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The Kiln Sites of the “Torp Chey” Area (Cambodia)

Production and Distribution

Valérie Thirion-Merle, Armand Desbat,
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Abstract

This article presents the typological and archaeometrical results obtained on the brown glazed stoneware of the Torp Chey kiln sites area. The ceramics were studied as part of the Cerangkor project, and several kiln sites were surveyed and analysed, including: Torp Chey, Veal Svay, Chong Samrong and Teuk Lek. More than sixty samples of brown glazed stoneware from the different kiln sites have been analysed chemically by XRF-WDS, twentyfive among them also petrographically. The data obtained indicate that the different kiln sites use similar raw materials suggesting the exploitation of the same geological formations for the whole area. Only one reference group has been therefore established, distinct from the productions of other Angkorian kiln sites and also from the productions of similar brown glazed stoneware from the Buriram sites (Thailand). Furthermore, the analysis of brown glazed stoneware obtained from consumption sites makes it possible to propose the first map showing the distribution of ceramics from production sites.

Keywords: ceramics; glazed stoneware; Cambodia; Angkorian period; Torp Chey; Buriram; X-ray fluorescence spectrometry; petrography; provenance.

Résumé

Cet article présente les résultats des études typologiques et archéométriques réalisées sur les grès à glaçure brune des fours de la région de Torp Chey. Ces études ont été réalisées dans le cadre du projet Cerangkor et plusieurs sites de fours ont été prospectés et caractérisés, notamment Torp Chey, Veal Svay, Chong Samrong et Teuk Lek. Plus de soixante échantillons de grès à glaçure brune provenant des différents sites de fours ont été analysés chimiquement par XRF-WDS, dont vingt-cinq également par pétrographie. Les données obtenues indiquent que les différents sites de fours utilisent des matières premières similaires, ce qui suggère l'exploitation des mêmes formations géologiques pour toute la région. Un seul groupe de référence a donc été établi, bien distinct des productions des autres sites de fours angkoriens mais également des grès bruns du Buriram (Thaïlande). De plus, l'analyse de grès à glaçure brune découverts sur différents sites de consommation permet d'esquisser une première carte de distribution de ces sites producteurs.

Mots-clés : céramiques ; grès à glaçure ; Cambodge ; période angkoriennne ; Torp Chey ; Buriram ; spectrométrie de fluorescence X ; pétrographie ; provenance.

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Introduction

Brown glazed stonewares and in particular large storage jars with brownblack glaze and comb decoration are a typical product of the end of the Angkorian period (late 13th–14th centuries) (figs. 1 and 2). The first kiln sites discovered that produced brown glaze stonewares are located in Thailand near Ban Kruat in Buriram; it was also assumed that their production could have occurred in Cambodia in the western province of Banteay Meanchey (Ea 2009). The Thnal Mrech kiln site, well known for its green glazed stoneware production, also manufactured brown glazed ware though in small quantities probably during a terminal use of the kiln area (Cerangkor 2008; Desbat 2020, p. 69). The discovery in 2007 of kiln sites located about 60 km east of Angkor has permitted new research and proved the production of this type of stoneware in Cambodia. This newly discovered group of kilns was situated on the royal road connecting Angkor to the large provincial centre of Preah Khan of Kompong Sway, near the Torp Chey temples (Hendrickson 2008). Field surveys in the following years along this royal road, notably by the APSARA Authority, led to the discoveries of the two additional kiln sites of Veal Svay and Chong Samrong (Hein, Cort & Ea 2013; Tabata *et al.* 2015) (see map on fig. 3).

Unlike the five large-scale production sites around Angkor (Ea 2009, 2010), which produced green glazed and unglazed stonewares, those located in the Torp Chey area produced only brown glazed stonewares, many storage jars of various sizes but also other types of ceramics that we see appearing on many Angkorian sites from the end of the 13th century onwards.

The Cerangkor Project¹ was developed in order to investigate the ceramics produced at the kiln sites located in the region of the ancient Khmer

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1. Created in 2008, this project is a collaborative research programme with the French Centre National de la Recherche Scientifique (CNRS—National Scientific Research Centre), the Siem Reap Centre of the EFEO (École française d’Extrême Orient / French School of Asian Studies), and the APSARA Authority (the Authority for the Protection and Management of Angkor and the Region of Siem Reap) with funding from the French Ministry of Foreign Affairs (Cerangkor 2008 to 2015; Mafkata-Cerangkor 2016 to 2019).



Fig. 1 — Examples of Torp Chey type jars from the National Museum of Cambodia in Phnom Penh.

capital Angkor, from the period between the 9th and the 15th century AD, with two main objectives. The first aimed to define for each known kiln site the characteristics of production, especially the repertoire of forms and technical aspects; the second objective sought to identify the chemical compositions of each ceramic type of each kiln site associated with their petrographic fabric. Research was thus designed to develop a characterisation of the pottery based on a combination of typology (technical styles) and chemical composition. This programme stands out for its breadth and extent, since until then typological and chemical compositional analyses of Angkorian stoneware were limited to a few case studies (Ea 2009, 2010; Yamamoto 2011) and also for its approach which takes into account the categories of stoneware produced (Grave *et al.* 2017).

The analyses carried out make it possible to build up a geochemical database which allows a study of the distribution of the stoneware from these workshops on the one hand and the lifespan of these manufacturing locales on the other through the analysis of ceramics present at consumption sites. The five kiln sites near Angkor that produced green glazed and unglazed stoneware have all been characterised, and compositional reference groups have been defined and a typology established (Thirion-Merle, Thierrin-Michael & Desbat 2019). The objective of this paper is to present the results obtained for the later production of brown glazed stoneware from the Torp Chey area.

