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► To cite this version:

Valérie V. Thirion-Merle, Gisela Thierrin-Michael, Armand Desbat. Archaeometrical study of Khmer stoneware from the Angkorian period: some results of the Cerangkor Project. 14th International Conference of the European Association of Southeast Asian Archaeologists (EurASEAA 14), University College Dublin, Sep 2012, Dublin, Ireland. hal-01394076

HAL Id: hal-01394076

<https://hal.science/hal-01394076v1>

Submitted on 8 Nov 2016

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Archaeometrical study of Khmer stoneware from the Angkorian period: some results of the Cerangkor Project

Valérie Thirion-Merle, Gisela Thierrin-Michael and Armand Desbat

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Abstract

In the area around Angkor, a number of ceramic kilns dating from the 9-15th centuries AD have been discovered since 1995. The technical, typological and compositional characterization of their production has been one of the main goals of the Cerangkor Project ([Desbat *et al.* 2008, 2009, 2010, 2011 and 2012](#)).

Since 2008, more than 300 samples of Khmer stoneware produced in the Angkor region have been analyzed chemically by XRF-WDS, and forty-three of these have also seen petrographic analysis. The ceramics comprise green-glazed 'Kulen type' stoneware and non-glazed stoneware from five kiln sites (Anlong Thom, Sor Sei, Tani, Khnar Po and Bankaong), as well as brown-glazed stoneware from the Anlong Thom site. The data indicate that some workshops used quite similar raw materials for the same types of ceramics, suggesting the exploitation of the same geological formations for the whole region. Differentiation of the compositional groups characterizing each workshop proved, therefore, to be fairly difficult, but small differences allow us to distinguish between some groups of workshops.

Introduction

The archaeometrical study of Khmer stoneware presented here has been carried out since 2008 as part of the Cerangkor Project. This project, created in 2008, is a collaborative research program between the CNRS (National Center for Scientific Research of France), the EFEO Center in Siem Reap (French School of Asian Studies) and the APSARA Authority (Authority for the Protection and Management of Angkor and the Region of Siem Reap) with funding of the Ministry of Foreign Affairs of France ([Desbat *et al.* 2008, 2009, 2010, 2011, 2012](#)). It was developed to investigate the ceramics produced at the kiln sites in the region of the ancient Khmer capital of Angkor, from the period between the 9-15th centuries AD. In this paper, we concentrate on the results concerning the production of the kiln sites Anlong Thom and Sor Sei, situated respectively on and at the foot of Phnom Kulen, as well as Khnar Po, Tani and Bankaong, between Phnom Kulen and the lake of Tonlé Sap (Fig. 1). ([Aoyagi. *et*](#)

al. 2000; Aoyagi and Sasaki 2006; Tabata and Chhay Visoth 2007; Miksic *et al.* 2008; Ea Darith 2010). All these sites are situated in the Siem Reap Province.

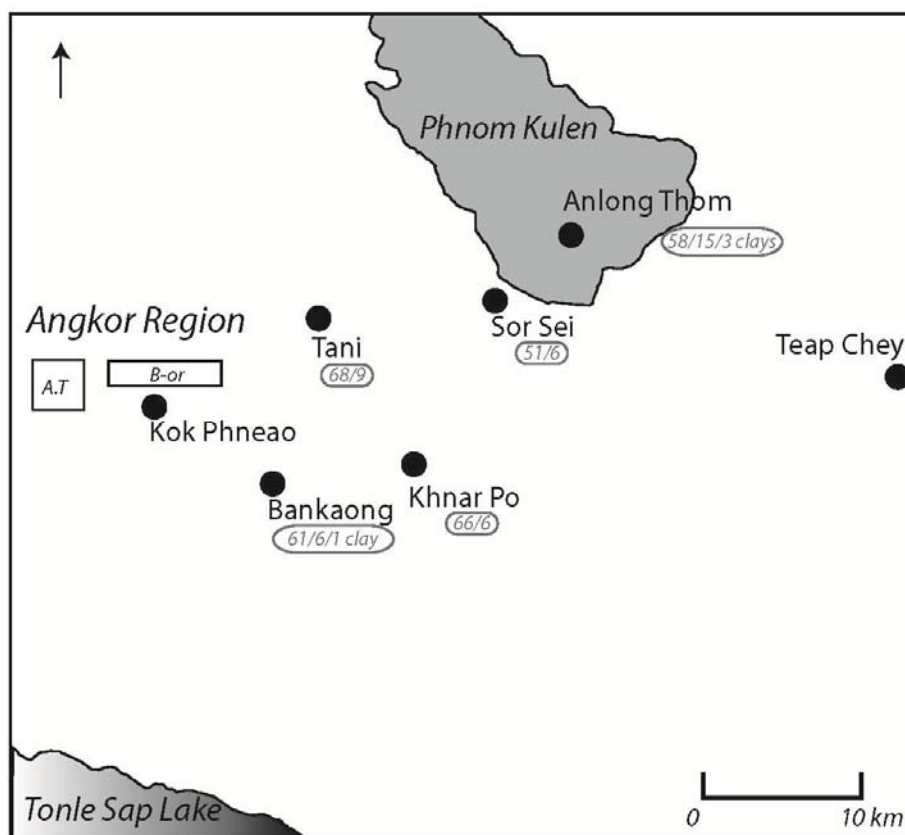


Figure 1 : Geographical situation of the kiln sites; number of analyzed samples in brackets (chemical analyses/petrographical analyses); AT Angkor Thom, B-or = eastern Baray

Site context and sample collection

The pottery samples discussed here were collected on these kiln sites during our own field prospectations. Clay and sand samples for comparison were taken either directly at the kiln sites or from locations situated within perimeters under 5 km around the kiln sites. All of the kiln sites studied are characterized by the presence of huge quantities of sherds, distributed in several manners at the sites: in Anlong Thom, the sherds are dispersed in the forest as well as concentrated in the partially-excavated kiln structures due to the villagers’s looting (Desbat *et al.* 2008); in Tani, Sor Sei and Khnar Po the ceramics were concentrated around the kiln remains, which appear as mounds in the landscape (Desbat *et al.* 2008, 2009 and 2010), while the dispersal zone of sherds around the kilns is larger at the site of Bankaong (Desbat *et al.* 2008). Some kilns at each site were excavated prior to this project (Aoyagi. *et al.* 2000; Aoyagi and Sasaki 2006; Tabata and Chhay Visoth 2007; Miksic *et al.* 2008; Ea Darith2010). At Khnar Po, several kilns were destroyed and cut at the level of the firing chamber during road works and field remodeling, and are now plainly visible (Desbat *et al.* 2009). At most kiln sites several types of wares were produced: unglazed stoneware, green-

glazed stoneware and earthenware. In addition, brown glazed stoneware was produced at Anlong Thom, while unglazed ware was rarely found there (Desbat *et al.* 2008).

Goals and methods

The main goal of this research was the creation of a reference database for future provenance studies. This meant characterizing kiln production chemically and petrographically, as well as attempting to differentiate the workshops. The study also aimed to increase our technological information concerning raw materials and ceramic paste preparation, and to answer the following questions: what kind of clay(s) was/were used; is it possible to identify the location of the clay resources; and how was clay prepared (washing/levigating, mixing with sand or of several clays, differences between wares, etc.)?

Two analytical methods were combined: chemical and petrographical analyses. The main analytical method applied was chemical analyses by Wavelength Dispersive X-Ray Fluorescence Spectrometry (WD-XRF), according to the standard procedures of the Archaeometry and Archaeology Laboratory at CNRS–University of Lyon. This procedure supplies the bulk chemical composition of the ceramic (matrix and sandy fraction) and consequently of the material used for its manufacturing (Thirion-Merle 2014, Waksman 2014). XXX). Measurement is carried out on glass tablets of homogenous composition containing 800 mg of powdered sample. For each sample, twenty-four components were determined. Several uni-, bi- and multivariate statistical data treatments have been applied to interpret the chemical results. Among the multivariate methods used, here we present results mainly from cluster analysis, a statistical treatment using Euclidian distances, calculated in this case on sixteen chemical components: magnesium oxide (MgO), alumina (Al₂O₃), silica (SiO₂), potassium oxide (K₂O), calcium oxide (CaO), titanium oxide (TiO₂), manganese oxide (MnO), iron oxide (Fe₂O₃), vanadium (V), chrome (Cr), nickel (Ni), rubidium (Rb), strontium (Sr), zirconium (Zr), baryum (Ba), and cerium (Ce). The dendrogram produced (see for exemple figure 5) represents the relative distances between samples, where the most similar samples are linked at the smallest distances. (see Picon 1984; Baxter 1994)

The petrographical analyses on thin sections under the polarising microscope were applied to a reduced number of samples. They were chosen because they are representative of the different chemical compositional groups of each kiln site. This method shows the nature, frequency and shape of the inclusions contained in the ceramics as well as the texture of the matrix. A slice of about four mm is cut through the sherd at right angles to the rim (or turning direction), and the wall of this is used for sample preparation. This slice is then mounted on a glass slide and ground down to a standard thickness of 30 μm.

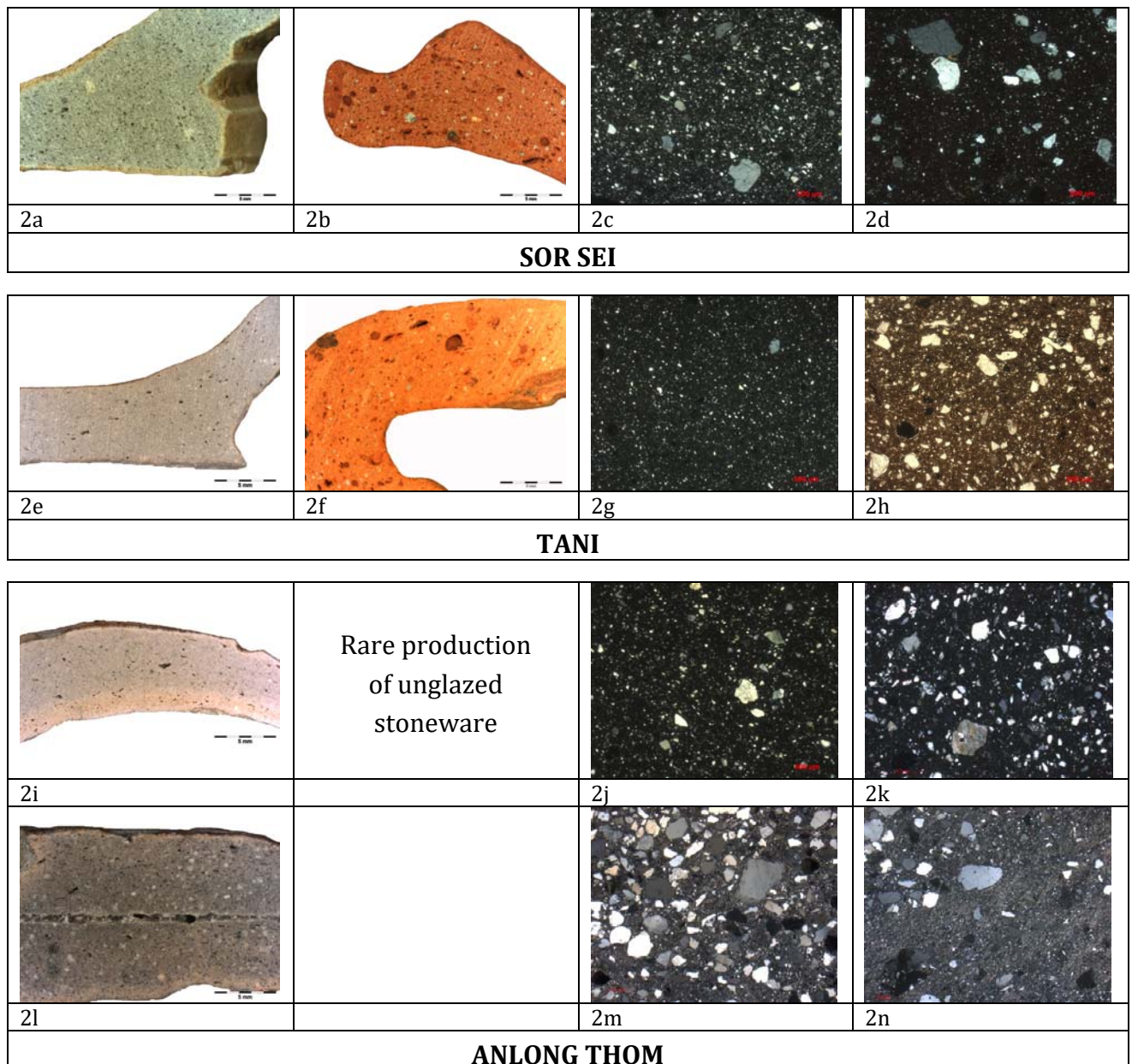
Over 300 samples from the kiln sites were analyzed chemically, as well as clay samples, modern bricks and ceramics. Forty-three of the chemically-analyzed sherds, as well as some clay and sediment samples were studied petrographically under the microscope. The number of analyses per kiln site is shown in Figure 1.

