SUDAN & NUBIA

The Sudan Archaeological Research Society

Bulletin No. 17 *2013*

ASWAN
1st cataract
Egypt
RED SEA
Wadi el- Allaqi
2nd cataract
Batn el-Hajar
Akasha
Wadi Gabgaba
Sedeinga
Jebel Dosha
Tinare
Jawgul
3rd cataract
Sudan
ABU HAMED
Nile
El-Ga'ab
Basin
Kawa
Sudan Military
Railway
KAREIMA
4th cataract
Fifth
Cataract
el-Kurru
Dangeil
Usli
Berber
ED-DEBBA
ATBARA
Wadi Howar
Gala
Abu Ahmed
es-Sour
el-Metemma
Atbara
Wadi el- Melik
Wadi Muqaddam
6th cataract
OMDURMAN
KHARTOUM
KASSALA
Eritrea
Blue Nile
MODERN TOWNS
Ancient sites
WAD MEDANI
Atbara/Setiet
White Nile
GEDAREF
Aba Island
KOSTI
SENNAR
N
Ethiopia
South
Sudan
0
250 km

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Front cover: The descendary of Tomb IV T 1 near Sedeinga under excavation (© V. Francigny / SEDAU).

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Dangeil, A Preliminary Report on the Petrography

Meredith Brand

Eighteen samples of Meroitic pottery from the temple and settlement site of Dangeil were examined by petrographic analysis.[1] This preliminary analysis has identified four broadly discernable petrofabric groups: 'Dangeil Nile'; 'Dangeil Mixed Clay'; 'Dangeil Kaolin' of which there are two sub groups, 'Dangeil Kaolin 1' and 'Dangeil Kaolin 2'; and finally 'Dangeil Granitic'. This study of Dangeil pottery fabrics is particularly important, as petrographic analysis has not been conducted on pottery from the Berber-Abidiya region nor in the areas just to the north or south of the Fifth Cataract. As such, one of the aims of this article is to provide a brief comparison of the Dangeil petrofabrics with published petrographic studies from other sites in the Sudanese Nile Valley. This comparison also highlights future goals to be pursued in the final publication of the Dangeil petrographic study.[2] The first future goal is to characterize variability in Dangeil Nile, mixed Nile, and kaolin clays. This will further enable a detailed study on ceramic paste preparation that will lead to a more in depth understanding of pottery manufacture, as well as inter-and intra-regional trade.

Preliminary Comments on the Geology of the Dangeil Region

Dangeil is located on the east bank of the Nile, approximately 60km south of the Fifth Cataract (Anderson and Ahmed 2006, 95). This region, located between Berber and Abidiya, exhibits a high degree of geological complexity. The area around Dangeil on the east bank of the Nile is comprised of a thin strip of Nubian sandstone (approximately 5km wide). Dangeil is also located at the juncture of two basement complexes; to the north of the site is the Precambrian schist basement complex and to the south is the Precambrian gneiss basement complex. On the west bank of the Nile is a thin ribbon (approximately 5km wide) of the Precambrian schist basement complex with outcrops of basic volcanic rocks (namely basalt). The nearest granite outcrop is on the west bank of the Nile 40km north and about 5km west of the river (see Geological Map of the Sudan 1981) (Figure 1).

Methodology

The Dangeil samples were prepared by the author at the Royal Ontario Museum (ROM) Petrographic Laboratory. The samples were analyzed using the methodology of the ROM Petrographic Laboratory with the types of inclusions, their grain size, shape and degree of sorting recorded and analyzed at 100x magnification[3] (as discussed in Mason 2004, 6-16). The mineral abundance is expressed in overall percentages of the various inclusions and was established using inclusion abundance charts (from Terry and Chillingar 1955). The scale of the degree of sortedness used in this study (e.g. poor, medium, well, and very well) is derived from Pettijohn *et al.* (1987, fig. A-1). The terminology employed to describe grain shape (e.g. angular, sub-angular, sub-rounded, rounded and well rounded) is also based on charts by Pettijohn *et al.* (1987, fig. A-2), and has been further modified by Mason (2004, fig. 2.4). The data from this preliminary analysis are presented in Tables 1, 3 and 5 with the mineralogy, voids, argillaceous inclusions, and their abundance, degree of sorting, and shape given for each sample (see the key to Tables 1, 3 and 5 for the abbreviations used in these tables).

Grain size was further recorded on the 18 samples by point counting inclusion in an area (i.e. area counting) following Middleton (Middleton *et al.* 1985) where 150 grains[4] were counted and their sizes recorded[5] at x100 magnification. This data was then recalculated to 100% so that the point counts represent the size of grains in relation to the 150 grains counted, and not the entire sample (Middleton *et al.* 1985; Mason 2004). The recalculated data is presented in histograms to give an idea of the relative proportions of each mineral in a size classification (Figures 2-6). The ROM petrography laboratory's size classifications were used for point counting, with the following categories: 0.0-0.0125mm; 0.0125-0.025mm; 0.025-0.05mm; 0.05-0.075mm; 0.075-0.1mm; 0.1-0.125mm; 0.125-0.15mm; 0.15-0.175mm; 0.175-0.2mm; 0.2-0.225mm; and > 0.25mm. These grain sizes groups are correlated with Folk's (1980) sediment size classification in Table 2.

Despite several studies that include voids and opaques in point counting for Nile silt clays (e.g. Bourriau *et al.* 2000, 3; Smith 1991), they were not incorporated in the point counting

[1] The author would like to thank the Royal Ontario Museum (ROM) Petrographic Laboratory and Professor Robert Mason for their assistance with this study, as well as Stanley Klassen and the directors of the Berber-Abidiya Archaeological Project, Julie Anderson and Salah Mohamed Ahmed. The Berber-Abidiya Archaeological Mission is grateful to the National Corporation for Antiquities and Museums, Sudan, and to the British Museum, UK, for their assistance and support.

[2] The author is currently analyzing 41 additional samples from Dangeil for future publication.

[3] Up to 400x magnification was used to identify minerals; however, all recording and analysis was at 100x magnification.

[4] The methodology regarding point counting for grain size distribution is an ongoing process of research connected with the broader study of textural analysis (Quinn 2013, 100-115). One of the most influential articles on textural analysis by Middleton *et al.* (1985, 72) purports that most methods of point counting are reliable with as few as 50 grains. In the Middleton *et al.* study, measurements were collected in 2-4 subsets of 50 to 150 grains (1985, 65), accordingly, their study does not suggest a target number of grains that should be counted. Some scholars have built on Middleton *et al.* (1985) and measured 200 grains (e.g. Bourriau *et al.* 2000). This study, however, employs the ROM Petrography Lab guidelines for grain size distribution with point counting of 150 grains, as discussed by Mason (2004, 12-13).

[5] Grain sizes were measured with an eye-piece graticule and the maximum diameter was obtained by calculating the mean of the maximum length and width.

