AN ABSTRACT OF THE THESIS OF

Jeremias Pink for the degree of Master of Arts in Applied Anthropology presented on September 4, 2014

Title: Rural Ceramic Production, Consumption, and Exchange in Late Classic Oaxaca, Mexico: A View from Yaasuchi

Abstract approved:

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Leah D. Minc

The Valley of Oaxaca, Mexico was home to one of the most intensively-studied archaic states in the New World. Centered at the hilltop city of Monte Albán, the Zapotec State first arose around 500 BC and eventually encompassed much of the present-day state of Oaxaca. But by the Late Classic (AD 550 – 850), the state began to dissolve from a regional power into a series of autonomous city-states. The organization of the Zapotec economy in the centuries preceding state decline has been alternatively characterized as a state administered system or a commercial market economy, but most work hinges upon a continued assumption of mutual dependence between rural agricultural producers and urban manufacturers of craft goods. Yet little empirical research has focused on the economic behavior of households in rural communities.

To address these assumptions, over 300 archaeological ceramics from the rural site of Yaasuchi were submitted for compositional analysis using INAA at the OSU Archaeometry Laboratory in order to establish provenance. These ceramics were drawn from two Late Classic domestic structures, a ceramic-production firing feature, and surface collections taken throughout the site. Together, they provide insight into patterns of production, consumption, and exchange at a small, rural community in Monte Albán’s hinterland. Comparisons of these data to compositional information from a large database of clays and ceramics from throughout the region show that as much as 90% of Yaasuchi ceramics were produced on site and exchanged between households. Of the remaining

10%, one third were produced in communities near Monte Albán while the remainder came from sources closer to Yaasuchi. These results suggest that Yaasuchi households were not dependent on exchange in urban centers for access to ceramics. Nor however, were they divorced from the regional economy. Rather, households employed a range of economic strategies to fulfil domestic needs, including craft production for intra-site and regional exchange. I argue that this pattern of economic behavior is consistent with a view of the Late Classic economy in which the growing autonomy of sub-regional polities resulted in an incompletely integrated, overlapping market network. The structure of this exchange system would have impacted the reliability of markets as both a source of goods and income, discouraging rural participation in regional exchange.

Rural Ceramic Production, Consumption, and Exchange in Late Classic Oaxaca, Mexico: A View from Yaasuchi

by

Jeremias Pink

A THESIS

submitted to

Oregon State University

in partial fulfilment of
the requirements for the
degree of

Master of Arts

Presented September 4, 2014
Commencement June 2015

Master of Arts thesis of Jeremias Pink presented on September 4, 2014

APPROVED:

Major Professor, representing Applied Anthropology

Director of the School of Language, Culture, and Society

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Jeremias Pink, Author

ACKNOWLEDGEMENTS

The act of writing a thesis often seems a solitary endeavor, but this work would not have been possible without the contributions and support of a large number of people and institutions. This work does not merely represent an individual academic achievement, but the final outcome of a long collaboration.

First and foremost, I owe a tremendous debt to Dr. R. Jason Sherman, who excavated the site of Yaasuchi for his dissertation research 14 years ago. Ceramic collections from this excavation are at the core of this research, but more importantly, the strength of Dr. Sherman's scholarship, thorough documentation, and ongoing interest in this project have been essential to my interpretation of the data. I owe equal gratitude to the *Consejo* Arqueología of INAH and members of INAH, Oaxaca, for generously granting access to collections held at the archaeological repository in Cuilápan de Guerrero. Agustín Andrade of INAH, Oaxaca was particularly helpful with the application process.

A special thanks is also due to Dr. Robert Markens of the IIE, UNAM for his willingness to oversee a season of fieldwork in Oaxaca over the summer of 2012 and his continued interest in this research. His generosity of spirit is perhaps matched only by Lic. Cira Martínez López, and Dr. Marcus Winter, who graciously lent their time and expertise to assist in the sample selection process at Cuilápan. I must also thank Lic. Adriana Giraldo, who facilitated access to the Yaasuchi collections at Cuilapan and kindly endured my intrusion into her work-space, as well as Romeo Moreno, for his assistance with collection of clay samples throughout the Valley of Oaxaca.

Naturally, sample selection is only the first stage of research in a laboratory-based thesis project. I also received an enormous amount of help with sample preparation and analysis from the crew of the OSU Archaeometry Laboratory, especially Mark Lanza, Jamie Klotz, and Molly Mossman. Particular thanks are also due to members of the Radiation Center staff, including Robert Schickler, Gary Walker, and Steve Smith, for their help with irradiations and troubleshooting.

Further geochemical analysis using LA-ICP-MS at OSU's Keck Collaboratory was crucial to my interpretation of the Yaasuchi data. I am therefore especially grateful to Dr. Adam Kent for his encouragement and technical assistance with this portion of the project, as well as his willingness to serve as a committee member for my minor field of study. Coursework under Dr. Kent substantially enriched my knowledge and appreciation of the field of geochemistry beyond applications in archaeology. His interest in this this research has been equally rewarding. Further thanks are due to Richard Bradshaw, who provided additional assistance with sample preparation and LA-ICP-MS analysis.

My thesis research was punctuated by two seasons of unrelated archaeological fieldwork, first in my home state of Idaho, then in Oaxaca. Over the summer of 2013, Dr. Loren Davis graciously brought me on to assist with excavations and instruction at the Cooper's Ferry geoarchaeological field school in western Idaho. This experience, combined with coursework under Dr. Davis at OSU, has forever altered my approach to excavation. In the spring of 2014, I again took leave of my thesis research to work with Dr. Gary Feinman and Linda Nicholas of the Field Museum at the site of Lambityeco in Oaxaca. Even a cursory reading of this thesis will show that their 30 years of research in Oaxaca have been foundational to my understanding of economic issues in Oaxacan archaeology. Having an opportunity work with them directly and discuss these topics in depth reinvigorated my interest in the area and my enthusiasm for archaeology in general.

My deepest gratitude is reserved for my advisor, Dr. Leah Minc, whose wisdom and patience have helped me overcome the inevitable moments of doubt and carried me through graduate study at OSU. I am especially grateful to her for introducing me to Mesoamerican archaeology and encouraging me to pursue research in Oaxaca using the Yaasuchi material. I arrived at Oregon State with little knowledge of the archaeology of complex societies, compositional analysis through INAA, or multivariate statistical methods. To the extent that I have any competence in those subjects today, I owe that entirely to her mentorship and guidance. Dr. Minc is at once demanding and compassionate, rigorous and understanding. I have been consistently humbled by her professional and intellectual example, and can only hope that this thesis honors her investment in my education.

Finally, I could not have brought this project to completion without a wealth of support from friends and family. I am particularly grateful to my father, who taught me that if one is going to do something, one should do it right, and to my mother, who taught me that if in pursuit of perfection one does not complete a project, it doesn't count. If this thesis has any merit, it is by way of their example. I have also enjoyed the encouragement of my brother Cody, innumerable members of my extended family, and many friends old and new in Oregon, Idaho, Oaxaca, and around the world. I have benefitted immensely from friendship and conversation with my peers in the OSU anthropology department, especially Braden Elliott, Sarah Walker, Molly Kirkpatrick, Cayla Hill, and Lindsey Stallard. I owe equal gratitude to many friends outside of the department as well, especially Melinda Walker, Monica Tromp, Mike Oldham, Matt Cooper, Sam Schnake, Kate Self, and many others. Each has contributed to the realization of this thesis in many ways large and small.

This research was made possible through a National Science Foundation award to Dr. Leah Minc, titled "Support of Coordinated, Regional Trace-Element Studies at the OSU-RC" (NSF Award No. 1005945). Additional funding for field research in Oaxaca was provided by the School of Language, Culture, and Society at Oregon State University.

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For my father,

Dr. Bob Pink

CHAPTER I: INTRODUCTION

In the study of archaic states, the economic behavior of rural households is rarely a focus of investigation (Hirth 2013). And yet, in many areas of the world, hypotheses regarding the nature of ancient economies hinge upon assumed relationships between rural communities and large, urban centers. In the Valley of Oaxaca, Mexico, the economy has been alternatively characterized as either a centrally administered exchange system (e.g. Feinman 1982), or a highly commercialized market network (e.g. Feinman and Nicholas 2012; Lind and Urcid 2010). Throughout this literature however, rural communities have been consistently characterized as agricultural producers dependent upon urban centers for access to craft goods, in exchange for a portion of their agricultural surplus.

This study examines how the organization of market exchange under the Zapotec state in Oaxaca, Mexico during the Late Classic (AD 550-850) affected rural household craft production, consumption, and exchange at the site of Yaasuchi. The Late Classic was a time of immense change in the Valley of Oaxaca. At some point during this period, the Zapotec state – under the leadership of the capital, Monte Albán – began to dissolve from a unified regional polity into a loose network of smaller, competing city-states (Balkansky 1998; Blanton *et al.* 1999; Feinman and Nicholas 2011b; Flannery and Marcus 1983). This balkanization of political authority would have been accompanied by equally dramatic changes in the organization of the regional economy; of particular interest in this study is how these changes in regional political and economic organization affected the production and exchange decisions of rural households, which comprised the bulk of the Prehispanic population.

With an estimated population of only 115, Yaasuchi is the smallest Late Classic site that has been subject to controlled, stratigraphic excavation in the Valley of Oaxaca (Sherman 2005). Using compositional analyses of ceramics from the site to identify locally-produced and imported wares, I argue that Yaasuchi's participation in regional markets was somewhat limited and that the majority of ceramic production and exchange occurred within the community. This is not to say that Yaasuchi was a self-sufficient community divorced from the regional economy. Rather, Yaassuchi households employed a range of economic strategies conditioned by market structure and differential access to resources, including craft production for exchange in regional markets.

If the results of this study are generalizable to rural sites elsewhere in the Valley, rural dependence on urban commodities may have been more limited than is often assumed in many models of the Late Classic economy (e.g. Feinman *et al.* 1984; Lind and Urcid 2010:71-72). If so, these results are consistent with a view of Late Classic political reorganization that calls for a shift from an integrated territorial state to a loose network of sub-regional polities with discrete but overlapping market zones. Under this scenario, poor regional market integration would have constrained the flow of goods and price information between market areas, with consequences for the reliability of market exchange as a source of goods and income for rural communities. At Yaasuchi, rural households responded to the opportunities and constraints posed by the Late Classic political and economic environment in a number of ways. Some households diversified labor, engaging in multiple forms of craft production for exchange within the community and regional markets to supplement income from agricultural production. Other households obtained the majority of goods through intra-community exchange, relying less on regional exchange as either a source of income or craft goods.

This research is part of a larger study of political and economic networks in the Valley of Oaxaca during the Classic Period (AD 350 – 850) coordinated by the OSU Archaeometry Laboratory. As the only rural site included in this larger study, Yaasuchi provides a view of the economic strategies employed by peasant households in response to the changing political and economic conditions beyond urban centers during the Late Classic Period. A brief overview of the organization of this study is provided below.

Chapter 2: The Valley of Oaxaca during the Late Classic

In the second chapter I will provide necessary background information on the Valley of Oaxaca and its archaeology. The chapter begins with an overview of the geography of the Valley, the history of archaeological research in the area, and summarizes political developments in the area from the rise of the Zapotec state in ca. 500 BC to its decline by

850 AD. I then discuss the Late Classic period in depth, with particular focus on the principal political and economic models that have been proposed for this period. The chapter concludes with a broad discussion of rural market participation, and defines the core research objectives of this study.

Chapter 3: Rural Craft Production, Consumption, and Exchange

Chapter 3 provides a theoretical framework for interpreting patterns of craft production, consumption, and exchange at Yaasuchi. The chapter begins with a review of the primary dimensions of the organization of craft production in archaic states and then discusses relationships between the organization of production and exchange. This is followed by a discussion of the organization of market exchange and a definition of four idealized models of regional market system structure. For each of these, a series of expectations are outlined for the organization of ceramic production, exchange, and rural market participation. The chapter concludes with a discussion of previous research at Yaasuchi, and defines specific expectations for rural craft production, consumption, and exchange at the site under alternative models of Late Classic political and economic organization.

Chapter 4: Materials and Methods

In the fourth chapter, I outline the methods used to evaluate ceramic production, consumption, and exchange at Yaasuchi. At the core of this research is the determination of geographic provenance (or source) of ceramics based on their elemental signature. The chapter accordingly begins with a description of sample selection, field research and comparative databases, as well as the principal analytical methods used to determine elemental composition of a sample of Yassuchi ceramics. Next, I discuss the statistical procedures used to identify the likely geographic source of ceramics manufactured in different areas, followed by results linking Yaasuchi ceramics to either local clay sources or other communities in the Valley. At the end of the chapter, I address the problem of possible temper addition or clay modification in the manufacture of Yaasuchi ceramics and its impact on our ability to determine geographic provenance.

Chapter 5: Rural Market Participation at Yaasuchi

In the fifth chapter, I discuss how the results of ceramic provenance determinations were used to understand the organization of craft production and exchange at Yaasuchi. The chapter begins with a discussion of craft production at Yaasuchi, including assessments of the intensity of production, product specialization, and production contexts. This is followed by a discussion of ceramic consumption and exchange, with particular focus on similarities and differences in consumption and exchange patterns observed between households.

Chapter 6: Conclusions

In the final chapter of this thesis, I discuss the implications of this research for our understanding of rural market participation, the organization of exchange, and regional political integration during the Late Classic Period in the Valley of Oaxaca. I conclude that patterns of consumption, production, and exchange observed at Yaasuchi are consistent with a model of an overlapping market network. The structure of this system implies poor regional integration and market unreliability, both as a source of goods and income, with clear consequences for rural economic behavior. Such a regional economic system is, in turn, consistent with a decentralization of political authority during the Late Classic.

CHAPTER II: THE VALLEY OF OAXACA DURING THE LATE CLASSIC

Geographic Overview

The Valley of Oaxaca is the geographic and political center of the present day state of Oaxaca, one of the most culturally and linguistically diverse regions of Mexico (Figure 2.1). Hosting a higher proportion of indigenous peoples than any other state, Oaxaca is home to speakers of sixteen officially recognized native languages. The most populous of these groups are the Zapotec, whose cultural heartland is the Valley of Oaxaca (Marcus and Flannery 1996:10-14). A broad, flat expanse of land in an otherwise mountainous region, the Valley has provided a suitable environment for maize agriculture for at least 4,000 years (Marcus and Flannery 1996:71-73).

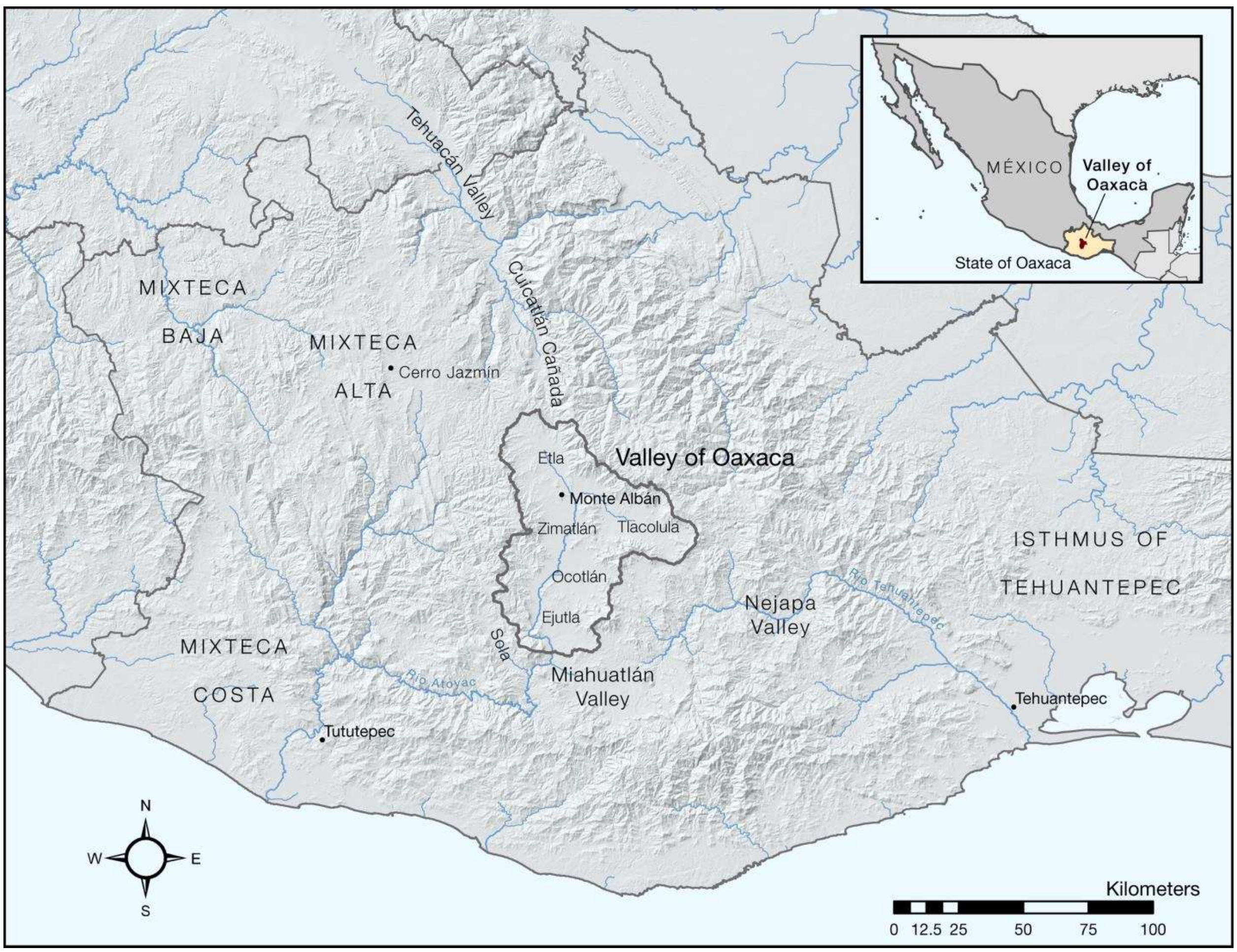

Figure 2.1: The Valley of Oaxaca and neighboring regions.

