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THE GREAT *HAFIR* AT MUSAWWARAT ES-SUFRA. FIELDWORK OF THE ARCHAEOLOGICAL MISSION OF HUMBOLDT UNIVERSITY BERLIN IN 2005 AND 2006

This report presents the results of the 2005 and 2006 fieldwork of the Archaeological Mission of Humboldt University Berlin at the Great *Hafir* in Musawwarat es-Sufra.[1] These works were undertaken as the *Hafir* — incidentally the largest archaeological monument of the Sudan — was acutely threatened by destruction. When developments took a dramatic turn in early 2005, we decided to carry out archaeological salvage work at the site on short notice.

Today in many areas of the world ancient installations for water harvesting, storage and management are recognized as crucial technological innovations and important testimony of the cultural development of early complex societies. This is also true of the Sudanese *hafirs*. They certainly should be ranged as a major technological and cultural achievement of Kushite society in the 1st millennium BC.

With this background in mind, the Great *Hafir* at Musawwarat es-Sufra is to be classified as a historical monument of considerable importance. It is the result and testimony to a complex strategy for resource management and a technological masterpiece of the highest rank. To put it explicitly, for Musawwarat to develop as the main religious center of the Meroitic Empire, it needed a stable source of water throughout or at least for most of the year — and it needed it *before* commencing the main building activities, which resulted in the construction of the Great Enclosure and other monuments at the site. Thus, the Great *Hafir* is a key structure for the proper understanding and evaluation of the site of Musawwarat.

The *hafirs* in the Keraba, the region east of the Nile north of Khartoum, belong among the largest archaeological monuments in the Middle Nile region. But despite their size and, as argued above, their historical importance, they have received little attention in previous research. Their overpowering dimensions coupled with a visual plainness apparently did not make them an attractive subject for study. Notable exceptions are the contributions by the late Marion Hinkel (1990; 1991; 1994) and the hydrologist Adolf Kleinschroth (1979; 1984; 1986) which deal with *hafirs* in general. Both authors underlined their role for Meroitic economy and defined them as seminal for the extension of state power into the Keraba region (cf. also Edwards 1996: 22-26 and Bradley 1992: 213-215).

In Meroitic times, the climatic conditions in Musawwarat differed only marginally from what is there today. The annual rainfall will have been somewhat higher, up to twice as much as today, and interannual variations were probably smaller (Scheibner 2004: 40-41; recent rainfall amounts to 100 mm [mean value]). The main difference from present conditions was the existence of an intact ecosystem, which was more effective in storing and using the available water. Thus, in contrast to the (semi)arid environment seen today, the landscape of Meroitic times can be pictured as a dry savannah (Scheibner 2005: 17).

But even these somewhat more favorable conditions called for complex resource management. Annual rains from June to September were the only source of water in Musawwarat. While the recent water table is at a depth of c. 85 m, it can be estimated to have been somewhat higher in Meroitic times (Scheibner 2004: 40). But even a depth between 50 and 70 m would have made the use of wells inefficient (Scheibner 2004: 41;

[1] In 2005, the author became the head of the mission. The actual fieldwork at the site was conducted by Thomas Scheibner as field director and Rebekka Mucha. I wish to thank the National Corporation for Antiquities and Museum, first and foremost Director Hassan Hussein, for continued support. My gratitude also goes to our NCAM inspector Zaroug Bakri Mohamed Ahmed for his commitment and to our workmen who conducted the hard excavation work in the *Hafir* until late in April. Finally, I would like to thank the Ministry of Foreign Affairs of the Federal Republic of Germany and the German Embassy in Khartoum, whose financial and logistical support — granted generously at remarkably short notice — enabled us to carry out the work reported here.

contra Bradley 1992: 176, 191 and Edwards 1996: 23; cf. also Kleinschroth 1986: 86, 88). Thus, another solution had to be developed in order to guarantee a continuous availability of substantial amounts of water — the *conditio sine qua non* for settled life and the construction and maintenance of complex cultural installations as the religious centers at Musawwarat and Naga.