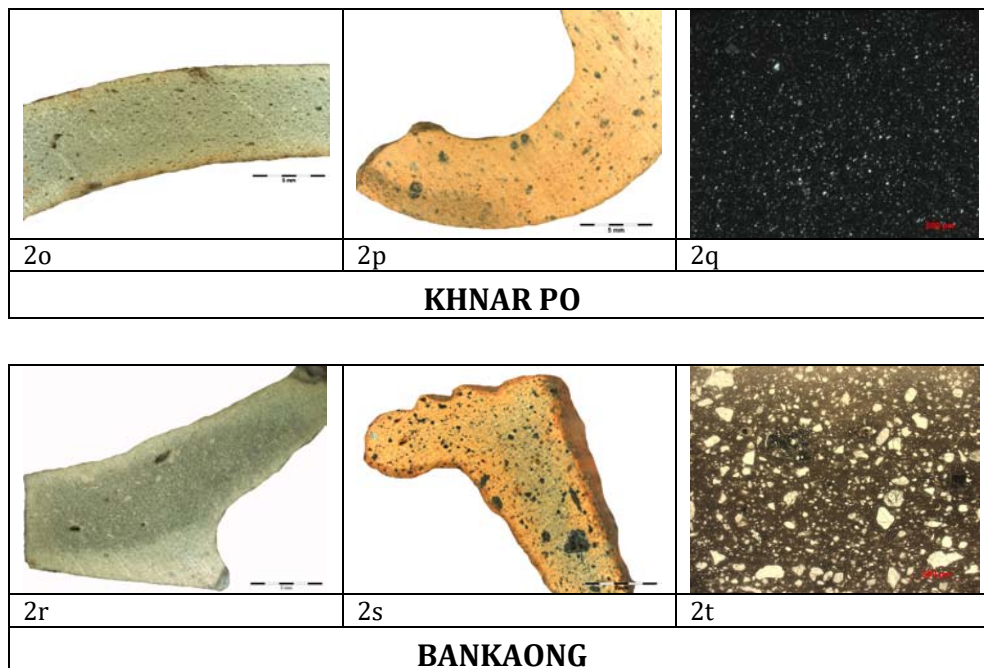
Results

Comparison between wares

To the naked eye, the green-glazed and unglazed stoneware and earthenware present quite different fabrics (Fig. 2). Fabrics of the green-glazed ware are fine-grained and generally light-colored, while the unglazed ceramics as well as the earthenware show coarser, orange to red fabrics with ferruginous nodules. From visual inspection alone, it cannot be determined whether the color differences are due to different iron content or to different firing atmospheres, or to both. In addition it was not clear whether the granulometric differences noted indicate quite different clay sources or different preparations of basically the same clay.

Figure 2 : Fabrics of the glazed and unglazed stoneware, and details of clay sample KHM351 (2m, 2n): macroscopic and microscopic views (XPL, except 2h and 2t; same magnification for all). Green-glazed: 2a/2c, 2e/2g, 2i/2j, 2o/2q, 2r; biscuit: 2k; brown-glazed: 2l; unglazed: 2b/2d, 2f/2h, 2p, 2s/2t.





Under the microscope, both granulometric differences related to inclusions, and differences in the clay matrices were apparent. In the fine-grained fabric noted above, the matrix contains many very fine inclusions which are not visible to the naked eye, while the matrix in the coarser pottery is almost devoid of such fine grains (Fig. 2). This indicates clearly that the two types of wares are made from different clays, as this difference can result neither from levigating the coarser clay used for unglazed stoneware, nor from adding sand to the finer clay used for the green-glazed ware. Levigating or washing a coarse clay will diminish or eliminate the coarse fraction, but not add fine inclusions; adding sand to a clay containing many fine inclusions will result in a coarse paste also rich in fine inclusions (biblio à rajouter par Gisela). The nature of the inclusions, however, almost exclusively grains of quartz, is the same in all analyzed samples.

Chemically, green-glazed and unglazed wares from the same workshop form two groups clearly differentiated by several of the analyzed parameters, as demonstrated in Figure 3 by an example of two parameters. While both wares possess typical stoneware compositions characterized by the high silica (SiO_2) and alumina (Al_2O_3) content usual for clays rich in kaolinite (the chemical formula of which is $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$), the unglazed ware always shows higher contents of iron (Fe_2O_3) (plus some of its correlated elements), as well as potassium (K_2O) and correlated rubidium (Rb). (See table 1). Because of these differences, the comparison between workshops is discussed below separately for each type of ware.

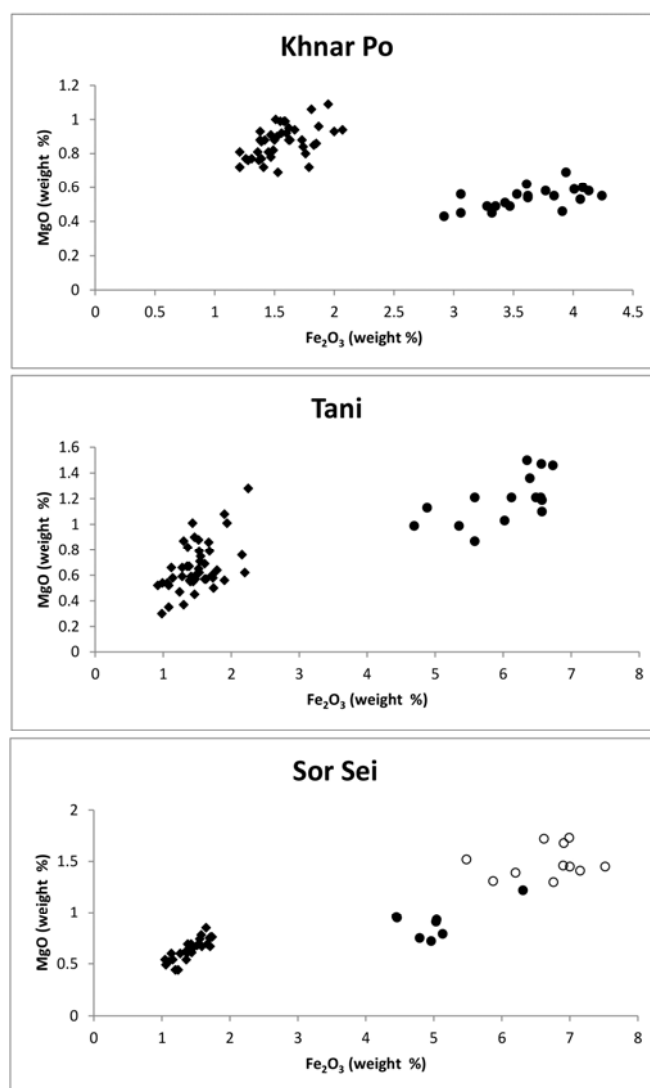


Figure 3 : Binary plots of MgO/Fe₂O₃ with all analyzed samples of green-glazed (diamonds) and unglazed stoneware/earthenware (circles) for each workshop.

Green-glazed stoneware

The green-glazed stoneware of the so-called ‘Kulen type’ was produced at five of the studied kiln sites (Tabata 2005; Ea 2009, 2010). The typological variety seen is presented in Figure 4; urns and boxes with lids of spectacularly-elaborated designs, bottles, and bowls are among the most important forms represented in the sample collection (Desbat 2008, 2009, 2010, 2011, 2012). Chronologically, the earliest vessels come from the workshops of Khnar Po and Tani (Desbat in these proceedings).

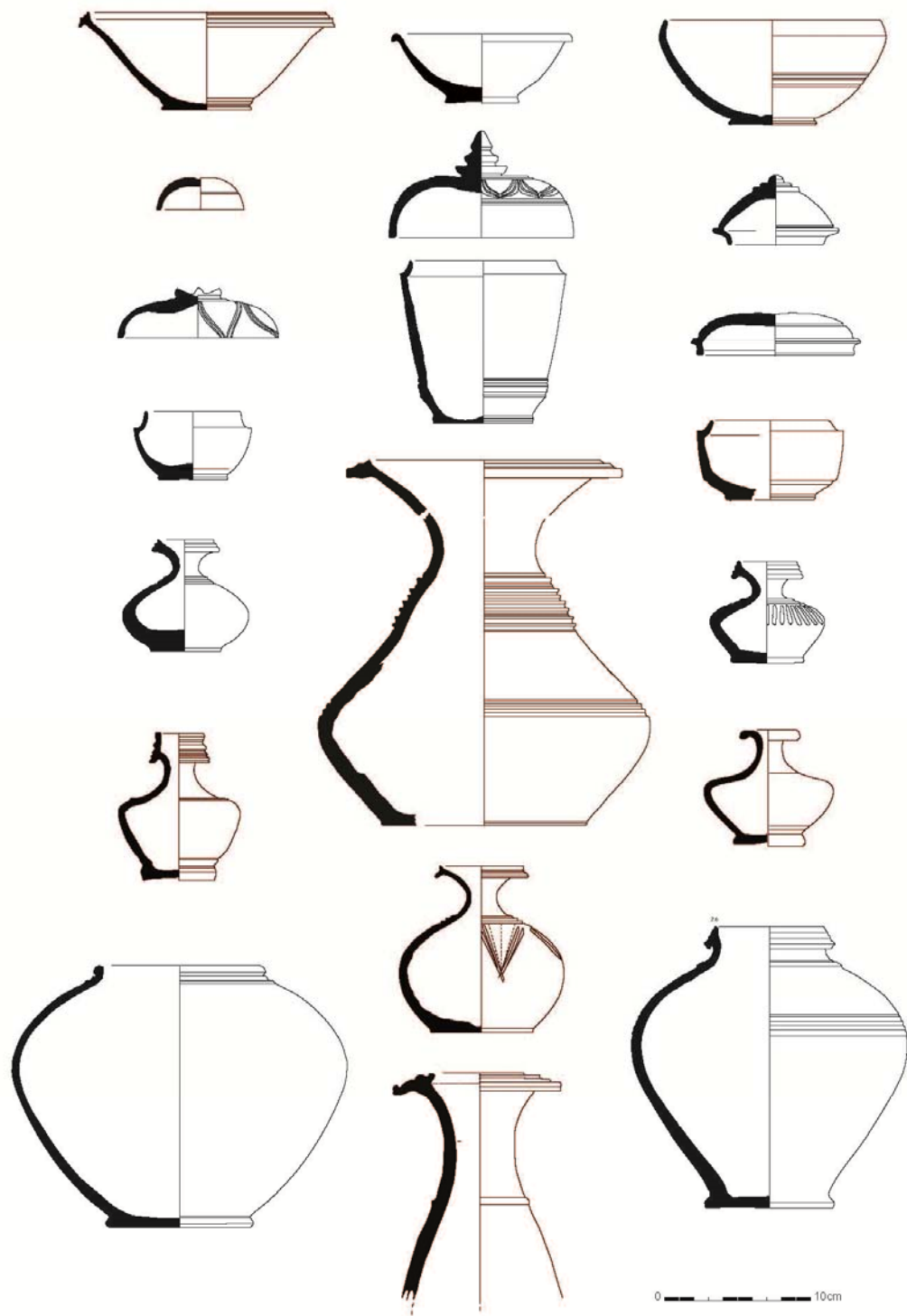


Figure 4 Most important forms of green-glazed stoneware from the different kiln sites.

The chemical composition of this ware is characterized by high silica and alumina contents and very low contents of most other components (table 1). This is typical of ceramics made of quite pure, white-firing kaolinitic clays. These common characteristics indicate that this type of clay was used in all of the five workshops to fabricate green-glazed stoneware. The question was then whether it is possible to further distinguish these ceramic productions by their chemical compositions and/or petrography in spite of the similar raw material.

In order to classify the analyses and to test resemblances, multivariate statistical data treatment was undertaken. The dendrogram of the cluster analysis shows that samples from one workshop are not grouped strictly together (Fig. 5). The analyses separate into two main clusters, the first composed essentially of samples from Khnar Po and Tani, the second of samples from Sor Sei and Anlong Thom. A subgroup from Anlong Thom, chemically distinct from the main group, clusters with the Khnar Po/Tani samples, while a subgroup from Tani is found in the Sor Sei/Anlong Thom cluster. The samples from Bankaong are distributed over the two clusters.

