EÖTVÖS LORÁND UNIVERSITY
DOCTORAL SCHOOL OF EARTH SCIENCES
GEOLOGY/GEOPHYSICS DOCTORAL PROGRAMME

VERONIKA SZILÁGYI

ARCHAEOMETRICAL INVESTIGATION OF INKA PERIOD CERAMICS (PARIA, BOLIVIA): PROVENANCE AND TECHNOLOGY

THESES OF THE DOCTORAL (PHD) DISSERTATION

Supervisor:
Dr. Szakmány György, *PhD, associate professor*

Head of the Doctoral Programme: **Dr. Monostori Miklós**, *DSc, professor*
Head of the Doctoral School: **Dr. Gábris Gyula**, *DSc, professor*

FFI DEPT. OF PETROLOGY AND GEOCHEMISTRY
BUDAPEST
2010

I. INTRODUCTION, AIMS

The scientific investigation of archaeological finds is a relatively new field of Hungarian applied geological research. This interdisciplinary branch of science is called archaeometry. The main goal of the archaeometrical research is to provide data about the finds which are hidden in the material, and impossible to extract by classical archaeological methods. These complementary data are especially important in the reconstruction of former everyday life and handicraft activities (e.g. pottery).

My study is involved in the archaeometrical research on ceramic objects. Its main goal is to complete the archaeological investigation of an Inka period ceramic assemblage from Paria (Dept. Oruro, Bolivia), an Inka administrative centre and its surrounding region by scientific (geological) methods. Two important results were achieved. On the one hand, direct information on the ceramic manufacturing process (from the selection and preparation of raw materials to the firing) was gained. On the other hand, indirect evidence of the organization of the potter’s handicraft in Paria as it evolved from the pre-Inka to the Inka period was also obtained. Based on these facts, this applied geological study has become an effective tool and a useful part of the comprehensive processing of archaeological ceramics.

The Inkas established the greatest state of the Pre-Columbian South America (A.D. 1438–1535). According to the historical and archaeological research, the well organized Inka administrative system was able to control all the distant conquered provinces. Furthermore, it also managed to solve the long-distance exchange of people and goods, and to ensure the economic-social and political connection among the different territories. In addition, the Inkas created a uniform material culture which contributed to the unity of the empire. Evidence of the centralized economic-social system is recorded in the archaeological material. Objects (e.g. pottery) representing the unified architectural and tool making Inka Imperial style which was developed in the heart of the empire appear in the archaeological material with a sudden change at the boundary of pre-Inka and Inka strata. The ’standardizing Inka influence’ had a different impact on the provincial units depending on the local (social-political) circumstances, the temporal length of the control and their role in the state [1,2,3]. Stylistic classification of the Inka archaeological material is based on identifying the rate of standardization in the shape, decoration and manufacturing technique. The most common archaeological find at Inka period sites is ceramic, which sensitively reflects the social(-political) changes through its style versions. However, little is known about the workshops manufacturing the huge amount of Inka period pottery. This raises the question of how the new demand for Inka Imperial style fineware appearing with the Inka expansion was met.

Based on the archaeological processing of the ceramic assemblages it is found that three stylistic types of pottery existed simultaneously in every region: the local pre-Inka, the Inka Imperial and many transitional versions between the two. The classical Inka Imperial style ceramics show the same external appearance (vessel shape, surface treatment and decorative motifs) throughout the whole empire. This unified characteristic of the pots suggests strict standardization of the pottery making process. According to Morris [4] and D'Altroy [5] the Inka Imperial ceramics were manufactured in state controlled pottery workshops from where the wares were distributed on the imperial level. On the contrary, Hayashida [6] supposed that the uniformity of potter's goods was guaranteed by spreading the know-how to the distant provinces. However, it is a matter of question whether this was done by resettling experts or the teaching of local potters about the improved techniques and stylistic regulations.

