Contemporary pottery from São Vicente, Madeira (old captaincy of Machico): physical and chemical characterization

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Archaeological prospecting conducted in 2008 in Lameiros, São Vicente led to the identification of an unusual pottery production site with a kiln, whose dating can go back to the 19th century. The pottery centre has supplied a considerable area in the northern part of Madeira Island through the local markets, merchants and coastal shipping. The typological universe includes containers for storage of liquids and solids, with printed and carved decoration, as well as tiles and bricks. X-ray Fluorescence Spectrometry allowed a chemical characterization of samples of ceramic fragments obtained from the archaeological prospecting, as well as for local clays, for 13 different chemical elements. With the analytical results, chemical groups have been determined by a multivariate statistical analysis of the hierarchical clustering type. The results allowed us to form two groups, slightly different from each other, the first one with 43 samples and the second with 13 samples. Local clays are well included in the first group, even if relevant scattering has been observed in some minor elements, like calcium and manganese. The two groups differ especially in iron and titanium contents, with the other elements showing a quite similar chemical composition pattern. This work allowed us to obtain a full characterization of local pottery productions from São Vicente, in Madeira, helping in the determination of the origin of archaeological ceramic fragments found in that island and elsewhere.

KEYWORDS: X-RAY FLUORESCENCE SPECTROMETRY, POTTERY, ARCHAEOLOGICAL CERAMIC FRAGMENTS, CHEMICAL CHARACTERIZATION, LOCAL POTTERY PRODUCTIONS

11.1 Introduction

The present paper intends to briefly think over the chemical characterization results of samples coarse pottery fragments obtained from the archaeological prospecting from São Vicente, Madeira. This will help to determinate the origin of the archaeological ceramic fragments and the clay classification in the island and elsewhere.

In addition, this short communication intends to refer the following three crucial subjects: the historical and geographical context, the typological and morphological issues of the kiln and coarse ceramic (examining the origin, production, and form), and the two groups of chemical characterization.

Location

The Banda do Sol Kiln Pottery site is located on the site of Lameiros, in São Vicente, in the North of Madeira Island, at 400 m of altitude. It is possible to witness local exuberant volcanic mountains and rural landscapes stones terraces (locally called *poios*).

Until the 18th century this village belonged to the captaincy of Machico, an area that geographically included half of Madeira Island.

Part of this site is included in the Madeira Nature Park and here it is possible to observe several species of indigenous forest, the *Laurissilva*, which is classified as World Natural Heritage by UNESCO.

The pottery industry of the São Vicente dates back to the 17th century, when the settlement process in the North of Madeira was established. However there are still no archaeological evidences of ceramic from this period. This situation embodies the absence of archaeological rescue and preservation works in the historical centre and the surrounding area.

The Archaeological Prospection and the Oral Tradition History—2008

In 2008, a project entitled "*The Pottery in the Madeira Archipelago*" detects the first physical evidences from the pottery kiln of Banda do Sol, at Lameiros, São Vicente. In this research we identified several coarse potsherds at the surface and the exact location of the kiln.

In addition, we have recorded oral traditional with locals who witnessed the production of pottery vessels that were produced in the local pottery kiln, whose dating can go back to the second half of the 19th century.

The interview led us to Mrs Gregory Andrade, an 81 years old person who was crucial to find the exact location of the pottery kiln, the clay extraction sites, and to understand the process of manufacture and to understand the correct terminology of the pottery forms.

The Pottery Kiln and the pottery forms

The cited oral interview allowed us to realise that the structure of the pottery kiln was quadrangular, built with red and yellow volcanic *tufa* blocks (Figure 11.1). It can be inferred that while the lower part of the kiln, with the combustion chamber, appears to be more or less intact, the roof has collapsed.

These rural potteries were usually close to the clay pits and were operated part-time by farmers, in a familiar industry, which normally was passed down through the generations.

According to the data collected during the archaeological prospection, it was possible to identify different forms of Madeira coarse pottery, with different functions. At first, the major production, as the oral tradition confirmed, are the salting pot fragments (or cylindrical jars, locally called *salgadeiras*) (Figure 11.2), mixing pots (*alguidares*) (Figure 11.3), and large rounded jugs (*púcaras*) (Figure 11.4).

