

SUDAN & NUBIA

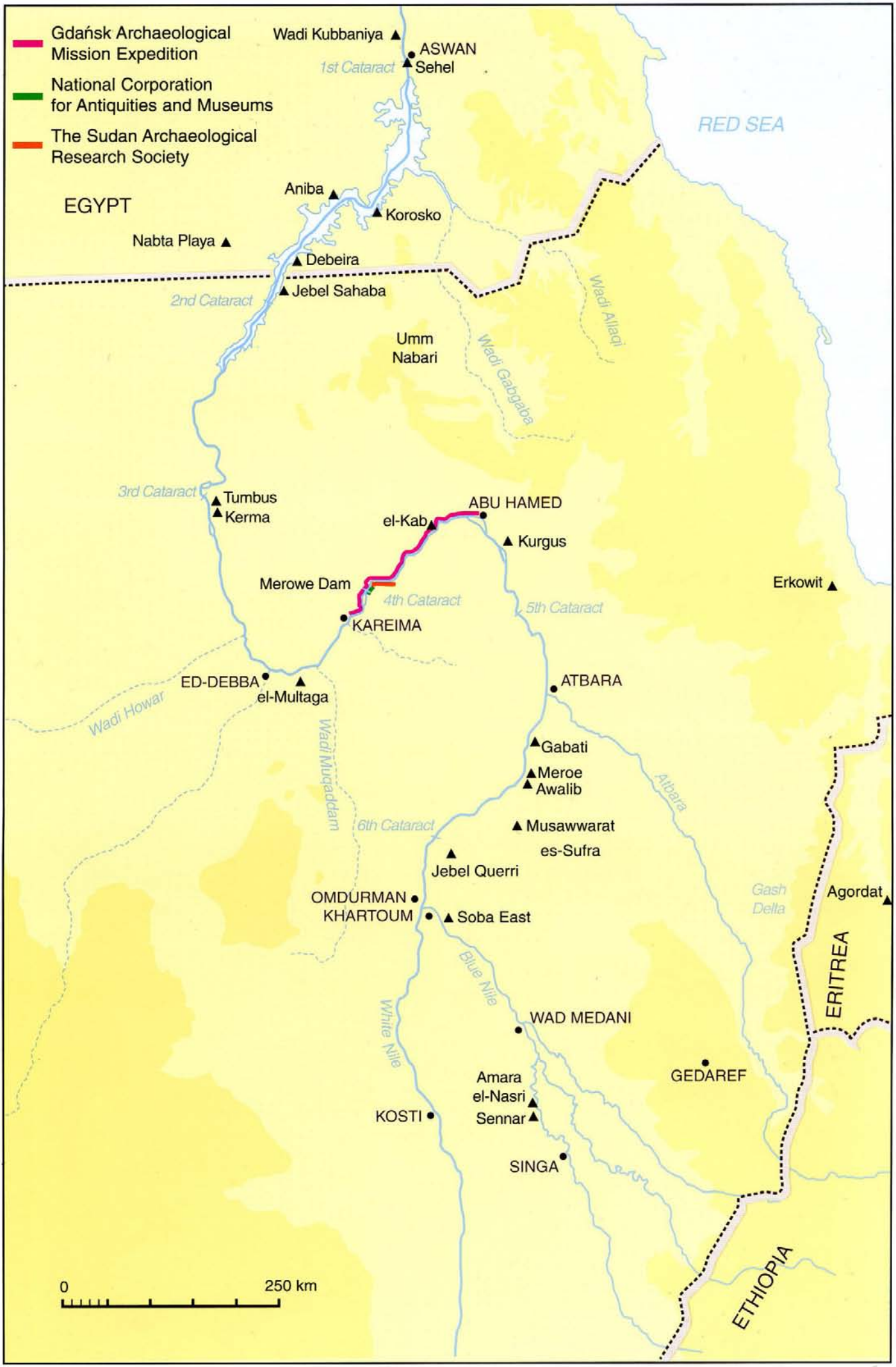
The Sudan Archaeological Research Society



Bulletin No. 7

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SUDAN & NUBIA

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Introduction

Vivian Davies

The Society's two major events of the year, the results of which are published here - the Kirwan Memorial Lecture delivered in October, 2002, and the colloquium on recent fieldwork held in May, 2003 - were extremely well attended. The colloquium incorporated a special session, led by Dr. Salah Mohamed Ahmed, NCAM Director of Excavations, on the Merowe Dam salvage project. The response has been encouraging. Since the colloquium, several organisations have applied for concessions, joining the existing four missions of Gdańsk, NCAM, the French Unit and SARS. Many more are still needed. Interested parties should contact Dr Salah at NCAM tel./fax. 249 11 786784 or the International Society for Nubian Studies c/o dwelsby@thebritishmuseum.ac.uk.

New Investigations into the Water Supply at Musawwarat es-Sufra: results from the 2002 season

Thomas Scheibner

1. Investigations in Area IA-SW

1.1 Starting points and objective

The area under investigation lies south west of the Great Enclosure, between Courtyards 416 and 601. In Hintze's seventh excavation season (1968), two tanks dug into the natural soil were discovered here (DV 94), about 5m apart. However, these tanks were insufficiently documented, leaving questions unanswered, in particular, their exact position which was no longer discernible. The geophysical investigations in the 2002 season, therefore, included soundings in this area in order to find the tanks again and document them anew.

Before the grid system was set up for the geophysical investigation, however, the necessary surface clearance of this area was begun. The tanks known from the 1960s were rediscovered during this clearance and for this reason no further geophysical investigation was undertaken here, in favour of other areas.

Instead, it was deemed more useful to investigate the area by means of intensive surface clearance. The objective of this surface clearance, aside from exposing and documenting the tanks, was to place these features within their wider structural and hydraulic engineering context. This also included the search for further associated structures, such as inflow or outflow conduits, other channels and additional tanks.

1.2 Implementation and results

1.2.1 Overview

The survey grid was marked in an area of 20 x 20m, extending from the co-ordinates 10280 – 10300 East and 11020 – 11040 North. Subsequently, soundings over 400m² were carried out in this area. The surface was cleared of loose drifting sand and other sediment, as well as small plants. Larger bushes were not removed. The clearance began in the vicinity of the two tanks originally located, which in the course of their exposure were indeed revealed to be those described during the seventh season. From these tanks, clearance proceeded outward as far as the marked borders of the investigation area. This method led to the discovery of two further tanks. Surprisingly, these were located in the immediate vicinity of the two known. One was located in between the two tanks, which were only *c.* 6m apart, and the other just

half a metre further north.

