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THE CONTROL OF OBSIDIAN BLADES AT SAN LORENZO

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ABSTRACT

Several theories have been proposed for the use of obsidian blades discovered at the Olmec site of San Lorenzo. One theory is that the blades were used by social elites as a means of establishing their dominance over the non-elites (Clark 1987). An alternative theory is that social status had little to do with the acquisition and distribution of prismatic blades and that the blades indicate a domestic economy model (De León 2008). This thesis applies a geographic approach using GIS to new data from San Lorenzo and seeks to examine a possible relationship between elite social status and obsidian blade location.
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Coming into my senior year at Penn State I knew that I would write a thesis on archaeology. I also knew that I wanted to expand my knowledge of Mesoamerica, since my previous studies had focused on Old World cultures. To accomplish this, I approached Dr. Kenneth Hirth simply with the proclamation; I’m interested in learning about Mesoamerica for my honors thesis. Within hours I received an email back from Dr. Hirth explaining a project that dealt with analyzing lithic distributions at San Lorenzo. From there on, Dr. Hirth helped me find articles, edit materials, brainstorm ideas, and much more in order that I may accomplish my goal. Without him, none of this would have been possible. Without him, I would not have been able to accomplish my goal of learning about a new civilization in my senior year. For this I owe him my upmost gratitude and respect as both an academic and mentor.

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Introduction

Since the inception of the profession, Archaeologists have made considerable advancements in realizing the importance of analytical data that can augment the understanding of artifacts (Trigger 2006). Analytical data have gradually expanded to include a wide variety of data sources including environmental information, deposition patterns, and soil chemistry. Expansion in the types of data collected have not only been precipitated by a change in theory but also an expansion in the capabilities of technology. Archaeologists now have far greater access to a greater array technology than was only dreamed of in the recent past.

One technology that has recently come to the forefront of archaeological investigation is Geographic Information Systems (“GIS”). GIS permits archaeologists to examine certain hypotheses, which previously would have taken weeks, months, or even years to calculate by more traditional means. When used effectively to add new information, GIS can greatly improve our understanding of researched subjects through enhanced pattern recognition. This approach allows for the examination of archaeological data in a spatial context. This new information allows us to examine previously held hypothesis in new ways and to raise many new questions. The effective application of GIS in archaeology, provides the academic an enhanced understanding of the geography of the world that was once inhabited by their subjects of interest.

The objective of this thesis is to use GIS and Spatial data to augment with a previously examined inquiry. The goal is, to evaluate whether geographical information can be used to examine theories about acquisition of obsidian prismatic blades, among other obsidian objects, at the Olmec site of San Lorenzo. De León (2008) proposes a model of individual household procurement of obsidian blades proposed hypothesis. In contradiction to the model proposed by Clark (1987), in which Political Economy was the dominant force in obsidian blade
De León’s dissertation presents compelling information in support of this hypothesis but lacks a truly geographical approach to the problem. The additional evidence presented by this thesis supports his hypothesis, while empirically rejecting the likelihood for many other hypotheses. The discussion of how I intend to demonstrate this will be discussed later in this thesis. Firstly, it is essential that a geographical setting be presented representing the physical world of the Olmec.
The Geography of San Lorenzo

The site of San Lorenzo is located in Coatzacoalcos River drainage of southern Veracruz (Clark 2007). Prior to human occupation, the area was likely a heavily forested tropical jungle that the Olmec would have utilized a variety of ways (Cyphers 1996:61-63). The two geographical features that have been most influential in shaping the San Lorenzo site are the low plateaus, where the settlement congregated throughout the Early Formative period, and the relationship that the site had to the surrounding rivers.

Figure 1: Map of the region of San Lorenzo (From Symonds 2000: Fig 17)
The Plateau

George Kroster was the first to map the plateau on which San Lorenzo is located. Kroster did this at the bequest of Michael Coe and which required considerable effort to accomplish. The effort exerted on this process was rewarded when Coe’s team discovered that the plateau was a manmade formation. Previous investigations led by Stirling, believed the plateau was natural features whose surfaces were the result of mostly natural processes (Coe and Diehl 1980:27). Coe’s interpretations were based on the observation that some of the ridges seem to mirror each other. He believed that this was unlikely to have occurred naturally and must have been shaped by the inhabitants of San Lorenzo (Breiner and Coe 1972:1). The amount of labor, organization and planning necessary to modify the natural plateau of San Lorenzo surpasses that of other monumental sites, elsewhere in Mesoamerica during pre-Columbian times (Cyphers 1996). The current total estimated settlement area on the artificial plateau during the San Lorenzo phase, and its surrounding area was approximately 500 ha (Symonds et al. 2002:66). Unfortunately, erosion has obscured what is observable on the plateau today.

Figure 2: Topographic map of San Lorenzo plateau demonstrating the possible extent during the San Lorenzo Phase (From Symonds et al. 2002: Figure 67)
The Rivers

The other defining geographic features of San Lorenzo include the water bodies of the Río Coatzacoalcos, the Río Chiquito, and the Río Tatagapa. The rivers’ locations are what likely determined the settling of the plateau during the Initial Formative period and possibly helped the site rise to prominence. The original reason for the site’s location may have also been to establish a settlement above the flooding level at about the 24 meter contour, yet close enough to the river to benefit from its many advantages (Coe and Diehl 1980:19-20). The first of these is the rich wet lands around the site which provide residents with an important array of subsistence resources. Coe (1994:69) views these wetlands differently and feels that that the control of these lands permitted the production of an agricultural surplus that allowed for the elite to ascend to power creating non-egalitarian culture. Secondly, the river provides a means of trade, communication, and transportation that allowed to the Olmecs to flourish and to develop into a complex society (Cyphers 1996). Whatever was most beneficial to the inhabitants of San Lorenzo is not critical to this discussion. The key point is that the site and its inhabitants were shaped by the rivers that cut oxbow lakes across the landscape. It has been suggested that the rivers were so important to life at San Lorenzo that a change in the rivers due to volcanic uplift helped to end its dominance around 900 B.C.E (Cyphers 1996).

The next section outlines the occupational history of San Lorenzo as revealed by archaeological research.
Historical Background

In 1945 Matthew W. Stirling and Philip Drucker explored San Lorenzo Tenochtitlán for the Smithsonian Institution and the National Geographic Society (Stirling 1947, 1955). During their tenure at the site, they discovered many of the large basalt monuments which now characterize San Lorenzo. However, according to Coe and Diehl (1980), little attention was paid to analyzing the rest of the data. By not considering the other data, Stirling and Drucker created a situation that allowed for “unfounded speculations … as to the age and nature of Olmec Civilization” (Coe and Diehl 1980:23).

