Title

Geochemical and Technological Analysis of Lithic Artifacts from Guadalupe, a Cocal Period (AD 1000 to 1530) Site in Northeast Honduras

Author

Stroth, Luke R

Publication Date

2018

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA, SAN DIEGO

Geochemical and Technological Analysis of Lithic Artifacts from Guadalupe, a Cocal Period (AD 1000 to 1530) Site in Northeast Honduras

A Thesis submitted in partial satisfaction of the requirements for the degree Masters of Arts

in

Anthropology

by

Luke Reyneri Stroth

Committee in Charge:

Professor Geoffrey E. Braswell, Chair
Professor Jade A. d'Alpoim Guedes
Professor Paul S. Goldstein

2018

The Thesis of Luke Reyneri Stroth is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

2018

DEDICATION

This thesis is dedicated to Steve Stroth, Adriana Reyneri, and Jacob Stroth. As with all things, grace under pressure.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

Archaeology is a team sport, in the field and the laboratory. The technological and chemical analysis would not have been possible without the support of and collaboration with many talented researchers. I would like to thank my advisor, Geoffrey Braswell for his hands-on guidance during laboratory work and visual sourcing as well as his thorough feedback, my first reader Jade d'Alpoim Guedes for her feedback on each additional draft, James Daniels, Jr., for the use of his equipment, lab space, and guidance with the chemical analysis, Raquel Otto for her collaboration in this technological and visual analysis, Markus Reindel for access to the obsidian collection, and Lisa Korpos for her guidance with technical illustration.

The data from the technological analysis (Section 3) was generated in collaboration with Raquel Otto, and will be appearing in her Honors Thesis, *Analisis de la Obsidiana de las unidades dos y tres, del Sitio Guadalupe*, on file at the Department of Anthropology, National Autonomous University of Honduras.

ABSTRACT OF THE THESIS

Geochemical and Technological Analysis of Lithic Artifacts from Guadalupe, a Cocal Period (AD 1000 to 1530) Site in Northeast Honduras

By

Luke Reyneri Stroth

Master of Arts in Anthropology

University of California, San Diego, 2018

Professor Geoffrey E. Braswell, Chair

355 obsidian artifacts from Guadalupe, a Cocal Period (AD 1000 to 1530) site on the north coast of Honduras, were subjected to chemical analysis using a portable X-Ray fluorescence device. I used multivariate analyses to determine the raw material from which each artifact was produced, with a discussion of the implications for contacts with other parts of Mesoamerica. The majority of the assemblage was composed of Güinope obsidian, a low-quality Honduran source frequently found in small cobbles. The organization of production at Guadalupe was assessed through a technological analysis. It was determined that prismatic blades were produced onsite using Güinope obsidian, the first evidence for blade production

using this raw material. To make use of small cobbles, initial core shaping was done through cortex-grinding and decortication flakes. The platforms were ground, and flakes were struck using hand-held techniques. In addition, formal tools and complete prismatic blades were imported of La Esperanza (Honduran) and Ixtepeque (Guatemalan) obsidian. A causal industry of Güinope, La Esperanza, and Otumba (Mexican) obsidian is also present. The inhabitants of Guadalupe adapted foreign technologies to local conditions and materials, a common occurrence in Lower Central American archaeology.

1. Introduction

The archaeology of Lower Central America, the culture region between western Honduras and the Darién Gap, has come far in the past few decades. Previously characterized as an intermediate area between Mesoamerican and Andean states (Coe 1962), local populations were presented as passive in the face of influence from the north and south. The term "intermediate" was a pejorative, dismissive (Sheets 1992). Many early analyses focused on chronological studies emphasizing ceramic and lithic typologies (Strong 1973). As a result, "little attention [was] paid to the recovery of organic remains, the reconstruction of utility areas, [and] the functional study of lithic artifacts" (Linares 1979:30). In contrast, recent work has focused on local developments and social interaction (Creamer 1987). Contemporary anthropological issues such as the construction of identity construction and the active and purposeful manipulation of foreign ideas are common themes in the archaeology of this region, which has moved beyond simple diffusionism (Carmack and Salgado González 2006, Cuddy 2007, Salgado González and Vázquez Leiva 2006). Unfortunately, large spatial and temporal gaps still exist in our understanding of the region; in particular, the northeast coast of Honduras and its relationship to Mesoamerica and the rest of Lower Central America (Dennett 2007).

In the context of the reevaluation of Central American prehistory, I explore the organization of lithic technology by the inhabitants of Guadalupe, a Cocal Period (AD 1000 to 1530) site on the north coast of Honduras. Geochemical and technological analyses of 355 obsidian tools provide insight into the ways that a Mesoamerican prismatic-blade technology was modified to suit local lithic industries and raw materials. The production process differed for each material according to its relative availability and abundance and functional constraints. To produce blades from small Güinope cobbles, initial core shaping was done through cortex grinding and decortication flakes. Cobbles were held in the hand due to their small size. The platforms of these cores were pecked and ground so as to increase stability. In this way, the inhabitants of Guadalupe actively adapted Mesoamerican technology to local materials. Although blades made from Güinope obsidian have been reported elsewhere (e.g., Braswell 1997, Braswell et al. 2002, Healy et al. 1996a, 1996b, Stross et al. 1992), Guadalupe is the first site at which evidence for production of Güinope blades has been found.

Using a portable X-ray florescence device, relative chemical concentrations were measured for each artifact. These artifacts were assigned group memberships approximating the geological source of origin (Hughes 1998). Through non-destructive X-ray florescence combined with visual sourcing, 122 artifacts were determined to have been made from La Esperanza obsidian (a Honduran obsidian), 223 from Güinope (Honduran), 9 from Ixtepeque (Guatemalan), and 1 from Otumba (Mexican). A behavioral typological analysis, performed by myself, Raquel Otto, and Geoffrey Braswell, allowed for the description of the production history and techniques (Sheets 1975). Each raw material, due to differences in relative abundance and physical traits, constituted a different aspect of the overall production strategy.

Questions remain regarding the degree to which lithic production was centralized at Guadalupe. It is probable that northeastern Honduran settlements were at a chiefdom level of complexity during the Cocal Period (Healy 1992). The presence of blade industries in the Arctic and Paleolithic Europe prove that complexity is not needed to sustain a blade industry (Sanger 1970). Clark (1988) does suggest that prismatic blades were one trade unit among many (including, perhaps, religious ideas; Helms 1992) traded within prestige-networks between chiefdoms throughout Lower Central America. Regardless of the level of complexity at Guadalupe, the incorporation of a Mesoamerican industry into local networks is yet another example of ancient Hondurans adapting foreign ideas and prestige goods to local needs (Begley 1999, Joyce 1996).

1.1 The Site of Guadalupe and Honduran Archaeology

The modern borders of Honduras contain a heterogeneous archaeological heritage. Seven major language groups were present at the time of contact with the Spanish. Different culture groups of Mesoamerica, Lower Central America, and South America have each influenced some aspect of local development, though South American influence is not strongly felt in the northeast (Creamer and Haas 1985, Healy 1992). The archaeological record for Honduras, both geographically and temporally, is “incomplete, and hardly uniform” (Healy 1992:86). Broad regional chronologies are often adjusted to fit local histories, usually based on ceramic chronologies (Drennan 1996, Lange and Stone 1984). In particular the northeast coast, the region in which Guadalupe is located, is still not fully understood (Dennett 2007). Excavations at Guadalupe, directed by Markus Reindel and Franziska Fecher, offer an opportunity to refine chronology within an understudied cultural area.

The site of Guadalupe (Figure 1), the subject of the *Proyecto Arqueológico Guadalupe*, a collaboration between the German Institute of Archaeology and the Universidad Nacional Autónoma de Honduras, is located in the municipality of Santa Fe in the Department of Colón, on the north coast of Honduras (Reindel and Fecher 2016). The north coast is drier than the Pacific containing many river valleys and floodplains between mountain ranges along the Caribbean lowland, which is comprised of pine-covered savanna. Closer to the sea are mountain chains running from east to west (Healy 1984a). The three main ecological zones are the narrow coastal plain around Trujillo, the estuary zone around the Gunimreto Lagoon, and the Aguan River Valley, connected to the coastal plain by the estuary zone (Healy 1984c). Guadalupe is situated by an ancient river knoll on the north coastal plain. The site itself consists of a small, roughly rectangular round 20 meters in diameter with a maximum height of 1 meter above the plain. In 2016, a 12x2 meter trench running east to west was set onto the east side of the mound. The goals of the excavation were to gather information about the occupational history of the site itself, information about the north coast in general, and fine-tune regional and chronological typologies (Reindel and Fecher 2016).

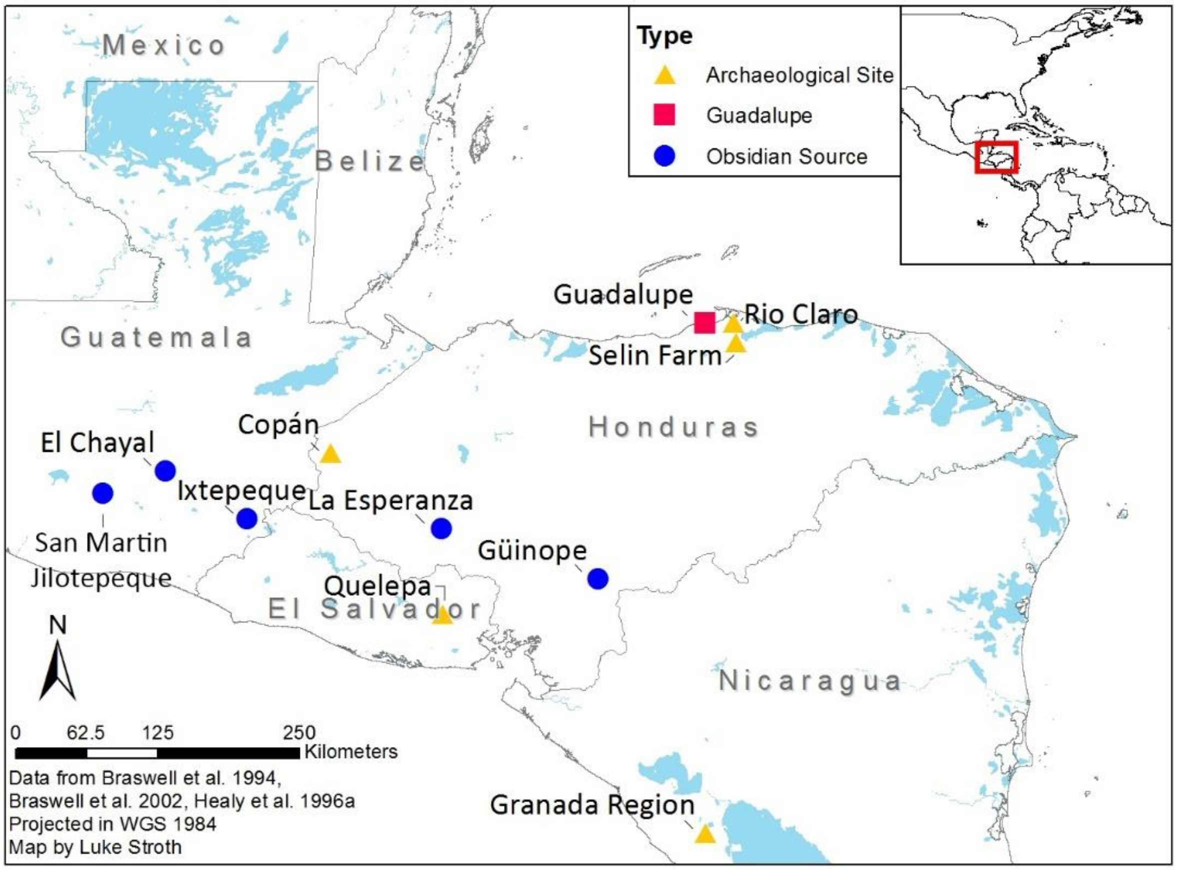

Figure 1. Map of region, noting important sources of obsidian and some archaeological sites mentioned in the text.

The 2016 field season recovered an exceptional amount of ceramics, many of which were decorated, and included vessel supports. Other artifacts include fish bones, some of which are incised, an abundance of caracol shell, some of which are decorated, a bell and needle made of copper, a few pieces of greenstone, and many pieces of obsidian, mostly blade fragments. The ceramics date to the Cocal period (AD 1000 to 1530), with potentially older material below (Reindel and Fecher 2016). Maize agriculture was introduced to the northeast around AD 300 as part of a mixed-subsistence that included a fishing-foraging economy until the intensification of agriculture around AD 1000 (Healy 1992). Most sites in the region combined an agricultural economy with riverine and coastal resources, with little hunting as compared to the Selin Period. New settlements were established at defensive locations (Healy 1984b). Although Guadalupe is located next to a dried-up river knoll, it is unlikely this was chosen for purely defensive reasons; the site is only 1 meter in elevation above the plain (Reindel and Fecher 2016). The decision was more likely related to a mixed fishing-agricultural subsistence, given the abundance of fish bones and caracol shells.

Table 1. Archaeological periods of northeast Honduras.

Period	Date Range	Description	Obsidian
Cuyamel	1650 to 400 BC	Burials within Cuyamel caves. Offerings include Olmecoid bowls.	N/A
Selin Farm	AD 300 to 1000	Social organization is egalitarian. Few monumental constructions. Mixed economy including maize agriculture, hunting, fishing, and foraging.	Obsidian is rare, but prismatic blades are present.
Cocal	AD 1000 to 1530	Sites are larger, more orderly, and located in defensive positions. Chiefdoms and maize agriculture. Less hunting in favor of coastal and marine resources.	Obsidian becomes more common. Cores and projectile points remain rare. Prismatic blade fragments ('bladelets') are most common artifact.

Major periods of north coast archaeology are summarized in Table 1. The Cocal Period is characterized is divided into the Early (AD 1000 to 1400) and Late Cocal (AD 1400 to 1530) phases. In contrast to the depopulation of large settlements in western and central Honduras, sites in the northeast began to grow and develop (Healy 1984a, Hirth 1988). Cocal sites were larger and more orderly than their Selin Period (AD 300 to 1000) predecessors and appear to be full chiefdoms (Healy 1984b, 1992). Spanish accounts describe ranked societies (Lara Pinto and Hasemann 1988). At contact, the paramount political entity in the northeast was the Pech chiefdom of Taguzgalpa (Cuddy 2007; though Cuddy does suggest that the Spaniards used the term 'cacique' to refer to any group leader, and thus is skeptical that chiefdoms were as common throughout Lower Central America). This social reorientation occurred as the climate became locally warmer and drier, but this does not appear to have played a role in any social changes (Messenger 1991). Healy (1992) ascribes this transition to the development of maize agriculture introduced from the west. Messenger (1991) speculates that it might be manioc agriculture.

