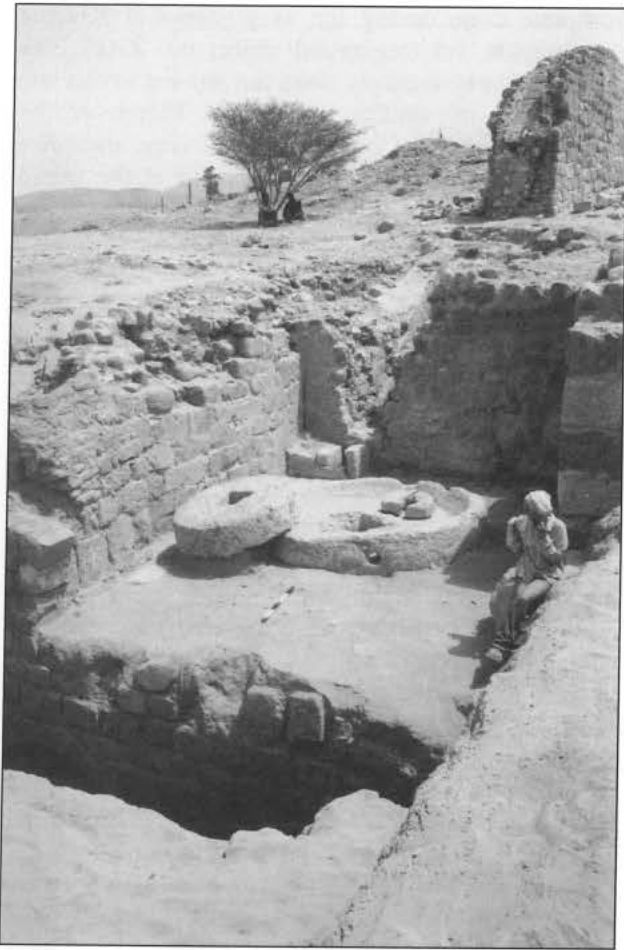
It was established from a brief investigation of the vaulted chamber that the structure was reused

1. The scale of the overall installation is comparable to the second mill at Kouklia in Cyprus. The major difference between these two installations is that at Kouklia the mill is divided into two main parts, the mill-house and the grind-

ing hall and only the pressing-out of the cane mash was water-powered while the grinding of the cane was animal-powered (von Wartburg and Maier 1983: 303). At aṣ-Ṣāfi all three mills are water-powered.



14. Plan of mill chamber, Trench VI, Ṭawāḥin as-Sukkar, Ghawr aṣ-Ṣāfi.



15. The mill chamber and penstock chute in Trench VI from north (photo: K. D. Politis).

as a burial area once its original function had ceased. It can be stated confidently that this vaulted chamber originally housed a wheel emplacement similar to that found in the second complex at Kouklia in Cyprus (TST 1) (Maier and Karageorghis 1984: 334). Similarly, the gravity-flow aqueduct system would have terminated in a covered pressure channel tapering narrowly towards a narrow spout. The water jet issuing from this spout would have operated a horizontal wheel which would have driven the upper millstone by means of a wooden vertical shaft and cross beam. The shaft may also have engaged with some kind of wooden gear as indicated by corresponding sockets in the eastern wall elevation of the upper storey. As aforementioned, the tail-stream exited the complex through a subterranean conduit which runs northward from the complex.

### C. The Northern Façade of the Eastern Mill House

Excavation in the northern section of the trench uncovered the northern façade of the eastern mill chamber revealing a finely constructed two-storied

façade. This northern wall was cleared to a depth of 4.20m whereupon a cobbled surface was reached. Its level at the threshold of the doorway which pierces the wall verifies that this cobbling represents the original ground surface.

The upper storey of the northern wall of the mill chamber incorporated two broad-spanning arches which formed the northern façade of the substantial mill chamber described above. The lower storey of the façade constituted a solid stone wall pierced by an arched doorway (Fig. 16).

