

Obsidian in Northern Ecuador: A Study of Obsidian Production and Site Function in Pambamarca

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**OBSIDIAN IN NORTHERN ECUADOR: A STUDY OF OBSIDIAN PRODUCTION
AND SITE FUNCTION IN PAMBAMARCA**

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University of Pittsburgh, 2010

For several years the Pambamarca Archaeology Project has been investigating a dynamic frontier in the northern Ecuadorian highlands at the edge of the País Caranqui: a confederation of small-scale, autonomous, inter-warring pre-Inkan polities whose nearly twenty year resistance to Inka conquest resulted in the largest concentration of military fortresses in the Inka Empire. In addition to its violent past, Pambamarca is located within 25km of high quality obsidian sources, making it an important region for understanding obsidian production when it is part of local, non-elite exchange. This study analyzes obsidian, non-obsidian flaked lithics, and ceramics to elucidate patterns of obsidian production and site function at five of the Pambamarca sites ranging chronologically from the Early Integration period to the early Colonial Period. Directions for future research which would better clarify these patterns are also proposed.

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PREFACE

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1.0 INTRODUCTION

Pambamarca, located in northern highland Ecuador, has a militaristic and violent history. Here, the largest concentration of Inka fortresses throughout the entire empire (Hyslop 1990, D'Altroy 2000, Alconini 2004) are witness to the war fought between the Inka armies and local Cayambe forces for control of the Pambamarca region. In addition, it is thought that warfare was endemic among the many small autonomous polities which preceded the Inka conquest. After Spanish colonization legends say that the area strongly resisted European rule leading a local hacienda to be considered one of the cruelest in the country for its suppression of the indigenous people.

Prior to the Inka occupation it is thought that the local polities were economically interdependent through local markets and long distance status traders despite periodic warfare (Salomon 1986, 1987). These exchange systems make this region distinct from the central Andes where economies relied on redistributive and reciprocity-based mechanisms. A final factor in the significance of the Pambamarca region is the close proximity to quality obsidian sources making obsidian part of local, non-elite production and exchange.

The purpose of this study is to provide preliminary proposals of pre-historic and colonial developments in Pambamarca through an analysis of obsidian production and site function. These suggestions will be based upon samples of obsidian, non-obsidian flaked lithics, and ceramics from five sites excavated by the Pambamarca Archaeology Project (PAP). The sites come from four time periods beginning with the Early Cayambe period around 600 C.E. and ending with the colonial occupation around 1580 C.E. (Table 1). The proximity of obsidian flows to the sites makes this an opportunity to see obsidian production when it is a local, non-

sumptuary, ubiquitous good, rather than a rare exotic obtained through long distance exchange systems. Analyses of obsidian reduction categories and debitage are used to establish patterns of obsidian production. This is then used, together with frequencies of non-obsidian lithics and ceramics, to infer site function. Considerations of obsidian production, site function, and distance to the sources suggest connections with local exchange patterns and other known processes.

A final section will propose directions for future research to further investigate the patterns indicated by this study. Because the sample considered here only includes one site per time period, except in the case of the Inka war, a major extension would be for comparisons between contemporaneous sites both within Pambamarca where possible and the larger Cayambe valley. As a final note, this study is based overwhelmingly upon the English-language literature.

Years	Pambamarca Chronology	Ecuadorian Chronology	Highland Peruvian Chronology*	Example Pambamarca Site
600 C.E. – 900 C.E.	Early Cayambe	Integration Period	Middle Horizon	Oroloma
1250 C.E. – 1505 C.E.	Late Cayambe		Late Intermediate	Pukarito
1505 C.E. – 1532 C.E.	Inka	Inka	Late Horizon	Pingüilmi (Cayambe) Quitoloma (Inka)
Begins 1532 C.E.	Colonial	Colonial	Colonial	Hacienda Guachalá

*(Moseley 2001)

Table 1: Pambamarca Chronology

2.0 PAMBAMARCA CHRONOLOGY

2.1 NORTHERN HIGHLAND ECUADOR: GEOGRAPHY AND ENVIRONMENT

The two cordilleras of the Andes Mountains extend along the western coast of South America from Colombia in the north to Chile in the south. Created by tectonic processes and prone to volcanic eruptions and earthquakes, the mountains rise sharply from the coast creating an environment where climate changes rapidly as one moves eastwards. Throughout the southern and central Andes this proximity of different climate zones was a factor in the development of the vertical archipelago system whereby kin groups used permanent colonies to access the products of various climatic zones (Moseley 2001, Stanish 1991, 2001).

In Ecuador the two cordilleras reach their narrowest point causing even greater proximity between climatic zones (Salomon 1986, Bray 1992). These micro-climatic zones are small enough that single groups could access them through local markets without establishing permanent colonies to the same extent as in Peru. Pambamarca is located on the northern rim of the Quito Basin in highland Ecuador (Figure 1). It is the southern-most edge of the País Caranqui, a confederation of Late Integration period small-scale autonomous polities (Salomon 1986, 1987, Bray 1992, 1995, 2005). Of the political centers in the País Caranqui, Pambamarca is geographically closest to Puntiachíl, now the modern town of Cayambe (Cordero-Ramos 1993) and likely fell within its polity. While the basin itself, at an altitude of 2,200msl to 2,400msl (Bray 1992:220), is temperate and fertile, the high altitude paramo, or grasslands, where some of the Pambamarca sites are located around 3800msl (Ogburn 2008:744), is harsh

and cold, although not to the same degree as sites of similar altitude in the southern and central Andes.

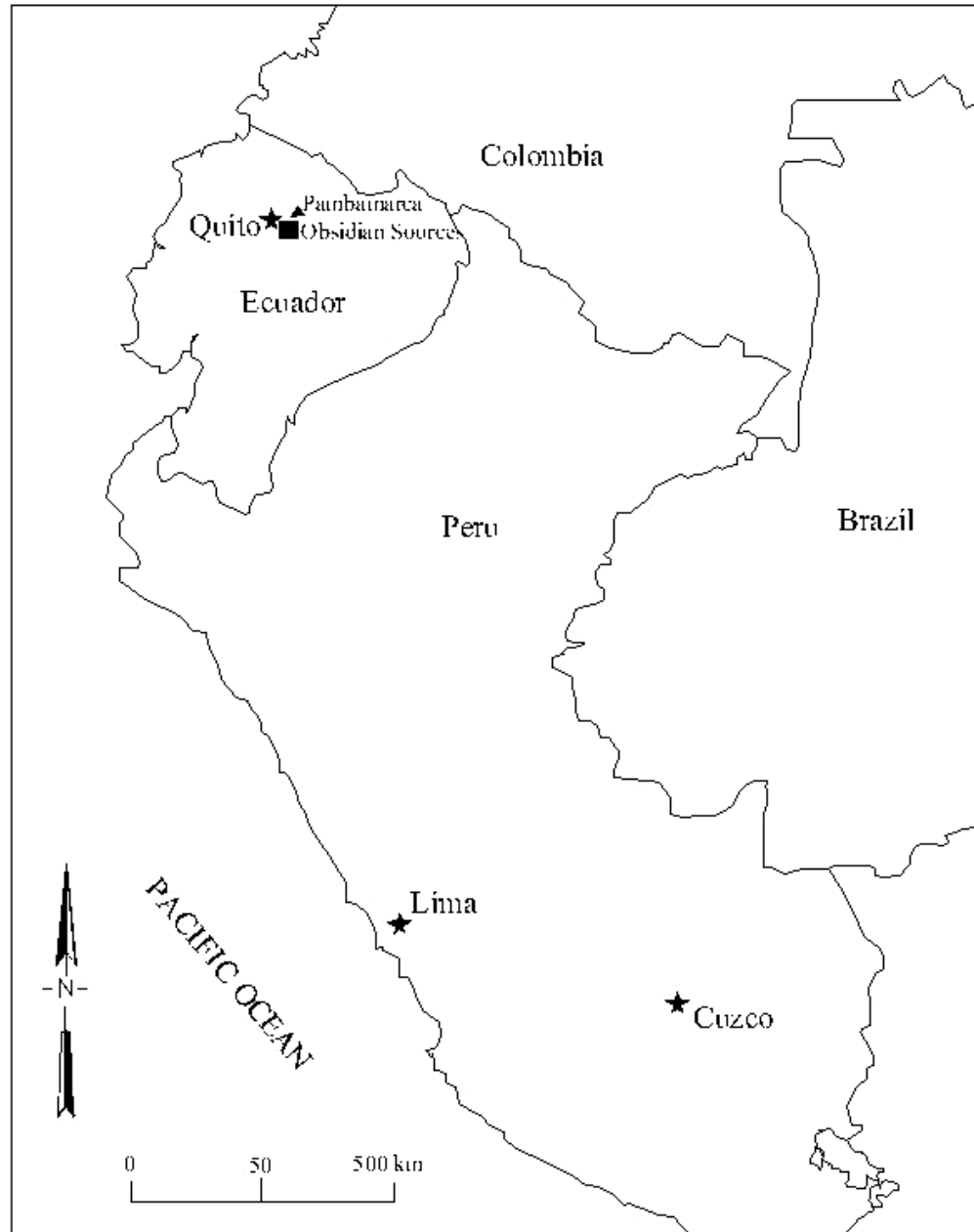


Figure 1: Location of Pambamarca

2.2 NORTHERN HIGHLAND OBSIDIAN SOURCES

Obsidian, a volcanic glass that is easily flaked and has an extremely sharp edge, is highly valued in many societies as either 1) a useful material, 2) a desirable elite status item, or 3) a ritual substance. In the Andes, although metal was known and used, few, if any, metal tools were manufactured before the arrival of the Spanish. This makes obsidian an important material for tool production. In other places, obsidian is often exchanged over long distances (Peterson 1997, Rice 2000, Saunders 2001, Drennan 2002, Stanish 2002, Hirth 2006) and reliant upon region exchange systems. Chemical analyses which allow archaeologists to compare archaeological obsidian with known source locations can be useful in determining acquisition methods and exchange patterns.

Elsewhere, such as at in Mesoamerica (Drennan 2002), obsidian reduction for transport occurs in the context of long distance elite trade. In the Maya area, Colha craft specialists of northern Belize produced formal chert, another high quality lithic material, tools for both utilitarian and ritual exchange throughout Belize and parts of Mexico (Shafer and Hester 2002). During the Aztec empire obsidian was manufactured for distribution by state-sponsored Pochteca (Berdan 2002).

In most cases where these types of distribution patterns were present obsidian was an exotic exchange item within a regional exchange network. The obsidian sources utilized by the Pambamarca residents, however, are located less than 25km from the sites (Figure 2), although the actual walking distance may be longer due to topography. There is little evidence for residence near the sources so obsidian at Pambamarca was mostly likely directly obtained. This provides a rare opportunity to consider how obsidian was obtained and produced by groups living within walking distance of the raw sources.

There are three known large obsidian sources in the northern highlands: Mullumica, Yanaurco-Quiscatola, and Callejones (Asaro 1994, Burger 1994, Ogburn 2008), which are located in the Sierra de Guamaní highlands to the south of Pambamarca. Another source, known as La Chimba, has been chemically identified but has not been located (Asaro 1994, Burger 1994, Ogburn 2008). Of these, Mullumica obsidian is the most commonly recovered in archaeological contexts (Burger 1994, Ogburn 2008). Salazar (Asaro 1994) has indicated the presence of workshop activity at the Yanaurco-Quiscatola obsidian flow, but no date is mentioned. Proportions of obsidian from each source for the Pambamarca sites were calculated using the data published by Ogburn (2008) (Table 2).

	Mullumica	Callejones	Yanaurco-Quiscatola	La Chimba	Pieces Analyzed
Oroloma (Early Cayambe)	0.85	0.06	0.03	0.06	34
Pukarito (Late Cayambe)	0.67	0.17	0.00	0.17	6
Pingülmí (Inka War: Cayambe Occupation)	0.80	0.13	0.00	0.07	15
Quitoloma (Inka War: Inka Occupation)	0.93	0.00	0.04	0.04	28
Guachalá (Colonial)	0.75	0.00	0.00	0.25	4

Table 2: Proportions of Analyzed Obsidian from Each Source (From Ogburn 2008)

The three obsidian flows discussed above are located in the Sierra de Guamaní highlands to the southwest of the Pambamarca sites (Figure 2). Yanaurco-Quiscatola is the furthest source, possibly the reason that it disappears from Pambamarca contexts after the Early Cayambe period. Callejones, the only source not utilized by the Inka, lies slightly to the southeast of Pambamarca on the side of the Cayambe fortresses. It is possible that this was in territory not yet conquered

by the Inka at the time of the Pambamarca campaign and that they therefore did not have access to it (Ogburn 2008).

