STUDY OF THE PRODUCTION AND DISTRIBUTION OF MIDDLE HORIZON POTTERY OF CUZCO, PERU BY k_0-BASED INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

Montoya E.(1) emontoya@ipen.gob.pe; Glowacki M.(2); Zapata J.(3); Mendoza P.(1) pmendoza@ipen.gob.pe

1) *Departamento de Química – IPEN / Lima, Perú*
2) *Smithsonian Institution, USA.*
3) *Universidad Nacional San Antonio Abad / Cuzco, Perú*

1. INTRODUCTION

A very important period of the Andean prehistory known as the Middle Horizon (A.D. 540-900) is associated with the widespread expansion of the Wari state from the region of Ayacucho. During this time, the Wari occupied much of Cuzco, building the large architectural complex of o Pikillacta and a large settlement located in Huaro Valley (southeast of Pikillacta), including the elite cemetery of Batan Urqu and a complex of domestic structures referred to as Ccotocotuyoc (see figure 1).

The objective of the present research was to establish, in general terms, the provenience of certain pottery styles dating to the Middle Horizon which are known to the Southern Highlands, Cuzco region. The specific goal was to determine which of these ceramic styles were made in other regions and brought to Cuzco and which were imitations locally manufactured, and to compare their patterns of production and distribution with those of local ceramic styles. These data, in turn, being helpful for understanding some aspects of the social, economic and political dynamics of the Middle Horizon period at Cuzco.

To reach the aforementioned objective, a set of 306 ceramic samples (taken from a population of more than 137000 specimens) were chemically analyzed by k_0-based instrumental neutron activation analysis [1,2] and the results processed by multivariate statistical methods.

Special care was taken in our research to maintain quality control of the analytical results, which were produced in duplicate for every sample, and for repeated analysis of the NIST SRM 2704 (Buffalo River Sediment) and other reference materials as e.g. the well known OLD OHIO RED CLAY. All of the work was performed within the framework of the IAEA Regional Coordinated Research Program on Nuclear Analytical Techniques in Archaeological Investigations, under the terms of contract PER 9398/R1.

2. EXPERIMENTAL PART

Sample selection

The analyzed samples were selected taking into account the criteria of abundance at archaeological sites, style variability, presence of exotic styles and fragment size. A number of samples from some Cuzco and Paruro ceramic styles dating to the Late intermediate Period (AD 900-1473), like as Killke, Colcha, and black incised ware, were included to help compositionally distinguish Cuzco Middle Horizon styles from one another. Finally, a set of 306 samples constituted the work data base as can be seen in Table 1.

Table 1. Styles and a priori provenience of selected samples.

STYLE	FOUND IN (SITE)	N
ARAWAY	CCOTOCOTUYOC (HUARO)	3
ARAWAY	COLLASUYO (CUZCO)	16
ARAWAY	Q'ORIPATA (HUARO)	2
BANDOJA	BATAN URQO (HUARO)	6
BANDOJA	KULLUPATA (POMACANCHI)	3
BANDOJA	WIMPILLAY (CUZCO)	2
BLACK INCISED	MUYUROCCO (CUZCO)	16
CCOIPA	BATAN URQO (HUARO)	3
CCOIPA	CCOTOCOTUYOC (HUARO)	2
CCOIPA	PARURO	18
CCOIPA	WIMPILLAY (CUZCO)	1
CCOTOCOTUYOC	CCOTOCOTUYOC (HUARO)	18

COLCHA	PARURO	25
HUARO	BATAN URQO (HUARO)	11
KILLKE	COLLASUYO (CUZCO)	26
MUYU ORQO	BATAN URQO (HUARO)	12
MUYU ORQO	KULLUPATA (POMACANCHI)	3
PLAIN	CCOTOCOTUYOC (HUARO)	3
PUCARA	BATAN URQO (HUARO)	2
Q'OTAKALLI	BATAN URQO (HUARO)	22
Q'OTAKALLI	CUZCO	19
Q'OTAKALLI	HUARO	1
WARI	AYACUCHO / CONCHOPATA	25
WARI	BATAN URQO (HUARO)	13
WARI	CCOTOCOTUYOC (HUARO)	1
WARI	HUARO	52
WARI	Q'ORIPATA (HUARO)	1

SAMPLE PREPARATION AND CHEMICAL ANALYSIS

Preliminary Processing of Samples

Before carrying out the analysis each sherd were cleaned, coded, photographed, and recorded in a digital from for archival purposes. Pertinent information for each sherd was recorded in a spreadsheet database. These data included site provenience, intra-site provenience (i.e., excavation context, when applicable, ceramic style, ware quality, decoration, vessel part and inferred vessel form.

