SUDAN & NUBIA

The Sudan Archaeological Research Society

Bulletin No. 16 *2012*

ASWAN
1st cataract
Hisn al-Bab
Egypt
RED SEA
Afyeh
Wadi el-Allaqi
Gebel Adda
2nd cataract
Wadi Gabgaba
Amara West
Sedeinga
Sai
3rd cataract
Tombos
Sudan
El-Ga'ab Basin
H29
ABU HAMED
Nile
5th cataract
Abu Sideir
KAREIMA
4th cataract
Napata
Wadi Abu Dom
Dangeil
ED-DEBBA
Gala Abu Ahmed
Wadi Howar
ATBARA
Meroe
Qalaat Shanan
Atbara
Wadi el-Melik
Wadi Muqaddam
6th cataract
Jebel Sabaloka
OMDURMAN
KHARTOUM
KASSALA
Eritrea
Blue Nile
MODERN TOWNS
Ancient sites
WAD MEDANI
GEDAREF
White Nile
SENNAR
KOSTI
N
Ethiopia
South Sudan
Azaza
0
250 km

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The round structures of Gala Abu Ahmed fortress in lower Wadi Howar, Sudan

Michael Flache

Introduction

The Gala Abu Ahmed fortress (GAA) is located in the South Sahara of North-western Sudan. More specifically, in the lower reaches, i.e. the eastern part of Wadi Howar, about 110km west of the river Nile. Since 2008 the fortress is excavated by the University of Cologne's Gala Abu Ahmed project (see Jesse and Peters 2009; Eigner and Jesse 2009; Eger *et al.* 2010). Two round structures, Rotunda1 (RUB1) and Rotunda2 (RUB2) (german: *RUndBau*) are located in the north-eastern area of the fortress, adjacent to the northern enclosure wall (Figure 1, Plate 1).

Approximately 10m south of these rotundas are the structures of the complex multi-roomed building excavated in trench 10. The round structures are part of this trench 10 and thus bear the official designation 84/95-10-RUB1 and 84/95-10-RUB2.

The two circular buildings were buried under sand. RUB2 is partially covered by the remains of a further circular secondary structure, which is of more recent date.

Rotunda1 (RUB1)

During the first excavation season in 2008/2009, a small elevation located north of the complex building in trench 10 was noticed. This area mainly consists of aeolian sand and several boulders of larger size. It was then examined in more detail during the second field season in 2009 when trench 10 was extended to the north. After the removal of approximately 200 mm of wind-blown sand and loose sandstone fragments and boulders scattered on the surface, the wall of a circular structure became visible. Sand dunes have accumulated behind the northern enclosure wall and had to be partly removed to completely uncover the rotunda. Several trenches were then excavated to get more information about the architecture (Figure 2).

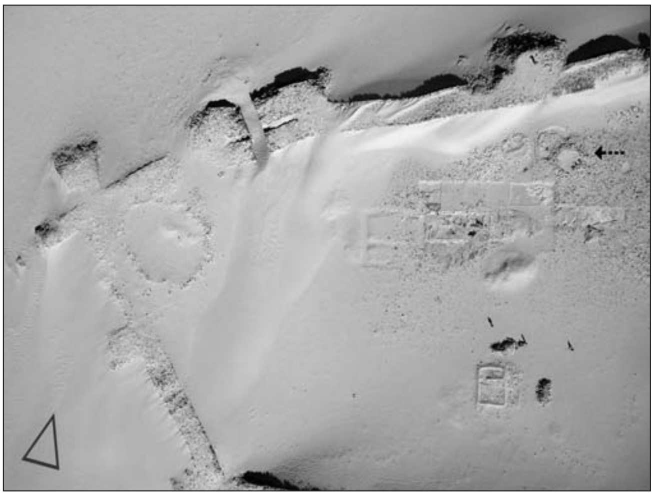


Plate 1. Aerial photograph of Gala Abu Ahmed, with rotundas in the north.