Other forms such as soup bowls (*terrinas*), stoops (*bilhas*) and semi-cylindrical ceramic tiles were observed. Unfortunately no archaeological excavation has been performed in this site thereby the information about its production is still unclear and it is not possible to confirm if they were made there. The maximum diameter of the salting pot (Figure 11.2) is 400 mm. The border is simple outcurved with a slightly rounded lip. The paste is red M37 (Cailleux 1986). The body wall is approximately 10 mm thick. The rim flanges can be up to 10 mm across.

The mixing pot has a flat inverted rim. The rim diameter is 200 mm with fine to medium-fine textured red paste, N25 (Cailleux 1986). The body wall diameter of the large rounded jug is approximately 8 mm.

In this short sample of coarse ceramic it was also possible to detect the marks from wheel-thrown. The red surfaces were also decorated with incised designs (with wavy and straight lines). This decoration is also found in several objects from the 17th century from the archaeological contexts in the city of Machico and Funchal (Sousa 2011).

The most characteristic paste colour is pale red or orange, with medium texture. Some of them had samples of deliberate inclusions (grogs). It was also possible to detect small crushed stones from geological origin.

It is possible to assume that the ceramics were not finished since the pottery has been fired but was not glazed. From an historical point of view, glazed pottery was only introduced in the Madeira archipelago during the 19th century, particularly in the historical urban centre of the capital, Funchal, with clays samples from the Portuguese mainland (Sousa 2011).

11.2 Chemical analysis of ceramic and clays samples interest for archaeological studies

A chemical characterization of samples of ceramic fragments obtained from the archaeological prospecting, as well as for local clays, was done by X-ray Fluorescence Spectrometry for 13 different chemical components: SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, Mn, Ba, Zr, Sr and Rb. The analytical methodology included the cleaning of the surface of samples, its milling and the production of a fusion bead with a lithium borate based preparation. Chemical results were then normalized to 100 % for the 13 components, thus avoiding contamination effects, like moisture, vegetable and other organics as well as chlorides, from culinary uses, for example.

The statistical treatment of the results considered hierarchical clustering methods, then comparing groups and individual samples compositions with those present in a large database managed by Laboratory of Chemical Analysis of TecMinho, Guimarães, Portugal. This database contains hundreds of provenance and archaeological groups, derived from more than 2,000 analysed samples mainly from archaeological and ethnographic ceramics, as well as clays, from Portugal and from some regions in the North of Spain (Castro *et al.* 1997; Castro 1999; 2004). The comparison of the chemical compositions of the groups with those in the database was done by the calculation of the Mahalanobis distance between groups.

A total of 56 ethnographic ceramic fragments and 4 local clays were analysed. Ceramic fragments were of different types: 26 pottery fragments, 26 brick fragments, and 4 tile fragment. All fragments presented in Figures 11.2 to 11.4 are included in the 26 pottery fragments samples.

The obtained results allowed to form 2 different groups of ceramic samples—group S. Vicente 1 accounting for 43 samples, and group S. Vicente 2, for 13 samples—, as well as one group for clay samples—with the 4 clay samples.

The belonging of samples types to each of the so formed groups is indicated in the Table 11.1 below presented.

For pottery samples, no relationships were found between chemical groups and ceramic typology, when considering forms, paste colour, grain size and texture. The fact that all brick samples are included inside group 1 could suggest that they were made with a lower quality or less depurated clay. However, the observed paste typology does not allow us to confirm this premise, as no relevant differences were found in this context.

The following Table 11.2 summarizes the obtained results, in terms of group average and standard deviation for each component.

These results show very slight differences between the 3 groups. As a matter of fact, the differences between these groups are not very significant from a statistical point of view. Except for elements Fe and Ti, where some significant differences appear between the groups S.

Vicente 1 and S. Vicente 2. A scatter plot is shown bellow (Figure 11.5), illustrating the differences in content for these two components, inside the 3 groups.

The fact that the differences between groups are quite small and that no major relationship between chemical composition and typologies, lead us to consider the formation of one global group, that we consider representative of the S. Vicente production, whose chemical average charactericanstics are shown in Table 11.3.