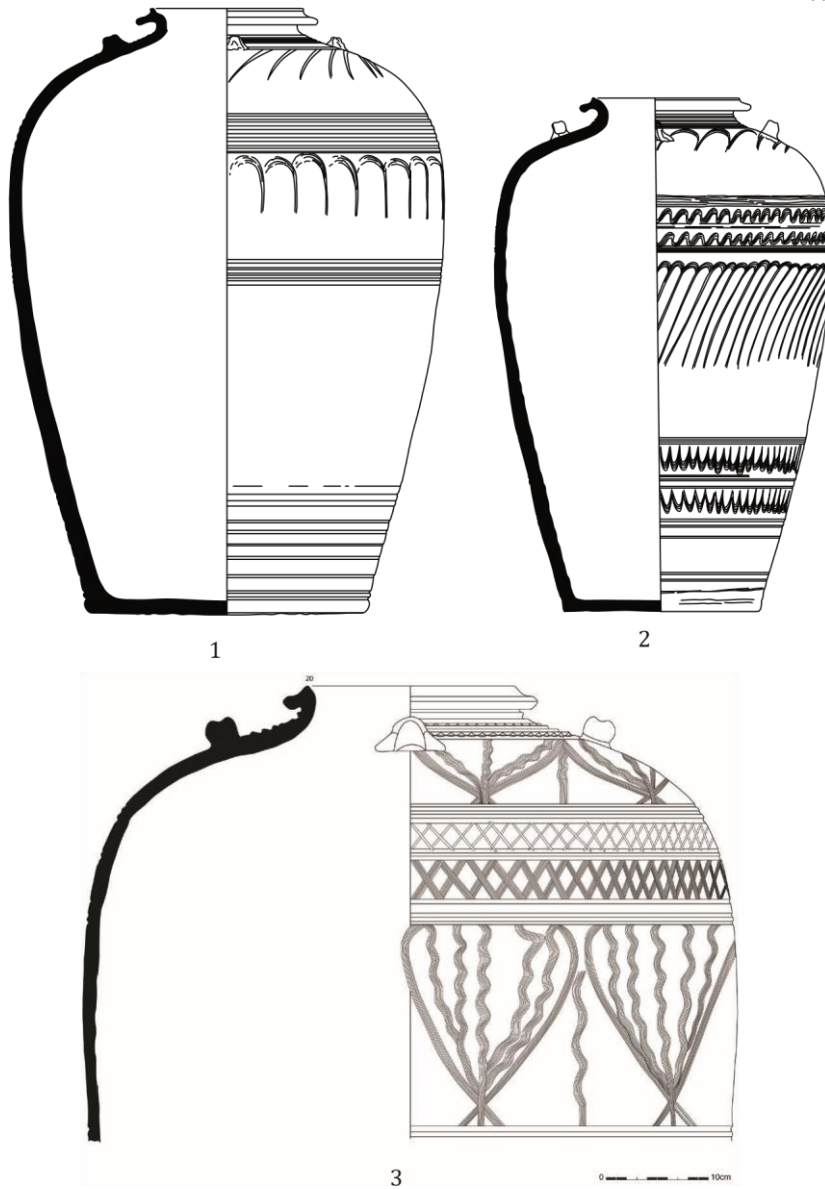


Fig. 2 — Other examples of Torp Chey type jars. 1. Preah Enkosei provenance; 2. and 3. Unknown provenance (Dépôt de la Conservation d'Angkor) (Desbat 2017).

Kiln sites and their production

Localisation of the different kiln sites studied

As already mentioned, in the Torp Chey area, located 60 km north-east of Siem Reap, along the royal road from Angkor to the provincial centre of Preah Khan of Kompong Svay, researchers have identified three separate kiln sites (fig. 3).

The first site discovered in 2007 by Mitch Hendrickson, Torp Chey, is located about 10 km from the Beng Mealea temple in the Torp Chey village (Hendrickson 2008). This site was previously named Teap Chei. It includes at least twelve kilns in proximity to temples, and kiln number 2 was selected for excavations, revealing a kiln of unique and sophisticated design (Ea 2013).

The second site, Veal Svay, also named Village 103 or Mouyroy bei, is located about 2.5 km from Torp Chey. This site consists of three kilns with only one kiln excavated in 2015 (Tabata *et al.* 2015; Sugiyama, Sato & Tabata 2017; Cerangkor 2012).

The third kiln site, Chong Samrong, situated approximately 5 km southeast of Torp Chey, is more extensive and contains more than a dozen kilns. One kiln was excavated by APSARA Authority and the Smithsonian in 2013 (Hein, Cort & Ea 2013; Cerangkor 2012).

We have tentatively identified a fourth at Teuk Lek, closer to the temple of Beng Mealea. At this last site, we have not seen any mounds corresponding to kilns but only concentration of sherds. Therefore, the interpretation that this is a kiln site remains uncertain in this case (Mafkata-Cerangkor 2019).

The kiln remains appear as huge quantities of sherds scattered in a large area around mounds. The sherds consist principally of brown glazed stoneware as well as of fragments of fired clay, probably parts of kiln walls or roofs.

Production of the kiln sites

The pottery samples discussed here were collected from the mentioned kiln sites during our own field surveys made between 2009 and 2013. The collected ceramics show a diversity of types. Jars dominate the production with several types varying in size and shape (fig. 4). The most common type is the large jar, with small plated handles and triangular rim, with an opening diameter ranging from 15 to 30 cm (fig. 4, no. 1 to 7) (Desbat 2020). There are other types with a wide flared neck and beaded rim (fig. 4, no. 8 to 11), or with a narrow neck and overhanging rim (fig. 4, no. 12).

The wall and shoulder of the jars are frequently decorated with comb decoration forming waves or arcades and horizontal lines. On large jars, there are also other decorative motifs, such as cross-braces, vertical lines, heart-shaped motifs, or sinuous lines. The base of the vessels is underlined by horizontal grooves. Their body diameter varies from 24 to 48 cm, but the latter measurement is exceptional.

