Re-evaluating Ceramic Economy at Ayala (AD 1–1250), Granada, Pacific Nicaragua

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Abstract: Located on the flanks of Mombacho volcano to the southeast of Granada City, Ayala was the largest occupied center in the area until roughly AD 800, after which its prominence declined. Investigations in the 1990s determined that the site likely played an important local sociopolitical role, as well as being connected to distant groups along vast networks. This interpretation derived, in part, from ceramic evidence including the earliest compositionally verified polychromes manufactured in Pacific Nicaragua ca. AD 500–800 (e.g., Momta and Belo polychromes) and a variety of ceramic types associated with west-central Honduras and El Salvador (e.g., Usulután negative resist and Las Vegas polychromes). Yet, evidence for the (re)distribution of those wares to other known sites in Pacific Nicaragua was lacking. Recent recovery of Ayala's polychromes at the 13 km-distant site of El Rayo, however, has drawn the site back to the foreground of study. Coupled with advances in volcanology and geochemistry, compositional analyses (INAA and petrography) not only challenge long-held assumptions about the organization of the ceramic economy in Pacific Nicaragua, but also amplify our understanding of Ayala's specific role within the revised model. Results indicate that (a) Ayala's unique polychromes were manufactured, at least in some measure, for off-site mortuary-related destinations, (b) the site was only sporadically receiving vessels from west-central Honduras, more frequently creating well-crafted local versions, and (c) rather than simply a consumer of key diagnostic styles after AD 800 (e.g., Papagayo Polychrome) as previously assumed, Ayala was a principal producer and distributor, if not a leader in their development.
Keywords: Pacific Nicaragua; pre-Columbian ceramic economy; ceramic compositional analysis; Instrumental Neutron Activation Analysis (INAA); petrography.

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Una reevaluación de la economía de la producción cerámica en el sitio Ayala (1-1250 d.C), Granada, Pacífico de Nicaragua
Resumen: El asentamiento denominado Ayala, está situado al sureste de la ciudad de Granada, en las faldas del volcán Mombacho. En esa área, fue el sitio con una ocupación más prolongada hasta aproximadamente el 800 d.C., cuando su importancia declinó. En la década de los años 1990, las investigaciones indicaron que este desempeñó un papel sociopolítico importante, que incluyó el mantener amplias redes de contacto e intercambio con grupos de regiones distantes. Esto se derivó, en parte, de la evidencia cerámica que incluyó, la determinación mediante análisis composicional, de los primeros policromos manufacturados en el Pacífico durante el periodo 500-800 d.C. en Nicaragua, así como una variedad de tipos cerámicos asociados con el oeste y centro de Honduras y El Salvador (p. ej. Usulután Negativo Resistente y Las Vegas Policromo). Sin embargo, se desconocía la distribución de estas cerámicas hacia otros sitios conocidos del Pacífico de Nicaragua, con raras excepciones. El hallazgo de policromos en el sitio El Rayo, localizado 13 kilómetros al este de Ayala, manufacturados en este último, permitió una nueva mirada a las dinámicas de la producción cerámica en el sitio. Junto con recientes avances en vulcanología y geoquímica, los resultados del análisis composicional (AANI y la petrografía) han cuestionado no solo las asunciones anteriores acerca de la producción cerámica en el Pacífico de Nicaragua, sino también ha ampliado el conocimiento del papel específico de Ayala dentro del modelo establecido. Los resultados indican que los policromos producidos en ese sitio fueron: a) manufacturados, al menos en parte, para una función funeraria y quizás doméstica fuera del sitio, (b) que sólo esporádicamente se recibieron vasijas del oeste y el centro de Honduras, mientras que con frecuencia se hicieron con características similares, y (c) que en lugar de ser un consumidor de estilos cerámicos diagnósticos como el Papagayo Policromo después 800 d.C., Ayala fue el principal productor y distribuidor, y quizás el innovador en su desarrollo, contrario a lo antes pensado.
Palabras clave: Pacífico de Nicaragua; economía cerámica precolombina; análisis composicional de la cerámica; análisis por activación neutrónica instrumental (AANI); petrografía.

Introduction

Ayala (N-GR-2) was a large and important Bagaces-period center (Figure 1), long recognized by archaeologists for the number and variety of nonlocal material goods, technologies, and styles it has yielded, and particularly those related to Lenca potting traditions from west-central Honduras and eastern El Salvador. Equally intriguing are the numerous ceramic types manufactured at the site and consumed locally, many of which—Momta and Belo Polychrome, for example—were virtually unknown from archaeological contexts outside of Ayala until very recently.

The discovery of Ayala-manufactured polychromes at the 13 km-distant mortuary site of El Rayo, located on the Asese peninsula off the coast of the Mombacho volcano in Lake Nicaragua (Figure 1), provides a new angle from which to view the past. New ceramic compositional data indicate that the site differed significantly from its pottery-producing peers in Pacific Nicaragua. When combined with other, equally important developments in the environmental sciences, particularly in volcanology, these data allow us to evaluate and make sense of Ayala's complex interactions with both surrounding and regional centers, as well as broader interregional exchange networks.

Figure 1: Approximated locations of the principal sites discussed.

Here we seek to revitalize scholarly interest in Ayala by demonstrating its important role in the ceramic economy of Pacific Nicaragua. We begin with a brief background on archaeological research that has been carried out at the site and its external connections. This is followed by an introduction to the methods utilized in the ceramic compositional analyses and presentation and discussion of the analytical results. The results are then contextualized and discussed in a period-by-period format.

Brackground: The Ayala Site

Located approximately 8 km south-southwest of modern Granada City at the base of the northwestern flank of the Mombacho volcano, Ayala sits just east of the highway between Granada and Nandaime (Figure 2). The site was first identified in the 1960s by Albert Norweb (1964), when he conducted limited excavations there in two test pits. The materials from those excavations were analyzed decades later, in the early 1990s, by Silvia Salgado. From its observable, humble beginnings, the site stands out as unique in several respects. Salgado's (1996a) regional survey, for example, has demonstrated that Ayala was the main regional settlement in the Granada area throughout the entire Bagaces period, during which time it experienced significant physical expansion, group nucleation, and population growth. The site is also significant due to the sheer variety of local and nonlocal ceramic types present in the archaeological stratigraphy. From roughly AD 300–800 a standard and limited set of types and varieties were produced in Pacific Nicaragua. Ayala, however, had most of these (see Salgado, 1996a), as well as a series of previously unidentified local types and several trade wares (including Delirio Red-on-White, understood then to derive from El Salvador; and Ulúa and Tenampua Polychromes, from west-central Honduras).

Ceramic artifacts recovered at Ayala included vessel sherds, figurines, earspools, and reworked sherds, with a significant number of vessel sherds indicating interaction with both regional and interregional sociopolitical networks. As introduced briefly above, it also manufactured a unique set of ceramic types that clearly differentiated it from other sites in all Greater Nicoya at that time. Based on Norweb's field notes and excavated materials from the site, Salgado (1996a) constructed the first formal chronological sequence for the Granada area, and introduced several previously unidentified Late Bagaces ceramic types and varieties (e.g., Ayala Plain, Ayala Slipped, Astorga Cream, Momta Polychrome, Belo Polychrome, Rosalita Polychrome). Salgado (1996b) initially suggested that occupation in this localized area was constrained to the Bagaces period (AD 300–800), although hints at its earlier and subsequently continued role in the ceramic economy following the Bagaces-to-Sapoá transition (ca. AD 700–900) are evident at the site and are discussed in greater detail below.

Ayala Beyond Mombacho

Located directly on the Asese peninsula (Figure 2), El Rayo (N-GR-39) was at least partly in use as a repository for the dead throughout the Late Bagaces and Sapoá periods (Dennett, 2016; McCafferty and McCafferty, 2017). A significant number of Ayala-derived early polychromes were recovered there as part of the Proyecto Arqueológico Granada, Nicaragua (PAGN) excavations led by Geoffrey McCafferty in 2009–2010, along with associated radiocarbon samples from deep stratigraphic contexts (see Dennett, 2016; McCafferty and McCafferty, 2017). The site is one of the only excavated sites beyond Ayala to demonstrate the full Bagaces through Sapoá material-culture transition in the Department of Granada.

The Ceramic Compositional Analyses

Frederick Lange and Ronald Bishop initiated the Greater Nicoya Ceramic Project (GNCP) in 1979 (Bishop, Lange, and Lange, 1988), now the longest-running analytical program in the history of southern

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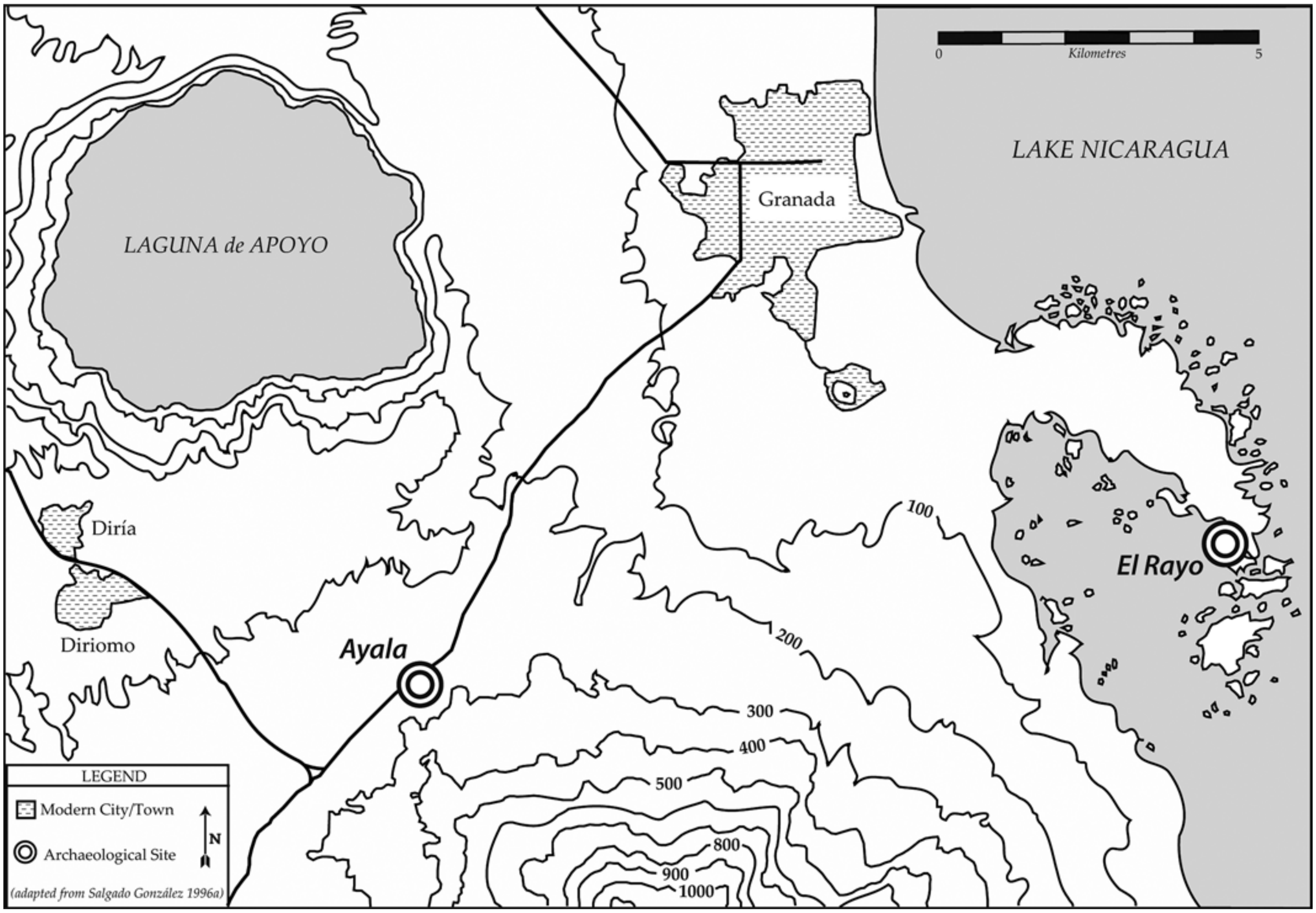

Figure 2: Physical map of the Granada-Mombacho area, with approximated locations of the Ayala and El Rayo archaeological sites (cropped basemap courtesy of NASA/JPL/NIMA, http://photojournal.jpl.nasa.gov/catalog/PIA03364, public domain, Wikimedia Commons).