Shaped like an inverted Y, the Valley has three discrete branches or subvalleys. In the north, the upper reaches of the Atoyac flow through the narrow, fertile Etla Subvalley. In the east, the Río Salado flows through the broad, dry Tlacolula Subvalley. From their confluence near the present-day capital of Oaxaca, the Atoyac then flows south through the Zimatlán and Ocotlán Subvalleys (together often called the Valle Grande) toward the Ejutla Subvalley and the southern extent of the Valley of Oaxaca (Marcus and Flannery 1996:10-11). To the south, the Sola and Miahuatlán Valleys form the remainder of the Central Valley System.

With an average elevation of over 1500 m and moderate annual rainfall of 55cm, the Valley of Oaxaca is cooler and more temperate than much of Mesoamerica. Its land can be divided into three physiographic zones with differing productive potentials: alluvium, piedmont, and montane. The fertile alluvium of the valley floor is best-suited for agricultural production. Here, water-tables are close to the surface, allowing dry-land farming or hand-irrigation from shallow wells. In contrast, the piedmont zone is a drier, hillier province in the foothills between the alluvium of the valley floor and the surrounding mountains. Due to its lower water-tables, dry-land farming of the piedmont is more risky, making check-dams, diversions, and other irrigation structures more common in these areas. The montane zone is generally not suitable for agriculture, but would have provided a source of timber and game in prehistory (Blanton *et al.* 1999:31-33).

Differences in the relative abundance of alluvium, piedmont, and montane zones within each sub-region of the Valley, combined with differences in elevation and rainfall have historically contributed to differences in each area's land-use and productive potential. To the North, the Etla Subvalley has the most fertile alluvium, highest annual rainfall, shallowest water-tables, and thus the highest agricultural productivity. In the East, the broad, dry Tlacolula Subvalley has the lowest irrigation potential, encouraging farmers to cultivate drought resistant plants such as maguey rather than maize. To the South, the Zimatlán-Ocotlán Subvalley has the highest acreage available for agriculture, but much of this is irrigation-dependent piedmont and maize production is risky in dry years.

At the center of the Valley of Oaxaca, overlooking each of these regions, a series of hills rise up to 400 meters above the valley floor. Around 500 BC, on the highest of these hills, the Zapotec built Monte Albán, one of Mesoamerica's first urban centers (Blanton 1978; Blanton *et al.* 1999:22). While later eclipsed by the growth of larger cities in other areas of Mesoamerica, Monte Albán remained the pre-eminent center in the Valley of Oaxaca and political capital of the Zapotec state until the Xoo Phase of the Late Classic (AD 650-850), over 1300 years later (Marcus and Flannery 1996).

Early Excavations and Regional Survey

The Valley of Oaxaca is one of most intensively studied areas of primary state development and decline in the New World. Our knowledge of the Zapotec state comes from intensive excavation (and reconstruction) of the administrative core of Monte Albán, coupled with systematic survey of the capital's residential zones, extensive regional survey of the wider valley, and targeted excavations at regional political/administrative centers.

Early surveys and excavations by Mexican archaeologists Alfonso Caso, Ignacio Bernal, and Jorge Acosta provided the first systematic studies of Zapotec urbanism, writing, calendrics, and ceramic sequence. Between 1931 and 1958, Caso, Bernal, and Acosta conducted extensive excavations at Monte Albán and numerous other sites throughout the region. Based on this work, they defined five major periods (designated Monte Albán I-V) corresponding to differences in architecture and ceramics between Monte Albán's establishment and the colonial period. As their excavations progressed, the original five periods were continually modified, combined, or split, until publication of their definitive work on the subject, *La Cerámica de Monte Albán* (Caso *et al.*1967). Although some aspects of their sequence continue to be debated and revised, the end result was a basic chronological framework for documenting major changes in the socio-political dynamics of the area from the rise of Monte Albán to its decline.

In the 1960's, a burgeoning interest in the evolution of complex societies initiated a new period in Oaxaca archaeology. Under the auspices of the Oaxaca Human Ecology Project, Kent Flannery and Joyce Marcus (Flannery, ed. 1976; Marcus and Flannery, eds. 1983; Marcus and Flannery 1996) directed an ambitious multi-disciplinary project exploring the transition from hunter-gatherer lifestyles to an agricultural economy through excavations of archaic caves and early villages. This work culminated in excavations at San José Mogote (e.g. Flannery and Marcus 2005), an urban precursor of Monte Albán, and contributed greatly to our knowledge of Valley political dynamics in the centuries preceding the development the Zapotec state. In cooperation with this project, Richard Blanton, a student of Flannery, conducted an intensive survey of Monte Albán, using Caso, Bernal, and Acosta's ceramic typology to outline its development from founding to decline (Blanton 1978; Blanton *et al.* 1999:24). This work led directly to a comprehensive regional survey of the Valley in the late 1970s and 1980s.

During the Valley of Oaxaca Settlement Pattern Project, researchers mapped the regional distribution of settlements corresponding to each ceramic phase throughout the Valley. Survey crews mapped settlement distributions based on the remains of mounded architecture and artifact scatters on a field by field basis, assessing the density of artifacts at each location to estimate population size, and recording the range of ceramic types of different ceramics phases present in order to determine the sequence of occupation (Blanton 1978; Blanton *et al.* 1982; Feinman and Nicholas 1990; Kowalewski *et al.* 1989). The results were published as a series of settlement pattern maps for each ceramic phase that provide an overview of the dynamics of state development.

Following completion of the regional surveys, archaeologists renewed focus on excavation, with particular attention to the problems of state formation and decline and the Late Classic/Early Postclassic transition. As part of this agenda, excavations at key Late Classic secondary sites – including Jalieza (Casparis 2006; Elson *et al.* 2011), Lambityeco (Lind and Urcid 2010), Ejutla, El Palmillo (Feinman and Nicholas 2007a), and Macuilxóchitl (Faulseit 2013; Markens *et al.* 2008) provide important insights into economic and political developments outside of Monte Albán during this transitional period. By contrast, relatively little work has given attention to rural communities within the Valley of Oaxaca since the settlement surveys (but see Fargher 2004; Sherman 2005).

Table 2.1: Valley of Oaxaca Ceramic Chronologies. [1]Lind 1994, Markens 2008; 2010, Lind and Urcid 2010. [2]Caso, Bernal and Acosta1967. [3]Blanton 1978; Blanton *et al.* 1982; Kowalewski *et al.* 1989; Blanton *et al.* 1993. [4]Feinman and Nicholas 2011.

<table>
<tr><th>Year</th><th>Mesoamerican Period</th><th>Lind (1994) Phase Name[1]</th><th>CBA (1967) Period Number[2]</th><th>Settlement Survey Phase Number[3]</th><th>F and N (2011) Phase Number[4]</th></tr>
<tr><td rowspan="20">1400
1200
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800</td><td rowspan="2">Late Postclassic</td><td rowspan="2">Chila</td><td rowspan="6">Monte Albán V</td><td rowspan="4">Monte Albán V</td><td>Late Monte Albán V</td></tr>
<tr><td rowspan="4">Early Monte Albán V</td></tr>
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<tr><td rowspan="3">Monte Albán IV</td></tr>
<tr><td rowspan="3">Late MA IIIB-IV</td></tr>
<tr><td rowspan="3">Late Classic</td><td rowspan="2">Xoo</td><td rowspan="2">Monte Albán IIIB-IV</td></tr>
<tr><td rowspan="3">Monte Albán IIIB</td></tr>
<tr><td>Peche</td><td>Transición IIIA-IIIB</td><td rowspan="2">Early MA IIIB-IV</td></tr>
<tr><td rowspan="2">Early Classic</td><td rowspan="2">Pitao</td><td rowspan="2">Monte Albán IIIA</td></tr>
<tr><td rowspan="2">Monte Albán IIIA</td><td rowspan="2">Monte Albán IIIA</td></tr>
<tr><td rowspan="5">Late Formative</td><td rowspan="2">Tani</td><td rowspan="2">Transición II-IIIA</td></tr>
<tr><td rowspan="3">Monte Albán II</td><td rowspan="3">---</td></tr>
<tr><td>Nisa</td><td>Monte Albán II</td></tr>
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<tr><td rowspan="2">Late Monte Albán I</td><td rowspan="2">---</td></tr>
<tr><td rowspan="4">Middle Formative</td><td rowspan="2">Danibaan</td><td rowspan="2">Monte Albán Ia</td></tr>
<tr><td>Early Monte Albán I</td><td>---</td></tr>
<tr><td>Rosario</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>Guadalupe</td><td>---</td><td>---</td><td>---</td></tr>
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Overview of the Rise and Decline of the Zapotec State

The Valley of Oaxaca was home to settled agriculturalists as early as 1700 BC and ranked, chiefdom level polities by 1200 BC, but until the Rosario Phase of the Middle Formative (700 – 500 BC) communities remained relatively small and autonomous. Around this time, villages began to be consolidated under competing pre-state polities centered in each arm of the Valley. In the Etla Subvalley, the village of San José Mogote grew to an estimated 1,000 persons and presided over 18-23 villages. In the Valle Grande, the site of El Mogote presided over several small villages. In the Tlacolula Subvalley, Yegüih was the largest village. An 80 km^2 settlement-free buffer-zone was maintained between the three polities (Marcus and Flannery 1996:93-158), and for 200 years, a kind of détente was maintained between them.

During the Danibaan Phase of the Middle Formative (or Early MA I; 500 – 250 BC), many communities in the Etla Subvalley, including San José Mogote, were suddenly abandoned and a new urban center was established in the buffer zone at Monte Albán. Constructed at the top of a 400 m high, virtually waterless mountain, Monte Albán grew rapidly from about 5,000 people at the beginning of the Danibaan Phase to over 17,000 by the Pe Phase (Late MA I; 250 BC to AD 1) (Marcus and Flannery 1996:138-145). But political consolidation of the Valley of Oaxaca did not immediately follow the establishment of Monte Albán. For a time, rival polities in the Tlacolula Subvalley and Valle Grande maintained their independence, even as Monte Albán's sphere of influence grew larger. Monte Albán first expanded outside the Valley of Oaxaca, taking control over the Cuicatlán Cañada to the north and Sola Valley to the south (Balkansky 2002; Marcus and Flannery 1996; Spencer and Redmond 1997, 2001; Spencer *et al.* 2008). Only after three centuries of territorial expansion was Monte Albán able to consolidate political control within the Valley (Marcus and Flannery 1996:172-175), where the population expanded considerably and settlements were able to move from the piedmont to less defensible positions on the valley floor (Kowalewski *et al.* 1989). Outside of the Valley, the state continued to expand through the Late Formative, eventually encompassing much of the present-day state of Oaxaca (Marcus and Flannery 1996:197-208).

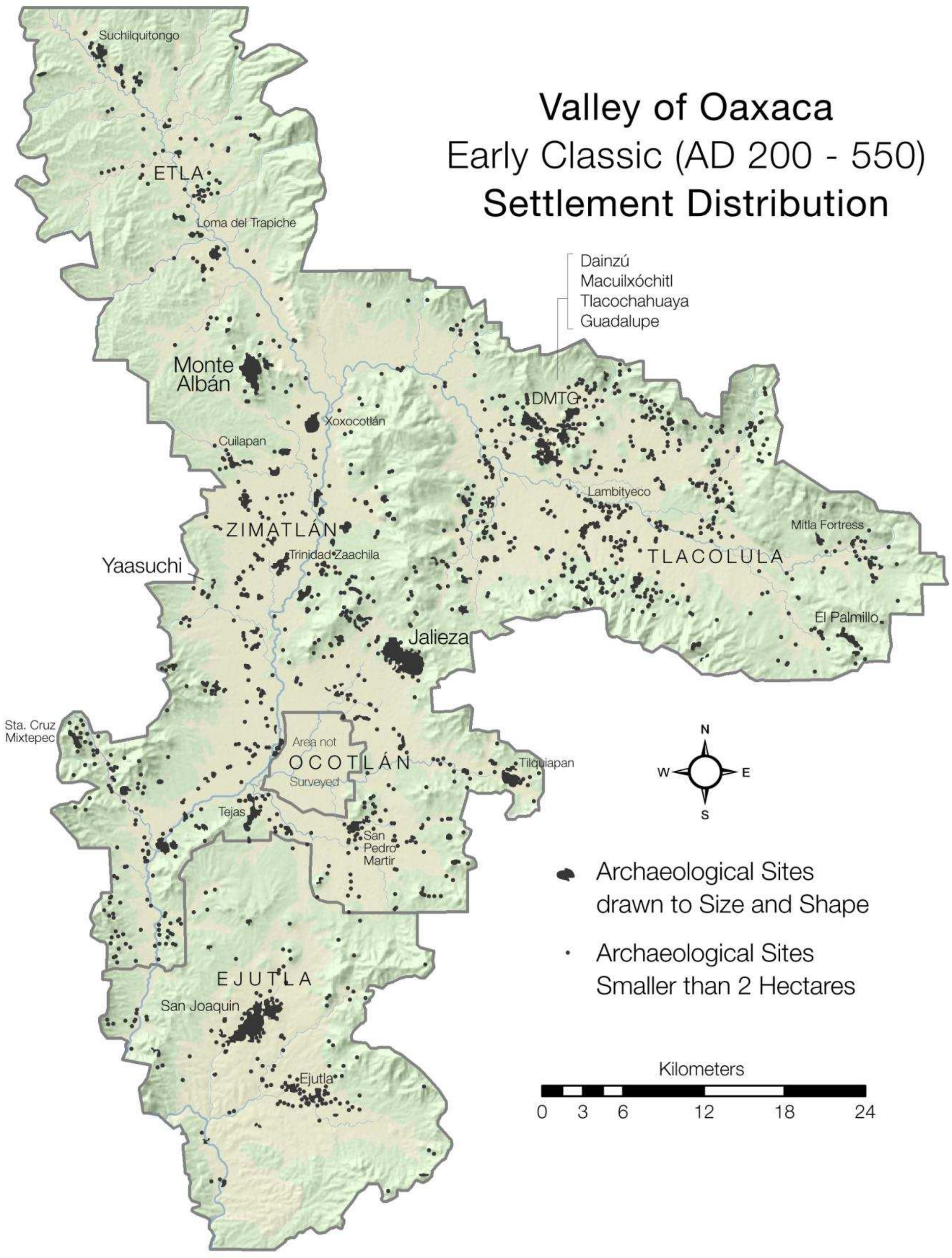

Figure 2.2: Early Classic settlement distributions in the Valley of Oaxaca. Adapted from Kowalewski *et al.* (1989: Map 5) and Feinman and Nicholas (1990: Figure 10).

Marcus and Flannery (1996) have referred to the subsequent period of the Early Classic (MA IIIA; AD 350 – 550) as the "Golden Age" of the Zapotec state. During this period, Monte Albán developed into major regional power with all the markings of a mature state, including a four-tiered settlement hierarchy, elaborate elite residences and tombs, administrative complexes, and multi-roomed temples (Flannery 1998). Within the Valley, the distribution of Zapotec iconography and ceramics was more uniform than any other period, suggesting that for the first time, the entire Valley was unified (Kowalewski *et al.* 1989). However, a lack of Zapotec ceramics and iconography outside the Central Valley system suggests that territory in many formerly affiliated areas was lost or ceded; Monte Albán's influence appears to have contracted to an area encompassing the Valley of Oaxaca, Ejutla, the Sola Valley, and the surrounding mountain regions (Lind and Urcid 2010: 326-327; Feinman and Nicholas 1990; Balkansky 1997).

Within the Valley of Oaxaca, settlements multiplied and the population more than doubled, possibly due to immigration to the area from areas that had previously been under Monte Albán's control (Balkansky 1998:478-479). Development favored the piedmont zone over the valley floor and many sites were built with defensive structures (Elam 1989; Feinman and Nicholas 1990; Kowalewski *et al.* 1989). In addition, a number of large centers emerged within the Valley that rivaled Monte Albán in population. Settlement surveys show Monte Albán, Jalieza, and a cluster of sites in the Tlacolula arm dubbed the DMTG complex (Dainzú-Macuilxóchitl-Tlacochahuaya-Guadalupe) forming an equilateral triangle roughly 20 km apart, each presiding over a different sector of the Valley (Figure 2.2; Kowalewski *et al.* 1989: Map 5; Feinman and Nicholas 1990: Figure 10). Monte Albán's population remained the greatest at 16,500 (Kowalewski *et al.* 1989:227), but the size/rank disparity between centers was greatly reduced over previous periods (Balkansky 1998).

During the Late Classic (MA IIIB-IV; AD 550 – 850), the populations of both Monte Albán and the Valley grew to unprecedented levels and monument construction at Monte Albán reached its peak (Blanton 1978; Kowalewski *et al.* 1989; Lind and Urcid 2010:326). But by the end of this period, the population of Monte Albán had begun to decline, monument construction ceased, and rival political centers arose or broke away from its control elsewhere in the Valley (Blanton 1978; Winter 2003). By the Late Postclassic (AD 1250 – 1521), political power in the Valley was divided among a multitude of small, autonomous city-states (Blomster, ed. 2008). Understanding the political and economic causes and consequences of this change have been some of the most contentious issues in Oaxaca archaeology since Caso, Bernal, and Acosta defined MA IIIB-IV as the Classic-Postclassic transition.

The Valley of Oaxaca during the Late Classic

The cessation of monument construction at Monte Albán toward the end of the Late Classic has historically been considered the event signaling the decline of the Zapotec state (Blanton 1978:103; Blanton *et al.* 1993:104-105). Most scholars now agree that collapse was not an event, but a gradual rebalancing of power as the state fragmented into competing, autonomous, sub-regional polities over perhaps hundreds of years (Balkansky 1998; Blanton *et al.* 1993; Flannery and Marcus, eds. 2003[1983]; Kowalewski *et al.* 1989; Winter 2003). Until recently, our view of the changing political dynamics of the Valley beyond Monte Albán has been hampered by ambiguities in the regional ceramic sequence. Recent progress toward the resolution of this issue (Markens 2008; Martinez Lopez *et al.* 2000) has permitted renewed inquiry into the nature of the Classic/Postclassic transition.