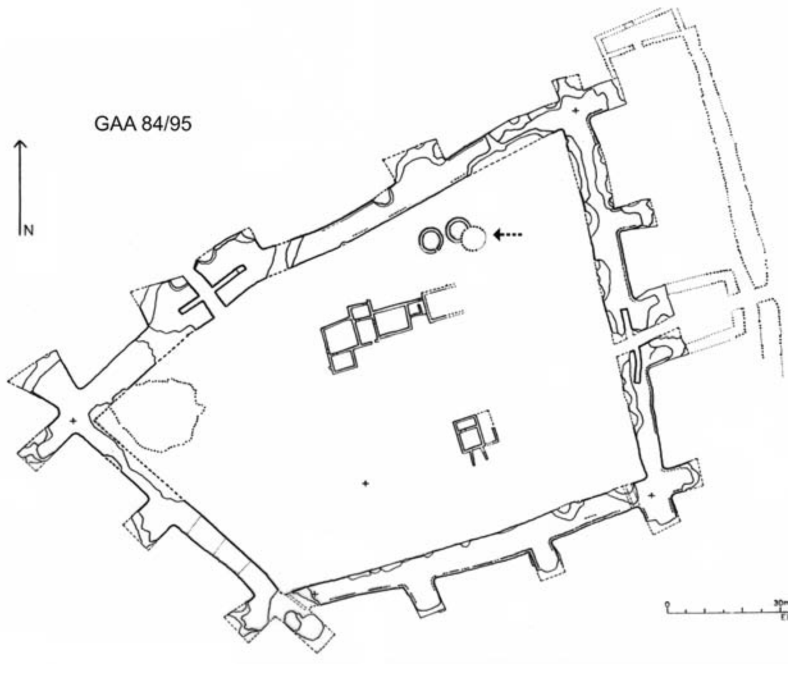
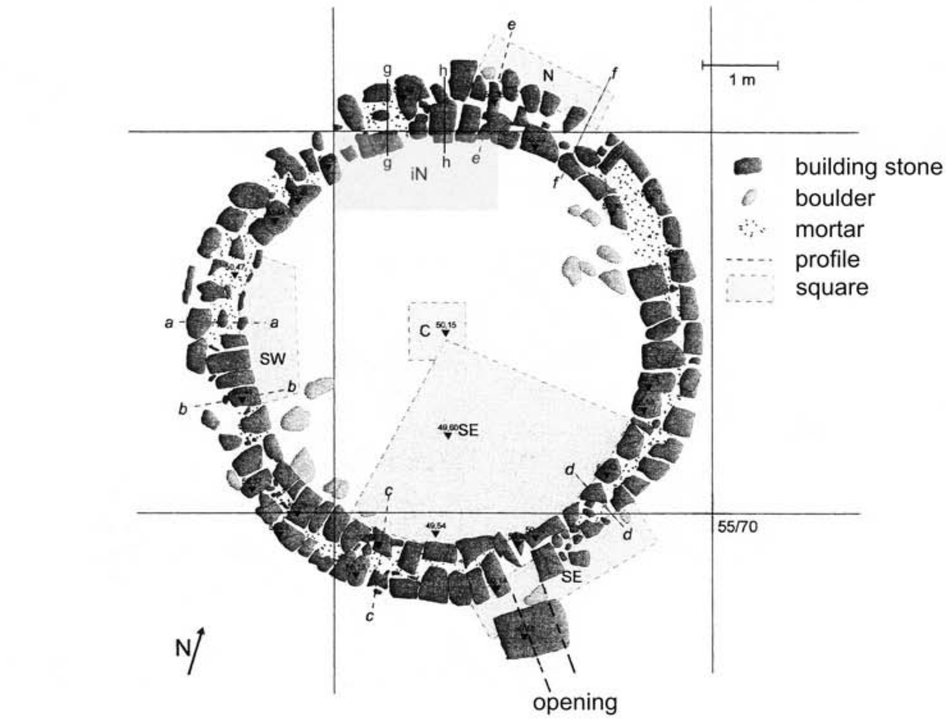


Figure 1. Plan of Gala Abu Ahmed, showing trench 10 as well as RUB1, RUB2 and the secondary structure (scale 1:2000) (Eigner 2011).

Description

Rotunda1 is entirely built with rough sandstone blocks. A large number of the stones, measuring from 100mm to 500mm in length, 100mm to 400mm in width and about 150mm in height, are of slight trapezoidal shape. The outside diameter of the rotunda varies between approximately 6.74m (east-west direction) and 7.03m (north-south direction). The wall usually consists of two rows of sandstone blocks and is approximately 700mm to 800mm thick (Figure 2).

While in the south-eastern and southern part only three or four courses of sandstone blocks are preserved, six still exist in the northern and north-western part. Some scattered pieces of a seventh course are also *in situ*. The rough sandstone blocks are bonded with a very firm clay mortar. This clay mortar was also used to fill any gaps in the walls and was up to 150mm thick. The wall of the building took advantage of the sandstone bedrock as a foundation. Any differences in elevation in the area of the base of the wall were either compensated for by foundation trenches made with a pick or with a filling of small sandstone fragments. The wall of the rotunda is slightly inclined towards the centre of the building. A significant overhang of the upper courses of the wall was recognized during excavation. At a height of 1.0m of the wall