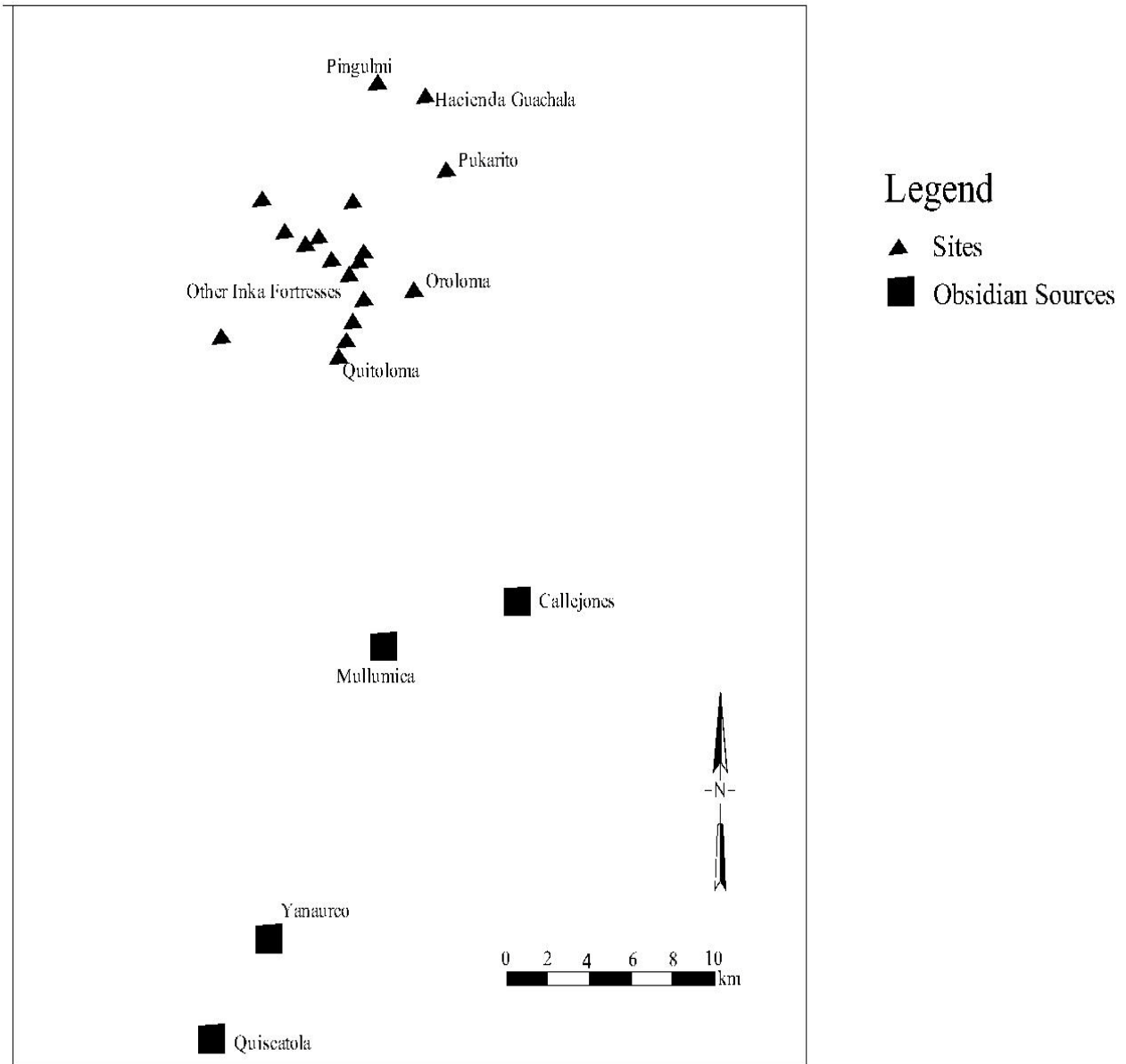


Figure 2: Locations of Pambamarca Sites and Sierra de Guamaní Obsidian Sources

In the Pre-ceramic Period, obsidian was in use at El Inga located 8km from Mullumica, at other sites in the nearby area, and in minute quantities at Chobshi Cave about 300 km from the sources (Burger 2004). During the Formative Period limited amounts of obsidian were recovered

from southern Ecuadorian occupations while northern highland residents utilized it extensively. During the Regional Development Period obsidian from the northern highlands reached the Santa Elena peninsula on the south Ecuadorian coast, the Río Tamba drainage, the Guayas drainage, and the Valdivia drainage, all of which are over 300 km from the Sierra de Guamaní sources (Burger 2004). Chemical analysis has shown that obsidian at these sites came from the Sierra de Guamaní obsidian flows. After the Regional Development Period however, obsidian is rarely recovered outside the northern highlands and adjacent coast despite its possibilities as a long distance trade item (Burger 2004).

In Pambamarca, obsidian was unlikely to have been transported by local high status traders, or mindaláes (Burger 1994), and was probably exchanged in local markets with other subsistence goods. Reduction patterns have been characterized as “smash and bash” (Burger 2004) as flakes are generally large and tools are informal and unretouched.

The reduction patterns and toolkits people produce are influenced by many factors. Although most studies have focused on formal tools produced by hunter-gatherers the same principles may often have applied to sedentary, agricultural communities such as those at Pambamarca. Understanding the factors which affect toolkits can provide suggestions about the primarily informal pattern of tool production in Pambamarca.

Many authors have considered hunter-gatherer lithic technology as a reflection of the inefficiency or ‘cost’ associated with lithic materials or the activities for which lithic material is used (Bamforth 1986, Jeske 1989, Ricklis and Cox 1993, Andrefsky 1994b). In general, these authors consider the cost of lithic material as the primary factor determining lithic technological system efficiency or inefficiency. Factors which affect cost include settlement systems (Bamforth 1986, Jeske 1989, Ricklis and Cox 1993), raw material distribution (Bamforth 1986,

Jeske 1989, Ricklis and Cox 1993, Andrefsky 1994b), activity for which the technology is intended (Jeske 1989, Ricklis and Cox 1993), and lithic material quality (Andrefsky 1994b). Jeske (1989) also mentions social organization, but does not discuss it extensively.

Once the factors associated with lithic cost are established, most authors propose “economizing strategies” (Jeske 1989) which occur in response to increased lithic material cost. Jeske (1989) discusses how artifact forms standardization (particularly bifaces) promotes economical raw materials use, easier hafting, and multipurpose utilization, all of which prevent waste of limited raw material. Bamforth (1986) discusses curation (activities such as maintenance and recycling) as a response to raw material shortages. Ricklis and Cox (1993) associate higher costs with biface thinning to reuse existing tools and with substitution of other materials as the preferred material becomes scarce. Andrefsky (1994b) discusses relationships between lithic quality, abundance, and formal and informal tool forms. He proposes that, while low quality material will generally be used for informal tool forms regardless of abundance, scarcity of high quality material is associated with formal tool forms, while high abundance of high quality material allows for both formal and informal forms (Andrefsky 1994b:30).

Along with raw material costs, time and energy available to tool producers affects lithic assemblages (Jeske 1992). Increased time and energy stress results in simpler assemblages (Jeske 1992:468). With this consideration lithic technology is an industry embedded within a social group whose members have many constraints on their time and energy, and who therefore may not always choose the most economical technology. Tradition also has a role in tool production (Pfaffenberger 1992, Sackett 1990). Tools are often made a certain way because that it is seen as the ‘proper’ form by the producers. How conceptions of the ideal tool form interact with material costs and time and energy stress will vary culturally.

Because the Pambamarca toolkit is primarily informal it is possible that many of the costs and stresses which influenced the toolkits of the societies discussed above were not major factors for the Pambamarca residents. It would be possible that warfare during the Late Cayambe and Inka Periods and the oppression of indigenous workers during the Colonial Period would have increased the costs associated with obsidian despite its proximity to Pambamarca. This would have resulted in higher rates of formal tools which could be used for many purposes and would have a long uselife. However, this is generally not the case. Throughout all time periods the predominant tools in Pambamarca are unretouched utilized flakes, suggesting that obsidian is abundant and easily accessible leading to an expedient pattern of production.

2.3 EARLY CAYAMBE PERIOD (600 C.E TO 900 C.E)

The Integration period in Ecuador begins around 600 C.E. and ends with the Inka conquest. In Pambamarca, this period is divided into the Early Cayambe and Late Cayambe Periods (Table 1). The Early Cayambe is from 600 C.E. until the eruption of Mt. Cayambe in 900 C.E. After this the region appears to undergo drastic population loss until the Late Cayambe period beginning around 1250 C.E. To date, little research has been done on the Early Cayambe period in the northern highlands. The absence of the complex societal structures which existed in the Late Cayambe period suggests a less complex society, though likely with already established long distance trade connections.

Cosanga ware from Oroloma, an Early Cayambe site, shows that exchange with the eastern slopes of the Andes was already occurring in this early period (Cox 2009, Gonzales 2009). Large amounts of obsidian from Early Cayambe sites suggest active local exchange as well. Chemical analysis by Ogburn (2008) shows that residents of the Early Cayambe site of

Oroloma utilized obsidian from all four major highland sources (Mullumica, Yanaurco-Quiscatola, Callejones, and La Chimba).

2.4 LATE CAYAMBE PERIOD (1250 C.E. TO 1505 C.E.)

The Late Cayambe period begins around 1250 C.E. with the construction of the earliest ramped platform mounds, or tolas, and continues until the Inka arrival in 1505 C.E. During the Late Cayambe period the Cayambe valley was organized into multiple autonomous, loosely interconnected, internally stratified, inter-warring, small scale polities with extensive trade networks located between the Pisque river and Imbabura (Salomon 1986, 1987, Bray 1992, 1995, 2005). Each polity had its own settlement hierarchy (Bray 1995). Central sites included tolas and were likely similar to the still-visible site of Cochasquí. Irrigation ditches dating to at least 1300 C.E. have been found in the País Caranqui (Myers 1974) and are thought to have been part of organized agricultural production systems.

Markets and market exchange are thought to be the means by which pre-Inkan northern highland peoples acquired produce outside their immediate area (Salomon 1986, 1987). Using ethnohistorical evidence Salomon (1986, 1987) describes the mindaláes; specialized long distance merchants similar to the Aztec Pochteca. They are thought to have specialized in high value, low weight goods and may have been part of the regional market exchange system or employed directly by local elites (Salomon 1986, 1987, Bray 1992, Burger 1994).

The majority of research on exchange during this period has focused on long-distance exchange of items that were likely in restricted or elite use (Salomon 1987, Bray 1992, 1995, 2005, Cox 2009,). Evidence of exchange between Amazonian groups and the northern highlands is extensive, and is based mostly on Panzaleo ceramics which occur in small amounts in most

northern highland assemblages (Bray 1992, 1995, 2005, Cordero Ramos 1993). Compositional analysis by Bray (1995) has shown that Panzaleo ware was most likely manufactured at the eastern foot of the Andes. As a long distance, restricted-use trade good, these ceramics may have been a commodity traded by mindaláes. PAP has carried out surveys showing the existence of Inkan and pre-Inkan roads leading to the town of Oyacachi at the edge of the Amazon (Sistruck) which may have been a route by which these ceramics were brought to the Cayambe valley.

Goldstein (2000) notes that elites often use exotic items to differentiate themselves from non-elites, causing them to develop long distance networks with other elites in order to obtain valuable extra-local items. These elite networks are not restricted by cultural boundaries and can be quite different from the trade networks in which utilitarian goods travel (Goldstein 2000, Peterson 1997). It is possible that elites may have maintained such networks to obtain long-distance, status-bearing materials such as Panzaleo pottery, while local subsistence materials such as obsidian moved in different distribution spheres. Obsidian, although likely considered a valuable commodity, is unlikely to have been traded by mindaláes. Its absence from regions outside the northern highlands suggests that it was not part of elite long distance exchange despite its potential.

Ogburn's (2008) chemical analysis of Pambamarca obsidian included the site of Pukarito which has both Late Cayambe and Inka period occupations. Residents of Pukarito utilized obsidian from the two closer Sierra de Guamaní sources (Mullumica and Callejones) and from La Chimba, but not from the further Yanaurco-Quiscatola source (Ogburn 2008).

2.5 THE INKA WAR (1505 C.E. TO 1532 C.E.)

The Inka armies arrived in Pambamarca around 1505 C.E. According to Bernabe Cobo (1979) the Inka ruler Wayna Capac, the last Sapa Inka before the arrival of the Spanish, conquered the lands north of Quito. From Tumibamba, the Inka seat in Ecuador, Wayna Capac sent armies north of Quito but

“many times the troops of the Inca were defeated and routed and not a few times the king himself fled. The Cayambes, particularly, being men of valor and courage, made it so difficult for the Inka Guayna [Wayna] Capac and his captains that in conquering them a great deal of time and blood were lost.” (Cobo 1979:157)

Cobo testifies that the Inka himself led the battle into Cayambe territory and that the Cayambes had to retreat into a fortress. The Inka laid siege to the fortress but the Cayambes retaliated. In the battle Wayna Capac himself was almost killed (Cobo 1979). Accounts of how long the Cayambes resisted the Inka differ. Cobo (1979) gives no exact date but researchers in the area have put the time period of indigenous resistance between eight (Ogburn 2008) and seventeen (Salomon 1987) years. Cobo (1979) recounts the death of the Inka's brother, Auquituma, in an Inkan attack on the Cayambe fortress. After the final Inka conquest of the region it is said that all the Cayambe men were killed and their bodies thrown into the Imbabura lake. The Inka replaced much of the nearby Guayllabamba valley population with their subjects from elsewhere in the empire through mitmaq, a policy of relocating peoples within the Inka Empire (Bray 1992).

Subsequently, as the Inka occupied northern Ecuador for less than 20 years the region was never fully consolidated into the empire and can therefore exemplify the earliest stage of Inka imperial conquest and administration strategy. Several authors have discussed the dynamic process by which areas outside empires are gradually incorporated into imperial control and the strategies which the Inka employed to subdue and exploit regions under their rule (Dillehay 1977, Schreiber 1987, Hastorf 1990, Stanish 1997, Covey 2000, D'Altroy 2000, Alconini 2004), although the effects of Inka occupation on lithic production and distribution patterns is usually not discussed. The Inka tailored their strategies to the specific regional situation (Covey 2000, D'Altroy 2000, Alconini 2004), but many studies have shown the Inka to commonly employ strategies such as settlement reorganization, mitmaq importation, and intensified, imperial-controlled economic exploitation of the region's most advantageous or desirable resources (Hastorf 1990, Stanish 1997, Covey 2000, D'Altroy 2000). One important counter-example to the pattern of increasing control as a region is incorporated into the empire is seen in the Carahuarazo Valley of central Peru. There, Inka influence on local settlement and economic structures appears to have been minimal (Schreiber 1987).

