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To Temper or Not to Temper: A Petrographic Textural Study of Clays and Formative Ceramic Sherds from the Valley of Oaxaca, Mexico

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TO TEMPER OR NOT TO TEMPER:

A PETROGRAPHIC TEXTURAL STUDY OF CLAYS AND FORMATIVE CERAMIC SHERDS FROM THE VALLEY OF OAXACA, MEXICO

by

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ABSTRACT

TO TEMPER OR NOT TO TEMPER
A PETROGRAPHIC TEXTURAL STUDY OF FORMATIVE PERIOD CERAMIC SHERDS FROM THE VALLEY OF OAXACA, MEXICO

by

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Under the Supervision of Professor R. Jason Sherman

Ceramics are one of the best forms of material culture archaeologists can use to analyze questions of social, political, economic, and ideological complexity. The purpose of this thesis research is to determine if the clays used to manufacture later Middle Formative-Terminal Formative ceramics in the Valley of Oaxaca were tempered or otherwise modified by looking at texture of sherds petrographically. Clay samples from around the valley, modern sherds, and Formative sherds were examined and compared using six different forms of analysis. The results show that it is most probable that the Formative sherds were not tempered. However, several sherds exhibited unusual texture that could be considered suspect for tempering. This research provides an approach to textural analysis that is helpful in the comparison of results from other forms of compositional analysis.

To

Gama and Papa,

Thomas,

and the Perfect Week

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Chapter 1: Introduction

Ceramics are one of the best forms of material culture archaeologists can use to analyze questions of social, political, economic, and ideological complexity. The purpose of this thesis research is to determine through petrographic analysis of natural clay samples and pottery sherds whether the clays used to manufacture later Middle to Terminal Formative ceramics in the Valley of Oaxaca, Mexico, were tempered or otherwise modified. Petrography can be an effective method of recognizing regionally distinctive tempering materials which can be traced geologically to potential sources of raw materials used in pottery production (Sinopoli 1991:104).

Determining whether ceramics were tempered or made with refined clays can certainly be a challenge. Nevertheless, this work is important in understanding the role ceramics played in the sociopolitical arena during the Formative Period (2000 B.C. - A.D. 250) in the Valley of Oaxaca. Reconstructing pottery production and distribution networks not only can yield insights into the organization of the regional economic system, but this information may also provide insights into how ceramics were used to mediate political relationships and negotiate status (e.g., Elson 2006; Elson and Sherman 2007; Feinman 1986; Minc and Sherman 2011; Minc et al. 2007, 2016). Elite ceramics more often than not signify control of production and distribution (Sinopoli 1991:144). Understanding production and distribution of ceramics can help build a framework in which questions of interaction between groups as well as diffusion and exchange systems can be examined (Sinopoli 1991:103). Distribution patterns can illuminate if there was centralized control of the ceramic economy as well as being an indicator of early market systems (Minc and Sherman 2011; Minc et al. 2007, 2016; Sinopoli 1991:103).

Brief Introduction to Region of Research Focus

Although humans have been occupying the Valley of Oaxaca for more than 10,000 years, the Formative Period was a time of particularly major change. The archaeological record includes evidence of storage pits, burials and grave goods, as well as excavated residences showing status differentiation by 1000 B.C. Groups in the Valley of Oaxaca also benefited from trade networks and participated in the Pan-Mesoamerican Olmec art style (Marcus and Flannery 1996:119). This interaction is one of the reasons for increasing social differentiation in the valley, particularly at San José Mogote (Blanton et al. 1999:42).

During the Middle Formative (850-500 B.C.), socio-political changes continued in the Valley of Oaxaca, and there is evidence that by the Rosario phase (700-500 B.C.) there were multiple complex polities ("chiefdoms") characterized by three-tier settlement hierarchies (Marcus and Flannery 1996:121). At the beginning of the Early Monte Albán I period (Early MA I, 500-300 B.C.), the urban center of Monte Albán—one of the first cities in Mesoamerica—was founded atop a 400-meter-high mountain in the middle of the valley. Eventually, Monte Albán would become the capital of one of the first states in Mesoamerica. It is important to be able to source ceramics and trace their movements within the valley in order to understand political boundaries and economic activity before and during primary state formation in the Valley of Oaxaca.

Significance

My thesis research builds on recent studies of the production and movement of ceramics in the Oaxaca Valley (e.g., Minc and Sherman 2011; Minc et al. 2007, 2016) by focusing specifically on the issue of whether the clays used to make pottery were modified with the addition of temper or otherwise refined (removal of large particles or inclusions). Thin sections of archaeological sherds from five sites in the valley (Monte Albán, El Mogote, El Palenque, Cerro Tilcajete, and Yaasuchi) that span the later Middle to the Terminal Formative periods were used in the analysis. In an effort to create a "control" group, clay samples from the Oaxaca Clay Survey (Minc and Sherman 2011; see discussion in Chapter 2) were also analyzed, as well as fragments of modern ceramic vessels produced in several different towns in the valley for which production techniques were known. It was my hope that patterns would be clearer when the Formative samples could be compared with known ethnographic and pure clay samples. I chose to focus on textural rather than mineralogical analysis of Formative sherds since the larger research program that my thesis dovetails with has focused more on the mineralogical and chemical composition of ceramics (Minc et al. 2016; J. Sherman, pers. comm. 2016). In broader terms, my research illustrates an approach to textural analysis that may be useful in other petrographic studies, while also generating data that may be compared to the results of other forms of compositional analysis.

Recognizing Modification of Clays

Forms of Modification

The primary goal of my research was to determine if the clays used to make Formative pottery were modified—in particular, through the addition of temper. Rice (1987:406) has stated that "'Temper' is perhaps the most used, abused, and imprecise term employed in archaeological and technological descriptions of pottery." She further explains that there has been little agreement about precisely what temper is, and that temper has been used as both a noun and a verb (Rice 1987:406-407). In this research I follow Quinn (2013:156) and define temper as simply "inclusions intentionally added by the potter."

It is rare to encounter clays that are ready to use in pottery production. Most clays will have to go through some type of modification, either through the addition of temper or refinement of the clay (Quinn 2013:154). Temper can take many forms; crushed rock, sand, bone, ash, shell, fiber, and grog (crushed pottery) are the most common examples found in prehistoric and modern pottery (Rice 1987:74). Temper may be added for various reasons, such as to add strength, increase thermal shock resistance, or protect against thermal stress (Quinn 2013:156-159; Rice 1987; Sinopoli 1991; Shepard 1956:24-31). Color and texture are also considerations in the material selected (Sinopoli 1991:12).

Refinement of clay can take several forms. The simplest kind of refinement involves picking out debris such as twigs and vegetation. Other forms of refinement such as levigation and sieving are done in order to remove larger inclusions to create a fine paste. Levigation is the process in which clay and water are mixed so that coarse particles and inclusions separate out (Rice 1987:118). Sieving is a process of screening out larger inclusions and debris using a

basket, twigs and branches, screens, or cloth (Rice 1987:118). In her ethnographic study of ceramic production in San Marcos Acetopan, Mexico, Isabelle Druc (2008:81) noted that sieving was followed by a second process called decantation. Decantation is a process in which clay is placed in water until the larger, heavier particles fall out and settle to the bottom while the lighter material is poured off. Payne (1994:9) has noted that this technique may have been used by Formative potters, but it is difficult to determine from the archaeological record. He experimented with clays of less desirable quality from exposed piedmont profiles in the Valley of Oaxaca and found that decanting improved their quality, just as the potters in the town of Atzompa do with some of their clays today (Payne 1994:9).

Recognizing Modification of Clays Using Petrography

While recognizing if clays were modified can certainly be a challenge, it is an important step in understanding raw material sources, production loci, and exchange patterns. Stoltman (1991:116) stated that although it is not easy, it must be done in order for the term “temper” to not be reduced to a mere synonym for mineral inclusion. Shepard (1964:520) reminds us that temper identification is only part of technological analysis and will only be meaningful if we adopt a broader perspective on pottery including its use, style, and how it fits into a culture as a whole. In order to accomplish this, she stated that texture, shape, finish, and decoration should be considered and that large samples are needed to conduct textural sorting (Shepard 1964:519).

Rice (1987:409) enumerates four criteria that may be helpful in determining whether inclusions in a ceramic paste are natural or purposely added: (1) the identity of the material; (2) particle shape; (3) size range; and (4) the amount. However, Rice (1987:409) cautions that this

will not indicate whether two or more clays were mixed together as temper. Quinn (2013:161) notes that the temper added by potters is usually larger in size than the naturally occurring inclusions in the clay and this then modifies the grain-size distribution of the paste. A bimodal grain size distribution will occur when coarse temper has been added to clay with fine, well sorted natural inclusions. Since clear bimodal grain size patterns do not occur naturally, such a pattern can indicate that a sample is tempered (Quinn 2013:161). If a clay is used with a wide variety of grain sizes or is poorly sorted, it can be difficult to discern if the inclusions are natural or not, particularly if the variously sized inclusions are mineralogically similar, as may be the case when temper is derived from the same source as clay (Quinn 2013; Stoltman 1989, 1991). It can be easier to recognize temper obtained from a different location because the mineralogy of the inclusions will vary from what is seen in the paste. Stoltman (1989, 1991) has cautioned that it can be near impossible to distinguish actual sand temper in clay. Rice (1987:410) notes that the angularity of quartz sand grains can be examined, and that rounded grains typically signify natural inclusions that have been transported and altered. However, once again it is important to recognize that highly angular particles can be found in clays that are near to their parent material, as alteration from weathering and movement has not occurred as much (Rice 1987:410). A relatively simple way of distinguishing grit (crushed rock) and sand temper is that grit temper tends to be larger-grained, more angular, and polymineralic in composition, whereas sand temper is generally smaller, rounded, and has a simple mineral composition (Feinman et al. 1989:335; Quinn 2013; Stoltman 1989, 1991, 2001). One way to distinguish temper and natural inclusions more effectively is to sample local clays to understand their composition and then compare them to ceramic samples (Peterson 2009:12; Quinn 2013:128-129; Rice 1987:420-426; Stoltman 2001:304).

Cleaning dry clays by winnowing, thus separating large particles from the clay, is almost impossible to detect in thin sections unless clays were found at the production site or the clay source is found (Quinn 2013:154). Water processing including levigation and sieving will also result in the removal of larger inclusions and can produce clays that have predominately fine inclusions. Quinn (2013:156) also notes that fine clays may occur naturally, thus making identification of refinement problematic. However, textural analysis of the size of inclusions can show if a "strongly unimodal skewed or truncated grain-size distribution" is present, which may be the result of refinement through sieving or levigation (Quinn 2013:156). As Rice (1987:422) points out, modification processes (tempering or refinement) may significantly change the trace-chemical composition of clays—an effect that may have important ramifications for the use of compositional analyses such as instrumental neutron activation analysis (INAA). This is very important to keep in mind as the results of such bulk analyses can be misleading if clay modification is not recognized.

INAA in Archaeological Studies: Potential Issues

Researchers in Mesoamerica have not used petrographic analysis as often as other forms of compositional analysis such as INAA and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) (Fargher 2007:313). Petrography is used to identify the minerals and rocks present in clays and pottery, while INAA is used to analyze the chemical composition of such samples. While these two methods can be complementary, petrography can also be undertaken to check the accuracy of INAA data that are used to address topics like ceramic production and exchange (Stoltman and Mainfort 2002; Stoltman et al. 2005).

The reliability of INAA and its ability to trace ceramic movements and locate production sites was addressed by Anna Shepard (1966) in her response to an article by Bennyhoff and Heizer (1965) regarding ceramics from Cuicuilco and Teotihuacán. Bennyhoff and Heizer (1965:349) argued that based on a single element (manganese), INAA was able to differentiate between two clay sources found at Cuicuilco and to link one of those sources to pottery with similar tempering material used at Teotihuacán. Further, they interpreted these data as clear evidence of trade and that particular phases were contemporaneous in the Valley of Mexico (Bennyhoff and Heizer 1965:349). Shepard (1966:871) countered that their study raised "fundamental questions" about the choice of analytical methods and how results were interpreted, particularly the reliance on a single element. She argued that the materials used in pottery are far too complex for tests to be based on a single element, adding that it does not matter what new and exciting techniques are developed/adopted if researchers do not truly understand ceramics and the various factors that affect how they are formed and altered (Shepard 1966:871). She then cautioned researchers in general, stating that "[n]o single method can meet all requirements," especially if it is used without an understanding of the nature of ceramic materials (Shepard 1966:871).

In another study that highlighted potential issues associated with methods like INAA, Stoltman and Mainfort (2002) conducted petrographic analysis on ceramics from Pinson Mounds, Tennessee, that had previously been analyzed via INAA. The goal of their study was to assess the effectiveness of the two techniques which were used to distinguish locally produced ceramics from imported ceramics at prehistoric sites (Stoltman and Mainfort 2002:1). The INAA results for the Pinson Mounds material appeared to indicate that the ceramics were of local origin. However, their petrographic analyses yielded contradictory results. While the INAA data

suggested that several samples from vessels labeled as either "outlier" or "unassigned" were produced locally, petrographic analysis revealed that these products were imported exotics, based on significant textural differences that could not be distinguished using only INAA (Stoltman and Mainfort 2002:29). The results led Stoltman and Mainfort (2002:30) to conclude that INAA data were not sufficient to distinguish local vs. nonlocal production of individual vessels, and that bulk analysis does not necessarily yield sufficient data to make reliable inferences about past human behaviors.

More recently, a major debate about the reliability of INAA and petrography was spawned by a study of "Olmec" pottery in Mesoamerica. Using INAA data, Blomster et al. (2005) argued that ceramics with distinct Olmec motifs originated from the San Lorenzo region on the Mexican Gulf Coast and were then traded to other regions like Oaxaca. Stoltman et al. (2005) responded to this claim with a study based on petrographic data which they argued demonstrated that the ceramics were actually produced in multiple places and widely traded throughout Mesoamerica. They added that during the period of 3100-2850 B.P., the "chiefdoms" in Mexico emulated each other's wares, and that a simple visual inspection of ceramics would not suffice; rather one would need to link pottery to the bedrock geology in different source areas to truly understand ceramic exchange networks (Stoltman et al. 2005:11213). Their petrographic study shed light on widely distributed pottery like white kaolin and carved gray ware, which were made in more regions than previously thought and therefore were not exclusive to the Olmec (Stoltman et al. 2005:11218).

Although the details of this heated debate—which continued with additional co-authored publications (Flannery et al. 2005; Neff et al. 2006; Sharer et al. 2006)—are not directly relevant to this thesis, it does highlight the potential tensions between different approaches to

compositional analysis (particularly INAA and petrography) and the limitations of data derived from them. This debate, and the other studies noted above, also demonstrate the importance of understanding how clays can be modified by potters, and thus the need for caution in interpreting our analytical results. While Stoltman (1991:117) argued that petrography was "virtually unrivaled in its ability to provide reliable qualitative identification of mineral tempers in ceramics," he also recognized the value of elemental analysis, particularly when the two approaches were used together (Stoltman 2001:298). As Shepard (1966:871) argued decades before, "…clays are exceedingly complex, and we still have much to learn about the factors that affect their composition and about effective ways of distinguishing and identifying them."

Thesis Organization

In Chapter 2, I provide an introduction to the Valley of Oaxaca's geography and geology, a review of archaeological research that has been conducted in the valley, and a description of sociopolitical developments in this region during the later Middle to Terminal Formative periods. In order to understand the arguments that various researchers in Oaxaca have made concerning modification of clays by pre-Hispanic potters, I also provide an overview of Formative ceramic studies that have focused specifically on the valley.

Chapter 3 describes the clay and ceramic samples that I analyzed, as well as the petrographic methods I used in my research. In addition to explaining how I collected my raw data, I outline what we might expect to see if the clays used to make Formative pottery were modified, and the various ways I chose to analyze the petrographic data in order to test those expectations.

In Chapter 4, I give an in-depth analysis of the petrographic data, including charts and tables to convey my findings. Using criteria laid out in Chapter 3, I assess the results for the six different data analyses that I performed. I also discuss individual sherds whose textural characteristics were unusual in comparison to other samples I analyzed.

Finally, in Chapter 5, I review the results of my research and discuss how they relate to research on ceramic production and exchange currently being conducted in the Valley of Oaxaca. Photographs of the thin-sections are used to offer visual comparison of the textures between clays, modern sherds, and Formative sherds. I conclude by offering recommendations for additional petrographic studies in the future.

Chapter 2: Background

In this chapter, I provide background information on the geography and geology in the Valley of Oaxaca as well as a description of sociopolitical developments that occurred during the later Middle to the Terminal Formative periods. I also highlight a number of earlier studies that focused on Formative pottery in the Valley of Oaxaca.

Introduction to Valley Geography and Geology

The modern state of Oaxaca, located in southern Mexico, includes very diverse environments: the tall peaks of the Sierra Madre Oriental and Sierra Madre del Sur mountain ranges, highland valleys such as the Valley of Oaxaca, and tropical lowlands that hug the Pacific coast. The “Y”-shaped Valley of Oaxaca has three subvalleys: the fertile Etla subvalley in the north, where the Río Atoyac commences; the southern Valle Grande, including both the Zimatlán and Ocotlán regions through which the Atoyac flows; and to the east, the dry Tlacolula Valley where the Río Salado flows (Figure 2.1). Two other valleys to the south, Ejulta and Miahuatlán, also belong to the Central Valley System and were linked through political ties to the Valley of Oaxaca (Marcus and Flannery 1996:9-11).

The Valley of Oaxaca averages 1,500-1,700 meters above sea level in elevation and has a temperate, semi-arid environment with an annual average rainfall of 550 mm. The land in the valley is divided into three topographic zones: alluvium, piedmont, and montane. Each of these zones has a different level of agricultural potential. Alluvium (floodplain) is found next to the Atoyac River and its tributaries and provides the most fertile soils suited for agriculture. In this

zone the water table is near the surface, requiring wells of only one to five meters deep in order to access it.

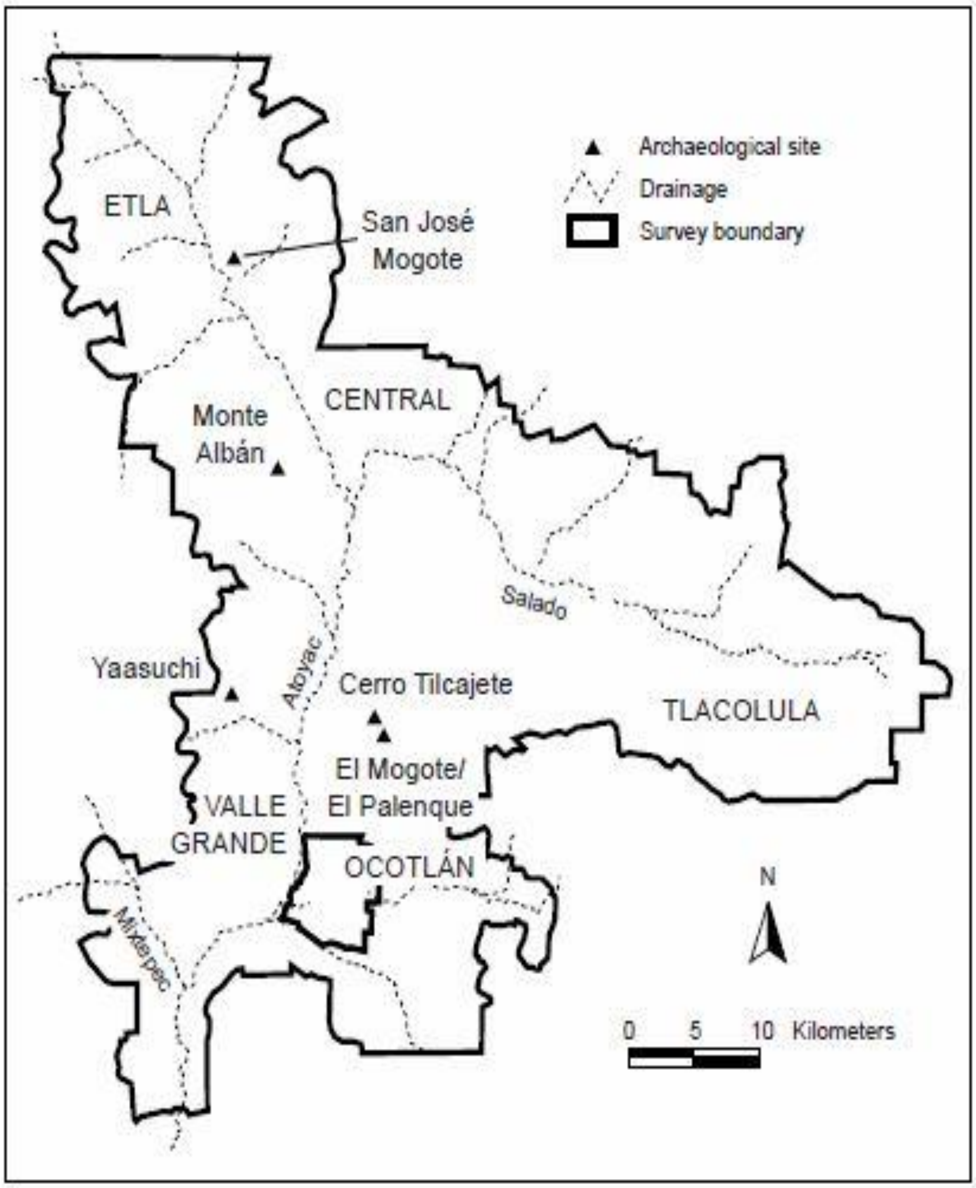

Figure 2.1: Map of the Valley of Oaxaca showing key sites mentioned in text (adapted from Sherman et al. 2010: Figure 2).

Above the alluvium is the piedmont zone (sloping foothills) that typically has thin soils. The piedmont is not as well suited for agriculture because the water table is much further below the surface than in the fertile alluvium zone. Because of this, agriculture in the piedmont zone is dependent on rainfall, making agricultural success a gamble for farmers. However, it has been noted that in years of abundant rain, crops like maize can be successful in the piedmont. The forested montane (mountainous) zone can be found all around the valley. This zone is not productive agriculturally, but can provide useful resources such as wood and game animals (Blanton et al. 1999:31-32).

The Valley of Oaxaca has a bedrock geology that was created in different developmental stages (Lorenzo 1960, cited in Payne 1994:7). The oldest stages are represented by Precambrian metamorphic rocks, mainly gneiss and schist. The second stage includes Cretaceous limestones; the western part of the Valley and Monte Alban have exposed limestone which often contains veins of chert and chalcedony, supreme material for stone tools (Payne 1994:8). The bedrock geology also includes Miocene volcanic tuffs (ignimbrites) found in the eastern part of the valley, where mesas and cliffs were formed from the exposure of these rocks. Most of the alluvium from the Atoyac River and its tributaries was deposited on the valley floor beginning in the Pleistocene. The movement of the river over time would also have served as an impetus of change and erosion for various kinds of rock.

Archaeological Research in and around the Valley of Oaxaca

Monte Albán, the largest and most important site in the Valley of Oaxaca, had escaped notice of the colonial Spanish and travelers until the 1800s when Charles IV of Spain sent

explorers to seek out archaeological sites (Gonzalez-Licón 2001:18). The results of this expedition were published in London (1830) and Paris (1834) in a book titled *The Antiquities of Mexico*, which contained illustrations done by Jose Luciano Castaneda (Gonzalez-Licón 2001:18). Although Monte Albán continued to be written about and studied, Alfonso Caso was the first to conduct large-scale, scientific archaeological excavations at the site, starting in 1931. The Mexican government sponsored this work and other archaeological projects in order to explore Mexico's prehistoric past and to bolster tourism (Joyce 2010:10). Caso has been credited with finding one of the richest artifact burials in Mesoamerica: Tomb 7 at Monte Albán (Caso et al. 1967; see also Blanton 1978; Joyce 2010; Gonzalez-Licón 2001; Marcus and Flannery 1996). Caso continued his work at Monte Albán and other Oaxacan sites with his colleague Jorge Acosta as well as his former student Ignacio Bernal. Together they are credited with the first systematic studies of ceramics from Monte Albán. Based on these studies they were able to define five major periods, Monte Albán I-V, spanning from the founding of Monte Albán to the colonial period. Their book *La Cerámica de Monte Albán* (Caso et al. 1967) continues to be the most important source on Oaxacan ceramics dating to these periods. As studies in the region continued, some of the sequence defined by Caso, Bernal, and Acosta has been revised or debated, yet for the most part, their framework still stands.

In the 1960s, research increasingly focused on how and why the Zapotec state centered at Monte Albán had come into being (Marcus and Flannery 1996:29). Three major research projects spanning over 30 years helped to further understanding of social evolution in the Valley of Oaxaca: the "Prehistory and Human Ecology of the Valley of Oaxaca," begun by Kent Flannery in 1964 to study the origins of agriculture and village life; the "Prehistoric Settlement Patterns of the Valley of Oaxaca" project started in 1971 by Richard Blanton, that included

intensive full-coverage surveys of Monte Albán (Blanton 1978) as well as the rest of the valley (Blanton et al. 1982; Kowalewski et al. 1989); and the "Zapotec Monuments and Political History" project which Joyce Marcus started in 1971 to elucidate Zapotec hieroglyphic texts (Blanton et al. 1999:24; Marcus and Flannery 1996:29). Marcus and Flannery (1996:29) have called attention to the importance of collaboration in research as multiple lines of evidence can help enlighten all in common research problems (see also Flannery 1976).

Other projects conducted in the valley have focused on changes to residential households over time, forms of residential architecture, and organizations high status residences (Winter 1974). Lind (2008) examined social development at Lambityeco during the collapse of Monte Albán. Excavations and preservation at the site of Monte Albán itself has continued on and off since the 1990s with projects sponsored by the Instituto Nacional de Antropología e Historia (INAH), including additional excavations (e.g., Winter 1994), more detailed mapping of the site (e.g., Martínez Lopez et al. 2000) and work by epigrapher Javier Urcid (e.g., 1994, 2001) who analyzed newly discovered carved stone monuments.

Researchers have also studied how Monte Albán influenced other communities in the valley, such as San Martín Tilcajete (e.g., Elson 2007; Spencer and Redmond 2001, 2004) and Yaasuchi (Sherman 2005). Related studies have also documented Monte Albán's influence in neighboring regions, such as the Cuicatlán Cañada to the north (e.g., Spencer and Redmond 1997) and the Ejutla Valley (Feinman and Nicholas 1990) and Sola Valley (Balkansky 2002) to the south and southwest. Important archaeological and paleoenvironmental research has also been conducted by Arthur Joyce and his colleagues along the Oaxacan Pacific coast since the late 1990s (e.g., Barber 2005; Barber and Joyce 2007; Joyce 2013; Joyce et al. 1998).

Sociopolitical Developments in the Oaxaca Valley

Although humans have been occupying the Valley of Oaxaca for more than 10,000 years, the Formative Period, spanning roughly 2000 B.C.– A.D. 250, was a time of particularly major change. Around 2000 – 1500 B. C. (during the Early Formative), people became more sedentary, residing in villages, engaging in agriculture, and making pottery. The archaeological record includes evidence such as storage pits, burials and grave goods, as well as excavated residences that reflect status differentiation by 1000 B. C. The village of San José Mogote in the Etla subvalley was the largest and fastest growing community in the Early Formative period, due in part to specialized production of prestige items (Blanton et al. 1999:34-42; Marcus and Flannery 1996:78-92).

Evidence also suggests that around 1000 B.C. (the Early Formative and continuing into the Middle Formative), wealth was most likely accumulated by a few households, yet it is most likely that members of these households worked side-by-side with lower-ranking people in daily activities. The archaeological evidence suggesting this includes nearly identical tools left behind in food preparation areas and storage pits (Blanton et al. 1999:38). Groups in the Valley of Oaxaca also benefited from trade networks and participated in the Pan-Mesoamerican Olmec art style. This interaction is one of the reasons for increasing social differentiation in the valley, particularly at San José Mogote (Blanton et al. 1999:42).

During the Middle Formative (850-500 B.C.), socio-political changes continued in the Valley of Oaxaca, and there is evidence that by the Rosario phase (700-500 B.C.), there were multiple complex polities ("chiefdoms") characterized by three-tier settlement hierarchies (Marcus and Flannery 1996:121). San José Mogote was the valley's largest center with an estimated population of 1,000 people. Population also increased at other settlements, the largest

being Yegüih in the Tlacolula arm and Tilcajete in the Valle Grande (Blanton et al. 1999:42). These main villages had smaller communities clustered closely to them. Interestingly, a large area of empty land, roughly 80 square kilometers, was maintained in the center of the valley between these three larger settlement clusters. This buffer zone along with the archaeological evidence of burned wattle-and-daub structures, a possible defensive wall around a settlement west of San José Mogote, and a stone slab uncovered at San José Mogote (Monument 3) with a carving thought to depict a sacrificial captive point to increased competition and warfare between the largest center, San José Mogote, and the other smaller centers in the valley (Marcus and Flannery 1996:124, 128-130).

At the beginning of the Early Monte Albán I period (Early MA I, 500-300 B.C.), the urban center of Monte Albán—one of the first cities in Mesoamerica—was founded atop a 400-meter-high mountain in the middle of the buffer zone. During the same period, San José Mogote was largely depopulated (Marcus and Flannery 1996:139). During Early MA I, Monte Albán's population was around 5,000 people. By Late MA I (300-100 B.C.), the population had increased to an impressive 17,000 people. In spite the establishment of Monte Albán as the most important regional center, some scholars believe political consolidation of the entire valley did not occur swiftly (see below). Current evidence appears to indicate that it was not until the Monte Albán II period (MA II, 100 B. C.– A.D. 200) that communities in the Valle Grande and Tlacolula subvalleys were subjugated by the Monte Albán polity (Marcus and Flannery 1996:172-194).