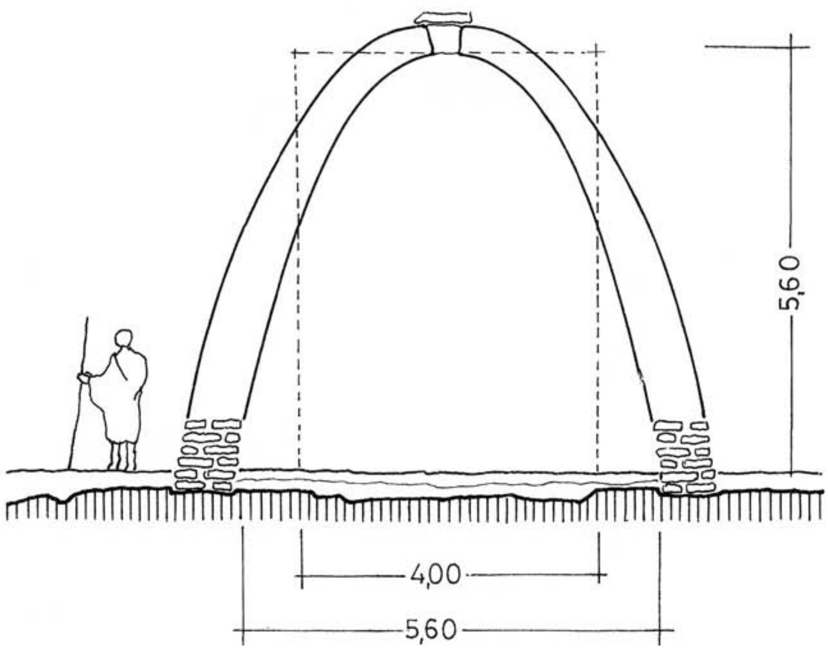


Figure 2. Drawing of RUB1, including trenches and possible reconstruction, including assumed circular cylinder (scale 1:100) (Flache 2009; reconstruction drawing, Eigner 2011).

Plate 2. The inclination of the inner north wall of RUB1.

the offset is up to 250mm in some sections. The inclination of the wall was also observed on the outside of the rotunda (Figures 3-4, Plate 2).

On one of the sandstone blocks in the eastern part of the uppermost course of the wall an approximately 150mm long chisel mark in the form of a triangle with two prolonged legs was recorded.

The amount of sandstone rubble found in the interior, as well as around the rotunda seems to be far too little to assume that the building was completely made of sandstone blocks. The excavations revealed a decrease in the amount of rubble and also the archaeological material towards the rammed clay ground floor of the rotunda, which was reached at a depth of about 400mm below the actual surface. A large number of ash lenses of varying size and intensity were recorded here. Underneath the floor a levelling layer of clay and coarse gravel was found which was used to fill any undulations in the bedrock. In several places honeycomb-like insect nests, reaching down to the bedrock were observed. The inner surface of the wall of Rotunda1 was still partly plastered with mortar. No hints for any kind of support have been found in the centre of the building. There was also no visible evidence for the use of mud bricks as a building material, although clay was used for the floor surface as well as for mortar.

The opening

In the south-eastern section of Rotunda1 an opening was documented which was apparently deliberately blocked with stones (Figure 5, Plate 3). Here the wall is preserved four courses high with the bottom layer acting as a kind of threshold, therefore the opening starts with the second stone

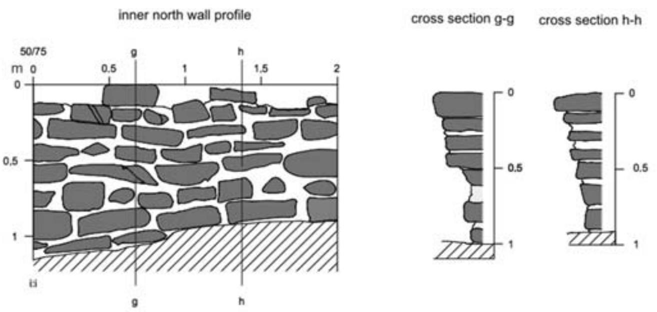


Figure 3. Profile and cross sections of inner north wall of RUB1 (scale 1:50) (Flache 2009).

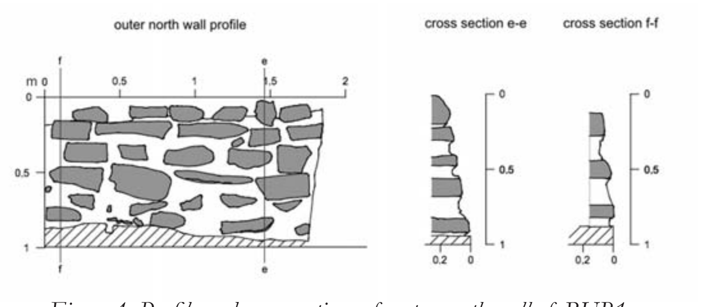


Figure 4. Profile and cross sections of outer north wall of RUB1 (scale 1:50) (Flache 2009).

layer. With a width of 500mm it is fairly narrow. Because of the few remaining wall courses the total height of the entrance cannot be specified. In general, the opening seems to be too narrow for a door. What was obviously the lintel was found directly in front of the opening: a rough sandstone block of 1 x 0.6m in size bearing unspecific pick marks on its top. Presumably the block turned when falling down or was turned by external forces about 180 degrees and therefore the rougher bottom side actually faces upwards (Plate 4).

