Instrumental Neutron Activation Analysis of Ionian Cups from the Western Mediterranean

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Introduction

This report describes the preparation, analysis, and interpretation of 92 pottery samples from two sites: a late 6^{th}-century shipwreck Pointe Lequin 1A, and the "Bourse" excavations in Marseille. The primary goal of this research is to address production location of the Ionian cups recovered from the shipwreck site. In this report we describe sample preparation, data collection, statistical procedures, address chemical group assignments, and possible matches with other pottery in the MURR database. The following analysis describes potential effects of the salt water on the shipwreck samples, the development of three distinct compositional groups and their cultural significance, and the comparison of this data to other Mediterranean data available in the MURR database.

Sample Preparation

Pottery samples were prepared for INAA using procedures standard at MURR. Fragments of about $1cm^2$ were removed from each sample and abraded using a silicon carbide burr in order to remove glaze, slip, paint, and adhering soil, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research.

Two analytical samples were prepared from each source specimen. Portions of approximately 150 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg of each sample was weighed into clean high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, Standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

Irradiation and Gamma-Ray Spectroscopy

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of 8×10^{13} n cm^{-2} s^{-1} The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24–hour irradiation at a neutron flux of 5×10^{13} n cm^{-2} s^{-1}. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr).

The element concentration data from the three measurements are tabulated in parts per million using the EXCEL spreadsheet program. Descriptive data for the archaeological samples were appended to the concentration spreadsheet. The data are also stored in a dBASE/FOXPRO database file useful for organizing, sorting, and extracting sample information. The data file enclosed with this report contains the sample database in EXCEL format.

Interpreting Chemical Data

The analyses at MURR described previously produced elemental concentration values for 33 elements in most of the analyzed samples. Calcium levels are often high enough to require the computational correction of the other elements according to the calcium concentrations; however the correction had no impact on the group composition, and thus was nut used in the analysis. A section below discusses the differences in the corrected and uncorrected datasets. The following is a description of the calcium correction procedure. Because calcium has the potential to affect (dilute) the concentrations of other elements in the analysis, all samples were mathematically corrected to compensate for any possible calcium included effects (the data were examined before and after calcium correction and the results were similar). The following mathematical correction was used as it has been proven to be effective in other calcium-rich datasets (Cogswell et al. 1998:64; Steponaitis et al. 1988):

$$e' = \frac{10^6 e}{10^6 - 2.5c}$$

where e' is the corrected concentration of a given element in ppm, e is the measured concentration of that element in ppm, and c is the concentration of elemental calcium in ppm. After the calcium correction, statistical analysis was subsequently carried out on base-10 logarithms of concentrations on the remaining 31 elements. Use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as calcium, on one hand and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify distinct homogeneous groups within the analytical database. Based on the provenance postulate of Weigand *et al*. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., clay samples) or by indirect methods such as the "criterion of abundance" (Bishop *et al*. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis *et al*. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential "sources" intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as "centers of mass" in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from non-compositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition technique to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). Each of the techniques has it own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components.

It is well known that PCA of chemical data is scale dependent (Mardia *et al*. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. As a result, standardization methods are common to most statistical packages. A common approach it to transform the data into logarithms (e.g., base 10). As an initial step in the PCA of most chemical data at MURR, the data are transformed into log concentrations to equalize the differences in variance between the major elements such as Al, Ca and Fe, on one hand and trace elements, such as the rare-earth elements (REEs), on the other hand. An additional advantage of the transformation is that it appears to produce more nearly normal distributions for the trace elements.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000z), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a "biplot" in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from a biplot can be verified directly by inspecting bivariate elemental concentration plots. [Note that a bivariate plot of elemental concentrations is not a biplot.]

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber *et al*. 1976, Bishop and Neff 1989) is defined by:

$$D^2_{y,X} = [y - \overline{X}]^t I_x [y - \overline{X}]$$

where y is the 1 x m array of logged elemental concentrations for the specimen of interest, X is the n x m data matrix of logged concentrations for the group to which the point is being compared with $\overline{X}$ being it 1 x m centroid, and I_x is the inverse of the m x m variance-covariance matrix of group X. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2, which is the multivariate extension of the univariate Student's t.

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon “stretchability” in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator’s preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90% of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

Results and Conclusions

The primary questions addressed here are 1) Are there any apparent effects of the salt water on the chemical composition of the ceramics? 2) What is the internal compositional group structure? 3) Are there any culturally significant trends in the compositional group assignments? 4) Are there any possible matches between the samples discussed in this report and those in the MURR ceramic database of approximately 50,000 samples? 5) Are there any available data sets that are appropriately comparable to these samples that might provide some evidence as to the origin of the shipwreck samples? These questions are addressed below.

As described above, one of the initial considerations in analyzing the data is whether or not to correct for the calcium content of the samples. In areas that use shell or other calcium-rich tempers this can be quite useful in matching similar pastes, particularly when calcium comprises more than one percent of the sample. However, your samples are relatively consistent in calcium concentration, suggesting that a calcium correction would shift the data, but not create significant relative changes. Figure 1 displays the samples according to their compositional group membership (described later) in both the corrected and uncorrected versions of the data. Because there was so little shift in the data, and no changes to the compositional group structure we have decided to leave the data uncorrected for the remainder of this analysis.

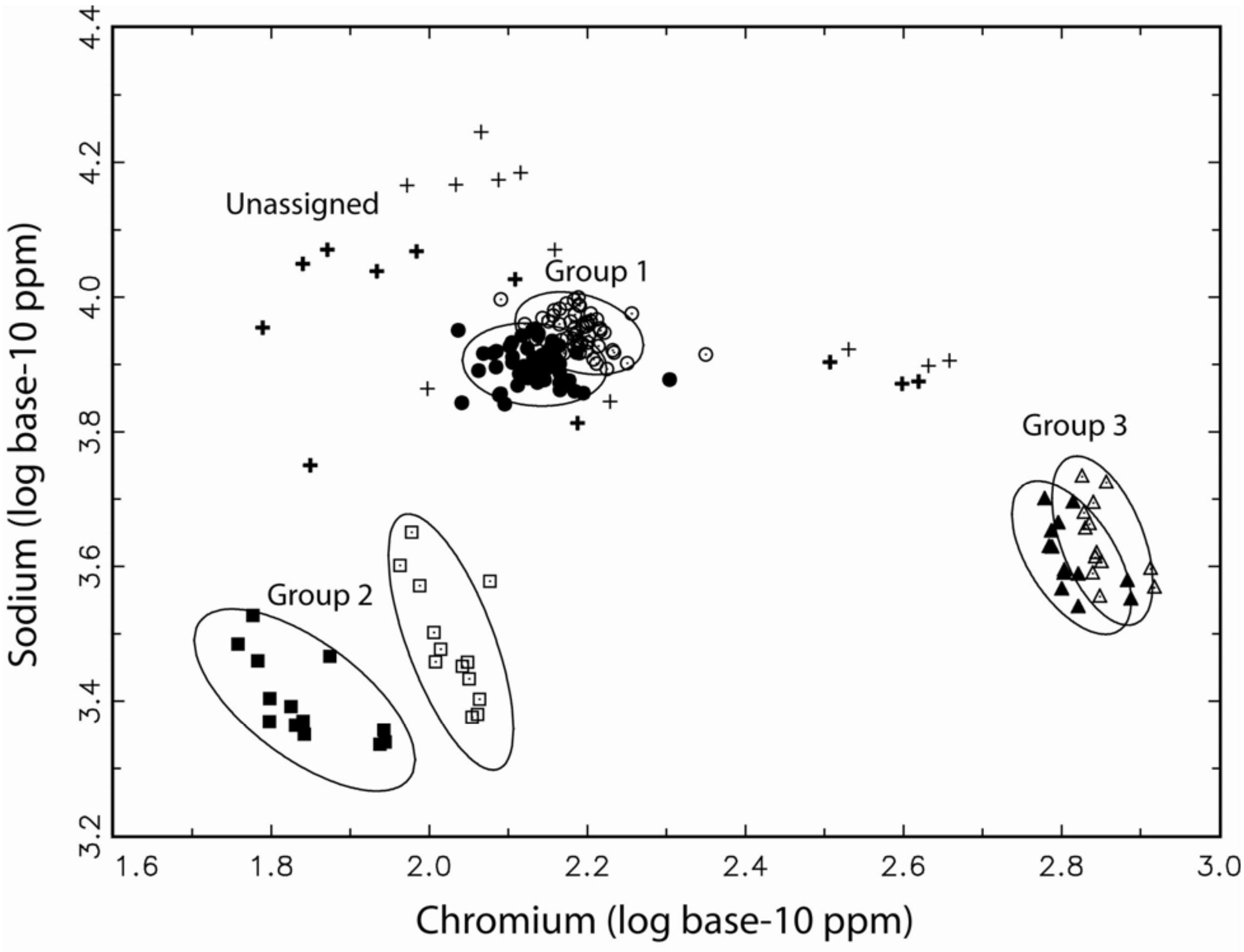

Figure 1: Bivariate plot of sodium and chromium base-10 logged concentrations showing the minimal differences as a result of the calcium correction procedure. The uncorrected data is shown in solid symbols while the corrected data is shown in open symbols. Unassigned samples are shown with a "+" symbol. Ellipses represent a 90% confidence level for membership in the group.

Table 1 displays the group assignments and some descriptive data for the samples. Table 2 provides the eigenvalues and variances for the first ten principal components, which was helpful in both assigning the compositional groups and in validating the groups using a Mahalanobis distance calculation based on a subset of these principal components.

Table 1: Descriptive information and group assignments for Krotscheck samples.

ANID	Comp. Group	Site Name	Ceramic Type, Form	Sherd type	Date	Presumed Provenance
UKR001	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR002	1	Pointe Lequin 1A	B2 cup	foot	550-500BCE	East Medit. or Italy
UKR003	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR004	1	Pointe Lequin 1A	B2 cup	foot	550-500BCE	East Medit. or Italy
UKR005	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR006	1	Pointe Lequin 1A	B2 cup	handle	550-500BCE	East Medit. or Italy
UKR007	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR008	1	Pointe Lequin 1A	B2 cup	foot	550-500BCE	East Medit. or Italy
UKR009	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR010	1	Pointe Lequin 1A	B2 cup	handle	550-500BCE	East Medit. or Italy
UKR011	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR012	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR013	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR014	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR015	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR016	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR017	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR018	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR019	1	Pointe Lequin 1A	B2 cup	wall, red	550-500BCE	East Medit. or Italy
UKR020	1	Pointe Lequin 1A	B2 cup	wall, red	550-500BCE	East Medit. or Italy
UKR021	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR022	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR023	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR024	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR025	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR026	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR027	1	Pointe Lequin 1A	B2 cup	handle frgt	550-500BCE	East Medit. or Italy
UKR028	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR029	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR030	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR031	3	Pointe Lequin 1A	Attic cup	wall	550-500BCE	Athens or Italy
UKR032	3	Pointe Lequin 1A	Attic cup	wall	550-500BCE	Athens or Italy
UKR033	3	Pointe Lequin 1A	Attic cup	rim	550-500BCE	Athens or Italy
UKR034	3	Pointe Lequin 1A	Attic cup	rim	550-500BCE	Athens or Italy
UKR035	3	Pointe Lequin 1A	Cassel cup	wall	550-500BCE	Athens or Italy
UKR036	3	Pointe Lequin 1A	Eye cup	wall	550-500BCE	Athens or Italy
UKR037	3	Pointe Lequin 1A	Eye cup	wall	550-500BCE	Athens or Italy
UKR038	3	Pointe Lequin 1A	Cassel cup	wall	550-500BCE	Athens or Italy
UKR039	Unas.	Pointe Lequin 1A	B2 cup	handle	550-500BCE	East Medit. or Italy
UKR040	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR041	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR042	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR043	Unas.	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy

UKR044	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR045	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR046	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR047	1	Pointe Lequin 1A	B2 cup	rim	550-500BCE	East Medit. or Italy
UKR048	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR049	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR050	1	Pointe Lequin 1A	B2 cup	wall	550-500BCE	East Medit. or Italy
UKR051	1	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR052	3	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR053	1	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR054	3	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR055	3	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR056	3	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR057	1	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR058	1	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR059	3	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR060	1	Pointe Lequin 1A	Stemmed bowl	rim	Late 6th/early 5th c. BCE	Athens or Italy
UKR061	Unas.	Pointe Lequin 1A	Amphora	wall	6th-5th c BCE	Miletus (East Med)
UKR062	1	Pointe Lequin 1A	Amphora	wall	6th-5th c BCE	Miletus (East Med)
UKR063	Unas.	Pointe Lequin 1A	Amphora	wall	6th-5th c BCE	Miletus (East Med)
UKR064	Unas.	Pointe Lequin 1A	Amphora	wall	6th-5th c BCE	Miletus (East Med)
UKR065	Unas.	Bourse	Misfiring, local	N/A	550-525 BCE	Marseille, France
UKR066	Unas.	Bourse	Misfiring, local	N/A	550-525 BCE	Marseille, France
UKR067	Unas.	Bourse	Misfiring, local	N/A	550-525 BCE	Marseille, France
UKR068	Unas.	Bourse	Misfiring, local	N/A	550-525 BCE	Marseille, France
UKR069	1	Bourse	Import B2 cup	rim	550-525 BCE	East Medit. or Italy
UKR070	1	Bourse	Import B2 cup	rim	550-525 BCE	East Medit. or Italy
UKR071	1	Bourse	Import B2 cup	rim	550-525 BCE	East Medit. or Italy
UKR072	1	Bourse	Import B2 cup	rim	525-500 BCE	East Medit. or Italy
UKR073	1	Bourse	Import B2 cup	rim	550-525 BCE	East Medit. or Italy
UKR074	1	Bourse	Import B2 cup	rim	550-525 BCE	East Medit. or Italy
UKR075	1	Bourse	Import B2 cup	rim	525-500 BCE	East Medit. or Italy
UKR076	1	Bourse	Import B2 cup	rim	525-500 BCE	East Medit. or Italy
UKR077	1	Bourse	Import B2 cup	rim	525-500 BCE	East Medit. or Italy
UKR078	2	Bourse	Local B2 cup	rim	550-525 BCE	Marseille, France
UKR079	2	Bourse	Import B2 cup	rim	500-450 BCE	East Medit. or Italy
UKR080	2	Bourse	Local B2 cup	rim	550-525 BCE	Marseille, France
UKR081	2	Bourse	Local B2 cup	foot	550-525 BCE	Marseille, France
UKR082	2	Bourse	Local B2 cup	rim	550-525 BCE	Marseille, France
UKR083	Unas.	Bourse	Local B2 cup	wall	550-525 BCE	Marseille, France
UKR084	2	Bourse	Local B2 cup	rim	525-500 BCE	Marseille, France
UKR085	2	Bourse	Local B2 cup	foot	525-500 BCE	Marseille, France
UKR086	2	Bourse	Local B2 cup	Handle	525-500 BCE	Marseille, France
UKR087	2	Bourse	Local B2 cup	foot	525-500 BCE	Marseille, France
UKR088	2	Bourse	Local B2 cup	rim	500-450 BCE	Marseille, France
UKR089	2	Bourse	Local B2 cup	rim	550-525 BCE	Marseille, France
UKR090	2	Bourse	Import B2 cup	rim	500-450 BCE	East Medit. or Italy
UKR091	2	Bourse	Local B2 cup	foot	550-525 BCE	Marseille, France
UKR092	Unas.	Pointe Lequin	Local plate	rim	550-450 BCE	Marseille, France

Table 2: Eigen values and variances for the first ten principal components.