Based on the above detailed statements, it is important to decide whether the Inka Imperial style ceramics excavated at Inka sites far from the heart of the empire are made from local or foreign raw material. In addition, it is possible to investigate the temporal changes of raw material usage and manufacturing technique by comparative analysis of Inka Imperial, pre-Inka local and transitional style pottery of a certain archaeological site. By collecting such data, the pre-Inka local pottery making tradition, the new techniques and raw material selection used after the Inka conquest and transitional solutions due to the interaction of the different social groups can be determined. The making of ceramics is thus an everyday handicraft activity reflecting the unifying efforts of the empire. In this way, by learning about the changes of its traditions, indirect evidence on the organization of the Inka economic-social system can be gained.

The objects of my study are ceramic finds of an Inka administrative centre and its pre-Inka and Inka period surroundings situated in the present Bolivia – i.e. relatively far from the capital. Archaeometrical investigation of Inka period pottery of this region is limited to a single conference abstract [7]. This means that our knowledge of the potter's craft traditions and their changes during the Inka period in this southern province of the Inka Empire is weakly supported by scientific investigations. Paria is located at the intersection of the north-to-south Inka imperial road and the eastward road to an important subtropical, agricultural sector [8]. This geographic position established the key role of Paria in the storage and distribution of imperial goods. The major aim of this archaeological research project was to get detailed knowledge on this important role of Paria in the empire and in the life of the local population.

Due to its stylistic-typological composition and chronology, the observed ceramic assemblage from Paria provided a possibility to investigate the above described problems of the 'standardizing Inka influence'. Namely, the archaeometrical study resulted in complementary data for the present Bolivian region. My research aimed to investigate the temporal and spatial changes or continuity of the ceramic raw material usage. By the selection of a representative sample set and its study applying detailed petrographic, mineralogical and geochemical investigations the following questions can be answered. (1) Are there differences between the Inka Imperial and pre-Inka local style ceramics concerning their raw material and technology? In this way, it can be determined if the new ceramic types appearing in the ceramic assemblage with the Inka conquest can or can not be related to a new (relatively to the pre-Inka traditions) pottery technology. (2) Are there raw materials similar to that of the Inka Imperial ceramics in the Paria Basin? These results can help to establish or reject the idea of derivation of the Inka Imperial pottery from distant workshops (i.e. idea of its importation to Paria). (3) Are there differences between the Inka Imperial style and the transitional, imitating, Inka period ceramics concerning their raw material and technology?

II. METHODS

In order to investigate some steps of the ceramic manufacturing technology (i.e. raw material selection and preparation, firing) I selected a representative sample set of 205 sherds from the archaeological pottery and carried out its petrographic (by polarizing microscope), mineralogical (by XRD) and geochemical (by XRF, INAA and PGAA) characterization. In addition, other non-ceramic samples collected in the field were also investigated. The same analytical processes were applied to these comparative archaeological (adobe and building stone) and geological (sediment and rock) samples.

As fundamental step of the research, I made macro- and microscopic investigations (using Nikon ALPHAPHOT-2 type polarizing microscope, Eötvös L. University, Dept. Petrology and Geochemistry), which was completed with instrumental mineralogical and geochemical analyses. The microscopic observations established the compositional characterization of the archaeological ceramics. Furthermore, they gave information about the natural or artificially mixed feature of the ceramic materials. These results determined the further interpretation of the instrumental analytical data.

Selection of the instrumental methods was based on their found effectiveness in archaeometrical researches and the infrastructural accessibilities. The phase analyses (HAS Institute for Geochemical Research, Phillips PW 1730 type X-ray diffractometer, Bragg-Brentano alignment, Cu Kα radiation, 45 kV tension, 35 mA intensity, 0.05°–0.01° 2Θ step size, 1 sec time constant, 1–1° detector-divergence, PW-1050/25 type goniometer, graphite monochromator, proportional detector) completed the petrographic data with mineralogical composition information of the fine-grained, plastic component of the paste. The XRD data established the firing temperature and atmosphere estimations. The measurements and evaluation of XRD were done by Mária Tóth.