This situation warns us of what can develop if a phase or period is discussed in isolation. In order to develop context for this discussion, and to avoid falling into the same trap I present, a general discussion of all relevant periods and phases of occupation found at San Lorenzo. These include the Initial (c. 1600-1200 B.C.E), Early (c. 1200-900/800 B.C.E) and Middle Formative (c. 900-600 B.C.E) periods (Evans 2004). Each of these contains several phases that will be discussed in order of their appearance, with the earliest coming first (Table 1).
The first occupation phase at San Lorenzo is the Ojochi phase. This phase lasted between 1500-1350 B.C.E, and is identified by several different ceramic types such as Camano Coarse, Moral Buff to Cream, and Chaya Punctate (See Coe and Diehl 1980:137-143). Most notably occurring during this period was the formation of a three tiered settlement system. This created the possibility of the formation of a tribute system (De León 2008; Symonds et al. 2002). Archaeological evidence at San Lorenzo from this phase is relatively sparse (Coe and Diehl 1980:137). Data from El Manatí however, located 18 km to the Southwest of San Lorenzo, provides good archaeological evidence about the people of this time period.
Favorable anaerobic conditions present at El Manatí have preserved unparalleled biological remains, creating a dynamic environment where archaeologists are able to retrieve a variety of organic artifacts that would not have persisted elsewhere in the region. These artifacts were deposited ritually and can be split up into three time phases; Manatí A (c. 1700 – 1500 B.C.E.), Manatí B (c. 1500 – 1400 B.C.E.), and Macayal A (c. 1400 – 1200 B.C.E) (Pool 2007:95; Ortiz and Rodríguez 2000; Rodríguez and Ortiz 2005). Of these phases, Manatí B and the beginning of Macayal A are contemporary with the Ojochi phase at San Lorenzo. Several rubber balls were discovered in the Manatí B phase that were approximately 20 cm in diameter. These rubber balls demonstrate that even in the Ojochi phase, the pre-Olmecs were playing the ball game that would become widespread across Mesoamerican culture (Pool 2007:96). From the Macayal A phase, the most compelling find was the discovery of wooden busts. According to Pool (2007), these busts “exhibit the typical cylindrical head deformation and down-turned mouths of Olmec figurines” (97). El Manatí clearly provides a tradition for the monumental sculptures associated with later phases at San Lorenzo. El Manatí provides historical background about the Olmec that would not be possible with only an exclusive examination of the large site of San Lorenzo.

Figure 3: Four wooden sculptures that were found preserved at El Manatí (From Ken Garrett)
The Bajío Phase

The Bajío phase is when widespread occupation first occurred at San Lorenzo. This phase lasted from approximately 1350 - 1250 B.C.E and there is evidence of occupation during this phase throughout much of the site. However, the Bajío phase has not been the focus of extensive study, though there were several important developments during this phase. For example, Coe (1981) claims that during this phase large quantities of material were used to fill in depressions on the plateau and the long ridges were constructed. This indicates that Bajío phase leaders had enough authority to mobilize labor to produce large public works (Diehl 2004; Clark 2007). The ceramic assemblage also changed from the Ojochi phase. Several pottery and manufacturing techniques carried over from the previous phase including Camano Coarse, Chaya Punctate, and Centavito Red. The manufacturing techniques associated with ceramics of this period include vertical grooving and gardrooning. There were also several new additions to the ceramic assemblage during this phase which include bottles, black-and-white pottery, Hernandez Punctate, Embarcadero Zoned which resembles South America ceramic complexes and the appearance of the first hollow baby figurines (Coe and Diehl 1980:143-144). The Bajío phase witnessed the beginnings of traditions that would survive throughout the Early Formative period.

The Chicharras Phase

The Chicharras phase, which lasted from c. 1250 – 1150 B.C.E, is fundamental to the emergence of the Olmec at San Lorenzo. Furthermore, this phase catalyzed new material traditions similar to the artistic contributions to the Olmec culture found at El Manatí. One of the most profound changes was an almost complete transformation of ceramic assemblage. The Chicharras phase ceramic assemblage consists of very few carryovers, including Camano Coarse
and Achiotal Gray. Many new pottery types appeared at this time including Xochiltepec White, Monjonera Black, and Tatagapa Red (Coe and Diehl 1980:150-151).

Changes also occurred in artistic traditions. Art had previous been restricted to relatively small materials such as wood and ceramics. In the Chicharras phase the artistic media expanded to include monumental stone sculptures. The archaeological evidence to support this claim derives from Coe’s (1980) discovery of a fragment of monumental art in Chicharras phase deposits (Figure 4). He proposes this fragment is the earliest example of a monumental sculpture at San Lorenzo (Coe and Diehl 1980:256). Clark suggests that the first kings of San Lorenzo were established during this phase (See Clark 2007:41). However, this early date for monumental Olmec sculpture has remained somewhat controversial (Pool 2007:133-134; cf. Lowe 1989; Hammond 1989).

Figure 4: Fragment suggesting evidence of monumental sculpture during the Chicharras phase (Coe and Diehl 1980: 246)
Sudden changes in pre-Olmec occupation at San Lorenzo have led some to suggest that site growth was not autochthonous. Scholars have suggested possible alternative heartlands for the Olmecs. Some of the places that have been suggested are: Morelos (Piña Chan 1955); Guerrero (Covarrubias 1957; Gay 1973; Griffin 1981); and Oaxaca (Wicke 1971) (See Pool 2007:18). Cyphers (1996:65-67) however, supports the autochthonous theory and that it was the local coalescence of power at San Lorenzo that led to the rise of the Olmec. During the Bajío phase a major transformation occurred to the people of San Lorenzo, redefining their culture. With little doubt, it seems that the inhabitants of the Chicharras phase were the same people that occupied the site during its approaching apogee.

**The San Lorenzo A and San Lorenzo B Phases**

The San Lorenzo period phases are San Lorenzo A (c. 1150 – 1000 B.C.E.) and San Lorenzo B (c. 1000 – 850 B.C.E.) (De León 2008; Cyphers 2008). Throughout these two phases, there is an explosion of archaeological evidence of an Olmec state. Major supporting evidence for this comes from an increase in both population size and a large number of basalt sculptures. Further evidence of state formation can be derived from population distributions, craft specialization, and trade (Clark 2007).

Population evidence comes from the dramatic increase in the population that inhabited the San Lorenzo region (Coe 1981:19; Clark 2007:26). A spike in population growth saw population rise to approximately 13,644 people during the San Lorenzo phases. This is a twenty-fold increase over population projections during pre-Olmec times. This coincided with about a tenfold increase in the area of San Lorenzo to approximately 500 ha (Symonds et al. 2002:57-58; Clark 2007:25-26). From its population and size San Lorenzo was clearly a location of great importance.
Another well cited piece of evidence for state formation during this period is the creation of colossal heads, which have become synonymous with Olmec art and culture. These colossal heads and many other basalt monuments are difficult to date due to the fact that they are often found out of context. While there is some evidence of monumental sculpture during the Chicharras phase, it clear that by the San Lorenzo A phase, the Olmec were creating these impressive works. The overwhelming majority of the sculptures were sculpted before c. 900 B.C.E. (Coe and Diehl 1980:294-295). These monuments were produced at considerable expense because of the difficulty in transporting basalt blocks, from the Tuxtla Mountains located 60 km away, as well as the cost of supporting specialist masons (Clark 2007:28; Heizer 1962). Also constructed at this time were elite structures such as the Red Place (Cyphers 1996:65-67). The formation of an elite material culture at San Lorenzo will be analyzed in a later section of this thesis.