Principal Components Analysis

Simultaneous R-Q Factor Analysis Based on Variance-Covariance Matrix

Eigenvalues and Percentage of Variance Explained:

	Eigenvalue	%Variance	Cum. %Var.
1	0.5727	69.9848	69.9848
2	0.0716	8.7501	78.7348
3	0.0483	5.9023	84.6372
4	0.0326	3.9821	88.6193
5	0.0200	2.4461	91.0654
6	0.0166	2.0306	93.0960
7	0.0128	1.5696	94.6656
8	0.0096	1.1759	95.8415
9	0.0082	1.0029	96.8444
10	0.0063	0.7730	97.6174

Eigenvectors (largest to smallest):

As	0.5472	-0.3675	-0.1510	-0.0434	0.1443	-0.0795	0.5436	0.4358	-0.1013	-0.0024
La	-0.0550	-0.0410	0.0225	-0.1222	-0.0175	-0.0180	-0.0983	0.1146	-0.1369	0.0091
Lu	0.0538	-0.0712	0.1341	-0.1330	-0.1727	-0.0957	-0.0670	-0.0012	-0.0537	0.0107
Nd	-0.0212	-0.0334	0.0344	-0.1240	-0.0371	-0.0035	-0.1119	0.0697	-0.1272	-0.0558
Sm	-0.0061	-0.0198	0.0666	-0.1254	-0.0343	-0.0565	-0.0626	0.0600	-0.1288	-0.0214
U	0.1664	-0.1862	0.2741	-0.2618	-0.5653	-0.3182	0.1135	-0.2782	0.2223	0.1797
Yb	-0.0145	-0.0555	0.0089	-0.0690	-0.0159	-0.0691	-0.2152	0.1545	-0.1477	-0.0201
Ce	-0.0385	-0.0163	0.0552	-0.1255	-0.0077	-0.0284	-0.0762	0.1095	-0.1324	-0.0170
Co	0.1674	0.2439	0.1727	-0.0359	0.0585	-0.1250	-0.0123	-0.0157	-0.0216	0.0681
Cr	0.3179	0.2942	0.0443	0.2742	0.0348	-0.2040	-0.0384	-0.0913	0.1284	-0.2589
Cs	-0.2054	-0.4014	-0.0387	0.0444	0.3688	-0.5747	-0.2131	0.0098	0.1943	-0.1986
Eu	-0.0037	-0.0033	0.0350	-0.0743	-0.0068	0.0073	-0.1025	0.1164	-0.0999	-0.0052
Fe	0.0448	0.1332	0.1156	-0.0841	0.0397	0.0010	-0.0489	0.1727	0.0508	0.0104
Hf	-0.0244	-0.1004	0.0659	-0.0645	-0.0256	-0.0852	-0.0760	0.0469	-0.0780	-0.0580
Ni	0.4041	0.3818	-0.1426	0.0893	-0.0831	-0.3647	-0.2324	-0.0576	-0.3410	-0.1471
Rb	-0.1724	0.0120	-0.0487	-0.2134	0.3437	-0.2922	0.1708	-0.2348	-0.1445	0.0052
Sb	0.5049	-0.2490	0.1146	-0.2938	0.3559	0.3555	-0.3829	-0.3745	0.1015	0.0481
Sc	0.0500	0.1221	0.0815	-0.0527	0.0809	-0.0343	-0.0285	0.0870	0.0512	-0.0625
Ta	-0.0429	-0.0928	0.0509	-0.1314	-0.0520	0.0662	-0.1037	0.1182	-0.1442	0.0498
Tb	-0.0077	-0.0061	0.0550	-0.1308	0.0080	-0.0615	-0.1356	0.1510	-0.1996	0.0814
Th	-0.0283	-0.0341	0.0840	-0.1709	-0.0130	0.0071	-0.1467	0.1305	-0.2055	-0.0265
Zn	0.0368	0.1894	-0.0276	-0.3191	-0.0419	-0.0176	0.0720	0.2122	-0.0009	0.0911
Zr	0.0271	-0.1927	0.1611	-0.0117	-0.2309	-0.2089	0.0350	-0.0968	0.0225	-0.0862
Al	-0.0308	0.0261	0.0492	-0.1134	0.0074	0.0311	-0.0734	0.0794	0.0202	-0.0233
Ba	-0.0904	0.2079	-0.1471	-0.5484	-0.0629	0.0979	0.1442	0.0373	0.2690	-0.6343
Dy	-0.0049	-0.0393	0.0301	-0.1267	0.0130	-0.0846	-0.1898	0.1475	-0.1826	-0.0315
K	-0.0846	0.1945	-0.2228	-0.2971	0.1716	-0.1198	0.2818	-0.3755	-0.2823	0.3580
Mn	0.0185	0.2857	0.1388	-0.1259	0.2053	-0.1805	-0.1106	0.3465	0.5054	0.4689
Na	-0.0966	0.0930	0.7937	0.0794	0.2243	0.0650	0.2787	-0.0029	-0.2325	-0.1505
Ti	0.0482	0.0165	0.0458	0.0255	-0.0323	0.1002	-0.0392	0.0215	0.0263	-0.0353
V	0.0859	0.0650	0.1216	-0.0352	0.2008	-0.0483	0.1501	-0.1243	0.1546	-0.1392

Examination of Potential Salt Water Diagenesis of the Shipwreck Samples

In previous studies of pottery recovered from shipwrecks, we have observed significant diagenesis of the chemical composition resulting in the inability to compare shipwreck data with samples recovered on land. As a result of this past experience, one of us (Dr. Glascock) suggested examining the potential differential diagenesis as a result of the thickness of the sample. The first ten samples are duplicate pairs of five samples. The odd numbers are thin samples taken from the vessel walls, while the even numbers are thick samples taken from the vessel feet. For example sample UKR001 and UKR002 are from the same vessel, only UKR001 is from the thin vessel wall versus UKR002 taken from the thickest available portion of the foot. Table 3 lists the percent difference in concentration between the thin and thick samples from the same vessel. Sodium is the only element for which the change is in the same direction for each comparison, but these differences are relatively small. There are some differences that might seem alarming, such as a 57% difference in the cesium values for samples 009 and 010, yet these large values typically occur in cases where the absolute number is quite small, thus any changes represent large percentages.

Table 3: Percent changes in the concentration between the thin and thick samples.

	1 to 2	3 to 4	5 to 6	7 to 8	9 to 10
As	9.0	-74.9	7.4	-7.5	29.0
La	-0.6	0.2	6.1	2.3	-2.7
Lu	-0.1	2.8	23.3	3.7	12.5
Nd	-3.8	3.9	5.8	5.4	-10.0
Sm	-0.2	0.5	6.4	2.1	2.5
U	-2.5	-7.6	21.1	4.5	22.6
Yb	-3.7	0.6	10.0	-12.8	-3.8
Ce	-0.9	0.2	7.8	2.8	0.7
Co	-0.8	4.6	15.3	-0.1	9.9
Cr	-1.0	4.2	13.5	1.8	6.2
Cs	8.9	1.1	-31.1	3.1	-56.8
Eu	-0.0	0.1	6.1	1.5	0.6
Fe	-0.1	3.1	11.8	0.8	7.0
Hf	0.5	4.8	11.7	-0.3	6.2
Ni	37.6	-11.0	x	-30.1	18.5
Rb	0.3	1.2	-21.3	3.2	-21.1
Sb	-0.8	-53.9	35.6	-0.9	12.4
Sc	1.0	2.0	4.1	1.6	-1.5
Sr	6.3	-8.3	-6.6	7.4	-60.9
Ta	-1.3	1.5	12.5	-0.4	6.8
Tb	10.4	-12.7	13.7	6.4	2.9
Th	-3.3	2.2	10.9	2.6	7.5
Zn	-3.0	-5.3	12.8	-6.6	5.1
Zr	-9.5	5.5	13.9	-5.8	-6.1
Al	0.3	1.8	6.8	-0.4	4.4
Ba	8.9	10.3	1.3	-9.7	10.4
Ca	-0.6	-6.0	2.7	1.7	-40.4
Dy	-0.9	1.6	-4.6	10.4	0.8
K	8.7	-8.2	-21.7	1.3	1.3
Mn	0.6	3.8	12.0	-0.9	-0.6
Na	-1.7	-4.4	-6.1	-1.6	-1.4
Ti	-0.3	-16.1	20.1	7.8	5.1
V	-1.6	5.7	-6.2	-7.5	-8.4

Figure 2 shows a plot of sodium and chromium (the two elements that provide the best group separation in the data) for the ten duplicate samples along with arrows showing the direction of the shift. In sum, there is little evidence from the samples of thin and thick sherds to suggest systematic diagenesis of the pottery due to the saltwater exposure. It is possible that the entire sherds were altered, regardless of the thickness, but that is a more challenging possibility to examine.

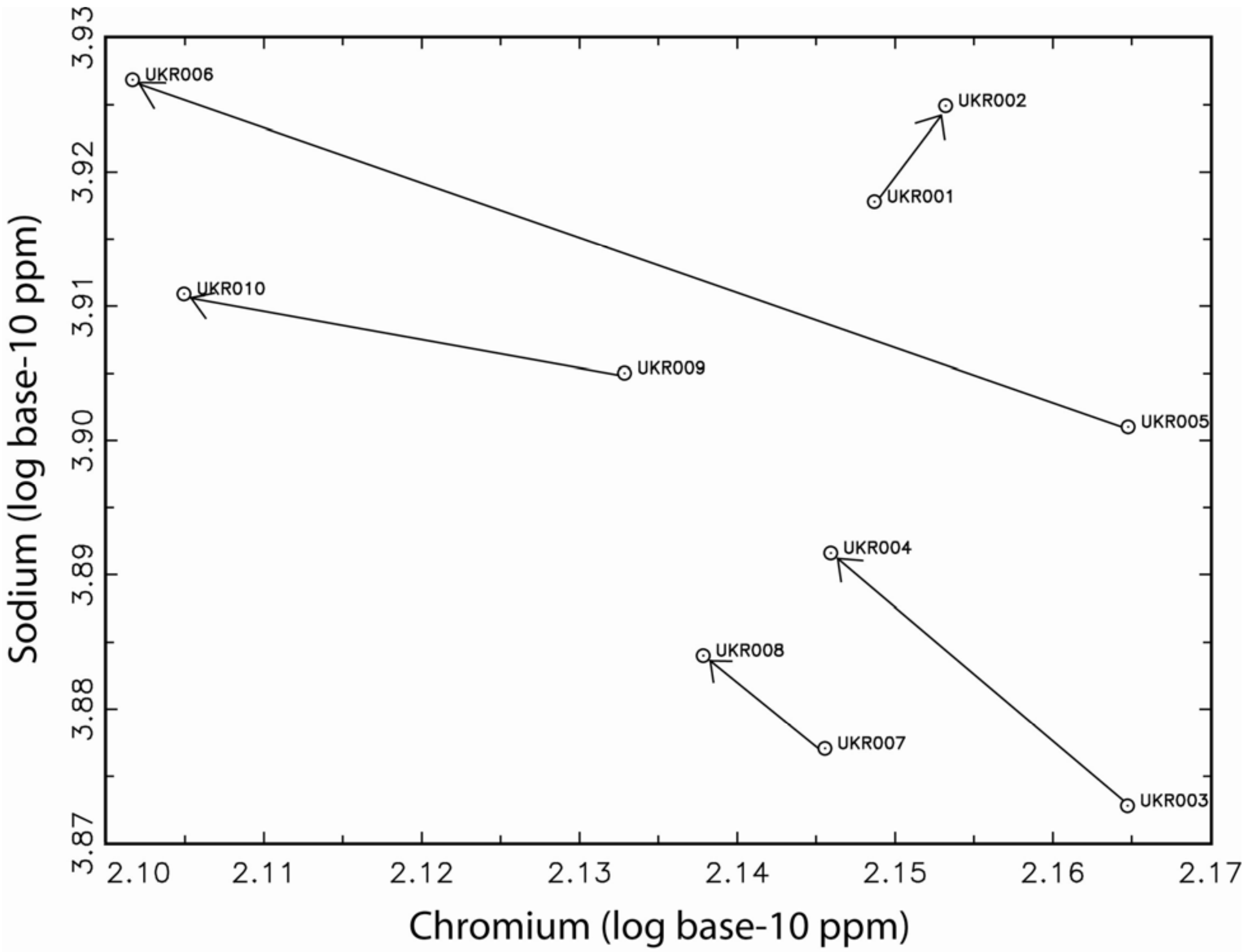

Figure 2: Bivariate plot of sodium and chromium base-10 logged concentrations showing the differences between the thin wall samples and the thick foot samples.

There are some differences in the elemental concentrations between the shipwreck and land samples that suggest at lease the possibility of some diagenesis of the shipwreck sherds. Figure 3 shows plots of separate ellipses for the shipwreck and the land samples for cesium and chromium. Cesium is the only element that the shipwreck data appears to be reduced in concentration. Most other elements either show no systematic change or are higher (as in the case of Zinc shown in Figure 4). We would expect the shipwreck samples to have been reduced in more elements if the salt water was leeching trace minerals, yet this is not the case. It is certainly possible that there is little diagenesis of these sherds, and they simply represent distinct paste recipes. This is discussed further in the following section.