Most of the studies discussed above address areas which were well incorporated into the Inka Empire prior to the Spanish Conquest. In contrast, Pambamarca may have been abandoned after Inka conquest and, even if it was still occupied, it only underwent a short period of Inka rule. Therefore, Pambamarca can be seen as an example of Inka frontier and early incorporation strategies. One study of frontier strategies has been carried out by Alconini (2004) at the southeastern border of the Inka Empire with Amazonian groups. Unlike Pambamarca this is an area where the Inka never conquered indigenous populations and it appears that they had very different strategies for controlling the border than in Ecuador (Alconini 2004). This southeastern

border was a “soft military frontier” compared with the “hardened perimeter” (Alconini 2004) of the Inka fortresses at Pambamarca and around Quito. In contrast with the southeastern border Pambamarca provides an example of Inkan conquest by force rather than by preferred means such as intimidation or diplomacy.

The chemical analysis carried out by Ogburn (2008) included two of the Inka fortresses in Pambamarca: Quitoloma and Campana Pukara. The analyses showed that all, or nearly all, of the obsidian at the fortresses came from the local Ecuadorian sources and not from obsidian flows within the empire. Ogburn (2008) suggests that this indicates a rapid consolidation of the region immediately south of Pambamarca by the Inka forces, allowing them to utilize the resources of the region, including obsidian, through tribute. Further, Ogburn’s analyses (2008) show that only obsidian from the sources behind the front Inka lines (Mullumica and Yanaurco-Quiscatola) were utilized at the fortresses. The La Chimba source was also utilized (Ogburn 2008).

Surprisingly, although it is located on the border of Inka territory, residents of the Inka-contemporary fortress at Pingülmi continued to primarily utilize obsidian from Mullumica (Ogburn 2008). Obsidian from Callejones and La Chimba was also utilized (Ogburn 2008). The only source not utilized at Pingülmi is Yanaurco-Quiscatola, which is located furthest from Pambamarca.

2.6 THE SPANISH CONQUEST (1532 C.E.)

The Spanish arrival in South America in 1532 was preceded by European diseases which had already decimated Central American cultures such as the Aztec and Maya (Moseley 2001). According to Cobo (1979), Wayna Capac and his heir died of smallpox soon after learning of

Francisco Pizarro's landing at Tumbez in the western coast of South America. According to other sources Wayna Capac died several years before Pizarro's arrival (Moseley 2001). Either way, civil war erupted between Wayna Capac's sons Huascar and Atahualpa just before the Spanish conquistadors landed on the South American coast (Cobo 1979, Moseley 2001). Huascar was named Sapa Inka in Cuzco, but Atahualpa claimed to be the Sapa Inka of Quito and planned to create a new kingdom in the northern highlands separate from the rest of the empire (Cobo 1979). The combination of disease and the Inkan civil war augmented the Spanish ability to overthrow the empire.

After the Spanish conquered the empire they instituted the *encomienda* system, where land was divided into rural estates run by conquistadors who were focused on exploiting the full economic potential of the land (Andrien 2001). In Pambamarca, local villages came under the rule of the Hacienda Guachalá, which continues to have a role in the region up to the present day where it is the residence of the mayor of Cayambe.

Hacienda Guachalá was established in 1580 (Ogburn 2008) around 50 years after the first arrival of the conquistadors in South America. It controlled much of the nearby indigenous population and has been called one of the cruelest haciendas in Ecuador. Some villages that fell under the rule of Hacienda Guachalá and which still exist to the present day, such as modern Pambamarca, resisted Spanish rule and to this day distrust outsiders. However, other sources seem to contrast with this view of Guachalá. Andrien (2001) claims that people from all around the Quito region came to Guachalá for work, making the hacienda a multi-ethnic and varied community. The two accounts are not necessarily incompatible as it is possible that workers at Hacienda Guachalá came from a wide variety of situations.

Excavations by PAP in an obraje, or dye workshop, at Hacienda Guachalá show the continued use of obsidian tools by the workers, who were likely indigenous. Ogburn's (2008) analysis showed that obsidian at Hacienda Guachalá came from Mullumica and La Chimba, the only two sources which are utilized at every Pambamarca site analyzed.

Colonial period archaeology is almost non-existent in Andean South America (Jamieson 2005). What archaeology has been done suggests different acculturation patterns in different regions. Important concepts that have arisen from colonial archaeology are active perspectives of native peoples and the view of acculturation as a process (Deagan 2004, Rodriguez-Alegría 2003). These studies have allowed researchers to move away from viewing indigenous peoples as passive recipients of European culture, or as conquered, victimized, and marginalized populations paralyzed by the weight of European imperialization.

3.0 METHODS

3.1 OBSIDIAN PRODUCTION

The first section of this analysis will focus on comparing obsidian production at five Pambamarca sites (Table 3). As discussed earlier, obsidian tools in Pambamarca usually take the form of informal utilized flakes. Retouching is uncommon, and worked formal tools are rare. For the purposes of this study the obsidian assemblage was divided into debitage, informal tools, and formal tools, which will be defined further below.

3.1.1 Production Sequence

Although there are some consistent similarities in the lithic production sequence cross-culturally, knappers make many choices both of what tool they will make and how they will produce it. At the most basic level producing a lithic tool involves striking lithic material with a hammer (often stone, bone, or antler) to remove flakes known as debitage (Andrefsky 1994a).

A knapper may decide to shape the material for a specific purpose or to produce an edge which will last longer than that of an unmodified flake. These formal tools were often multi-functional, curated, recycled, and discarded away from the use area (Keeley 1982). However, often unmodified debitage flakes are utilized. In Pambamarca such tools make up the majority of the utilized obsidian. These informal tools, in contrast, are often discarded immediately after use and in the vicinity of use (Keeley 1982).

3.1.2 Definition of Production Categories

Debitage consists of waste flakes produced during reduction and which do not show evidence of utilization noticeable with a hand lens. They usually have identifiable flake features such as ventral surfaces, and flake scars are few, if present.

Informal tools are morphologically identical todebitage but are utilized. Retouched flakes are classified as informal when the retouching is restricted to the working edge and not meant to change the morphology of the flake.

Formal tools are utilized obsidian which shows evidence of having been worked as an objective piece beyond retouching. This is usually seen in the presence of flake scars on more than one side of the piece and lack of flake characteristics such as ventral surfaces and bulbs of percussion. Most are classified as bifaces or unifaces without a specific function being readily apparent from the morphology. While these categories are subjective, since the bulk of the Pambamarca assemblage is made up of informal flakes anddebitage, worked tools are distinctive.

Comparisons of the proportions of these categories in the Pambamarca assemblage will be used to evaluate the goals of obsidian production at each site. Because production in the region is thought to primarily produce informal tools, the obsidian assemblage should consist of a majority ofdebitage with a sizable proportion of informal tools and few formal tools.

3.1.3 Identification of Reduction Stages

Analysis ofdebitage flakes can reveal the predominant reduction stage which produced flakes in a particular assemblage. Comparing the predominant reduction stage at different sites

can reveal differences in the obsidian production process. Production could differ for various reasons, including raw material costs and societal stresses as discussed earlier, specialization or concentration of economic activities, or other site functions.

Obsidian from each site was categorized using the Sullivan and Rosen Typology (SRT) to determine reduction stage (Sullivan and Rosen 1985). The SRT categorizes flakes into four discrete, interpretation-free categories (shatter, flake fragments, broken flakes, and complete flakes) and then uses combined proportions of these categories to infer the predominant reduction stage (Sullivan and Rosen 1985). Higher proportions of flake fragments and broken flakes correspond to later stage lithic reduction such as the production of tools while higher proportions of shatter and complete flakes are produced during early stage reduction such as core reduction. The validity of the SRT when used alone has been questioned by several authors (Amick and Mauldin 1989, Baumler and Downum 1989, Tomka 1989, Prentiss and Romanski 1989, Prentiss 1998) so other analyses are included.

Proportions of cortex on obsidian debitage will be compared. Cortex is the outer surface of raw nodules and differs visually from the inner material which is used for tool production. The earliest stages of core reduction remove the cortex leaving only the higher quality inner material (Andrefsky 1994a). Therefore higher proportions of cortex in the obsidian assemblage indicate early stage reduction, just as do high proportions of shatter and complete flakes in the SRT.

A size grade analysis based loosely on Ahler's mass-debitage analysis (1989) was conducted on the obsidian debitage. However, screens in different sizes were not available so the analysis was done using drawn squares. The square sizes were 1in, 1/2in, 1/4in, and 1/8in. A flake was considered to pass through the square if it fit through in its largest dimension. This will not produce as accurate a division of size grades as with screens and because of how the sizing

was done the proportions will skew to the larger sizes. Larger flakes are thought to be produced during earlier stage reduction (Andrefsky 1994a).

Lastly, mean weight of the obsidian for each sample was calculated. However, because this was calculated from the total obsidian weight divided by frequency without data on individual flake weights no standard deviation is given. Heavier flakes are usually produced earlier in the reduction process, so a higher mean weight is indicative of earlier stage reduction.

3.2 SITE FUNCTION

The second section of the analysis will use the results of the obsidian production patterns discussion with analysis of the artifact assemblage at each site to make inferences about site function. The materials which are discussed include obsidian (as a single group, not by reduction categories), non-obsidian flaked lithics, and ceramics. Other known aspects of the sites such as architecture (defensive, residential, ritual etc.), presence of weaponry, proximity to trade routes, and known site activities will be incorporated.

3.2.1 Lithics: Obsidian and NOL

Although obsidian and NOL are both used to produce lithic tools a central issue in this study is the activities for which each was used. Obsidian, as a volcanic glass, does not have an internal crystalline structure and is therefore an excellent material for lithic tool production as it flakes easily and predictably and also produces an extremely sharp edge (Andrefsky 1994a, Cotterell and Kamminga 1987). However, although the initial obsidian edge is extremely sharp it is also short lived. The edge can be retouched for a longer uselife but will not have the same

sharpness as the initial edge. The other commonly used flaking material in Pambamarca is a basalt like material here referred to as NOL (Non-Obsidian Lithic). NOL has large rough crystals which create many internal fracture planes causing it to flake less predictably than obsidian. However, NOL flakes would have a stronger edge than obsidian and may have been preferable for certain activities.

Obsidian, easier to flake with a sharper but weaker edge, could have been used for activities such as butchering and textile production among others. There is no evidence that obsidian was used for weapons. Flaked NOL, although more difficult to produce, would have had a stronger edge preferable for activities on harder materials such as wood, stone or bone. In addition, flaked NOL could have been used for or produced during weaponry or groundstone manufacture (Hayden 1987) and may have been used for agricultural implements as well. While this study did not include weaponry or groundstone, debitage produced through chipping would not appear different from other flaked NOL and so would be included.

Andrefsky (1994b) suggests that the use of low quality lithic material can be a response to high costs associated with high quality material, meaning that NOL and obsidian could be used for the same activities and that differing concentrations would reflect the cost of obsidian. This possible confounding factor would be illuminated by usewear analysis on both obsidian and NOL from the same sites to see if they were used for the same activities. However, no such work has been done to date in the region of the País Caranqui. Cultural preferences for particular materials could also account for differences in proportions. For instance, if the Inka preferred to use NOL for all activities regardless of its aptness more NOL would be present in the assemblage. However, for this study I assume that, since the properties of NOL and obsidian are

different and would be advantageous for separate activities, it is likely that they had different uses.

Differing proportions of obsidian and NOL could indicate differences in site activities. For instance, a large amount of obsidian, production focused on tools, and prevalence of residential architecture could indicate a focus on activities such as hide production, textile production, or processing of faunal remains. In contrast, a large proportion of NOL and the presence of defensive architecture could reflect a military occupation.

3.2.2 Ceramics

Archaeological ceramics are associated with various activities. Vessels were used for cooking, food preparation, water storage, chicha brewing and fermentation, to eat or drink from, to serve food, or to display ritual or status symbols (Rice 1987). Large, heavily decorated vessels are often interpreted as used for feasting activities during which elites displayed their wealth and power (Cook and Glowacki 2003).

Often composition, morphological, and decorative variation relates to vessel function (Braun 1983, Henrickson 1983, Hally 1986, Rice 1987, Wilson 2002). However, since ceramics in this study are only included as frequencies it is not possible to identify functions. In Northern Ecuador Panzaleo ceramics acquired through long distance trade with the eastern slopes of the Andes have been extensively discussed (Bray 1992, 1994, 2005, Cordero-Ramos 1993, Cox 2009, González 2009) but there has been little analysis of the overall assemblage. Analysis of different ceramic types based upon attributes such as composition and morphology would be useful to better understand the Pambamarca sites.

Here it is assumed that ceramics indicate household activities because the majority of ceramics, in general, are utilitarian wares (Costin and Hagstrum 1995, Bray 2005) which are generally used and discarded in residential contexts. However, considering proportions of different ceramics types in each assemblage would allow different usage contexts to be differentiated.

NOL may have been used during ceramic production. An ethnoarchaeological study of Cuzco valley ceramic production (Chavez 1992) recorded that potters used “porous, volcanic rock” and “hard, fine grained rock” in ceramic production. However, as there is limited evidence on ceramic production sequences for Northern Ecuador, this study does not interpret NOL as evidence of ceramic manufacture.

3.3 DISTANCE FROM SOURCES

Because the sample for this study contains only one site per time period any discussion of changes in regional patterns over time is limited. However, by considering the obsidian assemblage at each site, the distance between the sites and the obsidian sources, and what is known about exchange patterns and the political context of each time period some observations can be made. These observations will be drawn from a simple catchment analysis and considering the relationship between the distance to the sources and proportions of obsidian in site assemblages to suggest how obsidian came to each site.