Since the entire area was densely interspersed with water channels filled with sediment, the soft fills of which we removed, the surface was uneven after clearance. Moreover, the surface consisted only in part of the natural soil, identified by its reddish coloration and its firmness, which occurred below the topmost ground surface. In other areas, the surface was formed of heavily compacted yellowish-brown, sandy-silty sediments which were located beneath the soft material that was cleared away. For these reasons the author created arbitrary levels in the cleared expanse, which were in part excavated using hoes (*turiya*).

The features, four in total, of which three can in all probability be identified as tanks, lie virtually in a row orientated approximately north-north-east – south-south-west (Figure 1). The total length of the installation is around 10m. The tanks, of differing shapes and sizes, were numbered from south to north (tanks 1-4); the area-specific find numbers are IA-SW/1 to IA-SW/4.

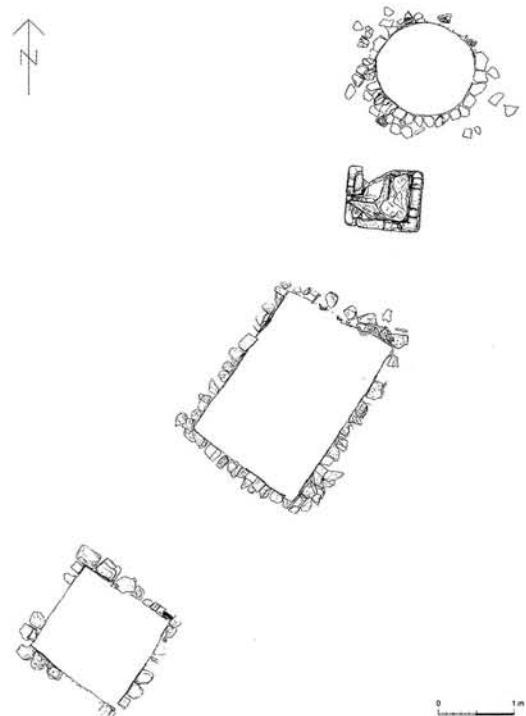


Figure 1. Plan of Tanks IA-SW/1-4 (based on drawings P-LA/631+632).

1.2.2 Water tank IA-SW/1

This tank was dug into the natural soil and has an approximately square ground plan (Plate 1). The internal dimensions are 1.26-1.36m (NNE-SSW), 1.34-1.37m (ESE-WNW) and it is preserved to a depth of 330mm. As this tank had already been excavated in 1968, an examination of the fill was unnecessary.

In the subterranean part the walls were of flat ferricrete slabs set in earth mortar abutting against the sides of the pit. In the level above the surface of the natural soil were the

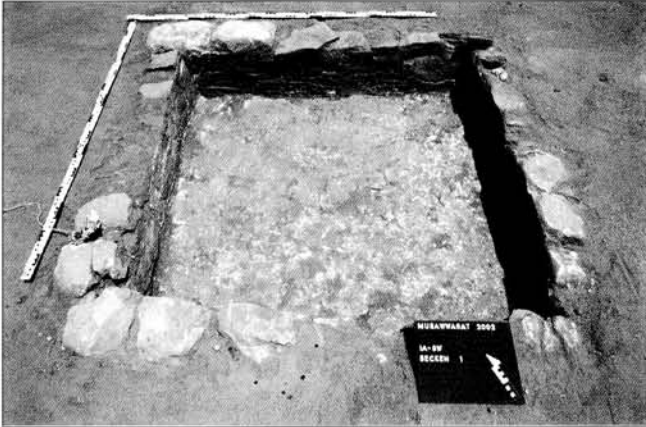


Plate 1. Water tank LA-SW/1 from the south (transparency 2002-24-19).



Plate 2. Water tank LA-SW/2 from the east (transparency 2002-24-24).

remains of a border made of roughly dressed sandstone blocks, the smoothed fronts of which face towards the interior of the tank. It is unclear whether this upper border consisted of only one layer of blocks or originally reached higher and perhaps formed a parapet. However, no fallen blocks which could indicate this were found, although it should be noted that the tank was originally cleared in the 1960s. The thickness of the border is around 200mm, so that the external dimensions of the tank increase correspondingly to about 1.7 x 1.8m.

The tank was lined with a single layer of light greyish-white lime mortar, which was only partially preserved. The lime mortar coating of the stone pavement in the base of the tank is virtually complete, although the surface has been damaged in places. The lining merged seamlessly from the walls to the pavement.

1.2.3 Water tank IA-SW/2

This tank was discovered about 2m north-north-east of Tank 1. It was likewise dug into the ground and has exactly the same orientation, its western wall virtually on the same axis as that of Tank 1. However, this new tank is rectangular, and with internal dimensions of about 2.4m (NNE-SSW) x 1.6m, it is markedly bigger (Plate 2). The north-west corner of the tank has collapsed inwards, so that the original rectangular basic shape is no longer discernible.

The walls of this tank also were constructed of ferricrete slabs. They end level with the surface of the natural soil. In the north wall there was a crushed and cracked sandstone block – the interpretation of this as the remains of a former retaining wall or border is uncertain. The interior of this newly discovered tank was half sectioned along the longitudinal axis revealing that the tank had probably been left open and gradually filled with sediment as a consequence of drainage processes. In addition to fallen ferricrete slabs from the tank wall, the sediment layers also contained numerous sherds and animal bone fragments. The tank interior was eventually fully excavated.

The depth is 290mm at the rim, 295mm in the north-east corner, and 320mm in the centre. It was, therefore, possible for all the water to flow into the middle of the tank. This tank was also lined with lime mortar. The plasterwork was not complete. On the stone pavement it was preserved only as irregularly distributed remains; therefore it was possible to ascertain that the tank floor was also constructed of ferricrete slabs laid flat. It is possible that the stone pavement's plaster coating never covered the entire floor, but simply sealed the gaps between the slabs. This could be supported both by the impermeability of the ferricrete sandstone and the fact that the remaining fragments of the lime mortar coating partially lie lower than the surface of the slabs. Especially in the north-east corner (Plate 3) the extremely high-quality workmanship of the lime mortar lining can still be discerned. The plasterwork here merges seamlessly, with a gentle concave transition into the floor coating, which is well preserved at this point.

