4.3 Understanding Meroitic Pottery and Its Production – Research Design and Methodology of an Interdisciplinary Research Project

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The study site

Musawwarat es-Sufra is located about 180 km northeast of the modern Sudanese capital Khartoum and 25 km away from the Nile in the semiarid landscape of the Keraba. Its main archaeological remains are distributed over a core zone of ca. 1 x 3.5 km within a wide wadi bordered by escarpments of Cretaceous sandstone plateaus. The site was a major sacral center of the Meroitic period (ca. 300 BC–AD 350) and the earliest evidence of the will of the Meroitic rulers to integrate the regions away from the Nile Valley into their socio-political sphere of influence. As Musawwarat shows, one of the means to realize this ambition was to turn these regions into an arena of religious life by equipping them with temples and making them part of the Empire's religious topography.[1]

The main monument of Musawwarat is the so-called Great Enclosure (Fig. 1), an architecturally unique assemblage that covers an area of ca. 43 000 m² and comprises several building complexes that are partly erected on artificial terraces; connected by ramps, corridors, and passages; and surrounded by huge walled courtyards. The function as well as the exact chronological attribution of the Great Enclosure are still widely debated, not least because it almost completely lacks formal decoration i.e., reliefs and related inscriptions, which could aid interpretation. Its first excavator suggested it was a religious site and pilgrimage center, whose central Temple 100 was dedicated to Amun-Ra, while the courtyards may have served as gathering and sheltering places for the large

1 Bebermeier et al. 2016, 21.

crowds coming from the Nile Valley during religious festivals.[2] Later researchers saw it as the Meroitic 'National Shrine', as the main place of worship of the Meroitic lion god Apedemak, or as a palace and a place of investiture of the Meroitic kings.[3] Today, it is widely accepted that the three main building complexes represent temples and that many of the ancillary rooms were related to cult activities and the presence of the king during religious ceremonies.[4] Recent 14-C dates confirm older investigations that suggest that most of the extant parts of the Great Enclosure belong to the early Meroitic period, i.e. the 3rd to 2nd centuries BC.[5]

In 1997, excavations in one of the courtyards of the Great Enclosure revealed a substantial deposit of a loose ashy material that was of up to 0.8 m thick and contained a substantial amount of potsherds. Its interpretation as the dump of a pottery workshop[6] was supported by the finding of potter's tools, including stamps for impressed decoration, pigments, and production debris within the debris. In addition, parts of a potter's wheel had already come to light in the excavations of the 1960s in a room (Room 225, 225.3 in Fig. 2) adjacent to the courtyard.[7] Due to the amount of finds – in all 25 000 sherds from a 25 m² trench – the investigation of the deposit was suspended after one season. The ceramic material was subjected to a first analysis by David Edwards,[8] who also outlined a preliminary fabric series based on earlier work by Anne Seiler on another pottery corpus from Musawwarat.[9] Edwards identified fabric groups A (Nile silt), B (mixed clay), and C (kaolin), and introduced fabric group H, which according to him represents pottery "manufactured from locally-dug wadi silts".[10] He also noted the "unusual nature of the assemblage as a whole, which includes a relatively limited number of different wares or fabric types, while being quantitatively dominated by a single (local) range of products".[11]

Work in the 'pottery courtyard' was resumed in 2013, with the aim to exploit the unique potential of the assemblage more fully and to study the production and consumption of ceramics at the site using a combination of archaeological, ceramological, geophysical, and ethnoarchaeological research components.[12] This multi-perspective

2 F. Hintze and U. Hintze 1970, 50; F. Hintze 1984, 337–338.
3 For a synopsis of the history of these interpretations see Wolf 2001.
4 Eigner 1999; Eigner 2010; Wolf 2001.
5 Scheibner 2011; Näser 2016.
6 Wenig and Wolf 1998, 29–33; Edwards 1998; Edwards 1999.
7 Edwards 1999, 42, Fig. 5, pls. 6.32–34; Näser and Wetendorf 2015, 56, 63.
8 Edwards 1998; Edwards 1999.
9 Seiler 1998; Seiler 1999.
10 Edwards 1999, 18, 27.
11 Edwards 1999, 16.
12 This project was conducted under the auspices of the Qatar–Sudan Archaeological Project (2013–2015) and the Berlin Topoi Excellence Cluster (2013–2018), see http://www.topoi.org/project/a-6-5/ (last visited on 04/20/2020). Parts of the analysis were funded by the Warsaw University of Technology. The support of these institutions is gratefully acknowledged. The authors also thank the colleagues of the National Corporation for Antiquities and Museums of Sudan, particularly its director general, Dr Abdelrahman Ali, for their support and the permission to export samples for analysis.

approach should also allow researchers to gain a firmer ground for placing the results of the investigation at Musawwarat into the wider patterns of distribution and use of pottery in the Meroitic period and to use this group of materials to study how Musawwarat was integrated into the wider social, cultural, economic, and political contexts of the Meroitic Empire. Fieldwork at the site was undertaken from 2014 to 2015 (Fig. 2);[13] the study of the find material is ongoing.[14]

Research strategy and implementation

The following chapter describes the trajectory of the 'Musawwarat Pottery Project' from its start in 2013 up to its current state in mid-2017, discussing the starting points of the analyses, data recovery, and sampling strategies; the integration of the individual strands of the investigation; and how results – expected and unexpected – informed the subsequent steps and progress of the overall research strategy.

Kick-off analysis

Prior to starting new excavations and generating new finds, the first step of the project was to analyze a first series of samples (n=39) from the 1997 excavations, in order to build a preliminary classification that would facilitate and inform the processing of the new finds by providing a prior knowledge of the range of fabric groups that were to be expected. This step proved to be crucial, as it saved valuable time when dealing with the first bulk of newly excavated material. The first series of samples was chosen in a systematic re-examination of the diagnostic material of the 1997 excavation. The series should encompass both fine ware and coarse ware sherds representing a spectrum of macroscopically differentiable fabrics, as well as different form and decoration types.[15] All samples were subjected to abridged MGR-analysis and chemical analysis by WD-XRF. A seminal corpus of reference for this material is the 'Sudan Database' (SDB) containing the results of analyses on archaeological pottery and raw materials from Sudan conducted by Małgorzata Daszkiewicz since 1991. Currently, the SDB comprises 1235 entries deriving from ceramic fragments dating from the Mesolithic to the Medieval period and 120 entries relating to chemically analyzed raw materials.

13 Näser and Wetendorf 2014, Näser and Wetendorf 2015.

14 Näser and Daszkiewicz 2013; Daszkiewicz and Wetendorf 2014; Daszkiewicz, G. Schneider, Wetendorf, et al. 2015; Daszkiewicz, Bobryk, and Wetendorf 2016; Daszkiewicz, Wetendorf, et al. 2016; Daszkiewicz and Wetendorf 2017; Näser and Wetendorf 2014, Näser and Wetendorf 2015.

15 Due to the small amount of handmade wares, as well as the general assumption that handmade pottery should represent household production, the focus of selected samples was on wheel made coarse wares and fine ware pottery.

