Chapter 12

Investigating Obsidian Procurement at Integration Period (ca. AD 700-1500) *Tola* Sites in Highland Northern Ecuador via Portable X-ray Fluorescence (pXRF)

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The study of long-distance exchange has long been a focus of research on Ecuadorian prehistory. One of the more prominent archaeological avenues for research on this front has been obsidian sourcing. While much attention has been paid to locating Ecuadorian obsidian sources and documenting their variability, only a few studies have focused on sourcing archaeological artifacts to understand the processes responsible for the distribution of obsidian in prehistory. The results of some of the first chemical characterization analyses of obsidian from Integration Period (ca. AD 700-1500) earthen mound (*tola*) sites in the País Caranqui region of highland northern Ecuador are presented in this chapter. The analyses of obsidian assemblages from two *tola* sites, Huataviro and Puntiachíl, suggest that there was differential access to low Fe Callejones obsidian during the Integration Period. Results also suggest that independent procurement processes most likely are responsible for the obsidian distribution patterns observed in the archaeological record. This initial research demonstrates that Caranquis primarily exploited Callejones and Mullumica obsidian. These sources most likely were utilized because of their proximity and it appears that there was some connection between the expedient flake technology employed

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by Caranquis and the lower quality obsidian from these sources. From the standpoint of chemical characterization research, the results of this study demonstrate that the Bruker Tracer III-V+ SD portable X-ray fluorescence (pXRF) instrumentation is capable of producing data that are accurate and precise enough to attribute artifacts to known Ecuadorian obsidian source signatures. The ability to bring portable XRF instrumentation to Ecuador will significantly aid in the further examination of some of the initial findings presented in this chapter.

Introduction

The movement of raw materials and resources in prehistoric Ecuador commonly is viewed as an exception to the non-commercial economies that are believed to have dominated much of the prehistoric Andes. In northern Ecuador, there is ethnohistoric evidence for both long-distance exchange conducted by traders known as *mindaláes* and marketplaces or *tianguеces* in cities such as Quito (*1–7*). Ethnohistoric and archaeological evidence also suggest that the following goods likely were involved in some form of long-distance exchange: coca, capsicum pepper, cinnamon, cotton, salt, pottery, gold, shell, greenstone axes, and obsidian (*1*, *2*, *4*, *8–10*).

Unfortunately for archaeologists, many of these resources either are perishable and do not survive in the archaeological record, or have proven difficult to tie to raw material sources. Some studies have attempted to document the movement of ceramic wares (*3*, *11*) but most of the research conducted on exchange goods has focused on the distribution of obsidian (*2*, *12–24*). A majority of this research has been devoted to documenting the existence of various obsidian sources and their respective geochemical signatures (*12–17*, *19–22*) and only a few researchers have attempted to use geochemical sourcing data to address archaeological questions (*2*, *18*, *23*, *24*).

In this chapter, we examine the nature of long-distance exchange during the Integration Period (ca. AD 700-1500) in the País Caranqui region of highland northern Ecuador. As probable habitation and burial areas for elites, large earthen mounds called *tolas* often display evidence of long-distance exchange (*5*, *25–27*). We present the results of portable X-ray fluorescence (pXRF) analyses on 49 obsidian source specimens as well as 87 obsidian artifacts from excavated contexts at the *tola* sites of Huataviro and Puntiachíl.

From a geochemical perspective, these results demonstrate that the Bruker Tracer III-V+ SD pXRF instrumentation is capable of producing data that are accurate and precise enough to differentiate between Ecuadorian obsidian source areas and assign artifacts to known sources. From an archaeological standpoint, the results suggest that Mullumica and Callejones were the primary obsidian sources utilized by late prehistoric groups living in the northern highlands. Data also suggest differential access to a low Fe variant of Callejones obsidian between *tola* sites and a relationship between the Caranqui's expedient flake technology and the utilization of Mullumica and Callejones obsidian. These findings suggest

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that individuals at Huataviro likely had a different mechanism for procuring obsidian than individuals at Puntiachíl. While further analyses from additional *tolas* are planned, these initial results suggest that elites at different *tola* sites procured obsidian via different interaction networks and not through some form of centralized process.

Background

Compared to its Andean counterparts, highland Ecuador has not received much attention in archaeological circles. Much of the recent archaeological research has focused on the Inka's advance into regions of Ecuador and the resulting responses by local populations (*18*, *23*, *28–33*). A notable byproduct of the increasing interest in Inka imperial conquest and consolidation has been a better understanding of the late prehistoric Ecuadorian societies that the Inka encountered. This archaeological research has benefited greatly from ethnohistoric documents that describe local societies (*1*, *34–47*). To orient the reader, the background section is divided into three sub-sections: the Integration Period in the País Caranqui, obsidian research in Ecuador, and information on the two sites examined in this research.

Integration Period in the País Caranqui

The País Caranqui is a small region in the northern highlands of Ecuador bounded by the Mira-Chota River in the north and the Guayllabamba River in the south (*5*, *25*). The eastern and western boundaries are less defined, but Bray (*5*) proposes the continental divide in the east and the Intag River to the west. These proposed boundaries produce a region of roughly 3,600 km^2 (*5*). A map of the País Caranqui with sites discussed can be found in Figure 1.

País Caranqui society is best characterized as a collection of relatively equivalent chiefdoms with status continually negotiated along multiple dimensions (*5*). The region's inhabitants appear to have had a shared ethnic identity based on a common lingua franca, artistic tradition, level of technological expertise, and style of monumental earthwork (*1*, *5*, *27*, *48*, *49*). The monumental earthworks, or *tolas*, that dot the landscape have been the focus of the majority of archaeological research to date (*8*, *26*, *27*, *50–55*). These *tolas* appear to have been the realm of elite individuals and served as occasional gathering places for ceremonial activities (*5*, *43*, *50*, *52*, *55*, *56*).

Tolas can be divided into two varieties: hemispherical and quadrilateral. Examples of these two varieties can be seen in Figure 2. The two varieties are often found within a single cluster (i.e., they are not mutually exclusive), and the quantity of *tolas* in a cluster typically numbers between 10 and 40 (*5*). Hemispherical *tolas* appear as early as AD 500 and were a well-established feature of the region by AD 700 (*5*, *8*, *26*, *48*). These *tolas* range from 3-6 meters in diameter and 1-2 meters in height to 30 meters in diameter and 5 meters in height (*5*). Smaller hemispherical *tolas* appear to have served as burial mounds whereas larger hemispherical *tolas* were used for both habitation and burials (*5*, *25*).

Quadrilateral *tolas* appear to be a later phenomenon marking a shift in the sociopolitical organization of the region tied to increased population size and agricultural productivity (*5*, *25*, *48*, *57*, *58*). The quadrilateral *tolas* were first constructed around AD 1250 and are as large as 90 meters on a single side and up to 20 meters in height (*25*, *48*). These larger *tolas* were the foundations for circular habitation structures and occasionally burials (*5*, *53*). Arguably the most notable features found on *tolas* are canal-like features with conical stones that are believed to have been hearths for the production of *chicha* (fermented maize alcohol) for special feasts and other rituals (*1*, *5*, *8*, *25*, *53*). These features highlight the ability of elites to hold feasts as a likely status indicator (*8*).