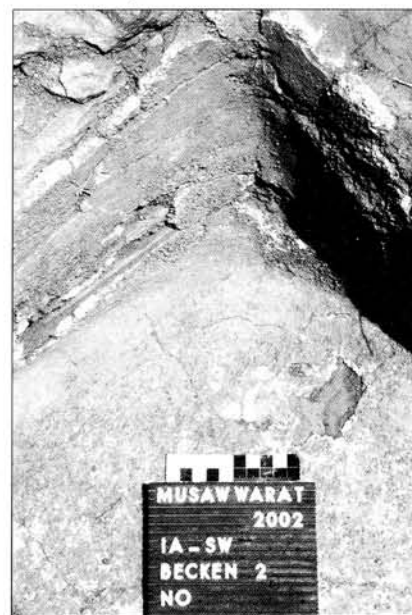


Plate 3. Detail of the north-east corner (transparency 2002-24-33).

On the east side of the tank there is a dense concentration of ferricrete slabs lying next to and on top of one another. Although here this seems to function as paving, this interpretation is questionable. It is more probable that these are slabs dislodged by water action from the tank wall; their position correlates with the flow direction of the numerous drainage channels. The slabs from the western wall lie correspondingly in the fill of the tank interior.

1.2.4 Tank-like structure IA-SW/3

This feature is completely different from the other three tanks (Plate 4). It was first uncovered in 1968 and was described as the south-east corner of an otherwise ruined tank. The new investigation does not confirm this interpretation. It is certainly a tank-like structure, but it is virtually completely preserved and has several special features.



Plate 4. The tank-like structure IA-SW/3 from the west (transparency 2002-25-05).

It was erected above ground, has a different orientation, and was constructed completely of sandstone. The reconstructed dimensions are 1m west-east and 800mm north-south. Notwithstanding the surface appearance, it seems that we may actually be dealing here with a monolithic sandstone slab which has been repeatedly cracked – possibly along clefs – so that, especially at the edges, the impression is of joints between a number of blocks placed one beside the other. A large part of the north-west corner is broken off and was lying beside the feature. Nevertheless it was possible to reconstruct its original position for documentation purposes.

The ‘tank interior’ was chiselled out of this slab. This produced a bulging, convex rim around 100-150mm thick and about 100mm high (Plate 5). The interior corners in particular are very cleanly dressed. Approximately 290mm from the east interior rim and 260mm from the south interior rim, the interior surface has a right-angled ledge or step, so that the base lies around 30mm lower in the centre. The width of this sunken section cannot be precisely ascertained, as the opposing north and west edges have not survived. In a north-south direction this lower section is offset, i.e., its north rim extended at least to the inner rim of the structure. If the



Plate 5. Detail of the south-east corner of structure IA-SW/3. The sunken interior area, the bulging rim and the remains of the lime mortar plastering are clearly discernible (transparency 2002-25-12).

sunken area was symmetrically arranged at least in a east-west direction, it can only have been around 100mm wide. Its function is uncertain. It is possible that a stele was actually set into the ‘tank’ floor at this position, as suggested by S. Wenig (pers. comm.).

The remains of a lime mortar layer present here makes it probable that this structure was somehow associated with water. Lime mortar was found both on the interior walls of the lower rim and on the interior surface, although it could not be demonstrated that the lime mortar was present in the central sunken area.

Regardless of the fact that the south and west rim bulges are incompletely preserved and the blank areas give the impression that a part was knocked off (although no broken fragments were found), possible traces of working or processing in the middle of the south side suggest that there originally could have been an opening in the rim here – an observation attributed to D. Eigner. This would then probably be identified as an overflow vent or outlet.

On the whole this feature remains enigmatic. It certainly did not serve for the storage of water. The volume would have been very small, especially as the top edges of the rims give no indication that they were originally higher or could have consisted of one or more further layers. Moreover, if there had originally been an opening that existed in the south wall at the level of the interior surface, higher rims would not have had any retaining function anyway.

The extremely high quality workmanship of the feature, still distinguishable today, suggests that it was an altar or sacrificial site – possibly with a stele or similar. The lime plaster would not be at all inconsistent with this idea – on the contrary, in fact. Despite their close proximity, there is no discernible direct relationship with the three adjacent water tanks.

1.2.5 Water tank IA-SW/4

Unexpectedly, a further unknown tank (Plate 6) was discovered only about half a metre to the north of IA-SW/3. This too has a peculiarity – it is round. No round water tanks have



Plate 6. Water tank LA-SW/4 from the south
(transparency 2002-25-22).

hitherto been found at Musawwarat. The tank was located in the same manner as Tanks 1 and 2. It was dug into the natural soil and its walls were constructed of ferricrete slabs. Like the two other tanks, it ends at the surface of the natural soil; no remains of any sandstone walling or edging were in evidence.

The tank is not perfectly circular. It has a diameter of 1.2m north-south, while it measures a maximum of 1.3m east-west. It is deeper than Tanks 1 and 2 at 600mm. The fill of this tank was sectioned in a north-south direction and the eastern half excavated. It was filled only with alluvial sediment in which relatively numerous, probably broken, ferricrete slabs, as well as sherds and bone fragments were deposited. The tank was lined with very well-preserved lime plasterwork, and the base was of ferricrete slabs, which were visible where the plaster was missing.

Notwithstanding its different shape and depth, the construction of Tank 4 suggests a temporal connection with Tanks 1 and 2, although it is positioned about 1m to the west of the central axis formed by these. The distance (from inner rim to inner rim) between Tanks 2 and 4 is around 3m.

1.2.6 Further finds

The entire area was severely disturbed by drainage channels,

which had a flow direction to the south east. No channels or other water inflow or outflow routes to or from the tanks could be seen. West of Tank 2, around 2m from the rim, was the remains of a pit, now preserved only in truncated form, in which a fragment of a vessel, part of the rim with the base of the neck, was buried with the mouth downward (Plate 7). It was probably a wide-mouthed open storage vessel with an everted rim. The rim diameter was around 350mm. Owing to lack of time it could not be further documented and was left *in situ*.