Catchment circles will be drawn with a radius of 20km. This is a relatively arbitrary distance following Flannery (1976), based upon that villagers at San José Mogote would travel 15-20km to collect wood for house construction and firewood. The most commonly used lithic at San José Mogote was chert from about 3km away (Flannery 1976), much closer than the Sierra

de Guamaní obsidian sources to the Pambamarca sites. However, the evidence that the Mesoamerican villagers would travel further to collect preferred material (wood) even when other types of the same material were available nearby (Flannery 1976) makes it possible to suggest that the Sierra de Guamaní sources were within direct reach of the Pambamarca residents. Comparing the distance from the sources with the obsidian assemblage at each site may clarify other aspects of obsidian use and site function.

In many models, the distance between sites and material sources is thought to be a major factor in access to those sources (Renfrew 1991). Although the Pambamarca sites are all within 25km of the nearest Sierra de Guamaní sources it is still possible that distance to the sources played a role in access to and use of obsidian at the sites. Distances from the sources are plotted as the distance between the sites and Mullumica because Mullumica is overall the most heavily utilized source and the only source used by all five sites whose location is known (Ogburn 2008). Both the proportion of obsidian out of all materials and the proportions of debitage out of all obsidian are plotted. To clarify the relationship between proportion of debitage and distance, the inverse proportion is also plotted.

3.4 SAMPLE SELECTION

The analysis draws on material samples from five Pambamarca sites excavated by PAP. The samples from each site are essentially grab samples but are not necessarily incomparable. Table 3 details the time period, cultural affiliation and characteristics of each site sample. The aim of the sample collection was to include enough obsidian from each site to make inferences about that site's assemblage. For all the sites except Oroloma this meant that all recovered

obsidian which could be assumed to come from the desired time period was included. Table 4 and Table 5 include the units in the sample and the material from each.

Years	Pambamarca Chronology	Site	Cultural Affiliation	Site Characteristics	Sample Contexts
690 C.E. – 900 C.E.	Early Cayambe	Oroloma	Cayambe	Residential Architecture, Ubiquitous Obsidian	Habitation and Midden Contexts
1250 C.E.– 1505 C.E.	Late Cayambe	Pukarito	Cayambe	Ritual and Defensive Architecture	Defensive Contexts
1505 C.E.– 1532 C.E.	Inka	Pingüلمي	Cayambe	Habitation and Defensive Architecture, Extremely Windy	Survey
		Quitoloma	Inka	Habitation, Administrative, and Defensive Architecture	Habitation Contexts
Begins 1580 C.E.	Colonial	Hacienda Guachalá	Colonial	Dye Workshop	Workshop Context

Table 3: Sample Sites

PAP’s numbering system assigns an Operation number (OP) to categorize separate projects. Usually an OP number refers to a single site, but each site can have multiple OP numbers. A Built Division (BD) number indicates a specific area of a site and the Built Space (BS) number indicates which building a unit is in, if any. Not all units have BS numbers. Only NOL and ceramics from the same units which contained obsidian were included. For example, if NOL or ceramics were recovered unaccompanied by obsidian they were not included. This decision was made primarily because of time considerations. Despite attempts to include comparable samples special consideration is necessary in the interpretation of the samples from three of the sites.

At Oroloma, the massive amounts of obsidian recovered made it impossible to analyze more than a small amount in the time available. Therefore, only material from comparable levels in two discrete units was included. The amount of obsidian yielded by these two levels is more than was recovered at all the other sites combined, which gives an idea of the quantity of obsidian at the site (Table 4). Because the sample comes from only two contexts it is unclear whether the patterns observed here reflect Oroloma as a whole or just these specific contexts.

Pukarito was the only site which showed clear evidence of occupation over a long period, beginning in the Late Cayambe and continuing until the Inka period. Therefore, to look at the Pre-Inkan Late Cayambe occupation only obsidian from levels below Inkan ceramics was included. The obsidian sample from Pukarito is the smallest from any site in the study (Table 4). This likely has more to do with the site's function than the sample selection as the units and levels which were not included also contained very little obsidian. Because of the small size of the obsidian sample error ranges for proportions are extremely large and differences between proportions are not significant. In addition, one of the debitage pieces weighs 32g, while the mean weight without that piece is 0.96g. Because this piece would have a very strong effect on the mean weight it is not included in that calculation.

The last site where special consideration is necessary is Pingülmi. The site is located on an extremely windy hill with little soil deposition. Excavations recovered little material and so material from a surface collection was used for analysis. Material from the collection was divided into that recovered from the different Built Divisions (BD) of the site. There are issues associated with comparing a surface collection to excavated assemblages. Specifically, the size grade analysis and mean weight calculation from Pingülmi should not be compared with that from the other sites as a survey will recover generally larger (and therefore heavier) obsidian

than from a screen during excavation. For this reason, Pingülmi is not included on the graphs of size grades and mean weight although the proportions and mean can be found in the tables. In addition to problems with the debitage analyses, it is very probable that the relatively enormous amount of ceramics in comparison to the small amount of obsidian and scarcity of NOL recovered at the site is due to the recognizability of each material during survey. In particular, the very small amount of NOL is due to its similarity in color to dirt as well as the common difficulty of differentiating between culturally produced lithics and natural rocks.

Another consideration with the sample is that the contexts from each site are not necessarily directly comparable (Table 3). At Oroloma, for instance, the sample comes from habitation and midden contexts, while at Pukarito it is from defensive areas, and at Hacienda Guachalá from a textile workshop. In general this incongruity was unavoidable as excavation at most of the sites includes only a small proportion of the total site and the placement of units included a different range of contexts at each site. Decisions about units and levels to include were based on presence of obsidian, the chronological context of the units, and legibility and completeness of the excavation reports. Restricting the sample to one time period per site (especially at Pukarito) was meant to simplify comparisons between time periods but also led to the inclusions of only a single site in each time period which limits the plausibility of any regional inferences or chronological comparisons.

	Obsidian Debitage	Informal Tools	Formal Tools	Total Obsidian	NOL	Ceramics
Oroloma	467	18	0	485	21	91
Pukarito	15	2	0	17	58	0
Pingülmi	108	35	3	146	23	7492
Quitoloma	74	11	2	87	96	788
Guachalá	57	14	6	77	72	11

Table 4: Frequency of Material from Each Site

	OP	BD	BS	Unit	Levels	Obsidian Debitage	Tools	NOL	Ceramics
Oroloma (Early Cayambe)	22	3	N/A	11	3	145	5	10	91
	23	2	1	10	4	322	13	11	0
Pukarito (Late Cayambe)	25	1	1	1	2,3,4	11	2	42	0
	25	1	1	2	4,5	4	0	16	0
Pingülmí (Inka War: Cayambe Occupation)	8	1	N/A	N/A	N/A	6	2	6	2942
	8	2	N/A	N/A	N/A	15	5	8	1767
	8	3	N/A	N/A	N/A	9	4	4	286
	8	5	N/A	N/A	N/A	59	21	2	2244
	8	6	N/A	N/A	N/A	1	0	0	0
	8	7	N/A	N/A	N/A	18	6	3	253
Quitoloma (Inka War: Inka Occupation)	4	5	14	2	3,4,5	5	5	10	230
	4	5	14	3	3	0	1	1	43
	4	5	16	1	3,4	4	0	10	72
	4	5	17	1	3,4,5,6	36	3	58	208
	4	5	18	1	2	3	0	3	155
	7	5	19	3	2	3	0	3	7
	7	5	3	1	1,3	5	3	0	25
	7	5	3	2	3,4	10	0	10	34
	7	5	3	3	2	0	1	1	14
	30	8	0	8	N/A	8	0	0	0
Guachalá (Colonial Period)	21	1	1	2	3,4,5	21	9	3	0
	21	1	1	3	5	15	2	0	0
	21	1	1	5	4,5	15	9	0	0
	21	1	1	6	4,5	5	1	0	0
	21	1	1	13	1,2	1	0	69	11

Table 5: Units and Corresponding Material

4.0 ANALYSIS

4.1 GRAPHS AND CHARTS

I completed all obsidian analyses and compiled NOL frequencies during the 2008 PAP field season. Katrina Eichner compiled the ceramic frequencies during the 2009 PAP field season. Error bars on all histograms correspond to a 90% confidence interval based upon a Student's T distribution. If the error bars overlap then the proportions are not significantly different.

4.1.1 Obsidian Production

4.1.1.1 Obsidian Production: Reduction Categories

At all sites the most common production category is debitage (Figure 3), which is expected when tools are being produced or modified at the site rather than brought to the site finished. At all sites informal tools make up the majority of the tools recovered. Only at Hacienda Guachalá is the proportion of informal tools not significantly higher than the proportion of formal tools. Overall, Oroloma has the highest difference between the proportion of debitage and proportion of informal tools, implying that fewer flakes were being utilized. Pingülmi has the lowest difference between debitage and informal tools, showing that more of the produced flakes were being utilized.

	Debitage	Informal Tools	Formal Tools	Total Obsidian
Oroloma (Early Cayambe)	0.96	0.04	0.00	485
Pukarito (Late Cayambe)	0.88	0.12	0.00	17
Pingülmí (Inka War: Cayambe Occupation)	0.74	0.24	0.02	146
Quitoloma (Inka War: Inka Occupation)	0.85	0.13	0.02	87
Guachalá (Colonial)	0.74	0.18	0.08	77

Table 6: Proportions of Reduction Categories

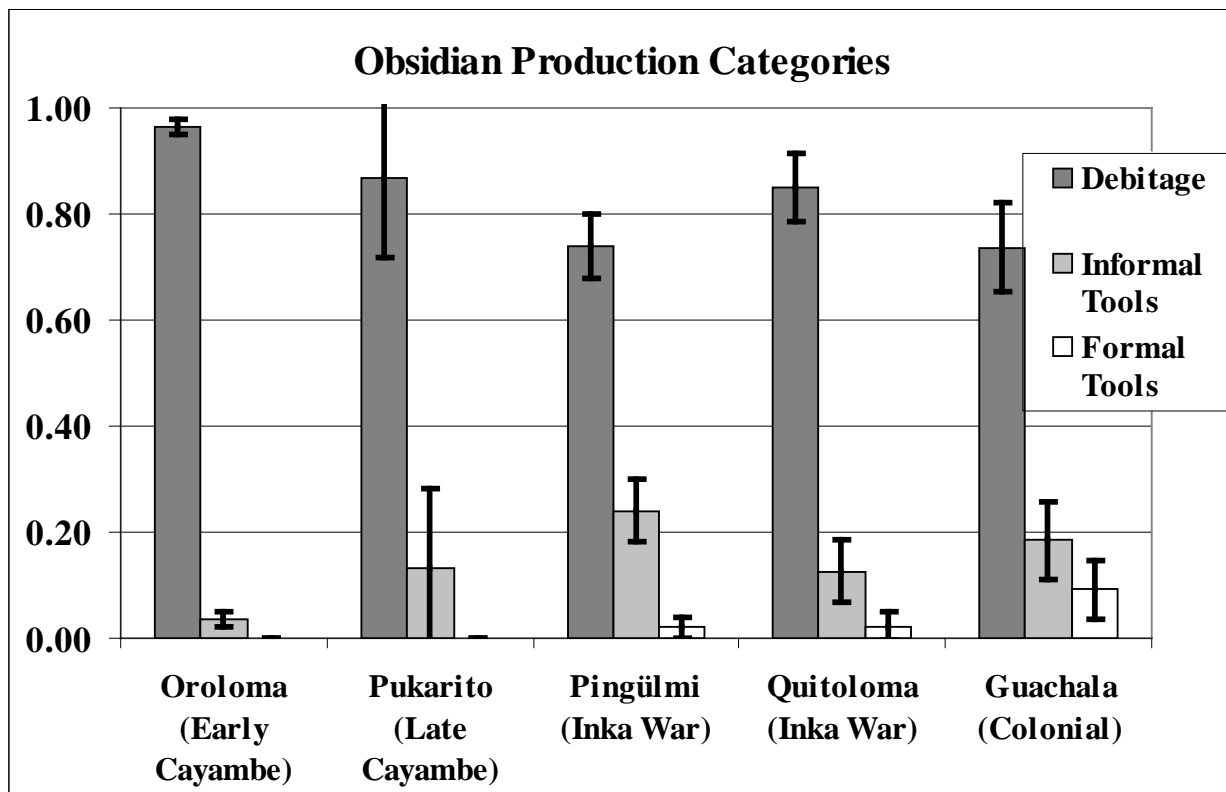


Figure 3: Production Categories

4.1.1.2 Obsidian Production: SRT

Figure 4 abbreviates the Sullivan and Rosen categories (1985) as SHCF (shatter and complete flakes) and BFFF (broken flakes and flake fragments). The SRT showed that all sites except Oroloma had a majority of broken flakes and flake fragments, although the difference is not always significant (Figure 4). This suggests that obsidian production at Oroloma was more focused on early stage reduction. Of the other sites, Quitoloma had the smallest difference between the proportion of shatter and complete flakes and the proportion of broken flakes and flake fragments.