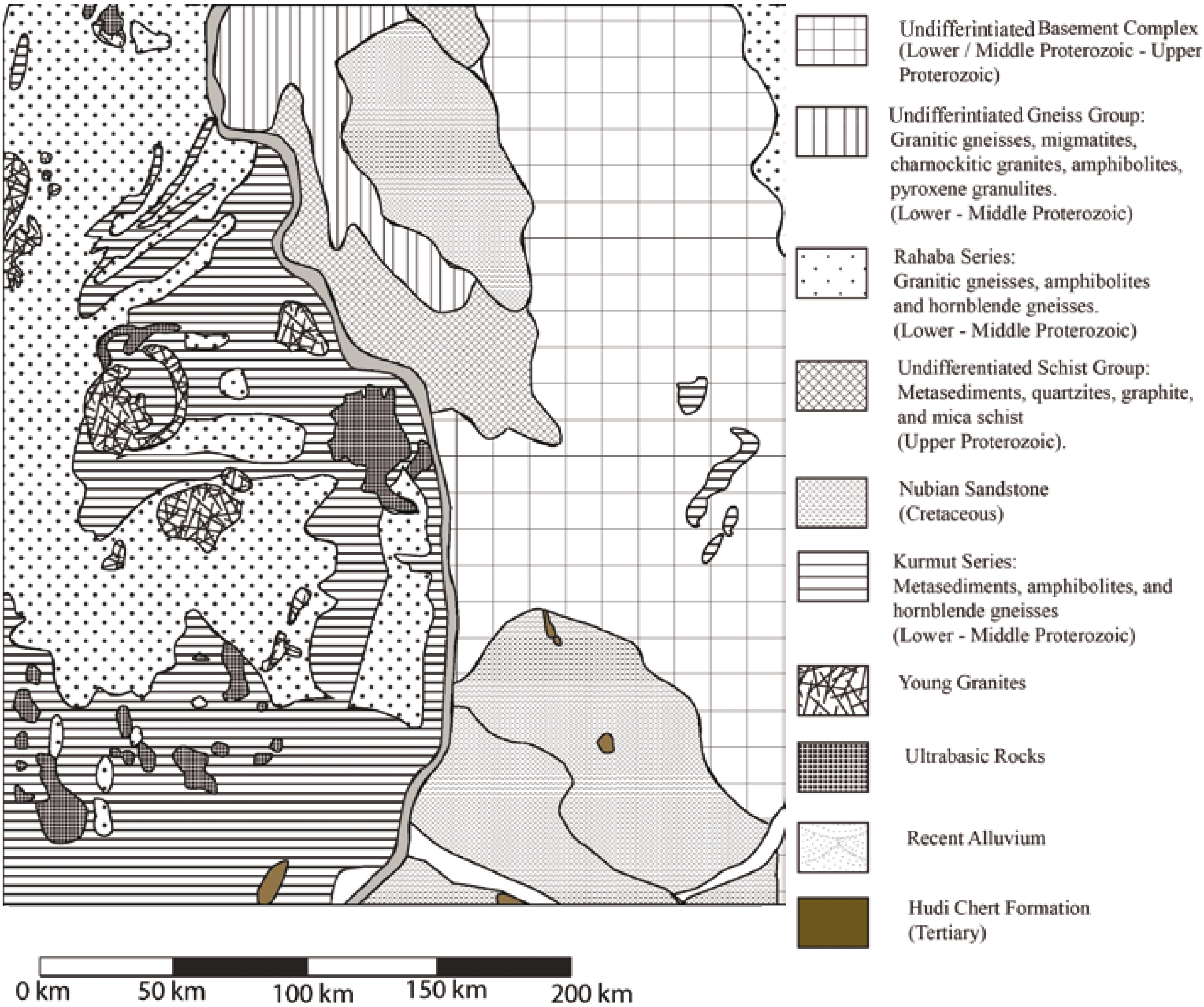

Figure 1. Geology of the Dangeil region (after Geological Map of the Sudan 1981).

of the Dangeil samples because many sherds[6] were fired for relatively short amounts of time, which caused thick black or dark grey cores, or were fired in reducing atmospheres[7]. This made the identification of dark red and black opaques dubious for large areas of the samples, and it would not be statistically valid to conduct point counts on the edges and not the core or the center of the thin section. However, the overall percentages of voids and opaques are given for each sample in Tables 1, 3 and 5,[8] and in future studies will address the feasibility of included opaques in point counting, so as to better understand the manufacturing process of Dangeil pottery.

[6] Eight of the 18 samples were either low fired or fired in a reducing atmosphere.

[7] For the relationship between firing condition and colour, see Nicholson (1993, 103-106) and Rice (1987, 331-345).

[8] The identification of opaques was made in plain polarizing light (PPL) and was taken mostly from the edges of the thin section (i.e. outside the core where dark opaques were hard to see).

Petrofabric Groups

As discussed by Mason and Grzymski (2009, 88) when a clay source is unknown the names of petrofabric groups are given in quotation marks and if the clay source is known (e.g. through analysis of kiln furniture, wasters, or local clay) then the petrofabric names are written without quotation marks. The names of all the petrofabric groups from Dangeil are given in quotation marks because the clay source(s) are currently unknown and have not been analyzed. At Dangeil, based on preliminary analysis, the petrographic groups are as follows: 'Dangeil Nile'; 'Dangeil Mixed Clay'; 'Dangeil Kaolin' of which there are two sub groups, 'Dangeil Kaolin 1' and 'Dangeil Kaolin 2'; and finally 'Dangeil Granitic' petrofabric.

'Dangeil Nile' petrofabric

The first clay fabric, 'Dangeil Nile' is the most abundant, represented by 10 out of 18 samples and includes Dangeil sample numbers 4, 6, 7, 9, 10, 11, 16, 18, 19 and 20. Overall, a similar mineral suite and organic material common to Nile clays characterizes this broad petrofabric group (see Plates 1-4) (Bourriau and Nordström 1993, 160-161).

The fired clay matrix of the 'Dangeil Nile' Petrofabric is comprised of 3-10% quartz (cloudy, sub-cloudy and clear) with both straight and undulose extinction and also includes

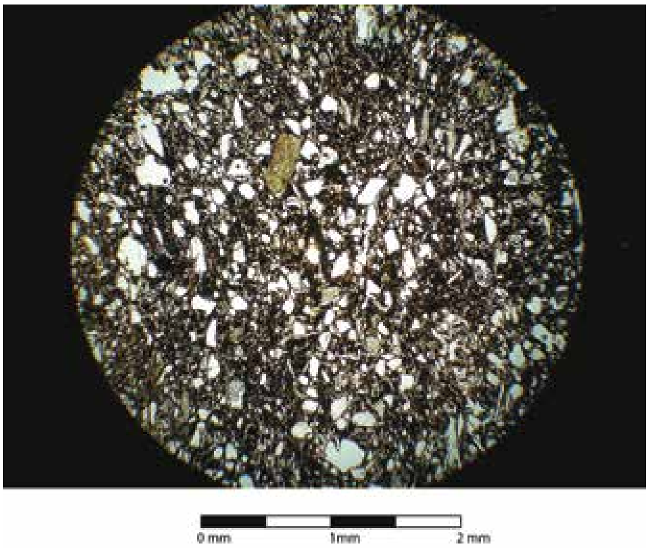

Plate 1. 'Dangeil Nile' petrofabric with a high abundance of mineral and organic inclusions in plain polarized light (PPL) (Dangeil Sample 6).

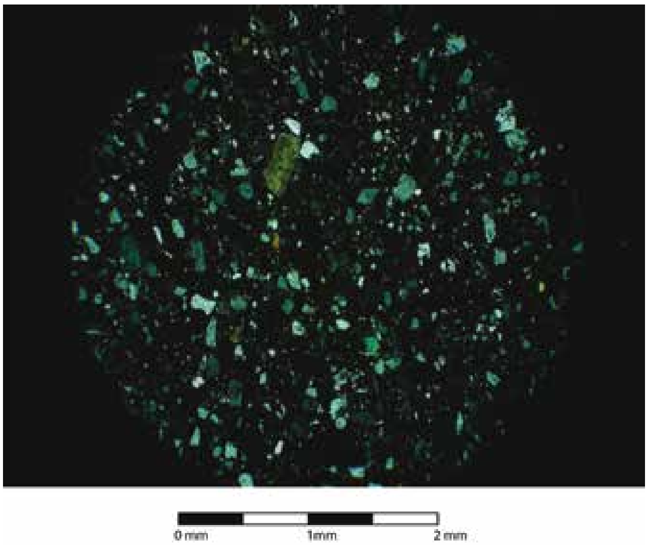

Plate 2. 'Dangeil Nile' petrofabric with a high abundance of mineral and organic inclusions in cross polarized light (XPL) (Dangeil Sample 6).

polycrystalline quartz. There is 1-3% plagioclase with none to trace amounts of microcline and orthoclase; 1-2% clinopyroxene that is both white and green in plain polarized light, trace amounts to 2% amphiboles and trace amounts to 2% biotite. There is about 2% micritic carbonate in this petrofabric, as well as trace amounts of basalt, and 1-3% granitic rock fragments. In this report, the term 'granitic rock fragment' refers to a rock fragment that contains both quartz and feldspar, is generally larger than 0.05mm in size,[9] and

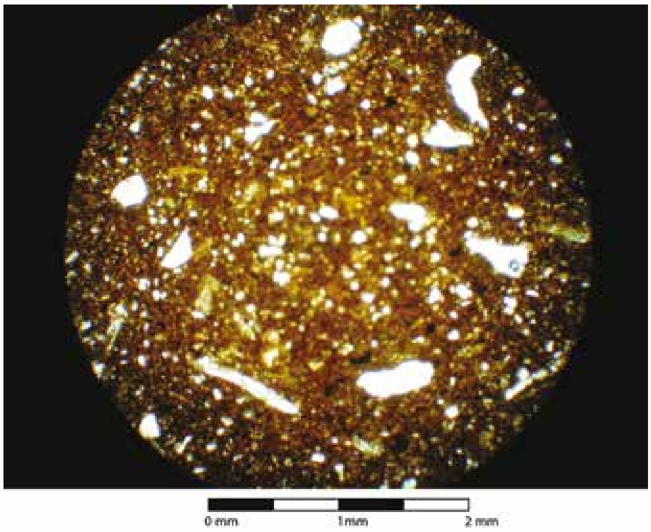

Plate 3. 'Dangeil Nile' petrofabric with a low abundance of mineral and organic inclusions in PPL (Dangeil Sample 10).

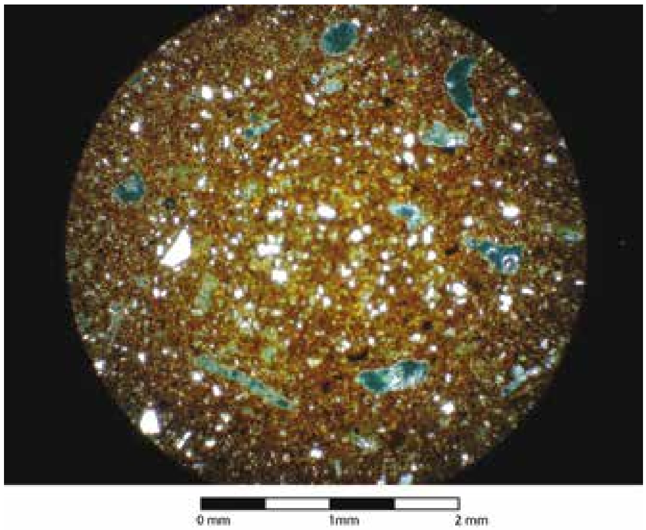

Plate 4. 'Dangeil Nile' petrofabric with a low abundance of mineral and organic inclusions, in XPL (Dangeil Sample 10).

is sub-round to sub-angular. A granitic rock fragment with quartz and feldspar could be many types of rocks including: granite, igneous granite, and metamorphic granite rocks.

