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X-Ray Diffraction Analysis of Greater Nicoya Ceramics

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Ethnohistoric sources describe the Greater Nicoya region of Pacific Nicaragua and northwestern Costa Rica as a complex ethnic and political mosaic during the Postclassic period (800-1530 CE). Several colonial chronicles describe Mesoamerican groups of the Nahua (Nicarao) and Oto-Manguean (Chorotega) language families controlling chiefdom level polities (Motolinia 1951; Oviedo y Valdes 1976; Torquemada 1975-83), while maintaining characteristic Mesoamerican cultural traits such as religion, economics, and political organization (Chapman 1974; Fowler 1989; Healy 1980; Leon Portilla 1972). Art historians and archaeologists have interpreted symbolically rich polychrome pottery as examples of the Mixteca-Puebla stylistic tradition to support these claims of Mesoamerican cultural affiliation (Day 1994; Healy 1988; Lothrop 1926; McCafferty and Steinbrenner 2005a).

Beginning in 2000, the *Proyecto Arqueologico Santa Isabel, Nicaragua* (SIN) conducted intensive excavations at a large Postclassic site on the western shore of Lake Nicaragua, near the modern city of Rivas. Santa Isabel was identified as the largest site in the region by Karen Niemel's (2003) settlement pattern survey, and was initially believed to have been the capital of the Nicarao capital of Quauhcapolca, ruled by the *teyte* Nicaragua at the time of Spanish contact in 1522. Previous archaeological testing at the site was conducted by Gordon Willey and Albert Norweb in the early 1960s (Norweb 1964), and as a consequence Santa Isabel became one of the cornerstones for the regional ceramic classification developed by Paul Healy (1980). In four field seasons (2000-2005), Project SIN, under the direction of Dr. Geoffrey McCafferty, expanded investigations to sample five residential mounds from the site center using a combination of shovel testing and horizontal excavation to identify domestic practices on a community level (McCafferty, in press). Seventeen radiocarbon dates establish the site occupation to the Sapoa period (800-1250 CE; McCafferty and Steinbrenner 2005b), suggesting that the dominant ethnic group may have been Chorotega, though non-Mesoamerican traits also imply Chibchan ethnicity.

Included in the ongoing analysis of the Santa Isabel material culture is an intensive analysis of the abundant ceramics by Larry Steinbrenner (2002; dissertation in preparation). In conjunction with this study, students from an Archaeological Ceramics (ARKY471) class at the University of Calgary conducted x-ray diffraction analysis of sherds from the Santa Isabel assemblage. Previous compositional studies from the Greater Nicoya region include Healy's (1980) original type-variety classification that featured macroscopic inspection of ceramic pastes as a basis for dividing the polychrome types. Additionally, neutron activation analysis of ceramics collected throughout the Greater Nicoya region has suggested some spatial patterning of types as indication of local production (Bishop, Lange, and Lange 1988; Bishop et al. 1992).

The premise behind the x-ray diffraction study was an evaluation of the extent to which different types and varieties shared paste composition, suggesting common manufacturing origins, or whether the same types and varieties might feature distinct pastes, suggesting that they were manufactured at different locales. Since the sherds used for the analysis all come from the Santa Isabel site, and from a fairly limited time span, it was hoped that this study would provide a baseline for interpretations of ceramic marketing and exchange, as well as create a framework for subsequent studies with samples from other sites.

X-ray diffraction analysis is one of several techniques used to characterize the composition of ceramic materials. Ideally it is used in conjunction with other techniques, especially petrography which is better suited for recognizing tempering materials and other inclusions. X-ray diffraction operates on the principal that different minerals feature distinctive crystalline structures (Weymouth 1973); by bouncing x-rays off of the powdered clay matrix those crystalline planes can be recognized. At the University of Calgary's Geology lab this was done by placing small containers (approximately 5 ml) of finely powdered material in the x-ray chamber of a diffractometer. Results were captured and interpreted using the JADE program (JADE 6.5), which recognizes over 30,000 different diffraction signatures, each associated with different minerals. Louise Klatzel-Mudry was the technician at the University of Calgary who oversaw these analyses.

In the initial study, students analyzed samples of various different types and varieties in order to compare and contrast the mineral composition. These included four varieties of Papagayo Polychrome, four types associated with Steinbrenner's (2002) Isla Suite (perhaps manufactured on Ometepe Island), and two varieties of Vallejo Polychrome type. Types and varieties are distinguished based on details of paste color and design structure. Fifty-five samples were run in total (Table 1).