The Great *Hafir* (II H) of Musawwarat is part of an assemblage of features, comprising three small shrines (II A, B, D), the well known Apedemak Temple (II C) with its enclosure wall (II E), a workshop area (II G) and a habitation site (II J) as well as water ducts (II F), artificial gravel mounds in front of the inlet area of the *Hafir* (II K) and several linear stone settings of unknown function (II L, M). The common designation in the site nomenclature (area II) is based solely on their topographical connection. It says nothing about a chronological and functional relationship, which in fact has still to be established, especially for the more marginal components of the assemblage.

It is noteworthy that the Great *Hafir* is not the only monument of its type in Musawwarat. There are at least three other *hafirs* [*Fig. 1*]:

- the so-called Small *Hafir*, northeast of the Great Enclosure (I E);
- a *hafir* at the foot of Gebel el-Gafa, near the Northern Quarries, which is probably also ancient (I J);
- another *hafir* in the upper reaches of Wadi es-Sufra, about 3 km east of the main site (V A) (Scheibner 2004: 57-58).

Structurally, *hafirs* consist of two main components [*Fig. 2*]: first the reservoir basin surrounded by an embankment and second the various installations in the inlet area, designed to channel, direct and clear incoming water. Previous investigations into Meroitic *hafirs* were limited to the first component, as it consists of features still discernible above or on the ground.

Like other monuments of its type, the Great *Hafir* of Musawwarat is enclosed by a concentric embankment which still stands to c. 8 m high today [*Fig. 2*]. It was made of material from the digging of the reservoir basin. It is important to realize that this embankment did not contribute to the water storage proper. First, it was a dump, though it probably also served as an additional protection for the reservoir (Hintze 1962a: 459 and Scheibner 2004: 47, 55-57; contra e.g. Kleinschroth 1986: 80, 82). The embankment of the Great *Hafir* has a diameter of c. 250 m at the top of the structure.[2] In the east it has an opening of about 55 m width, which is flanked by two straight earthworks running parallel for about