Figure 5: The monument known as EL Ray is the largest head that thus far has been found and San Lorenzo (Coe and Diehl 1980: 23)
The Nacaste Phase

The final phase of interest to this thesis is the Nacaste phase. This is the period over which the Olmecs of San Lorenzo suffered a period of significant decline (c. 850 B.C.E – 700 B.C.E). According to Cyphers, during this phase the site suffered a significant population loss, which remained low until the Classic period (1996). Coe and Diehl suggest the site was violently destroyed based on an abrupt change in the ceramic record (1980:188); interestingly this hypothesis is not widely supported by a majority of scholars. After this phase, power shifted to La Venta. Several aspects of San Lorenzo Olmec culture are continued during this period such as basalt sculpture although considerable changes also occurred in carving style and beginning of pyramid construction, including the monumental Great Pyramid at La Venta (see Drucker et al. 1959)

During the San Lorenzo A and San Lorenzo B phases, a concentration of power occurred to create what has classically been called Olmec culture and will be the focus of this thesis. The next section will provide a brief background as to archaeological investigations at San Lorenzo.
The Archaeological Investigations of San Lorenzo

Excavations at San Lorenzo have not been continuous. Research has been led by three teams of scholars and has extended over sixty years. The first academic to investigate the site was Matthew Stirling in the 1940s. Stirling’s investigations were followed in the 1960s, by Michael Coe who led a team from Yale University to examine the site. After an extended hiatus of field work at San Lorenzo Ann Cyphers took over investigations at San Lorenzo which have continued since the early 1990s.

The first archaeological group that investigated San Lorenzo and the surrounding sites was led by Matthew Stirling and Phillip Drucker. These archaeological investigations were conducted with the support of the Smithsonian Institution and National Geographic Society in 1945 and 1955 (Coe and Diehl 1980:23; Stirling 1947, 1955). The goal of their work was to examine the chronology of the Olmec in relation to the ancient Maya. We know that Stirling and Drucker were dedicated Olmequisitas due to their deep-seated belief in the antiquity of the Olmec over the Maya. To establish a chronology, they examined many Olmec sites throughout the region, attempting to form a complete picture of the civilization, not just San Lorenzo (Stirling 1947). Long after Stirling’s investigations had stopped, radiocarbon dates would settle the argument in the Olmequistas favor (Coe and Diehl 1980:3).

Stirling also developed some of the fundamental hypotheses and questions about the Olmecs during his investigations. Many of these continue to be investigated at the site today. The first of these questions is what the colossal basalt heads symbolize. Stirling claimed that the heads represented prominent secular individuals. Another question he asked was how the landscape changed from antiquity to modern times. This remains an important inquiry of research today (Cyphers 1996:63-63). Though a great deal of material was collected from the
investigations during this period, it was never properly examined (Coe and Diehl 1980:23). This left an impetus for Coe to initiate research at to the site about twenty years later.

Figure 6: Stirling examining a colossal head from Tres Zapotes in 1939 (from Stirling 1943: Plate 4a; copied from Pool 2007: figure 1.1)

The investigations of San Lorenzo by Michael Coe started in 1966 with assistance of Richard A. Diehl. The main focus of their investigation was to establish a chronology for the site and to date the manufacture of San Lorenzo’s important stone monuments (Pool 2007:51; Coe 1968a:44). Coe established a chronology which is used in this thesis with only minor modifications (Coe and Diehl 1980). Another, important contribution that Coe made with assistance from Ray Kroster was the creation of the first topographic map of the site (Cyphers 1996:64).

Coe was also responsible for several new site level interpretations. The most important of these for this thesis was the new way he started to understand elites. Instead of viewing elites as religious functionaries he saw them as secular rulers (Coe 1968b). He came to this conclusion,
through an examination of the material assemblage and how elite material can be expressed and interpreted (Cyphers 1996:64). Coe’s introduction to the questions such as the nature of elite rule has proved imperative in conceptualization of the Olmec culture.

The most recent investigations of the site started in the early 1990s and were led by Dr. Ann Cyphers of the Universidad Nacional Autónoma de México. Under a project known as Proyecto Arqueológico San Lorenzo Tenochtitlán, Cyphers focused her investigations on the site’s habitation areas (De León 2008:9). While this was her initial goal, the scope of the project expanded to include many aspects of settlement patterns. These goals facilitated a regional survey by Symonds (1995) and Lunagomez (1995) that covered 400 kilometers of the site’s regional hinterland. This has given Cyphers the information to interpret relationships on a regional level (See Cyphers 1996:65). These excavations continue to this day and her research has contributed to a great many projects including this thesis.

Our understanding of San Lorenzo has been shaped by over 60 years of research. This thesis attempts to add one small piece to a long history of scientific enquiry. It’s goal is to add a geographical perspective to site level interpretations. In the following section, a discussion is presented on the nature of prismatic blades and other obsidian artifacts recovered at San Lorenzo.
Obsidian: A Vital material to Olmec Life

The Material

Obsidian is an igneous glass formed from the rapid cooling of extrusive lava (Pires-Ferreira 1976:292). The ancient Mesoamerican’s appreciated the aesthetic properties of obsidian and often created decorative pieces from it, such as ear spools (Thomsen and Thomsen 1970). The main reason that obsidian was desired at San Lorenzo was its use in the formation of razor sharp cutting tools.

The homogeneity of obsidian glass and its lack of crystalline structure, give it excellent properties that allow for shaping flaked stone tools. The properties of obsidian enable it to be fashioned into tools that are far sharper then modern surgical blades (Cotterell and Kamminga 1990:127-128). Obsidian was not available to all native cultures and alternatives such as chert were exploited. Although obsidian was widely used in Mesoamerica, it is located in only a few areas. Its wide distribution and use has made obsidian the focus of much study.

Sources of Obsidian for San Lorenzo

In Mesoamerica, obsidian is found in the transverse volcanic axis that extends east to west across central Mexico, and in the highlands of Guatemala (Figure 7). Obsidian from different sources vary in quality (in regards to tool making ability), luster, chemistry, and color. A number of these attributes have been used to identify the sources used in the past using analytical approaches. Two of the most important source identification methods are x-ray fluorescence and neutron activation (Pires-Ferreira 1976:292). There were two important investigations in sourcing material from San Lorenzo in the 1970s. These were carried out by Jane W. Pires-Ferreira (1976) and Cobean et al. (1971).
The study by Jane W. Pires-Ferreira used neutron activation to identify obsidian sources. This method determined the composition of the rock by examining the percentage of sodium (Na) and manganese (Mn) in the material (Pires-Ferreira 1976:292). Original source locales are established by comparing geological samples to obsidian tools found at archaeological sites. However, it is important to remember that sourcing alone cannot identify anything about the procurement method by which obsidian was obtained. Despite this, knowing the source is still useful for determining which cultures had contact with each other, as well as relative costs of moving raw material over space.

