On the Importance of Using Sc to Normalize Geochemical Data Previous to Multivariate Analyses Applied to Archaeometric Pottery Studies

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Abstract

Among the several Roman ceramic production centres identified in the Tagus and Sado basins of Portugal, three were studied – Quinta do Rouxinol and Porto dos Cacos (Tagus) and Herdade do Pinheiro (Sado). Due to the homogeneity of the used raw materials (estuarine sediments), the distinction and establishment of signatures for each production center becomes difficult.

In this work a multivariate statistical approach after normalization of the chemical contents to a conservative element (Sc) was done, which able the differentiation among the three productions centers, allowing the establishment of provenance for amphorae.

A normalization procedure has been commonly used; however the criteria for its selection may vary. In this work it is emphasised the importance of taking into account geochemical behaviour of the element chosen for normalisation.

Introduction

Several Roman ceramic production centres have been identified in the Tagus and Sado basins of Portugal. Porto dos Cacos (PC) and Quinta do Rouxinol (QR) in the Tagus basin, and Herdade do Pinheiro (HP) in the Sado basin are the most important ones. Recent research also allows the detection of very broad chronological continuities (amphorae and common ware) between the 1st and the 5th centuries [1]. In the estuaries of the Tejo and Sado Rivers an intense occupation occurred in roman times, with fish-salting facilities close to the river mouth and small peripheral units further away, and with pottery centres located upstream, upon the banks of the main river and its tributaries. Regarding the importance of these Roman production centers, a spread of amphorae occurred all over the Roman Empire, thus being very important the establishment of each production center signature, which contributes to the trade reconstruction.

Amphorae produced in PC, QR and HP were not easily distinguished by mineralogical and textural (petrographic analysis) approaches [2]. This is mainly explained by the similarity of the used raw materials – estuarine sediments with a high degree of evolution, even between the two basins. Previous work showed that multivariate analyses applied to chemical contents doesn t clearly distinguish the three production centers, which could only be achieved using geochemical fingerprints [3].

Materials & Methods

Chemical analysis was done by means of instrumental neutron activation analysis (INAA), using the Portuguese Research Reactor, at Sacavém, Portugal, obtaining the concentrations of Na, K, Fe, Sc, Cr, Co, Zn, As, Rb, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Th, U. Multivariate statistical, namely clustering methods were employed by using the Statistica program [4], specifically the joining tree-clustering method, using the absolute concentration of the chemical elements and element/Sc ratios as variables. Sc was used due to its geochemical conservative behaviour. The amalgamation rule employed in the joining tree-clustering was the unweighted pair-group average, also referred as UPGMA (unweighted pair-group method using arithmetic averages).

In this method the distance between two clusters is calculated as the average distance between all pairs of objects in the two different clusters. The Euclidean mean was used as the similarity coefficient to identify outliers, and the Pearson correlation coefficient to evaluate correlation between chemical parameters.

Results

When trying to figure out chemical differences between and within the two basins, a first chemical differentiation based on cluster analysis using the absolute chemical elements contents as variables, enhanced the difficulty to distinguish productions within the same geological setting (Fig.1). On the other hand, when normalisation is done, performing element/Sc ratios, the three production centers are clearly differentiated (Fig. 2).

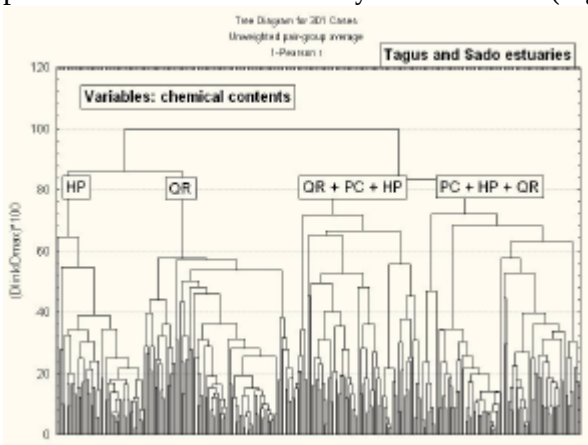

Fig. 1- Hierarchical tree – clustering of amphorae using chemical contents as variables.

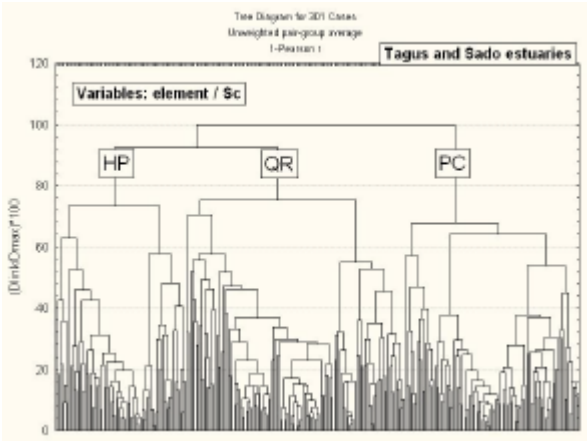

Fig. 2- Hierarchical tree – clustering of amphorae using element/Sc ratios as variables.

Conclusions

Comparative studies of ceramics produced with similar raw materials, like estuarine sediments, must pass by a first step of normalization procedure, in order to a better establishment of chemical signatures of productions. The normalization is also very important when temper mainly composed of quartz was used, diluting chemical differences. Among the elements with more residual behaviour, Sc (obtained with good precision and accuracy by INAA) was selected to normalize data prior to any statistical treatment, allowing to clearly differentiating the three production centers.

Conservative elements are more appropriate to normalize chemical data then other elements, even their variability is higher, since the raw materials are related with a specific geological context which has to be considered.

References

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