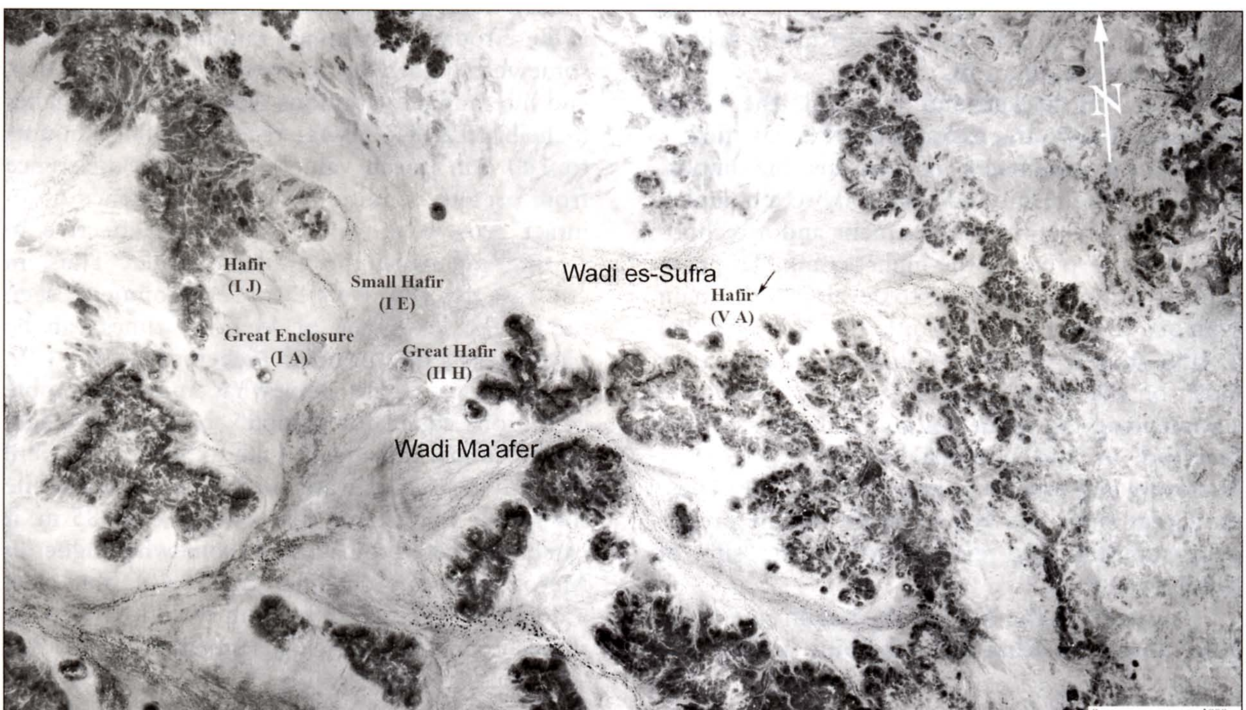

Fig. 1. Aerial photograph of the valley of Musawwarat and its surroundings with the known hafirs indicated (after Scheibner 2004)

[2] For comparison: the *hafirs* of Awlib, Basa and Umm Usuda are of almost the same size, but the preserved embankment height is much lower; cf. Hinkel 1991: Fig. 12 with further references.

70 m. These earthworks frame the inner part of the inlet area, the individual features of which are not visible above the ground today.

By its general position and alignment the Great *Hafir* is oriented towards the drainage system in the valley of Musawwarat (Scheibner 2004: 41-46) [Fig. 1]. It received its water mainly from Wadi es-Sufra in the north, which opens up a catchment area of c. 12 square kilometers. Possibly a further influx came from Wadi Ma'afer, which would have enlarged the catchment area by another 6 square kilometers.[3] The Great *Hafir* was constructed outside the main run-off zone of Wadi es-Sufra, which stretches as a corridor c. 500 m wide between the building ground of the *Hafir* and the foot of the Gebel es-Sufra plateau. The diversion of the water into the *Hafir* resulted for one thing in a reduction of its speed and a calming of the current. By this, the *Hafir* was effectively protected from damage by fluvial erosion and overfilling.

In the run-off corridor, a conspicuous stone alignment was detected in 2002 and 2005 (II L, II L-2) (Jeuthe 2004: 78, Fig. 18; Scheibner 2004: 43; 2005: 27, 31, Fig. 26) [Fig. 7]. With interruptions, it could be followed over a length of c. 300 m, almost up to the southern inlet embankment of the *Hafir*. Stratigraphical data gained on this structure in an excavation in 2004 are ambivalent, and further investigations will be needed to decide whether the badly disturbed alignment belonged to an installation built to divert the waters into the *Hafir*. This assumption has been reinforced, however, by geomagnetic prospection, which also indicated a linear structure in the southern part of the inlet area (Scheibner 2004: 45).

The only excavations previously undertaken in Meroitic *hafirs*, were conducted by Fritz Hintze at the western fringe of the Great *Hafir* in Musawwarat in the early 1960s (Hintze 1962a: 459-460, Fig. 25, Pls 21a-b; 1962b: 196-197, Fig. 26, Pls 65a-b; 1963a: 67-71, Figs 2-3, 7-9, Pls 5-6; 1963b: 221-225, Figs 2-3, 4, Pl. 47. Contra Hinkel 1991: 37: "Südostteil"). Among other things, they resulted in the discovery of a sculpture depicting a seated lion (Hintze 1963a: 68-69, Fig. 8, Pl Va-b) [Fig. 3][4] and a water duct of possibly post-Meroitic date (Hintze 1962a: 459-460, Fig. 25, Pl. 21; 1963a: 68-70, Fig. 9; 1963b: 222-225, Pl. 47, Fig. 4; but note Scheibner 2002: 29-34). But they also produced seminal data on the construction of the embankment and the upper parts of the reservoir basin. The embankment, which was investigated in three trenches, proved to consist

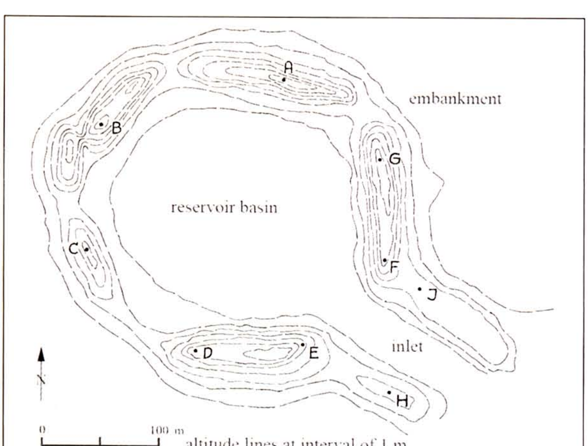

Fig. 2. Ground plan of the Great Hafir (after Scheibner 2004)

Fig. 3. Lion sculpture from the Great Hafir (after Scheibner 2005)

[3] For traces of an anthropogenic development of the catchment area, cf. Scheibner 2004: 57-58 on the *hafir* near the quarries I J.