Central American archaeology. By the mid-1990s the GNCP had significantly increased the number of samples under analysis and subsequently identified dozens of compositional groupings for Greater Nicoya, although only a subset of these original identifications have stood the test of time (see Bishop and Lange, 2013; Bishop, Lange, Abel-Vidor, and Lange, 1992; Bishop et al., 1988; Lange, Bishop, and Lange, 1987). Despite limited knowledge of gross geological trends and volcanology in the region, a distinct north-south compositional division within Greater Nicoya was identified near the modern Nicaragua-Costa Rica political border (Bishop et al., 1988; Lange et al., 1987), and demonstrating sector-specific type production and diachronic patterns and trends in distribution. Supplemental samples gathered in Pacific Nicaragua in the 1980s provided broader representation (Bishop et al., 1992), and instrumental neutron activation analysis (INAA) results indicated the presence of four identifiable manufacturing zones within the northern sector of

Greater Nicoya (Rivas and Granada, Managua, Chontales, Leon and Chinandega), although our knowledge at the time was "limited to large, poorly defined subregions" (Bishop et al., 1992, p. 138).

For Pacific Nicaragua, the Department of Rivas has historically been characterized as an important 'hub' connecting major centers in the northern and southern sectors of Greater Nicoya. Until relatively recently the majority of scholars working in the region have assumed that local potters were likely responsible for the manufacture of (a) early red-slipped pottery before AD 800 (Figure 3a, b), (b) the majority of later white-slipped Papagayo and Pataky Polychromes (Figure 3c, d), and (c) were the general source of 'Ometepe Island' products including Madeira and Luna Polychromes from roughly AD 800–1250 (Figure 3e, f) due to their sheer numbers in local archaeological contexts (Abel-Vidor et al., 1987; Bishop et al., 1988; Bishop and Lange, 2013; Haberland, 1992; Healy, 1980; Lange, Sheets, Martinez, and Abel-Vidor, 1992; Lothrop, 1926; McCafferty, 2008; McCafferty and Steinbrenner, 2005; Steinbrenner, 2010). In the Department of Granada (e.g., Hughes, 1980; Norweb, 1964; Salgado, 1996a, 1996b) located directly to the north, however, the role of ceramic manufacture has been broadly viewed as somewhat peripheral or secondary to the main activities thought to have been occurring in Rivas.

Several years ago, a collaborative compositional research program was initiated to supplement and refine our knowledge of ceramic production on the Isthmus of Rivas, building on earlier analytical research conducted under the GNCP (see Bishop et al., 1988; Lange et al., 1987). This research sought to reconstruct segments of the Greater Nicoya ceramic economy, particularly those in Pacific Nicaragua, and to observe how that economy intersected with external regions such as Chontales and regions of west-central Honduras (Ulúa-Yojoa and Comayagua). Thanks to advances in our understanding of volcanological geochemistry in the region (e.g., Carr, Feigenson, Patino, and Walker, 2004), not only can several of these compositional groups be tied to specific volcanic centers, but we are now also able to discriminate between ceramic manufacturing sites/centers located on different sectors of the same volcanic complex.

The formal research component involved a complementary and comparative set of analytical measures: INAA and petrography. These techniques characterize various components, specifically the mineral, lithic, and chemical content and ratios found in the ceramic paste samples tested (Bishop et al., 1988). The combination of these techniques leads to particularly powerful results and interpretations because what is not visible in petrographic analysis can often be elucidated in chemical analysis and vice versa. Bishop, Rands, and Holley (1982) have noted that:

> [i]n most respects, chemical analysis is a more powerful method than petrology, and it can distinguish more readily between clays. However, if carried out in isolation from mineralogical studies... it is less likely than petrology to give the investigator readily recognizable information about the nature of the variation introduced by mineral grains. In the absence of such supplemental data, problems of basic interpretation may be compounded (p. 288).

Figure 3: Late Bagaces period redware types (a) Tola Trichrome (cat. no. PK-7-0359) and (b) Chávez White-on-Red (cat. no. PK-7-0364), and Sapoá period white-slipped types (c) Papagayo Polychrome (cat. no. PK-7-2201), (d) Pataky Polychrome (cat. no. PK-7-2301), (e) Madeira Polychrome (cat. no. PK-7-1118), and (f) Luna Polychrome (cat. no. PK-7-1015). Photos by Erin L. Sears; courtesy of Mi Museo, Granada, Nicaragua.

Indeed, the combined use of petrographic and chemical analyses serves not only to assist with issues of typological construction or refinement, but also provides much greater support for interpretations involving aspects of craft specialization, intraregional production and distribution, and interregional exchange of ceramics on a cultural landscape (Bishop and Neff, 1989). Below we summarize the results of the current research, as the details have been presented elsewhere (Dennett, 2016).

The Results

INAA indicated nine (9) distinct and statistically significant compositional groupings associated with the Granada (Groups C, D, E), Mombacho (Groups F, H), and Rivas-Ometepe zones (Groups M, N, O, P). Table 1 presents descriptive statistics, including the arithmetic mean and coefficient of variation (CV) for each of the proposed groupings.

To visually demonstrate how the chemical (INAA) compositional groupings varied, and to what degree, centers of clustered density were laid out on reference axes. Data were transformed and normalized to show the co-efficient of variation (CV) between groups, and separation is clearly visible based on elemental abundances and/or elemental ratios. Variation in geochemical composition in Pacific Nicaragua derive from specific elemental ratios that correlate with geographical position along the Central American Volcanic Arc (CAVA) (Carr et al. 2004). Results indicate that gross interregional variation along the CAVA is principally determined by the elemental ratio Ba/La, where the results demonstrate chemical, and thus geospatial, clustering among several of the proposed groupings. Gross intraregional variation, on the other hand, is best demonstrated by the elemental ratio La/Yb. Figure 4 demonstrates this variation and the relationship between the two ratios. In this graph, one cluster of compositional groupings (red symbols; Groups C-H) is associated with the Granada-Mombacho area, which exhibits distinctively low La/Yb ratios and high Ba/La. The second cluster (green symbols; Groups M-P) is associated with the Rivas-Ometepe signal, as indicated by the diagnostic extreme and inverse relationship between Ba/La—Rivas-Ometepe has the lowest on the Isthmus of Rivas—and La/Yb.

The Mombacho volcano has the highest Ba/La ratio along the Isthmus of Rivas and the elevated readings found in petrofabric Groups F and H (Figure 4) are consistent with those results. These manufacturing centers were located directly on the lower piedmont flanks of the Mombacho volcano, and this propinquity to the source serves to differentiate this complex from the Granada complex to the north-northeast. However, for the cluster of groupings associated with the Granada-Mombacho zone, the elemental ratio Ba/Th also distinguishes between different production locations/centers. Variation is best visually demonstrated in relation to the relative abundance of Cr. In Figure 5 we see significant overlap between Groups D and E, on one hand, and Groups F and H on the other. Group C is differentiated, sitting apart from, but still associated with, these other groups.

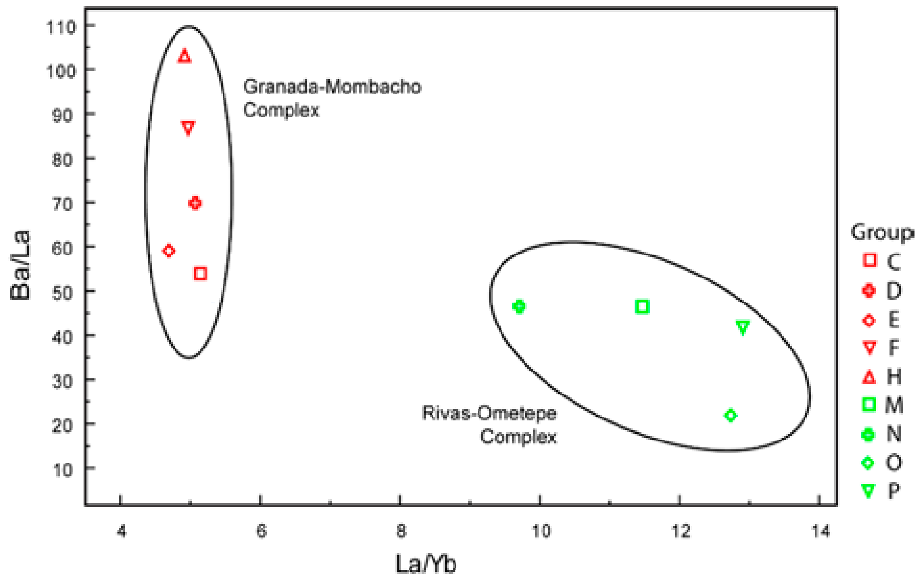

Figure 4: Elemental ratios Ba/La and La/Yb indicate regional geochemical trends for major volcanic centres along the Central American Volcanic Arc, as well as intraregional variation at a more refined scale (see Table 1 for group centroid data; adapted from Dennett [2016]). Within the upper left ellipse are compositional groupings tied to the Granada-Mombacho Complex. In the bottom right ellipse are groupings associated with the Rivas-Ometepe Complex. Ellipses do not indicate statistical probabilities, they are simply a visual aid to identify members of the complexes under discussion.

Variation in otherwise overlapping groups was determined to derive primarily from differences in the relative abundances of select elements. For Groups F and H (Figure 6), Cr shows a strong point of correspondence between the groups, whereas Hf serves to separate them.

As noted above, through the combination of INAA and petrography, as well as developments in volcanology, these complexes can now be confidently tied to their geographical area of origin. The petrofabrics discussed here include products from Granada, Mombacho, and Rivas-Ometepe. Table 2 visually organizes the INAA results, listing the ceramic types associated with each of the manufacturing complexes and their associated chemical compositional groupings.

A basic overview of the mineralogy and lithic composition of each petrofabric grouping is presented in Table 3. This is followed by a visual demonstration of the petrographic differences between the Mombacho, Granada and Rivas-Ometepe complexes. Because of the volcanic nature of the region, various diagnostic 'varieties' of andesite have previously been established for the GNCP thin section dataset by Peter C. Lange (see Bishop et al., 1988) and are redefined below for reference (Dennett, 2016):

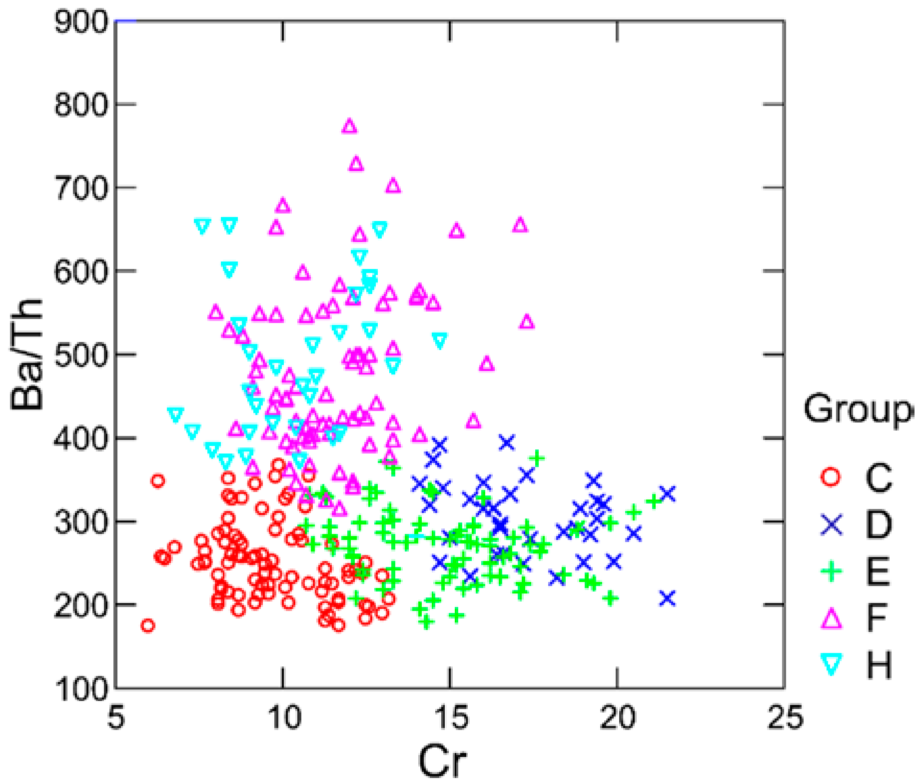

Figure 5: Ba/Th and Cr signals serve to clearly demonstrate elemental variation among compositional groupings in the Granada-Mombacho zone (from Dennett [2016]).