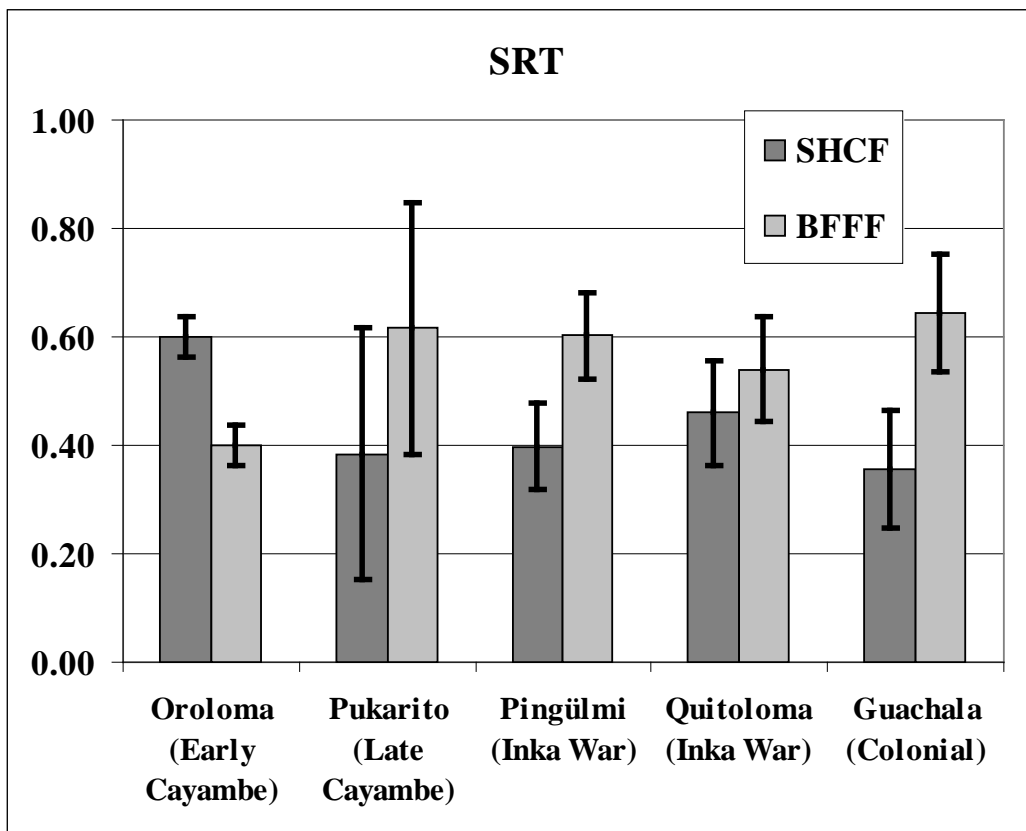


Figure 4: Sullivan Rosen Typology, Combined Categories

	Shatter (SH)	Complete Flakes (CF)	Broken Flakes (BF)	Flake Fragments (FF)	Cortex	Total Debitage
Oroloma (Early Cayambe)	0.44	0.16	0.08	0.16	46	467
Pukarito (Late Cayambe)	0.31	0.08	0.08	0.08	0	15
Pingülmí (Inka War: Cayambe Occupation)	0.35	0.05	0.12	0.05	2	108
Quitoloma (Inka War: Inka Occupation)	0.35	0.11	0.15	0.11	2	74
Guachalá (Colonial)	0.36	0.00	0.13	0.00	2	57

Table 7: Obsidian Debitage, Sullivan Rosen Typology and Cortex

4.1.1.3 Obsidian Production: Cortex

The proportion of debitage with cortex shows a similar pattern to the SRT (Figure 5). Oroloma has the highest proportion of cortex of all the sites and the difference is significant. This supports the results of the SRT that early stage reduction was more important at Oroloma. Hacienda Guachalá has the next highest proportion of debitage with cortex, although it is not significantly higher than at Pingülmí or Quitoloma. None of debitage at Pukarito had cortex (Table 7).

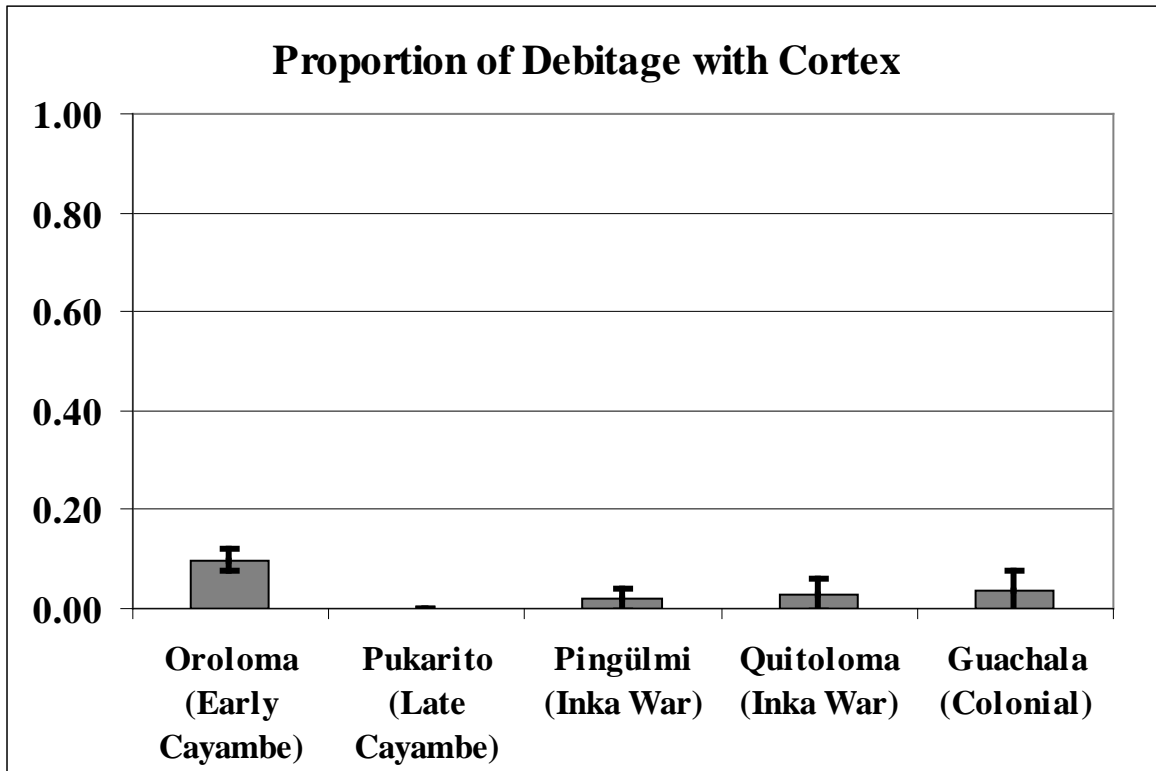


Figure 5: Proportion of Cortex

4.1.1.4 Obsidian Production: Size Grades

Because of the limitations of the Pingülmi obsidian sample, only proportions of debitage in each size grade from Oroloma, Pukarito, Quitoloma and Hacienda Guachalá are displayed in Figure 6. Table 8 contains the proportions for all sites. The Pukarito sample is the most different from the other sites, but due to the small sample size this could easily not reflect the site as a whole. Of the remaining sites for which the size grade analysis is comparable, Oroloma is the only site where there is a significantly higher proportion of debitage in the 1/2in category than the 1/4in category, which are the most common categories at each site. At both Quitoloma and Hacienda Guachalá the difference between the 1/2in and 1/4in categories is not significant. This suggests that there was more larger debitage at Oroloma than the other sites, which supports the

conclusions of the SRT and cortex analyses because larger debitage is generally produced earlier in the reduction process.

	1in	1/2in	1/4in	1/8in	Mean Weight
Oroloma (Early Cayambe)	0.10	0.56	0.32	0.02	1.92
Pukarito (Late Cayambe)	0.08	0.77	0.15	0.00	0.96
Pingülmi (Inka War: Cayambe Occupation)	0.03	0.85	0.10	0.02	2.25
Quitoloma (Inka War: Inka Occupation)	0.03	0.39	0.53	0.05	1.49
Guachalá (Colonial)	0.07	0.48	0.43	0.02	1.62

Table 8: Size Grade Proportions and Mean Obsidian Weight

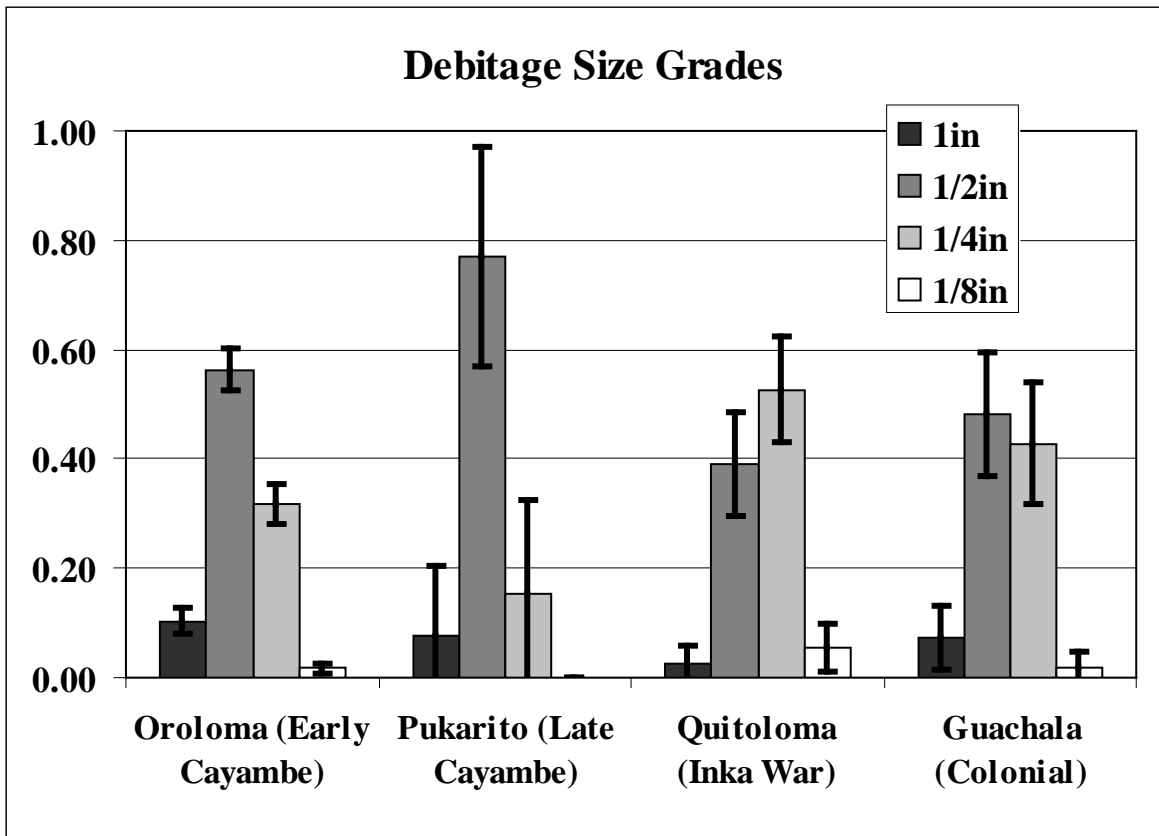


Figure 6: Debitage Size Grades

4.1.1.5 Obsidian Production: Mean Debitage Weight

Mean debitage weight was calculated as the total debitage weight divided by the total number of debitage flakes. Because weights of individual debitage flakes were not taken standard deviation and error ranges could not be calculated. However, even without error ranges, the mean weights suggest the same pattern as the other debitage analyses (Figure 7 and Table 8). Oroloma has the highest mean debitage weight, maintaining the conclusions of the SRT, cortex, and size categories that early stage reduction was more important there.

Supporting the conjecture that the size category proportions for Pukarito are not representative is the low mean debitage weight for Pukarito, which contrasts with the high proportion of 1/2in debitage but corresponds with the SRT and cortex analyses for that site, none of which support that Pukarito was focused on early stage reduction.

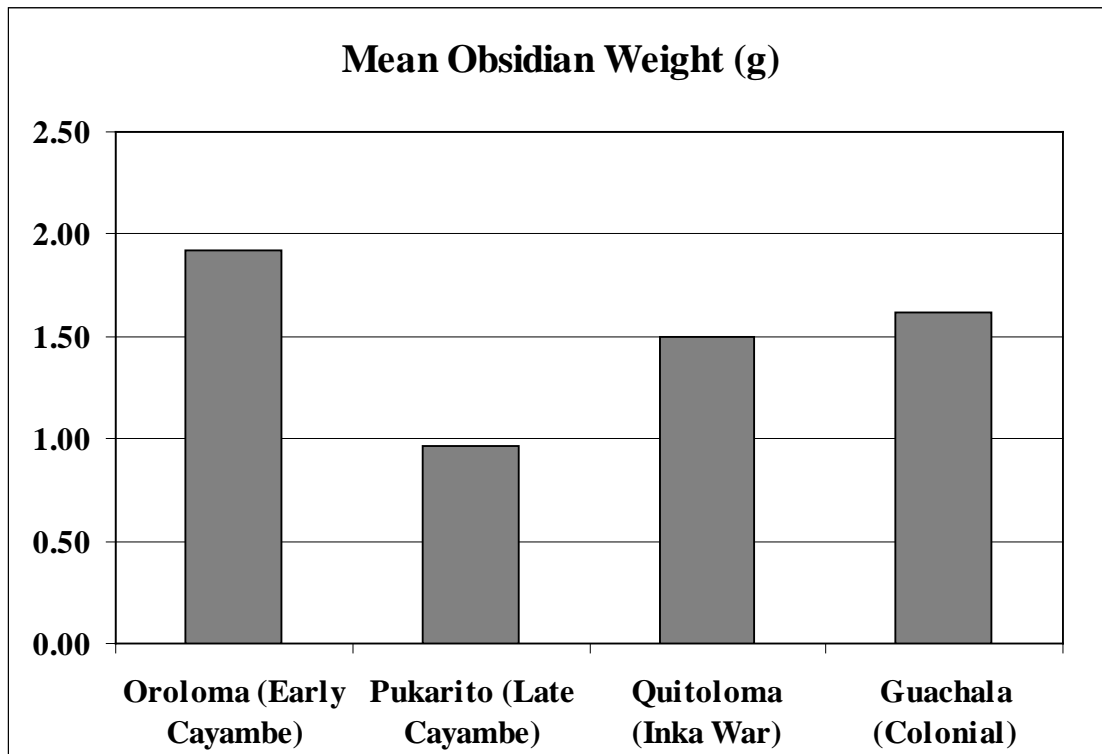


Figure 7: Mean Obsidian Weight

4.1.2 Site Function

Figure 8 shows the proportions of obsidian, NOL, and ceramics in the sample from each site. Oroloma has the highest proportion of debitage, suggesting a focus on lithic reduction. Pukarito has the highest proportion of NOL. This could explain why the obsidian sample at the site is so small; activities at Pukarito seem to have relied upon NOL instead of obsidian which is likely due to site function.