[4] The statue was found near water duct II F in the interior of the *Hafir*, c. 0.91 m below the edge of the reservoir basin. It was left *in situ* and reexcavated in 2004 with the goal of transporting it to the on-site museum in the Great Enclosure. Logistic difficulties prevented this and it was left *in situ*; cf. Wenig 2004: 9, Fig. 1; Scheibner 2004: 56-57 and 2005: 18, Fig. 2. Further sculptures of this type are to be expected close to the modern surface in or near the reservoir embankment.

of alternating layers of stone, gravel and sand. The lower reaches on its interior face were reinforced by stone packings (Scheibner 2004: 55-56, Fig. 6).[5] In our 2005 excavations, more of such a stone feature was revealed at the foot of the northern embankment of the inlet area (Scheibner 2005: 30, Fig. 24) [*Figs 4, 7*]. It consisted of a heavy stone

Fig. 4. Stone reinforcement at the foot of the northern inlet embankment (after Scheibner 2005)

packing and a rough retaining wall built on top of this packing. As similar walls were higher up the inlet embankments, the entire structure probably had a stepped or terraced appearance.

In both of his excavation areas, Hintze established the edge of the dug-out reservoir basin close to the foot of the embankment (Hintze 1963a: 68, Figs 7-8; cf. also Scheibner 2004: 48, 54). While he estimated the diameter of the basin at c. 150 m, our reassessment showed that it measured c. 210 m SW-NE and 230 m SE-NW (Scheibner 2004: 47; 2005: 18). At the deepest point of Hintze's trench A, which was 6.30 m below the ancient ground surface, the bottom of the reservoir basin had not yet been reached (Hintze 1963a: 68).

These earlier archaeological data suggested several hypotheses about the construction of the *Hafir*. While there was a consensus that the reservoir basin had the shape of a *frustrum*, i.e., a reversed (truncated) cone, speculations about its exact execution and size differed considerably.

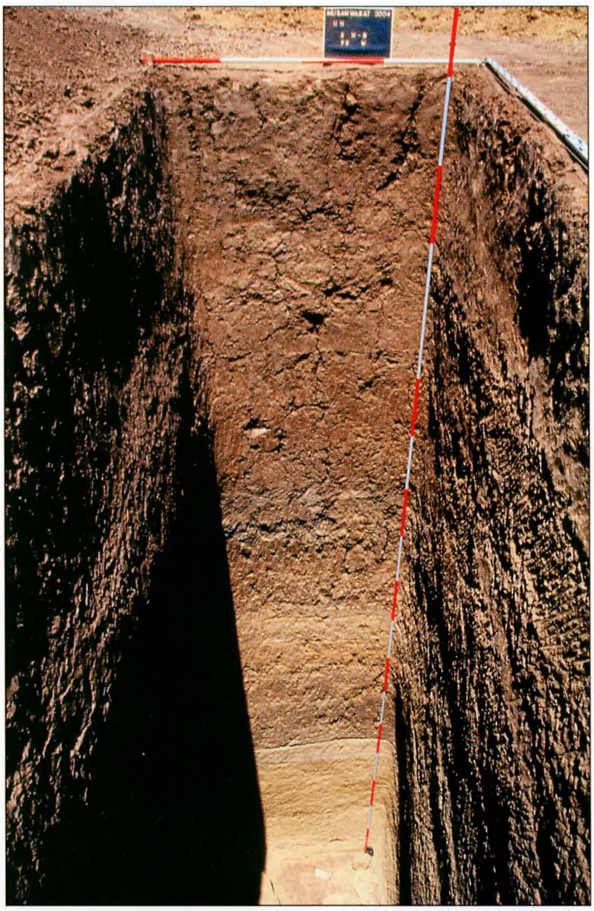

Fig. 5. Western section of sounding H-8 with a depth of 8.65 m (after Scheibner 2004)