This separation into two main groups is due to small differences in some parameters, principally vanadium, iron, rubidium, silica, zirconium and cerium (Fig. 6). From the cluster analysis it is apparent that the samples from Bankaong do not form a coherent group, which is also demonstrated in Figure 6, where the points representing pieces from that site scatter over the entire variation field occupied by the two ensembles. Although collected at one kiln site, these few samples of green-glazed wares seem to be not of local production at Bankaong, but imported from other workshops.

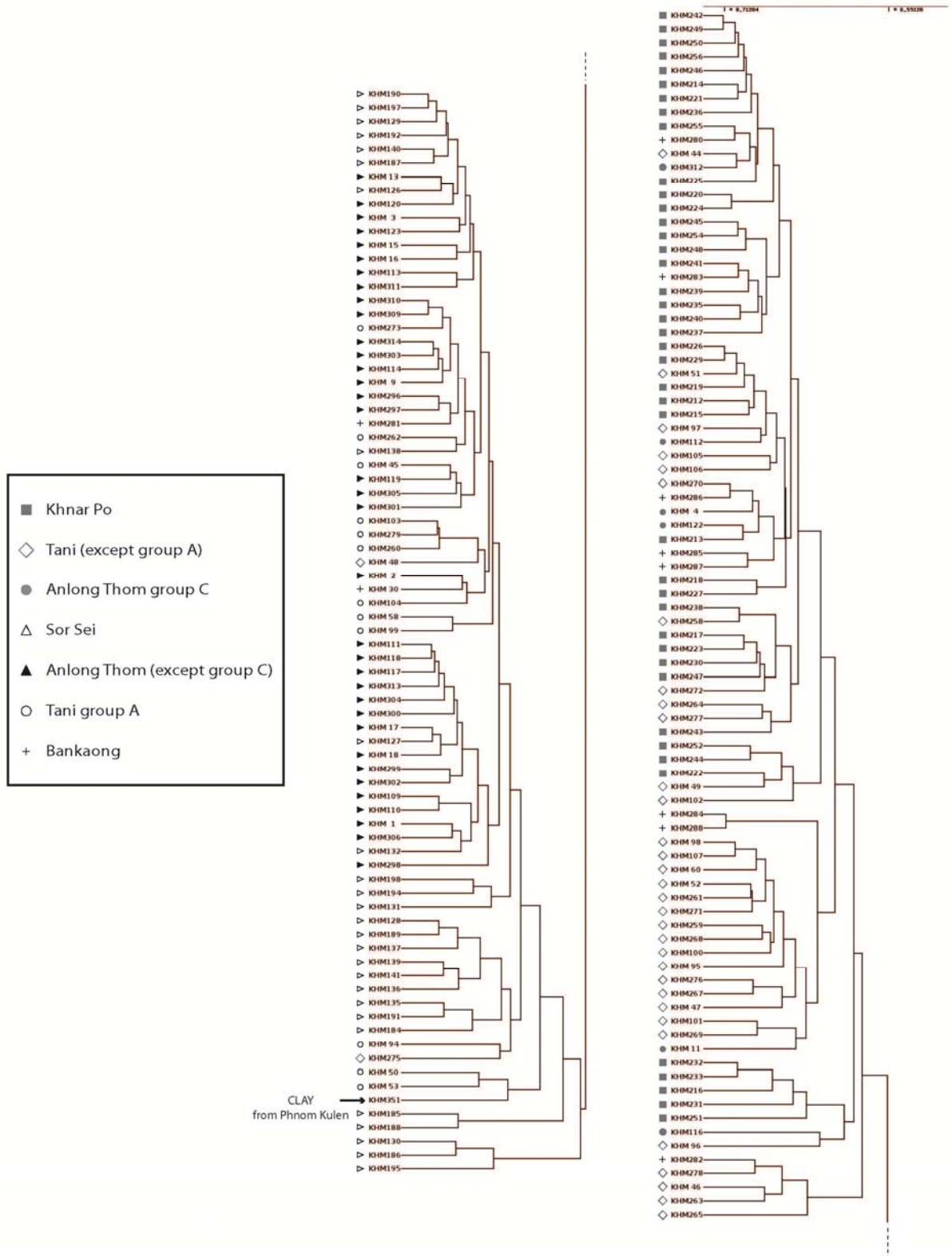


Figure 5 : Dendrogram of cluster analysis of all analyzed green-glazed stoneware from Tani, Bankaong, Anlong Thom, Sor Sei and Khnar Po (calculated on 16 components).

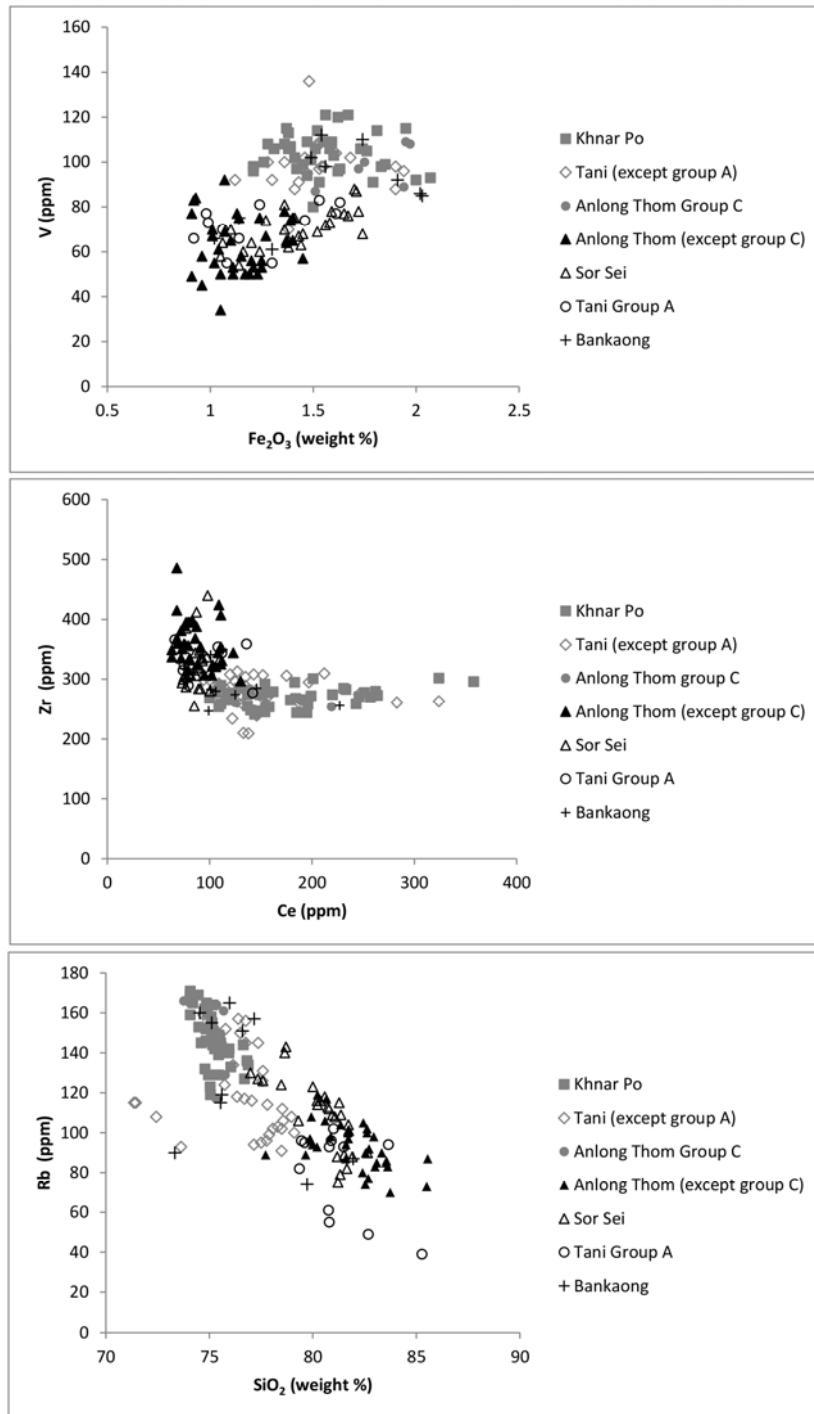


Figure 6 : Selected binary plots with all analyzed samples of green-glazed stoneware.

The ensembles formed on the basis of chemical resemblance can also be distinguished by their granulometry. The fabric of the pieces making up the Anlong Thom/Sor Sei ensemble contains inclusions of various sizes (silt to coarse sand size), while the fabric of those forming the Khnar Po/Tani group mostly shows fine-grained inclusions (silt to fine sand size) and rare larger grains (medium sand size; Fig.2). As mentioned above, the nature of the inclusions, mainly quartz, does in this case not contribute to the differentiation.

In the course of field prospection, clays were collected and analyzed. Among these, one clay source on the Phnom Kulen could be matched chemically to the green-glazed stoneware group from Anlong Thom and Sor Sei. It is marginally integrated into the cluster (Fig. 5) and its granulometry also fits with that group (Fig. 2m, 2n). The details shown in Figure 2 seem to underline the variability in the clay source; it has to be mentioned, however, that the clay sample was not processed prior to thin section preparation (no kneading, wedging or similar treatments). No other clay source for white-firing stoneware, corresponding to our other group, has as yet been discovered.

In summary, the results concerning the stoneware suggest that two groups can be distinguished and defined analytically; each group is composed of most of the representatives of two workshops plus a subgroup from a third (Fig. 7). We also found that the different workshops are not neatly separable into analytically-defined groups, and that very similar kaolinitic, white-firing clays were used at all workshops. Clay for the Anlong Thom/Sor Sei group was well-homogenized prior to pot forming, but was not otherwise processed.

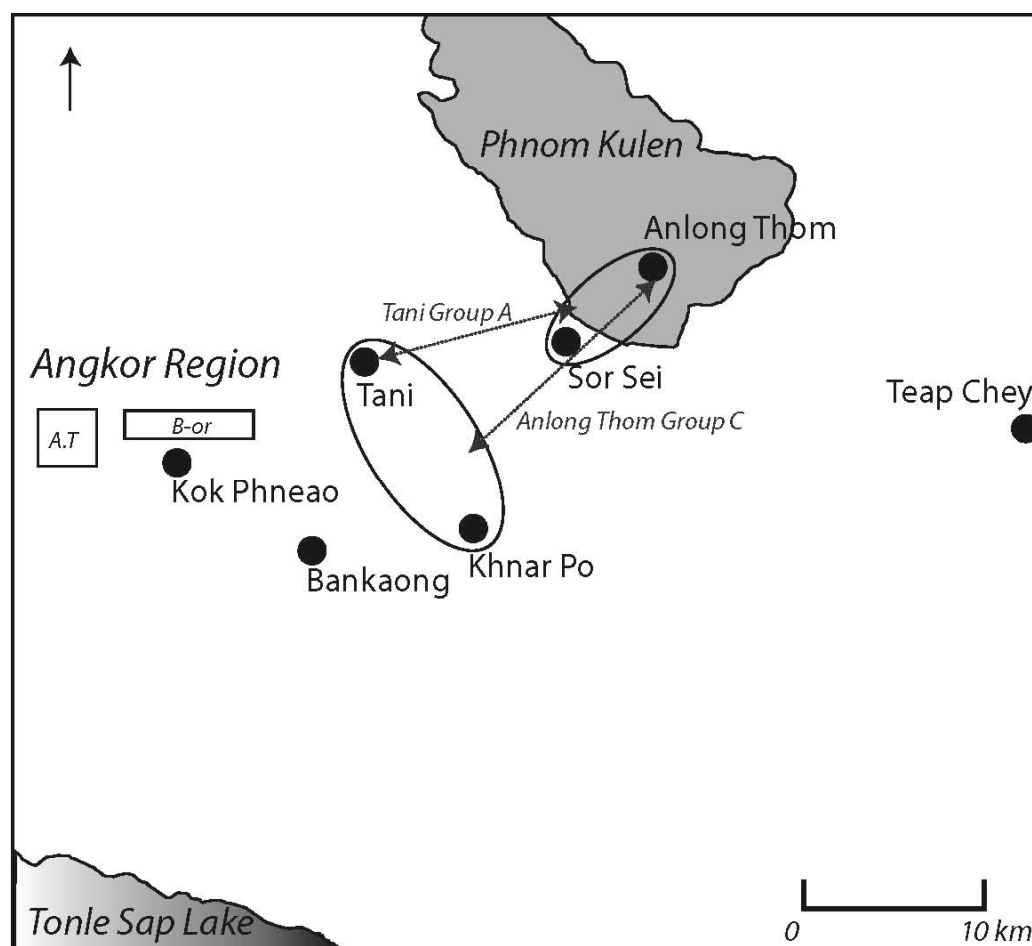


Figure 7 Relationship of green-glazed stoneware production projected onto basemap (ovals); arrows show dissident subgroups.