The amount of both red and black opaques ranges from 2-7%. Red opaques are most likely oxidized hematite, while the black opaques have more of a brownish colour and are probably hematite that started the process of oxidization (Mason 2004, 11; Mason pers. comm. 2011). There are 2-3% elongated voids from burned out plant matter and 1-2% phytoliths. As with Nile clays in Egypt, there are some samples with trace amounts of argillaceous inclusions (clay nodules) that are similar to the surrounding clay matrix (Bourriau *et al.* 2000) suggesting these clay nodules result from poor mixing of Nile clay and not mixing of another clay type with Nile clay.

While Nile clays have a similar geological origin and min-

[9] Granitic rock fragments smaller than 0.05mm are identified based on comparative analysis of larger granitic rock fragments found within the same sample, that exhibit similar properties.

eral composition indicative of one broad petrofabric group, the texture of inclusions and the clay content exhibit variation (Bourriau and Nordström 1993, 160; Bourriau *et al.* 2000, 2). A future goal for the final Dangeil petrographic report is to further divide this broad petrofabric group into subgroups through textural analysis (see Middleton *et al.* 1985). Given that most Meroitic pottery (and Sudanese pottery as a whole) is made of Nile clays, a more in-depth study of these clays has the potential to greatly increase our understanding of the Meroitic potting industry. By providing a more detailed analysis of the 'Dangeil Nile' petrofabric group, it would perhaps facilitate inter-site comparisons of other Nile petrofabrics.

The plastic and aplastic inclusions and their percentages in 'Dangeil Nile' petrofabric are given in Table 1 and the results of the grain size analysis are presented in histograms in Figures 2 and 3. Despite the homogeneity of the types of minerals, voids, opaques and phytoliths in these samples, there is some variation present. There is a wide range in the percentage of quartz (from 3-10%), the overall mineral abundance, grain size and sorting. The samples with a higher mineral abundance, for example with 7-10% quartz, (e.g. Dangeil sample numbers 6, 9, 16 and 19 (Plates 1 and 2)) tend to be less well sorted and have a more diverse range of mineral sizes. Additionally, the samples with a higher abundance of minerals also have more organic inclusions, as can be seen in the higher percentage of voids. Whereas clays with less mineral density, for example quartz ranging from 3-4% (e.g. Dangeil samples 4, 10, 11, 18 and 20 (Plates 3 and 4)), tend to be better sorted and have lower percentages of organic inclusions. The relationship between mineral abundance, grain size, degree of sorting and plant inclusions will be explored further in future works.

The variation in Nile clays can be the result of two processes stemming from the geological origin of the clay and technological choices involved in clay preparation. Due to the geomorphic complexity of the Nile Basin, there are local geological variations present resulting from *wadi* drainage systems and differences in the flow of the river (Butzer and Hansen 1968, 6-7; Butzer 1997). This is demonstrated by X-ray diffractograms of Pleistocene Nilotic sediments in Upper Egypt/Lower Nubia (the Korosko, the Masmas and the Gebel Sisila Formations), which have shown substantial differences in the composition of clay minerals (Butzer and Hansen 1968, 483-487). Accordingly, the variation in both grain size and mineral abundance could be the result of local differences in the Nile Basin in the Berber-Abidiya region, the location of the clay source, the depth of quarrying. Another possibility, as noticed by Bourriau *et al.* (2000, 6), are differences in clay preparation, or a combination of clay preparation and the use of sources of finer Nile clay. Further research on the effect of clay preparation techniques and local geology on the mineralogy, the abundance of inclusions,

Table 1. 'Dangeil Nile' petrofabric inclusions, abundance, sortedness, grain shape, and mean grain size.

No.	QTZ	ext	PLG	MIC	FSP	AMP	CPX	BIO	MSC	CRB	BST	CHT	GRN	ARG	OPQ	VOID	PHY	MEAN	MAX	SRT	RND
9	10	u	3	-	tr	1	1	1	tr	1 (m)	tr	-	3	-	2	1	1	0.01	0.45	m	sr /sa
19	10	su /st	1	tr	tr	2	2	1	tr	tr (m)	tr	tr	1	-	na	5	2	0.04	0.4a	m-w	sr-sa
6	10	st/u	2	-	1	1	2	2	1	tr (m)	tr	tr	tr	tr	2	10	1	0.05	0.85	p-m	sr / sa
7	10	st /u	1	-	1	1	tr	tr	tr	2 (m)	tr	-	1	-	3	3	1	0.05	0.55	m	sr /sa
16	7	u	1	-	tr	1	tr	1	2	-	tr	-	1	-	5	5	1	0.03	0.43	m- w	r-sr-sa
20	3	st/u	1	-	tr	tr	tr	1	1	tr (m)	1	tr	tr	-	5	3	2	0.01	0.37	m-w	r-sr
18	3	st	-	-	tr	tr	tr	tr	tr	1 (m)	tr	-	1	-	na	3	1	0.06	0.67a	m	sr
11	4	st/u	tr	-	-	tr	1	1	1	1 (m)	tr	-	1	-	2	3	3	0.05	0.53	m	r-sr-sa
4	3	su /st	1	tr	tr	tr	1	tr	tr	1 (m / c)	tr	-	-	-	7	2	2	0.05	0.55 a	m	r-sr
10	3	st/su	tr	-	tr	tr	1	tr	tr	2 (m)	-	-	tr	-	3	1	1	0.06	2.7a	m -w	sr/sa

Key: Tables 1, 3 and 5.
= sample number, **QTZ** = quartz, **ext** = quartz extension (**u** = undulose, **su** = slightly undulose, **st** = straight), **PLG** = plagioclase, **MIC** = microcline, **FSP** = un-twinned feldspar (orthoclase), **AMP** = amphibole group, **CPX** = clinopyroxene group, **BIO** = biotite, **MSC** = muscovite, **CRB** = carbonate (**m**= micritic carbonate, **c**=coarsely crystalline carbonate), **OPQ** = opaques (**b** = black, **r** = red), **BST**=basalt, **CHT** = chert, **GRN** = Granite, **ARG** = argillaceous inclusions, **VOID** = void, **PHY** = phytoliths, **MEAN** = mean grain size, **MAX**= maximum grain size, (**a**=the largest grains are aeolian), **SRT**= sortedness (**w** = well, **ms** = moderately sorted, **p** = poorly sorted), **RND** = roundness (**sa**= subangular, **sr** = subrounded).

Table 2. Grain size categories used in point counting Dangeil petrographic samples as compared to Folk's (1980) grain size classification.

Size (mm)	Folk (1980) Grain Size Classification
0-0.025	Silt (<0.0625mm)
0.025-0.05	
0.05-0.075	Silt (<0.0625) – Very Fine Sand (0.0625-0.125mm)
0.075-1	Very Fine Sand (0.0625-0.125mm)
>0.1	Fine Sand (0.125 – 0.25mm)