Again, much of our knowledge of this time period comes from the settlement surveys. One of the survey researchers' principal interests was documenting changes in settlement size, density and distribution in the periods leading up to and following the decline of Monte Albán. Caso, Bernal, and Acosta had defined Periods IIIB and IV based on the cessation of monument construction at Monte Albán. Unfortunately, ceramics from the two periods were virtually indistinguishable, and in *La Cerámica de Monte Albán* (1967), they were forced to combine them into a single period they designated Monte Albán IIIB-IV. At the time of the surveys however, researchers believed that sites dating to the Late Classic (MA IIIB) and Early Postclassic (MA IV) could be distinguished based on the presence of a few key ceramic markers found at Lambityeco, a site thought to post-date the cessation of monument construction at Monte Albán (Blanton *et al.* 1982; Blanton *et al.* 1993; Kowalewski *et al.* 1989; Paddock 1983). In order to achieve a finer chronological resolution for the period of Monte Albán's apogee and decline, researchers of the Valley of Oaxaca settlement surveys eliminated the transitional Monte Albán IIIB-IV ceramic period proposed by CBA (1967), breaking it into Monte Albán IIIB and IV (Blanton 1978; Blanton *et al.* 1982; Kowalewski *et al.* 1989).

The result was a puzzling series of settlement pattern maps for the Classic and Early Postclassic that appeared to show cycles of abandonment and migration between different sectors of the Valley between MA IIIA, IIIB, and IV (Kowalewski *et al.* 1989: Maps 5, 6, and 7) Between the Early (IIIA) and Late Classic (IIIB), the maps showed an apparent depopulation of the Tlacolula and Zimatlán-Ocotlán Subvalleys and a wholesale movement of the Valley's population to the Etla Subvalley. The combined population of Greater Monte

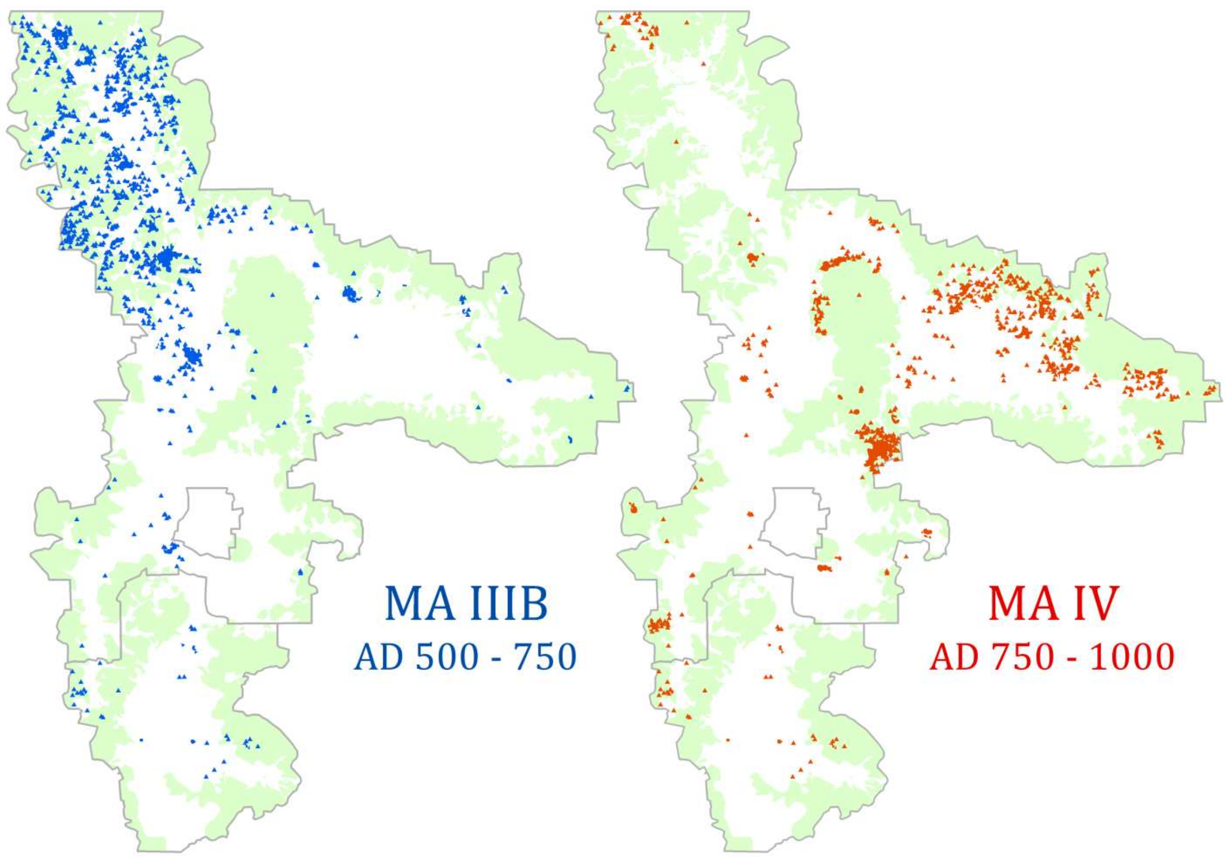

Figure 2.3: Generalized settlement distributions for MA IIIB and MA IV as mapped during the Valley of Oaxaca Settlement Surveys. Most researchers now recognize that these sites are largely contemporaneous within the Late Classic (AD 550-850). Adapted from Kowalewski *et al.* (1989: Maps 6 and 7) and Feinman and Nicholas (1990: Figure 11).

Albán (including Atzompa, El Gallo, Monte Albán Chico, and other sites) reached a peak of 24,000, but at a regional scale, populations seemed to decline radically as communities in the Tlacolula, Ejutla, and Zimatlán-Ocotlán Subvalleys evaporated, including Jalieza, the DMTG Complex, and San Joaquin (Figure 2.3; Feinman and Nicholas 1990: Figure 10; Kowalewski *et al.* 1989: Map 6). Settlement pattern maps for the Early Postclassic (IV) showed an equally puzzling shift in population. This time, the Etla Subvalley appeared to be abandoned in favor of the Tlacolula and Zimatlán Subvalleys. Monte Albán's population appeared to plummet to 4,000, while populations at Jalieza and the DMTG Complex resurged to new heights. With an estimated population of 16,000, Jalieza now appeared to be the largest center in the Valley (Figure 2.3; Feinman and Nicholas 1990: Figure 11; Kowalewski *et al.* 1989: Map 7).

The publication of these results was met with immediate criticism. A reevaluation of radiocarbon dates from Lambityeco (Winter 1989) showed that the ceramic markers used by the Settlement Pattern Project to distinguish MA IV from MA IIIb dated to the Late Classic and did not post-date the decline of Monte Albán. Lind (1991) argued that continued use of Caso, Bernal, and Acosta's (1967) chronology could only lead to additional confusion as phase numbers continued to be recombined or split. To address this issue, he proposed a new series of phase names loosely corresponding to the Monte Albán sequence. In this chronology, MA IIIB and IV were combined to form the Xoo Phase (AD 650 – 850) and MA V was broken into the Liobaa Phase (AD 850-1200) and the Chila Phase (AD 1200-1521). Earlier phases largely corresponded to those defined by Caso, Bernal, and Acosta (Martinez López *et al.* 2000; Markens 2004, 2008). This chronology was bolstered by the development of a refined ceramic sequence with improved age estimates for each phase developed through a seriation of ceramics from dated contexts spanning the Classic and Postclassic Periods (Markens 2004, 2008, Markens *et al.* 2010; Martinez López *et al.* 2000).

Using similar data, Feinman and Nicholas (2011b) have proposed a series of phases that largely correspond to those outlined by Markens (2010) but using Caso, Bernal, and Acosta's nomenclature. A principal difference is that the Late Classic is divided into two phases – Early MA IIIB-IV (AD 500 – 650) and Late MA IIIB-IV (AD 650 – 900) – based on the relative abundance of Early Classic and Early Postclassic ceramics in MA IIIB-IV contexts. Under Markens' (2010) chronology these phases roughly correspond to the Peche (AD 550 – 650) and Xoo Phases (AD 650 – 850). While Feinman and Nicholas (2011b) make compelling arguments for the continued use of Caso, Bernal, and Acosta's nomenclature, and the dates used in their chronology are well-supported, critical/diagnostic changes in the ceramic sequence differentiating their proposed phases have not yet been described in detail. All ceramic chronologies discussed in this section are summarized in Table 2.1.

Evidence for the Fragmentation of the Zapotec state

As it became clear that the ceramic markers used in the settlement surveys to define the Early Postclassic actually dated to the Late Classic Period, the survey model of sub-regional declines, resurgences, and population shifts was largely abandoned (Feinman and Nicholas 2011b; Flannery and Marcus, eds. 2003[1983]:x; Lind 1991; Lind and Urcid 2010:18-19; Winter 1989). In its place, some have suggested simply combining the MAIIIB and IV settlement pattern maps to form a single MAIIIB-IV settlement pattern map revealing the Late Classic occupation of the Valley of Oaxaca (Figure 2.4) (Kowalewski *et al.* 1989:251-254; Lind and Urcid 2010:18-19; Flannery and Marcus 2003[1983]:x; cf. Feinman and Nicholas 2011b). This revised map shows three qualities of Xoo Phase settlement patterns that Balkansky (1998) has argued demonstrate the fragmentation of the Zapotec state: (1) the apparent parity in size between Monte Albán and Jalieza, and Macuilxóchitl-Tlacochahuaya, reflecting the rise of important secondary centers; (2) the predominance of piedmont settlement, possibly indicating a preference for more defensible site locations in a politically contentious landscape; and (3) sparse occupation of large areas of land between settlement clusters, possibly representing the presence of areas of "no-man's land" between competing or conflicting polities.

A closer look at population estimates for Monte Albán lends some support to the argument for increasing population parity between it and other centers. During the Xoo Phase, Monte Albán would have remained the largest settlement in the Valley, but its oft-cited population of 24,000 (Kowalewski *et al.* 1989) may be overstated. This figure represents a combined estimate for Monte Albán, Atzompa, El Gallo, Monte Albán Chico,

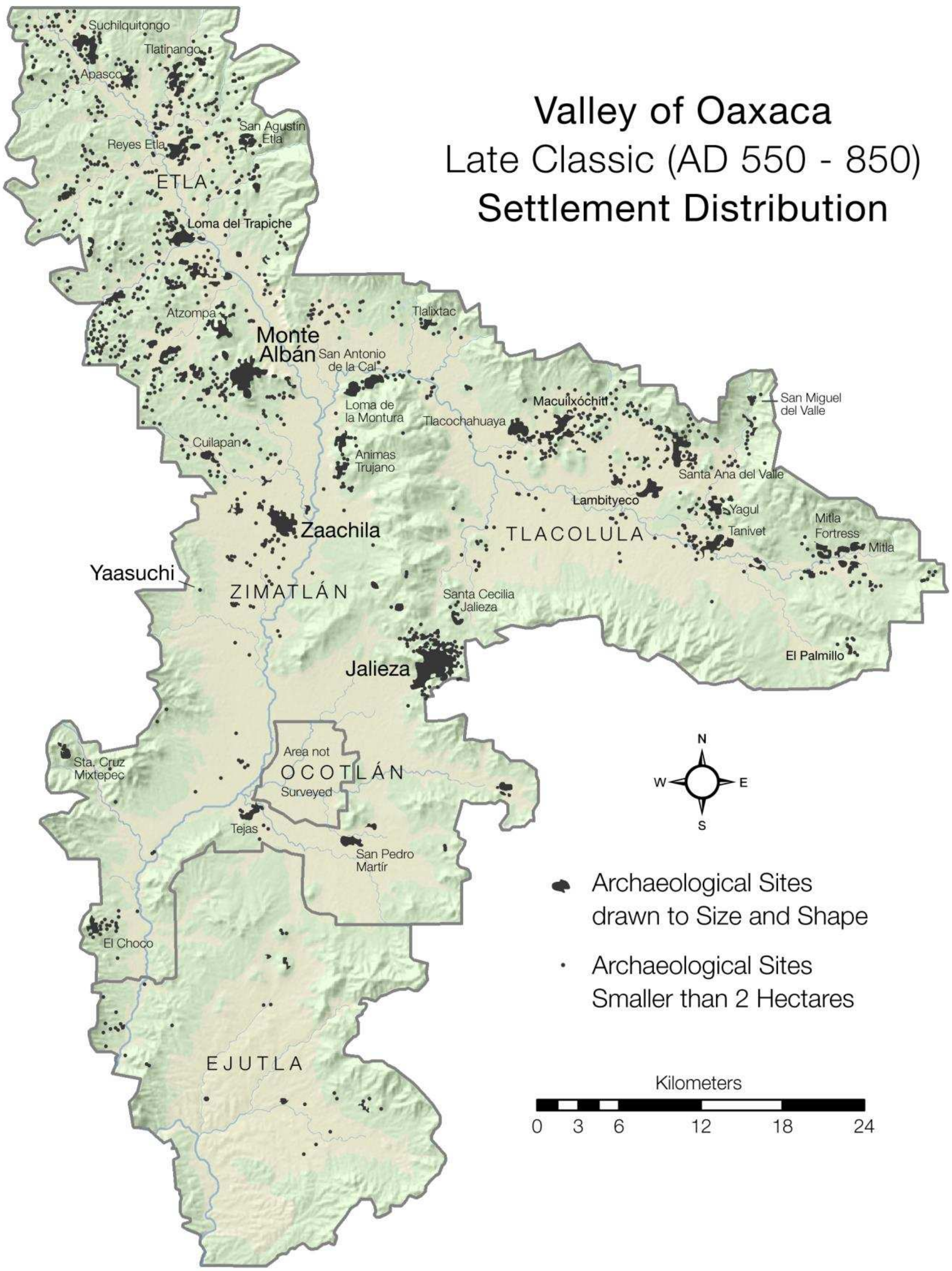

Figure 2.4: Late Classic settlement distributions in the Valley of Oaxaca. Adapted from Kowalewski *et al.* (1989: Maps 6 and 7) and Feinman and Nicholas (1990: Figure 11).

and a number of other sites in the vicinity of the mountain (Blanton 1978; Winter 2003). Insofar as this is the only site among those surveyed for which the population estimate is a combined figure for a number of discontinuous settlements, this figure overstates the size of Monte Albán proper relative to other sites, an historic artifact of the area being mapped separately from and prior to the rest of the Valley (Blanton 1978). Atzompa and Monte Albán occupy neighboring hilltops, but greater than two kilometers separate the occupational limits of the two cities. No other settlements separated by such a distance are combined in the survey reports. When the mean population estimates for Atzompa and the other discontinuous settlements are removed from Monte Albán's estimated population, its size falls to about 16,800. This is comparable to Jalieza's estimated Late Classic population of 16,000, making the cities appear nearly equal in rank when considering population alone. If only the population of Atzompa is removed, the estimated population for the Greater Monte Albán area is still only about 19,000.

On the other hand, there remain two important differences between Monte Albán and Jalieza that indicate a substantial contrast in site function during the Late Classic. First, the volume of mounded architecture at Monte Albán (833,200 m^3, excluding Atzompa) grossly exceeded that of Jalieza (33,700 m^3) (Blanton 1978; Kowalewski *et al.* 1989). This is partially due to Monte Albán's longer occupational history, but while Jalieza ranked second in the Valley in terms of population, it ranked *twelfth* in terms of mound volume. Jalieza appears to have had "no administrative core" but was rather a dispersed settlement of residential terraces (Kowalewski *et al.* 1989:118-119). Secondly, settlement density in the vicinity of Jalieza is extremely sparse relative to other areas of the Valley. Whereas Monte Albán was flanked by a number of large communities with high volumes of mounded architecture, the area surrounding Jalieza appears to have been barely inhabited (Figure 3.4). If Jalieza managed to achieve a degree of political independence during the Late Classic, it appears to have done so without becoming a major administrative center or governing substantial populations within its immediate hinterland.

Another potential indicator of Late Classic political instability is the predominance of piedmont settlement. Figure 2.4 shows that during this period, a majority of settlements were moved to hilltop or ridgeline positions. Jalieza was moved to a ridgeline overlooking both the Ocotlán and Tlacolula Subvalleys (Elson *et al.* 2011; Finsten 1995), Settlement at Macuilxóchitl was concentrated on Cerro Danush (Faulseit 2013, 2014), and many sites on the valley floor, such as Ejutla, fell into decline (Feinman and Nicholas 1990). Some large valley floor settlements experienced their heyday during the Late Classic – most notably Reyes Etla, Lambityeco and Zaachila – but these cases were an exception to the rule. It is tempting to speculate that this change reflects an increased need for defensible positions, but there is currently no direct evidence for conflict or warfare within the Valley during the Xoo phase. Conceivably, communities like Jalieza may have been constructed at hill-top sites for ideological, religious, or even aesthetic reasons (Spores and Balkansky 2013:76-77); thus, their elevated positions alone do not indicate conflict or political independence.

With regard to the third line of evidence, an examination of Late Classic settlement patterns reveals that not only are the majority of settlements located in the piedmont zone, hilltop positions, or on Valley margins, they are clustered in nucleated groups separated by broad areas of unsettled territory (Figure 2.4). Compared to settlement patterns for the Early Classic, the southern valley arm (including the Zimatlán, Ocotlán, and Ejutla Subvalleys) appears especially depopulated. SUBThe principal communities in this area (Zaachila and Jalieza) are separated by wide areas of empty land and lack a regular settlement hierarchy of dependent communities. In the Tlacolula Subvalley, the area south of the Río Salado is almost wholly depopulated while to the north, smaller buffer zones separate settlement clusters organized around Macuilxóchitl, Lambityeco, Yagul, and Mitla. These unoccupied spaces could be interpreted as "no-man's lands" between competing city-states, but the breaks between settlement clusters are discontinuous and the largest settlements are those that are closest to Monte Albán (Lind and Urcid 2010:35-40). Like hilltop settlement, it is tempting to view these unoccupied areas of land as evidence of uneasy relationships between increasingly autonomous, competing polities, but again, there is no direct evidence for conflict during the Late Classic.