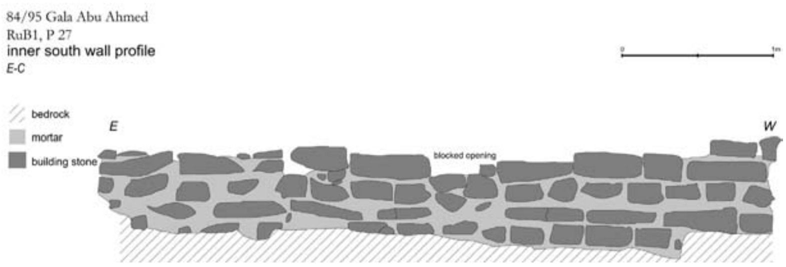


Figure 5. Profile of the inner south wall of RUB1, including the blocked opening (scale 1:50) (Flache 2009).

Plate 3. The blocked opening of RUB1.

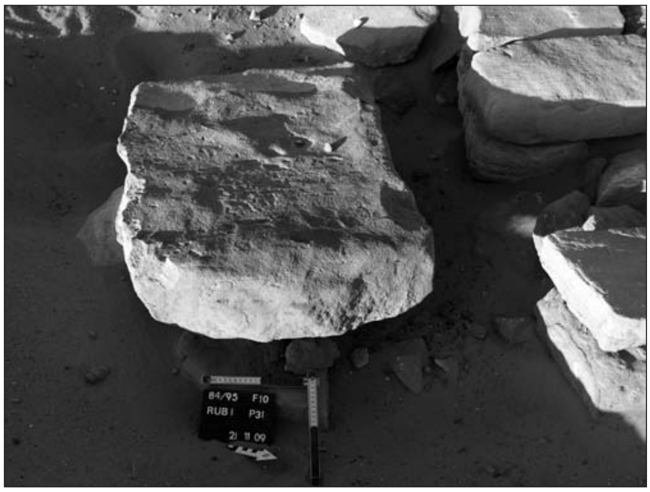


Plate 4. The lintel lying a little to the south of the blocked opening of RUB1.

Rotunda2 (RUB2)

Already during the detailed investigation of Rotunda1 in 2009 the remains of a further, obviously similar structure east of Rotunda 1 had been noticed. This second structure was explored in more detail during the 2011 campaign. For this purpose, trench 10 was again extended to the north and east.

Description

Rotunda2 is located about 1.5m east of Rotunda1. As already mentioned a further circular structure, the so-called "Secondary structure", partly overlies Rotunda2 (Figure 1, Plate 1).

Due to the Secondary structure only about 60% of the wall of Rotunda2 could be revealed (Figure 6). The use of rough sandstone blocks, the construction of the wall and the clay mortar correspond to the features of Rotunda1. The wall was made of two rows of stone blocks and had a width of approximately 750-800mm. Four courses of stone blocks were visible. Most of the rough sandstone blocks were on average about 100-500mm long, 200-400mm wide and about 150mm high and of a slightly trapezoidal shape. Only the upper course of the wall of Rotunda2 has been excavated. An inclination of the wall comparable to Rotunda1 can, however, be suggested due to the slightly oval shape of the building (Figure 6). The outer diameter of Rotunda2 was 7m north-south. The exact dimension east-west could not be determined, but should have a similar value. An opening was not found but can be expected as in Rotunda1 in the southern section of the building which is hidden by the Secondary structure. A large amount of sandstone rubble is present inside and outside of Rotunda2.

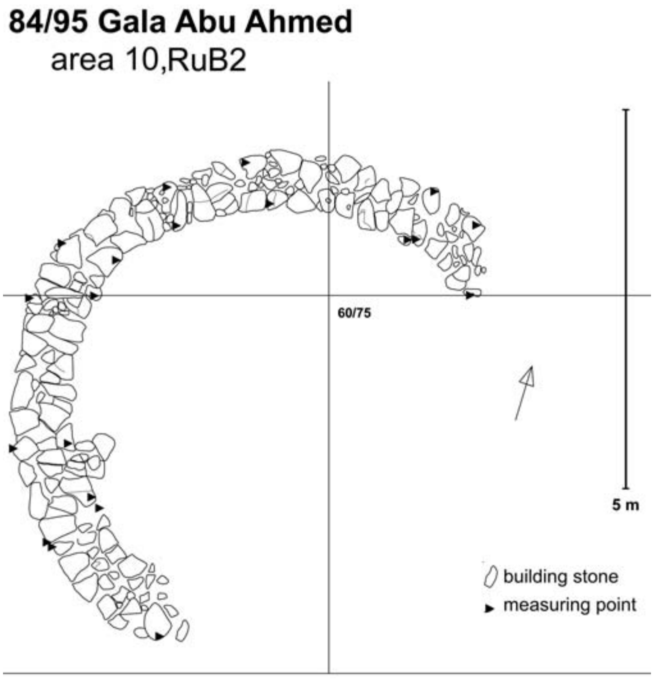


Figure 6. Plan of the excavated part of RUB2 (Flache 2011).