The nature of political organization and cultural interaction in the northeast in particular and Honduras in general have been the subjects of ongoing debate. The area is seen as an intermediate (but not necessarily an intermediary) between Mesoamerica and Lower Central America (Cuddy 2007, Dennett 2007, Healy 1992). Mesoamerican iconography, architecture, and technologies are present within the region, but often they are adapted to local needs within local social networks and power dynamics (Begley 1999, Joyce 1996). Although western Honduras and El Salvador are often seen as the as a frontier with Mesoamerica (Braswell et al. 1994, McFarlane 2005), it is a porous border with no clear ecological boundary (Aoyama 1994, Begley 1999, Linares 1979). Complex societies within Honduras were not directly planted as Mesoamerican colonies, but the development of complexity may have been fostered by agriculture and prestige goods from the west (Healy 1992, Lara Pinto and Hasemann 1988). The east may have closer ties to Lower Central America than western and central Honduras. The depopulation of western and central Honduras in Period V (AD 500 to 1000) coincides with the Classic Maya collapse (Healy 1984a). The nature of these ties will not be resolved here, but some light will be shed on the adoption of Mesoamerican lithic technology.

1.2 Obsidian Sources in Honduras and Lower Central America

La Esperanza, Ixtepeque, and Güinope obsidian have all been used to produce cutting tools in Honduras and Lower Central America, but there is no local source of obsidian in northeast Honduras (Healy et al. 1996a). Ixtepeque is one of two major obsidian sources in the Guatemalan highlands, the other being El Chayal. Although sometimes present at the same site as economic relationships change through time, one is often favored over the other (Daniels and Braswell 2014). Ixtepeque was traded down the Rio Motagua and distributed along the Caribbean Coast (Hammond 1972). La Esperanza and Güinope are located in southern Honduras near the Salvadorian and Nicaraguan borders, respectively (Figure 1). La Esperanza artifacts are typically found as prismatic blades and blade cores characteristic of a Mesoamerican lithic industry, though bifaces and casual industries are also known. La Esperanza was accessed at the source with vertical shaft mines. Güinope has been reported mostly as part of a casual percussion industry. Güinope has no single outcrop, but is rather collected as small (<10cm) nodules from colluvial and alluvial deposits. (Sheets et al. 1990). The use of Honduran and Guatemalan obsidian sources vary as political and economic relationships shift (Hirth 1988). New exchange networks were formed during the Epiclassic (AD 650 to 1000), when Ixtepeque, usually found as part of a prismatic-blade industry, became the primary source of raw material in western Honduras and El Salvador (Braswell 2003).

Güinope blades are not common in Honduras, but there are several Güinope blades from the site of Ayala in Granada, Nicaragua (Braswell 1997), and another one in the Late Polychrome site of San Cristobal (Healy et al. 1996a). Braswell (1997) has suggested that a Güinope blade industry may have been practiced somewhere in eastern Honduras or possibly Quelepa (Braswell et al. 2002). The sample from Guadalupe represents the first evidence of blade production using this raw material. Obsidian is rarer in Nicaragua (Lange et al. 1992), especially on the southern Pacific coast (Valero Lobo and Salgado González 2000). Obsidian artifacts are almost completely absent any further south (Sheets 1994, Cooke 1984). Sites reporting formal tools, including blades, made of Güinope obsidian are summarized in Table 2.

Table 2. Güinope obsidian artifacts reported in site reports.

Site/Region	Date	Güinope Artifacts/Total Artifacts Sourced	Industry	Source
Dept. of Colon, Honduras	AD 300 to 800	1/2	Prismatic Blade	Healy et al. 1996b
Culmí Valley, Honduras	AD 500 to 1000	1/5	Unspecified	Begley 1999
Ayala, Nicaragua	AD 300 to 800	4/48	Prismatic Blade	Braswell 1997
San Cristobal, Nicaragua	AD 1200 to 1550	1/10	Prismatic Blade	Healy et al. 1996a
Lake Nicaragua Region, Nicaragua	AD 1200 to 1550	6/14	Prismatic Blade (4) and Casual (2)	Lange et al. 1992, Stross et al. 1992
Granada, Nicaragua	AD 800/900 to 1200	--	Casual	Braswell et al. 2002

Relative concentrations of obsidian increased during the Cocal Period. Prismatic blade cores and projectile points remained rare, whereas bladelets became the "overwhelming trade commodity unit" (Healy 1984b:349). Blades in general are more common in Postclassic Lower Central America. Although the number of blades at a site decreases with distance from an obsidian source, reflecting dyadic down-the-line exchange (Braswell 2010), their consistent presence within lithic assemblages suggests that prismatic blades met a consistent technological or prestige-based need of Lower Central American communities (Healy et al. 1996a). Mexican obsidian was introduced to the Maya area and Lower Central America during the Late Postclassic along the Pacific coast (Braswell 2003), but other than a piece of green obsidian on the Bay Islands (Wells and Figuero 2009) and one piece of Otumba within the Guadalupe sample, there are no reports of Mexican obsidian in northeast Coast – perhaps reflecting participation in a Caribbean trade route.

1.3 Obsidian Artifacts in Mesoamerica

At the site of Quelepa in El Salvador, using material analysis and architectural evidence, Braswell and others argue that “highly stable economic boundary [existed] between southeastern Mesoamerica and lower Central America [at the site of Quelepa], lasting from the Late Formative through the Late Classic period.” (Braswell et al. 1994:188). South and east of the porous Mesoamerican boundary, different geographical and political landscapes produced different stone tool industries in response to local conditions (Sheets 2003). Obsidian was traded over hundreds of kilometers (Braswell 2003). Sidrys observed that increasing “‘ceremonialism’ at a site… is apparently related to an increase in trade activity for obsidian.” (1976:454) In the Formative through Classic Period, obsidian is typically found in elite contexts and offerings, suggesting a prestige/ritual element to its use (Clark 1987). Obsidian was not widely accessible to non-elites until the Late Classic and Postclassic Periods (Aoyama 2001).

Blade technology fluoresces in the Formative Period, but never completely replaces flake technologies (Clark 1987). Local material is often used in domestic contexts even when of exceedingly poor quality (e.g., Dahlin et al. 2011). In many places the obsidian industry was secondary to chert or other more accessible raw materials (McAnany 1988). Although some blades do enter commoner spheres through redistribution or markets, they are not abundant until the Postclassic (Sidrys 1976). Prismatic blade industries have advantages; they are efficient in their use of raw material, have two long cutting edges to easily alternate between scraping and cutting, may be retouched into other formal tools, and 100 blades can be produced within an hour. Despite these advantages, prismatic blades are fragile. Dorsal ridges are difficult to remove, and may limit the size of any tools made from a blade. The process is not flexible or transportable (Sheets and Muto 1972, Patterson 1979, Clark 1987).

A prismatic core is prepared by producing a flat platform, either smashing a nodule on an anvil or removing of a flat platform flake. Direct percussion shapes the core, removing cortex and straightening the edges. Blades are removed using a crutch with the core held securely in the feet. The core is continuously rotated to maintain the same angle and pressure. Blades reduce in size as reduction continues (Clark 1985, Crabtree 1968, Hirth 2003a, Sheets 1972). There is regional and chronological variation to blade production; an important diagnostic of the Postclassic period is the grinding of lips and platforms (MacNeish et al. 1967, Sheets 1978).

1.4 Mesoamerican Influence in Honduras

The earliest evidence for occupation within northeast Honduras is at the Cuyamel Caves in Period IV (1000 BC to AD 500), corresponding to the local Cuyamel Period (1650 to 400 BC). These sites are burials with offerings in caves, including Olmecoid bowls suggesting ties, however indirect, with Mesoamerica (Healy 1984c). After IVb (300 BC to AD 500) the region became relatively isolated. Western and central Honduras show sustained interaction with Mesoamerica until the end of Period V (AD 500 to 1000), but any Mesoamerican influence on the development of the northeast was “sporadic and without lasting impact.” (Healy 1992:100)

Honduran elites frequently incorporated foreign traits into existing ideologies (Begley 1999). Central Honduran elites participated in a Mesoamerican interaction sphere, used prestige goods such as prismatic blades, local Ulúa Polychrome and imitations of Maya polychromes, to gain status in local social networks (Joyce 1996). Ballcourts and other architectural templates show that exchanges of ideology and knowledge were more important than exchange of material culture (Begley 1999). Such “symbols [were used] to craft their own distinctive identity” (Cuddy 2007:131). Chiefdoms in central Honduras during Period IV (1000 BC to AD 500) were modest agricultural sites oriented towards Mesoamerican ceramic spheres (Healy 1984a). In Period V (AD 500 to 1000), interaction with the Maya region increased in intensity until the eventual coincident depopulation of the central valleys and Maya lowlands (Healy 1984a, Hirth 1988).

With the increasing importance of importance of long-distance overland and coastal trade, the Maya of Belize encouraged the Bay Islanders to produce and distribute Bay Island Polychrome during the Postclassic (Cuddy 2007, Hirth 1988). Despite this trade with the Bay Islands, Mesoamerican influence on the north coast declines after Period IV (Begley 1999). Honduras as a whole and the northeast in particular began to orient towards Lower Central America (Healy 1984c). In adopting a corporate identity and “a generalized system of domestic subsistence” using resources from the diverse ecology in which these communities were situated (Cuddy 2007: 139), societies in northeast Honduras were more stable than their more complex neighbors to the west. Long-term stability through generalized subsistence and low-level complexity is an adaptive strategy present throughout Lower Central America (Sheets 1992).

If, as Helms (1992) has suggested, Lower Central American chiefdoms were “too far away geographically from the major states of Mesoamerica and the Central Andes to be significantly structurally modified by contacts with these polities, even though bits and pieces of material culture could be avidly sought as long-distance chiefly goods” (Helms 1992:326), then the inhabitants of Guadalupe were making active choices in how to adopt certain traits from the West. Craftsmanship was an expression of power, and prestige goods such as prismatic blades indexed powerful foreign relationships (Clark 1987). Helms suggests (1992) that both political and spiritual relationships were represented through horizontal and vertical redistribution of these goods. This mode of redistribution focused on short-term, local extensions of chiefly connections. Natural limits to the distance of these connections precluded further complexity. Whatever indirect contact with Mesoamerican populations seems to have worked out in favor of the inhabitants of Guadalupe, who were able to make use of fairly low-quality Güinope obsidian within a prismatic-bladelet lithic industry.

2. Sourcing the Obsidian Sample

2.1 Geochemical Sourcing through Multivariate Analysis

The 355 pieces of obsidian were analyzed using a Bruker Tracer III-V pXRF analyzer. The device was mounted face-up with a lead platform attached. This allowed samples to be placed covering the aperture. A lead cap was placed over the sample during analysis to prevent X-rays from escaping. The samples were exposed to an X-ray beam with the setting of 17 keV to 40 keV. This setting was just above the absorption edges of the elements of interest. In this way, the elements from iron (Fe) to molybdenum (Mo) would be excited. The X-ray beam was set to 40kV and 18 µA and passed through the 12 mil Al, 1 mil Ti, 6 mil Cu "green" filter. Each sample was exposed for 180 seconds. Secondary X-rays were counted and processed using the S1PXRF software, then converted into PPM using S1CalProcess, and Excel calibration macro generated by Bruker. PPM were produced for manganese (Mn), iron (Fe), zinc (Zn), gallium (Ga), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Of these, the most useful are Rb, Sr, and Zr, but Fe, Zn, and Y may also be used to assign group membership (Sheets et al. 1990).

Portable X-ray florescence (pXRF) has become an important part of obsidian sourcing studies. Although initially controversial, it has become increasingly recognized that pXRF data, treated with caution, can be used quite effectively in obsidian sourcing studies (Forster and Grave 2012, Johnson 2014, Sheets et al. 1990). Particular concerns include X-ray attenuation, penetration, aperture size, and heterogeneity of samples (Forster and Grave 2012). Elements with low atomic values, such as calcium or potassium, should not be included (Johnson 2014). Using this particular Tracer-III model, Daniels discourages using Mn, Ga, and Th because "Mn is below the optimized level of excitation, Ga often has very low and dubious values, and the L-line of Th may not be accurately detected." Fe was also excluded, because more so than other elements it may vary due to thickness of the sample (2014:65). PPM should not be seen as exact measurements, but rather "inaccurate elemental concentrations that pattern in accurate ways" (Johnson 2014:564). These patterns are not *real*, but they are meaningful (Schulze 2013). Hughes (1998) prefers the term 'chemical group' to 'source,' as it refers to chemical similarity as measured by the instrument, which is not a direct equivalent to the geological source.

After collecting the chemical data, multivariate analyses were performed to determine to which chemical group the artifacts belonged. The reference samples included in these tests were from the Mexican sources of Ucareo, Pachuca, Otumba, Zacualtipan, and Zaragoza, the Guatemalan sources of San Martin Jilotepeque, El Chayal, and Ixtepeque, and the Honduran sources of Güinope and La Esperanza. These reference samples were provided by James Daniels and the UCSD Mesoamerican Archaeology Lab (Daniels 2014).