The Founding of Monte Albán and Primary State Formation

The original name of Monte Albán is not known, but local Zapotec speakers refer to it as *Danibaan* or "Sacred Mountain" (Blanton 1978:5). Blanton (1978:5) also cites Caso et al. (1967), stating that it may have been referred to as "Hill of the Jaguar," and Marcus (1983:178) may have identified a sign that would mean "Hill of 1 Jaguar" on the Estela Lisa. Carved on the underside of this stela, which was found at the northwest corner of the South Platform at Monte Albán, is a scene showing four men in a line moving toward a Zapotec lord. All four have glyph names, yet the Zapotec lord appears to be associated with a hill sign and glyph referring to 1 Jaguar. The name "Hill of 1 Jaguar" could potentially be a reference to Monte Albán, or to one of the hills that make up Monte Albán (Marcus 1983:178) (Figure 2.2).

Figure 2.2: Estela Lisa with glyph for "Hill of 1 Jaguar" (adapted from Flannery and Marcus 1996: Figure 261.)

Researchers have proposed several models of why the city of Monte Albán was founded and how it evolved into the capital of a state between 300 and 100 B.C. Blanton and colleagues (e.g., Blanton 1978; 1983; Blanton et al.1999) have described Monte Albán as a "disembedded" capital. According to this model, several autonomous polities came together to form a multi-

center regional polity, with a new capital established in an area deemed politically neutral in order to defend themselves against a threat from outside of the valley (Blanton 1978; Blanton et al 1999:65). Thus, culture, politics, and the economy did not reflect just one of the groups in the union; rather a new social system was established. In Early MA I, the city of Monte Albán's population was about 5,000 while San José Mogote's declined to less than 1,000. By Late MA I, the population of Monte Albán had increased to 17,000, while the second largest settlement in the area had only 1,400-1,700 inhabitants (Blanton et al. 1999:63).

In contrast, Spencer and Redmond (2001) have proposed what they call a "Rival Polity Model," according to which Monte Albán's political domain during MA I included the Etla/Central subregion, but not the Ocotlán/Zimatlán or Tlacolula areas (see also Marcus and Flannery 1996:163). Based on their excavations at Tilcajete, Spencer and Redmond (e.g., 2001, 2004, 2006) argued that the Tilcajete polities resisted incorporation into the expansionistic Monte Albán polity during the Rosario phase and MA I period. They base their argument on various lines of archaeological evidence, including the relative lack of crema (cream ware) ceramics at Tilcajete—a kind of pottery made with distinctive clays obtained from sources close to Monte Albán (Shepard 1963:19; Sherman et al. 2010:287). Spencer and Redmond (2004) also found other evidence of resistance at Tilcajete, such as movement of settlements to defensible locations, defense walls around the settlements, and greater nucleation of population. Political organization of both the Monte Albán and Tilcajete polities became more complex—evolving into primary states—as a result of Monte Albán's expansion and Tilcajete's bid to maintain political autonomy and resist subjugation by Monte Albán (e.g., Spencer and Redmond 2001, 2004).

Recently, Sherman and colleagues (2010) reviewed the archaeological evidence and argued that the Monte Albán state formed during a period of militaristic expansion in the valley as well as into neighboring regions, and that state institutions emerged in what they refer to as "experiments in territorial control" (Sherman et al. 2010:278). They maintain that the founding of Monte Albán was the result of inter-polity conflict within the valley—a model evidenced by the site's defensible location and defensive wall, as well as monumental carvings at Monte Albán known as *danzantes* which depict captives that had been slain, similar to the earlier monument at San José Mogote (Marcus and Flannery 1996:151-153; Sherman et al. 2010:281) (Figure 2.3.). Sherman and colleagues (2010) also argue that the expansion of the Monte Albán polity was a way for elites at the site to establish and maintain the flow of resources and exotic goods that could not be found in the Valley of Oaxaca.

Figure 2.3: Photo showing *danzantes* at Monte Albán.

Other models for the founding of Monte Albán include that proposed by Marcus Winter (2011:394-398), who suggests that Monte Albán's central location would have made it an ideal center of exchange in the valley. He also proposed that Monte Albán was established to defend the Xoxocotlan hinterland—part of the central valley area that Monte Albán's earliest occupation overlooked (along with part of the Etla Valley). Winter (2011:398-399) believes that the settlers of Monte Albán came from Xoxocotlan, Tierras Largas, possibly El Rosario, and other villages abandoned after the Rosario phase (Winter 2011:398-399).

Unlike the majority of researchers, Winter (2011:394) argues that the *danzantes* at Monte Albán were created from social memory, like a photograph in time that depicted the founding of Monte Albán. He further argues that the longevity of the city's layout was something that was a memory of "a basic element of urban society" (Winter 2011:394). Based on the archaeological evidence, I believe the most plausible models regarding the founding of Monte Albán are those that focus on inter-polity rivalries and militarism.

Formative Ceramic Studies

As previously noted, Caso, Bernal, and Acosta (1967) laid the foundation for Oaxacan ceramic analyses by conducting the first systematic study of ceramics from Monte Albán. They defined four primary wares: *amarillo* (yellow ware), *café* (brown ware), *crema* (cream ware), and *gris (*gray ware) (Figures 2.4 and 2.5).

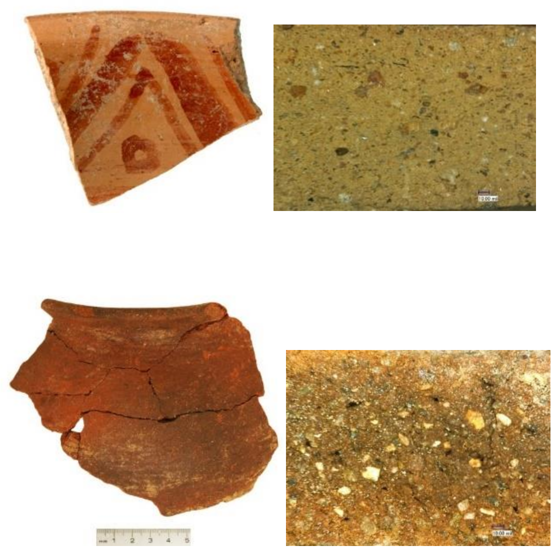

Figure 2.4: Examples of *amarillo* pottery (top) and *café* pottery (bottom) (images courtesy of L. Minc).

Figure 2.5: Examples of *crema* pottery (top) and *gris* pottery (bottom) (images courtesy of L. Minc).

Caso, Bernal, and Acosta (1967) defined each of these wares according to the color of the paste, texture, and types of inclusions. Further, they divided each of the four wares into types based on

decoration and other attributes. Each type was designated by an alphanumeric code, including the first initial of the ware (café uses the letter ‘k’ as not to confuse with crema ware), followed by a number (e.g., G.12). This typology is still widely used today for identifying Oaxacan ceramics produced after the founding of Monte Albán (a pre-Monte Albán ceramic sequence in the valley has also been established by other researchers [e.g., Flannery and Marcus 1994]). Caso, Bernal, and Acosta’s volume includes an important contribution by Anna O. Shepard (1967), who provided a detailed discussion of the pastes for the wares as well as information about pottery production in modern communities. Shepard was a pioneer in petrographic studies of archaeological ceramics in Oaxaca as well as the American Southwest.

In an effort to better understand the economic aspects of ceramics found archaeologically, Shepard (1963) found it helpful to engage in ethnographic studies of modern potters in the Oaxaca Valley. She proposed cooperation between ceramicists and archaeologists in order to identify intercommunity trade (Shepard 1963:17). Shepard collected data on modern potters in the valley in order to understand the economics of pottery production and investigate questions others had failed to note (Shepard 1963:10). Pairing the ethnographic component with sherds included in Caso, Bernal, and Acosta’s study, Shepard attempted to answer questions regarding temper and its geological source locations in the valley as well as understanding the economic relationships between Monte Albán and surrounding villages.

Shepard (1963, 1967) suggested that certain classes of pottery defined by Caso, Bernal and Acosta were tempered. Shepard correlated modern pottery samples the gray, cream, orange/yellow, and brown pottery wares from Monte Albán defined by Caso, Bernal, and Acosta (Shepard 1963:14). She felt that the majority of ceramics were tempered with sand, with amarillo being exclusively tempered with sand while some gris and café pottery was tempered with

diorite (Shepard 1967:479). Crema ware was found to be exclusively tempered with diorite (Shepard 1967:479).

During the 1970s, the ceramicist William Payne conducted studies in the Valley of Oaxaca in order to better understand Formative pottery. He was able to link clays to their general areas of geological origin, noting examples of pottery made from these clays (Payne 1994). Payne also found that Early Formative pottery was made with residual clays, which form in situ above the parent rock. The clays derived from the oldest rocks in the valley, including Precambrian gneiss and schist, are examples of residual clays. Payne (1994:8) argued that Early Formative potters took advantage of washes where piedmont gneiss was easily accessible. The Valley of Oaxaca's western piedmont, which is made mostly of Precambrian gneiss, runs roughly 70 km from the north at Huitzo to the south at Ayoquezco (Flannery and Marcus 1994:4).

In his research, Payne found that the clays from the piedmont arroyos or washes could be used as is, with little or no modification except for the possible removal of debris or sieving of large particles/inclusions. In contrast to Shepard's arguments, he suggested that no temper would be needed, at least in pottery made with residual clays. (Payne 1994). Traditional potters in modern Oaxaca use homemade screens constructed from twigs and thin tree branches (Payne 1994:9). The plasticity of these clays is due to the variety of their components, such as feldspar found in gneiss and other kaolinites present in the clay. This would allow for pottery that could reach hardness at low temperatures (Payne 1994:8). Other geological materials have been identified in Formative ceramics including Miocene volcanic tuffs in clays of the montmorillonite group, hydrothermal clays from ancient hot springs and transported alluvial clays from the valley floor (Payne 1994:8). These re-deposited clays typically have a fine texture

as a result of being transported by natural processes over great distances from the parent material. As a result, alluvial clays can have various mineral bits from different eras, such as Mesozoic limestone (Payne 1994:8)

Gary Feinman and his colleagues helped further our understanding of ceramic production and the development of market systems in the Oaxaca Valley (e.g., Feinman 1982a, 1982b, 1986; Feinman et al. 1984a, 1984b). Although some of the studies they conducted were based on regional survey data rather than compositional data like most of the research summarized in this section, they did establish a framework in which the results of compositional studies can be interpreted.

In a study that did involve compositional analyses, Feinman and colleagues (1989) focused on various gris (gray ware) types in the valley to understand the technical changes that took place over time, from MA I to Monte Albán V (A.D.900-Spanish conquest). Such changes had been attributed to different ethnic groups and their way of manufacturing gris utilitarian pottery (Caso et al. 1967). Feinman and colleagues (1989: 333) collected and analyzed raw clays from across the Oaxaca and Ejutla Valleys to examine the range of minerals and chemical variability in the area. They also conducted four analyses on the sherds including estimation of firing temperature, porosity experiments, and petrographic and elemental analyses using an electron microscope and EDS analyzer (Feinman et al. 1989:333). Based on the petrographic and clay analyses, they argued the gris ware was made in the Valley of Oaxaca with no significant mineral differences in the pastes. They also concluded that ethnicity was not the catalyst for change; rather it was due to sub-regional differences in craft production and networks of intra-regional exchange (Feinman et al. 1989:339). This study helped to dispel Caso, Bernal, and Acosta’s (1967) argument that changes in gray ware were due to “Mixtec” influence.

In their study of gris ceramics from the Ejutla Valley, Carpenter and Feinman (1999) combined experimental, petrographic, and chemical analyses to understand the diversity of ceramics and their compositional signatures. Using petrographic analysis, they examined the mineralogical composition of various sherds and a natural clay in order to determine if anything could have been added to or removed from the clay. The sherd pastes were noted to vary from coarse to fine. Carpenter and Feinman (1999:784-785) then conducted experiments to better understand fine-textured sherds by sieving one sample of clay and levigating another (as Feinman and colleagues [1990] had noted that modern potters in San Marcos Tlapazola refined their local clay through sieving).

To further investigate the behaviors that would have influenced ceramic production, the researchers made tiles using clays from Ejutlaand San Marcos Tlapazola (used as a control group) and fired them at various temperatures (650, 750, 800, and 950 C˚) (Feinman and Carpenter 1999:787). Inductively coupled plasma mass spectrometry (ICP-MS) was then used to collect elemental data on the clay tiles and ancient sherds excavated in Ejutla (Carpenter and Feinman 1999). Feinman and Carpenter concluded that ancient potters in Ejutla used their local clay with little or no modification to create coarse-paste vessels, while fine-paste vessels were most likely refined through levigation. Both the fine and coarse ceramics had the same types of inclusions, but the fine exhibited different proportions (Carpenter and Feinman 1999:794). Furthermore, this study highlighted the fact that clays from the same location but fired at different temperatures may mislead researchers into believing that vessels were produced at multiple production centers rather than one (Carpenter and Feinman 1999:795).

Stoltman et al. (2005) conducted petrographic studies of pottery from various Formative sites to show that exchange of ceramics between highland and lowland chiefly centers occurred.

One of the key issues they sought to clarify was the origin of carved "Olmec" style ceramics that were said to come solely from the Gulf Coast (see discussion of Blomster et al. [2005] in Chapter 1). During the Formative, many chiefdoms emulated each other's styles making visual inspection of pottery an unreliable basis for inferring trade networks. Petrographic analysis demonstrated the widespread and reciprocal exchange between chiefdoms, particularly of white kaolin ware and carved gray ware (Stoltman et al. 2005:11217).

More recently, Lane Fargher (2007) conducted petrographic analysis of gris ceramics from Monte Albán. He examined how specialized ceramic production affected economics and politics around the time that the site was founded (Fargher 2007:314). Using geological maps of the Valley of Oaxaca, he defined 16 clay zones associated with different types of bedrock and then focused on Zones 1 (the western area of the Valle Grande and several Formative sites), and Zone 2 (Monte Albán, and a MA I-II pottery making village) (Fargher 2007:314). He examined clay, modern pottery, and Formative sherds in his study. Fargher (2007:322) also sought to differentiate between natural inclusions, which he argued would be round to subangular due to natural geological processes, and temper, which should be highly angular. He acknowledged that sand can be used as a temper, yet depending on the source of the sand temper, one may be able to determine whether it was intentionally added. Fargher (2007:322) argued that if clays and sand temper were derived from different geological sources, compositional differences between silt and fine inclusions (considered natural) and medium to coarse inclusions (considered temper) might be evident petrographically. If the clay source and sand temper source are the same, no compositional break will be present and it can be assumed that inclusions are natural (Fargher 2007:322). Based on his clay sourcing and petrographic findings, Fargher concluded that during Monte Albán's foundational years, there were a lot of small-scale ceramic producers at other

sites which led to diversity in pastes, although the materials used to make pottery were derived from the same geological sources. Eventually, the demand for ceramics increased and Monte Albán had to import gris ceramics, until the Classic period when gray ware was intensively produced by highly specialized workers and Monte Albán became an important economic center.

Over the past decade, Leah Minc, Jason Sherman, and colleagues (Minc and Sherman 2001: Minc et al. 2007, 2016) have employed chemical (INAA) and petrographic analyses to better understand production and exchange of pottery in the Valley of Oaxaca as well as relationships between the ceramic economy and inter-polity conflict, state formation, and political consolidation in the later Formative periods. Their preliminary trace-element data seemed consistent with the rival-polity model in which some sites were allied with Monte Albán, while conflict between Monte Albán and polities like Tilcajete prevented exchange of goods such as ceramics (Minc et al. 2007:224).

Building on this initial study, Minc conducted the Oaxaca Clay Survey (OCS) which was intended to generate trace-element and mineralogical databases to help determine ceramic provenance in the Oaxaca Valley (Minc and Sherman 2011:286). In the initial phase of the survey, 135 locations throughout the valley were sampled; another 185 samples were collected in its second phase for a more robust and complete coverage of all areas in the valley (Minc and et. al 2016:30). The objectives of the OCS were to assess variability in natural clays and to define regional trends in clay compositions (Minc and Sherman 2011:286). As noted earlier in this chapter, the surficial geology of the valley includes a complex mixture of some of the oldest rocks in Mexico as well as some of the newest. The OCS mapped out ten major bedrock units throughout the valley that affect the quality, plasticity, and mineral composition of clays (see Figure 3.1). These major geological units include Precambrian gneiss [pC(Gn)]; Precambrian

meta-granite [pC(Gr)]; Precambrian meta-anorthosite [pC(An)]; Cretaceous lutite and sandstone [Ki(lu-ar)]; Cretaceous limestone [Ki(cz)]; the Sierra de Juarez Mylonitic Complex [SJMC]; Tertiary andesite and andesitic tuff [Tom(A)]; Tertiary rhyolitic ignimbrite [Tom(R-lg)]; Tertiary polymictic conglomerates/Tertiary sandstone (coarse) [Ti(cg) and Ts(ar)]; and Quaternary alluvium, silt, and sand [Q(al)] (Minc and Sherman 2011:286-288). Clays associated with these different types of bedrock were analyzed using INAA and petrography. Although these analyses demonstrated the difficulty of defining distinct clay zones due to the complex geological history of the valley, they did allow the researchers to develop a continuous regional model of clay composition (Minc and Sherman 2011:311).

In addition to their study of clay samples, Minc and colleagues (2016) also greatly expanded the sample of Formative pottery included in their study. INAA and petrographic analyses were conducted on sherds from five different sites, including Monte Albán; Yaasuchi, a small administrative center in the western Valle Grande (Sherman 2005); and three large sites in the Tilcajete locality: El Mogote and El Palenque, both of which appear to have been capitals of polities that resisted incorporation into the Monte Albán polity during the Rosario phase and MA I (Spencer and Redmond 2004, 2006), as well asCerro Tilcajete, is a site that was founded in MA II after the Tilcajete polity was subjugated by Monte Albán (Elson 2007). As I will discuss in Chapter 3, my own research included sherds from these same five sites, in addition to some of the clays collected during the OCS.

Minc and colleagues (2016:32) found that the soil profiles in the Valley of Oaxaca consist of well weathered clays that have a range of inclusions from fine to coarse. Based on their petrographic studies, they believe that the Formative sherds they analyzed were untempered as their pastes closely resemble natural clays found in the valley (Minc et al. 2016:32). Instead,

they argue, clays that had a range of textural variation from the same location were used in production. At the same time, they emphasize that recognizing whether clays were modified or not is a difficult issue, and that further research with larger samples of Formative sherds and clays may help us better understand how these practices may have affected the mineral and chemical composition of ceramic pastes (Minc et al. 2016:32). In previous petrographic studies, Minc and Sherman (2011) had primarily focused on mineral identification rather than grain angularity and paste textures (J. Sherman, pers. comm. 2016). Therefore, as a continuation of their research, I chose to examine the question of clay modification in Formative ceramics in the Oaxaca Valley. As I noted above, scholars have debated whether the clays used to make Formative pottery were tempered or otherwise modified (see Carpenter and Feinmann 1999; Caso et al. 1967; Minc et al 2016; Payne 1994; Shepard 1963, 1965, 1967). In order to assess this question, I chose to conduct a more intensive textural analysis of clay samples, modern sherds, and Formative sherds. In designing my research, I made a conscious effort to employ methods similar to those used by Minc and Sherman (2011) and Minc et al. (2016) so that my data would be comparable to theirs, and thus would contribute to ongoing research on the nature of ceramic production and exchange in Formative Oaxaca.

In the next chapter I describe the clay and pottery samples I analyzed, the petrographic methods I used, and the types of data I collected. I also explain the results I expected from my data analyses, and what those results might indicate about modification of clays used to make Formative pottery in the Oaxaca Valley.

Chapter 3: Methods

In this chapter I explain the methods I used to assess whether the clays used to make Formative pottery in the Valley of Oaxaca were modified through the addition of temper or refined by removal of natural inclusions. Since Minc and Sherman (2011) and Minc et al. (2016) had already conducted research on the samples using INAA and petrographic analysis, the decision to investigate the samples further using a textural analysis was made. I deliberately focused on texture rather than mineralogy because previous research had focused on the mineralogical composition of these samples rather than detailed textural observations. I recorded data on the shape, size, angularity, and quantity of inclusions in an attempt to determine if the Formative samples were tempered or otherwise modified. Overall, I analyzed 112 samples including natural clays, Formative sherds, and fragments of vessels from modern pottery-making communities.

Thin sections of archaeological sherds from five sites in the valley (Monte Albán, El Mogote, El Palenque, Cerro Tilcajete, and Yaasuchi) that spanned the later Middle to Terminal Formative periods were used. In an effort to create a "control" group, clay samples from the OCS (see Minc and Sherman 2011) were analyzed also, as well as modern ethnographic samples from around the valley for which production techniques were known. It was my hope that patterns would be more discernible when the Formative samples were compared to the ethnographic and pure clay samples.

Because I did not personally compile the Formative samples, sample size for some of the pottery wares is rather small. Also, certain sites may have yielded more samples than others. While this did not create the ideal archaeological ceramic sample, relevant information can still be obtained from the collection and this information can contribute to current and ongoing research (see Minc et al. 2007; 2016 and Minc and Sherman 2011).

Description of Samples in Study

The clay samples used in this research were from the first Oaxaca Clay Survey (OCS), which I described in the previous chapter. Upon starting this research, it was necessary to organize and catalog the slides that were available at UWM. A total of 46 clay samples were analyzed. The samples are associated with eight out of the ten major bedrock units in the Oaxaca Valley (Figure 3.1). In their research, Minc and Sherman (2011) analyzed both residual and alluvial clays as well as clay samples from modern communities that are known to be very similar to pre-Hispanic pastes (Flannery and Marcus 1996; Payne 1994; Shepard 1963). The clay samples were formed into uniform tiles and then fired in an oxidizing environment with that reached temperatures of approximately 800˚C, which is the temperature that traditional potters achieve (Minc and Sherman 2011:292). These samples were then used in INAA and petrographic analysis (Minc and Sherman 2011). My current research included a textural analysis of these tiles.

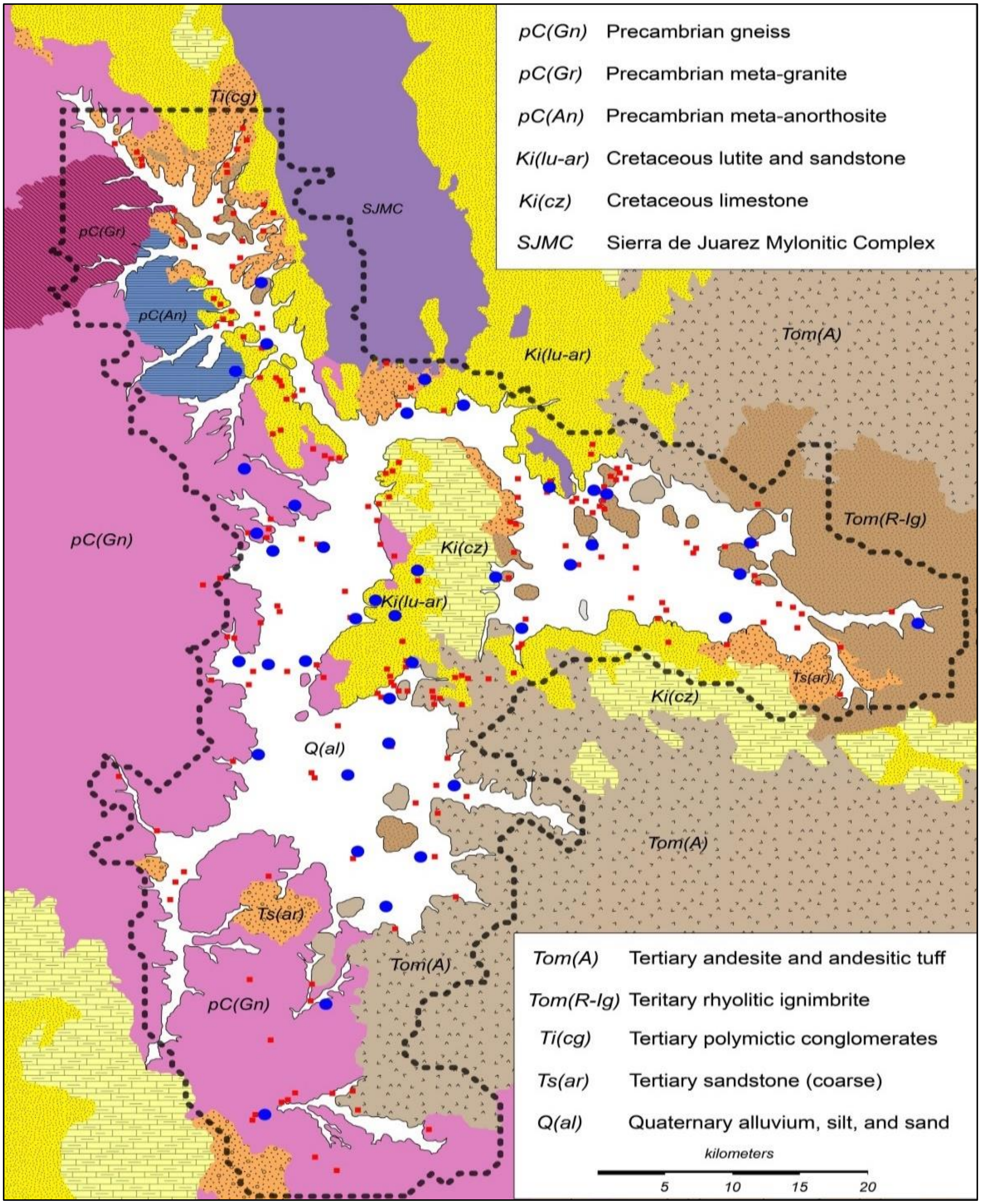

Figure 3.1: Oaxaca Clay Survey map showing bedrock units and sites where clay samples were collected. The locations where samples analyzed in this study were collected are indicated by blue dots. Small red dots represent other locations where clays were collected (adapted from Minc and Sherman 2011:287).

Modern Ethnographic Sherds

In addition, my study includes an analysis of thin sections of sherds from three different modern pottery-making communities in the Oaxaca Valley. Because it is known how the clays in the modern ethnographic samples were treated, textural analysis of these samples yielded valuable data that could be compared to patterns observed in the Formative ceramic samples. Leah Minc (Oregon State University) provided a total of 11 modern pottery samples from three separate locations in the valley: San Mateo Mixtepec, San Bartolo Coyotepec, and San Marcos Tlapazola. The samples from San Mateo Mixtepec were purchased by Minc in the Mercado de Abastos, Oaxaca City. They included fragments of three different *comales* made with mixed clays and sand temper (samples OAX-279A, OAX 297B, and OAX 279C) (Martinez 2014). The fragments from San Bartolo Coyotepec (a town known for its black ceramics see Mindling 2010; Van de Velde and Van de Velde 1939), came from vessels made with unmodified naturally fine clays including three different *cantaros*, or containers for liquids. Two of the three sherds were obtained from the surface of San Bartolo (samples OAX-272B and OAX-278) and the third sample (OAX-274) was a modern sample, but possibly older than the other two sherds and was collected from a river bank. The remaining modern sherds come from San Marcos Tlapazola, a town known for its red pottery. Minc was able to collect fragments of five different vessels from two separate locations in town (samples OAX-276B; OAX-276C; OAX-276D; OAX-277A; and OAX-277B). These vessels were made with sifted fine sand temper (L. Minc, pers comm. 2016).

Formative Sherds

The UWM Archaeological Research Laboratory (UWM-ARL) curates a large group of thin sections of Formative pottery from the Valley of Oaxaca. The slides represent a mix of vessels collected during excavations directed by various researchers. The UWM collection includes a total of 105 slides from the following Oaxaca Valley sites: Monte Albán, El Mogote, El Palenque, Cerro Tilcajete, and Yaasuchi (see Figure 2.1 in Chapter 2).

All four wares defined by Caso et al. (1967) are represented in the collection, including 68 gris sherds, 14 café sherds, 20 crema sherds, and 4 amarillo sherds. These samples span from the later Middle Formative (Rosario Phase, 900-400 B.C.) to the Terminal Formative (MA II, 400 B.C.-A.D. 250) periods. The majority of Formative samples come from bowls, with a few *comales*, vases, jars, and a possible plate also represented. While the clay samples represent the range of clays from around the valley, I recognized the limitations of the Formative ceramic collection, particularly the small number of café and amarillo sherds available for analysis. Thus, every effort was made to complete all slides of these wares in the sample. During my research I analyzed all of the amarillo and café slides, as well as 12 crema and 25 gris sherds, bringing my total sample size to 55, which is more than half of the samples present in the available collection (Tables 3.1 and 3.2). I decided not to analyze all of the crema sherds in the collection since the provenance of this ware has been well established (see Elson and Sherman 2007). Although I did not do mineralogical analysis in my research, each slide required two to four hours to completely analyze depending on the number of points I was able to count in the thin section.

Table 3.1: Formative Sherds Analyzed in this Study, by Ware and Site.

Site	Gris	Café	Crema	Amarillo
Monte Albán	8	2	3	1
El Mogote	5	0	1	0
El Palenque	4	4	2	0
Cerro Tilcajete	6	5	3	2
Yaasuchi	2	3	3	1
Completed Totals	**25**	**14**	**12**	**4**

Table 3.2 Ceramic Types Represented in Analyzed Sample

Gris	**Amarillo**	**Crema**	**Café**
G.12 = 9	A.9 = 4	C.2 = 2	K.3 = 5
G.15 = 2		C.6 = 1	K.7 = 1
G.17 = 4		C.7 = 2	K.14 = 1
G.21 = 3		C.11 = 2	K.17 = 3
G.25 = 1		C.12 = 2	Unknown = 4
G.29 = 3		C.20 = 3	
G.15 or G.16 = 2			
Unknown = 1			
Total = 25	**Total = 4**	**Total = 12**	**Total = 14**

While there are certainly limitations to only examining the texture of the samples, a point I will revisit in Chapter 5, textural data still contribute to a better understanding of ceramics in the Oaxaca Valley and can help us assess whether the clays used to make those ceramics were or were not modified.

