MSC MONOGRAPHS IN MATERIALS AND SOCIETY, 2

THE CERAMICS CULTURAL HERITAGE

Proceedings of the International Symposium
The Ceramics Heritage of the
8th CIMTEC-World Ceramics Congress and Forum on New Materials
Florence, Italy June 28-July 2, 1994

Edited by

P. VINCENZINI
National Research Council, Italy

TECHNA
Faenza 1995

The Ceramics Cultural Heritage
P. Vincenzini (Editor)

NEUTRON ACTIVATION ANALYSIS OF ROMAN FINEWARE POTTERY FROM THE PALATINE HILL, ROME

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The massive amount of pottery excavated from the Late Roman 'domus' on the Palatine Hill in Rome includes several classes of fine-bodied wares of suspected local and regional manufacture. Selected samples, along with fired samples of regional clays, are being analyzed by neutron activation at the University of Illinois to determine provenience. The results should clarify patterns of ceramic manufacture and use around Rome during the fourth and fifth centuries A.D.

1. INTRODUCTION

This paper is a preliminary presentation of results from neutron activation analysis (henceforth NAA) of several classes of fine-bodied pottery recovered from late Roman contexts from the Soprintendenza Archaeologica di Roma/American Academy in Rome excavations on the northeast slope of the Palatine Hill in Rome. The analysis is being performed at the University of Illinois department of Nuclear Engineering.

Our general objective is to clarify supply sources for the Roman tableware market during the fourth and fifth centuries A.D., a period during which the city evolved from the capital of a Mediterranean-wide empire to a diminished role in both political and economic spheres. Since imported wares (particularly those of African origin) in the regional tableware market have already been extensively documented, the focus here is the chemical characterization of wares thought to be of local origin.

The specific goals of this project are to identify distinct compositional groups among Palatine finewares and to determine the likely proveniences of these groups through comparison with pottery and clay specimens of known origin. The results will

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be used to define patterns of ceramic manufacture and movement of craft goods in and around Rome during the Late Roman and Early Medieval periods.

2. PROJECT DESIGN

Vessels for analysis were selected out of tablewares from large fills dumped into a late Roman *'domus'* located on the northeast slope of the Palatine Hill.[1] These fills, each of which is datable to within about 25 years, span the first half the third century to the late fifth or early sixth century A.D. The selection of specimens for analysis was governed by three considerations: 1) budgeting for a maximum of 201 analyses, 2) limiting the study to fine-bodied calcareous wares of the sort widely manufactured in west-central Italy in historical times, and 3) choosing at least 20-25 specimens for each presumed class to permit the use of certain statistical techniques.

Pottery chosen from several Palatine contexts, with most specimens taken from A 105 (dated to the early 4th century) and B 180 (dated to the mid 5th century). Specimens from the following classes were included: Undecorated *fineware* (unslipped tablewares with a fine, pale brown to pink body); *Color-coat fineware* (same as fineware, but with a low-quality, reddish slip);, Slip-decorated *fineware* (similar to Color-coat, except the slip occurs as stripes and swirls); *Glazed fineware* (same as fineware, but with a blue-green lead glaze); *Roman Red-slip A* ware (reddish body with a crazed reddish slip); *Roman Red-slip B* ware (reddish, micaceous body with a flaky reddish slip); miscellaneous examples of Italian *sigillata* and red-slipped pottery; and test tiles made from specimens of fine, calcareous clays from two sources in the Rome area, plus one Arretine clay for comparison.