Pires-Ferreira established three different exchange networks for the Early Formative period that contributed the majority of the obsidian found at San Lorenzo. The first is the
“Guadalupe Victoria Exchange Network” which provided 62.2% of the obsidian material (in the sample) for San Lorenzo (Pires-Ferreira 1976). Though Guadalupe Victoria is located 300 km away from San Lorenzo, distance alone does not define a radius for trade since the Las Bocas, Puebla located 100 km to the west of Guadalupe Victoria contains no obsidian from this site. At San Lorenzo, the Guadalupe Victoria source provided a lot of the low quality obsidian which was inappropriate for the manufacturing of pressure blades (Pires-Ferreira 1976:301-302). Instead this obsidian was used for the production of simple percussion flake tools. High quality blade obsidian was available from an alternative network: the “Barranca de los Estetes Exchange Network”. Barranca de los Estetes only supplied about 4.8% of the total obsidian in the sample. It is likely that San Lorenzo was only indirectly incorporated into this network during the Initial Formative period, accounting for the low number of pressure blades in its assemblage (Pires-Ferreira 1976:303-304). The third system is the “El Chayal Exchange Network”, with obsidian originating from El Chayal region in the highlands of Guatemala. This source contributed 21.7% of the sample at San Lorenzo and is located even further away from the site (580 km) than the “Guadalupe Victoria Exchange Network” (Pires-Ferreira 1976:302-303). This site was the source of higher quality obsidian then Guadalupe Victoria and was appropriate for the manufacture of pressure blades (Hammond 1972).

Figure 8: Proposed exchange networks that involved San Lorenzo during the Early Formative. The triangles represent areas that are involved in the trade and the numbers represent obsidian sources. The obsidian sources are: Barranca de los Estetes (12), Guadalupe Victoria (14), and El Chayal (18). (Adapted from Pires-Ferreira 1976: Figure 10.8)
Cobean and others (1971) examined the obsidian recovered at San Lorenzo in much greater detail. They used a method of x-ray emission spectroscopy to determine major elements and then used neutron activation to examine their analytical samples. From this they confirmed the reliance on obsidian from the Guadalupe Victoria source and other sources that originate from Orizaba Volcano throughout the early Formative period. They also identified several other sources that contributed heavily to the assemblage. These include: Altotonga, Veracruz; Teotihuacan, Mexico; Pachuca, Hidalgo; El Paraiso, Querétaro; as well as El Chayal and Ixtepeque, Guatemala. It was not that the obsidian came from specific sources that interested them, but that the Olmec expanded had their procurement network to include new sources. The Olmec of San Lorenzo developed new sources of obsidian supply, during the San Lorenzo A and San Lorenzo B phases, expanding the number to a total of eleven. This increase corresponds to a substantial increase in the occurrence of pressure blades in their sample (Cobean et al. 1971). Whether it was demand for prismatic blades that caused an expansion in the number of sources recovered or vice versa is not clear. What is evident, however, is that there is a substantial increase in blades during the San Lorenzo B phase.

Figure 9: “Occurrence of obsidian artifacts and maize-grinding stones (metates and manos) at San Lorenzo, by phase” (Cobean et. al 1971: Figure 1)
The Cost of Obsidian Tools

Sanders and Santley conducted a detailed energetic study of the cost of creating and distributing obsidian blades (1983). Although their approach discusses a later period than the occupation at San Lorenzo, the costs that they propose for transportation and production would not have been greatly different. The first part the analysis was to determine the cost of producing blades. In one day, a specialist could produce approximately 125 blades, which represents a maximum potential of 37,500 blades a year. Given their estimates for the use of approximately 21 obsidian tools per household per year, in a year one specialist could produce enough to supply an estimated 5,600 consumers. Using even a generous population of 10,000, as proposed by Clark (2007:15), it is clear that San Lorenzo would have needed no more than a couple of specialists to fulfill their needs. If this is true the people of San Lorenzo collectively would have needed to provide each specialist with 1,650 kg of maize per year in order to support the specialists’ families. The cost to each consumer in the sites total population would not have exceeded between 1.47-2.5 kg of grain a year. This makes the production costs relatively inexpensive.

The other main cost of obsidian is the transportation of the blades. Since beasts of burden were unavailable in Mesoamerica, products were transported by human porters. Though not accounted for here, access to river transport at San Lorenzo could have greatly reduced some of the costs that are about to be described. Sanders and Santley created three assumptions for the calculation of costs. The first assumption is that the further away you are from the site, the greater the cost, since the transporter will be able to make fewer trips per year. The second assumption is the average transporter will need about 1,837 kg of maize to support his family every year. The third assumption is an adult male can carry about 23 kg over a distance of 30 km
each day. These 23 kg of obsidian are enough to provide for 216 families. Distance will have a logarithmic effect on people who can be provided. Every time distance from a source is doubled, only half as many people can be provisioned. Despite these conclusions, even at 1,200 km away, the costs would only be 2.64 kg of corn for transportation for 21 obsidian tools that is required for a household in a year (see Table 2). Though Sanders and Santley do not account for quarrying costs, they perceive the total cost of obsidian tools needed to support a household to be only 5.04 kg of corn per year even at the 1,200 km range.

Determining where obsidian came from and its costs is an effective means of demonstrating what can be learned from the obsidian at San Lorenzo. It already seems unlikely that the costs associated with pressure blade production could have led to the dominance of flakes over blades at San Lorenzo. In the next section I discuss the different tool types that the Olmecs made from obsidian during the Initial and Early Formative periods. A comparison of prismatic blades and percussion flake tool types is essential to understanding why scholars have suggested contrasting procurement strategies.

<table>
<thead>
<tr>
<th>One-Way distance in km</th>
<th>No. of trading trips</th>
<th>No. of families supplied</th>
<th>Direct transport costs</th>
<th>Direct production costs</th>
<th>Total direct costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>150.0</td>
<td>32,400</td>
<td>0.07 kg</td>
<td>2.40 kg</td>
<td>2.47 kg</td>
</tr>
<tr>
<td>60</td>
<td>75.0</td>
<td>16,200</td>
<td>0.13 kg</td>
<td>2.40 kg</td>
<td>2.53 kg</td>
</tr>
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<td>90</td>
<td>50.0</td>
<td>10,800</td>
<td>0.20 kg</td>
<td>2.40 kg</td>
<td>2.60 kg</td>
</tr>
<tr>
<td>120</td>
<td>37.5</td>
<td>8,100</td>
<td>0.27 kg</td>
<td>2.40 kg</td>
<td>2.67 kg</td>
</tr>
<tr>
<td>150</td>
<td>30.0</td>
<td>6,480</td>
<td>0.33 kg</td>
<td>2.40 kg</td>
<td>2.73 kg</td>
</tr>
<tr>
<td>180</td>
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<td>210</td>
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<td>2.40 kg</td>
<td>2.87 kg</td>
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<tr>
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<td>4,061</td>
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<tr>
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<tr>
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<td>3.07 kg</td>
</tr>
<tr>
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<td>1,620</td>
<td>1.34 kg</td>
<td>2.40 kg</td>
<td>3.74 kg</td>
</tr>
<tr>
<td>1,200</td>
<td>3.8</td>
<td>820</td>
<td>2.64 kg</td>
<td>2.40 kg</td>
<td>5.04 kg</td>
</tr>
</tbody>
</table>

Table 2: Obsidian Costs per Household in Maize-Kilograms as a Function of Distance (Sanders and Santley 1983: Table 11.6)
Pressure Blades and Percussion Flakes

One possibility for the increase in blade use during the San Lorenzo B phase is that obsidian blades were a superior product to an obsidian flake. The ergonomic attributes of a blade’s sleekness and the beauty of the object are undeniable. However, while blades first arrived in the archaeological landscape during the Early Formative period it did not become the dominant tool technology at that time (Clark 1987). Instead flakes, in all relevant phases, represent a larger proportion of the material assemblage than do blades at San Lorenzo (see results section). The implication is that flakes must have had advantages over blades. The advantages are not found in the quality of the tool, but in its ease of manufacture.