The results of the archaeometric analysis indicated:[16]

- that all analyzed samples were made of raw materials sourced from the same region,
- that they represent a raw material group which was not documented from any other site in the Middle Nile Valley so far, and
- this group also includes sherds from Musawwarat analyzed in a previous study.[17]

In sum, this kick-off analysis from 'old' material strongly suggested that all sampled pottery was produced from local raw material in Musawwarat in a workshop whose existence is evidenced by the dump in Courtyard 224. The analysis further revealed that 19 coarse ware samples from this series (MGR-groups 101, 102, 102.1, and 102.2) were made from wadi clays – thus, corresponding to fabric group H in Edward's classification – with low contents of potassium and tempered with varying amounts of conglomerates of quartz with a white firing matrix. These samples were lumped as reference group Mus4 in the SDB. In contrast, the fine wares of the sample group were made from ceramic bodies featuring a variety of recipes based on kaolinitic clays colored by iron compounds. They were preliminarily divided into three groups (reference groups Mus1–3 in the SDB). Together, these groups seemed to represent the bulk of the local pottery production present in the dump of Courtyard 224.

Generation of find material and first series of refinement analyses

After the results of the first analyses had been obtained, archaeological investigations were resumed with a new trench in the dump, next to the 1997 excavation. Stratigraphic findings of the earlier seasons could be refined and complemented with the first 14C-dates.[18] They indicated that pottery production at the site may have started in the 1st century BC and continued into the 1st and possibly 2nd centuries AD.

In this first season, ca. 9000 sherds with a total weight of 365 kg were recovered. Of these, ca. 2000 pieces (equaling 42 kg) were diagnostic and ca. 7000 pieces (equaling 323 kg) were non-diagnostic. All sherds were macroscopically classed by fabric in the field, based on the groups identified in the laboratory kick-off analysis. While this was partly successful, the process also showed that macroscopic identification was difficult, and that also shapes, surface treatments, and types of decoration did not provide safe

16 Näser and Daszkiewicz 2013.

17 Gerullat 2001; Daszkiewicz and G. Schneider 2001a, chemical group GI.

18 Näser and Wetendorf 2014.

criteria for distinction.[19] It also became clear that more attention should be given to the handmade wares, a group that had been neglected in the first series of samples. Despite the fact that they represented less than 1% of the overall corpus, it was obvious from the macroscopic analysis that their fabrics differed significantly from the range established for the wheelmade wares. They were provisionally classified into four main groups and three sub-groups.

To evaluate and refine the results of this first round of macroscopic analysis in the field, a second series of archaeometric analyses was initiated, focusing on the wheelmade coarse wares and the handmade wares (n=35). Again, all these samples were subjected to abridged MGR-analysis and chemical analysis by WD-XRF.

This second series confirmed the identification of the group of wheelmade coarse wares (Mus4) that were made from ceramic bodies of similar chemical and mineralogical composition and represent a local production. Adding to the results of the first analysis, it also emerged more clearly that wheelmade fine ware and coarse ware were made from wadi clays with similar geochemical parameters. In addition, several samples represented pottery made from other wadi clays of probably local or regional origin. The handmade coarse ware specimens (with the exception of two sherds) were not locally produced, but came from elsewhere and include vessels made from various Nile alluvial clays and other clays of different unidentified origins (Fig. 3).[20]

Generation of further find material and second series of refinement analyses

In 2015, excavations continued and produced another 18 000 sherds with a weight of 673 kg. Of these, 2000 were diagnostic (equaling 75 kg), while 16 000 were non-diagnostic (equaling 598 kg). On top of that, numerous tools and gadgets used in pottery production, such as stamps for decorating fine ware pottery, polishing stones, and a turning device were registered among the finds from the deposit.[21]

Macroscopic fabric identification still proved to be difficult.[22] A new series of coarse ware samples was submitted for analysis in order to confirm attributions within the system and to place 'uncertain' sherds (n=26).

Next to the well-known group of locally produced fine wares (Mus1–3) and coarse ware pottery (Mus4), a new group of locally manufactured pottery was differentiated (Mus5). This group included, among other specimens, a series of cooking pots from Room 225 and is particularly significant in respect to chronology, since these vessels derive from older contexts.

19 Näser and Wetendorf 2014, 82; cf. Näser and Wetendorf 2015, 50.

20 Daszkiewicz and Wetendorf 2014.

21 Näser and Wetendorf 2015.

22 Näser and Wetendorf 2015, 50.

Re-classifications and a third series of refinement analyses

In the third season, ceramological work continued with a re-classification of the complete corpus – 27 000 sherds with a weight of ca. 1000 kg – to match the current state of the fabric system after its last refinement. In this process, another series of samples (n=70) was extracted for a final round of analyses to evaluate the correctness of the attributions and clarify 'uncertain' cases.

This season's reinvestigation showed that the 'spiraling' design of integrating field and laboratory ceramological analyses had been a necessary and successful measure to counter the problems that the corpus presented in the macroscopic analysis.

Repeated refinement and control through a successive series of archaeometric analyses was the only means to master this challenge. The process had resulted in a development of a clear and concise sampling strategy that is to:

- constantly evaluate the correctness of attributions of the analyzed pottery to specific fabric groups during the macroscopic analyses in the field,

- archaeometrically document and integrate new fabric types in the emerging fabric system, and

- generate representative reference samples for all fabric groups.

The results of the last series of laboratory analyses generally confirm the outcomes of previous series, but enlarge the number of reference groups of locally produced fine ware and coarse ware pottery (Mus1–12), as well as the number of imports (Fig. 4). One group of handmade pottery has a very characteristic fabric with a large amount of mineral temper in the sand fraction. In the light of current research, this group must be understood as an import from an unknown location from a great distance.[23]

The raw material survey

Already the 2013 kick-off analysis indicated that the majority of the pottery in the investigated corpus was made from raw materials sourced from the same region. The refinement analyses showed that they represent groups that are not known from other sites in the Middle Nile Valley and that they are composed of kaolinite-bearing wadi clays, which were used for the production of both wheelmade coarse wares and fine wares.

23 SDB: clay type O, reference group O1. Pottery fragments belonging to this group were found in Hamadab, Muweis, and Abu Erteila; see Daszkiewicz and Malykh 2017.

Taken together, this suggested that enquiries should be made into suitable raw material sources in the vicinity of Musawwarat. This strand of the research was implemented in an exhaustive raw material survey in the second project year. The coverage of the survey and the selection of samples followed three main objectives:

- to identify raw materials from the wadis in the immediate vicinity of the site that match the materials identified in the analysis of the ancient pottery (reference groups Mus1–12), including the identification of materials that could have been added as temper to the ceramic body (appearing in the pottery as white aggregates);

- to identify raw materials in the immediate and wider vicinity of the site that match the materials identified as 'potentially locally' produced in the analysis of the ancient pottery; and

- to identify raw materials that match the materials identified as produced from alluvial clays in the analysis of the ancient pottery (Fig. 5).[24]

A special category of locales sampled were ancient, i.e. Meroitic, and modern hafayir (sing. hafir). These are partly monumental water harvesting and storage installations, which constitute a common type of monument in the region of Muswwarat. Hafayir consist of catchment and inlet installations and roughly circular reservoir basins that are excavated in the ground and reach depths of more than 15 m and diameters of up to 230 m.[25] In the raw material survey, samples were obtained from the recent bottom deposits of one ancient hafir (Great Hafir) and four modern specimens, which had been dug by the local nomadic population to collect water during the annual rainy season (Hafir Khalifa, Hafir Said, Hafir Hamad, and one unnamed).