1.3 Summary and discussion

In the c. 400m² investigated two further water tanks and the location of a vessel in addition to two objects (1 and 3) known from the 1968 season were found. These features are concentrated in an area 10m (NNE-SSW) x 3m located in the central section of the western half of the investigated area.

The fact that no further structures were found in the surroundings of the tanks makes the interpretation of the whole complex more difficult. Even though the designation as water tanks may be taken as secure in individual cases (with the exception of feature 3), the classification into a superordinate functional context remains uncertain. Possibly the features were part of a craft production unit. In this connection we noted the unusual pungent smell coming from the soil in the tank interiors and in the cracks in the tank walls (at the points where the plaster was missing). This may be an indication of their use as tanning pits. The analysis of soil samples could provide information on this. On practical considerations, I would like to exclude the conjecture, occasionally voiced, that they were cattle watering troughs, as it would have been more sensible to erect a trough above rather than digging it into the ground.

Also still to be clarified is the question of from where the water to fill the tanks was drawn. There does not seem to have been any direct link to a water supply system and there are also no indications of an overflow-type connection, at least between Tanks 1, 2 and 4. These tanks cannot have had proper outlets or vents in any case, due to their position dug into the earth.

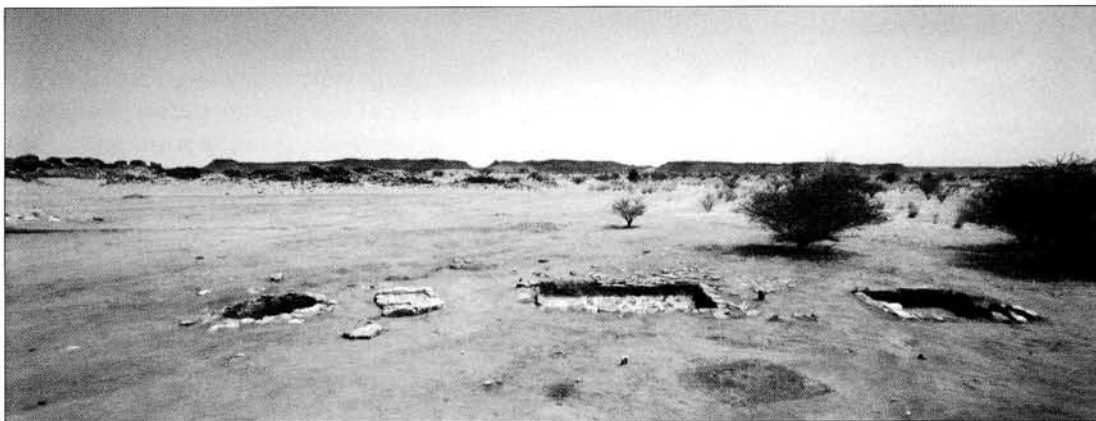


Plate 7. General view of the four tanks from the west. In the foreground the site of the vessel fragment, distinguishable by the square cleaned area. In the background the southern section of the Great Enclosure (transparency 2002-25-37).

Finally it should be mentioned, that inside the courtyard of the Small Enclosure (I B) of Musawwarat, another feature (Plate 8) is now to be identified likewise as a water tank, rather than as a “sand box” (Hintze 1962, 460) or “grit trough” (Fitzenreiter 1999, 10). There are significant parallels in shape, size and construction with the tanks in area IA-SW, Tank 2 in particular.



Plate 8. The water tank in the courtyard of the Small Enclosure (I B) during the 1961-62 season (negative 252-36).

2. Investigations of the Water Pipes II F and 223 and the new Water Pipe II F-2

2.1 Starting points

A water pipe made of sandstone blocks, dug into the ground or the embankment of the *hafir*, was found on the west flank of the Great *Hafir* as early as the 1960s. It was possible to follow this in sections westward around 300m into the Wadi es-Sufra in the direction of the Great Enclosure (Hintze 1962; 1963). In 2000, a subterranean sandstone water pipe was recorded in Courtyard 115 and Room 116 of the Great Enclosure; at its western end this pipe is connected with Water Tank 242 (Mucha and Scheibner 2001). Following this discovery in the Great Enclosure, the author put forward the hypothesis that this could represent the extension, or an extension, of *hafir* Water Pipe II F.

2.2 Soundings on Water Pipe II F

The objectives of this re-examination were to record further construction details of this pipe and to obtain more precise, geometrically correct levelling values for the pipe floor. A prerequisite for the survey was the transference of the relative height system from the Great Enclosure into the area of the Great *Hafir*.

The archaeological investigations began on a section of Water Pipe II F at the eastern wadi edge. As part of the

survey work for the geophysical investigation of the wadi area (cf. below), this section of Water Pipe II F, which had been recorded in the 1960s, was rediscovered in the easternmost survey corridor (10900-10910 E/10876.88-10926.88 N).¹ The pipe section was measured so that henceforth there would be a set of co-ordinates to enable it to be transferred onto the overall plan. However, the state of preservation of this section was so poor that, despite several soundings, it was not possible to obtain detailed information about its construction or the height level of its floor.

The author therefore decided to reopen a section of the old Water Pipe W 3 from the 1961/62 season (Hintze 1963, 64, Fig. 2; Scheibner 2003b). This section was located in a north-south direction on the outer western side of the *hafir* immediately below the embankment. The reopened segment encompassed specifically that area on the western profile where Water Pipe II F, which is still visible on the surface at this point, had been sectioned during the 1961/62 season. The pipe was exposed in vertical section revealing the following picture:

The internal section of the pipe at this point as already known, measured 450mm in width and 850mm in height. The pipe was constructed from roughly worked sandstone blocks and consisted on the south side of five to six, and on the north side of six courses of medium-sized blocks (Colour plate XL). It was covered by thick, diagonally laid sandstone slabs. At this point the pipe has a sandstone floor. This was not discernible in the documentation from the 1960s, and – apart from a brief comment in the preliminary report (Hintze 1962, 460), in which the pipe is described generally as “surfaced with smooth stones” – was not mentioned again.²

The floor level (upper edge) is at 10.48m relative height.³ Over this floor there is a compacted layer approximately 50mm thick made up of sandstone chunks and loam, which might possibly be an additional waterproofing seal. The entire transverse section of the pipe above this was filled with alluvial gravels and sands. Sandy-gravel layers of the alluvial fan of the Great *Hafir* are also present on the

¹ Over the years this section was probably covered over by sediments and therefore was no longer visible. The situation in the wadi changes from year to year, and often traces of wall structures are revealed at sites where a year before there was only a sand dune.