Geographically, the relationship between the workshops appears as presented in Figure 7. This picture could indicate a geological basis for the compositional differences of the clays used, as both workshops next to Phnom Kulen fit together and may have used the same clay pit, different from the outcrops used by the workshops situated in the plain. However, chronological factors may have played a role as well. This possibility cannot be verified on the basis of our sample collection (surface collection).

Unglazed stoneware and earthenware

The unglazed stoneware and earthenware show similar compositions and are therefore discussed together here (table 1). Analyses on these wares were carried out for four of the workshops: Tani, Sor Sei, Khnar Po and Bankaong. At Anlong Thom this type of ceramic was found only in very small numbers, and therefore has not been analyzed. The analyzed sample collection comprises mainly larger bottles and jars in stoneware, bowls in earthenware (Desbat 2008, 2009, 2010, 2011, 2012).

While products from Bankaong and Khnar Po show light-coloured fabrics (yellow to salmon-coloured), those from Sor Sei and Tani display darker, orange to red colors (Fig. 2). Under the microscope no obvious differences were observed apart from the color, although Sor Sei wares appear to contain the coarsest inclusions from the wares analysed (no petrographic analysis was carried out on ceramics from Khnar Po). Inclusions are almost exclusively quartz, plus different types of ferruginous nodules.

Figure 8

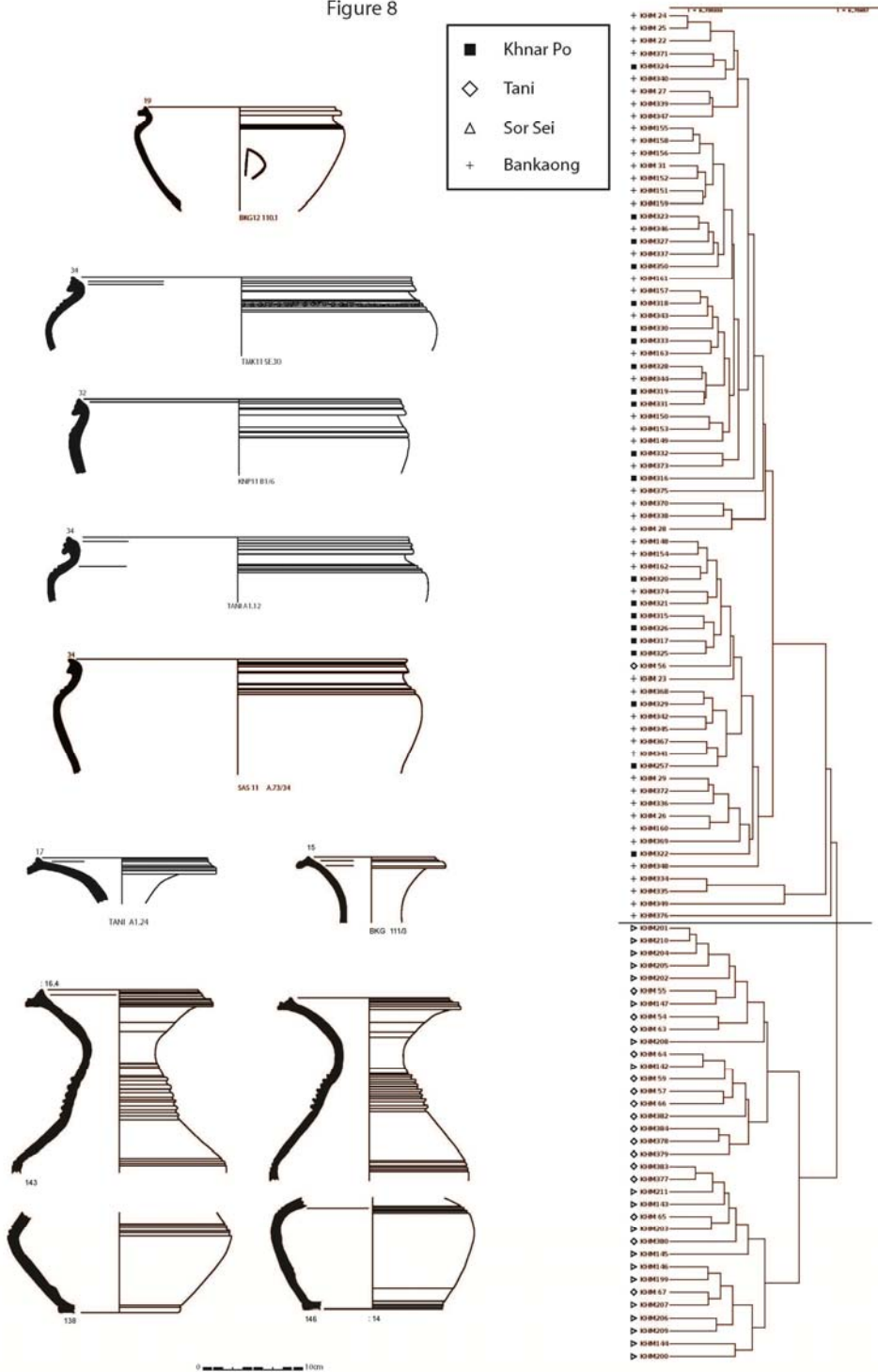


Figure 8 : Dendrogram of the cluster analysis of all analyzed unglazed stoneware and earthenware from Tani, Bankaong, Sor Sei and Khnar Po (calculated on 16 components); typical forms of unglazed stoneware from these kiln sites.

With only one exception, the dendrogram of the cluster analysis reflects this separation into two groups (Fig. 8). Samples from Khnar Po and Bankaong, showing the light fabric, are together in cluster one, and those from Tani and Sor Sei, with the darker fabric, in cluster two.

The separation is due not only to the iron content; other parameters such as potassium oxide, the correlation of alumina and silica, as well as titanium and magnesium oxides contribute as well, as demonstrated by the distribution in the binary plots of Figure 9.

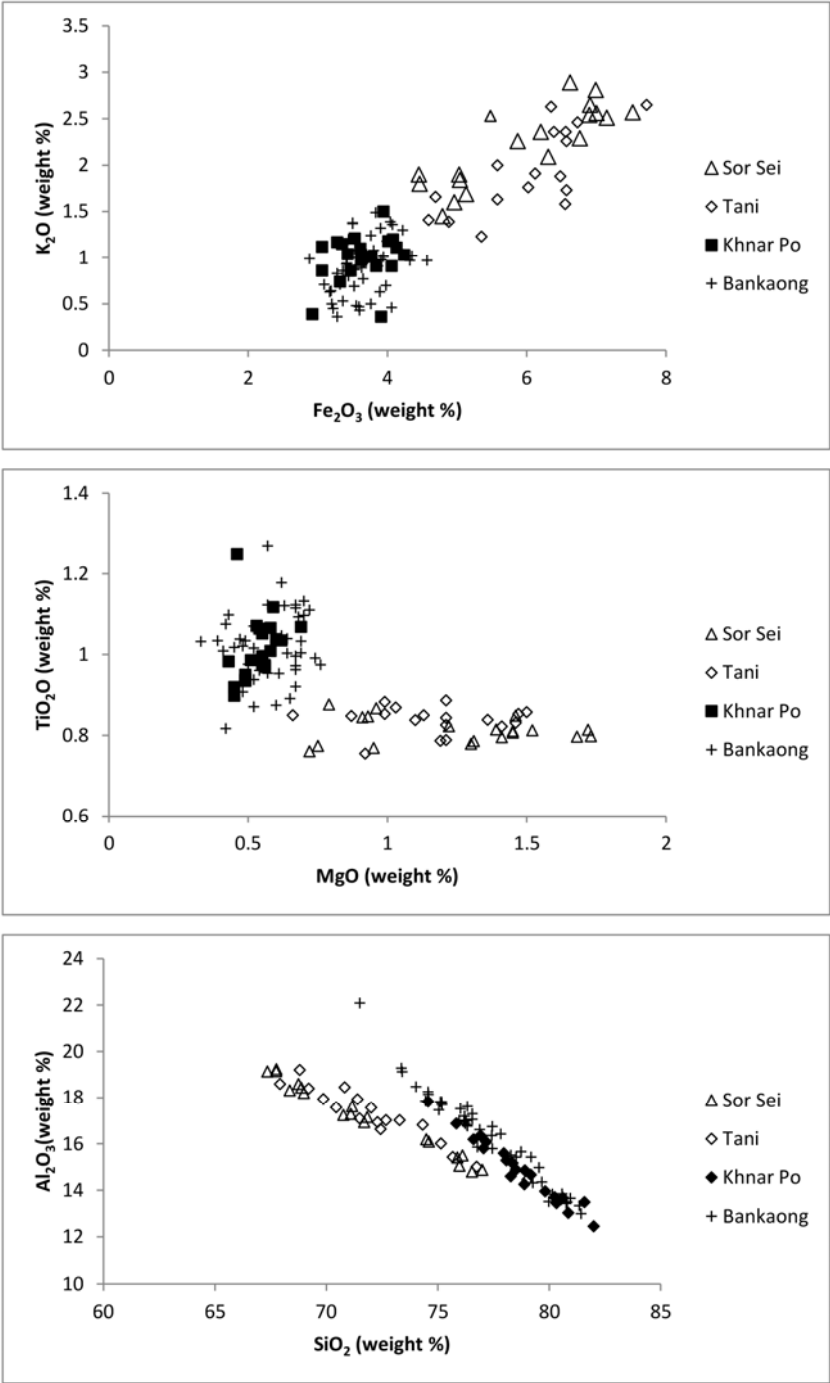


Figure 9 Selected binary plots with all analyzed samples of unglazed stoneware and earthenware.

Projected on the map, the correspondences concerning the unglazed ware mark again two groups, but with different connections compared to the green-glazed ware (Fig.10). Tani and Khnar Po are linked by the use of very similar clays for the green-glazed ware, but do not show this connection concerning unglazed stoneware and earthenware. The relationships between the workshops, based on the use of similar raw materials, appear to be quite different for the unglazed stoneware. As no potential raw materials for these wares have been discovered during field prospection as yet, no explanation for these facts are proposed here.

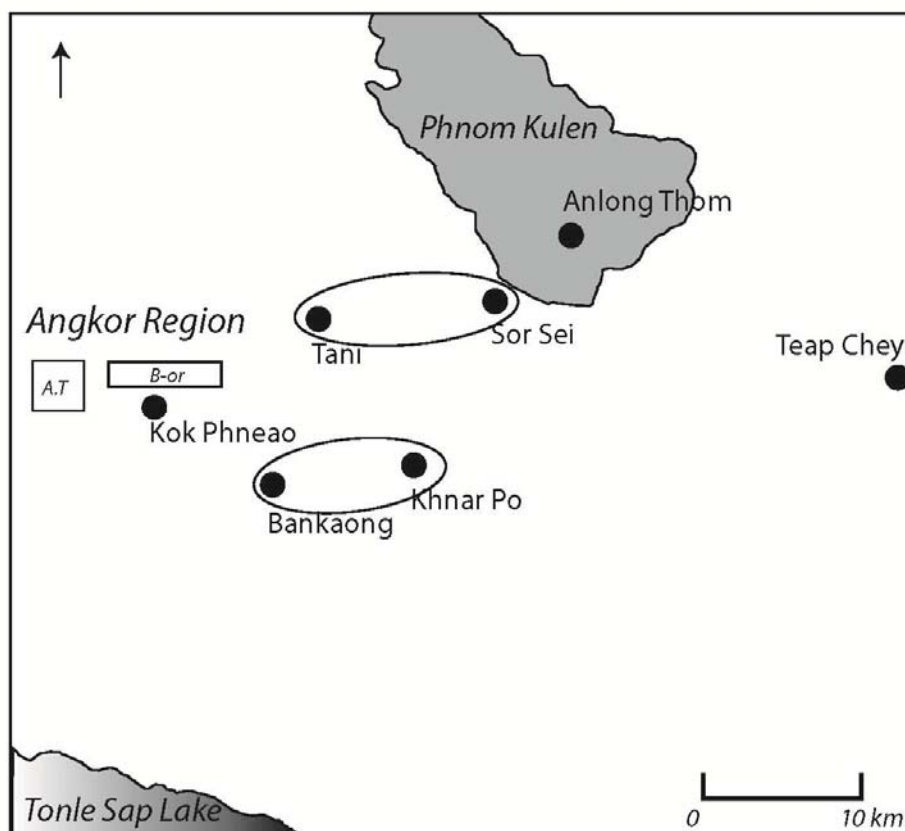


Figure 10: Relationship of unglazed stoneware and earthenware productions projected onto basemap.

Brown-glazed stoneware

Additionally to green-glazed ware, some brown-glazed stoneware was produced in Anlong Thom, mainly urns and lids, similar to those made in the green-glazed fabric (Desbat 2008, 2009, 2010, 2011, 2012). The brown-glazed stoneware shows chemical compositions different from the green-glazed stoneware and forms another, compositionally relatively homogeneous group (Fig.11, table 1).