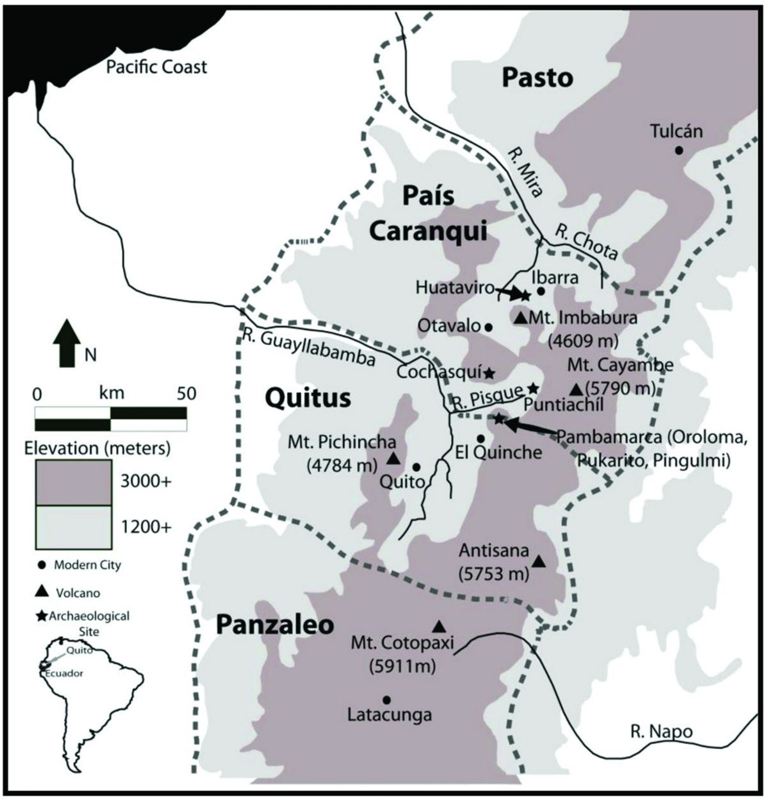

Figure 1. Map of highland northern Ecuador with sites mentioned in chapter. Pambamarca area includes the sites of Oroloma, Pukarito, and Pingulmi mentioned in the discussion.

Evidence from *tola* investigations and ethnohistorical documents suggests that obtaining non-local prestige goods was another major avenue for elites to maintain and demonstrate their status in Caranqui society (*1*). A pair of archaeological contexts exemplify the importance of non-local goods in the late prehistory of this region. Research at sites in the Mira-Chota valley in the northern reaches of the País Caranqui has encountered non-local goods that include obsidian, gold, shell,

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greenstone axes, and non-local pottery (*3*, *4*, *54*, *59–63*). Meanwhile, excavations at one of the sites examined in this paper, Huataviro, have uncovered funerary contexts that included goods such as shell beads, a gold mask, gold bracelets, and gold rings (*27*).

Figure 2. Photo at Cochasqui with examples of the two tola varieties. A hemispherical tola is in the right foreground while a pair of quadrilateral tolas can been seen in the left background (Eric Dyrdahl).

Although archaeological research provides evidence for the movement of non-local goods into the País Caranqui, little insight exists regarding the mechanisms utilized to procure non-local goods. Fortunately, ethnohistoric documents highlight a pair of processes that were utilized by Caranquis. Ethnohistoric documents discuss the importance of *mindaláes*, a group of traders that specialized in the trade of low-weight, high-value prestige goods (*1*). Ethnohistorians have debated whether the mindalá were attached or independent specialists (*1*, *46*), and hopefully future archaeological research can address this issue. Regardless of the exact nature of their relationship with elites, the goods transported by *mindaláes* most likely would have been marketed toward elites. Documents from colonial times also suggest that households maintained their own exchange networks to procure non-local goods (*1*, *5*). There is no evidence that non-local resources were obtained solely from *mindaláes* or more informal exchange networks and the reality is most likely varying combinations of the two.

Considering the ethnohistoric evidence for the importance of non-local goods and the archaeological documentation of caches of these goods, it is surprising that artifact assemblages from *tolas* are relatively limited (*5*, *54*). In most instances, there is little evidence for differentiation among groups. It has been suggested that chiefs, or *caciques*, maintained a residence in their home community as well as at a *tola* cluster (*1*), so minimal evidence for occupation is not necessarily surprising (*5*, *43*). Bray (*5*) suggests that considering the homogeneity and rudimentary nature of the artifact assemblages from occupation contexts, the most likely explanation is that each social unit produced its own crafts and tools. The mortuary contexts found in *tolas* typically have limited assemblages, with few ceramic vessels, including non-local Panzaleo ceramics, and a *mano* or *metate* (*5*). Additionally, the location of the *tolas* themselves normally is limited to the prime maize-growing area of the region and does not appear to suggest any control of special resource zones (*5*, *25*, *55*). Simply put, more research is needed to better understand the discrepancy between the importance placed on long-distance exchange documented in portions of the archaeological and ethnohistorical records and the limited assemblages found in many *tola* excavations.

Obsidian Research in Ecuador

Obsidian is arguably the best non-local resource available to investigate Integration Period procurement strategies. Obsidian tool production is an ideal process to examine in studies on long-distance resource procurement for a pair of reasons. First, the production of sharp cutting edges of obsidian requires the reduction of nodules from raw material sources. The process of obsidian nodule reduction produces both finished tools and waste that can be analyzed to understand the manufacturing techniques employed because of obsidian's predictable conchoidal fracture pattern (*64*). Throughout northern Ecuadorian prehistory, it appears that obsidian was the material of choice for producing expedient flake tools that could be utilized for a variety of tasks (*2*).

The other key aspect of obsidian relevant to studies of procurement strategies is that it is a product of rapidly-cooled lava from volcanic eruptions. This process limits the distribution of obsidian to small numbers of discrete, chemically homogenous flows often located in difficult-to-reach locations at higher elevations (*2*, *12–22*). Twelve obsidian sources have been documented in Ecuador. A map with the location of the 11 obsidian sources located in northern Ecuador can be found in Figure 3. Carboncillo, the 12th obsidian source in Ecuador, is located in the southern highlands in the Loja Province (*20*). Geochemical characterization of archaeological artifacts suggests that only six of these sources were utilized in prehistory (*2*, *18*, *20–24*).

For northern Ecuador, research conducted to date suggests that the most important sources were the Mullumica, Callejones, Yanaurco, and Quiscatola sources along with two La Chimba types whose source areas remain uncertain (*2*, *18*). As depicted in Figure 3, the four documented sources are located in a relatively tight cluster to the south-southeast of the País Caranqui, roughly 35 km east of Quito in the Sierra de Guamaní (*18*, *21*). In contrast, the two La Chimba types, first identified by Asaro et al. (*22*), receive their name from the site with the first documented artifacts with these geochemical signatures (*22*).

Unlike most other regions of the world, chemical characterization studies of Ecuadorian obsidian are somewhat challenging. Two sets of source areas adjacent to one another, Callejones-Mullumica and Yanaurco-Quiscatola, are chemically indistinguishable and often lumped together (*21*). Additionally, obsidian from both the Callejones and Mullumica source areas have highly variable compositions. It appears that at least one low Fe variant for both Callejones and Mullumica can be differentiated from a high Fe Callejones-Mullumica signature (*17*, *18*). While Ogburn et al. (*18*) present the high Fe Callejones-Mullumica cluster as high Fe Mullumica, recent research has suggested that distinguishing between high Fe Mullumica and Callejones often is not possible (*21*). Therefore, in the discussion section we treat Ogburn et al.'s (*18*) high Fe Mullumica assignments as high Fe Callejones-Mullumica.