The first of these tests was to perform a Principal Component Analysis (PCA) on the Honduran samples alone. The purpose of a PCA is to determine the association between different variables (in this case, elemental composition) and possibly identify groups of different composition (Baxter 1994). The elements used in this analyses were Sr, Zr, Zn, Y, Rb and Nb. Using elements with similar energy, such as Rb, Sr, and Zr, will resolve the thickness error

(Sheets et al. 1990). There is a clear separation into at least two different groups (Figure 2). Nb, Zr, Rb, and Sr, are strong drivers in variation

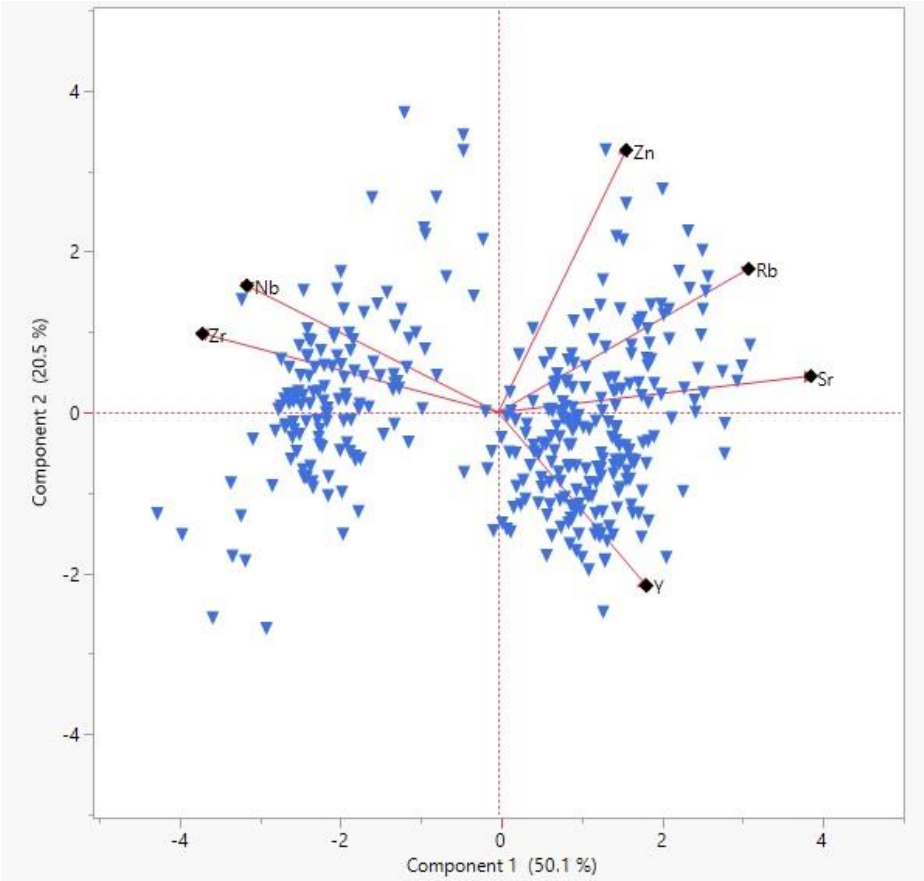

Figure 2. First and second principal components. The first component corresponds to 50.1% of the variation. Sr, Zr, Rb, and Nb are the most significant. The second component corresponds to 20.5% of the variation. Zn and Y are most significant.

Having established that there are at least two groups to be distinguished, the next step was to perform a principal component analysis that included the reference samples. The results of this second PCA are shown in Figures 3. Zacualtipan, Zaragoza, and Pachuca separated from the main cluster. The Guadalupe assemblage seems to cluster around El Chayal, Güinope, and Ixtepeque. Y, Sr, Zr, and Nb are significant drivers of variation.

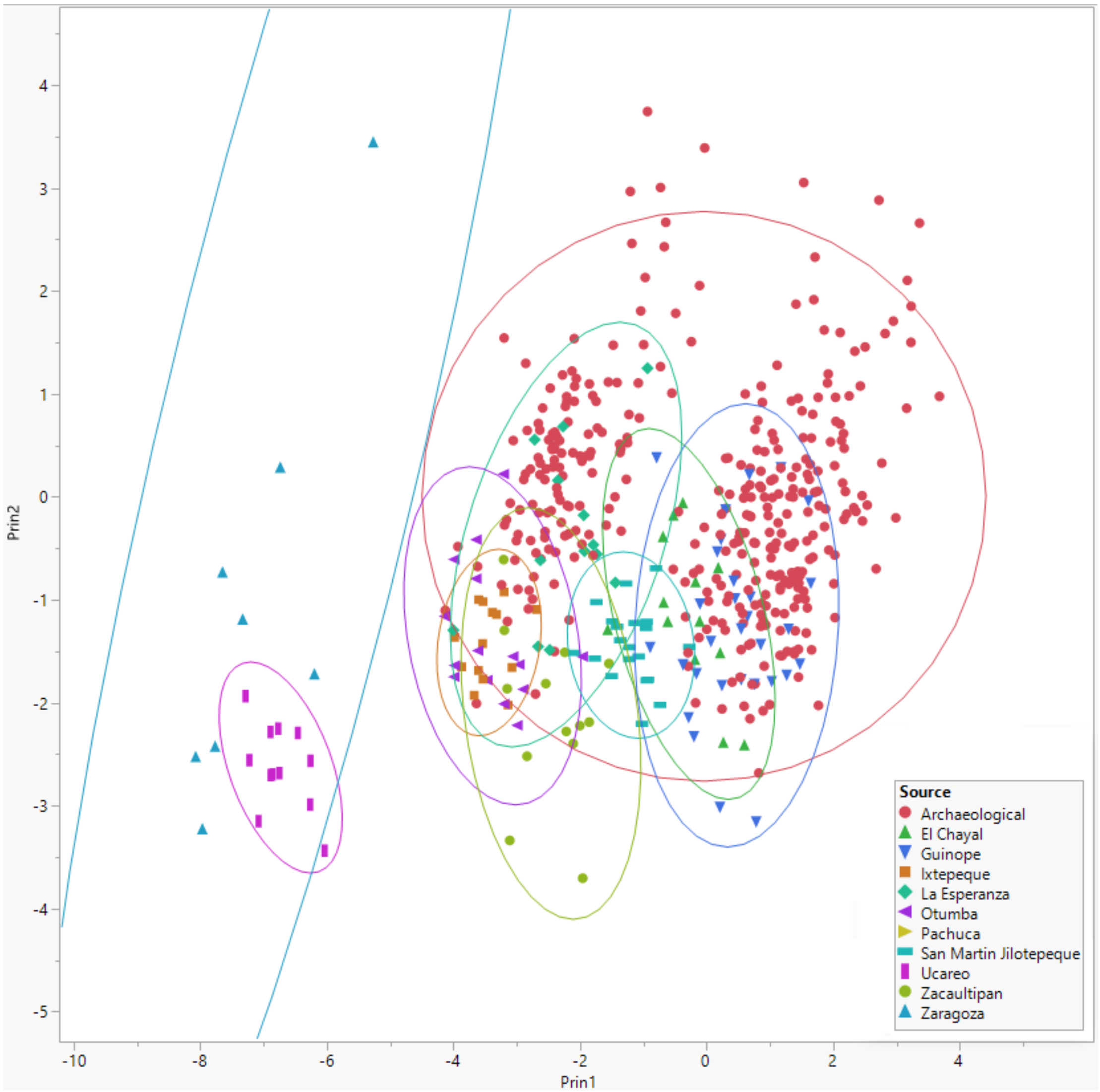

Figure 3. Scatterplot of first and second principal components. Note 95% confidence ellipsoids. Many reference samples separate from the archaeological material. There is considerable overlap between El Chayal, La Esperanza, Güinope, and the archaeological material. The first component corresponds to 64.4% of total variation. Y, Zr, Nb, and Sr are most significant. The second corresponds to 14.9% of total variation. Rb and Zr are most significant.

Based on how the reference collections appeared to group with the archaeological samples, a Mahalanobis distances and a Canonical Discriminant Analysis were performed to assign the material to groups, representing geological sources, based on similarity in relative concentrations of elements. The reference groups used were Güinope, La Esperanza, El Chayal, Ixtepeque, San Martin Jilotepeque and Otumba. The elements included as variables were Zn, Rb, Sr, Y, Zr, and Nb. Mahalanobis distance is a standardization of Euclidian distances that accounts for correlation between variables. A discriminant analysis assigns group memberships to unknown objects based on new variables which best distinguish between known groups (Baxter 1994). The Mahalanobis distance analysis was performed using the program GSRUN and the Canonical Discriminant Analysis using the program JMP.

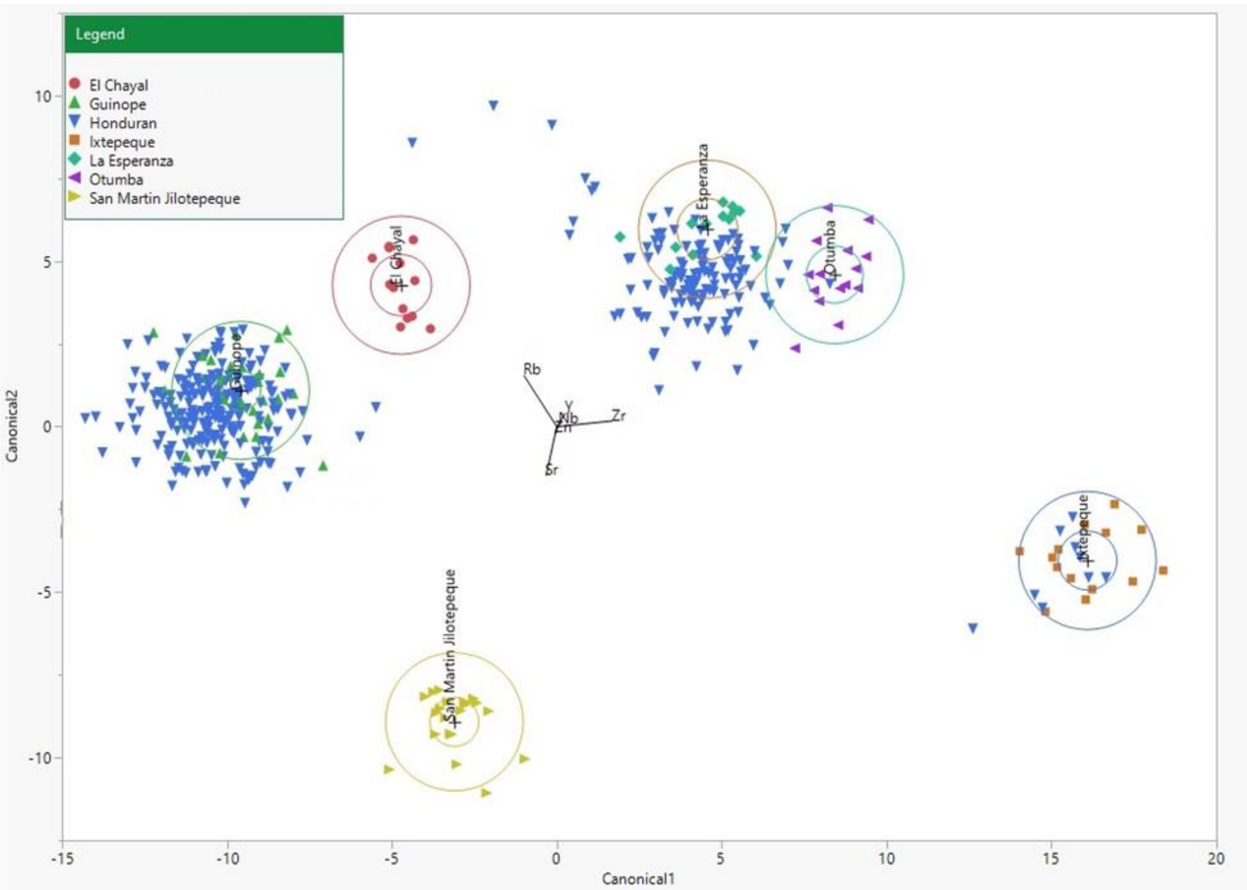

Figure 4. Projection of CDA. As can be seen, none of the Honduran samples seem to be clustering with San Martin Jilotepeque, El Chayal, or Otumba. There is overlap between Güinope and La Esperanza but they seem to pull apart. The Ixtepeque artifacts are quite distinct from each the other groups. Note 95% confidence intervals.

For the most part these two analyses agreed with each other. A summary of group membership results are presented in Tables 3. There was disagreement on 18 pieces (5.07% of the sample), a reminder that such group assignments are based on statistical similarity of measurements reported by an imperfect instrument (Hughes 1998, Johnson 2014, Schulze 2013).

It is necessary to be critical, but not always skeptical, of these group assignments. Disagreements can be resolved through destructive chemical analysis or visual sourcing. Further, the results are still 95% replicable, a fairly standard confidence level for most scientific experiments.

Table 3. Summary of group membership results, not including the Otumba piece, which had to be re-analyzed with the pXRF at a later date and identified as Otumba using JMP.

	GSRUN	JMP
El Chayal	0	2
Güinope	208	220
Ixtepeque	8	9
La Esperanza	138	123

Given the disagreement generated by the different statistical methods, visual sourcing was selected as a method to determine the group membership of those artifacts for which the statistical assignments were in disagreement.

2.2 Visual Sourcing

Visual sourcing is the attribution of provenience based on a reference collection (e.g., Braswell 1997). This is distinct from visual sorting, which is the grouping of an assemblage with an unknown provenience based on visual attributes (e.g., Heller and Stark 1998). Visual sourcing of obsidian was one of the earliest analytical methods available to archaeologists interested in questions of trade, exchange, and mobility (Evans 1928, Xanthudidēs 1924). Cann and Renfrew (1964) proscribe 6 criteria for visual sourcing: color of transmitted light, color of reflected light, fracture, translucency, transparency, and luster. A modified form of these criteria are still used (Braswell et al. 2000). As chemical sourcing became more readily available, visual sourcing was criticized as difficult, subjective, and individually variable (Griffin et al. 1969, Nelson 1989). Nevertheless, accurate and destructive chemical analyses are not always possible, particularly in field conditions or for rare artifacts. Although accurate visual sourcing requires practice, and is improved by access to reference collections, Braswell and others demonstrated (2000) that experienced analysts can have an accuracy rate of up to 95%, with results replicated by different analysts. Despite certain criticisms, visual sourcing remains as valuable a part of an archaeologist's toolkit as typing pottery.

The visual sourcing of the Guadalupe sample required two steps. The first was to do a blind study to evaluate our accuracy. The second was to assign sources to the unknown samples. We had each had the opportunity to examine the sample during the coding process, and were able to describe the visual characteristics of the four sources. Ixtepeque was lustrous and clear, with a dark brown or brown-grey color. When banding was present it was often lighter than the rest of the obsidian. Güinope had luster but was not quite as clear as Ixtepeque. It was often a dark grey or black. Banding was dark, and the obsidian could be milky or cloudy. La Esperanza had a matte or pitted texture, and appeared dirty or "foamy." The color was dark gray/brown, with dark banding. The Otumba piece was quite dark and opaque, but this was likely due to the thickness of the piece.