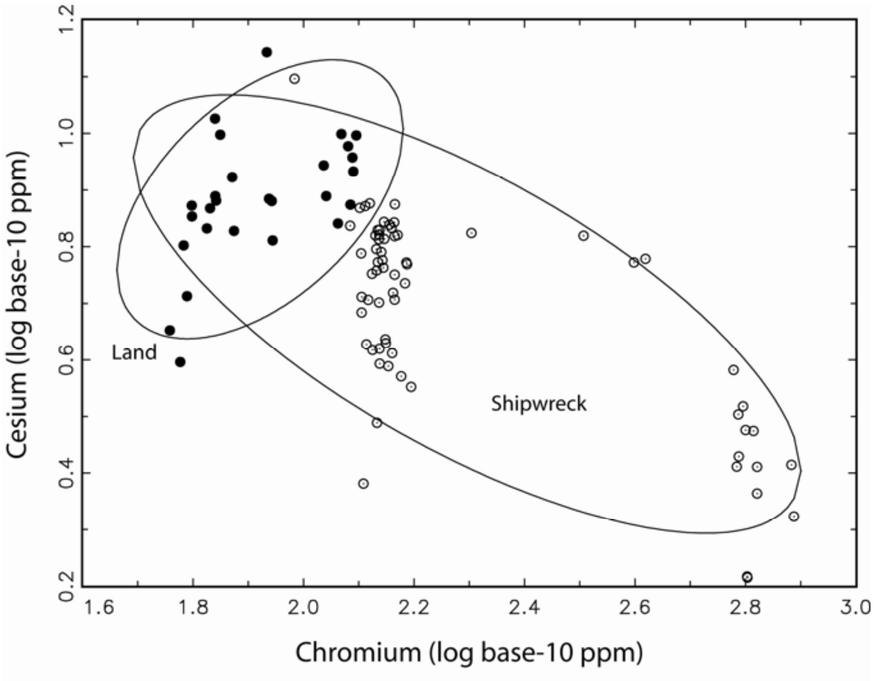

Figure 3: Bivariate plot of chromium and cesium showing the differences between the shipwreck and land samples. Ellipses represent the 90% confidence interval for group membership.

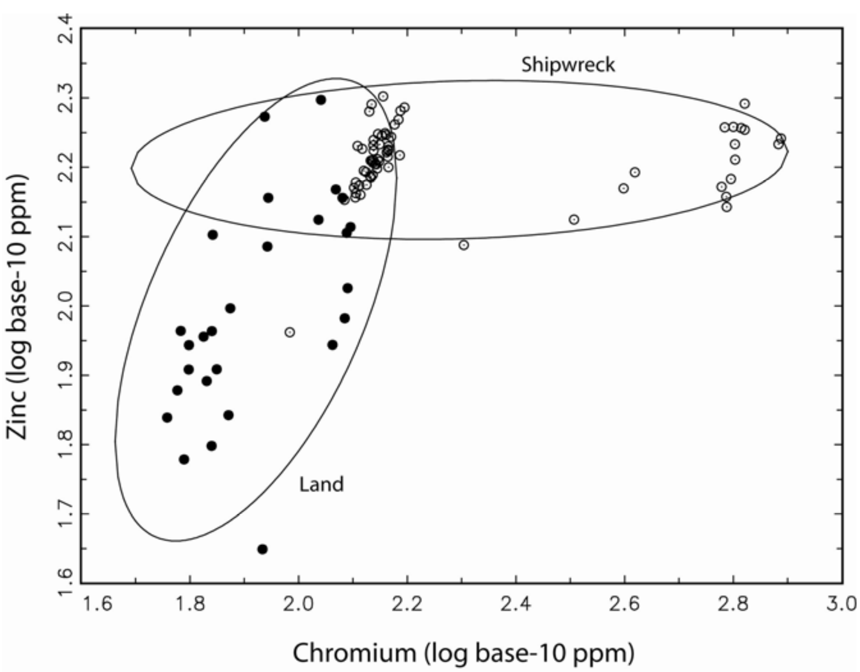

Figure 4: Bivariate plot of chromium and zinc showing the differences between the shipwreck and land samples. Ellipses represent the 90% confidence interval for group membership.

Compositional Group Structure

The compositional groups for this project were developed by examining bivariate plots of logged elemental concentrations, and then validated by principal component plots, Mahalanobis distance calculations and projections, and hierarchical cluster analysis.

The cluster analysis provides an interesting result, and brings into question the validity of Group 1 (described below). The first split divides sample 092 from the rest of the samples, and this is not surprising as this was presumed to be an intrusive sample. The second split perfectly separates the shipwreck from the Bourse samples. This is troubling because there are members of group 1 that were collected from both sites. Within the Bourse cluster, the next split perfectly separates the members of Group 2 from those assigned to Group 1. The second split within the shipwreck samples completely isolated all of the members of Group 3. Groups 2 and 3 separate well according the hierarchical cluster analysis, however it does raise some question as to whether there is some division within Group 1 that is not discernable in the elemetal bivariate plots used to develop the groups.

As is often the case, chromium was the most useful element for placement on the x-axis, and the best separation is found in a plot of chromium and sodium. Figure 5 shows the three compositional groups along with the unassigned samples.

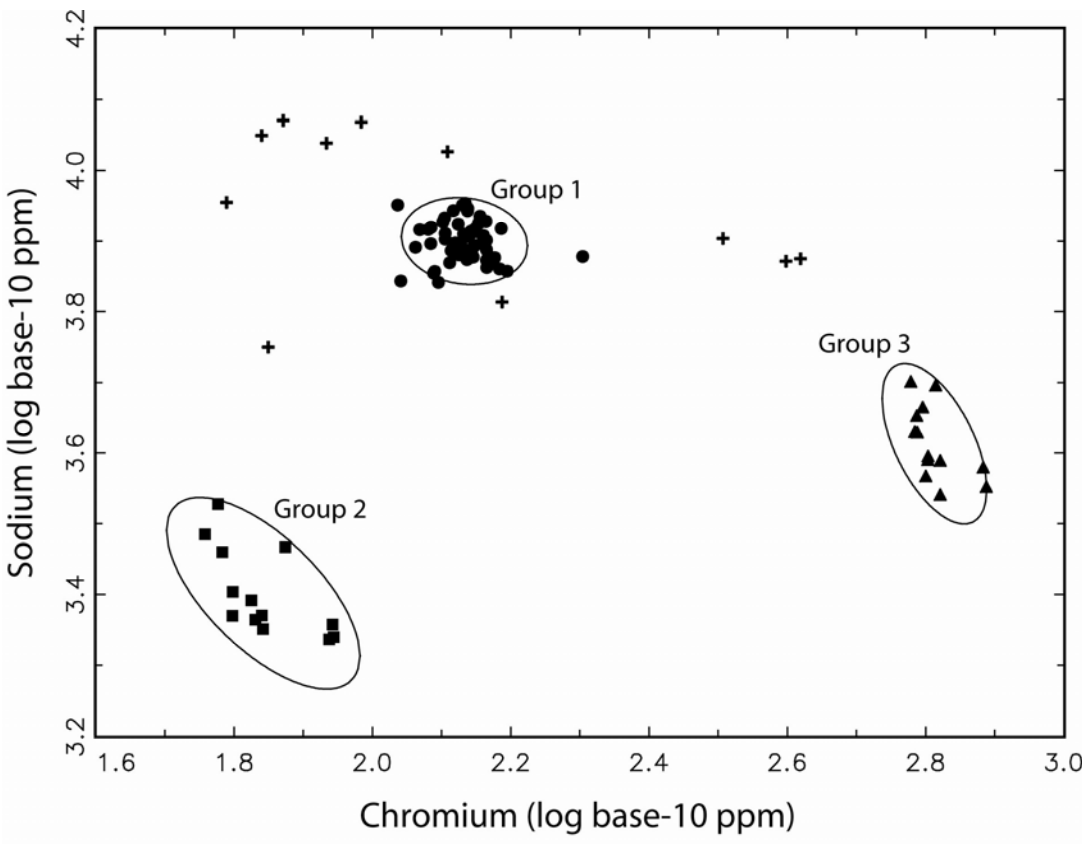

Figure 5: Bivariate plot of chromium and sodium showing the separation of the three compositional groups as well as the distribution of the unassigned samples (shown with a "+" symbol). Ellipses represent the 90% confidence interval for group membership.

The groups separate remarkably well in many elemental plots, but validating the group structure using a Mahalanobis distance calculation is a valuable second test. Unfortunately the sample sizes for both Groups 2 and 3 are only 13, leaving them well short of the minimum number of samples for a calculation using all of the elements (the minimum number in this case is 33, or two greater than the number of variables). In cases of small sample sizes we use a subset of the principal components, as long as the principal component plots also reveal good group separation. Figure 6 is a biplot of the first two principal components along with the eigenvectors.

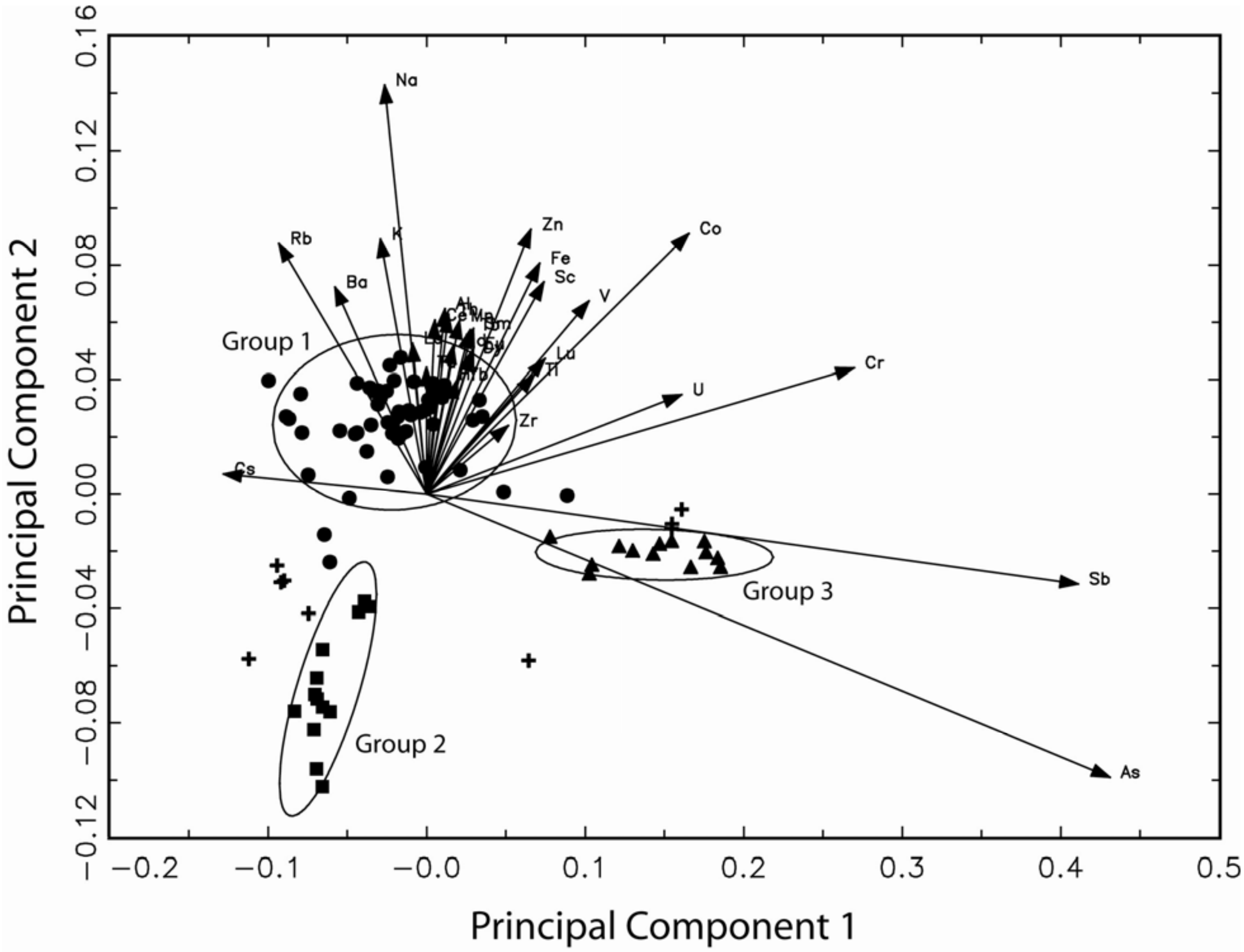

Figure 6: Biplot of the first two principal components along with the relative influence of each of the elemental variables. Unassigned samples are plotted with a "+" symbol. Ellipses represent the 90% confidence interval for group membership.

Table 4 lists the probability of group membership based on the first five principal components for all samples assigned to a group. As shown in Table 2, the first 5 principal components account for more than 91 percent of the variability in the dataset. The probabilities shown in Table 4 are extremely strong support for the current group structure. Most samples have 0.000 percent probability of membership in the groups they were not assigned to. Table 5 uses a Mahalanobis distance projection to determine the probability of group membership for each of the unassigned samples. Only sample 043 has much of a probability of membership in any group, however we have left it unassigned because it does not consistently plot with Group 1 in elemental bivariate plots. If a similar projection is done using all of the elements (only possible with Group 1 due to sample size) the probability drops to only 5%. It is really a judgment call as to whether or not this sample should be included in Group 1.