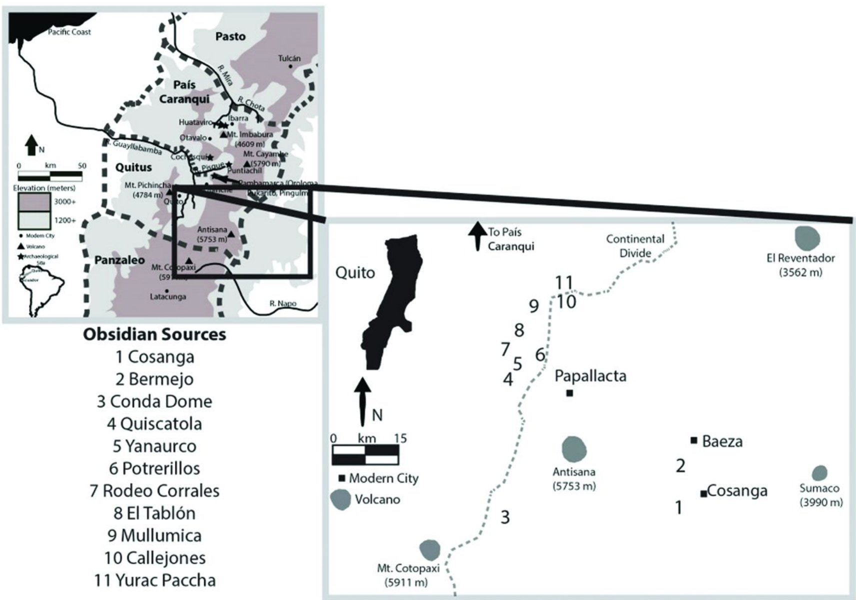

Figure 3. Map of obsidian sources in northern Ecuador.

The recent collection of new geologic samples from these sources documented the potential low Fe variant of Callejones in the eastern reaches of the source area (*17*). This chemical signature matches one of Asaro et al.'s (*22*) La Chimba types (*18*), potentially leaving only one undocumented source area in Ecuador (i.e., the other La Chimba type signature). However, considering the different techniques employed in the relevant studies and the resulting issues of data comparability (see (*65*, *66*)), this conclusion should be treated with caution and highlights the need for further sampling of these complex source areas. Following Ogburn et al. (*18*), we tentatively treat the one La Chimba type signature that appears to have the same chemical signature as a section of the Callejones source area as a "low Fe variant of Callejones." Meanwhile, the remaining La Chimba type signature from a source area of unknown origin is referred to as the "La Chimba type."

Another issue that must be addressed is how representative obsidian procurement is of the procurement processes for the other non-local goods valued in Caranqui society. The available evidence for obsidian utilization in the País Caranqui indicates obsidian was used almost completely for the production of expedient flake tools (*2*, *4*). This makes obsidian a utilitarian, high-weight, low-value good that stands in stark contrast to the other non-local goods of low weight and high value that were brought into the País Caranqui. This fact makes it likely that obsidian was not a resource within the *mindaláes*' purview (*2*), but it potentially could still have been moved via informal exchange networks.

Site Background

A majority of the obsidian artifacts (n=65) sourced in this study came from the site of Huataviro. This site, first examined during a cultural resource management salvage project, contains a single hemispherical *tola* located in the parish of San Antonio de Ibarra outside of the modern city of Ibarra (Figure 1) (*27*). An investigation of the *tola* was undertaken because a tractor plowing the area uncovered human remains and archaeological artifacts.

This large hemispherical *tola* included evidence of both occupation floors and burials (*27*). For the most part, these contexts alternate in the site's stratigraphy with one stacked on top of another. The excavations focused on documenting the 11 burials within the *tola*. Multiple burials contained goods indicative of long-distance exchange: non-local, fineware ceramics, shell beads, gold rings, gold bracelets, and a gold mask (*27*). Radiocarbon dates of organic materials from burial contexts returned dates ranging from cal. AD 680 to 1300 at two sigma confidence intervals (*27*).

Interestingly, obsidian was not found as a grave good in any of these tombs. Instead, it was routinely found in small quantities in the fill placed between the *cangahua* (hard-packed volcanic mud) blocks used to line the tombs (*27*). The nature of this location makes it difficult to definitively demonstrate which primary context these goods were produced in. Therefore, the results of our geochemical characterization research are treated as merely representative of the site's overall obsidian assemblage and no attempt is made to compare assemblages from various tomb contexts. Despite the lack of clear primary contexts, the obsidian assemblage still is most likely the product of elite activities because the available evidence and our current understanding of Caranqui society suggest there was no permanent non-elite activity at this *tola* site. In total, 97 lithic artifacts were found during excavations at Huataviro, and roughly 80% of the lithic assemblage was obsidian (*27*). An examination of the obsidian found that 65 artifacts were suitable for pXRF analysis. An ideal sample for pXRF analysis is at least 5 mm wide, 8 mm long, and 5 mm thick with at minimum one flat, homogenous surface.

The other set of obsidian artifacts (n=22) analyzed came from the multi-*tola* site of Puntiachíl located in the eastern portion of the modern town of Cayambe. Unlike Huataviro, Puntiachíl was occupied at the time of the Inka's arrival in the region (*8*, *26*). The site is believed to be the center of the Cayambe polity during late prehistory. Notably, Larrain (*67*) suggests that the Cayambe *cacique* Nasacoto Puento was the most powerful *cacique* in the region based on his spearheading the joint resistance to Inka subjugation (*5*).

In the mid-1980's, Buys et al. (*68*) surveyed Puntiachíl and identified seven quadrilateral mounds and nine hemispherical mounds of varying sizes. Due to multiple destructive factors, most of these mounds had been destroyed or were in the process of being ruined at the time of their survey (*8*). As part of her dissertation research, Cordero conducted excavations at the main quadrilateral *tola* at Puntiachíl. Her research documented a significant amount of non-local Panzaleo ceramics that likely came from the eastern lowlands (*3*, *8*, *26*). Organic material pulled from excavations at this mound returned radiocarbon dates ranging from cal. AD 670 to well into historic times (*8*, *26*), suggesting that Puntiachíl was occupied throughout the Integration Period.

All of the obsidian artifacts from Puntiachíl that are analyzed in this study came from various levels of a single *tola*, Tola Peña. Minimal excavations were undertaken at this secondary *tola* and a limited sample of obsidian artifacts was recovered. Although obsidian was obtained from six levels within Tola Peña's stratigraphy, most of it came from a single context. The limited obsidian assemblage available, combined with the lack of absolute dates for Tola Peña, led to the decision to consider the sample as representative of its entire occupation and not to draw inferences about change through time in obsidian procurement. Despite its limitations, the available sample is a useful starting point for understanding the variation in procurement practices and documenting the different obsidian sources utilized by the elite segment of Caranqui society.