Fifty-three random samples with secure source assignments were selected. The analysts separately recorded their group assignment on a sheet of paper, and then results were tallied. The results are present in Table 6. The results are kept anonymous. Researcher A had a success rate of 87%, and was biased towards assigning Güinope. Researcher B had a success rate of 76%. Researcher B had some difficulty distinguishing between Ixtepeque and Güinope without banding, but was somewhat consistently erring. There does not appear to be a bias in either direction. Researcher B was biased towards assigning La Esperanza. Researcher C had a success rate of 72%, and was biased towards La Esperanza and underassigning Güinope. Each researcher marked the pieces they were not certain about. If we were to take the uncertain pieces and set them aside for further chemical analysis and assume they were correctly sorted, then Researcher A's success rate becomes 94%, B's 83%, and C's 87%. Rates of accuracy are likely a result of experience.

The next step was to assign group membership to the unknown sources. Once again, each researcher separately recorded their group assignment for each of the unknown pieces. These results were then compared, with the bias of each individual researcher being taken into account, and a final group membership was assigned. These memberships were used in the technological analysis.

Table 4. Visual sourcing of uncertain artifacts. Italicized entries indicate guesses. In the instances where visual sourcing assigned an artifact as Güinope and group membership assigned a source as El Chayal, the Güinope determination was kept without controversy given the close geochemical similarity between the two sources.

Artifact No	A	B	C	XRF	Decision
43-1	Gui	Gui	Ixt	Esp/Ixt	Gui
47-4	Esp	*Esp*	Esp	Esp/Otu	Esp
52-7	Esp	Esp	Esp	Esp/Otu	Esp
7-2	*Gui/Esp*	Esp/Gui	Gui	Gui/Esp	Gui
7-16	Gui	Gui	Esp	Gui/Esp	Gui
7-24	Gui	Gui	Ixt	Gui/Esp	Gui
7-25	Gui	Gui	Esp	Gui/Esp	Gui
9-18	Gui	Gui	Esp	Gui/Esp	Gui
9-22	*Esp/Gui*	Esp	Esp	Esp/Chy	Esp
11-3	Gui	Gui	Esp	Esp/Otu	Gui
11-14	*Gui/Esp*	Gui	Gui	Esp/Chy	Gui
21-5	Gui	Ixt	Ixt	Esp/Gui	Ixt
21-11	Gui	Gui	Gui	Gui/Esp	Gui
21-22	*Gui/Esp*	Gui	Esp	Gui/Esp	Gui
23-10	Gui	Gui	Esp	Gui/Esp	Gui
23-20	Gui	Esp	Esp	Gui/Esp	Esp
31-13	Gui	*Ixt/Gui*	Ixt	Gui/Esp	Gui
16-11	Gui	Gui	Ixt	Esp/Chy	Gui

Although our analysis was not 95% accurate (Braswell et al. 2000), the purpose of visual sourcing was to assign group membership to artifacts of uncertain provenience. Based on these results, we argue for the membership of the above artifacts to certain groups. It is interesting that the discriminate analysis mapped more closely to our visual assessment than did the group membership based on Mahalanobis distances. Visual sourcing will remain the primary way to resolve conflicts in future analyses when destructive analysis is not possible.

2.3 Discussion

As determined by pXRF and confirmed through visual sourcing, the Guadalupe sample consists of 122 pieces from La Esperanza, 223 Güinope, 9 Ixtepeque, and 1 Otumba artifacts. These results are unusual in that the majority of obsidian used in northern Honduras is La Esperanza, with Guatemalan sources such as Ixtepeque occurring relatively rarely (Braswell 2003). In contrast, most artifacts in the Guadalupe sample come from the lower-quality (Sheets et al. 1990) Güinope source. Formal tools of Güinope are uncommon at other sites. Blades may have been produced as part of a bladelet industry, where small cobble-size is not a limitation. Güinope cobbles were consistently larger than Nicaraguan cobbles that were not large enough to foster a blade-core industry (Lange et al. 1992).

3. Technological Analysis

Creating chipped stone tools is a reductive process. Each flake possesses attributes that describe the reduction process, which can be used in a technological analysis (Cotterell and Kamminga 1987, Sanger 1970, Steffen et al. 1998). Lithic analysis is not merely typological, but provides insight into the production process of a series of tools, and how their production and use was incorporated into other aspects of social organization (Shott 1994). Although coding for individual attributes takes more time, it offers a high-resolution approach to stone tool analysis, reduces potential interpretive bias during data-collection, and provides greater flexibility in how the data can be used (Steffen et al. 1998). The obsidian artifacts from Guadalupe were coded for 18 attributes: source, condition, industry, type, series, platform, retouch, lip grinding, cortex, termination, number of dorsal ridges, bulbar scar, cutting edge, length, width, thickness, bulb thickness, and mass. This created a behavioral typology where variation in a lithic assemblage is due to change in activity sets through the intent of the original knapper (Bradley 1975, Collins 1975, Sheets 1975). The artifacts were coded by Luke Stroth and Raquel Otto under the guidance of Geoffrey Braswell.

"Source" refers to the group assignment through the above chemical and visual sourcing: La Esperanza, Güinope, Ixtepeque, or Otumba. "Condition" follows Shott's modification (1994) of Sullivan and Rozen (1985): complete, proximal, medial, or distal fragment. "Industry" refers to the percussion industry or industries to which a piece belonged: casual, bipolar, retouch, or prismatic blade. "Type" refers to the kind of artifact produced through reduction: flake, blade, small percussion blade, core, nodule, or chunk. Blades are flakes that are twice as long as they are wide. Prismatic blades have parallel sides, dorsal ridges, and shallow or absent bulb of percussion (Sheets 1978). "Series" is a category used for prismatic blade artifacts, referring to the first, second, and final series of removal from the core (Clark 1988). First series blades are identified by irregularities and presence of cortex on the dorsal surface which are evidence of the initial shaping of the core (Sheets 1972). Second series blades are identified by regular proximal but irregular or cortical distal ends. Third or final series blades are regular and show no evidence of cortex or core shaping.

"Platform" refers to the treatment during production: absent (broken), plain (unmodified), scratched (little scars on the surface), ground (entire surface is rough), abraded (long, thin, drag marks on surface), crushed, or too-small to identify. "Retouch" was either bifacial or unifacial.

“Lip grinding” is either present or absent. “Cortex” is graded in percentage quartiles of total surface area, not just the dorsal surface (Andrefsky 2005). “Termination” refers to the termination of the flake: broken, feather, step, or hinge. “Number of dorsal ridges” referrs to the total number of dorsal ridges which were at least two-thirds of the total length. “Bulbar scar,” sometimes called an *eraillure* scar, is either present or absent.

“Cutting edge” refers to the total usable cutting edge. For straight-edged artifacts this was measured by holding the calipers along each edge. For irregularly shaped artifacts, a length of string was run around the edge, then straightened and measured (Andrefsky 2005). Length, width, and thickness follow Andrefsky (2005); “length” refers to the path taken by the force as it exited the stone, running in a straight line from platform to termination, even if it is not the maximum linear length. “Width” is the widest point along that axis. “Thickness” is the thickest point perpendicular to the width and length. All measurements are recorded to the nearest tenth of a millimeter. Mass is measured on a scale, and recorded to the nearest tenth of a gram.

The complete sample contained 355 artifacts. 346 of these artifacts were prismatic blades. Other than three projectile points and a complete blade-core, the remaining artifacts belonged to a mix of causal and bipolar industries (Table 5). Some, such as casual flakes produced from exhausted prismatic cores, and prismatic blades retouched into projectile points, belong to more than one industry.

Having collected the metric and technological attributes from each artifact, it was possible to describe variation within the assemblage, and make inferences about the organization of production at Guadalupe. By comparing variations in metric attributes, cortical coverage, and termination, it appears that prismatic blade production occurred using Güinope obsidian. Formal tools and complete blades of La Esperanza and Ixtepeque were imported. Some La Esperanza and Otumba material may have been available for casual and bipolar reduction. A casual industry of Güinope obsidian made use of exhausted prismatic cores.

Table 5. Number of artifacts corresponding to each industry by raw material. Artifacts belonging to more than one industry, such as a projectile point retouched from a prismatic blade, are listed multiple times.

Source	# Artifacts	# Blades	# Casual	# Bipolar	# Formal Tools (non-blade)	# Blade Cores
ESP	122	119	2	1	2	0
GUI	223	218	3	3	1	5
IXT	9	9	0	0	0	0
OTA	1	0	1	0	0	1
Total	355	346	6	4	3	6

3.1 Metrics Attributes by Raw Material

The modal edge, length, width, thickness, and edge/length ratios for each raw material and completeness category are presented in Table 8. When rounded to the nearest millimeter, a chi-squared test rejected the null hypothesis that source and cutting-edge were independent (p-value<2.2e-16), that source and length were independent (p-value<2.2e-16), and that source and width were independent (p-value=0.02874). A chi-squared test did not reject the null hypothesis that thickness and source were independent (p-value=0.7119). Any differences in metric attributes were in terms of millimeters and in the case of thickness in terms of tenths of a millimeter. These slight differences are more likely due to the physical properties of the raw material rather than deliberate technological choices.

Principal component analyses were performed on the metric attributes (edge, length, width, thickness) for each completeness category. Source was not included because an initial round of PCAs consistently separated into groups by raw material, obscuring the impact of metric attributes. Given that there are only 9 complete blades, the results are not robust. Cutting edge and length (consistently >90% correlation between the two) are a consistent source of variation within the sample, although there does not appear to be separation between raw material. Artifacts of similar raw materials did not cluster together, though Güinope and La Esperanza proximal fragments seem to pull away on components 2 (38.3% – low cutting edge/length, high width/thickness) and 3 (9.4% – low width, high thickness, and Güinope and La Esperanza medial fragments pull away on components 2 (29.3% – high width/thickness) and 3 (14.2% – low width/thickness). When only blades were compared, Güinope blades were consistently thinner than the other sources.

An ANOVA was performed to evaluate the extent to which difference between group means were statistically significant. Groups were established by geological source. Width and cutting edge were evaluated separately for complete blades, proximal, medial, and distal fragments. Of the eight tests, only the difference in means in width for both proximal ($p=.00002$) and medial ($p<0.0001$) fragments are statistically significant. Otherwise, differences in metrics are not statistically significant.

There is a strong relationship between cutting edge and length, consistent with the typical observation of cutting edge measuring slightly less than twice the length of the artifact (Sheets and Muto 1972). Several artifacts of Güinope obsidian were cortical along one edge. In these instances, the edge was not measured, reducing the average edge/length ratio. The presence of cortical edges suggests first series blades, and is evidence for production onsite. The most significant difference between raw materials is width, particularly in proximal and medial fragments. Width is more likely to be a result of the starting core size, which will be constrained by the small cobbles in which Güinope is found. In contrast, length is not a very useful metric, as it could be affected by the production sequence – in particular, the snapping of blades to create composite tools. Although a small cobble is a disadvantage when the desired product is a long blade with a cutting edge (Patterson 1979), this is not a disadvantage when the small bladelet is the desired product, as is the case in the Cocal Period (Healy 1984b). This made production using Güinope obsidian viable, although the blades may have been less wide on average.

Table 6. Modal metrics by raw material and completeness. Measurements in millimeters.

Modal Blade				
Source	Edge	Length	Width	Thickness
Esp	84.53	41.9	12.63	3.33
Gui	83.15	42.82	11.18	3.68
Modal Proximal				
Source	Edge	Length	Width	Thickness
Esp	46.13	25.3	12.94	3.71
Gui	49	26.26	10.38	3.34
Ixt	60.1	31.3	11.75	2.75
Modal Medial				
Source	Edge	Length	Width	Thickness
Esp	36.84	19.74	12.42	3.11
Gui	38.44	20.79	10.36	2.8
Ixt	40.44	23.99	11.09	2.94
Modal Distal				
Source	Edge	Length	Width	Thickness
Esp	42.35	22.69	10.78	2.79
Gui	41.65	22.74	9.97	2.93

Frequency graphs were created for all blade artifacts for thickness and width to compare how these metrics were affected by raw material. Width and thickness will both decrease as the core becomes smaller (Sheets and Muto 1972, Sheets 1972), but the maximum width/thickness is still constrained by the starting size of the core, which again is a result of the physical properties of each raw material. These metrics are less affected than length by technological choices, such as snapping complete blades for use as bladelets in composite tools, or accidental breaking by taphonomic processes, and are more useful for showing variation by raw material. Minimum width and thickness are likely unaffected by raw material, as there is only so small a prismatic blade can be before it is not useable (Patterson 1979).

As shown in Figure 5, La Esperanza artifacts were on average wider than Güinope artifacts. This may be a functional constraint of the small size of the Güinope materials; the difference between modal widths is not large but the distributions are skewed left and right, respectively.