Description of Petrographic Methods

Before I began my analysis I decided which information I wanted to collect from each sample and created a data recording sheet that would allow me to document that information systematically (see Appendix A). I used a point-counting technique similar to that described by Stoltman (1989, 1991). I used a standard petrographic microscope with both plane-polarized and cross-polarized light and a moveable stage that allowed for points (locations where the cross-hairs land on the thin section) to be counted within a grid of 1 mm intervals. Although Stoltman (1989:150-151) suggests that counting a total of 100-300 points per sample yields the most reliable data, this was not always possible in my study. I instead chose to count as many points as possible per slide in an attempt to cover the entire slide. Out of the 112 samples I analyzed, the minimum amount of points counted on a sample was 49 and the maximum was 600, with an average of 227 points per slide. Whatever the cross-hairs landed on was tallied as matrix, void, or inclusion. If the cross-hairs landed on an inclusion, I recorded the grain size and shape on my data sheet. The categories for grain size were as follows: silt (≤ 0.0624 mm); fine sand (0.0625-0.249 mm); medium sand (0.25-0.49 mm); coarse sand (0.50-0.99 mm); very coarse sand (1.00-1.99 mm); or gravel (≥ 2.00 mm) (Quinn 2013; Stoltman 1989) (see Appendices B, C, and D for the raw data). In designing my research, I made a conscious effort to employ methods similar to those used by Minc and Sherman (2011; Minc et al. 2016) so that my data would be comparable to theirs and would thus contribute to ongoing research on the nature of ceramic production in Formative Oaxaca.

The overall shape of the inclusions was classified as either round or elongated. I also distinguished four angularity categories which cross-cut the grain shape categories. This

classification was derived from shape and angularity charts developed by archaeological petrographer Patrick S. Quinn (2013:84) and Kenneth A. Bevis (2014), each of whom defined six categories of angularity (referring to the edges on an inclusion) in addition to the elongated and round grain shape categories. I felt that that their two most extreme categories ("very angular" and "well rounded") were too subjective for me to identify consistently. The distinctions between "very angular" vs. "angular" and "well rounded" vs. "round" were in my opinion, very subtle differences. Therefore, I modified their charts, dropping these categories while retaining the following categories: round-angular, subangular, subround, and round; and elongated-angular, subangular, subround, and round (Figure 3.2).

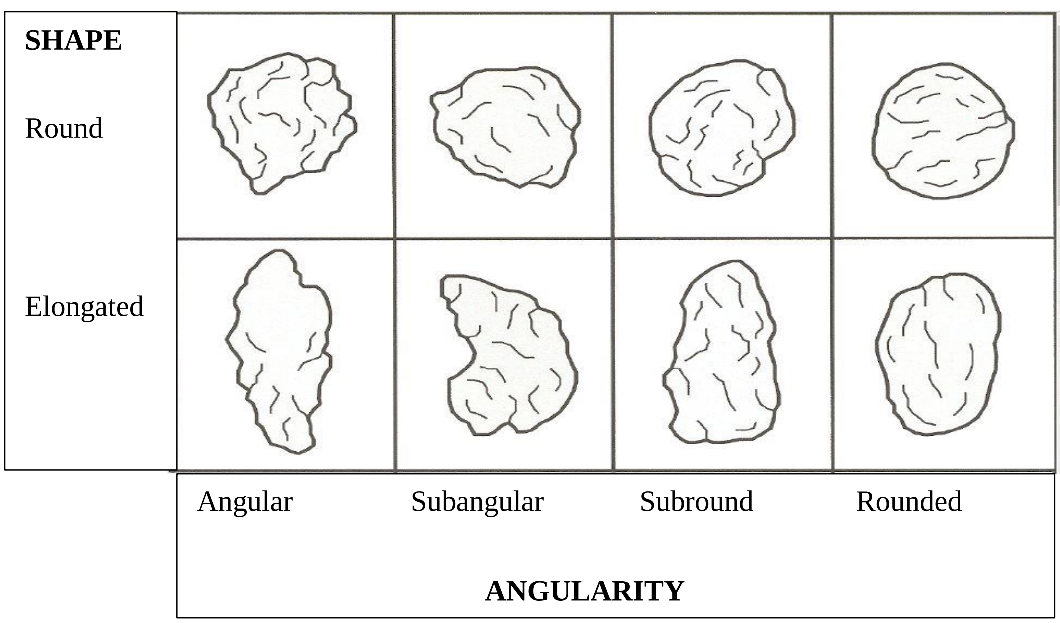

Figure 3.2 Grain shape and angularity categories (adapted from Bevis 2014).

Expected Observations

After observing all three types of samples available to me for this research, including natural clays, modern ethnographic sherds, and Formative sherds, I anticipated a clearer picture to emerge regarding the issue of temper. As I discussed in Chapter 2, Shepard (1965) believed that some pottery in the valley was tempered, but Payne (1994:9) had noted that clays from the piedmont arroyos (washes) could be used as is, with little or no modification except for the possible removal or sieving of large particles or inclusions, thus eliminating the need for temper. He also found that traditional potters today use homemade screens made of twigs and thin tree branches to remove larger inclusions and particles (Payne 1994:8). Likewise, Carpenter and Feinman (1999) conducted experiments including sieving and levigation of clays in Ejutla, and found that coarse-paste ceramics were created with little modification to the raw local clay while coarser inclusions were probably removed (e.g., by levigation) from clays to make fine-paste ceramics. Furthermore, Minc and colleagues (2016:32) found that the Formative sherds they examined had similar particle sizes and degrees of sorting as natural clay samples. Indeed, a number of researchers in Oaxaca feel that if clays were modified, it would have been to remove larger inclusions through sieving or levigation (e.g., Minc et al. 2016:32; J. Sherman, pers. comm. 2016). Being able to recognize if a sample is modified or natural is important in allowing researchers to draw conclusions about ceramic production and exchange that may not otherwise be made (Stoltman 2002:301).

If the clays used to manufacture Formative pottery were indeed modified by the addition of temper, I would expect to see the following: (1) highly angular inclusions; (2) larger average grain size of inclusions; (3) high percentages of inclusions relative to matrix; and/or (4) a greater abundance of one grain size that can be seen as a unimodal or strongly bimodal grain-size

distribution (Minc and Sherman 2011; Minc et al. 2016:31; Quinn 2013:156-168; Rice 1987:406-411; Shepard 1956:161-165; Stoltman 1991; 2002:299-304). Crushed rock (grit) temper should look like particles were freshly fractured compared to other naturally occurring inclusions, and would have a higher degree of angularity. If crushed rock was used, I would also expect many of the inclusions to be in the coarse, very coarse, and/or gravel grain-size categories. However, Stoltman (2002:301) cautions that if sand is used as temper, larger grain size and increased angularity would not be reliable criteria for distinguishing between natural or modified samples. Unfortunately, some of the modern ethnographic samples are sand tempered; in this case, percent of inclusions per slide and also grain-size distributions may still be possible ways to assess whether inclusions are natural or added. Overall, I would also expect the Formative sherds to be similar in appearance to the modern ethnographic samples that are known to have been tempered.

If the clays used to manufacture the Formative pottery were refined, I would expect to see sherds with a uniform distribution of smaller grain sizes and a near total absence of coarse grain size (Rice 1987:118). Quinn (2013:154-156) states that refinement through sieving and levigation could be detected texturally through a strongly unimodal skewed, or small grain size distribution, but cautions that the process of refinement cannot typically be detected in archaeological samples unless the source of raw materials are identified or unused clay is also present at a production site and mineralogical analysis is performed.

If the clays used to make Formative pottery are not modified, I would expect the Formative sherds to demonstrate the following: (1) the inclusions would appear more weathered, i.e., more rounded particles and not angular (Quinn 2013:156-168; Rice 1987:406-411; Shepard 1956:161-165; Stoltman 1991; 2002: 299-304); (2) higher percentages of silt, fine, and medium

size particles; and (3) higher percent of matrix than inclusions. I would also expect the Formative sherds to resemble the raw fired clay samples that Minc and Sherman (2011) studied. Furthermore, several ethnographic samples in my study are known to have been made with unmodified clays, so I would expect the Formative slides to be similar in appearance to those samples.

Data Analysis

I analyzed my point-count data six different ways in order to glean the information necessary to draw conclusions about the modification of Formative clays based on the criteria enumerated above. Given that texture is one of the primary characteristics that distinguish the four main wares in Caso et al.'s (1967) system, I decided to divide the Formative samples by ware (amarillo, gris, café, and crema) as well as to treat all of the samples as one group. When analyzing the data, modern ethnographic sherds were divided according to whether they were made with modified or unmodified clays. Finally, the clay samples were treated as a single group in my analyses.

I began my data analyses by calculating the percentages of matrix, silt, and sand for each sample as well as mean percentages for each group of samples. Next, I calculated a grain-size index following Stoltman (1989, 1991) who created an ordinal scale of 1-5 by assigning a number to each grain-size category as follows: 1 = fine sand (0.0625-0.249 mm); 2 = medium sand (0.25-0.49 mm); 3 = coarse sand (0.50-0.99 mm); 4 = very coarse sand (1.00-1.99 mm), and 5 = gravel ($\geq$ 2.00 mm). Stoltman chose not to include silt in his grain-size index because he felt it was too difficult to determine whether these finest inclusions were natural or had been added

(Stoltman 1991:109). I chose to include silt in my grain-size index and assigned it the number 1, making the scale 1-6 (silt-gravel).

Using Stoltman's idea of the grain-size index, I also created an angularity index in order to put a numeric value on something that could be construed as subjective. The angularity categories that I used when point counting were each assigned a number on an ordinal scale of 1-4. After a sample was completed, the total number of angular inclusions (regardless of their overall grain shape, round or elongated) were summed; the same was done for each angularity category. Round was given a value of 1, subround a value of 2, subangular a value of 3, and angular a value of 4. I then computed the angularity index for each sample, as well as the average index for each group of samples. The minimum, maximum, and median values were also noted.

I also calculated the percentages of round and elongated inclusions per sample, and average percentages for each group of samples. This was done to see if one grain shape was more predominant than the other. Rice (1987:74) has stated that a good natural clay for pottery needs angular inclusions in a wide range of sizes, as clay that has only silt or coarse inclusions would be weak. Admittedly, the shape of an inclusion can be dependent upon the particular characteristics of different minerals (e.g., crystal habitat, cleavage). This will be discussed further in Chapter 5.

I also calculated the percentages of inclusions in each of the four angularity categories (angular, subangular, subround, and round) in each sample, as well as the average percentages for groups. Like the angularity index, these percentages may indicate whether a sample contains many angular or more rounded inclusions. Finally, I looked at the percentage of each grain size observed in each sample to determine if a larger grain-size category was predominant (which might suggest addition of temper), or if silt, fine, and medium inclusions were more common

(suggesting clay with natural inclusions). Examining the average percentages of different grain-sizes for the sample groups might also reveal a telltale unimodal or bimodal grain-size distribution.

In Chapter 4, I discuss the results of these analyses for individual specimens as well as groups of samples, including clays, unmodified modern sherds, modified modern sherds, and the four different Formative wares.

Chapter 4: Data Analyses

In this chapter, I present the results of the six analyses I described in Chapter 3: (1) percentages of matrix, silt, and sand; (2) grain size index (1-6); (3) angularity index (1-4); (4) percentages of round versus elongated inclusions; (5) percentages of angular, subangular, subround, and round inclusions; and (6) percentages of each grain size (silt-gravel). Each analysis was run on the clay samples, unmodified modern samples, modified modern samples, and all the Formative samples both as a single group and broken down by ware. The four expectations laid out in Chapter 3 are used to assess the resulting data to determine if the clays in each of the samples may have been modified (either through adding temper or removal of large inclusions) or unmodified. For the most robust inferences, data from various analyses should be combined as no single test will definitively indicate whether clays were modified or unmodified.

Percentages of Silt, Sand, and Matrix

Table 4.1 lists the average percentages of silt, sand, and matrix for each group of samples. As a group, Formative sherds have nearly identical percentages of silt, sand, and particularly matrix as that of the clays. As expected, the percentage of matrix in the modern tempered sherds was the lowest for all sample groups, and these sherds had an extremely high percentage of sand as well. The modern unmodified sherds exhibit the opposite pattern: theses samples contain the highest percentage of matrix and by far the lowest percentage of sand among all of the samples analyzed.

Table 4.1: Average Percentages of Silt, Sand, and Matrix for All Samples in Each Group

Sample Type	Silt	Sand	Matrix	Sample Size
Clays	11.0	23.1	65.9	46
Modern Unmodified	18.0	8.1	73.9	3
Modern Tempered	8.1	39.2	52.7	8
Amarillo	12.1	18.1	69.7	4
Crema	10.3	29.9	59.9	12
Café	11.7	28.5	59.7	14
Gris	11.4	19.3	69.3	25
All Formative	11.5	24.9	63.6	55

These data, coupled with the grain-size distributions discussed below, suggest that the supposedly modern unmodified sherds had been made with levigated or sieved clays. The results of this test and the grain-size percentages are so strikingly different from those for the clay samples collected by Minc that they appear suspicious. Table 4.2 lists the average, minimum, maximum, and median for the clay samples, while Table 4.3 lists the same data for the modern unmodified and tempered sherds. This table demonstrates the variable texture of the clays from very fine to “gritty”. Table 4.4 lists the comparable data for the Formative samples.

Table 4.2: Percentage of Silt, Sand and Matrix for Clay Samples

	%Silt	%Sand	%Matrix	
Clays (46)				
	11.0	23.1	65.9	**Average**
	0.2	0.0	39.9	**Min**
	21.9	52.1	88.8	**Max**
	10.6	22.5	68.1	**Median**

Table 4.3: Percentages of Silt, Sand, and Matrix for Modern Sherds

	%Silt	%Sand	%Matrix	
Modern Unmodified (3)				
	18.0	8.1	73.9	**Average**
	10.6	6.9	61.8	**Min**
	31.2	10.2	82.3	**Max**
	12.2	7.1	77.6	**Median**
Modern Tempered (8)				
	8.1	39.2	52.7	**Average**
	3.7	28.1	43.1	**Min**
	14.4	46.4	61.2	**Max**
	7.7	39.6	53.8	**Median**

Table 4.4: Percentages of Silt, Sand, and Matrix for Formative Sherds

	%Silt	%Sand	%Matrix	
Amarillo (4)				
	12.1	18.1	69.7	**Average**
	6.5	13.5	59.4	**Min**
	21.7	23.0	80.0	**Max**
	10.2	18.0	69.7	**Median**
Café (14)				
	11.7	28.5	59.7	**Average**
	4.6	11.3	45.4	**Min**
	21.6	48.8	73.6	**Max**
	11.4	28.0	60.1	**Median**
Crema (12)				
	10.3	29.9	59.9	**Average**
	4.7	17.2	42.7	**Min**
	17.5	45.3	78.1	**Max**
	9.2	29.1	60.1	**Median**
Gris (25)				
	11.4	19.3	69.3	**Average**
	4.3	7.2	53.7	**Min**
	22.6	35.3	82.4	**Max**
	10.9	18.4	68.6	**Median**
All Form (55)				
	11.5	24.9	63.6	**Average**
	4.3	7.2	41.3	**Min**
	22.6	48.8	82.4	**Max**
	11.2	24.7	62.9	**Median**

Tri-plot software (Graham and Midgley 2000) was used to generate four ternary diagrams showing the percentages of silt, sand, and matrix in the clay samples, Formative sherds, and modern unmodified and modern tempered sherds. The results are striking as the Formative samples and clay samples appear quite similar (Figures 4.1 and 4.2). Judging from these plots and the data listed in Tables 4.2 and 4.4 it appears that the Formative samples are very similar to clays that have been unmodified.

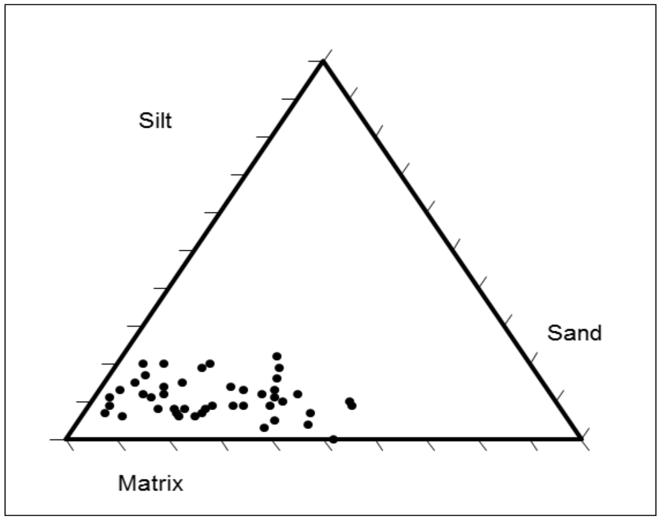

Figure 4.1: Ternary plot showing percentages of silt, sand, and matrix for all clay samples.

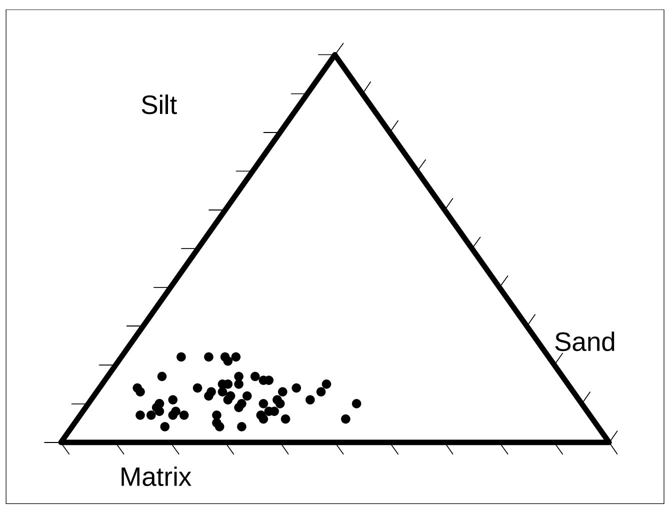

Figure 4.2: Ternary plot showing percentages of silt, sand, and matrix for All Formative sherds. Note the similarity to the clay sample ternary plot.

While the ternary plot for the modern unmodified sherds (Figure 4.3) likewise indicates matrix-rich pastes, the ternary plot for the modern tempered sherds (Figure 4.4) clearly demonstrates the higher percentages of sand present in these samples. However, the clay samples also demonstrate a wide variability in grain-size, suggesting that the composition of the modern tempered sherds may not be all that unusual.

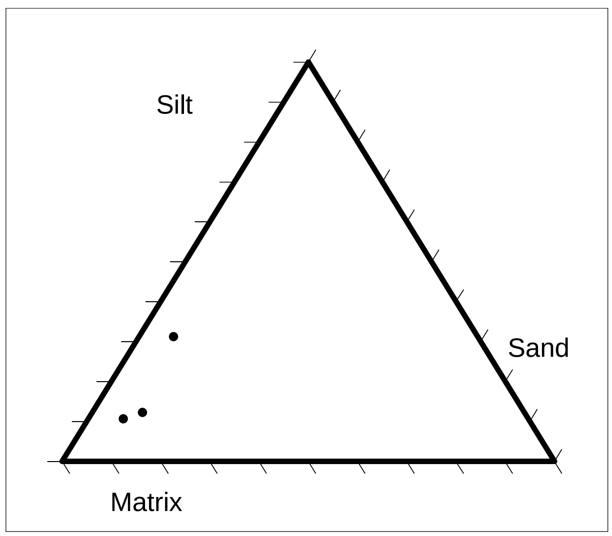

Figure 4.3: Ternary plot showing percentages of silt, sand, and matrix for modern unmodified sherds.

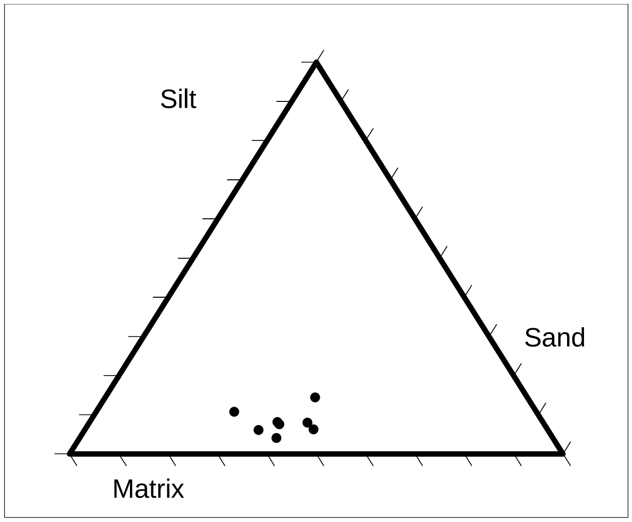

Figure 4.4: Ternary plot showing percentages of silt, sand, and matrix for modern tempered sherds.

Grain Size Percentages

I used the clay samples and modern unmodified sherds as a basis for understanding what the percentages of different grain sizes in natural clays look like graphically. Table 4.5 lists the average, minimum, maximum, and median percentages of each grain size in all of the clay samples. The clays contain primarily silt and fine inclusions, and the percentages of larger grain sizes drop off quickly (Figure 4.5).

Table 4.5: Grain Size Percentages for Clay Samples

Grain Size	Average	Min	Max	Median
Silt	38.4	0.3	100	31.4
Fine	31.3	0	65.1	29.5
Medium	13.6	0	35.2	12.6
Coarse	9.6	0	31.8	7.4
V. Coarse	5.9	0	26.5	3.4
Gravel	1.1	0	10	0

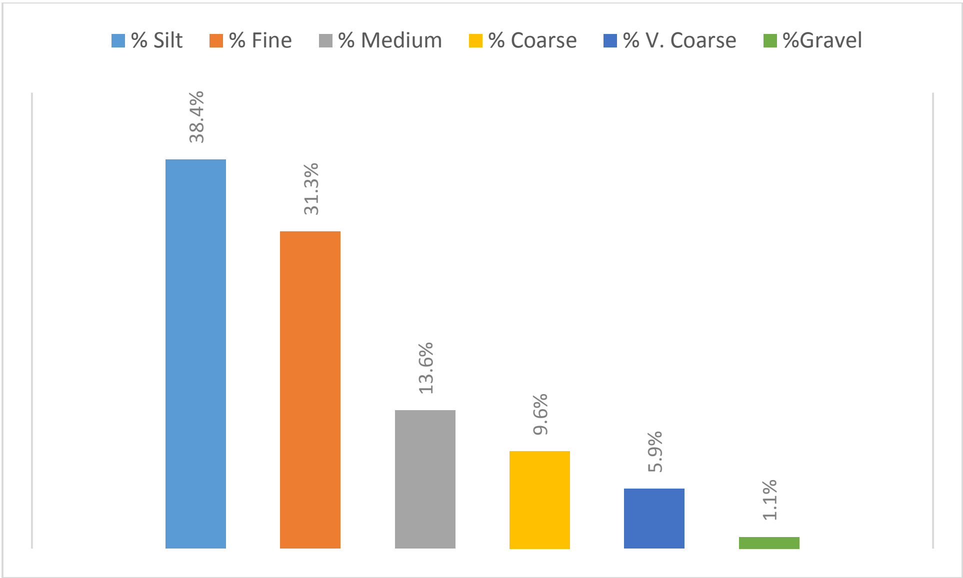

Figure 4.5: Average grain-size percentages for clays

Likewise, the modern sherds made with unmodified clays contain primarily silt (65.5%) and fine inclusions (22.2%), with few larger inclusions (Figure 4.6).

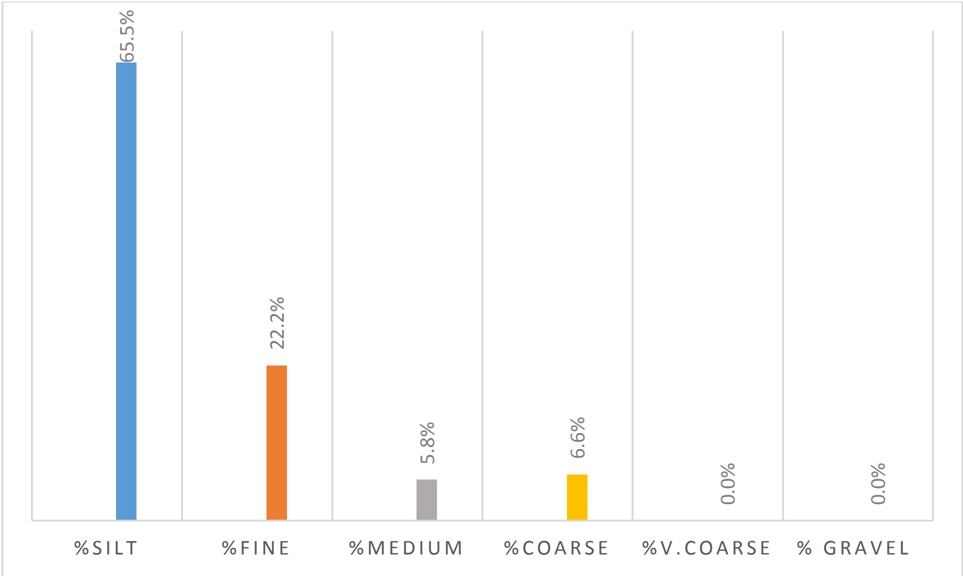

Figure 4.6: Average grain-size percentages for modern unmodified sherds.

Rice (1987:411) has noted that when silt and fine particles constitute the overwhelming majority of inclusions in pottery, they are most likely natural and not added. The modern unmodified sherds seem to follow this pattern. In contrast, the modern tempered samples exhibit the most unusual grain-size distribution of all the samples I analyzed, with nearly equal percentages of fine, medium, coarse inclusions (Figure 4.7). This was the only sample group that was not characterized by high percentages of smaller inclusion sizes with a sharp decrease in the percentages of larger inclusions, or a unimodal curve (Sherman and Minc 2011; Minc et al. 2016:31; Quinn 2013: 156-168; Rice 1987:406-411; Shepard 1956:161-165; Stoltman 1991; Stoltman 2002:299-304). Table 4.6 lists the average, minimum, maximum, and median percentages for the grain-size categories in the modern unmodified and tempered samples.

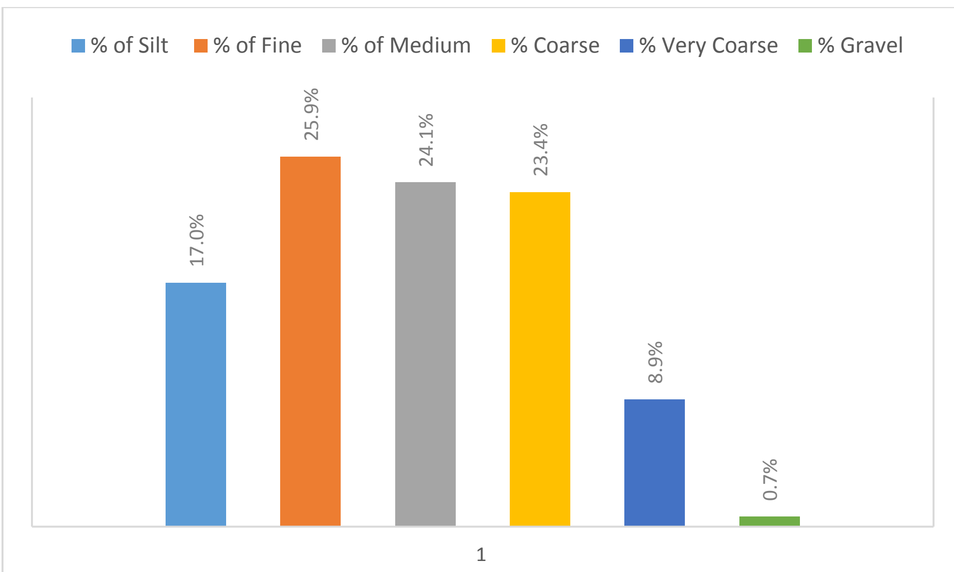

Figure 4.7: Average grain-size percentages for modern tempered sherds

Table 4.6: Grain-size Percentages for Modern Unmodified and Tempered Samples

Sample Group	%Silt	%Fine	%Medium	%Coarse	%V.Coarse	% Gravel	
Modern Unmodified (3)							
	65.5	22.2	5.8	6.6	0.0	0.0	**Average**
	54.5	15.2	1.5	0.0	0.0	0.0	**Min**
	81.8	28.6	11.4	18.2	0.0	0.0	**Max**
	60.0	22.7	4.5	1.5	0.0	0.0	**Median**
Modern Tempered (8)							
	17.0	25.9	24.1	23.4	8.9	0.7	**Average**
	8.3	14.6	12.8	12.6	1.5	0.0	**Min**
	27.7	36.4	38.8	32.4	17.4	2.1	**Max**
	15.7	26.3	23.2	24.0	9.1	0.4	**Median**

Table 4.7 lists the grain-size percentages for all the Formative sherds as a group and by ware. The Formative sherds exhibit a similar grain-size distribution as the clays, with the bulk of inclusions in the silt and fine categories and a quick drop off in the percentages of larger inclusions when looking at the individual wares (Figures 4.8-4.11). Inspection of the graph that represents all the Formative slides together (Figure 4.12), suggests a grain size distribution that is very similar to that of the clays, with remarkably similar percentages. These grain-size data suggest that the clays used to make the Formative pottery were generally not modified.