ANDI: Andesite ash flow or ash flow tuff that contains a clear-glass groundmass including minute plagioclase laths and magnetite cubes (typically shows a dense light grey in plane light).

ANDII: An andesite vitric-crystal tuff of characteristic brown glass. This has far more brown glass and less mineral inclusions than ANDI (can vary greatly in appearance, but typically very glassy with very well-oriented microlaths or large unoriented crystals and laths in plane light).

ANDIII: A high-Fe (iron-rich) andesite porphyry, very dark grey to black in plane polar light and contains "dense, randomly oriented, well-formed and twinned plagioclase laths in a groundmass of hematite," with occasional relic pyroxene phenocrysts preserved in the matrix.

Group F is here tied to Ayala in the Mombacho Complex based on geochemical affinity and is the only known location—apart from El Rayo, which was not manufacturing ceramics—to demonstrate such (or any) quantities of archaeologically rare types that characterize the site. Subgroups F1 and F2 from Ayala demonstrate a clear chronological difference in clay recipe.

Subgroup F1 represents both Late Tempisque Usulután-related products and regionally unique and highly diagnostic Bagaces period types (e.g., Belo, Galo, Momta, and Rosalita Polychrome), which are

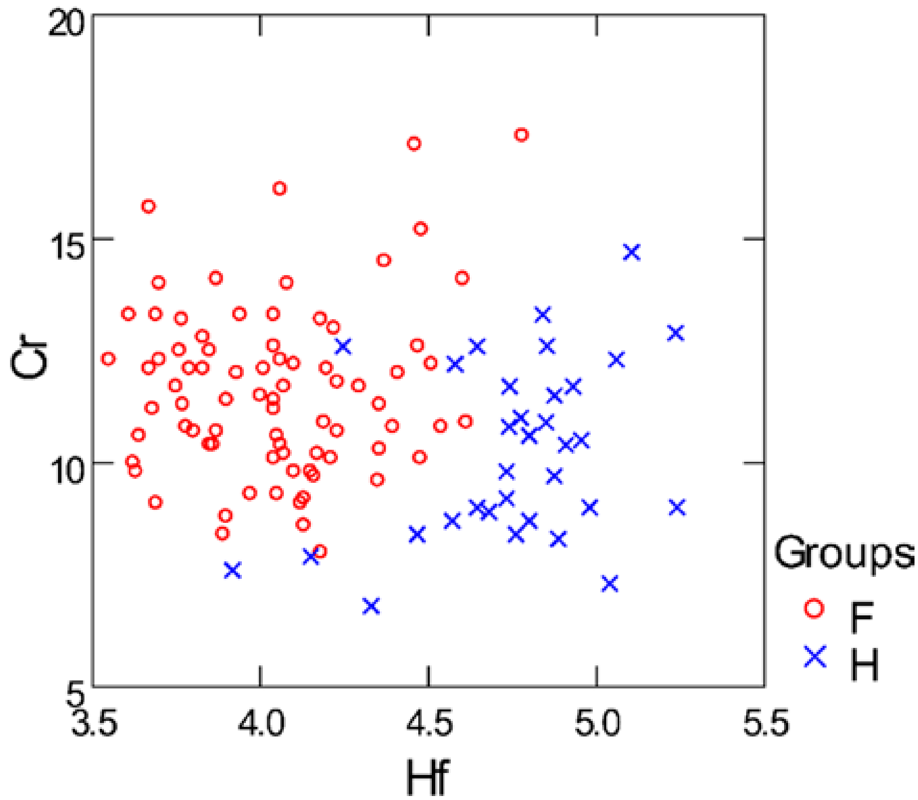

Figure 6: Elemental abundance of chromium (Cr) indicates correspondence between the groupings, while hafnium values (Hf) serve to differentiate the Mombacho Groups F and H (from Dennett [2016]).

only seen in rare and/or circumscribed instances outside of the Mombacho zone. The paste recipe is unique among its regional peers in that it is not tempered (Figure 7). The local clays are dominated by glass and ash fragments, and minerals present are generally pumice-derived phenocrysts.

Ayala's technique of clay preparation contrasts starkly with that of nearby Group D potters, who utilized generous amounts of diagnostic pumice tempering ca. AD 300–1250 (Figure 8). Located roughly 8 km to the north of the Mombacho volcano, Jalteva was a principal contact-period indigenous center within the vicinity of modern day Granada City (Oviedo y Valdés, 1581; Squier, 1860; Werner, 2000) and interpreted as the primary producer of Granada Redwares such as Tola Trichrome, León Punctate, and Chávez White-on-Red ca. AD 500–800 (Dennett, McCafferty, and Bishop, 2013). To the south, Rivas-Ometepe Complex groups are of some antiquity, producing Tempisque period (500 BC–AD 300) types (see Table1). Notably, Bagaces period manufacturing evidence from the Rivas-Ometepe Complex is lacking in both the GNCP chemical and Dennett's petrographic sample sets, and this is particularly true for the Late Bagaces (AD 500–800). It is currently unknown whether this reflects a reality of the past, a problem with our understanding of chronological production, or, rather, a negative reality of the sampling procedure.

Sometime around AD 700–800, ceramic paste recipes begin to change quite dramatically, particularly in the Mombacho and Granada zones, a phenomenon accompanying the emergence of both white-slipped polychrome ceramic styles (especially Papagayo and Pataky) and new/additional manufacturing workshops. Subgroup F2 samples from Ayala exhibit continuity in the base clays used but with the addition of abundant crushed, angular plagioclase sand tempering (Figure 9). Ayala began making all its own types from this new recipe shortly before AD 800, as well as imitations of popular foreign types it manufactured for local consumption (e.g., Delirío Red-on-White, Tenampua Polychrome; see Table 1).

In Granada, Jalteva (Group D) workshops continued to manufacture traditional pumice-tempered wares (see Figure 8), but by the close of the Bagaces period (AD 800) styles such as Tola Trichrome and Chávez White-on-Red were supplanted by new monochrome styles including Castillo Engraved and Rivas Red. Alongside this traditional ceramic industry at Jalteva, however, an additional manufacturing group (Group E) emerged around AD 800 that used the same clay source, but with Ayala's style of crushed plagioclase sand tempering (as opposed to pumice) for white-slipped types (Figure 10a). The development of this tempering technique is important as it was not only adopted by both main ceramic centers in the Granada-Mombacho zone (Ayala and Jalteva), but also represents the only identified paste preparation technique used after AD 800 across all known emergent workshops in this zone. These sand-tempered petrofabrics feature Group C products from Tepetate (Figure 10b), located approximately 2 km north of Granada City on the shore of Lake Nicaragua, and the unidentified Group H (Figure 10c), on the flanks of the Mombacho volcano.

Finally, ceramic petrofabrics from Rivas-Ometepe after AD 800 are very different from those in the Granada-Mombacho zone, primarily due to the nature and abundance of andesites and pyroxenes present (Figure 11).

Ayala's Role in the Ceramic Economy of Pacific Nicaragua

What follows is a proposed refinement, or update, on Ayala's role in pre-Columbian ceramic economy on a period-by-period basis, placing it within its broader environmental and historical contexts. The objective is to reveal previously unidentified mechanisms that contributed to making Ayala the thriving and progressive center it once was.

Tempisque period (500 BC-AD 300)

Environmental conditions varied considerably in the Late Tempisque period across Pacific Nicaragua. At the northern end of the Isthmus of Rivas, the Managua area was hit by three successive eruptions from different volcanos from roughly AD 1–300, resulting in generalized local disaster punctuated by pockets

Table 1: Descriptive statistics for the dataset partition (INAA groups) based on 13 individual elements and 8 elemental ratios considered in the final analysis. Represented here are the arithmetic mean and coefficient of variation (CV), or relative standard deviation, for each partition (adapted from Dennett [2016]).

Element/ Ratio	C	D	E	F	H	M	N	O	P
Sc	25,23 (0,112)	21,95 (0,085)	24,33 (0,082)	21,62 (0,097)	24,60 (0,070)	25,70 (0,123)	34,15 (0,094)	34,34 (0,113)	31,69 (0,114)
Cr	9,68 (0,175)	17,31 (0,119)	14,88 (0,166)	11,62 (0,165)	10,27 (0,192)	12,27 (0,275)	21,97 (0,196)	21,88 (0,174)	19,05 (0,175)
Fe	6,65 (0,131)	5,59 (0,086)	6,46 (0,084)	5,63 (0,145)	6,69 (0,073)	7,48 (0,129)	9,56 (0,121)	9,98 (0,113)	9,24 (0,127)
Cs	1,39 (0,229)	1,34 (0,265)	1,41 (0,228)	1,05 (0,263)	1,38 (0,299)	1,09 (0,574)	1,03 (0,389)	0,835 (0,296)	0,871 (0,311)
Ba	824,98 (0,192)	1127,97 (0,138)	857,96 (0,139)	1225,97 (0,209)	1512,52 (0,182)	1514,6 (0,239)	1162,72 (0,239)	717,35 (0,175)	838,08 (0,252)
La	15,49 (0,160)	16,35 (0,086)	14,72 (0,121)	14,46 (0,164)	15,13 (0,102)	33,22 (0,216)	25,44 (0,192)	31,45 (0,148)	21,61 (0,242)
Ce	24,41 (0,335)	34,25 (0,151)	22,98 (0,314)	26,69 (0,390)	23,84 (0,352)	66,50 (0,579)	65,29 (0,486)	60,33 (0,234)	36,62 (0,330)
Sm	4,49 (0,137)	4,51 (0,096)	4,58 (0,160)	4,21 (0,182)	4,51 (0,124)	6,34 (0,209)	5,57 (0,224)	5,82 (0,198)	3,44 (0,180)
Eu	1,33 (0,125)	1,08 (0,113)	1,32 (0,087)	1,19 (0,156)	1,33 (0,056)	1,58 (0,236)	1,34 (0,184)	1,46 (0,152)	0,865 (0,175)
Yb	3,01 (0,124)	3,22 (0,106)	3,14 (0,121)	2,93 (0,155)	3,06 (0,083)	3,02 (0,218)	2,66 (0,158)	2,50 (0,121)	1,71 (0,181)
Lu	0,467 (0,104)	0,483 (0,160)	0,476 (0,142)	0,441 (0,165)	0,470 (0,119)	0,458 (0,219)	0,405 (0,189)	0,408 (0,173)	0,294 (0,175)
Hf	4,97 (0,104)	5,77 (0,063)	4,83 (0,086)	4,06 (0,070)	4,75 (0,061)	6,87 (0,129)	6,42 (0,111)	6,54 (0,091)	6,36 (0,105)
Th	3,28 (0,101)	3,73 (0,065)	3,16 (0,103)	2,56 (0,106)	3,10 (0,093)	5,45 (0,180)	5,00 (0,130)	5,11 (0,122)	4,96 (0,111)
La/Yb	5,18 (0,130)	5,12 (0,109)	4,73 (0,129)	5,01 (0,171)	4,97 (0,106)	11,46 (0,269)	9,71 (0,201)	12,71 (0,174)	12,88 (0,252)
Th/Sc	0,131 (0,116)	0,171 (0,096)	0,130 (0,102)	0,119 (0,123)	0,126 (0,075)	0,217 (0,247)	0,147 (0,145)	0,150 (0,137)	0,160 (0,204)
Cr/Th	2,98 (0,182)	4,64 (0,116)	4,73 (0,180)	4,54 (0,170)	3,30 (0,182)	2,35 (0,373)	4,45 (0,212)	4,34 (0,217)	3,91 (0,225)

Table 1: Descriptive statistics for the dataset partition (INAA groups) based on 13 individual elements and 8 elemental ratios considered in the final analysis. Represented here are the arithmetic mean and coefficient of variation (CV), or relative standard deviation, for each partition (adapted from Dennett [2016]).