² That this mention exists at all is astonishing, since no such stone floor appears in any of the section drawings from the 1960s.

³ Abbreviated as r.h. These new relative heights relate to a geodetic point in the Great Enclosure randomly defined in 1995, whereby altitudes were calculated on the basis of a notional value of 10.00m, to ensure that no negative values would be obtained within the context of the excavation. According to D. Eigner, an alignment was also carried out with the elevations from the 1960s, which was possible in the area of prominent parts of buildings. Thus, both systems should be directly comparable and should show only the newly introduced altitude difference of 10.00m, as in the 1960s the values related to a notional altitude of 0.00m. However, this seems to apply – if at all – only within the Great Enclosure.



exterior of Water Pipe II F. They lie above a rubble stratum similar to a construction horizon, the upper edge of which adjoins the north side at 11m r.h., but falls away sharply towards the north. This horizon is approximately 150-200mm thick. Somewhat lower than this, separated by a sandy-gravel layer, there is a further compacted layer of sandstone rubble.

These layers appear to be the “bank” of the so-called moat (Hintze 1963, 68 and 77: Plate VI a), which ran immediately north of Water Pipe II F. However, investigations by the author (Scheibner 2003a, vol. 1, 148ff.) reveal that the object in question is not a moat in the true sense, but rather an overflow. These layers are part of the earthen bank of the southernmost of the two guide walls that flank this overflow. This does not rule out the interpretation of the upper rubble layer as the construction horizon for Water Pipe II F, but the stratigraphic relations involved need to be examined in a broader cross section.

The large transverse section, particularly the internal height of the pipe, is unusual, and we must proceed on the assumption that filling from the *hafir* was done either by hand or using lifting devices such as the *shaduf*. The quantity of water accumulated in this manner must hardly ever have been enough to fill this enormous transverse section. However, a functional explanation can be suggested. The water must have been channelled into the pipe somehow. Normally, a filling tank would probably have been used for this, out of which the pipe would run and which could be filled easily, for example using a *shaduf*. However, no tank of this type was uncovered in the excavations in the 1960s, during which the water pipe was traced back through the embankment and revealed as far as the inside of the *hafir*. It is possible, however, that the large transverse section of the water pipe, given its width in particular, in fact performed the function of the filling tank. It is likely that a *shaduf* container could quite comfortably be emptied into a water pipe about half a metre wide – if the water was not simply brought from the *hafir* by bearers anyway.

The internal height of the water pipe, on the other hand, plays only a secondary role. The full internal height of Water Pipe II F can very rarely have been filled in its entirety with flowing water, considering the methods of raising the water from the *hafir*. However, it is also not altogether proven that the full height of the transverse section was actually intended for this purpose, or that it was always in use. It is equally possible that the accumulation, outside and on top of the water pipe, of material brought down from the *hafir* embankment by alluvial processes was taken into consideration, in that the sides of the pipe were gradually increased in height over an extended period. Furthermore, it is conceivable that such a heightening of the sides could also have occurred as a result of sedimentation in the interior of the pipe and the associated raising of the floor level. Under some circumstances it would in fact have been desirable to make use of this quasi-natural increase in floor level by sedimentation at

the beginning of the water pipe, because this would have increased the difference in altitude as compared to the end of the pipe, and thus also the gradient.

The assumption of a gradual increase in the height of the sides of the pipe could be supported by the observation that the construction pit at the north side (the south side was not uncovered from the outside) was dug through all the alluvial gravel layers. This picture would result if, little by little – synsedimentarily – the sides were restored or increased in height by the addition of extra courses. To assume, accordingly, a late construction date for the pipe on the basis of the resulting positioning of the pit – which from a purely stratigraphic viewpoint is young – as occurred in the 1960s when Water Pipe II F was assigned to the post-Meroitic/Christian period (Hintze 1963, 70), is thus certainly a rather hasty but nonetheless tenable inference; however, this would stand in contradiction to the stratigraphically deeper position of the construction horizon of the water pipe referred to, which may be the original one.

On the whole there are still open questions with respect to Water Pipe II F and further research is necessary. One of these questions concerned the position of the water pipe in relation to the upper edge of the natural soil as defined by the ancient ground surface. The background to this question is formed by the height and/or gradient relationship between the floor of the water pipe and the dug-out edge of the *hafir* tank, which in fact is dug from the ancient ground level. This means that the height of the dug-out edge also marks the maximum filling level of the *hafir*, as – apart from the unevenness of the terrain – it actually also corresponds to the level of the inlet into the *hafir*.

To clarify this question and the deeper layer sequence, and to obtain a geometrically correct level value for the top edge of the natural soil, the sounding was extended deeper, because the vertical section described still exhibited no natural soil even in the bottom-most region, but only detritus and/or the stone floor of the water pipe. This also made it clear that the excavation level of the 1960s section had not yet been reached as Section W 3 had been dug down into the natural soil. This further investigation was carried out on the final day before departure.

2.3 Water Pipe II F-2

Beneath Water Pipe II F, however, we found not the natural soil, but an older water pipe (Colour plate XLI).⁴ We cannot understand how this feature escaped attention in the 1960s. It is certain, however, that this water pipe was destroyed by the old Section W 3 – presumably when Water Pipe II F was bisected – and is no longer present in the excavation level here. This is also revealed in the excavation photographs from the 1961/62 third season (Hintze 1963, 77, Plates VI a and

⁴ As usual, the most important results are found just when time has run out: this find was made on the afternoon of the last day before departure in 2002. More thorough investigation of this new water pipe was possible only in the 2003 season (Scheibner, in preparation).

b). On both photographs the old water pipe is visible in the western profile of Section W 3,⁵ although the excavation level lies still deeper – the water pipe was not identified as such (Plate 9). Nor is the lower water pipe documented anywhere on the section drawings of this or other water pipe sections. It should, however, be noted that there is no drawing of the western profile of Section W 3.