The archaeological material from the two rotundas

The finds collected in Rotunda1 and Rotunda2 fit well with the general assemblage of the Gala Abu Ahmed fortress. However, most of the pottery sherds, the lithic artefacts, the bones and the small finds (among them fragments of quartz ceramics and ostrich eggshell beads) have been excavated in the top sediment layers. A redeposition of these finds seems highly probable. Therefore, only the material relevant for the interpretation of the rotundas will be considered here, especially the botanical remains. The entomological evaluation of the honeycomb insect nests proved to be extremely difficult; first assumptions point to certain species of wasps (*Vespidae*), but this still has to be verified.

Among the fragments of charcoal acacia (*Acacia nilotica*) could be identified.[1] An analyzing of sediment samples collected during the excavation of the northern sondage in Rotunda1 showed that only a little botanical material is present. In samples 4 and 5, coming from a depth of about 600-700mm below the present surface and associated with the presumed occupation floor, charred seed fragments have been found. They belong to the gourd family (*Cucurbitaceae*) or more specific to colocynth or bitter apple (*Citrullus Colocynthis*).[2] These toxic and very bitter plants were used mainly for medicinal purposes to treat gastro-intestinal symptoms. In times of crisis the seeds are still used today as food (see Badura 2012, 79).

[1] Archaeobotanical identification: Barbara Eichhorn, Wiesbaden.
[2] Archaeobotanical identification: Stefanie Kahlheber, Frankfurt.

Rotunda1 and Rotunda2 – Interpretation and dating

The two rotundas integrate very well into the entire building complex of Gala Abu Ahmed. The type of masonry, the rammed clay floor with levelling layers beneath, and the use of rough sandstone blocks as a building material has also been observed in other buildings inside the fortress (see Jesse and Peters 2009, 63-64; Eigner and Jesse 2009, 147-149).

Foundation trenches carefully dug into the bedrock and the presence of smaller sandstone fragments at the bottom of the wall of Rotunda1 indicate a relatively high weight of the building. Based on the documented overhang of the upper layers of the wall, it can be assumed that Rotunda1 (and, therefore, probably also Rotunda2) must have been a corbelled dome (Figure 2). The inclination is detectable on the inside as well as on the outside of the wall. Thus, a vertical outer wall with a dome or dome-shaped roof can be excluded. The inside of Rotunda1 was obviously plastered with clay, which corresponded in its consistency to the clay mortar used for the wall construction. The existence of a clay layer outside of the building suggests that the exterior living floor was at about the top level of the second stone course of Rotunda1, approximately 200mm above the bedrock, and thus on the same level as the floor inside the structure. Therefore it appears that the building was slightly dug into the sediment and was surrounded by a rammed clay floor.

The ash lenses and fire reddenings on the clay floor documented inside Rotunda1 indicate that a small, controlled fire had frequently been burned there, although the inner wall showed no traces of soot or smoke.

Two charcoal samples, both from ash lenses excavated on the floor, and one sample of charred colocynth seeds have been submitted for radiocarbon dating. The resulting ages range between 930calBC and 1060cal BC (Table 1).

As the two dated charcoal samples and the seed sample originate from different areas of the building, a date of around 950 calBC can be assumed. Rotunda1 fits in quite well with the supposed period of occupation of the Gala Abu Ahmed fortress between about 1100 and 400 BC (Eigner and Jesse 2009, 155) and seems to have been built at the same time, or at least shortly after completion of the fortress. Furthermore, it may be assumed that the rotundas were used throughout the period (or periods) of use of the Gala Abu Ahmed fortress spanning from the Third Intermediate Period up to the end of the Napatan kingdom time. This seems to be evidenced by the blocked-opening in Rotunda1. Within fortifications, due to the shortage of building ground it would make no sense to leave a walled building.

How long the building survived intact before its collapse either due to structural failure and / or to external influences cannot be deduced. The amount of sandstone rubble found inside and outside Rotunda1 point at least to its stone walls having originally attained a much greater elevation.

Rotunda1 may best be interpreted as a storage space which is essential within fortifications. The round shape and the sup-

Table 1. The radiocarbon dating of Rotunda1.

Lab. No. *	Age bp	Age cal BC **	Origin ***	Material
Poz-35 879	2780 ± 35	930 ± 50	84/95-10-RUB1/SE	Charcoal (*Acacia nilotica*)
Poz-42 268	2785 ± 35	940 ± 50	84/95-10-RUB1/N	Charcoal (indeterminable)
Poz-42 275	2875 ± 30	1060 ± 50	84/95-10-RUB1/N	charred seeds (*Citrullus colocynthis*)

* Laboratory: Poznan, Poland; ** calibration was performed using the program "CalPal" (Version: March 2007), developed by Weninger, Jöris, Danzeglocke, Cologne; *** SE – South-eastern sondage, N - Northern sondage.

posed dome fit well with magazine construction evidenced several times in ancient Egypt and Sudan (see below). Such structures generally served as granaries or silos. The remote location of the Gala Abu Ahmed fortress and its function as a military trading post (Eigner and Jesse 2009, 156) made food storage facilities essential.