In addition to the settlement data, perhaps the most convincing line of evidence for the increasing autonomy of Late Classic Zapotec communities is the widespread appearance of so-called "genealogical registers" (Marcus 1983). Genealogical registers have been found at nearly 20 Late Classic centers, including Monte Albán, Zaachila, Noriega, Suchilquitongo, Xoxocotlán, and El Palmillo. Most are small stone monuments depicting elite marriage ceremonies accompanied by lists of ancestors that would have been displayed privately within elite tombs or residences, but similar themes are expressed in the plaster altar friezes of Mound 195 at Lambityeco. In their emphasis on local elite lineages and marital alliance, the genealogical registers are explicitly concerned with establishing the legitimacy of individual elite lineages outside of Monte Albán (Feinman 1999; Feinman and Nicholas 2011b; Blanton *et al.* 2003:277). When paired with (1) the curtailment of public monument construction, especially at Monte Albán; (2) the increasing size and importance of secondary centers; and (3) a shift in monumental architectural styles away from public plazas toward enclosed elite residential complexes (Feinman 1999), the registers suggest an increasing need or ability for local elites to strive for power in a changing political landscape,

The Timing of State Decline

One major question still puzzling archaeologists is the timing of Monte Alban's decline and the degree to which the Valley remained politically integrated throughout the Late Classic. Current views of the decline of the Zapotec state fall into three camps: (1) models arguing for early dissolution of the Zapotec state (Balkansky 1998); (2) models of Late Classic growth and decline that end in a radical depopulation of the Valley in the Early Postclassic (Winter 2003; Lind and Urcid 2010) and (3) models of gradual political reorganization of the Valley into autonomous city-states, some of which persisted until contact (Balkansky 1998; Blanton *et al.* 1999; Faulseit 2013; Feinman and Nicholas 2011b).

Researchers in the first camp argue for an early decentralization of Valley political authority, associated with a period of increasing political instability as secondary centers within the Valley began to assert a degree of political and economic autonomy. Balkansky (1998; Spores and Balkansky 2013:72-76) has argued that political fragmentation of the Zapotec state may have begun by AD 550, two or three centuries prior to the abandonment of Monte Albán. Thus, the Classic would have been a period of conflict and political instability as rival centers tried to break away from Monte Albán's control and were forcibly re-integrated. He suggests that the region remained consolidated under a unified

Zapotec state through the Early Classic, but Monte Albán increasingly competed for administrative influence with Jalieza and the DMTG complex, its status ultimately reduced to "first among equals" (Balkansky 1998:480). Blanton *et al.* (1982:92-95) argued that this decentralization of political authority may have been an administrative response to the problem of settlement expansion and population growth, but it also may have provided a foundation for the political fragmentation of the Zapotec state at the onset of the Late Classic (Balkansky 1998).

Contrary to this view, researchers in the second and third camps continue to place the dissolution of the Zapotec state closer to the traditional Classic/Postclassic transition (Blanton *et al.* 1993; Blomster 2008; Feinman and Nicholas 2011b; Flannery and Marcus 1983; Kowalewski *et al.* 1989; Lind and Urcid 2010).

Researchers in the second camp propose simply combining the Monte Albán IIIB and IV settlement survey maps to form a single new settlement map for the Xoo Phase of the Late Classic (Lind and Urcid 2010; Martínez López *et al.* 2000). In this model of Valley political development, the entire Valley remained occupied and populations continued to grow until the Early Postclassic. While this approach offers a simple solution to the problem of Late Classic settlement patterns, it creates a gap in the occupational history of the Valley during the Early Postclassic. This supports a view of regional population collapse during the Liobaa Phase of the Early Postclassic (AD 850 – 1200), but contradicts evidence from stratigraphic excavations and intensive survey at a number of sites, including Macuilxóchitl (Faulseit 2103; Markens *et al.* 2008), El Palmillo, and Mitla Fortress (Feinman and Nicholas 2011a), as well as smaller sites such as Gaii Guii (Fargher 2004).

Representative of the third perspective is the work by Feinman and Nicholas (2011a; 2013), whom propose a more nuanced demographic history for the Valley that builds upon their experience with the settlement surveys as well as data garnered from their excavations at Ejutla, El Palmillo, and Mitla Fortress. In this model, the settlement diagrams for Monte Albán IIIB and IV are again combined to show maximal potential population densities during a phase they call Early Monte Albán IIIB-IV (AD 500-750). Their diagram for the following phase, Late Monte Albán IIIB-IV, reflects the differential decline of various centers throughout the Valley. Rather than showing a wholesale depopulation of the region, it shows continued occupation throughout the Valley, albeit at reduced levels in some areas. Current evidence suggests that some sites, including Monte Albán (Winter 2003), Jalieza (Elson *et al.* 2011), and Lambityeco (Lind and Urcid 2010) were largely abandoned by AD 750-800, while others, including Macuilxóchitl (Faulseit 2013), Mitla Fortress, and El Palmillo (Feinman and Nicholas 2007, 2011a), continued to be occupied into the Early Postclassic. Population densities for this phase are thus shown as declining in the central and Etla areas of the Valley while remaining high in other regions (Feinman and Nicholas 2011b:266-269).

In summary, although not well understood, the Late Classic represents a period of substantial change in political dynamics in the Valley of Oaxaca. Most scholars agree that (1) during the Late Classic the population of Monte Albán both peaked and began to decline; (2) by the end of the Late Classic the Valley was no longer politically unified; and (3) this fragmentation of regional authority initiated a period of political reorganization or decline (Winter 2003; Blanton *et al.* 1993; Balkansky 1998; Lind and Urcid 2010; Feinman and Nicholas 2011b). A key lingering issue is the degree to which the Valley remained economically integrated through the Late Classic.

An Economic Perspective on the Late Classic Zapotec State

As is clear from the discussion above, despite decades of extensive study, there is little consensus regarding sociopolitical developments in the Valley of Oaxaca during the Late Classic. This study addresses the corollary question of the degree of economic interaction and integration, specifically from the perspective of market exchange. In many archaic states, market exchange forms the primary mechanism linking producers and consumers, articulating flows of both agricultural and basic craft goods. While we generally assume that a market system has invariant properties that distinguish it from other modes of economic organization, the structure of market systems vary with differential consequences for the economic integration of rural communities (C. Smith 1977; see next chapter).

Over the past thirty years, a number of models of Late Classic economic organization have proposed for the Valley of Oaxaca. In contrast with archaeological models of the economy proposed for other areas of the world – even elsewhere in Mesoamerica – market exchange has been an important component of most economic models proposed for Late Classic Oaxaca. Other major mechanisms for the transfer of goods, such as tribute and redistribution, have typically been down-played or rejected by researchers working in the area. Nevertheless, our view of the Late Classic economy has radically changed as research has progressed. Two major economic models have been proposed for this period: the first represents a regional perspective derived from the survey data; the second a series of community perspectives derived from subsequent excavations at a number of Late Classic centers.

A Regional Perspective on the Late Classic Economy

The first systematic treatments of the organization of production and exchange in the Valley of Oaxaca were a product of the regional settlement surveys (Blanton *et al.* 1982, 1993; Feinman 1980; 1982; Feinman *et al.* 1984; Finsten 1983; Kowalewski *et al.* 1989, 1990). Researchers involved in the settlement surveys examined changes in the economic organization of the Valley between the Early Formative and Late Postclassic on two fronts: (1) changes in land use and settlement distributions; (2) changes in the organization of craft production and exchange. Based on these two lines of evidence, they argued that Monte Albán had been founded as a disembedded capital serving a primarily administrative function (Blanton 1976, 1978), but that by the Late Classic, it served as both a political and commercial center exercising a high degree of control over the production and distribution of craft goods (Blanton *et al.* 1982; Feinman 1982). In this model, the Monte Albán administrative apparatus did not initially control most aspects of the economy. Rather, increasing demand for staple goods from the growing city and other urban communities encouraged the development of full-time craft specialists, concentrated first in a few villages, then primarily in urban centers, as a means of attracting much-needed agricultural produce into these centers. The result was an increasing division of labor between urban and rural areas, articulated through the development of a regional market system (Feinman *et al.* 1984). Both lines of evidence for this argument will be discussed below.

Commerce was not thought to be a principal function of Monte Albán during early periods of its development for one reason: it was constructed at the top of a 400m mountain above an area with relatively low agricultural potential. Given its geographic centrality, this mountain would have been a prime location for administrative oversight of the Valley during early stages of state development, but the location was ill-suited as both a market destination and as a center of agricultural production. Comparisons of population distribution to agricultural productivity showed that from its founding, Monte Albán could not have produced a sufficient quantity of produce to supply its population (Kowalewski 1982; Nicholas 1989). During the Late Classic, the population of the greater Monte Albán area approached 24,000 to 30,000 people. Nicholas (1989) estimated that a resource acquisition zone 12 to 16 kilometers in diameter would have been required to supply the city with sufficient food during this time.

Feinman *et al.* (1984:173) argued that rural households could have responded to this increase in demand for agricultural produce in several ways, including: (1) increasing family size to expand the household labor force; and (2) adopting a two-crop farming strategy where produce was grown both during the wet and dry season. Expanding the amount of land under cultivation would have become more problematic as populations continued to grow. As the amount of time devoted to agricultural production increased, rural families would have had less time to allocate to the production of craft goods. At the same time, the riskiness of piedmont farming and decreasing availability of land, especially near the administrative core, would have encouraged households in some communities to specialize in craft production as a secondary source of income. By the Late Classic, craft production would have been a full-time occupation for many households, especially in larger centers such as Monte Albán. The growing division of labor between agricultural and craft producers would have encouraged the development of a market system as an efficient means of moving goods between households and communities across the Valley (Feinman *et al.* 1984).

By itself, this perspective is consistent with a commercial model of economic development, in which "increases in specialization and exchange are seen as an integral part of the process of spontaneous economic growth" (Brumfiel and Earle 1987:1). As the economy grows, individuals are able to take advantage of the efficiencies offered by specialized production and exchange, gradually leading to a diversification of labor and social complexity. Proponents of these models assume an economic system characterized by (1) an elaborate division of labor in the production of both utilitarian and luxury goods; (2) a regional exchange system serving both elite and commoner populations; and (3) a relative absence of intervention from political elites. Researchers involved in the settlement surveys began to suspect, however, that there was substantial evidence for an increase in administrative involvement in the economy during the Classic Period.

To assess the degree of administrative involvement in the organization of craft production and exchange, Feinman (1982) examined changes in the diversity, standardization, and distribution of ceramics throughout the Valley for all periods. Ceramics were selected as a material of interest because of their durability, ubiquity, and chronological sensitivity. Feinman (1982) used five measures to address the degree of administrative involvement in ceramic production from the Formative through the Late Postclassic: (1) the scale and concentration of ceramic production; (2) the loci of production as identified from the presence of wasters and high concentrations of a single ceramic type; (3) the standardization of goods, in terms of form, finish, and size; (4) the diversity of wares; and (5) the degree of product investment. It was assumed that given a highly administered production system, that pottery would be manufactured in larger facilities concentrated in administrative centers. Increases in the scale of production and lower competition would have allowed producers to minimize costs by reducing labor investment and standardizing production (Feinman 1982:181-182).

The results of Feinman's analyses seemed to show that during the Late Classic (MA IIIB), Monte Albán shifted from being a purely administrative center to being the center of Valley economic activity as well (Feinman 1982). Evidence for this transition included:

(1) Direct evidence for ceramic production at Monte Albán, including a large concentration of ceramic production debris at the Atzompa *"barrio"* and Winter and Payne's (1976) excavation of two kilns associated with a Monte Albán residence;
(2) A lower diversity of vessel types than any other period, especially in non-administrative centers and in piedmont communities adjacent to Monte Albán;
(3) Late Classic ceramics appeared to be highly-standardized, low investment wares manufactured using a lower number of production steps in fewer paste types than any other period; and
(4) A relatively homogenous distribution of vessel forms across the survey region with no clear style zones, other than a greater prevalence of conical bowls with incipient bases, bolstered rims, or conical supports in the vicinity of Monte Albán.

The clear presence of ceramic production at Monte Albán and higher diversity of vessel forms in administrative centers seemed to indicate that ceramic production was concentrated in administrative centers. The simplicity, apparent standardization, and low diversity of vessel forms seemed clear evidence that they were mass-produced in centralized workshops. Finally, the homogenous distribution of vessel forms and lack of clear style zones seemed to indicate that ceramics were efficiently distributed across the survey region to a unified polity. Bowls with incipient bases or bolstered rims were taken as additional evidence of intensive production; their higher frequency near Monte Albán was again interpreted as evidence of mass-production in this area.

By contrast, Feinman's (1982) analysis of Early Postclassic (MA IV) ceramics appeared consistent with the view that the Valley had fragmented into a series of autonomous city-states during this period. Ceramics remained highly standardized and required even fewer production steps than MA IIIB vessels, suggesting that they continued to be mass-produced in administrative centers. Their distribution was more heterogeneous, however, suggesting discrete style zones surrounding Jalieza, Lambityeco, El Choco, and other settlement clusters. This seemed to indicate that the MA IIIB pattern of centralized ceramic production continued following the fall of Monte Albán, but that market zones had become more nucleated with the political fragmentation of the state, contracting to areas surrounding each political center.

We may recall however, that during the settlement surveys, Early Postclassic (MA IV) settlements were mapped using the presence of a few key ceramic markers identified at Lambityeco, a site now known to be contemporaneous with Monte Albán during the Late Classic (MA IIIB). Reviewing settlement pattern maps for the two periods (Figure 2.3), it now seems clear that rather than mapping temporal differences in the distribution of settlements, survey researchers mapped what was largely a spatial difference in the distribution of particular vessel forms, a possibility acknowledged by the survey researchers (Kowalewski *et al.* 1989:251-254). Thus, rather than being homogenously distributed across the Valley, Late Classic ceramics occur in two discrete style zones: one in the Central, Etla, and Zimatlán Subvalleys; the other in the Tlacolula Subvalley, Jalieza, and isolated sites at the Valley periphery. This would seem to indicate that, rather than a unified market system, substantial barriers to exchange were in place within the Valley during the Late Classic.

Community Perspectives on the Late Classic Economy

The survey model of Late Classic economic organization was further eroded following excavation of a number of Late Classic sites during the 1990's and 2000's. Survey researchers had argued that Late Classic ceramics were mass-produced in centrally-administered workshops based on two principal lines of evidence: (1) ceramics were highly standardized and manufactured using a minimal number of production steps; and (2) the loci of production identified during surveys were primarily located in sites with mounded architecture interpreted as administrative centers (Feinman 1982). Given these observations, it seems entirely reasonable to conclude that Late Classic ceramics were mass-produced. However, subsequent research has demonstrated that they were primarily manufactured at a smaller scale in domestic contexts (Balkansky *et al.* 1997; Feinman and Nicholas 2007a, 2012).

One of the difficulties facing survey researchers was the difficulty of identifying craft production facilities using surface survey. Ceramics are a case in point. While Prehispanic kilns are documented for the Valley of Oaxaca (Winter and Payne 1976), many, perhaps most Zapotec utilitarian ceramics may have been fired in pit kilns or open bonfires (Balkansky *et al.* 1997; Feinman *et al.* 1989; Feinman and Nicholas 2007a). Indeed, they are still made in this way in many Zapotec communities today (Mindling 2010; Stolmaker 1976). As the identification of such features in archaeological contexts is extremely difficult, the number of confirmed Classic ceramic production contexts is very low, and nearly all are in urban areas. Prior to the settlement surveys, only one Late Classic ceramic production location was identified through excavation in the Valley of Oaxaca. This consisted of two kilns associated with a low-status residence at Monte Albán (Winter and Payne 1976). A renewed focus on excavation and household archaeology following completion of the surveys yielded additional examples of pottery production in the form of pit kilns or surface concentrations of production debris at a number of Classic Period centers, including Ejutla (Balkansky *et al.* 1997; Feinman and Nicholas 2007a), Lambityeco (Lind 2008; Lind and Urcid 2010), El Palmillo (Feinman and Nicholas 2007a, 2012) and Macuilxóchitl (Faulseit 2012, 2013) – all of it associated with domestic terraces or residential structures. The majority of this evidence comes from excavations at larger secondary centers however, and it remains unclear whether domestic craft production was primarily an urban activity, or a ubiquitous household task. At the same time, no compelling evidence for large ceramic workshops has emerged.

As it became clear that Late Classic craft production was generally conducted at the household level rather than in centrally-administered workshops, the organization of craft production and exchange was reassessed. Most researchers now agree that household multi-crafting for exchange in regional markets was the predominant mode of production and exchange in Prehispanic Oaxaca (Balkansky *et al.* 1997; Balkansky and Crossier 2009; Blanton *et al.* 1999:99-100; Fargher 2007; Feinman and Nicholas 2007a, 2010, 2012; Lind and Urcid 2010). In this model, households would have engaged in multiple types of craft-production, often for domestic use, but some households would have also engaged in intensive production for exchange in regional markets. The strongest evidence for the latter may be found in high ratios of production debris to finished goods found in some households at a number of sites; clear evidence of production in excess of domestic needs

(Feinman and Nicholas 2007a, 2012). It is argued that household craft production, when coupled with access to a regional market network, would have been an effective means for households to supplement income, gain access to high status or exotic goods, or meet tribute demands (Balkansky and Croissier 2009; Feinman and Nicholas 2007a). For agricultural producers, it would have provided an important means of risk buffering and economic diversification, by providing a second line of income during periods of low agricultural productivity (Balkansky and Croissier 2009; Feinman 1986).

While most communities were able to produce a variety of goods, they were not economically independent. Ejutla, El Palmillo, and Lambityeco all evidenced manufacture of basic goods - ceramics, lithic tools, and textiles - to some degree (Balkansky *et al.* 1997; Feinman and Nicholas 2007a; Lind and Urcid 2010). But while households at each of these centers engaged in a variety of craft activities, each community specialized to a greater degree in the manufacture of particular goods. Ejutla was a key producer of shell ornaments, El Palmillo specialized in fiber processing and the production of chert tools (Feinman and Nicholas 2007a; Middleton *et al.* 2002), and Lambityeco specialized in salt production (Lind 2008; Lind and Urcid 2010). Again, high ratios of production debris to finished goods at these sites indicate surplus production for exchange. Excavations at Ejutla, for example, revealed an abundance of unworked or partially worked shell but very few finished shell ornaments, implying that these were exported to other centers (Feinman and Nicholas 2007). Furthermore, it is argued that the lack of evidence for state storage or redistribution centers, combined with the widespread occurrence of finished goods made from locally unavailable materials, indicates that production was not simply undertaken to meet taxation or tribute demands, but that these goods were redistributed through regional markets (Feinman and Nicholas 2011a). In this model, strong vertical and horizontal linkages between communities with different resources facilitated community product specialization and the efficient distribution of a range of goods through the regional market system. Again, this is consistent with a commercial model of economic development.

