SUDAN & NUBIA

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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
ABU HAMED
Nile
El-Ga'ab
Basin
H29
5th cataract
KAREIMA
4th cataract
Abu Sideir
Napata
Wadi Abu Dom
Dangeil
ED-DEBBA
ATBARA
Gala
Abu Ahmed
Wadi Howar
Meroe
Qalaat Shanan
Atbara
Wadi el-Melik
Wadi Muqaddam
6th
cataract
Jebel Sabaloka
OMDURMAN
KHARTOUM
KASSALA
Blue Nile
Eritrea
MODERN TOWNS
Ancient sites
WAD MEDANI
White Nile
GEDAREF
SENNAR
KOSTI
N
Ethiopia
0
250 km
South
Sudan
Azaza

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Front cover: Excavations in progress in the *Kerma Ancien* cemetery at site H29 in the Northern Dongola Reach (photo D. A. Welsby).

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Meroitic Building Techniques: a few observations from Dangeil

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The 2011 field season of the National Corporation for Antiquities and Museum's mission at Dangeil ran from mid October until the beginning of December. Dangeil is a Kushite site situated just north of the modern city of Berber and south of the Fifth Cataract of the Nile. Excavations were conducted in two areas: the 1^{st} century AD Amun temple which is the focus of this paper, and in the associated Kushite cemetery, designated WTC which will be discussed in a future publication.[1]

Work in the temple concentrated on the south side of the first court and upon clearing the southern half of the pylon entrance (Figure 1). The interior of the court is 11m east-west by 27m north-south while the pylon half is 5.5m wide by 12m long. At the end of 2010, excavation in the first court had stopped just above the floor surface in the southern half, the southern half of the pylon remained unexcavated and the substantial collapse of three columns (H770, 773 and 761) remained *in situ* (Plate 1). Removal of the collapsed columns provided an opportunity to examine more closely the building's construction, plastering techniques and brick composition (Plate 2). The temple was constructed of a mixture of materials including mud brick, fired brick, mud and lime mortars, palm wood and sandstone.

Plate 1. South half of the first court with column falls in situ.

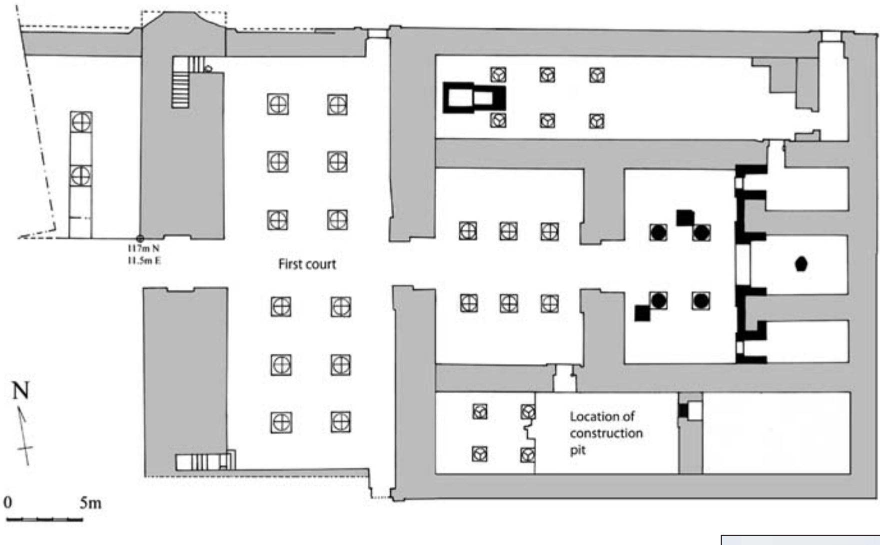

Figure 1. Plan of the Amun temple (scale 1:500).

Charred palm beams, charcoal and ash from the roof were preserved beneath the columns' tumble. The columns fell after the temple had burnt and the roof collapsed. The roof had been flat, consisting of a framework of palm beams, ribs and probably matting and mud plaster, supported on the columns and walls. The distance spanned by each roof beam would have been approximately 3.5m when the relative position of the walls and columns is taken into consideration. The instability of the columns was caused to a large degree by rainwater penetration of the mud mortar holding the columns together. However, without doubt, the nature of the column construction in the first court versus that, for example, in the second court was an important factor in aiding the percolation of water and thus creating structural weakness.