Methods

The 87 obsidian artifacts and 49 geologic source specimens were analyzed using a Bruker Tracer III-V+ SD XRF spectrometer equipped with a rhodium target X-ray tube and a silicon drift detector. The silicon drift detector has a resolution of ca. 145 eV FWHM for 5.9 keV X-rays (at 200,000 counts per second) in an area of 10 mm^2. All samples were measured at 40 kV, 25 µA, with a 12 mil Al, 1 mil Ti, 6 mil Cu filter placed in the X-ray path for a 200-second live-time count. Ten elements were measured: Mn, Fe, Zn, Ga, Th, Rb, Sr, Y, Zr, and Nb. Peak intensities for the Kα peaks of each element were calculated as ratios to the Compton peak of rhodium, and converted to parts-per-million using a calibration based on a set of 40 obsidian standards with known values provided by Bruker. The one exception was Th, for which the Lα peak was used. All analyses were conducted at the Center for Applied Isotope Studies at the University of Georgia in 2012.

Most source specimens (n=40) were loaned to the primary author by the University of Missouri Archaeometry Laboratory. The remaining nine source specimens were collected during a visit to the Mullumica source area in 2011. The geographical coordinates for the two contexts where Mullumica specimens were collected by the primary author can be found in Table I. The 87 obsidian artifacts were loaned to the primary author from the reserve of the Instituto Nacional de Patrimonio Cultural in Quito.

Table I. Information for collection locales at Mullumica source area

Context	*Longitude*	*Latitude*	*Number of Samples*
1	-78.22872	-0.23520	2
2	-78.22489	-0.23230	7

Coordinates are in decimal degrees.

A sample of USGS RGM-1 was analyzed daily over the duration of the analyses in order to check the accuracy and precision of the instrument and calibration. The results of these analyses and the recommended values and values documented by other researchers for this standard can be found in Table II. The data from the Bruker Tracer III-V+ SD instrumentation for RGM-1 are comparable to other published values, demonstrating that the data from our analyses are accurate and precise enough to confidently make source attributions for obsidian artifacts of unknown origin in instances where the relevant sources have discrete chemical signatures.

Table II. Summary statistics for replicate analysis of USGS RGM-1 compared to recommended values and other published values

	This Study (n=6)	*USGS Recom.*	*Shackley (2012)*	*Skinner (1996)*	*Hughes (2007)*
Mn	282 ± 5	279 ± 50	302 ± 14	291 ± 47	278 ± 10
Fe	12473 ± 223	13010 ± 210	13116 ± 308	13480 ± 745	13079 ± 140
Zn	32 ± 1	32	n.r.	37 ± 7	n.r.
Th	15 ± 1	15 ± 1.3	16 ± 3	n.r.	n.r.
Rb	153 ± 2	150 ± 8	151 ± 3	152 ± 3	143 ± 4
Sr	111 ± 2	110 ± 10	106 ± 3	107 ± 9	105 ± 3
Y	27 ± 1	25	25 ± 2	24 ± 3	23 ± 3
Zr	221 ± 3	220 ± 20	219 ± 5	217 ± 8	214 ± 4
Nb	10 ± 1	8.9 ± 0.6	9 ± 2	11 ± 1	8 ± 3

All concentration values are in parts per million (ppm) and unreported values are designated (n.r.).

Results

Summary statistics for the geologic source samples analyzed can be found in Table III. These data demonstrate that the best way to differentiate between the various source areas and geochemical signatures is a bivariate plot of two ratios: Sr/Zr and Rb/Zr. The data are presented in this format in Figure 4. This manner of presentation is preferable because it allows for the consideration of three important discriminating elements without having to present a three- dimensional plot on a two-dimensional surface. This bivariate plot demonstrates that with this particular methodology, the Bruker Tracer III-V+ SD instrumentation is able to differentiate among the major sources of Ecuadorian obsidian. The one issue is the small number of source samples available for the minor source of Bermejo. Although not enough samples were analyzed to produce a 95% confidence ellipse, it appears that this signature is discrete when looking solely at the source samples.

When the 87 artifacts are added to the source sample bivariate plot of Sr/Zr and Rb/Zr ratios as seen in Figure 5, a small theoretical Bermejo ellipse overlaps slightly with the low Fe Callejones ellipse. This issue was not apparent in Figure 4 because no source samples with the low Fe Callejones signature were available for inclusion in this research. The signature is only represented in the artifact assemblages. For these two ratios, the Bermejo samples also are quite comparable with the low Fe Mullumica variant as well as the Cosanga B signature. Fortunately, Bermejo and Cosanga B obsidian can be distinguished from low Fe Mullumica and Callejones obsidian because of their distinct Mn concentrations. This can be seen in the Mn vs. Nb bivariate plot in Figure 6 as well as the summary statistics presented in Table III. Once the Mn concentrations are taken into account, it is clear that none of the 87 artifacts analyzed in this research were produced with raw material from the Bermejo or Cosanga source areas.

The summary statistics for the groups of artifacts assigned to various source signatures are provided in Table IV. In addition to the previously mentioned low Fe Callejones variant, two other signatures not documented in the source material were identified. One of these is the La Chimba type whose source area is still unknown (*18*, *22*). This chemical signature is represented by two artifacts. The other new chemical signature is represented by a single artifact. This unassigned artifact has a chemical signature that does not match any known source area in the Andes.

Of the eight source signatures present in our analysis of the source samples, only two are relevant for the artifact assemblages. One of these is the high Fe cluster of Callejones-Mullumica. The other is the low Fe variant of the Mullumica source area. In previous research scholars have suggested that the range of variation in the low Fe Mullumica variant is best treated as one sub-signature (*18*). However, it appears that it might be possible to divide the low Fe Mullumica group in this study into two distinct sub-groups. One of these would cluster nicely with the primary author's source material and have a lower Sr/Zr ratio and higher Rb/Zr ratio than the other sub-group. The other sub-group's signature would vary only slightly and most likely is from the Mullumica source area, but it does not match any documented source material. In another research project, this issue will be examined further. For the purposes of this chapter, this set of artifacts is treated as part of the low Fe Mullumica group.

Source assignments for the archaeological obsidian are provided in Table V. At Huataviro, 79% of the samples analyzed (n=51) were produced with raw material from the high Fe Callejones-Mullumica cluster. Eleven artifacts, or 17% of the assemblage, were assigned to the low Fe Mullumica variant. Two other signatures, the low Fe Callejones variant and La Chimba type, were found in small quantities.