Table 4: Probabilities of group membership for each of the assigned specimens based on a Mahalanobis distance calculation using the first five principal components.

```
MAHALANOBIS DISTANCE CALCULATION AND POSTERIOR CLASSIFICATION
FOR TWO OR MORE GROUPS.


Variables used:
      PC01       PC02       PC03       PC04       PC05

Probabilities are jackknifed for specimens included in each group.

The following specimens are in the file  Group 1
           Probabilities:
```

ID. NO.	Group 1	Group 2	Group 3	From:	Into:
UKR001	93.332	0.000	0.000	1	1
UKR002	79.915	0.000	0.000	1	1
UKR003	79.251	0.000	0.000	1	1
UKR004	55.671	0.000	0.000	1	1
UKR005	0.866	0.001	0.000	1	1
UKR006	3.282	0.001	0.000	1	1
UKR007	82.593	0.000	0.000	1	1
UKR008	72.027	0.000	0.000	1	1
UKR009	10.808	0.000	0.000	1	1
UKR010	82.221	0.000	0.000	1	1
UKR011	56.379	0.000	0.000	1	1
UKR012	88.631	0.000	0.000	1	1
UKR013	20.059	0.000	0.000	1	1
UKR014	1.791	0.000	0.000	1	1
UKR015	50.370	0.000	0.000	1	1
UKR016	93.125	0.000	0.000	1	1
UKR017	94.793	0.000	0.000	1	1
UKR018	96.356	0.001	0.000	1	1
UKR019	43.415	0.000	0.000	1	1
UKR020	84.598	0.000	0.000	1	1
UKR021	30.092	0.000	0.000	1	1
UKR022	50.992	0.000	0.000	1	1
UKR023	34.741	0.000	0.000	1	1
UKR024	97.558	0.000	0.000	1	1
UKR025	96.279	0.001	0.000	1	1
UKR026	84.491	0.000	0.000	1	1
UKR027	98.878	0.000	0.000	1	1
UKR028	94.028	0.001	0.000	1	1
UKR029	83.491	0.000	0.000	1	1
UKR030	90.416	0.000	0.000	1	1
UKR040	55.163	0.000	0.000	1	1
UKR041	24.657	0.000	0.000	1	1
UKR042	0.412	0.000	0.000	1	1

UKR044	81.382	0.000	0.000	1	1
UKR045	95.275	0.000	0.000	1	1
UKR046	97.275	0.000	0.000	1	1
UKR047	92.211	0.000	0.000	1	1
UKR048	65.971	0.000	0.000	1	1
UKR049	81.602	0.000	0.000	1	1
UKR050	30.868	0.000	0.000	1	1
UKR051	72.060	0.001	0.000	1	1
UKR053	76.850	0.000	0.000	1	1
UKR057	96.434	0.000	0.000	1	1
UKR058	18.522	0.000	0.000	1	1
UKR060	82.767	0.000	0.000	1	1
UKR062	5.344	0.000	0.000	1	1
UKR069	10.337	0.000	0.000	1	1
UKR070	33.097	0.001	0.000	1	1
UKR071	0.018	0.001	0.000	1	1
UKR072	0.469	0.003	0.000	1	1
UKR073	32.315	0.000	0.000	1	1
UKR074	56.041	0.000	0.000	1	1
UKR075	4.771	0.003	0.000	1	1
UKR076	38.042	0.001	0.000	1	1
UKR077	19.204	0.000	0.000	1	1

The following specimens are in the file Group 2

	Probabilities:				
ID. NO.	Group 1	Group 2	Group 3	From:	Into:
UKR078	0.000	42.855	0.000	2	2
UKR079	0.000	27.526	0.000	2	2
UKR080	0.000	35.714	0.000	2	2
UKR081	0.000	86.346	0.000	2	2
UKR082	0.000	31.105	0.000	2	2
UKR084	0.000	66.844	0.000	2	2
UKR085	0.000	19.184	0.000	2	2
UKR086	0.000	41.358	0.000	2	2
UKR087	0.000	34.517	0.000	2	2
UKR088	0.000	97.064	0.000	2	2
UKR089	0.000	4.159	0.000	2	2
UKR090	0.000	40.509	0.000	2	2
UKR091	0.000	98.641	0.000	2	2

The following specimens are in the file Group 3

	Probabilities:				
ID. NO.	Group 1	Group 2	Group 3	From:	Into:
UKR031	0.000	0.000	92.942	3	3
UKR032	0.000	0.000	60.007	3	3
UKR033	0.000	0.000	8.554	3	3
UKR034	0.000	0.000	19.751	3	3
UKR035	0.000	0.000	59.322	3	3
UKR036	0.000	0.000	68.705	3	3
UKR037	0.000	0.000	54.720	3	3
UKR038	0.000	0.000	36.785	3	3
UKR052	0.000	0.000	50.884	3	3
UKR054	0.000	0.000	75.093	3	3
UKR055	0.000	0.000	37.402	3	3
UKR056	0.000	0.000	37.371	3	3
UKR059	0.000	0.000	35.932	3	3

Table 5: Probability of group membership for the unassigned specimens based on a Mahalanobis distance projection using the first five principal components.

```
MAHALANOBIS DISTANCE CALCULATION FOR MISCELLANEOUS SPECIMENS
PROJECTED AGAINST TWO OR MORE GROUPS.


Variables used:
      PC01       PC02       PC03       PC04       PC05


The following specimens are in the file  PCUNAS
           Probabilities:
ID. NO.   Group 1   Group 2   Group 3
UKR039      3.472     0.000     0.000
UKR043     39.216     0.000     0.000
UKR061      0.000     0.000     0.000
UKR063      0.000     0.000     0.000
UKR064      0.000     0.000     0.000
UKR065      0.000     0.289     0.000
UKR066      0.000     0.008     0.000
UKR067      0.000     0.046     0.000
UKR068      0.000     0.017     0.000
UKR083      0.000     0.003     0.000
UKR092      0.000     0.000     0.000
```

While the number of unassigned samples is small (only 12 percent) we are surprised that seven of the unassigned samples are almost entirely in sequence (061-068, missing only 062). This generally implies some shared characteristics that might indicate an additional group, however, these samples do not consistently plot together in elemental bivariate plots.

Correlations with Descriptive Traits

For all of the comparisons we have eliminated the duplicate sample for each of the first five sherds, resulting in a sample size of 87 rather than the 92 total samples analyzed. The simplest comparison to make is one comparing the compositional groups and archaeological sites (Table 6).

Table 6: Number of sherds from each site separated by compositional group.

Site	Group 1	Group 2	Group 3	Unassigned	Total
Pointe Lequin 1A	41		13	6	60
Bourse	9	13		5	27
Total	50	13	13	11	87

Group 1 is dominated by sherds from the shipwreck site. Groups 2 and three have perfect correlations with recovery site: Group 2 is entirely from the shipwreck, and Group 3 is entirely from the land site. While it is possible that this is somewhat the result of salt water diagenesis, given the above evidence to the contrary, there appears to be only a slight overlap between the recipes used in production of the two assemblages. The comparison by presumed provenance (shown in Table 7) is not as definitive, but no less interesting.

Table 7: Compositional group breakdown by presumed provenance.

Presumed Provenance	Group 1	Group 2	Group 3	Unassigned	Total
Athens or Italy	5		13		18
East Med. or Italy	44	2		2	48
Miletus (East Med.)	1			3	4
Marseille, France		11		6	17
Total	50	13	13	11	87

We are not sure what criteria were used to guess at the provenance, but there is some correlation with the compositional group structure. The strongest correlation is with the 11 of the 13 samples in Group 2 presumed to come from France. Without a better understanding of the criteria used it is difficult to make further interpretations, however, these data are patterned and should be of some use.

The breakdown by ceramic type and form is also quite patterned, as shown in Table 8.

Table 8: Compositional group breakdown by ceramic type and form.

Ceramic Type, Form	Group 1	Group 2	Group 3	Unassigned	Total
B2 Cup	35			2	37
Imported B2 Cup	9	2			11
Local B2 Cup		11		1	12
Stemmed Bowl	5		5		10
Amphora	1			3	4
Misfiring				4	4
Attic Cup			4		4
Cassel Cup			2		2
Eye Cup			2		2
Local Plate				1	1
Total	50	13	13	11	87

Not including the unassigned samples, there are only two of the ten ceramic type/forms that are not exclusive to one compositional group. It appears that at least Group three is an import, as none of the members are local types and they were all assumed to have come from Athens or Italy. Conversely, group 2 members are all from the land site and almost all are classified as Local B2 cups. Please advise us of other correlations to examine that would benefit your use of this data.

The last sample (092) is described as intrusive "Massiliote" ware, and the intrusive nature is supported by the unassigned status. 092 plots closest to Group 1, but does not consistently plot within this group. There appears to be little, if any, similarity between 092 and any of the three compositional groups, and this is supported by the hierarchical cluster analysis described above.

Comparisons with Other Datasets

The first step in the search for ceramics with similar chemical compositions was to conduct a Euclidian search of the complete MURR ceramic database. The database now contains more than 50,000 samples analyzed over the past 20 years, but unfortunately it includes few samples from the western Mediterranean region, particularly France and Italy. It is not surprising that almost none of the ten closest matches for each of your sherds were from the Mediterranean. In fact, the majority of the samples within the ten closest matches were from the American Southwest, suggesting some similarities in the geologic processes forming the clays in the two regions, but not any overlap in the use of specific clay sources. A listing of the ten closest matched for each sample are included at the end of this report in Appendix A.

Euclidian searches are not the only means of exploring links with other datasets. Although our database is short on comparative samples from the Mediterranean region, there are two datasets in particular that seemed like possible comparisons. Rotroff analyzed a number of course and fine Helenistic wares from Greece, and Kilikoglou submitted approximately 100 Greek vessels for analysis. In the analysis done by Hector Neff and Mike Glascock for Rotroff, they incorporated a larger database of Greek samples that were analyzed at the Brookhaven National Laboratory (BNL) that include four groups (AtticA, AtticB, AtticC, and Corinth). When conducting comparative analyses, it is critical that the same elements are used in exactly the same order, and because the BNL data contained 11 fewer elements (missing Al, Ti, V, Ni, As, Sr. Zr, Nd, Tb, Dy, and Th) and an additional 2 elements had too many missing values (Zn, and U), all of the datasets were reduced to be comparable (including La, Lu, Yb, Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Ta, Th, Ba, Ca, K, Mn, and Na). This reduced dataset is not a significant problem because the main elements used to differentiate your groups (Na and Cr) are still present.

All of the comparative datasets described above were combined to create a master dataset used to calculate a set of principal components. The first 5 principal components were used to calculate a probability of group membership for each of the comparative samples and the three groups developed from your data. The results of the Mahalanobis distance projection are included as Appendix B. Only two of the comparative samples had a greater than 1 percent probability of membership, and there is reason not to doubt these results, as in the final group, we tested your unassigned samples and the one sample that possibly belongs to Group 1 (043) shows a 15% probability o membership in Group 1. Interestingly, almost all of the samples that show any probability of membership in the groups tends to be related (although very slightly) with Group 3. This is the group limited exclusively to the shipwreck, and included all samples presumed to originate from Athens or Italy. This is very minor evidence, but at least a suggestion that the Group 3 sherds were produced in Greece or Italy. Appendix C displays the results of the inverse calculation. There are only 3 groups of Greek pottery with sufficient sample sizes to allow the projection of your data: AtticA, AtticB, and Corinth. None of your samples have a greater than 0.02% probability of membership in any of these groups.

Although the Mahalanobis distance projections leave little doubt that your samples differ significantly from the other Greek Ceramic material available for this analysis, it is still worthwhile to examine some bivariate elemental plots. Figure 7 displays your data along with the established Greek groups of Attic wares and the Corinth samples. As with most of the Greek samples, the Attic wares plot within the same range as your data, but the specific groups do not overlap.

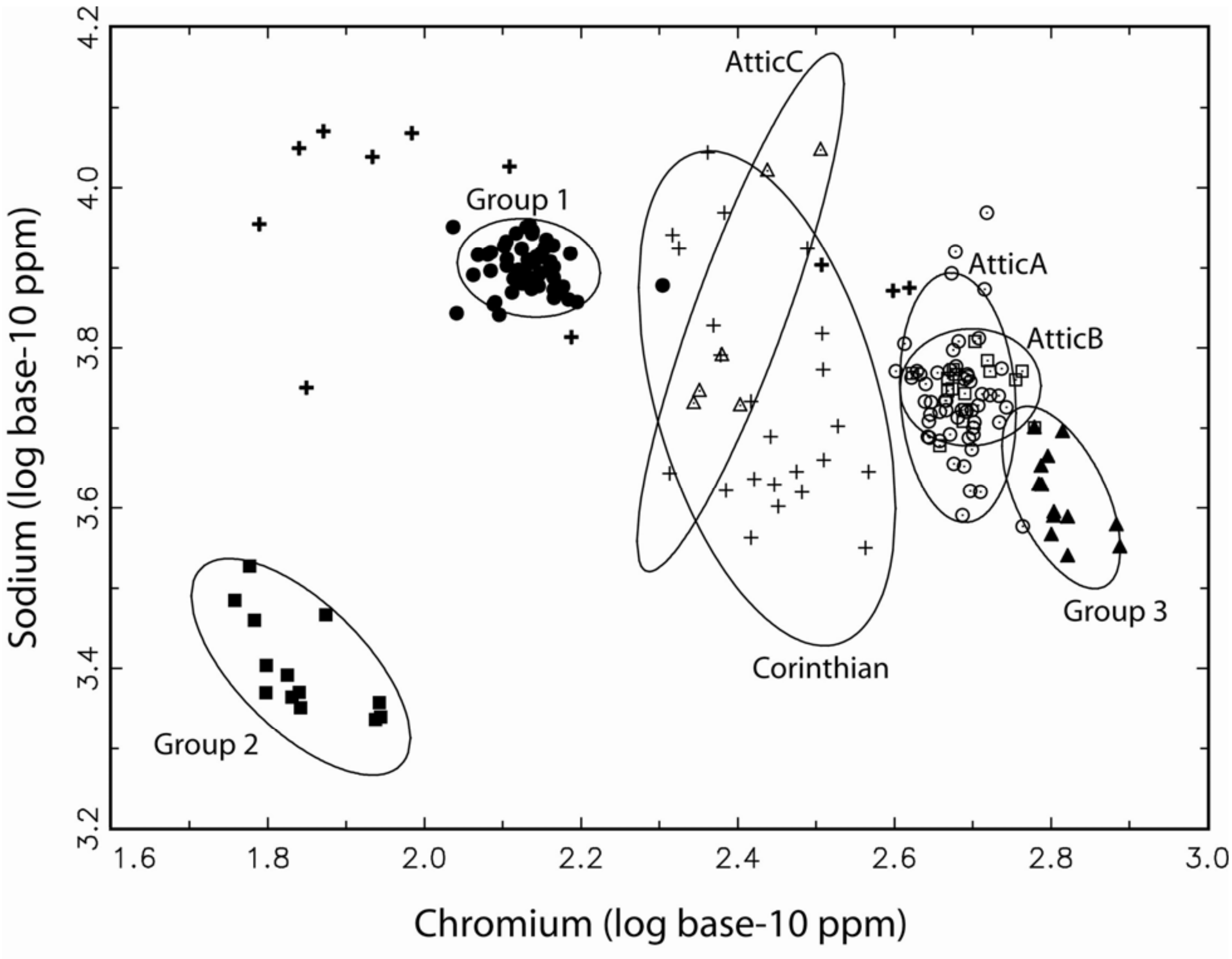

Figure 7: Bivariate plot of chromium and sodium showing the separation between your samples and the established Greek compositional groups. Your unassigned samples are displayed with a dark "+" symbol. Ellipses represent the 90% confidence interval for group membership.

A closer examination of the Rotroff data provide some interesting similarities. Figure 8 shows the significant overlap between a small number of samples submitted by Rotroff and Group 1. This overlap almost entirely correlated with the Cooking-S group (as shown in Figure 8) identified by Neff and Glascock (1999). This material was recovered from Athens, however, the clays have an unusually low level of calcium for Athens clays (although they note that low-calcium clays are present in the area). Interestingly, the only two elements the data differ significantly in are barium and calcium. It therefore seems likely that the Group 1 sherds have a similar paste to those of the Cooking-S group presumed to be manufactured in the vicinity of Athens. This is only complicated by the significant differences in calcium for which we have no obvious explanation. Figure 9 is a plot of your groups along with the Cooking-S group identified by Neff and Glascock (1999).