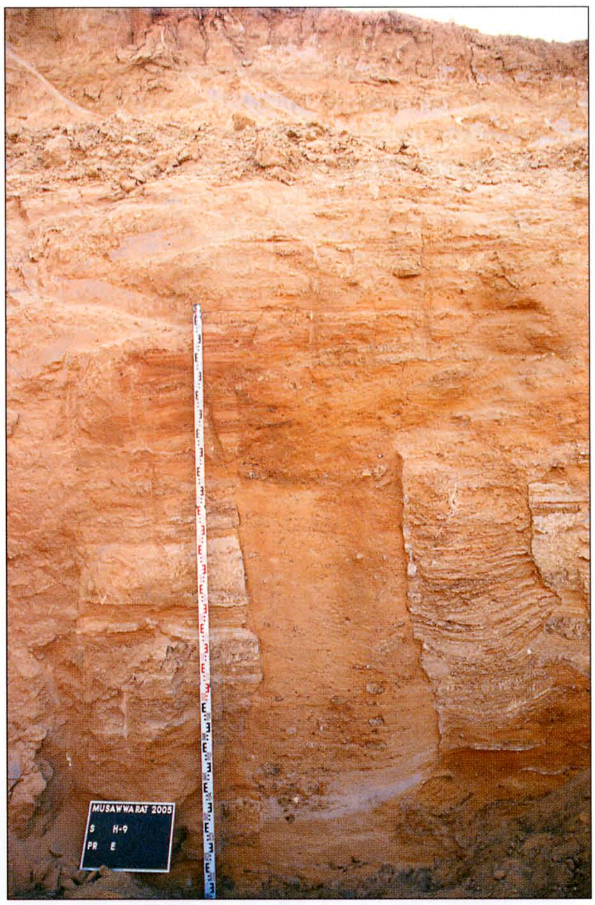

Fig. 6. Water holes cut into accumulated sediments within the Hafir, in the eastern section of the digger trench H-9 (after Scheibner 2005)

[5] For a stone packing found in Hintze's trenches A and C in the interior of the reservoir basin, see Hintze 1963a: 68, and with a reinterpretation, Scheibner 2004: 54-55.

Consequently, also the estimates of its capacity have ranged widely from 135,000 to 250,000 m^3:
- 170,000 m^3, depth 15 m (Hintze 1963a: 68 note 16)
- 250,000 m^3, depth not given (Hintze [in:] Hochfield and Riefstahl (eds) 1978: 89)
- 200,000 m^3, depth 15 m (Kleinschroth 1986: 82-83)
- 135,000 m^3, depth not much over 6.50 m (Hinkel 1991: 37)

In 2003 and 2004, the Humboldt University Mission resumed its work in the Great *Hafir*. Two deep soundings were manually excavated in order to explore the sedimentation in the reservoir basin and to reach its floor [*Fig. 7*: H-6, H-8] (Scheibner 2004: 47-48, 52-53). The sediments observed in the sections consisted of massive deposits of clays and silt with sandy and gravely bands in between [*Fig. 5*]. For safety reasons, the deepest trench, H-6, had to be given up at a depth of 13.50 m without reaching the bottom of the reservoir.

Geoelectrical measurements by GRAS in 2003 indicated that the floor of the basin was to be expected at a maximum depth of c. 17 m, i.e., c. 15 m below the ancient ground surface, which is hidden under c. 2 m of subsequent sedimentation. On the basis of these results, the capacity of the *Hafir* could be calculated at c. 262,000 m^3. If the estimated annual loss of water by evaporation amounts to probably about 1/6 of the total volume, this leaves c. 218,000 m^3 for use (Scheibner 2004: 50-51). The following example may help to evaluate this capacity: in order to provide 500 people with drinking water for one year, less than 1300 m^3 would be needed. Obviously the bulk of the water would have been used for other purposes, especially the construction and maintenance of the buildings and gardens at Musawwarat, and to provide for agricultural and pastoral needs.