Table III. Summary statistics for Ecuadorian obsidian sources analyzed via pXRF

Element	*Bermejo (n=3)*	*Carboncillo (n=6)*	*Cosanga A (n=6)*	*Cosanga B (n=7)*
Mn	630 ± 34	502 ± 26	901 ± 36	830 ± 22
Fe	5467 ± 145	9844 ± 328	5169 ± 280	6441 ± 152
Zn	36 ± 4	55 ± 3	52 ± 4	51 ± 3
Ga	19 ± 1	21 ± 1	20 ± 1	20 ± 2
Th	14 ± 2	14 ± 1	10 ± 1	13 ± 1
Rb	135 ± 1	134 ± 5	147 ± 7	132 ± 2
Sr	148 ± 17	85 ± 3	87 ± 5	180 ± 6
Y	17 ± 2	39 ± 2	22 ± 2	18 ± 1
Zr	91 ± 3	120 ± 5	65 ± 3	105 ± 9
Nb	18 ± 1	15 ± 1	21 ± 2	20 ± 1
Sr/Zr	1.63 ± 0.16	0.71 ± 0.02	1.34 ± 0.06	1.72 ± 0.15
Rb/Zr	1.48 ± 0.05	1.12 ± 0.03	2.26 ± 0.06	1.26 ± 0.09
Element	*Yanaurco-Quiscatola (n=5)*	*El Tablón (n=4)*	*High Fe Callejones-Mullumica (n=9)*	*Low Fe Mullumica (n=9)*
Mn	320 ± 39	436 ± 29	461 ± 32	341 ± 16
Fe	4394 ± 94	6816 ± 646	9733 ± 251	4802 ± 156
Zn	26 ± 3	55 ± 8	46 ± 5	31 ± 3
Ga	17 ± 1	20 ± 1	20 ± 1	18 ± 1
Th	18 ± 1	14 ± 1	16 ± 1	17 ± 2
Rb	165 ± 3	153 ± 14	123 ± 3	137 ± 3
Sr	78 ± 2	14 ± 2	247 ± 10	102 ± 4
Y	16 ± 1	25 ± 3	12 ± 2	13 ± 1
Zr	69 ± 1	118 ± 8	164 ± 4	85 ± 2
Nb	13 ± 1	15 ± 2	14 ± 1	11 ± 1
Sr/Zr	1.14 ± 0.03	0.12 ± 0.02	1.51 ± 0.04	1.20 ± 0.04
Rb/Zr	2.41 ± 0.03	1.30 ± 0.10	0.75 ± 0.02	1.61 ± 0.05

Concentration values for the 10 elements are in parts per million (ppm).

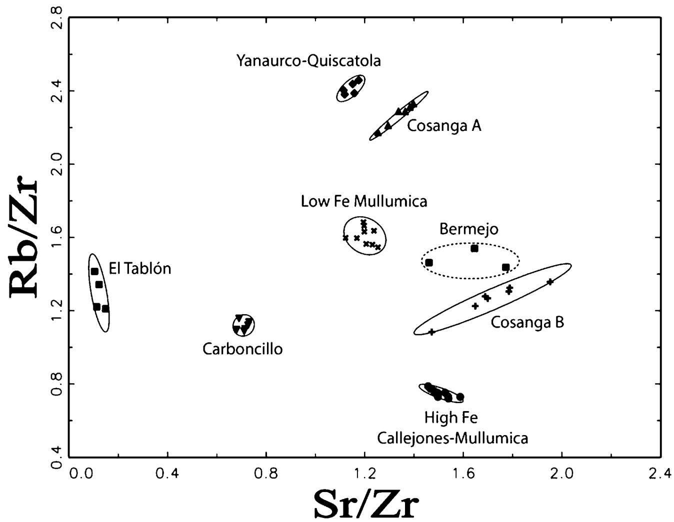

Figure 4. Bivariate plot of Sr/Zr vs. Rb/Zr for the 49 source samples analyzed via pXRF. All solid ellipses represent 95% confidence intervals, while the dotted-line ellipse represents a theoretical range.

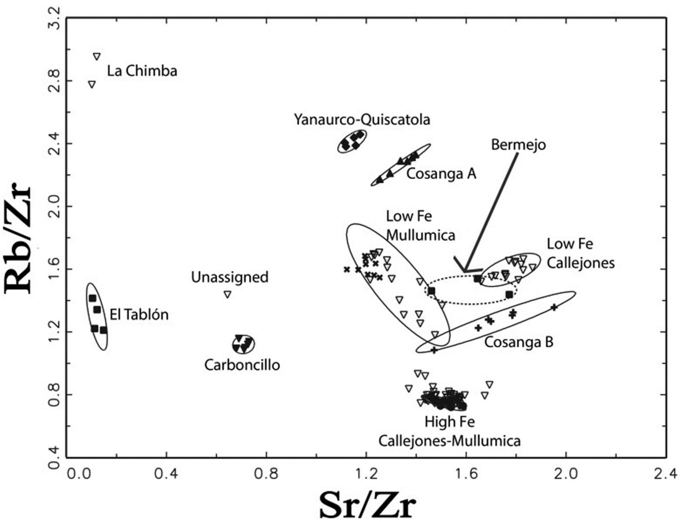

Figure 5. Bivariate plot of Sr/Zr vs. Rb/Zr for the 49 source samples and 87 artifacts analyzed via pXRF. Source samples are in bold and artifacts are presented as unshaded, inverted triangles. All solid ellipses represent 95% confidence intervals, while the dotted-line ellipse represents a theoretical range.

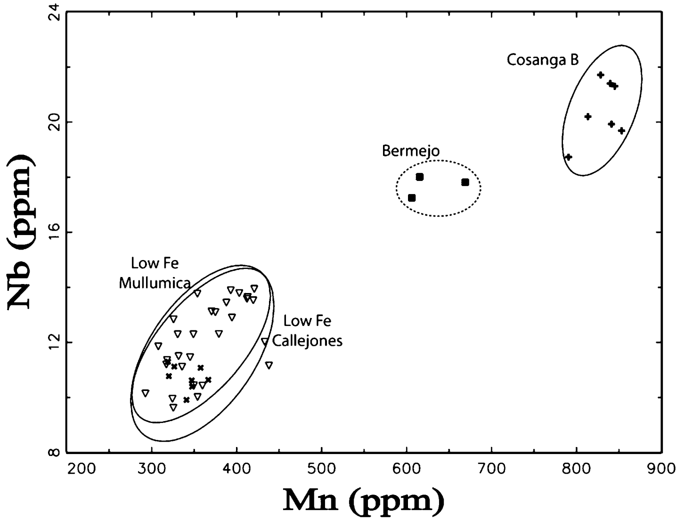

Figure 6. Bivariate plot of Mn vs. Nb for Bermejo, Cosanga B, low Fe Mullumica, and low Fe Callejones material. Source samples are in bold and artifacts are presented as unshaded, inverted triangles. All solid ellipses represent 95% confidence intervals, while the dotted-line ellipse represents a theoretical range. Concentration values are in parts per million (ppm).

Table IV. Summary statistics by source assignment for Ecuadorian obsidian artifacts

	High Fe Cal.-Mul. (n=55)	*Low Fe Mullumica (n=15)*	*Low Fe Callejones (n=14)*	*La Chimba (n=2)*	*n.a.*
Mn	469 ± 41	368 ± 243	360 ± 39	515 ± 76	316
Fe	10249 ± 829	6009 ± 508	6026 ± 630	6959 ± 163	6864
Zn	45 ± 5	34 ± 4	34 ± 5	42 ± 7	39
Ga	21 ± 2	19 ± 1	20 ± 2	20 ± 1	19
Th	16 ± 1	18 ± 2	20 ± 2	16 ± 1	16
Rb	130 ± 7	150 ± 9	149 ± 14	214 ± 2	141
Sr	253 ± 18	135 ± 22	166 ± 14	8 ± 1	63
Y	13 ± 2	14 ± 2	12 ± 2	39 ± 3	19
Zr	167 ± 7	101 ± 11	93 ± 8	75 ± 2	98
Nb	15 ± 1	13 ± 1	12 ± 1	18 ± 1	12

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Table IV. (Continued). Summary statistics by source assignment for Ecuadorian obsidian artifacts

	High Fe Cal.-Mul. (n=55)	*Low Fe Mullumica (n=15)*	*Low Fe Callejones (n=14)*	*La Chimba (n=2)*	*n.a.*
Sr/Zr	1.52 ± 0.06	1.33 ± 0.10	1.78 ± 0.06	0.11 ± 0.01	0.64
Rb/Zr	0.78 ± 0.04	1.49 ± 0.18	1.60 ± 0.05	2.87 ± 0.13	1.44

Concentration values for the 10 elements are in parts per million (ppm). The final column contains values for the single unassigned artifact in study (n.a.).