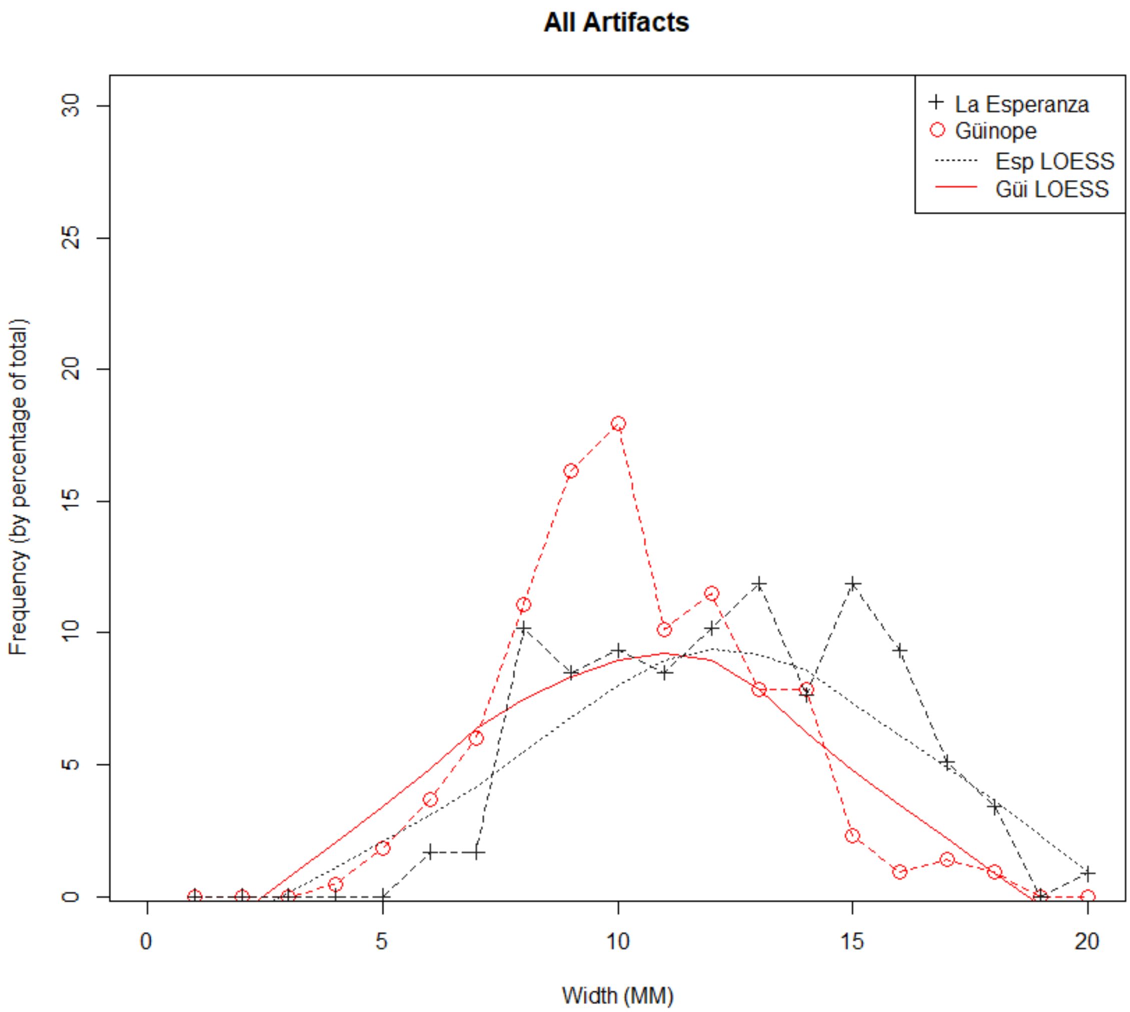

Figure 5. Frequency of observation, in percentage of the total assemblage, of width, rounded to nearest millimeter, of all Güinope and La Esperanza artifacts).

Figure 6 shows that Güinope artifacts were consistently thinner than La Esperanza artifacts, but the differences are slighter than that of width. Though Güinope has a smaller maximum thickness, a blade can only be so small before it cannot be used. For that reason, both distributions are skewed right.

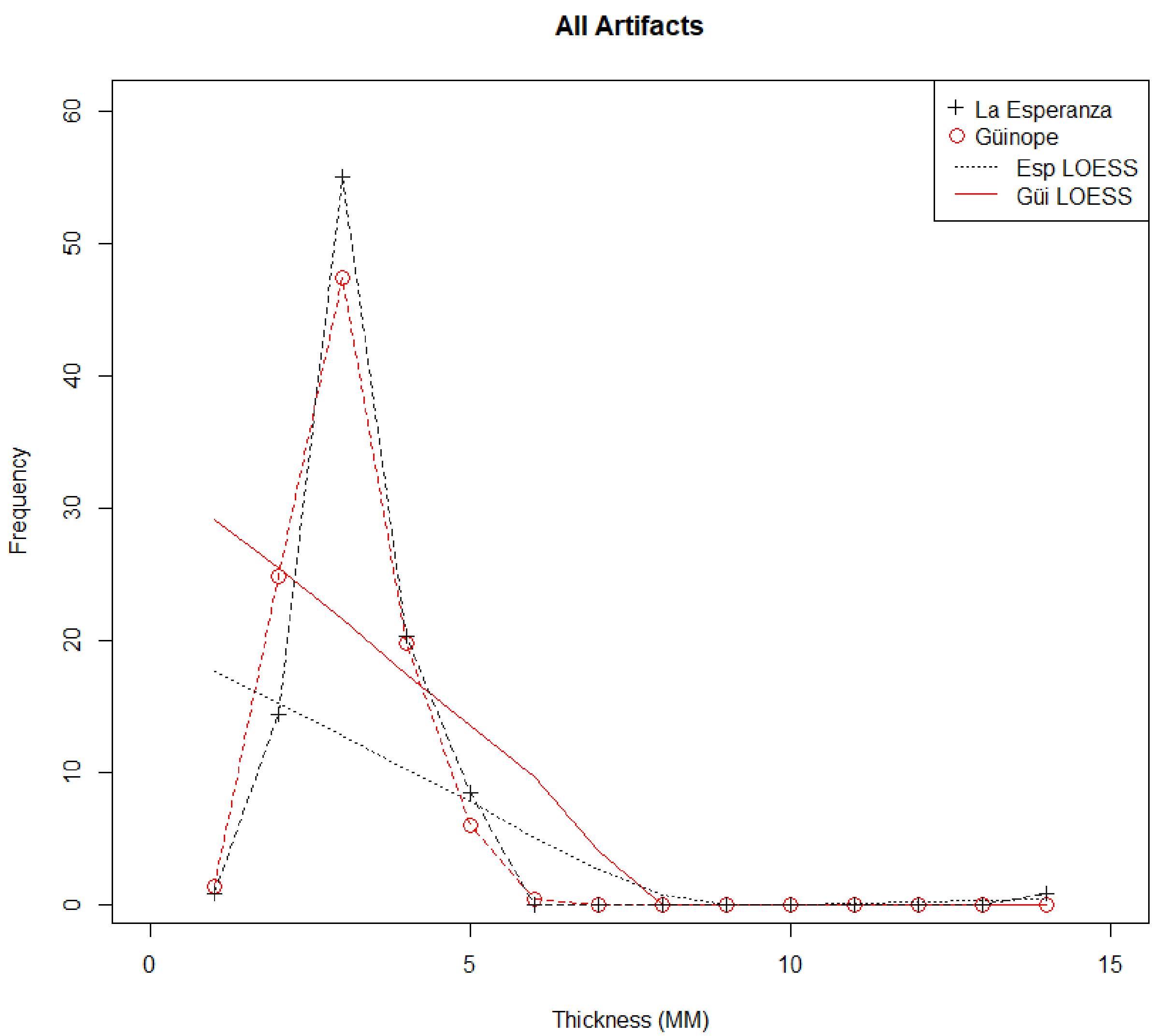

Figure 6. Frequency of observation, in percentage of the total assemblage, of thickness, rounded to nearest millimeter, of all Güinope and La Esperanza artifacts.

3.2 Cortex

Most of the artifacts from Guadalupe have no cortex. Güinope has the most (15.25%) cortical artifacts, as compared to La Esperanza and Ixtepeque (5.74% and 0%, respectively). The presence of cortex on the Güinope material could be evidence of primary production or a result of the small size of cobbles and nodules in which that source is primarily found (Sheets et al. 1990). Smaller cobbles produce artifacts with more cortex, because less cortex can be removed before the piece is unworkable. The percentage of cortex on Güinope material is within the 10.3 to 16.2% range given by Clark (1988:31) as evidence of the reduction of nodules on-site. Cortical artifacts may imply the absence of standardized production or regulation of access to an obsidian source (Sheets 1978), different access to higher and lower quality raw material by social class (Fowler 1991, Sheets 2003), or diachronic variations in availability of raw materials (Andrefsky 1994). The lack of cortex on La Esperanza and Ixtepeque suggests that they were imported in the form of a polyhedral core or finished artifacts (Clark 1988, Aoyama 2017). This follows with the absence of evidence of blade manufacture of La Esperanza or Ixtepeque.

Artifacts with more cortex were consistently thicker, but the two most cortical blades were thinner than average. Similarly, more cortical blades, with the exception of the two most-cortical, were consistently wider. Cortical artifacts occur earlier in the production sequence, and so will be of larger dimensions (Andrefsky 2005). Given that the two most cortical blades are Güinope they may simply come from a smaller initial core, but thin, cortical blades may also be decortication blades, a blade struck during core-shaping to remove cortex from obsidian while still producing a cutting edge (Hirth 2003b).

3.3 Retouch

There are few pieces that show retouch, only 2.25% of all artifacts and 2.69% of all blades (3 unifacially, 6 bifacially). There does not appear to be a retouch industry practiced at Guadalupe. Three projectile points, shown in Figure 7, were likely imported. These formal tools were modified from prismatic blades. One is a small, triangular, side-notched point made of La Esperanza. The base is flat, and appears to have been deliberately snapped. It has been retouched bifacially along the edges and unifacially on the dorsal surface of the base. The second is a small, corner-notched point made of La Esperanza. It has been retouched bifacially along the edges and base. The base has been retouched to be flat. There is a slight curve. The tip is slightly thicker and may have been the bulb of percussion. The third is the basal fragment of a projectile point made of Güinope. The base is concave and has been worked unifacially along the dorsal surface. It is not clear if it was side- or corner-notched as there is a hinge fracture right above the notches. There remains some small cortical coverage on the dorsal surface. Given that La Esperanza artifacts were produced elsewhere, these projectile points were probably also imported.

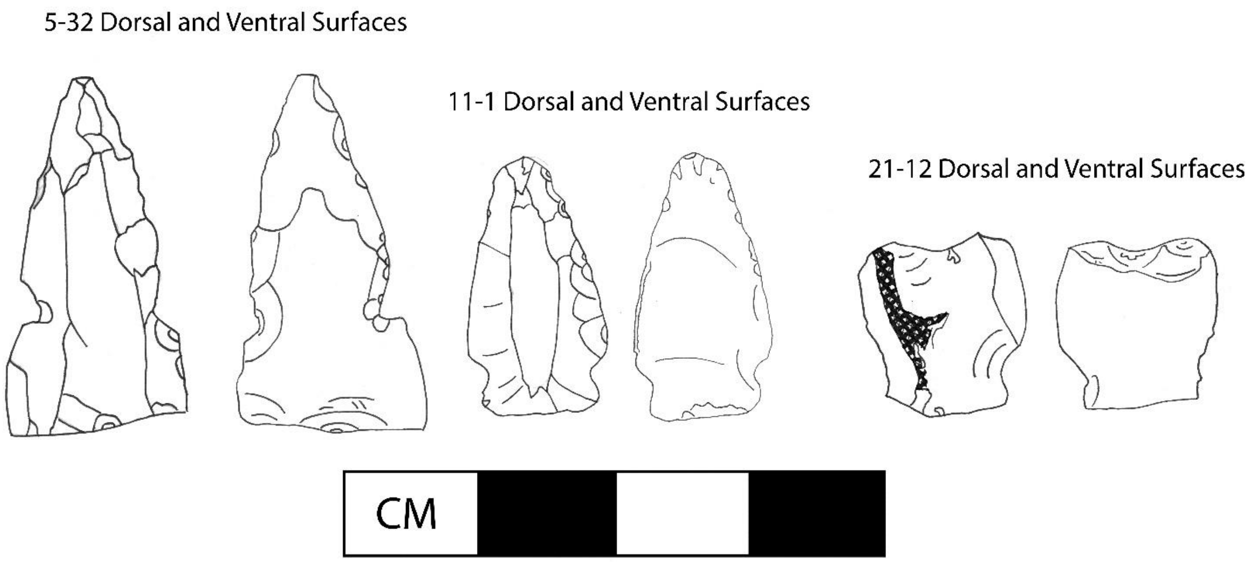

Figure 7. Dorsal and ventral surfaces of formal tools produced from prismatic blades. Centimeter scale.

3.4 Evidence for Production

Figure 8 shows a small core made of Güinope obsidian. The core is hemispherical in cross-section, flat where blades have been struck and cortical on the round surface. It appears that the cortex has been ground and made smooth prior to reduction, with the intention of either removing excess cortex or getting the cobble into the proper shape. Surfaces made rough by human action may sometimes be mistaken for cortex (e.g., Proskouriakoff 1962:431, Sheets 1978:14), but in this instance there is a clear difference between the platform and the cortical surface of the core. The platform is asymmetrical in its final reduction. It is likely that this core began as a small cobble (Sheets et al. 1990). These are not the first Güinope blades that have been reported, but to my knowledge this is the only reported example of a Güinope blade core.

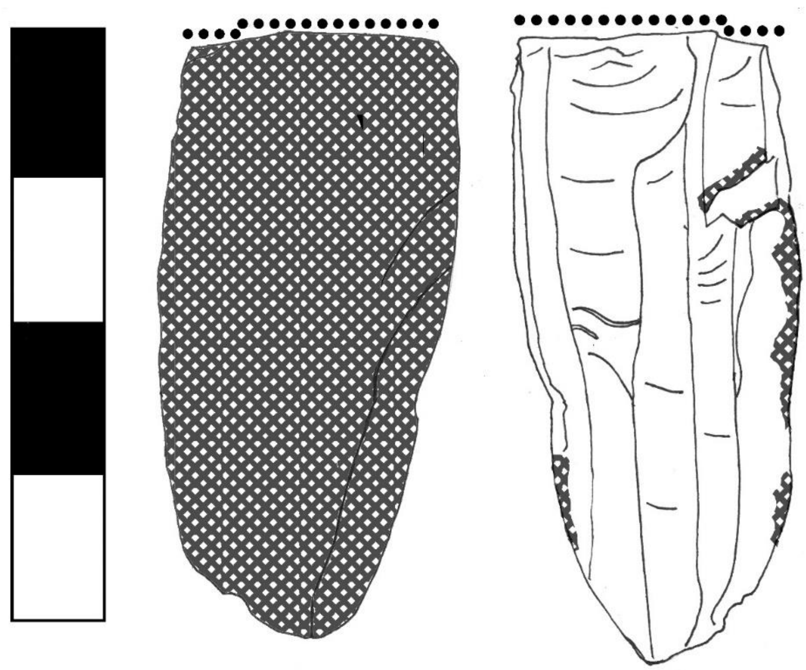

Figure 8. Dorsal and ventral surfaces of the prismatic core made from a Güinope cobble. Centimeter scale.

Figure 9 shows three casual flakes produced from exhausted blade cores, two of Güinope and one of Otumba obsidian. The dorsal surface of these flakes show parallel dorsal scars or ground platforms of the exhausted core. Otumba is a source near Mexico City (Clark 1979), and thus at least one prismatic core was imported a considerable distance, even if through indirect trade. No Otumba blades have yet been identified at Guadalupe.