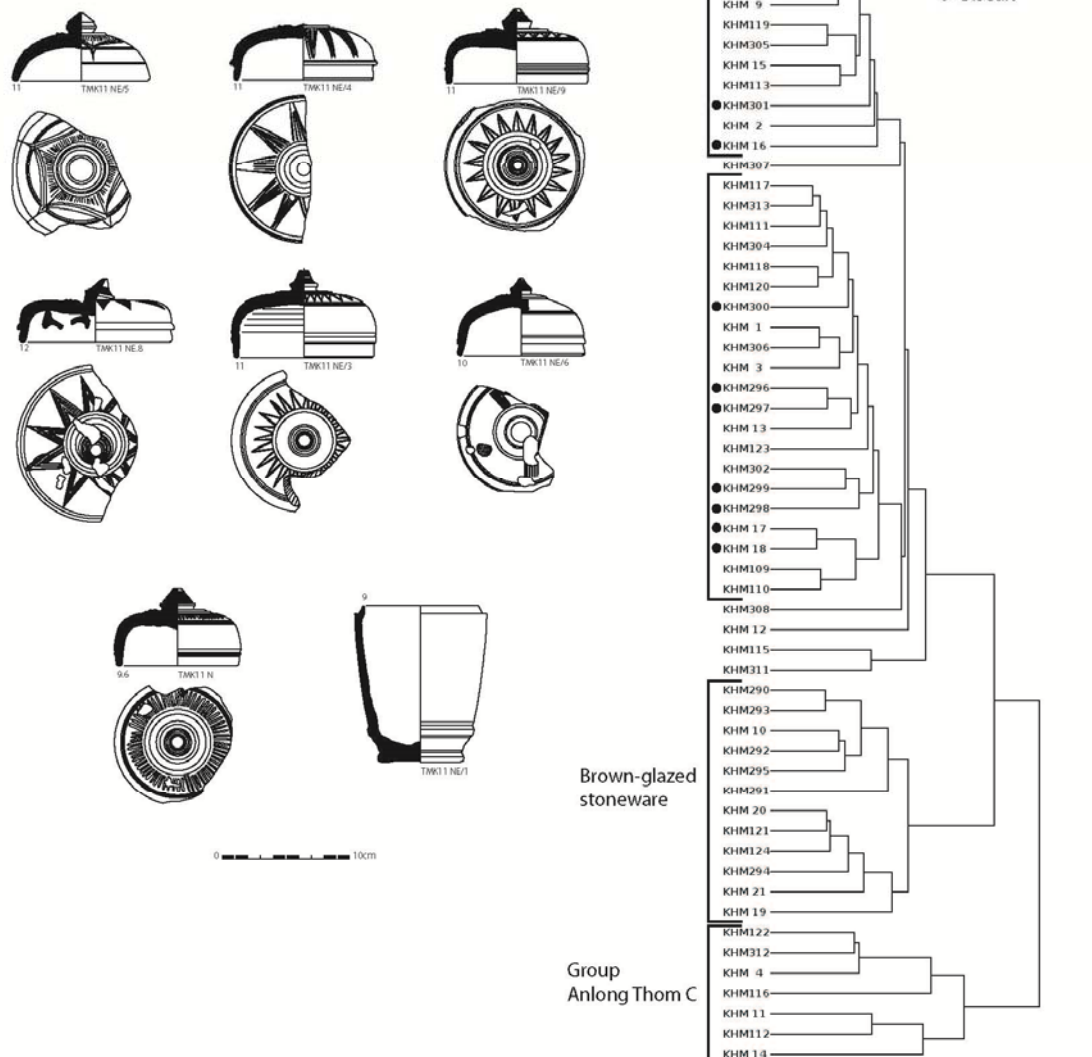


Figure 11: Some forms of brown-glazed stoneware from Anlong Thom and dendrogram of the cluster analysis of all analyzed glazed stoneware from Anlong Thom (calculated on 16 components).

Conclusions

The main goal, the definition of a solid reference database for stoneware produced in the Angkor region, has been realized, thus providing a useful tool for provenance determination of stoneware from consumer sites in future studies. Additionally, this study has addressed several issues. We suggest that the green-glazed stoneware from workshops in the Angkor region shows very similar compositions, and we can deduce the use of clay materials from the same geological origin. Two groups may be distinguished within this ware. Two groups were also distinguished for unglazed stoneware/earthenware, but the connections between workshops appear to be independent from the green-glazed groupings. Green-glazed and unglazed, as well as green-glazed and brown-glazed stoneware from the same workshop

show different compositions; for the reasons demonstrated, we deduce the use of a different raw material appropriate for each ware and not just different paste preparations. We also identified one homogeneous group for brown-glazed stoneware at Anlong Thom.

The possible reasons for the separation into two compositional groups are manifold, and include geological, geographical, or chronological variations, or a combination of these. We could evoke slight variations in the clay-beds at different locations; these may have been exploited by different workshops and/or at different periods. Perhaps the exploitation of resources was managed independent of the pottery workshops, and the separation reflects some kind of commercial or administrative connections. These possibilities are just some ideas of how these results concerning the workshops could be integrated into a larger concept of the Angkorian period. With these results, it is now possible to study the distribution of these angkorian stoneware productions on consumer sites.

Acknowledgements

The authors would like to thank the APSARA Authority who gave permission for us to analyse the samples, and special thanks to Chhay Rachna, who gave us the samples from the kiln site at Bankaong.

References

Aoyagi Y., Sasaki T. *et al.* 2000, Yoji Aoyagi, Tastsuo Sasaki, Kazuhiko Tanaka, Takenori Nogami, Masako Marui, Tokido Sumida, Excavation of a khmer ceramic kiln site : report of the investigation of Kiln B1, Tani kiln complex, *Journal of khmer Studies, UDAYA, 1.*, p.235-253

Aoyagi, Y. and Sasaki, T. 2006, *The Tani Kiln Site in Cambodia*. Tokyo: Sophia University.

Baxter, M. 1994. *Exploratory Multivariate Analysis in Archaeology*. Edinburgh University Press.

Ea Darith. 2009. New data on the distribution of Khmer ceramic kilns and the study of ceramics. In *Scientific Research On Historic Asian Ceramics: Proceedings of the Fourth Forbes Symposium at the Freer Gallery of Art*, Washington DC 2007, edited by Blythe McCarthy, Ellen Salzman Chase, Louise Allison Cort, Janet G. Douglas, and Paul Jett, publisher: Archetype Publications with the Freer Gallery of Art, 2009, p. 207-214

Ea Darith 2010. Angkorian Stoneware Ceramics : The Evolution of Kiln Structure and Ceramic Typology, PhD dissertation, Osaka Othani University.

Desbat *et al.* 2008, Desbat, A. (dir.) with the collaboration of A. Beukin, D Laduron, E. Llopis, Ch. Pottier, A. Schmitt, Socheat Chea, Savana Uong, A. Vierstraete, Recherches sur les ateliers de potiers angkoriens, *Rapport programme Cerangkor*, MAE, 2008. Unpublished report.

Desbat *et al.* 2009, Desbat, A. (dir.) with the collaboration of A. Bernet, A. Beukin, D Laduron, E. Llopis, Ch. Pottier, V. Thirion-Merle, Socheat Chea, Lanh Udomrengsey, Savana Uong, A. Vierstraete, Recherches sur les ateliers de potiers angkoriens, *Rapport programme Cerangkor*, MAE, 2009. Unpublished report.

Desbat *et al.* 2010, Desbat, A. (dir.) with the collaboration of A. Bernet, A. Beukin, D Laduron, E. Llopis, Ch. Pottier, V. Thirion-Merle, Socheat Chea, Hong Ranet, D. Soutif, G. Thierrin-Michael, Savana Uong, A. Vierstraete, Recherches sur les ateliers de potiers angkoriens, *Rapport programme Cerangkor*, MAE, 2010. Unpublished report.

Desbat *et al.* 2011, Desbat, A. (dir.) with the collaboration of A. Bernet, D Laduron, E. Llopis, Ch. Pottier, V. Thirion-Merle, Socheat Chea, Hong Ranet, D. Soutif, G. Thierrin-Michael, Tiev Vicheth, Recherches sur les ateliers de potiers angkoriens, *Rapport programme Cerangkor*, MAE, 2011. Unpublished report.

Desbat *et al.* 2012, Desbat, A. (dir.) with the collaboration of A. Bernet, Ch. Pottier, V. Thirion-Merle, Socheat Chea, Hong Ranet, D. Soutif, G. Thierrin-Michael, Phon Kaseka,

Yorn Sothearith, Recherches sur les ateliers de potiers angkoriens, *Rapport programme Cerangkor*, MAE, 2012. Unpublished report.

Desbat, A. 2012. Pour une révision de la chronologie des grès Khmers. *Aséanie* 27 (2011): 11-34.

Hendrickson, M. 2008. New evidence of brown glaze stoneware kilns along the East Road from Angkor. *Indo-Pacific Prehistory Association Bulletin* 28: 52-6.

Miksic J., Chhay Rachna, Heng Piphah and Chhay Visoth. 2008. Archaeological report regarding the assessment at the Thnal Mrech Kiln Site TMK 02, Anlong Thom, Phnom Kulen, Cambodia, Report for APSARA

Picon M. 1984. Le traitement des données d'analyses. In *Datation-caractérisation des céramiques anciennes*. PACT 10. Eds. T. Hackens and M. Schvoerer. : 379-99.

Tabata Y. and Chhay Visoth. 2007. Preliminary report of the excavation of the Angling Thom kiln site, Cambodia. *Journal of Southeast Asian Archaeology* 27: 63-9.

Tabata, Y. 2005. Stoneware ceramics production in the Angkor area in Cambodia – a comparative study of artifacts from the Tani, Anlong Thom and Sar Sei kilns. *Journal of Sophia Asian University* 23: 7-35.

Thirion-Merle V. 2014, Spectrométrie de fluorescence X, In *Circulation et provenance des matériaux dans les sociétés anciennes*, Dir. Dillmann P et Bellot-Gurlet L, Collection « Sciences Archéologiques », 2014, p.291-297

Waksman S.Y. 2014, Etudes de provenance de céramiques, In *Circulation et provenance des matériaux dans les sociétés anciennes*, Dir. Dillmann P et Bellot-Gurlet L, Collection « Sciences Archéologiques », 2014, p.195-215

Chemical compositions of green-glazed stoneware and clay samples (values recalculated to 100 weight%). Listing in the order resulting from the cluster analysis (see dendrograms in Fig.5)