Element/ Ratio	C	D	E	F	H	M	N	O	P
La/Sm	3,45 (0,089)	3,64 (0,071)	3,27 (0,142)	3,48 (0,143)	3,39 (0,107)	5,36 (0,229)	4,68 (0,188)	5,52 (0,184)	6,28 (0,158)
La/Lu	33,67 (0,165)	34,44 (0,136)	31,44 (0,162)	33,33 (0,185)	32,53 (0,128)	75,09 (0,244)	64,57 (0,245)	79,44 (0,229)	74,42 (0,268)
La/Ce	0,678 (0,243)	0,485 (0,131)	0,688 (0,262)	0,582 (0,253)	0,697 (0,290)	0,558 (0,248)	0,451 (0,351)	0,539 (0,199)	0,612 (0,195)
Ba/Th	252,82 (0,186)	303,39 (0,148)	273,58 (0,156)	481,83 (0,207)	488,68 (0,178)	284,53 (0,269)	233,31 (0,218)	140,58 (0,126)	170,01 (0,263)
Ba/La	53,85 (0,187)	69,20 (0,134)	58,79 (0,150)	85,55 (0,186)	101,28 (0,232)	46,86 (0,249)	46,93 (0,262)	23,06 (0,168)	42,13 (0,410)

and zones of outright devastation. This areal disturbance was likely supplemented by seismic episodes (earthquakes), for which the area is well known. In the Mombacho area a different kind of volcano-related disaster affected a significant portion of the Lake Nicaragua ecosystem for quite some time. In her survey of the Granada region, Salgado (1996a) noted overall little evidence for early ceramic types in the Granada area, with only five sites contributing sherds from the Tempisque (500 BC–AD 300) and earlier Late Orosí (800–500 BC) periods, including early varieties of Bocana Incised (see Sánchez, 2015). Importantly, these five early sites were all located at higher elevations along the flanks of the Mombacho volcano and the Apoyo Lagoon, making the 'archaeologically obvious aversion' to lakeshore occupation prior to AD 800 appear to have been a cultural choice.

Advances in volcanological studies, however, have demonstrated that human choice likely had very little to do with this lack of early occupation along the lakeshore. Instead, research (Shea, van Wyk de Vries, and Pilato, 2008; Stansell, 2013) indicates that prior to 1,770±30 BP (median 2-sigma date of AD 270) the entire northeast section of Mombacho collapsed into Lake Nicaragua forming the Asese Peninsula and "Las Isletas" archipelago from its falling debris (Figure 12). Whether Granada Complex groups were manufacturing in the area prior to the Las Isletas flank collapse is unknown, with potential evidence either buried beneath lacustrine sedimentary deposits and/or volcanic flank debris on land, or swept into Lake Nicaragua. In the Mombacho zone, however, evidence for human occupation and ceramic manufacture in the Late Tempisque is present at the site of Ayala (Group F). By far the largest center or cluster of communities in the Granada-Mombacho zone during the Late Tempisque, Ayala is of interest due to its geographical location. Figure 13 shows the fortunate placement of this important regional center at the base of the Mombacho volcano where it sat physically unmolested to the west of the Las Isletas shearing boundary.

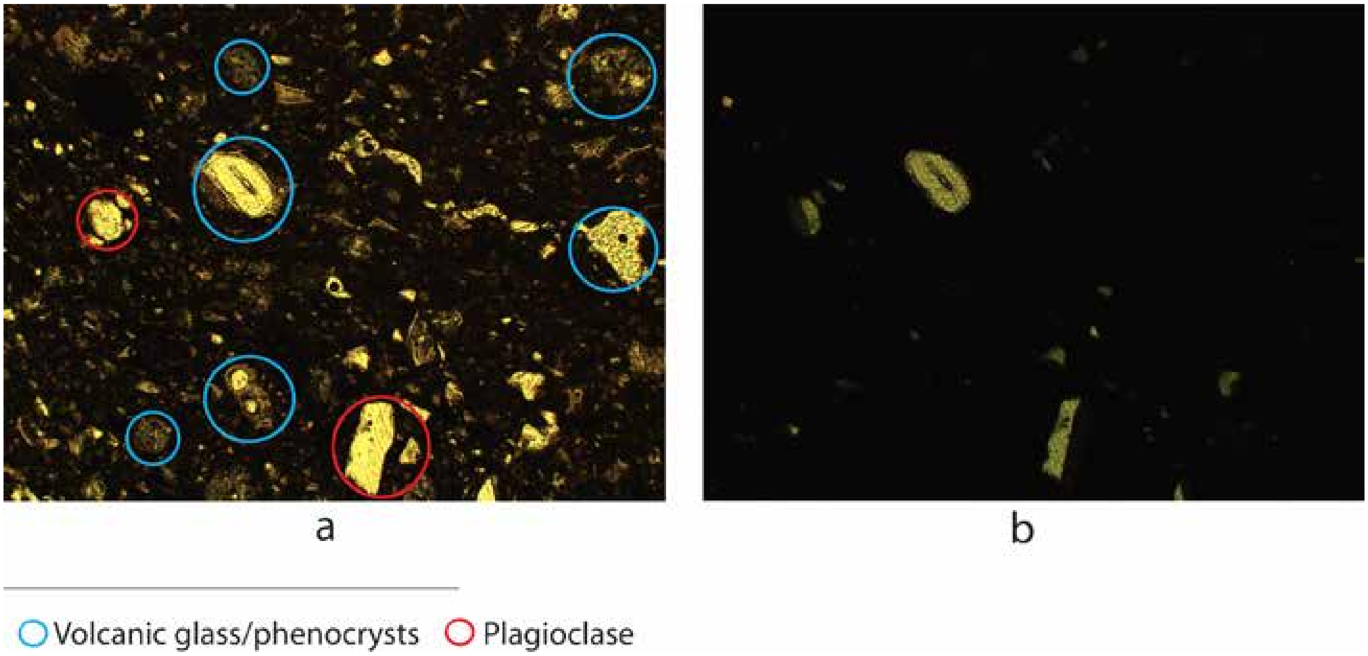

Figure 7: Mombacho Complex Group F1: Volcanic Glass-rich at 50× magnification. F.o.V. = 4 mm. (a) Momta Polychrome in PPL (CE36/NPC028). (b) Previous in XPL. Micrographs by C. Dennett.

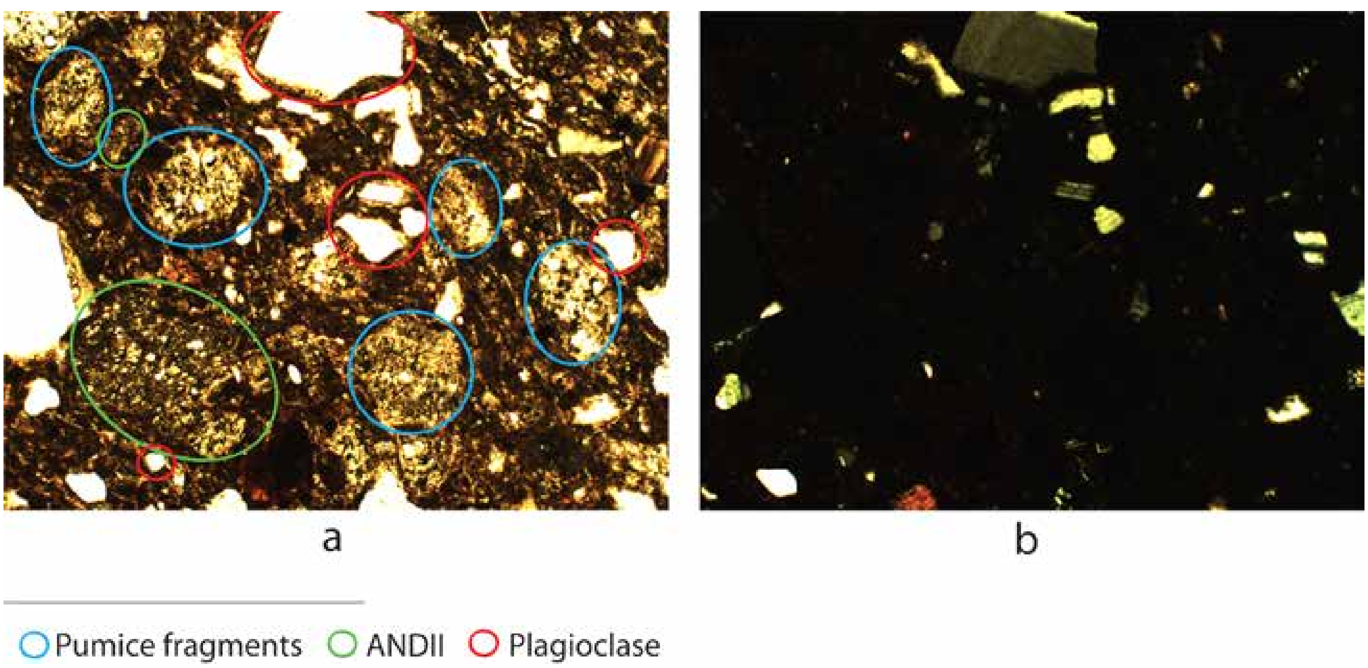

Figure 8: Granada Complex Group D: Pumice-tempered at 50× magnification. F.o.V. = 4 mm. (a) Chávez White-on-Red in PPL (CE40/NPC030). (b) Previous in XPL. Micrographs by C. Dennett.

Table 2: Chronological overview of the ceramic types associated with petrofabric complexes, groupings, and known sites (adapted from Dennett [2016]). Entries in italics designate nonlocal styles and/or foreign ceramic types.

Complex	Petrofabric Group	Late Tempisque (AD 1–300)	Bagaces (AD 300–800)	Sapoá (AD 800–1250)
Granada Complex	**Group C** Tepetate		*Delirio Red-on-White*	Papagayo Polychrome Pataky Polychrome Vallejo Polychrome *Las Vegas Polychrome*
	Group D Jalteva		Tola Trichrome Chávez White-on-Red León Punctate *Delirio Red-on-White*	Castillo Engraved Sacasa Striated Papagayo Polychrome *Las Vegas Polychrome*
	Group E Jalteva		Galo Polychrome *Delirio Red-on-White*	Papagayo Polychrome Pataky Polychrome Sacasa Striated Vallejo Polychrome Madeira Polychrome
Mombacho Complex	**Group F** Ayala	***Usulután-related*** Rosales Zoned Engraved	Momta Polychrome Belo Polychrome Rosalita Polychrome Galo Polychrome *Delirio Red-on-White* *Tenampua Polychrome*	Papagayo Polychrome Pataky Polychrome Sacasa Striated Vallejo Polychrome
	Group H unknown			Papagayo Polychrome Pataky Polychrome Vallejo Polychrome
Rivas-Ometepe Complex	**Group M** unknown	Bocana Incised Rosales Zoned Engraved Schettel Incised Charco Black-on-Red	Charco Black-on-Red	Madeira Polychrome Granada Polychrome
	Group N unknown	Bocana Incised Rosales Zoned Engraved		Madeira Polychrome Bramadero Polychrome Luna Polychrome
	Group O unknown	Rosales Zoned Engraved		Madeira Polychrome Bramadero Polychrome Luna Polychrome Banda Polychrome
	Group P unknown			Madeira Polychrome Granada Polychrome Bramadero Polychrome Luna Polychrome Banda Polychrome

Table 3: Basic mineralogy and lithic composition associated with complexes and petrofabric groupings (adapted from Dennett [2016]), presented in descending order of abundance for each. The mineralogical category 'opaques' refers to magnetite and hematite inclusions, generally and/or undifferentiated due to volcanic rework or replacement/alteration.