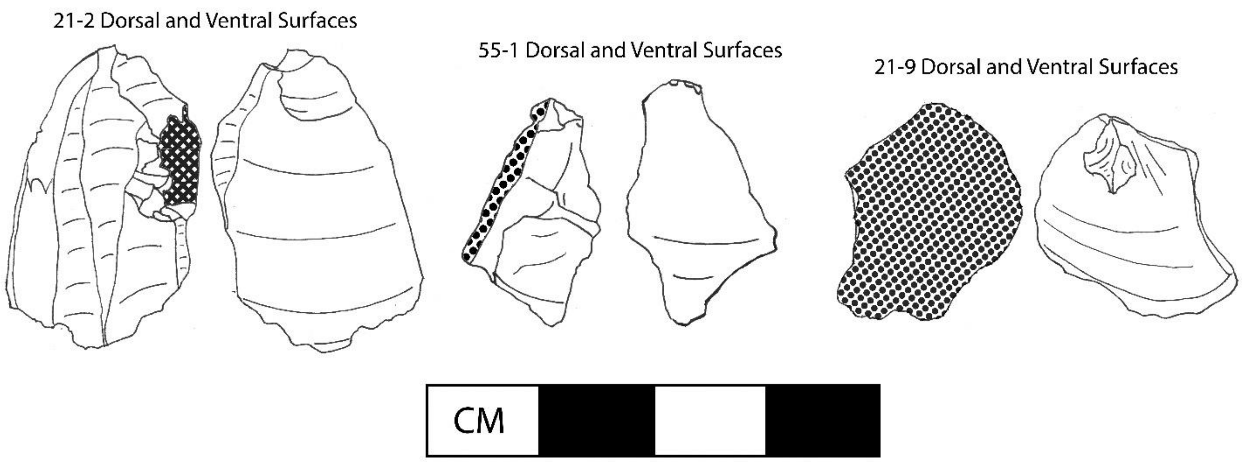

Figure 9. Dorsal and ventral surfaces of casual flakes produced from prismatic cores.

The data from this section was generated in collaboration with Raquel Otto, and will be appearing in her Honors Thesis, *Analisis de la Obsidiana de las unidades dos y tres, del Sitio Guadalupe*, on file at the Department of Anthropology, National Autonomous University of Honduras.

4. Discussion

4.1 Production at Guadalupe

The Güinope core and two casual flakes show that cores were produced of small cobbles and, when exhausted, turned on their side and reduced casually. The cortical side of 5-33 appears to have a blade scar, as if attempting to remove cortex through blade production. Hirth has reported similar behavior at Kaminaljuyu, using the term "decortication blades" (2003b:173, possibly after Clark's decortication flakes; 1988) to describe these artifacts. Macroblades, produced by direct percussion, were used to shape imported cores of El Chayal obsidian at Kaminaljuyu, followed by decortication blades (Hirth 2003b). Given the small size of the nodules at Guadalupe, heavy percussion shaping would remove too much obsidian mass. This may explain why the core was not reduced along its entire circumference. Cores recovered from

Pacific Nicaragua were only found to use 2/3 of the total circumference, perhaps due to inexperience with core-blade technology (Lange et al. 1992:57). Sheets describes 18 cores from the site of Bustamante, El Salvador, which "were not utilized around the entire circumference" (1972:25). Sheets interprets this as incompleteness rather than a deliberate choice.

Another possibility is that cortex was not removed to allow for the holding of the core without having the dorsal ridges cut one's hands (Crabtree 1968). Leaving one side cortical would enable the knapper to hold the core at a constant angle, as suggested by the flat surface (Clark 1985). That being said, a piece of leather would also protect the hands while still enabling the reduction along the full circumference of the core (Whittaker 1994). Flenniken and Hirth (2003) were able to reduce along the entire circumference of a core using handheld percussion.

Pecked-and-ground platforms are diagnostic of the Postclassic (MacNeish et al. 1967, Sheets 1978), but they appear at Xochicalco, Morelos during the Epiclassic (AD 650 to 900; Hirth et al. 2003). The primary source of obsidian in Xochicalco was exhausted cores, which were rejuvenated by pecking and grinding the platform. Ground platforms make it easier to keep a constant angle while producing successive prismatic blades, and reduces the necessary force of initiation (Flenniken and Hirth 2003). Handheld pressure flaking was used, rather than the more-common foot-held Mexica-style of pressure flaking (Hirth et al. 2003). Platform stability is crucial (Clark 1985). The Mexica-style enables more force, but becomes unstable when a core is smaller than 8 cm long or 4 cm in diameter (Flenniken and Hirth 2003). Smaller cores with ground platforms enabled the knapper to hold the core and required less pressure to produce a flake. Although Güinope cores at Guadalupe were reduced from small cobbles, the small core size upon exhaustion (1.76 cm in diameter, 4.02 cm in length) suggests that handheld pressure-flaking was the method used. The primary flakes taken off were decortication blades, to conserve the obsidian.

Modal Ixtepeque proximal fragments were 20 mm longer than Güinope. Although the small Güinope cobble size may have prevented larger outlier blades from being produced, a limitation not shared by the La Esperanza and Ixtepeque source material (Sheets et al. 1990), the Honduran lithic economy favored smaller blades in general. Bladelets were the “overwhelming trade commodity unit.” (Healy 1984b:349) La Esperanza bladelets at Guadalupe were even shorter than Güinope bladelets, despite La Esperanza typically being available in standardized prepared cores (Sheets et al. 1990). Ixtepeque, perhaps given its rarity, was not broken up into bladelets for use of composite tools. The small size of Güinope cobbles was not a limitation for a bladelet industry. When Güinope cores reached a minimum length, they were reduced by causal percussion to produce usable flakes.

It is possible that Otumba obsidian was imported as an exhausted core to be rejuvenated by more conservative flintknappers, who pulled at least one useful flake off the core by casual production. The inhabitants of Guadalupe also used casual and bipolar percussion on Güinope and La Esperanza. The ground platform is identical to 5-33, but given the ubiquity of platform-grinding in the Postclassic (Sheets 1978), until initial series Otumba blades are found at Guadalupe it is safest to assume that 21-9 represents the casual reduction of an imported, exhausted core. McFarlane and Schortman (2017) found that blade workshops in the Lower Cacaulapa Valley imported material from more-distant sources in the form of pre-shaped cores, but were able to produce cores from local material. A similar pattern is present here. Although the full production sequence of Güinope is present at Guadalupe, only the end-products are present for more distant sources.

Despite emphasis on a pan-Mesoamerican model of blade production, the specific reduction sequence is regionally variable (Sanger 1970). Examining differences between regions reveals how local conditions lead to different production techniques (Sheets 2003). Studying differences in production techniques "across materials from distinct sources highlight the importance of recognizing heterogeneity in blade production technologies even within one workshop." (McFarlane and Schortman 2017:592) In northeast Honduras, the focus was on small bladelets (Healy 1984b). Obsidian of any kind is incredibly rare in the earlier Cuyamel (1300 to 400 BC) and Selin (AD 300 to 1000) periods, and does not appear in great quantities until the Cocal (AD 1000 to 1530) period (Healy 1984c). It is likely that Güinope was the only source used to manufacture blades on site.

Güinope blades were prepared with pecked-and-ground platforms at higher rates (93.98%) than La Esperanza (51.61%) or Ixtepeque (50%) blades. Although 9 Ixtepeque artifacts is a small sample size, there is a robust enough sample of La Esperanza to show the differences in platform treatment. I suggest this difference is due to the small size of the cobbles of Güinope being reduced on site. These small cobbles were likely held in hand. The platform was ground to reduce the force of initiation and increase stability (Flenniken and Hirth 2003). The ground platform may also be a result of the grinding of cortex, to reduce the cortex needed to be removed without having to use direct percussion, thereby conserving obsidian.

Termination is an indicator of production. Distal ends are blunt and often removed prior to export. If there are fewer distal ends as compared to proximal or medial fragments, then production may have occurred elsewhere. The overall percentage of broken proximal ends in Ixtepeque and La Esperanza are higher than Güinope. 11.21% of the Güinope material are distal fragments, whereas 9.84% of La Esperanza and 0% of Ixtepeque were distal. 77.78% of the

Ixtepeque material are medial fragments. It appears Ixtepeque blades were well-processed before being imported to Guadalupe. By removing both proximal and distal ends, the final product was a long blade with a cutting edge on both sides that was at least twice as long as any which could be produced from small Güinope cobbles.

In conclusion, there are clear technological differences in how different obsidian sources were used. Güinope blades were thinner, more cortical, and their platforms were typically ground. La Esperanza platforms tended to be ground, but showed a greater diversity of platform types including several scratched and lightly abraded platforms. Güinope artifacts have the most cortex in terms of numbers as well as percentage of total coverage. No distal fragments of Ixtepeque were recovered, suggesting they were manufactured (and the blunt distal ends removed) elsewhere. Ixtepeque blades were longer on average. Although bladelets are the preferred product of the Cocal Period, likely for use in composite tools, there was evidently still a need for longer blades than could be produced from Güinope cobbles.

Obsidian is generally transported in the form of a prepared core rather than nodules, which are too bulky, or complete artifacts, which are too fragile (Braswell and Glascock 2011). Given the lack of evidence for production, few proximal and distal ends, and overall small sample size, Ixtepeque blades were likely imported or transported to the site. La Esperanza offers a large sample size, but few platforms, little cortex, and no blade-cores. Given the fragility of blades, the La Esperanza blades and projectile points were likely produced at a site between the Guadalupe and the original source before being imported or transported to Guadalupe. There are no Otumba blades at Guadalupe, and so the platform flake may be from an exhausted core that entered the Honduran obsidian trade quite indirectly.

These raw material sources were part of an integrated lithic technology and economy nested in the social organization at Guadalupe. The majority of the sample was Güinope material not because the occupants were settling for less, but because it was a viable source of raw material for the purposes of a bladelet industry. That said, the casual and bipolar production of La Esperanza and Güinope and heavy use-wear on most blades indicates that obsidian remained scarce. To conserve obsidian during production, platforms were ground, and cores were prepared through cortex-grinding and decortication blades. Güinope could be imported in the form of fairly small and easy to transport nodules without the trader requiring knowledge of blade production. La Esperanza and Ixtepeque were imported as finished artifacts, probably from a site in Honduras. La Esperanza was used to produce two formal non-blade tools, and Güinope one. The size of the original core is a limiting factor on the production of formal tools (Patterson 1979), but even a small Güinope blade or blade fragment could be retouched into a projectile point or composite tool. Given overall lack of a retouch industry at Guadalupe, it is likely that Güinope blades were produced locally and formal tools were imported. Some longer Güinope blades may also have been imported.

4.2 Formal Tools

Small, side-notch points are first introduced to the Maya region in the Postclassic (Chase and Chase 1988), although Mexican projectile points appear at Copán at the very end of the Classic Period (Aoyama 2005). Limited use of these items by elites may have been common in the Classic Period but the technology did not appear in earnest until the Postclassic. Dart points and other bifaces are still used until the contact period (Simmons 1995). Biface production and projectile points of Mexican obsidian are present throughout the Classic Period (Aoyama 2005). The technology may have been introduced through trade with or migration of Mexican peoples, including Mexicanized Maya (Proskouriakoff 1962). These side-notched points were common during the Colonial Period in the Southern Lowlands (Simmons 1995), and are still used by modern-day Lacadon Maya people (Meissner and Rice 2015). Small, side-notched points were typically retouched unifacially, sometimes bifacially from thin, longitudinally-curved chert flakes or prismatic blades (Marino et al. 2016, Proskouriakoff 1962, Shafer and Hester 1988). They are considered to be characteristic of the Postclassic and Colonial Periods (Simmons 1995). Projectile points were created within local production spheres, using raw material readily available. Some centers also received projectile points through trade (Meissner 2017). Points had multiple uses in hunting and ritual. In addition to stone arrowheads, blunt wooden arrows and bolts may have been used (Meissner and Rice 2015).

La Esperanza obsidian was available to the inhabitants of Guadalupe, but it does not appear that any production using this raw material, especially of projectile points, occurred at the site. Formal tools and projectile points made of obsidian in Lower Central America are generally rare (Braswell 2003). At Chalchuapa, El Salvador, unifacially-retouched projectile points are found in the Late Classic and Postclassic periods (Sheets 1978). South of Honduras, projectile points are less common. Dart points are found in Panama as part of a South American subsistence package that prioritizes darts and blowguns over the bow and arrow (Cooke 1984, Ranere and Cooke 1996). The projectile points at Guadalupe were likely based on the point technology ubiquitous throughou Mesoamerica during the Postclassic, but hunting and fishing was not as important a component to Cocal Period subsistence (Healy 1984b). The fact that most of these points were made of La Esperanza, and absence of a Güinope retouch industry onsite, suggests imports rather than local production.

5. Conclusion

Prior to the Cocal Period, obsidian is quite rare in northeast Honduras. The lithic industries in the Selin Period primarily consisted of groundstone artifacts. Projectile points and cores were rare, with bladelets being the primary form in which obsidian was found. Obsidian decreases in abundance the further it is from the sources being exploited, which are typically the Honduran sources of La Esperanza and Güinope. La Esperanza is typically found in a more Mesoamerican (prismatic blade) industry and Güinope more casually, though there are some examples of Güinope blades recovered from Honduras and Nicaragua. The results of this lithic analysis present new information about a Honduran blade industry based on exploiting small cobbles of Güinope obsidian. Though Healy and others speculate that there may be an intermediate between Mesoamerica and the Intermediate Area to supply prismatic blades to less-complex societies (1996b), by the Cocal Period at least Guadalupe was able to produce blades and possibly supply them to Honduras and Lower Central America.

Heavy pecking and grinding of the platform and presence of arrow point technology are reliable indicators of the Terminal or Postclassic periods (Aoyama 2005, Sheets 1978). Cortical coverage may be related to standardization of production but is also a result of the functional constraints of cobble size (Aoyama 2017, Clark 1988). It has been argued that certain levels of complex political organization and economic centralization were required to develop and maintain a prismatic blade industry (Clark 1987), but less-complex societies and chiefdoms without access to raw material are able to participate in the extended trade network of prismatic blades (Braswell et al. 2002, Lange et al. 1992).

It is appropriate to orient the site of Guadalupe towards a Mesoamerican lithic industry. Although there are no Mesoamerican ceramics in northeast Honduras after the Formative Period

(Healy 1992), it is likely that Guadalupe was able to take advantage of circum-Caribbean trade that was taking place during the Postclassic, as evident by the copper artifacts. During the Postclassic, metallurgical traditions were present in the Yucatán, Belize, and Maya Honduras (Hosler 1994, Meanwell et al. 2013, Simmons and Shugar 2013, Urban et al. 2013). The copper bell and needle at the site suggests that the inhabitants of Guadalupe traded with sites within either the Mesoamerican or Columbian metalworking sphere. The former is more likely given that these are made of copper, not gold, and do not display Colombian iconography (Hosler 2003, Graham 1996). Trade with Belize is almost certain given the presence of Honduran ceramics at Moho Cay (Otto 2017, personal comm) and importance of coastal trade in the Postclassic (Chase and Rice 1985, Smith and Berdan 2003). Obsidian alone does not make Guadalupe a Mesoamerican site; even sites in Nicaragua imported obsidian. Further, the majority of the material comes from Honduras, not a highland Guatemalan or Central Mexican source. Although not a Mesoamerican site, the local variations on prismatic blade production shows that Mesoamerican technologies were integrated into the local lithic industry.

