Petro-Chemical Characterization and Statistical Multivariate Analysis of Ancient Pottery from Syracuse, Sicily

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Abstract

The petro-chemical composition of 54 samples of fine pottery coming from the archaeological site of Syracuse (common pottery, black varnished pottery, lamps, and 5 kiln wasters) have been established by means of X-Ray Fluorescence and optical microscopy. 12 samples of Hellenistic Achroma pottery produced in Syracuse were used as reference materials. Three groups were recognized on the basis of their petrographic features (i.e. micaceous-fossil rich matrix, micaceous-fossil poor matrix, micaceous quartz-rich matrix). Chemical data were transformed following the method proposed by Aitchison [1] and next processed by means of biplots. These latter allowed us to the identification of two main chemical groups (namely A and B) partially corroborating the petrographic observations. Moreover the discriminant analysis was useful for some provenance inferences. In particular the results showed that samples of group A are probably local as kiln wasters are classified in their group whilst the group B could be imported.

Introduction

The analysis of fine pottery is a complex topic in the archaeometric studies of provenance mainly because of the small size of the inclusions. In this framework the petrographic analysis have to be joined by additional techniques such as chemical and statistical analysis. This latter is particularly powerful if it's needed to find out reference groups and provenance areas of the imported artefacts. In this work 54 pottery samples coming from the archaeological site of Syracuse and referred to the Hellenistic-Roman period were analysed for petrographical and chemical composition with the aim to characterize the ceramic production of this important Greek colony.

The compositional data were processed following the method proposed in reference [1] with the purpose to i) compare the results of the petrographical and statistical analysis and ii) give some suggestions about the provenance of the analysed samples.

Materials & Methods

54 samples of fine pottery (common pottery, black varnished pottery, lamps, and 5 kiln wasters) were analysed for chemical and petrographical compositions. 12 samples of Hellenistic Achroma pottery produced in Syracuse were used as reference materials [2].

Chemical analyses, for major and trace elements, were performed by X-ray fluorescence spectrometry, (Philips PW 2404/00) on powder pressed pellets; total loss on ignition was gravimetrically estimated after overnight heating at 950°C. The petrography of the samples was studied by means of polarized light microscopy.

The statistical methodology is mainly based on the log-ratio technique introduced by Aitchison [1] and employed in order to avoid the constant sum problem; the centred logratio transformation (clr) of data is applied as follows:

$x \in SD \rightarrow y = \log (xD / gD (x)) \in RD$

Where x = composition, xD = (x1, x2, ….xD), y = log transformed composition and gD(x) = $D\sqrt{(x1 \cdot x2 \cdots\cdots xD)}$. This operation transforms the data from their constrained sample space, the simplex Sd, into the real space Rd where parametric statistical methods can be applied to the

transformed data. Next the clr-transformed dataset is explored by biplots, a graphical representation of variables and cases projected onto principal components planes. Both clr-transformation and biplots calculation have been obtained by using CoDaPack [3], a compositional software that implements the basic methods of analysis of compositional data based on log-ratios, following the methodology introduced by Aitchison [1].

The discriminant analysis has been performed by the SPSS software package.

Results

The petrography of the analysed samples was described by means of the Whitbread [4] method. Three groups were distinguished: 1) micaceous-fossil rich matrix, 2) micaceous-fossil poor matrix, 3) micaceous quartz-rich matrix.

Common, black varnished potteries and kiln wasters are characterized by an homogeneous chemical composition in which SiO_2 is generally around 60% and CaO is higher than 6-8%. The lamps have a more heterogeneous composition with higher SiO_2 contents and variable CaO values.

The statistical analysis of compositional data started with the calculation of the *clr* variance: CaO, P_2O_5 and MnO amongst major elements and Nb, Th, and Ni amongst trace elements account for the largest variability and this is also confirmed by biplots. In particular the biplot of major oxides partially corroborates the petrographic observations as two main chemical groups were observed: group A (micaceous-fossil rich matrix + micaceous-fossil poor matrix) and group B (micaceous quartz-rich matrix). The discriminant analysis was performed considering the major elements of chemical groups (A and B) in order to find out the link between the pottery samples and the kiln wasters. For this reason the latter were not assigned to any predicted group. Moreover a group of reference materials (Hellenistic Achroma Pottery) was added too (i.e. group C). The results also validated by cross-validation, stress the correct classification of samples in the predicted groups and point that kiln wasters are classified in the first group (A). Samples of group C are clearly discriminated from the analyzed samples.

Conclusions

Multivariate statistical techniques applied to the chemical composition of ancient pottery were coupled with petro-chemical analysis with the aim to characterize the ceramic production during Hellenistic-Roman period in Syracuse. The occurrence of three groups found by means of petrographical analysis (framework composition and texture) was partially corroborated by the results of statistical processing. Furthermore discriminant analysis support the hypotheses that samples belonging to group A (micaceous-fossil rich matrix and micaceous-fossil poor matrix) are probably local as kiln wasters are classified in their group whilst pottery samples of group B (micaceous-quartz rich matrix) could be imported or produced by different raw materials. Reference materials produced in Syracuse (Hellenistic Achroma pottery) are clearly discriminated from the above-mentioned groups and this could be due to producing with different clays.

References

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