Analysis	Kiln sites	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	Na ₂ O	P ₂ O ₅	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu
KHM242	Khnar Po	0.10	1.56	0.824	3.02	75.09	18.15	0.92	0.0097	n.d.	0.12	255	72	158	23	74	19	86	651	121	137	43	38	374	23
KHM249	Khnar Po	0.11	1.52	0.824	3.05	74.78	18.48	0.90	0.0095	n.d.	0.12	245	76	162	22	73	19	82	660	114	154	49	38	287	15
KHM250	Khnar Po	0.11	1.62	0.843	3.05	74.91	18.20	0.95	0.0111	n.d.	0.12	265	69	163	23	76	16	56	669	120	116	46	38	274	19
KHM256	Khnar Po	0.10	1.67	0.855	2.95	74.08	19.03	0.94	0.0109	n.d.	0.14	254	78	159	22	81	17	103	610	121	158	70	49	497	27
KHM246	Khnar Po	0.10	1.47	0.827	3.08	75.17	18.12	0.91	0.0094	n.d.	0.12	254	69	164	24	70	12	65	733	109	109	49	31	260	14
KHM214	Khnar Po	0.11	1.55	0.816	3.15	74.06	18.87	0.99	0.0106	0.08	0.15	241	82	169	38	69	26	81	668	109	144	44	14	301	19
KHM221	Khnar Po	0.10	1.51	0.834	3.11	74.86	18.20	1.00	0.0100	0.06	0.13	259	68	165	54	68	25	59	640	106	111	39	16	257	15
KHM236	Khnar Po	0.12	1.81	0.833	3.19	74.08	18.53	1.06	0.0111	n.d.	0.12	248	84	171	39	76	22	96	698	114	140	89	46	506	20
KHM255	Khnar Po	0.08	1.87	0.822	2.88	74.98	18.08	0.96	0.0118	n.d.	0.11	270	72	156	35	77	24	104	562	105	158	64	38	312	50
KHM280	Bankaong	0.09	1.74	0.837	2.97	75.11	17.96	0.96	0.0110	n.d.	0.11	274	62	155	29	74	23	79	538	110	125	47	43	393	19
KHM 44	Tani	0.11	1.94	0.839	3.01	74.72	18.03	1.01	0.0110	n.d.	0.14	262	69	159	32	65	24	69	703	114	127	42	15	185	28
KHM312	Anlong T. C	0.11	1.95	0.798	3.04	75.35	17.38	1.05	0.0112	n.d.	0.12	261	67	164	69	69	31	60	577	109	125	74	33	268	24
KHM225	Khnar Po	0.11	1.60	0.884	2.71	74.83	18.57	0.92	0.0105	n.d.	0.14	277	63	146	24	70	27	56	661	103	120	39	20	243	26
KHM220	Khnar Po	0.09	1.59	0.815	3.10	74.20	18.75	0.99	0.0099	0.08	0.16	244	85	165	26	59	37	96	617	109	195	88	11	316	23
KHM224	Khnar Po	0.10	1.58	0.816	3.11	74.14	18.74	0.99	0.0106	0.15	0.15	244	86	166	27	69	40	98	660	106	185	83	13	301	22
KHM245	Khnar Po	0.12	1.74	0.822	2.77	75.26	18.09	0.84	0.0124	n.d.	0.13	270	75	150	32	70	27	139	478	106	257	116	40	362	34
KHM254	Khnar Po	0.11	1.76	0.837	2.72	74.60	18.82	0.80	0.0119	n.d.	0.12	259	88	145	26	71	28	129	623	105	243	97	42	384	30
KHM248	Khnar Po	0.08	1.73	0.826	2.73	75.11	18.26	0.88	0.0133	n.d.	0.14	273	81	149	51	71	30	132	576	106	264	126	46	469	39
KHM241	Khnar Po	0.10	1.63	0.835	2.84	74.49	18.85	0.88	0.0094	n.d.	0.14	271	85	153	33	76	22	133	623	97	246	141	47	376	41
KHM283	Bankaong	0.12	1.54	0.836	2.97	74.53	18.76	0.88	0.0095	n.d.	0.14	256	82	160	28	74	24	124	568	112	227	89	38	318	20
KHM239	Khnar Po	0.09	1.49	0.815	2.70	75.16	18.56	0.82	0.0089	n.d.	0.12	278	84	144	27	72	34	143	592	101	251	140	41	351	33
KHM235	Khnar Po	0.09	1.36	0.818	2.86	75.20	18.52	0.81	0.0094	n.d.	0.13	265	76	151	21	74	13	108	651	108	179	60	32	196	28
KHM240	Khnar Po	0.10	1.39	0.818	2.77	75.46	18.36	0.77	0.0114	n.d.	0.12	266	78	149	24	76	23	109	645	107	191	60	35	191	40
KHM237	Khnar Po	0.15	1.45	0.822	2.85	74.83	18.76	0.81	0.0104	n.d.	0.12	258	83	152	26	73	22	119	615	99	196	61	36	196	23
KHM226	Khnar Po	0.09	1.42	0.817	2.77	75.49	18.15	0.88	0.0090	n.d.	0.15	279	73	148	33	63	27	78	655	97	139	46	21	211	22
KHM229	Khnar Po	0.10	1.39	0.832	2.75	75.42	18.25	0.87	0.0081	n.d.	0.15	285	71	147	21	63	27	75	656	106	129	46	22	197	21
KHM 51	Tani	0.08	1.30	0.817	2.86	75.78	17.96	0.87	0.0084	n.d.	0.14	283	62	152	19	60	23	55	684	108	107	44	18	229	18
KHM219	Khnar Po	0.10	1.21	0.828	2.80	75.28	18.43	0.81	0.0061	0.18	0.14	282	74	149	133	60	25	83	691	98	137	44	19	199	30
KHM212	Khnar Po	0.09	1.38	0.815	3.01	74.90	18.49	0.93	0.0080	0.06	0.12	247	83	160	24	58	33	80	607	106	146	50	15	347	18
KHM215	Khnar Po	0.10	1.38	0.812	2.76	75.54	18.12	0.88	0.0086	0.06	0.15	274	71	145	25	60	44	66	667	113	137	45	19	215	23
KHM 97	Tani	0.08	1.46	0.754	2.80	76.75	16.84	0.90	0.0070	0.08	0.14	275	67	145	33	52	26	77	838	90	145	77	20	35	87
KHM112	Anlong T. C	0.10	1.51	0.791	2.58	75.76	18.13	0.77	0.0074	0.09	0.11	276	80	129	18	55	17	83	636	87	159	51	26	32	n.d.
KHM105	Tani	0.09	1.43	0.741	3.05	76.76	16.49	1.01	0.0084	0.13	0.11	259	55	156	67	51	43	63	537	97	132	115	19	94	86
KHM106	Tani	0.11	1.52	0.858	2.47	77.58	16.17	0.88	0.0084	0.11	0.12	279	56	131	57	56	38	64	548	99	125	167	18	106	64
KHM270	Tani	0.10	1.90	0.780	2.89	76.39	16.56	1.08	0.0108	n.d.	0.10	282	56	157	85	67	38	53	560	104	105	126	29	141	56
KHM286	Bankaong	0.10	1.91	0.783	3.04	75.98	16.75	1.10	0.0117	n.d.	0.13	283	55	165	54	68	33	59	605	92	101	143	30	148	48
KHM 4	Anlong T. C	0.08	1.94	0.769	3.14	75.69	16.92	1.12	0.0088	n.d.	0.11	266	51	161	57	58	39	63	602	89	121	91	20	122	50
KHM122	Anlong T. C	0.09	1.75	0.791	2.90	75.09	17.92	1.04	0.0109	0.07	0.14	258	72	155	35	60	34	77	604	100	154	65	11	290	22
KHM213	Khnar Po	0.08	2.00	0.783	2.85	75.13	17.85	0.93	0.0103	0.07	0.11	279	67	155	40	56	40	89	594	92	162	96	17	206	21
KHM285	Bankaong	0.05	1.49	0.803	2.87	76.60	16.89	0.93	0.0092	n.d.	0.16	285	59	151	71	70	37	70	673	102	146	215	26	51	69
KHM287	Bankaong	0.06	1.56	0.766	2.95	77.16	16.29	0.94	0.0093	n.d.	0.09	280	54	157	65	66	26	59	560	98	106	123	28	83	91
KHM218	Khnar Po	0.08	1.62	0.788	2.74	75.58	17.87	0.88	0.0107	0.10	0.13	274	61	143	37	61	40	110	428	96	220	172	17	262	15
KHM227	Khnar Po	0.09	1.50	0.780	2.77	76.64	16.84	0.88	0.0085	0.18	0.11	283	54	144	109	55	28	112	409	80	233	102	11	321	27
KHM238	Khnar Po	0.07	1.21	0.815	2.66	75.95	18.26	0.72	0.0084	n.d.	0.12	272	79	142	26	71	18	98	638	98	199	47	32	161	53
KHM258	Tani	0.06	1.12	0.824	2.53	76.14	18.37	0.66	0.0062	n.d.	0.11	261	80	134	19	69	19	118	552	95	187	48	25	149	78
KHM217	Khnar Po	0.09	1.31	0.875	2.31	75.04	19.20	0.77	0.0074	0.06	0.15	295	75	123	56	65	29	106	578	106	183	59	19	269	32
KHM223	Khnar Po	0.10	1.26	0.838	2.44	74.79	19.40	0.77	0.0079	n.d.	0.16	285	87	132	126	61	33	129	565	100	231	78	18	246	63
KHM230	Khnar Po	0.11	1.37	0.887	2.40	75.45	18.66	0.76	0.0098	n.d.	0.14	292	72	129	21	68	35	86	527	115	154	51	26	148	29
KHM247	Khnar Po	0.09	1.41	0.897	2.22	75.05	19.29	0.72	0.0071	n.d.	0.12	301	69	119	21	80	25	97	564	102	201	62	39	267	33
KHM272	Tani	0.10	1.54	0.924	2.20	76.70	17.50	0.71	0.0078	n.d.	0.13	275	74	117	27	64	28	109	451	100	246	125	39	265	26
KHM264	Tani	0.09	1.36	0.811	2.76	76.49	17.36	0.82	0.0086	n.d.	0.12	286	57	150	22	73	15	50	594	103	114	48	37	287	17
KHM277	Tani	0.08	1.55	0.896	2.39	77.56	16.51	0.75	0.0096	n.d.	0.10	293	60	126	23	71	n.d.	67	632	90	109	36	34	110	n.d.
KHM243	Khnar Po	0.10	1.28	0.884	2.76	75.25	18.67	0.76	0.0077	n.d.	0.10	274	77	142	23	81	n.d.	71	615	108	151	47	36	240	n.d.
KHM252	Khnar Po	0.10	1.79	0.828	2.42	74.95	18.83	0.72	0.0078	n.d.	0.13	296	75	129	30	69	34	158	428	91	358	110	37	279	45
KHM244	Khnar Po	0.09	1.53	0.807	2.35	76.70	17.50	0.69	0.0081	n.d.	0.12	302	66	127	23	63	27	161	422	91	324	105	41		

Chemical compositions of green-glazed stoneware and clay samples (values recalculated to 100 weight%). Listing in the order resulting from the cluster analysis (see dendrograms in Fig.5)