The Percussion Flake

The production of percussion flake tools is a relatively simple process, involving three steps. Step one is to find a suitable obsidian material that is larger than the desired flake to serve as a core. Step two is to locate a stone (hammerstone) that is harder than the core material and preferably able to fit into one hand. Finally (step 3), strike an area of the core material with the hammerstone. The result from this process will be the production of a flake, as long as sufficient force was applied (see De León 2008:69-71). While experience and knowledge can help the producer make better flakes with less waste, almost any able-bodied adult can produce a simple flake. Production of flakes does not require a trained specialist, which allows production to avoid the associated costs and social organization that specialists typically entail.
Another advantage of the production of obsidian flakes is that the core material does not have to be of particularly high a quality compared to that needed for production of prismatic pressure blades. Flakes produced from far lower quality obsidian can still create a satisfactory tool. In Pires-Ferreira’s study, this is demonstrated by the relationship found between blade production and high quality sources. Contrastingly, flakes can be produced from lower quality obsidian like that found at Guadalupe Victoria (1976). The ability to produce flakes from a wider array of materials than blades adds to the appeal of flake production technology. Being able to utilize a close-by inferior source of obsidian is important where distance from location significantly impacts material cost.

**The Pressure Blade**

The above discussion indicates that the manufacture of percussion flakes is an expedient form of production. While flakes can be produced by wider variety of individuals, the versatility in production does not make it a superior technology for several reasons. First, blades can be produced with high efficiency. In one study, approximately 200 blades were produced from one
core in two hours (260; Sheets and Muto 1972). Also, extracting 200 percussion flakes from a core of the same size with the same amount cutting edge would be almost impossible. Finally, the pressure blades produced are far more standardized then any assemblage of flakes (Clark 1987).

A far more complicated manufacturing process is involved for the production of blades than is used for flakes. The Manufacture of blades requires high quality obsidian and the services of a trained blade production specialist. The manufacture of blades is a complicated procedure that involves many steps, practice, and experience. Through experimental archaeology several archaeologists have designed possible blades production sequences (see Hirth and Andrews 2002). During the Classic and Postclassic periods later Mesoamericans had many different blade production traditions (Hirth and Flenniken 2002). This creates a problem with trying to determine the specific procedure used in blade production at San Lorenzo. However the general process showing the complexity of blade production is summarized by Hirth and Andrews (2002) (Figure 11).

First, a core platform is prepared from the raw obsidian nodule which will eventually become a blade pressure core. This involves the use of percussion flaking to prepare the platform of the core in a process called “platform preparation”. Percussion flakes will subsequently be removed from the platform to shape the core. The nodule is now called a “core preform”. The core preform is then further reduced by percussion techniques to remove large flakes from its lateral sites. If successful, a “primary macrocore” is formed for the creation of percussion blades.

The creation of percussion blades from the macrocore is initiated with the removal of long thin macroblades. By doing this, the craftsman prepares the core for the elimination of the remaining cortex and further removal of small percussion blades. After the macroblades have
been removed, small percussion blades are subtracted from the core. At this stage, the macrocore becomes a polyhedral core. The next part of the process involves the removal of first and secondary series pressure blades. The resultant product is the creation of the “pressure core” which is needed for the production of final third series blades (See Figure 8).

Figure 11: A generic production sequence of prismatic pressure blades (From Hirth and Andrews 2002a: Figure 1.1)
In conclusion, there are two vital components for the creation of obsidian blades. The first is the procurement of high quality obsidian. The second is a specialist who is capable of transforming a raw nodule into a beautiful prismatic pressure blade. It is due to these two requirements that archaeologists have proposed several models to explain the occurrence of blades in the archaeological record. These models correspond to the political economy and domestic economy which are discussed in the next sections.
Political Economy

Political economy refers to the institutional section of society. A political economy depends on the fundamental principle that individuals do not have equal access to wealth. Many studies of the Early Formative period deal with this concept (Hirth 1998:205). However, archaeologists generally focus on only one of three main concepts of a political economy: “These [concepts] are (1) production and exchange relationships, (2) food and commodity relationships, and (3) economic and ideational linkages” (Hirth 1998:207). Though all these concepts can demonstrate aspects of political economy, when they are combined into a complimentary system, the potential for a more informative analysis emerges.

A model that has been suggested for political economy is that elite control of craft production substantiates the ability to maintain power. This model only focuses on production and exchange relationships while largely ignoring the other concepts. Despite this, political economy is the basis used by Clark (1987) to explain the production and distribution of blades at Early Formative sites. Clark proposes that blades were an object manipulated by the political economy because of the complex technology used in their production. In his hypothesis, the elites control production of blades and their distribution to non-elites (Clark 1987). He suggests that if blades were produced for the masses, it “would have nullified the social, political, and religious benefits of privileged consumption of expensive, ready-made blades” (Clark 1987:279). By ignoring other factors, and not examining the other concepts beyond vague speculation, Clark does not provide context to support his claims.

Hirth created a model that accounts for various aspects of political economy (1996). The next several paragraphs present a discussion of what these principles of political economy are
and how they can be archaeologically determined. The goal is to develop a possible model for blades functioning in a political economy at San Lorenzo.

**Accumulation Principle**

The first part of Hirth’s model examines the role of political economic systems in the accumulation of resources (1996:221); either individuals or institutions must collect resources and then justify this collection to the public (Smith 1991). The reason political economies must accomplish this relationship comes from two distinct possibilities. The first of these, as proposed by Brumfiel and Earle (1987), employs an adaptionalist perspective where resources were accumulated in order to protect against possible resource shortfalls (Hirth 1996:221). Conceptually, people were willing to accept unequal access to wealth, as long as those in charge took action to mitigate against shortages. The other, perspective given stipulates that resource accumulation can occur because of an abundance of resources. With abundance, people are able to manipulate the dispersion of resources in order to substantiate their power (Cowgill 1975; Hirth 1996:221). In both perspectives, the accumulation of resources would be used by the elites to manipulate their authority over non-elites (Brumfiel 1992, 1994).

This accumulation of resources can be difficult to determine archaeologically. As a result I employ a process very similar to that used by De León (2008) which examines the differences between blades and flakes to determine whether the elites were in the business of accumulating blades. However, with the use of GIS, discussed later, my research departs from De Leon’s approach.

The perspective employed is that flakes are an imperfect alternative to blades; they are just as sharp and as useful as blades in most tasks (Clark 1987). Though, there is the downside of flakes not being as interchangeable as blades in hafted tools, this alone cannot justify major
utilitarian differences. This creates a circumstance where blade demand is not driven purely by utility. So if blades at San Lorenzo were used by the elites as a means of establishing control over its resident population, the accumulation principle would predict that the quantity of blades in elite residences would be higher than it is in non-elite residence. On the other hand, the quantity of flakes in residences should be unaffected by class (De León 2008:44). To simplify the accumulation principle at San Lorenzo, blades would have accumulated in elite areas beyond consumption demands.