In contrast with this view, Lind and Urcid (2010) have argued that Monte Albán may have sought to control some aspects of the economy toward the end of the Late Classic.

This model is consistent with a broader set of models of economic organization that emphasize the role of elites. In this view, elite involvement in the economy is seen as primarily self-interested and any benefits for the populations they administer are incidental (Brumfiel and Earle 1987:3-4). Elites are seen as rational actors who consciously manipulate the organization of production and exchange to “create and maintain social inequality, strengthen political coalitions, and fund new institutions of control, often in the face of substantial opposition from those whose well-being is reduced by such actions” (Brumfiel and Earle 1987:3-4). Mobilization of goods from producers to political elites allows elites to finance new institutions of political control such as a military, tax collection, a judiciary, or law-enforcement (Brumfiel and Earle 1987:3).

Lind and Urcid (2010) argue that at the end of the Late Classic, Monte Albán may have sought to control production of certain goods in an attempt to reassert its hegemony over the Valley of Oaxaca in the decades prior to its decline. To support this view, they point to an apparent transition from household salt production to production in centralized workshops at Lambityeco immediately prior to its abandonment. They argue that this change in the organization of production was part of late-stage attempt by Monte Albán to co-opt salt production as a lucrative source of wealth and reassert its authority in an increasingly commercialized Tlacolula Subvalley. The competitive exchange environment described by this model is one in which Monte Albán’s status was reduced to “first among equals”, supporting Balkansky’s (1998) view that the Postclassic pattern of competitive city-states was in place by the Late Classic. Under such a system, the increasing autonomy of subject city-states would have been supported through trade of bulk prestige goods (such as salt) between centers of equal rank. If Monte Albán indeed attempted to reassert control at Lambityeco or elsewhere, it would have done so because the development of exchange linkages between these secondary communities granted local elites a potent source of political and economic power while undermining Monte Albán’s resource base (Lind and Urcid 2010:326-332).

It should be noted that Lind and Urcid’s (2010) model for the organization of production and exchange prior to Monte Albán’s meddling in salt production is otherwise in keeping with a commercial view of the Late Classic economy. Households in communities like Lambityeco took advantage of locally available resources to specialize to a greater degree in the production of goods for regional exchange, but the majority of craft production was conducted at the household level as a secondary source of income. Households at Lambityeco engaged in multiple types of craft production, including salt, textiles, and ceramics, but relied upon exchange with other centers to obtain chipped stone tools and groundstone (Lind and Urcid 2010:49-81). Based on survey data reported by Finsten (1983), they argue that the Tlacolula Subvalley was divided into a series of political/economic districts centered on Macuilxóchitl, Lambityeco, Yagul, and Mitla. Each district specialized to a greater degree in the manufacture of a given craft good according to local resource availability, but that the majority of craft production was confined to district centers. Districts would have been inter-dependent, exchanging bulk prestige goods such as salt between centers, but each district would have also had its own base of agricultural communities (Lind and Urcid 2010:40-47). This model echoes the urban-rural dependence scenario outlined by the survey researchers, but rural communities are tied more directly to nearby secondary centers. As in the survey model, rural households are primarily regarded as agricultural producers able to rely upon urban markets for access to finished craft goods.

Remaining Issues

While recent excavations have done much to clarify the organization of craft production in the Classic Period, the majority of this research has been conducted in larger, secondary centers, resulting in an emphasis on horizontal exchange linkages between communities of equivalent scale. Meanwhile, the economic role of rural communities has continued to be assumed, and little research has addressed the question of vertical exchange linkages between communities at a range of scales. Rural production and market participation is especially understudied, despite the prominent role it plays in most models of the Late Classic economy.

The above discussion highlights a number of other important issues. These include:

(1) What was the spatial scale and organization of market exchange? That is, was the valley integrated into a single system of market exchange centered on Monte Albán, or a series of sub-regional market zones organized around district centers?

(2) What was the relationship between the Monte Albán state apparatus and systems of production and exchange? Was the market system a commercial system, relatively free of state intervention, or is there evidence of direct state control?

(3) How was the organization of production and exchange affected by political developments and the increasing decentralization of political power?

Rural Market Participation

This work was initiated under the simple premise that in order to understand the political or economic organization of a state with an agrarian resource base, one must understand how rural households were integrated with the regional economy. While one of the hallmarks of a state-level society is a hierarchy of urban centers, the political and economic base of an agrarian state is agricultural production. The vast majority of people living in an agrarian society are peasant farmers, upon whom urban centers are dependent for a substantial portion of their staple goods (R. Hodges 1988:2). Cancian (1989:127) outlines three qualities distinguishing rural peasants from urban elites: (1) geographic separation; (2) political subordination; and (3) a capacity for self-sufficiency. On the one hand, he argues, peasants are poor, rural people primarily concerned with subsistence and the maintenance of their fields and communities. At the same time, they are vulnerable to wider political and economic conditions beyond their control. Market systems, in particular, may either benefit or repress rural communities, depending on how they constrain the relative market power of rural producers (C. Smith 1977). Peasants may rely upon market access as a source of additional income and outside goods (Hodges 1988:2), but they are also capable of self-sufficiency through subsistence production given unfavorable terms of exchange. The opposition of these qualities makes the economic behavior of rural households a sensitive indicator of broader economic conditions. Rural market participation is not a given, but is conditioned by market structure, access and incentives.

As noted above, one of the fundamental issues facing an agrarian state is how to mobilize staple goods from rural areas to urban centers. In modern and historic agrarian states, regional market systems are a common institution linking rural producers with urban consumers, and both urban and rural households tailor their production, consumption, and exchange choices to the economic options available given their place in the exchange network. Yet these market systems are rarely symbiotic relationships characterized by a balance of trade and perfect competition (Johnson 1970; C. Smith 1974). Rather, the structure of exchange systems may be manipulated to maintain or enforce dependencies between rural and urban communities, generally to the advantage of urban centers (Johnson 1970; Little 1987; C. Smith 1977). In these cases, the imbalances in market power between an urban core and rural periphery pose differential opportunities and constraints on households in each area, affecting their production and exchange decisions (Johnson 1970; Minc 1994:304-311; C. Smith 1976a).

Insofar as market exchange was a key integrative mechanism linking urban centers during the Classic period (Feinman *et al.* 2012; Feinman and Nicholas 2007a, 2012), it seems likely that it would have been one of the primary institutions linking urban centers to rural agricultural communities as well. Yet rural market participation has often been assumed rather than studied. In the changing political and economic climate of the Late Classic, it is not clear whether the structure of regional exchange networks served to mobilize staple goods from the rural hinterland to the state's urban core at Monte Albán, whether rural communities were primarily linked to nearby secondary or tertiary urban centers, or whether rural participation in regional markets was limited.

Defining the structure of an exchange network requires a regional analysis of relationships between sites on a continuum of scale from rural to urban. While substantial attention has been devoted to Formative rural communities and households in the Valley of Oaxaca (e.g. Drennan 1976; Flannery 1976; Whalen 1981; Winter 1972), most information on Classic Period rural communities has been gathered through regional surface survey

(Blanton *et al.* 1982; Fargher 2004; Kowalewski *et al.* 1989). While this data is useful for understanding site hierarchies, community sizes, settlement patterns, and the regional distribution of goods, it lacks the contextual information necessary for direct comparisons of the economic activities of rural and urban households (Hirth 2013:123-124). Furthermore, it glosses over the production and exchange decisions of individual households in favor of a regional or community-scale view of the economy. A closer examination of rural household economic strategies during the Late Classic may provide critical insight into the opportunities and pressures faced by peasant households during this period.

To explore rural economic behavior in Late Classic, Oaxaca, this study examines household domestic ceramics and ceramic production debris from the site of Yaasuchi, a small rural site roughly 16 km south of Monte Albán. During the Late Classic, the estimated population of Yaasuchi was only 115, making it the smallest community that has been subject to controlled stratigraphic excavation in in the Valley of Oaxaca from this time period (Sherman 2005:188-214). Excavations in the eastern portion of the site uncovered the remains of two Late Classic residential structures, as well as the remains of a surface firing feature used for the production of ceramic vessels.

The goal of this study is to determine through compositional analysis what ceramics Yaasuchi produced, whether these were produced for local use or regional exchange, and what ceramics Yaasuchi might have imported from other sites. As noted in the introduction, this research is part of a larger, collaborative project exploring the structure of Classic Period (AD 350 – 850) political and economic networks prior to the decline of the Zapotec state undertaken by the OSU Archaeometry Lab in cooperation with a number of researchers in the United States and Mexico whom have excavated in the area. As such, it benefits from access to a large database of compositional data from a large corpus of Late Classic ceramics and natural clays from the Valley of Oaxaca. Comparisons of the compositional data from the Yaasuchi material to that of this larger clay and ceramic database were used to determine the geographic provenance of the Yaasuchi material and assess the degree of regional market participation at the site.

As the only rural site included in this larger study, Yaasuchi provides a singular view of production, consumption, and exchange in Late Classic Oaxaca outside of an urban center. In the next chapter, I will outline a framework for the interpretation of patterns of ceramic production and procurement observed at the site.

CHAPTER III: RURAL CRAFT PRODUCTION, CONSUMPTION, AND EXCHANGE

> *"Peasants may be fully drawn into a market economy – dependent upon the market to price the goods they produce and consume and to price their factors of production – without obtaining the economic and other benefits supposedly following from market integration. They may just as easily become underdeveloped as developed. Thus, …it becomes increasingly irrelevant to ask* how much *peasants are integrated by or responsive to a market economy and increasingly relevant to ask* how *the market that structures their economy is instituted."*

C. Smith (1977:144)

Most models of the Late Classic economy continue to assume that households outside of urban settlements were primarily engaged in agricultural production, generating surplus staple goods in exchange for craft goods in regional markets. Addressing the validity of this model is not a simple matter of ascertaining the *degree* of rural market participation, but of interrogating *how* regional economic and political integration conditioned rural economic behavior. In this chapter, I will outline a framework for the interpretation of archaeological evidence for rural craft production and market participation. I begin with a broad discussion of the organization of craft production, follow this with a discussion of relationships between the organization of production and exchange, and then outline how differences in market organization affect the economic options and behavior of households in rural communities. I conclude with a series of alternative expectations for rural craft production, consumption, and exchange at Yaasuchi under three models of Late Classic market structure.

The Organization of Craft Production in Archaic States

Early definitional criteria for archaic states often included the development of full-time craft specialization and an elaborate division of labor (Wright 1977; Clark and Parry 1990). In some areas of the world, including Late Classic Oaxaca, the widespread use of simple, utilitarian ceramics, was initially taken as evidence of mass production and the development of full-time craft specialists (Feinman 1982). Yet vessels may be both simple and standardized without being mass-produced. At the same time, a lack of standardized wares does not necessarily indicate a lack of full-time specialists. It has since become clear that there was enormous variability in the organization of craft production in early states and that a shift from low intensity to high intensity production was not a universal phenomenon (M. Smith 2004). Craft production, like regional market systems, encompasses multiple alternatives. Important work by Cathy Costin (1991, 2000) clarified its dimensions of variability.

Dimensions of Craft Production

Costin (1991, 2000) argued that the organization of craft production could be described along a continuum of four independent parameters: intensity, density, scale, and context. *Intensity* is simply a measure of the relative amount of time devoted to the production of specialized goods (full vs. part-time) and reflects most closely what other archaeologists have meant by specialization (Costin 1991, 2001). *Density* refers to the concentration of production locations within a given area. Loci of production may be variously concentrated along a continuum of nucleated to dispersed. In some societies, craft production is aggregated within a small number of communities while in others it is distributed throughout all communities. The *scale* of production refers to the relative size of production sites. Craft production may be conducted at either a household level, in workshops, or in larger factories. Finally, *context* refers to the level of elite control or sponsorship of production. Craft producers may be independent, manufacturing their wares for domestic use or market exchange. Or, they may be attached specialists working in elite, government, or patron sponsored workshops. Wage labor in commercial settings is seen as independent rather than attached (Costin 1991, 2001). Of these dimensions, scale and intensity tend to be correlated. When craft production is conducted in domestic contexts, it tends to be on a part-time basis. When it is conducted in large workshops or at an industrial scale it tends to be a full-time operation (Rice 1987:270).

Dimensions of Craft Products

In many areas of the world it is uncommon for archaeologists to encounter the manufacturing facilities or workshops where craft production was carried out. The lack of such direct evidence for craft production requires that other lines of evidence be used to infer its organization. Another powerful line of evidence is the products of specialization themselves; the ceramic sherds, lithic debris, and other materials that comprise the assemblage of a site. The kind and quality of goods produced in a society with a regional market system are potent indicators of how producers responded to consumer demand (Arnold 1985:229-230; Minc 1994:305, 319). There are three dimensions of craft products that may be used as an additional line of evidence in our interrogation of the organization of production and exchange: product specialization, investment, and standardization (Minc 1994:305).

Product specialization refers to the degree to which craft production was limited to a particular good (Rice 1987:190-191). Producers may either limit their production to a single class of good, such as ceramic, or engage in multi-crafting (Shimada 2007), the diversified production of multiple classes or types of goods. Higher levels of product specialization typically reflect a greater intensity of production as producers seek to optimize the efficiency of the production process (Rice 1987:190-191). Under a regional market system it implies a high degree of economic integration: producers are only able to restrict production to a limited range of craft products because they have ready, consistent access to subsistence goods through the market (Plattner 1989a:203).

Investment refers to the amount of time, energy and/or raw materials used in the production of a particular good (Costin 1991:37). Goods can be produced on relative scales of simple to elaborate or low-quality to high-quality. The degree of product investment may sometimes reflect the intensity of production, with low-investment, simple goods indicating a higher intensity of production, but this is not always the case. In a society with a regional market system, investment is as likely to reflect producer's need to balance consumer demand with competition (Minc 1994:319-320). If demand is high and competition low, producers need not invest substantially in the production of a good to ensure sales. Conversely, if competition is high and demand limited, producers may invest additional care or labor in the manufacture of their products to differentiate them from their competitors and attract buyers.

Finally, *standardization* refers to a product's relative degree of homogeneity. Products may be assessed on a scale ranging from standardized to heterogeneous, as measured through their relative stylistic, dimensional, or compositional variability. Standardization implies a need for either efficiency or consistency in the manufacturing process (Rice 1987:202-203). As with investment, it is often taken to reflect the scale, density, or intensity of production (Costin and Hagstrom 1995), with a more standardized product frequently regarded as representing mass production. While sometimes true, this is not always the case. Stylistic uniformity may simply reflect the functional requirements of a product and compositional uniformity may merely reflect a low natural variability in raw materials (Arnold 2000; Costin and Hagstrom 1995). Under a market system, standardization may also reflect producers' strategies to attract and retain consumers under various competitive conditions. Given high competition and limited demand, production may be standardized within productive units to ensure consistency as a strategy for generating repeat sales.

Relationships between the Organization of Production and Exchange

Decisions about what to produce, where to produce, and how much to produce are affected by a number of political, economic, social, and environmental factors, but market conditions play an especially critical role in the organization of craft production in states with commercial economies. Minc (1994:306) identified three inter-related market factors affecting the organization of production and market participation: consumer demand, agricultural productivity, and the organization of the market system. Of these, the organization of the market system emerged as the most crucial. Both consumer demand and agricultural productivity must be sufficient to support specialized craft production. But even given high consumer demand and agricultural productivity, the market system must be organized to ensure an adequate, consistent supply of subsistence goods to support specialized labor. The degree of vertical and horizontal integration of a regional market system affects the competitive dynamics of the system, with consequences for its efficiency in linking urban and rural producers and consumers. Craft producers must organize their production in response to these constraints, deciding what to produce, where to produce, and to what degree of intensity.

To clarify how this works, I would like to draw a distinction between market structure and what economists sometimes refer to as market form[1]. *Market structure*, discussed at length below, refers to the system of vertical and horizontal linkages between market centers and market zones within a region. *Market form* refers to the relative balance of supply and demand for a particular good. A market with a large number of buyers and sellers, no barriers to entry, and a perfectly elastic demand curve may be characterized as having *perfect competition*. Perfect competition is largely theoretical; most markets have a degree of imbalance in the ratio of buyers to sellers, resulting in market imperfection and unfavorable prices for either suppliers or consumers. In a *monopoly*, one supplier controls the manufacture or distribution of a particular product to a multitude of consumers. The inverse of this is a *monopsony*, where there is only one buyer for a product and many sellers. In *oligopolies* and *oligopsonies*, there are only a few suppliers or buyers respectively.

The structure of market systems may be expected to strongly influence market form and the balance of market power between producers and consumers of particular goods within a region. The degree to which producers and retailers can negotiate favorable prices is in large part determined by the amount of competition they have from producers or retailers of equivalent goods or services. If the production or distribution of a given good is monopolized, pricing will favor the supplier. If a number of suppliers must exchange with a sole buyer, pricing will favor the consumer. Producers must tailor their production choices to consumer demand and competition. We may thus expect the organization of craft production to vary with market structure as producers respond to the opportunities and constraints posed by the structure of their exchange network.

The Archaeological Assessment of Market Systems

Archaeologists have increasingly recognized that market exchange was the primary redistributive mechanism operating in Oaxaca and throughout Highland Mesoamerica from at least the Classic Period onward (Feinman and Nicholas 2010; Hirth and Pillsbury2013).

[1] What I refer to as *market form* is more commonly referred to as *market structure* in economics. Because *market structure* has been used to refer to a different phenomenon in economic geography and anthropology, we must employ the less-common term from economics here.

Yet little attention has been devoted to the study of market institutions in archaeology in the last thirty years (Garraty 2010:3; Minc 2006:82). The result is that theoretical approaches to the study of market exchange in prehistory remain underdeveloped relative to methods used for tracing the origin of archaeological materials. Indeed, detection of market exchange is often treated on a presence/absence basis by archaeologists (e.g. Hirth 1998; Feinman and Nicholas 2012) neglecting potential variability in the structure of market networks or its articulation with other institutions. M. Smith (2004:84) argues that this is due to a continued overreliance on Polanyi's (1957) "simplistic triad" of reciprocity, redistribution, and market exchange. And yet, for archaeologists working in many areas of the world, demonstration of general market exchange is a first step in an ongoing rebuttal to earlier regional models assuming a command economy operationalized through redistribution (e.g. Feinman and Nicholas 2012). Only having demonstrated the importance of market exchange in a given area may archaeologists begin to examine how it was articulated with political institutions.