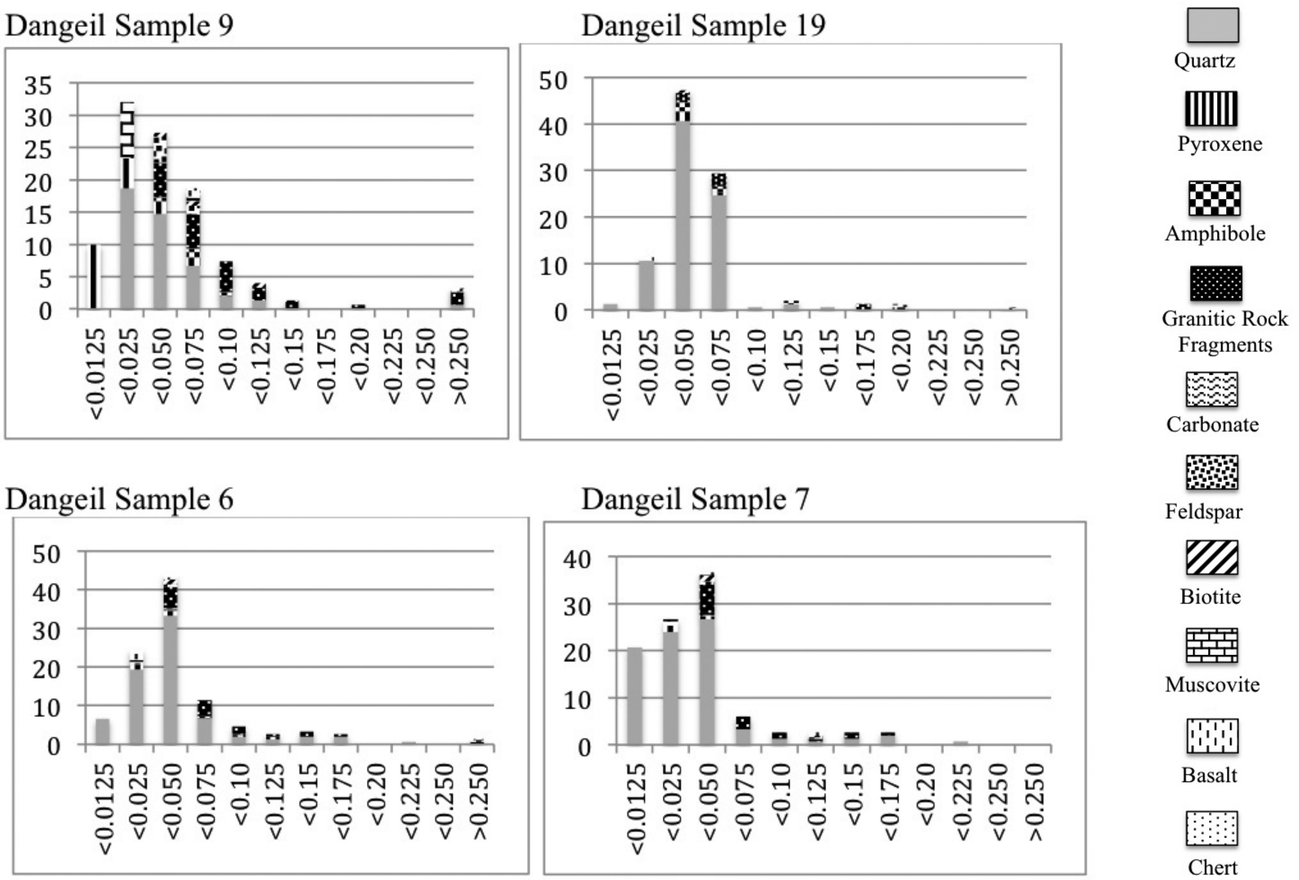

Figure 2. 'Dangeil Nile' petrofabric grain size distributions, samples 9, 19, 6 and 7.

and grain size is needed and will be an important aspect of future research on the Dangeil pottery.

'Dangeil Mixed Clay' petrofabric

There are five samples (Dangeil sample numbers 3, 12, 17, 21 and 23 (Plates 5-8)) from the 18 samples analyzed that are the result of mixing of Nile clay and another type(s) of clay that is currently unknown. This fabric group is characterized primarily by the presence of clay nodules that are different from the surrounding clay body, indicating a mixture of two distinct types of clay (Smith 1997; Mason and Grzymski 2009, 88-89). While clay nodules are helpful for identifying a poor mixture of two different clays, there still needs to be a method for identifying well prepared mixed clays as was done with mixed Nile and marl clays from the New Kingdom in Egypt (Bourriau *et al.* 2000).

'Dangeil Mixed Clay' petrofabric is comprised of a mineral

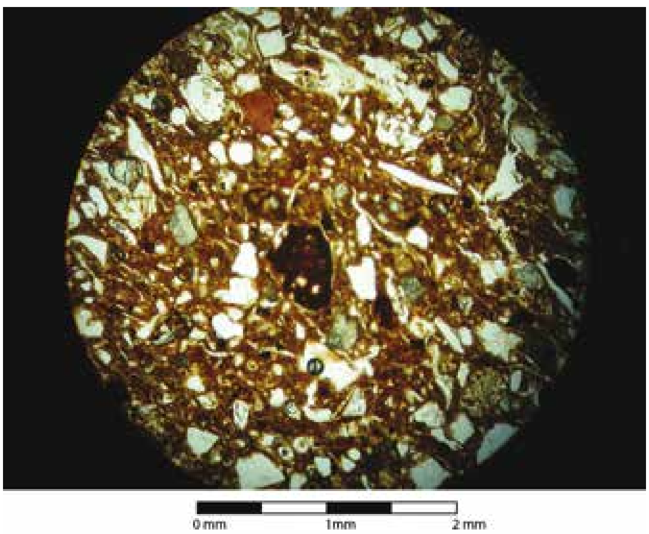

Plate 5. 'Dangeil Mixed Clay' petrofabric with a Nile clay pellet in a mixed clay matrix, in PPL (Dangeil Sample 23).

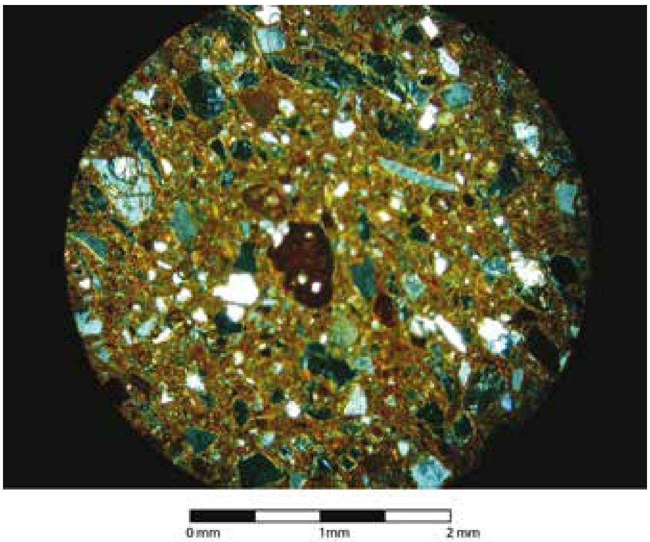

Plate 6. 'Dangeil Mixed Clay' petrofabric with a Nile clay pellet in a mixed clay matrix, in XPL (Dangeil Sample 23).

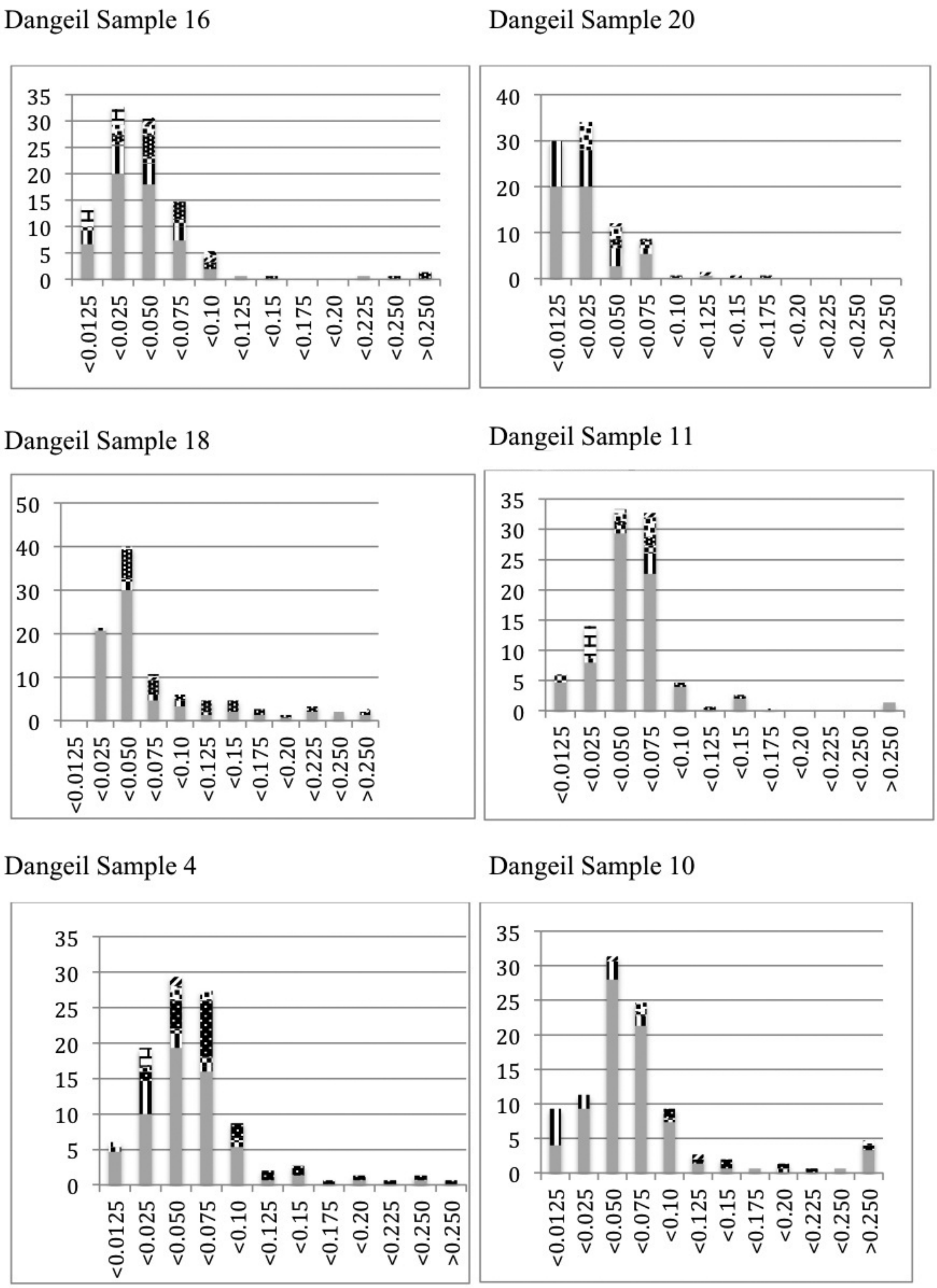

Figure 3. 'Dangeil Nile' petrofabric grain size distributions, samples 16, 20, 18, 11, 4 and 10. For the legend see Figure 1.

suite similar to the 'Dangeil Nile' petrofabrics: 3-7% quartz with both straight and undulose extinction; 1-3% plagioclase with trace amounts to no micrite, trace amounts to 1% feldspar (orthoclase); trace amounts to 1% amphiboles; trace amounts to 2% clinopyroxene, trace amounts to 1% biotite; trace amounts to 1% muscovite; trace amounts to 2% micritic carbonates, 3-5% opaques (hematite/iron oxide, see above); trace amounts of basalt, trace amounts of chert; 1-3 % granitic rock fragments; trace amounts of argillaceous inclusions (clay nodules); trace amounts to 1% voids (mostly plant inclusions); and (with the exception of sample 21) 1-2% phytoliths. The percentages of inclusions are given in Table 3. The results of the grain size distribution are presented in histograms in Figure 3. When comparing grain sizes, the 'Dangeil Mixed Clay' petrofabric group is not as well sorted as the 'Dangeil Nile' petrofabric group.

