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The ceramic assemblages from Sai Island (Northern Sudan): connecting technological choices to cultural traditions between the 6th and the 3rd millennium BC

Pottery may be considered as one of the principal sources of evidence among the many elements which make up a material culture, as it yields a wealth of information about the societies of past ages. The many different stylistic and technological choices adopted in the manufacturing sequence of a vessel reveal a number of decisions which have a cultural importance (i.e. Gosselain 1998; 2000; Sillar and Tite 2000). In other words, the style and technology of pottery production appear as the expression of the social and cultural identity of human groups, both in terms of their individual history and background and also of their relations with other groups.

This paper proposes a comparative study on the pottery manufacturing sequences that characterized Sai Island (Northern Sudan) during the recent Nubian prehistory. A selected sample of Khartoum Variant (c. 7000-5000 BC), Abkan (c. 5000-4000 BC) and Pre-Kerma (c. 3300-2600 BC) ceramics collected from four different sites on the island was studied with regard to both its stylistic and technological characteristics. The archaeological data were integrated with petrographic (OM), mineralogical (XRPD) and chemical (XRF) analyses - carried out on fifty-six samples - in order to provide an analytical description of the different ceramic assemblages of Sai Island that may contribute to enlarge the general knowledge of the Nubian pottery traditions.

Sai Island: geographical, geological and cultural background

Sai Island is located between the Second and the Third Cataracts of the Nile, in a strategic geographical position on the border between Upper and Lower Nubia, and also close to the Nabta-Kiseiba area and to the oases of the Western Desert (Fig. 1).

Geologically, this segment of the valley contains two main outcropping domains: the Precambrian basement complex - mostly consisting of granites and metamorphic rocks - and the Nubian Sandstone Formation that lies upon it (Hays and Hassan 1974; Klemm et al. 2001; Shang et al. 2010). Small, scattered outcrops of Precambrian schist and quartz veins characterize the geological substratum of Sai Island too, while most of its inner surface is covered by eroding beds of Pleistocene and Holocene silts and gravel bars from Nile paleochannels (Goossens et al. 1997; Geus 2000; Garcea and Hildebrand 2009). The sandstone outcrop of the Jebel Adu represents one of the main geological features of the island (Fig. 1).

In the Early Holocene - during the Khartoum Variant period - Sai was limited to just the pediment surrounding the Jebel Adu. Weather conditions and seasonal precipitation for this period have been recorded (Garcea and Hildebrand 2009). The human people that lived at site 8-B-10C were sedentary or near-sedentary groups of hunter-fisher-gatherers (Fig. 1). Site 8-B-10C was dated to the final stage of the Khartoum Variant complex, at the end of the sixth/beginning of the fifth millennium BC[1].

Toward the middle Holocene a progressive desiccation of the climate affected many regions of Northern Sudan (Nicoll 2004; Kuper and Kröpelin 2006). Sai then was inhabited by Abkan groups with a subsistence economy based on hunting and fishing, integrated for the first time with animal husbandry, who lived at site 8-B-76, on the southern-western side of the island (Fig. 1).

The Pre-Kerma horizon can be placed during the so-called "Marginalization Phase" (c.f., Kuper and Kröpelin 2006) between the third and the second millennium BC: at that time arid or very arid conditions characterized the climate of the Western Desert and also part of the Egyptian and Sudanese Nile valley. Sai Island was inhabited by communities with an agro-pastoral economy. Two different sites can be referred to the Pre-Kerma complex: site 8-B-10A , a stratified settlement located on the south-eastern side of the island, and site 8-B-52A (Fig. 1): a granary site consisting of more than seventy storage pits used to store both wild and domestic plant seeds, including Asian domesticates grains and local specimens[2] (Geus 2004; Hildebrand 2006-07).

[1] Charcoal from hearths in level 1 was dated to 5980±40 BP (4950-4770 cal. BC) (KIA -24464) and 6080±35 BP (5070-4900 cal. BC) (KIA- 24463) (Garcea 2006-07).

[2] The barley was directly dated to 4151 ± 44 BP (UtC-5295) and 4142 ± 48 BP (UtC-5294), or between 2872 and 2612 cal. BC (Geus 1998).

