CONTRIBUTION OF NUCLEAR ANALYTICAL TECHNIQUES TO ARCHAEOMETRIC STUDIES

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This research is inserted in an archaeometry program at Activation Analysis Laboratory - LAN. In the last seven years, instrumental neutron activation analysis has been undertaken on ceramics of archaeological sites from several states: São Paulo, Minas Gerais, Pernambuco, Mato Grosso do Sul, and Amazonas in collaboration with various archaeologists. The archaeologists community from different universities of the country has responded enthusiastically to this program and we expect this research continue to grow. Evidence for the popularity of the Archaeometry Group at LAN includes its support for several research projects and analysis of hundreds archaeological specimens (ceramics and clays) since 1997. In addition, the Archaeometry Group has provided research training students from São Paulo University and others universities.

The students participate in the entire analysis beginning with sample preparation, irradiation, and measurement and continuing through the statistical analysis and data interpretation.

In our laboratory the sample preparation is made cleaning the ceramic fragment with tungsten carbide rotary file attached to the end of a flexible shaft, variable speed drill. Four or five holes are drilled as deep into the core of the sherd as possible without drilling through the walls. The powdered samples are dried in an oven at 100° C for 24 h.

Neutron activation analysis procedure at LAN for this program consists of four stages: -about 100 mg of ceramic samples and one standards (NIST-SRM-1633b Constituent Elements in Coal Fly Ash) it is weighed in polyethylene bags and involved in Al foil. Groups of 6-8 samples and one reference material are packed and irradiated in the swimming pool research reactor, IEA-R1, at a thermal neutron flux of about 5 x 10^{12} n cm^{-2} s^{-1} for 8 h.. Arsenic, Ba, K, La, Lu, Na, Nd, Sm, and YB are measured after 7 day cooling time and Ce, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Tb, Th, Zn and U after three or four weeks. Normally the interference of ^{235}U fission in the determination of La and Ce is negligible because U concentration is less than 5ppm and the REE are not too low. The main components of the clays (i.e., Al_2O_3, SiO_2 and water). However, it is the trace constituents - elements at concentration below 1,000 ppm - whose presence in clays is effectively accidental that provide the primary basis for provenience analysis.

It is reasonable to anticipate that a more complete analysis, especially one which determines the trace elements constituents, will increase the likelihood of success when utilizing chemical characterization for source determination. Also it is important to determine as many elements as possible to differentiate between chemical groups (i.e., geographical source areas). Comparisons between source areas in different regions will not necessarily use the same elements for the most effective separation.

The quantitative analysis at LAN use the log base-10 concentration; there are two reasons for this preference. First, for trace elements the data appear to be more normally distributed when treated as logarithms of the measured concentrations. The second reason is that transformation of concentration data into logarithms compensates for the differences in the magnitudes between the major elements, such as K, Fe, and the trace elements, such as the REE.

Frequently the statistical interpretation data in our group is made using several multivariate analysis, such as Mahalanobis distance, cluster analysis, principal components analysis, kernel density, discriminant analysis, Procrustes analysis, etc. Mahalanobis diatance we use to determine outliers in multivariate data.

Cluster analysis using the squared-mean Euclidean distance represented in a dendrogram as an initial step in the identification of groups. In principal components analysis the transformation of the data set is based on eigenvector methods to determine the direction and magnitude of maximum variance in hyperspace. However, Canonical discriminant analysis extracts a new set of variables that maximize the differences between two or more groups rather than maximizing the total variance of the data set. It is based on the assumption that the pooled variance-covariance matrix is an accurate representation of the total variance and covariance. It is assumed that all elements in the data necessarily belong to one of the known groups.

Procrustes analysis with stopping rule is used for selection of subsets of variables preserving multivariate data structure.