In both courts, the column drums were constructed of red-brick quarter-circles mortared together. The diameter of the columns in the first court was greater at 1.25m, than those of the second court which only measured 1.08m. The size of the red-brick quadrants used in the drums in both courts is the same. Each has a radius of 520mm. The difference in diameter was

Plate 2. South half of the first court at the end of the 2011 season.

[1] The team consisted of Julie Anderson, Salah eldin Mohamed Ahmed, Amal Attala, Fakhri Hassan, Julian Reade, Mahmoud Suliman, Rihab Khider, Caroline Rocheleau, Tracey Sweek, Tajasir Mohamed, Omima Abdelrahman, Yassin Mohamed Saeed. The mission is grateful to the National Corporation for Antiquities and Museums, Sudan, the British Museum, UK and Archeology4All, Italy for their support.

created by varying the size of the gaps between the quadrant bricks in each drum. In addition to mud mortar, galletting was also used in the first court (Plate 3). It largely consisted

Plate 3. Column in the first court with galletting.

of fragments of broken red brick that were inserted into the wet mud mortar between the bricks during the laying of each drum. As the gap to be filled by the mortar was large, *c.* 200mm, the addition of galletting served to strengthen and reinforce the bond; however, there still remained a larger gap between the bricks comprising the drums of the first court columns than those elsewhere, through which water could percolate. The gap between the bricks in the second court for example, was only *c.* 40mm.

Each column was covered with an unevenly applied 'scratch coat' of lime plaster up to 20mm thick, with spiral lines incised in it which encircled the column. Close examination indicated that the plaster was extremely thick when applied; so thick that folds or rolls were created when the plaster was incised (Plate 4). Mud plaster was applied on top

Plate 4. Lime-plaster scratch coat.

of the scratch coat over which a wash of lime was applied. The mud plaster averaged 8mm thick but the lime wash was under a millimetre. Pigments were applied to the lime wash (Plate 5). The mud plaster was extremely friable and the pigments themselves are fugitive so together this creates a very

Plate 5. Column with a layer of mud plaster overtop of a lime plaster scratch coat. Lime wash and pigments have been applied to the mud plaster.

unstable decorative medium. The same technique was used on the walls with mud plaster being applied directly to the red-brick face then a lime wash applied over top. The nature of the pigments themselves and the paintings discovered have been discussed previously so need not be repeated here (see Anderson and Salah Mohamed Ahmed 2006; 2008; 2011).

Column bases were covered with cement (30mm in thickness) consisting of rounded desert pebbles (*c.* 20–30mm in size) mixed with lime (Plate 6). The cement was covered with a thick layer of lime plaster to which the artificial pigment identified as Egyptian blue, a copper silica compound ($CaCu(S_{14}O_{10})$), was applied. Similarly in the kiosk situated in front of the temple straddling the processional way, pigments were applied directly to a lime plaster finishing coat without an intervening layer of mud plaster and lime wash. These colours were less fugitive and better preserved than

Plate 6. Cement consisting of lime and rounded pebbles on a column base in the first court.

those on the upper parts of the columns and walls within the temple. It is possible that they were painted while the plaster was still slightly damp as this partly would account for their solidity. The Kushites utilized a less stable method for applying decoration within the temple yet were aware of and actually used a better technique elsewhere in the same sacred complex and often on the same architectural feature (e.g. the columns); the question is why?

The choice of technique may be part of an artistic convention. The interior walls of the temple and the upper parts of the columns show depictions of gods, rulers, processions etc., and may have been created by a team of artisans who were different from those engaged in construction work or adding simple washes of colour. The column bases and the kiosk were decorated in solid colours. Another factor might simply be physical location. Thick lime plaster is more waterproof than mud plaster with lime wash. The kiosk exterior and column bases within the temple were likely in contact with a greater amount of rain or water than the interior walls and upper parts of the columns protected by the roofing.