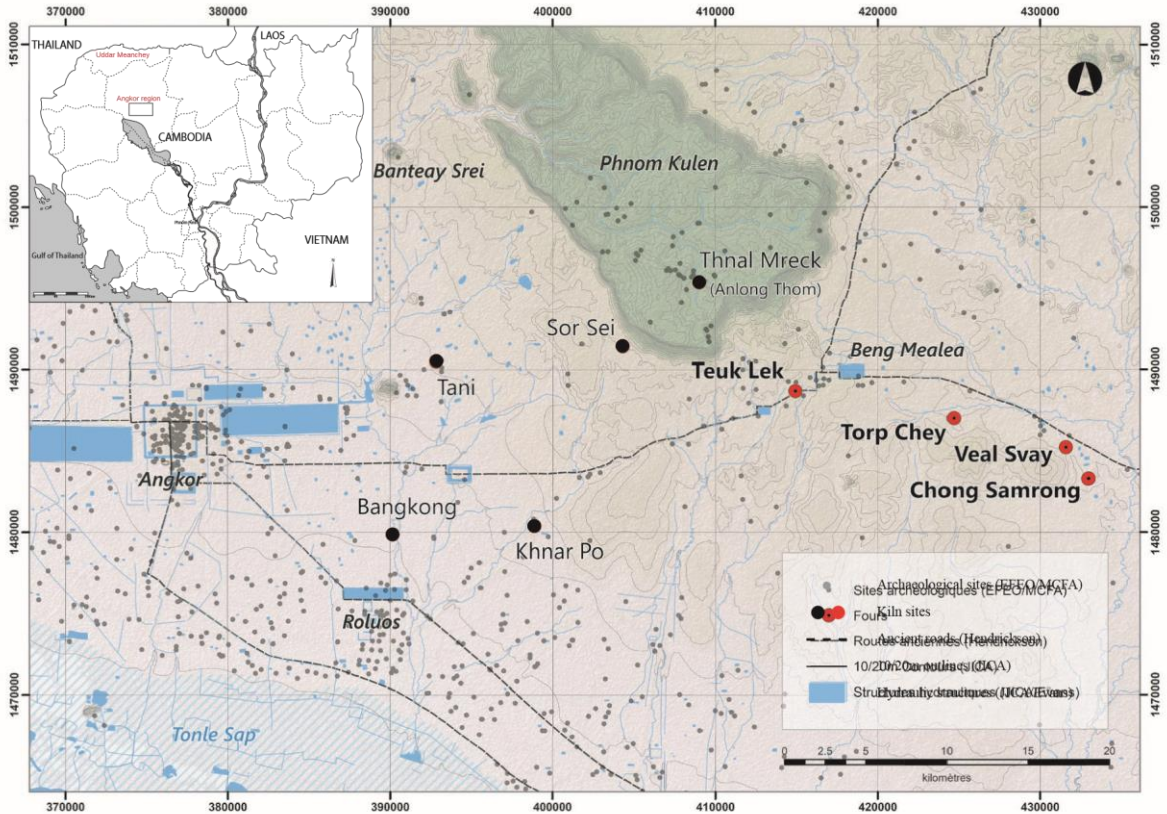


Fig. 3 — Location of known stoneware kiln sites (four) in Cambodia. In red, sites discussed in the article. Map background: EFEO/GAP/JICA (École française d'Extrême Orient / Great Angkor Project / Japan International Cooperation Agency).

The repertoire of shapes includes also hemispherical bowls with rims underlined by striations, sometimes with a wavy decoration (fi g. 5, no. 1 to 6), some bottles (fi g. 5 no. 7 to 9, fi g. 6) as well as bowls or basins with carinated shoulders, some of them of very large diameter (fi g. 5, no 10 to 14). There are also some pots with round rims and wide mouth.

In addition, the kilns of Torp Chey produced also some roof tiles (Ea 2015, p. 73) and animal shape figurines (Ea 2015, pp. 75–76).

On macroscopic inspection, the fabrics of Torp Chey type stoneware appear significantly coarser than those of the Kulen stoneware produced in the kiln sites near Angkor. They are highly varied, and generally they present numerous red or dark grey to black nodules and a lot of white to grey transparent grains of different size (fi g. 7). They sometimes have a marbled appearance and contain large iron oxide nodules up to 2 mm in size. But there are also fabrics with finer grains. When overfired, they may take on a scoriaceous appearance resulting from the fusion of the ferruginous nodules. We do not observe significant differences between the productions of the four kiln sites, either in terms of typology, decoration or fabric features.

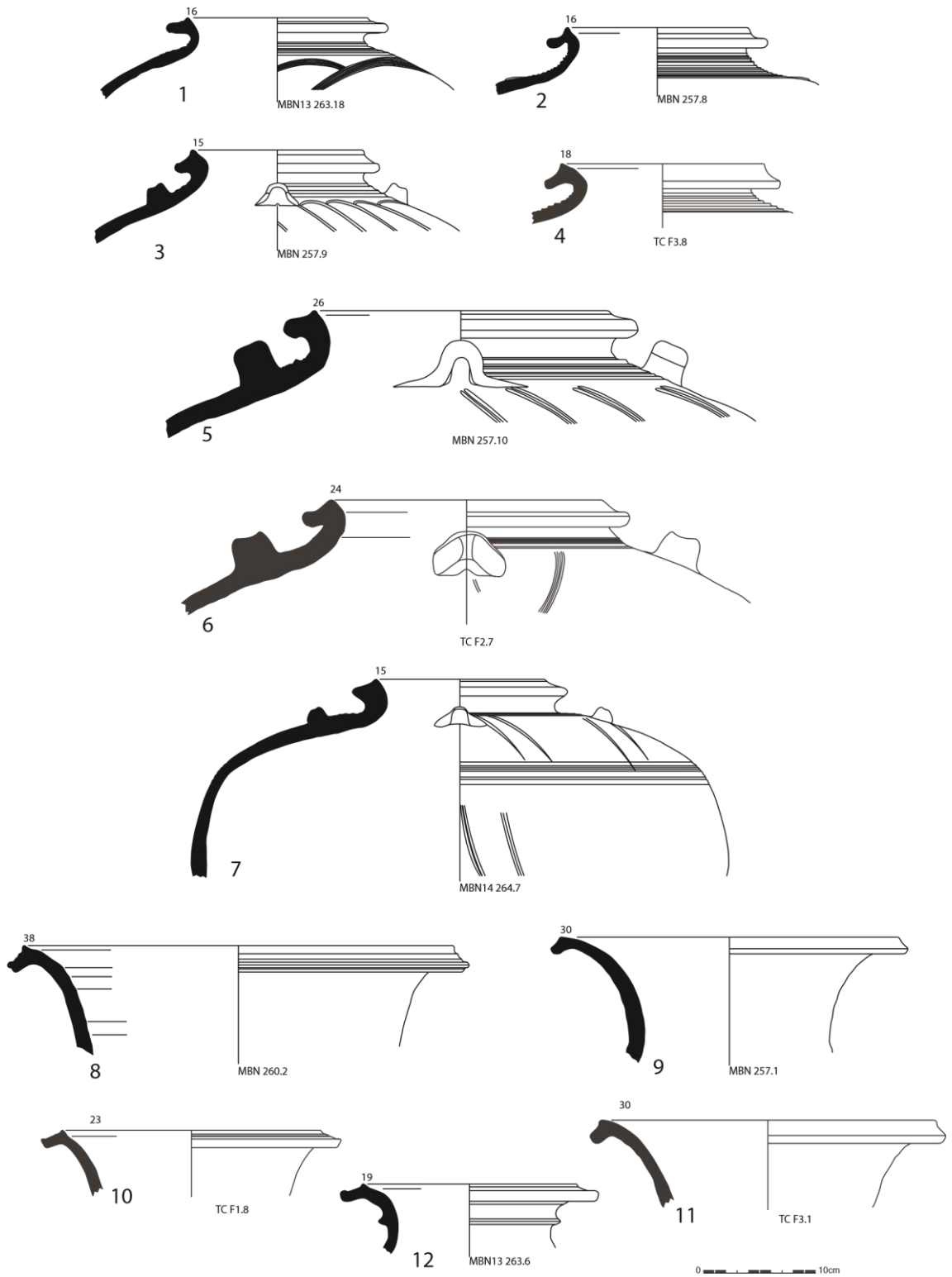


Fig. 4 — Some examples of the brown glazed jars produced at Torp Chey (TC) and Chong Samrong (MBN).