**Context Principle**

The next principle is the context principle. Instead of being focused on the accumulation of material, this principle focuses on the determination of where and how resource accumulation takes place (Hirth 1996:223). However, there are two different systems under which accumulation can occur. The first is the individual oriented context accumulation system in which people accumulate resources for themselves. These resources, in turn, can be used in personal activities such as weddings and funerals (Hirth 1996:223). Hirth predicts very little state involvement in this system (Hirth 1996:223). Material used exclusively in this context would not likely be under the control of the political economy.

The other possible system would involve elite control of material flowing through the economic system (Hirth 1996:223). According to Clark (1987), blades could have moved through a system where elites had the ability to distribute the material as they saw fit. The issue here is to see if there is an abundance of obsidian blades in elite contexts, compared to what is found in non-elite contexts. If material is not distributed with regard to rank, then it can be inferred that individual procurement is governing the assemblage. Conversely if the amount of
blades found in elite contexts is high, the findings would support the contention that blades were incorporated in the political economy as a form of elite control.

**Matrix Control Principle**

The next principle that Hirth suggests is the matrix control principle, which states that the elites normally attempt to control the means of production or trade. The elites would attempt to control resource flows by inserting themselves into key positions along the production/distribution sequence. It is doubtful that obsidian would have been acquired at source for Ojochi period (Clark 2007). This leaves two alternatives. The first is that the elites controlled production of obsidian blades via attached specialists. Clark thinks this was the way that large basalt sculptures were produced by specialists attached to the elites (Clark 1996; Heizer 1962). According to Clark if this occurred, there would be production evidence either at elite households or workshop areas (Clark 2007:29). The second alternative is that the blades were produced by offsite specialists and then imported as finished goods. In this scenario elites would insert them into the trade network to establish regulation. Once regulation was established, the elites would be able shape distribution in a way that gave themselves access to a far greater amount of blades than non-elites. If the data demonstrates that the elites are controlling the distribution chain then, the blades at San Lorenzo would likely have been part of the political economy.

**Ideology Principle**

The final principle in Hirth’s approach dissects how the elites validate the differences in wealth (Hirth 1996:225). In capitalist societies today, we can often accept differentiation in wealth without understanding the ideologies that fundamentally allow for differential accumulation to occur. Hirth hypothesizes that elites accumulate resources by giving the non-
elites idealized end usages that stress maintaining the communities well-being (Hirth 1996:225). These idealized end usages function by two means. The first is to convince non-elites that the elites will provide services, often religious in nature, which they must pay for. The second method created by the ideology is that the non-elites owe resources for outstanding obligations. To facilitate these resource flows elites will create new ideologies to increase their influence and therefore their resource control (Hirth 1996:226).

In order to accumulate wealth from the non-elites, the elites need a way to convert material from perishable to durable wealth. To effect this change, elites must create conversion ideologies. These ideologies: “(1) structure the form of exchange relations, (2) stimulate the flow of resources through exchange systems, (3) create imperishable ‘wealth’ that can be converted to food or other resources as needs arise, and (4) allow for the accumulation of wealth items in the hands of the political elite (Hirth 1996:226).” If blades functioned as an item of possible wealth, they should adhere to the previously mentioned principles (De León 2008:55). None of these principles immediately excludes blades from serving as durable wealth. As a standard means exchange; the elites would have attempted to control more blades, representing more control of resources. The expectation would be that this would also be reflected in the archaeological record by more blades in elite areas.

The accumulation, context, matrix, and ideology principles outlined by Hirth, are all methods in which a political economy may be examined. If the situation indicates that the political economy does not affect the distribution of the material, an alternative explanation is required to account for the distribution of blades. For this, I turn to the concept of domestic control, in which the household is responsible for production. Like De León, I believe that domestic control is the more likely scenario in the case of blades (2008).
Domestic Economy Model

While political economies of the Ancient Mesoamerica provide significant information about social organization, the household economy forms the backbone of civilization. Despite this fact, only in the past thirty years has the household and its economic organization become a focus of investigation (Hirth 1993:21). Prior to the study of households, professionals had focused more on artifact oriented studies, in order to identify culture contact or to establish chronologies for archaeological sites (Santley and Hirth 1993:3). Currently, however, archaeologists understand the shortcomings of this approach and have determined that greater potential lies in studying households. One reason, of course, is that houses are archaeologically identifiable. A second reason is that households can function as a consistent framework of comparison due to their presence in all societies. Ultimately, the final and most important, consideration is that households are the simplest and most fundamental unit in a society (Hirth 1993:21; Hirth 2009:13).

Typically, a household would be a straightforward concept, but for this study it is imperative to identify what truly constitutes a household. All households serve to meet three requirements. First, the household must produce agricultural products, trade, or engage in craft specialization to covert human labor into tangible resources. Second, all households must obtain sufficient resources to support their members and to maintain the health of their members. A household must provision those individuals that are unable to work because they are either too old or too young. Third, a household must reproduce biologically. This is the basic requirement of all humans in society, especially since the household’s primary goal is survival. (Santley and Hirth 1993:3-4)
Because survival was the main focus of households at San Lorenzo, I employ Hirth’s dynamic view of households in an attempt to study the factors that strongly impact household longevity (Hirth 2009:18-19). The first of these factors is the acquisition of resources. Households must procure resources during times of abundance in order to sustain their members during lean times. This is especially important in a society that lacks major institutional safety nets (Hirth 2009:18-19). At San Lorenzo it follows that households, not the elite, would be personally responsible for procuring the resources they need on a individual basis; this includes a wide array of utilitarian items ranging from agricultural commodities to obsidian tools (Hirth 2009:18-19). The second important force affecting a household is a need to intensify production because of internal factors. A household must ensure the survival of both the elderly and the young. There is great variability in these survival costs as people get older and inevitably die. Consequently, the resources a household needs will vary significantly over its normal life cycle and must mobilize its available labor to meet these needs (Hirth 2010:18-19). The final and arguably most important factor considered in this research is that households are never self-sufficient; to some degree every household must establish linkages with outsiders to acquire non-local materials. One way that households accomplish this is to establish their own personal trade partners through which resources move (Hirth 2009:18-19).

This final aspect of the household is the foundation for my working hypothesis. I propose that both elite and non-elite individuals at San Lorenzo provisioned themselves through normal household networks without the assistance of the political economy. This leads to a situation in which a household will attempt to acquire resources by any means necessary. As a result it is not hard to imagine a circumstance in which non-elite may have been well positioned access to a resource like obsidian.
Under these conditions it is expected that household assemblages will reflect a considerable amount of variability. Some households may have more blades simply because they trade with other households or individuals linked to blade dominant procurement systems, opposed to a system where nodules suitable to percussion flaking are obtained. The opposite circumstance to this may also be true. Nevertheless if household networks determine access to obsidian blades, there will be considerable variability in how those assemblages were composed at San Lorenzo. The next section discusses the methodology used to determine elite status at San Lorenzo.
Determining Elite Status

Elite status is used to designate ranked individuals that have obtained “unequal distribution of power and wealth” (De León 2008:15). Several ways have been used by archaeologists to determine the presence of elites in a society. The first way is to use material culture to determine differential access to scarce resources. The second method uses architectural differences in an attempt to identify elite residences. However, a problem with the use of these methods alone is that they ignore issues of transitional change. The people of San Lorenzo during the Early Formative were undergoing rapid transitional change in regard to status (Cyphers 1996). It is unlikely that the distinction between elites and non-elites was clean cut. In all likelihood there was great variation inside the classes with transitional forms.