Table 4.7: Grain-size Percentages for Formative Sherds

Sample Group	%Silt	%Fine	%Medium	%Coarse	%V.Coarse	% Gravel	
Amarillo (4)	38.1	45.3	10.4	5.7	0.5	0.0	**Average**
	31.0	35.7	5.9	3.6	0.0	0.0	**Min**
	53.6	55.9	14.6	8.3	2.1	0.0	**Max**
	33.9	44.8	10.5	5.5	0.0	0.0	**Median**
Café (14)	30.0	34.3	21.5	10.5	3.1	0.8	**Average**
	10.7	11.7	2.7	0.0	0.0	0.0	**Min**
	65.6	56.5	35.0	28.9	13.9	6.4	**Max**
	25.7	33.2	23.5	7.3	2.0	0.0	**Median**
Crema (12)	25.4	29.1	20.7	16.6	7.3	0.9	**Average**
	14.3	9.1	10.3	7.9	1.7	0.0	**Min**
	36.2	35.9	27.5	32.7	18.2	3.6	**Max**
	26.0	32.3	20.6	16.3	6.5	0.0	**Median**
Gris (25)	38.0	34.7	17.3	7.5	2.5	0.1	**Average**
	14.0	11.8	3.0	0.0	0.0	0.0	**Min**
	65.2	50.0	46.0	16.3	10.3	1.4	**Max**
	38.6	35.1	15.4	7.7	2.0	0.0	**Median**
All Formative (55)	33.2	34.1	18.6	10.1	3.5	0.4	**Average**
	10.7	9.1	2.7	0.0	0.0	0.0	**Min**
	65.6	56.5	46.0	32.7	18.2	6.4	**Max**
	31.8	34.1	18.8	8.8	2.1	0.0	**Median**

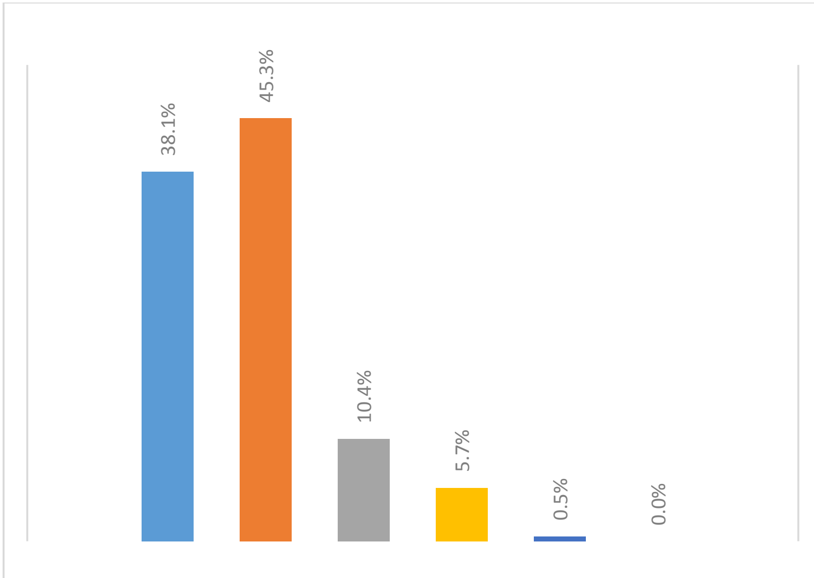

Figure 4.8: Average grain-size percentages for all amarillo sherds

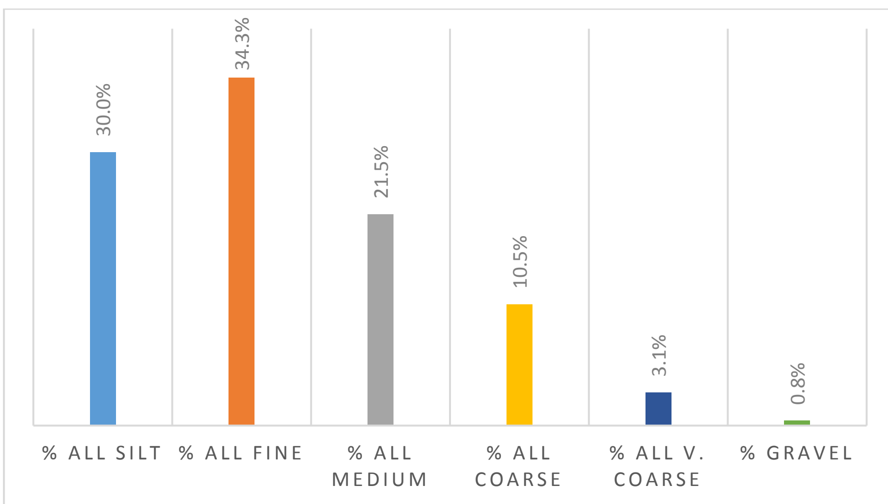

Figure 4.9: Average grain-size percentages for all café sherds

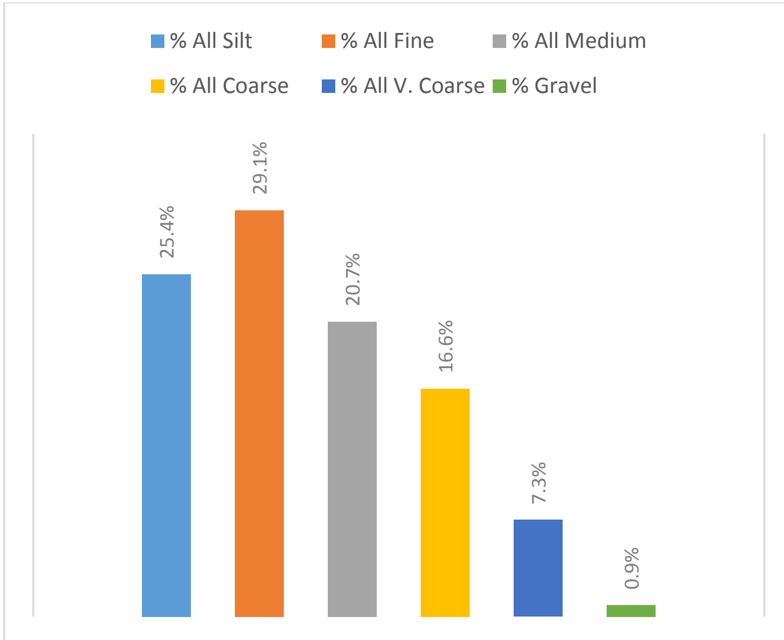

Figure 4.10: Average grain-size percentages for all crema sherds.

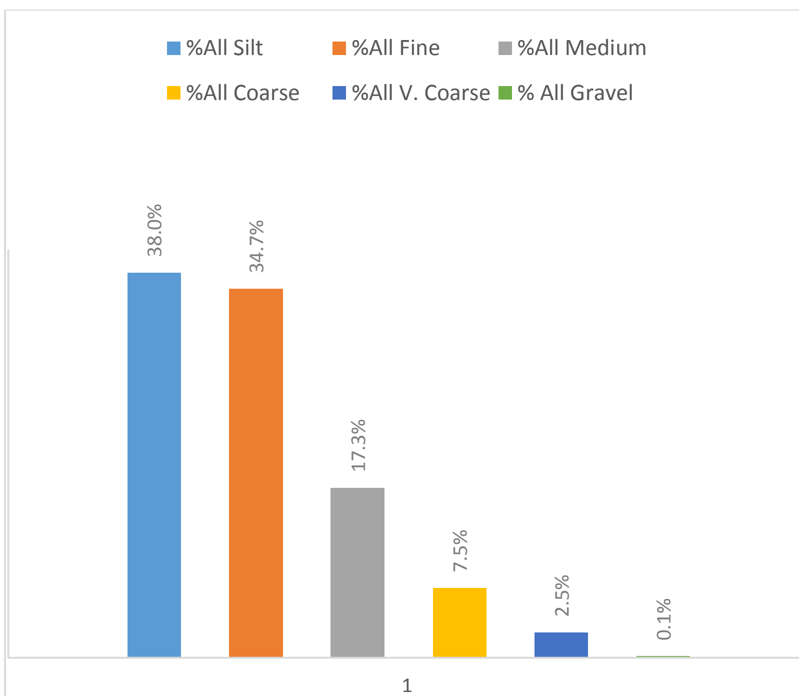

Figure 4.11: Average grain-size percentages for all gris sherds.

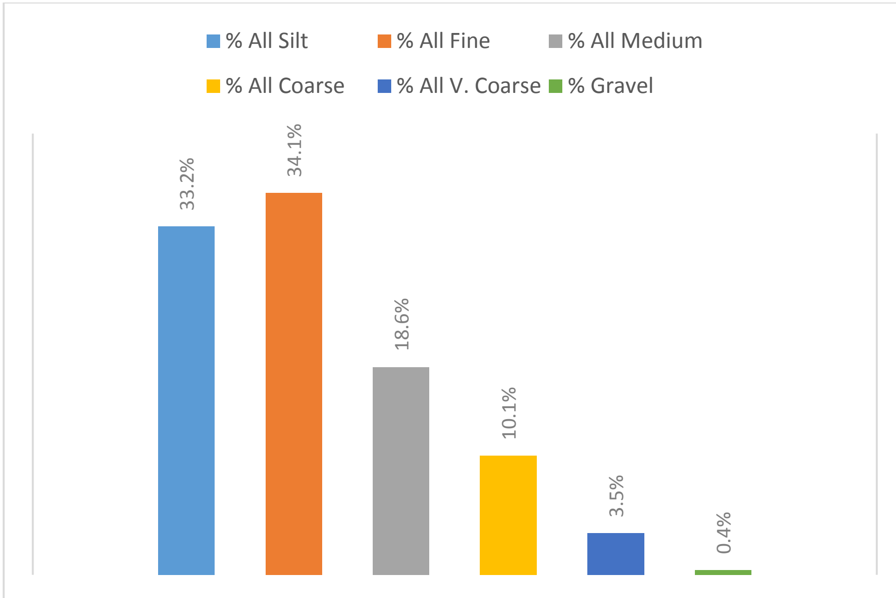

Figure 4.12: Average grain-size percentages for all Formative sherds together.

However, when the Formative samples are analyzed individually, several have grain-size distributions that differ markedly from the general pattern described above. These include three café sherds, two gris sherds, and one crema example (Table 4.8). None of the amarillo sherds exhibit a significantly different pattern.

Table 4.8: Individual Formative Samples with Grain Size% for Further Investigation

Slide #	Site	Period	Type	%silt	%Fine	%Med.	%Coarse	%V.Coarse	% Gravel
OAX-105	Cerro Tilcajete	MAII	K.3	10.7	28.3	23.3	28.9	8.8	0.0
OAX-118	Yaasuchi	MAI-II	K.3	13.9	25.0	25.0	19.4	13.9	2.8
OAX-148	Cerro Tilcajete	MAII	K.7	50.0	47.3	2.7	0.0	0.0	0.0
OAX-217	El Mogote	Early MAI?	C.2	21.8	9.1	14.5	32.7	18.2	3.6
OAX-029	Cerro Tilcajete	MAII	G.12	20.5	17.9	41.0	10.3	10.3	0.0
OAX-218	El Palenque	Late MAI	G.17	39.4	48.5	3.0	9.1	0.0	0.0

Two café (type K.3) sherds, OAX-105 and OAX-118, are distinguished by their relatively large percentages of medium through very coarse inclusions compared to the other samples, and their low percentages of silt. In comparison to these two samples, as well as the other café sherds in the study, sample OAX-148 exhibits a very different pattern. This café (type K.7) sherd contains almost exclusively silt and fine particles, and is thus similar to the pattern exhibited by the modern unmodified sherds. Two gris sherds also stand out for their extreme values. Sample OAX-029 (type G.12) has a larger percentage of medium sized inclusions than silt and fine combined, while gris sample OAX-218 (type G.17) contains primarily silt and fine particles and a notable "bump" in coarse compared to medium sized inclusions. Finally, more than half of the inclusions in the crema sample OAX-217 (type C.2) are coarse to gravel in size. The high percentages of sand-sized inclusions (and in two cases even gravel) in these samples—evident as either a unimodal or a bimodal distribution—may indicate the addition of temper (Quinn 2013; Rice 1987). Clearly, these samples merit further investigation (see Chapter 5).

Grain Size Index

As I explained in Chapter 3, I calculated a grain-size index as one way to assess whether clays had been modified. A low grain-size index value (silt to fine) might indicate natural inclusions, whereas a higher value may indicate the addition of coarser grains as temper. Table 4.9 shows the average, minimum, maximum, and median values for each group of samples.

Table 4.9: Grain-size Index for Clays and Sherds

Sample Type	Average Grain Size Index Number	Min	Max	Median	Sample Size
Clays	2.2	1.0	3.2	2.1	46
Modern Unmodified	1.7	1.5	1.8	1.7	3
Modern Tempered	2.8	2.6	3.2	2.8	8
Amarillo	1.9	1.6	2.0	1.9	4
Crema	2.5	2.2	3.3	2.6	12
Café	2.2	1.4	3.0	2.2	14
Gris	2.8	1.8	3.2	2.8	25
All Formative	2.2	1.4	3.3	2.2	55

As would be expected, the modern tempered sherds have a high average grain-size index value of 2.8. The Formative gris sherds have the same value, which would seem to place the modern tempered and gris sherds in the medium sand category (0.25-0.49 mm). However, the spread of grain-size values for the individual gris sherds was quite wide; some samples have much lower values than the modern tempered sherds. Surprisingly, the grain-size index values for the clays and the modern unmodified sherds are not as close as might be expected. Rather, the amarillo samples most closely resemble the modern unmodified samples in terms of grain size index. Notably, the spread of values for the clays (1.0-3.2) brackets nearly all of the Formative sherds except for some of the coarser crema samples.

Several sherds stand out because of their grain-size index and should be further investigated; these include OAX-217, a crema sample, and OAX-122, a café sample. The crema sample has the highest grain index value of any Formative sample in the study (3.3) while the café sample has one of the lowest (1.4), even when compared to some of the clay samples.

Percentages of Angular, Subangular, Subround, and Round Inclusions

In addition to the angularity index, I also calculated the percentages of angular, subangular, subround, and round inclusions in each of the clays and sherds. This was done for individual samples as well as groups. I was able to graph the individual samples in categories that had smaller sample sizes, including café, gris, amarillo, modern tempered, and modern unmodified sherds. Data for larger groups with many samples such as clays, all Formative sherds, and gris were more difficult to graph in this way. Thus, the decision was made to create graphs representing these whole groups. Table 4.10 lists the average, minimum, maximum, and median percentages of angular, subangular, subround, and round inclusions for the different Formative wares as well as all Formative samples combined. Table 4.11 shows this same information for the clay samples and the modern tempered and unmodified sherds.

Table 4.10: Percentages of Angular, Subangular, Subround, and Round Inclusions in Formative Sherds.

	%Angular	%Subangular	%Subround	%Round	
Amarillo (4)					
	42.3	21.4	20.4	15.9	**Average**
	35.6	11.8	15.3	6.3	**Min**
	52.1	32.1	27.1	26.5	**Max**
	40.8	20.9	19.5	15.5	**Median**
Café (14)					
	46.9	18.8	22.0	12.3	**Average**
	32.4	12.5	13.3	0.0	**Min**
	63.1	27.4	32.7	18.9	**Max**
	48.6	18.0	21.5	13.1	**Median**
Crema (12)					
	39.5	24.1	24.6	11.8	**Average**
	23.8	16.5	15.4	2.6	**Min**
	52.7	36.5	39.4	21.3	**Max**
	37.7	22.8	27.0	11.6	**Median**
Gris (25)					
	37.2	21.0	23.0	18.8	**Average**
	6.5	6.4	7.8	6.1	**Min**
	59.0	33.3	39.4	54.3	**Max**
	37.2	21.4	24.2	15.0	**Median**
All Formative (55)					
	40.5	21.2	22.9	15.4	**Average**
	6.5	6.4	7.8	0.0	**Min**
	63.1	36.5	39.4	54.3	**Max**
	39.2	21.1	21.9	13.3	**Median**

Table 4.11: Percentages of Angular, Subangular, Subround, and Round Inclusions in Natural Clays and Modern Sherds.

	%Angular	%Subangular	%Subround	%Round	
Clays (46)					
	33.8	15.6	20.2	30.4	**Average**
	0.0	0.0	6.3	10.5	**Min**
	64.9	27.3	35.5	73.7	**Max**
	37.4	15.6	20.0	23.0	**Median**
Modern Unmodified (3)					
	25.0	29.7	26.9	18.5	**Average**
	13.6	25.8	20.0	11.4	**Min**
	37.1	31.8	31.8	22.7	**Max**
	24.2	31.4	28.8	21.2	**Median**
Modern Tempered (8)					
	46.6	23.5	21.0	8.9	**Average**
	31.9	16.4	14.3	5.9	**Min**
	63.0	38.3	30.9	13.2	**Max**
	45.8	21.0	18.9	8.2	**Median**

In most of the Formative and modern tempered sherds, angular inclusions predominate (Figures 4.13 and 4.14). The subangular and subround inclusions tend to fall in the middle for most of the Formative and modern tempered sherds. Compared to most Formative sherds, modern tempered sherds have more angular inclusions and fewer round (Figure 4.14). Overall, café and amarillo sherds are most similar to the modern tempered sherds in terms of their angularity percentages.

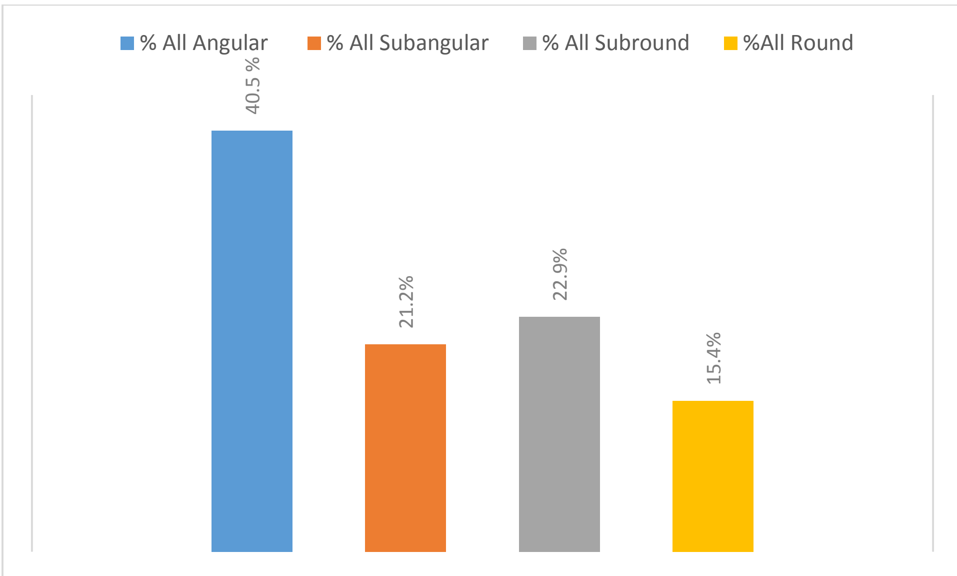

Figure 4.13 Percentages of angular, subangular, subround, and round inclusions for all Formative sherds.

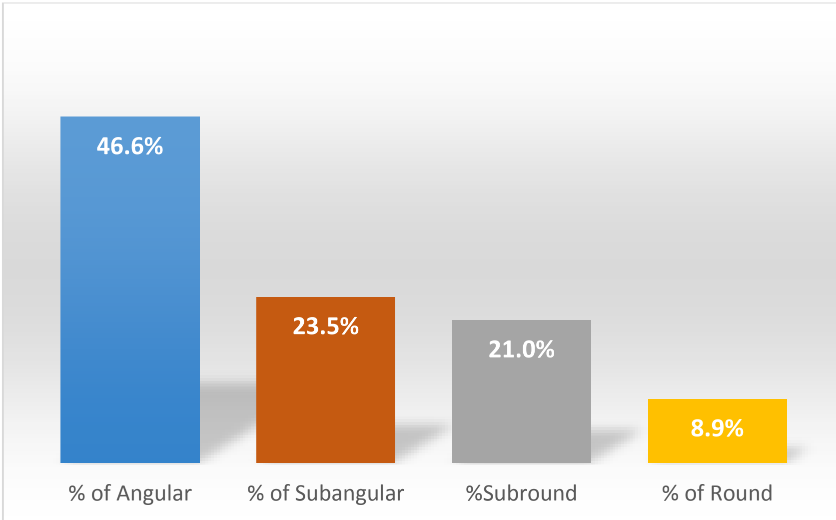

Figure 4.14 Percentages of angular, subangular, subround, and round inclusions in modern tempered sherds.

Compared to the Formative and modern tempered sherds, the modern unmodified sherds show a more even distribution across the four angularity categories (Figure 4.15). This sample set is also the only one to not have the greatest percentage of angular inclusions compared to the other three categories. Instead, subangular inclusions are most common followed by a nearly even split between angular and subround inclusions.

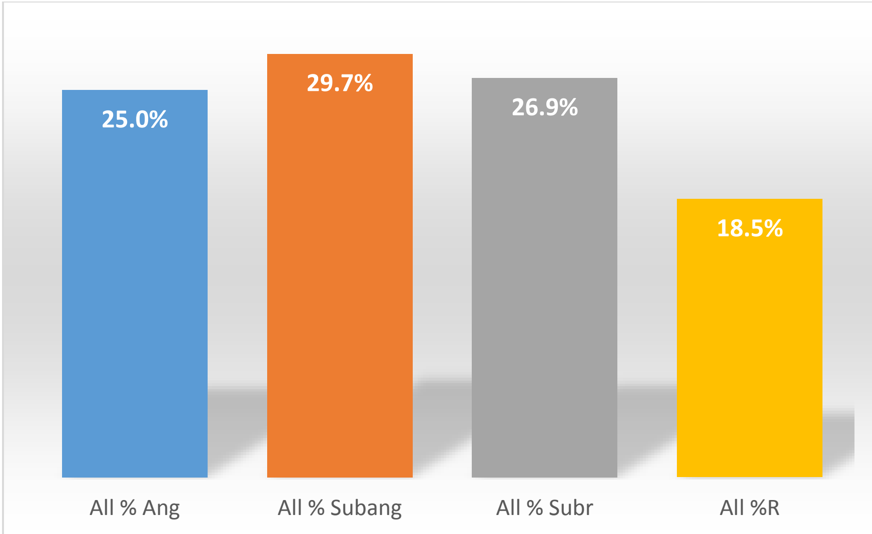

Figure 4.15: Percentages of angular, subangular, subround, and round inclusions in all modern unmodified sherds showing a near equal distribution.

The clay samples, like the Formative and modern tempered sherds, have the largest percentages of angular inclusions. However, unlike the sherds in which round inclusions are least common, round inclusions comprise the second highest percentage in the clay samples (Figure 4.16).

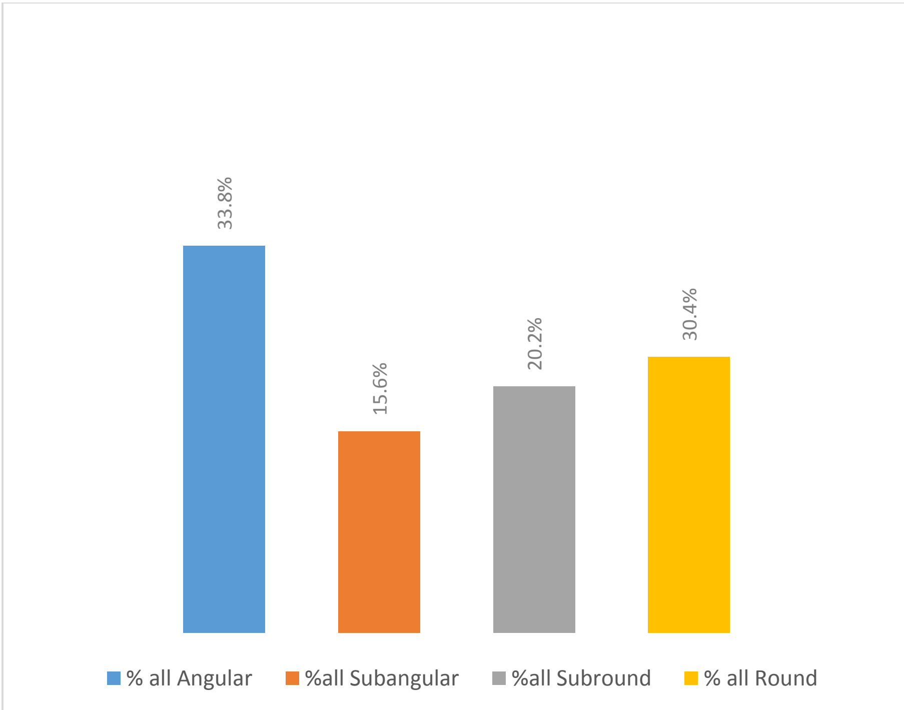

Figure 4.16: Percentages of angular, subangular, subround, and round inclusions in all clay samples

Comparing these results to the angularity index, we do see a slight difference. While the average angularity index for the Formative and modern tempered sherds is closest to the subangular value (3), angular inclusions are actually most frequent in these samples. In fact, for the café and the modern tempered sherds, nearly half of the inclusions fall in the angular category (Figures 4.14 and 4.17).

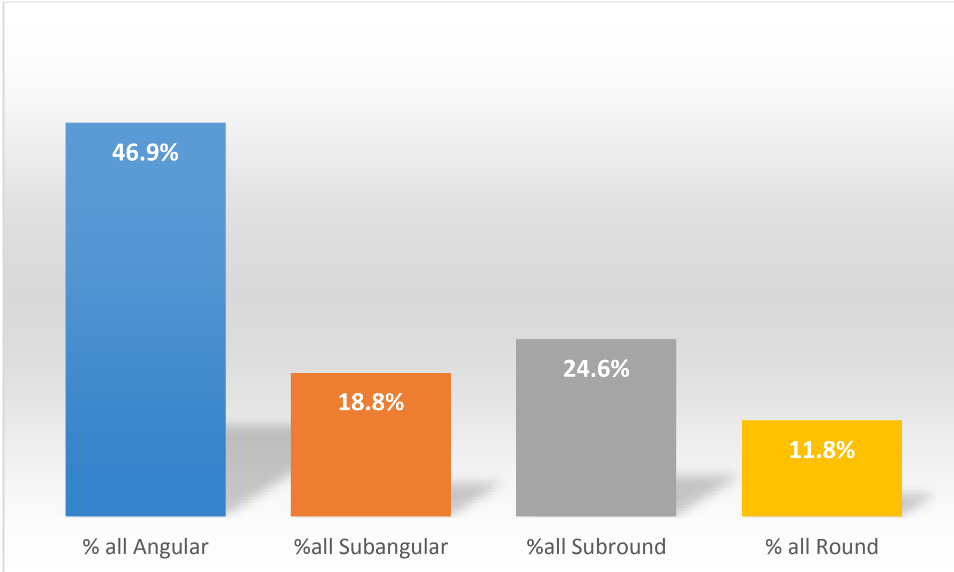

Figure 4.17: Percentages of angular, subangular, subround, and round inclusions in all café sherds.

Several individual Formative samples stand out as a result of this test (Table 4.12). Café sherd OAX-105 from Cerro Tilcajete has a large percentage of angular inclusions and few round particles. Another café sherd, OAX-118 from Yaasuchi, had no round inclusions with angular being the largest group and the subangular and subround evenly split. Two gris sherds (OAX-008 and OAX-029) have high percentages of angular inclusions while gris sherd CTL-001 has an unusually high percentage of round inclusions (54%). Four clay samples also have interesting percentages in each of the angularity categories. Samples OCS-037U and OCS-089 have unusually large amounts of round inclusions and very few to—in the case of OCS-037U—no angular grains. Samples OCS-051 and OCS-73C have the opposite, with very high percentages of angular inclusions, 64.9% and 61.0% respectively. As a comparison, the modern tempered sherd OAX-279B has a high percentage of angular inclusions with a very low percentage of round inclusions.

Table 4.12: Sherds with Unusual Angularity Percentages

Slide #	Site	Period	Type	% Angular	% Subangular	% Subround	%Round
CTL-001	Cerro Tilcajete	MAII	G.29	6.5%	19.6%	19.6%	54.3%
CTL-105	Cerro Tilcajete	MAII	G.21	38.6%	6.4%	30.0%	25.0%
OAX-008	Yaasuchi	MAII	G.21	57.5%	12.3%	21.9%	8.2%
OAX-029	Cerro Tilcajete	MAII	G.12	59.0%	12.8%	20.5%	7.7%
OAX-105	Cerro Tilcajete	MAII	K.3	63.1%	12.5%	20.0%	4.4%
OAX-118	Yaasuchi	MAI-II	K.3	50.0%	25.0%	25.0%	0.0%
OCS-037U C	San Isidro Zegache	Clay		0.0%	20.0%	20.0%	60.0%
OCS-051	NW Cuilapan de Guerrero	Clay		64.9%	14.0%	7.0%	14.0%
OCS-073C	E of San Pablo Villa de Etla	Clay		61.0%	7.3%	9.8%	22.0%
OCS-089	NW of San Juan Guelavía	Clay		5.3%	0.0%	21.1%	73.7%
OAX-279B	San Mateo Mixtepec	Modern	Tempered	63.0%	16.8%	14.3%	5.9%

Angularity Index

Table 4.13 shows the angularity index values for all of the sample categories.

Table 4.13: Angularity Index for Each Group of Samples

Sample Type	Average Angularity Index	Min Index	Max Index	Median	Sample Size
Clays	2.5	1.4	3.3	2.7	46
Modern Unmodified	2.6	2.4	2.9	2.5	3
Modern Tempered	3.1	2.9	3.4	3.0	8
Amarillo	2.9	2.7	3.1	2.9	4
Crema	2.9	2.6	3.3	2.9	12
Café	3.0	2.7	3.3	3.0	14
Gris	2.8	1.8	3.2	2.8	25
All Formative	2.9	1.8	3.3	2.9	55

As might be predicted, the samples with the highest angularity index (average 3.1) are the modern tempered samples. The modern unmodified sherds and the clay samples have nearly the same average angularity index (although the clays had a spread of values) perhaps reflecting the "ready to use" nature of many of the clays in the valley. Taken together, the Formative samples have a slightly higher average index of 2.9 and the individual wares have almost the same value. Café samples, which had the highest index number (3.0), are most similar to the modern tempered samples.

Several individual samples stand out in this analysis. Sherd CTL-001, a gris sample, has the lowest angularity index number by nearly a full point (1.8). Two café sherds, OAX-105 and OAX-118, as well as one crema sherd, OAX-012, have angularity index numbers of 3.3. It would be worth examining these samples more carefully (see Chapter 5).