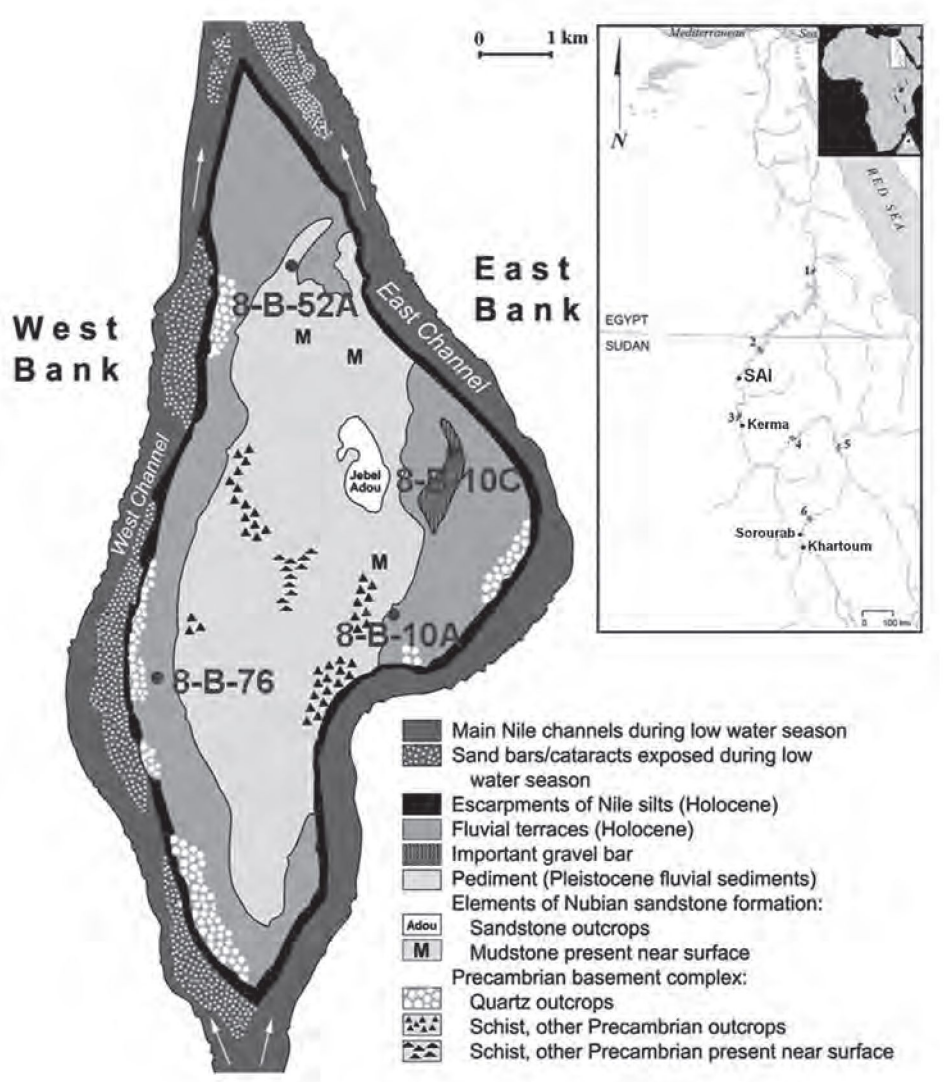

Fig. 1. Geological map of Sai Island (adapted from Garcea and Hildebrand 2009) showing the location of sites 8-B-10C, 8-B-76, 8-B-52A and 8-B10A

The ceramic assemblage: macroscopic data

The ceramic assemblage analysed comes from the four sites described above and consists of over 3,000 potsherds which have been selected during successive field seasons, starting from January 2009[3].

All data were entered in a relational database on an Access ® platform designed by Garcea (Garcea and Caputo 2004). The database collects information regarding the entire manufacturing sequence, including type, size and frequency of inclusions, texture, vessel body parts and thickness, surfaces treatment, as well as decorative techniques and motifs, following to the hierarchical system developed by Caneva (Caneva 1988; Caneva and Marks 1990).