In all, 43 geological samples including clays and sandstones were taken and archaeometrically analyzed. On the one hand, the results allowed for the matching of the fabrics of the archaeological samples with local raw material sources in the vicinity of the site. On the other hand, none of the sampled raw materials matched any of the pottery samples that had been identified as being made of Nile alluvium.

Analyzing materials involved in the production process

Another strand of the investigation started from questions related to the production process of the pottery. Next to the deposit in Courtyard 224, which was obviously composed of production debris, Room 225 was identified as a locale where (part of) the

24 Daszkiewicz, Wetendorf, et al. 2016, 184–191.

25 Näser 2010; Näser and Scheibner 2012.

production may have taken place.[26] Kilns, however, were still missing. A geophysical investigation proved unsuccessful in identifying anomalies that might have indicated their existence.[27] Thus, the question to be investigated was whether the pottery could have been fired in a bonfire – a scenario that had so far been deemed implausible, particularly for the Meroitic fine wares.[28] Other sites, such as Hamadab[29] and Muweis,[30] had produced kilns that were directly associated with pottery production.[31]

Several findings from Courtyard 224 indicate repeated heat exposure. They include decolored areas in the surrounding sandstone walls and ancient floor surfaces with signs of burning (Fig. 6). While some of the earlier excavators assumed that the decolored walls derive from kilns that once stood in these locations,[32] this has been doubted by others.[33] The composition of the deposit itself, which consists of an extremely loose grey material mixed sandstone rubble and finds (Fig. 6), seemed to support the hypothesis of an open fire.[34]

In order to learn more about the firing process, two types of samples were investigated: pottery and the grey material that constituted the main component of the deposit. The pottery fragments were analyzed to estimate the original firing temperature (Teq).[35] K-H analysis and X-ray diffraction undertaken on samples of local wheelmade coarse wares showed that they had been fired at temperatures above 1000°C.[36] Mullite[37] detected in these samples through the X-ray diffraction analysis confirms their exposure to temperatures in this range.[38]

Analyses of the grey material from the deposit gave a surprising result: X-ray diffraction showed that what had previously been described as 'ash' consists of quartz, mullite,

26 Näser and Wetendorf 2015.

27 Näser and Wetendorf 2015, 67.

28 Previous research produced the impression that Meroitic wheel made pottery was kiln-fired throughout, see e.g. Adams 1986, 13, 31–33; Robertson and Hill 2004, 115–117.

29 Wolf, Nowotnick, and Hof 2014, 730–733, pls. 8–9.

30 Baud 2008, 53–54, Fig.1.

31 In Hamadab, fine ware pottery was found together with other ceramics and rubbish in the kilns; Wolf, Nowotnick, and Hof 2014, 729–730. For pottery kilns in Meroe, see Török 1997, 173–174, pls. 140–142.

32 Wolf 1997, 27; Wenig in Edwards 1999, 6.

33 Edwards 1999, 41; Onasch 2004, 67–69.

34 Näser and Wetendorf 2014, 73–76, 91–92; Näser and Wetendorf 2015, 35–40, 68–71; cf. Edwards and Onasch in Edwards 1999, 11, Fig. 9.

35 In the case of additional contact with fire (besides the original firing), "Teq" shows the highest temperature to which the analyzed pottery fragment had been exposed; see Chapter 5 in this volume; cf. Daszkiewicz and Maritan 2016.

36 Daszkiewicz, Bobryk, and Wetendorf 2016, 213.

37 Mullite is a high-temperature phase formed in ceramics, especially those made from kaolinitic clays. Mullitization temperature is dependent on the parameters of the starting material. In the case of Musawwarat wadi clays, mullite was not formed during firing up to 1000°C (see Fig. 1 in Chapter 3 in this volume). In contrast to its presence in ceramics, natural mullite is not a common mineral. For detailed information about phases (mullite, anorthite, hematite, and chrystoballite) mentioned in the text see e.g. Searle and Grimshaw 1960.

38 Daszkiewicz, Bobryk, and Wetendorf 2016, 213. Similar firing temperatures have already been established for Meroitic wares that were found in the area of the Fourth Cataract, but were identified as imports to the region; Daszkiewicz, Bobryk, and G. Schneider 2003.

anorthite, and hematite. On the basis of the data obtained so far, it is difficult to define from which material mullite was formed in this context. An analytical setup to follow up on this issue is currently being developed.

Alteration effect (in cooperation with Ewa Bobryk)

Model analyses were used to assess whether the exposure of pottery to a firing environment of a bonfire – namely the deposition of the vessels in the fuel and the resulting ashes – would have caused alterations in the ceramics.[39] Of particular interest was to explore whether the ashes of different fuels penetrate into the pores of the fired pottery and, if so, how they change the chemical composition and the physical properties of the ceramics, which could lead to changes in the results of the chemical analysis and the MGR-analysis of the sherds. Furthermore, this analysis was to elucidate whether potential residues in the pottery would allow researchers to determine which fuel had actually been used in the firing of the pottery.

This investigation was conducted as a simulation of alteration effects in a climatic chamber using samples of cow and donkey dung, as well as samples of several acacia species present in the study region today. The selection of samples followed the assumption that roughly similar climatic conditions in the Meroitic period would have supported a similar dry savannah flora, which would have provided similar options for obtaining fuels.[40] The results of the analyses showed that:

- Depositing a sherd in a layer of Zayal tree ash had no impact on the sherd's degree of vitrification; only a minimal change of shade was noted in the sherd's color.

- Depositing a sherd in a layer of Zamur tree ash affected the sherd's properties because glass-forming compounds migrated into the sherd. As a consequence, a ceramic sample classified as having a slightly over-melted matrix type developed an over-melted matrix type after the simulation.

- Deposition in a layer of Zelam tree ash as well as in a layer of ash from cow dung and donkey dung does not affect the thermal behavior of the samples in the subsequent MGR-analysis.

- Depositing a sherd in the grey material, which constituted the main component of the deposit in Courtyard 224, had no effect on its chemical composition and

39 Bebermeier et al. 2016, 21; cf. Eide, Hägg, and Török in Eide et al. 1998, nos. 187, 195, 202, 203, 206.

40 These analyses were partly funded by Warsaw University of Technology.

thermal behavior.

In all cases, identical results of the chemical analysis and the MGR-analysis were obtained for samples before and after the simulation. This indicates that deposition effects, i.e. alterations associated with the deposition of samples in ash (dung and acacia) and in the grey material that constituted the main component of the deposit in Courtyard 224, are negligible in provenance studies based on these methods.

Fuels and experimental firing

Assuming, that a range of locally available materials could have been used as fuels in the firing of the pottery from Courtyard 224, the next step was to test these materials for their suitability, focused on the question of whether pottery could be produced in bonfires reaching temperatures of minimum 1000°C with these fuels. The ethnoarchaeological studies that accompanied this investigation (see below, 2.11) showed that in current production contexts dried cow dung is used as fuel, whereas dry donkey dung is applied as temper to the ceramic body (Fig. 7).