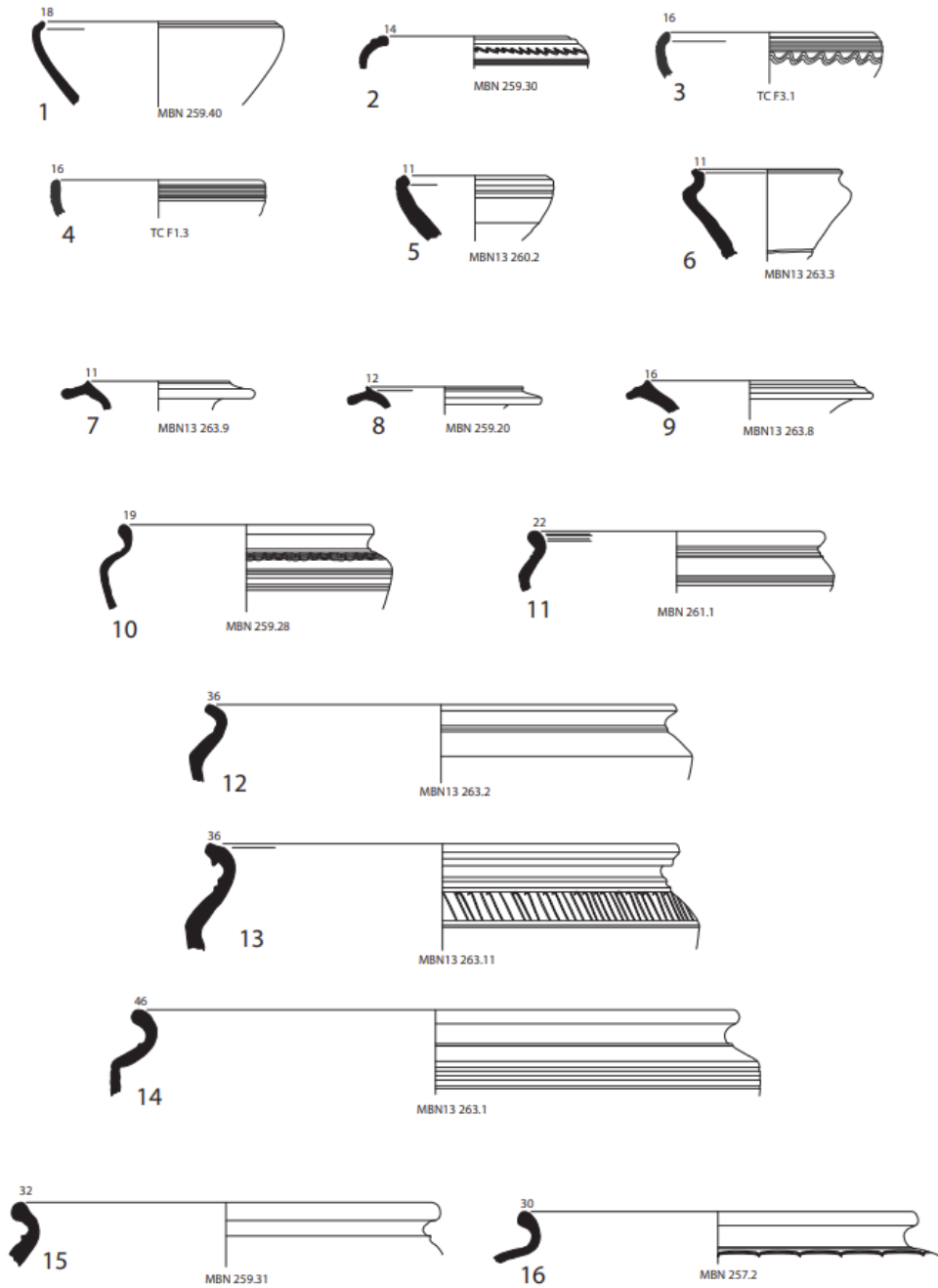
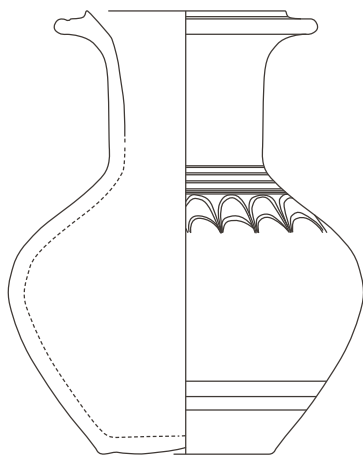


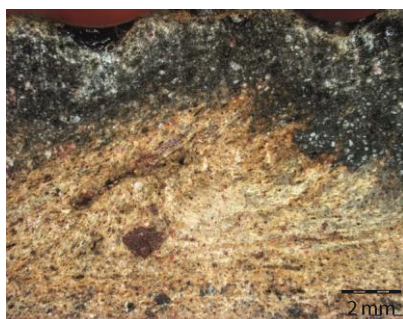
Fig. 5 — Other forms of brown glazed stoneware produced at Torp Chey (TC) and Chong Samrong (MBN).



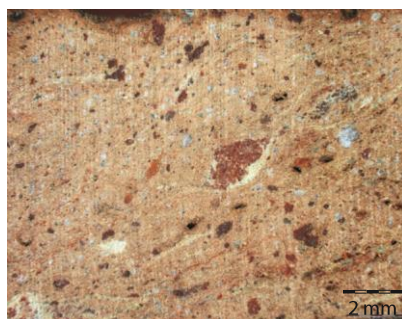
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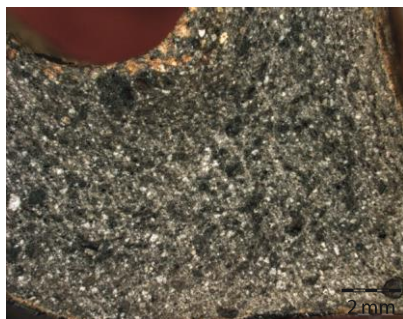
Fig. 6 — Example of a whole Torp Chey type bottle of the National Museum of Cambodia in Phnom Penh.



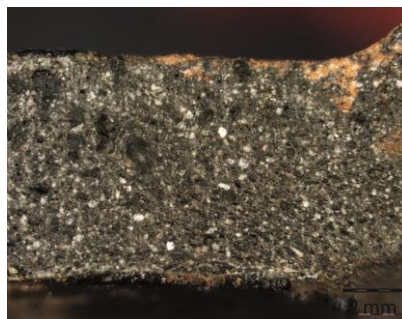
KHM355, *Torp Chey*



KHM357, *biscuit, Torp Chey*



KHM550, *Veal Svay*



KHM568, *Chong Samrong*

Fig. 7 — Examples of the fabrics of brown glazed stoneware or biscuit from the different kiln sites.

The glazes are often very thick and runny, especially on the jars (fig. 8). Their colour is very variable and often not very homogeneous: dark green to black with occasional yellow spots.

At kiln sites, the presence of unglazed sherds, most often red in colour, interpreted as biscuits, indicates that the glaze was placed on ceramics after a first firing, as observed on all other Angkorian kiln sites (biscuit, fig. 9).

Fig. 8 — Example of the glaze on jar sherd. Note the thick drips and brown spots due to iron oxides.



Fig. 9 — Examples of biscuits found on the kiln sites.