The Khartoum Variant assemblage from site 8-B-10C

The ceramic assemblage from site 8-B-10C comprises 905 potsherds from the surface and from layers 1, 2 and 3 of the settlement[4]. This pottery represents the most ancient production on the island and is characterized by a sandy texture due to a large quantity of mineral inclusions in the paste. A small percentage of sherds contains also flat, organic remains of a vegetable nature (c.f., Livingstone Smith 2001). Surfaces are plain or just smoothened. Only few ceramics show burnishing and/or polishing marks; it is worth noting that when polishing occurs, it is mostly on the inner surfaces of the vessels, suggesting a function choice rather than a decorative need. Characteristic shapes are open bowls with straight walls, and thickness usually ranges from 6 to 10 mm. Body decorations include the typical Khartoum Variant impressed motifs made with the rocker stamp technique and often structured in bands of dotted wavy line (mostly short or arch shaped waves) (Gatto 2002; 2006; Jesse 2002; 2004; Honegger 2004). Rims were decorated with milled or notched impressions (Table 1; Fig. 2).

The Abkan pottery from site 8-B-76

The Abkan assemblage consists of 39 sherds that come from two test units, 1 x 1m each, excavated at the site 8-B-76. This pottery contains both mineral and organic inclusions, is light and brittle and shows a distinctive porous fabric. Surfaces are mostly black or brown on the inner side and greyish-brown externally,

[3] This study is part of my Ph.D research project during which I joined the Research Unit on Later Prehistory on Sai Island and took part in the investigations conducted by Elena A. A. Garcea of Cassino and Southern Latium University, in charge of the Research Unit for the Later Prehistory at Sai Island.

[4] The ceramic assemblage from the surface and from level 1 was previously studied by Garcea (Garcea and Hildebrand 2009; Garcea 2011-12; 2012). These results are here presented and discussed together with the evidences from layers 2 and 3.

Table 1. Technological and stylistic features of the four ceramic assemblages

Cultural horizon	Khartoum Variant	Abkan	Pre-Kerma	
Site	**8-B-10C**	**8-B-76**	**8-B-52A**	**8-B-10A**
Technological features				
Texture	medium; fine and coarse	fine; medium	medium; fine	medium; fine
Mineral inclusions	small and medium	small	small	small
	common; frequent	common	frequent; common	frequent; common
	angular	angular and rounded	rounded	angular
Organic inclusions	rare	common	frequent	frequent
	flat (vegetal remains)	tubular (herbivore dung)	flat and tubular (herbivore dung; vegetal remains)	tubular (herbivore dung)
Surfaces treatment	not present; rare burnishing/ polishing inside	not present; rare inside or inside/outside burnishing	inside/outside burnishing; inside polishing	inside/outside burnishing; rare polishing
Morphological features				
Shape	open bowls with straight walls	globular bowls; vessels with straight walls	storage jars; rare open bowls	small and medium open bowls; rare jars/vessels with inverted rims
Wall thickness	6-10 mm	3-8 mm	4-9 mm; > 15 mm (storage jars)	4-9 mm
Stylistic features				
Decorative technique	rocker impression	not decorated; incision; ripple ware	rocker impression; APS	incision; simple impression
Implement	combs with 3/4 teeth	stylus	plain and serrated combs; double pronged implements	stylus
Motif	DWL (short or arch shaped waves); dotted/dashed zig-zags	single lines	straight and dotted/ dashed zig-zags; paired lines	single/individuals lines
Structure	banded		continuous	panelled; herring bone and geometric
Rim decoration	milled/notched impressions	Black Topped	Black Topped	Black Topped

and only seldom appear burnished, whereas polishing does not seem to have been employed. Vessels display straight and globular walls with thicknesses ranging from 3 to 8 mm. Most of the sherds are not decorated; when decorations occur, they are mainly concentrated on the rim and may include simple incisions and impressions. Occasional ripple and black-topped wares were also recorded (Table 1; Fig. 3).

The Pre-Kerma pottery from sites 8-B-52A and 8-B-10A

The Pre-Kerma corpus comprises 2943 sherds, of which 448 come from site 8-B-52A (from silos 7, 39 and 44) and 2495 from settlement 8-B-10A. This pottery shares similar technological traits: it has fine-medium pastes containing small, frequent mineral inclusions as well as organic tempers. Both internal and external surfaces are burnished; while polishing is common only in the production of the granary site 8-B-52A, where it was mainly applied to the inner surfaces of the vessels. Pottery from the two sites display also a similar distribution regarding the wall thickness values, which are commonly between 4 and 9 mm, even if some sherds show wall thicknesses exceeding 15 mm. However, while at the granary site 8-B-52A ceramic shapes consist mainly of vessels with inverted rims and large jars suitable for the storing of goods; smaller bowls with everted or straight walls characterize the production of the settlement 8-B-10A. Decorations include incised motifs, as well as rocker-stamped and alternately pivoting stamped impressions (APS); black-topped and ripple wares are also frequent. Rims show milled impressions, geometric patterns or herringbone incisions (Table 1; Fig. 4).