Firing experiments were conducted on 81 vessels, which were produced for this purpose using four plastic raw material sources (three wadi clays [AD 236, AD 237, and AD 880] and one hafir clay [AD 291]) and three different tempers (cow dung, donkey dung, and white-firing kaolinitic sandstone), as well as combinations of the latter. One series of vessels was left free of intentional temper.[41] To obtain maximum information, further firing experiments were conducted using straw and charcoal as additional fuels, next to those discussed in the previous section (cow and donkey dung, acacia specimens). The experiments showed that in a bonfire fuelled by cow dung, a temperature of 1050°C can be reached in 30 minutes – mullite was detected by X-ray diffraction in vessels fired this way (Fig. 8).[42] With all other fuels, only significantly lower temperatures between 600 and 800°C were reached. This result is consistent with the observations in ethnoceramological studies that indicate that traditional potters in Sudan use cow dung as fuel and donkey dung as temper added to ceramic bodies.[43]

41 See also Daszkiewicz, G. Schneider, Wetendorf, et al. 2015, 89–91; Daszkiewicz, Wetendorf, et al. 2016, 140–143; Daszkiewicz, Bobryk, and Wetendorf 2016, 208–214.

42 For more details see Daszkiewicz and Wetendorf 2017.

43 See e.g. Daszkiewicz, Wetendorf, et al. 2016, 143; Daszkiewicz and Malykh 2017.

Model studies concerning the influence of tempering materials on the properties of the finished pottery products (in cooperation with Ewa Bobryk)

Another strand of the investigation concerned the impact of tempering on the properties of the ceramics. First, the nature of the white-firing aggregates, which are present in all Musawwarat fabrics, had to be established. Occurring in various amounts, they do not necessarily represent intentional additions, but could also be natural inclusions. Results of the MGR-analysis and thin-section studies of pottery fragments, as well as the results of firing tests of raw materials, suggest two potential identifications: crushed fragments of kaolinitic sandstone or aggregates of a kaolinitic-clayey material.[44]

In order to learn more about the impact of different tempers, mechanical properties (tensile strengths) as well as physical ceramic properties (apparent density, open porosity, and water absorption) were assessed on small test briquettes that were produced using different samples from the raw material survey, namely wadi clay (AD 236), hafir clay (AD 291), and Nile alluvial clay sampled in the vicinity of Shendi (AD 261).[45] The briquettes of 20 mm in diameter and ca. 5 mm in height were prepared by adding a variety of tempers, namely crushed kaolinitic sandstone and pore-forming agents (crushed dry cow and donkey dung).[46] One series remained free of intentional temper.

The analysis showed that the mechanical properties of ceramics made from wadi clay (AD 236) tempered with kaolinitic sandstone fragments and fired at high temperatures (about 1100°C) are improved in comparison to the dung-tempered and untempered wadi clay samples (Fig. 9, left).[47] In contrast, ceramics made from hafir clay (AD 291) or Nile alluvial clay (AD 261) tempered with dung display a similar resistance to mechanical stress when fired at lower temperatures (700–800°C) (Fig. 9, right). These results indicate that mechanical properties depend on the firing temperature, the clay, and the temper used. The mechanical properties of Nile clay are improved through the addition of dung. In contrast, wadi clay has better properties when tempered with fragments of kaolinitic sandstone than with dung (Fig. 9).

The stratigraphic sequence of the deposit in Courtyard 224 revealed several lenses of clay raw material (AD 676) as well as numerous chunks of ceramic bodies, i.e. prepared material (AD 223), some of which clearly derive from throwing the vessel on the wheel.[48] Due to their position in the archaeological context, these raw materials and ceramic bodies can be directly associated with the ancient production processes. They were identified as wadi clays equal to group Mus4. Samples of these materials were used to

44 Cf. Daszkiewicz, Bobryk, and Wetendorf 2016, 192–208; Daszkiewicz, Wetendorf, et al. 2016, 140–143; contra Edwards 1999, 18; Seiler 1999, 60–61; Seiler 1998, 57.

45 All tests were funded by Warsaw University of Technology.

46 Daszkiewicz, Wetendorf, et al. 2016, 140–143.

47 Daszkiewicz, Bobryk, and Wetendorf 2016, 208–214.

48 Näser and Wetendorf 2014, 76, figs. 6–7; Näser and Wetendorf 2015, 36, 52, figs. 2–3, 15.

produce a series of small vessels. These vessels as well as a number of the samples from the raw material survey in the shape of briquettes (see previous paragraph) were used to test functional properties, namely water permeability (Fig. 10). This model analysis showed that all samples, i.e. those made from wadi clays and hafir clays, as well as Nile alluvial clays, are permeable to water. Investigations also confirmed that to obtain water-impermeable vessels, the surface has to be compacted through polishing or burnishing or the application of a slip or wash.[49]

In a next step, 26 selected coarse and fine ware sherds from the 'pottery courtyard' that had been identified as slipped or washed in the macroscopic analysis were investigated with regard to their surface treatment. Due to the partial erosion of vessel surfaces, it was not always possible to distinguish between slipped and washed surfaces, or even to identify a coating in general. Several of the fine wares seemed to have no coating at all, but only polished surfaces. Thus, the aims of the analyses were:

– to ascertain whether the macroscopic evaluation was correct,

– to ascertain whether the individual specimens had a slip or a wash, and

– to identify colorants used in the coatings.

Previous researchers had suggested that Meroitic pottery from Musawwarat and elsewhere were coated with a wash.[50] The current series of samples were subjected to p-XRF, SEM-EDX, and RTI (Reflectance Transformation Imaging)[51] screening in order to establish their surface treatments. Preliminary results indicate that some of them had a slip (e.g. red slipped fine ware pottery AD 716 and white slipped coarse ware pottery AD 717). Final results of these investigations are not yet available, as the analyses are ongoing.[52]

49 Daszkiewicz, Wetendorf, et al. 2016, 140–143; Daszkiewicz, Bobryk, and Wetendorf 2016, 208–214. For a general definition of slip (mixture of clay, pigment, and liquid) and wash (pigment and liquid) see e.g. Arnold 1993, 86; Rice 1987, 147–152.

50 Based on her analysis of the pottery from the Small Enclosure in Musawwarat, Seiler had used the term 'wash' in connection with the wheel made coarse ware pottery (Gebrauchskeramik); Seiler 1999, 62. Gerullat 2001, 72–77, also speaks of 'wash' in her descriptions of wheel made coarse ware pottery from Musawwarat. Dittrich 2003, 87, observed "eine helle oder gewaschene Oberfläche der cremefarbenen Feinware" in Hamadab.

51 These analyses were funded by ARCHEA, Warsaw.

52 Malgorzata Daszkiewicz and Manja Wetendorf. "Surface Treatments of Meroitic Pottery from Musawwarat es-Sufra". *Novensia* 28 (in preparation).