Complex	Petrofabric Group	Mineralogical and Lithic Composition		
		Dominant	Frequent/Common	Few/Present
Granada	Group C – *Andesite-rich*	ANDII	plagioclase feldspar, opaques, ANDI, pumice fragments, Fe-stained glass, argillaceous rock	clinopyroxene, orthopyroxene, quartz, chert, ANDIII, welded flow tuff
	Group D – *Pumice Tempered*	pumice fragments	ANDII, plagioclase feldspar, opaques	clinopyroxene, biotite, ANDI, orthoclase feldspar, olivine, augite, ANDIII, Fe-stained glass, chert, argillaceous rock, welded flow tuff
	Group E – *Plagioclase Tempered A*	plagioclase feldspar	pumice fragments, opaques, volcanic glass, ANDI, ANDII	Fe-stained glass, orthopyroxene, clinopyroxene, chert
Mombacho	Group F1 *Volcanic Glass-rich matrix*	volcanic glass (weathered ash and pumice)	plagioclase feldspar, pumice fragments, opaques, argillaceous rock	Fe-stained glass, olivine, pyroxene, biotite, ANDI, ANDII
	Group F2 *Plagioclase Tempering*	plagioclase feldspar	pumice fragments, volcanic glass, opaques, ANDI, ANDII, Fe-stained glass, argillaceous rock	pyroxene, quartz, olivine, biotite, chert
	Group H *Plagioclase Tempered B*	plagioclase feldspar	magnetite, hematite, ANDI, pumice fragments, argillaceous rock	pyroxene, ANDII, chert
Rivas-Ometepe	Group M *Pyroxene-Tempered*	clinopyroxene, magnetite	hematite, plagioclase feldspar, ANDII, ANDIII, Fe-stained glass	quartz, AND I, argillaceous rock
	Group N *Andesite-Pyroxene Tempered A*	ANDII, ANDIII, orthopyroxene, magnetite	plagioclase feldspar, clinopyroxene, hematite, Fe-stained glass	biotite, ANDI, argillaceous rock
	Group O *Pyroxene-Andesite Tempered*	pyroxene, ANDIII	plagioclase feldspar, magnetite, Fe-stained minerals	hematite, devitrified Fe-stained glass, argillaceous rock, quartz, ANDI, ANDII
	Group P *Andesite-Pyroxene Tempered B*	ANDIII, pyroxene, opaques	plagioclase feldspar, ANDII, Fe-stained minerals and glass	quartz, olivine, hematite clots, biotite, ANDI

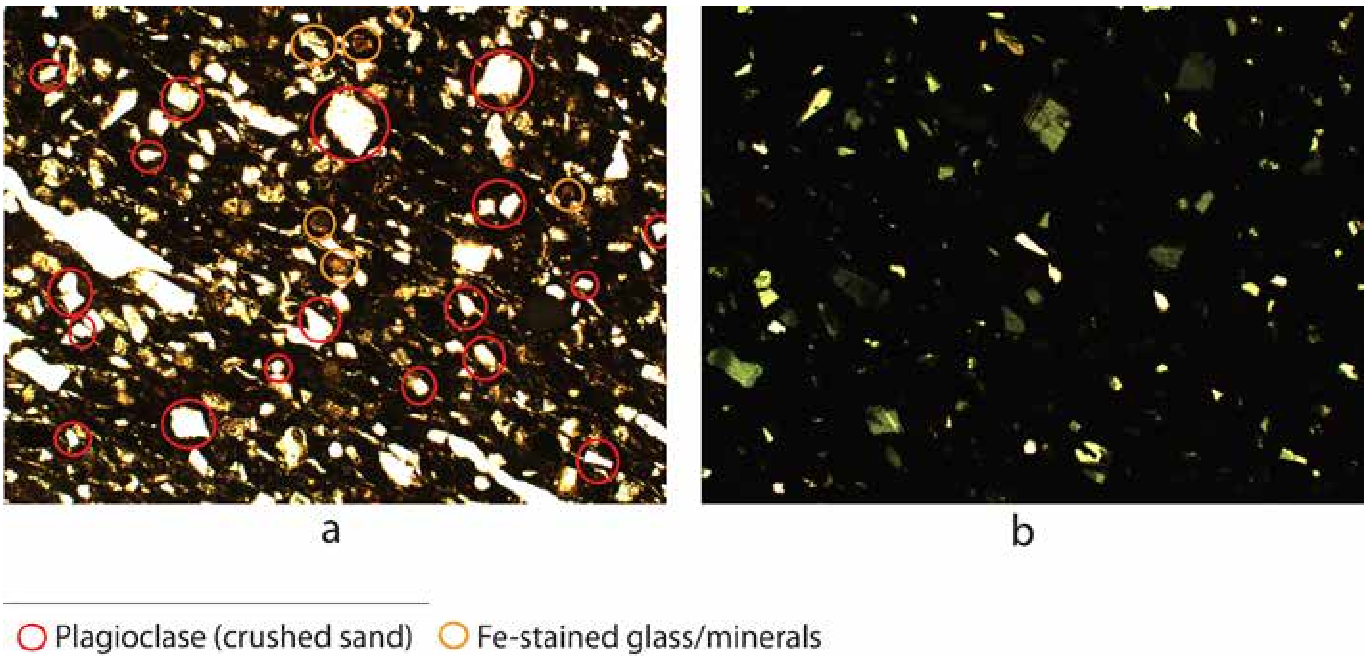

Figure 9: Mombacho Complex Group F2: Plagioclase Tempering at 50× magnification. F.o.V. = 4 mm. (a) Papagayo Polychrome: Cervantes variety in PPL (CT43/NPC061). (b) Previous in XPL. Micrographs by C. Dennett.

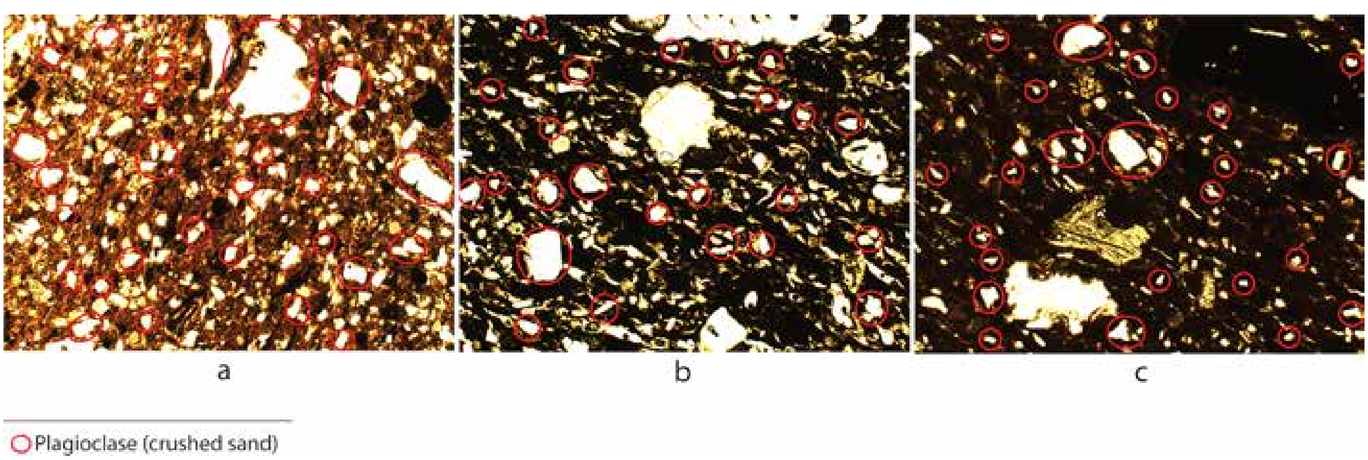

Figure 10: (a) Granada Group E: Pataky Polychrome (CE1/NPC043). (b) Granada Group C: Papagayo Polychrome (CS32/NPC077). (c) Mombacho Group H: Papagayo Polychrome (TS5048/MSR516). All images in PPL at 50× magnification. F.o.V. = 4 mm. Micrographs by C. Dennett.

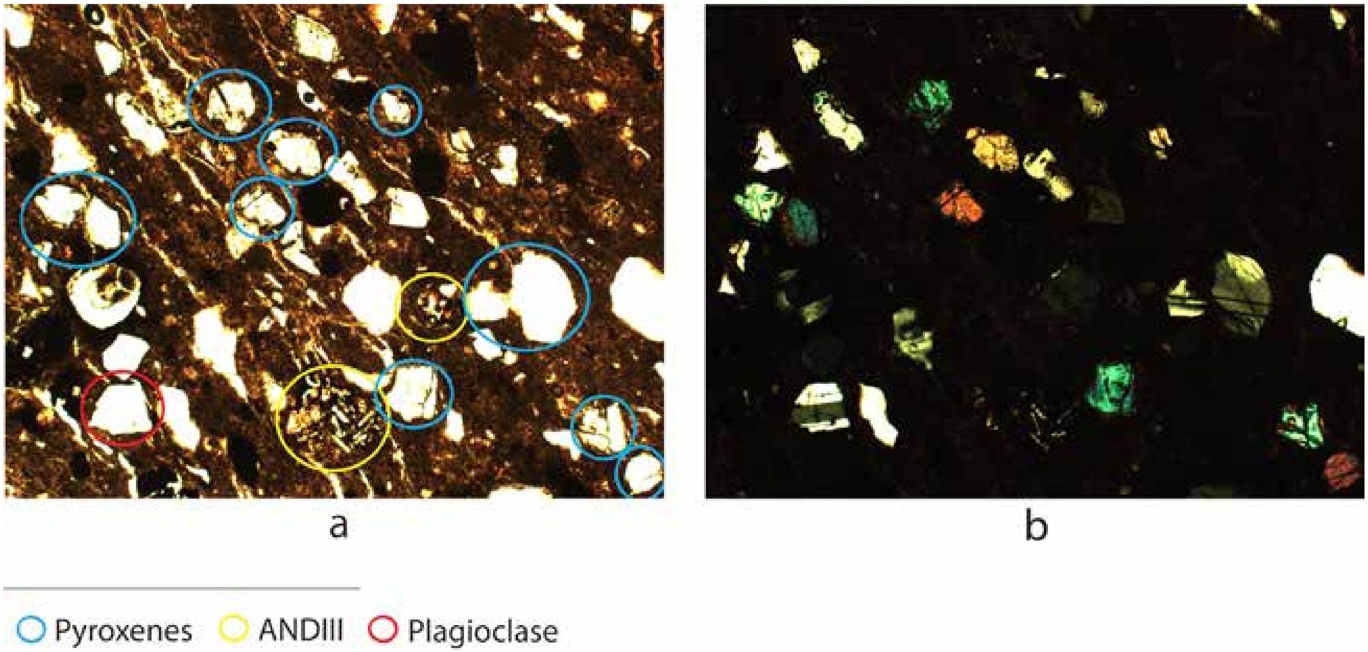

Figure 11: Rivas-Ometepe Complex Group P: Andesite-Pyroxene-tempered B at 50× magnification. (a) Luna Polychrome: Luna variety in PPL (TS5006/MSR557). (b) Previous in XPL. F.o.V. = 4 mm. Micrographs by C. Dennett.

Ayala's ceramic producers constituted a unique community of practice in the Late Tempisque, utilizing shared clay sources, paste preparation and vessel manufacturing techniques, as well as shared mental templates for finished products (Dennett, 2016). However, the true breadth of their manufactured products is difficult to estimate for this early timeframe as the present results contain a very limited range of evidence. Among this evidence, however, are Rosales Zoned Engraved samples from La Arenera, Managua (Figure 1; McCafferty and Salgado, 2000), that were manufactured at Ayala.

That relationships between pottery-producing groups in disparate realms were deemed fruitful and/or meaningful is borne out in such endeavours as local manufacture and long-distance import of Usulután-related (negative resist) wares, for example (Salgado, 1996a). This type of participation directly ties Pacific Nicaraguan manufacturing practices into intensive long-distance networks operating between west-central Honduras and western El Salvador after AD 1. It is now well established that Usulután-related wares occurred across two distinct yet interacting 'spheres' of manufacture along the traditional Mesoamerican southeast periphery. El Salvador has long been considered the original production sphere for Usulután negative resist design techniques and styles in southern Central America (see Demarest and Sharer, 1982). Once fully developed, the "Uapala Sphere" of Usulután-style manufacture emerged alongside, with stylistically similar versions manufactured in west-central Honduras (Cagnato, 2008; Goralski, 2008; Robinson, 1987).