The archaemetric analyses

Sampling and analytical methods

The archaeological data were integrated with petrographic, mineralogical and chemical analyses. Our pilot sampling consisted of fifty-six sherds, of which: fourteen come from the Khartoum Variant site 8-B-10C, seven from the Abkan site 8-B-76, and thirty samples were selected from the two Pre-Kerma sites (seventeen from site 8-B-52A and thirteen from site 8-B-10A). Five clay lumps were also sampled from the Pre-Kerma settlement 8-B-10A (D'Ercole et al. in press) (Table 2).

All the archaeometric analyses were performed at the "Dipartimento di Scienze della Terra e Geoambientali dell'Università degli Studi di Bari". Petrographic observation of thin sections was carried out with a Carl Zeiss "Axioskop 40 pol" polarized light microscope (OM). For X-ray powder diffraction analysis (PXRD) we used a PANalytical X'Pert pro MDS powder diffractometer with CuK radiation, and em-

Fig. 2. Examples of Khartoum Variant pottery from site 8-B-10C

Fig. 3. Examples of Abkan pottery from site 8-B-76

Fig. 4. Examples of Pre-Kerma pottery from sites 8-B-52A and 8-B-10A

Table 2. Ceramic samples selected for the archaeometric analyses

No. Sample	Cultural Horizon	Site	No. Square/ Silos	Layer	Decoration	No. Sample	Cultural Horizon	Site	No. Square/Silos	Layer	Decoration
SAI 01	Pre-Kerma	8-B-10A	N21/E19	S		SAI 29	Khartoum Variant	8-B-10C	101N/106E	2	
SAI 02	Pre-Kerma	8-B-10A	N20/E48	2		SAI 30	Khartoum Variant	8-B-10C	103N/106E	2	
SAI 03	Pre-Kerma	8-B-10A	N20/E49	3		SAI 31	Khartoum Variant	8-B-10C	103N/103E	1	
SAI 04	Pre-Kerma	8-B-10A	N20/E49	3		SAI 32	Khartoum Variant	8-B-10C	101N/102E	1	
SAI 05	Pre-Kerma	8-B-10A	N20/E48	5		SAI 33	Khartoum Variant	8-B-10C	103N/106E	1	
SAI 06	Pre-Kerma	8-B-10A	N20/E49	7		SAI 34	Khartoum Variant	8-B-10C	103N/106E	1	
SAI 07	Pre-Kerma	8-B-10A	N20/E49	7		SAI 35	Khartoum Variant	8-B-10C	103N/105E	1	
SAI 08	Pre-Kerma	8-B-10A	N20/E48	10		SAI 36	Khartoum Variant	8-B-10C	103N/106E	1	
SAI 09	Pre-Kerma	8-B-10A	N20/E48	10		SAI 37	Khartoum Variant	8-B-10C	102N/106E	1	Rocker Impression (DWL)
SAI 10	Pre-Kerma	8-B-10A	N20/E48	10		SAI 38	Khartoum Variant	8-B-10C	102N/106E	1	Rocker Impression (DWL)
SAI 11	Pre-Kerma	8-B-52A	silos 7		Rocker Impression	SAI 39	Khartoum Variant	8-B-10C	102N/105E	1	
SAI 12	Pre-Kerma	8-B-52A	silos 7			SAI 40	Pre-Kerma	8-B-10A	N20/E48	S	Incision
SAI 13	Pre-Kerma	8-B-52A	silos 7		Rocker Impression	SAI 41	Pre-Kerma	8-B-10A	N20/E48	7	Incision
SAI 14	Pre-Kerma	8-B-52A	silos 39		APS	SAI 42	Pre-Kerma	8-B-10A	N20/E48	9	Rocker Impression
SAI 15	Pre-Kerma	8-B-52A	silos 39			SAI 43	Pre-Kerma	8-B-52A	silos 39		APS
SAI 16	Pre-Kerma	8-B-52A	silos 39			SAI 44	Pre-Kerma	8-B-52A	silos 39		Rocker Impression
SAI 17	Pre-Kerma	8-B-52A	silos 39			SAI 45	Pre-Kerma	8-B-52A	silos 39		Incision
SAI 18	Pre-Kerma	8-B-52A	silos 44			SAI 46	Pre-Kerma	8-B-52A	silos 39		APS
SAI 19	Pre-Kerma	8-B-52A	silos 44			SAI 47	Pre-Kerma	8-B-52A	carré 15		BT