The botanic remains discovered in Rotunda1 give no indications, however, for the storage of cereals such as wheat or barley. Only charred seeds of colocynths have been found so far. The ash lenses and the insect nests are also unusual features for a granary. The latter were only found close to the clay floor. Maybe the ash lenses have to be seen as the result of some sort of "pest control", undertaken from time to time, or that the insects colonized the building shortly after it was abandoned.

Rotunda2 closely resembles Rotunda1 so it can be assumed that they represent identical structures built around the same time to form a single complex.

The "Secondary structure" above Rotunda2

As already mentioned, a circular structure partly overlies Rotunda2 (Plate 5). The stone circle of the so-called "Secondary structure" is built of loosely stacked rough sandstone blocks and opens towards the south / south east. Its interior is covered by wind-blown sand. The outer diameter is about 8m, the inner diameter is of approximately 5m and the preserved height is of about 600-800mm. A sediment layer about 200-300mm thick was observed between the uppermost stone layer of Rotunda2 and the secondary structure. Most of the sandstone blocks of the secondary structure have a trapezoidal shape and their dimensions and appearance match those used for the construction of Rotunda1 and 2. Probably collapsed sandstone blocks from the two rotundas have been re-used to build the secondary structure of still unknown function. Also the age of this structure has to remain open. The secondary structure was built when Rotunda1 and 2 were ruinous and a sediment layer had accumulated above their remains.

Plate 5. RUB1, RUB2 and the secondary structure looking eastwards.

Rotunda1 – attempts at a reconstruction

Combining the evidence available for Rotunda1 with already published reconstruction drawings of round grain silos and ancient illustrations of round, dome-shaped buildings (Arnold 1994, 135, fig. B; Badawy 1948, 116ff.; Brinks 1981, 885, fig. 5; Kemp 1991, 298) an attempt at a reconstruction of Rotunda1 is made.[3] Corbelled domes show different types of cross-sections, semi-circular or parabolic. Of which the parabolic cross-section is statically more stable. It is likely that the builders of the Gala Abu Ahmed fortress chose this safer cross-section. The assumed height of Rotunda1 is based on Arnold (1994, 135, fig. B), who takes the inner diameter of the ground floor area as an approximate height in his reconstruction drawing.

For Rotunda1 with its outer diameter of about 7m and a wall thickness of about 800mm, an inner diameter of 5.4m can be established. Taking into account the different levels of wall layers and the inclination, an inner diameter at the level of the living floor of around 5.6m seems to be more appropriate. In relation to Arnold's proposition, the height of Rotunda1 would have been approximately 5.6m. As the enclosure walls 5m away are at least 5.3m high (including the parapet, see Eigner and Jesse 2009, 147), the two circular buildings represented quite impressive structures in the context of the fortress (Figure 2).

[3] I would like to thank the architects Dieter Eigner, Vienna and Andrea Phillip, Regensburg for useful comments and discussions.

The careful construction of the foundations suggests a high weight and therefore a considerable height of the rotunda. Also, the height of the wall found in situ and the inclination are unusual for a foundation wall. As no evidence for mud-brick walls was found, it is quite possible that the entire rotunda was built with rough sandstone blocks. However, the amount of rubble found is insufficient to allow the reconstruction of buildings of such proportions.

In the upper part of the rotunda some sort of filling hole can be supposed which might, on analogy with similar buildings elsewhere, have had a diameter of approximately 400-500mm (Dieter Eigner, pers. comm.). This opening was at the apex of the building (see the reconstruction drawing: Figure 2) or to the side, as proposed by Arnold (1994, 135, fig. B). Various representations of other rotundas (Badawy 1948, 117 ff., fig. 123-128) suggest a filling tube about two-thirds up the assumed height of Rotunda1. To avoid unnecessary interference this filling tube would probably not have been located vertically above the south-facing discharge opening. As there is a steady north-east wind in the area of Gala Abu Ahmed, an opening to the west would be probable. However, an opening in the apex is just as likely, because this design is also used in recent, although mostly much smaller domes (Eigner 1984, 84ff. and pers. comm.). No evidence for any kind of stair construction has been found. To access the filling tube, a wooden ladder would be the simplest solution, although wood was a rare material in this region and must have been quite valuable.

It can be assumed that a support structure was used for the construction of the upper part of the rotundas of the Gala Abu Ahmed fortress. Up to chest height a dome may certainly be built without any support. This also gives the possibility to light a small fire inside the sheltered half-finished building for warmth or for food preparation. A supporting structure does not necessarily have to be made from wood, which is very precious in this region. Filling with sand, to the appropriate height, fulfilled the same purpose (Dieter Eigner, pers. comm.).