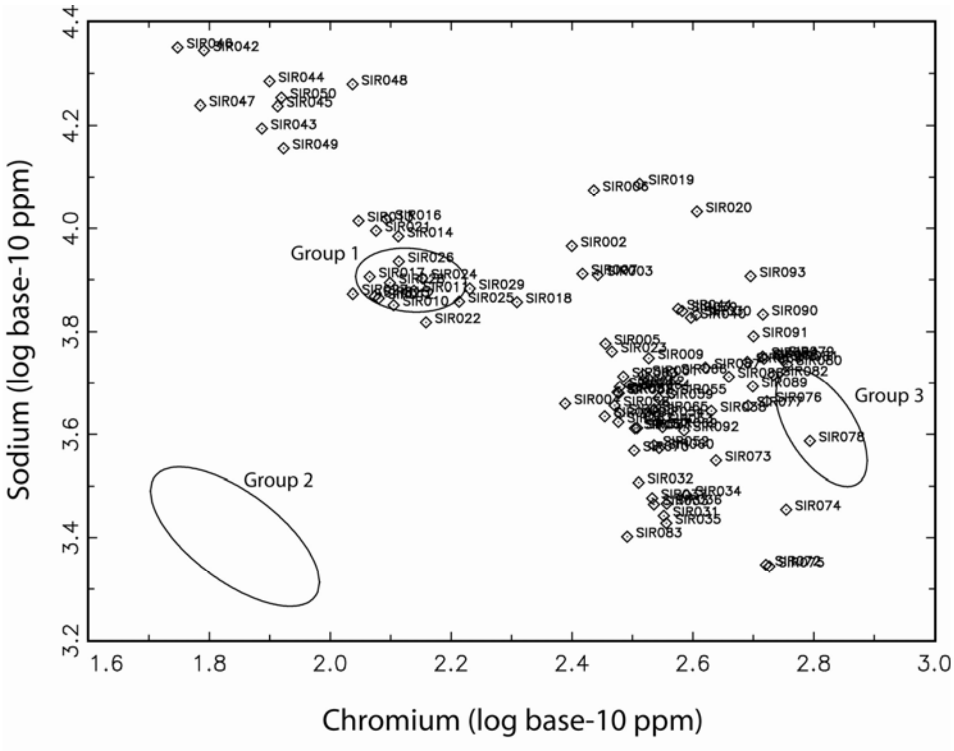

Figure 7: Bivariate plot of chromium and sodium showing the Rotroff data projected against your groups. Ellipses represent the 90% confidence interval for group membership.

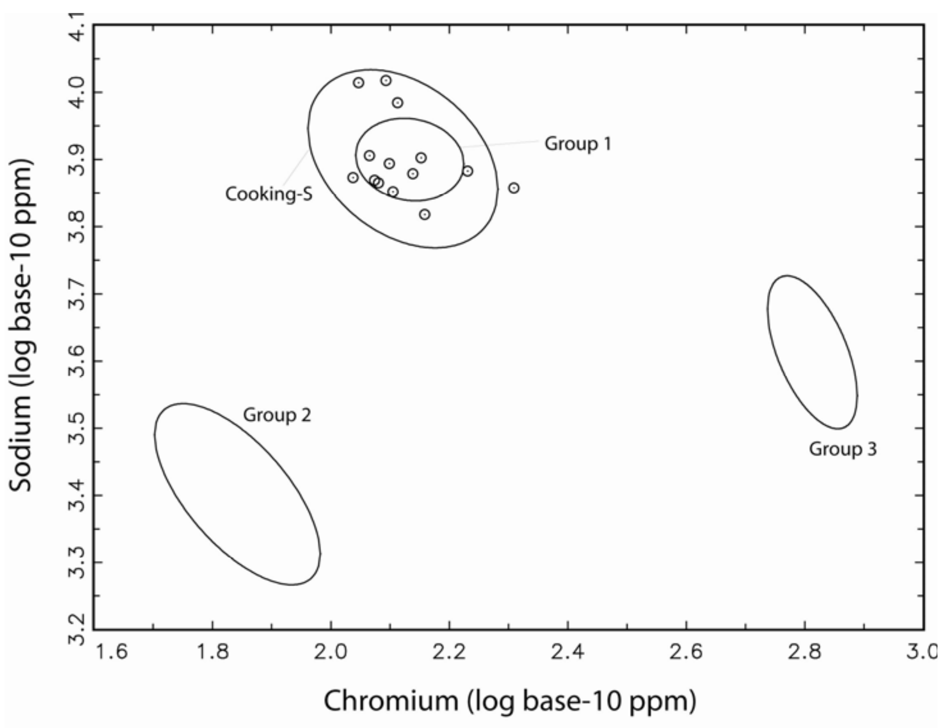

Figure 7: Bivariate plot of chromium and sodium showing the overlap between the Cooking-S group and your Group 1. Ellipses represent the 90% confidence interval for group membership.

The other dataset of relevance to your samples was submitted by Kilikoglou. We do not perform the interpretation of the data for him, and unfortunately that leaves little information about any of his samples. There are two samples (SOIL7a and SOIL7b that have some overlap with your Group 2 (see Figure 10), however, these samples are a soil standard collected in Ebensee, Upper Austria. There is no other consistent overlap between your groups and the samples submitted by Kilikoglou.

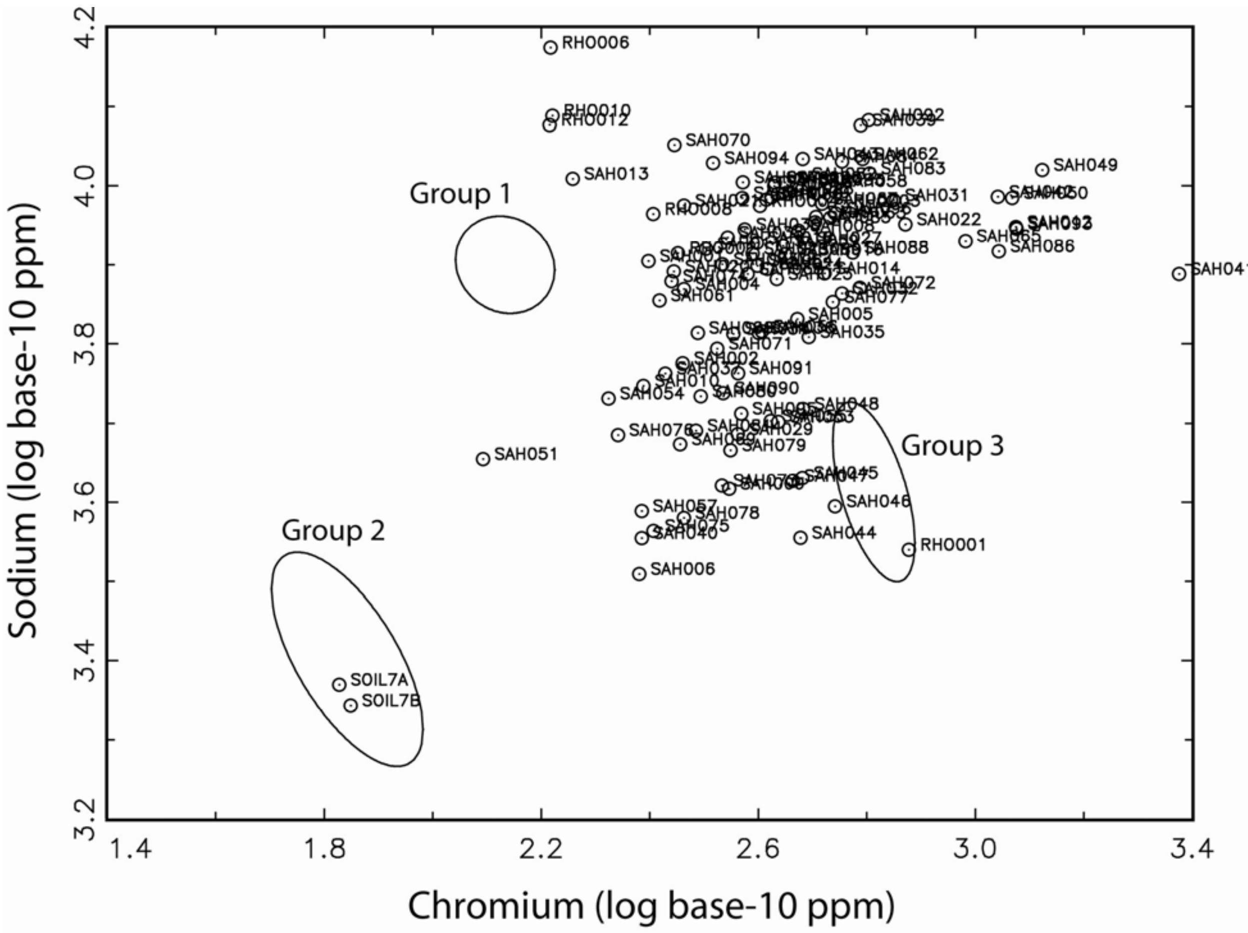

Figure 10: Bivariate plot of chromium and sodium showing the lack of overlap between your samples and those submitted by Kilikoglou. Ellipses represent the 90% confidence interval for group membership.

Conclusions

This report described the preparation, irradiation, and interpretation of 92 ceramic samples submitted in part from the shipwreck site of Pointe Lequin 1A and the land site "Bourse" excavations in Marseille. The primary question is whether there is evidence that the shipwreck samples were manufactures in Greece or Italy. While the production location remains unresolved (although there are some possibilities outlined here), there is some interesting internal group structure that has strong correlations with most of the descriptive information. We have identified three very distinct chemical groups and suggest that at least Group 3 vessels may have been produced in Greece. There is additional evidence based on comparisons submitted by Rotroff that the members of Group 1 have some similarities with the Cooking-S group identified by Neff and Glascock (1999), and presumed to be of local manufacture near Athens. While it is possible that some of the interpretive challenges posed by these data are the result of salt-water diagenesis of the shipwreck samples, there is no direct evidence of this.

Acknowledgments

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Appendix A: Results of a Euclidian distance search.

Here are the 10 closest specimens to UKR001

GSR124	0.026968
LV051	0.027550
PAM010	0.028397
LV110	0.028429
JQ0015	0.028733
GSR049	0.029113
LV098	0.029183
GSR035	0.029268
GSR021	0.029366
GSR154	0.029606

Here are the 10 closest specimens to UKR002

GSR124	0.027870
LV051	0.028654
JQ0015	0.029258
LV110	0.029359
PAM010	0.029365
GSR049	0.029763
GSR021	0.030003
LV098	0.030184
GSR035	0.030214
GSR151	0.030324

Here are the 10 closest specimens to UKR003

GSR124	0.025523
LV051	0.026107
LV110	0.027247
LV098	0.028117
GSR154	0.028183
JQ0015	0.028372
GSR151	0.028612
LV109	0.028699
PAM010	0.028903
GSR049	0.029039

Here are the 10 closest specimens to UKR004

GSR124	0.026314
LV051	0.028254
GSR154	0.028654
JQ0015	0.029135
GSR151	0.029270
LV110	0.029454
GSR035	0.029991
GSR037	0.030094
LV098	0.030407
GSR146	0.030437

Here are the 10 closest specimens to UKR005

JEC208	0.030897
LV051	0.032439
PAM010	0.032492
JEC172	0.033369
GSR124	0.033503
IND213	0.033632
PAM040	0.034212
PAM066	0.034342
LV098	0.034371
LV110	0.034536

Here are the 10 closest specimens to UKR006

MAC419	0.025294
LV051	0.025355
JEC208	0.025549
MAC403	0.026545
MAC285	0.026580
PAM010	0.026849
SIC207	0.027006
SIC207	0.027006
SIC484	0.027192
LV110	0.027305

Here are the 10 closest specimens to UKR007

LV051	0.025484
GSR124	0.025539
LV110	0.026827
LV097	0.027582
LV098	0.027664
PF769	0.027777
PAM010	0.027879
SIC484	0.028012
SIC207	0.028060
SIC207	0.028060

Here are the 10 closest specimens to UKR008

LV051	0.024668
GSR124	0.025256
LV110	0.025738
LV098	0.026740
LV097	0.026821
SIC484	0.026949
PF769	0.027001
PAM010	0.027224
SIC207	0.027240
SIC207	0.027240

Here are the 10 closest specimens to UKR009

GSR124	0.026936
LV110	0.027591
LV051	0.027783
GSR035	0.027798
JQ0015	0.028502
GSR021	0.028595
LV098	0.028933
PAM010	0.029062
GSR033	0.029163
GSR151	0.029454

Here are the 10 closest specimens to UKR010

GSR124	0.021637
LV051	0.022809
LV110	0.022891
GSR035	0.024247
LV098	0.024397
JQ0015	0.024696
LV109	0.025269
GSR049	0.025375
GSR021	0.025742
GSR151	0.025828

Here are the 10 closest specimens to UKR011

JEC208	0.023746
SIC484	0.024476
LV051	0.024574
SIC207	0.024832
SIC207	0.024832
MAC285	0.024985
LV110	0.025006
MAC419	0.025258
LV098	0.026008
GSR124	0.026110

Here are the 10 closest specimens to UKR012

GSR124	0.028521
LV051	0.029000
PAM010	0.029671
GSR154	0.030191
JQ0015	0.030486
LV110	0.030571
GSR151	0.030648
PAM040	0.030835
PAM066	0.031131
LV098	0.031152

Here are the 10 closest specimens to UKR013

JEC172	0.033147
JEC208	0.033358
PAM010	0.033500
IND213	0.034348
PAM040	0.034538
LV051	0.034593
WCRM013	0.034619
WCRM013	0.034619
JEC142	0.034671
PAM066	0.034809

Here are the 10 closest specimens to UKR014

GSR124	0.026546
GSR154	0.027691
JQ0015	0.027937
GSR151	0.028388
DIA537	0.028425
GSR037	0.028662
MJ0165	0.028790
LV051	0.028945
GSR146	0.029308
GSR013	0.029327

Here are the 10 closest specimens to UKR015

LV051	0.027750
GSR124	0.027753
LV110	0.028469
SIC207	0.028569
SIC207	0.028569
WCRM013	0.028591
WCRM013	0.028591
JEC008	0.028614
JEC019	0.028622
PAM010	0.028763

Here are the 10 closest specimens to UKR016

GSR124	0.027531
LV051	0.027800
PAM010	0.028424
LV110	0.029052
LV098	0.029625
PAM040	0.029629
PAM066	0.029758
JQ0015	0.030179
GSR154	0.030295
GSR049	0.030335

Here are the 10 closest specimens to UKR017

LV051	0.026074
GSR124	0.026755
PAM010	0.026895
LV110	0.027479
SIC484	0.027903
LV098	0.027992
SIC207	0.028079
SIC207	0.028079
RWP086	0.028176
PAM040	0.028204