No. Sample	Cultural Horizon	Site	No. Square/ Silos	Layer	Decoration	No. Sample	Cultural Horizon	Site	No. Square/Silos	Layer	Decoration
SAI 20	Pre-Kerma	8-B-52A	silos 44			SAI 48	Pre-Kerma	8-B-52A	carré 19		Rocker Impression (BT)
SAI 21	Pre-Kerma	8-B-52A	silos 44			SAI 49	Abkan	8-B-76	TU1	4	
SAI 22	Abkan	8-B-76	TU2	1		SAI 50	Abkan	8-B-76	TU1	1	
SAI 23	Abkan	8-B-76	TU2	1		SAI 51	Abkan	8-B-76	TU2	1	Incision
SAI 24	Abkan	8-B-76	TU2	1		SAI 52	Pre-Kerma	8-B-10A	TU2	5	
SAI 25	Abkan	8-B-76	TU2	1		SAI 53	Pre-Kerma	8-B-10A	N20/E48	6	
SAI 26	Khartoum Variant	8-B-10C	92N/106E	2		SAI 54	Pre-Kerma	8-B-10A	N20/E49	6	
SAI 27	Khartoum Variant	8-B-10C	98N/106E	2		SAI 55	Pre-Kerma	8-B-10A	N20/E48	7	
SAI 28	Khartoum Variant	8-B-10C	101N/106E	2		SAI 56	Pre-Kerma	8-B-10A	N20/E49	8	

ploying NaF as an internal standard. Major elements determination was performed by X-ray fluorescence (XRF) with a Philips PW 1480/10 spectrometer, following analytical techniques outlined by Franzini *et al.* (1972; 1975). Loss on ignition (LOI) was determined by heating the samples at 1,000°C for 12 hours.

Results: mineralogical and petrographical data

According to X-ray Powder Diffraction analysis (XRPD) the fifty-six ceramic samples were classified in to three main mineralogical groups, each of them characterized by specific phase associations:

1. QPl (Quartz-Plagioclase) group: samples from this group contain mainly quartz and plagioclase, with a minor amount of K-feldspar and micas. Traces of calcite and clino-pyroxenes were also detected. This group includes most of the Abkan (six sherds) and the totality of the Pre-Kerma samples.
2. QKfs (Quartz-K-feldspar) group: samples from this group (twelve Khartoum Variant and only one Abkan sample) display the co-occurrence in X-ray patterns of picks of quartz, K-feldspar (commonly present in large quantities) and micas.
3. Q (Quartz) group: the two Khartoum Variant samples belong to this group are characterized by the only presence of quartz.

Microscopic observation on thin sections (OM) confirmed the mineralogical groupings; in addition this analysis revealed the presence, within each group, of different fabrics (or sub-groups), based on technological and textural differences between samples.

The QPl (Quartz-plagioclase) Pre-Kerma ceramics are all similar with respect to the mineral phases present inside them: mostly mono- and poly-crystalline quartz and plagioclase with a minor amount of K-feldspar, micas and micritic calcite aggregates plus some accessory phases (i.e. Fe-aggregates, epidote minerals, augite, green hornblende). However, the samples from the granary site 8-B-52A showed in comparison with those from the settlement 8-B-10A a higher amount of organic tempers: both plant fibres and glumes and particles of herbivore dung consisting of crumbled vegetal remains (Fig. 5, c). This could be explained as a specific functional choice in relation to the use, at the granary site, of large pots as storage containers for wild and domestic grains.

In the Abkan samples from the same QPl group, the organic content is mainly constituted by sub-millimetrical charcoal fragments that, since they display a high degree of angularity, are likely to have been added by the potter as an intentional filler (Fig. 5, b).