Table 3. 'Dangeil Mixed Clay' petrofabric inclusions, abundance, sortedness, grain shape, and mean grain size.

No.	QTZ	ext	PLG	MIC	FSP	AMP	CPX	BIO	MSC	CRB	BST	CHT	GRN	ARG	OPQ	VOID	PHY	MEAN	MAX	SRT	RND
21	10	su/st	1	tr	tr	1	2	1	tr	tr (m)	tr	tr	2	tr	5	tr	-	0.02	0.41	w	sr/sa
12	4	u	2	-	1	1	1	1	1	2 (m)	tr	tr	3	tr	7	3	1	0.05	1.5 a	m	r-sr-sa
23	7	su	3	tr	tr	tr	tr	tr	tr	2 (m/c)	1	-	1	tr	6	3	2	0.07	0.92	m	sr /sa
17	3	st/u	1	tr	tr	tr	tr	tr	1	tr (m)	tr	tr	-	1	7	1	2	0.04	0.37	m	r-sr-sa
3	5	st	tr	-	tr	-	tr	tr	tr	-	-	tr	1	tr	3	1	1	0.05	0.9 a	m	sr/ sa

This may be a result of mixing two different clay types with differing grain sizes.

Based on the presence of three different kinds of clay nodules (yellow and white clays in samples 12 and 21, pink clays in samples 3 and 12, and the dark brown clay in samples 17 and 23), there appears be a great deal of complexity in clay mixing (see Table 4), which has also been observed in mixed clays from Meroe (Mason and Grzymski 2009, 88-89). This complexity is further attested in sample 12, which contains two different types of clay nodules. Based on the presence of fabrics with Nile clay matrix and kaolin clay nodules at Meroe (Mason and Grzymski 2009, 88-89) and the similarity to Dangeil samples 3, 12 and 21 (see Plates 7 and 8), it is likely that these samples are composed of predominately Nile clay mixed with kaolin. Additionally, Mason noted samples with a kaolin clay matrix and Nile clay nodules (Mason and Grzymski 2009, 88-89); this type of mixing could be present in Dangeil samples 17 and 23 (see Plates 5 and 6). However, the overall percentages of minerals, namely quartz, that are abundant in kaolin clays are rather low in Dangeil samples 17 and 23, which have 3% and 7% quartz respectively. As such, there seems to be great variation in the mixed clays in the 'Dangeil Mixed Clay' petrofabric group, which indicates a more complex process than simply mixing kaolin and Nile clays. Other combinations of different clays with Nile silt are possible and have been observed by Whiteman, who briefly

Table 4. Clay pellets and surrounding clay matrix in 'Dangeil Mixed Clay' petrofabrics.

No.	QTZ	ext	PLG	MIC	FSP	AMP	CPX	BIO	MSC	CRB	BST	CHT	GRN	ARG	OPQ	VOID	PHY	MEAN	MAX	SRT	RND
21	10	su/st	1	tr	tr	1	2	1	tr	tr (m)	tr	tr	2	tr	5	tr	-	0.02	0.41	w	sr/sa
12	4	u	2	-	1	1	1	1	1	2 (m)	tr	tr	3	tr	7	3	1	0.05	1.5 a	m	r-sr-sa
23	7	su	3	tr	tr	tr	tr	tr	tr	2 (m/c)	1	-	1	tr	6	3	2	0.07	0.92	m	sr /sa
17	3	st/u	1	tr	tr	tr	tr	tr	1	tr (m)	tr	tr	-	1	7	1	2	0.04	0.37	m	r-sr-sa
3	5	st	tr	-	tr	-	tr	tr	tr	-	-	tr	1	tr	3	1	1	0.05	0.9 a	m	sr/ sa

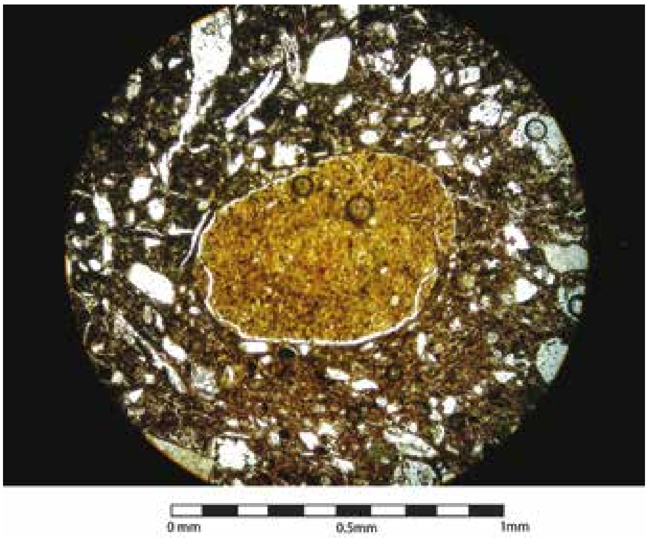

Plate 7. 'Dangeil Mixed Clay' petrofabric with a yellow clay pellet in a mixed clay matrix, in PPL (Dangeil Sample 12).

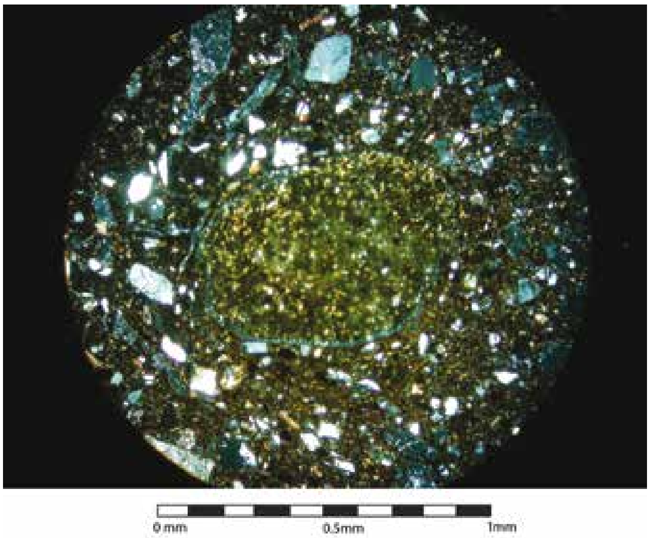

Plate 8. 'Dangeil Mixed Clay' petrofabric with a yellow clay pellet in a mixed clay matrix, in XPL (Dangeil Sample 12).