The collapsed western arch of the upper storey was composed of fourteen finely-cut blocks (average dimensions 0.50m x 0.35m x 0.25m) including a reused architectural block bearing an incised cross (registered object no. Z-GS 27). The collapsed arch rested on alternating layers of collapsed and disintegrating adobe brick. These deposits signify the final collapse of the structure following the abandonment of the mill (although the duration of the period between the cessation of operation and the collapse is not, as yet, clear).

The lower storey of the northern wall of the eastern mill house consisted of ten horizontal courses of finely-cut stone blocks (average dimensions 0.40m x 0.30m). An arched doorway (2.05m x 1.90m) pierced the wall facilitating access to the vaulted chamber (which would have held the wheel emplacement). The doorway presumably allowed access for maintenance and supervision of the operation of the wheel mechanism. The arch of the doorway was composed of a series of very crudely-shaped voussoirs. No impost blocks defined the spring of the arch and no defining keystone was positioned at its apex. The base of the doorway, and the original ground surface, was identified by a cobble layer and by the fact that the lowest tier of the wall (corresponding with this cobble layer) ex-



16. Lower storey of the northern wall of mill chamber with arched doorway Location of Arabic inscription being indicated (photo: K. D. Politis).

tended into the threshold of the doorway (for 0.10m) forming a slight lip.

An Arabic inscription was positioned to the west of the doorway at a height of 1.3m above the original ground surface level, i.e. roughly at shoulder height, and reads ١ د ع (Fig. 17).

The northern wall of the vaulted chamber was effectively flanked by wall 053 which formed the northern façade of the installation, essentially creating a double northern wall for the vaulted chamber. The doorway in wall 053 also corresponded with the inner arched entrance to the barrel-vaulted chamber.

#### *D. Activity Immediately North of the Eastern Mill House*

At the base of the northern wall of the mill house (and immediately north of the arched doorway) a layer of broken sugar pots was cleared from a test trench measuring 1m x 1m. The test trench yielded 24 *goufas* of sugar pot fragments (mostly consisting of the upper cones) and four fragments of iron crucibles. Such findings identify the layer, and the associated area, as the area where the upper sugar pots or cones were smashed at the production site. This action was necessary to remove the sugar loaf from the upper cone-shaped vessels which sat in the mouth of the lower molasses jar. The density of sugar pots in the layer concurs with the contemporary estimate that 2,500-3,000 vessels were needed as basic stock for a sugar refinery (von Wartburg 1983: 309).

That the removal of the sugar loaf or crystal from the cone was a very difficult operation often leading to the breaking of the ceramic cone is also well attested at Kouklia in Cyprus where the ratio between cones and jars is remarkably uniform, with the cones consistently predominating (von Wartburg 1983: 309). In the light of this knowledge, it was particularly surprising to discover a



17. Engraved Arabic inscription west of doorway on lower storey of northern wall of mill chamber (photo: K. D. Politis).

complete cone during the excavations at Khirbat ash-Shaykh 'Īsā (registered object no. Z-GS 29). This discovery securely links the ancient urban site with the nearby milling installation. Moreover, the complete condition of the ceramic cone indicates that these pots were being produced at the urban centre as complete cones rarely survive at industrial sites and usually only feature as fragments by the very nature of their function and use.

The example of a complete sugar cone found at Khirbat ash-Shaykh 'Īsā (with a diameter of 0.332m) is comparable to type IV from Kouklia (von Wartburg 1983: 313, fig. 10, plate LII 2 and 3). Large cones of this type are thought to be used for the production of crystal sugar, as opposed to the fine quality sugars formed in the smaller cones (von Wartburg 1983: 314). Luttrell deduces that the predominance of the pottery cones used for making crystal sugar, over moulds used for the more expensive sugar loaf, at both Kouklia and Episkopi in Cyprus, indicates that the cheaper type played a more important role at these sites (1986: 165), this theory is applicable, by inference, to the Ghawr aş-Şāfi site.

Finally, a copper cauldron for boiling the produce was accidentally discovered at the site in the early 1980s and is now on exhibit in the Karak Archaeological Museum. Its presence completes a refining cycle of mashing, boiling, collecting and cooling which are attested on the site.