Function and importance of the rotundas for the Gala Abu Ahmed fortress

There is little doubt that the two round buildings of the Gala Abu Ahmed fortress are granaries (or "silos").[4] Each settlement and especially a fortress such as Gala Abu Ahmed needed storage facilities to ensure the continuous supply of basic food for its occupants. Bread and beer are of fundamental importance in this regard (Kemp 2006, 172). The main types of grain, which were available in those days, are emmer wheat (Triticum dicoccum) and barley (Hordeum vulgare) (Kemp 1986, 132). The fact that no such cereals have been found so far in Rotunda1 in Gala Abu Ahmed can possibly be explained by the walled opening, as this suggests that the store was completely emptied and cleaned before being abandoned. The few remaining cereal grains have probably been consumed by animals (mice, insects, etc.), who left only the charred seeds of colocynths.

Based on the above proposed reconstruction of Rotunda1 (see Figure 2), the storage capacity of the two circular buildings would allow a stock of more than 112 tons of cereals.[5] According to Tietze (1986, 72), who assumes an annual consumption of 500-600 kg per person for Amarna, this would mean that the annual consumption of more than 200 people could be provided from the two rotundas.[6] However, he refers to additional food from the surrounding area. Kemp (1986, 132) even suggests, by comparisons with Roman daily rations, only 0.6-0.8kg per day per soldier, i.e. 219-292kg per year, which could have roughly fed 400 - 500 men for a year and points out that the additional food in Egypt is considered to be rather little. However, he considers such information itself as questionable. Eigner is a little more cautious in his calculations. He assumes a value of 800kg per year as more realistic, especially when compared with modern industrial states which consume 700-1000kg per person and per year. This result gives a number of more than 140 people whose basic cereal needs for a year could be covered (Dieter Eigner, pers. comm.). Eigner's large amount of 2.2kg per soldier per day appears to be useful insofar as there is no clear evidence of the usage for these rations, and possibly family members or / and private farm animals (e.g. donkeys, chicken) had to be supplied as well (Kemp 2006, 240).

Presumably, the two granaries were never completely filled. Even if some sources stated a year or even two-year storage strategy for the Egyptian fortresses of the Second Cataract (Kemp 1986, 134) at least a more or less continuous flow of grain to the Gala Abu Ahmed fortress is conceivable.

The calculated numbers of inhabitants fits quite well with other statistics on troops. Steiner (2008, 81) acts on the assumption that for a reasonable defensive strength at least one soldier is necessary at every 2m of the enclosure wall of the Middle Kingdom fortresses. The minimum manning of the Gala Abu Ahmed fortress would then have amounted to about 225 men.[7]

The two rotundas were part of the construction phase of the fortress as is indicated by the radiocarbon evidence, at least as planned the fortress was expected to have a garrison of about 200 men. This in turn would mean that Rotunda1 and Rotunda2 covered the entire demand for grain storage facilities and therefore no further silos of this type and size are to be expected at the fortress.

So far no traces of any military attack have been found at

[4] Egyptian: *šnw.t* classifier sometimes with two rotundas () (see Wb IV, 510.1-16).

[5] The calculation results of the comparison with a circular cylinder of 4m diameter and a height of 5.6m. (Dieter Eigner, pers. comm.). Formula: $r^2 * \pi * H = x$; $(2m)^2 * \pi * 5.6m = 70{,}37m^3$. Tietze (1986, 72) assumes a grain density of $800kg/m^3$; this results in $800kg/m^3 * 70{,}37m^3 = 56296kg = 56{,}296t$ per rotunda.

[6] Formula: (56296kg*2) / person per year consumption kg = x

[7] Formula: length of the enclosure wall of Gala Abu Ahmed /2=x; ~450m/2=225 (for the enclosure wall see Plate 1).

the fortress and it is therefore conceivable that the number of troops varied in later times. In this context one silo might have been sealed to make it more resistant to environmental factors, but to still have it available if needed.

Rotundas, grain silos and granaries

Rotundas represent one of the simplest and probably earliest architectural designs. Round buildings are already known in the Predynastic period at Merimde, el-Omari and Maadi (Trigger *et al.* 1983, 22ff.; Bietak 1984, 318). First built as wooden structures with braided mats, there were already, beside huts, round silos embedded in the ground and plastered with clay (Bietak 1984, 318). Such constructions are still seen today in Africa. Pictures from Abydos (1st Dynasty) show that round buildings were well known to the early Egyptians (Brinks 1981, 883; Badawy 1948, 9, figs 7a, 7b). Round architecture was built for a variety of purposes, such as simple worker dwellings, stoves, wells, Nilometre, as sacred places or in grave architecture as well as grain silos (Bietak 1984, 318). Rotundas with an arched roof construction are classified as domes. The round grain silos belong to the category of ground domes.[8] These buildings are constructed mainly with mud bricks and are slightly set into the ground without further foundations and show a semicircular or parabolic cross-section (Brinks 1981, 883). Although Arnold (1994, 136) assigns the brick domes to the New Kingdom, Brinks (1981, 883), however, stated that round grain silos were already built in the Old Kingdom. This is also proved by floor plans of buildings at Giza and Dahshur (Badawy 1948, 119, figs 129, 131; Kemp 2006, 208, fig. 74, 210, fig. 75). The silos had in the lower section a small discharge opening and were filled from the top through another opening. This was located in the apex or upper portion of the building and has been reached by a ladder or by solid stairs. Arnold (1994, 136) gives capacities of up to 400m3. The ancient Egyptians were familiar with the calculation of the volume of these domes, although the number π was not yet known then.[9]