Comparators and Neutron Flux Monitors

Mixed comparators of Au and Na were prepared using 250 µL of a primary standard containing 20.0 ppm of Au (III) and 20000 ppm of Na (I) in 1 M HCl medium. The solution was dried on high purity cellulose contained in small polyethylene capsules, producing a well-defined cylindrical disk of 9.0 mm in diameter and 2 mm in height. For the f and α determinations, high purity Zr foil disks of a 10 mm diameter and weighing 100 mg were used with the standards. The values of α and f parameters were determined using, respectively, the classic methods of three bare and two bare monitors [3].

Sample Preparation

The surface of each selected sample was carefully removed using a motorized hand drill and special high purity tungsten carbide drill bits. The sherd was then frozen in liquid nitrogen for 20 minutes and pulverized in an agate mortar. The pulverized samples were collected in glass vials, dried for 24 hours at 105 ^{o}C, and homogenized for 3 hours. The analytical samples, weighing approximately 250 mg, were then placed inside polyethylene capsules (like those used for comparators) and sealed.

Irradiation and Counting

All samples were irradiated at a nominal neutron flux of 1.4 x 10^{13} n cm^{-2} s^{-1} using a pneumatic transfer system to rigorously control irradiation and decay times. A well-thermalized irradiation site was employed to ensure a high value of the f parameter. For every f and α determination, a zirconium foil disk was irradiated between two standards for 30 minutes. Every sample was irradiated with a mixed standard. Special care was taken to ensure that each sample and comparator was irradiated in a reproducible method and with nearly identical neutron flux. Irradiation times varied from 5 seconds to 40 minutes, depending on the elements analyzed. After the appropriate decay times elapsed, samples and comparators were counted using high-resolution gamma spectrometry with a moderately low efficiency HP(Ge) detector (15%) and a source-detector distance of at least 7 cm to minimize self-coincidence effects. The maximum allowed dead time was 10 % and kept approximately constant during the counting process. Data reduction of the gamma spectra was accomplished using DBGAMMA V5.0 software. The efficiency curve of the gamma detector was periodically determined using ^{152}Eu, ^{241}Am and ^{133}Ba sources.

Data Processing and Quality Control

Calculations were made with an ad hoc computer program, which interacts with DBGAMMA. To assess the quality of the analytical results, the Analysis of Precision technique [4] was used, ensuring statistical control. Accuracy was assessed by frequent analysis of reference materials and the use of the α,β t- tests recommended by the National Institute for Standards and Technology (NIST) [5]. Special care was taken during the overall analytical process to get a set without any missing data.

STATISTICAL ANALYSIS

The analytical results, in logarithmic units, were further processed using the multivariate statistic analysis methods of: a) extraction of a set of principal components (without rotation) and b) hierarchical clustering: dendrogram formation using the method of averaged linkage (between groups) and Euclidean distance measures (not squared ones). The first five principal components were used as independent variables for the clustering. Many weeks were spent during the preliminary statistical analyses determining which elements were useful in characterizing and identifying ceramic groups. The following were ultimately selected: Ce, Cr, Dy, Eu, Fe, La, Sm, Sc, Th and Yb. The selection was made because this elements lead a set of principal components, which the first three of them (after rescaled) explained almost 90 per cent of the observed variance in the data.

3. RESULTS AND DISCUSSION

The three first principal components for some selected pottery styles are represented in figure 2. It can be appreciated that the samples of Wari pottery found in Ayacucho (solid red circles) form at least three compositional groups. This figure also allows to see the five samples of Wari pottery, which are located in the main core of the local group. These samples shows a marked compositional affinity with diverse non Wari local pottery (represented by black small characters like as small x, void triangles and void circles for Cuzco, Paruro and Ccotocotuyoc styles). Also it can be seen that Wari style samples recovered from the Batan Urqo cemetery (solid green circles) spreads along the compositional space suggesting it's diverse provenience, including Cuzco, Huaro, Paruro and Ayacucho sources. Finally, the spatial distribution of the Wari samples found in Huaro (solid blue circles) also suggest up to four sites of manufacture, including two different places in Ayacucho, one in Cuzco and other perhaps in Huaro. This proposition is in general agreement with the results from Glowacki's [6] analysis of pottery from Pikillacta, Who identified two possible centers of Wari ceramic production, one of which was Paruro.