Chemical composition (i.e. concentrations of 11 major and 29 trace elements) of the samples was determined using different methods. The X-ray fluorescence spectroscopic measurements and evaluation were fulfilled by Dr. Heinrich Taubald (XRF: University of Tübingen, Dept. Geochemistry; Bruker AXS S4 Pioneer type, WDS X-ray fluorescence spectrometer, Rh tube, 4 kW). The prompt-gamma activation analysis was done with the help of Dr. Zsolt Kasztovszky (PGAA: Budapest Research Reactor, HAS Institute of Isotopes; 10^8 $cm^{-2} \cdot s^{-1}$ flux, cold neutron beam, Compton-suppressed HPGe detector).

Instrumental neutron activation measurements and spectrum evaluation are due to Dr. Márta Balla (INAA: Budapest University of Technology and Economics, 2.4×10^{12} $ncm^{-2}s^{-1}$ thermal neutron flux, 8 h irradiation, 1.95 keV resolution, 20.5% relative efficiency, Canberra type HPGe detector, Canberra S100 type multichannel analyser). As a result of the chemical composition investigations, the distribution of major and trace elements could be observed in the archaeological and in the comparative samples. In addition, it established the provenance study for the ceramics by identification of genetic relationships with the potential raw materials.

III. NEW SCIENTIFIC ACHIEVEMENTS

1.

Applying microscopic petrographic investigations, I distinguished three main groups and several subgroups of Inka period archaeological ceramics. The distinctive parameters were the petrographic-mineralogical composition and the fabric. The three main groups are Ist the pyroclastic-volcanic, IInd the siliciclastic and IIIrd the mica schist raw material related ones. The pyroclastic-volcanic Ist group of pottery can be divided into four subgroups according to their dominant non-plastic inclusion type. Ceramics of subgroup I/A contain pumiceous pyroclastic rock fragments with two types of mineralogical association (andesine-biotite-hornblende and oligoclase-biotite). Subgroup I/B pots have non-plastic content of pyroclastic glass shards which can be quasi monotypical (with curved X-Y shape or irregular shape) or accompanied by pumiceous or sedimentary rock fragments. The heterogeneous subgroup I/C consist of volcanic lithofragments of unweathered or weathered ground mass in its pottery fragments. Subgroup I/D can be characterized exceptionally with mineral fragments as non-plastic inclusions. The IInd siliciclastic main group contains ceramics with shale-claystone-siltstone, siltstone-sandstone or sandstone clasts. The IIIrd group of pottery is subordinated in the assemblage and the sherds consist of clearly distinguishable mica schist fragments.

2.

The reliability of the petrographic classification of Inka period pottery was supported by the instrumental mineralogical and geochemical investigations. But, the phase and chemical compositional data do not provide any possibility for further refinement of the grouping. For this reason, I considered the polarizing microscopic petrographic investigations as the most sensitive method of ceramic material classification. Combining the microscopic observations with the XRD analysis of the submicroscopic material of the ceramics and the major and trace element composition of the bulk samples, I am reporting comprehensive petrographic, mineralogical and geochemical data about Inka period ceramics for the first time from the present Bolivian region.

3.

Fabric analysis of Inka period ceramics revealed that the different material groups have different raw material preparation techniques. The Ist pyroclastic-volcanic group includes sherds which (with the exception of subgroup I/D) could be fashioned by the mixing of two (a fine-grained plastic and a coarsed-grained tempering) components. The plastic part most probably was cleaned with levigation or sieving. The silt-sand-sized temper has pyroclastic-volcanic origin and it is freshly broken (pumice, glass shard, volcanic rock) or, rarely, is collected from sandy sediment of weathered volcanic rocks. On the contrary, paste of subgroup I/D pots is fine-grained and it is quite unlikely that its raw material was prepared in any way. The IInd siliciclastic group of pottery could be manufactured from medium-grained alluvial sediment without any preparation. The IIIrd mica schist related group of ceramics is likely made with direct (not treated) utilization of an autochtonous weathering product of a metamorphic schistose formation.

4.