Analysis	Kiln sites	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	Na ₂ O	P ₂ O ₅	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu
KHM140	Sor Sei	0.06	1.38	0.765	1.91	81.73	13.33	0.61	0.0078	n.d.	0.09	320	52	101	19	48	26	48	429	62	89	32	23	11	n.d.
KHM187	Sor Sei	0.05	1.36	0.770	1.88	81.71	13.38	0.61	0.0073	n.d.	0.08	337	51	104	111	37	23	60	427	70	97	33	21	20	n.d.
KHM 13	Anlong T.	0.02	1.40	0.769	1.88	81.34	13.82	0.62	0.0078	n.d.	0.04	359	33	104	21	48	20	48	196	65	75	40	22	20	n.d.
KHM126	Sor Sei	0.04	1.37	0.706	1.97	81.07	14.04	0.63	0.0069	n.d.	0.06	344	38	108	22	43	19	42	307	65	86	33	20	13	n.d.
KHM120	Anlong T.	0.06	1.45	0.713	1.71	82.71	12.52	0.62	0.0082	n.d.	0.06	324	33	92	23	42	17	39	206	57	89	40	18	34	n.d.
KHM 3	Anlong T.	0.07	1.37	0.756	1.67	81.69	13.69	0.51	0.0081	n.d.	0.07	388	32	100	21	46	26	53	322	64	87	68	20	14	16
KHM123	Anlong T.	0.05	1.25	0.757	2.03	80.59	14.39	0.64	0.0096	0.07	0.08	368	35	106	21	34	18	52	431	53	86	39	22	28	n.d.
KHM 15	Anlong T.	0.04	1.14	0.768	2.08	79.92	15.16	0.67	0.0074	n.d.	0.08	307	48	108	20	53	22	51	382	75	95	41	20	36	34
KHM 16	Anlong T.	0.02	1.25	0.752	1.70	79.65	15.78	0.63	0.0065	n.d.	0.08	297	52	89	22	43	19	73	319	56	130	43	18	49	n.d.
KHM113	Anlong T.	0.08	1.40	0.764	2.23	80.23	14.20	0.75	0.0092	0.09	0.09	354	46	119	21	47	20	65	456	75	111	47	21	73	n.d.
KHM311	Anlong T.	0.06	1.39	0.718	2.04	80.66	14.26	0.59	0.0090	n.d.	0.10	344	53	117	22	44	13	45	718	74	123	38	33	43	n.d.
KHM310	Anlong T.	0.06	1.01	0.823	1.61	80.20	15.66	0.43	0.0074	n.d.	0.08	321	40	93	14	47	14	53	405	67	106	37	25	32	n.d.
KHM309	Anlong T.	0.05	1.13	0.803	1.60	79.99	15.76	0.46	0.0064	n.d.	0.07	325	39	94	15	45	16	58	345	77	111	40	25	36	n.d.
KHM273	Tani A	0.04	1.24	0.785	1.58	81.49	14.21	0.47	0.0076	n.d.	0.05	344	37	93	16	47	n.d.	61	379	70	112	44	30	44	14
KHM314	Anlong T.	0.07	1.07	0.749	1.69	82.43	13.30	0.50	0.0066	n.d.	0.06	324	45	105	19	50	18	62	333	69	103	36	23	41	n.d.
KHM303	Anlong T.	0.06	1.01	0.788	1.83	81.71	13.87	0.51	0.0062	n.d.	0.08	354	39	101	15	52	19	47	392	70	91	39	27	33	30
KHM114	Anlong T.	0.06	0.93	0.780	1.80	81.60	14.03	0.53	0.0065	0.08	0.06	344	46	94	11	46	13	56	300	84	108	39	25	24	n.d.
KHM 9	Anlong T.	0.07	0.91	0.822	1.74	81.71	14.04	0.49	0.0070	n.d.	0.06	315	36	97	16	53	20	49	263	77	79	33	21	24	n.d.
KHM296	Anlong T.	0.06	1.15	0.825	1.51	81.58	14.24	0.48	0.0084	n.d.	0.04	335	30	87	19	51	n.d.	33	230	58	72	35	23	30	n.d.
KHM297	Anlong T.	0.05	1.04	0.783	1.54	82.62	13.35	0.47	0.0077	n.d.	0.04	337	35	100	16	42	n.d.	40	227	61	63	32	24	37	n.d.
KHM281	Bankaong	0.08	1.30	0.807	1.38	81.94	13.79	0.47	0.0064	n.d.	0.10	341	37	87	17	53	n.d.	50	305	61	101	36	26	37	n.d.
KHM262	Tani A	0.07	1.06	0.734	1.70	83.65	12.06	0.54	0.0072	n.d.	0.05	290	43	94	20	48	15	24	448	66	79	28	21	40	17
KHM138	Sor Sei	0.10	1.06	0.772	1.58	81.17	14.60	0.49	0.0073	n.d.	0.10	300	52	88	10	42	11	51	426	64	74	32	24	48	n.d.
KHM 45	Tani A	0.04	0.92	0.776	1.88	79.60	16.01	0.52	0.0058	n.d.	0.11	306	66	95	14	60	14	58	505	83	100	37	20	23	n.d.
KHM119	Anlong T.	0.04	0.92	0.725	1.84	79.91	15.79	0.50	0.0072	0.06	0.08	323	55	96	10	44	14	53	461	83	103	33	20	15	n.d.
KHM305	Anlong T.	0.05	1.36	0.752	1.83	79.85	15.41	0.51	0.0066	n.d.	0.09	332	54	97	13	52	n.d.	55	551	78	81	36	35	44	19
KHM301	Anlong T.	0.06	1.07	0.814	1.81	80.86	14.62	0.54	0.0061	n.d.	0.09	331	51	98	17	66	n.d.	66	478	92	112	42	28	35	n.d.
KHM103	Tani A	0.07	1.53	0.866	1.77	80.89	14.00	0.62	0.0077	0.08	0.06	324	39	96	21	50	23	48	204	77	80	32	22	21	n.d.
KHM279	Tani A	0.05	1.61	0.887	1.76	80.99	13.97	0.57	0.0072	n.d.	0.05	337	39	102	23	61	22	61	203	82	77	33	23	30	n.d.
KHM260	Tani A	0.05	1.63	0.859	1.67	79.44	15.62	0.57	0.0079	n.d.	0.04	315	40	96	19	53	19	55	244	73	88	44	28	44	17
KHM 48	Tani B	0.03	1.35	0.883	2.28	78.72	15.75	0.67	0.0090	n.d.	0.14	310	50	112	32	56	24	64	518	87	114	81	16	138	n.d.
KHM 2	Anlong T.	0.06	1.24	0.806	1.52	77.72	17.94	0.50	0.0060	n.d.	0.07	307	40	89	17	58	26	105	255	75	102	31	19	48	n.d.
KHM 30	Bankaong	0.00	1.02	0.886	1.31	79.72	16.45	0.47	0.0071	n.d.	0.04	318	33	74	16	52	18	47	206	66	75	40	22	28	n.d.
KHM104	Tani A	0.06	0.99	0.835	1.45	79.35	16.43	0.54	0.0086	0.06	0.14	277	45	82	22	47	32	71	291	74	142	111	15	146	n.d.
KHM 58	Tani A	0.03	1.46	0.847	1.13	80.79	15.06	0.45	0.0060	n.d.	0.11	315	48	55	16	43	15	46	349	55	74	31	15	18	n.d.
KHM 99	Tani A	0.04	1.30	0.792	0.98	80.75	15.45	0.37	0.0080	0.05	0.13	324	40	61	11	40	14	41	534	66	75	30	22	38	n.d.
KHM111	Anlong T.	0.05	1.11	0.774	1.45	83.61	12.28	0.49	0.0085	0.07	0.07	368	30	83	16	34	14	37	142	53	68	36	26	16	n.d.
KHM118	Anlong T.	0.06	1.20	0.724	1.60	83.32	12.33	0.55	0.0081	n.d.	0.08	360	30	90	20	35	17	43	219	56	69	37	19	15	n.d.
KHM117	Anlong T.	0.04	1.21	0.762	1.45	83.54	12.27	0.53	0.0072	n.d.	0.07	349	35	85	18	36	19	40	290	53	63	31	24	23	n.d.
KHM313	Anlong T.	0.04	1.02	0.760	1.55	82.54	13.49	0.42	0.0074	n.d.	0.06	356	28	90	17	38	15	37	276	55	79	29	19	26	n.d.
KHM304	Anlong T.	0.04	1.17	0.755	1.48	85.55	10.36	0.49	0.0083	n.d.	0.05	358	27	87	19	41	16	36	198	50	76	37	22	26	n.d.
KHM300	Anlong T.	0.05	0.96	0.801	1.24	82.67	13.66	0.46	0.0067	n.d.	0.04	399	25	77	11	37	13	50	194	58	83	38	27	35	n.d.
KHM 17	Anlong T.	0.03	1.05	0.699	1.39	82.53	13.57	0.54	0.0086	n.d.	0.06	395	30	74	17	36	17	63	372	50	79	40	18	32	n.d.
KHM127	Sor Sei	0.03	1.14	0.719	1.70	82.64	12.96	0.60	0.0092	n.d.	0.08	385	37	90	20	35	16	46	354	54	77	36	21	24	n.d.
KHM 18	Anlong T.	0.05	1.05	0.687	1.28	83.00	13.21	0.54	0.0090	n.d.	0.06	395	33	83	18	38	19	45	350	34	77	40	22	30	n.d.
KHM299	Anlong T.	0.05	1.23	0.750	1.42	83.08	12.80	0.46	0.0087	n.d.	0.07	424	33	85	17	42	15	57	483	50	109	41	29	37	n.d.
KHM302	Anlong T.	0.04	1.27	0.778	1.61	82.94	12.67	0.50	0.0077	n.d.	0.06	407	36	98	17	46	n.d.	59	294	67	111	40	28	31	n.d.
KHM109	Anlong T.	0.10	0.96	0.691	1.32	85.50	10.75	0.45	0.0089	0.05	0.07	415	31	73	14	28	11	38	231	45	68	35	18	28	n.d.
KHM110	Anlong T.	0.09	0.91	0.702	1.27	83.73	12.59	0.43	0.0086	0.06	0.10	389	35	70	14	31	12	43	320	49	76	34	20	28	n.d.
KHM 1	Anlong T.	0.09	1.11	0.740	1.62	83.55	12.10	0.55	0.0079	n.d.	0.09	351	41	86	17	42	17	45	326	50	73	36	21	29	n.d.
KHM306	Anlong T.	0.11	1.19	0.750	1.68	82.62	12.97	0.51	0.0108	n.d.	0.06	381	33	102	17	40	16	41	327	50	72	39	22	23	n.d.
KHM132	Sor Sei	0.10	1.20	0.766	1.51	81.32	14.41	0.44	0.0095	n.d.	0.09	412	39	79	15	42	14	39	489	64	87	32	22	72	n.d.
KHM298	Anlong T.	0.04	1.10	0.786	1.43	82.40	13.60	0.47	0.0074	n.d.	0.04	486	35	80	15	46	n.d.	46	298	65	68	44	31	20	n.d.
KHM198	Sor Sei	0.10	1.05	0.719	1.57	81.64	14.02	0.54	0.0084	0.06	0.12	331	71	82	116	42	20	66	685	58	109	37	18	32	n.d.
KHM194	Sor Sei	0.07	1.16	0.758	1.65	81.51	13.96	0.54	0.0061	0.05	0.09	334	41	89	280	39	21	47	906	60	80	38	17	140	n.d.
KHM131	Sor Sei	0.04	1.24	0.640	1.53	81.21	14.62	0.44	0.0055	n.d.	0.11	255	46	75	10	37	13	40	781	60	85	31	n.d.	244	n.d.
KHM128	Sor Sei	0.07	1.58	0.748	2.51	78.64																			

Chemical compositions of unglazed stoneware and earthenware (values recalculated to 100 weight%). Listing in the order resulting from the cluster analysis (see dendrogram in Fig.8)