Standards and protocols for neutron activation analysis (NAA) were chosen to be compatible with those used by the Smithsonian Institution to add to the databank already created on similar pottery and clays from west-central Italy.[2]

3. SAMPLING AND NEUTRON ACTIVATION PROCEDURES

Distinctive rim or base sherds were selected for NAA to reduce the risk of analyzing the same vessel two or more times. Each pottery specimen was prepared for sampling by cleaning a small portion of the surface with a drill equipped with a tungsten-carbide burr. Next, a small piece of the exposed body was broken off and

crushed in an agate mortar. About 200 mg of the resulting powder was placed into a sterile capsule for transport to Illinois. Upon arrival at the laboratory, samples were weighed into plastic vials suitable for irradiation, dried in an electric oven at 105 degrees° C for 24 hours, and weighed a second time to account for water loss. The large number of samples (201) made it necessary to divide the vials into batches. Two sets of replicates were included to test analytical precision from batch to batch.

For calibration of the two germanium detectors, the Illinois laboratory employed National Institute of Standards and Technology (NIST) 1633a (coal fly ash) and 1632a (coal) using the certified values consensus values reported by Gladney.[3] Quality control was performed using the Ohio Red Brick reference material with other 1633a samples as check standards.

For the determination of short-lived elements, samples were divided into 4 batches of 50 each (the final batch had 51). Samples were irradiated in the TRIGA research reactor at a power level of 500 kw at a flux of 3.7 X 10^{12} n/cm^{2}s for 20 seconds. After a 1000 second decay time, they were counted for 600 seconds in two germanium detectors, with concentrations obtained for Al, Ca, Dy, K, Mn, Na, Sr, Ti, and V.

For both medium-lived and long-lived elements, samples were irradiated with standards in five batches (batch one was run in two groups of 25) in a LAZY SUSAN facility at 1500 kw for four hours at a flux of 3.4 X 10^{12} n/cm^2/s. After seven days, samples were counted for one hour, yielding values for As, La, Lu, Sb, Sm, and U. After an additional four week decay period, samples were counted again for three hours to determine the long lived elements Ce, Co, Cr, Cs, Eu, Fe, Hf, Nd, Ni, Rb, Sc, Ta, Tb, Th, and Zr.

4. DATA ANALYSIS

Three different numerical procedures employing programs developed by Brookhaven National Laboratory and adapted by the Missouri Reactor group are being employed to define compositional groupings and match these with potential source clays.[4] In the first of these, hierarchical aggregative cluster analysis (using the programs MCONDIST and MAGGLUS) is being used to identify compositional groups on a preliminary basis. In the second, plots of selected pairs of elements (using the program

MADPLOT) are being employed towards a similar end. Finally, Hotelling's T^2 statistic (using the program MADCORR) is being employed to evaluate the internal consistency of compositional groups identified using the first two programs and to evaluate the statistical probability that unknowns, in this case, clay specimens, may also belong to such groups.