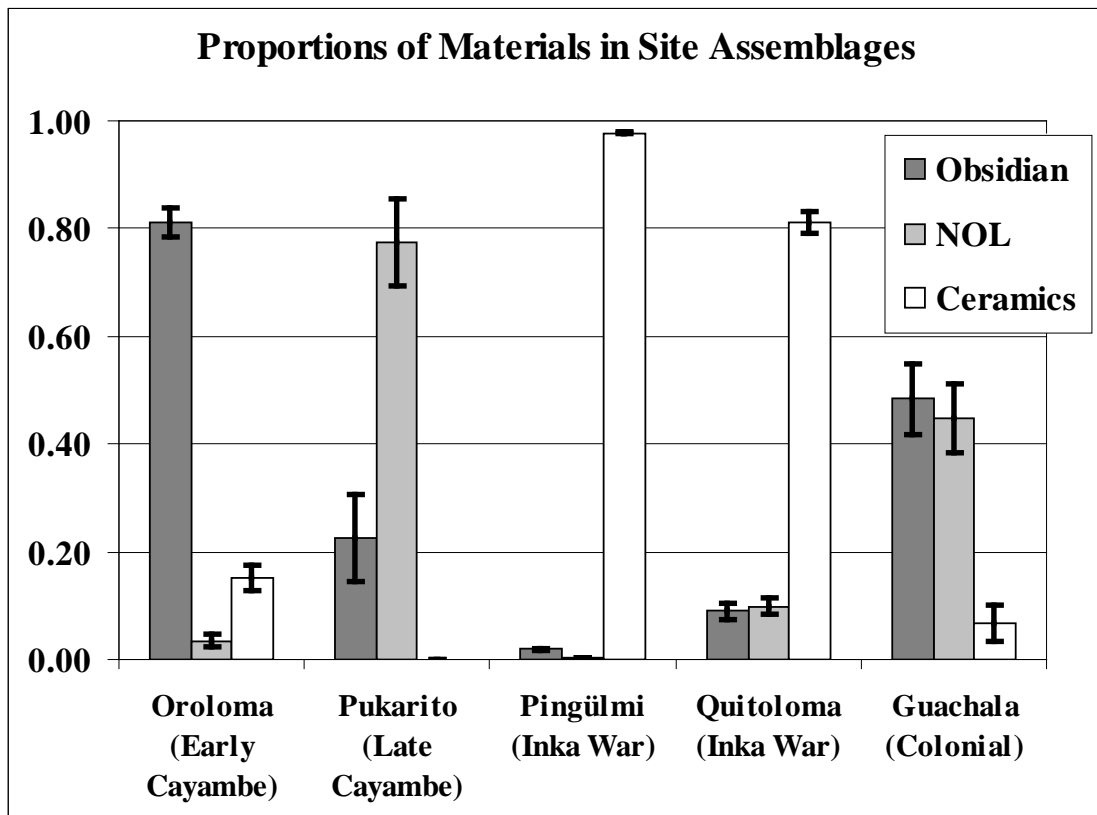


Figure 8: Assemblage Proportions

Pingülmí has the highest proportion of ceramics, indicative of a residential function. While the proportion of NOL at the site appears to be 0 (Table 9), NOL was recovered but in such small quantities that it constitutes less than 1% of the assemblage (Table 4). As discussed

earlier, it is possible that the prevalence of ceramics and extremely small amount of NOL recovered at Pukarito is due to the collection strategy at the site.

Like Pingülmí, Quitoloma has a majority of ceramics, but the proportions of obsidian and NOL are substantial and statistically not different. This suggests residential occupation and activities involving both obsidian and NOL. In contrast, Hacienda Guachalá has the lowest proportion of ceramics, which is consistent with its function as a workshop rather than a residential site.

	Obsidian	NOL	Ceramics	Total Material
Oroloma (Early Cayambe)	0.81	0.04	0.15	597
Pukarito (Late Cayambe)	0.23	0.77	0.00	75
Pingülmí (Inka War: Cayambe Occupation)	0.02	0.00	0.98	7661
Quitoloma (Inka War: Inka Occupation)	0.09	0.10	0.81	971
Guachalá (Colonial)	0.48	0.45	0.07	160

Table 9: Assemblage Proportions

4.1.3 Catchment

Catchment circles were split onto two maps for better legibility. As Pingülmí and Quitoloma are contemporaneous they are plotted on the same graph (Figure 10) while Oroloma, Pukarito and Hacienda Guachalá are plotted on the other (Figure 9). Table 10 contains the distance in km from each site to the major sources.

4.1.3.1 Catchment: Oroloma, Pukarito and Hacienda Guachalá

Oroloma is the furthest south of these sites and its arbitrary 20km catchment includes both Mullumica and Callejones (Figure 9). These sites are also within 20 km of Pukarito, but over 20 km from Hacienda Guachalá.

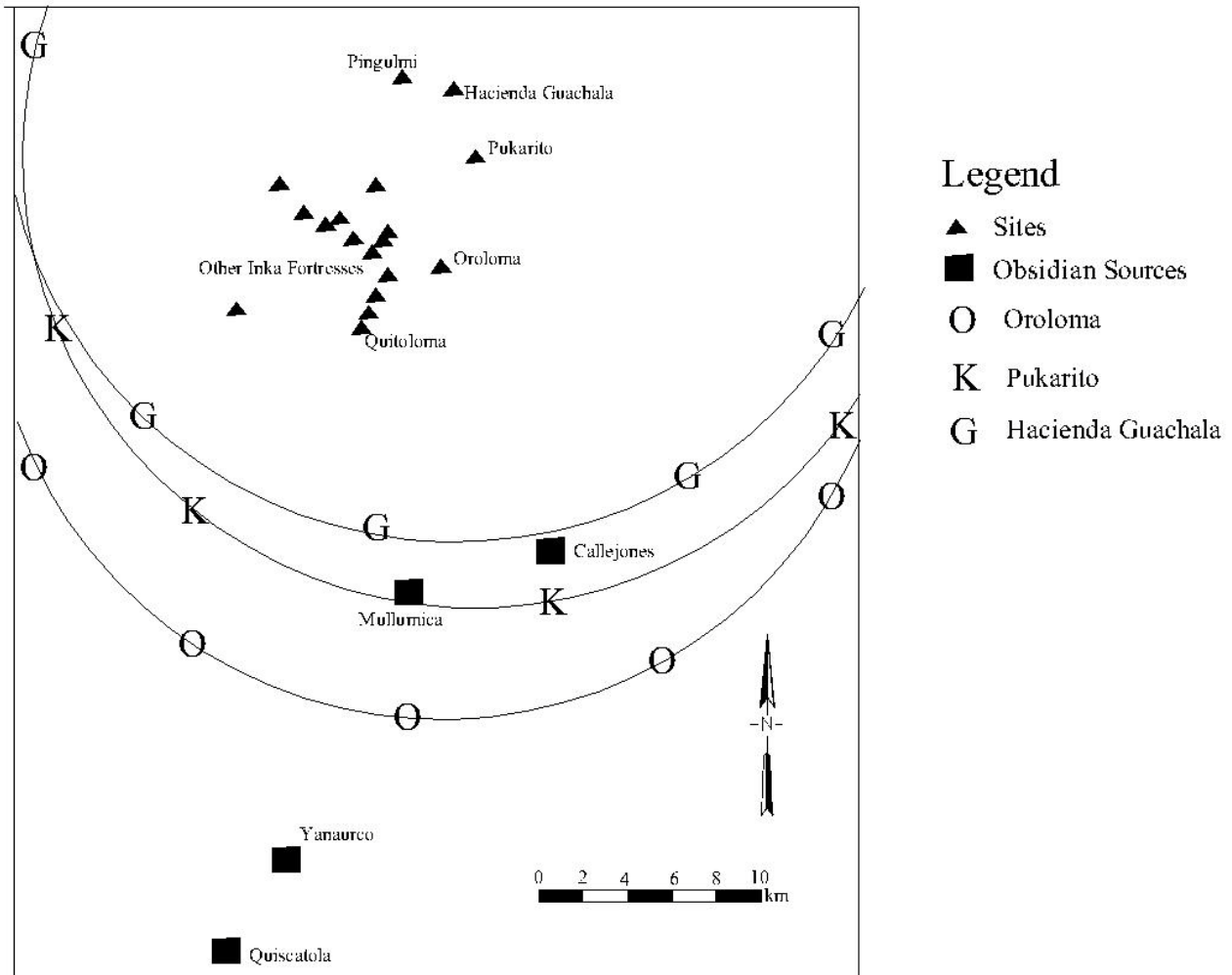


Figure 9: Catchment; Oroloma, Pukarito and Hacienda Guachalá

4.1.3.2 Catchment: Pingülmí and Quitoloma

Quitoloma is the furthest south of all the sites in this study and also of the Inka fortresses in Pambamarca. This makes Mullumica and Callejones well within 20km. However, obsidian from Callejones was not found at Quitoloma (Table 2). Also, Yanaurco-Quiscatola, which was utilized at Quitoloma, is not far out of the 20km range (Table 10). Pingülmí, in contrast, is over 20km from all the obsidian sources.

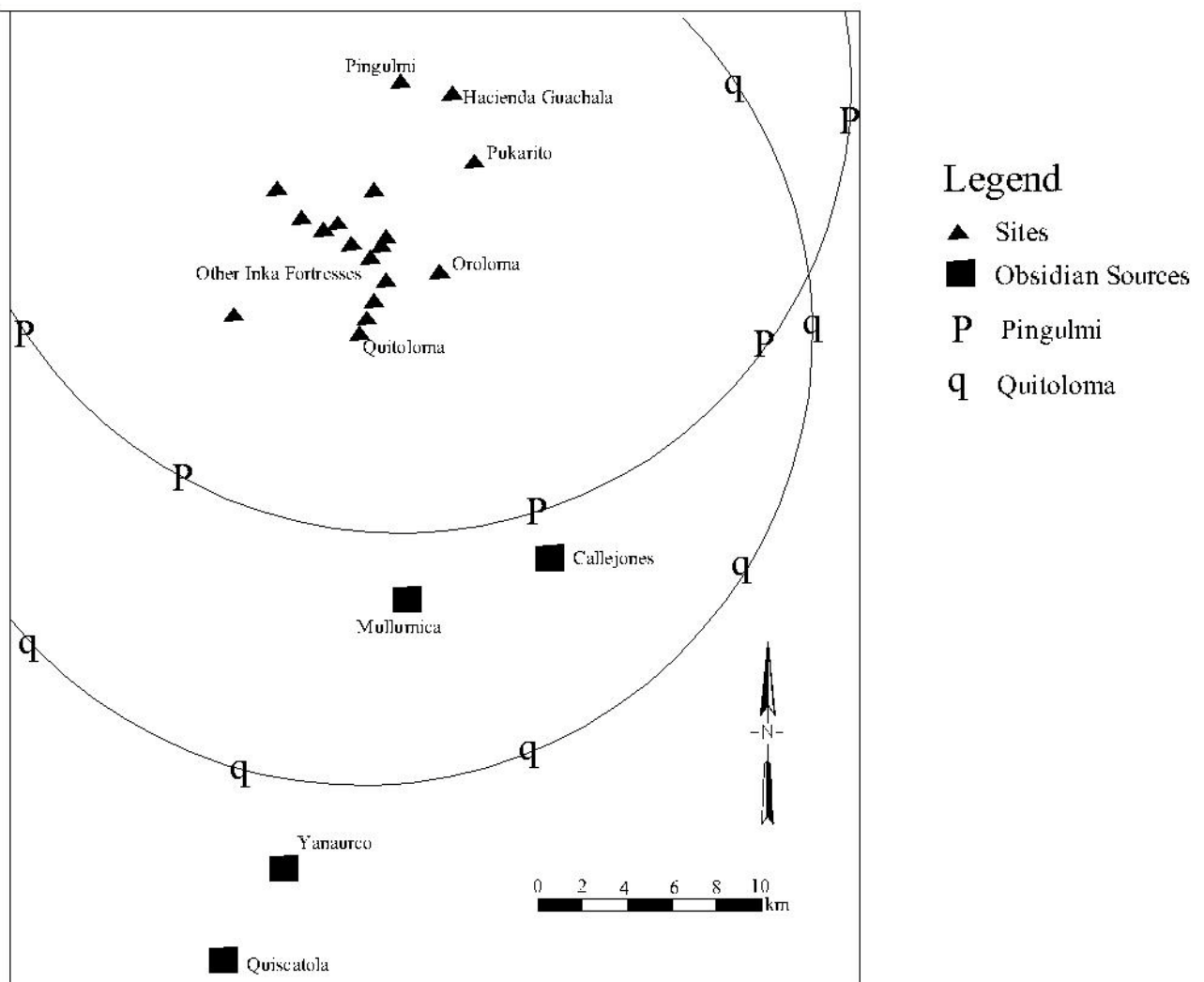


Figure 10: Catchment; Quitoloma and Pingülmí

	Mullumica	Callejones	Yanaurco-Quiscatola
Oroloma (Early Cayambe)	15	14	28
Pukarito (Late Cayambe)	20	18	34
Pingülmí (Inka War: Cayambe Occupation)	23	23	37
Quitoloma (Inka War: Inka Occupation)	12	14	25
Guachalá (Colonial)	23	23	37

Table 10: Distance from Sierra de Guamaní Sources (KM)

4.1.4 Distance to Sources

Plotting proportion of obsidian out of all material (obsidian, NOL, and ceramics) against distance of the sites from Mullumica shows no clear patterns (Figure 11).