Four basic minerals not included in Table 1 (quartz, cristobalite, albite, and anorthite) were found in virtually all samples, and in relatively high intensity. Quartz (SiO2) and cristobalite (SiO2) are virtually identical, with cristobalite produced from quartz as it transforms at high temperatures. Albite and anorthite are both feldspars.

Some patterning is apparent in relation to the different types. Varieties of Papagayo Polychrome consistently include hematite, and phlogomite, trydimite, and yeelimite also occur. In the types from the Isla Suite, hematite is again common, as are magnetite and orthoclase. The Bramadero Polychrome type is the only one to contain muscovite; it has been suggested that Bramadero Polychrome may be an import from Costa Rica. The Lazo variety of Vallejo Polychrome is more typical of the Papagayo Polychrome pattern (featuring trace minerals found in Papagayo Polychrome varieties), perhaps as an indication that it develops out of this ceramic tradition. Vallejo: Vallejo variety, however, is characterized by a unique set of trace minerals (sanidine, paragonite, and sepiolite).

Based on these indicators for distinctive 'recipes,' the recognized types and varieties do seem like meaningful categories, and raise the possibility of specialized potting traditions for the creation of the different pottery. This may be at the community level, or even a kin-organized specialization within the same community. Future research will search for concentrations of the trace minerals in order to attempt to map these production centers on the Greater Nicoya landscape.

Buoyed by the results of this preliminary study, one of the students, Jillian Logee, undertook a more intensive study of monochrome ceramics for her honor's thesis project. She selected samples from Castillo Engraved (n=5), Ricardo Bichrome (n=10), Tolesmaida Monochrome Group 1 (fine ware; n=10), Tolesmaida Monochrome Group 2 (utilitarian ware; n=35), and Sacasa Striated (n=25). These types comprise almost the entire corpus of Sapoa period monochrome ceramics at the Santa Isabel site, and include both serving and utilitarian vessel forms. It should be noted that some of these types, especially Tolesmaida Monochrome and Ricardo Bichrome, are types being proposed by Larry Steinbrenner for his dissertation (still in process), and some refinement to the classification has occurred since this x-ray diffraction analysis. Results of this analysis can be found in Table 2.

The four basic minerals of quartz, cristobalite, albite, and anorthite were again present in strong intensities in virtually all samples, and therefore are not particularly useful for distinguishing clays from these samples. Interpretation of the other minerals reveals some interesting patterns which generally support our emerging hypothesis that most of Santa Isabel's monochromes belong to a common monochrome potting tradition. Macroscopically, the first four types listed in Table 2 feature similar-appearing pastes (typically grey with large-grained inclusions or temper, producing a very durable ceramic material), while Sacasa Striated features a crumbly, sandy tan or orange paste (apparently untempered) that is much more friable. Partially for this reason, the two utilitarian ware types – Tolesmaida Monochrome Group 2 (synonymous with the "Rivas Red" of previous studies, e.g. Healy 1980), and Sacasa Striated – are typically interpreted as being products of different traditions. However, the XRD data suggest that the mineral content of Sacasa Striated in fact shares some similarities to Tolesmaida Monochrome Group 2 and the other three types, although it lacks petalite and the presence of donpeacorite and gismondine is relatively rare. More research should be directed at clarifying this relationship.

Additionally, the presence of baratovite exclusively in Tolesmaida Monochrome Group 2 raises the possibility that this mineral was present in temper added to increase the strength of vessels in this type, which are typically larger than vessels in the other three types with similar appearing pastes.

Logee's work also found that these samples were further distinguished by vessel form, and that interesting distinctions emerged when form was considered. For example, donpeacorite and gismondine were present among Tolesmaida Monochrome Group 1 necked *ollas* (bottles), but lacking in composite silhouette bowls of the same type, which instead had margarite and petalite. This may suggest that distinct 'recipes' were used to produce different vessel forms, or perhaps that different forms were manufactured in slightly different production locales. Similarly, moganite appeared only in Ricardo Bichrome composite silhouette bowls, never in other vessel forms. Different utilitarian vessel forms associated with Tolesmaida Monochrome Group 2 and Sacasa Striated also displayed variations in specific mineral composition that correlated with form.

Finally, it is interesting to note that the trace minerals found in the monochrome pottery were not found in the polychromes examined in the original study. The conclusion is that monochrome and polychrome pots were created using rather different recipes, which has a variety of potential implications.