Plate 9. The same western cross section of Section W 3 during the 1961-62 season (negative 326-33A).

This lower and older (on the basis of its position beneath Water Pipe II F – a designation which is presumably reasonable although based purely on stratigraphic considerations) water pipe, which I have called Water Pipe II F-2 (Scheibner 2003b), is smaller in transverse section than Water Pipe II F, and is somewhat differently constructed (Colour plate XLII). On the other hand, it corresponds in many structural details with that segment of Water Pipe 223 in the Great Enclosure which was constructed not out of sandstone pipes but rather out of upright slabs and covering stones, because Water Pipe II F-2 is also constructed in this manner. Its very cleanly dressed sides consist of sandstone slabs 200mm in height and 100mm thick, laid lengthways on end; these incline slightly inwards at the top. A 120mm thick sandstone slab laid cross-wise on top of this serves as a cover. This cover simultaneously forms the bottom of Water Pipe II F referred to above, which is laid over the top of it – clearly a case of intentional re-use.

In contrast, II F-2 does not have a stone floor – a compacted mass of loam / clay 20-30mm thick serves as

⁵ At least if one knows that it is there. Previously, the author had also failed to notice it on the photographs.

the base here. It lies approximately 30-40mm above the lower edges of the sides at a height of 10.135m r.h. The transverse section of the pipe measures 200mm wide at the floor and 160mm at the top beneath the cover, and its height is around 150mm. Above the floor level, the transverse section is completely silted up with loamy and sandy-gravel alluvial layers. The pipe appears in any case to run along the natural ground surface; at least, no pit is discernible in this cross-section. In this connection it should be noted that Water Pipe II F-2 also lies in or – from a stratigraphic point of view – under the above-mentioned south guide wall of the possible *hafir* overflow.

In 2002 this newly discovered water pipe was recorded only in this profile section so it is not possible at this point to make any more detailed statements about its point of origin in the *hafir*. In this respect, however, it should be assumed on the basis of its small transverse section that this water pipe has its beginning in an as-yet undiscovered filling tank at the edge of the *hafir* interior. The beginning and the further course of the water pipe are therefore uncertain at present.⁶

2.4 Water Pipe II F-2 and Water Pipe 223 – from the Great *Hafir* to the Great Enclosure?

2.4.1 Starting points

In 2000, after Water Pipe 223 was discovered in the Great Enclosure, the author put forward the working hypothesis that this water pipe, based on its characteristics and its orientation, could be directly connected to the Great *Hafir* and that, therefore, it could possibly be a continuation of *hafir* Water Pipe II F. However, there were numerous question marks associated with this, particularly with respect to the configuration of Water Pipe II F as an open channel in the wadi. The results of the 2002 season described above, especially the finding of Water Pipe II F-2, now give cause for this hypothesis to be modified. In any case, these new discoveries represent the culmination of a whole series of investigations that were planned and carried out against the background of these considerations.

In this context, during the 2002 season geophysical investigations⁷ with georadar (Ground Penetrating Radar - GPR) were carried out in the wadi by SONTEC. The purpose of the soundings in the westernmost survey strips in the wadi was to check the geophysical results and verify possible structures. In addition, on the basis of the known position of Water Pipe 223 in Room 116, soundings were carried out in

⁶ The results of the 2003 season (Scheibner, in preparation) already allow clearer conclusions to be drawn in this respect, but do not permit any conclusive statement.

⁷ These geomagnetic and georadar surveys, as previously in the 2001 season, were financed by the Kommission für Allgemeine und Vergleichende Archäologie (KAVA) [Committee for General and Comparative Archaeology], for which our thanks are due in particular to Dr Burkhardt Vogt as director of KAVA. In addition, the financial support of SONTEC (Oranienburg, Germany) itself also facilitated the investigations.



Courtyard 305 and also east of this Courtyard outside the Great Enclosure.

2.4.2 The survey in Wadi es-Sufra

2.4.2.1 Premise

A notional starting point for the investigations in the wadi was the verification of a direct link of this kind between the Great *Hafir* and Water Pipe 223 in the Great Enclosure. Before the geophysical investigation in the wadi could be carried out, however, the survey conditions for laying out the planned five north-south investigation strips, which it was thought would cross the route of this water pipe in the wadi, had first to be established.

For this purpose, we first had to measure the segments of *hafir* Water Pipe II F which were visible above ground in the area of the embankment or the alluvial body of the Great *Hafir*.⁸ Then, the course of this water pipe as far as the Great Enclosure had to be theoretically predicted. Directional and positional clues as to the course of the water pipe could be provided only by the excavated section of Water Pipe 223 in Courtyards 115 and 116 of the Great Enclosure. A co-ordinate axis was worked out from the start and end co-ordinates of the hypothetical water pipe route established in this way. Finally, the co-ordinates of the points of intersection between the theoretical water pipe route and the planned investigation strips were calculated, to make it possible to transfer them onto the terrain.⁹

The subsequent discovery, and particularly the position and course of a segment of the water pipe on the east side of the wadi (see above), confirmed these notional and calculation-based projections, because this section of pipe had had no bearing at all on the preparations, as it had been re-discovered only while the survey corridors were being marked out. However, it crossed the investigation strips which had been established on the basis of theoretical considerations exactly in the middle, as per the predictions.

Unfortunately, for reasons of time, it was possible to carry out a radar survey of only the westernmost of the five survey corridors that were marked out. The subsequent archaeological soundings in these investigation strips in the wadi were undertaken with the intention of checking the results of these geophysical soundings and verifying possible finds.

2.4.2.2 Excavations in the region of the georadar area 10550-10560E/10993.77-11043.77 N in Wadi es-Sufra

This 10m wide north-south oriented area was sounded with 11 georadar profiles set out at intervals of 1m on the longitudinal axis. The archaeological soundings were arranged in accordance with the radar findings. Particular attention was given to two disturbances of the subsoil discernible in the

⁸ At this point in the 2002 season Water Pipe II F-2 had not yet been found.

⁹ Thanks are extended to Mr Holger Rothe, qualified engineer (Rothe Surveying, Seefeld, Germany), for providing the survey equipment and for carrying out the survey work together with the author.

radar profiles, which on the basis of their depth and size were considered to be a possible continuation of the water pipe(s), especially as they could be followed across the entire width of the investigation corridor and therefore revealed themselves to be linear structures.