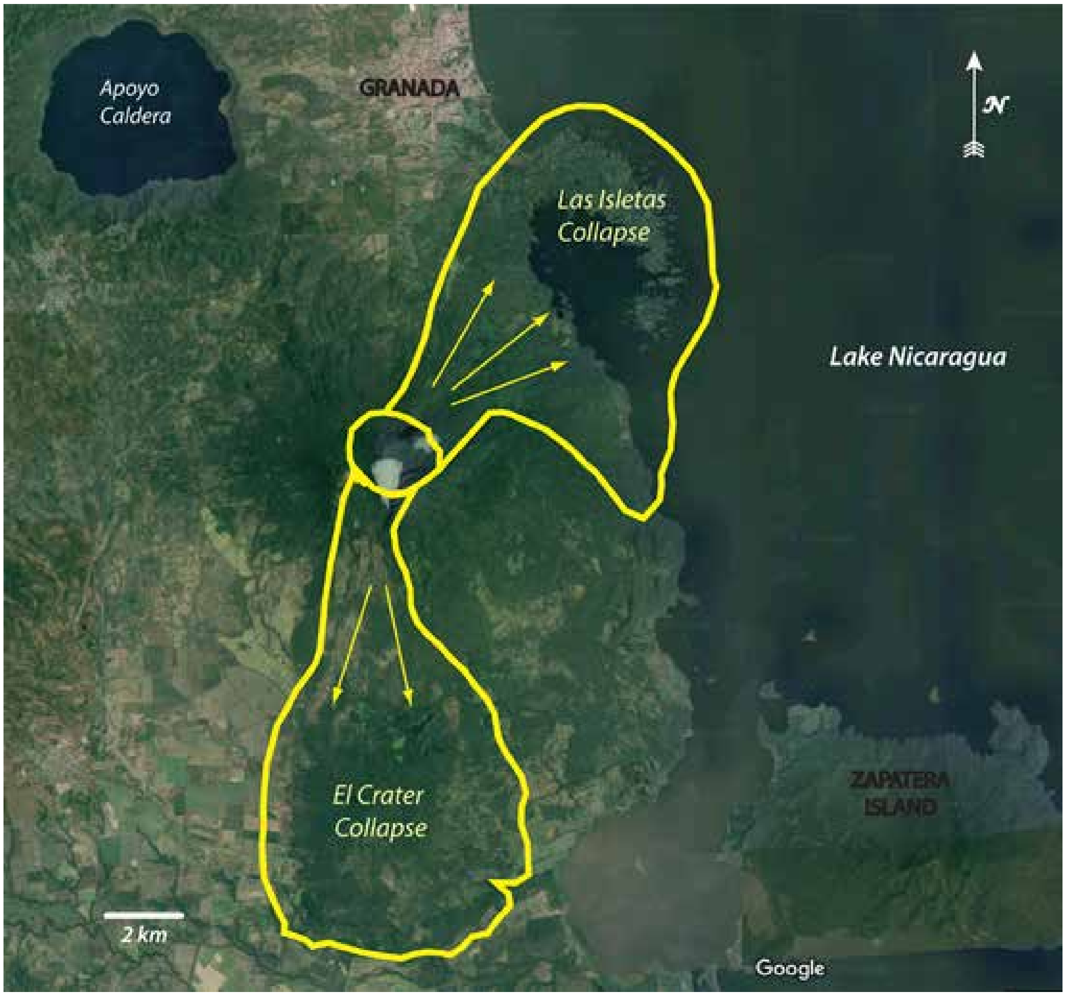

Figure 12: Approximated debris avalanche fields (in yellow) for the Las Isletas and El Crater flank collapse events at Mombacho volcano (overlay details adapted from Shea et al. [2008]).

We have argued elsewhere (see Dennett, Platz, and McCafferty, 2011; Platz and Dennett, 2011) that imported Usulután-style wares from west-central Honduras alongside locally manufactured Usulután-like versions in Pacific Nicaragua constitute direct evidence for participation in the Uapala network as a manufacturer, distributor, and consumer. As noted above, Usulután-like wares manufactured at Ayala have been recovered as far north as Managua, and were certainly consumed locally along with trace amounts of Usulután-style wares from the Comayagua Valley (Lange, Sears, Bishop, and Salgado, 2003; Salgado, 1996a). Only after AD 500, however, would intensive and direct involvement with Honduras-derived ceramics (e.g., Ulúa, Tenampua, and Las Vegas Polychromes) become increasingly visible at Ayala (Lange et al., 2003). Thus, involvement in the shared practice of negative-resist Usulután-related manufacture serves to formally mark the existence of a 'Honduran connection' at Ayala that would persist for more than 1,000 years.

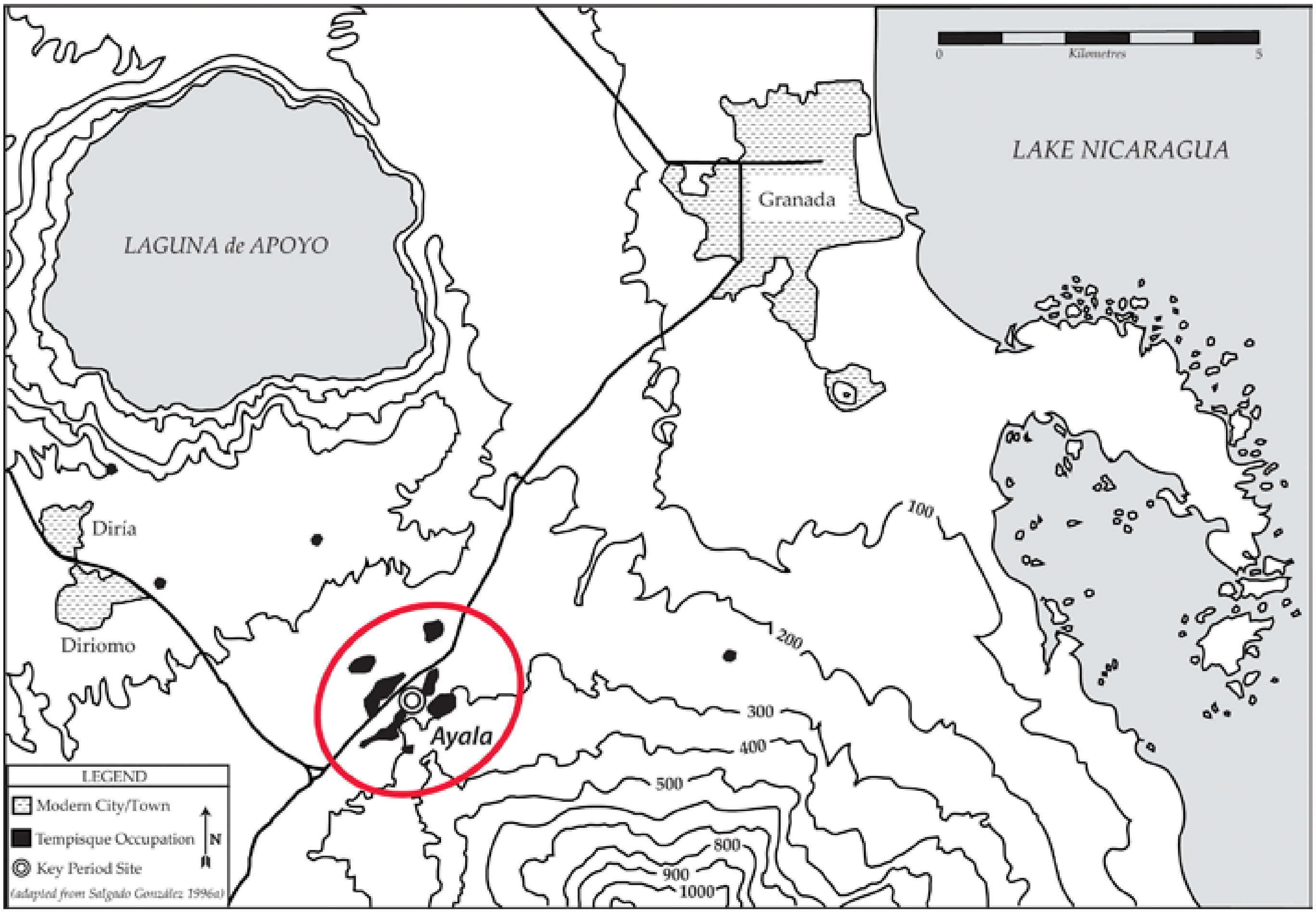

Figure 13: Tempisque period occupation in the Granada-Mombacho zone (adapted from Salgado [1996a]).

Bagaces period (AD 300–800)

Due to the complete remodeling of the local landscape following the Las Isletas flank collapse just prior to AD 300, there is no evidence for human occupation in the Granada-Mombacho region at elevations below 200 m asl prior to and in the early centuries of the Bagaces period (AD 300-500). As demonstrated in Figure 12, a subsequent collapse (called El Crater) occurred on Mombacho's southern flank prior to 1,560±80 BP (median 2-sigma date of AD 490), an event that may be partly responsible for the area's delayed emergence in the regional ceramic economy until roughly AD 500. The entire landscape reconfiguration surrounding Mombacho was complete sometime before 1,325±50 BP (median 2-sigma date of AD 700) (Shea et al., 2008; Stansell, 2013).

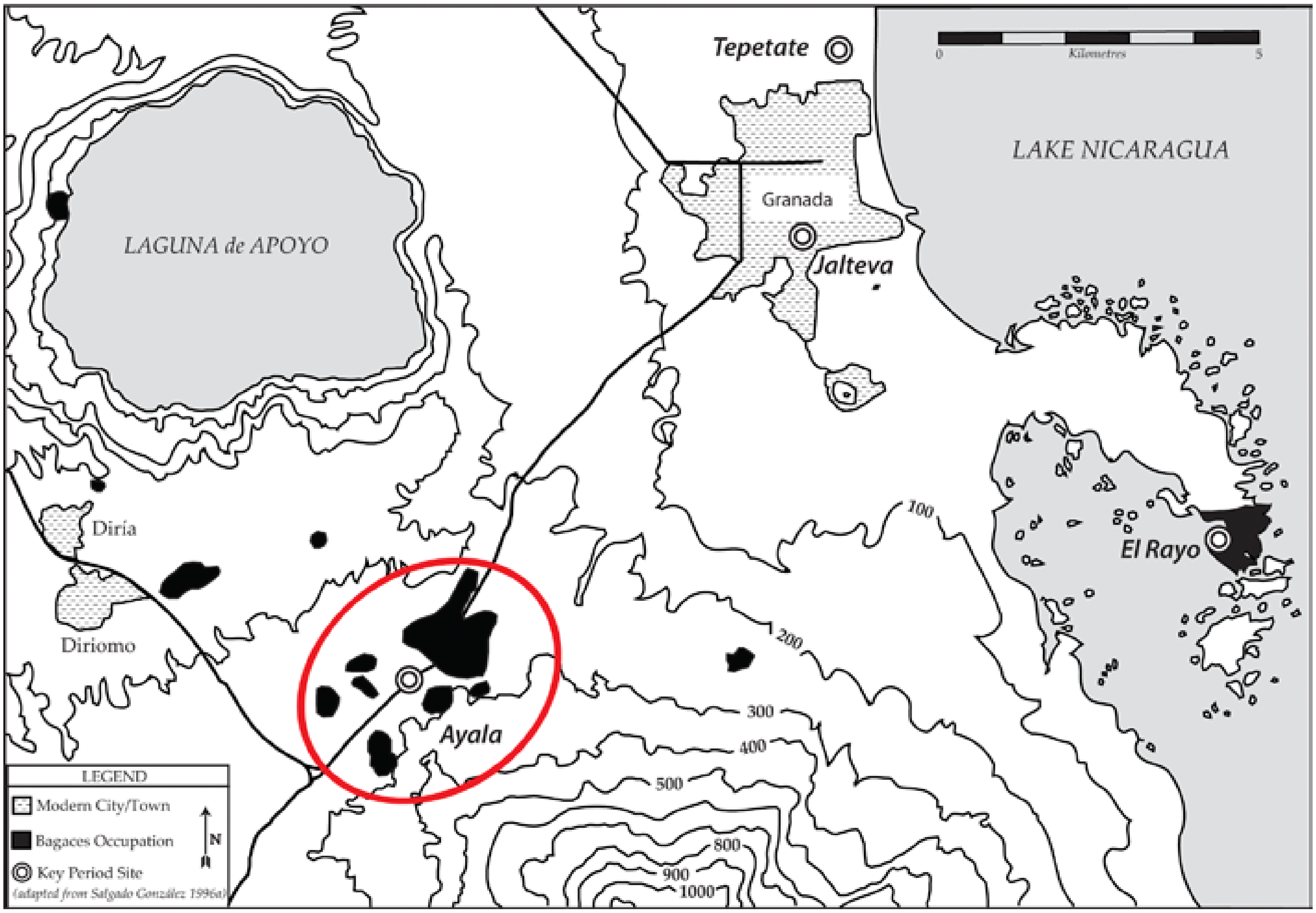

Figure 14: Bagaces period occupation in the Granada-Mombacho zone (adapted from Salgado [1996a]).