Table V. Source assignments for the Huataviro and Puntiachíl assemblages

Source	*Huataviro*	*Puntiachíl*	*Total*
High Fe Callejones-Mullumica	51	4	55
Low Fe Mullumica	11	4	15
Low Fe Callejones	1	13	14
La Chimba type	2	0	2
Unassigned	0	1	1
Total	65	22	87

The Puntiachíl assemblage has a much different composition. Thirteen artifacts, or 59% of the assemblage, were assigned to the low Fe Callejones variant. In ongoing dissertation research being conducted by the primary author, Puntiachíl stands alone as the single site out of 80 whose assemblage consists of more than 10% of the low Fe Callejones variant. Both the high Fe Callejones-Mullumica cluster and the low Fe Mullumica variant constituted 18% of the assemblage. Finally, the single artifact in this study that could not be assigned to a known source area came from Puntiachíl.

Discussion

Although artifacts from two known source areas are present at Huataviro and Puntiachíl, the highly variable nature of these sources provides the opportunity to identify multiple extraction locales in each source area (*18*). The data suggest that Huataviro and Puntiachíl had separate means of procuring obsidian. In fact, the two assemblages are almost the inverse of one another. Huataviro's assemblage consists of primarily high Fe Callejones-Mullumica with smaller quantities of the low Fe variants of Mullumica and Callejones and the La Chimba type. On the other hand, the majority of Puntiachíl's assemblage is low Fe Callejones with small quantities of high Fe Callejones-Mullumica and low Fe Mullumica. The issue of the contemporaneity of the various intra-site contexts is difficult to address, but based on the available data there is no reason to believe that the artifacts analyzed are not representative of each site's overall assemblage.

The ability to make inferences about the processes responsible for the documented patterns is severely limited by the scope of this initial study. Using geochemical data, archaeologists sometimes are able to differentiate between independent and centralized procurement processes (*69*). In this instance, the data presented in this chapter suggest that *mindaláes* were not responsible for the transport and exchange of obsidian (*2*). If *mindaláes* or some centralized process was responsible, we typically would expect to find more evidence of homogenization in assemblages because a small group of individuals would be responsible for a significant portion of the obsidian distribution in the País Caranqui (*69*).

The small quantities of obsidian found at Integration Period sites provide additional support for informal distribution processes moving obsidian. Although obsidian constitutes the majority of lithics found at Caranqui sites, the quantity of obsidian typically numbers in the hundreds. This pales in comparison to the assemblages from major blade production areas such as central Mexico that often number in the hundreds of thousands (e.g. (*64*, *69*)). Based on the small quantities of lithics present, it would appear that obsidian artifacts either were heavily curated or a large number of perishable tools were employed in lieu of lithics. If merchant-like entities such as *mindaláes* were involved in obsidian distribution, we would expect to find much larger assemblages of obsidian and evidence for more intensive quarrying activity.

The available data suggest that an independent, decentralized process was responsible for the differences in the assemblages. The most likely process would be the household-to-household exchange networks outlined in the ethnohistorical record (*1*). Based on the differences in the two assemblages presented in this chapter, additional research and analysis of obsidian from more *tola* sites is underway. In particular, an effort to obtain more obsidian artifacts from Puntiachíl will be undertaken because of its assemblage's unique composition.

Some of the more interesting findings from this study of obsidian procurement at *tola* sites come from comparisons with the limited set of artifacts previously sourced by other researchers. In the seminal work on Ecuadorian obsidian sourcing, Burger, Asaro and colleagues suggest that Yanaurco, Quiscatola, and Mullumica were the most heavily utilized source areas in Ecuadorian prehistory (*2*). While the Callejones obsidian source only had recently been identified at the time of their publication (*2*), the notable finding of our research is that Yanaurco-Quiscatola obsidian probably was not heavily utilized in the País Caranqui during the Integration Period. This finding supports Ogburn et al.'s (*18*) analyses of material from late Caranqui fortifications that did not include any Yanaurco-Quiscatola material. This also supports the hypothesis that utilization of the Yanaurco and Quiscatola source areas ceased around AD 1000 and was not reinitiated until the Inka arrived in the region (*15*, *18*).

Part of the explanation for the lack of Yanaurco-Quiscatola obsidian in the País Caranqui during the Integration Period might stem from the lithic technology employed. The obsidian assemblage typically includes only small flake fragments (e.g. (*4*, *18*)) or artifacts that exhibit evidence of bipolar reduction. Therefore, it appears that most obsidian raw material in the País Caranqui was utilized to produce crude expedient flake tools. Based on his research on the Mullumica and Quiscatola source areas, Salazar (*12*, *14*) suggests that the Quiscatola source is much more homogenous than Mullumica and contains higher quality obsidian (*2*). It is probable that in locales where blade production was undertaken, raw material from the higher quality Quiscatola source would have been utilized (*2*).

The lack of Yanaurco-Quiscatola obsidian suggests that individuals might have prioritized limiting procurement costs over obtaining higher quality obsidian. The Mullumica and Callejones source areas are slightly closer to the País Caranqui than Yanaurco and Quiscatola and would have been easier to access based on least-cost path analyses (*23*) (Figure 3). Considering the lithic technology employed in the País Caranqui did not require the highest quality obsidian available, it would have been possible to make the trade-off of lower quality obsidian for lower procurement costs. Alternatively, the lithic technology could have been constrained by package size and the inability to access obsidian of a higher quality than Mullumica or Callejones. At this time, we believe that the former possibility is more likely because there is no available evidence that suggests Caranquis would have been unable to access the Yanaurco or Quiscatola sources that were no more than 25 additional km away (Figure 3). Future research will investigate this issue further.

As part of their study on military procurement strategies, Ogburn et al. (*18*) analyzed 29 obsidian artifacts from the rural habitation site of Oroloma (Figure 1). The inhabitants of this site likely focused on exploiting the mountainous grassland *páramo* ecozone found at elevations above 3200 masl (*18*, *70*). A radiocarbon date and composition analysis of a relevant volcanic ash lens suggest that this site dates to the earlier portion of the Integration Period (cal. AD 690-930) (*70*).

Recently Schreyer (*23*) reanalyzed Ogburn et al.'s (*18*) samples as well as some additional obsidian from Oroloma. She modified some source assignments based on a combination of inductively coupled plasma mass spectrometry and pXRF data. However, considering the issues related to comparing data produced via different chemical characterization techniques (see (*65*, *66*)), we refer only to Ogburn et al.'s (*18*) original source attributions for the Oroloma assemblage. The same practice was applied when considering the obsidian assemblages from the sites of Pukarito and Pingulmi mentioned later in this section.