The first sounding was arranged and excavated within the co-ordinate area of these structures. It was 4 x 1m in size and was positioned between 10559 – 10560 E and 11022 and 11026 N. In several stages with intermediate levels, it was excavated to around 700mm under the ground surface. The result was negative. To rule out co-ordinate errors or profile axis inversions, four further soundings were subsequently laid out, which joined up into a section with a total length of 20m, 1m wide and between 500 and 800mm deep. Forming a strip 1m wide (toward the east), as described above (10559 – 10560 E), it extended from 11006 to 11026 N. The entire investigation came to nothing.

It is possible that, due to the hardness of the ground, a sufficient sounding depth could not be reached in the time available. The water pipe could have been relocated deeper here in the wadi to protect it from the effects of the water channels, which shift annually. Considering its gradient between the Great *hafir* and the tank in courtyard 115 of the Great Enclosure, and its possible function on the principle of communicating pipes, a slightly vertically bowed longitudinal section would not have caused any problems, because the subterranean pipe could withstand a certain amount of pressure.

On the other hand, as the radar data showed a depth position of only 500mm for the subsoil disturbances recorded, these structures registered by the radar should most likely be assumed to be buried former water channels, which have been encountered several times in the area undergoing archaeological sounding. Consequently, continuing these soundings to a greater depth has a good prospect of success, and is therefore desirable for the future – not least on the basis of results obtained in the course of the further sounding of Water Pipe 223 within and immediately in front of the Great Enclosure in the 2002 and 2003 seasons (see next section).

2.4.3 Investigations in Courtyard 305 and east of the Courtyard outside the Great Enclosure

Based on the known position of Water Pipe 223 in Room 116, soundings were carried out in Courtyard 305 and also east of this Courtyard outside the Great Enclosure (Scheibner 2003b). First of all, a sounding was laid out in the southwestern wedge of the Courtyard, north of Room 306. This sounding measured 2.5m north east-south west and 1.5m north west-south east, and lay 1.5m east of Wall 305/116+117 and the same distance north of Wall 305/306.

After working through sterile intermediate levels, we reached the level of the natural soil. The trench discoloration of Water Pipe 223, for which we were searching, was clearly apparent here. The water pipe, therefore, leads at least

from Courtyard 305 into Room 116 and then onwards to Courtyard 115. To follow its further course to the east, a trench was set out approximately in the middle of Courtyard 305 across the extended alignment of the water pipe. This also demonstrated the presence of the water pipe.

It was now necessary to record the water pipe at the east wall of the Great Enclosure as well, in the interior of Courtyard 305. However, several smaller trial sections were required for this, as the water pipe apparently made a slight change in direction to the north in the eastern half of the Courtyard. Nevertheless, in the end we were able to record the pipe in this area and follow it as far as the outer wall 305/E, in fact around 13m south of main entrance 305/E to the Great Enclosure.¹⁰ To be certain, the water pipe ditch itself was sectioned in the area of this sounding. Inside it was found Water Pipe 223, which had been laid underground, here also consisting of wall stones, but missing its cover (Plate 10).

Since the water pipe passed under Wall 305/E, a sounding was also opened immediately outside by the wall. This yielded the final confirmation that the water pipe did indeed lead from outside, and in fact from the wadi, into the Great Enclosure. It should also be pointed out here, from a stratigraphic and chronological perspective, that it is not in the position of the water pipe under Wall 305/E but rather under the construction horizon of the wall that we may find a *terminus ante quem* for the construction of the water pipe. In the construction phase plan by Hintze and Hintze (1970, 53: drawing 2), this wall was assigned to the third construction phase of the Great Enclosure. This assignment, however, is now in doubt (Scheibner 2003a, vol. 2, 32ff.), and the new results of the 2003 season also support this doubt (Scheibner, in preparation). Moreover, at present we cannot exclude the possibility that the outer wall of the Great Enclosure was opened to let Water Pipe 223 pass through it. If this were the case, the pipe would lie not under the actual construction horizon, but rather under a repair stratum of Wall 305/E.

A further trial section positioned around 20m east of the outer wall on the presumed alignment of the water pipe, around 6m in length, unfortunately produced no finds. However, the leeway for the preparation of sections was severely restricted due to the block deposits laid out at this point, as well as the track. It is possible that the water pipe once again changed direction to a certain extent outside the Great

¹⁰ It should be noted here that the southern half of the trench discoloration of the water pipe, curiously, was in part located within the level of a section from the 1996 season (Section 305.21), in the laying out and investigation of which the author had also been involved. It had not been noticed at that time, which can be explained by the nature of the fill material of the water pipe ditch. At this point it is virtually identical to the natural soil and is also overlaid by the construction horizon of Wall 305/E, so that even the sandstone chips partly contained within the fill were able to escape notice. This water pipe ditch was actually recognisable only if one was already aware of its existence and its appearance. However, this was only the case after the 2000 season.

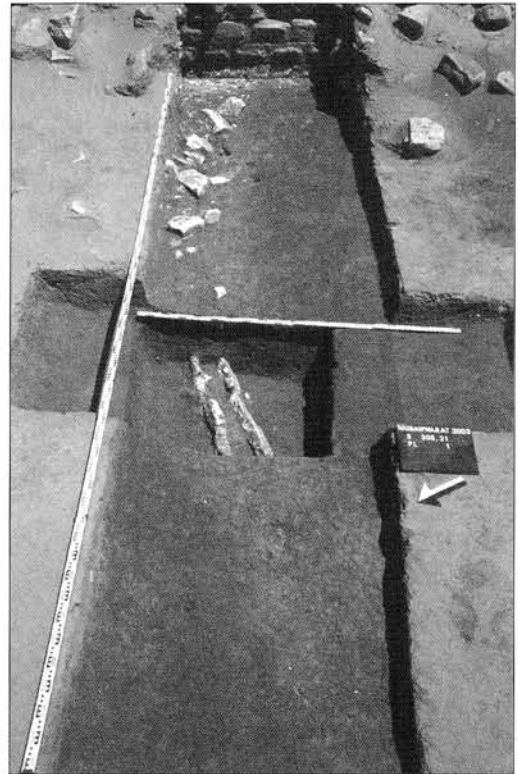


Plate 10. Level of Section 305.21 in Courtyard 305 with the trench discoloration and the bisected Water Pipe 223 in front of external wall 305/E of the Great Enclosure. Length of the left scale 5m (photograph from 2003).