In societies undergoing transitional change it might be useful to examine quantities of material remains to identify elite status. For example the presence of a specific type of material in his or her house (e.g. jade); could be used to identify membership within a specific class. There is, however, a major problem with this approach. In this method, objects are not independent variables, especially in research questions that involve material assemblages. Cyphers suggests an alternative way to determine status that can function as an independent variable: the use of distance. She suggests that eliteness will be inversely related to distance from the center (1996:67). This means that the further a residence is from the site core, the less elite power it holds. This hypothesis has been partially corroborated by the location of low status families and households on the terraced slopes away from the central elite core at San Lorenzo (Coe and Koontz 2002; Cyphers 1996). Likewise Clark suggests that status will be expressed by geographical location such that those living on the fringes of San Lorenzo were of lower status, due urban-rural class distinctions (2007:26-28).
This study was this geographical reasoning when examining elite status. The use of distance as an independent variable can serve as a means of examining objects in relation to ideas about rank and status. It can be applied to the site of San Lorenzo by taking the area that has traditionally been seen as the core of the site and determining the distance from this core to each excavation. The further away an excavation is located the less elite the locale can be construed to be. This provides a system of relative geographical rank. This method is by no means full proof, since elites and non-elites may not conform to strict residence rules. Nevertheless it provides a framework to examine spatial difference that may reflect difference in rank.

The next section performs tests will be examine Political and Domestic economy. Finally, observations will be drawn based on what has been learned about the nature of obsidian blade distribution at San Lorenzo.
Hypothesis Testing

Two tests are proposed to examine the hypothesis of household obsidian procurement discussed above. The first of these tests examines the involvement of the political economy model in obsidian procurement. Its purpose is to determine whether the political economy was in control of obsidian distribution. The second test examines the domestic economy model. In this model, the goal is to evaluate whether each household had its own individual procurement strategy to obtain obsidian.

Examination of these propositions involved recording the ratios of blades within the available obsidian tool assemblage. These ratios will then be analyzed to see if there is a relationship between blade concentrations and distance from the core. This relationship will be examined using a linear regression for four phases—Chicharras, San Lorenzo A, San Lorenzo B, and Nacaste.

Political Economy Expectations

The political economy model states that elites had a large role in the distribution of blades in order to control power. Whether this was to affirm their own power or to control non-elites, the expectations would be the same in a whole-site analysis. Elite involvement would be corroborated if there is a high correspondence of obsidian blades in more elite sites. In the data, this would be demonstrated in the statistical output of a slope that demonstrates a gradual decline in the ratio of obsidian blades to total obsidian lithic. The slope must also have a significant Chi Square value of 95% or above to demonstrate that it is distance from the site core that accounts for the variance in the data.
Domestic Procurement

The domestic procurement test should demonstrate that elites would have only had limited control over the distribution of obsidian blades. Other forces, such as household craft production, should account for the assemblage (De León 2008:455). There should be no, or at best a weak positive to moderate relationship of blade ratios to distance from the site center with the data having an insignificant Chi Square value. This would indicate that individual households were responsible for their own acquisition of obsidian blades, regardless of status.

The San Lorenzo Data

The data from San Lorenzo varies by time period and location. Some areas, for instance, were excavated more intensively than others and, therefore, are more or less representative far of their location than other areas (Personal Communication; Hirth 2012). This is the reason that ratio measurements were used to compare assemblage contents.

Data were available for 39 unique geographic locations. Several of these locations did not contain data in time periods relevant to this study. Listed below are the data breakdowns for locations in each period of interest. The site core epicenter was identified as area B3-5 in group D, and the distance to other excavations were measured using this point. Tables 3-5 show the ratios for each of the periods chosen for exploration by site, as well as that site’s distance from the core. The presence of a zero in the chart represents that was obsidian found, but there were no blades represented in the assemblage. Individual obsidian totals and particulars of assemblage makeup will not be given here, since they are still pending publication.
Excavation Locations at San Lorenzo

Figure 12: Excavation locations at San Lorenzo, key below.
<table>
<thead>
<tr>
<th>Area found</th>
<th>Distance from Core</th>
<th>Chicharras</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 ILMENITAS CHE</td>
<td>361.24798584000</td>
<td>0</td>
</tr>
<tr>
<td>B JOBO CW</td>
<td>524.78601074200</td>
<td>0</td>
</tr>
<tr>
<td>B JOBO EHG</td>
<td>491.35000610400</td>
<td>0</td>
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<td>B JOBO MVG</td>
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<td>0.111111111</td>
</tr>
<tr>
<td>C5-6 &amp; SL-17</td>
<td>633.02801513700</td>
<td>0</td>
</tr>
<tr>
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<td>0.014184397</td>
</tr>
<tr>
<td>GRUPO D: B3-5</td>
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<tr>
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<td>0</td>
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<td>0.016129032</td>
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Table 3: Data from the Chicharras Phase on Blade/Total Obsidian Ratios at San Lorenzo

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<th>Area found</th>
<th>Distance from Core</th>
<th>San Lorenzo A</th>
</tr>
</thead>
<tbody>
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<td>0</td>
</tr>
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</tr>
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</tr>
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<td>B JOBO CW</td>
<td>524.78601074200</td>
<td>0.01010101</td>
</tr>
<tr>
<td>B JOBO EHG</td>
<td>491.35000610400</td>
<td>0.021052632</td>
</tr>
<tr>
<td>C5-6 &amp; SL-17</td>
<td>633.02801513700</td>
<td>0</td>
</tr>
<tr>
<td>D4-7</td>
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</tr>
<tr>
<td>GRUPO C</td>
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<td>0</td>
</tr>
<tr>
<td>GRUPO D: B3-11</td>
<td>76.48529815670</td>
<td>0.236842105</td>
</tr>
<tr>
<td>GRUPO D: B3-17</td>
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<tr>
<td>GRUPO D: SL-30 &amp; SONDEOS A INTERVALOS</td>
<td>33.54100036620</td>
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<tr>
<td>GRUPO E: SL-14</td>
<td>221.47200012200</td>
<td>0.056603774</td>
</tr>
<tr>
<td>GRUPO E: SL-73</td>
<td>201.80400085400</td>
<td>0.125</td>
</tr>
<tr>
<td>P. CAMILO DGZ</td>
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<td>0.583333333</td>
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<tr>
<td>P. FELIX DGZ: NO-3,E0-2</td>
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<tr>
<td>P. FIDELIA FDZ: SONDEO #3</td>
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<tr>
<td>P. MIGUEL ROSAS</td>
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<tr>
<td>P. PERFECTO DGZ-LO</td>
<td>900.12500000000</td>
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</tr>
<tr>
<td>P. PERFECTO DGZ-TV</td>
<td>832.06097412100</td>
<td>0</td>
</tr>
<tr>
<td>P. SIMON HDZ DH &amp; IPG</td>
<td>67.08200073240</td>
<td>0</td>
</tr>
<tr>
<td>P. SIMON HDZ-PS</td>
<td>333.05398559600</td>
<td>0.727272727</td>
</tr>
<tr>
<td>SL-112</td>
<td>108.16699981700</td>
<td>0.153846154</td>
</tr>
<tr>
<td>SL-53</td>
<td>619.56000000000</td>
<td>0.008368201</td>
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</table>