Percentages of Round and Elongated Inclusions

The final analysis I conducted focused on overall grain shape (rounded versus elongated). Overwhelmingly, all sample categories contain more round than elongated inclusions (Table 4.14). The café sherds and clay samples have the most even distribution. The modern sherds made with unmodified clays have similar percentages to the grain-size data reviewed earlier (65.5% silt and 22.2% fine particles). This accords with Rice's (1987:411) observation that small, rounded inclusions are usually natural components of clays.

Table 4.14: Percentages of Round and Elongated Inclusions in All Samples

Sample Type	% Round	% Elongated	Sample Size
Clays	54.3	45.8	46
Modern Unmodified	69.1	30.9	3
Modern Tempered	53.8	46.2	8
Amarillo	60.4	39.6	4
Crema	61.5	38.5	12
Café	55.0	45.0	14
Gris	61.3	38.7	25
All Formative	59.5	40.5	55

The café sherds exhibit the most even split between round and elongated inclusions, with round inclusions the majority in all but two cases. As previously discussed in Chapter 3, this test has limitations. The way an inclusion will break is partly dependent upon its mineralogical composition and how those minerals naturally cleave. Thus, identification of minerals present in inclusions, followed by a study of where in the valley these minerals may typically be found, would help elucidate whether the round versus elongated distinction is truly meaningful.

Chapter 5: Conclusion

This thesis research focused on the textural analysis of 112 samples in an attempt to determine if the ceramics from five sites in the Oaxaca Valley spanning the later Middle to Terminal Formative periods were tempered or not—a challenging but important issue for researchers in this area who have relied on other forms of compositional analysis like INAA. This was accomplished by conducting six different analyses on the petrographic data I collected for this study. This chapter discusses the implications of the patterns that are seen in the analyses described in Chapter 4. The chapter concludes with possible future research opportunities in regards to textural analysis of ceramics from the Oaxaca Valley.

General Textural Patterns

This research focused on the shape, frequencies, and degree of angularity of inclusions in natural clays and sherds. These raw data were analyzed in various ways and tested against a series of four expectations (Chapter 3) in order to determine if the clays used to make Formative ceramics were modified. This research also used samples of 46 natural clays from various locations around the valley as well as 11 samples of modern pottery with known production methods. When all the data are examined together, it is not possible to say definitively that *all* pottery was or was not tempered (or otherwise modified) in the Oaxaca Valley during the Formative Period. However, based on the individual analyses, I conclude that most (if not all) of the samples in the study data set were probably not tempered.

The clay samples displayed quite a variation in texture. The diversity was particularly pronounced in two of the analyses that I conducted, the grain-size index and the angularity index.

In the grain-size index, the values ranged from 1.0 to 3.2. The angularity index also had a large range with values from 1.4 to 3.3, reflecting textural variability from rounded inclusions to highly angular. In comparison, the modern unmodified sherds displayed a rather consist grain-size index number and angularity index values (1.5-1.8 and 2.4-2.9 respectively). Some clays, such as OCS-051 and OCS-073C, have many angular inclusions (Figure 5.1). Sample OCS-051 shows a lot of smaller angular inclusions, with almost 65% of the inclusions in the sample being angular in nature.

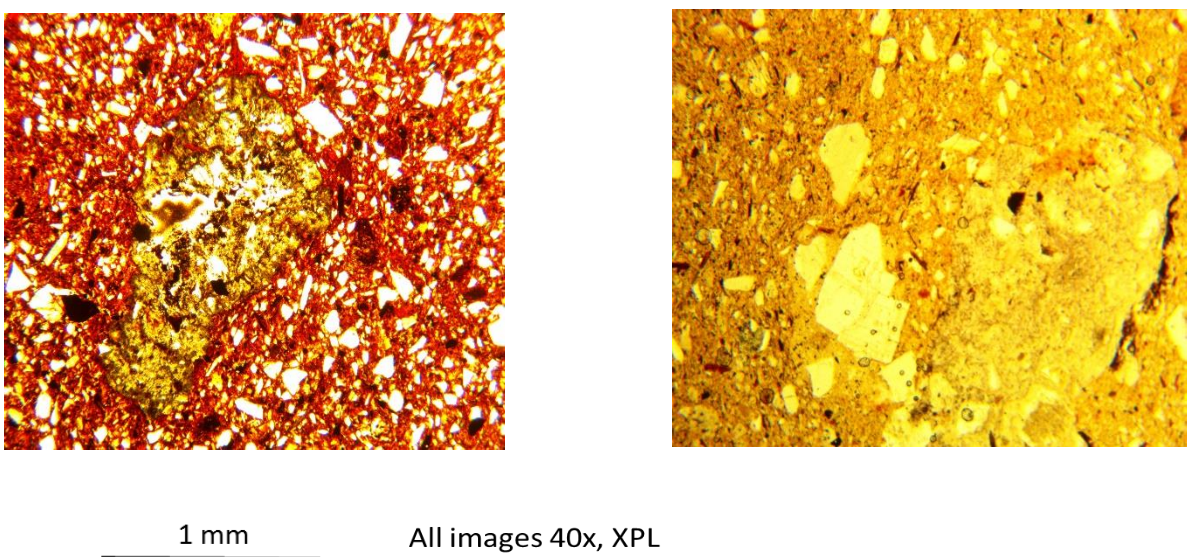

Figure 5.1: OCS-051 (left) and OCS-073C (right) clay samples displaying highly angular inclusions.

In contrast, other clays such as OCS-089 and OCS-037Ua contain mostly small, round inclusions (Figure 5.2). Sample OCS-089 had the lowest angularity index (1.4), displaying very small rounded particles. Although a rather large inclusion is evident in Figure 5.2, note the rounded edges of the inclusion. Sample OCS-037Ua had the lowest grain-size index number of all samples and sherds in this research (1.0).

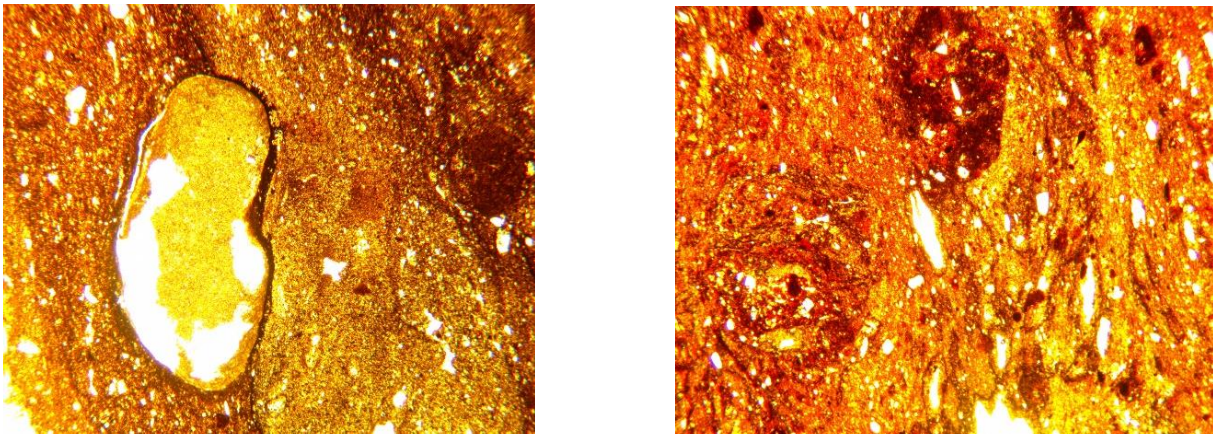

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Figure 5.2: OCS-089 (left) and OCS-037Ua (right) clay samples displaying rounded inclusions.

The considerable textural and color variation evident in the clays can be seen in Figures 5.3 and 5.4. In particular, note the mixture of angular and round inclusions as well as the polymineralic inclusion in OCS-061 (Figure 5.4).

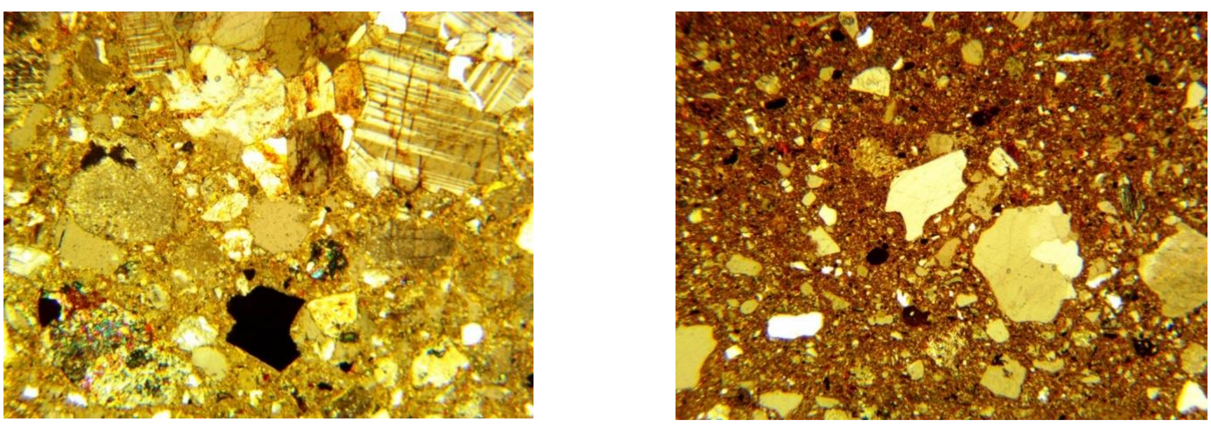

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Figure 5.3: Clay samples OCS-064B (left) and OCS-009 (right) demonstrating variability in

texture and color.

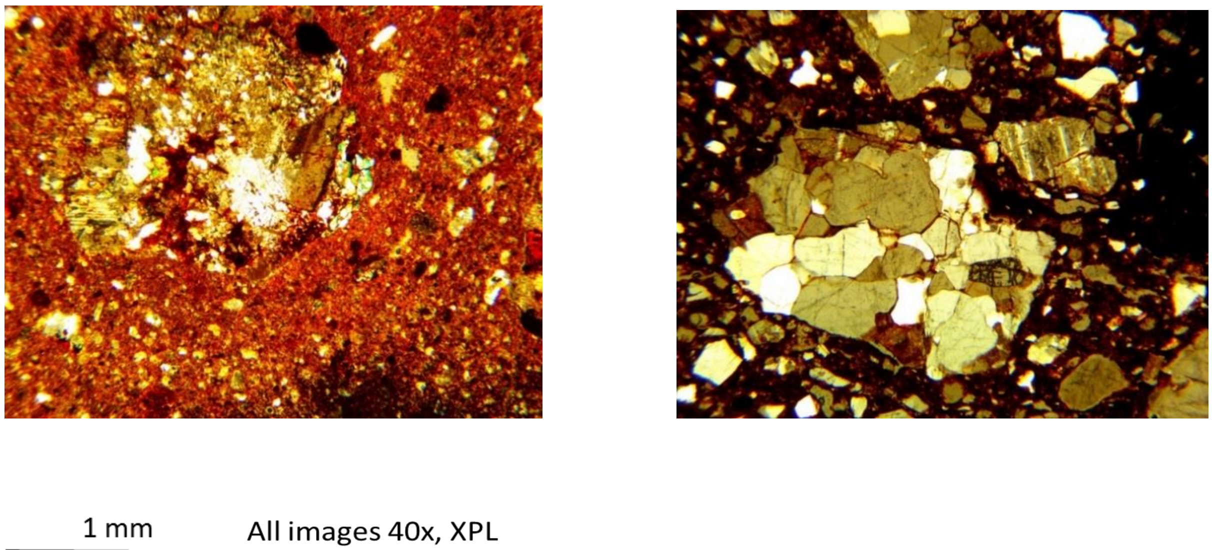

Figure 5.4: Clay samples OCS-035 (left) and OCS-061 (right) demonstrating variability in texture and color.

Analysis of modern sherds that were tempered and made with unmodified clays yielded valuable data that could be compared not only with the Formative sherds but the clay samples as well. The unmodified clays of the modern sherds displayed similar characteristics, including many small, rounded, and well sorted inclusions (Figure 5.5).

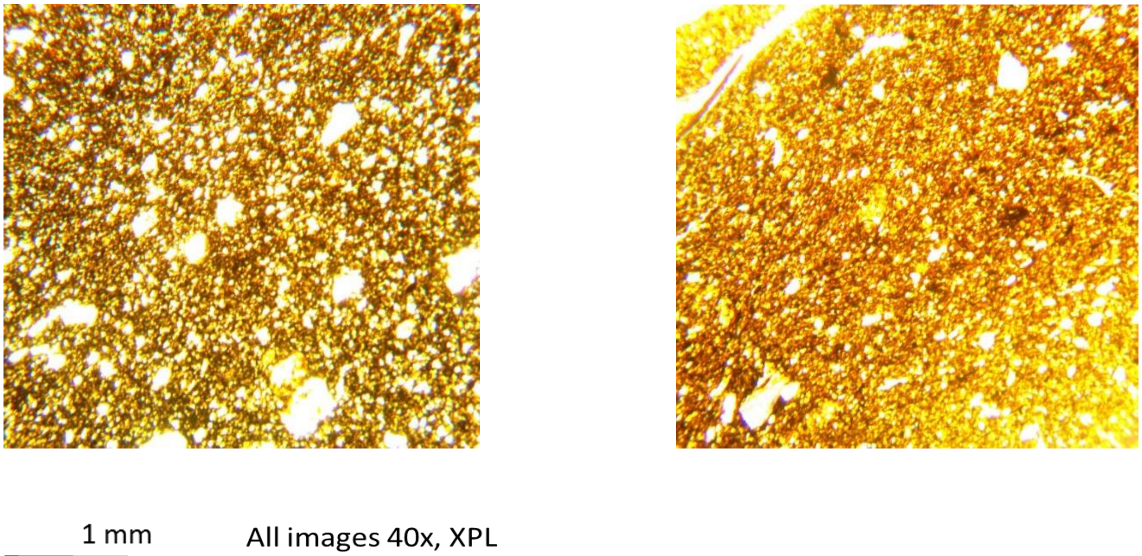

Figure 5.5: Modern unmodified sherds OAX-272B (left) and OAX-274 (right).

Upon first inspection of the results for the modern unmodified sherds, I was slightly skeptical that they could contain so much silt and fine inclusions. However, several clay samples actually contained even higher percentages of small inclusions than the unmodified sherds (Figure 5.6). Given the variability among the clays, it seems entirely possible that naturally fine clays were used to make the modern pottery.

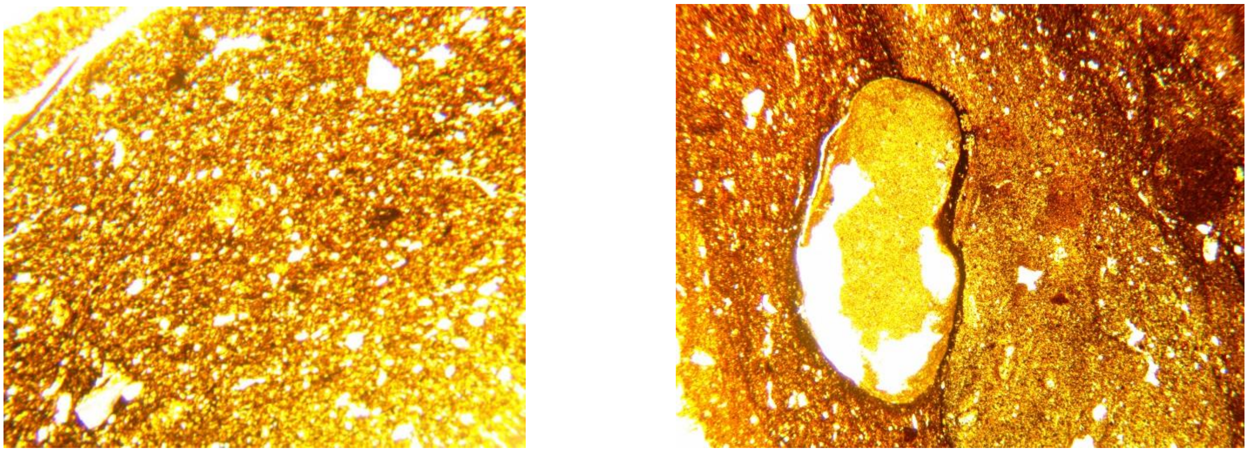

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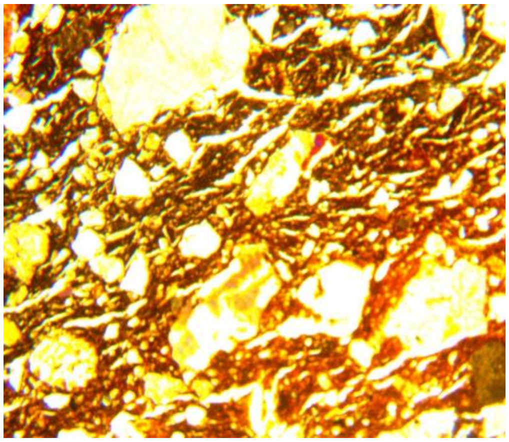
Figure 5.6: Modern unmodified sherd OAX-274 (left) and clay sample OCS-089 (right).

The modern tempered sherds were known to have either sifted fine sand or mixed clay with sand temper (Figure 5.7). The maximum grain-size index for the modern tempered sherds and the clays were exactly the same (3.2). However, the clays showed a wider variability and had a minimum index number of 1.0, while the minimum index for the modern tempered sherds was 2.6. Nevertheless, the maximum angularity index for the clays (3.3) was similar to the maximum value for the tempered modern sherds (3.4).



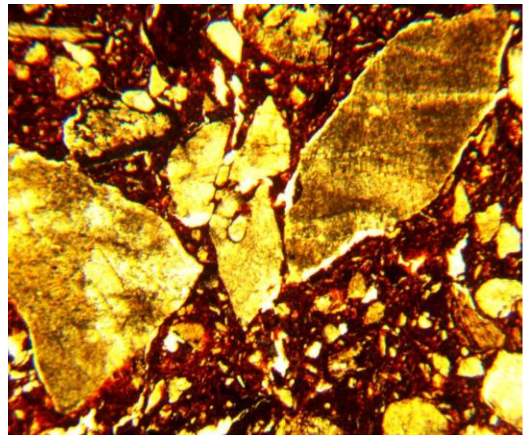


Figure 5.7: Modern tempered sherds OAX-277B (left), made with sifted fine sand, and OAX-279A (right), made with mixed clays and sand temper.

Because the clays show great variability and the modern unmodified and modern tempered sherds also display variability, the expectation for the Formative sherds was that they would be most similar to the clays and unmodified modern sherds. As mentioned in Chapter 3, the possibility of refinement was also considered. If some of the Formative sherds were made with refined clays, I would expect them to contain more uniform silt, fine, and possibly medium inclusions, as potters would have removed larger inclusions from the clays through one or more of the methods discussed in Chapter 1. As mentioned above, when comparing the clay samples to the modern unmodified sherds, it became evident that the natural clays in the valley could indeed be very fine in nature. After examining the modern tempered sherds and comparing them to the clays, some resemblance could be discerned. However, because the modern tempered sherds contained either fine sifted sand or a mix of clays with additional sand temper, larger grain size and increased angularity would not be reliable criteria for comparing them to

Formative sherds. Assessment of Formative sherds that may have been tempered would need to note the grain-size distribution and the number of inclusions per slide.

The Formative sherds exhibit textural variability that is similar to the natural clays, as is evident from the nearly identical ternary plots presented in Chapter 4. The thin sections shown in Figures 5.8 and 5.9, including examples of the four different wares, demonstrate the considerable textural variation evident in the Formative sherds. In terms of angularity index values, the Formative sherds had a higher average value (2.9) than the clays (2.5) or the modern unmodified sherds (2.6). However, in terms of the average grain-size index, the Formative sherds and the clays had identical values (2.2). The grain-size index for the modern unmodified sherds was 1.7.

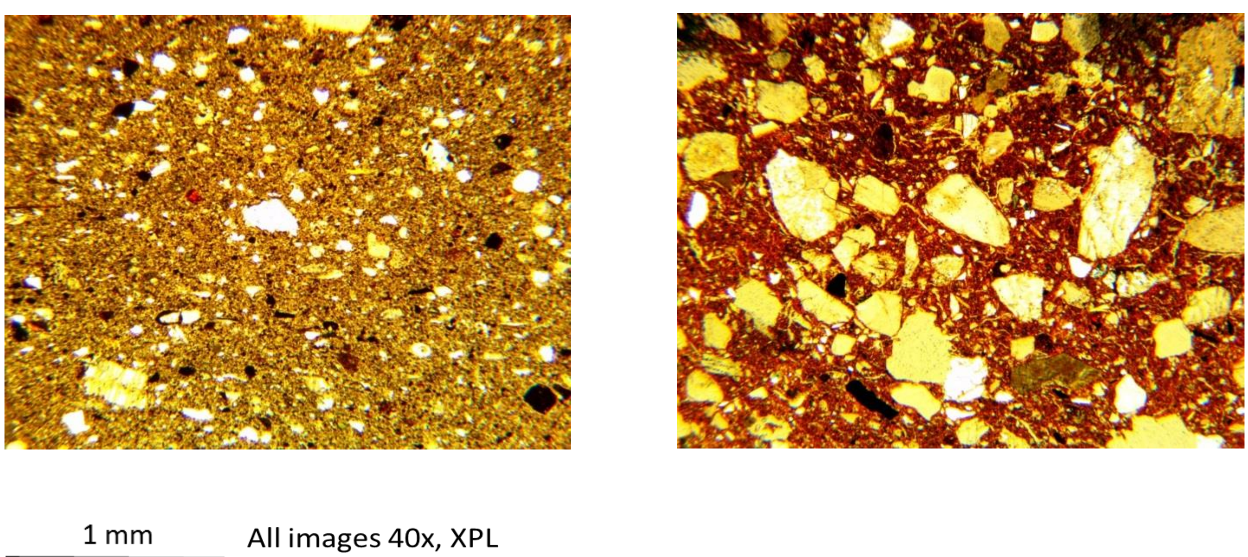


Figure 5.8: Thin sections of an amarillo sherd, OAX-100 (left), and a café sherd, OAX-226 (right).

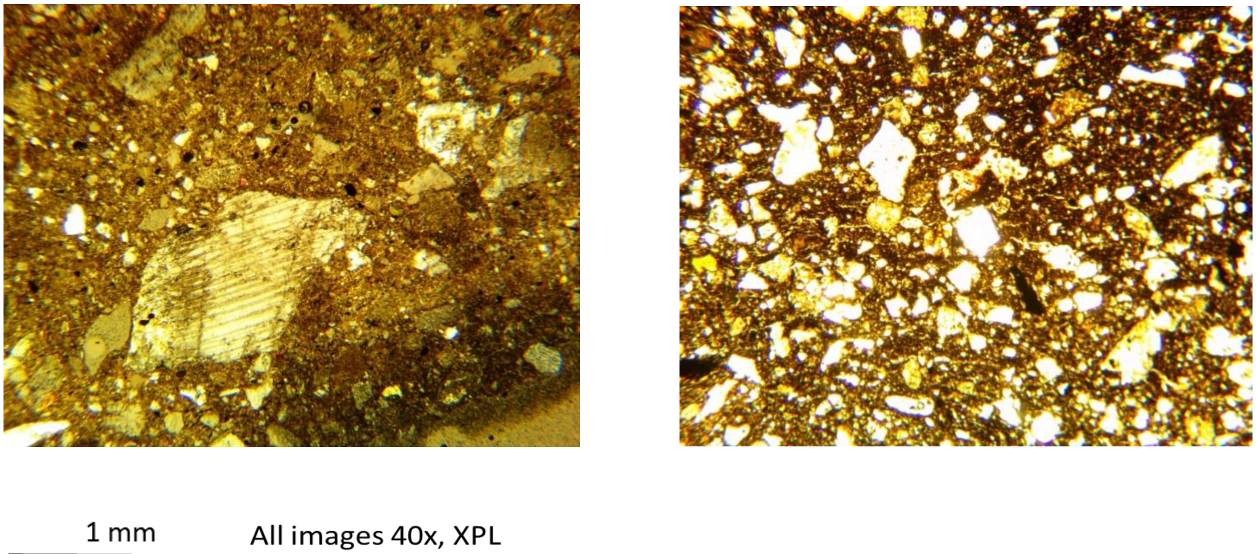


Figure 5.9: Thin sections of a crema sherd, OAX-010 (left), and a gris sherd, MA-019 (right).

Variability can also be seen within the wares themselves. For example, the gris sherds vary in terms of their matrix colors, as well as the sizes, shapes, and distribution of their inclusions (see, for example, Figures 5.10 and 5.11). Gris sherds CTL-105 and CTL-001 contain high percentages of round inclusions, mainly silt and fine sand, and in fact CTL-105 has the second lowest grain-size index out of all Formative sherds (see further discussion below). Other gris sherds, such as OAX-029 and MA-019, exhibit the opposite texture, with many large, angular inclusions.

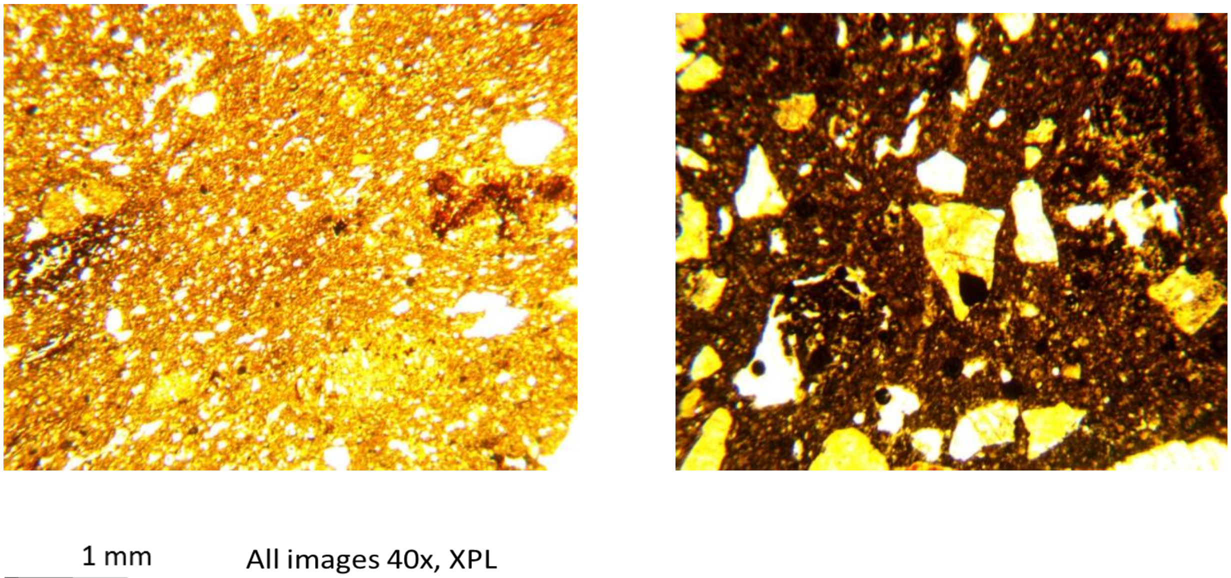


Figure 5.10: Two examples of gris ware, CTL-001 (type G.29, left) and OAX-029 (type G.12, right).

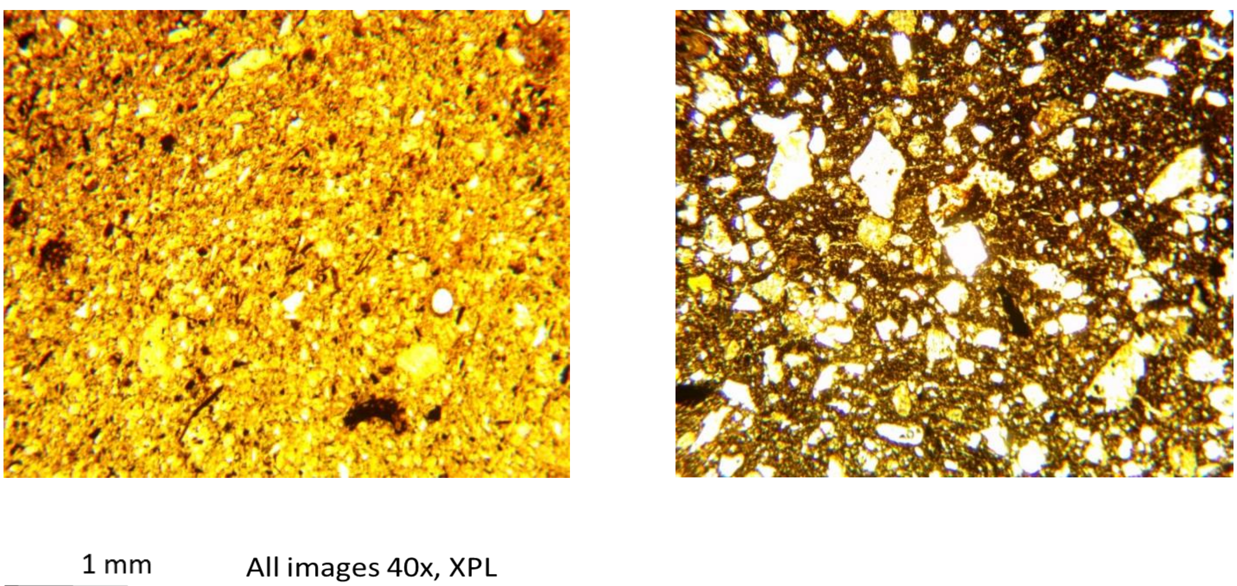


Figure 5.11: Two examples of gris ware, CTL-105 (type G.21, left) and MA-019 (type G.12, right).

Similarly, the café sherds displayed variety as well. Figure 5.12 shows two examples of café (type K.3) sherds displaying very different textures. OAX-118 has larger inclusions, including some polymineralic rock fragments which could represent crushed rock temper. In contrast, sherd OAX-122 had the lowest grain-size index (1.4) out of all Formative sherds and the modern unmodified and modern tempered sherds.