Analysis	Kiln sites	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	Na ₂ O	P ₂ O ₅	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu
KHM 24	Bankaong	0.15	3.50	0.972	1.38	76.22	16.87	0.67	0.0430	n.d.	0.06	272	57	105	50	56	34	54	398	97	100	38	20	30	25
KHM 25	Bankaong	0.15	3.50	0.963	1.37	76.32	16.80	0.67	0.0439	n.d.	0.05	268	57	105	48	57	38	49	419	92	96	39	19	25	25
KHM 22	Bankaong	0.21	3.83	0.975	1.49	74.02	18.47	0.76	0.0663	n.d.	0.04	269	54	117	50	57	35	50	349	98	93	32	21	44	27
KHM371	Bankaong	0.11	3.90	0.996	1.32	74.56	18.25	0.67	0.0367	n.d.	0.03	247	47	107	52	65	25	35	366	108	106	43	23	52	23
KHM324	Khnar Po	0.16	3.94	1.068	1.50	74.57	17.83	0.69	0.0535	n.d.	0.05	252	56	113	49	63	23	48	363	107	84	31	23	53	25
KHM340	Bankaong	0.11	3.99	0.891	1.18	75.16	17.76	0.65	0.0815	n.d.	0.05	243	39	101	52	65	30	50	351	108	92	36	24	53	23
KHM 27	Bankaong	0.11	4.04	0.991	1.39	73.40	19.13	0.74	0.0402	n.d.	0.04	262	49	109	53	66	42	42	316	112	85	32	21	32	21
KHM339	Bankaong	0.06	4.22	0.921	1.30	73.37	19.28	0.67	0.0301	n.d.	0.04	250	37	105	47	68	35	38	268	110	92	33	24	48	21
KHM347	Bankaong	0.09	4.23	1.033	1.04	74.58	18.14	0.69	0.0359	n.d.	0.05	275	35	88	57	65	37	32	275	111	80	32	26	48	12
KHM155	Bankaong	0.07	3.86	1.115	0.91	76.18	16.95	0.67	0.0620	n.d.	0.06	264	37	84	45	49	32	52	224	89	99	34	25	37	27
KHM158	Bankaong	0.07	3.70	1.093	1.04	75.96	17.01	0.68	0.0718	0.21	0.05	251	44	96	46	51	31	49	250	85	96	37	23	33	25
KHM156	Bankaong	0.07	3.91	1.110	0.98	75.12	17.82	0.72	0.0579	n.d.	0.06	279	39	80	49	53	34	44	221	89	96	37	24	22	24
KHM 31	Bankaong	0.08	3.44	1.039	1.20	76.20	17.20	0.64	0.0337	n.d.	0.05	271	44	85	43	55	31	42	240	101	90	33	20	49	19
KHM152	Bankaong	0.08	3.76	1.070	1.24	76.33	16.77	0.52	0.0522	n.d.	0.06	266	47	93	41	54	28	46	285	104	96	35	20	26	19
KHM151	Bankaong	0.06	3.80	1.132	1.08	75.18	17.82	0.70	0.0559	n.d.	0.06	257	38	84	47	57	32	45	229	98	90	34	26	32	27
KHM159	Bankaong	0.08	4.07	1.123	1.36	74.45	17.85	0.67	0.0485	0.17	0.07	252	47	97	45	53	31	51	265	108	97	35	20	42	24
KHM323	Khnar Po	0.14	4.08	1.038	1.20	75.83	16.88	0.60	0.0598	n.d.	0.05	280	47	97	52	61	29	47	326	98	95	35	24	52	12
KHM346	Bankaong	0.12	3.56	1.003	1.00	76.88	16.61	0.64	0.0424	n.d.	0.03	286	40	85	50	63	28	31	298	94	98	36	24	41	24
KHM327	Khnar Po	0.09	4.01	1.117	1.18	76.60	16.19	0.59	0.0557	n.d.	0.05	264	42	91	43	60	24	49	289	104	97	34	27	47	11
KHM337	Bankaong	0.11	4.35	1.097	1.02	75.05	17.46	0.70	0.0641	n.d.	0.04	280	37	85	55	66	33	46	280	89	98	36	25	44	19
KHM350	Khnar Po	0.07	4.13	1.066	1.11	77.05	15.80	0.58	0.0307	n.d.	0.05	277	41	88	38	67	29	51	240	103	81	31	24	47	13
KHM161	Bankaong	0.13	3.93	1.105	0.95	74.97	18.17	0.48	0.0135	0.07	0.07	263	50	78	32	52	24	56	273	89	105	40	18	29	22
KHM157	Bankaong	0.08	3.44	1.021	0.80	78.52	15.43	0.48	0.0589	n.d.	0.06	287	33	63	27	51	30	32	230	101	67	29	22	29	23
KHM318	Khnar Po	0.07	3.62	1.064	0.97	78.36	15.16	0.54	0.0375	n.d.	0.07	282	36	82	38	53	27	50	227	101	73	31	25	35	15
KHM343	Bankaong	0.10	3.53	1.034	0.87	77.42	16.36	0.49	0.0344	n.d.	0.04	282	35	75	39	57	30	35	243	94	84	30	27	37	21
KHM330	Khnar Po	0.09	3.62	0.976	0.99	77.96	15.60	0.55	0.0373	n.d.	0.06	278	36	81	46	59	30	50	294	98	57	29	21	39	11
KHM333	Khnar Po	0.14	3.77	1.009	1.01	77.17	16.08	0.58	0.0690	n.d.	0.04	286	39	88	51	57	30	51	297	87	77	33	28	42	22
KHM163	Bankaong	0.08	3.41	0.975	0.93	78.28	15.51	0.56	0.0667	n.d.	0.06	267	40	77	45	48	32	38	260	86	82	32	20	31	23
KHM328	Khnar Po	0.10	3.35	0.939	1.15	78.91	14.85	0.49	0.0497	n.d.	0.04	288	43	88	38	55	29	38	281	86	102	35	20	33	18
KHM344	Bankaong	0.08	3.94	0.985	1.01	77.45	15.79	0.53	0.0625	n.d.	0.03	273	37	88	47	56	28	44	296	94	100	34	25	45	23
KHM319	Khnar Po	0.10	3.53	0.974	1.21	78.51	14.89	0.56	0.0495	n.d.	0.04	280	45	92	42	57	20	41	300	91	98	37	23	36	21
KHM331	Khnar Po	0.10	3.28	0.935	1.17	79.17	14.66	0.49	0.0485	n.d.	0.04	281	43	88	38	53	26	53	277	97	85	34	23	37	20
KHM150	Bankaong	0.08	4.57	0.875	0.97	76.78	15.86	0.60	0.0273	0.05	0.08	269	38	83	48	47	28	41	259	92	85	34	18	21	12
KHM153	Bankaong	0.06	3.59	0.985	1.08	78.05	15.47	0.55	0.0369	n.d.	0.08	260	42	80	40	43	29	45	255	97	92	33	23	45	19
KHM149	Bankaong	0.07	4.32	0.953	0.97	75.19	17.70	0.61	0.0255	n.d.	0.07	264	32	83	40	52	31	32	226	108	77	29	25	42	n.d.
KHM332	Khnar Po	0.07	3.84	1.052	0.91	78.08	15.28	0.55	0.0300	n.d.	0.08	295	31	74	35	63	23	49	186	89	97	31	26	43	16
KHM373	Bankaong	0.08	3.89	1.047	0.63	76.02	17.52	0.62	0.0433	n.d.	0.04	294	27	55	48	66	28	44	195	91	76	33	24	40	25
KHM316	Khnar Po	0.13	3.61	1.035	1.10	76.91	16.36	0.62	0.0585	n.d.	0.04	274	40	93	58	56	25	50	351	59	93	36	26	43	23
KHM375	Bankaong	0.16	3.42	1.016	0.94	76.55	17.06	0.52	0.0579	n.d.	0.15	262	38	75	52	68	34	n.d.	293	136	93	28	22	51	17
KHM370	Bankaong	0.06	3.55	1.121	0.48	76.33	17.62	0.63	0.0683	n.d.	0.04	303	21	48	62	68	39	44	184	88	92	35	27	54	30
KHM338	Bankaong	0.05	3.60	1.268	0.43	76.55	17.30	0.57	0.0901	n.d.	0.04	292	22	42	53	62	32	33	145	89	77	30	28	41	27
KHM 28	Bankaong	0.05	3.98	1.178	0.70	76.27	17.00	0.62	0.0423	n.d.	0.05	300	28	51	47	53	34	46	153	77	90	34	24	32	25
KHM148	Bankaong	0.09	3.36	0.976	0.86	80.14	13.84	0.50	0.0382	n.d.	0.06	309	37	64	29	46	26	41	231	86	74	32	18	21	19
KHM154	Bankaong	0.07	3.09	0.938	0.71	81.43	12.99	0.52	0.0443	n.d.	0.07	292	38	56	41	43	27	n.d.	249	82	69	31	19	29	19
KHM162	Bankaong	0.09	3.63	0.954	0.89	79.98	13.51	0.57	0.0393	0.13	0.11	295	35	61	38	52	29	n.d.	251	87	66	29	19	25	14
KHM320	Khnar Po	0.13	3.47	0.950	0.86	80.86	13.03	0.49	0.0497	n.d.	0.05	307	36	69	36	55	24	n.d.	273	81	72	29	19	29	13
KHM374	Bankaong	0.07	3.52	0.817	0.69	80.81	13.50	0.42	0.0315	n.d.	0.04	295	30	63	37	51	20	33	226	78	70	26	20	28	18
KHM321	Khnar Po	0.11	3.06	0.898	0.86	82.00	12.45	0.45	0.0282	n.d.	0.04	308	36	65	30	50	21	n.d.	256	72	83	28	19	33	18
KHM315	Khnar Po	0.15	3.06	0.969	1.12	80.24	13.70	0.56	0.0406	n.d.	0.04	303	44	87	44	51	28	n.d.	286	72	83	37	28	42	20
KHM326	Khnar Po	0.07	3.43	0.986	1.04	79.82	13.96	0.51	0.0288	n.d.	0.04	300	38	84	38	52	25	49	235	82	89	32	24	27	21
KHM317	Khnar Po	0.11	4.24	0.996	1.03	78.27	14.60	0.55	0.0559	n.d.	0.04	288	41	82	45	57	24	45	274	78	83	33	23	41	20
KHM325	Khnar Po	0.09	4.06	1.071	0.91	78.89	14.26	0.53	0.0493	n.d.	0.04	303	34	70	42	55	28	46	227	79	71	32	22	41	22
KHM 56	Tani	0.17	3.66	0.850	0.96	79.02	14.45	0.66	0.0198	n.d.	0.08	302	49	58	42	52	31	30	268	93	67	29	20	26	22
KHM 23	Bankaong	0.11	2.88	0.871	0.99	80.58	13.85	0.52	0.0396	n.d.	0.04	267	42	77	32	44	24	50	301	73	95	34	20	26	22
KHM368	Bankaong	0.11	3.17	0.908	0.63	79.54	14.97	0.48	0.0481	n.d.	0.04	305	26	55	31	51	18	35	217	97	57	23	23	49	12
KHM329	Khnar Po	0.08	3.32	0.920	0.74	80.61	13.67	0.45	0.0471	n.d.	0.06	309	28	63	33	58	22	35	211	93	59	24	21	34	1

Chemical compositions of unglazed stoneware and earthenware (values recalculated to 100 weight%). Listing in the order resulting from the cluster analysis (see dendrogram in Fig.8)

Analysis	Kiln sites	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	Na ₂ O	P ₂ O ₅	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu
KHM383	Tani	0.40	6.73	0.831	2.46	69.21	18.40	1.46	0.0380	0.28	0.05	224	91	134	77	72	39	42	482	116	71	33	21	44	26
KHM377	Tani	0.44	6.56	0.853	2.36	69.87	17.94	1.47	0.0410	0.24	0.08	221	85	128	77	69	39	33	468	108	78	34	19	30	24
KHM211	Sor Sei	0.32	7.00	0.807	2.56	68.87	18.44	1.45	0.0628	0.28	0.06	234	76	145	191	67	41	43	467	115	74	32	23	35	32
KHM143	Sor Sei	0.48	6.62	0.814	2.89	67.74	19.15	1.72	0.0384	0.34	0.07	209	83	154	87	62	41	40	495	116	82	33	21	32	25
KHM 65	Tani	0.36	6.35	0.858	2.63	68.80	19.20	1.50	0.0841	n.d.	0.07	229	80	141	79	63	42	48	463	124	104	37	18	38	22
KHM203	Sor Sei	0.37	6.90	0.849	2.54	68.75	18.59	1.46	0.0508	0.28	0.06	225	74	142	84	59	42	47	428	112	95	34	22	24	29
KHM380	Tani	0.53	6.39	0.839	2.36	70.44	17.58	1.36	0.0714	0.23	0.05	229	70	127	75	67	47	57	538	107	97	36	19	42	26
KHM145	Sor Sei	0.28	5.48	0.813	2.53	71.15	17.62	1.52	0.0533	0.33	0.06	224	87	143	74	54	39	43	644	107	95	38	20	38	24
KHM146	Sor Sei	0.35	5.87	0.786	2.26	71.70	16.93	1.31	0.1447	0.42	0.07	233	74	126	75	56	42	44	523	103	103	37	17	45	30
KHM199	Sor Sei	0.30	6.20	0.815	2.36	71.10	17.29	1.39	0.1104	0.23	0.05	231	80	136	67	58	42	52	538	112	105	31	16	30	32
KHM 67	Tani	0.20	6.57	0.787	2.26	71.49	17.10	1.19	0.1708	n.d.	0.08	241	63	123	68	57	42	38	473	106	102	28	18	51	23
KHM207	Sor Sei	0.23	6.76	0.779	2.29	70.76	17.24	1.30	0.1364	0.31	0.05	237	68	134	65	59	42	45	446	109	89	30	14	31	26
KHM206	Sor Sei	0.32	7.15	0.796	2.51	68.99	18.21	1.41	0.1394	0.25	0.06	231	73	145	218	67	42	45	446	115	87	30	18	40	23
KHM209	Sor Sei	0.31	7.52	0.811	2.57	68.36	18.32	1.45	0.1674	0.27	0.06	228	75	144	74	65	42	41	538	125	107	32	21	55	28
KHM144	Sor Sei	0.44	6.99	0.798	2.81	67.35	19.14	1.73	0.1147	0.39	0.07	212	94	151	86	64	43	40	609	123	90	35	15	32	29
KHM200	Sor Sei	0.39	6.91	0.797	2.65	67.76	19.24	1.68	0.1234	0.24	0.05	221	81	145	87	66	56	45	457	111	104	29	19	35	26

n.d. = not determined

Chemical compositions of brown-glazed stoneware from Anlong Thom (values recalculated to 100 weight%).

Analysis	Kiln sites	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	Na ₂ O	P ₂ O ₅	Zr	Sr	Rb	Zn	Cr	Ni	La	Ba	V	Ce	Y	Th	Pb	Cu
KHM 10	Anlong T.	0.09	2.76	0.815	1.81	77.56	15.69	0.93	0.0572	0.05	0.09	328	41	100	66	54	44	62	332	71	97	44	16	146	20
KHM 20	Anlong T.	0.09	2.27	0.823	1.81	77.15	16.60	1.01	0.0170	n.d.	0.10	304	39	101	56	56	47	76	257	75	91	42	20	105	17
KHM 21	Anlong T.	0.13	2.45	0.851	1.66	77.55	16.08	1.06	0.0130	n.d.	0.08	337	39	93	75	57	40	41	250	82	80	55	17	150	14
KHM121	Anlong T.	0.09	2.45	0.818	2.14	77.18	15.96	1.05	0.0157	0.08	0.08	308	39	117	51	54	41	53	349	87	100	51	19	148	12
KHM124	Anlong T.	0.08	2.45	0.808	1.74	76.76	17.03	0.82	0.0205	n.d.	0.10	311	40	102	52	55	41	72	335	86	119	100	17	144	15
KHM290	Anlong T.	0.12	3.36	0.739	2.00	76.94	15.57	0.99	0.0621	n.d.	0.08	279	41	117	51	59	33	38	328	80	103	40	29	123	14
KHM291	Anlong T.	0.20	3.36	0.861	1.87	75.68	16.60	1.11	0.0675	n.d.	0.10	330	46	110	53	61	35	59	348	76	101	42	38	242	13
KHM292	Anlong T.	0.11	3.17	0.835	1.83	76.47	16.30	1.01	0.0532	n.d.	0.08	330	39	110	49	61	35	39	304	79	121	36	32	155	22
KHM293	Anlong T.	0.13	3.64	0.767	1.90	76.02	16.19	1.05	0.0658	n.d.	0.09	300	43	114	72	59	39	37	322	78	93	49	38	188	15
KHM295	Anlong T.	0.12	3.27	0.840	1.82	76.50	16.13	1.00	0.0835	n.d.	0.09	331	44	107	65	63	40	52	340	73	107	41	31	121	14

n.d. = not determined