Although often noted in ceramics textbooks as one of the fundamental methods for compositional analysis, in fact x-ray diffraction has rarely been applied to archaeological ceramics (Beck 1981; Ruvalcaba-Sil et al. 2001; Zhu et al 2004). Although preliminary in nature, these studies indicate that x-ray diffraction analysis can provide useful information that may offer insights into ceramic production in the Greater Nicoya region. Polychrome types and varieties all featured minor mineral inclusions that made them distinctive. Not only did the monochrome types also display unique characteristics, but even the vessel forms were distinctive. This suggests an unexpected degree of specialization, albeit based on established potting traditions, with potters using unique recipes for different types, varieties, and even vessel forms.

With renewed funding from the Social Sciences and Humanities Research Council of Canada, we plan to continue this line of investigation, including petrographic analysis of the temper and inclusions, as well as expanding the sample size of the study collections. Furthermore, we intend to collect samples from other controlled contexts from sites within the Greater Nicoya region, in hopes of pinpointing production loci for the different ceramic types. At this point, we are encouraged by the initial results, and excited about the prospects of continuing research.

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References

Beck, Curt W.
1981 X-Ray Diffraction Analysis and Petrography as Useful Methods for Ceramic Typology. *Journal of Field Archaeology* 8(4): 511-513.

Bishop, Ronald L., Frederick W. Lange, and Peter C. Lange
1988 Ceramic Paste Compositional Patterns in Greater Nicoya Pottery. In *Costa Rican Art and Archaeology: Essays in Honor of Frederick R. Mayer*, edited by F. W. Lange, pp. 11-44. Boulder: Johnson Books.

Bishop, Ronald L., Frederick W. Lange, Suzanne Abel-Vidor, and Peter C. Lange
1992 Compositional Characterization of the Nicaraguan Ceramic Sample. In *The Archaeology of Pacific Nicaragua*, edited by F. W. Lange, P. D. Sheets, A. Martinez, and S. Abel-Vidor, pp. 135-162. Albuqueque: University of New Mexico Press.

Chapman, Anne C.
1974 *Los Nicarao y los Chorotega segun los fuentes historicas.* Ciudad Universitaria, Costa Rica.

Day, Jane Stevenson
1994 Central Mexican Imagery in Greater Nicoya. In *Mixteca-Puebla: Discoveries andResearch in Mesoamerican Art and Archaeology*, edited by H. B. Nicholson and E. Quizones Keber, pp. 235-248. Culver City: Labyrinthos Press.

Fowler, William R., Jr.
1989 *The Evolution of Ancient Nahua Civilizations: The Pipil-Nicarao of Central America.* Norman: University of Oklahoma Press.

Healy, Paul F.
1980 *Archaeology of the Rivas Region, Nicaragua.* Waterloo, Ontario: Wilfred Laurier University Press.

1988 Greater Nicoya and Mesoamerica: Analysis of Selected Ceramics. In *Costa Rican Art and Archaeology*, edited by F. W. Lange, pp. 293-301. Boulder: University of Colorado Press.

JADE 6.5
2003 JADE 6.5. Materials Data, Inc. Livermore, CA.

León-Portilla, Miguel
1972 *Religión de los Nicaraos: Análisis y Comparación de Tradiciones Culturales Nahuas.* Instituto de Investigaciones Historicas, Universidad Nacional Autónoma de México, Mexico, DF.

Logee, Jillian R.
2006 *X-Ray Powder Diffraction Analysis of Monochrome Ceramics from Santa Isabel, Nicaragua.* BA Honor's thesis, Department of Archaeology, University of Calgary, Calgary, AB, Canada.

Lothrop, Samuel K.
1926 *The Pottery of Costa Rica and Nicaragua*, 2 vols. Heye Foundation, Museum of the American Indian Memoir 8, New York, NY.

McCafferty, Geoffrey G.
N.D. Domestic Practice in Postclassic Santa Isabel, Nicaragua. *Latin American Antiquity*, in press.

McCafferty, Geoffrey G. and Larry Steinbrenner
2005a The Meaning of the Mixteca-Puebla Stylistic Tradition on the Southern Periphery of Mesoamerica: The View from Nicaragua (with Larry Steinbrenner). In *Art for*

Archaeology's Sake: Material Culture and Style across the Disciplines. Proceedings of the 33rd Annual Chacmool Conference, edited by A. Waters-Rist, C. Cluny, C. McNamee and L. Steinbrenner, pp. 282-292. The Archaeological Association of the University of Calgary, AB.