In 2003, the Sudan Civilization Institute started large-scale mechanical digging works in the Great *Hafir*, which have been continued since 2005 with dramatic effects. The works were initiated and coordinated by Dr. Jaafar al-Mirghani, director of the aforementioned Institute. They aim at a reactivation of the *Hafir* and are part of a wider scheme redesigning the environment of the valley of Musawwarat, allegedly for tourist and recreational purposes.

The Mission's protests were futile and in view of the disastrous consequences to the archaeological substance at the *Hafir*, salvage excavations were conducted. They are by no means a sanctioning of SCI activities, but merely a reaction prompted by professional responsibility for the site, with regard to the damage already done and in the hope of preventing at least the loss of further archaeological data.

In 2005, the work was concentrated on the hitherto completely unknown inlet area of the *Hafir*.[6] Nothing of its potential installations was discernible on the surface. In order to gain as much information as possible, a complex system of trenches was laid out [*Fig. 7*]. Led by the findings in several key areas, the excavations were then gradually expanded, with 37 trenches in all being investigated.

One of the main results of these excavations was the discovery of the inlet channel of the *Hafir*. It was detected in a series of trenches arranged perpendicularly in the inlet area and along the longitudinal axis of the monument extended to the southeast [*Fig. 7*]. As the cross section shows [cf. *Fig. 8*], the inlet channel is a simple, dug installation without any architectural reinforcement. At the transition to the reservoir basin, it has a maximum depth of 4.05 m below the ancient ground surface and is about 35 m wide. It has steeply inclining walls at the southern side, in contrast to a rather shallow sloping on the opposite, northern side, a difference which is probably due to the impact of fluvial erosion. As a special point of reference, the northern edge of the inlet channel at its transition into the reservoir basin could be established in trench H-44 [*Fig. 7*].

The full length of the inlet channel was traced in 14 trenches laid out along the ideal central axis of the *Hafir* [*Fig. 7*]. The channel is c. 85 m long, its beginning in the east roughly aligned with the tips of the inlet embankments. It has an average incline of 4.8%. This rather small gradient conforms well with the expectation that the speed of the incoming water had to be reduced to prevent fluvial damages in the *Hafir*.

The investigations have permitted a realistic representation of the longitudinal section through the *Hafir* [*Fig. 9*]. The inlet channel can be seen to lead smoothly into the reservoir basin without any change in the gradient. In contrast to previous assumptions, the walls of the basin were probably not straight but stepped or terraced (Scheibner 2004: 49-50). Its lower part was cut into natural sandstone (Scheibner 2004: 51-53).

In front of the inlet channel, a sedimentation basin for clearing the incoming water was expected (Scheibner 2004: 43-44). Confirming this assumption, the excavations in this area revealed a dugout structure, refilled with sedi-

[6] For full details, see Scheibner 2005. This archaeologically sensitive area had already suffered heavily from lorries moving over it when transporting the soil excavated from the *Hafir*. Cf. Wenig 2004: 16, Fig. 12.