One remaining question is the source of the Güinope blades present at the site of Selin Farm during the Basic Selin phase (Healy et al. 1996b). Pre-Cocal occupation of Guadalupe has not been established (though further excavations at Guadalupe will likely find early occupations; Reindel and Fecher 2016), so this site is not the source for all Güinope blades in Lower Central America. Thus, while certain innovations are present at Guadalupe to make the most of the raw material, they did not necessarily originate there. There may instead have been an intensification and possibly centralization of blade production during the Cocal Period (Healy 1984b). This method of production may have been introduced to the north coast through the growth of coastal trade within the increasingly integrated Postclassic Mesoamerica. In the Granada region of the

Gran Nicoya, sustained trade with and immigration of Mesoamerican peoples during the Bagaces period precedes an increase in the use of obsidian during the Postclassic. Similar to Honduras, in the Gran Nicoya region there is a change from importing to manufacturing obsidian blades (Carmack and Salgado González 2006, Valero Lobo and Salgado González 2000).

At Guadalupe, the technology may have been a local adoption of a foreign idea. Lange and others emphasize the lack of Mesoamerican architecture in Pacific Nicaragua (1992), suggesting a limit to the role played by Mesoamerican immigrants in fostering blade industries. Begley argues that even the presence of Mesoamerican-style ballcourts in eastern Honduras represent a deliberate adoption of certain aspects of ideology over others (1999). Regular trade and exposure to technology, rather than Mesoamerican expatriates, may be responsible for the spread of a prismatic blade industry. The production of Ixtepeque blades in Pacific Nicaragua by AD 800 (Salgado González and Vázquez Leiva 2006) predates even the early date given by McCafferty and Steinbrenner (2005) for the arrival of the Nicarao in AD 1200. Circum-Caribbean trade produced less marked cultural changes than population movements, but enabled the circulation of lithic technologies such as prismatic blades and side-notched projectile points.

Mesoamerican stratified societies were known to sponsor blade production (Clark 1987). At least chiefdom-level complexity was known to exist on the northeast coast at the time of contact (Cuddy 2007, Healy 1992), but the technological analysis alone does not show if the industry at Guadalupe was under direct elite control. Further analysis of the spatial contexts from which these materials have been recovered may reveal the organization of production. The presence of copper bells and greenstone indicates both mercantile engagement and prestige items. Elites may have imported higher quality obsidian from Ixtepeque and La Esperanza, while organizing the production and distribution of lower-quality blades of Güinope. The bipolar and casual industries of La Esperanza and casual reduction of exhausted Güinope show a tendency to conserve and recycle material. The majority of the blades of all raw material show extensive use-wear, similar to other assemblages in Lower Central America where obsidian is scarce (Healy 1990). Production of blades on-site was conservative with raw material. Complete blades of La Esperanza and Ixtepeque were imported, but cores were not. Although Güinope nodules are not local to the region, their abundance in alluvial and colluvial deposits may make them fairly easy to gather and transport north. Whereas importation of La Esperanza cores would require that they were prepared at the source before transportation, Güinope cobbles could be gathered by itinerant merchants or groups with no knowledge of blade production themselves. The inhabitants of Guadalupe made the most of the material available, both through casual percussion of exhausted material and innovations within the prismatic blade industry.

With the chemical sourcing of over 350 obsidian artifacts from the north coast of Honduras, the presence of Güinope blade production, long predicted by other scholars, has finally been found. This is an exciting time for Central American archaeology, where long-standing gaps are being filled in and anthropological questions can be asked alongside culture-historical ones. Lithic economy nests within social and political organization. Assessing one provides insights into the other. As work continues at Guadalupe, and the rest of Honduras, it is possible to situate decisions regarding lithic technology in their social and historical contexts.

Bibliography

Andrefsky, William J.
1994 Raw-Material Availability and the Organization of Technology. *American Antiquity* 59(1):21-34

Andrefsky, William J.
2005 *Lithics: Macroscopic approaches to analysis*, 2nd Ed. Cambridge University Press, Cambridge.

Aoyama, Kazuo
1994 Socioeconomic Implications of Chipped Stone from the La Entrada Region, Western Honduras. *Journal of Field Archaeology* 21(2):133-145.

Aoyama, Kazuo
2001 Classic Maya State, Urbanism, and Exchange: Chipped Stone Evidence of the Copán Valley and Its Hinterland. *American Anthropologist* 103(2):346-360.

Aoyama, Kazuo
2005 Classic Maya Warfare and Weapons: Spear, dart, and arrow points of Aguateca and Copan. *Ancient Mesoamerica* 16(2):291-304.

Aoyama, Kazuo
2017 Preclassic and Classic Maya Interregional and Long-Distance Exchange: A diachronic analysis of obsidian artifacts from Ceibal, Guatemala. *Latin American Antiquity* 76(2):213-231.

Baxter, M. J.
1994 *Exploratory Multivariate Analysis in Archaeology.* Edinburgh University Press, Edinburgh.

Begley, Christopher Taylor
1999 *Elite Power Strategies and External Connections in Ancient Eastern Honduras*. Unpublished Doctoral Dissertation. Department of Anthropology, the University of Chicago.

Bradley, Bruce A.
1975 Lithic Reduction Sequences: A glossary and discussion. In *Lithic Technology: Making and using stone tools*, edited by E. Swanson, pp. 1-13. Mouton Publishers, Paris.

Braswell, Geoffrey E.
1997 E1 intercambio comercial entre los pueblos prehispan icos de Mesoamerica y la Gran Nicoya. *Revista de la Universidad del Valle de Guatemala* 7:17-29.

Braswell, Geoffrey E.
2003 Obsidian Exchange Spheres. In *The Postclassic Mesoamerican World*, edited by M. E. Smith and F. F. Berdan, pp. 131-158. The University of Utah Press, Salt Lake City.

Braswell, Geoffrey E.
2010 The Rise and Fall of Market Exchange: A dynamic approach to ancient Maya economy. In *Archaeological Approaches to Market Exchange in Ancient Societies*, edited by C. P. Garraty and B. L. Stark, pp. 127-140. University of Colorado Press, Boulder.

Braswell, Geoffrey E., John E. Clark, Kazuo Aoyama, Heather I. McKillop and Michael D. Glascock

2000 Determining the Geological Provenance of Obsidian Artifacts from the Maya Region: A test of the efficacy of visual sourcing. *Latin American Antiquity* 11(3):269-282.

Braswell, Geoffrey E. and Michael D. Glascock

2011 Procurement and Production of Obsidian Artifacts at Calakmul. In *The Technology of Maya Civilization: Political economy and beyond in lithic studies*, edited by Z. X. Hruby, G. E. Braswell, and O. C. Mazariegos, pp. 119-129. Equinox Publishing, Oakville, CT.

Braswell, Geoffrey E., E. Wyllis Andrews V, and Michael D. Glascock

1994 The Obsidian Artifacts of Quelepa, El Salvador. *Ancient Mesoamerica* 5(2):173-192.

Braswell, Geoffrey E., Silvia Salgado González, Laraine A. Fletcher, and Michael D. Glascock

2002 La Antigua Nicaragua, la periferia sudeste de Mesoamérica y la región maya: interacción interregional (1-1522 d.C.). *Mayab* 15:19-39.

Cann, J. R. and Colin Renfrew

1964 The Characterization of Obsidian and its Application to the Mediterranean Region. *Proceedings of the Prehistoric Society* 30:111-133.

Carmack, Robert M. and Silvia Salgado González

2006 A World-Systems Perspective on the Archaeology and Ethnohistory of the Mesoamerican/Lower Central American Border. *Ancient Mesoamerica* 17(2):219-229.

Chase, Diane Zaino and Arlen Frank Chase

1988 *A Postclassic Perspective: Excavations at the Maya site of Santa Rita Corozal, Belize*. Pre-Columbian Art Research Institute, San Francisco.

Chase, Arlen F. and Prudence M. Rice

1985 *The Lowland Maya Postclassic*. University of Texas Press, Austin.

Clark, John E.

1979 A Specialized Obsidian Quarry at Otumba, Mexico: Implications for the study of Mesoamerican obsidian technology and trade. *Lithic Technology* 8(3):46-49.

Clark, John E.

1985 Platforms, Bits, Punches, and Vises: A potpourri of Mesoamerican blade technology. *Lithic Technology* 14(1):1-15.

Clark, John E.
1987 Politics, Prismatic Blades, and Mesoamerican Civilization. In *The Organization of Core Technology*, edited by J. K. Johnson and C. A. Morrow, pp. 259-284. Westview Press, Boulder.

Clark, John E.
1988 *The Lithic Artifacts of La Libertad, Chiapas, Mexico: An economic perspective.* Paper No.52. New World Archaeological Foundation. Provo, Utah.

Coe, Michael D.
1962 Costa Rican Archaeology and Mesoamerica. *Southwestern Journal of Anthropology* 18(2):170-183.

Collins, Michael B.
1975 Lithic Technology as a Means of Processual Inference. In *Lithic Technology: Making and using stone tools*, edited by E. Swanson, pp. 15-34. Mouton Publishers, Paris.

Cooke, Richard
1984 Archaeological Research in Central and Eastern Panama: A review of some problems. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 263-302. University of Mexico Press, Albuquerque.

Cotterell, Brian and Johan Kamminga
1987 The Formation of Flakes. *American Antiquity* 52(4):675-708.

Crabtree, Don E.
1968 Mesoamerican Polyhedral Cores and Prismatic Blades. *American Antiquity* 33(4):446-478.

Creamer, Winifred
1987 Mesoamerica as a Concept: An archaeological view from Central America. *Latin American Research Review* 22(1):35-62.

Creamer, Winnifred and Jonathan Haas
1985 Tribes versus Chiefdoms in Lower Central America. *American Antiquity* 50(4):738-754.

Cuddy, Thomas W.
2007 *Political Identity and Archaeology in Northeast Honduras*. University Press of Colorado, Boulder.

Dahlin, Bruce H., Marjukka Bastamow, Timothy Beach, Zachary X. Hruby, Scott R. Hutson, and Daniel Mazeau

2011 Phantom Lithics at Chunchucmil, Yucatán, Mexico. In *The Technology of Maya Civilization: Political economy and beyond in lithic studies,* edited by Z. H. Hruby, G. E. Braswell, and O. C. Mazariegos, pp. 76-86. Equinox Publishing, New York.

Daniels, James T.

2014 Nondestructive Geophysical and Archaeometric Investigations at the Southern Belize Sites of Lubaantun and Nim li Punit. Unpublished Master's Thesis. Department of Anthropology. University of California, San Diego.

Daniels, Jr., James T. and Geoffrey E. Braswell

2014 Procurement, Production, and Distribution of Obsidian in the Southern Belize Region. *Resesarch Reports in Belizean Archaeology* 11:289-296.

Dennett, Carrie Lynd

2007 The Rio Claro Site (AD 1000-1530), Northeast Honduras: A Ceramic Classification and Examination of External Connections. Unpublished Master's Thesis. Department of Anthropology. Trent University.

Drennan, Robert D.

1996 Betwixt and Between in the Intermediate Area. *Journal of Archaeological Research* 4(2):95-132.

Evans, Arthur

1928 *The Palace of Minos: A comparative account of the successive stages of the early Cretan civilization as illustrated by the discoveries at Knossos.* 2(1): *Fresh lights on origins and external relations: the restoration in town and palace after seismic catastrophe towards close of M. M. III, and the beginnings of the new era.* Biblo and Tannen, New York City.

Flenniken, J. Jeffrey and Kenneth G. Hirth

2003 Handheld Prismatic Blade Manufacture in Mesoamerica. In *Mesoamerican Lithic Technology: Experimentation and interpretation*, edited by K. G. Hirth, pp. 98-107. The University of Utah Press, Salt Lake City.

Forster, Nicola and Peter Grave

2012 Non-destructive PXRF analysis of museum-curated obsidian from the Near East. *Journal of Archaeological Science* 39:729-736.

Fowler, Jr., William R.

1991 Lithic Analysis as a Means of Processual Inference in Southern Mesoamerica: A review of recent research. In *Maya Stone Tools: Selected papers from the second Maya* *lithic conference*, edited by T. R. Hester and H. J. Shafer, pp. 1-19. Prehistory Press, Madison.

Graham, Mark Miller
1996 Merchants and Metalwork in Middle America. In *Paths to Central American Prehistory,* edited by F. W. Lange, pp. 237-252. University Press of Colorado, Niwot.

Griffin, James B., A. A. Gordus and G. A. Wright
1969 Identification of Sources of Hopewellian Obsidian in the Middle West. *American Antiquity* 34(1):1-14.

Hammond, Norman
1972 Obsidian Trade Routes in the Mayan Area. *Science* 178(4065):1092-1093.

Healy, Paul F.
1984a The Archaeology of Honduras. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 113-161. University of Mexico Press, Albuquerque.

Healy, Paul F.
1984b The Prehistory of Northeast Honduras: Cultural change on a Pre-Columbian Mesoamerican Frontier. *Research Reports – National Geographic Society* 16:339-358.

Healy, Paul F.
1984c Northeast Honduras: A Pre-Columbian frontier zone. In *Recent Developments in Isthmian Archaeology: Advances in the prehistory of Lower Central America*, edited by F. W. Lange, pp. 227-241. B.A.R. Publishing, Oxford.

Healy, Paul F.
1990 *The Archaeology of the Rivas Region, Nicaragua*. Wilfrid Laurier University Press, Waterloo, Ontario.

Healy, Paul F.
1992 Ancient Honduras: Power, wealth, and rank in early chiefdoms. In *Wealth and Hierarchy in the Intermediate Area: A symposium at Dumbarton Oaks 10th and 11th October 1987*, edited by F. W. Lange, pp. 85-108. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Healy, Paul F., Frank Asaro, Fred Stross, and Helen Michel
1996a Precolumbian Obsidian Trade in the Northern Intermediate Area: Elemental analysis of artifacts from Honduras and Nicaragua. In *Paths to Central American Prehistory*, edited by F. W. Lange, pp. 271-284. University Press of Colorado, Niwot.