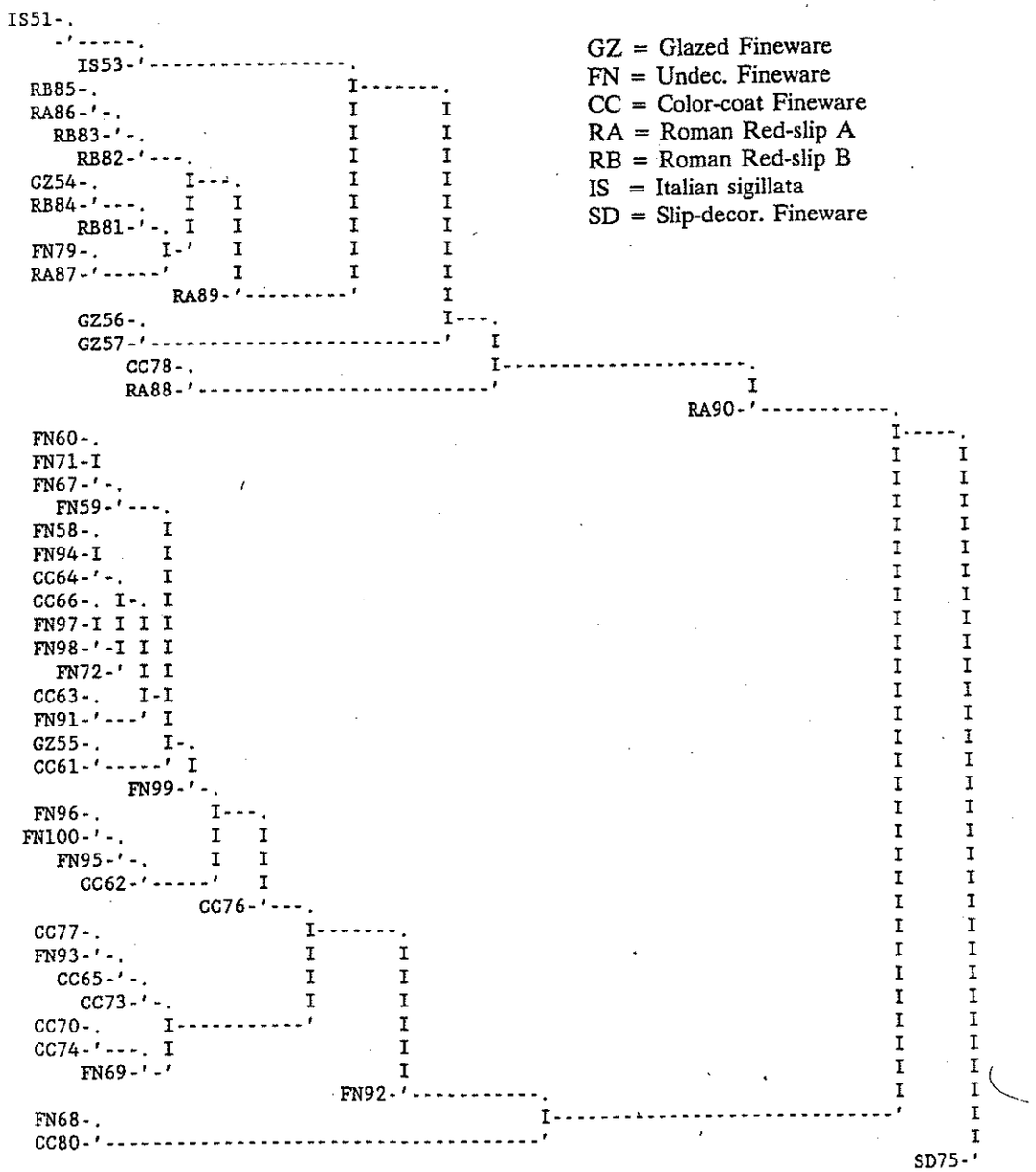
5. RESULTS AND DISCUSSION

Elemental concentrations for 150 samples have been obtained. Data for the remaining 50 samples, among which are all the clay test tiles, will soon be available for quantitative analysis. Analytical precision from batch to batch is being evaluated by comparison with the values obtained for check standards and replicates. In a preliminary evaluation, the NAA results agree with those obtained from NIST standards and reference materials within $\pm 7\%$.

Some idea of the structure of the data can be obtained at this early stage of our research from cluster analysis and bivariate plots for groups of samples irradiated in the same batch. In both approaches, the elements employed and the parameters used are those found in previous research to provide good partitioning of ceramics and test tiles made of calcareous clays from different sources in west-central Italy.[5] Batch 2 (samples 51-100) was chosen due to the representative group of materials in it.

Figure 1 displays a dendrogram generated by the cluster analysis of 49 samples in Batch 2 (the 50th sample was a check standard). This dendrogram shows good separation of the major pottery classes. In the upper cluster are pottery classes suspected to have been manufactured outside of Rome: Glazed fineware (except for sample 55), Roman red-slip A, Roman red-slip B, and an Arretine clay sample (51) and Arretine sherd (53). In the lower cluster are pottery classes suspected to be of local manufacture (in and around Rome): Undecorated fineware (except for sample 79), mixed with Color-Coat fineware (except for 78). The single Slip-decorated fineware (75) is clearly distinct. This basic grouping holds true in at least two other dendrograms generated using different parameters (not illustrated).