Analysis of related find material

The study of the non-ceramic find material from the deposit in Courtyard 224, as well as the analysis of the findings from Room 225, which was tentatively identified as workshop locale, confirm the assumption that pottery was produced in the immediate vicinity of the excavated deposit. A range of items that include several objects directly identified as tools used in the production process – such as part of a potter's wheel and stamps for decorating fine ware pottery – throw additional light on local manufacturing techniques and conditions.[53] Analyses of this material and the integration of the insights derived from it are ongoing.[54]

Ethnoarchaeological studies

Investigations into recent contexts of pottery production were undertaken to supplement the archaeological and archaeometric analyses.[55] This branch of the research included visits to and interviews with potters in Musawwarat and the nearby market town of Shendi, as well as a visit to a pottery production center in Omdurman. Whereas pottery was fired in a wood-fuelled kiln in the larger facility at Omdurman, the traditional potters in Shendi and Musawwarat fired their vessels in bonfires, using dried cow dung as fuel (see also 2.7).[56]

As a next step, a test excavation was conducted at the firing place of the potter's workshop in Shendi. Its aim was to collect data that would help to evaluate the deposit in Musawwarat and to test the hypothesis that it represents the gradual build-up of an open firing place. While the two features, i.e. the firing place in Shendi and the deposit in Musawwarat, shared several elements, they differed significantly in their stratigraphic composition and other aspects.[57] This finding underlined the need to understand the deposit internally, i.e. based on data extracted from the deposit itself.

Results

Despite it still being a work in progress, the 'Musawwarat Pottery Project' has already yielded a wealth of results. The following discussion will outline major insights, their integration into wider issues of socio-economic organization, and how they triggered advances and new approaches in the research design.

53 Näser and Wetendorf 2014, 2015.
54 See already Näser and Wetendorf 2015.
55 Näser and Wetendorf 2015, 68–71.
56 Similar observations were made by M. Daszkiewicz and G. Schneider in field studies between the Sixth and Fourth Cataracts in 2008.
57 Näser and Wetendorf 2015, 68, figs. 2–3, 45–46.

Understanding Meroitic pottery and its production

The closely integrated ceramological and archaeometric approach has greatly informed understanding of the pottery corpus recovered from Courtyard 224 in Musawwarat. First and foremost, it has allowed researchers to clearly characterize the local production of both fine wares and coarse wares. Analyses revealed that the majority of the ceramics was made of local wadi clays, which were used for both, wheelmade coarse ware and fine ware pottery.[58] The white to beige-white-firing inclusions that are characteristic of these fabrics were identified as either crushed fragments of kaolinitic sandstone or a kaolinitic-clayey material. Wheelmade coarse wares were fired over 1000°C, at such a high temperature that the formation of the mullite and even crystoballite[59] was possible. In contrast, fine wares were fired at a lower range of about 800–950°C.

As no kilns could be traced at the site, investigations advanced to the question of whether and how temperatures above 1000°C could be reached in open fires. Experimental firings of replicated vessels indicated that bonfires fuelled with cow dung produce temperatures in this range.

Further strands of the study looked into the functional properties of the pottery. In order to make vessels impermeable, regardless of the type of clay and temper used and the original firing temperature, surfaces had to be treated, e.g. coated with a slip or wash and/or polished or burnished.

The next step was to explore the mechanical properties of the pottery. Model analyses showed that in order to achieve a similar resistance to mechanical stress, pottery from wadi clay had to be fired at higher temperatures (ca. 1100°C) than pottery made from alluvial and hafir clays (ca. 700–800°C).

One particularly interesting group of material is the handmade wares. They make up less than 1% of the overall corpus, but display the widest variety in terms of fabrics. They include vessels produced from different wadi and hafir clays that are local or at least from the wider region of Musawwarat and pottery from several Nile alluvial clays, as well as a very distinct group of pottery made from clay of an unidentified source that is suspected comes from a more distant location (Group O).[60] Only few of the wadi clay fabrics are also present in wheelmade coarse wares specimens.[61] This pattern provokes the revision of some more general assumptions about the organization and dynamics of pottery production. Contrary to the widespread postulate that handmade wares represent local household productions, while fine wares testify to the existence of nucleated

58 A similar scenario has been suggested for Hamadab, where wadi clays were also used for some of the fine wares, whereas the actual eggshell ware is typically made from kaolinitic clays, pers. comm. Ulrike Nowotnick.

59 Chrystoballite is a high-temperature polymorphic variety of silica, see footnote 37.

60 See above, chapter 3. Cf. also Näser and Wetendorf 2015, 51.

61 Cf. Daszkiewicz and Wetendorf 2014, 102.

workshops[62], the corpus of handmade pottery from Musawwarat clearly comprises a variety of imports, while fine ware pottery was produced primarily for 'home requirements' (aside from a few exceptions).

The interplay between archaeological enquiries, macroscopic ceramological studies, and archaeometric analysis also added a chronological dimension to this observation. While the horizon of the pottery workshop in Courtyard 224 is almost devoid of imported wheelmade pottery, earlier contexts at the site produced a significant ratio of non-local pottery, made e.g. from Nile alluvial clays.[63] This finding does not only herald a fabric-based dating system for Meroitic pottery (which is notoriously difficult to date) at Musawwarat, but also indicates a development in the patterns of its production, distribution, and use – for which the corpus analyzed in the current project provides a uniquely detailed data set available for future extensions and comparisons.

Integrating the results

The pottery corpus analyzed in this study displays a clear distribution pattern. The majority of the material from Courtyard 224 represents local production. Only 2% of the whole material can be identified as imported to Musawwarat. Vessels made of Nile alluvium and various other clays of unknown sources derive from stratigraphically older contexts below the deposit and from adjacent units (e.g. Room 225, N227) – some also appear in irregular distribution in the deposit itself. The fabrics of the imports were compared with the SDB database, which currently comprises 1235 samples of ceramics and raw materials from 28 sites, representing 16 study regions in Sudan (Fig. 11).[64] Only for four samples, a provenance could be established: Two of them match a local group in es-Zuma, one sample matches a local group in Hamadab, while the fourth sample matches pottery found in Muweis and Hamadab.[65] Vice versa, no pottery associated with the local production in Musawwarat has been identified at any other site in the Middle Nile valley so far.[66] Thus, ceramics at Musawwarat were clearly not produced for wider distribution, but for on-site use. The workshop can thus be interpreted as a special purpose installation with a functionally specific, immediate relationship to the site where it is located – criteria that assign it to the 'attached specialized production' category of Earle and Costin, which is "defined as production on command for elites and the social and political institutions they control".[67] The use of the term 'command', substituting 'demand', already signals the characteristics of the organizational setting that

62 E.g. Costin 1991.
63 Näser 2016, 12.
64 For the SDB see above, chapter 3.
65 See Daszkiewicz, Wetendorf, et al. 2016, 215; see also Daszkiewicz and G. Schneider 2011, 247–265.
66 This statement is based on the data assembled in the SDB.
67 Earle 1981; Costin 1991. For the quote see Costin 1991, 7.

goes with this kind of production.[68] Control of the production, which Costin names as "a central concern in attached specialization" and sees manifested "archaeologically through architecture and spatial arrangements aimed at segregating production activities and restricting or monitoring the flow of personnel to the facilities",[69] may well have been a major consideration in establishing and maintaining the production at Musawwarat. Next to the close proximity of production and consumption areas, the spatial separation from other production, distribution, and consumption contexts may explain the unusual locale chosen for this workshop.