Here are the 10 closest specimens to UKR018

SIC484	0.019598
SIC207	0.019638
SIC207	0.019638
LV051	0.020175
LV110	0.020683
LAZ128	0.021189
LAZ128	0.021189
LAZ128	0.021189
PF769	0.021350
RWP086	0.021617

Here are the 10 closest specimens to UKR019

GSR124	0.024042
LV110	0.024274
LV051	0.024486
SIC207	0.025506
SIC207	0.025506
LV098	0.025756
SIC484	0.025854
LV082	0.025953
JEC037	0.026075
PAM010	0.026151

Here are the 10 closest specimens to UKR020

LV051	0.024685
GSR124	0.024967
LV110	0.025403
PAM010	0.025882
LV098	0.026336
SIC207	0.026352
SIC207	0.026352
SIC484	0.026685
WCRM013	0.026960
WCRM013	0.026960

Here are the 10 closest specimens to UKR021

JEC208	0.025954
LV051	0.027779
MAC419	0.027802
PAM010	0.027987
MAC285	0.028002
SIC484	0.028080
SIC207	0.028264
SIC207	0.028264
WCRM013	0.028405
WCRM013	0.028405

Here are the 10 closest specimens to UKR022

GSR124	0.026139
LV051	0.026751
LV110	0.028377
PAM010	0.028424
LV098	0.028883
GSR154	0.029103
GSR151	0.029297
PAM066	0.029434
PAM040	0.029474
JQ0015	0.029511

Here are the 10 closest specimens to UKR023

GSR124	0.029192
LV051	0.030996
JQ0015	0.031128
GSR154	0.031141
GSR151	0.031802
DIA537	0.031880
GSR035	0.031918
LV110	0.032002
MJ0165	0.032053
GSR021	0.032145

Here are the 10 closest specimens to UKR024

LV051	0.023477
LV110	0.024130
GSR124	0.024329
SIC207	0.024550
SIC207	0.024550
SIC484	0.024952
LV098	0.025214
MAC419	0.025940
RWP086	0.026052
PAM010	0.026093

Here are the 10 closest specimens to UKR025

SIC484	0.022923
MAC419	0.023011
SIC207	0.023136
SIC207	0.023136
LV051	0.023510
MAC285	0.024035
LV110	0.024039
CHP214	0.024790
MAC380	0.024892
SIC401	0.024975

Here are the 10 closest specimens to UKR026

LV051	0.026107
SIC207	0.027169
SIC207	0.027169
SIC484	0.027277
LV110	0.027289
PAM010	0.027586
GSR124	0.027728
LV098	0.027839
JEC208	0.027886
MAC285	0.028117

Here are the 10 closest specimens to UKR027

GSR124	0.024206
LV051	0.024511
LV110	0.025771
PAM010	0.026039
LV098	0.026514
PAM066	0.027762
LV097	0.027786
PAM040	0.027788
GSR035	0.027906
JQ0015	0.027910

Here are the 10 closest specimens to UKR028

LV051	0.023600
GSR124	0.024580
LV110	0.025069
LV098	0.025312
PAM010	0.025536
JEC019	0.025746
GSR049	0.025890
SIC207	0.026180
SIC207	0.026180
JEC008	0.026187

Here are the 10 closest specimens to UKR029

LV051	0.021788
GSR124	0.022076
LV110	0.022512
LV098	0.023729
LV097	0.023874
LV109	0.024370
SIC484	0.024733
LV082	0.024778
PAM010	0.024859
SIC207	0.024998

Here are the 10 closest specimens to UKR030

LV051	0.022281
GSR124	0.023630
LV110	0.023669
SIC207	0.024047
SIC207	0.024047
PF769	0.024196
RWP086	0.024337
LV098	0.024371
LAZ128	0.024443
LAZ128	0.024443

Here are the 10 closest specimens to UKR031

GSR154	0.048748
JQ0015	0.048771
GSR151	0.049134
GSR030	0.049157
GSR124	0.049361
GSR146	0.049553
GSR141	0.050494
GSR033	0.050580
DIA537	0.050955
TD069	0.051090

Here are the 10 closest specimens to UKR032

DIA537	0.055409
GSR151	0.058989
JQ0015	0.059084
GSR154	0.059392
SUN069	0.059550
GSR030	0.059688
GSR146	0.060042
GSR037	0.060108
MOC082	0.060297
TJS015	0.060313

Here are the 10 closest specimens to UKR033

DIA537	0.053215
GSR151	0.058240
SUN069	0.058290
JQ0015	0.058306
GSR154	0.058424
GSR037	0.058569
GSR030	0.058791
TJS015	0.058800
GSR146	0.059300
GSR124	0.059877

Here are the 10 closest specimens to UKR034

DIA537	0.051021
JQ0015	0.051561
GSR151	0.051794
GSR154	0.052175
GSR030	0.052329
GSR124	0.052556
GSR037	0.052570
GSR146	0.052807
GSR033	0.053359
GSR141	0.053657

Here are the 10 closest specimens to UKR035

GSR151	0.057147
JQ0015	0.057214
GSR030	0.057778
GSR154	0.057928
MOC082	0.057938
GSR037	0.058228
GSR146	0.058303
DIA537	0.058807
GSR124	0.058929
GSR141	0.058953

Here are the 10 closest specimens to UKR036

DIA537	0.059898
MOC082	0.060772
GSR151	0.062578
JQ0015	0.062613
GSR154	0.062978
TJS015	0.062998
GSR030	0.063251
GSR146	0.063590
GSR037	0.063643
CPT098	0.063699

Here are the 10 closest specimens to UKR037

MOC082	0.060389
DIA537	0.061062
GSR151	0.062777
JQ0015	0.062783
GSR154	0.063312
CPT098	0.063494
GSR030	0.063723
GSR146	0.063872
TJS015	0.063903
GSR037	0.063911

Here are the 10 closest specimens to UKR038

JQ0015	0.054962
GSR151	0.055080
GSR030	0.055460
GSR154	0.055482
GSR124	0.055984
GSR146	0.056088
GSR037	0.056308
DIA537	0.056584
GSR141	0.056699
JQ0005	0.057293

Here are the 10 closest specimens to UKR039

JEC208	0.026612
DKG020	0.030288
IND183	0.030406
JEC037	0.031449
JEC165	0.031652
LV110	0.031753
GSR035	0.031843
GSR124	0.031989
IND213	0.032044
LV051	0.032222

Here are the 10 closest specimens to UKR040

LV051	0.024784
GSR124	0.024809
LV110	0.025175
SIC207	0.026301
SIC207	0.026301
LV098	0.026371
SIC484	0.026385
PF769	0.027080
RWP086	0.027087
LAZ128	0.027207

Here are the 10 closest specimens to UKR041

LV051	0.026392
JEC208	0.026405
LV110	0.026592
GSR124	0.027038
PAM010	0.027579
LV098	0.027722
JEC008	0.027796
GSR049	0.027888
JEC019	0.028194
JQ0005	0.028212

Here are the 10 closest specimens to UKR042

DIA537	0.028177
GSR037	0.034159
TJS015	0.034269
JQ0015	0.035062
GSR021	0.035386
GSR124	0.035650
GSR151	0.036097
GSR154	0.036407
GSR013	0.036619
GSR048	0.036787

Here are the 10 closest specimens to UKR043

PAM010	0.029248
LV051	0.029350
PAM040	0.029600
GSR124	0.030065
PAM066	0.030185
SUN021	0.030794
LV110	0.031109
WCRM013	0.031245
WCRM013	0.031245
LV098	0.031444

Here are the 10 closest specimens to UKR044

LV051	0.026304
LV110	0.026683
JEC208	0.026777
GSR124	0.026801
PAM010	0.026993
LV098	0.027688
SIC207	0.027779
SIC207	0.027779
JEC037	0.028126
LV082	0.028209

Here are the 10 closest specimens to UKR045

LV051	0.023788
LV110	0.025032
GSR124	0.025127
SIC207	0.025236
SIC207	0.025236
LV098	0.025737
SIC484	0.025789
PAM010	0.025790
RWP086	0.025924
PF769	0.025987

Here are the 10 closest specimens to UKR046

LV051	0.024316
GSR124	0.024652
LV110	0.025127
LV098	0.025979
PAM010	0.026141
LV082	0.026709
GSR049	0.026823
LV134	0.026833
SIC207	0.026857
SIC207	0.026857

Here are the 10 closest specimens to UKR047

LV051	0.025235
GSR124	0.025596
PAM010	0.026516
LV110	0.026817
LV098	0.027257
GSR049	0.027913
JQ0015	0.028263
JEC019	0.028270
PAM040	0.028381
PAM066	0.028449

Here are the 10 closest specimens to UKR048

GSR124	0.026664
LV051	0.028156
JQ0015	0.028538
LV110	0.028666
PAM010	0.029161
GSR154	0.029436
GSR049	0.029507
GSR035	0.029637
GSR151	0.029806
LV098	0.029862

Here are the 10 closest specimens to UKR049

GSR124	0.024677
LV051	0.025284
LV110	0.026461
LV098	0.027743
LV109	0.028060
GSR035	0.028565
JQ0015	0.028726
LV097	0.028769
MJ0092	0.028801
PAM010	0.029069

Here are the 10 closest specimens to UKR050

PAM010	0.031779
JEC208	0.032722
GSR124	0.033058
LV051	0.033141
PAM040	0.033209
PAM066	0.033474
JEC172	0.034210
JEC019	0.034501
LV110	0.034553
WCRM013	0.034638

Here are the 10 closest specimens to UKR051

LV051	0.025797
GSR124	0.026943
LV110	0.027056
LV098	0.028202
PAM010	0.028366
GSR049	0.028722
LV109	0.028952
GSR035	0.028957
LGD936	0.029229
LV097	0.029384

Here are the 10 closest specimens to UKR052

GSR151	0.046970
JQ0015	0.046992
GSR030	0.047207
GSR154	0.047581
GSR124	0.047606
GSR146	0.047928
GSR033	0.048093
TD069	0.048377
GSR141	0.048597
LV110	0.048925

Here are the 10 closest specimens to UKR053

LV051	0.026479
LV110	0.027850
GSR124	0.028202
PAM010	0.028374
LV098	0.028803
SIC484	0.029000
MAC419	0.029013
SIC207	0.029188
SIC207	0.029188
GSR049	0.029466

Here are the 10 closest specimens to UKR054

DIA537	0.051865
JQ0015	0.052992
GSR154	0.053036
GSR151	0.053182
GSR030	0.053450
GSR146	0.053497
GSR124	0.053910
GSR141	0.054563
GSR033	0.054796
TJS015	0.055016

Here are the 10 closest specimens to UKR055

GSR124	0.043857
GSR154	0.044719
JQ0015	0.044807
GSR030	0.044866
TD069	0.044923
GSR033	0.045079
LV110	0.045081
GSR151	0.045221
GSR146	0.045300
LV107	0.045568

Here are the 10 closest specimens to UKR056

DIA537	0.051654
SUN069	0.056383
GSR151	0.056943
GSR154	0.057086
JQ0015	0.057106
GSR030	0.057290
TJS015	0.057458
GSR146	0.057731
GSR037	0.057791
GSR141	0.058630

Here are the 10 closest specimens to UKR057

LV051	0.024261
GSR124	0.025231
LV110	0.025247
LV098	0.026303
GSR049	0.027097
LV109	0.027181
GSR035	0.027681
PAM010	0.027964
JQ0015	0.028017
LGD936	0.028055

Here are the 10 closest specimens to UKR058

GSR124	0.028259
LV051	0.028879
LV110	0.030109
PAM010	0.030899
LV098	0.031077
GSR049	0.031870
LGD936	0.031905
JQ0015	0.031960
GSR154	0.032031
MJ0092	0.032243

Here are the 10 closest specimens to UKR059

GSR030	0.045872
JQ0015	0.046009
GSR151	0.046083
GSR154	0.046292
GSR124	0.046516
GSR146	0.046761
GSR033	0.047124
GSR141	0.047403
TD069	0.047684
JQ0005	0.047926

Here are the 10 closest specimens to UKR060

LV051	0.025664
LV110	0.026890
PAM010	0.027399
LV098	0.027684
GSR124	0.027707
MAC419	0.028045
GSR049	0.028078
SIC207	0.028379
SIC207	0.028379
SIC484	0.028493

Here are the 10 closest specimens to UKR061

JQ0015	0.050003
GSR154	0.050351
DIA537	0.050568
GSR151	0.050819
GSR013	0.051274
GSR146	0.051308
GSR124	0.051689
GSR030	0.052073
GSR021	0.052216
GSR141	0.052544

Here are the 10 closest specimens to UKR062

GSR124	0.035328
PAM010	0.035450
GSR037	0.035775
PF881	0.036145
SUN021	0.036798
PAM066	0.036916
PAM040	0.037144
PAM011	0.037451
GSR151	0.037862
PAM072	0.037867

Here are the 10 closest specimens to UKR063

CPT098	0.052380
CPT099	0.052510
GSR089	0.054357
GSR037	0.054540
GSR013	0.054797
MJ0069	0.055054
GSR148	0.055097
JQ0015	0.055552
MJ0076	0.055763
MJ0066	0.055800

Here are the 10 closest specimens to UKR064

GSR154	0.051770
JQ0015	0.051922
DIA537	0.052355
GSR151	0.052798
GSR124	0.053175
GSR146	0.053635
GSR030	0.053833
GSR037	0.053910
GSR013	0.054017
GSR141	0.054652

Here are the 10 closest specimens to UKR065

VIW244	0.015910
VIW244	0.015910
CHP015	0.016033
MAC380	0.017274
DLH145	0.018237
MAC285	0.018301
RWP086	0.018498
VIW090	0.018910
VIW090	0.018910
CHP214	0.018958

Here are the 10 closest specimens to UKR066

RWP090	0.017009
MAC419	0.017816
LAZ159	0.018860
LAZ159	0.018860
RWP086	0.018943
GSR069	0.019382
VIW343	0.019458
VIW343	0.019458
VIW185	0.019594
VIW185	0.019594

Here are the 10 closest specimens to UKR067

ANI011	0.021854
ANI011	0.021854
MAC419	0.022189
PF959	0.022596
LOA112	0.022789
CHP125	0.022938
PAM102	0.023041
OT141	0.023044
OT141	0.023044
VIW343	0.023280

Here are the 10 closest specimens to UKR068

OT141	0.025267
OT141	0.025267
OT148	0.025929
OT148	0.025929
OT163	0.026458
OT163	0.026458
CHP238	0.027465
PAM102	0.028075
OT162	0.028292
OT162	0.028292

Here are the 10 closest specimens to UKR069

SIC484	0.021602
VIW125	0.022374
VIW125	0.022374
RWP086	0.022883
LAZ128	0.023129
LAZ128	0.023129
LAZ128	0.023129
VIW261	0.023220
VIW261	0.023220
VIW127	0.023335