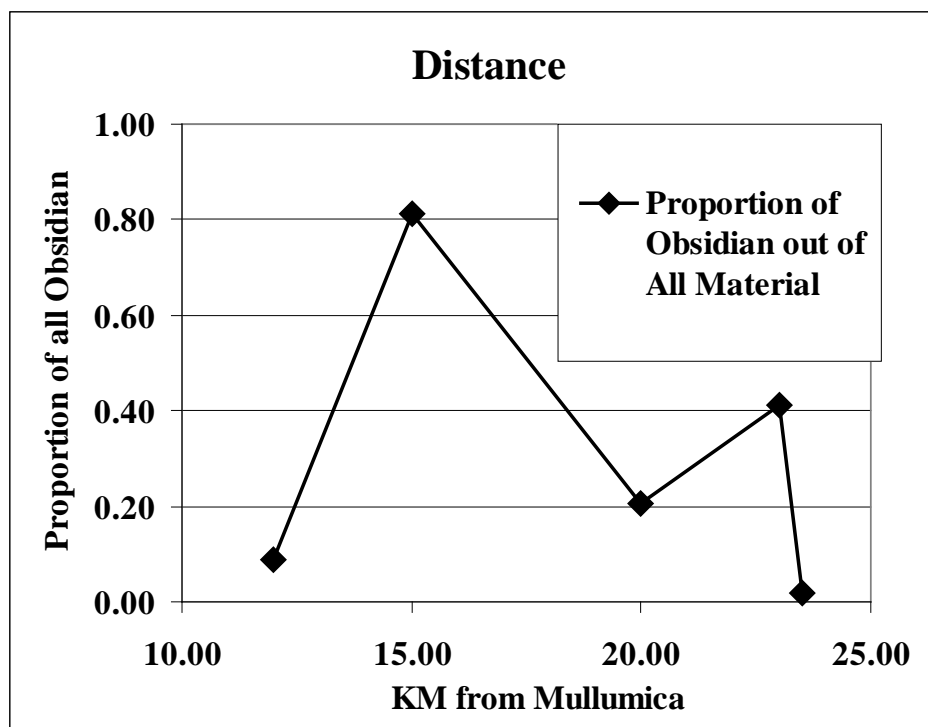


Figure 11: Proportion of Obsidian vs. Distance to Mullumica

However, if obsidian production categories are plotted against distance there is a possible relationship. Both the proportion of debitage out of all obsidian and the proportion of tools (both formal and informal) out of all obsidian were plotted against distance in Figure 12. These proportions are inverses of each other, but plotting them both shows how the difference between the proportions becomes smaller as the distance to the sources increases. In other words: more debitage flakes are being used as tools at sites further from the sources.

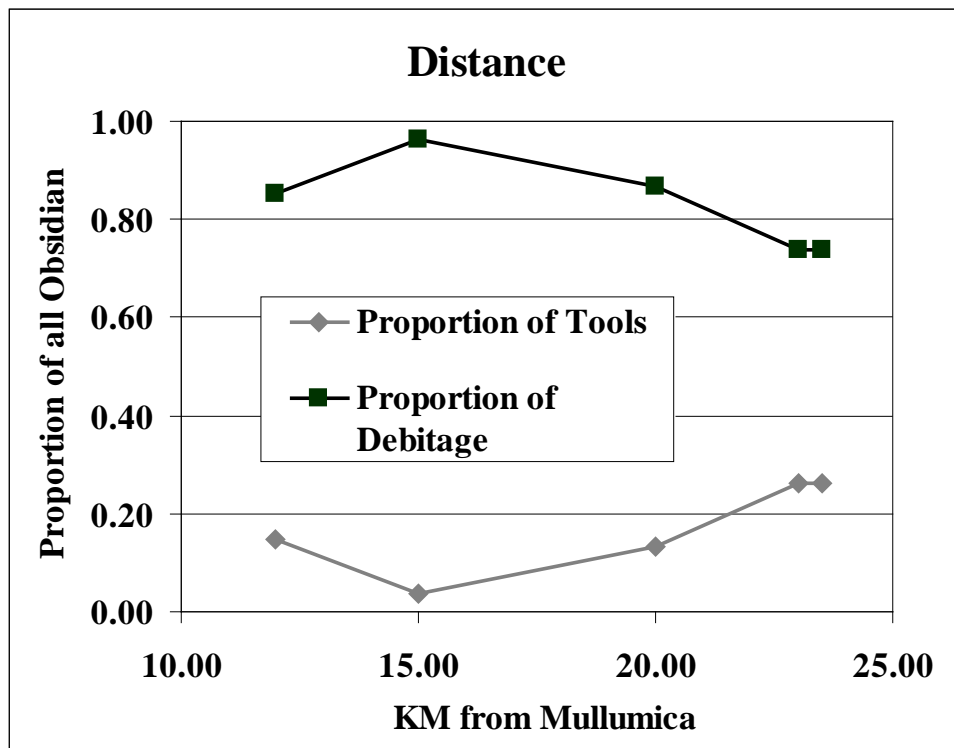


Figure 12: Proportions of Tools and Debitage vs. Distance from Mullumica

The first point on the chart is Quitoloma, which is the closest to the sources and does not follow the pattern that the other sites show. However, the proposed means by which Quitoloma supplied itself with obsidian, through tribute, is also different from any other site. The three Cayambe sites (Oroloma, Pukarito, and Pingülmi) most likely acquired obsidian through local

markets or direct access. If the means of access at these three sites were the same then that might account for the relationship between distance and proportions of debitage and tools.

A major problem with drawing concrete conclusions from this relationship, however, is that each site is from a different time period and it is both possible and likely that methods of access varied for each site. A more reliable picture would require multiple sites from each time period and samples from similar contexts at each site.

4.2 SITE SUMMARIES

4.2.1 Site Summaries: Oroloma (Early Cayambe Period)

Oroloma (literally ‘gold hill’) is the earliest inhabited site included in the study. It is dated from 690 C.E. to 900 C.E. (Gonzalez 2008) which is the Early Cayambe period in Pambamarca and analogous to the Early Integration period for Ecuador as a whole (Table 1). Oroloma is an intensely inhabited site located at 3200masl in the paramo, or high grassland, ecozone (Ogburn 2008). It is near a trade route connecting the highlands to the Amazon (González 2009) and has been intensely looted by local villagers due to rumors of gold, leading to its name (González 2005). The site was excavated in 2005 by PAP. Architecture at the site has been categorized as residential by excavators. Walls are made of local cangahua stone, as is typical of Cayambe sites. The contexts of the Oroloma sample are a habitation unit and a midden unit (Table 3).

4.2.1.1 Oroloma: Obsidian Production

Oroloma has the highest proportion of debitage of all the sites included in this study (Table 6). The proportion is significantly higher than at any other site except for Pukarito, which has such a small sample that its error ranges are disproportionately large. All tools were informal. The amount of debitage relative to tools is higher than would be expected if production was focused on the production of flakes to immediately utilize. This suggests that reduction at these locations in Oroloma was not for utilization in the same location.

Oroloma is the only site where shatter and complete flakes (indicating early stage reduction) make up the majority of the debitage assemblage. The combined proportion of shatter and complete flakes is also significantly higher than the corresponding proportion at any site except Pukarito (Figure 4). However, since only two contexts from Oroloma and none from any contemporary sites were included in this study it is unclear if this is a pattern reflecting the Early Cayambe period, reduction patterns at Oroloma, or reduction in these particular contexts.

Continuing the pattern of prevalent early stage reduction, the debitage at Oroloma had significantly more cortex than at any other site (Figure 5), and the proportion of 1/2in debitage is significantly higher than 1/4in debitage (Figure 6). This shows that there is a higher frequency of larger debitage at Oroloma than at Quitoloma and Guachalá, the sites for which size grades are comparable. Finally, although no confidence interval was calculated, Oroloma has the highest mean obsidian weight (Figure 7). This data, along with the SRT, shows that Oroloma, or these specific locations within Oroloma, were emphasizing primary reduction rather than tool production.

4.2.1.2 Oroloma: Site Function

Oroloma has a significantly higher proportion of obsidian relative to NOL and ceramics than any other site in the study (Figure 8). The low proportion of ceramics appears to suggest that the area was not residential. However, this may be because of the spatial limitations of the sample. In addition, the low proportion of NOL suggests that activities for which it was required were not emphasized at these locations. The contexts included in this sample may have focused on primary reduction of obsidian which would then be utilized elsewhere. Other areas may have been responsible for cooking or food processing, and others for activities with NOL.

It is possible that Oroloma, being located near a trade route and the closest to the obsidian sources of sites in the Cayambe valley, processed obsidian for secondary distribution into the Cayambe valley to the north which would later become the País Caranqui. This distribution could have occurred through precursors of the markets described by Salomon (1986, 1987) for the Late Cayambe Period.

4.2.1.3 Oroloma: Catchment

The two closer obsidian sources, Mullumica and Callejones, are well within the 20km catchment zone for Oroloma (Figure 9). Yanaurco-Quiscatola, located at least 28km away (Table 10), is not. However, Ogburn's (2008) chemical analyses showed that Yanaurco-Quiscatola obsidian was also utilized at Oroloma despite the distance, although not as heavily as Mullumica obsidian. The proximity of the sources suggests that obsidian was obtained through direct access.

4.2.2 Site Summaries: Pukarito (Late Cayambe)

Pukarito (literally ‘little fortress’) was first inhabited during the Late Cayambe period and continues to be inhabited today. It is located at 3000masl (Ogburn 2008) within the modern village of San Pedro. Pukarito is thought to be a multipurpose fortress. A cangahua wall showing three construction phases was uncovered on the site’s southwestern side (González 2005) and the highest excavation levels contain Inka ceramics. The sample was taken only from levels below Inka materials in an attempt to isolate the pre-Inkan occupation. Both fortifications and possible ritual structures made of local cangahua stone have been excavated. While habitation areas have not been uncovered it is possible they are located beneath the agricultural fields and therefore out of reach of archaeological excavations. The obsidian from the site comes from excavations in 2005 by PAP and is mostly associated with defensive architecture.

4.2.2.1 Pukarito: Obsidian Production

The sample of obsidian from Pukarito is extremely small; fifteen pieces of debitage and two informal tools (Table 4). The small sample size makes comparisons between Pukarito and other sites questionable. The SRT showed that the majority of debitage are flake fragments and broken flakes although the small sample size creates very large error ranges so the majority is not significant (Figure 4). None of the debitage had cortex (Figure 5), but with a larger sample that is likely to be different. Most of the debitage was in the 1/2in size category (Figure 6), and the mean weight was the lowest out of the comparable sites (Figure 7). However, these patterns cannot be taken as reflective of the site as a whole because the sample is so small and from a restricted range of contexts.

4.2.2.2 Pukarito: Site Function

Pukarito is the only site where the majority of the artifactual assemblage consists of NOL, and ceramics are not present (Figure 8). Since the sample comes from defensive contexts this is likely not the pattern for the entire site but only for these specific contexts. NOL, as a heavy, durable material, may have been used for weapons. The high proportions of the material associated with defensive architecture suggest that the material was used for a purpose associated with that location. Activities associated with obsidian and ceramics likely took place in residential contexts elsewhere on the site.

4.2.2.3 Pukarito: Catchment

As with Oroloma, the Mullumica and Callejones obsidian sources are within the 20km catchment of Pukarito (Figure 9). This seems to conflict with the scarcity of obsidian at the site itself but, as discussed above, may be due to the context of the sample. Obsidian may have been readily available at the site but was not necessary at the defensive locations where excavation has been done. It is also possible that endemic warfare disrupted local trade.

4.2.3 Site Summaries: Pingülmi (Inka War: Cayambe Occupation)

Two sites, one each to represent the local and Inka forces, were included from the period of the Inka war in Pambamarca before the region was occupied and controlled by the Inka. The local fortress, Pingülmi, is located at 3000masl (Ogburn 2008) and commands a vantage of several of the Inka fortresses on the rim of the Quito valley. Although located within the valley the multi-purpose hill fortress is extremely windy and there is little to no soil deposition (Christina Cox and Douglas Smit, personal communication). The sample from Pingülmi is from

a surface collection in 2006 by PAP. It was considered reasonable to use a surface collection to represent the Inka period occupation by the Cayambes as no Inkan ceramics and no Inkan or colonial architecture have been recovered at the site. Therefore it was probably abandoned after the defeat of the Cayambe armies by the Inka. In addition, very little artifactual material was recovered in excavations. The surface sample comes from all identified areas of the site including both defensive structures and habitation areas. Architecture at the site is similar to the other Cayambe sites with walls made of local cangahua.

4.2.3.1 Pingülmi: Obsidian Production

Pingülmi has the smallest difference between the proportion of debitage and proportion of tools out of the five sites (Figure 3). The proportions of reduction categories at Pingülmi are not significantly different from those at Quitoloma or Guachalá (or Pukarito, but that could be due to the small sample). This suggests that reduction was generally similar at all three sites; probably focused on the production of flakes for immediate use resulting in primarily informal tools and debitage in the assemblage.

The SRT showed that there were significantly more flake fragments and broken flakes (suggesting later stage reduction) than shatter and complete flakes at Pingülmi (Figure 4). Only a small proportion of the Pingülmi obsidian debitage had cortex (Figure 5) and the proportion was not significantly different from Quitoloma or Hacienda Guachalá. All this suggests that reduction was focused on producing flakes for utilization. Because the Pingülmi sample comes from a surface survey it is likely that obsidian would be larger and heavier than at sites where the sample was excavated. Therefore, size categories and mean weight are not discussed for Pingülmi.