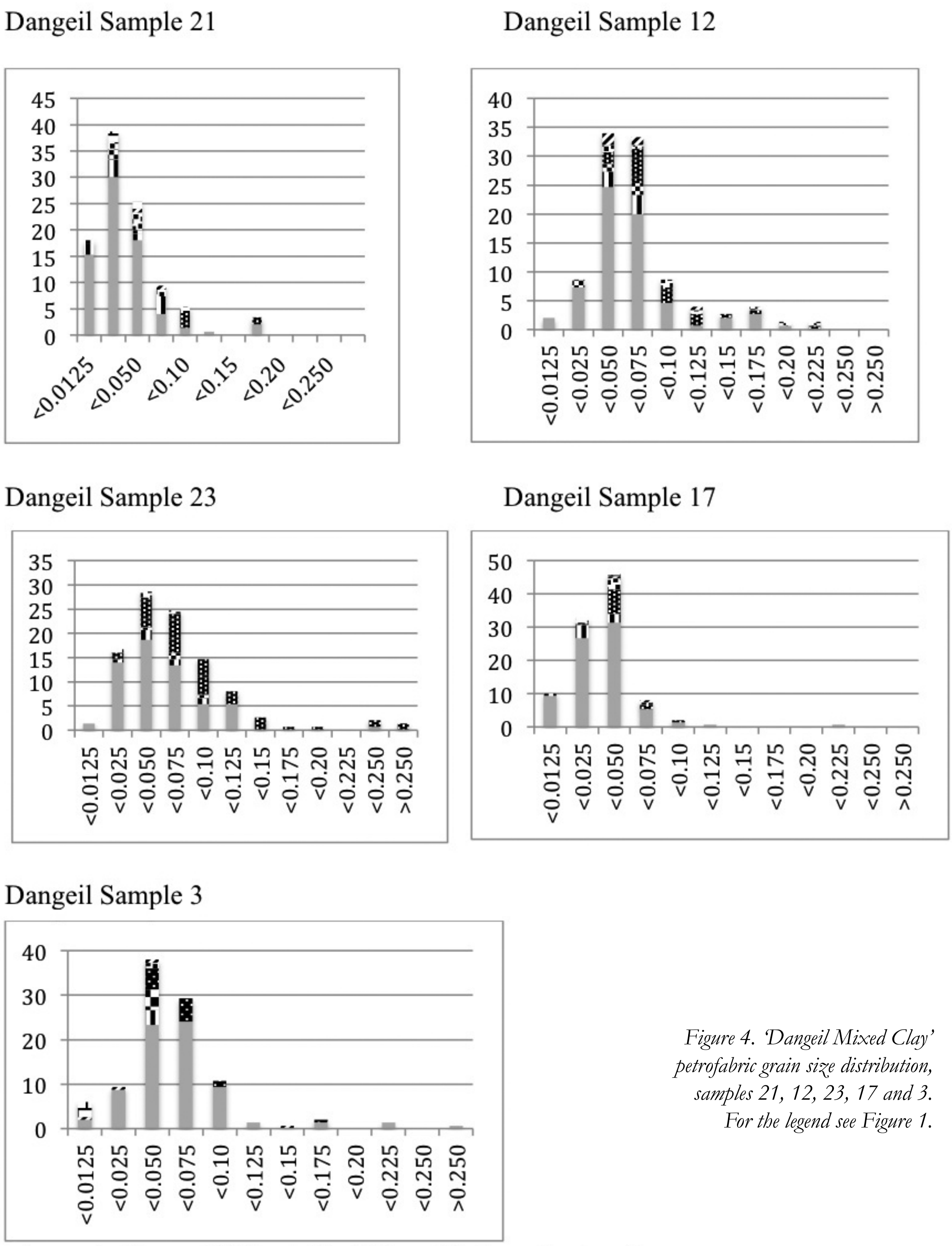

Figure 4. 'Dangeil Mixed Clay' petrofabric grain size distribution, samples 21, 12, 23, 17 and 3. For the legend see Figure 1.

mentions the practice of mixing ground mudstone from the Nubian Formation with Nile clay by modern potters (Whiteman 1971, 248).

'Dangeil Kaolin' petrofabrics

Kaolin clay, used to make Meroitic finewares, is better studied than Nile and mixed Nile clays from Sudan (for example, Smith 1997; 1999). Kaolin is formed from the clay mineral kaolinite, which is an advance stage of weathered granitic rocks or micaceous schist (Rice 1987, 45). As such, kaolin clays can be found in specific geological environments. Known deposits of kaolin clays in Sudan appear, for example, in Lower Nubia (First and Second Cataracts) (Smith 1997) and in Upper Nubia around Meroe (Robertson 1975), Umm Ali (Smith 1997) and Musawarat es-Sufra (Smith 1999). Unfortunately, evidence is lacking from the Berber-Abidiya area, which makes Meroe the closest known source of kaolin. There are two kaolin petrofabric groups among the Dangeil samples that differ in the mineral inclusions, abundance, grain size, and degree of sorting. Both are these groups are distinguished by only one sample; however, with future work on kaolin pottery samples from Dangeil will further expand these fabric groups.

'Dangeil Kaolin 1' petrofabric

This fabric group is confirmed by one sample (Dangeil sample 25 (Plates 9 and 10)), and is a pale orange/light pink clay that has 10% quartz, 1% plagioclase, amphibole, biotite and muscovite and trace amounts of clinopyroxene. There are 6% opaques both the brownish black and red described above as possible hematite, as well as trace amounts of sandstone. There are also trace amounts of lighter yellow/white clay nodules with 20% quartz grains (sizes range from 0.01-0.03 mm) and 7% black opaques. The overall grain size in 'Dangeil

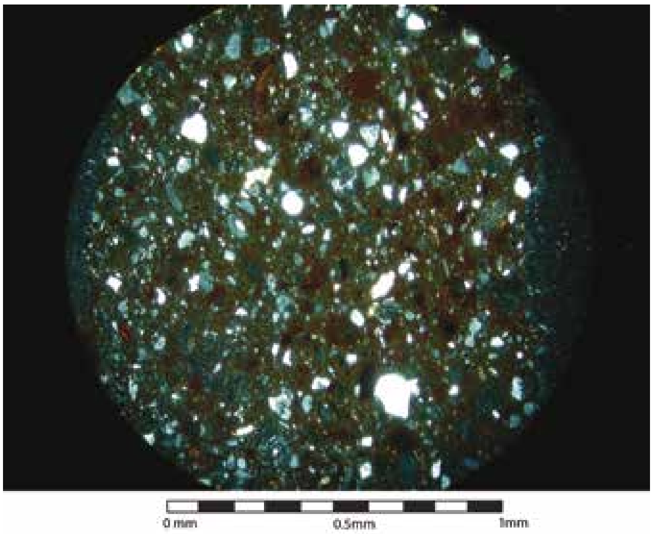

Plate 9. 'Dangeil Kaolin 1' petrofabric in PPL (Dangeil Sample 25).

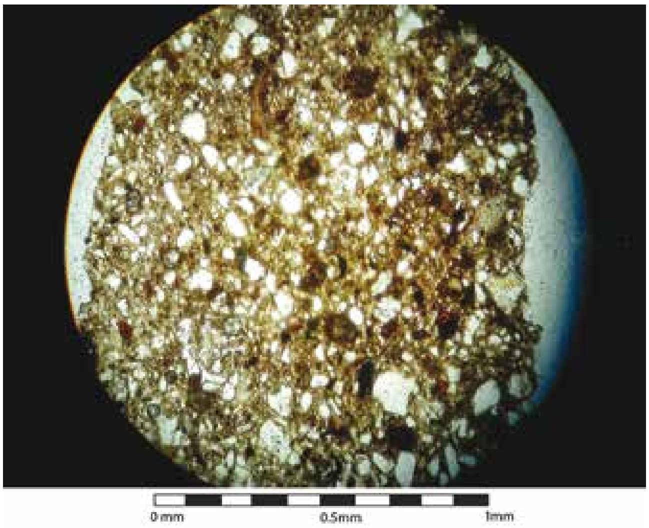

Plate 10. 'Dangeil Kaolin 1' petrofabric in XPL (Dangeil Sample 25).

Kaolin 1' is larger than in 'Dangeil Kaolin 2' as seen in the grain size distribution histograms in Figures 5 and 6. In addition to having a more diverse mineral suite and larger grain size, 'Dangeil Kaolin 1' is also moderately sorted as compared to 'Dangeil Kaolin 2,' which is well sorted. The presence of clay nodules that differ from the surrounding matrix, and a higher diversity of minerals in greater size and abundance, may attest to mixing of kaolin clays used to make finewares as observed by Smith (1997; 1999).

'Dangeil Kaolin 2' petrofabric

This group is also made up of one sample (Dangeil sample number 15 (Plates 11 and 12), which is a white clay with 20% sub-cloudy quartz with straight extinction. There are trace amounts of amphiboles, clinopyroxenes, biotite and muscovite; 3% opaques described above as possible hematite, and traces of voids. There are also trace amounts of slightly darker yellow/orange clay nodules with a similar mineral composition to the surrounding clay, indicating a poorly mixed clay as opposed to a kaolin clay mixed with another clay type.

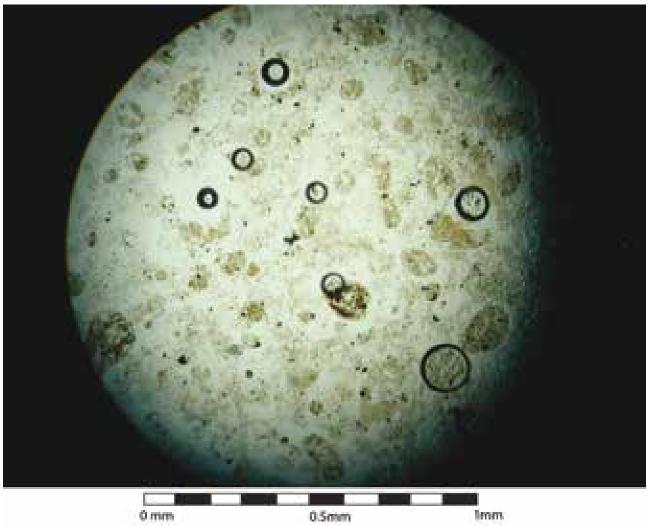

Plate 11. 'Dangeil Kaolin 2' petrofabric in PPL (Dangeil Sample 15).

Plate 12. 'Dangeil Kaolin 2' petrofabric in XPL (Dangeil Sample 15).

'Dangeil Granitic' petrofabric

'Dangeil Granitic' petrofabric group is comprised of one sample (Dangeil sample number 13 (Plates 13 and 14)). This fabric group has 10% felsic rock (granite) fragments, 3% plagioclase, 2% microcline, 2% orthoclase and 1% quartz with a minimum size of 0.12mm, mode of 0.5mm, and a maximum of 1.1mm. The source for this clay is most probably granitic rock given that 10% of these large inclusions are granitic rock fragments and the other large grains are potassic feldspars

Table 5. 'Dangeil Kaolin' petrofabric inclusions, abundance, sortedness, grain shape, and mean grain size.