By interpreting the phase composition of Inka period ceramics, I made estimations for the circumstances of the firing process. Vessels of the Ist and IInd ceramic groups probably were fired during a moderate (600–900°C) maximum temperature, dominantly oxidizing (but with heterogeneous oxygen supply) atmosphere, long soaked firing process. Making a model for the thermal treatment of the potential local raw materials of the Paria Basin, I hypothesized a moderate (700–900°C) maximum temperature, appropriately long soaked, oxidizing atmosphere firing on a bonfire of the local materials to create a similar phase composition to that of the investigated ceramics. The IIIrd mica schist related group of white ceramics could be fired in a dominantly oxidizing atmosphere, but at higher maximum temperature (850–950°C) than the other pottery. This is proved by the detection of a high temperature phase of mullite.

5.

I identified the dried clay (adobe) building materials of the major archaeological site of the Paria Basin as products surely derived from local raw materials. I used these samples as reference for local materials accessible during the Inka period and found that their petrographic-mineralogical and geochemical composition showed a strong similarity to that of the IInd siliciclastic group of pottery. As a part of my study, I made a sampling of possible ceramic raw materials for Inka period ceramics in the Paria Basin. My field work was based on the preliminary knowledge of the petrographic composition of archaeological ceramics and on the study of accessible geological maps. To represent a possible source of the fine-grained plastic component of ceramic raw materials, I collected recent local alluvial sediments of the Paria Basin. For a possible source of the coarser-grained non-plastic (sometimes tempering) component of ceramic raw materials, I sampled the local siliciclastic rocks (Silurian shale-claystone-siltstone-sandstone rocks of the Eastern Cordillera) and the Miocene pyroclastic-volcanic formations (tuffs and lava rocks of the Morococala ignimbrite field and the Soledad caldera) of the Paria Basin. All potential raw material samples were petrographically, mineralogically and geochemically characterized.

6.

Comparative analysis of archaeological and geological samples proved that ceramic raw materials similar to the theoretical ones of the Ist pyroclastic-volcanic group (with the exception of some subgroup I/C specimens) and the IInd siliciclastic group of pottery can be found in the Paria Basin. Vessels of the Ist pyroclastic-volcanic group which contain pyroclastic rock fragments (I/A-B-D) can be connected to the tuff sources of the two volcanic units (Morococala ignimbrite field and Soledad caldera) close to Paria (10–30 km). The pyroclastic materials as temper were most probably utilized as freshly broken clasts. Certain samples of subgroup I/C have volcanic rock derived tempers which were formed during different volcanic activities than known ones near the Paria Basin. These sherds, of limited number, presumably came to the region by trade. However, another part of subgroup I/C can be interpreted as made by tempering with clastic material of the nearby volcanic sources. The exact source of the plastic fine-grained paste of pots belonging to the Ist pyroclastic-volcanic group could not be determined. However, it is very probable that it was local since on the basis of the whole sample chemistry I could model the composition of Ist group ceramics as a mixture of nearby pyroclastic rocks and local fine-grained alluvial sediments. Petrographic and geochemical features of the IInd siliciclastic group of pottery can be identified with high probability with the local (max. ~5 km distant) alluvial sediments of the Paria Basin. Likewise, ceramics of this group show similarity to the dried clay (adobe) building materials of the Inka period object. A raw material source of the IIIrd mica schist related group of white ceramics could not be localized in the Paria Basin and its wider vicinity (~50 km). Based on this fact, I interpreted this ware as manufactured far away of foreign raw material and imported into the region.

7.

I compared the dominantly siliciclastic, subordinately volcanic rock derived alluvial sediments (also brick clays exploited nowadays) of the Paria Basin to the fine-grained constituents of the archaeological ceramics and building materials (adobe). The similarities and differences of their petrographic, mineralogical and geochemical characteristics suggest that raw materials were expertly selected from the local alluvial sources not only for pottery making but also for building construction. The expressed geochemical similarity of both IInd group pottery and adobe samples to the local fine-grained alluvial sediments verifies their local origin.