Within the top cluster of Figure 1, Roman Red-slip A appears to fall into at least three sub-clusters, suggesting a high degree of heterogeneity. This is not surprising given the somewhat coarse texture of mineral grains visible in its fabric under a



GZ = Glazed Fineware
FN = Undec. Fineware
CC = Color-coat Fineware
RA = Roman Red-slip A
RB = Roman Red-slip B
IS = Italian sigillata
SD = Slip-decor. Fineware

Figure 1. Dendrogram (Samples 51-100)

Calculations were made using log transformed data, squared Euclidean distances, and a mean-within clustering procedure. Elements used: CA MN NA SM LU CE CO CR CS EU FE HF ND RB SC TA TH.

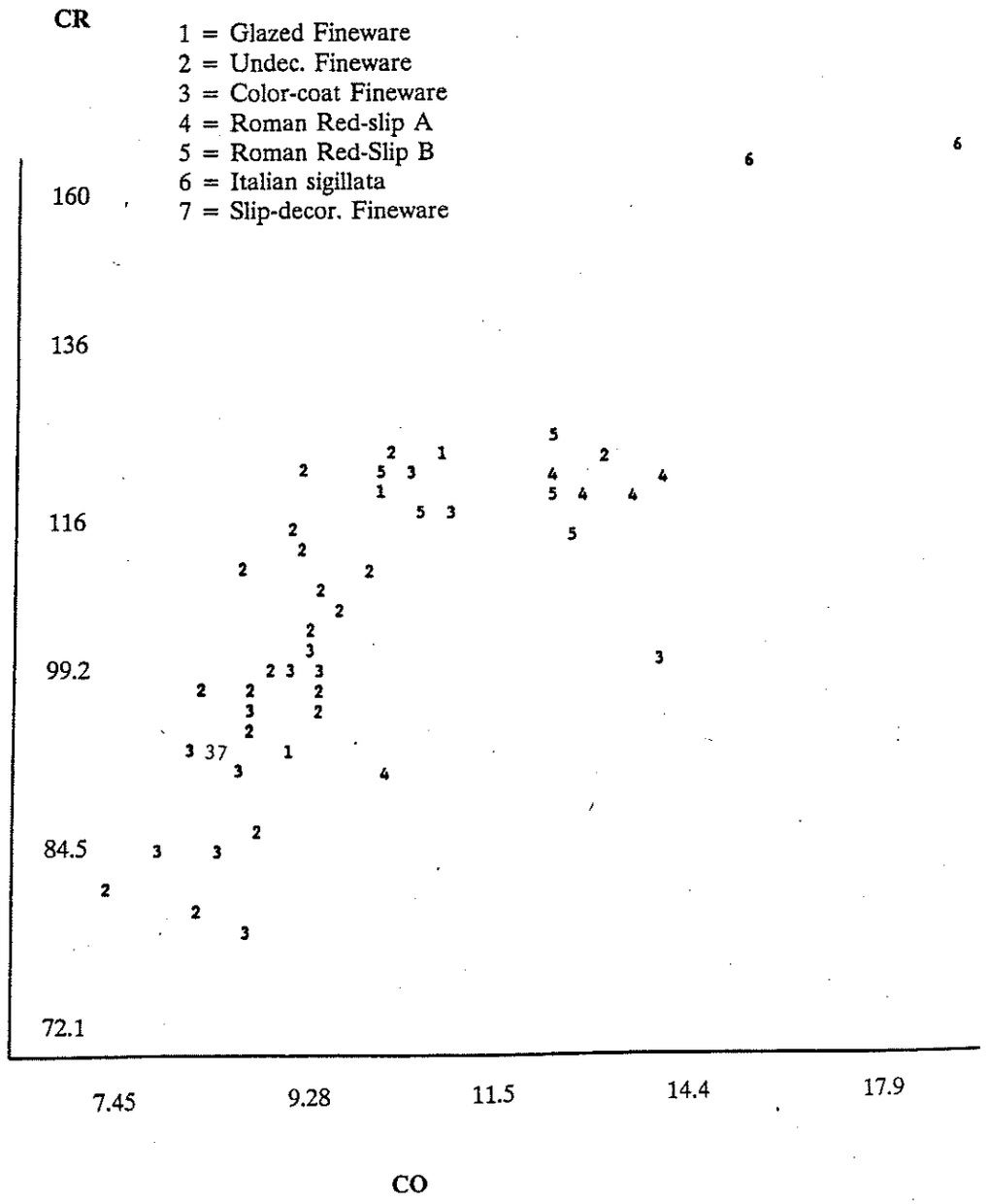


Figure 2. Cr/Co Bivariate Plot (Samples 51-100)

binocular microscope. Roman Red-slip B falls into one fairly tight cluster, or possibly two closely related sub-clusters. The Glazed fineware falls into two sub-groups in the top cluster and one in the lower, fineware cluster.

The odd specimens of Undecorated fineware (79) and Color-coat (78) in the upper cluster are distinct visually as well as chemically: sample 79 is from a form expected to prove residual (1st-2nd century A.D.), and sample 78 appears to have a more micaceous fabric than most of the other Color-coat.

Within the lower cluster of mixed Undecorated and Color-coat finewares, there appear to be three to four sub-clusters. This suggests that further analysis may reveal several distinct chemical fingerprints for pottery from the Rome area.

In Figure 2, the values for only two elements, in this case Co and Cr, are used to generate a bivariate plot for the same group of samples. The same basic division seen in the dendrogram persists, with only minor variations. Pottery classes of suspected non-Roman manufacture occur in several groups in the upper right portion of the plot, while nearly all the Undecorated and Color-coat finewares appear in an elongated cloud on the lower left. Similar results have been obtained using another pair of elements, La/Ce (not illustrated).

6. CONCLUSIONS

The project is at an advanced stage of data collection, with preliminary results available for samples 1-150. Only one batch of 49 samples have received detailed quantitative analysis to date. The degree of analytical precision from batch to batch (agreement of replicates) must be further evaluated prior to the use of multivariate techniques on the entire set of 201 samples.