Investigations into the process of pottery production at Musawwarat revealed an unexpected divergence between the quality of the finished vessels and the relatively simple organization of production. It did not only solely rely on local raw materials that could be procured with little effort, but also technological investment was low. Fuel – most likely cow dung – and other necessary materials could also be obtained locally. The firing procedure was apparently managed without purpose-built kilns. The majority of the tools recovered from the excavation[70] were also made using easily available resources; e.g. the stamps used to decorate the fine ware pottery were themselves made from clay. The major point with regard to investment into the production would have been to establish and maintain the specialists producing the pottery at the site.[71] Topographically and ecologically, Musawwarat was a marginal locale, 25 km away from the Nile Valley and its infrastructural networks.[72] However, simultaneously, it was a central place – the first and most important sacral site of the Meroitic Empire outside the Nile Valley. Establishing a pottery production catering for the religious institutions and/or the needs of the site's elite occupants, can be seen as part of the political interest in the site. At the same time, the locale and the absence of evidence for inter-site distribution, indicate that the pottery workshop at Musawwarat was part of a 'dispersed' pattern of production.[73] However, it shows the problems inherent in this model when Costinmaintains that "most attached producers are nucleated to some extent because they will produce near their patrons, and wealth and power tend to be concentrated in central places"[74] – in this sense the production at Musawwarat would have to be classed as 'nucleated'.

Concerning scale and intensity of production,[75] estimates are difficult. The actual demand in pottery was probably not very high, not least since the site was not perma-

68 Brumfiel and Earle 1987, 5–6; Costin 1991, 7.

69 Costin 1991, 27.

70 Edwards 1999; Näser and Wetendorf 2014; Näser and Wetendorf 2015.

71 For the characterization of technological knowledge and the degree of specialization evidenced by the ceramics from Musawwarat see Wetendorf, Manja. "Die Keramikproduktion in Musawwarat es-Sufra/Sudan: Untersuchungen zu Herstellung, Gebrauch und Distribution". PhD diss., Humboldt University Berlin (in preparation).

72 Bebermeier et al. 2016, 9–10, 21–24, 28.

73 So far, evidence from other sacral sites is missing, but a workshop from the settlement of Hamadab seems to support this hypothesis; see Wolf, Nowotnick, and Hof 2014, 729–733, pls. 8–9.

74 Costin 1991, 14–15.

75 Costin 1991, 16.

nently occupied by any significant number of consumers. It has been argued that the Great Enclosure was used intermittently, mainly for religious festivals.[76] As a consequence, it seems very likely that the production of pottery was also not continuous but sporadic, or possibly even limited to one, perhaps extended, episode. From these assumptions, we can conclude that efficiency and labor intensity would not have been important criteria in the organization of production in this case.

Methodological considerations

This paper outlined the course that the 'Musawwarat Pottery Project' took in a framework that closely integrated archaeology, macroscopic ceramological analysis, archaeometry, experimental archaeology, and ethnoarchaeology. The questions asked and the analyses employed to answer them sprang consecutively from rather straightforward and conventional initial enquiries that focused on the identification of fabrics and the provenance of the associated raw materials. Further issues relating to closer descriptions of materials from the archaeological context, the production process, and the functionality of the recovered pottery eventually led to an incremental development of the overall research design.

The combination of classification by refiring (MGR-analysis), chemical analysis (by WD-XRF), and thin section studies proved particularly beneficial for the fabric description and provenance identification. Ethnoarchaeological enquiries informed the thinking about raw material procurement, production processes, particularly the tempering of the ceramic bodies and the firing. Experimental archaeology and model analysis supported the arguments, which had been formed through the observations made in the ethnoarchaeological studies with regard to the production process, particularly the firing.[77] In sum, the interaction of all methods and investigations proved to be very fruitful and makes Musawwarat one of the most extensively studied sites.

76 See the first paragraph of this paper for references.

77 An exhaustive evaluation and interpretation of the results is reserved for Wetendorf forthcoming, PhD project (A-6-5-1). Wetendorf, Manja. "Die Keramikproduktion in Musawwarat es-Sufra/Sudan: Untersuchungen zu Herstellung, Gebrauch und Distribution". PhD diss., Humboldt University Berlin (in preparation).

Fig. 1 Great Enclosure seen from the east.

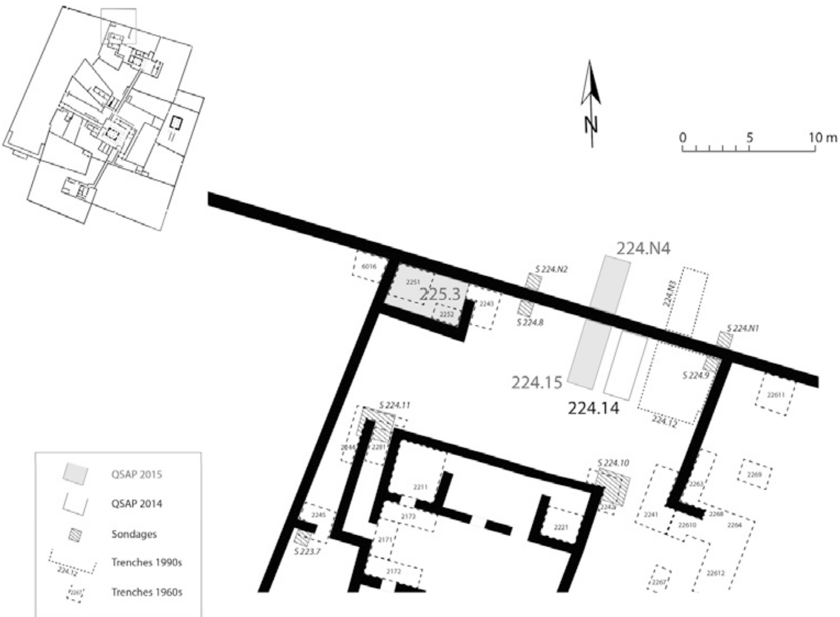

Fig. 2 Excavation plan of 'pottery courtyard' 224 and surroundings.

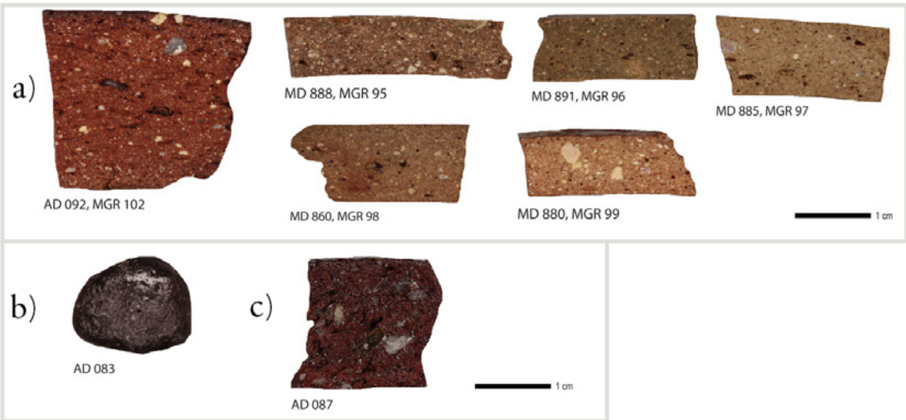

Fig. 3 Pottery fragments after re-firing at 1200°C. a) = pottery made in Musawwarat (MGR 102 coarse ware, MGR 95–99 fine ware samples), b) = import of Nile alluvial clay, and c) = import of clay of a different origin.