As a part of the interdisciplinary (archaeological-geological) research of the Paria Basin, the archaeometrical study of Inka period ceramics provided not only direct information on the ceramic manufacturing process, but also indirect evidence on the local organization of the potter's handicraft as it evolved from the pre-Inka to the Inka period. Involving my archaeometrical results into the archaeological interpretation, the following statements could be made:

8.

The Ist pyroclastic-volcanic group consists of predominantly fineware, while the IInd siliciclastic group of ceramics mostly contains coarseware. As a result of my study, I connected these two groups to real, local/nearby raw material sources. In this way, I established a new correlation based on macroscopic observation for use the future ceramic processing made by the archaeologist.

9.

The raw material types used do not correlate directly with the vessel function. The only uniquely established correlation is between the IIIrd mica schist related group of white ceramics and the bowl or plate function. However, the raw material types applied do correlate directly with the ceramic style. The Ist pyroclastic-volcanic group of pottery consists of early cultural (before A.D. 1000) style and Inka, Inka-Colonial style sherds. Furthermore, most of the Inka Imperial and Inka pacaje vessels are classified into the glass shard containing subgroup I/B. The IInd siliciclastic group of ceramics show stylistic features related to the pre-Inka period (A.D. 1000/1200–1438). Transitional, Inka imitating and local Inka or pre-Inka style potteries are predominantly made from the raw material of the IInd siliciclastic group.

10.

The results of this study proved by independent scientific methods that the potter's technology which used local alluvial sediments without preparation and moderate temperature bonfiring was developed and widely utilized before the Inka conquest. This handicraft tradition survived during the Inka period. However, a new fineware manufacturing technology also appeared and became abundant during the Inka period. This technology was characterized by tempering the cleaned paste with freshly broken (and maybe sieved) porous tuff or compact lava rocks from near sources and bonfiring similar to the former times. This technological change can be connected to the new, different quality demand for the fine ceramic of the Inkas. However, it has to be mentioned that tuff tempering was found also in the early cultural ceramic material, so this technique was developed but later forgotten in the region of Paria. Concluding the above statements, local ceramic manufacturing technique and raw material usage became binomial in the Paria Basin during the Inka period. The old tradition was mainly applied for coarseware, while the innovation was mainly used for vessels representing the unity and control of the Inka state. As a peculiar fineware in the region, the mica schist related group of white bowls and plates seemed to be of foreign origin; also its firing technique was unknown at Paria.

11.

An important conclusion of this study is that standardized Inka Imperial ceramics of the Paria pottery assemblage could be fashioned from local-near raw materials of the Paria Basin. Hence, this ware was not imported into the region but manufactured locally with knowledge of the Inka imperial regulations.

IV. CITED REFERENCES

[1] HYSLOP, J., 1993: Factors influencing the transmission and distribution of Inka cultural materials throughout Tawantinsuyu. *In: Rice, D. (ed.): Latin American Horizons. Dumbarton Oaks, Washington, D.C., pp. 337-356.*

[2] MORRIS, C., 1995: Symbols to power: styles and media in the Inka State. *In: Carr, C. & Neitzel, J.E. (eds.): Style, society, and person. Plenum Press, New York, pp. 419-433*.

[3] MALLPASS, M.A. & ALCONINI, S. (EDS.), 2010: Distant Provinces in the Inka Empire. Toward a deeper understanding of Inka imperialism. *University of Iowa Press, Iowa City, USA, 355 p.*

[4] MORRIS, C., 1978: The archaeological study of Andean exchange systems. *In: Redman, C.L. (ed.) Social archaeology: beyond subsistence and dating. Academic Press, New York, pp. 315-328.*

[5] D'ALTROY, T.N., 1992: Provincial Power in the Inka Empire. *Smithsonian Institution Press, Washington, D.C., 272 p*

[6] HAYASHIDA, F., 1998: New insight into Inka pottery production. *MASCA Research Papers in Science and Archaeology, Supplement to Vol. 15 (Andean Ceramics), pp. 313-335.*