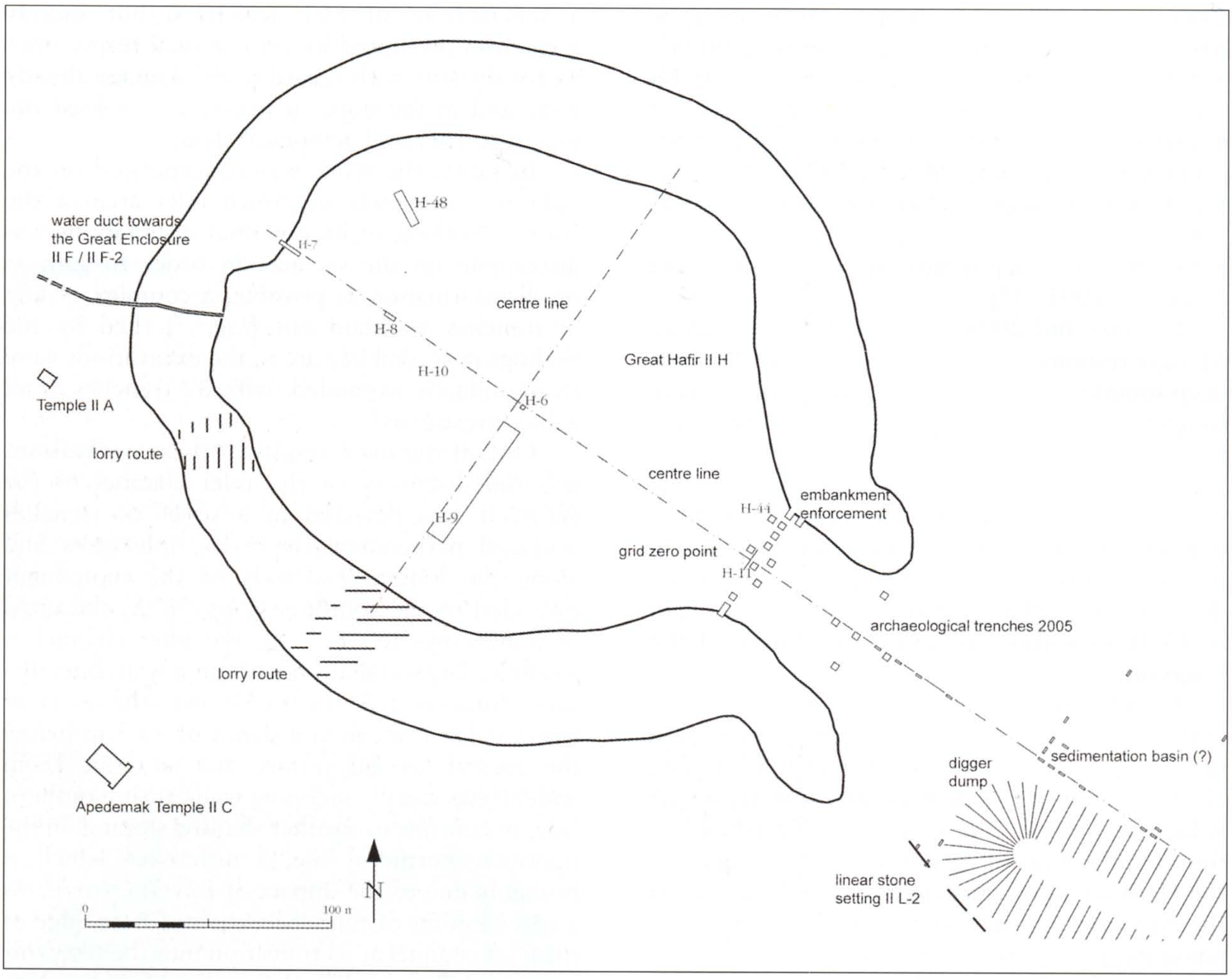

Fig. 7. *Plan of the Great Hafir showing the trenches of the 2005 excavations and further relevant features (after Scheibner 2005)*

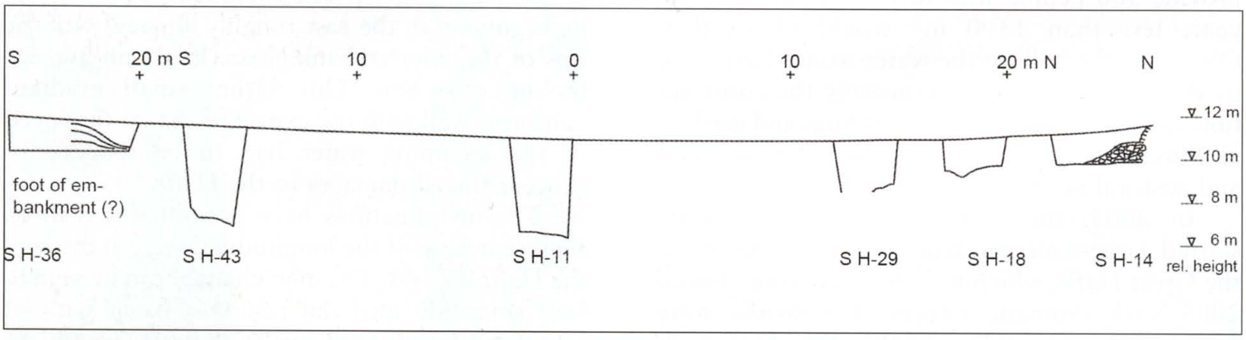

Fig. 8. *Cross-section through the inlet channel of the Great Hafir at 1 m E (after Scheibner 2005)*