Despite all this environmental upheaval Ayala grew to a relatively massive size by the close of the late Bagaces period (AD 500–800). Figure 14, shows Bagaces period settlements identified by Salgado in her regional survey. Because the site was estimated through surface survey it is currently impossible to know whether it represents a single large community or an agglomeration/cluster of smaller sites in a highly localized area (Salgado, 1996a). Of note, the total number of sites/centers in the Granada-Mombacho zone does not increase significantly from the previous period (from five to eight over roughly 300 years). Instead, we see growth of existing centers, which involved normal population growth coupled, perhaps, with refugee intake at 'safe locations' such as Ayala following the natural disasters taking place at the Tempisque-to-Bagaces transition. Salgado's (1996a) survey found no evidence for (re)occupation along the shore of the lake in the late Bagaces period. However, recent investigations at El Rayo indicate that while people may have been reluctant to occupy the damaged shore, they had certainly begun to utilize and/or occupy the newly created Asese peninsula prior to AD 600 (1430±40 BP) (Dennett, 2016).

Figure 15: Bagaces period examples of (a) Belo Polychrome (cat. no. PK-7-1866) and (b) Momta Polychrome (cat. no. PK-7-1038) styles from Mombacho. Photos by Erin L. Sears; courtesy of Mi Museo, Granada, Nicaragua.

While there are no strong visible developments in the local ceramic economy until roughly AD 400–500, new and diagnostic products from the Granada and Mombacho ceramic complexes rapidly increase in both volume of manufacture and general popularity in the local archaeological record once they begin. Whatever the mechanism, these ceramic developments mark a turning point in recovery following what must have seemed an unending localized series of violent abuses from nature, and they suggest very different trajectories and perhaps end goals in ceramic production endeavours. For example, pumice-tempered Group D Granada Redwares (e.g., Tola Trichrome, Chávez White-on-Red) manufactured at Jalteva in the Granada City area were distributed along networks that reached not only southward into Costa Rica, but also northward to Managua and beyond. Group F early polychromes manufactured at Ayala, on the other hand, appear to have been destined for purposes other than commercially oriented exchange at the local and/or regional scale.

Bagaces period ceramics manufactured at Ayala include a wide variety of new polychrome types including local versions of Galo: Lagarto, as well as the unique and poorly understood Belo, Momta, and Rosalita Polychromes (Salgado, 1996b; also Lange et al., 2003). Ayala was also manufacturing what may represent a local version of Granada Redware called Ayala Plain (Salgado, 1996a, 1996b). Each of the polychromes is complex in derivation and reminiscent in many respects of contemporaneous popular foreign styles. For example, Belo and Rosalita Polychromes appear to develop from, or represent a local version of, a combination of Ulúa and Galo Polychrome styles at Ayala (see Salgado, 1996b). Where Belo exhibits principally black painted decoration (Figure 15a), Rosalita combines stark red and black, yet both are frequently highlighted by crocodilian motifs that clearly recall the Lagarto variety of Galo (Salgado, 1996b) and other more southerly types such as Carrillo Polychrome, which has standardized and painted horizontal bands at the interior rim like those seen in Momta (Figure 15b) and on later Papagayo varieties. To date, Ayala types such as Momta, Belo, Rosalita, and the Lagarto variety of Galo Polychrome have only been recovered at the site itself and within the mortuary complex at El Rayo. At El Rayo, the working hypothesis

Figure 16: Map detail indicating the location of Tenampua and the Güinope obsidian source of west-central Honduras in relation to the study areas in Pacific Nicaragua (cropped basemap courtesy of NASA/JPL/NIMA, http://photojournal.jpl.nasa.gov/catalog/PIA03364, public domain, Wikimedia Commons).

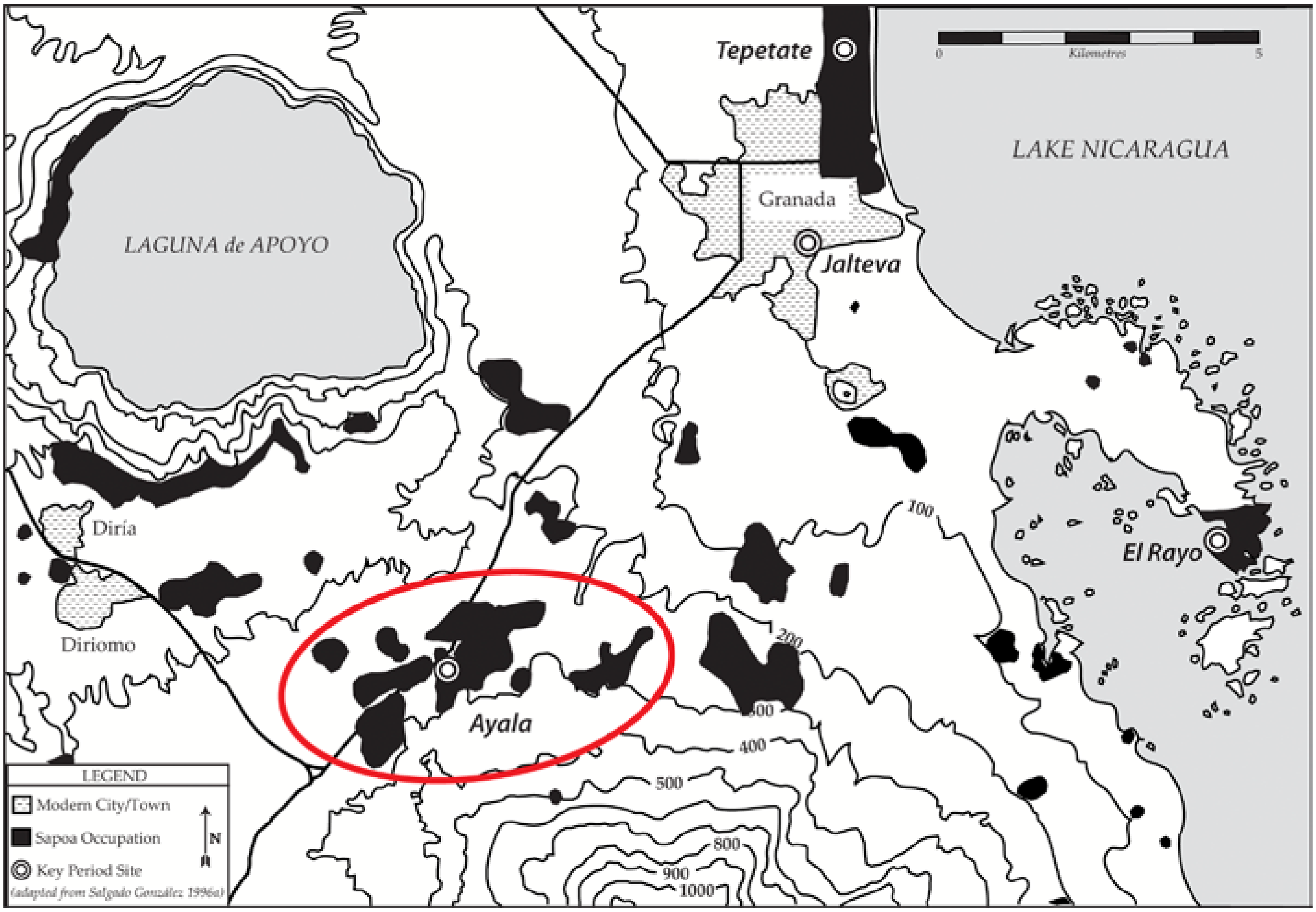

Figure 17: Sapoá period occupation in the Granada-Mombacho zone (adapted from Salgado [1996a]).

is that Ayala, and perhaps Jalteva, contributed their dead and ceramic products into the rocky landscape based on ceramic type frequencies from the site (see Dennett, 2016).

At the regional level, it appears quite plausible that Ayala replaced Managua as the main interregional node of connectivity in Pacific Nicaragua following the environmental 'problems' Managua experienced in the Late Tempisque. Where Ayala seemed to have played a somewhat peripheral role in the Usulután-related network of the Late Tempisque, it gained increasingly intimate contact with Honduran centers over the course of the Late Bagaces period ca. AD 500–800 (Dennett, 2016; Lange et al., 2003; Salgado, 1996b), and likely served as a principal point of entry for local innovation associated with foreign manufacturing techniques, styles, and decorative designs from other regions. We are not suggesting that this influence was imposed from the outside but, rather, engaged with actively from within to establish and maintain distant network connections.

Silvia Salgado (e.g., 1996a, 1996b; Salgado and Zambrana, 1994; Salgado, Bolaños, Guerrero, and Román, 2006; Salgado, Niemel, Guerrero, and Román, 2007) and Rosemary Joyce (e.g., 1993, 2016, 2017, n.d.), have each contributed regionally unique insights on the pre-Columbian connections between Honduras and Greater Nicoya over the years, with the primary focus of analysis being the development of Galo Polychrome varieties, which in many ways represent a Greater Nicoyan variant of Honduran Ulúa Polychromes (Joyce, 2017, n.d.). Galo Polychrome emerged in Greater Nicoya after AD 500 (Salgado, 1996b) and appears to have developed into a coveted mortuary-related item. An extremely well-made and well-finished polychrome, Galo brought with it several new advances directly related to Honduran manufacturing technologies and decorative styles. Bishop and Lange (2013) note that Galo seems to first appear in the Bay of Culebra area and attribute its manufacture to a new node in the ceramic economy they designate as the 'Guanacaste Polychrome School I.' Joyce (1993, 2017) has suggested that the nexus of this relationship exists between 'Nebla subclass Picadilly Ulúa Polychrome' manufactured at Tenampua in the Comayagua Valley and 'Galo Polychrome: Jaguar variety' from Nicoya, with the latter reproducing all the elements of the former.

Of interest, however, is that while scant in Costa Rica, Galo Polychrome: Lagarto variety has been principally recovered in Pacific Nicaragua (Abel Vidor et al., 1987; Salgado, 1996b). As determined by INAA, Ayala is manufacturing at least some of the Lagarto variety of Galo Polychrome, suggesting a complex though poorly understood relationship involving central Honduras, the Granada zone, and the Bay of Culebra. Lorelei Platz (2014, 2015) has recently demonstrated that Late Tempisque Usulután-like pottery likely produced in Managua was recovered at the Loma Corral 3 site on the Bay of Culebra, further indicating that a connection between Nicoya and Ayala is plausible. Authentic Ulúa Polychromes have been recovered archaeologically in sufficient numbers (Lange et al., 2003; Salgado, 1996b) to argue for at least intermittent contact along a network system. In this respect, Galo Polychrome represents a second definable 'wave' of connectivity between Greater Nicoya and west-central Honduras, following directly on the decline of Usulután-related industry. This suggests that the 'new Galo connection' may not be new at all but, rather, an extension of the earlier Uapala sociopolitical connections and physical exchange routes.