4.2.3.2 Pingülmí: Site Function

The artifactual assemblage at Pingülmí is overwhelmingly dominated by ceramics (Figure 8), suggesting that the fortress was residential and probably occupied by a wider segment of the population than just soldiers. Compared to ceramics, obsidian and NOL make up only a small part of the sample. However, over six times as many obsidian pieces were recovered as NOL flakes (Table 4). This is likely merely the result of the collection strategy. NOL, being the same color as dirt, would be much more difficult to see during a windy surface survey than shiny obsidian.

4.2.3.3 Pingülmí: Catchment

Ogburn's (2008) analysis showed that obsidian at Pingülmí came from the two closest Sierra de Guamaní sources, Mullumica and Callejones, and also from the unlocated La Chimba source. Both Mullumica and Callejones are beyond the 20km catchment of Pingülmí, but not so far that it is unlikely for residents to have gone there (Figure 10). More interesting is that to reach the sources Pingülmí residents would have had to pass the front line of Inka fortresses and go near, or into, Inka controlled territory. Mullumica, the most commonly used source, lies partly within Inka territory although the eastern side of the flow may have been more accessible. Even though the flow was probably not entirely within Inka territory, because the Pambamarca frontier is characterized as a 'hard perimeter' (Alconini 2004) it is unlikely that the Inka would have allowed enemy groups through to collect obsidian. However, it is probable that they either did not consider small groups accessing the source as a threat, or that the Cayambes had a route to the sources which did not pass through Inka territory.

That informal tools were the predominant tool type at Pingülmí despite the Inka presence between them and the sources suggests that residents still had sufficient obsidian for their needs.

The local markets may not have been severely affected by the Inka, or Pingülmí residents may have had other ways to obtain obsidian such as scavenging or raids into Inka territory.

4.2.4 Site Summaries: Quitoloma (Inka War: Inka Occupation)

Several Inkan fortresses have been excavated or otherwise investigated by PAP. The fortresses, or pukaras, are located along rim of the Quito valley in the paramo. Quitoloma (literally ‘Quito hill’), the Inkan site included in this analysis, was the first identified fortress in Pambamarca (Oberem 1969) and several phases of excavation and mapping have been carried out at the site. Quitoloma is located at 3800masl (Ogburn 2008) and overlooks a road leading to the Quito valley and Inka controlled territory. With walls and buildings made of cut stone, Quitoloma differs architecturally from the local fortresses. As it is located slightly to the rear of the other Inka fortifications it is thought to have been either a stopping point for forces bound for the front line or a rear line of defense for the Quito valley. The sample included in this study comes from residential structures excavated during various seasons of the project.

4.2.4.1 Quitoloma: Obsidian Production

The pattern of obsidian reduction categories at Quitoloma is similar to that of Pingülmí and Hacienda Guachalá: a predominance of debitage but a higher proportion of tools than at Oroloma (Figure 3). The proportion of debitage is higher than at Pingülmí or Hacienda Guachalá but not significantly different.

The majority of the debitage at Quitoloma is broken flakes and flake fragments but the proportion is not significantly different from the proportion of shatter and complete flakes (Figure 4). The debitage has slightly more cortex than at Pingülmí but not significantly more

(Figure 5). 1/4in debitage is most common but the proportion is not significantly higher than that for 1/2in debitage (Figure 6). Mean obsidian weight is lower than at Oroloma but higher than for Pukarito (Figure 7). The low amount of cortex, tendency towards smaller flakes, and lower mean weight support the SRT pattern showing a slight predominance of tool production over core reduction.

4.2.4.2 Quitoloma: Site Function

Although the sample comes from residential contexts it is likely that Quitoloma occupants were primarily soldiers and did not include many other members of society as was probably the case at Pingülmi. Ceramics make up the majority of the assemblage and the proportion is significantly higher than that of obsidian or NOL (Figure 8). This supports that Quitoloma was a residential fortresses. The proportions of obsidian and NOL are not significantly different. Both materials were likely important; obsidian for daily activities and NOL produced during manufacture of weaponry or groundstone.

4.2.4.3 Quitoloma: Catchment

Ogburn (2008) proposes that the Inka fortresses received obsidian as part of tribute from the populations they had already conquered to the southwest of the País Caranqui. Obsidian at Quitoloma comes from the Sierra de Guamaní sources and not from obsidian flows further within the empire (Ogburn 2008). Quitoloma is the furthest south of the sites in this study and both Mullumica and Callejones are well within its 20km catchment (Figure 10). However, obsidian at Quitoloma comes from Mullumica, Yanaurco-Quiscatola, and the unlocated La Chimba source, but not from Callejones (Table 2). Callejones is the furthest east of the sources

and, if the line of Inka fortresses is extended south, Callejones is outside of Inka controlled territory (Ogburn 2008, see Figure 2).

That the Inka obtained obsidian through tribute could also explain how Pingülmí residents were able to easily access obsidian despite the Inka presence. The Inka may have relied on local villages in the Quito basin to access and process obsidian for their soldiers. In that case they would not have military installations near the sources, allowing the Cayambes to easily access obsidian as long as they circumvented the line of fortresses in Pambamarca.

4.2.5 Site Summaries: Hacienda Guachalá (Colonial)

The fifth site included in this study represents the use of obsidian by indigenous peoples during the colonial period. The sample comes from excavations at Hacienda Guachalá which are usually carried out at the beginning of each season to teach excavation techniques to PAP field school students. Hacienda Guachalá is located at a lower altitude than the fortresses and the climate is more temperate. According to legends workers were imprisoned in the obraje. Dye was produced from crushing walnut shells, large amounts of which have been found at the site. The obsidian sample comes from pre-modern levels in units dug in the obraje.

4.2.5.1 Guachalá: Obsidian Production

The pattern of reduction categories at Hacienda Guachalá is similar to and not significantly different from that at Pingülmí and Quitoloma (Figure 3). Guachalá has the highest proportion of formal tools, but is not significantly different from that at Pingülmí and Quitoloma.

The SRT showed that flake fragments and broken flakes make up significantly more of the debitage assemblage at Hacienda Guachalá than shatter and complete flakes (Figure 4).The

proportion of debitage with cortex is slightly higher than at Pingülmí and Quitoloma, but not significantly different (Figure 5). 1/2in debitage is most common, but the proportion is not significantly higher than that of 1/4in debitage (Figure 6). The mean weight is slightly higher than at Quitoloma, but not as high as at Oroloma (Figure 7). This implies a focus on later stage reduction. Probably reduction at Hacienda Guachalá followed a pattern similar to that at Pingülmí and Quitoloma: primarily the production of flakes for immediate use.

4.2.5.2 Guachalá: Site Function

The obraje at Hacienda Guachalá was not a residential site in the usual sense. Although workers may have been imprisoned there they likely did not undertake the same daily activities as at a usual residence. Following this, ceramics make up only a small proportion of the assemblage, significantly less even than Oroloma (Figure 8). Obsidian and NOL occur in roughly equivalent proportions. NOL could have been used in the processing of walnut shells to make dye while obsidian would have been useful in cutting and manufacturing textiles.

4.2.5.3 Guachalá: Catchment

None of the obsidian sources are within the 20km catchment of Guachalá (Figure 9). In addition, it is unlikely that imprisoned workers at the obraje walked to the sources or were able to access markets. The slightly higher proportion of formal tools (Figure 3) could suggest that Guachalá workers were more concerned with conserving material than their ancestors but the overall pattern still shows a focus on informal tools. Ogburn's (2008) analyses showed that Guachalá obsidian was primarily from Mullumica, the most heavily utilized source in all times, with some from La Chimba (Table 2). Obsidian could have been obtained by scavenging or could have been brought by the workers to the obraje. Also, if there were a large community of

workers at Guachalá, both in the workshop and elsewhere, as suggested by Andrien (2001) obsidian could have been obtained by imprisoned workers in the obraje from workers who had more liberty to directly access it.

5.0 CONCLUSIONS

5.1 DISCUSSION

Several interesting observations can be made despite the limitations of the samples from each site. The Oroloma sample shows a clear focus on early stage reduction rather than tool production and usage. Whether this is a pattern reflecting activities specific to the loci included in the sample, related to a regional function of Oroloma as a whole, or due to a pattern of obsidian production of the time period is unclear. However, the proximity of Oroloma to the Sierra de Guamaní obsidian sources and a regional trade route would be advantageous if it were a center of early stage obsidian reduction for secondary distribution to sites to the north.

The low proportion of NOL at Oroloma is likely specific to these loci and not indicative of the site or time period as a whole. NOL may have been used for agricultural purposes which occurred elsewhere on the site, or residents may have obtained agricultural products through trade. If NOL was produced through the manufacture of armaments it could be that this was done elsewhere on the site or that there was less warfare in this period than in later ones.

At Pukarito the extremely small size of the obsidian sample precludes any conclusions about production and usage. However, the large amount of NOL recovered in association with defensive structures suggests that it was produced in relation to those structures, specifically in production of weaponry. It is strange that weapons may have been produced near the walls rather than manufactured elsewhere and brought to the walls finished. Possibly armament production and maintenance was done while at the walls as well as elsewhere, or NOL may have moved from areas higher in the site to the walls through post-depositional processes. Both the defensive

architecture and large amount of NOL support the argument that the pre-Inkan polities of the País Caranqui were often engaged in warfare with each other making production of armaments and construction of defensive walls necessary.

The sample from Pingülmi reflects contexts from multiple parts of the site. The large quantity of ceramics supports the argument that it is a multipurpose fortress with residence being one of the functions. Also interesting is that obsidian production at Pingülmi does not appear to have been drastically affected by the Inka presence. Pingülmi residents utilized obsidian which had to be obtained near Inka territory but still produced primarily informal tools.

Like Pingülmi, the high proportion of ceramics at Quitoloma indicates that it was also a residential fortress. Obsidian at the site comes only from the sources within Inka controlled territory (Mullumica and Yanaurco-Quiscatola) and La Chimba, whose location is unknown. Despite the proximity of Callejones to Quitoloma, obsidian from that source did not show up in Ogburn's (2008) analysis.

Interestingly, the most intensely used source at both Pingülmi and Quitoloma is Mullumica, even though Mullumica is partly within Inka controlled territory. Since the Inka were generally very adept at fitting their consolidation strategies to each region, and since Pambamarca was a hard, military frontier, it is improbable that they would have allowed local economies to continue unmodified. However, it is possible that the Inka may have required tribute but did not otherwise control the distribution of obsidian. This would have allowed the Cayambes to directly access the sources as long as they took a route circumventing the Inka fortresses.

It is unclear how the markets discussed by Salomon (1986, 1987) were affected by warfare with the Inka. It is possible that they shut down markets in the Quito valley as part of

economic reorganization of the region or in order to undermine the intense resistance in Pambamarca. However, it is also possible that they did not think that was necessary, or that they chose to let the markets continue functioning to maintain the subsistence economy of the region. As the Inka tended to fit their consolidation strategies to each region it is difficult to infer what their response may have been without archaeological data from the wider region.

At Hacienda Guachalá obsidian production continues to focus primarily on informal utilized flakes although a higher proportion of formal tools was present in the assemblage than at the other sites. Mullumica and La Chimba, which are utilized at every site in this study, are the only two sources used at Hacienda Guachalá. However, it is unlikely that imprisoned obraje workers were walking to the sources to acquire obsidian or trading in markets. Given that the indigenous population at Guachalá may have been large and in a variety of situations, those with more liberty may have been able to obtain obsidian and distribute it to those who could not.

5.2 FUTURE DIRECTIONS

Chemical sourcing by Ogburn (2008) has been invaluable in understanding Pambamarca developments. However, how obsidian traveled with Pambamarca and the wider northern highland region is still relatively unclear. Mullumica is always the most utilized source although Callejones is closer by a direct line to Pambamarca (Figure 2). It may be that Mullumica is the easiest to reach or that obsidian from there was preferred. Furthermore, this study only included one site from each time period. Comparisons between multiple sites could clarify the mechanisms of local exchange in different time periods. Addressing these issues will provide a better understanding of local exchange and site interaction.

At Oroloma it is first necessary to assess if the focus on early stage reduction is specific to the loci used in this study or to the site as a whole. If this focus is consistent for the entire site it is likely that Oroloma was a center of production for secondary distribution within the Cayambe valley. If distinctive cores or blanks can be found it may be possible to track the distribution of obsidian reduced at Oroloma within the wider region.

The Pukarito sample used for this study is generally difficult due to its small size and the restriction in the range of contexts from which it was drawn. However, understanding the roles of obsidian and NOL in the Cayambe tool kit will clarify many of the questions about this site.

The previously known functions of Pingülmí and Quitoloma are consistent with this study. Comparing these results with contemporaneous sites could clarify the Inkan affect on local exchange and specific consolidation strategies they used in the region.

Hacienda Guachalá is a unique site which should not be taken as representative of indigenous communities during the Colonial period. The use of obsidian, after the introduction of metal by the Spanish, is interesting, as is the continued focus on informal tools. A better understanding of obsidian production and indigenous exchange during this time period would help explicate how the Hacienda Guachalá workers accessed obsidian. Analyses of indigenous colonial period residential sites would provide an interesting opportunity to examine the effect of the Spanish on indigenous economic patterns.

The association between distance to the obsidian sources and proportions of obsidian reduction categories for these sites (Figure 12) is interesting and suggestive but far from indicative of a regional exchange pattern. In order to assess this pattern, more sites from each time period and samples from comparable loci are needed.

5.3 CONCLUSION

This study has suggested several interesting patterns of obsidian production and shown that there are many avenues for future research on the Pambamarca sites and the northern Ecuadorian highlands in general. The interpretations offered by this study, while not conclusive, show that many of the Pambamarca sites had different functions and possibly focused on different aspects of obsidian production. Better understanding of these functions and obsidian usage will help to clarify the intra-regional interactions of northern highland communities during the development of complex societies from the Early Cayambe to the Late Cayambe, during the Inka war, and in the early years of colonization.

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