Central Place Theory

One of the first models utilized by archaeologists to understand market system dynamics was Central Place Theory, originally developed by German geographer Walter Christaller in 1933 to account for the geographic distribution of cities and towns in Southern Germany. Christaller argued that market access was a key factor influencing the siting of communities in this area, resulting in a patterned distribution of settlements that could be observed in other areas of the world (1966). Christaller's model relies on a number of conditions: (1) market exchange must be integrated into a single, regional system; (2) the landscape must be an undifferentiated environment with an even distribution of resources and ease of transport in all directions; (3) both population and purchasing power must be evenly distributed; (4) both market suppliers and consumers are rational optimizers with good price information – suppliers seeking to maximize profits while consumers seek to minimize costs; and finally (5) suppliers are numerous and competitive (C. Smith 1974:168-169). If all conditions are met, Central Place Theory predicts that price competition between retailers seeking optimal positions to exchange their goods will result in an even distribution of ranked market centers. In order to maximize market choice and obtain favorable prices for their goods, smaller communities will tend to be sited mid-way between market centers. Centers of equivalent rank are evenly distributed in relation to each other as each seeks to minimize their distance to higher-order centers in all directions while maximizing distance to competing centers providing equivalent services. The result is a nested hierarchy of evenly-spaced centers providing access to low-order and high-order goods and services. (Christaller 1966; C. Smith 1974, 1976a). Naturally, most of these conditions are rarely met in the real world, but Christaller's model provided a baseline for Carol Smith's (1974, 1976a) development of a number of alternative models of market structure in the 1970's.

In the 1970's and 1980's there was a flurry of interest in Central Place Theory in archaeology. In keeping with Christaller's hypothesis, the majority of this work sought to evaluate the structure of market networks through using spatial data on the size and distribution of settlements gathered through regional settlement surveys (e.g. Appel 1986; M. Smith 1979). Unfortunately, the distribution of settlements in a given area may be due to a complex of political, ecological, and economic factors, limiting the utility of a spatial approach (Stark and Garraty 2010:38-40). Parting with Christaller, even Carol Smith (1974:170-171) cautioned against using Central Place Theory to evaluate settlement pattern distributions, noting that while market services provide an economic base for many communities, they are not the only one. Communities are as often sited to facilitate access to natural resources, transportation routes, or maintain defensive positions. Early attempts to evaluate market exchange through the distribution of goods met with similar trouble. Renfrew (1975, 1977) found that the distance goods travel from a production center may be equivalent under both central place redistribution and central place market exchange. These and other problems of equifinality led to Central Place Theory's near abandonment in archaeology. This was coincident with a general shift in archaeological interest from market exchange to issues such as the organization of craft production and household archaeology in the 1980's and 1990's (Stark and Garraty 2010:38-43).

The Distributional Approach to Regional Exchange

An important break in the study of market exchange in prehistory was an influential paper by Kenneth Hirth (1998). Hirth argued that market exchange could be detected through a distributional approach to household artifact assemblages. Because (1) marketplaces offer equal access to all goods to consumers regardless of their social status, and (2) households (whether low-status or high-status) arrive with similar resources and engage directly in market exchange, households within a given community are likely to have similar consumption patterns. This would result in similar material culture assemblages within a community among households of equivalent status, providing archaeologists a means to detect market exchange in ancient societies.

Recent work by Minc (2006, 2009) expands on Hirth's (1998) distributional approach to model the structure of regional market systems in prehistory. Minc argues that the homogenizing effects of market exchange should hold beyond households and may be used to delimit market zones and interactions between communities at a regional scale. "Where markets provide the primary mechanism for exchange and commodity distribution", Minc argues, "Hirth's analyses suggest that the degree to which communities share similar artifact assemblages can be used to detect the degree to which they attend the same market centers" (Minc 2006:88). Because communities attending the same market centers will have similar artifact assemblages and those participating in different exchange networks may be expected to have different assemblages, the distribution of certain classes of goods may be used to map the market networks and exchange relationships between communities at different scales.

Regional Market Structure and Variability

Building on concepts from Central Place Theory (Christaller 1966) and the work of the economic geographer Carol Smith (1974, 1976), Minc (1994, 2006) defines a market system as composed of a network of market centers and market zones. *Market centers* function as the locational centers of exchange while *market zones* are the areas served by those centers (Minc 2006:83). The *structure* of regional market systems may be variously organized on dimensions of scale, network, hierarchy, and political congruence. *Scale* simply refers to the spatial extent of a market zone. *Network* refers to the level of horizontal integration between market zones of equivalent scale, while *hierarchy* refers to the level of vertical integration between market zones at increasing levels of scale. *Political Congruence* measures the degree of agreement between the spatial extent of the market system and "features of political geography including administrative centers and territorial boundaries" (Minc 2006:84).

By crossing the two primary dimensions of network and hierarchy, Minc (2006) outlines four idealized types of market systems: solar, overlapping, dendritic, and interlocking market networks (Figure 3.1, Table 3.1). While these models may not account for the full degree of variation in the organization of market systems, they serve as a point of departure for evaluating the organization of systems in a given region (Minc 2006:84; Hodges 1988:18). Insofar as the organization of market systems affects production, consumption, and exchange practices at the regional, community, and household level, patterned differences in the distribution of goods at each of these scales may be used to infer the structure of a given system.

Below a brief description of the organization of exchange under each model is provided, accompanied by expectations for the organization of craft production, rural economic participation, and archaeological correlates. This section will serve as a guide for our evaluation of various economic models that have been proposed for Late Classic Oaxaca and our interpretation of ceramic production, consumption, and exchange patterns at Yaasuchi. Expectations for relationships between the organization of craft production and market exchange are summarized in Tables 3.2 and 3.3.

Solar Market Systems

Organization of Exchange

Solar market systems, or simple centralized market systems, are characterized by both poor horizontal and vertical integration between market zones. A typical market zone consists of a single administrative center serviced by a few smaller market centers, such as would be characteristic of a small city-state polity. This administrative center provides

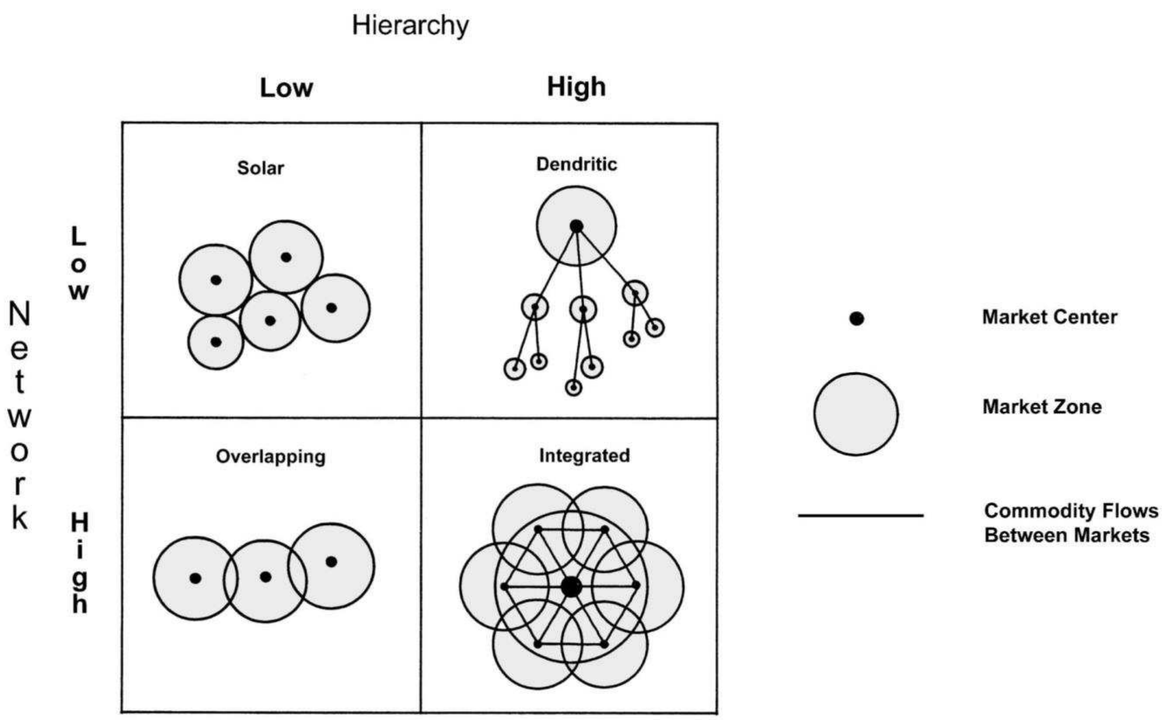

Figure 3.1: Four idealized market systems organized by their degree of network and hierarchy. Reproduced from Minc (2006: Fig. 1).

Table 3.1: Dimensions of market system variability. Reproduced from Minc (2006: Table 1).

Dimension of Variation	Regional Market Systems			
	Solar	Overlapping	Dendritic	Interlocking
Scale	Small, local	Small, relatively local	Large, regional	Large, regional
Network	Poorly developed	Well developed	Poorly developed	Well developed
Hierarchy	Poorly developed	Poorly developed	Well developed	Well developed
Political Congruence	Coterminous with local polity	Not constrained by political boundaries	Coterminous with control by primate center	Coterminous with regional polity

Table 3.2: Relationships between the organization of market exchange and dimensions of craft production. Adapted from Minc (1994:312, Table 8.2). Market form is specified for utilitarian craft goods.

Market Exchange		Craft Production			
Structure	Form	Density	Intensity	Scale	Attachment
Interlocking	Perfect Competition	Dispersed	Full time	Workshop to Factory	Unattached
Dendritic					
Core	Oligopoly	Concentrated	Full time	Workshop	Attached
Periphery	Monopoly	Dispersed	Part time	Domestic	Unattached
Solar	Monopoly	Concentrated	Part time to full time	Domestic to Workshop	Semi-attached to Unattached
Overlapping	Oligopoly	Dispersed	Part time	Domestic	Unattached

Table 3.3: Relationships between the organization of market exchange and dimensions of craft products. Market form is specified for utilitarian craft goods.

Market Exchange		Dimensions of Craft Products		
Structure	Form	Specialization	Investment	Standardization
Interlocking	Perfect Competition	High	High	High
Dendritic				
Core	Oligopoly	Some	Low	High
Periphery	Monopoly	Low	Low	High
Solar	Monopoly	Low	Low	High
Overlapping	Oligopoly	Low	Moderate	Low

both political and economic functions to communities within the market zone. "As a result, the extent of political control is spatially congruent with the sphere of economic influence" (Minc 2006:84). At a regional scale, solar systems are characterized by low-level hierarchies within market zones and poor articulation between zones. Producers and consumers within a given zone have little choice in market destinations and are forced to rely on the primary center for both economic and administrative services (Minc 2006:84; Smith 1974:176-177).

Organization of Craft Production

One of the major problems facing administrative elites in solar market systems is their high dependence upon the immediate rural hinterland for access to subsistence goods. One way to encourage rural market participation is to control access to craft or prestige goods not available in the hinterland. This may be accomplished through control over access to imports or prohibitions on rural craft production. Craft production in a solar market system may thus be expected to be monopolized and concentrated in market centers. However, because the market for these goods is limited by the small scale of the market zone, production is rarely high-intensity. The majority of production may be expected to take place in domestic or workshop contexts on a part-time basis. To the extent that urban producers serve both the ruling elite and the rest of the community, some may work in semi-attached positions on behalf of elites (Minc 1994:307). Because craft production would be carried out by a limited number of manufacturers for a captive market, products may be expected to be low-investment and fairly standardized within a market zone. The small scale of market zones would inhibit a high degree of product specialization.

Rural Market Participation

Under a solar market system, the administrative center enjoys a monopsony in the market for subsistence goods produced in its hinterland. Rural agricultural producers bringing their goods to market face a high degree of competition from other producers and a demand limited by the small size of the urban center, resulting in unfavorable prices for rural goods. Moreover, because the center consumes the majority of produce brought to market, rural producers cannot depend on it for redistribution of subsistence goods. Rural producers thus have little incentive for market participation and attempt to maintain a degree of market independence (Minc 1994:307).

As discussed above, urban centers may attempt to incentivize rural market participation through control over access to craft goods. Outlying communities will be integrated with the urban market through exchange of primary produce for these goods, and assemblages at rural sites will be dominated by goods produced at a single adjacent center. Minimal craft production of utilitarian goods may occur in rural households, primarily for domestic use. Access to imports or prestige goods from outside the market zone will be limited.

Archaeological Correlates

Goods produced in a solar marketing system are redistributed through the primary market center to the area it serves, resulting in a high degree of homogeneity in material assemblages within market zones. At the same time, poor integration between market zones results in sharp discontinuities in commodity distributions (Minc 2006:84; Smith 1974:176-177). At a regional scale, the material signature of this system would be a pattern of bounded, discontinuous market territories spatially coterminous with political administrative areas.

Within rural communities, high dependence on a single market center for access to craft goods results in highly similar material assemblages among rural households within a given market zone. A significant proportion of craft goods consumed by rural households will be imported from the nearest market center and access to goods produced in other centers will be extremely limited. Some craft production may be conducted in rural households, but this will be almost exclusively for domestic use and will be limited to low-investment utilitarian goods. Very little exchange occurs between rural communities. Thus, at the scale of the rural household, we may expect a binary consumption pattern. Some proportion of goods will be imported from a single nearby market center. The remainder will consist of utilitarian goods produced within the household.

Overlapping Market Systems

Organization of Exchange

Overlapping (or non-centralized) market systems have a high degree of horizontal integration but low degree of vertical integration (Minc 2006:84-85; C. Smith 1974:179-180). Political authority is relatively weak, decentralized, and does not constrain the flow of goods between market zones. Horizontal linkages facilitate exchange between adjacent market zones, but the flow of goods and price information is limited by poor vertical integration. At a regional level, the structure of this system is characterized by a number of small-scale, overlapping market zones that are not coterminous with political or administrative units. Unlike households in solar systems, producers and consumers have the ability to attend markets in more than one center, resulting in better competition and more favorable prices for rural producers. Goods are free to move between zones, but political instability prevents the development of a market hierarchy, and economic interaction between communities becomes more limited at greater distances.

Organization of Craft Production

The absence of a strong market hierarchy in overlapping market systems inhibits the flow of goods and price information between market zones, limiting regional system integration and the development of a strong division of labor (Minc 1994:308). Craft production is thus more generalized and dispersed than in solar market systems. Wares are produced part-time or seasonally in domestic contexts, primarily for household use. Those producers that manufacture goods for market exchange face a degree of competition, encouraging additional investment in products to attract consumers. Because production is dispersed, small-scale, and low-intensity but competitive, craft goods tend to be less standardized both within market zones and regionally.

Rural Market Participation

The higher horizontal integration of adjacent market zones affords rural producers greater choice in markets to sell their goods. The lack of monopsony control over the market for subsistence goods results in a higher degree of competition between market centers and more favorable prices for rural producers. Thus, rural producers have greater incentive to participate in market exchange, both as producers of staple goods and craft products. As noted above however, poor vertical integration inhibits the flow of goods and a strong division of labor. Rural households may therefore be unable to rely entirely on market exchange to provision to provision household needs. Thus, they may exchange in household craft production, both to supplement goods acquired through the market, and as a secondary source of income in market exchange.

Archaeological Correlates

At a regional scale, the material signature of this system reveals individual market zones, but with indistinct, fluid boundaries (Minc 2006:84-85; C. Smith 1974:179-180).

Neighboring communities have similar material assemblages, but this declines with distance. Rural communities located between centers may be thus expected to have mixed assemblages that reflect their access to multiple markets. By contrast, urban households may be expected to have assemblages dominated by goods produced in the surrounding hinterland, with a minority of goods coming from neighboring centers.

In rural communities, those goods acquired elsewhere will be imported from multiple adjacent centers in frequencies proportional to their distance from the rural community in accordance with the tenants of central place theory. Within a given community, household consumption patterns will largely reflect the relative distance of that community to multiple market centers. At the same time, a greater choice in market destinations may result in differences in consumption between households within a given community. Given the poor vertical integration of the market system, we may also expect some evidence of rural household craft production, primarily for domestic use, but also for exchange. Goods produced for domestic use will be largely restricted to simple, utilitarian wares while those produced for exchange will exhibit a greater degree of investment.

Dendritic Market Systems

Organization of Exchange

Dendritic market systems have a strongly developed market hierarchy but a weak market network. That is, while vertical linkages between low and high order market centers are strong, horizontal linkages between centers of equivalent rank are minimal. This is the result of strong political and economic control by a primate center over the exchange network. The high degree of vertical integration allows goods to flow to and from the primate center, but horizontal exchange between rural centers of equivalent rank is limited. At a regional level, goods flow in a linear fashion between the primate center and dependent communities of progressively lower rank, resulting in a dendritic structure of exchange (Johnson 1970; Minc 2006:86; C. Smith 1974:177-179).

Administration of the regional system is conducted to ensure the political and economic interests of elites in the primate center rather than market efficiency. Goods are drawn from the hinterland toward the core, generally through low order bulking or wholesaling centers. These are located and timed not to ensure market access or efficiency, but to serve elite interests – namely the acquisition of subsistence goods or other commodities for the urban market or foreign export (Johnson 1970; Little 1987). The economic importance of lower-order centers is determined by their proximity to the primate center. Rather than locating an even distance between high-order centers, lower-order centers tend to cluster around the primate center, increasing market integration near the core, while isolating sectors of the periphery (C. Smith 1974:177). The high ratio of rural producers to buyers both in the core and in peripheral bulking centers leads to unfavorable pricing for rural producers, discouraging market participation with distance from the primate center. (C. Smith 1976a:34-35). Again, the result is a gradient of integration between the core and periphery, with incumbent differences in the organization of craft production in each area.

Organization of Craft Production

Near the core of a dendritic system, craft and trade specialization may be supported both by urban demand and trade with the periphery (C. Smith 1976b). As in solar market systems, rural market participation must be encouraged to channel subsistence goods to the urban core. One way to foster urban/rural dependencies is through monopolization of the production and distribution of finished craft goods for exchange in the periphery. Political/economic elites may sponsor centralized, large-scale, high-intensity production of craft goods for regional distribution. Low competition and monopoly control allow them to manufacture low-investment, standardized products to control costs and increase margins. Their ability to control the market for these goods leverages pricing in their favor, channeling resources from the hinterland and contributing to its poor development (Johnson 1970).