Here are the 10 closest specimens to UKR070

SIC484	0.018229
LAZ167	0.019118
LAZ167	0.019118
VIW125	0.019205
VIW125	0.019205
VIW127	0.019356
VIW127	0.019356
SIC207	0.019442
SIC207	0.019442
PLW002	0.019609

Here are the 10 closest specimens to UKR071

SIC299	0.017900
SIC299	0.017900
SIC484	0.018119
VIW090	0.018339
VIW090	0.018339
GSR069	0.018399
LV134	0.018823
SIC207	0.018973
SIC207	0.018973
SIC306	0.019015

Here are the 10 closest specimens to UKR072

SIC484	0.016447
SIC207	0.016969
SIC207	0.016969
VIW090	0.017327
VIW090	0.017327
LV097	0.017374
LV110	0.017388
LAZ130	0.017596
LAZ130	0.017596
LAZ130	0.017596

Here are the 10 closest specimens to UKR073

VIW125	0.020097
VIW125	0.020097
SIC484	0.020126
VIW148	0.020939
VIW148	0.020939
PLW002	0.021294
VIW126	0.021594
VIW126	0.021594
LAZ167	0.021702
LAZ167	0.021702

Here are the 10 closest specimens to UKR074

SIC484	0.019198
VIW125	0.020354
VIW125	0.020354
SIC207	0.020906
SIC207	0.020906
VIW126	0.020990
VIW126	0.020990
VIW127	0.021212
VIW127	0.021212
VIW148	0.021507

Here are the 10 closest specimens to UKR075

SIC484	0.021403
CHP214	0.022134
VIW125	0.022158
VIW125	0.022158
MAC419	0.022360
SIC401	0.022392
SIC401	0.022392
SIC207	0.022822
SIC207	0.022822
MAC285	0.023139

Here are the 10 closest specimens to UKR076

SIC484	0.017169
SIC207	0.018680
SIC207	0.018680
MAC419	0.018920
SIC401	0.019202
SIC401	0.019202
SIC478	0.019244
MAC285	0.019481
GSR069	0.019640
SIC180	0.019675

Here are the 10 closest specimens to UKR077

SIC484	0.019852
SIC207	0.020835
SIC207	0.020835
VIW148	0.021167
VIW148	0.021167
LAZ167	0.021379
LAZ167	0.021379
VIW125	0.021804
VIW125	0.021804
PLW002	0.022086

Here are the 10 closest specimens to UKR078

PAM040	0.017661
PAM072	0.017700
PAM066	0.018420
GUA037	0.019416
SUN021	0.021252
PAM073	0.021981
PAM010	0.022946
PAM045	0.023603
PAM084	0.023852
PAM011	0.024516

Here are the 10 closest specimens to UKR079

PAM011	0.016824
PAM045	0.017379
PAM084	0.017781
PAM014	0.017793
PAM042	0.017942
PAM010	0.018194
PAM003	0.018601
PAM081	0.019522
PAM027	0.019600
PAM055	0.019759

Here are the 10 closest specimens to UKR080

PAM072	0.018327
PAM040	0.019082
PAM066	0.019298
PAM073	0.019652
PAM084	0.023344
PAM010	0.023657
GUA037	0.024196
PAM045	0.024376
PAM011	0.024520
PAM042	0.024843

Here are the 10 closest specimens to UKR081

GUA037	0.017687
PAM040	0.018707
PAM066	0.019258
PAM072	0.020211
MJ0176	0.021183
SUN021	0.021696
PAM010	0.022306
MJ0189	0.022636
MJ0089	0.022765
MJ0162	0.023145

Here are the 10 closest specimens to UKR082

PAM010	0.017021
CHP015	0.017064
PAM011	0.017309
GUA037	0.017523
PAM066	0.017649
PAM040	0.017886
PAM072	0.018108
PAM045	0.018229
PAM084	0.018235
PAM042	0.018263

Here are the 10 closest specimens to UKR083

MJ0092	0.024022
DIA865	0.025063
GSR124	0.025734
JQ0050	0.026191
MJ0198	0.026590
GSR049	0.026826
LGD936	0.026967
MJ0087	0.027078
PF873	0.027278
VIW200	0.027654

Here are the 10 closest specimens to UKR084

GUA037	0.015957
CHP015	0.017572
PAM040	0.017891
PAM066	0.018293
MJ0176	0.018534
PAM072	0.018777
MJ0162	0.019752
PAM010	0.019874
SUN021	0.020086
PAM045	0.020533

Here are the 10 closest specimens to UKR085

GUA037	0.018309
PAM040	0.019395
PAM066	0.019845
PAM072	0.021088
MJ0176	0.021435
PAM010	0.022123
CHP015	0.022503
MJ0089	0.022984
MJ0189	0.023000
CWM-066	0.023145

Here are the 10 closest specimens to UKR086

GUA037	0.018259
PAM040	0.020442
MJ0176	0.021007
MJ0162	0.021061
PAM066	0.021166
SUN021	0.022079
MJ0164	0.022202
MJ0089	0.022268
MJ0166	0.022281
PAM010	0.022319

Here are the 10 closest specimens to UKR087

SUN021	0.020773
GUA037	0.021091
PAM040	0.021530
PAM010	0.021745
PAM066	0.022016
PAM072	0.022095
MJ0176	0.022268
MJ0162	0.022996
CHP015	0.023422
PAM011	0.023547

Here are the 10 closest specimens to UKR088

GUA037	0.018398
PAM066	0.019063
PAM040	0.019114
PAM072	0.019393
PAM010	0.019439
CHP015	0.019605
PAM011	0.020032
PDL320	0.020190
PAM045	0.020314
PAM042	0.020528

Here are the 10 closest specimens to UKR089

PAM072	0.020599
PAM073	0.021021
PAM040	0.021641
PAM066	0.021824
GUA037	0.024356
PAM010	0.025601
PAM084	0.025792
DLH144	0.025821
SUN021	0.025915
DAM024	0.026364

Here are the 10 closest specimens to UKR090

PAM042	0.015640
PAM011	0.016197
PAM014	0.016471
PAM045	0.016774
PAM084	0.016789
PAM081	0.017492
PAM003	0.017554
PAM010	0.018015
PAM027	0.018329
PAM036	0.018689

Here are the 10 closest specimens to UKR091

GUA037	0.016945
PAM040	0.018363
PAM066	0.019005
PAM072	0.019690
MJ0176	0.019783
SUN021	0.020341
MJ0162	0.021218
CHP015	0.021263
PAM010	0.021332
MJ0166	0.022070

Here are the 10 closest specimens to UKR092

JQ0015	0.050024
GSR037	0.051232
JQ0050	0.051470
GSR154	0.051498
GSR151	0.051938
GSR013	0.052267
JQ0016	0.052356
GSR124	0.052453
GSR146	0.053097
GSR030	0.053229

Appendix B: Probability of group membership in the three Krotscheck groups for other Greek pottery calculated using a Mahalanobis distance projection using the first five principal components.

MAHALANOBIS DISTANCE CALCULATION FOR MISCELLANEOUS SPECIMENS
PROJECTED AGAINST TWO OR MORE GROUPS.

Variables used:
PC01 PC02 PC03 PC04 PC05

The following specimens are in the file AtticA

ID. NO.	Probabilities: Group 1	Group 2	Group 3	BEST GP.
DFD259	0.000	0.000	0.004	3
DFD260	0.000	0.000	0.007	3
DFD266	0.000	0.000	0.019	3
DFD267	0.000	0.000	0.002	3
DFD268	0.000	0.000	0.039	3
DFD269	0.000	0.000	0.009	3
DFD270	0.000	0.000	0.140	3
DFD502	0.000	0.000	0.003	3
DFD506	0.000	0.000	0.004	3
DFD507	0.000	0.000	0.053	3
DFD508	0.000	0.000	0.085	3
DFD509	0.000	0.000	0.014	3
DFD510	0.000	0.000	0.033	3
DFD511	0.000	0.000	0.036	3
DFD512	0.000	0.000	0.017	3
DFD514	0.000	0.000	0.022	3
DFD516	0.000	0.000	0.024	3
DFD517	0.000	0.000	0.020	3
DFD519	0.000	0.000	0.008	3
DFD520	0.000	0.000	1.190	3
DFD522	0.000	0.000	0.285	3
DFD523	0.000	0.000	0.042	3
DFD524	0.000	0.000	0.939	3
DFD527	0.000	0.000	0.015	3
DFD529	0.000	0.000	0.027	3
DFD530	0.000	0.000	0.001	3
DFD531	0.000	0.000	0.002	3
DFD538	0.000	0.000	0.006	3
DFD539	0.000	0.000	0.059	3
DFD540	0.000	0.000	0.085	3
DFD542	0.000	0.000	0.016	3
DFD543	0.000	0.000	0.264	3
DFD544	0.000	0.000	0.015	3
DFD545	0.000	0.000	0.100	3
DFD546	0.000	0.000	0.065	3
DFD547	0.000	0.000	0.106	3
DFD548	0.000	0.000	0.003	3
DFD550	0.000	0.000	0.003	3
DFD551	0.000	0.000	0.001	3
DFD552	0.000	0.000	0.002	3
DFD553	0.000	0.000	0.069	3
DFD554	0.000	0.000	0.053	3
DFD583	0.000	0.000	0.006	3
DFD593	0.000	0.000	0.062	3
DFD594	0.000	0.000	0.014	3
DFD602	0.000	0.000	0.004	3
DFD603	0.000	0.000	0.000	3
DFD604	0.000	0.000	0.003	3
DFD631	0.000	0.000	0.033	3
DFD632	0.000	0.000	0.015	3
DFD640	0.000	0.000	0.003	3
DFD641	0.000	0.000	0.027	3
DFD642	0.000	0.000	0.002	3
DFD643	0.000	0.000	0.009	3

The following specimens are in the file AtticB

ID. NO.	Probabilities: Group 1	Group 2	Group 3	BEST GP.
DFD263	0.000	0.000	0.006	3
DFD264	0.000	0.000	0.009	3
DFD265	0.000	0.000	0.004	3
DFD271	0.000	0.000	0.016	3
DFD557	0.000	0.000	0.233	3
DFD558	0.000	0.000	0.021	3
DFD559	0.000	0.000	0.230	3
DFD561	0.000	0.000	0.655	3
DFD562	0.000	0.000	0.104	3
DFD563	0.000	0.000	0.066	3
DFD564	0.000	0.000	0.266	3
DFD565	0.000	0.000	0.592	3
DFD566	0.000	0.000	0.747	3
DFD568	0.000	0.000	0.508	3
DFD569	0.000	0.000	0.336	3
DFD637	0.000	0.000	0.014	3

The following specimens are in the file AtticC

ID. NO.	Probabilities: Group 1	Group 2	Group 3	BEST GP.
DFD570	0.000	0.000	0.002	3
DFD571	0.000	0.000	0.004	3
DFD573	0.000	0.000	0.006	3
DFD634	0.000	0.000	0.007	3
DFD635	0.000	0.000	0.002	3
DFD636	0.000	0.000	0.006	3

The following specimens are in the file Corintian

ID. NO.	Probabilities: Group 1	Group 2	Group 3	BEST GP.
DFD526	0.000	0.000	0.005	3
DFD579	0.000	0.000	0.008	3
DFD580	0.000	0.000	0.008	3
DFD585	0.000	0.000	0.002	3
DFD589	0.000	0.000	0.119	3
DFD605	0.000	0.000	0.007	3
DFD606	0.000	0.000	0.001	3
DFD608	0.000	0.000	0.036	3
DFD609	0.000	0.000	0.084	3
DFD610	0.000	0.000	0.146	3
DFD611	0.000	0.000	0.001	3
DFD612	0.000	0.000	0.159	3
DFD613	0.000	0.000	0.015	3
DFD614	0.000	0.000	0.312	3
DFD615	0.000	0.000	0.066	3
DFD616	0.000	0.000	0.001	3
DFD617	0.000	0.000	0.002	3
DFD618	0.000	0.000	0.002	3
DFD619	0.000	0.000	0.006	3
DFD622	0.000	0.000	0.001	3
DFD624	0.000	0.000	0.050	3
DFD625	0.000	0.000	0.048	3
DFD626	0.000	0.000	0.013	3

The following specimens are in the file Rotroff Data

ID. NO.	Probabilities: Group 1	Group 2	Group 3	BEST GP.
SIR001	0.000	0.000	0.003	3
SIR002	0.000	0.000	0.000	3
SIR003	0.000	0.000	0.001	3
SIR004	0.000	0.000	0.001	3
SIR005	0.000	0.000	0.003	3
SIR006	0.000	0.000	0.002	3
SIR007	0.000	0.000	0.000	3
SIR008	0.000	0.000	0.038	3
SIR009	0.000	0.000	1.523	3

SIR010	0.000	0.000	0.000	3
SIR011	0.000	0.000	0.000	3
SIR012	0.000	0.000	0.000	3
SIR013	0.000	0.000	0.000	3
SIR014	0.000	0.000	0.000	3
SIR015	0.000	0.000	0.000	3
SIR016	0.000	0.000	0.000	3
SIR017	0.000	0.000	0.000	3
SIR018	0.000	0.000	0.000	3
SIR019	0.000	0.000	0.000	3
SIR020	0.000	0.000	0.000	3
SIR021	0.000	0.000	0.000	3
SIR022	0.000	0.000	0.000	3
SIR023	0.000	0.000	0.000	3
SIR024	0.000	0.000	0.000	3
SIR025	0.000	0.000	0.000	3
SIR026	0.000	0.000	0.000	3
SIR027	0.000	0.000	0.000	3
SIR028	0.000	0.000	0.000	3
SIR029	0.000	0.000	0.000	3
SIR030	0.000	0.000	0.000	3
SIR031	0.000	0.000	0.041	3
SIR032	0.000	0.000	0.041	3
SIR033	0.000	0.000	0.079	3
SIR034	0.000	0.000	0.061	3
SIR035	0.000	0.000	0.094	3
SIR036	0.000	0.000	0.007	3
SIR037	0.000	0.000	0.064	3
SIR038	0.000	0.000	0.126	3
SIR039	0.000	0.000	0.029	3
SIR040	0.000	0.000	0.239	3
SIR041	0.000	0.000	0.045	3
SIR042	0.000	0.000	0.000	2
SIR043	0.000	0.000	0.000	2
SIR044	0.000	0.000	0.000	2
SIR045	0.000	0.000	0.000	2
SIR046	0.000	0.000	0.000	2
SIR047	0.000	0.000	0.000	2
SIR048	0.000	0.000	0.000	2
SIR049	0.000	0.000	0.000	2
SIR050	0.000	0.000	0.000	2
SIR051	0.000	0.000	0.000	3
SIR052	0.000	0.000	0.000	3
SIR053	0.000	0.000	0.000	3
SIR054	0.000	0.000	0.000	3
SIR055	0.000	0.000	0.000	3
SIR056	0.000	0.000	0.000	3
SIR057	0.000	0.000	0.000	3
SIR058	0.000	0.000	0.000	3
SIR059	0.000	0.000	0.000	3
SIR060	0.000	0.000	0.000	3
SIR061	0.000	0.000	0.000	3
SIR062	0.000	0.000	0.000	3
SIR063	0.000	0.000	0.000	3
SIR064	0.000	0.000	0.000	3
SIR065	0.000	0.000	0.000	3
SIR066	0.000	0.000	0.000	3
SIR067	0.000	0.000	0.000	3
SIR068	0.000	0.000	0.000	3
SIR069	0.000	0.000	0.000	3
SIR070	0.000	0.000	0.000	3
SIR071	0.000	0.000	0.000	3
SIR072	0.000	0.000	0.004	3
SIR073	0.000	0.000	0.003	3
SIR074	0.000	0.000	0.004	3
SIR075	0.000	0.000	0.001	3
SIR076	0.000	0.000	0.013	3
SIR077	0.000	0.000	0.007	3
SIR078	0.000	0.000	0.002	3
SIR079	0.000	0.000	0.002	3