2005b Chronological Implications for Greater Nicoya from the Santa Isabel Project, Nicaragua. *Ancient Mesoamerica* 16(1): 131-146.

Motolinía, Fray Toribio de Benavente
1951 *History of the Indians of New Spain* (translated by F.B. Steck). Academy of American Franciscan History, Washington D.C. [Originally written in 1540].

Niemel, Karen Stephanie
2003 *Social Change and Migration in the Rivas Region, Pacific Nicaragua (1000 BC - AD1522).* PhD dissertation, Department of Anthropology, State University of New York, Buffalo, NY.

Norweb, Albert H.
1964 Ceramic Stratigraphy in Southwestern Nicaragua. *Actas, 35th International Congress of Americanists* 1: 551-561.

Oviedo y Valdés, Gonzalo Fernando de
1976 *Nicaragua en las Crónicas de Indias: Oviedo.* Banco de America, Fondo de Promoción Cultural, Serie Cronistas 3, Managua, Nicaragua.

Ruvalcaba-Sil, JL, MA Ontalba Salamanca, L Manzanilla, J Miranda, J Canetas Oretega, and C Lopez
2001 Characterization of pre-Hispanic pottery from Teotihuacan, Mexico, by a combined PIXE-RBS and XRD analysis. *Geoarchaeology* 16(8): 591-596.

Steinbrenner, Larry Leonard
2002 *Ethnicity and Ceramics in Rivas, Nicaragua, AD 800-1550.* MA thesis, Department of Archaeology, University of Calgary, Calgary, AB.

Torquemada, Fray Juan de
1975-83 *Monarquía Indiana,* 7 volumes (coordinated by M. Leon-Portilla). Instituto de Investigaciones Historicas, Universidad Nacional Autonoma de México, Mexico D.F. [Originally written in 1615].

Weymouth, John W.
1973 X-Ray Diffraction Analysis of Prehistoric Pottery. *American Antiquity* 38: 339-344.

Zhu, Jiping, Jie Shan, Ping Qin, Ying Qin, Changsui Wang, Deliang He, Bo Sun, Peihua Tong, and Shuangheng Wu
2004 The Multivariate Statistical Analysis and XRD Analysis of Pottery at Xigongqiao Site. *Journal of Archaeological Science* 31(12): 1685-1692.

TABLE 1: Rates of Encounter of Marker Minerals for Polychrome Varieties

	Hema	Magn	Orth	Phlo	Tryd	Yeel	Musc	Sani	Para	Sepi
Papagayo type										
Alfredo var	+++	-	-	+++	-	-	-	-	-	-
Casares var	++	-	-	-	+++	-	-	-	-	-
Cervantes var	+++	-	-	-	-	++	-	-	-	-
Mandador var	+	-	-	++	-	-	-	-	-	-
Vallejo type										
Lazo var	++	-	-	-	++	++	-	-	-	-
Vallejo var	-	-	-	-	-	-	-	++	++	++
Isla suite										
Madeira	+++	+++	-	-	-	-	-	-	-	-
Banda	-	+++	+++	-	-	-	-	-	-	-
El Menco	+++	-	+++	-	-	-	-	-	-	-
Bramadero	+++	-	-	-	-	-	+++	-	-	-

Hema=Hematite, Magn=Magnetite, Orth=Orthoclase, Phlo=Phlogopite, Tryd=Trydimite, Yeel=Yeelimite, Musc=Muscovite, Sani=Sanidine, Para=Paragonite, Sepi=Sepiolite

Scale: - = absent; + = 33% of samples; ++ = 67% of samples; +++ = 100% of samples

TABLE 2: Rates of Encounter of Marker Minerals for Plain Ware Ceramics

	Quar	Cris	Albi	Anor	Bara	Donp	Gism	Marg	Moga	Peta
Castillo	++++	++++	++++	++++	-	++++	+++	++	-	+
Ricardo	++++	++++	++++	++++	-	+++	++	+++	++	+
Tolesmaida G1	++++	++++	++++	++++	-	++	++	+	-	+
Tolesmaida G2	++++	++++	++++	++++	++	++	+	+++	-	+
Sacasa	++++	++++	++++	++++	-	+	+	++	-	-

Quar=Quartz, Cris=Cristobalite. Albi=Albite, Anor=Anorthite, Bara=Baratovite, Donp=Donpeacorite, Gism=Gismondine, Marg=Margarite, Moga=Moganite, Peta=Petalite

Scale: 0-19% = -; 20-39% = +; 40-59% = ++; 60-79% = +++. 80-100% = ++++