Communities in the rural hinterland are not however, dependent upon the primate center for access to craft goods. Because each branch or sector of the periphery is economically isolated, rural households at the periphery of the system may not be well served by market function, decreasing their level of dependence on markets as either a source of goods or an outlet for their products (Minc 2006:86). For the same reason, rural producers cannot capitalize on local comparative advantages and engage in product specialization. Rather, the optimizing strategy in the periphery is to diversify production to buffer economic risk (Little 1987). For rural households, the question becomes not where to buy and what to produce, but whether to buy or produce. Towns with superior access to resources for producing particular goods do not become product specialists. Instead, they produce the full range of goods required for daily life, both for domestic consumption and exchange. Craft production in these areas is low-intensity, dispersed, and primarily undertaken for domestic consumption or exchange within the community. The products themselves are low-investment, utilitarian wares exhibiting a degree of sub-regional variation between market sectors (Minc 1994:310).

Rural Market Participation

A key feature of dendritic systems is the gradient of integration of communities into the regional system based on their distance from the primate center. Rural producers often only have access to a single low-order retail center, and this usually functions to distribute commodities to rural households rather than purchase their surplus produce. Rural peasants must either travel a great distance at their own expense to reach a wholesale market, or sell to traveling wholesalers who control price information. At wholesaling centers, low competition allows wholesalers to acquire goods at minimal cost for resale in the primate center (C. Smith 1976:34-35). The imbalance of power between the primate center, wholesalers, and the hinterland is exacerbated by the linear nature of exchange. Buyers in the center have access to price information from all sectors of the system while rural producers only get information from a single source. Prices in dendritic systems are thus extremely prone to monopoly control, becoming increasingly unfavorable with distance from the center (C. Smith 1974:177-178). As a result, households at the periphery of these systems have little commercial incentive to participate in market exchange. Market access to rural subsistence goods from other sectors of the hinterland is especially limited (C. Smith 1976a:34-35), contributing to food insecurity in the event of sub-regional crop failures.

Archaeological Correlates

At a regional level, we may expect the following product distribution patterns given a dendritic market system: (1) a highly integrated core zone around the primate center displaying a high degree of market participation through a diversity of goods from each contributing sector of the hinterland; (2) decreasing market integration with distance from the primate center; and (3) low economic integration between sectors (Minc 2006:86). The low horizontal integration in the hinterland of a dendritic system will contribute to the isolation of each sector or branch of the exchange network, limiting the flow of goods between sectors. Some goods may cross between sectors, but only through the primate center, and these will tend to be limited to foreign or wealth items.

The high vertical integration of dendritic systems is achieved, in part, through control over access to craft goods produced in or imported to the primate center. Yet the primate center is also a major consumer of goods produced in all sectors of the region. Household assemblages within the primate center may thus be expected to be more diverse than those in outlying secondary centers or rural communities in the hinterland. Rural consumption and production strategies will differ with distance from the core of the system; rural households near the core may be expected to display a high degree of dependence on urban craft producers. Those in the distant hinterland will diversify production in response to poor market access and unfavorable prices. With distance from the core, rural assemblages will be increasingly dominated by goods produced within the community. To the extent that craft goods are acquired through the market, these will be restricted to those available at the primate market center. These goods may either be manufactured in the primate center or in a secondary bulking center to reduce transport costs to rural consumers.

Interlocking Market Systems

Organization of Exchange

A regional market system characterized by both high vertical and horizontal integration is known as a hierarchically integrated or complex, interlocking market system.

These systems most closely resemble the evenly distributed, nested hierarchy of market centers and zones described under Christaller's classic Central Place model. In these systems, goods move through local and regional centers serving nested market zones at a range of scales. Low-order market centers are linked to multiple higher level centers, creating a network with multiple levels that efficiently moves goods both within and between zones. Market zones are overlapping and unbounded, facilitating the coordination of supply and demand, communication of price information, and regional product specialization (Minc 2006:86-87; C. Smith 1976d: 320).

Interlocking market systems are highly competitive and efficient, providing strong incentive for specialized production of craft goods. High vertical and horizontal market integration encourages the flow of both goods and price information between market zones allowing producers to capitalize on local comparative advantages to produce a limited range of goods. Market form is characterized by perfect competition, with a high number of buyers and sellers and few barriers to market entry. This balance of influence between producers and consumers encourages market efficiency, a complex division of labor, and product specialization and intensification (Plattner 1989:203; C. Smith 1976d:354).

Organization of Craft Production

High market integration facilitates specialization at two levels. First, economic dependence between urban and rural areas grows with an increasing division of labor between primary and secondary producers. Secondly, it encourages greater specialization within industries. The loci of craft production may be in either rural or urban contexts, with consideration toward labor costs, transport costs, taxes, and other factors (Minc 1994:311; C. Smith 1976d:355). Regardless of location, production will be conducted in larger scale, nucleated facilities with a high rate of output in order to accommodate the greater market demand. The competitive market environment encourages production of a diversity of goods ranging in quality and form to attract consumers across a range of status and demographic backgrounds. Products from a given facility may be highly standardized to improve efficiency, reduce costs, and develop brand identity, but separate producers will seek to differentiate their products from those of their competitors, resulting in greater variety in available goods. The distinctiveness of these wares marks them as products of a particular firm or community, signaling its reputation, adding to their value, and increasing their distribution regionally.

Rural Market Participation

Market efficiency improves market access to a greater range of goods, encouraging rural market participation and product specialization. Rural communities may depend upon the market, both as a source of products and an outlet for their goods. This allows them to focus on the production of goods that will bring the highest returns in the market. Rural communities need not specialize in agricultural production. They may, given access to an obsidian quarry for example, choose to primarily engage in obsidian production. Most households in rural communities will continue to engage in agricultural production, but even this may be diversified regionally to take advantage of favorable environmental conditions in different areas. Exchange of these goods in regional markets will be used to acquire most other products.

Archaeological Correlates

Because interlocking market systems are characterized by a high degree of economic integration, goods are efficiently distributed throughout the system. High market efficiency facilitates exchange over greater distances, allowing communities to depend on the market for a greater portion of their material needs and engage in specialized production. At a regional scale, this has the effect of homogenizing the distribution of goods throughout the system (Minc 2006:87), resulting in the highly similar domestic assemblages predicted by Hirth (1998) for archaeological contexts.

Because rural communities are well-integrated into the market system, there should be no sharp differences in urban and rural market participation (Minc 2006:87). Transport costs may impact consumption of some goods in rural areas, but overall consumption patterns should reflect high market access and participation. In rural craft production contexts, a high standardization of goods is to be expected, but rural domestic assemblages will contain a high diversity of materials often acquired from distant sources.

Evaluating Rural Market Participation at Yaasuchi

An examination of the structure of Late Classic market networks requires study of exchange relationships between communities at a variety of scales across the region, a project that is beyond the scope of this thesis. However, it should be clear from the previous discussion that one of the primary factors conditioning rural economic behavior is the structure of regional exchange networks. Indeed, the economic vulnerability of rural households to the ways in which market structure links producers and consumers of different goods makes them a potent barometer of regional economic conditions. As the only well-documented rural site in the Valley of Oaxaca that has been subject to controlled stratigraphic excavation, Yaasuchi provides an excellent opportunity to examine rural patterns of craft consumption and exchange during the Late Classic.

Yaasuchi is located on a prominent hilltop on the western margin of the Zimatlán Sub-valley 16.5 km south of Monte Albán and 18 km west of Jalieza (Figure 2.4). Thus, the site is situated roughly halfway between two administrative centers that were either (a) the first- and second-ranked sites within a valley-wide political and economic system; or (b) competing centers. The closest Late Classic center would have been Zaachila; 8 km to the northeast with an estimated population of 2135 (Kowalewski *et al.* 1989:260-261). The greater proximity of Zaachila to Monte Albán (11km) makes it more likely that it was a subsidiary of Monte Albán than Jalieza (16 km).

In this section, I will briefly discuss prior evidence for craft production and exchange from excavations at Yaasuchi. I will then outline a set of alternative expectations for ceramic production and consumption given three models of Late Classic market organization.

Prior Research at Yaasuchi

Survey and excavation at Yaasuchi by Sherman (2005) showed that the site was settled during the Late Formative (300-100 BC), a time of heavy competition between

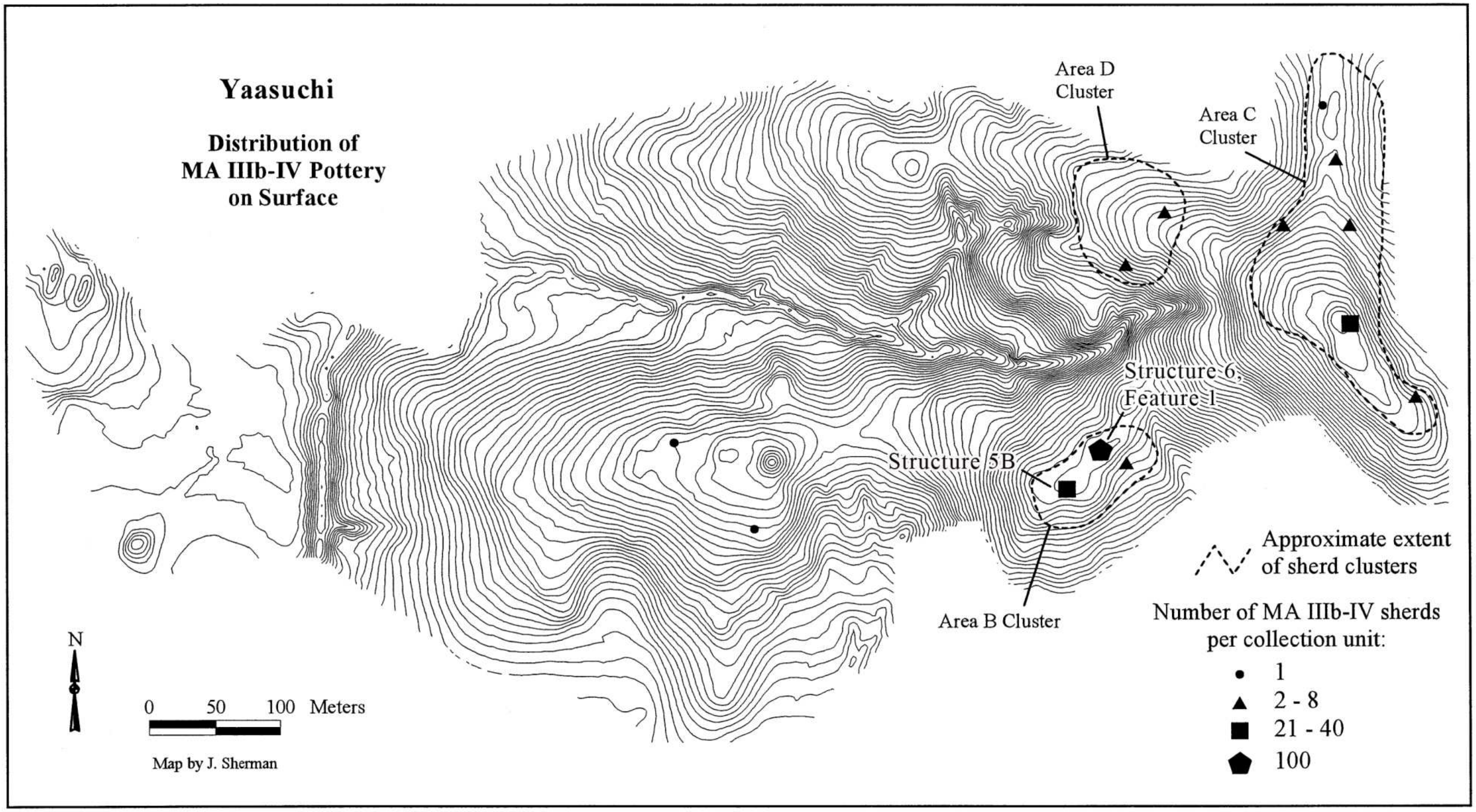

Figure 3.2: Distribution of Late Classic pottery recovered in surface collections at Yaasuchi. Reproduced from Sherman (2005: Figure 4.5).

Monte Albán and other autonomous polities (Sherman 2005; Spencer and Redmond 2012). Located across the Valley from one of Monte Albán's chief Formative rivals, Yaasuchi may have initially been a strategic settlement established to secure trade routes south to the Coast through a portion of the Valley inhospitable to the nascent state (Sherman 2005; Sherman *et al.* 2010). Occupation of the site was maintained through the Terminal Formative, when the population of Yaasuchi climbed to its maximal size of about 370 people (Blanton *et al.* 1982; Sherman 2005:71). The site was largely abandoned during MAIIIA, reflecting valley-wide shifts in settlement away from the piedmont toward the Valley floor. It was reoccupied during MAIIIB-IV, reaching an estimated population of 110, but again abandoned prior to the Late Postclassic (Sherman 2005).

Intensive surface survey at Yaasuchi showed that its MAIIIB-IV occupation was concentrated in the upper, eastern portion of the site (Figure 3.2; Sherman 2005: Figure 4.5), conforming to the Late Classic pattern of hilltop, piedmont settlement. Excavations in this area uncovered the remains of two residential structures dating MAIIIB-IV: Structure 5B and Structure 6. Structure 6 consisted of at least two rooms adjoining a small, square, sunken patio (Figure 3.3; Sherman 2005:196-198). Its size, architecture, and layout were consistent with the low-status, commoner residences at Monte Albán described by Winter (1974). Structure 5B was built upon the remains of an earlier, Formative building (Structure 5A) and had been heavily disturbed by erosion and plowing. It too appeared to have been a patio-focused residence, but was considerably larger than Structure 6, possibly indicating that it was more of an elite residence (Figure 3.4; Sherman 2005:207-209, 213).

Architectural similarities and ceramic assemblages at Stuctures 5B and 6 suggested that they were roughly contemporaneous within MAIIIB-IV (Sherman 2005:295-297). Separated by only about 25 meters, both structures had a patio-oriented design and incorporated sherds as a building material (Sherman 2005:298). The most common vessel type used in construction of both residences was the G.35 conical bowl, a Classic period diagnostic form. Similar use of sherds as a construction material at Lambityeco led Paddock to speculate that this was a diagnostic feature of MA IV (Paddock 1983), initially suggesting that Structures 5B and 6 dated to the Early Postclassic (Sherman 2005:298-299). As noted

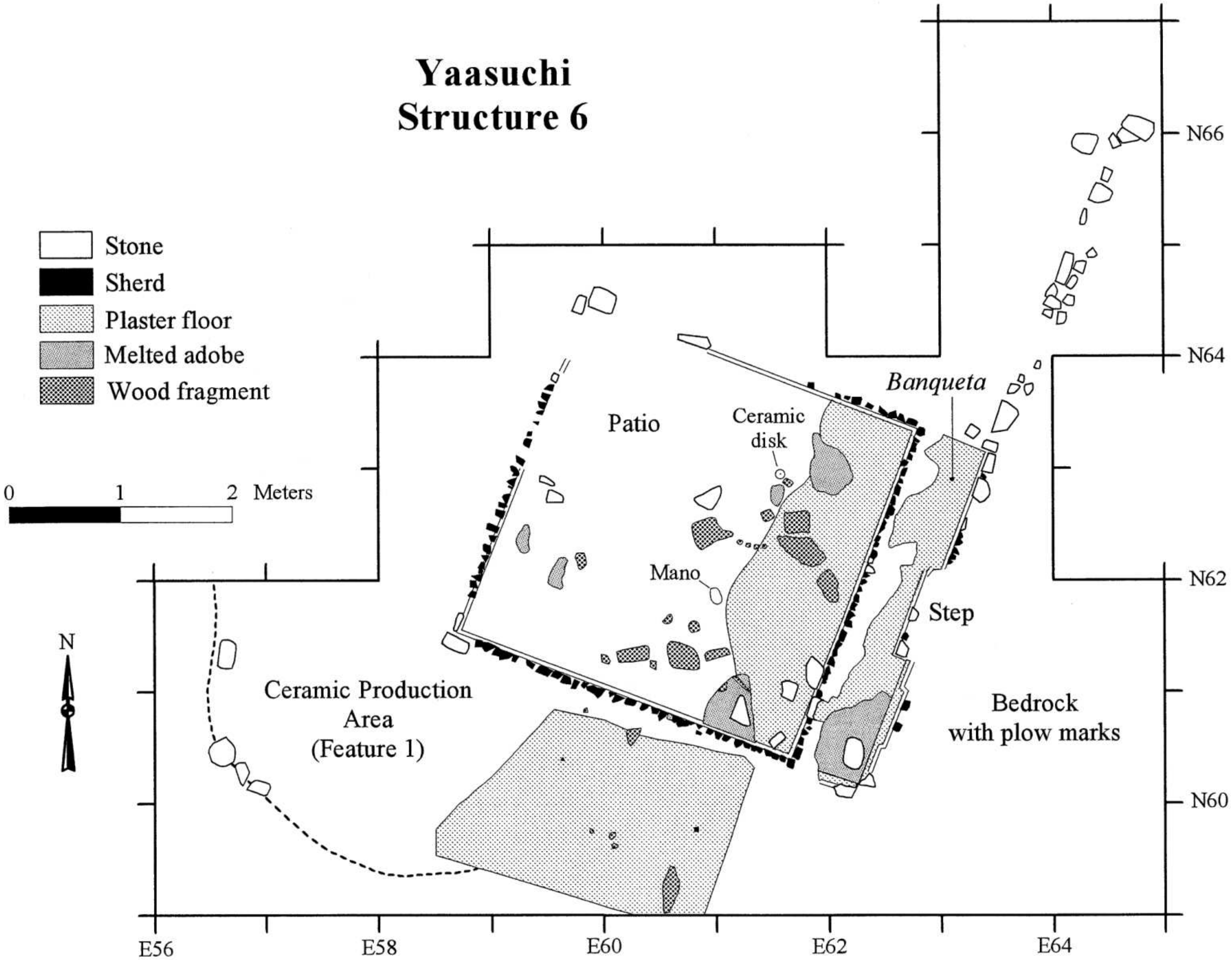

Figure 3.3: Plan view of Structure 6 and Feature 1. Reproduced from Sherman (2005: Figure 4.8).