Tool marks were visible in the lime plaster and ridges were created when the plaster was applied and the plaster thickness is irregular (Plate 7). In many cases the shape of the tool marks does not appear to correspond to those produced by a plasterer's float, a tool still used today and which was

Plate 7. Tool marks visible in the lime plaster on a column base.

present in ancient Egypt, though not a common find. One such example of a wooden plasterer's float was discovered by W. M. Flinders Petrie at Kahun dating to the 12th Dynasty (1985–1795 BC) (Petrie 1917, 42, pl. XLVII; see also David 1986, pl. 18). Reused pot sherds were among the tools used for the application and scoring of lime plaster and cement and several were discovered, though this is not to say that they were the only tools utilized (Plate 8). Mud plaster may also have been applied by hand.

In addition to the charred roof beams mentioned previously, further evidence for the temple's fiery destruction came from the well-preserved staircase that led up to the top of the south end of the entrance pylon (Figure 1), and from the

Plate 8. Pot sherd reused as a tool for lime plaster application.

fire-reddened bricks of the south wall of the first court (Plate 9). It seems that the fire which destroyed the temple started inside the south pylon's stairwell, with the stairwell perhaps drawing wind to create a forced draught fire that was thus fanned and spread.

Plate 9. The staircase leading up the south pylon.

Following the fire, subsequent related structural collapse and the abandonment of the temple as a formal religious building, the stairwell was blocked. Beneath this blockage, mixed with the temple's destruction debris was part of the left foot of a large granite statue (Plate 10). It was part of the statue of the Kushite ruler Taharqo discovered in the temple in 2008 (see Anderson and Salah Mohamed Ahmed 2009). This fragment was found a substantial distance away from the other pieces, the majority of which were discovered in the south-eastern room of the temple, and seems to suggest that statue fragments could be found in the destruction layer anywhere within the temple.

The southern part of the pylon (H109) was constructed

Plate 10. Interior of the stairwell with the left foot of Taharqo statue in situ.

with a red-brick foundation and a mud-brick core faced with red bricks on the exterior sides and the upper courses. There is no evidence to suggest the presence of a red-brick bonding course running through the pylon. The stairwell and its landing were also of red-brick. Evidence for this construction is visible both on the top of the pylon in holes where the red-brick capping had been removed at some point in the past, and on the sides where the red-brick facing has fallen away from the mud-brick core (Plate 11). This construction differs from the north half of the pylon (H13), which as far as can be determined appears to be solidly constructed of red brick.

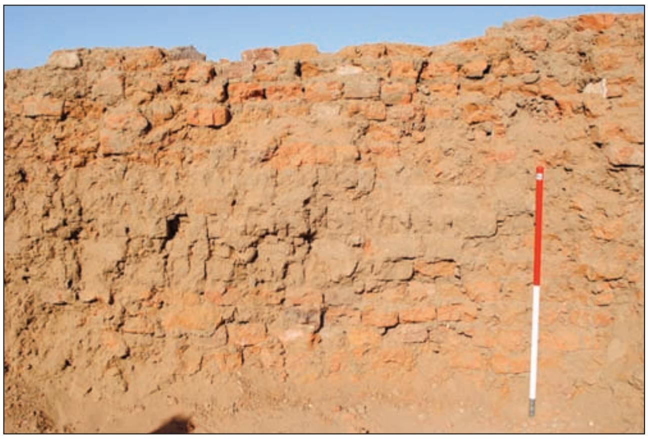

Plate 11. South pylon with mud bricks visible in the structure's core.

During excavation it quickly became clear that the south half of the pylon was one of the last parts of the temple constructed, if not in fact, the last. In contrast to the pylon half opposite, it contained an extensive amount of poorly laid reused red bricks of various shapes and sizes from columns, torus and cornice mouldings, along with poorly fired rectangular bricks. Lime finishing plaster still adhered to some of the reused bricks situated in the core of the structure, and unlike the northern half, portions of the south pylon were built askew, with the orientation corresponding neither to the contemporary structure nor to that of the earlier mud-brick building. Further, the south wall of the court abutted the pylon rather than joining it.

The standard brick size, whether fired or sundried, used throughout the temple was 340–360 x 180–190 x 80–90mm. The length of the standard rectangular brick is half its width. Mud bricks found in lower wall courses were the exception being slightly thinner than those in the upper courses in several instances. The weight of the upper courses appears to have compressed those in the lower courses slightly. The lower courses may also have been laid when slightly damp.