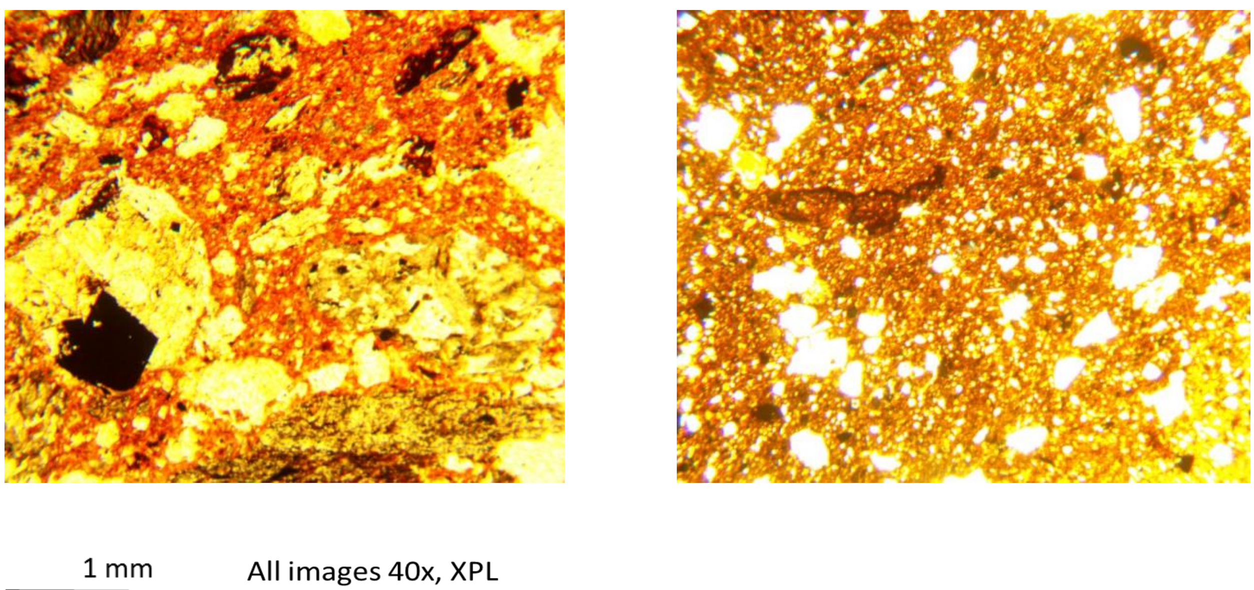


Figure 5.12: Two café (K.3) sherds showing great textural variability, OAX-118 (left) and OAX-122 (right).

Sherds with Unusual Textural Characteristics

As mentioned in Chapter 4, my data analyses identified several Formative sherds with unusual textural characteristics that deserve further examination (Table 5.1). Several of the sherds, including CTL-001, OAX-029, OAX-105, OAX-118, and OAX-217, exhibited unusual textural characteristics in more than one analysis (see Figures 5.9-5.11).

Table 5.1: Formative Sherds with Unusual Textural Characteristics

Slide #	Site	Period	Type	Form
CTL-001	Cerro Tilcajete	MAII	G.29	bowl
CTL-105	Cerro Tilcajete	MAII	G.21	bowl
OAX-008	Yaasuchi	MAII	G.21	bowl
OAX-012	Yassuchi	MAII	C.11	bowl
OAX-029	Cerro Tilcajete	MAII	G.12	bowl
OAX-105	Cerro Tilcajete	MAII	K.3	comal
OAX-118	Yaasuchi	MAI-II	K.3	bowl
OAX-122	Monte Albán	MAI-II	K.3 ?	bowl
OAX-148	Cerro Tilcajete	MAII	K.7	bowl
OAX-217	El Mogote	Early MAI ?	C.2	jar
OAX-218	El Palenque	Late MAI	G.17	plate

Several of the Formative sherds with unusual textural characteristics have striking resemblances to clays as well as the modern tempered and modern unmodified sherds. Figure 5.13 juxtaposes OAX-105, a café sherd, and OAX-276D, a modern tempered sherd. Note in the Formative sherd the polymineralic inclusion which could be indicative of crushed rock or added temper. Figure 5.14 shows OAX-105 next to clay sample OCS-035 for comparison. I believe that OAX-105 appears most similar to the modern tempered sherd of OAX-276D than the clay sample.

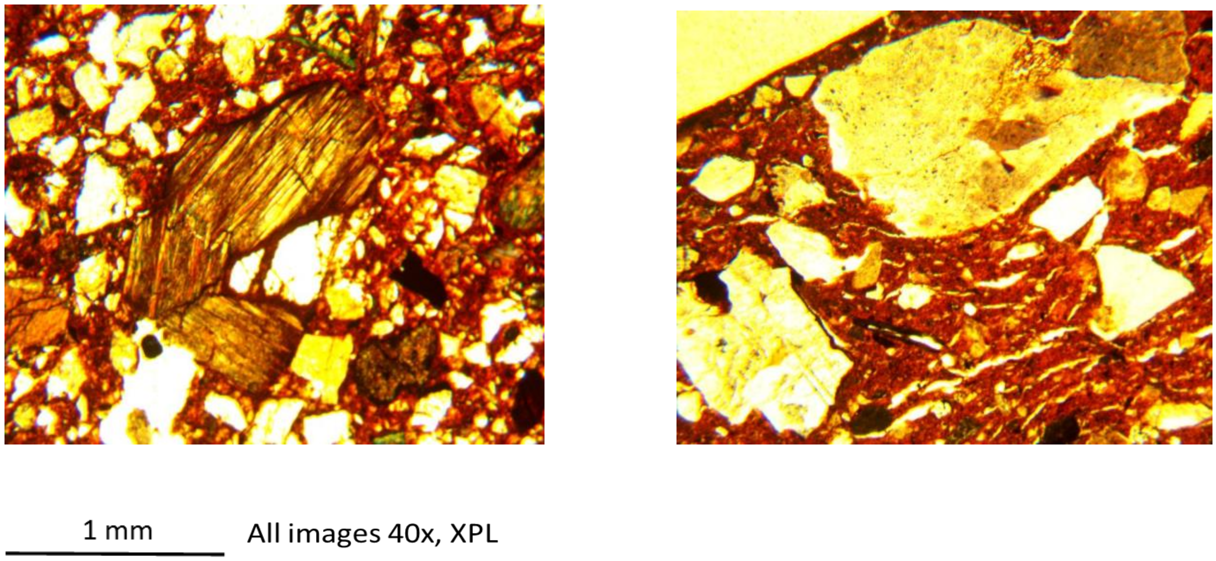


Figure 5.13: Formative café sherd OAX-105 (left) and modern tempered sherd OAX-276D (left).

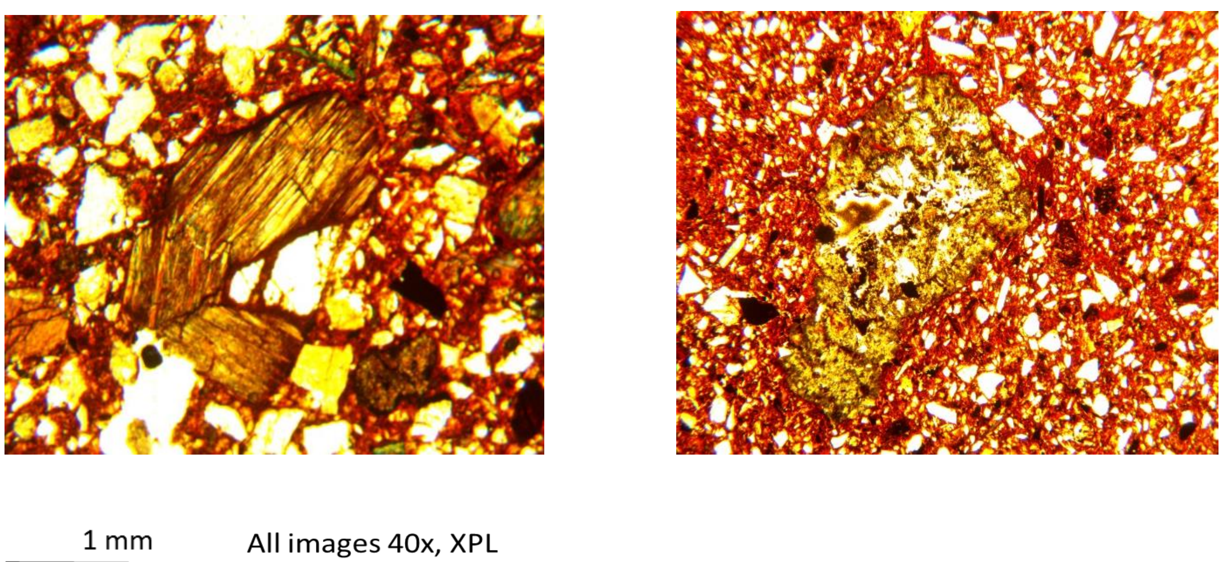


Figure 5.14: Formative café sherd OAX-105 (left) and clay sample OCS-035 (left).

Formative sherd MA-019, a gris sherd and modern tempered sherd OAX-277B have the same angularity index number of 2.9. When placed side by side with modern tempered sherd OAX-277B, which was tempered with sifted fine sand, there is a resemblance (Figure 5.15).

However, the modern tempered sherd has inclusions from every category (silt through gravel) while the MA-019 does not contain any very coarse or gravel size inclusions.

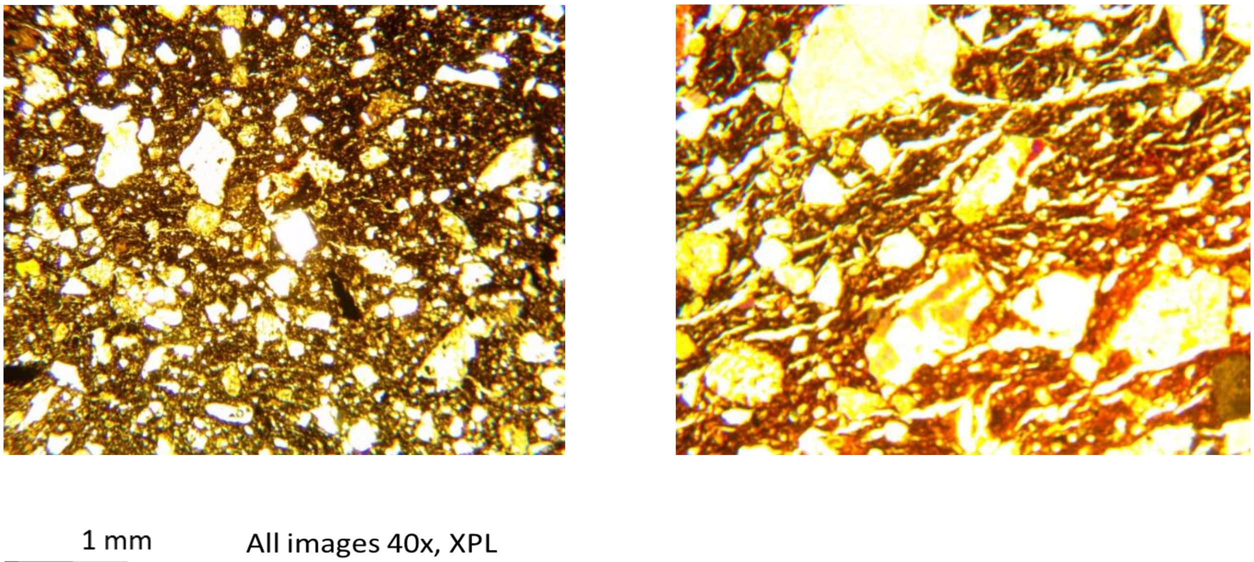


Figure 5.15: Formative sherd MA-019 (left) compared to modern tempered sherd OAX-277B.

Comparison of the modern unmodified sherds to the Formative sherds also seems to support the argument that the Formative ceramics were made with unmodified clays. Figure 5.16 shows Formative sherd CTL-001 next to OAX-274, a modern unmodified sherd. The textures are strikingly similar.

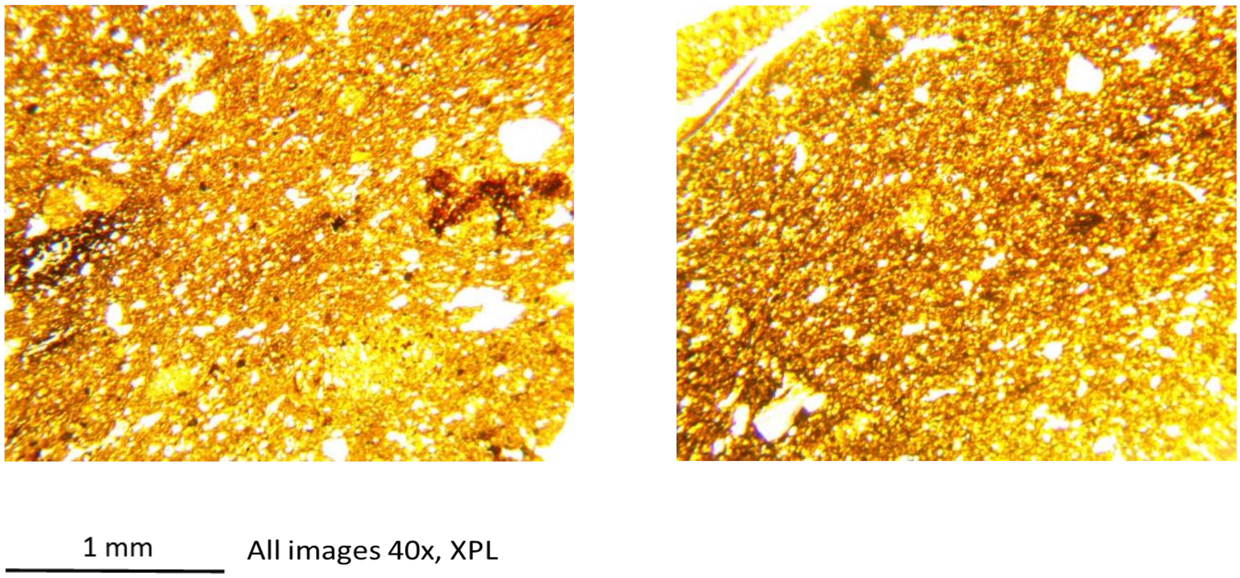


Figure 5.16: Formative sherd CTL-001 (left) and modern unmodified sherd OAX-274 (right).

OAX-218 is another Formative sherd that should be analyzed more closely. This particular gris sherd contains mainly silt and fine inclusions, with some coarse grains. Figure 5.17 shows the generally fine texture of the paste with a large inclusion toward the bottom middle of the sample. Formative sherd OAX-217, a crema, has a large number of coarse, very coarse, and even gravel-sized inclusions (Figure 5.17). The grain-size index for this sherd (3.3) was the highest for any Formative sherd. A modern modified sherd (OAX-279B) had the highest overall angularity index of 3.4.

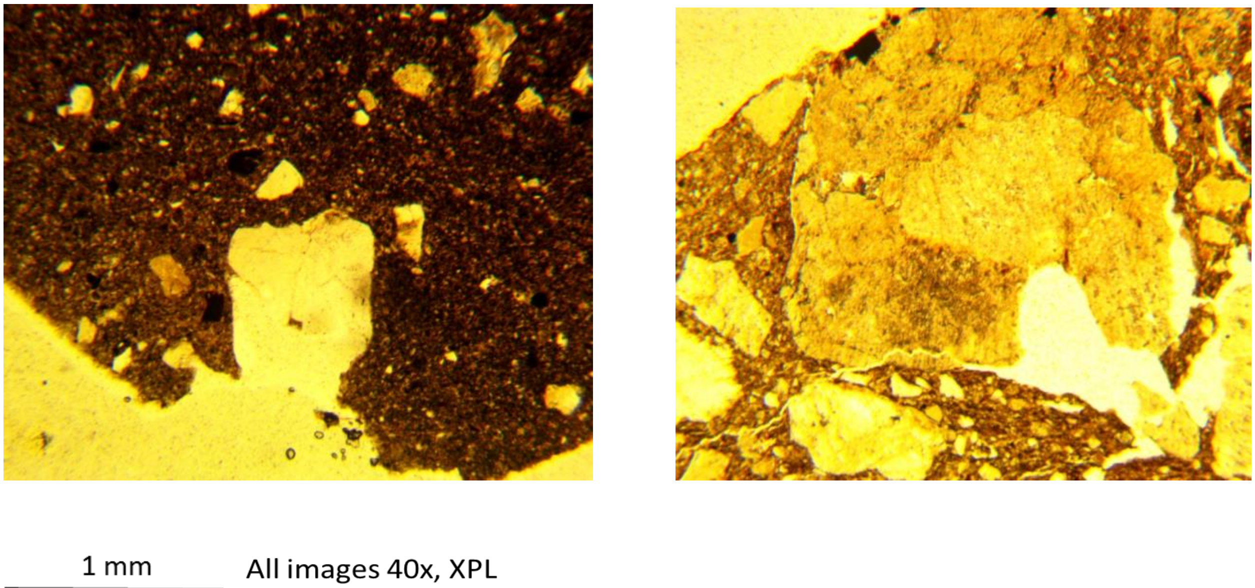


Figure 5.17: Gris sherd OAX-218 (left) with silt and fine inclusions and a few larger inclusions (left), and crema sherd OAX-217 (right) which had the highest angularity index of Formative sherds.

Clay samples (OCS-037U; OCS-089) have a very high percentage of round inclusions and very few angular particles, as well as two clay samples (OCS-051; and OCS-073C) and one modern tempered sherd (OAX-279B) that exhibited very high percentages of angular inclusions. The majority of the Formative sherds in the study represent fragments of bowls. However, sherds representing one *comal*, one jar, one plate, and two unknown vessel types were included also. It would worth noting what type of vessel sherds came from to also assess possible tempering based on vessel function.

These clay samples and the modern sherd should be examined and used as a comparison for the unusual Formative sherds. The best practice for analysis would be to pair textural and mineralogical studies together. Doing this would also help clarify the patterns revealed in my analysis of round vs elongated inclusions.

Recommendations for Future Studies

One of the limitations of this particular research project was that the sample sizes for certain Formative wares were small. The distribution of samples from the five sites in the valley was also uneven, with some wares not represented at all for particular locations. In order to rectify this, it would be beneficial to expand the sample in future analyses, particularly the amarillo and café samples. Overall, I believe the number of clay samples included in this research provides a sufficiently robust comparative base. The addition of modern sherds greatly enhances our interpretations of the Formative samples by providing knowledge of how the modern ceramics had been made. It would thus be valuable to look at more modern samples, particularly when assessing Formative samples with unusual textural characteristics, such as high grain angularity or large percentages of silt or sand. It would also be valuable to find modern pottery communities that refine their clays and obtaint samples from those communities to further investigate. Payne (1994) and Shepard (1967) both mentioned a few communities in which potters refine their clay.

The majority of the Formative samples are fragments of bowls, with a few other vessel forms present. If paste recipe varies with vessel form, understanding which type of vessel each sample came from may help explain why certain sherds exhibit an unusually high or low number

of inclusions. Temper is used not only to make clays more workable, but also for thermal stress resistance, which is the ability for pottery to go through cycles of heating and cooling without breaking (Sinopoli 1991:14) The one example that was distinguished by a high percentage of medium and coarse inclusions was OAX-105, which was a *comal* (a type of griddle). Some minerals are better suited for heat such as plagioclase and calcite, while quartz is not well suited to cooking vessels due to its high rate of thermal expansion (Rye 1976: 118-119; Sinopoli 1991: 14-15; for general considerations about temper, see Rice [1989] and Shepard [1956]).

I would also recommend doing some experimental archaeology if possible. Collecting clay samples in the valley and mixing them would also be beneficial to see if textures like those observed in the modern tempered pottery made with mixed clays and sand temper could be replicated, and if comparable textures are present in any Formative sherds. Additional experiments with clay refinement, such as those conducted by Payne (1994) and Carpenter and Feinman (1999), might also prove fruitful.

Significance of Research

This research built on existing studies of the production and movement of ceramics in the Oaxaca Valley by focusing on the specific goal of discerning whether the clays used to manufacture later Middle to Terminal Formative ceramics were modified with temper or were refined. Minc, Sherman, and colleagues (Minc and Sherman 2011; Minc et al 2007, 2016) have used geochemical and mineralogical analyses to further explicate the developments in the valley during state formation. By understanding patterns of production and distribution, economic and

political ties can be traced allowing for deeper understanding of the sociopolitical environment and changes taking place during the later Middle to Terminal Formative (Minc et al. 2016:45).

The research presented here contributes to previous and ongoing petrographic analysis in the Oaxaca Valley (e.g., Fargher 2007; Minc and Sherman 2011; Minc et al. 2007, 2016; Shepard 1967; Stoltman et al. 2005) by adding a textural component to the data set. This allowed the question of clay modification versus the use of natural clay to be more intimately explored. Petrographic analyses of temper can enhance our understanding of not only ceramic sources, production, and exchange, but also technology and function (Stoltman 1991:116). In the broadest sense, this research also contributes to ceramic studies by demonstrating textural analytical methods that may allow us to discern whether pottery was produced with modified or unmodified clays. It is essential that we address this issue so that we can interpret the results of other forms of compositional analysis correctly.

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APPENDIX A: DATA COLLECTION SHEET

	Silt	Fine	Medium	Coarse	Very Coarse	Gravel	Matrix
	≤ 0.0624mm	0.0625-0.249mm	0.25-0.49mm	0.50-0.99mm	1.00-1.99mm	≥ 2.00mm	
Rounded Angular							
Rounded Subangular							
Rounded Subround							
Rounded Rounded							
Elongated Angular							Voids
Elongated Subangular							
Elongated Subrounded							
Elongated Rounded							

APPENDIX B: CLAYS RAW DATA

Slide #	Site	Group	Total Round	Total Elongated	Total Angular (4)	Total Subangular (3)	Total Subround (2)
OCS-006	Cerro Tilcajete pass S	Clay Sample	62	57	45	19	20
OCS-008	SE of Colonia Vicente Guerro	Clay Sample	73	113	9	50	66
OCS-009	N of Reyes Mantecón	Clay Sample	39	30	3	16	14
OCS-012	W of San Martín Tilcajete	Clay Sample	38	14	23	8	12
OCS-14A	Octlán de Morelos	Clay Sample	53	57	16	15	28
OCS-017	West of Santiago Apóstal	Clay Sample	73	35	45	17	22
OCS-020A	N of Sta. Lucía Ocotlán	Clay Sample	12	3	1	3	3
OCS-024	E of El Vergel	Clay Sample	22	19	15	11	7
OCS-029	Between Río de Ejutla and Taniche	Clay Sample	19	10	12	4	5
OCS-029B	Between Río de Ejutla and Taniche	Clay Sample	19	12	9	6	10
OCS-032	E of Magdalena Ocotlán	Clay Sample	16	18	15	3	5
OCS-034	N of San Pedro Apóstol	Clay Sample	21	9	6	4	3
OCS-035	N of San Pedro Apóstol	Clay Sample	108	88	43	27	39
OCS-037U A	San Isidro Zegache	Clay Sample	20	8	1	3	9
OCS-037U B	San Isidro Zegache	Clay Sample	8	8	4	2	1
OCS-037U C	San Isidro Zegache	Clay Sample	5	0	0	1	1
OCS-039L	SW of San Pablo Huixtepec	Clay Sample	22	16	10	8	12
OCS-043	NW of Zimatlán de Alvarez	Clay Sample	66	53	25	24	25
OCS-044	E of Ciénega de Zimatlán	Clay Sample	72	80	65	32	30
OCS-046B	Río Seco N of Zimatlán	Clay Sample	47	64	59	26	13
OCS-050A	S of Cuilapan de Guerrero	Clay Sample	34	44	39	11	7
OCS-051	NW of Cuilapan de Guerrero	Clay Sample	22	35	37	8	4
OCS-054	E of San Bartolo Coyotepec	Clay Sample	103	102	71	56	37

Slide #	Site	Group	Total Round	Total Elongated	Total Angular (4)	Total Subangular (3)	Total Subround (2)
OCS-056	E of Emiliano Zapata	Clay Sample	107	93	58	45	56
OCS-060	Río Valiente N of Villa de Zaachila	Clay Sample	125	179	96	67	101
OCS-061	E of Ojo de Aqua	Clay Sample	130	110	98	51	55
OCS-062A	SE of Tiracoz	Clay Sample	43	30	42	11	12
OCS-064A	Minas de Atzompa	Clay Sample	46	32	14	7	18
OCS-064B	Minas de Atzompa	Clay Sample	88	102	80	41	49
OCS-064D	Minas de Atzompa	Clay Sample	124	72	72	49	52
OCS-065	La Laguna, Atzompa	Clay Sample	10	13	4	6	2
OCS-067B	SW of San Andrés Huayapam	Clay Sample	14	13	10	2	7
OCS-068B	NW Tlalixtac de Cabrera	Clay Sample	22	16	18	6	9
OCS-073C	E of San Pablo Villa de Etla	Clay Sample	18	23	25	3	4
OCS-079	N of San Lucas Quiavini	Clay Sample	23	14	15	4	10
OCS-089	NW of San Juan Guelavía	Clay Sample	12	7	1	0	4
OCS-091	E of Sta. Cruz Papalutla	Clay Sample	13	9	10	2	5
OCS-092	S of San Juan Teitipac	Clay Sample	103	52	68	25	30
OCS-095	San Sebastián Teitipac	Clay Sample	79	43	49	16	30
OCS-096	Santa Lucía del Camino	Clay Sample	43	37	35	5	16
OCS-097B	Río Seco, E of Tlacolula de Matamor	Clay Sample	43	26	37	7	9
OCS-100B	NW of Tlacolula de Matamoros	Clay Sample	56	27	34	14	12
OCS-102B	NW of Dainzú	Clay Sample	45	15	22	4	10
OCS-103A	N Zona Arqueologica, Dainzú	Clay Sample	23	10	7	0	5
OCS-105	E of San Francisco Lachigolo	Clay Sample	27	13	18	7	6
OCS-108B	N of Santiago Etla	Clay Sample	41	34	39	5	20

Slide #	Total Round (1)	Total Silt ≤ 0.0624mm	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular	Total Rounded Subangular	Total Rounded Subrounded
OCS-006	35	62	32	11	5	9	0	23	15	4
OCS-008	61	13	121	36	11	4	1	1	12	29
OCS-009	36	16	27	13	6	7	0	1	6	7
OCS-012	9	11	23	12	5	1	0	20	6	8
OCS-14A	51	18	70	19	2	1	0	7	5	11
OCS-017	24	26	57	9	10	4	2	33	10	14
OCS-020A	8	10	3	0	2	0	0	1	2	1
OCS-024	8	9	13	4	8	2	4	8	4	2
OCS-029	8	14	10	2	2	1	0	10	1	2
OCS-029B	6	9	11	4	7	0	0	6	2	7
OCS-032	11	7	7	4	6	9	1	9	1	2
OCS-034	17	17	9	3	1	0	0	4	0	3
OCS-035	87	103	58	21	4	9	1	21	19	23
OCS-037U A	15	21	4	1	2	0	0	1	1	6
OCS-037U B	9	7	7	1	0	0	1	2	1	0
OCS-037U C	3	5	0	0	0	0	0	0	1	1
OCS-039L	8	9	8	8	8	3	2	6	7	3
OCS-043	45	84	27	5	1	1	1	14	12	11
OCS-044	25	38	66	38	7	3	0	35	19	6
OCS-046B	13	47	48	13	2	1	0	22	13	5
OCS-050A	21	42	23	9	4	0	0	17	1	1
OCS-051	8	21	25	7	3	1	0	13	3	0
OCS-054	41	64	88	40	8	4	1	35	31	13

Slide #	Total Round (1)	Total Silt ≤ 0.0624mm	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular	Total Rounded Subangular	Total Rounded Subrounded
OCS-056	41	25	52	51	41	29	2	25	32	25
OCS-060	40	1	104	107	48	38	6	44	37	32
OCS-061	36	76	93	42	21	8	0	56	32	23
OCS-062A	8	10	33	11	11	8	0	28	4	4
OCS-064A	39	61	13	3	1	0	0	6	5	8
OCS-064B	20	27	47	47	42	25	2	41	28	9
OCS-064D	23	16	53	57	46	22	2	48	33	30
OCS-065	11	16	4	0	3	0	0	2	4	1
OCS-067B	8	19	7	0	1	0	0	5	0	1
OCS-068B	5	12	14	6	2	3	1	11	3	5
OCS-073C	9	11	14	11	1	4	0	13	1	1
OCS-079	8	13	17	6	0	1	0	14	3	1
OCS-089	14	12	2	1	2	2	0	0	0	4
OCS-091	5	6	4	2	7	2	1	7	1	0
OCS-092	32	55	37	33	23	6	1	47	18	11
OCS-095	26	30	22	25	24	19	2	35	12	14
OCS-096	24	22	22	15	12	6	3	20	1	8
OCS-097B	16	17	18	10	5	17	2	23	5	3
OCS-100B	23	17	23	13	10	18	2	23	13	5
OCS-102B	24	31	20	4	4	1	0	17	3	5
OCS-103A	21	26	6	1	0	0	0	4	0	4
OCS-105	9	20	11	3	3	3	0	12	6	2
OCS-108B	11	21	28	16	8	2	0	18	3	14