[7] WILLIAMS, V.I., VARGAS C.S., ROMERO, A., SPEAKMAN, R.J. & GLASCOCK, M.D., 2006: Inka Pottery Production and Consumption in NW Argentina, Northern Chile, and Bolivia. *Abstract for the 71st Annual Meeting of the Society for American Archaeology, San Juan, Puerto Rico, 26-30 April 2006.*

[8] GYARMATI, J. & CONDARCO CASTELLÓN, C., in press: Sítios prehispanicos tardíos de la Cuenca de Paria y centro administrativo incaico en el Altiplano Boliviano. Bulletin de l'Institut Français d'Etudes Andines.

V. RESEARCH RELATED ARTICLES AND CONFERENCE ABSTRACTS

Papers

SZILÁGYI, V. & SZAKMÁNY, Gy., 2009: Comparison of volcaniclastic-tempered Inca Imperial ceramics from Paria, Bolivia with potential sources. *In: Quinn, P.S. (ed.): Interpreting Silent Artefacts: Petrographic Approaches to Archaeological Ceramics. Archaeopress, Oxford, pp. 211-225*.

SZILÁGYI, V., SZAKMÁNY, Gy., GYARMATI, J. & TÓTH M., 2007: Preliminary Comparative Archaeometric Results of Colonial and Inka Pottery in Paria (Oruro, Bolivia). *In: Waksman, Y.S. (ed.): Archaeometric and Archaeological Approaches to Ceramics: Papers presented at EMAC'05, 8th European Meeting on Ancient Ceramics, Lyon 2005, BAR International Series 1691, 2007, pp. 195-199.*

SZILÁGYI, V., SZAKMÁNY, Gy. & GYARMATI, J., 2005: Inka kori kerámiák petrográfiai vizsgálatának előzetes eredményei (Paria, Bolívia). *Archeometriai Műhely (http://www.ace.hu/am/index.html), 2005/2, pp. 42-47.*

SZILÁGYI, V., GYARMATI, J., TÓTH, M., TAUBALD, H., BALLA, M., KASZTOVSZKY, Zs. & SZAKMÁNY, Gy., under review: Investigation of aplastics provenance and technology of Inka Period ceramics from Paria, Bolivia. *(Journal of Anthropological Archaeology)*

Conference abstracts

SZILÁGYI, V., SZAKMÁNY, Gy., GYARMATI, J., TÓTH, M., 2008: A geokémiai értelmezés jelentősége a régészeti kerámiák eredetvizsgálatában – bolíviai inka korú leletek alapján. *„A geokémiai interpretáció jelentősége az archeometriai kutatásban" c. előadói nap, Budapest, 2008. november 19., Program (not numbered pages).*

SZILÁGYI, V., SZAKMÁNY, Gy., TAUBALD, H., BALLA, M., KASZTOVSZKY, Zs., 2008: Az eredetazonosítás lehetőségei mérsékelten kontrolált körülmények között módosított természetes üledékekben (régészeti kerámiákban) műszeres geokémiai módszerekkel (XRF, INAA, PGAA). *Őszi Radiokémiai Napok, Hajdúszoboszló, 2008. október 29-31., Program és az előadások kivonatai, pp. 48-53.*

SZILÁGYI, V., 2007: Inka Ceramic Manufacture: imperial standardization, local particularity and importation. *9th European Meeting on Ancient Ceramics, Budapest, Program and Abstracts, p. 67.*

SZILÁGYI, V., SZAKMÁNY, Gy. & GYARMATI, J., 2007: Provenance inquiry of Inka period ceramics: a petrographic study. *Geophysical Research Abstracts, Vol. 9., CD supplement (ISSN: 1029-7006), General Assembly o f the European Geosciences Union, 15-20 April 2007, Vienna, Austria.*

SZILÁGYI, V., 2005: Archaeometrical Investigation of Ceramics: What is the Message of the Inca Pottery? *5th International Conference of PhD Students, Miskolc, 2005. augusztus 14-20. Programs and Abstracts, p. 187.*