Fifty-nine percent of the obsidian (n=17) analyzed from Oroloma was attributed to the high Fe Callejones-Mullumica signature. Material with the low Fe Mullumica signature also constituted a healthy portion of the assemblage, representing 28% (n=8) of the samples analyzed. Finally, two artifacts were attributed to both the low Fe Callejones variant and the La Chimba type (*18*).

The composition of the Oroloma assemblage matches the Huataviro assemblage presented in this chapter. In both instances, the high Fe Callejones-Mullumica signature constitutes the majority of the assemblage. Low Fe Mullumica material represents roughly 30-40% of the assemblage and the La Chimba type and low Fe Callejones variant are found in small quantities. This finding suggests that Huataviro and Oroloma utilized similar procurement strategies to obtain obsidian. It also reiterates that the Puntiachíl assemblage is

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distinct from the other assemblages analyzed to date. Considering the limited research and the large time spans covered by these sites, it is difficult to determine whether this difference is a product of independent processes or a shift through time in obsidian procurement strategies.

However, additional evidence from Ogburn et al. (*18*) indicates that the Puntiachíl assemblage would be unique even if Tola Peña was only occupied at the end of the Integration Period and was not contemporaneous with Huataviro or Oroloma. As part of their study, Ogburn and colleagues also analyzed obsidian from two late prehistoric Caranqui fortresses: Pukarito and Pingulmi. The obsidian assemblages from these two fortresses had compositions similar to the Huataviro and Oroloma assemblages (*18*). The only notable difference is none of the seven artifacts analyzed from Pukarito were produced from raw material with the low Fe Mullumica signature (*18*). The fact that this type of assemblage composition appears to extend to the end of the Integration Period suggests that a different procurement network is likely responsible for the Puntiachíl assemblage. More research will be done to try to determine which of the possibilities is more likely.

Conclusion

This research produced some interesting findings despite the fact that it represents only an initial examination of obsidian assemblages from Integration Period *tola* sites. The analysis of a combination of source samples and artifacts demonstrates that the Bruker Tracer III-V+ SD is capable of characterizing Ecuadorian obsidian in a manner that is useful to archaeologists. This is important given the portability of pXRF instrumentation and its rapid method of characterization which allows for its use outside traditional laboratory settings (*71*). This is especially significant considering the possibility that the low Fe Mullumica signature can be divided into multiple sub-groups. A much larger assemblage is needed to examine this possibility and the characteristics of pXRF instrumentation will greatly aid in this endeavor.

The most exciting finding of this study from an archaeological perspective is that Puntiachíl has a unique obsidian assemblage compared to other sites in the País Caranqui. This suggests that some form of independent procurement process was responsible for the distribution pattern of obsidian observed in this study. A second important archaeological finding is that Callejones and Mullumica obsidian were more heavily utilized than material from Yanaurco and Quiscatola. This likely is related to the use of a lithic technology in the País Caranqui that could employ obsidian of an adequate yet lower quality. Ultimately, the initial findings of this study demonstrate the need for additional research on Ecuadorian obsidian along a number of fronts.

Conflict of Interest Statement

Eric Dyrdahl received support from Bruker AXS in order to attend the archaeological chemistry symposium at the American Chemical Society meeting in New Orleans in April 2013. Robert J. Speakman maintains a professional relationship with Bruker AXS specifically with respect to instrument and application development in archaeological science. Speakman's laboratory, The Center for Applied Isotope Studies at the University of Georgia, occasionally conducts work for Bruker AXS on a fee for service basis.

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References

1. Salomon, F. *Native Lords of Quito in the Age of the Incas: The Political Economy of North Andean Chiefdoms*; Cambridge University Press: New York, 1986.
2. Burger, R. L.; Asaro, F.; Michel, H. V.; Stross, F. H.; Salazar, E. *Latin Am. Antiquity* **1994**, *5*, 228–255.
3. Bray, T. L. *J. Field Archaeol.* **1995**, *22*, 137–148.
4. Bray, T. L. *J. Field Archaeol.* **2005**, *30*, 119–141.
5. Bray, T. L. In *Handbook of South American Archaeology*; Silverman, H., Isbell, W., Eds.; Kluwer Academic Publishers: New York, 2008; pp 527−543.
6. Topic, J. In *Merchants, markets and exchange in the Pre-Columbian World*; Hirth, K. G., Pillsbury, J., Eds.; Dumbarton Oaks Research Library and Collection: Washington, DC, 2013; pp 335−360.

7. Hirth, K. G.; Pillsbury, J. *Curr. Anthropol.* **2013**, in press.
8. Cordero, M. Ph.D. Thesis, University of Pittsburgh, Pittsburgh, PA, 1998.
9. Martin, A. Ph.D. Thesis, University of Pittsburgh, Pittsburgh, PA, 2009.
10. Oberem, U. In *Native South Americans: Ethnology of the Least Known Continent*; Lyon, P. L., Ed.; Waveland Press: Prospect Heights, IL, 1974; pp 346−357.
11. Yanchar, K., Minc, L. Oregon State University, unpublished.
12. Salazar, E. *Talleres prehistóricos en los altos Andes del Ecuador*; Departamento de Difusión de la Universidad de Cuenca: Cuenca, Ecuador, 1980.
13. Salazar, E. *Miscelánea Antropológica Ecuatoriana* **1985**, *5*, 129–160.
14. Salazar, E. In *Arqueología en América Latina Hoy*; Politis, G., Ed.; Editorial Presencia: Bogotá, Columbia, 1992; pp 116−131.
15. Bigazzi, G.; Coltelli, M.; Hadler, J. C.; Osorio Araya, A. M.; Oddone, M.; Salazar, E. *J. South Am. Earth Sci.* **1992**, *6*, 21–32.
16. Bellot-Gurlet, L.; Poupeau, G.; Dorighel, O.; Calligaro, T.; Dran, J. C.; Salomon, J. *J. Archaeol. Sci.* **1999**, *26*, 855–860.
17. Bellot-Gurlet, L.; Dorighel, O.; Poupeau, G. *J. Archaeol. Sci.* **2008**, *35*, 272–289.
18. Ogburn, D.; Connell, S. V.; Gifford, C. *J. Archaeol. Sci.* **2009**, *36*, 740–751.
19. Santi, P.; Renzulli, A.; Oddone, M. *J. Archaeol. Sci.* **2010**, *37*, 1753–1760.
20. Ogburn, D. *Latin Am. Antiquity* **2011**, *22*, 97–120.
21. Knight, C. L. F.; Cuellar, A. M.; Glascock, M. D.; Hall, M. L.; Mothes, P. A. *J. Archaeol. Sci.* **2011**, *38*, 1069–1079.
22. Asaro, F.; Salazar, E.; Michel, H. V.; Burger, R. L.; Stross, F. H. *Latin Am. Antiquity* **1994**, *5*, 257–277.
23. Schreyer, S. L. MA Thesis, California State University-Fullerton, Fullerton, CA, 2012.
24. Zeidler, J. A., Giauque, R. L., Asaro, F., Stross, F. H. In *Regional Archaeology in Northern Manabí, Ecuador, Volume 1: Environment, Cultural Chronology, and Prehistoric Subsistence in the Jama River Valley*; Zeidler, J. A., Pearsall, D. M., Eds.; Department of Anthropology, University of Pittsburgh: Pittsburgh, PA, 1994; pp 141−144.
25. Athens, S. J. University of Hawaii, unpublished.
26. Cordero, M. *El cacicazgo Cayambi: Trayectoria hacia la complejidad social en los Andes sepentrionales*; Abya-Yala: Quito, Ecuador, 2009.
27. Pazmiño, E., Montalvo, C., Cajas, O. Instituto Nacional del Patrimonio Cultural, Quito, Ecuador, unpublished.
28. Bray, T. L. Ph.D. Thesis, State University of New York-Binghamton, Binghamton, NY, 1991.
29. Ogburn, D. Ph.D. Thesis, University of California-Santa Barbara, Santa Barbara, CA, 2001.
30. Connell, S. V.; Gifford, C. H.; González, A. L.; Carpenter, M. *Antiquity* **2003**, *77*, 295.
31. Fries, E. C. MA Thesis, University of California-Los Angeles, Los Angeles, CA, 2010.