Chronology

This ware was principally produced at the end of the Angkorian period. The location of the Torp Chey kilns on the Preah Khan road to Kompong Svay and near a staging post suggested that the installation of these kilns was related to the reforms of Jayavarman VII at the end of the 12th century (Hendrickson 2008). However, brown glazed stoneware of this type is found on practically all Angkorian sites, especially in the late levels (13th–14th centuries) and it does not seem that production started before the 13th century, or even before the end of that century. The Torp Chey type stoneware, based on technical characteristics, thus seems to represent the last group of stoneware that Bernard Philippe Groslier placed at the end of the 13th century.¹

Radiometric dating carried out on the Veal Svay kiln (Tabata *et al.* 2015) confirmed a late dating, with two possibilities: 1281–1312 AD or 1358–1388 AD (2 sigma dating). More recently, the recalibration of the radiometric dating of Veal Svay and Torp Chey has confirmed a 14th century production date (Marriner *et al.* 2018).

Materials and methods

Analytical methods

In the archaeometrical part of the program, we sought to determine the chemical composition of the fabric of the brown glazed stoneware in order to define the chemical composition of the ceramic body. To accomplish this goal, we used a long-established analytical method, the wavelength Dispersive X-ray fluorescence spectrometry (WD-XRF). In the Archaeometry and Archaeology Laboratory in Lyon (CNRS, France), we employed a Bruker 4kW S8 Tiger spectrometer with a Rh excitation source. We followed the protocol established by our laboratory defining the conditions for samples preparation as well as the apparatus parameters used and the proper calibration settings (Thirion-Merle, Thierrin-Michael & Desbat 2019; Thirion-Merle 2014; Waksman 2014). This procedure applied on sherds from which the external layers were removed provides the bulk chemical composition of the ceramic (matrix plus inclusions) and consequently of the material used for its manufacture. Twenty-four elements are determined, including some typical majors and traces characterising clay material, but also other elements, such as phosphorous, that point to contamination following burial of the samples.

Petrographic analyses on thin sections under a polarising microscope were also carried out on a selection of chemically analysed samples with the main aim to identify the nature of the inclusions contained in the stoneware. The selected ceramic samples are representative of the identified chemical compositional subgroups.

¹. “It is therefore, only approximately, that I place the appearance of a last group towards the end of the 13th Century. It includes stoneware with very thick, runny and marbly glaze. It goes from black to dark green with sulphur-yellow marbling.” (Groslier 1981, p. 30.)

The samples

Sixty-nine samples collected from the four mentioned kiln sites during our field surveys made between 2009 and 2013 were analysed chemically (Torp Chey n=29, Veal Svay n=7, Chong Samrong n=24 and Teuk Lek n=9). The analysed samples correspond mostly to glazed jars of different sizes but also to basins and bottles. The sampling also includes six samples which can be considered as biscuits, in so far as they are unglazed and do not appear to be fired at high temperature. We also analysed five samples of clayey material collected near the kiln sites as potential raw materials.

The petrographic analyses on thin sections under the polarising microscope were carried out on twenty-five chemically analysed samples.

Results and discussion

Compositions of the samples

The chemical compositions obtained by XRF analyses of the brown glazed stoneware of the four kiln sites are presented in Appendix 1 (Major and minor elements are given in oxides weight %, trace elements in parts per million). The results are presented in their order of appearance on the dendrogram of figure 11. The compositions of this type of stoneware is characterised by high silica (SiO_2) and alumina (Al_2O_3) contents and low contents in alkaline (Na_2O^2 , K_2O) and alkaline-earth components (CaO , MgO), which denotes the use of kaolinitic clay materials (containing a high proportion of the clay mineral kaolinite with the chemical formula $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$). The compositions are also distinguished by very high iron oxide contents.

The mean composition for each kiln site is quite similar (table 1). We also observe notable variations in some major components like lime (CaO), magnesia (MgO), potash (K_2O), manganese oxide (MnO) as well as in some trace elements such as nickel (Ni), strontium (Sr) or cerium (Ce), expressed in high values of s%.

Among the five samples of clay collected near the kiln sites, two show very different compositions, including high contents of silica (>83 wt%) associated with high contents of zirconium (Zr) and low contents of alumina (about 10 wt%). The data indicate that this material was too sandy, and therefore not adapted to the manufacture of ceramics (Appendix 1). The other clays have compositions which, while not exactly corresponding to those of stoneware (notable differences on lanthanum, barium, or potash) nevertheless share common characteristics with inter-element correlations similar to those of stoneware (see the binaries of fig. 10 where the clays are represented by a red dot; KHM824 is the most different).

² 3. Besides, this component is below the detection limit fixed at 39 ppm with our spectrometer.

	CaO	Fe	TiO	K	SiO	Al	MgO	MnO	Zr	Sr	Rb	Zn	Cr	Ni	La*	Ba	V	Ce
	wt%								ppm									
Torp Chey kiln site (n=29)																		
m	0,29	6,89	0,763	1,59	69,53	19,90	0,82	0,0130	249	51	81	39	74	23	39	276	116	64
s	0,12	0,87	0,035	0,35	1,77	1,04	0,16	0,0030	23	11	17	12	8	9	11	40	13	16
s%	41	13	5	22	3	5	20	23	9	22	21	31	10	40	27	15	12	25
La* = mean calculated on 26 values																		
Teuk Lek (n=9)																		
m	0,28	7,45	0,765	1,60	68,69	20,21	0,83	0,0139	250	45	88	46	82	26	46	286	121	66
s	0,14	0,64	0,028	0,36	1,32	0,72	0,14	0,0034	25	12	15	12	7	11	13	35	8	26
s%	48	9	4	22	2	4	17	24	10	26	17	25	8	43	29	12	7	39
La* = mean calculated on 6 values																		
Veal Svay (n=7)																		
m	0,26	7,81	0,764	1,39	68,40	20,49	0,74	0,0108	245	43	77	40	80	24	51	267	125	69
s	0,13	1,23	0,034	0,19	1,63	0,87	0,10	0,0016	9	10	7	13	7	12	19	60	17	28
s%	50	16	4	13	2	4	13	15	4	23	9	33	8	50	37	22	14	40
La* = mean calculated on 5 values																		
Chong Samrong (n=24)																		
m	0,30	6,96	0,746	1,37	70,07	19,64	0,78	0,0142	265	44	79	42	76	26	53	267	113	70
s	0,12	0,98	0,057	0,22	2,36	1,48	0,12	0,0045	22	10	12	10	7	8	19	56	13	34
s%	42	14	8	16	3	8	16	32	8	23	15	25	9	30	35	21	11	49
La* = mean calculated on 15 values																		

Table 1 — Average chemical composition of brown glazed stoneware for each kiln site, obtained by wavelength-dispersive X-ray fluorescence spectrometry (WDS-XRF), expressed as wt% for majors and minors and as ppm for traces (s = standard deviation, s% relative standard deviation).