#### **The Date of the Operation of the Mill**

The pottery profile from the excavations at Tawāhin as-Sukkar (which consists predominantly of sugar cone fragments) did not produce a conclusive date for the initial functioning of the mill and we can only suggest that operations commenced in the Ayyubid-Mamluk period. It is hoped that a more thorough pottery analysis may clarify this vital point.

Nonetheless, while the date of the earliest commencement of the operation of the mill is somewhat vague, we can confidently state that the operating life of the mill must have been lengthy enough for the upper millstone to be replaced on at least one occasion. A large building block at the top of the western wall of the mill-room was identified as a fragment of an upper millstone. The stone constitutes an arc of an upper millstone, with the squared edge of the central aperture and the outer curving edge still preserved. Several 15th/16th-century AD burials excavated within the mill (Photo-Jones *et al.* 2002) suggest that operations at the mill were abandoned by this time which would also comply with the ceramic profile.

This evidence accords with events in the wider trade network. In the 15th century the Spanish and Portuguese introduced sugar cane into the islands of Madeira, the Canaries, Santiago and Sao Tome. By the later part of the 15th and the early 16th centuries sugar from these islands was flooding European markets, with ruinous effects on the sugar industry of both the Christian and the Muslim Mediterranean (Watson 1983). Alternatively, Luttrell argues that the Mamluk sugar industry fell into decline before such competitive market forces were introduced to the Mediterranean, and he points to an overarching crises caused by recurrent plagues and civil wars leading to dramatic depopulation, a situation aggravated by government interference, over-taxation and technological stagnation (1996: 169).

### Conclusions

The excavation of the sugar mill at Ṭawāhin as-Sukkar in aş-Şāfi has established a high degree in sophistication in the mill type in the area to the southeast of the Dead Sea. Von Wartburg and Maier claim, when describing the sugar mill at Kouklia in Cyprus, that technical improvements (such as an increase in motive jet power through the use of a high pressure water jet and the employment of specially-constructed wheels) resulted in a type of Cypriot mill which was more advanced than the type normally used in the Levant, and which was powerful enough to operate heavy edge-runner mills (1989: 179). While this argument is valid, the fact that these features are present in the mill at aş-Şāfi refutes any notions of retardation in the Levantine industry, as is often suggested. Luttrell attributes the decline in the Levantine sugar industry on the supposed absence of features such as gearing arrangements (1996: 166), a feature which was probably present at aş-Şāfi. Ashtor too makes much of the stagnation of the industry in the Levant and claims that most mills were driven by animals (1992: 111). At aş-Şāfi all three mills are water-powered and water-powered mills are evident throughout the region.

The sophistication of the mill installation at aş-Şāfi is attested by the fact that nearly all the refining processes are attested on the site. The degree of industrial sophistication here is not surprising considering that the refining process was perfected in the Near East with Syrian specialists of high repute in charge of the refining of the whole sugar production on Cyprus until July 1468 (Maier and Karageorghis 1984: 329). The presence of three mill-houses, the vast quantities of water conducted to the complex and the sheer quantity of broken

sugar pots on site indicate a highly-developed installation whose progressive mechanisms should prompt a reassessment of the sugar industry both in Jordan and the Levant.

### The Staff

Archaeological excavations were conducted by Amanda Kelly (TeS), Rebecca Foote (KSI), Salha Sulieman Ghareeb (TeS and KSI) and Robert Schick (AN) with the collaboration of Lisa Usman, forensic specialist. The survey was carried out by Daniel Hull with the assistance of Konstantinos Politis. Leslie Acton and Lisa Usman were responsible for the conservation of archaeological objects. The Department of Antiquities was represented by Imad al-Drous. Locally hired workers came from the Ghawr aş-Şāfi. The project was directed by Konstantinos Politis.

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Konstantinos D. Politis,  
Hellenic Society for Near Eastern Studies,  
Athens, Greece  
kdpolitis@hsnes.com

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