No.	QTZ	ext	PLG	MIC	FSP	AMP	CPX	BIO	MSC	CRB	BST	CHT	GRN	ARG	OPQ	VOID	PHY	MEAN	MAX	SRT	RND
21	10	su/st	1	tr	tr	1	2	1	tr	tr (m)	tr	tr	2	tr	5	tr	-	0.02	0.41	w	sr/sa
12	4	u	2	-	1	1	1	1	1	2 (m)	tr	tr	3	tr	7	3	1	0.05	1.5 a	m	r-sr-sa
23	7	su	3	tr	tr	tr	tr	tr	tr	2 (m/c)	1	-	1	tr	6	3	2	0.07	0.92	m	sr /sa
17	3	st/u	1	tr	tr	tr	tr	tr	1	tr (m)	tr	tr	-	1	7	1	2	0.04	0.37	m	r-sr-sa
3	5	st	tr	-	tr	-	tr	tr	tr	-	-	tr	1	tr	3	1	1	0.05	0.9 a	m	sr/ sa

(e.g. orthoclase and microcline), quartz and plagioclase, which are all components of granite. These large granitic fragments and feldspars are angular suggesting they were crushed from a granitic source and are not granitic rock fragments present in Nile clays. The rest of the clay body is composed of 1% clear and sub-cloudy quartz inclusions with straight extinction that are well sorted and sub-round to sub-angular, trace amounts of amphiboles and clinopyroxenes and 3% dark red and black opaques that are probably hematite, as discussed above. So far, a petrofabric similar to 'Dangeil Granitic' has not been attested in other petrology studies from sites in the Nile Valley (Carreno *et al.* 2008; Mason 2001; Mason and Grzymski 2009; Smith 1997) and in central Sudan at Soba (Smith 1991)

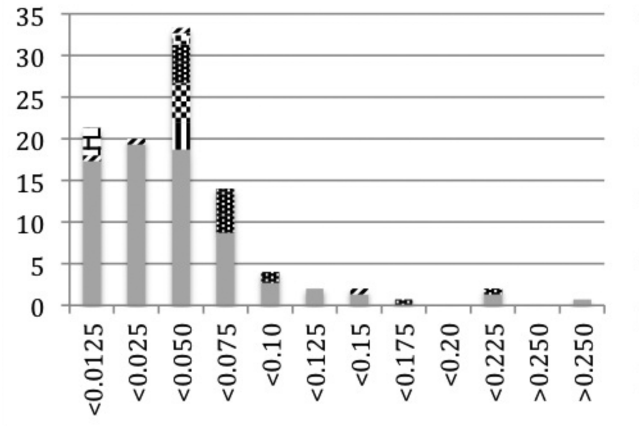

Figure 5. 'Dangeil Kaolin 1' petrofabric, sample 25. For the legend see Figure 1.

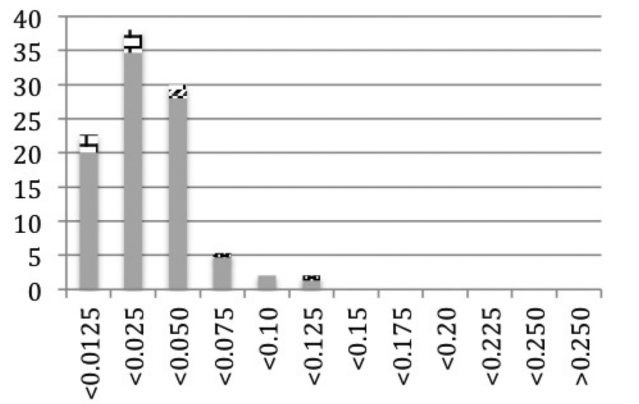

Figure 6. 'Dangeil Kaolin 2' petrofabric, sample 15. For the legend see Figure 1.

and Musawarat es-Sufra (Daszkiewicz and Schneider 2001; Smith 1999). This clay fabric is of great interest and requires further analysis in the future.

Comparison of 'Dangeil Nile' petrofabric and Nile clays in Sudan

Overall, one of the defining characteristics of Nile clays is their similar mineralogies derived from the Ethiopian highlands and deposited on the banks on the Nile. Therefore, a general mineral suite of quartz, feldspars, amphiboles, clinopyroxenes, mica, rounded fragments of volcanic rock (e.g. basalt) and phytoliths from vegetation are common. From the few studies that include detailed analysis of Sudanese Nile clays (north of the confluence of the Blue and White Niles), 'Dangeil Nile' petrofabric is similar to pottery from the Second and Third Cataract areas from the sites of Tombos, Askut, and Hannek (Carrano *et al.* 2008, 94), Christian period pottery from Hambukol in the Letti Basin between the Third and Fourth Cataracts (Mason 2001) and the Meroitic pottery from Meroe (Mason and Grzymski 2009). Additionally, petrography of 11th and 12th century AD wares from Soba has shown a mineral suite and percentages similar to 'Dangeil Nile' clays (Smith 1991).

The most striking difference between 'Dangeil Nile' petrofabric and Nile clays from the above sites in Sudan is the types and abundance of rock fragments. From Tombos, Askut and Hannek rock fragments include metamorphic rock fragments ranging from 0-0.3%, volcanic rock fragments ranging from 0-0.5% and carbonates from 0-4.3% (Carrano *et al.* 2008, 94). At Hambukol some clays have up to 3% volcanic rock fragments and up to 4% metamorphic rock fragments (Mason 2001, 151). In Meroe Nile clays, which are the most similar to the Dangeil samples in terms of the general mineral suite and similar low quantities of basalt and carbonates, the only rock fragments are trace amounts to 1% of basalt and trace amounts of carbonates (Mason and Grzymski 2009). 'Dangeil Nile' petrofabric, on the other hand, has trace amounts of up to 3% granitic rock fragments. While the Hambukol samples have similar high percentages of rock fragments, the Dangeil samples exhibit more granitic rock fragments than other Sudanese Nile clays. This relatively high presence of granitic rock in the 'Dangeil Nile' petrofabric will be examined further through petrographic analysis of additional samples

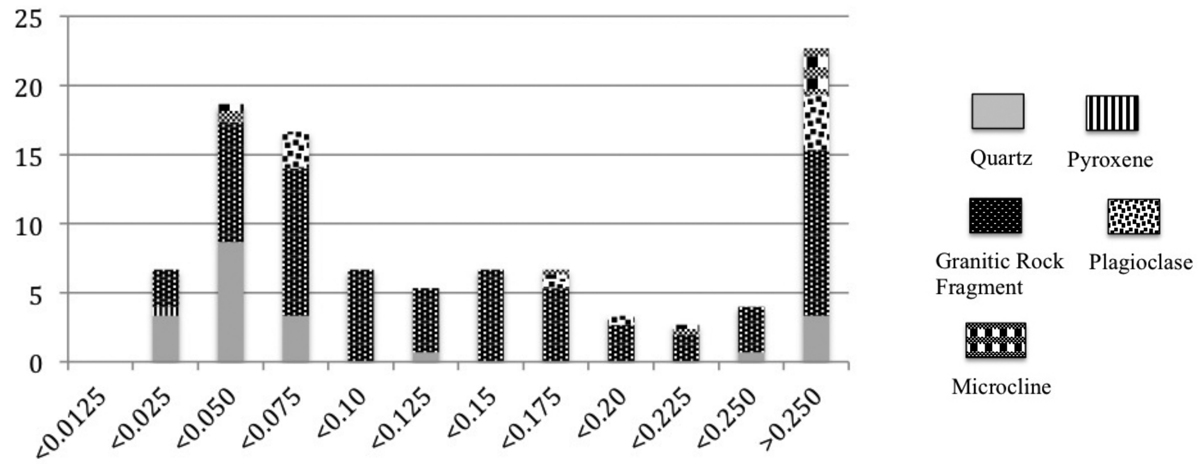

Figure 7. 'Dangeil Granitic' petrofabric grain size distribution.

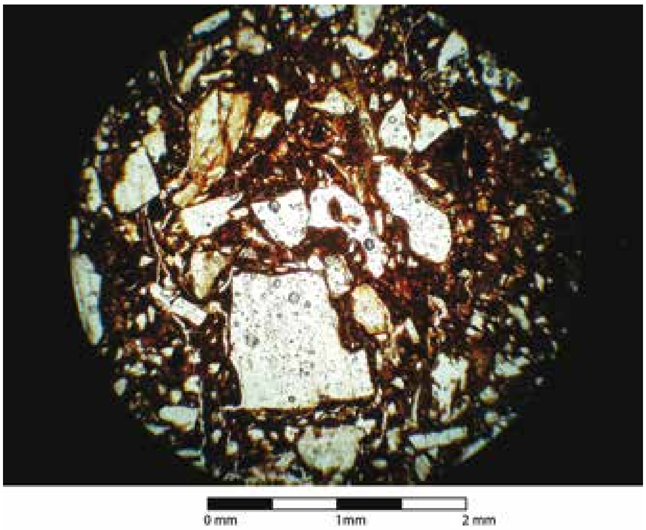

Plate 13. 'Dangeil Granitic' petrofabric in PPL (Dangeil Sample 13).