32. Lippi, R. D., Gudiño, A. M. In *Distant Provinces in the Inka Empire: Toward a Deeper Understanding of Inka Imperialism*; Malpass, M. A., Alconini, S., Eds.; University of Iowa Press: Iowa City, IA, 2010; pp 260−278.
33. Sistrunk, H. *Ñawpa Pacha* **2011**, *30*, 189–208.
34. de Aguilar, F. G. In *Relaciones Geográfica de Indias*; Jiménez de la Espada; Tipografia de los Hijos de M. C. Hernández: Madrid, Spain, 1897; Vol. 3, pp 124−127.
35. Borja, P. A. In *Relaciones Geográfica de Indias*; Jiménez de la Espada; Tipografia de los Hijos de M. C. Hernández: Madrid, Spain, 1897; Vol. 3, pp 128−136.
36. Paz Ponce de León, S. In *Relaciones Geográfica de Indias*; Jiménez de la Espada; Tipografia de los Hijos de M. C. Hernández: Madrid, Spain, 1897; Vol. 3, pp 105−120.
37. Cabello Balboa, M. *Miscelánea Antártica:Una Historia del Peru Antiguo*; Instituto de Etnología Seminario, Universidad Nacional Mayor de San Marcos: Lima, Peru, 1951.
38. Cobo, B. *History of the Inca Empire: An account of the Indians' Customs and Their Origin, Together with a Treatise on Inca legends, History, and Social Institutions*; University of Texas Press: Austin, TX, 1979.
39. Espinosa, W. *Bulletin de L'Institut Francais d'Etudes Andines* **1980**, *9*, 89–119.
40. Espinosa, W. *Los Caranquis y Los Cayambes*; Colleción Pendoneros; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1983.
41. Espinosa, W. *Los Cayambes y Carangues: Siglos XV-XVI: El Testimonio de la Etnohistoria*; Colección Curiñán; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1988; Volumes 3−4.
42. Caillavet, C. *Revista Andina* **1985**, *3*, 403–423.
43. Caillavet, C. *Etnias del Norte: Etnohistoria e Historia de Ecuador*; Ediciones Abya-Yala: Quito, Ecuador, 2000.
44. de Cieza de León, P. *The Discovery and Conquest of Perú: Chronicles of the New World Encounter*; Cook, A. P., Cook, N. D., Eds.; Duke University Press: Durham, NC, 1998.
45. Salomon, F. *Ethnohistory* **1987**, *34*, 63–77.
46. Ramirez, S. E. In *Ethnicity, Markets, and Migration in the Andes: At the Crossroads of History and Anthropology*; Larson, B., Harris, O., Eds.; Duke University Press: Durham, NC, 1995; pp 135−164.
47. de Gamboa, P. S. *History of the Incas*; Markham, C., Ed.; Cambridge University Press: Cambridge, U.K., 2007.
48. Athens, S. J. In *Resources, Power, and Interregional Interaction*; Schortman, E. M., Urban, P. A., Eds.; Plenum Press: New York, 1992; pp 193−219.
49. Schuller, F. P. *La incursión Inca en el septentrión andino ecuatoriano: antecedentes arqueológicos de la convulsiva situación de contacto cultural: primer informe preliminary*; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1976.
50. Jijón y Caamaño, J. *Contribución al Conocimiento de los Aborígenes de la Provincia de Imbabura*; Blas y Cía: Madrid, Spain, 1914

51. Jijón y Caamaño, J. *Boletín de la Sociedad Ecuatoriana de Estudios Históricos* **1920**, *4*, 1–120, 183–245.
52. Oberem, U. *Verhandlungen des 38th Internationalen Amerikongresses* **1969**, *1*, 317–322.
53. Oberem, U. *Cochasqui: Estudios Arqueológicos*; Colección Pendoneros; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1981; Volumes. 3−5.
54. Athens, S. J. *El Proceso Evolutivo en las Sociedades Complejas y la Ocupación del Periodo Tardío-Cara en los Andes Septentrionales*; Colección Pendoneros; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1980.
55. Gondard, P., Lopez, F. MAG, PRONAREG, ORSTOM, Quito, unpublished.
56. Uhle, M. *Boletín de la Academia Nacional de Historia* **1939**, *18*, 5–14.
57. Currie, E. *Antiquity* **2000**, *74*, 273.
58. Currie, E. *Internet Archaeology* **2001**, *10*.
59. Berenguer, J. *Gaceta Arqueológica Andina* **1984**, *10*, 4–5.
60. Bray, T. L. *Sarance* **1994**, *20*, 135–146.
61. Echeverria, J.; Uribe, M. V. *Sarance* **1981**, *9*, 25–45.
62. Jaramillo, A. *Repertorio Arqueológico Imbaya*; Editorial Cultura: Otavalo, Ecuador, 1968.
63. Rodriguez, E. *Fauna Precolombina de Nariño*; Fundación de Investigaciones Arqueológicas Nacionales; Instituto Colombiano de Antropología: Bogotá, Columbia, 1992.
64. Hirth, K. G. In *Obsidian Craft Production in Ancient Central Mexico: Archaeological Research at Xochicalco*; Hirth, K. G., Ed.; University of Utah Press: Salt Lake City, UT, 2006; pp 3−17.
65. Glascock, M. D. *Int. Assoc. Obsidian Stud. Bull.* **1999**, *23*, 13–25.
66. Hancock, R. G. V.; Carter, T. *J. Archaeol. Sci.* **2010**, *37*, 243–250.
67. Larrain, H. *Demografía y Asentamientos Indígenas en la Sierra Norte del Ecuador en el Siglo XVI: Estudio Etnohistórico de las Fuentes Tempranas (1525−1600)*; Instituto Otavaleño de Antropología: Otavalo, Ecuador, 1980.
68. Buys, J., Manosalvas, O., Camino, B., Benavides, H. Instituto Nacional de Patrimonio Cultural del Ecuador, Quito, unpublished.
69. Hirth, K. G. *Latin Am. Antiquity* **2008**, *19*, 435–457.
70. Gonzalez, A. L. MA Thesis, University of Hawaii, Honolulu, HI, 2010.
71. Craig, N.; Speakman, R. J.; Popelka-Filcoff, R. S.; Glascock, M. D.; Robertson, J. D.; Shackley, M. S.; Aldenderfer, M. S. *J. Archaeol. Sci.* **2007**, *34*, 2012–2024.