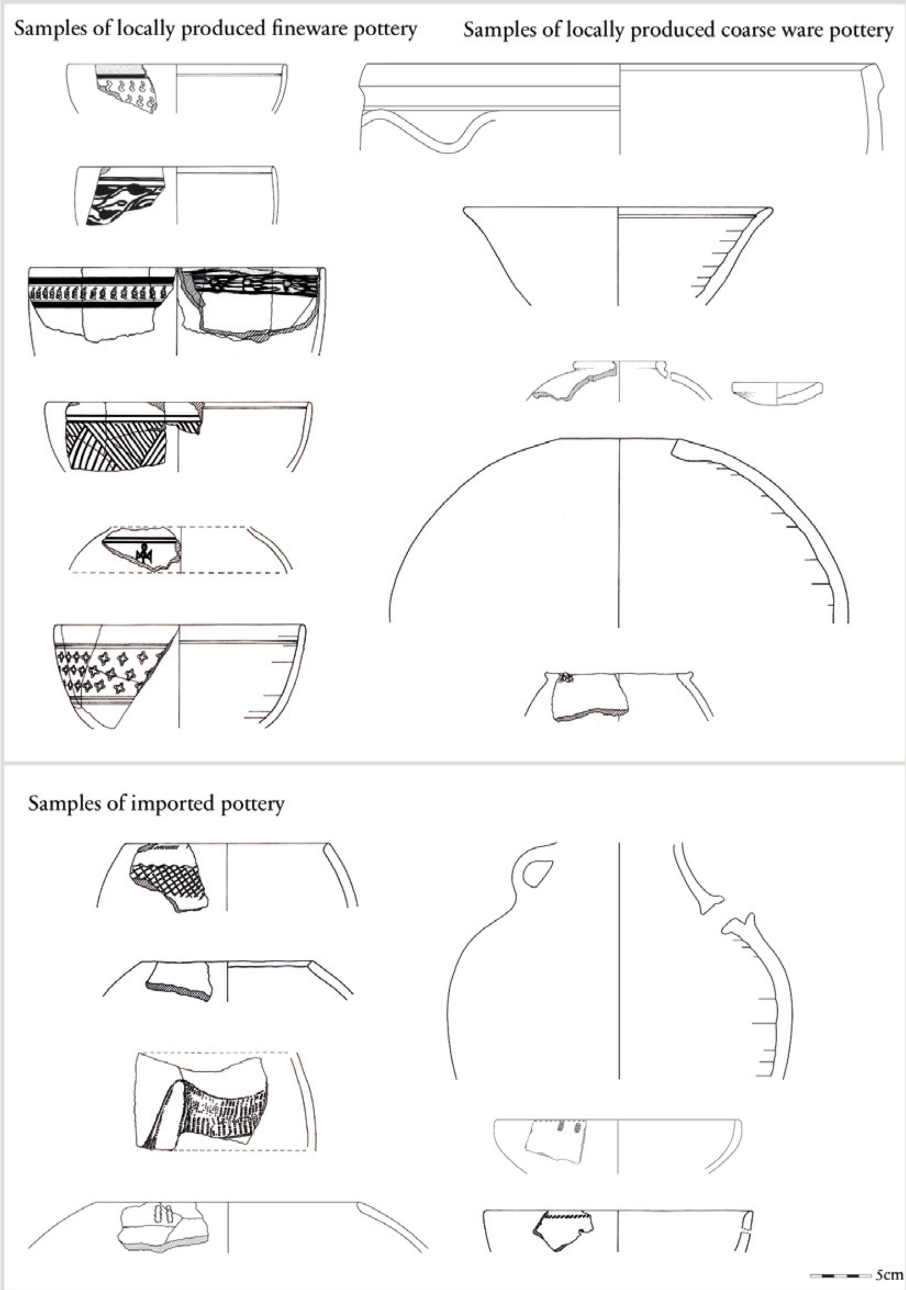

Fig. 4 Examples of pottery from 'pottery courtyard' 224.

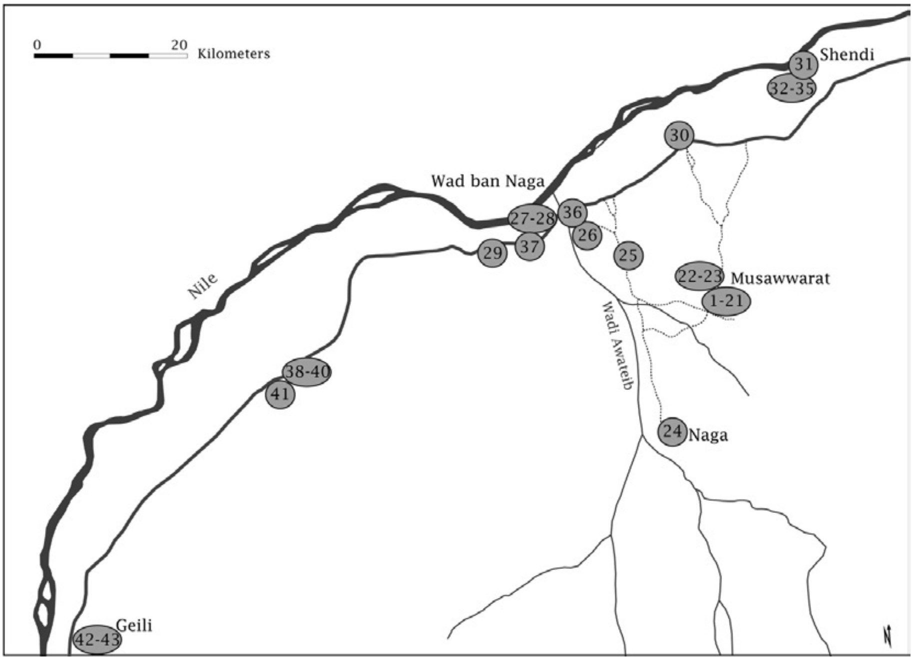

Fig. 5 Extraction points of raw material samples taken in 2014. Thick black line = modern tarmac road, dashed line = recent main tracks through the Keraba used by local communities, figures in circles = number of samples taken from each spot, and N = 43.

Fig. 6 Features connected with firing in Courtyard 224. Left = decolored area in a sandstone wall bordering the courtyard, center = signs of burning on an ancient floor surface, and right = the grey material of the ceramic deposit visible in a section of trench 224.15.

Fig. 7 Ethnoarchaeological observation. Above = dried donkey dung used as temper and below = dried cow dung used as fuel; both by a contemporary potter in Musawwarat.