As regards the Khartoum Variant ceramics ascribed to the QKfs group, we can distinguish between two sub-groups: QKfs-Bt (prevalence of biotite mica) and QKfs-Ms (prevalence of muscovite mica), where the first one displays also a higher content of K-feldspar and a coarser grain size compared to the latter (Fig. 5, a). In these samples the presence of organic inclusions is rare and it seems to be only accidental.

Results: chemical data

The chemical data obtained by X-ray Fluorescence analysis (XRF) are consistent with the mineralogical and petrographic results. Only comparing the major elements, we can distinguish between the Khartoum Variant/QKfs samples, rich in potassium (K2O) oxide and the Pre-Kerma and Abkan samples from the QPl group, rich in calcium oxide (CaO2) (Fig. 6). The ceramic samples from the QPl group contain also higher percentages of Fe2O3 and TiO2 compared with the ones from the QKfs group. The content of SiO2 is quite homogeneous in all the samples, however its contribution appears particularly significant in the Quartz group (Table 3).

In conclusion, chronologically distinct products can be discriminated from a compositional point of view. Both chemistry and petrography suggest that the ceramics from the oldest Khartoum Variant horizon (QKfs group) were locally made using primary clayey sediments, containing large quantities of non-plastic mineral inclusions of angular quartz, K-feldspar and metamorphic rock fragments. The Precambrian basement complex may have represented the principal source for this raw material and tempers.

As regards the Abkan and Pre-Kerma ceramics from QPl group, the mineral suite (prevalent presence of quartz grains and plagioclase) and the finer grain size of the samples point to the selection of alluvial sediments related to the Nile river activity.

Final remarks

The comparison between the analytic and the macroscopic data allows us to perceive the existence of numerous variables affecting the production of pottery on Sai Island, to be attributed in part to the conscious technological choices made by the potter at the moment of production, and in part to the varying make-up of the raw materials selected to make the pots with. In the context of Sai therefore, pottery will have experienced, since the time of its first appearance during the Khartoum Variant horizon, a series of changes which are not merely stylistic, but in fact are mainly technological.

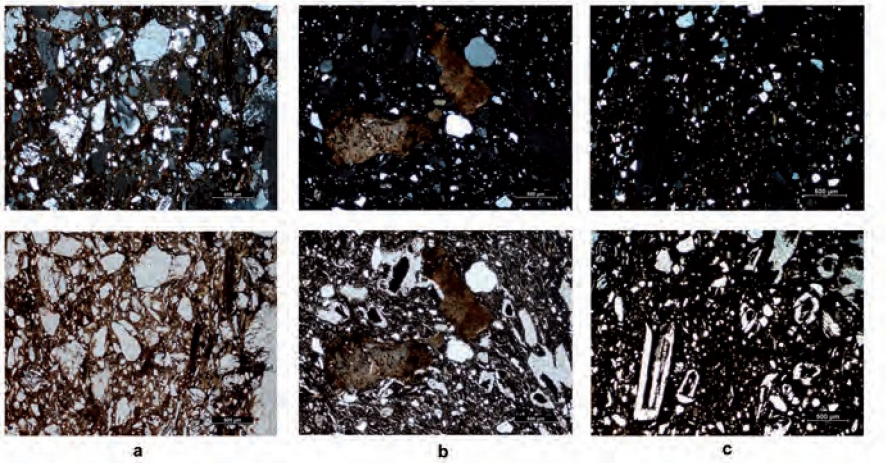

Fig. 5. Photomicrographs taken with cross polarized light (on top) and with plane polarized light (on bottom) of thin sections of (a) QKfs Khartoum Variant sample, (b) QPl Abkan sample and (c) QPl Pre-Kerma sample