Comparison of the Torp Chey area productions

We employed a statistical approach to compare all the samples and to classify them into groups based on their compositions. The dendrogram resulting from Hierarchical Cluster Analysis³ on the 69 samples shows the variability of the compositions of this type of stoneware. Indeed, several subgroups appear on the dendrogram as well as two isolated samples situated between these groups (fig. 11).

³. This hierarchical cluster analysis is a statistical data treatment using Euclidian distances calculated in this case on reduced centered data of seventeen chemical components. The dendrogram produced represents the relative distances between samples: the most similar samples are linked at the lowest distances. The objective is to group together homogenous data so as to identify compositional groups. The ceramics in the same group are more similar to each other than to those in other groups.

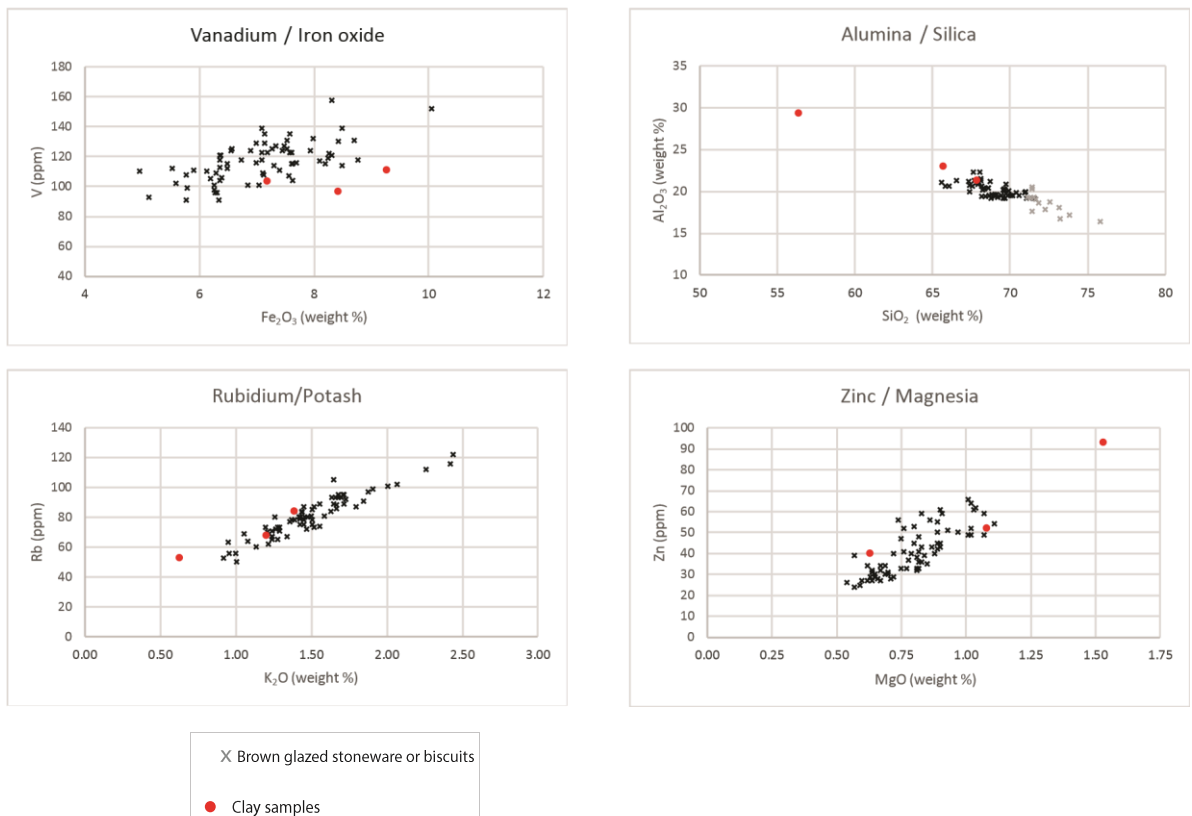


Fig. 10 — Selected binary plots with all analysed samples of the brown glazed stoneware and three clay samples.

Careful examination of the compositions of the stoneware that compose these five subgroups reveals slight variations, particularly in the contents of silica (SiO_2), alumina (Al_2O_3), potash (K_2O), rubidium (Rb), lime (CaO), magnesia (MgO), zinc (Zn) and nickel (Ni).

Thus, samples in subgroup 2 present higher contents of lime, magnesia, zinc and nickel. Those in subgroup 4 exhibit the highest potash, magnesia and rubidium values. Those in subgroups 3 and 5 contain more silica for less alumina. Subgroup 5's samples are distinguished, in addition, by higher potash, rubidium and manganese oxide contents. These variations are consistent with slightly varying proportions of clay minerals in the clay used by the potters.

An inverse correlation of silica/alumina is observed for all stoneware of our sampling (see binary SiO_2/Al_2O_3 on fig. 10 where stoneware of subgroups 3 and 5 are in grey). This silica/alumina inverse correlation is likely related to the existence of a sandy phase of variable abundance between groups. It is difficult to know if these variations are the reflection of a deliberate addition of sand made by the potters for the stoneware of subgroups 3 and 5 or whether the variation is simply due to the place of extraction of the clay.

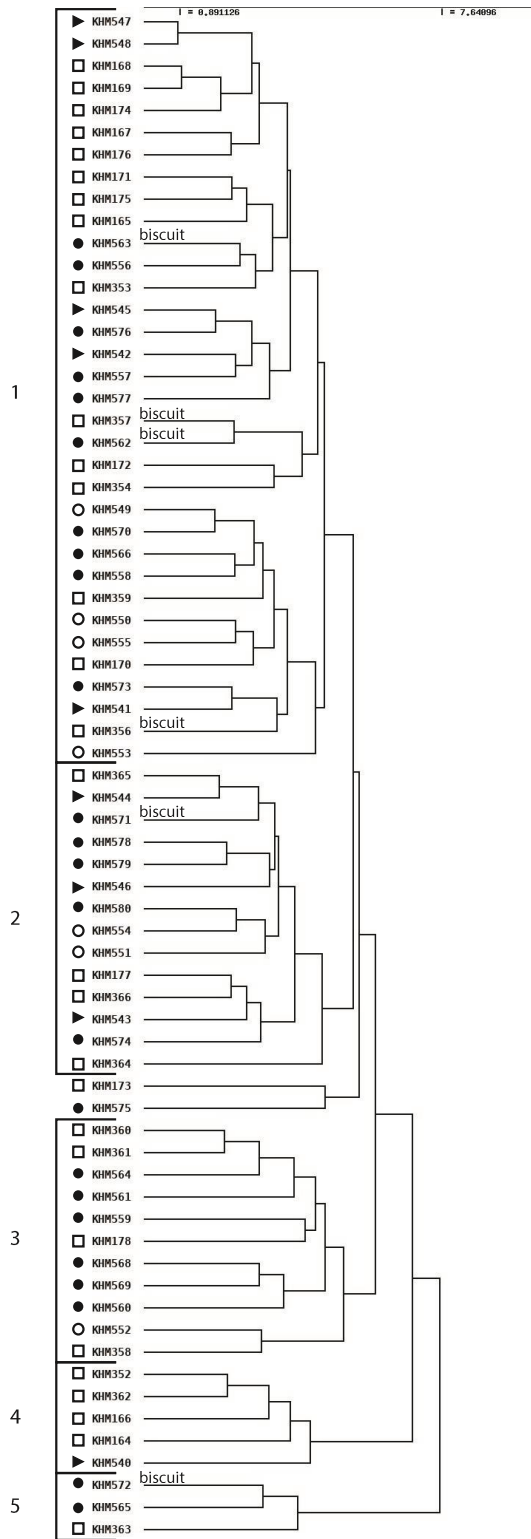


Fig. 11 — Dendrogram of the cluster analysis of all analysed brown glazed stoneware from Torp Chey, Chong Samrong, Veal Svay and Teuk Lek (calculated on 17 components).