Slide #	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix	Voids	Rounded Angular Silt ≤ 0.0624mm
OCS-006	20	22	4	16	15	488	336	33	11
OCS-008	31	8	38	37	30	476	274	16	0
OCS-009	25	2	10	7	11	152	68	15	0
OCS-012	4	3	2	4	5	134	65	17	0
OCS-14A	30	9	10	17	21	202	73	19	0
OCS-017	16	12	7	8	8	325	183	34	4
OCS-020A	8	0	1	2	0	122	96	11	0
OCS-024	8	7	7	5	0	147	95	11	0
OCS-029	6	2	3	3	2	127	85	13	2
OCS-029B	4	3	4	3	2	131	85	15	0
OCS-032	4	6	2	3	7	139	88	17	2
OCS-034	14	2	4	0	3	164	117	17	2
OCS-035	45	22	8	16	42	578	339	43	6
OCS-037U A	12	0	2	3	3	177	133	16	1
OCS-037U B	5	2	1	1	4	132	100	16	1
OCS-037U C	3	0	0	0	0	49	39	5	0
OCS-039L	6	4	1	9	2	127	60	29	1
OCS-043	29	11	12	14	16	578	386	73	3
OCS-044	12	30	13	24	13	550	347	51	5
OCS-046B	7	37	13	8	6	226	104	11	8
OCS-050A	15	22	10	6	6	245	126	41	6
OCS-051	6	24	5	4	2	129	55	17	4
OCS-054	24	36	25	24	17	558	301	52	8

Slide #	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix	Voids	Rounded Angular Silt ≤ 0.0624mm
OCS-056	25	33	13	31	16	579	264	115	0
OCS-060	12	52	30	69	28	600	278	18	0
OCS-061	19	42	19	32	17	555	250	65	6
OCS-062A	7	14	7	8	1	155	69	13	2
OCS-064A	27	8	2	10	12	598	461	59	2
OCS-064B	10	39	13	40	10	370	127	53	3
OCS-064D	13	24	16	22	10	529	201	132	2
OCS-065	3	2	2	1	8	117	85	9	0
OCS-067B	8	5	2	6	0	99	67	5	3
OCS-068B	3	7	3	4	2	162	111	13	5
OCS-073C	3	12	2	3	6	178	122	15	1
OCS-079	5	1	1	9	3	194	134	23	2
OCS-089	8	1	0	0	6	179	150	10	0
OCS-091	5	3	1	5	0	82	44	16	1
OCS-092	27	21	7	19	5	430	248	27	11
OCS-095	17	14	4	16	9	576	367	88	3
OCS-096	14	15	4	8	10	201	102	19	2
OCS-097B	12	14	2	6	4	171	80	22	2
OCS-100B	15	11	1	7	8	202	93	26	0
OCS-102B	20	5	1	5	4	331	210	61	6
OCS-103A	15	3	0	1	6	147	99	15	2
OCS-105	7	6	1	4	2	144	91	13	5
OCS-108B	6	21	2	6	5	179	86	18	2

Slide #	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm	Rounded Subangular Medium 0.25-0.49mm
OCS-006	0	5	0	7	0	5	8	2
OCS-008	1	0	0	0	0	0	9	3
OCS-009	1	0	0	0	0	0	2	4
OCS-012	8	8	3	1	0	1	3	2
OCS-14A	4	3	0	0	0	0	5	0
OCS-017	17	5	3	2	2	3	5	1
OCS-020A	0	0	1	0	0	2	0	0
OCS-024	4	3	1	0	0	1	1	0
OCS-029	6	1	1	0	0	1	0	0
OCS-029B	4	1	1	0	0	1	0	1
OCS-032	2	1	1	3	0	0	1	0
OCS-034	1	1	0	0	0	0	0	0
OCS-035	3	7	1	3	1	3	12	3
OCS-037U A	0	0	0	0	0	0	1	0
OCS-037U B	1	0	0	0	0	0	1	0
OCS-037U C	0	0	0	0	0	1	0	0
OCS-039L	2	1	1	1	0	0	1	1
OCS-043	7	3	0	1	0	5	5	1
OCS-044	15	13	2	0	0	0	9	8
OCS-046B	12	1	0	1	0	2	7	4
OCS-050A	6	2	3	0	0	0	0	1
OCS-051	7	1	1	0	0	1	1	1
OCS-054	17	6	3	1	0	6	15	9

Slide #	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm	Rounded Subangular Medium 0.25-0.49mm
OCS-056	11	4	7	3	0	2	13	11
OCS-060	6	21	11	4	2	0	15	11
OCS-061	23	16	10	1	0	4	22	6
OCS-062A	10	8	4	4	0	1	2	0
OCS-064A	1	3	0	0	0	4	1	0
OCS-064B	8	11	10	7	2	5	8	7
OCS-064D	10	13	15	7	1	3	9	11
OCS-065	0	0	2	0	0	3	1	0
OCS-067B	2	0	0	0	0	0	0	0
OCS-068B	4	1	0	0	1	2	1	0
OCS-073C	6	4	0	2	0	0	1	0
OCS-079	9	3	0	0	0	0	3	0
OCS-089	0	0	0	0	0	0	0	0
OCS-091	1	1	3	1	0	0	1	0
OCS-092	13	10	10	2	1	5	5	6
OCS-095	3	6	11	10	2	1	4	4
OCS-096	8	8	0	0	2	0	1	0
OCS-097B	5	7	1	8	0	1	2	1
OCS-100B	3	6	3	10	1	2	5	3
OCS-102B	7	1	3	0	0	0	2	1
OCS-103A	2	0	0	0	0	0	0	0
OCS-105	4	0	1	2	0	2	2	1
OCS-108B	8	5	3	0	0	0	3	0

Slide #	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00-1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624m	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
OCS-006	0	0	0	4	0	0	0	0
OCS-008	0	0	0	2	22	4	1	0
OCS-009	0	0	0	0	1	2	3	1
OCS-012	0	0	0	2	5	0	1	0
OCS-14A	0	0	0	1	10	0	0	0
OCS-017	1	0	0	2	10	1	1	0
OCS-020A	0	0	0	0	0	0	1	0
OCS-024	0	0	2	0	1	0	1	0
OCS-029	0	0	0	2	0	0	0	0
OCS-029B	0	0	0	1	4	1	1	0
OCS-032	0	0	0	0	0	2	0	0
OCS-034	0	0	0	1	2	0	0	0
OCS-035	1	0	0	13	6	2	1	1
OCS-037U A	0	0	0	5	0	0	1	0
OCS-037U B	0	0	0	0	0	0	0	0
OCS-037U C	0	0	0	1	0	0	0	0
OCS-039L	3	2	0	1	1	0	1	0
OCS-043	0	0	1	7	4	0	0	0
OCS-044	2	0	0	1	4	1	0	0
OCS-046B	0	0	0	1	4	0	0	0
OCS-050A	0	0	0	0	0	1	0	0
OCS-051	0	0	0	0	0	0	0	0
OCS-054	1	0	0	5	7	1	0	0

Slide #	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00-1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624m	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
OCS-056	6	0	0	1	5	9	6	4
OCS-060	6	5	0	0	14	15	3	0
OCS-061	0	0	0	10	9	3	0	1
OCS-062A	1	0	0	1	2	1	0	0
OCS-064A	0	0	0	7	1	0	0	0
OCS-064B	6	2	0	3	2	2	2	0
OCS-064D	10	0	0	2	10	12	3	3
OCS-065	0	0	0	0	1	0	0	0
OCS-067B	0	0	0	0	0	0	1	0
OCS-068B	0	0	0	1	4	0	0	0
OCS-073C	0	0	0	1	0	0	0	0
OCS-079	0	0	0	1	0	0	0	0
OCS-089	0	0	0	1	2	0	1	0
OCS-091	0	0	0	0	0	0	0	0
OCS-092	2	0	0	6	1	4	0	0
OCS-095	2	1	0	7	4	3	0	1
OCS-096	0	0	0	2	3	1	2	0
OCS-097B	0	1	0	0	2	0	1	0
OCS-100B	3	0	0	1	3	0	1	0
OCS-102B	0	0	0	3	1	0	1	0
OCS-103A	0	0	0	3	0	1	0	0
OCS-105	1	0	0	2	0	0	0	0
OCS-108B	0	0	0	5	6	3	0	0

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624mm	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624mm	Elongated Angular Fine 0.0625-0.249mm
OCS-006	0	17	3	0	0	0	0	6	9
OCS-008	0	8	23	0	0	0	0	0	2
OCS-009	0	16	8	0	1	0	0	0	2
OCS-012	0	4	0	0	0	0	0	0	3
OCS-14A	0	12	17	1	0	0	0	1	6
OCS-017	0	13	3	0	0	0	0	0	8
OCS-020A	0	7	1	0	0	0	0	0	0
OCS-024	0	5	2	1	0	0	0	2	0
OCS-029	0	6	0	0	0	0	0	0	0
OCS-029B	0	4	0	0	0	0	0	0	1
OCS-032	0	2	1	0	1	0	0	0	1
OCS-034	0	10	3	1	0	0	0	1	1
OCS-035	0	37	8	0	0	0	0	7	7
OCS-037U A	0	10	1	1	0	0	0	0	0
OCS-037U B	0	4	1	0	0	0	0	0	1
OCS-037U C	0	3	0	0	0	0	0	0	0
OCS-039L	0	6	0	0	0	0	0	0	0
OCS-043	0	29	0	0	0	0	0	8	2
OCS-044	0	11	1	0	0	0	0	5	13
OCS-046B	0	5	2	0	0	0	0	17	14
OCS-050A	0	9	6	0	0	0	0	13	6
OCS-051	0	5	0	1	0	0	0	8	11
OCS-054	0	15	7	2	0	0	0	6	18

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624mm	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624mm	Elongated Angular Fine 0.0625-0.249mm
OCS-056	0	13	2	3	5	1	1	1	7
OCS-060	0	1	11	0	0	0	0	0	17
OCS-061	0	17	2	0	0	0	0	9	11
OCS-062A	0	3	3	0	1	3	3	2	6
OCS-064A	0	24	3	0	0	0	0	7	1
OCS-064B	0	6	0	3	1	0	0	2	6
OCS-064D	0	4	6	3	0	0	0	1	5
OCS-065	0	3	0	0	0	0	0	2	0
OCS-067B	0	8	0	0	0	0	0	3	2
OCS-068B	0	3	0	0	0	0	0	0	1
OCS-073C	0	2	1	0	0	0	0	1	4
OCS-079	0	4	0	0	0	1	0	1	0
OCS-089	0	7	0	1	0	0	0	1	0
OCS-091	0	4	1	0	0	0	0	1	0
OCS-092	0	24	3	0	0	0	0	4	7
OCS-095	0	10	2	5	0	0	0	2	1
OCS-096	0	12	2	0	0	0	0	2	4
OCS-097B	0	10	2	0	0	0	0	1	4
OCS-100B	0	11	3	1	0	0	0	0	3
OCS-102B	0	17	3	0	0	0	0	1	3
OCS-103A	0	14	1	0	0	0	0	3	0
OCS-105	0	7	0	0	0	0	0	2	3
OCS-108B	0	6	0	0	0	0	0	3	7

Slide #	Elongated Angular Medium 0.25-0.49mm	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm
OCS-006	3	3	1	0	3	1	0	0	0
OCS-008	4	0	1	1	1	25	7	4	1
OCS-009	0	0	0	0	0	3	1	2	4
OCS-012	0	0	0	0	0	1	0	1	0
OCS-14A	1	1	0	0	0	3	5	1	1
OCS-017	1	1	2	0	0	5	1	1	0
OCS-020A	0	0	0	0	0	1	0	0	0
OCS-024	0	2	1	2	0	4	1	1	1
OCS-029	1	0	1	0	1	1	0	1	0
OCS-029B	0	2	0	0	2	1	0	1	0
OCS-032	1	1	2	1	1	1	0	0	0
OCS-034	0	0	0	0	1	1	1	1	0
OCS-035	4	1	3	0	0	6	2	0	0
OCS-037U A	0	0	0	0	2	0	0	0	0
OCS-037U B	0	0	0	1	1	0	0	0	0
OCS-037U C	0	0	0	0	0	0	0	0	0
OCS-039L	3	0	0	1	0	1	0	0	0
OCS-043	0	1	0	0	10	2	0	0	0
OCS-044	8	2	8	0	2	9	2	0	0
OCS-046B	5	1	0	0	6	5	1	1	0
OCS-050A	2	1	0	0	6	2	2	0	0
OCS-051	3	1	1	0	0	4	1	0	0
OCS-054	10	1	1	0	4	9	9	1	2

Slide #	Elongated Angular Medium 0.25-0.49mm	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm
OCS-056	8	7	9	1	1	5	3	1	3
OCS-060	13	7	12	3	0	12	8	5	5
OCS-061	8	9	5	0	6	10	2	1	0
OCS-062A	0	3	3	0	1	5	0	0	1
OCS-064A	0	0	0	0	0	1	0	1	0
OCS-064B	7	10	14	0	5	10	11	12	2
OCS-064D	7	4	6	1	0	4	4	6	2
OCS-065	0	0	0	0	1	1	0	0	0
OCS-067B	0	0	0	0	0	2	0	0	0
OCS-068B	3	1	2	0	0	2	0	1	0
OCS-073C	4	1	2	0	1	0	1	0	0
OCS-079	0	0	0	0	0	0	1	0	0
OCS-089	0	0	0	0	0	0	0	0	0
OCS-091	0	2	0	0	0	0	1	0	0
OCS-092	5	4	1	0	0	1	3	3	0
OCS-095	2	4	5	0	2	0	1	1	0
OCS-096	3	3	3	0	1	1	1	1	0
OCS-097B	1	2	4	2	0	0	0	0	2
OCS-100B	1	1	5	1	0	0	0	0	1
OCS-102B	0	0	1	0	1	0	0	0	0
OCS-103A	0	0	0	0	0	0	0	0	0
OCS-105	1	0	0	0	0	0	0	0	1
OCS-108B	6	3	2	0	0	1	1	0	0

Slide #	Elongated Subangular Gravel ≥ 2.00mm	Elongated Subround Silt ≤ 0.0624mm	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm
OCS-006	0	6	8	1	0	1	0	10	3
OCS-008	0	0	23	10	3	1	0	2	16
OCS-009	0	0	2	3	0	2	0	0	2
OCS-012	0	1	1	2	0	0	0	3	2
OCS-14A	0	0	10	7	0	0	0	4	15
OCS-017	0	0	5	0	3	0	0	4	4
OCS-020A	0	1	1	0	0	0	0	0	0
OCS-024	0	1	1	0	3	0	0	0	0
OCS-029	0	1	2	0	0	0	0	1	1
OCS-029B	0	1	1	0	1	0	0	0	0
OCS-032	0	0	1	0	1	1	0	2	0
OCS-034	0	0	0	0	0	0	0	2	1
OCS-035	0	7	6	1	0	2	0	30	10
OCS-037U	0	1	1	0	1	0	0	2	1
OCS-037U	0	0	1	0	0	0	0	1	2
OCS-037U	0	0	0	0	0	0	0	0	0
OCS-039L	0	0	2	3	3	0	1	1	1
OCS-043	0	9	4	1	0	0	0	13	3
OCS-044	0	5	12	5	1	1	0	9	3
OCS-046B	0	3	3	2	0	0	0	5	1
OCS-050A	0	3	2	1	0	0	0	5	1
OCS-051	0	2	1	0	1	0	0	1	1
OCS-054	0	7	12	2	2	0	1	13	3

Slide #	Elongated Subangular Gravel ≥ 2.00mm	Elongated Subround Silt ≤ 0.0624mm	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm
OCS-056	0	2	7	9	7	6	0	5	2
OCS-060	0	0	11	30	15	12	1	0	18
OCS-061	0	11	14	6	1	0	0	13	2
OCS-062A	0	0	4	2	2	0	0	0	1
OCS-064A	0	7	3	0	0	0	0	10	2
OCS-064B	0	5	10	11	12	2	0	3	6
OCS-064D	0	3	7	4	5	3	0	1	2
OCS-065	0	0	1	0	0	0	0	7	0
OCS-067B	0	5	1	0	0	0	0	0	0
OCS-068B	0	1	1	2	0	0	0	0	1
OCS-073C	0	1	1	1	0	0	0	4	1
OCS-079	0	3	5	1	0	0	0	2	0
OCS-089	0	0	0	0	0	0	0	3	0
OCS-091	0	0	1	0	2	1	1	0	0
OCS-092	0	1	7	4	4	3	0	4	0
OCS-095	0	3	4	3	4	2	0	2	4
OCS-096	0	1	2	0	4	1	0	2	1
OCS-097B	0	1	1	1	1	2	0	2	2
OCS-100B	0	0	2	2	2	1	0	3	4
OCS-102B	0	1	2	2	0	0	0	2	2
OCS-103A	0	0	1	0	0	0	0	4	2
OCS-105	0	0	2	1	1	0	0	2	0
OCS-108B	0	1	3	0	2	0	0	4	0

Slide #	Elongated Round Medium 0.25-0.49mm	Elongated Round Coarse 0.50-0.99mm	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
OCS-006	0	2	0	0
OCS-008	8	3	1	0
OCS-009	3	0	2	0
OCS-012	0	0	0	0
OCS-14A	2	0	0	0
OCS-017	0	0	0	0
OCS-020A	0	0	0	0
OCS-024	0	0	0	0
OCS-029	0	0	0	0
OCS-029B	1	1	0	0
OCS-032	0	2	3	0
OCS-034	0	0	0	0
OCS-035	2	0	0	0
OCS-037U A	0	0	0	0
OCS-037U B	1	0	0	0
OCS-037U C	0	0	0	0
OCS-039L	0	0	0	0
OCS-043	0	0	0	0
OCS-044	1	0	0	0
OCS-046B	0	0	0	0
OCS-050A	0	0	0	0
OCS-051	0	0	0	0
OCS-054	1	0	0	0

Slide #	Elongated Round Medium 0.25-0.49mm	Elongated Round Coarse 0.50-0.99mm	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
OCS-056	4	2	3	0
OCS-060	9	1	0	0
OCS-061	1	0	1	0
OCS-062A	0	0	0	0
OCS-064A	0	0	0	0
OCS-064B	1	0	0	0
OCS-064D	3	3	1	0
OCS-065	0	1	0	0
OCS-067B	0	0	0	0
OCS-068B	0	0	1	0
OCS-073C	1	0	0	0
OCS-079	1	0	0	0
OCS-089	0	1	2	0
OCS-091	0	0	0	0
OCS-092	1	0	0	0
OCS-095	1	2	0	0
OCS-096	2	2	2	1
OCS-097B	0	0	0	0
OCS-100B	0	0	1	0
OCS-102B	0	0	0	0
OCS-103A	0	0	0	0
OCS-105	0	0	0	0
OCS-108B	1	0	0	0

APPENDIX C: MODERN SHERDS RAW DATA

Slide #	Site	Period	Group	Total Round	Total Elongated	Total Angular (4)
OAX-272B	San Bartolo Coyotepec (UNMODIFIED)	Modern	Ethnographic	25	10	13
OAX-274	San Bartolo Coyotepec (UNMODIFIED)	Modern	Ethnographic	15	7	3
OAX-276B	San Marcos Tlapazola (Temp-sifted fine sand)	Modern	Ethnographic	25	23	27
OAX-276C	San Marcos Tlapazola (Temp-sifted fine sand)	Modern	Ethnographic	67	36	46
OAX-276D	San Marcos Tlapazola (Temp-sifted fine sand)	Modern	Ethnographic	34	21	24
OAX-277A	San Marcos Tlapazola (Temp-sifted fine Sand)	Modern	Ethnographic	24	44	24
OAX-277B	San Marcos Tlapazola (Temp-sifted fine sand)	Modern	Ethnographic	24	23	15
OAX-278	San Bartolo Coyotepec (UNMODIFIED)	Modern	Ethnographic	45	21	16
OAX-279A	San Mateo Mixtepec (Mixed clays and sand temper added)	Modern	Ethnographic	72	72	77
OAX-279B	San Mateo Mixtepec(Mixed clays and sand temper added)	Modern	Ethnographic	64	55	75
OAX-279C	San Mateo Mixtepec (Mixed clays and sand temper added)	Modern	Ethnographic	61	45	54

Slide #	Total Subangular (3)	Total Subround (2)	Total Round (1)	Total Silt ≤ 0.0624mm	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular
OAX-272B	11	7	4	21	10	4	0	0	0	12
OAX-274	7	7	5	12	5	1	4	0	0	3
OAX-276B	9	9	3	4	13	15	11	5	0	16
OAX-276C	24	20	13	18	15	40	22	8	0	35
OAX-276D	9	17	5	8	20	9	11	6	1	14
OAX-277A	20	20	4	11	19	15	22	1	0	10
OAX-277B	18	9	5	13	12	6	13	2	1	10
OAX-278	17	19	14	54	10	1	1	0	0	13
OAX-279A	45	30	12	17	24	42	36	25	0	43
OAX-279B	20	17	7	18	41	29	15	15	1	45
OAX-279C	19	19	14	27	26	19	27	7	1	32

Slide #	Total Rounded Subangular	Total Rounded Subrounded	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix
OAX-272B	8	2	3	1	3	5	1	218	163
OAX-274	4	4	4	0	3	3	1	112	76
OAX-276B	4	3	2	11	5	6	1	131	61
OAX-276C	14	9	9	11	10	11	4	273	120
OAX-276D	5	10	5	10	4	7	0	149	78
OAX-277A	7	4	3	14	13	16	1	170	79
OAX-277B	8	3	3	5	10	6	2	144	74
OAX-278	8	11	13	3	9	8	1	204	107
OAX-279A	11	9	9	34	14	21	3	311	130
OAX-279B	11	4	4	30	9	13	3	265	109
OAX-279C	11	7	11	22	8	12	3	230	81

Slide #	Voids	Rounded Angular Silt ≤ 0.0624mm	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm
OAX-272B	20	5	6	1	0	0	0	6	1
OAX-274	11	0	0	0	3	0	0	2	1
OAX-276B	22	0	3	7	3	3	0	0	2
OAX-276C	50	1	5	11	14	4	0	2	1
OAX-276D	16	2	5	3	2	2	0	0	3
OAX-277A	22	1	3	2	4	0	0	2	3
OAX-277B	22	1	4	3	1	1	0	2	3
OAX-278	31	10	2	0	1	0	0	7	1
OAX-279A	37	3	9	12	9	10	0	0	0
OAX-279B	37	7	21	8	7	2	0	3	2
OAX-279C	43	3	12	8	7	2	0	4	2

Slide #	Rounded Subangular Medium 0.25 0.49mm	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00-1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624mm	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
OAX-272B	1	0	0	0	2	0	0	0	0
OAX-274	1	0	0	0	3	1	0	0	0
OAX-276B	1	1	0	0	1	0	2	0	0
OAX-276C	9	1	1	0	4	2	3	0	0
OAX-276D	1	0	0	1	4	4	2	0	0
OAX-277A	0	2	0	0	0	3	1	0	0
OAX-277B	1	2	0	0	2	1	0	0	0
OAX-278	0	0	0	0	11	0	0	0	0
OAX-279A	6	4	1	0	0	1	3	4	1
OAX-279B	3	2	1	0	0	1	3	0	0
OAX-279C	3	1	1	0	1	4	0	2	0

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624m	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624mm	Elongated Angular Fine 0.0625-0.249mm	Elongated Angular Medium 0.25-0.49mm
OAX-272B	0	2	1	0	0	0	0	0	1	0
OAX-274	0	4	0	0	0	0	0	0	0	0
OAX-276B	0	1	1	0	0	0	0	0	2	2
OAX-276C	0	6	2	1	0	0	0	0	1	7
OAX-276D	0	2	1	0	1	1	0	0	2	1
OAX-277A	0	2	1	0	0	0	0	1	1	4
OAX-277B	0	3	0	0	0	0	0	1	0	1
OAX-278	0	13	0	0	0	0	0	0	3	0
OAX-279A	0	6	3	0	0	0	0	3	1	12
OAX-279B	0	2	2	0	0	0	0	2	5	10
OAX-279C	0	9	1	1	0	0	0	2	1	4

Slide #	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm	Elongated Subangular Gravel ≥ 2.00mm
OAX-272B	0	0	0	1	1	1	0	0	0
OAX-274	0	0	0	0	2	0	1	0	0
OAX-276B	5	2	0	0	1	2	2	0	0
OAX-276C	2	1	0	1	2	3	3	1	0
OAX-276D	4	3	0	0	2	1	1	0	0
OAX-277A	7	1	0	1	4	4	4	0	0
OAX-277B	2	0	1	2	3	0	4	1	0
OAX-278	0	0	0	5	3	1	0	0	0
OAX-279A	8	10	0	1	2	4	5	2	0
OAX-279B	5	8	0	1	3	2	1	1	1
OAX-279C	11	3	1	1	3	2	2	1	0

Slide #	Elongated Subround Silt ≤ 0.0624m	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm	Elongated Round Medium 0.25-0.49mm	Elongated Round Coarse 0.50-0.99mm
OAX-272B	4	0	1	0	0	0	1	0	0	0
OAX-274	2	1	0	0	0	0	1	0	0	0
OAX-276B	1	4	1	0	0	0	1	0	0	0
OAX-276C	2	2	5	1	1	0	2	0	1	1
OAX-276D	0	3	1	3	0	0	0	0	0	0
OAX-277A	4	3	4	5	0	0	0	1	0	0
OAX-277B	1	0	1	4	0	0	1	1	0	0
OAX-278	7	1	0	0	0	0	1	0	0	0
OAX-279A	2	7	5	6	1	0	2	1	0	0
OAX-279B	2	6	2	0	3	0	1	1	1	0
OAX-279C	4	3	1	4	0	0	3	0	0	0

Slide #	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
OAX-272B	0	0
OAX-274	0	0
OAX-276B	0	0
OAX-276C	0	0
OAX-276D	0	0
OAX-277A	0	0
OAX-277B	0	0
OAX-278	0	0
OAX-279A	0	0
OAX-279B	0	0
OAX-279C	0	0

Appendix D: Formative Sherds Raw Data

Slide #	Site	Period	Group	Ware (A, C, G, K)	Type	Total Round	Total Elongated	Total Angular (4)
CTL-001	Cerro Tilcajete	MAII	Formative	G	G.29	29	17	3
CTL-029	Cerro Tilcajete	MAII	Formative	G	G.15	19	14	13
CTL-050	Cerro Tilcajete	MAII	Formative	A	A.9	22	12	15
CTL-063	Cerro Tilcajete	MAII	Formative	C	C.20	36	24	22
CTL-077	Cerro Tilcajete	MAII	Formative	C	C.11	31	27	29
CTL-102A	Cerro Tilcajete	MAII	Formative	C	C.7	40	25	32
CTL-105	Cerro Tilcajete	MAII	Formative	G	G.21	85	55	54
MA-019	Monte Albán	MAI	Formative	G	G.12	34	12	19
MA-026	Monte Albán	MAI	Formative	G	G.17(?)	35	41	29
MA-033A	Monte Albán	MAI	Formative	C	C.20	59	29	24
MA-040	Monte Albán	MAII	Formative	G	G.15 or G.16	50	20	39
MA-045	Monte Albán	MAI	Formative	G	G.12	53	27	27
MA-047	Monte Albán	MAI	Formative	G	G.15 or G.16	33	15	10
MA-058	Monte Albán	MAII	Formative	G	G.21	35	22	29
MA-066	Monte Albán	MAI	Formative	G	G.17	35	22	31
OAX-008	Yaasuchi	MAII	Formative	G	G.21	48	25	42
OAX-009	Yaasuchi	MAII	Formative	C	C.12	51	40	48
OAX-012	Yassuchi	MAII	Formative	C	C.11	18	21	20
OAX-015	Yaasuchi	Late Ma I or II	Formative	G	G.12	20	23	16
OAX-019	Yaasuchi	Late Ma I or II	Formative	C	C.7	48	23	20
OAX-029	Cerro Tilcajete	MAII	Formative	G	G.12	21	18	23
OAX-044	El Palenque	Late MAI	Formative	C	C.2	50	44	35
OAX-048A	El Palenque	Late MAI	Formative	C	C.6	46	17	15
OAX-057A	Monte Albán	MAII	Formative	C	C.12	47	22	33

Slide #	Site	Period	Group	Ware (A, C, G, K)	Type	Total Round	Total Elongated	Total Angular (4)
OAX-069	Monte Albán	MAI-II	Formative	C	C.20	57	32	29
OAX-075	El Palenque	Late MAI	Formative	G	G.17	30	17	9
OAX-094	Yassuchi	MAI	Formative	G	G.15	22	22	19
OAX-097	Cerro Tilcajete	MAII	Formative	A	A.9	33	26	21
OAX-100	Monte Albán	MAII	Formative	A	A.9	35	21	21
OAX-105	Cerro Tilcajete	MAII	Formative	K	K.3	77	83	101
OAX-107	El Palenque	Late MAI	Formative	K	K.3	44	46	45
OAX-108	Cerro Tilcajete	MAII	Formative	K	K.17	44	41	47
OAX-113A	Yassuchi	MAII	Formative	A	A.9	29	19	25
OAX-115	Yassuchi	MAII	Formative	K	K.17	24	23	23
OAX-118	Yaasuchi	MAI-II	Formative	K	K.3	20	16	18
OAX-121	Monte Albán	MAI-II	Formative	K	K.3 or C?	19	19	18
OAX-122	Monte Albán	MAI-II	Formative	K	K.3 ?	39	23	22
OAX-123	Cerro Tilcajete	MAII	Formative	G	G.29	25	15	18
OAX-129	Cerro Tilcajete	MAII	Formative	G	G.29	21	15	11
OAX-147A	El Palenque	Late MAI-II	Formative	K	Unknown	32	23	19
OAX-148	Cerro Tilcajete	MAII	Formative	K	K.7	41	33	24
OAX-149	Cerro Tilcajete	MAII	Formative	K	Unknown	37	36	31
OAX-153	Cerro Tilcajete	MAII	Formative	K	K.17	35	16	22
OAX-159	Yaasuchi	MAIIIb-IV	Formative	K	K.14	43	17	33
OAX-172	El Mogote	Early MAI	Formative	G	G.12	29	22	20
OAX-184	El Mogote	Early MAI	Formative	G	G.12	35	16	15
OAX-192	El Mogote	Early MAI	Formative	G	G.12	27	10	13
OAX-194	El Mogote	Early MAI	Formative	G	G.12	31	20	17