Healy, Paul F., Frank Asaro, Fred Stross, and Helen Michel
1996b Prehistoric obsidian trade in Honduras and Nicaragua. In *Chieftains, Power, & Trade: Regional interaction in the Intermediate Area of the Americas*, edited by C. H. Langebaek and F. Cardenas-Arroyo, pp. 13-30. Departamento de Antropologia, Universidad de los Andes, Bogota, Colombia.

Heller, L., and B. L. Stark
1998 Classic and Postclassic Obsidian Tool Production and Consumption: A Regional Perspective from the Mixtequilla, Veracruz. *Mexicon* 20:l l 9-128.

Helms, Mary W.
1992 Thoughts on Public Symbols and Distant Domains Relevant of the Chiefdoms of Lower Central America. In *Wealth and Hierarchy in the Intermediate Area: A symposium at Dumbarton Oaks 10th and 11th October 1987*, edited by F. W. Lange, pp. 317-329 Dumbarton Oaks Research Library and Collection, Washington, D.C.

Hirth, Kenneth G.
1988 Beyond the Maya Frontier: Cultural interaction and syncretism along the central Honduran corridor. In *The Southeast Classic Maya Zone*, edited by E. H. Boone and G. R. Willey, pp. 297-334. Dumbarton Oaks, Washington, D.C.

Hirth, Kenneth G.
2003a Experimentation and Interpretation in Mesoamerican Lithic Technology. In *Mesoamerican Lithic Technology: Experimentation and interpretation*, edited by K. G. Hirth, pp. 3-9. The University of Utah Press, Salt Lake City.

Hirth, Kenneth G.
2003b The Kaminaljuyu Production Sequence for Obsidian Prismatic Blades: Technological characteristics and research questions. In *Mesoamerican Lithic Technology: Experimentation and interpretation*, edited by K. G. Hirth, pp. 170-181. The University of Utah Press, Salt Lake City.

Hirth, Kenneth G., Bradford Andrews, and J. Jeffrey Flenniken
2003 The Xochicalco Production Sequence for Obsidian Prismatic Blades: Technological analysis and experimental inferences. In *Mesoamerican Lithic Technology: Experimentation and interpretation*, edited by K. G. Hirth, pp. 182-196. The University of Utah Press, Salt Lake City.

Hosler, Dorothy
1994 *The Sounds and Color of Power: The sacred metallurgical technology of ancient West Mexico.* The MIT Press, Cambridge, MA.

Hosler, Dorothy

2003 Metal Production. In Smith, M.E. and F.F. Berdan (editors): *The Postclassic Mesoamerican World*. The University of Utah Press, Salt Lake City. pp 159-171.

Hughes, Richard E.
1998 On Reliability, Validity, and Scale in Obsidian Sourcing Research. In *Unit Issues in Archaeology: Measuring time, space, and material*, edited by A. F. Ramenofsky and A. Steffen, pp. 103-114. The University of Utah Press, Salt Lake City.

Johnson, Jack
2014 Accurate Measurements of Low Z Elements in Sediments and Archaeological Ceramics Using Portable X-ray Fluorescence (PXRF). *Journal of Archaeological Method and Theory* 21(3):563-588.

Joyce, Rosemary A.
1996 Social dynamics of exchange: Changing patterns in the Honduran archaeological record. In *Chieftains, Power, & Trade: Regional interaction in the Intermediate Area of the Americas*, edited by C. H. Langebaek and F. Cardenas-Arroyo, pp. 31-45. Departamento de Antropologia, Universidad de los Andes, Bogota, Colombia.

Lange, Frederick W., Payson D. Sheets, Anibal Martinez, and Suzanne Abel-Vidor
1992 *The Archaeology of Pacific Nicaragua*. University of New Mexico Press, Albuquerque.

Lange, Frederick W. and Doris Z. Stone
1984 Introduction. In *The Archaeology of Lower Central America*, edited by F. W. Lange and D. Z. Stone, pp. 3-12. University of Mexico Press, Albuquerque.

Lara Pinto, Gloria and George Hasemann
1988 La Sociedad Indígena del Noreste de Honduras en el Siglo XVI: ¿Son la etnohistoria y la arqueología contradictorias? *Yaxkin* 9(2):5-28.

Linares, Olga F.
1979 What is Lower Central American Archaeology? *Annual Review of Anthropology*. 8:21-43.

MacNeish, Richard S., Antoinette Nelken-Terner, and Irmgard W. Johnson
1967 *The Prehistory of The Tehuacan Valley Volume Two: Nonceramic Artifacts.* University of Texas Press, Austin and London.

Marino, Marc D., Lucas R. Martindale, and Nathan J. Meissner
2016 Postclassic Tool Production at Santa Rita Corozal: Implications for domestic craft production and regional exchange in flaked stone. In *Perspectives on the Ancient Maya of*

Chetumal Bay, edited by D. S. Walker, pp. 251-263. University Press of Florida, Gainesville.

McAnany, Patricia
1988 The Effects of Lithic Procurement Strategies on Tool Curation and Recycling. *Lithic Technology* 17(1):3-11.

McCafferty, Geoffrey G. and Larry Steinbrenner
2005 Chronological Implications for Greater Nicoya from the Santa Isabel Project, Nicaragua. *Ancient Mesoamerica* 16(1):131-146.

McFarlane, William John
2005 *Power Strategies in a Changing World: Archaeological investigations of early Postclassic remains at El Coyote, Santa Barbara, Honduras*. Ph.D. Dissertation, Department of Anthropology, State University of New York at Buffalo. UMI Microfilms.

McFarlane, William J. and Edward M. Schortman
2017 Prismatic Blade Production in the Lower Cacaulapa Valley, Honduras: Implications for a Late Classic political economy. *Latin American Antiquity* 28(4):577-598.

Meanwell, Jennifer L., Elizabeth H. Paris, Wilberth Cruz Alvarado, and Carlos Peraza Lope
2013 Metallurgical ceramics from Mayapán, Yucatán, Mexico. *Journal of Archaeological Science* 40:4306-4318.

Meissner, Nathan J.
2017 A Social Network Analysis of the Postclassic Lowland Maya Obsidian Projectile Industry. *Ancient Mesoamerica* 28(2):137-156.

Meissner, Nathan J. and Prudence M. Rice
2015 Postclassic Petén Maya Bow-and-Arrow Use as Revealed by Immunological Analysis. *Journal of Archaeological Science* 64:67-76.

Messenger, Jr., William C.
1991 Climatic Settings and Prehistoric Social Complexity: The Central American Isthmus. In *The Formation of Complex Society in Southeastern Mesoamerica*, edited by W. J. Fowler, Jr., pp. 237-275. CRC Press, Boca Raton.

Nelson, Fred W.
1989 Resumen de los métodos analíticos usados en la identificación de yacimientos y artefactos de obsidiana. In *La Obsidiana en Mesoamerica*, edited by M. Gaxiola and J. E. Clark, pp. 21-25. Instituta Nacional de Antropología e Historia. Mexico, DF.

Patterson, L. W.
1979 Limitations in Uses of Large Prismatic Blades. *Lithic Technology* 8(1):3-5.

Proskouriakoff, Tatiana
1962 The Artifacts of Mayapán. In *Mayapán, Yucatan, Mexico*, edited by H. E. D. Pollock, pp. 327-432. Carnegie Institution of Washington, Washington, D.C.

Ranere, Anthony J. and Richard G. Cooke
1996 Stone Tools and Cultural Boundaries in Prehistoric Panamá: An initial assessment. In *Paths to Central American Prehistory*, edited by F. W. Lange, pp. 49-77. University Press of Colorado, Niwot.

Reindel, Markus and Franziska Fecher
2016 Proyecto Arqueológico Guadalupe: Temporada de 2016. Informe preliminar sobre la excavación en el sitio arqueológico de Guadalupe, Departamento Colón

Salgado González, Silvia
1996 The Ayala Site: A Bagaces Period site near Granada, Nicaragua. In *Paths to Central American Prehistory*, edited by F. W. Lange, pp. 191-219. University Press of Colorado, Niwot.

Salgado González, Silvia, and Ricardo Vázquez Leiva
2006 Was there a Greater Nicoya Subarea during the Postclassic? *Vínculos: Revista de Antropología del Museo Nacional de Costa Rica* 29(1-2):1-16.

Sanger, David
1970 Mid-Latitude Core and Blade Technologies. *Artic Anthropology* 7(2):106-114.

Schulze, Niklas
2013 How “Real” Does it Get? Portable XRF analysis of thin-walled copper bells from the Aztec Templo Mayor, Tenochtitalan, Mexico. In Shugar A.N. and S.E. Simmons (editors): *Archaeometallurgy in Mesoamerica: Current Approaches and New Perspectives*. University Press of Colorado, Boulder. pp 203-226.

Shafer, Harry J. and Thomas R. Hester
1988 Preliminary Analysis of Postclassic Lithics. In *A Postclassic Perspective: Excavations at the Maya site of Santa Rita Corozal, Belize*, edited by D. Z. Chase and A. F. Chase, pp. 111-117. Pre-Columbian Art Research Institute, San Francisco.

Sheets, Payson D.
1972 A Model of Mesoamerica Obsidian Technology Based on Preclassic Workshop Debris in El Salvador. *Ceramica de Cultura Maya* 8:17-33.

Sheets, Payson D.

1975 Behavioral Analysis and the Structure of a Prehistoric Industry. *Current Anthropology* 16(3):369-391.

Sheets, Payson D.
1978 Part One: Artifacts. In *The Prehistory of Chalchuapa, El Salvador, Volume Two: Artifacts and Figurines*, edited by R. J. Sharer, pp. 2-107. University of Pennsylvania Press, Philadelphia.

Sheets, Payson D.
1992 The Pervasive Perjorative in Intermediate Area Studies. In *Wealth and Hierarchy in the Intermediate Area: A symposium at Dumbarton Oaks 10th and 11th October 1987*, edited by F. W. Lange, pp. 15-41. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Sheets, Payson D.
1994 Chipped Stone Artifacts from the Cordillera de Tilarán. In *Archaeology, Volcanism, and Remote Sensing in the Arenal Region, Costa Rica*, edited by P. D. Sheets and B. R. McKee, pp. 211-254. University of Texas Press, Austin.

Sheets, Payson D.
2003 The Behavioral Model in Maya Core-Blade Technology: A historical view. In *Mesoamerican Lithic Technology: Experimentation and interpretation*, edited by K. G. Hirth, pp. 10-14. The University of Utah Press, Salt Lake City.

Sheets, Payson, Kenneth G. Hirth, Frederick Lange, Frederick Stross, Fred Asaro, Helen Michel
1990 Obsidian Sources and Elemental Analysis of Artifacts in Southern Mesoamerica and the Northern Intermediate Areas. *American Antiquity* 55(1):144-158.

Sheets, Payson D., and Guy R. Muto
1972 Pressure Blades and Total Cutting Edge: An experiment in lithic technology. *Science* 175(4022):632-634.

Shott, Michael J.
1994 Size and form in the Analysis of Flake Debris: Review and recent approaches. *Journal of Archaeological Method and Theory* 1(1):69-110.

Sidrys, Raymond V.
1976 Classic Maya Obsidian Trade. *American Antiquity* 41(4):449-464.

Simmons, Scott E.
1995 Maya Resistance, Maya Resolve: The tools of autonomy from Tipu, Belize. *Ancient Mesoamerica* 6:135-146.

Simmons, Scott E. and Aaron N. Shugar

2013 Archaeometallurgy at Lamanai, Belize: New discoveries and insights from the Southern Maya Lowland Area. In Shugar A.N. and S.E. Simmons (editors): *Archaeometallurgy in Mesoamerica: Current Approaches and New Perspectives*. University Press of Colorado, Boulder. pp 135-159.

Smith, Michael E. and Frances F. Berdan
2003 Postclassic Mesoamerica. In Smith, M.E. and F.F. Berdan (editors): *The Postclassic Mesoamerican World*. The University of Utah Press, Salt Lake City. pp 3-13.

Steffen, Anastasia, Elizabeth J. Skinner, and Peter W. Ainsworth
1998 A View to the Core: Technological units and debitage analysis. In *Unit Issues in Archaeology: Measuring time, space, and material,* edited by A. F. Ramenofsky and A. Steffen, pp. 131-146. The University of Utah Press, Salt Lake City.

Strong, William Duncan
1973 Anthropological Problems in Central America. In *The Maya and their Neighbors: Essays on Middle American anthropology and archaeology,* edited by C. L. Hay, pp. 377-385. Cooper Square Publishing, Inc. New York.

Stross, Fred, Frank Asaro, Helen Michel, Payson D. Sheets, and Fred Lange
1992 Elemental Analysis of Obsidian Samples from Pacific Nicaragua and from Northwest Costa Rica, and comments. In *The Archaeology of Pacific Honduras*, edited by F. W. Lange, P. D. Sheets, A. Martinez and S. Abel-Vidor, pp. 119-134. University of New Mexico Press, Albuquerque.

Sullivan, III, Alan P. and Kenneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50(4):755-779.

Urban, Patricia, Aaron N. Shugar, Laura Richardson, and Edward Schortman
2013 The Production of Copper at El Coyote, Honduras: Processing, Dating, and Political Economy. In Shugar A.N. and S.E. Simmons (editors): *Archaeometallurgy in Mesoamerica: Current Approaches and New Perspectives*. University Press of Colorado, Boulder. pp 77-112.

Valero Lobo, Wilson and Silvia Salgado González
2000 Análisis de las Industrias Líticas del Sitio Ayala, Región de Granada, Pacifico de Nicaragua (300-1500 A.C.) *Vínculos: Revista de Antropología del Museo Nacional de Costa Rica* 25(1-2):77-95.

Wells, Christian E., and Alejandro J. Figuero

2009 El Antigual, a Postclassic Hilltop Settlement on Roatan Island, Honduras. Paper Presented at the 74th Annual Meeting of the Society for American Archaeology, Atlanta, Georgia.

Whittaker, John C.
1994 *Flintknapping: Making and understanding stone tools*. University of Texas Press, Austin.

Xanthudidēs, Stéphanos A.
1924 *The Vaulted tombs of Mesará: An account of some early cemetaries of southern Crete*. Translated by J. P. Droop. University Press of Liverpool, London.