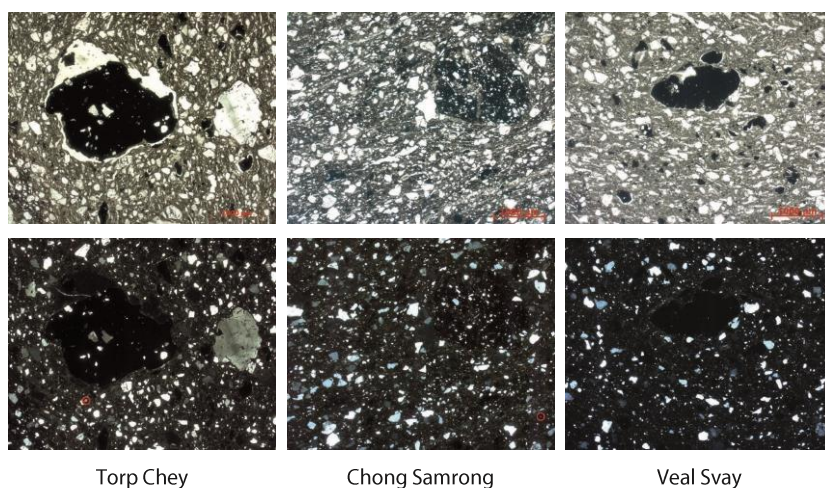


Fig. 12 — Fabric of stoneware from the Torp Chey area kilns. Thin section under the microscope, plane-polarised light above, crossed-polarised light below. Typical representatives from three kiln sites. Small amphibole grain circled red.

Petrographic description

All studied samples show very similar features under the microscope (fig. 12): particularly high proportion of angular to subrounded inclusions (about 40–45 vol%) and frequent iron-rich nodules. The grain size distribution appears unimodal, with a high amount of grains between 0.2 and 0.5 mm. Largest grain sizes range between 0.7 and 1.5 mm. Inclusions consist essentially of monocrystalline quartz grains. Rare microcrystalline quartz and plagioclase may also be present, as well as some small amphibole grains and some very small unidentified coloured grains. Ferruginous nodules reach diameters up to several mm. Some of them show a porous texture, while others contain small inclusions of quartz. The matrix colour varies from dark brown to reddish, and the difference in colour may be due to differences in the iron content or to different firing atmosphere or to both.

While the size and frequency of inclusions and nodules vary slightly among the samples, no subdivision into coherent subgroups is possible. Samples from the different kiln sites in the Torp Chey region are not distinguished by particular petrographic characteristics but form one fabric group. This finding corroborates the results of the chemical analyses.

Reference group constitution

One way to determine provenance is to link ceramic types directly to specific clay sources. However, due to many factors, it is often very difficult to connect the analyses of clays sampled nowadays to those of ancient ceramics, as exemplified by our case study. First of all, we have no way of knowing exactly where the potters procured their clay, or even whether the deposits still exist. In addition, practices employed in pottery making can cause changes in chemical composition. Such changes could occur in the processes of levigating the clay, by which coarse particles are removed or of tempering the clay, in which sand or rock fragments may have been added. Therefore, it is not surprising that our clay samples do not correspond entirely to the brown glazed stoneware produced between the 13th–14th centuries.

What is evident from our analytical results is that none of the identified subgroups on the dendrogram correspond to one particular kiln site, as the references of each kiln site are scattered over the whole dendrogram. Neither do we observe a cluster of the biscuits or of specific forms of ceramics. In addition, no distinction can be made on the basis of petrographic observations. These results indicate that the potters working on the four different kiln sites, regardless of the chronological period, made use of the same type of clay material to produce their brown glazed stoneware, at least clay material of the same geological formation if not from the same clay pits.

We propose therefore that all these samples constitute a single reference group for the brown glazed stoneware produced in this area. We have named this assemblage the ‘Torp Chey Reference Group’ since the kiln site of Torp Chey was the first discovered and studied.

One final remark regarding this reference group: it is clearly distinguished from the compositional groups established for the kiln sites located near Angkor, suggesting the use of a radically different clay raw material (Thirion-Merle, Thierrin-Michael & Desbat 2019; Grave *et al.* 2017). This is in fact an expected result as the productions of the kiln sites close to Angkor are totally different from the Torp Chey area productions from all points of view: ceramic types, repertoire of shapes as well as fabrics.

Distribution

These kiln sites produced brown glazed stoneware probably from the end of the 13th century to the 14th–15th centuries and distributed their products mostly to Angkor. Indeed brown glazed stonewares, which exhibit the same technical and typological characteristics (like specific decoration, coarse dark fabrics, thick walls, brown glaze often with thick drips, as described before) as those of the brown glazed stoneware discovered on the kiln sites of the Torp Chey area, are abundantly present on the most recent levels of occupation of numerous Angkorian sites. It seems that those kiln sites distributed their products much further than Angkor, especially to the west, as our own field survey identified this type on sites distant from Angkor located near royal roads notably in the Uddar Meanchey province (see map on fig. 3), even on sites supposed/proposed as local kiln sites (Ea 2009; Cerangkor 2015).

Fifteen sherds deriving from excavations of Angkorian sites (Trapeang Pong, Bakong [Mafkata 2007], Angkor Wat, Prasat Konnap Sud, Tuol Ta Lo [ASR 2016a and 2016b]), and six from three sites located in Uddar Meanchey province (Kok Yeah Degn, Thlock Akoang and Kok Kjeay [Ea 2009]) were analysed to confirm whether they were produced in the Torp Chey area, as could be determined on the basis of their chemical compositions.