Late Intermediate Period ceramic styles also helped clarify the compositional groupings of local Cuzco Middle Horizon styles. Production patterns of Q'otakalli pottery, the principal local Middle Horizon ceramic style of Cuzco, was found to be very similar to that of Wari pottery recovered in the Huaro Valley, with possible centers of manufacture in the Cuzco Basin and in Huaro. Glowacki's earlier study of Middle Horizon pottery recovered from Pikillacta likewise indicated a production center for Q'otakalli pottery in the northern sector of the Cuzco Valley, supporting our current findings. These results further suggest that Wari and Q'otakalli societies utilized or even shared the same clay and other resources in ceramic manufacture.

With respect to other local Cuzco ceramic styles, our analysis was likewise facilitated by Late Intermediate pottery. Ccoipa pottery, speculated to be a substyle of Q'otakalli, exhibited no evidence of this relationship but appears to have been a local Cuzco Middle Horizon ceramic style manufactured mainly in the province of Paruro. Compositional patterning of Bandoja indicated that this pottery was, in fact, a local ceramic style whose production was separate from that of Wari pottery. Muyu Orqo, another Cuzco ceramic style previously thought to be influenced by Tiwanaku culture [7], showed a composition pattern which suggest that it is a locally manufactured ceramic style whose center of production was the Cuzco Basin area. Finally, Black Incised Pottery, defined by B. Bauer [8], and speculated to be a Wari influenced, and possibly, a locally Wari produced ceramic style, exhibited a compositional character distinct and separate from all other local Cuzco groups but within the range of local production. Consequently, this ceramic style was classified as local but no association to other ceramic styles of the region was made.

Our study suggests that patterns of ceramic production during the Middle Horizon were quite different from those of the succeeding Late Intermediate Period. Wari ceramic production in its Cuzco province does not appear to have been nearly as standardized as previously thought. Production occurred in different parts of the region and was exchanged between centers for local distribution. This pattern was probably initiated at the outset of the Wari occupation of Cuzco, which was centered in the Huaro Valley. The Wari Cuzco occupation appears to have taken place gradually and with less state domination than had earlier been proposed. After becoming firmly established, the Wari designed and built Pikillacta, a highly structured architectural complex located a few kilometers north of Huaro. Further order was likely imposed on its Cuzco territory in the form of state political and economic control mandated by Wari administrators in Ayacucho. This theory would explain the diverse ceramic production patterns identified for Cuzco Wari pottery during the early stages of the Middle Horizon. It would further explain a more centralized pattern of ceramic production and distribution associated with the later site of Pikillacta, as indicated by Glowacki's research [9].

Our results likewise indicates considerable diversity of local Cuzco ceramic production, both in ceramic styles and production areas. From our data we can infer that local Cuzco groups co-existed with the Wari, sharing ceramic resources in pottery production and use. The appearance of certain ceramic styles, such as Black Incised Ware and a related orangeware [8], suggests that while Wari may have influenced the production of some local ceramic styles, they did not control local Cuzco pottery production neither its use. This relationship may have had its roots in the Early Intermediate Period, when Cuzco and Ayacucho populations may have first been in contact, as suggested by shared similarities of ceramic styles of these respective regions, namely, Q'otakalli and Huarpa [9].

Finally, our research confirms a bi-directional exchange of pottery between the Wari capital, Ayacucho, and its southern province, Cuzco. This finding is particularly interesting in light of the fact that the Wari, Ayacucho, ceramic samples used in this study were recovered by us from the site of Conchopata. Research conducted by D. Pozzi-Escot [10,11] at Conchopata indicates that the site functioned as a center of pottery production for settlements in Ayacucho. Perhaps, it likewise served as a distribution center, where many sources of pottery were collected and stored for later allocation.

4. REFERENCES

[1]. DE CORTE, F., Habil. Thesis, Univ. Gent, Belgium, 1987.

[2]. MONTOYA, E., (1995) MSc. Thesis, Univ. Per. Cayetano Heredia, Perú.

[3]. DE CORTE, F., SORDO - EL HAMMAMI, MOENS, L., SIMONITS, A., De WISPELAERE, A., HOSTE, J., J. Radioanal. Chem. 62 (1981) 209.

[4]. HEYDORN, K., (1980), Risoe-R-419, Risoe National Laboratory, Denmark. Ph.D. Dissertation.

[5]. BECKER, D., et al., (1992), NIST Special Publication 829.

[6]. GLOWACKI, M., (1996B), Análisis instrumental por activación de neutrones de cerámica Wari y otras pastas Wari coetáneas: una investigación preliminar sobre la producción cerámica en Cuzco, Perú durante el Horizonte Medio". Report submitted to the National Institute of Culture, Region of Cuzco, Peru.

[7]. BAUER, B., (1989), Muyu Orqo y Ccoipa: Dos nuevos tipos de cerámica para la región del Cusco. Revista Andina 7(2):537-542.