Dome-shaped silos are of limited use as storage space for other commodities apart from grain or substances with a similar consistency. For this reason and because of the need for more sophisticated architecture the round granaries were usually replaced by square buildings in the dynastic period. These were easy to expand, space saving and more flexible to use. Oval or rectangular-oval shapes are seen as transitional forms (Bietak 1984, 318). Square magazine buildings such as the "million year house" or Ramesseum of Ramesses II in Thebes, were mainly used as storage facilities in the Nile Valley (Kemp 2006, 259). They also had an upper opening for filling and a lower discharge opening. Nevertheless, round granaries were still used in the New Kingdom (Tietze 1986, 55ff.) and even later.

Parallels for the rotundas of the Gala Abu Ahmed fortress

As described in the previous section, rotundas were used in the Nile Valley to store grain at all times. Although the differences in shape and size are rather significant, several parallels to the two rotundas described in this paper can be found in Egypt and Sudan. On Sai round mud-brick silos with a diameter of up to 5.8m have been discovered in the New Kingdom town. The mud bricks are of a slight trapezoidal shape and approximately the same dimensions as the stones used in Gala Abu Ahmed (Azim 1975, 114ff.). In the Saite period fortress of Dorginarti round granaries are also reported, built of mud brick but partly with a stone foundation (Knudstad 1966, 183). Round stone buildings some of which might have been used as granaries have been discovered on a Napatan site in the region of the Fourth Cataract (Kolosowska and el-Tayeb 2012, 64).

In many Egyptian settlements and forts, the number of stores seems to have been adapted to the specific needs, by new constructions, renovation or demolition. In the Gala Abu Ahmed fortress the need for storage space seemed to have been carefully planned from the beginning. In Egypt, there is evidence that the store often is situated close to a place, office or building, from which a guard was able to control the filling and discharge of the silo (Kemp 1986, 129). If the same is applicable for Gala Abu Ahmed it still needs to be proved.

Concluding remarks

The two circular structures of the Gala Abu Ahmed fortress are the remains of ground-dome-shaped granaries. The enormous capacity of the two silos was sufficient to serve the needs of the garrison, based on the calculated manning of the fortress and, therefore, no further granaries inside the Gala Abu Ahmed complex should be expected. The two domes appear to have been built at the same time, around 950 BC. They formed an essential component of the grain supply strategy of their builders. It seems that, according to available radiocarbon dating (Friederike Jesse, pers. comm.), the foundation of the fortress took place during the Third Intermediate Period. Whether Egyptians or local princes built the Gala Abu Ahmed fortress still remains an open question. However, based on the archaeological material, especially the pottery and the small finds (Lohwasser 2004, 143ff.; 2009,

[8] For the different kind of domes see Brinks 1981, 882ff.

[9] "A circular container of 10 by 10 cubits.
Take away 1/9 of 10, thus 1 1/9; remainder 8 2/3+1/6+1/18
Multiply the 8 2/3+1/6+1/18 by 8 2/3+1/6+1/18 (ie square it); result: 79 1/108+1/324
Multiply the 79 1/108+1/324 by 10; it becomes 790 1/18+1/27+1/54. Add a half to it: it becomes 1185.
Multiply the 1185 by 1/20 giving 59¼. This is the amount that will go into it in quadruple-hekats, namely 59¼ hundreds of quadruple-hekats of grain."
(Rhind Mathematical Papyrus, Problem 42, papyrus British Museum EA 10057-8, quoted after Kemp 2006, 172).

159ff.) it is obvious that the Gala Abu Ahmed fortress was used during the Napatan period (800-400 BC), so maybe two phases of occupation have to be considered (see Eigner and Jesse 2009, 156).

The lack of evidence of a violent destruction and the blocked opening of Rotunda1 suggests that not only this building but the entire Gala Abu Ahmed fortress was deliberately abandoned and the fortress was no longer needed, for what reason ever.

The construction of the rotundas is generally comparable with Egyptian domes of the Nile Valley, however, a grain silo built entirely of sandstone has not previously been noted. It should be stressed that the amount of sandstone rubble close to the two rotundas does not allow of a complete reconstruction. As clay was a well known building material to the constructors of the fortress, superstructures of mud brick may be assumed, which then would have completely weathered (see Eger *et al.* 2010, 75). However, no traces of such mud bricks have been detected. So the question of the final way of construction has to remain open.

The scarce botanical material found in conjunction with the sealed opening of Rotunda1 indicates that the building was carefully emptied. The two rotundas in Gala Abu Ahmed must have been rather impressive buildings. If the hypothesis is confirmed, that Rotunda1 and Rotunda2 were built entirely of rough sandstone blocks, this would be the first proof for this type of construction. (Flache 2011).

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