Slide #	Site	Period	Group	Ware (A, C, G, K)	Type	Total Round	Total Elongated	Total Angular (4)
OAX-216	El Mogote	Rosario	Formative	G	Unknown	35	28	16
OAX-217	El Mogote	Early MAI ?	Formative	C	C.2	35	20	21
OAX-218	El Palenque	Late MAI	Formative	G	G.17	20	13	7
OAX-220	El Palenque	Late MAI	Formative	G	G.25	25	16	15
OAX-222A	El Palenque	Late MAI	Formative	G	G.12	23	12	11
OAX-226A	El Palenque	Late MAI	Formative	K	plain Unknown	43	31	37
OAX-259A	El Palenque	Late MAI	Formative	K	plain Unknown	33	27	29

Slide #	Total Subangular (3)	Total Subround (2)	Total Round (1)	Total Silt ≤ 0.0624m	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular
CTL-001	9	9	25	30	8	7	1	0	0	2
CTL-029	4	8	8	15	14	2	2	0	0	7
CTL-050	4	6	9	11	19	2	2	0	0	11
CTL-063	16	16	6	12	19	11	10	8	0	14
CTL-077	13	9	7	21	17	12	6	1	1	16
CTL-102A	14	13	7	14	19	15	13	4	0	22
CTL-105	9	42	35	54	61	12	7	5	1	29
MA-019	4	11	5	10	19	7	3	0	0	12
MA-026	14	19	14	26	37	9	3	1	0	13
MA-033A	29	24	11	22	29	18	13	6	0	14
MA-040	15	10	6	12	33	11	6	4	0	32
MA-045	23	20	9	41	34	5	0	0	0	15
MA-047	11	12	16	31	9	6	3	0	0	7
MA-058	10	10	8	24	20	8	5	0	0	20
MA-066	10	10	7	13	22	9	9	4	0	20
OAX-008	9	16	6	20	31	17	2	2	1	29
OAX-009	15	17	11	13	31	25	18	4	0	27
OAX-012	12	6	1	14	14	4	5	2	0	11
OAX-015	14	7	6	6	17	11	7	2	0	7
OAX-019	17	28	6	12	24	16	14	5	0	14
OAX-029	5	8	3	8	7	16	4	4	0	14
OAX-044	19	27	13	26	31	24	11	2	0	20
OAX-048A	23	18	7	17	22	17	5	2	0	12
OAX-057A	16	13	7	22	13	13	11	8	2	23

Slide #	Total Subangular (3)	Total Subround (2)	Total Round (1)	Total Silt ≤ 0.0624m	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular
OAX-069	15	26	19	24	24	17	15	7	2	21
OAX-075	9	14	15	29	11	2	2	3	0	8
OAX-094	12	6	7	14	13	10	7	0	0	11
OAX-097	16	9	13	18	29	8	3	0	0	16
OAX-100	18	12	5	30	20	4	2	0	0	11
OAX-105	20	32	7	17	45	37	46	14	0	53
OAX-107	14	24	7	21	27	25	14	3	0	22
OAX-108	11	18	9	11	48	18	7	1	0	25
OAX-113A	7	13	3	17	19	7	4	1	0	14
OAX-115	10	7	7	20	12	9	3	0	3	14
OAX-118	9	9	0	5	9	9	7	5	1	10
OAX-121	8	8	4	10	14	9	4	1	0	8
OAX-122	17	15	8	40	15	6	0	0	0	16
OAX-123	9	7	6	18	14	3	4	1	0	13
OAX-129	5	9	11	15	10	4	4	3	0	9
OAX-147A	9	18	9	17	21	14	2	1	0	13
OAX-148	16	20	14	37	35	2	0	0	0	13
OAX-149	14	16	12	12	41	14	4	2	0	21
OAX-153	9	14	6	19	9	16	2	1	0	16
OAX-159	11	8	8	22	26	5	3	2	1	25
OAX-172	16	4	11	20	25	5	0	1	0	12
OAX-184	17	11	8	30	6	9	5	1	0	13
OAX-192	8	4	12	14	12	9	2	0	0	8
OAX-194	11	13	10	22	21	8	1	0	0	11

Slide #	Total Subangular (3)	Total Subround (2)	Total Round (1)	Total Silt ≤ 0.0624m	Total Fine 0.0625-0.249mm	Total Medium 0.25-0.49mm	Total Coarse 0.50-0.99mm	Total Very Coarse 1.00-1.99mm	Total Gravel ≥ 2.00mm	Total Rounded Angular
OAX-216	15	24	8	10	21	29	3	0	0	11
OAX-217	10	15	9	12	5	8	18	10	2	12
OAX-218	11	13	2	13	16	1	3	0	0	5
OAX-220	7	13	6	15	10	10	5	1	0	12
OAX-222A	10	10	4	11	9	11	3	1	0	9
OAX-226A	13	12	12	18	27	19	9	1	0	25
OAX-259A	10	10	11	15	7	21	16	1	0	14

Slide #	Total Rounded Subangular	Total Rounded Subrounded	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix
CTL-001	5	4	18	1	4	5	7	236	177
CTL-029	1	6	5	6	3	2	3	156	110
CTL-050	3	2	6	4	1	4	3	180	136
CTL-063	12	5	5	8	4	11	1	156	82
CTL-077	5	5	5	13	8	4	2	138	72
CTL-102A	9	7	2	9	5	6	5	137	62
CTL-105	1	27	28	25	8	15	7	398	232
MA-019	4	6	5	7	0	5	0	125	66
MA-026	7	7	8	16	7	12	6	197	88
MA-033A	19	17	9	10	10	7	2	216	109
MA-040	9	7	2	7	6	3	4	182	87
MA-045	16	13	9	12	7	7	0	203	116
MA-047	9	6	11	3	2	6	5	194	135
MA-058	5	4	6	9	5	6	2	235	163
MA-066	5	5	5	11	5	5	2	208	122
OAX-008	6	7	6	13	3	9	0	356	237
OAX-009	9	4	11	21	6	13	0	222	117
OAX-012	3	3	1	9	9	3	0	139	81
OAX-015	6	2	5	9	8	5	1	148	94
OAX-019	10	18	6	6	7	10	0	134	50
OAX-029	2	2	3	9	3	6	0	245	145
OAX-044	8	13	9	15	11	14	4	209	96
OAX-048A	16	13	5	3	7	5	2	153	70
OAX-057A	10	9	5	10	6	4	2	202	120

Slide #	Total Rounded Subangular	Total Rounded Subrounded	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix
OAX-069	6	15	15	8	9	11	4	174	71
OAX-075	4	6	12	1	5	8	3	244	178
OAX-094	4	2	5	8	8	4	2	139	75
OAX-097	8	2	7	5	8	7	6	245	174
OAX-100	11	9	4	10	7	3	1	145	82
OAX-105	12	9	3	48	8	23	4	326	132
OAX-107	6	13	3	23	8	11	4	192	78
OAX-108	5	7	7	22	6	11	2	248	155
OAX-113A	4	9	2	11	3	4	1	152	87
OAX-115	5	1	4	9	5	6	3	141	67
OAX-118	6	4	0	8	3	5	0	131	55
OAX-121	4	4	3	10	4	4	1	153	106
OAX-122	8	9	6	6	9	6	2	200	125
OAX-123	5	2	5	5	4	5	1	193	133
OAX-129	2	2	8	2	3	7	3	174	126
OAX-147A	6	7	6	6	3	11	3	194	82
OAX-148	8	11	9	11	8	9	5	191	97
OAX-149	4	6	6	10	10	10	6	234	111
OAX-153	4	10	5	6	5	4	1	154	82
OAX-159	7	4	7	8	4	4	1	167	88
OAX-172	7	1	9	8	9	3	2	154	97
OAX-184	8	6	8	2	9	5	0	138	82
OAX-192	6	1	12	5	2	3	0	94	47
OAX-194	6	5	9	6	5	8	1	177	111

Slide #	Total Rounded Subangular	Total Rounded Subrounded	Total Rounded Round	Total Elongated Angular	Total Elongated Subangular	Total Elongated Subround	Total Elongated Round	Total Counted Inclusions, Voids, Matrix	Matrix
OAX-216	9	9	6	5	6	15	2	217	142
OAX-217	6	9	8	9	4	6	1	144	68
OAX-218	8	5	2	2	3	8	0	200	154
OAX-220	3	5	5	3	4	8	1	200	144
OAX-222A	6	5	3	2	4	5	1	157	62
OAX-226A	5	4	9	12	8	8	3	231	100
OAX-259A	7	4	8	15	3	6	3	206	99

Slide #	Voids	Rounded Angular Silt ≤ 0.0624mm	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm
CTL-001	13	1	1	0	0	0	0	1	2
CTL-029	13	1	4	1	1	0	0	1	0
CTL-050	10	3	7	0	1	0	0	0	2
CTL-063	14	1	2	5	3	3	0	3	4
CTL-077	8	2	8	4	2	0	0	1	1
CTL-102A	10	4	9	4	3	2	0	2	3
CTL-105	26	8	14	2	2	2	1	0	1
MA-019	13	4	5	2	1	0	0	1	2
MA-026	33	7	4	2	0	0	0	0	6
MA-033A	19	2	5	1	5	1	0	3	6
MA-040	25	4	9	8	4	3	0	3	4
MA-045	7	6	8	1	0	0	0	5	8
MA-047	11	3	3	1	0	0	0	6	1
MA-058	15	5	11	3	1	0	0	2	3
MA-066	28	1	6	6	3	4	0	0	2
OAX-008	46	12	10	5	0	1	1	0	4
OAX-009	14	5	9	7	4	2	0	1	3
OAX-012	19	5	4	1	0	1	0	0	2
OAX-015	11	148	0	3	3	1	0	0	2
OAX-019	13	1	5	5	1	2	0	1	2
OAX-029	61	3	2	7	1	1	0	0	0
OAX-044	19	4	10	4	2	0	0	1	4
OAX-048A	20	3	5	3	0	1	0	3	6
OAX-057A	13	7	2	4	5	4	1	3	3

Slide #	Voids	Rounded Angular Silt ≤ 0.0624mm	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm
OAX-069	14	3	3	5	5	4	1	2	2
OAX-075	19	4	3	1	0	0	0	3	1
OAX-094	20	1	5	4	1	0	0	0	3
OAX-097	12	3	8	3	2	0	0	2	5
OAX-100	7	6	4	1	0	0	0	8	2
OAX-105	34	3	17	16	15	2	0	2	3
OAX-107	24	4	6	9	2	1	0	2	1
OAX-108	8	3	11	10	1	0	0	0	4
OAX-113A	17	4	5	4	0	1	0	2	2
OAX-115	27	5	4	2	1	0	2	2	2
OAX-118	40	0	5	2	2	1	0	2	1
OAX-121	9	1	5	2	0	0	0	0	2
OAX-122	13	11	3	2	0	0	0	2	5
OAX-123	20	6	5	2	0	0	0	1	4
OAX-129	12	3	4	1	0	1	0	0	1
OAX-147A	57	5	6	2	0	0	0	1	4
OAX-148	20	6	7	0	0	0	0	3	4
OAX-149	50	2	14	4	1	0	0	2	1
OAX-153	21	7	4	5	0	0	0	0	2
OAX-159	19	9	10	3	1	1	1	4	3
OAX-172	6	2	9	1	0	0	0	3	4
OAX-184	5	4	3	2	4	0	0	6	0
OAX-192	10	0	0	8	0	0	0	0	6
OAX-194	15	6	5	0	0	0	0	3	1

Slide #	Voids	Rounded Angular Silt ≤ 0.0624mm	Rounded Angular Fine 0.0625-0.249mm	Rounded Angular Medium 0.25-0.49mm	Rounded Angular Coarse 0.50-0.99mm	Rounded Angular Very Coarse 1.00-1.99mm	Rounded Angular Gravel ≥ 2.00mm	Rounded Subangular Silt ≤ 0.0624mm	Rounded Subangular Fine 0.0625-0.249mm
OAX-216	12	0	8	3	0	0	0	1	3
OAX-217	21	0	2	3	4	2	1	0	0
OAX-218	13	2	3	0	0	0	0	3	4
OAX-220	15	1	5	5	1	0	0	1	0
OAX-222A	57	0	3	4	2	0	0	1	3
OAX-226A	57	5	8	8	4	0	0	1	2
OAX-259A	47	0	4	5	5	0	0	2	1

Slide #	Rounded Subangular Medium 0.25-0.49mm	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00 1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624mm	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
CTL-001	2	0	0	0	3	1	0	0	0
CTL-029	0	0	0	0	5	1	0	0	0
CTL-050	1	0	0	0	0	1	1	0	0
CTL-063	2	3	0	0	0	4	1	0	0
CTL-077	2	1	0	0	5	0	0	0	0
CTL-102A	2	0	2	0	2	1	1	3	0
CTL-105	0	0	0	0	11	10	3	3	0
MA-019	1	0	0	0	1	3	1	1	0
MA-026	1	0	0	0	1	5	0	1	0
MA-033A	6	4	0	0	5	7	4	1	0
MA-040	1	0	1	0	2	5	0	0	0
MA-045	3	0	0	0	10	3	0	0	0
MA-047	2	0	0	0	6	0	0	0	0
MA-058	0	0	0	0	3	0	0	1	0
MA-066	2	1	0	0	2	2	0	1	0
OAX-008	2	0	0	0	0	6	1	0	0
OAX-009	1	3	1	0	1	1	1	1	0
OAX-012	0	1	0	0	1	1	0	1	0
OAX-015	3	1	0	0	0	1	0	1	0
OAX-019	2	5	0	0	4	8	4	2	0
OAX-029	1	1	0	0	0	0	2	0	0
OAX-044	2	0	1	0	3	6	2	2	0
OAX-048A	6	1	0	0	5	3	4	1	0
OAX-057A	2	2	0	0	3	2	3	1	0

Slide #	Rounded Subangular Medium 0.25-0.49mm	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00 1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624mm	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
OAX-069	1	0	1	0	4	3	5	2	1
OAX-075	0	0	0	0	4	1	0	0	1
OAX-094	1	0	0	0	0	0	1	1	0
OAX-097	1	0	0	0	2	0	0	0	0
OAX-100	1	0	0	0	7	1	1	0	0
OAX-105	2	5	0	0	1	3	2	2	1
OAX-107	3	0	0	0	8	4	1	0	0
OAX-108	0	1	0	0	2	3	1	1	0
OAX-113A	0	0	0	0	6	1	1	1	0
OAX-115	1	0	0	0	1	0	0	0	0
OAX-118	1	1	1	0	2	1	0	0	0
OAX-121	1	1	0	0	3	0	1	0	0
OAX-122	1	0	0	0	7	2	0	0	0
OAX-123	0	0	0	0	0	0	0	1	1
OAX-129	0	0	1	0	1	1	0	0	0
OAX-147A	1	0	0	0	3	3	1	0	0
OAX-148	1	0	0	0	6	5	0	0	0
OAX-149	0	1	0	0	0	3	2	1	0
OAX-153	2	0	0	0	5	2	2	0	1
OAX-159	0	0	0	0	0	2	1	1	0
OAX-172	0	0	0	0	1	0	0	0	1
OAX-184	1	0	1	0	6	0	0	0	0
OAX-192	0	0	0	0	0	1	0	0	0
OAX-194	2	0	0	0	1	4	0	0	0

Slide #	Rounded Subangular Medium 0.25-0.49mm	Rounded Subangular Coarse 0.50-0.99mm	Rounded Subangular Very Coarse 1.00 1.99mm	Rounded Subangular Gravel ≥ 2.00mm	Rounded Subround Silt ≤ 0.0624mm	Rounded Subround Fine 0.0625-0.249mm	Rounded Subround Medium 0.25-0.49mm	Rounded Subround Coarse 0.50-0.99mm	Rounded Subround Very Coarse 1.00-1.99mm
OAX-216	4	1	0	0	3	3	3	0	0
OAX-217	0	4	2	0	1	1	1	5	1
OAX-218	0	1	0	0	3	2	0	0	0
OAX-220	1	0	1	0	4	1	0	0	0
OAX-222A	1	1	0	0	4	1	0	0	0
OAX-226A	1	1	0	0	0	3	1	0	0
OAX-259A	3	1	0	0	1	0	3	0	0

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624mm	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624m	Elongated Angular Fine 0.0625-0.249mm	Elongated Angular Medium 0.25-0.49mm
CTL-001	0	18	0	0	0	0	0	0	1	0
CTL-029	0	4	0	0	1	0	0	1	5	0
CTL-050	0	5	1	0	0	0	0	1	3	0
CTL-063	0	4	1	0	0	0	0	3	0	1
CTL-077	0	5	0	0	0	0	0	3	2	3
CTL-102A	0	2	0	0	0	0	0	2	2	2
CTL-105	0	22	5	1	0	0	0	6	10	5
MA-019	0	2	3	0	0	0	0	2	4	0
MA-026	0	4	3	1	0	0	0	3	10	3
MA-033A	0	7	0	1	1	0	0	0	1	5
MA-040	0	1	0	1	0	0	0	0	6	0
MA-045	0	8	1	0	0	0	0	4	8	0
MA-047	0	10	1	0	0	0	0	2	0	1
MA-058	0	6	0	0	0	0	0	2	1	4
MA-066	0	4	1	0	0	0	0	1	7	0
OAX-008	0	4	2	0	0	0	0	1	4	5
OAX-009	0	4	3	4	0	0	0	1	8	6
OAX-012	0	1	0	0	0	0	0	3	5	1
OAX-015	0	2	2	0	1	0	0	1	2	2
OAX-019	0	5	0	1	0	0	0	0	2	1
OAX-029	0	3	0	0	0	0	0	1	1	4
OAX-044	0	6	0	3	0	0	0	5	4	4
OAX-048A	0	3	0	1	1	0	0	1	1	0
OAX-057A	0	2	1	2	0	0	0	2	1	1

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624mm	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624m	Elongated Angular Fine 0.0625-0.249mm	Elongated Angular Medium 0.25-0.49mm
OAX-069	0	10	3	2	0	0	0	0	5	0
OAX-075	0	12	0	0	0	0	0	1	0	0
OAX-094	0	5	0	0	0	0	0	1	5	0
OAX-097	0	7	0	0	0	0	0	1	2	2
OAX-100	0	4	0	0	0	0	0	2	7	1
OAX-105	0	3	0	0	0	0	0	5	15	7
OAX-107	0	3	0	0	0	0	0	3	7	6
OAX-108	0	1	5	0	1	0	0	3	13	6
OAX-113A	0	0	2	0	0	0	0	3	4	1
OAX-115	0	3	0	0	1	0	0	2	4	2
OAX-118	1	0	0	0	0	0	0	0	0	5
OAX-121	0	2	1	0	0	0	0	3	3	2
OAX-122	0	6	0	0	0	0	0	3	3	0
OAX-123	0	4	0	1	0	0	0	3	1	0
OAX-129	0	6	0	2	0	0	0	1	1	0
OAX-147A	0	4	1	1	0	0	0	1	2	2
OAX-148	0	7	1	1	0	0	0	5	6	0
OAX-149	0	5	1	0	0	0	0	0	5	3
OAX-153	0	3	0	0	2	0	0	1	2	3
OAX-159	0	6	0	1	0	0	0	1	7	0
OAX-172	0	8	0	1	0	0	0	1	5	2
OAX-184	0	8	0	0	0	0	0	0	1	1
OAX-192	0	11	0	0	1	0	0	2	3	0
OAX-194	0	7	2	0	0	0	0	2	3	1

Slide #	Rounded Subround Gravel ≥ 2.00mm	Rounded Round Silt ≤ 0.0624mm	Rounded Round Fine 0.0625-0.249mm	Rounded Round Medium 0.25-0.49mm	Rounded Round Coarse 0.50-0.99mm	Rounded Round Very Coarse 1.00-1.99mm	Rounded Round Gravel ≥ 2.00mm	Elongated Angular Silt ≤ 0.0624m	Elongated Angular Fine 0.0625-0.249mm	Elongated Angular Medium 0.25-0.49mm
OAX-216	0	4	2	0	0	0	0	0	0	5
OAX-217	0	8	0	0	0	0	0	1	2	1
OAX-218	0	2	0	0	0	0	0	0	2	0
OAX-220	0	4	1	0	0	0	0	1	2	0
OAX-222A	0	3	0	0	0	0	0	0	1	0
OAX-226A	0	4	3	0	2	0	0	2	5	5
OAX-259A	0	8	0	0	0	0	0	1	2	5

Slide #	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm	Elongated Subangular Gravel ≥ 2.00mm
CTL-001	0	0	0	0	1	2	1	0	0
CTL-029	0	0	0	0	2	1	0	0	0
CTL-050	0	0	0	0	1	0	0	0	0
CTL-063	2	2	0	0	2	1	1	0	0
CTL-077	3	1	1	4	2	2	0	0	0
CTL-102A	3	0	0	1	1	1	2	0	0
CTL-105	1	3	0	0	7	0	1	0	0
MA-019	1	0	0	0	0	0	0	0	0
MA-026	0	0	0	4	1	1	1	0	0
MA-033A	1	3	0	2	8	0	0	0	0
MA-040	1	0	0	0	5	0	1	0	0
MA-045	0	0	0	4	3	0	0	0	0
MA-047	0	0	0	0	0	0	2	0	0
MA-058	2	0	0	2	2	0	1	0	0
MA-066	3	0	0	2	1	1	1	0	0
OAX-008	2	1	0	0	1	2	0	0	0
OAX-009	5	1	0	0	2	2	2	0	0
OAX-012	0	0	0	3	2	2	1	1	0
OAX-015	4	0	0	0	4	2	0	2	0
OAX-019	2	1	0	0	2	1	3	1	0
OAX-029	2	1	0	1	0	1	0	1	0
OAX-044	2	0	0	0	4	3	3	1	0
OAX-048A	0	1	0	1	4	0	2	0	0
OAX-057A	1	4	1	2	1	1	2	0	0

Slide #	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm	Elongated Subangular Gravel ≥ 2.00mm
OAX-069	1	1	1	2	1	3	3	0	0
OAX-075	0	0	0	0	4	0	1	0	0
OAX-094	2	0	0	3	0	2	3	0	0
OAX-097	0	0	0	0	6	2	0	0	0
OAX-100	0	0	0	1	5	0	1	0	0
OAX-105	17	4	0	0	0	6	1	1	0
OAX-107	5	2	0	0	5	1	2	0	0
OAX-108	0	0	0	0	5	0	0	1	0
OAX-113A	3	0	0	0	2	1	0	0	0
OAX-115	1	0	0	2	1	2	0	0	0
OAX-118	2	1	0	1	1	0	1	0	0
OAX-121	2	0	0	1	2	1	0	0	0
OAX-122	0	0	0	5	2	2	0	0	0
OAX-123	1	0	0	1	3	0	0	0	0
OAX-129	0	0	0	1	0	0	1	1	0
OAX-147A	1	0	0	0	2	1	0	0	0
OAX-148	0	0	0	4	4	0	0	0	0
OAX-149	1	1	0	0	5	5	0	0	0
OAX-153	0	0	0	1	2	2	0	0	0
OAX-159	0	0	0	0	2	1	1	0	0
OAX-172	0	0	0	4	4	1	0	0	0
OAX-184	0	0	0	3	1	4	1	0	0
OAX-192	0	0	0	0	1	0	1	0	0
OAX-194	1	0	0	2	1	2	0	0	0

Slide #	Elongated Angular Coarse 0.50-0.99mm	Elongated Angular Very Coarse 1.00-1.99mm	Elongated Angular Gravel ≥ 2.00mm	Elongated Subangular Silt ≤ 0.0624mm	Elongated Subangular Fine 0.0625-0.249mm	Elongated Subangular Medium 0.25-0.49mm	Elongated Subangular Coarse 0.50-0.99mm	Elongated Subangular Very Coarse 1.00-1.99mm	Elongated Subangular Gravel ≥ 2.00mm
OAX-216	0	0	0	0	2	4	0	0	0
OAX-217	1	4	0	0	0	2	2	0	0
OAX-218	0	0	0	1	1	1	0	0	0
OAX-220	0	0	0	0	0	2	2	0	0
OAX-222A	0	1	0	1	0	3	0	0	0
OAX-226A	0	0	0	1	3	2	2	0	0
OAX-259A	6	1	0	1	0	2	0	0	0

Slide #	Elongated Subround Silt ≤ 0.0624mm	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm	Elongated Round Medium 0.25-0.49mm
CTL-001	0	2	3	0	0	0	7	0	0
CTL-029	0	2	0	0	0	0	3	0	0
CTL-050	0	4	0	0	0	0	2	0	0
CTL-063	1	5	1	1	3	0	0	1	0
CTL-077	1	2	1	0	0	0	0	2	0
CTL-102A	1	2	2	1	0	0	0	1	3
CTL-105	2	12	1	0	0	0	5	2	0
MA-019	0	2	3	0	0	0	0	0	0
MA-026	3	6	1	1	1	0	4	2	0
MA-033A	2	2	0	1	2	0	1	0	1
MA-040	1	1	1	0	0	0	1	3	0
MA-045	4	3	1	0	0	0	0	0	0
MA-047	0	3	2	1	0	0	4	1	0
MA-058	3	2	1	0	0	0	1	1	0
MA-066	3	2	0	0	0	0	1	1	0
OAX-008	3	4	2	0	0	0	0	0	0
OAX-009	1	5	4	3	0	0	0	0	0
OAX-012	1	0	0	2	0	0	0	0	0
OAX-015	0	3	1	1	0	0	0	0	1
OAX-019	1	5	2	1	1	0	0	0	0
OAX-029	0	4	1	0	1	0	0	0	0
OAX-044	4	3	5	2	0	0	3	0	1
OAX-048A	0	2	3	0	0	0	1	1	0
OAX-057A	2	2	0	0	0	0	1	1	0

Slide #	Elongated Subround Silt ≤ 0.0624mm	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm	Elongated Round Medium 0.25-0.49mm
OAX-069	3	5	0	3	0	0	0	2	1
OAX-075	4	1	1	1	1	0	1	1	0
OAX-094	2	0	2	0	0	0	2	0	0
OAX-097	0	7	0	0	0	0	3	1	0
OAX-100	1	1	0	1	0	0	1	0	0
OAX-105	2	7	4	4	5	0	1	0	0
OAX-107	1	4	3	3	0	0	0	0	2
OAX-108	1	7	1	2	0	0	1	0	0
OAX-113A	1	3	0	0	0	0	1	0	0
OAX-115	4	1	0	0	0	1	1	0	2
OAX-118	0	1	1	1	2	0	0	0	0
OAX-121	0	0	2	1	1	0	0	1	0
OAX-122	4	1	1	0	0	0	2	0	0
OAX-123	2	1	0	2	0	0	1	0	0
OAX-129	2	1	1	3	0	0	1	2	0
OAX-147A	2	2	5	1	1	0	1	1	1
OAX-148	4	5	0	0	0	0	2	3	0
OAX-149	0	10	0	0	0	0	3	2	0
OAX-153	1	1	2	0	0	0	1	0	0
OAX-159	2	2	0	0	0	0	0	0	0
OAX-172	0	3	0	0	0	0	1	1	0
OAX-184	3	1	1	0	0	0	0	0	0
OAX-192	1	1	1	0	0	0	0	0	0
OAX-194	1	4	3	0	0	0	0	1	0

Slide #	Elongated Subround Silt ≤ 0.0624mm	Elongated Subround Fine 0.0625-0.249mm	Elongated Subround Medium 0.25-0.49mm	Elongated Subround Coarse 0.50-0.99mm	Elongated Subround Very Coarse 1.00-1.99mm	Elongated Subround Gravel ≥ 2.00mm	Elongated Round Silt ≤ 0.0624mm	Elongated Round Fine 0.0625-0.249mm	Elongated Round Medium 0.25-0.49mm
OAX-216	2	2	9	2	0	0	0	1	1
OAX-217	1	0	1	2	1	1	1	0	0
OAX-218	2	4	0	2	0	0	0	0	0
OAX-220	3	1	2	2	0	0	1	0	0
OAX-222A	1	1	3	0	0	0	1	0	0
OAX-226A	2	3	2	0	1	0	3	0	0
OAX-259A	0	0	3	3	0	0	2	0	0

Slide #	Elongated Round Coarse 0.50-0.99mm	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
CTL-001	0	0	0
CTL-029	0	0	0
CTL-050	1	0	0
CTL-063	0	0	0
CTL-077	0	0	0
CTL-102A	1	0	0
CTL-105	0	0	0
MA-019	0	0	0
MA-026	0	0	0
MA-033A	0	0	0
MA-040	0	0	0
MA-045	0	0	0
MA-047	0	0	0
MA-058	0	0	0
MA-066	0	0	0
OAX-008	0	0	0
OAX-009	0	0	0
OAX-012	0	0	0
OAX-015	0	0	0
OAX-019	0	0	0
OAX-029	0	0	0
OAX-044	0	0	0
OAX-048A	0	0	0
OAX-057A	0	0	0

Slide #	Elongated Round Coarse 0.50-0.99mm	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
OAX-069	1	0	0
OAX-075	0	1	0
OAX-094	0	0	0
OAX-097	1	0	0
OAX-100	0	0	0
OAX-105	2	1	0
OAX-107	2	0	0
OAX-108	1	0	0
OAX-113A	0	0	0
OAX-115	0	0	0
OAX-118	0	0	0
OAX-121	0	0	0
OAX-122	0	0	0
OAX-123	0	0	0
OAX-129	0	0	0
OAX-147A	0	0	0
OAX-148	0	0	0
OAX-149	0	1	0
OAX-153	0	0	0
OAX-159	0	1	0
OAX-172	0	0	0
OAX-184	0	0	0
OAX-192	0	0	0
OAX-194	0	0	0

Slide #	Elongated Round Coarse 0.50-0.99mm	Elongated Round Very Coarse 1.00-1.99mm	Elongated Round Gravel ≥ 2.00mm
OAX-216	0	0	0
OAX-217	0	0	0
OAX-218	0	0	0
OAX-220	0	0	0
OAX-222A	0	0	0
OAX-226A	0	0	0
OAX-259A	1	0	0