The exterior red-brick facing of the pylon (H109, 13) consisted of headers laid over stretchers, offset by half a header (50mm) each time so that long vertical joints and structural weakness would not be created (Plate 12). The foundations

Plate 12. Brick work in the north pylon (facing north west).

of the walls consisted of a course of red bricks laid on their sides. Throughout the building some of the thicker walls have two or three courses of fired bricks laid as headers on top of this lowest foundation course (Plate 13). These can protrude up to half a brick's length away from the main face of the wall and possibly functioned to inhibit the undercutting of the foundations particularly by environmental factors such as wind and rain. The columns in the first court required a firm base to ensure stability and were constructed on a foundation that consisted of four rows of red bricks laid in a single course of headers on each side and two diagonal rows in the centre (Plate 14). Presumably the columns elsewhere in the temple are similarly founded however their foundations have not been exposed.

The collapse of much of the east face of the south pylon (H109) can be attributed to its poor construction. Poorly fired red bricks in the exterior broke or were insufficiently bonded to the interior brick structure causing the facing to peel or break away (Plate 15). There appears to be no evidence for the insertion of wooden beams within the brickwork to tie it together. Unlike the exterior facings, bricks laid in the core were arranged in an irregular fashion adapting to whatever anomalous shape of brick that was to be inserted. Any avail-

Plate 13. Red-brick foundation courses beneath temple wall.

Plate 14. Red-brick foundation courses supporting the columns.

able material that remained towards the end of the building works appears to have been used in its construction. Workmen on site also noticed this and referred to the construction as 'Friday's work' ([*shughul youm jum'h*], work done on a weekend in haste when one would perhaps rather be elsewhere).

Mud mortar on top of the pylon contained numerous impressions of chopped stalks of vegetation which had been laid on top of every second course of wet mortar. The addition

Plate 15. East face of the south pylon, with outer facing damaged or missing.

of organic material functioned as additional binding and to keep the mortar and bricks damp as long as possible to limit shrinkage. Though this is good building practice, in this case it may have been a necessity due to the size of the wall and to the variety of material included within. A modern analogy would be the inclusion of horse hair in mortar renders to make them stronger. No actual vegetal material survived in the impressions; however, various straw-like materials and their fragmentation patterns were examined and compared with the mud impressions. This led to the tentative identification of the organic material as likely being chopped stalks of sorghum (Plate 16). This may be further indicative of the widespread

Plate 16. Mud plaster with vegetal impressions and a modern stalk of sorghum for comparison.

adoption and multiplicity of uses of sorghum made by the Kushites. Archaeobotanical analysis conducted on offering moulds and soil samples from the site have identified sorghum starch and phytoliths confirming that the Kushites utilized this resource at Dangeil (Anderson *et al.* 2007).

The same vegetal impressions are visible in the red bricks, though more prevalent in the non-rectangular bricks, suggesting that sorghum stalks were used as a temper. The soil used in the rectangular bricks was modified by the addition of coarse aggregates such as pot sherds and pebbles (Plate 17). The alluvial soil in the bricks appears sandy, and the soil may have been modified by the addition of sand however, particle analysis has not yet been conducted to determine the percentages of materials present in the bricks and to ascertain whether this is in fact correct.

The bricks were made in moulds, some specially shaped to create architectural features more normally found in stone such as torus and cornice mouldings (Plate 18). The dimensions of the regular rectangular bricks, mentioned above, do vary slightly but they are largely homogeneous in size and

Plate 17. Broken red brick with inclusions of pot sherds.

Plate 18. Red brick in a torus shape.

material so it is not unlikely that the bricks used in the temple were all made at the same time. Mud is a plastic substance and as such during manufacture, mud ran over the sides of the mould creating lips which are visible along the edges of the bricks. These lips can appear on both upper and lower edges (Plate 19). The upper face of a brick usually is less

Plate 19. Brick displaying a lip visible along the upper edge.

rough than the lower face, which takes the impression of the surface upon which it sits during manufacture, but despite this, sometimes it can be difficult to determine an upper from a lower surface.