Enclosure. The latter would in any case be expected if the water pipe is supposed to have been connected in a straight line with one of the *hafir* water pipes, particularly if it comes from the Small *Hafir*. With regard to the latter possibility, another radar investigation strip, 100m long, was marked out in an eastward direction from the outer corner of the Great Enclosure formed by Walls 307/E+307/N; this was intended to record any hydraulic connection between the Small *Hafir* and the Great Enclosure. For reasons of time, unfortunately, no further geophysical sounding could be carried out in this survey corridor.

2.4.4 Evaluation

Even though there was not sufficient time in the 2002 season for detailed investigation and complete documentation of the finds, the most significant result achieved is the evidence that the water supply to the Great Enclosure was effected firstly from the outside and additionally by means of a high-quality engineering facility – subterranean sandstone Water Pipe 223. Furthermore, it is becoming increasingly likely that this pipe was directly linked to the Great *Hafir*. In any case the proof that Water Pipe 223 was also present outside the Great Enclosure implies that if it does not come from the Great *Hafir*, then it must certainly come from the Small *Hafir*. The pipe must have been fed from one of the two *hafirs*, as there can hardly be another explanation for the connection.



Although more extensive and detailed investigations are necessary, the structural similarity between Water Pipe II F-2 and Water pipe 223 is unmistakable, especially with respect to that segment of Water Pipe 223 which was constructed not from sandstone tubes but rather from upright slabs and covering stones, and which it was possible to demonstrate from Room 116 as far as the eastern external wall of the Great Enclosure (Plate 11). By way of comparison, the inner transverse cross-section of Water Pipe II F-2 measures, at the foot of the *hafir* embankment, 200mm at the floor and 160mm at the top edge, and its height is also 160mm.



Plate 11. Water Pipe 223 at the western profile of Section 116.3 in Room 116 of the Great Enclosure (photograph from 2000).

The transverse section of the side section of Water Pipe 223 can only be approximately reconstructed¹¹ and measures, in the eastern profile of Section 116.3, about 140-160mm in width in the lower portion and 80-100mm in the upper. In Courtyard 305 the upper width is 100-120mm. The interior height, which depended on the position of the floor which was not located, would have to be around 160-180mm. At its tubular opening into Water Tank 242 in Courtyard 115, the transverse section (almost square here, because of the tube) of Water Pipe 223 measures 160mm in width and 145mm in height. In particular, the dimensions of the wall stones are also virtually identical in their thickness and height in both pipes, as is also the construction of the covering – despite their being about 550m apart.

The fact should not be overlooked that the difference in altitude between the pipe floor at the *hafir* (10.135 m r.h.) and the opening into Tank 242 in Courtyard 115 (8.675 m r.h.) is sufficiently great at 1.46m to ensure a direct flow of water over this distance of around 550m. It also appears possible from the orientation of these widely separated pipes, at the *hafir* and in the Great Enclosure, that they were once

¹¹ An exact comparison with the interior transverse section of the segment of Water Pipe 223 constructed out of upright set wall slabs is not possible, as the pipe was not bisected in the 2002 season, so as to preserve it completely without destroying it.

directly connected to one another.

However, all this need not necessarily mean that the tank in Courtyard 115 was the only one that could have been fed directly from a *hafir*. The probability certainly exists that – starting, for example, from Water Pipe II F-2 or also Water Pipe II F, but also going back to Pipe 223 – this could have been part of a supply system that branched out in many directions. This system could have functioned on the principle of communicating pipes or as a pure gravity-based channel on the basis of the gradient, provided by the differing altitudes. Further, the possibility should on no account be ruled out that there were other water pipes issuing from the Great or from the Small *Hafir*.

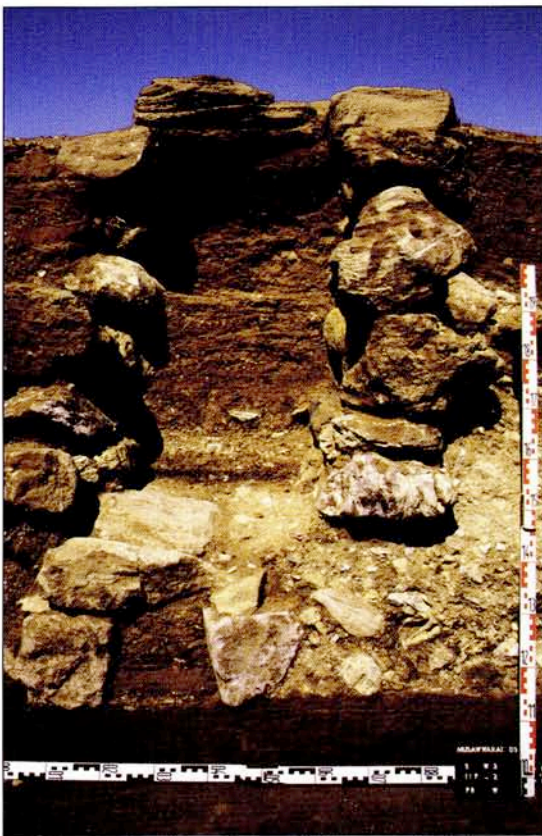
The further connection of subsystems as part of a transport or distribution subsystem issuing from either the Great or the Small *Hafir* thus remains unclear at present. Consequently, the question of the method of transportation of the water to the intended place of use, whether this was a construction site or an irrigation system, also remains to some extent open. Regardless of the engineering capabilities of the Kushites, it should not be ruled out that now and again perhaps the simplest solutions were employed, and that at least in certain circumstances bearers or pack animals were used to transport water.

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*Colour plate XL.
Musawwarat es-Sufra.
The western profile section of the
reopened Section W 3
(photograph from the 2003 season).*



*Colour plate XLI.
Musawwarat es-Sufra. Water pipe II
F-2 beneath Water Pipe II F in the
western profile of Section W 3
(photograph from the 2003 season).*

*Colour plate XLII.
Musawwarat es-Sufra.
Detail view of Water Pipe II F-2
(photograph from the 2003 season).*