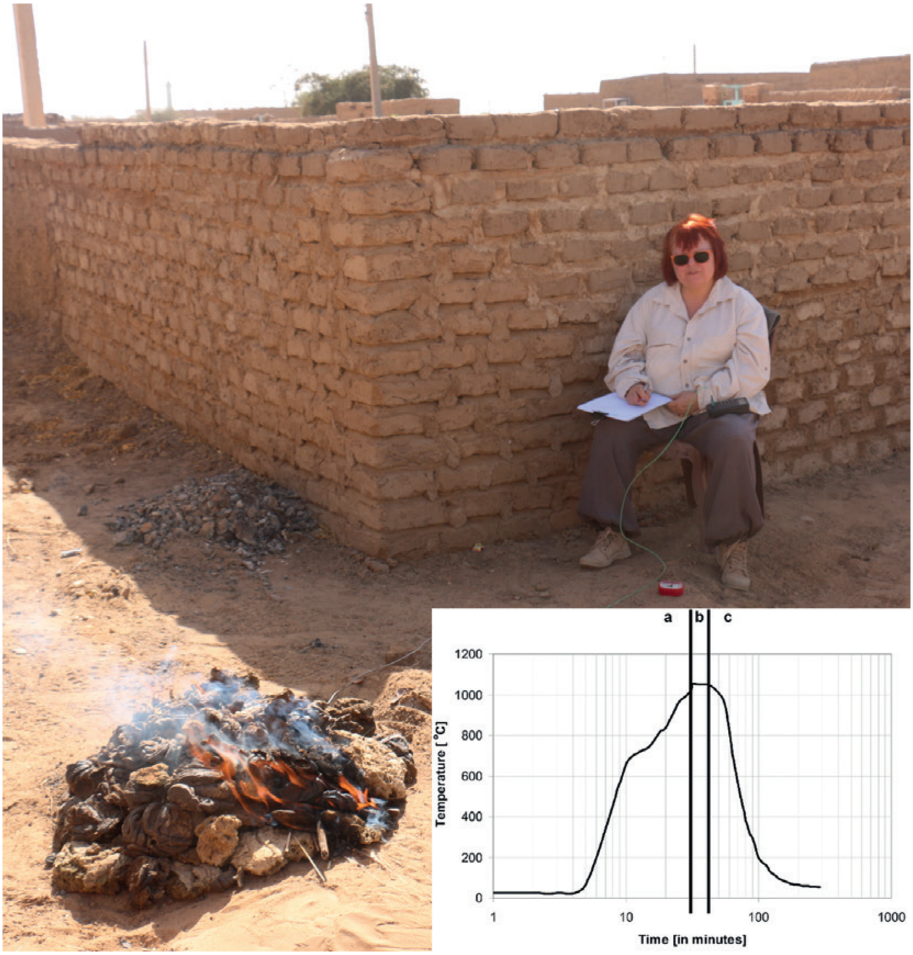

Fig. 8 Experimental firing. Left = a bonfire fueled by cow dung, reading of temperature using two thermocouples, and right = diagram showing that a temperature of 1050°C can be reached in 30 minutes in a bonfire fueled that way.

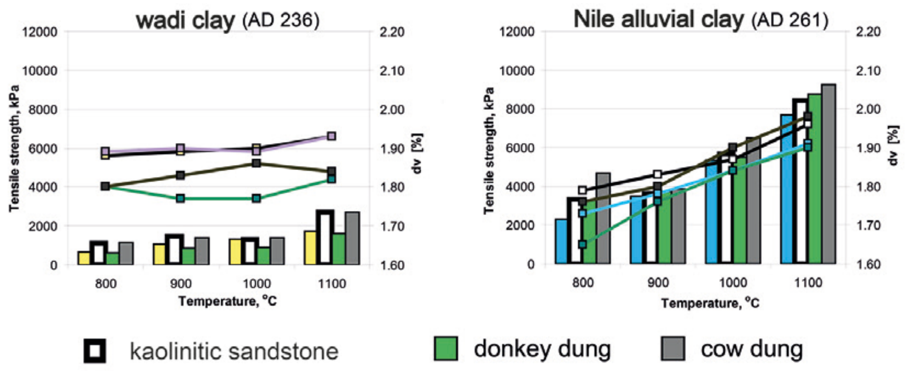

Fig. 9 Tensile strength of briquettes made from wadi clay (AD 236) on the left and Nile alluvial clay (AD 261) on the right side, tempered with either kaolinitic sandstone fragments, donkey dung, or cow dung fired at various temperatures; average values of tensile strength, cv < 15%.

Fig. 10 Vessels produced and used for the model analysis to assess functional properties (water permeability). Different tempers were added: C = cow dung, D = donkey dung, and K = kaolinitic sandstone.

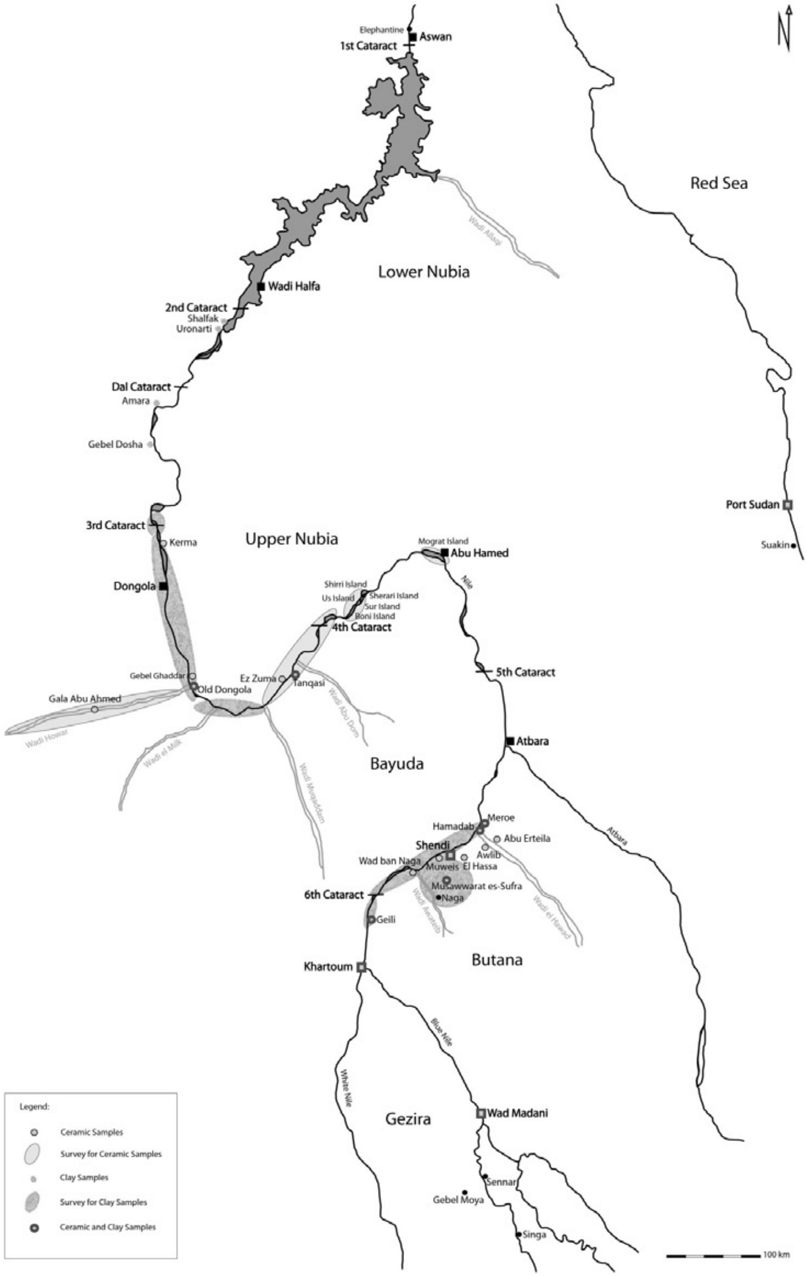

Fig. 11 Extraction points of raw material samples for the SDB taken in 2008, 2014, and 2017, and sites from which pottery was analyzed in 1997–2017.