Bricks are ubiquitous in Kushite and Egyptian architecture but there are few surviving examples of the moulds themselves and sources depicting brick manufacture are limited. Most analogous material comes from Egypt. For example, a wooden tomb model dated to the 12th Dynasty (1985–1795 BC) from Beni Hasan Egypt, now in the British Museum (EA 63837), depicts a team of brick makers with the small figure on the left putting the mud in moulds and the figures on the right mixing the mud (Plate 20). A surviving wooden brick

Plate 20. 12th Dynasty wooden tomb model of brick makers from Beni Hasan, Egypt (EA 63837). © Trustees of the British Museum.

mould, again of Middle Kingdom date, was found at the site of Kahun by W. M. F. Petrie (1971, 42, pl. XLVII; see also David 1986, pl. 18). A later example of brick making comes from a wall scene in the New Kingdom tomb of Rekhmire in Thebes (Davies 1943, pl. LVIII). Workmen collect water on the left, which is mixed with the earth piles in the centre of the scene. The mixed wet matrix is then brought to the persons setting the moulds. B. Kemp has noted that 'this very limited [ancient] documentation shows a way of working that seems to be identical to that of traditional brick-making in modern Egypt which has often been described (e.g. Clarke and Engelbach 1930, 208–9; Reisner 1931, 72–3; Petrie 1938, 4)' (Kemp 2000, 83). Similarly, this technique does not appear to differ much from brick manufacture today in the modern village of Dangeil as observed during the 2011 field season. The modern bricks were made in a wooden mould and were comparable in size, if not a little larger than the standard size of rectangular Kushite brick found in the Amun temple.

Initially, a slightly sandy mixture of desert sediments and alluvial soil was mixed with water to form a mud matrix.[2]

[2] The soil used originated from the material cleared and re-excavated from a large irrigation canal, thus there was a mixture of desert and alluvial sediments. The authors thank Mr Nigmedin Ahmed for demonstrating brick-making techniques for us in Dangeil.

Normally a depression (well) is created in the centre of the earth pile to which the water is added prior to mixing. The mud mixture was transported nearby to a relatively flat area where the bricks produced could be laid out in rows to dry in the sun. Mud selected was rolled in dry earth prior to insertion in an open framework rectangular wooden mould resting on the ground. Finger and hand-marks were made on the upper surface of the mud when it was slapped into the mould. This created a slightly uneven upper surface on the brick to enhance mortar adhesion. Such finger or hand marks are also present on many ancient bricks, particularly in the quadrants used in the columns and in vaulting bricks (Plates 21, 22). Finally, the upper surface of the mud now

Plate 21. Modern wooden mould used for making mud bricks.

Plate 22. Modern brick maker at Dangeil, Nigmedin Ahmed, making mud bricks.

sitting in the mould was dusted with a sprinkling of dry earth. Any extraneous material present in the dust could adhere to the brick. This technique helps prevent mud from sticking to the mould and the brick-maker. An analogy might be the dusting of surfaces with flour when making bread to stop the dough from sticking. The mould was then removed leaving the newly formed mud brick to dry in the sun and the process repeated beside it. Apart from being relatively flat, the ground surface was not prepared in any way to receive bricks. As a consequence any matter sitting on the ground surface can adhere to the bottom of the wet bricks.

A construction pit was uncovered in the southern room of the temple, just to the south of the second court (Figure 1, Plate 23). The pit had been used to mix mud mortar for the temple construction and interestingly, it was located within the building itself. A pile of dried mortar mixed with broken brick and sandstone remained at the east end of the pit. Upon completion of use, the pit had been filled with rubble remaining from the construction activities and was sealed beneath an earthen floor surface.

It is possible that wooden scaffolding was used during the construction of the upper parts of the walls. A row of large post-holes were found beside the construction pit adjacent to the north wall of this room (Plate 23). Such scaffolding

Plate 23. Construction pit within the south room of the temple.

may have been secured to the wall under construction by the insertion of horizontal scaffolding beams; however, no evidence for such holes has yet been found, possibly because the walls are not preserved high enough. If they were used, then the holes may have been filled after completion of work. A copper-alloy plumb-bob (field no. 77/09) was found in the construction pit – an essential tool for an architect (Plate 24). Similar plumb-bobs including some of Greco-Roman date

Plate 24. Copper-alloy plumb-bob (find no. 77/09).

contemporary with the Dangeil temple have been uncovered in Egypt (see Petrie 1917, 42, pl. XLVIII). The temple was designed by a professional architect and the walls, columns and dais were laid out precisely even if on occasion, such as in the south half of the main pylon, the builders implementing the plans did not achieve these goals.

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