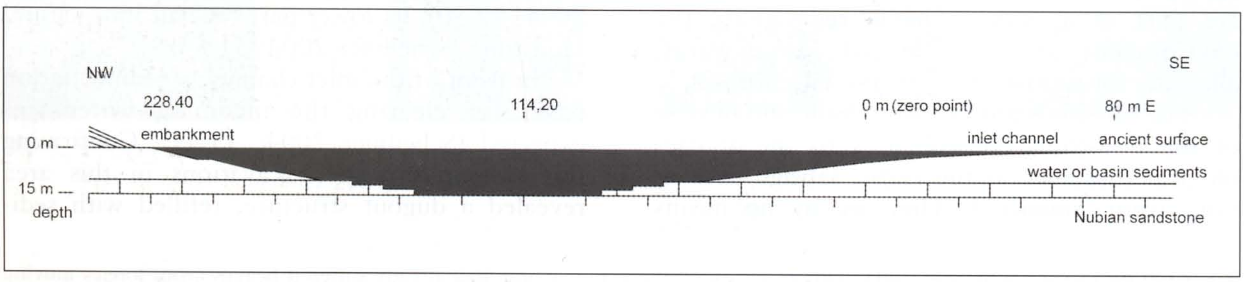

Fig. 9. *Schematic section through the basin and inlet channel (after Scheibner 2005)*

ments [*Fig. 7*]. It has a minimum length of 21 m and a depth of at least 2.20 m. Provided that the basin was periodically cleared, this is quite sufficient for the depositional purpose it was supposed to serve. The structure was traced up to 60 m in front of the inlet channel; a direct connection between the two installations could not yet be ascertained.

In 2006, salvage work in the *Hafir* had to be continued in view of the progressing destruction of the monument (for full details, see Scheibner 2006: 31-35). During the operation, the contour of the reservoir basin could be detected in a trench in the northwestern part of the structure [*Fig. 7*: H-48].

So far, there is almost no data on the use-life of the Great *Hafir*. It is unknown when exactly it was built, although there is reason to assume that it is older than the Apedemak Temple and younger than the Small *Hafir*. Likewise, it is unknown when it went out of use. Concerning its maintenance, there are two general options. Either its basin slowly filled with incoming sediments until it ceased to function because of this build-up, or it was periodically cleaned to preserve its storing capacities. In practice, we may assume a combination of both scenarios. Most probably, the reservoir was periodically cleaned at the beginning of its use; although it is uncertain whether, and if so, how often, these maintenance episodes reached the floor of basin. At a certain point in time, these activities stopped, and there was a final building-up of sediments, resulting in the layers which we now observe in the basin stratigraphy.

That the *Hafir* continued to be used even then is witnessed by two water holes cut into the accumulated sediments, which were revealed in the section of the digger trench H-9 [*Figs. 6, 7*]. They are c. 0.80 to 0.90 m wide and have a preserved depth of c. 3 m. They start about 4 m below the present surface. Although they cannot be dated precisely, they are clearly of some antiquity and testify to the collection of water from the wet *Hafir* sediments or standing ground water.

Returning to the original points made at the start of this report, I hope to have shown that Meroitic *hafirs* are not crude earthworks on a monumental scale. Their functioning — especially during the influx periods — and their maintenance required constant attention, a large workforce and a complex organization. Because of their sheer size alone, installations like the Great *Hafir* at Musawwarat could not have been built and run on a trial-and-error basis. Their construction presupposed a deep knowledge of hydrological and geomorphological conditions of chosen locales: they must have been placed in the right spot from the very beginning. Their capacity and the functionality of their individual elements must have been pre-calculated with high precision: if they failed to match the natural preconditions, either the *hafir* would not receive enough or any water, or *vice versa*, it would be destroyed by uncontrollable floods. How the Meroitic specialists acquired the necessary knowledge, how empirical or abstract it was, how they set about planning a monument like the Great *Hafir*, is still unknown. But their mastery certainly deserves our highest respect, and the monuments which they created with their skills should be valued as cultural and technological achievements of the highest order.

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