In general, to confirm the attribution of ceramics, it is necessary to explore all possible provenance hypotheses so as to exclude other proveniences. Buriram in Thailand is another well-known glazed stoneware production centre. Archaeologists have discovered over 100 kiln sites producing among others brown glazed stoneware from the end of the 12th century (Khwanyuen 1985; Srisuchat & Srisuchat 1989; Natthapatra 1990). Between 2015 and 2017, the Cerangkor team conducted several surveys of the Buriram kiln sites (Ban Kruat and Lahansai districts). Reference groups for each category of stoneware have been constituted and can be used for provenance studies (Cerangkor 2014 and 2015; Mafkata-Cerangkor 2016

to 2018). Buriram's productions include green glazed stoneware and brown glazed stoneware, as well as some two-tone glazed stoneware. The shapes are many and varied. The repertoire of forms is very different from that of Kulen stoneware and much richer. It includes bowls, urns, boxes, lime pots, zoomorphic pots, bottles, including anthropomorphic bottles, baluster vases and jars. This repertoire is also richer than that of the Torp Chey type stoneware. On some kiln sites, brown glazed stonewares form the majority of the assemblage. Most of the brown glazed stonewares are made of a coarser clay than the green glazed stoneware (Cerangkor 2014 and 2015; Mafkata-Cerangkor 2016 to 2018).

We compared the different stonewares found on consumption sites to the two reference groups, Torp Chey and Buriram. The cluster analysis of all the samples is given in figure 13. We observe that the reference samples from the Torp Chey kiln sites are totally distinct from those of the Buriram province, and the two reference groups are easily differentiated. Moreover, most of the samples from the different consumption sites are dispersed inside the Torp Chey references confirming that their compositions correspond to those of the Torp Chey kilns and not to the Buriram kilns. Some of them are nevertheless linked at a fairly high level at the end of the Torp Chey references group (ANK 1, KHM505, KHM780, KHM798) suggesting that the composition of these samples does not correspond exactly to those of the references.

Indeed, we note an erratic behaviour of certain chemical elements as those samples are distinguished only on the basis of one or two chemical elements. For example, the composition of ANK 1 sample is distinguishable on the higher cerium and manganese contents, for KHM505 principally its cerium content. This erratic behaviour of certain chemical elements also occurs naturally in clay deposits. In this case it would be possible that these particular samples do come from the Torp Chey area kilns.

We may not have analysed all the representative stoneware from this area and from all time periods, so we may have only a partial view of the characteristic chemical compositions. It is conceivable they are made at kilns in other as yet unknown areas.

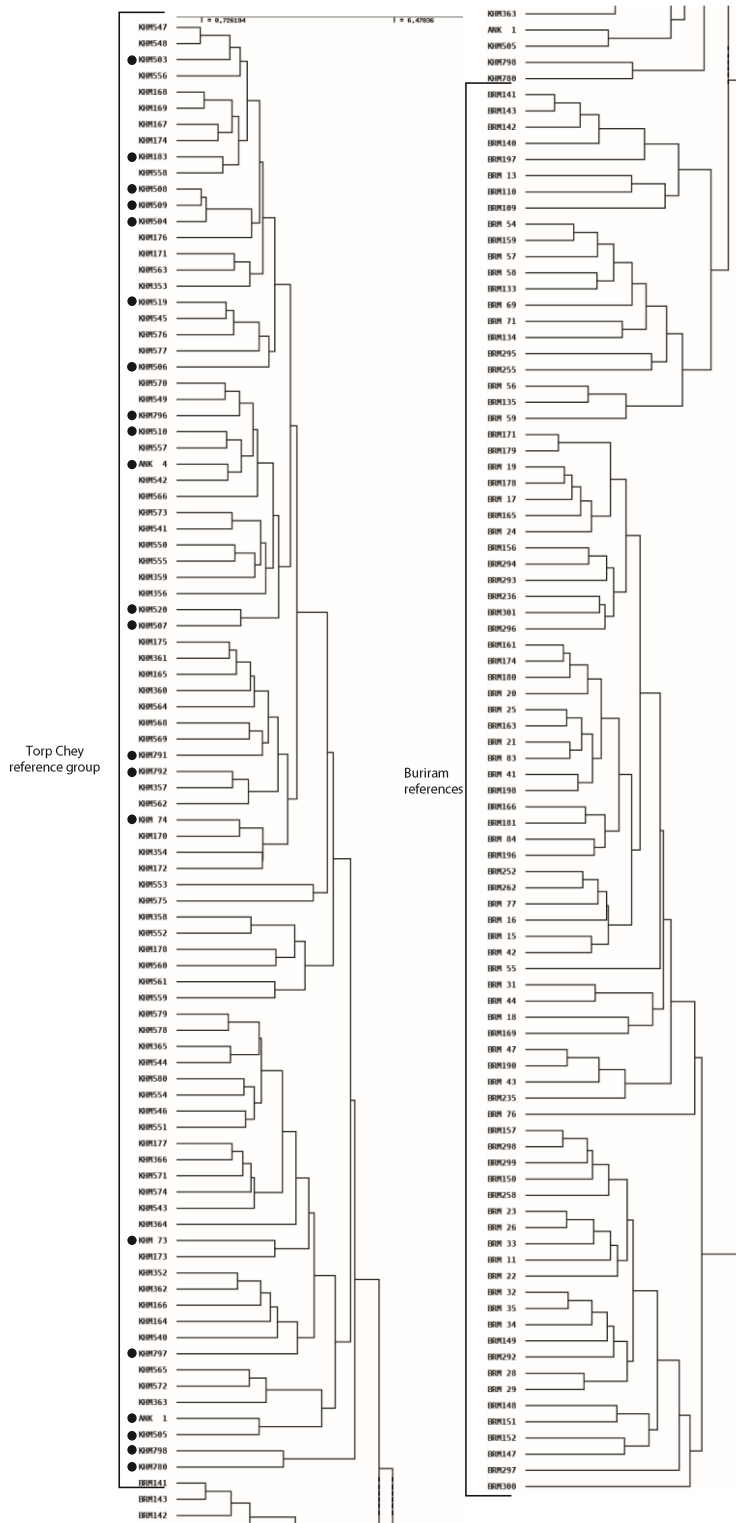


Fig. 13 — Dendrogram of the cluster analysis of the Buriram and Torp Chey references with the samples of unknown origin found in consumption contexts (black dot) (calculated on 17 components).

Conclusion

The brown glazed stonewares from the kiln sites located in the Torp Chey area present exactly the same characteristics. The repertoire of shapes, decorations, glazes, and also fabrics are strictly identical and indistinguishable from one site to another. As expected, their chemical and mineralogical compositions are similar and a single compositional reference group can be confidently defined. This reference group cannot be confused with the Kulen stoneware produced in the several kiln sites near Angkor. The clay used by the potters in the Torp Chey area was derived without any doubt from a different geological source.

This new reference group is readily differentiated from the Buriram products of quite the same chronological period. On the basis of these results, it is possible to determine the provenance of brown stoneware found in consumption contexts. The chemical analyses carried out confirm that the stonewares from the Torp Chey area are significantly present on most of Angkorian sites, even in remote provinces such as Uddar Meanchey. The results of our multipronged analysis thus validate the hypothesis of a wide diffusion of ceramics produced at the kilns sites of the Torp Chey area.

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