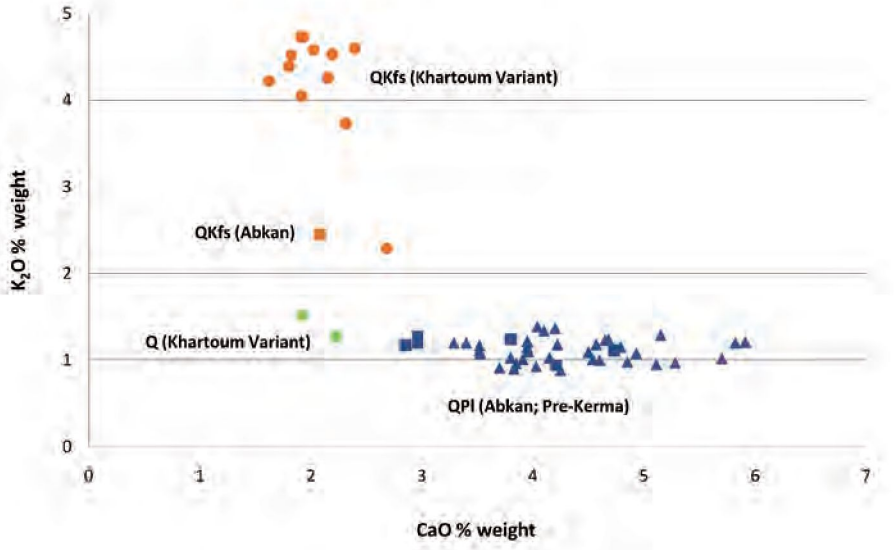

Fig. 6. CaO vs K2O plot (wt%). Blue triangles: Pre-Kerma (QPl) samples. Squares: Abkan samples; blue squares: QPl samples, orange squares: QKfs samples. Circles: Khartoum Variant samples; orange circles: QKfs samples, green circles: Q samples

Through the cultural sequence under consideration, two key moments can be seen to stand out, when the greatest number of changes seem to take place in the production of ceramics.

1. The transition, between ca. 5000 BC and 4000 BC from the Khartoum Variant horizon (site 8-B-10C) to the Abkan (site 8-B-76) when some of the most important technological and stylistic innovations have been recorded:
   a. The adoption of a new raw material (an alluvial sediment instead of the primary clayey sediment rich in mineral inclusions used for the Khartoum Variant ceramics);
   b. A different way of preparing the pastes, with the intentional addition of organic temper (mainly charcoal particles);
   c. A reduction in the thickness of the walls of the pots;
   d. The disappearance of certain techniques and decorative motifs typical of the earlier horizon (in particular dotted wavy line decoration) which are replaced by incised decorations and, for the first time, black topped wares;
   e. A more frequent use of different treatments for surfaces, in particular burnishing.
2. The transition, around 3000 BC, from the Abkan horizon (site 8-B-76) to the Pre-Kerma (sites 8-B-52A and 8-B-10A) in which the same raw material continues to be used (a silty alluvial sediment), but where the following technological and stylistic changes have been recorded:
   a. Preparation of pastes by addition of organic temper, both animal (herbivore dung) and vegetable;
   b. Production of pottery in a wider variety of shapes (open forms and storage vessels);
   c. The appearance of new decorative techniques, motifs, and structures (e.g., herringbone and other kind of geometric patterns) and at the same time, consolidation of earlier traditions (among them black topped and ripple ware);
   d. Common use of burnishing and polishing as treatments of the surfaces of pots.

These moments coincide not only with the well-known 'breaks' in the chronological sequence of the Recent Nubian Prehistory; more than anything, they take on importance when one considers what their real economic and cultural meaning is. In this light, it should be remembered that the transition from the Khartoum Variant horizon to the Abkan marks the decisive passage from an economy

Table 3. Chemical composition (wt%) of ceramic samples by XRF analysis

		SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	L.O.I
QPl (n=41) Abkan Pre Kerma	*x*	55,46	1,89	15,81	10,71	0,21	3,43	4,24	1,76	1,11	0,27	5,12
	σ	3,36	0,22	0,8	1,01	0,08	0,48	0,74	0,5	0,13	0,12	2,22
QKfs (n=13) Khartoum Variant Abkan	*x*	56,07	0,73	19,1	6,79	1,31	1,12	2,06	2,1	4,08	0,14	6,51
	σ	3,29	0,16	1,76	0,74	0,64	0,42	0,28	0,56	0,81	0,05	2,91
Q (n=2) Khartoum Variant	*x*	64,53	0,91	15,12	6,89	0,77	1,85	2,07	1,48	1,4	0,24	4,78
	σ	4,17	0,09	0,15	0,54	0,74	0,22	0,21	0,5	0,18	0,06	2,71

of hunting, fishing and gathering to the introduction of animal husbandry; while the beginning of the Pre-Kerma period is accompanied by the establishment of more complex societies, with a mixed agricultural-pastoral economy.

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