[8]. BAUER, B., (1999), The Early Ceramics of the inca Heartland, Fieldiana No. 31, Field Museum of Natural History.

[9]. GLOWACKI, M., (1996a), Ph.D. Dissertation. The Wari Occupation of the Southern Highlands of Peru: A Ceramic Perspective from the Site of Pikillact., Department of Anthropology, Brandeis University, Waltham, Massachusetts.

[10]. POZZI-ESCOT, D., (1982). Excavaciones en Conchopata. Gaceta Arqueológica Andina 1(4-5):9.

[11]. POZZI-ESCOT, D., (1991). Conchopata: A Community of Potters. In Huari Administrative Structure: Prehistoric Monumental Architecture and State, edited by William H. Isbell and Gordon F. McEwan, pp. 81-92. Dumbarton Oaks Research Library and Collection, Washington, D.C.

- 1 PAMPAILLA
- 2 QOTAKALLI
- 3 WIMPILLAY
- 4 SEÑORPA
- 5 BATAN URQU
- 6 QORIPATA
- 7 ISLA ESTÉVEZ
- 8 SUNTURBAY
- 9 TIWANAKU
- 10 CONCHOPATA
- 11 KULLUPATA
- * PIKILLACTA

Figure 1. Sampled archaeological sites.

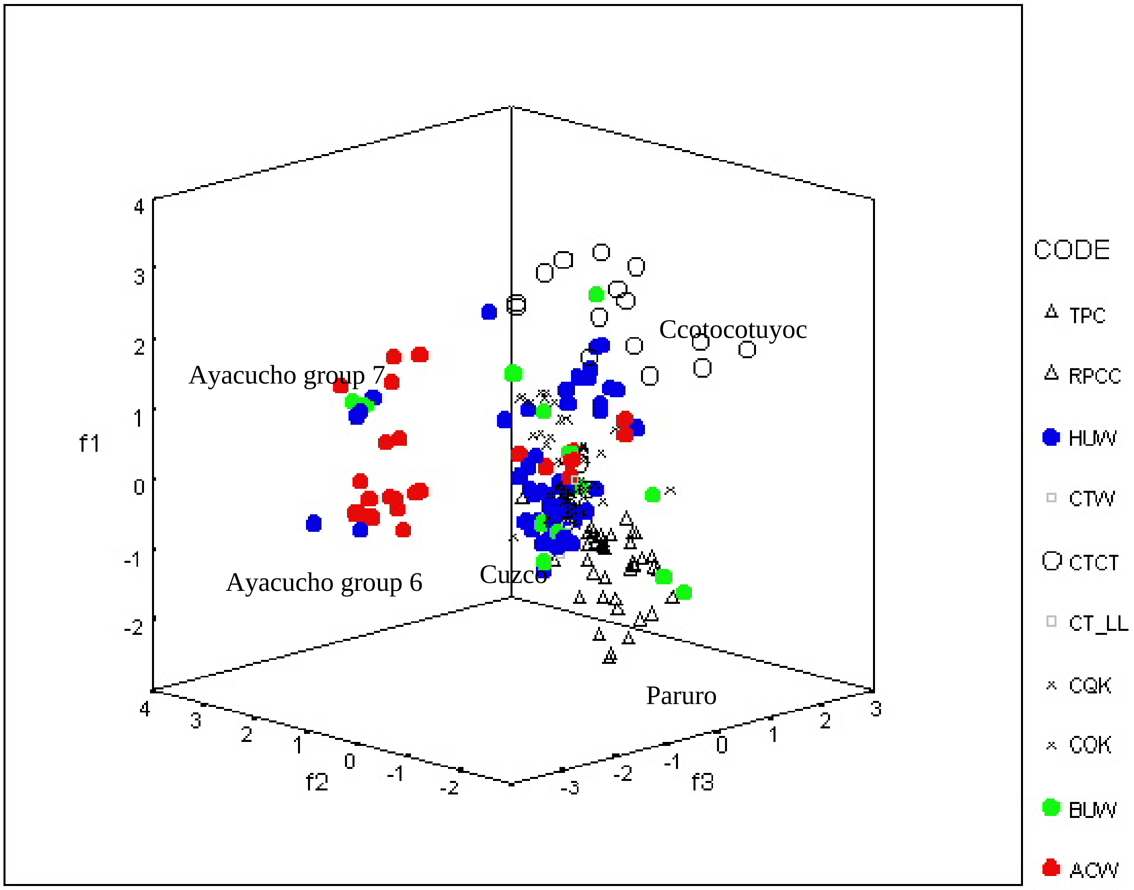

Figure 2. Graphical representation of first three principal components for selected pottery styles.