Sometime between AD 650–800 things begin to change, and not just at Ayala, but throughout Greater Nicoya (and in Honduras). The manufacture of Bagaces period polychromes such as Momta and Belo wanes significantly, as does the production and distribution of Jalteva's (Group D) traditional repertoire of pumice-tempered Granada Redwares. This has historically been interpreted as the decline/death of indigenous ceramic producing industries due to the in-migration of Chorotega-speaking foreigners from Mexico. We argue here, however, that what was occurring in this century or so was NOT a replacement by foreign pottery producers but, rather, a complete internal overhaul of production organization that was designed and executed locally. Although the mechanisms are not currently clear, it is apparent that two former independents and/or competitors in the Granada-Mombacho zone began a process of amalgamation, or development of a cooperative socioeconomic alliance, toward the close of the Bagaces period.

After AD 700, the major international ceramic types circulating and being emulated across broader interregional exchange networks included various subclasses of Ulúa Polychrome (representing the products of multiple valleys/centers in central Honduras), Cancique and Tenampua Polychrome (from the Comayagua Valley), Sulaco Polychrome (from the Sulaco Valley), Salua Polychrome and Delirío White-on-Red (from eastern El Salvador), and incipient Vallejo Polychrome (somewhere north of Granada) (see also Dennett, 2016; Joyce, 1993; Salgado, 1996b). Ceramic composition indicates that one of the earliest white-slipped foreign styles manufactured in Pacific Nicaragua, the Delirío Red-on-White type, originated in the Quelepa sphere of eastern El Salvador (Joyce, 1986). Examples of both foreign and locally manufactured examples of Delirío have been recovered at Ayala, Jalteva, and Tepetate in the Granada area, the La Huerta site in Masaya, and at Los Placeres in Managua (Salgado, 1996a; Salgado et al., 2006).

Chemical analysis (INAA) has similarly demonstrated that Tenampua Polychrome from the Comayagua Valley of west-central Honduras was brought into Ayala (with AD 750–850 as the production window; see Hendon, Joyce, and Lopiparo, 2014), and that local producers made at least a few imitations of their own, indicating a hands-on familiarity with the product. And while this connection with Tenampua Polychrome demonstrates familiarity and long-standing continuity in the relationship between Ayala and the Comayagua Valley, it also begs the question of why Ayala may have desired to maintain this specific contact for such a protracted period. The relationship likely involved far more than shared love of ceramic styles. Indeed, the site of Tenampua was the largest in the Comayagua Valley by the Late Bagaces and was situated at an intermountain pass leading to the Choluteca Valley (Hendon et al., 2014; Salgado, 1996a)—the corridor to El Salvador, Nicaragua and Costa Rica to the south (Figure 16). Importantly, this pass was a strategic chokepoint which may have allowed Tenampua to control the distribution of raw obsidian from the Güinope source (Hendon et al., 2014). Obsidian was an important resource, and Güinope represents the source of roughly 90% of all obsidian recovered in Pacific Nicaragua to date (Braswell, Salgado, Fletcher, and Glascock, 2002), providing at least one reasonable line of argument beyond international status-seeking or ritual production to explain the motivation in maintaining this long-distance connection.

Sapoá period (AD 800–1250)

Environmentally, volcanism remained in a state of relative quiescence in the region under study, with the exception of one significant event (Nejapa Tephra, VEI 3) occurring around AD 800–1000 in the Managua area (Rausch and Schmincke, 2010). Figure 17 shows the Sapoá period settlements identified by Salgado (1996a) in her regional survey. The overall number of occupied sites and their relative size increased enormously after AD 800, although it is possible that the Sapoá period occupation is overrepresented in surface survey due to its stratigraphic position and the sheer volume of materials produced. Nonetheless, it is apparent that local populations had not only recovered, but had grown significantly through the Sapoá period.

With the onset of Papagayo and Pataky Polychrome production bringing the Bagaces period to a close, formerly distinct communities were joined through direct participation in the mass production of ceramics involving shared knowledge and practice in design, decoration, and paste recipe. As discussed above in detail, the alliance between potters in the Granada (Jalteva, Group E) and Mombacho (Ayala, Group F2) zones—regardless of how it was achieved—developed into a constellation of shared ceramic manufacturing practices, which by AD 1300, following five centuries of continuous production, Papagayo is clearly divisible into a wide range of highly standardized varieties.

Not long following the initial amalgamation ca. AD 700-800, additional ceramic-producing centers (Groups C, E, and H) emerged relatively rapidly and were focused primarily on the manufacture of white-slipped polychrome wares. As detailed above, Papagayo and Pataky Polychromes have a very distinct and standardized petrofabric style that involves a significant amount of consistently prepared temper. This new focus and organization of activities embodies centralized production in a somewhat pure form, with all the diagnostic criteria being displayed in manufacture. Perhaps the most significant of these is the use of ceramic molds, typically for figurines and vessel supports, as well as some vessel lug styles. Ayala's unique connection to more northerly networks suggests that it was likely also the initial entry point for Honduran mold technologies into Pacific Nicaragua, particularly in the Granada-Mombacho zone where manufacture of the molds utilized in mass production would quickly develop into a localized sub-industry.

Consumed locally in mass quantities, Papagayo Polychrome is the most frequent archaeologically recovered polychrome ware in the Granada-Mombacho zone, representing 11–23% of all Sapoá period (AD 800–1250) ceramics from Ayala (Salgado, 1996a), anywhere from 20–40% from test units at Tepetate (Salgado, 2002), and from 20–63% of decorated serving wares from multiple contexts at El Rayo (see Dennett, 2016). Regionally, it was distributed in quantities to both Managua (e.g., 46% of polychromes collected at the site of San Cristóbal; Steinbrenner, 2010) and the Rivas-Ometepe zone (30–60% of decorated 'serving wares' collected at Santa Isabel "A"; Healy, 1980; Steinbrenner, 2010).

Papagayo produced specifically at Ayala has been recovered at the sites of Tepetate north of Granada City, at Santa Isabel in Rivas, and at several sites in Managua and Chontales, while Pataky Polychrome manufactured at Ayala has been found as far south as La Ceiba in northwest Costa Rica. Interestingly, Ayala also manufactured a local version of Vallejo, which has been recovered from mortuary contexts at El Rayo on the Asese peninsula and Managua at sites such as Acahualinca and Los Placeres (Dennett, 2016).

Within the Granada-Mombacho zone a particularly wide array of well-made nonlocal ceramic styles was manufactured, demonstrating the continuation and amplification of the 'Honduran connection.' Of interest is that centers in the Granada-Mombacho zone were both importing and manufacturing their own versions of Las Vegas Polychrome for local distribution. This appears particularly true for Ayala, whose well-made local versions of Las Vegas Polychrome are represented at El Rayo, and demonstrating Ayala's continued participation in the ceramic economy well into the Sapoá period.

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Discussion

In Pacific Nicaragua, the principal physical exchange patterns and sociopolitical connections that characterize the Bagaces (AD 300–800) and Sapoá (AD 800–1300) periods were already in place by at least the Late Tempisque period (AD 1–300). As demonstrated above, ceramic compositional analyses demonstrate Ayala's unique involvement with various ceramic manufacturing centers operating in Greater Nicoya, west-central Honduras, and eastern El Salvador throughout the entire sequence. Beginning early with participation in Usulután-related manufacture (Uapala sphere, ca. AD 1–300), Ayala potters survived the Mombacho volcano's Las Isletas collapse (ca. AD 300) to (re)connect with Ulúa Polychrome manufacturers based in the Ulúa-Yojoa region of Honduras after AD 500. Ayala's involvement in broad interregional networks diversifies ca. AD 700 with the addition of styles, technologies (particularly the focus on white slip), and iconography from the Comayagua Valley of Honduras and eastern El Salvador, particularly Tenampua Polychrome and Delirío Red-on-White, respectively, which themselves eventually give way to the Papagayo-Las Vegas Polychrome phenomenon.

Early involvement in the Usulután-related sphere of ceramic manufacture does not appear to have been primarily commercial in nature but, rather, more likely represented connections of social significance. Spielmann (2002), for example, has argued that among small-scale societies the intensification of exchange over long distances may have less to do with increasing demand for economically valued goods, and far more to do with increasing demand for socially valued goods—particularly those designed and necessary to perform ritual acts (e.g., ceremonies or obligatory transactions, such as feasting or gifting) associated with the maintenance and reproduction of society. She further suggests that the sustained and pressing need to fill the demand for those objects—which could serve multiple purposes in both formal and domestic or private ritual—can lead to complex forms of specialized craft production. While there remains much research to be conducted, it seems plausible that the spread of Usulután-related network transactions in the Late Tempisque period represents the first specialized (and thus recognizable) ritual mode of production linking Nicaragua with west-central Honduras. Indeed, the physical distance associated with these long-distance transactions may have served to imbue the objects or their associated concepts with increased ideological significance (Spielmann, 2002). The presence of foreign pottery styles in a site's ceramic assemblage, which are most frequently represented by high status vessels, implies that its populace was participating, to some degree, in broader sociopolitical processes.

From roughly AD 500–800, administrators and pottery producers at Ayala developed a series of polychrome types that featured varying degrees of decorative standardization in the earlier years, instead focusing on innovation, experimentation, and expression in a variety of true solid colours (e.g., Galo, Momta, Belo, and Rosalita Polychromes; Salgado, 1996b). Rather than the traditional style of imitation to assert long-distance social ties, prestige, and/or status, it appears Ayala was intent on defining itself among its 'peers,' real or perceived. The adoption of Galo Polychrome: Lagarto variety may well represent the first foray into what would ultimately become a highly intensive social feedback loop culminating in the co-development of white-slipped polychromes between Granada-Mombacho and the Comayagua Valley after AD 800.

In this sense, Ayala might be viewed as representing a community of ideological (ritual) and socioeconomic practice ca. AD 500, where the production of ceramics was seemingly not 'for profit' but, rather, to maintain and develop social structure and social connections that perhaps facilitated access to objects and knowledge of practical, sociopolitical, and likely spiritual significance. Indeed, this connection may well represent an extension of the ritual mode of production and exchange (Spielmann, 2002) discussed above for Usulután-related ceramics. Sometime around AD 700 a new style of administration in ceramic production with a new focus on prestige generation emerged at Ayala. This shift would perhaps foreshadow the aggressive identity building and/or product/brand marketing that would come to characterize most large regional centers of Pacific Nicaragua after AD 800.

One of the greatest artistic advancements of the Bagaces period was the transition to polychrome painted pottery. Yet, the emergence and developmental phase of polychrome pottery manufacture in Pacific Nicaragua has been very difficult to detect. Traditionally, the impression has been one of pre-established pottery types just 'showing up' in the archaeological record, and particularly anything with a white slip. In fact, this interpretation has stood as one line of support for the AD 800 Chorotega migration hypothesis (McCafferty and Dennett, 2013). We argue instead that the developmental sequence leading up to the emergence of Sapoá period white-slipped polychromes is, indeed, present at the site of Ayala throughout the entire Late Bagaces period (AD 500–800). Rather than the historical view that Sapoá period white-slipped pottery exploded onto the scene seemingly 'out of nowhere' (or out of Mexico), data now suggest that the polychrome tradition evolved locally over a period of roughly 200 years (Dennett, 2016; see also Bishop and Lange, 2013) and can be viewed particularly well in both Momta and Belo types (Salgado, 1996b), which potentially represent prototype or incipient Papagayo and Pataky Polychromes, respectively.

Toward the close of the Sapoá period (ca. AD 1250), the character of the ceramic economy begins to change once again in a discernable way. Unprecedented in the archaeological record of Pacific Nicaragua at that time, the ceramic economy seems to almost stop developing. As active archaeologists, we have slowly witnessed the sometimes-reluctant forfeit of the Ometepe period's role (ca. AD 1250–1522) in the ceramic economy in general. Once understood to be represented by the most "Mexican-looking" types such as Castillo Engraved and Vallejo, Luna, and Bramadero Polychromes (Abel-Vidor et al., 1987), this final period currently holds no identifiable unique serving ware types of its own, although significantly reduced and increasingly localized production and distribution of Late Sapoá types such as Luna Polychrome continues well after AD 1250.

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