Table 4: Data from the San Lorenzo A Phase on Blade/Total Obsidian Ratios at San Lorenzo
<table>
<thead>
<tr>
<th>Area found</th>
<th>Distance from Core</th>
<th>San Lorenzo B</th>
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<tbody>
<tr>
<td>A4 ILMENITAS CHE</td>
<td>361.24798584000</td>
<td>0</td>
</tr>
<tr>
<td>A4 ILMENITAS JZN</td>
<td>384.18701171900</td>
<td>0.351094196</td>
</tr>
<tr>
<td>A4 ILMENITAS LGL</td>
<td>372.59201049800</td>
<td>0.028846154</td>
</tr>
<tr>
<td>B JOBO CW</td>
<td>524.78601074200</td>
<td>0</td>
</tr>
<tr>
<td>B JOBO EHG</td>
<td>491.35000610400</td>
<td>0.033333333</td>
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<tr>
<td>C5-6 &amp; SL-17</td>
<td>633.02801513700</td>
<td>0.107526882</td>
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<tr>
<td>D4-7</td>
<td>507.56799316400</td>
<td>0.364608844</td>
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<tr>
<td>GRUPO C</td>
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<td>0.21</td>
</tr>
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<td>GRUPO D: B3-11</td>
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<td>GRUPO D: B3-17</td>
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<td>GRUPO E: SL-73</td>
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<td>P. FIDELIA FDZ: SONDEO #3</td>
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<tr>
<td>P. MIGUEL ROSAS</td>
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<td>0.804878049</td>
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<td>P. PERFECTO DGZ-LO</td>
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<td>P. PETRA RAMIREZ</td>
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<td>SL-53</td>
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<tr>
<td>TERRAZA GDE 94</td>
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</tr>
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<td>TRANSECTO 2S</td>
<td>1610.0400390600</td>
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</table>

Table 5: Data from the San Lorenzo B on Blade/Total Obsidian Ratios at San Lorenzo

<table>
<thead>
<tr>
<th>Area found</th>
<th>Distance from Core</th>
<th>Nacaste</th>
</tr>
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<tbody>
<tr>
<td>B JOBO ESLE</td>
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<td>836.37597656300</td>
<td>0.705882353</td>
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<tr>
<td>P. SIMON HDZ-PS</td>
<td>333.05398559600</td>
<td>0.363636364</td>
</tr>
<tr>
<td>TERRAZA GDE 94</td>
<td>392.58801269500</td>
<td>0.026666667</td>
</tr>
</tbody>
</table>

Table 6: Data from the Nacaste Phase on Blade/Total Obsidian Ratios at San Lorenzo
Results

A linear regression was run using this data, to see if there was any relationship with distance from the site core. The next several paragraphs present the results for each of the four phases examined here. The Chicharras was the first phase examined. When line of best fit (Figure 9) was calculated the results came back statistically insignificant. The correlation coefficient (r) equated to -.34. This means that only 34% of the variation in the data can be accounted for by the relationship between the distance from the site core and the blade ratios.

![Ratio of Blades to Total Obsidian Assemblage in Relation to Distance](image)

Figure 13: Attempt on a Linear Regression of Distance to Blade Ratios Data from the Chicharras Phase

Much more data was available for San Lorenzo A phase. This makes sense due to the fact that this was a period of expansion at San Lorenzo (refer to historical background). For this data the line of best fit (Figure 10) also came back insignificant. The correlation coefficient (r)
equated to only .19. This means that only 19% of the variation in the data can be accounted for by the relationship between distance from the site core and the blade ratios.

More data was available for the San Lorenzo B phase. This period was the apogee of development at San Lorenzo. During this phase, Cobean and others saw a sudden rise in the total number of blades at the site (1971). It was during this period that there is an increase in the proportion of blades at sites. When line of best fit (Figure 11) was applied for this data the results also came back as being insignificant. The correlation coefficient (r) equated to only .32. This means that only 32% of the variation in the data can be accounted for by the relationship between distance from the site core and the blade ratios.
The Nacaste phase is the final period of analysis. This period has the least amount of obsidian recovered from archaeological excavations. This makes sense since it was a period of rapid population shrinkage. Blades seem to be common in this period and are found at all sites in some density. But again, when line of best fit (Figure 12) was applied to the data the results also came back as insignificant. The correlation coefficient (r) equated to .60. This means that only 60% of the variation in the data can be accounted for by the relationship between distance from the site core and the blade ratios.
Conclusions

Data analysis demonstrates that political economy was not exclusively involved in the control and/or distribution of obsidian blades. Although there was a medium strength correspondence of the relationship of blade ratios and distance in the Chicharras, San Lorenzo A, and San Lorenzo B, this only accounts for about 34, 19, and 32 percent of the variation respectively. This leaves at least 66% of the variation in the data to be accounted for by other factors. The likely candidate for this variation is household procurement strategies, with the possibility for minor elite influence. In the Nacaste phase, although there is a strong relationship
between distance from core and blade ratios, there are not enough data points at this time to make a conclusive report on economic models during this phase. Generally the data conforms to the model of domestic economy as described in the previous section.

This conclusion adds support to one of the points that De León made in his dissertation (2008). He states that political economy has little to do with ability to access blades (2008). The use of distance from the core allowed the measurement of eliteness in terms of degrees rather as absolutes, as had previously been done. Although the GIS approach makes a number of important assumptions about the location of elite residence and site usage, it confirms to the ideas previously proposed by De León. Further research into the use of GIS technology to test concepts of population distributions as well as the assemblages of other materials may prove useful. I might be useful to compare distance relations of eliteness to the distribution of objects such as jade which are closely associated with elite status.
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Objective: To demonstrate experience gained in the academia throughout my time at The Pennsylvania State University

Education

The Pennsylvania State University, College of Liberal Arts
Schreyer’s Honors College
Paterno Fellows program
B.S in Archeological Science
Studied abroad in Greece
Minor in History
Dean’s List every semester

May 2012

Additional Experiences

The Pennsylvania State University, Department of Anthropology
Thesis Research, University Park, PA
Created and manage Geo-databases to facilitate data migration
Fashioned a spatial visualization in ArcGIS for catalog data
Managed a complex range of interrelating data and tables

Fall 2011 - present

Durham, England with Stanford University
Field School Volunteer
Excavated a roman archaeological site
Participated in recording information using ArcGIS explorer
Investigated the world of public outreach for archaeology

Summer 2011

The Pennsylvania State University, Department of Geography
Teaching Intern, University Park, PA
Taught students how to effectively use GIS computer software
Assisted students in labs and office hours

Fall 2010

The Pennsylvania State University, Department of Anthropology
Volunteer, University Park, PA
Worked with Dr. Hritz on her Lands Behind Baghdad Project
Modeled terrain in 3-D via ArcGIS, using contour maps

Spring 2010