This group is significantly different from any other groups present in the database, enabling us to consider this is the typical chemical composition pattern of local ceramic production in S. Vicente, Madeira Island. The quite high TiO_2 content is coherent with the volcanic origin of the Island of Madeira, where a volcanic stratigraphic unit is identified exactly for the local: the Lameiros Volcanic Unit (CVI2), according to the Geologic Map of the island (Brum *et al.* 2010). As a matter of fact, Fe-Ti correlations are expected in volcanic geological materials, where the presence of constituents like ilmenite ($FeO{\cdot}TiO_2$) is normal (Carmichael 1967; Ahmad and Shrivastava 2004). Our results suggest that, in the extraction of local clays, different iron titanates concentrations could appear in different extraction zones, thus resulting in different Fe-Ti concentrations. A global consideration of the local ceramic productions seems hence more adequate for future research purposes, as represented for chemical purposes by the "S. Vicente-global" group above described. The slight differences between S. Vicente 1 and S. Vicente 2 groups must however not be neglected; further research being need to confirm, or not, that such differences are relevant for archaeometric and ethnographic studies.

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	Group S. Vicente 1	Group S. Vicente 2
Pottery	15	11
Bricks	26	0
Tiles	2	2

Table 11.1: Belonging of samples to groups according to sample type.

Group		SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	TiO_2	CaO	MgO	Ba	Zr	Sr	Rb	Mn
S. Vicente 1	$\bar{x}$	51.86	25.47	14.37	0.69	0.64	3.33	1.19	1.91	310	580	123	44	1,501
	s	1.08	1.12	0.50	0.13	0.17	0.12	0.27	0.19	59	47	25	3	424
S. Vicente 2	$\bar{x}$	53.89	25.69	11.79	1.26	1.38	2.74	0.91	1.85	293	727	111	46	1,016
	s	1.04	0.51	0.72	0.22	0.28	0.11	0.18	0.22	55	49	25	8	276
S. Vicente clays	$\bar{x}$	53.97	23.98	13.48	0.72	0.79	3.22	1.42	2.13	308	515	119	45	1,705
	s	1.74	1.62	1.10	0.20	0.45	0.20	0.69	0.54	68	49	30	2	923

Table 11.2: Chemical analysis of formed groups. Ba, Zr, Sr, Rb and Mn in ppm. The other components in wt %. $\bar{x}$: mean. s: standard deviation.

		SiO_2	$Al_2 2O_3$	Fe_2O_3	K_2O	Na_2O	TiO_2	CaO	MgO	Ba	Zr	Sr	Rb	Mn
S. Vicente global	$\bar{x}$	52.23	25.49	13.80	0.83	0.82	3.19	1.18	1.95	308	614	123	44	1,363
	s	1.31	1.11	1.21	0.28	0.37	0.28	0.53	0.44	60	80	41	5	394

Table 11.3: Chemical average characteristics of the S. Vicente production. Ba, Zr, Sr, Rb and Mn in ppm. The other components in wt %. $\bar{x}$: mean. s: standard deviation.

Figure 11.1: Structures in red stone *tufa* from the pottery kiln of Banda do Sol.

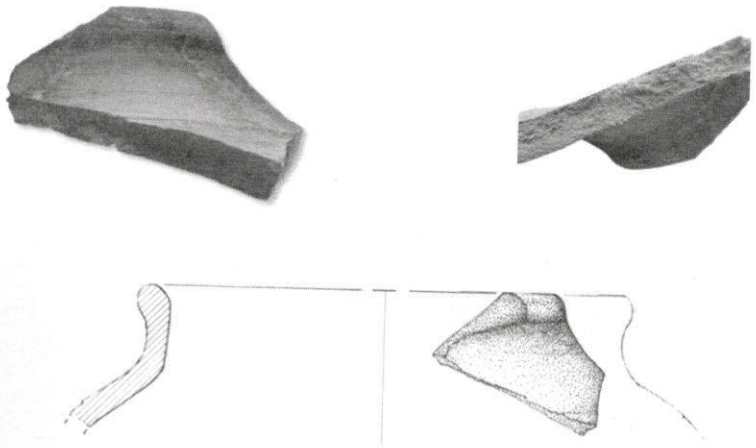

Figure 11.2: Salting pot (*salgadeira*).