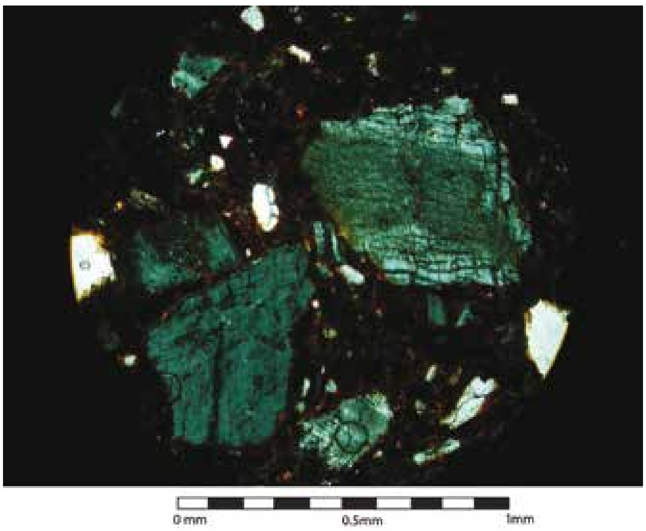

Plate 14. 'Dangeil Granitic' petrofabric in XPL (Dangeil Sample 13).

from Dangeil and a more in depth study of the regional geology of the Berber-Abidiya area.

Comparison of 'Dangeil Kaolin' petrofabrics and kaolin fabrics from Sudan

In general, the 'Dangeil Kaolin' clays have a more diverse mineral suite compared to Sudanese kaolin clays examined in previous studies. 'Dangeil Kaolin 1' petrofabric has a broader mineral suite with trace amounts of up to 1% of plagioclase, amphiboles, pyroxenes, muscovite, biotite and argillaceous inclusions, while 'Dangeil Kaolin 2' petrofabric has no plagioclase but does have trace amounts of amphibole, pyroxene, biotite, muscovite and argillaceous inclusions. This more diverse mineral suit does not correlate well with Smith's published clay groups from the Meroe area (Jebel Abu Shaar; Meroe Quarry, Meroe City; Sun Temple Wadi, Umm Ali) or with the fabrics from the First and Second Cataract areas (Aswan, Meinarti and Kalabsha) (Smith 1997, 79-80, 83-85) nor are they similar to finewares from Musawarrat es-Sufra (Smith 1999). The kaolinite clays analyzed by Mason from Meroe have a similar mineralogy to 'Dangeil Kaolin 2' petrofabric (particularly Meroe sample number 25), with the exception that 'Dangeil Kaolin 2' has more opaques (2% compared with trace amounts in Meroe sample number 25) and has traces of clay nodules (Mason and Grzymski 2009, 91). 'Dangeil Kaolin 1' petrofabric does not have any parallels with those from Meroe, and again as stated above might be a mixture of kaolin clay and Nile silt, as discussed by Smith (1999, 45-46). This preliminary study has shown that there is even greater diversity in kaolin clays than previously recognized, which needs to be studied further.

Conclusion

Based on a preliminary analysis of 18 samples of pottery from Dangeil, three fabric groups are attested ('Dangeil Nile', 'Dangeil Mixed Clay', and 'Dangeil Kaolin' petrofabrics) that have parallels with other petrofabrics from Sudan. This preliminary study characterized these petrofabrics at Dangeil with the aim of presenting material for comparison with other sites in Sudan. Additionally, a new petrofabric 'Dangeil Granitic' has been identified with no other known similar fabrics from Sudan. Future analysis hopes to better understand the local Dangeil clays through petrographic analysis of bread moulds that have been found in large quantities (Anderson and Ahmed 2006), suggesting a local origin. The abundance of felsic rock fragments in both the 'Dangeil Nile' and the Dangeil Mixed Clay' petrofabrics, as well as 'Dangeil Granitic' petrofabric will be examined in the future to better understand the sources of these clays.

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Gabati

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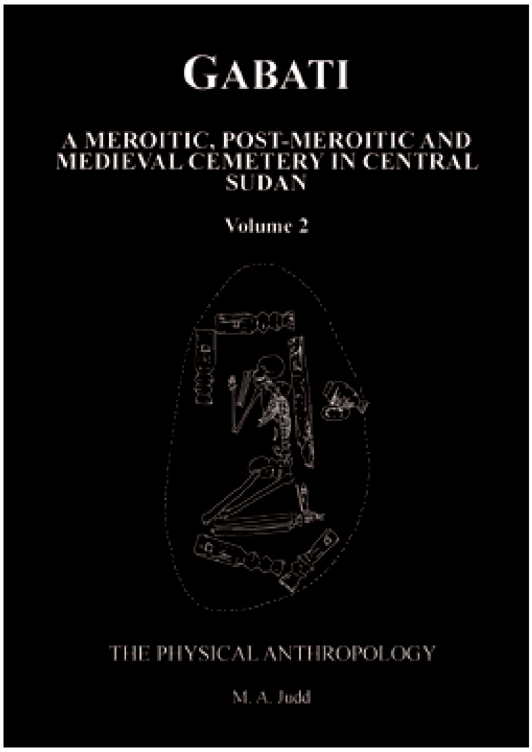

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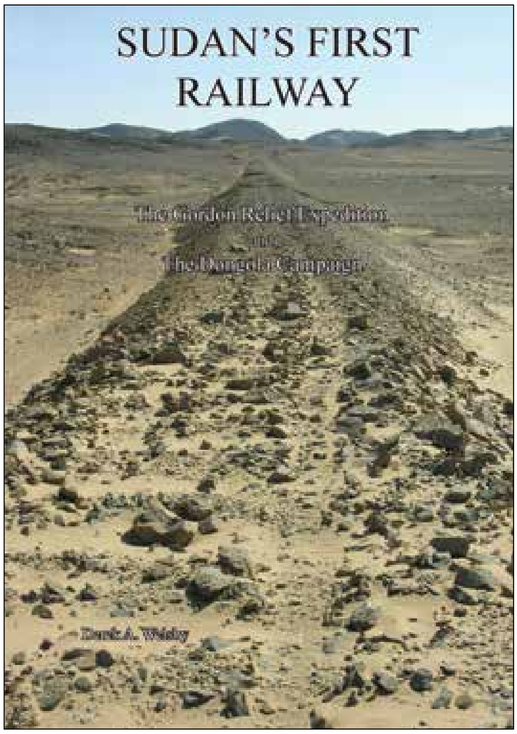

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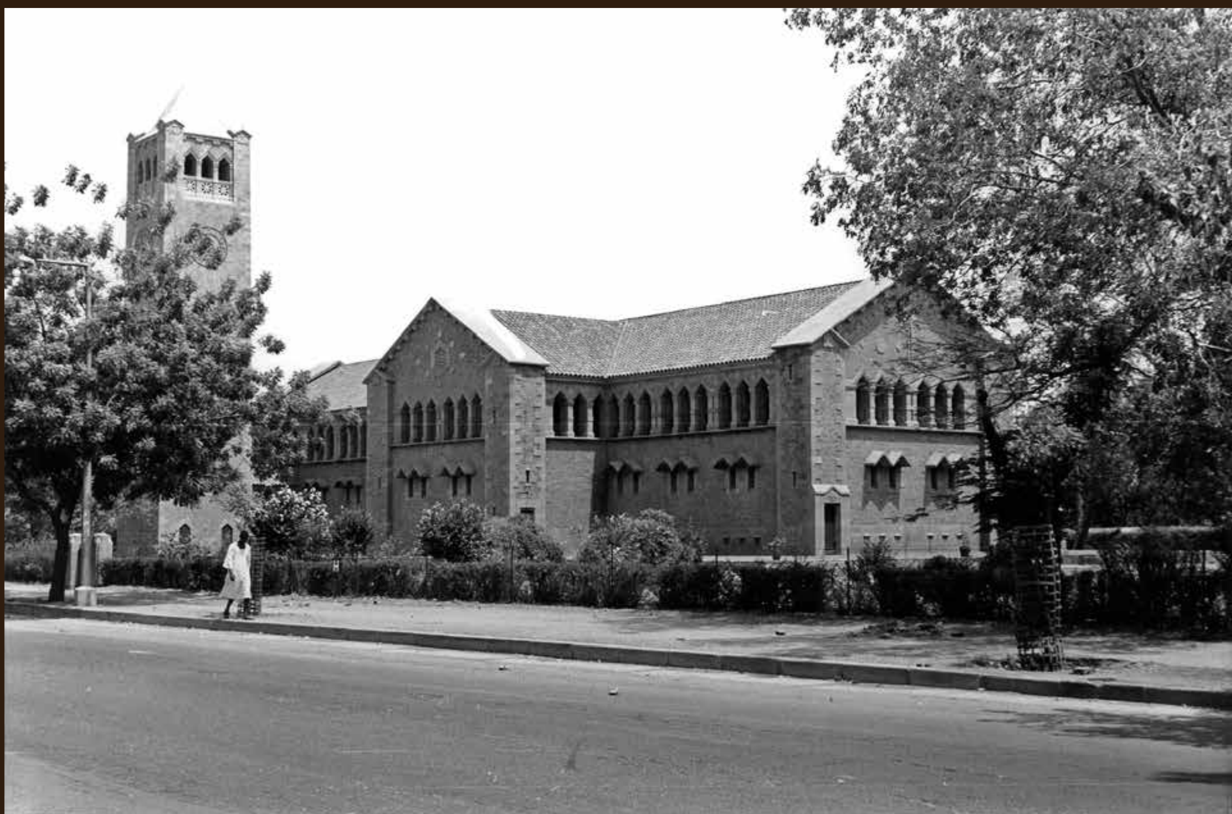

Khartoum. The Anglican cathedral in 1968. Now minus its bell tower it houses the Republican Palace Museum (photo SARS Hawkes Archive HAW P090.01).

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