SIR080	0.000	0.000	0.006	3
SIR081	0.000	0.000	0.009	3
SIR082	0.000	0.000	0.011	3
SIR083	0.000	0.000	0.001	3
SIR084	0.000	0.000	0.025	3
SIR085	0.000	0.000	0.027	3
SIR086	0.000	0.000	0.012	3
SIR087	0.000	0.000	0.158	3
SIR088	0.000	0.000	0.115	3
SIR089	0.000	0.000	0.011	3
SIR090	0.000	0.000	0.004	3
SIR091	0.000	0.000	0.010	3
SIR092	0.000	0.000	0.069	3
SIR093	0.000	0.000	0.074	3

The following specimens are in the file Kilikoglou Data

	Probabilities:			
ID. NO.	Group 1	Group 2	Group 3	BEST GP.
RHO001	0.000	0.000	0.000	3
RHO002	0.000	0.000	0.000	3
RHO003	0.000	0.000	0.001	3
RHO004	0.000	0.000	0.002	3
RHO006	0.000	0.000	0.000	3
RHO008	0.000	0.000	0.000	3
RHO009	0.000	0.000	0.001	3
RHO010	0.000	0.000	0.000	3
RHO012	0.000	0.000	0.000	3
SAH001	0.000	0.000	0.010	3
SAH002	0.000	0.000	0.000	3
SAH003	0.000	0.000	0.001	3
SAH004	0.000	0.000	0.006	3
SAH005	0.000	0.000	0.073	3
SAH006	0.000	0.000	0.000	3
SAH007	0.000	0.000	0.001	3
SAH008	0.000	0.000	0.000	3
SAH009	0.000	0.000	0.058	3
SAH010	0.000	0.000	0.000	3
SAH011	0.000	0.000	0.001	3
SAH012	0.000	0.000	0.000	3
SAH013	0.000	0.000	0.000	2
SAH014	0.000	0.000	0.000	3
SAH015	0.000	0.000	0.004	3
SAH016	0.000	0.000	0.000	3
SAH017	0.000	0.000	0.000	3
SAH018	0.000	0.000	0.000	3
SAH019	0.000	0.000	0.000	3
SAH020	0.000	0.000	0.016	3
SAH021	0.000	0.000	0.012	3
SAH022	0.000	0.000	0.000	3
SAH023	0.000	0.000	0.000	3
SAH024	0.000	0.000	0.004	3
SAH025	0.000	0.000	0.000	3
SAH026	0.000	0.000	0.001	3
SAH027	0.000	0.000	0.000	3
SAH028	0.000	0.000	0.004	3
SAH029	0.000	0.000	3.565	3
SAH030	0.000	0.000	0.000	3
SAH031	0.000	0.000	0.000	3
SAH032	0.000	0.000	0.000	3
SAH033	0.000	0.000	0.002	3
SAH034	0.000	0.000	0.001	3
SAH035	0.000	0.000	0.000	3
SAH036	0.000	0.000	0.000	3
SAH037	0.000	0.000	0.001	3
SAH038	0.000	0.000	0.000	3
SAH039	0.000	0.000	0.000	3
SAH040	0.000	0.000	0.000	3
SAH041	0.000	0.000	0.000	3
SAH042	0.000	0.000	0.000	3
SAH043	0.000	0.000	0.000	3

SAH044	0.000	0.000	0.004	3
SAH045	0.000	0.000	0.007	3
SAH046	0.000	0.000	0.019	3
SAH047	0.000	0.000	0.003	3
SAH048	0.000	0.000	0.003	3
SAH049	0.000	0.000	0.000	3
SAH050	0.000	0.000	0.000	3
SAH051	0.000	0.000	0.000	3
SAH053	0.000	0.000	0.001	3
SAH054	0.000	0.000	0.000	3
SAH055	0.000	0.000	0.001	3
SAH056	0.000	0.000	0.002	3
SAH057	0.000	0.000	0.010	3
SAH058	0.000	0.000	0.001	3
SAH059	0.000	0.000	0.009	3
SAH060	0.000	0.000	0.001	3
SAH061	0.000	0.000	0.033	3
SAH062	0.000	0.000	0.000	3
SAH063	0.000	0.000	0.001	3
SAH064	0.000	0.000	0.000	3
SAH065	0.000	0.000	0.001	3
SAH066	0.000	0.000	0.581	3
SAH067	0.000	0.000	0.114	3
SAH068	0.000	0.000	0.000	3
SAH069	0.000	0.000	0.044	3
SAH070	0.000	0.000	0.004	3
SAH071	0.000	0.000	0.000	3
SAH072	0.000	0.000	0.000	3
SAH073	0.000	0.000	0.001	3
SAH074	0.000	0.000	0.004	3
SAH075	0.000	0.000	0.646	3
SAH076	0.000	0.000	0.000	3
SAH077	0.000	0.000	0.000	3
SAH078	0.000	0.000	0.060	3
SAH079	0.000	0.000	0.001	3
SAH080	0.000	0.000	0.002	3
SAH081	0.000	0.000	0.008	3
SAH082	0.000	0.000	0.000	3
SAH083	0.000	0.000	0.000	3
SAH084	0.000	0.000	0.000	3
SAH085	0.000	0.000	0.002	3
SAH086	0.000	0.000	0.000	3
SAH087	0.000	0.000	0.000	3
SAH088	0.000	0.000	0.000	3
SAH089	0.000	0.000	0.000	3
SAH090	0.000	0.000	0.000	3
SAH091	0.000	0.000	0.026	3
SAH092	0.000	0.000	0.000	3
SAH093	0.000	0.000	0.000	3
SAH094	0.000	0.000	0.006	3
SAH095	0.000	0.000	0.001	3
SAH096	0.000	0.000	0.000	3
SOIL7A	0.000	0.026	0.000	2
SOIL7B	0.000	0.002	0.000	2

The following specimens are in the file Krotscheck unassigned

	Probabilities:			
ID. NO.	Group 1	Group 2	Group 3	BEST GP.
UKR039	0.319	0.000	0.000	1
UKR043	15.064	0.000	0.000	1
UKR061	0.000	0.000	0.006	3
UKR063	0.000	0.000	0.000	3
UKR064	0.000	0.000	0.007	3
UKR065	0.000	0.030	0.000	2
UKR066	0.000	0.001	0.000	2
UKR067	0.000	0.001	0.000	2
UKR068	0.000	0.045	0.000	2
UKR083	0.000	0.012	0.000	2
UKR092	0.000	0.000	0.000	2

Summary of Probabilities for Specimens in the file PCLATA

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	54	54	54	54	54	54	54
PCG2	54	54	54	54	54	54	54
PCG3	21	48	53	54	54	54	54

Summary of Probabilities for Specimens in the file PCLATB

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	16	16	16	16	16	16	16
PCG2	16	16	16	16	16	16	16
PCG3	3	7	16	16	16	16	16

Summary of Probabilities for Specimens in the file PCLATC

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	6	6	6	6	6	6	6
PCG2	6	6	6	6	6	6	6
PCG3	6	6	6	6	6	6	6

Summary of Probabilities for Specimens in the file PCLCOR

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	23	23	23	23	23	23	23
PCG2	23	23	23	23	23	23	23
PCG3	12	19	23	23	23	23	23

Summary of Probabilities for Specimens in the file PCLROT

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	93	93	93	93	93	93	93
PCG2	93	93	93	93	93	93	93
PCG3	71	88	92	93	93	93	93

Summary of Probabilities for Specimens in the file PCLKIL

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	106	106	106	106	106	106	106
PCG2	105	106	106	106	106	106	106
PCG3	92	102	105	106	106	106	106

Summary of Probabilities for Specimens in the file PCUNAS

Group:	0.01	0.10	1.00	5.00	10.00	20.00	100.00
			Probability Cutoff Values:				
PCG1	9	9	10	10	10	11	11
PCG2	8	11	11	11	11	11	11
PCG3	11	11	11	11	11	11	11

Summary of Best Classification of Projected Specimens:

From:	Into: PCG1	PCG2	PCG3	Total
PCLATA	0	0	54	54
PCLATB	0	0	16	16
PCLATC	0	0	6	6
PCLCOR	0	0	23	23
PCLROT	0	9	84	93
PCLKIL	0	3	103	106
PCUNAS	2	6	3	11
Total	2	18	289	309

Appendix C: Probability of group membership of the Krotscheck samples into established Greek groups based on a Mahalanobis didtance calculation using the first five principal components.

MAHALANOBIS DISTANCE CALCULATION FOR MISCELLANEOUS SPECIMENS
PROJECTED AGAINST TWO OR MORE GROUPS.

Variables used:
PC01 PC02 PC03 PC04 PC05

The following specimens are in the file Group 1

	Probabilities:			
ID. NO.	AtticA	AtticB	Corinth	BEST GP.
UKR001	0.000	0.000	0.000	3
UKR002	0.000	0.000	0.000	3
UKR003	0.000	0.000	0.001	3
UKR004	0.000	0.000	0.000	3
UKR005	0.000	0.000	0.002	3
UKR006	0.000	0.000	0.004	3
UKR007	0.000	0.000	0.006	3
UKR008	0.000	0.000	0.006	3
UKR009	0.000	0.000	0.000	3
UKR010	0.000	0.000	0.001	3
UKR011	0.000	0.000	0.004	3
UKR012	0.000	0.000	0.000	3
UKR013	0.000	0.000	0.000	3
UKR014	0.000	0.000	0.000	3
UKR015	0.000	0.000	0.002	3
UKR016	0.000	0.000	0.001	3
UKR017	0.000	0.000	0.005	3
UKR018	0.000	0.000	0.006	3
UKR019	0.000	0.000	0.002	3
UKR020	0.000	0.000	0.002	3
UKR021	0.000	0.000	0.002	3
UKR022	0.000	0.000	0.001	3
UKR023	0.000	0.000	0.000	3
UKR024	0.000	0.000	0.004	3
UKR025	0.000	0.000	0.005	3
UKR026	0.000	0.000	0.009	3
UKR027	0.000	0.000	0.002	3
UKR028	0.000	0.000	0.002	3
UKR029	0.000	0.000	0.002	3
UKR030	0.000	0.000	0.004	3
UKR040	0.000	0.000	0.006	3
UKR041	0.000	0.000	0.000	3
UKR042	0.000	0.000	0.000	3
UKR044	0.000	0.000	0.001	3
UKR045	0.000	0.000	0.004	3
UKR046	0.000	0.000	0.001	3
UKR047	0.000	0.000	0.002	3
UKR048	0.000	0.000	0.000	3
UKR049	0.000	0.000	0.013	3
UKR050	0.000	0.000	0.000	3
UKR051	0.000	0.000	0.002	3
UKR053	0.000	0.000	0.003	3
UKR057	0.000	0.000	0.002	3
UKR058	0.000	0.000	0.006	3
UKR060	0.000	0.000	0.003	3
UKR062	0.000	0.000	0.000	3
UKR069	0.000	0.000	0.005	3
UKR070	0.000	0.000	0.001	3
UKR071	0.000	0.000	0.000	3
UKR072	0.000	0.000	0.000	3
UKR073	0.000	0.000	0.001	3
UKR074	0.000	0.000	0.003	3
UKR075	0.000	0.000	0.001	3
UKR076	0.000	0.000	0.005	3
UKR077	0.000	0.000	0.012	3

The following specimens are in the file Group 2

ID. NO.	Probabilities: AtticA	AtticB	Corinth	BEST GP.
UKR078	0.000	0.000	0.000	3
UKR079	0.000	0.000	0.000	3
UKR080	0.000	0.000	0.000	3
UKR081	0.000	0.000	0.000	3
UKR082	0.000	0.000	0.000	3
UKR084	0.000	0.000	0.000	3
UKR085	0.000	0.000	0.000	3
UKR086	0.000	0.000	0.000	3
UKR087	0.000	0.000	0.000	3
UKR088	0.000	0.000	0.000	3
UKR089	0.000	0.000	0.000	3
UKR090	0.000	0.000	0.000	3
UKR091	0.000	0.000	0.000	3

The following specimens are in the file Group 3

ID. NO.	Probabilities: AtticA	AtticB	Corinth	BEST GP.
UKR031	0.000	0.000	0.000	2
UKR032	0.000	0.000	0.000	2
UKR033	0.000	0.000	0.000	2
UKR034	0.000	0.000	0.000	2
UKR035	0.000	0.000	0.000	2
UKR036	0.000	0.000	0.000	2
UKR037	0.000	0.000	0.000	2
UKR038	0.000	0.000	0.000	2
UKR052	0.000	0.000	0.000	2
UKR054	0.000	0.000	0.000	2
UKR055	0.000	0.001	0.000	2
UKR056	0.000	0.000	0.000	2
UKR059	0.000	0.000	0.000	2

The following specimens are in the file Unassigned

ID. NO.	Probabilities: AtticA	AtticB	Corinth	BEST GP.
UKR039	0.000	0.000	0.000	3
UKR043	0.000	0.000	0.002	3
UKR061	0.000	0.000	0.000	3
UKR063	0.000	0.000	0.000	3
UKR064	0.000	0.000	0.000	3
UKR065	0.000	0.000	0.000	3
UKR066	0.000	0.000	0.000	3
UKR067	0.000	0.000	0.000	3
UKR068	0.000	0.000	0.000	3
UKR083	0.000	0.000	0.000	3
UKR092	0.000	0.000	0.000	3