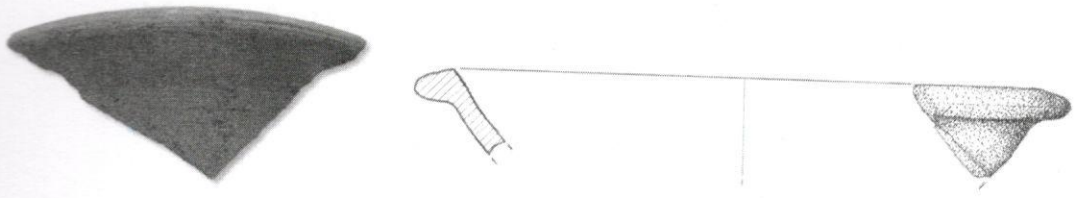

Figure 11.3: Deep dish (*alguidares*).

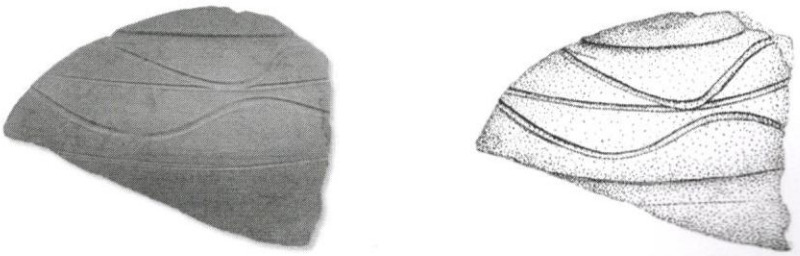

Figure 11.4: Jug (*púcara*).

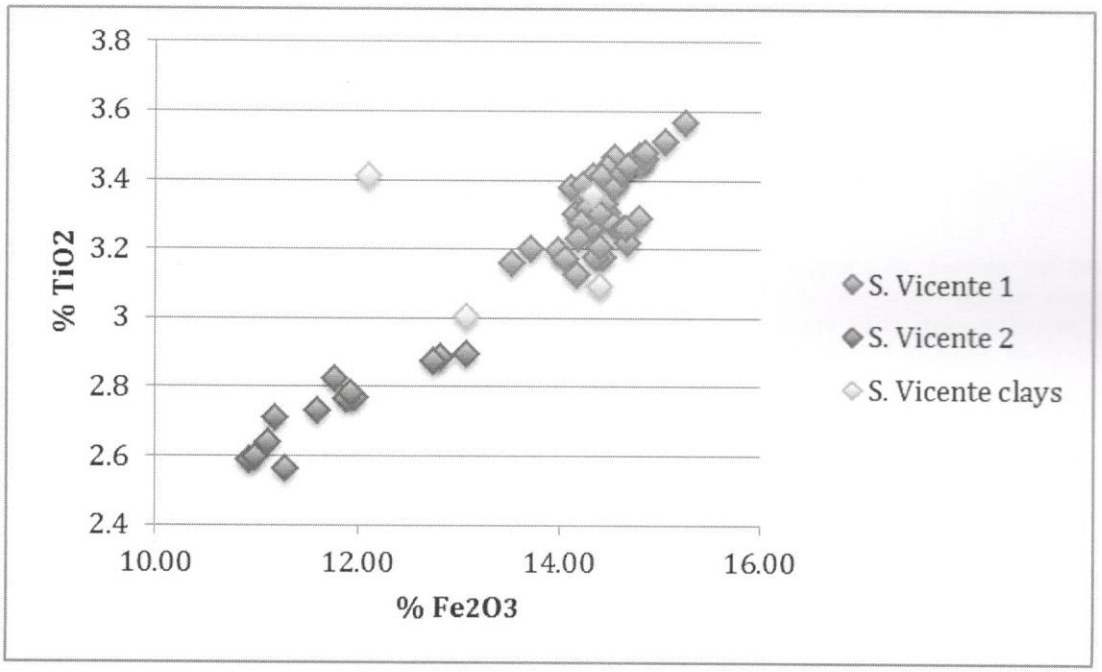

Figure 11.5: Scatter plot representation of Fe_2O_3 % and TiO_2 % in the formed groups.