Several groupings (as revealed by cluster analysis) of one batch of 49 specimens appear to have a high degree of chemical similarity, especially the closely-related pottery classes of Undecorated and Color-Coat finewares. There is also some separation between wares suspected to have been produced outside of Rome and those probably produced in or near the city. These observations are largely confirmed by the use of bivariate plots with different pairs of elements. While the bivariate plots do not provide optimum partitioning, they suggest that use of Hotelling's T^2 statistic (via MADCORR) will be successful in defining coherent compositional groups, and that

some of these will correspond to recognized pottery classes.

While the relationships between pottery classes should become clearer with further analysis, any determination of the number of different manufacturing centers and clay sources represented by our material will be difficult. Compositional variation may reflect differences in clay preparation practices, or chemical variation within the same clay bed, rather than the use of clays from different sources. Further observations must wait until analysis of all 201 pottery and clay samples is complete. When the archaeological and chemical profiles of Palatine materials are compared with equivalent data already assembled on pottery and clays from west-central Italy, the authors anticipate some clarification of patterns of ceramic manufacture in and around Rome during the Late Roman period.

ACKNOWLEDGMENTS

We thank the following individuals and agencies who made this project possible: Prof. Adriano La Regina, Dr. Irene Iacopi, and Arch. Giovanna Tedone of the Soprintendenza Archeologica di Roma; the American Academy in Rome; the Missouri Reactor Group; Eric Hostetter, excavation Director; the ATAM Program, the College of Fine and Applied Arts, the Research Board, and the Department of Nuclear Engineering at the University of Illinois; and Victor Martinez, sample preparator.

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