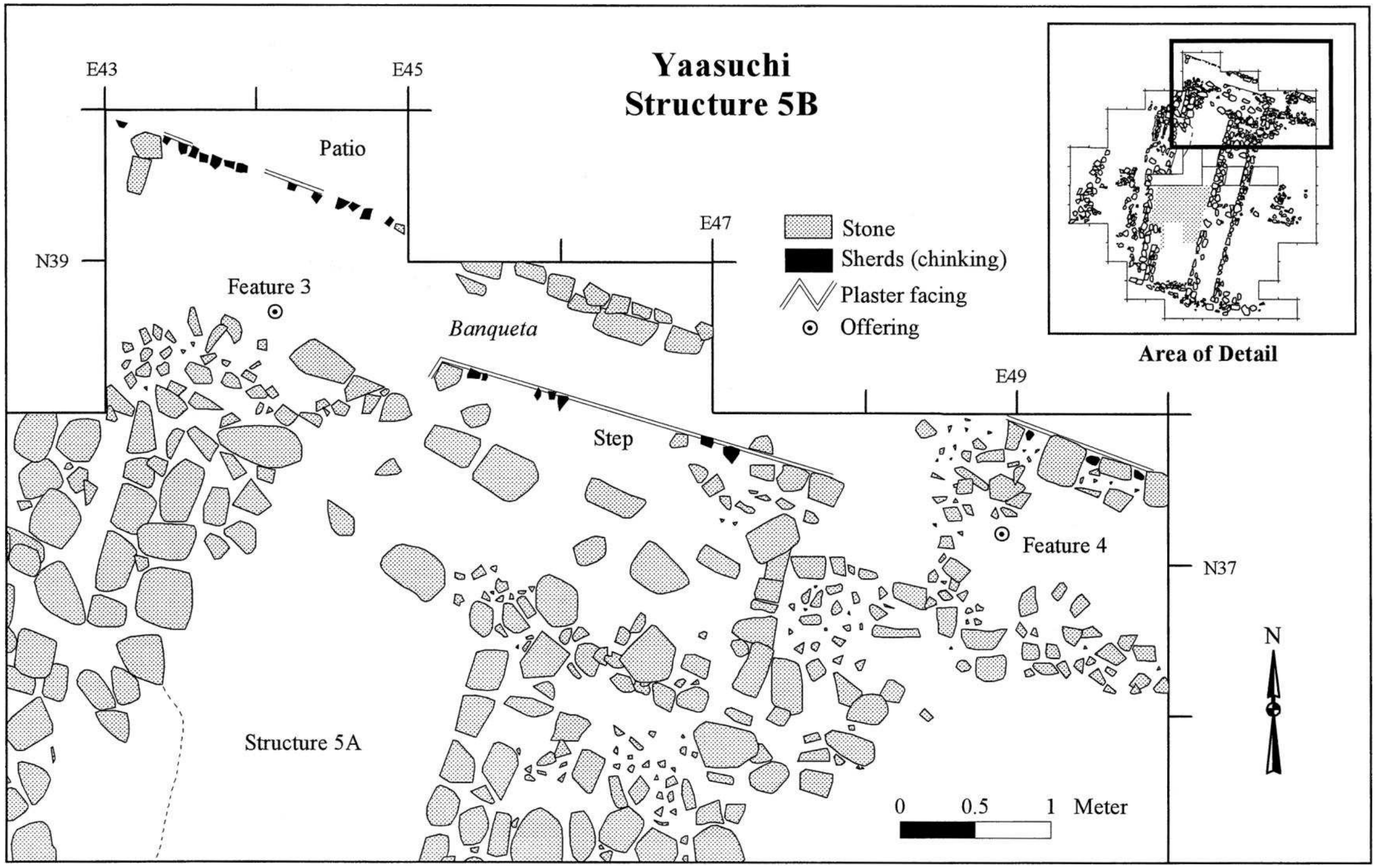

Figure 3.4: Plan view of Structure 5B. Reproduced from Sherman (2005: Figure 4.15).

in Chapter 2 however, it is now generally understood that the MAIV diagnostic features outlined by Paddock (1983) for Lambityeco more likely date to the Late Classic.

In order to assess the chronological relationship between the two residences at a finer scale, three organic samples were submitted for radiocarbon dating at DirectAMS in 2013 with the assistance of R. Jason Sherman. Two of these were wood samples taken from fill directly over the Structure 6 patio floor (excavation contexts 2194 and 2197; Sherman 2005:353). The third was a carbon sample taken from fill surrounding Feature 3 in Structure 5B; Feature 3 was an offering of two G.35 conical bowls containing a lump of unfired clay (Sherman 2005:354). Unfortunately, both wood samples were too mineralized to obtain a radiocarbon age. Results of analysis of the Structure 5B sample returned an un-calibrated age of 1296 ± 29 RYBP (D-AMS 004218; charcoal; $\delta^{13}C = -28.7‰$). This is equivalent to a 2σ calibrated calendar age of AD 660 -770 (calibrated using Oxcal 4.2 [Ramsey and Lee 2013]), placing Structure 5B within the first half of Xoo Phase of the Late Classic (AD 650 – 850). Given the lack of a conclusive date for Stucture 6, it is difficult to judge its chronological relationship with Structure 5B. As Sherman (2005:295-297) argued however, similarities in architecture and ceramic assemblages indicate that the two structures were roughly contemporaneous.

Evidence of Craft Production at Yaasuchi

Excavations at Yaasuchi revealed an ephemeral surface firing feature (Feature 1) associated with a small residence (Structure 6). The firing feature was similar to the pit kilns described by Balkansky *et al.* (1997), though less formally defined, and consisted of "a roughly circular concentration, some 3 m in diameter, of reddish-brown soil with charcoal fragments, ash, and chunks of burned earth/adobe intermixed" (Sherman 2005:200). Deposits from this feature contained a high density of Late Classic sherds, vitrified lumps of clay, and nine misfired ceramic wasters – incontrovertible evidence of ceramic production. The stratigraphic relationship between Feature 1 and Structure 6 showed that the firing feature predated the residence within the Late Classic Period. The sunken patio of Structure 6 was dug into Feature 1, which continued below the patio floor. It nevertheless seems likely that Feature 1 was associated with a residence – perhaps a previous incarnation of Structure 6 – because informal firing facilities were frequently relocated and commoner residences required continual refurbishment (Balkansky *et al.* 1997:151; Sherman 2005:299). Additional evidence of ceramic production may have been encountered at a nearby residence (Structure 5B), where two offerings of unfired clay stored between G.35 bowls were recovered from beneath the house-floor (Sherman 2005:210-211, 299).

Evidence of textile production was encountered at Yaasuchi as well. Seventeen whole or partial perforated ceramic disks were recovered from Late Classic contexts at the site (2005:212; Figure 4.3). Such objects are generally interpreted as spindle whorls, tools used in the manufacture of cotton or maguey fiber and important indicators of household textile production (Carpenter *et al.* 2011). Fifteen were associated with Structure 6 – including 12 from deposits in the sunken patio and another from the patio surface (see Figure 3.3). In contrast, only 2 perforated disks were recovered from Structure 5B, but this residence was not completely excavated (Sherman 2005:205, 212, Tables 4.2 and 4.3). Carpenter *et al.* (2012) argued that densities of 3 to 8 spindle whorls per 10,000 sherds in residences excavated at El Palmillo indicated elevated levels of textile production at that site. Sherman (2005: Tables 4.2 and 4.3) recovered densities of 23 and 88 spindle whorls per 10,000 sherds at Structure 5B and 6, respectively.

Evidence of lithic production was limited to a single chert core from Structure 6, and frequencies of chert, obsidian, and groundstone were low in both households. Fifty-eight pieces of obsidian, 6 pieces of chert, and 1 mano were recovered from Structure 6 (Sherman 2005: Table 4.2) and only 14 pieces of obsidian and 7 pieces of chert were recovered from Structure 5B (Sherman 2005: Table 4.3). The vast majority (>95%) of chipped stone identified at the two residences was classified as quartz (Sherman 2005: Tables 4.2 and 4.3), a "material of last resort" in the Valley of Oaxaca (Kowalewski *et al.* 1989:309). This high reliance on quartz may be a simple product of local resource availability, but Kowalewski *et al.* (1989:309) have argued that high ratios of quartz to other materials could indicate that households were unable to acquire more desirable materials through exchange (Kowalewski *et al.* 1989:309).

The domestic production of both ceramics and textiles at Yaasuchi is consistent with the strategy of multi-crafting described for larger centers in Classic Oaxaca (Balkansky and Croissier 2009; Feinman and Nicholas 2007), but it is not clear whether production was intended solely for domestic use, exchange within the community, or exchange in regional markets. Sherman (2005:300) cautions that while Feature 1 could be interpreted as consistent with the low-intensity domestic production identified at El Palmillo (Feinman *et al.* 2002), the use of ephemeral firing facilities does not necessarily denote low-intensity production (Balkansky *et al.* 2007). Surface firing is still used by many communities in Oaxaca today to produce ceramics destined for local and regional markets (Mindling 2010). Thus, evaluating the prevalence and intensity of ceramic production at Yaasuchi requires consideration of broader patterns of consumption and exchange at the site.

Craft Consumption and Exchange

Evaluating market participation at Yaasuchi using frequencies of material recovered at the site alone is problematic. Chert and obsidian were almost certainly acquired through exchange, but the frequencies of these artifacts were low and their provenances are not readily discernable. The abundance of ceramics at the site was higher, but the assignment of provenance based on formal and paste characteristics is problematic for Late Classic assemblages. The presence of a ceramic production feature at Yaasuchi indicates that some proportion of materials recovered at the site are of local origin, but discerning these from materials imported from other centers requires additional analysis.

To further interrogate how Yaasuchi was integrated with Late Classic exchange networks, a large sample of ceramics and clays were submitted for compositional analysis at the OSU-Archaeometry Laboratory to determine the geographic origin or provenance of Yaasuchi ceramics. This information was used to trace exchange connections between Yaasuchi and other sites in the valley. A detailed discussion of sample selection criteria and analytical methods will be provided in the next chapter. Specific expectations for patterns of ceramic production and consumption under alternative plausible market scenarios are outlined below.

Expectations under Alternative Market Scenarios

Given the political and economic models discussed in the last chapter, we cannot rule out any of the four idealized market structures as plausible scenarios for Late Classic Oaxaca. These would include: (1) a series of discontinuous solar market networks in a politically contentious landscape divided between Monte Albán, Jalieza, and other emergent centers; (2) a horizontally integrated, overlapping exchange network that facilitated exchange between emergent centers in an increasingly decentralized political landscape; (3) a vertically-integrated, dendritic exchange network that served to mobilize goods to and from Monte Albán in a centrally administered state economy; and (4) a highly efficient, commercial exchange network with both vertical and horizontal linkages between sites at all scales. Each of these alternatives carries assumptions about exchange relationships between rural and urban households that can be addressed through study of rural household economic behavior at Yaasuchi.

Solar Network

Of the four idealized market structures discussed above, solar market systems are the least plausible scenario for Late Classic Oaxaca. The regional distribution of Late Classic ceramics (Feinman 1982), substantial evidence for economic interdependence between communities (Feinman and Nicholas 2012; Finsten 1983; Lind and Urcid 2010), and multi-tiered settlement hierarchy (Kowalewski *et al.* 1989) all suggest a degree of regional integration. Tensions between Monte Albán and Jalieza could have inhibited exchange within the Valley, but it is unlikely that smaller centers could have maintained political and economic autonomy; secondary centers located on the Valley floor, such as Zaachila, would have been especially vulnerable to political domination. Nevertheless, Jalieza's size, geographic isolation, and lack of dependent communities may suggest that there were substantial barriers to exchange between Jalieza and other communities in the Valley. Conceivably, this may have inhibited market integration in nearby areas, including portions of the Northern Valle Grande.

If the regional exchange system was broken into a series of discontinuous solar market networks in the northern Valle Grande, Yaasuchi probably would have been tied exclusively to Zaachila, the closest political center. Access to goods produced in other centers, including both Monte Albán and Jalieza would be extremely limited and the majority of ceramics imported to Yaasuchi would come from Zaachila itself. Yaasuchi households would supplement craft goods acquired through the market with domestic production, but this would be limited to low-investment utilitarian goods. Lastly, Yaasuchi's dependence on a single market center would result in a high similarity of material assemblages between households; a proportion of goods would come from Zaachila, the remainder would be produced at Yaasuchi. Expectations for ceramic production, consumption, and exchange at Yaasuchi under a solar market system centered at Zaachila are summarized below.

Production: limited, low-intensity production of a range of utilitarian wares for household use;

Exchange: localized exchange only, in which staple goods were exported to Zaachila in exchange for craft products; local ceramics not exported to other households or communities;

Consumption: limited to goods produced locally or in Zaachila; very low access to goods produced in other centers, including both Jalieza and Monte Albán.

Overlapping Network

An overlapping market system is consistent with the view that the Zapotec state had begun to fragment into a series of politically independent sub-regional polities during the Late Classic, but that economic inter-dependence fostered continued interaction between these polities. Under an overlapping market system, Monte Albán would have competed for market power in the Valle Grande with Jalieza, but again, Yaasuchi's primary economic ties would have been to Zaachila. Poor vertical integration between Zaachila and Monte Albán would have increased Zaachila's dependence on goods produced in its immediate hinterland, allowing Yaasuchi households to supplement income from agricultural production with the export of craft goods. Through Zaachila, Yaasuchi would have had some access to goods from other communities in the Valle Grande, including both Jalieza and Monte Albán, but the availability of goods produced in more distant centers would be limited. Similarly, the absence of vertical market integration would inhibit product specialization, and imported goods from any given site would include a range of vessel forms, as would locally-produced ceramics. Dependence upon exchange in Zaachila would again result in a high similarity in consumption patterns between households at Yaasuchi. Expectations for ceramic production, consumption, and exchange at Yaasuchi given an overlapping network are summarized below.

> Production: low-intensity production of a range of goods, both for domestic use and exchange;
>
> Exchange: limited export of both craft and staple goods in exchange for craft goods produced in other communities;
>
> Consumption: majority of ceramics would be produced locally. Those imported to the site would come from Zaachila, Cuilápan, and other nearby centers in the northern Valle Grande, with lesser quantities of goods from Monte Albán and Jalieza. Frequencies of material from a given site would occur in proportion to the size of the site and its distance from Yaasuchi.

Dendritic Network

A dendritic market system is consistent with the administered economy model of Late Classic economic organization in which the needs of Monte Albán created a strong urban-rural symbiosis (Feinman 1982; Feinman *et al.* 1984). At 16.5 km from Monte Albán, Yaasuchi is located at the edge of the resource acquisition zone defined by Nicholas (1989:489-501) for Late Classic Monte Albán, likely placing it within the core zone of Monte Albán's sphere of influence.

Under a dendritic exchange system, Yaasuchi households would have exported staple goods to the Zapotec capital, acquiring finished craft goods in return for agricultural produce. As a result, a fairly large proportion of ceramics would come from Monte Albán itself. However, given the transport costs associated with supplying ceramics to a large rural populace, it is conceivable that ceramic production at Monte Albán may have been supplemented with production in secondary or wholesaling centers – most likely Zaachila. Goods produced in these centers would have served to attract staple goods from nearby rural communities which could then be bulked for resale at Monte Albán. Under this scenario, ceramic imports to Yaasuchi would be dominated by material produced at Monte Albán and/or other centers in the Northern Valle Grande, but access to goods produced in other sectors of the Valley would be limited. Unfavorable terms of exchange would have required Yaasuchi households to supplement access to craft goods acquired through the market with low-level domestic production. These locally-produced wares would be intended primarily for domestic consumption and would encompass the full range of vessel forms utilized by the household. The strong dependence upon a single chain of supply would result in high similarity between village of Yaasuchi and domestic consumption patterns at both houses. Expectations for craft production, consumption and exchange at Yaasuchi given a dendritic network are summarized below.

Production: limited, low-intensity production of a range of utilitarian wares for household use;

Exchange: staple goods exported in exchange for craft products; local ceramics not exported to other households or communities;

Consumption: ceramics obtained largely from Monte Alban proper and/or intermediate secondary or wholesaling centers such as Zaachila; access to goods produced in other sectors of the Valley would be limited by the linear nature of the exchange network.

Interlocking Network

An interlocking market network is consistent with a regional political hierarchy dominated by MA, but including Jalieza as an important secondary center in a regionally integrated commercial economy. If the exchange system had both strong vertical and horizontal integration, market efficiency would allow communities to engage in product specialization, improve access to goods produced in more distant parts of the Valley, and foster community inter-dependence. The result would be similar to the market system of historic Oaxaca, in which certain pottery producing communities specialized in the production of *comales* (griddles), while other potting communities manufactured water vessels (Cook and Diskin 1976). Thus, Yaasuchi potters would be able to focus production on a limited range of goods, acquiring others through market exchange, and exporting their own wares to supplement agricultural production. Imported goods would come from a larger number of centers and from greater distances; although the majority of imported ceramics would still come from nearby communities in the Valle Grande, there would be some occurrence of vessels produced in the Tlacolula, Etla, or Ejutla Subvalleys. Market efficiency would also result in a higher diversity of goods available in regional markets, granting households greater consumer choice and resulting in substantial variability in household consumption patterns (cf. Hirth's "homogenizing effects of markets"). Expectations for craft production, consumption and exchange at Yaasuchi under an interlocking network are summarized below.

> Production: fairly high-intensity production of a limited range of vessel forms; greater standardization of vessel attributes;
>
> Exchange: export of both staple goods and a limited range of vessel forms; import of vessel forms not produced locally;
>
> Consumption: strong reliance on imported goods over domestic production; ceramics imported from Monte Albán, Jalieza, Zaachila and more distant sites in other sectors of the Valley; high correlation between vessel type and provenance.

Network Scale

In the section above, I have outlined a series of expectations for ceramic production, consumption, and exchange at Yaasuchi given four idealized models of regional exchange during the Late Classic. An implicit assumption of the above discussion is that the structure of regional exchange was consistent throughout the Valley of Oaxaca during the Late Classic, a proposition that cannot be evaluated using data from Yaasuchi alone. Ceramic consumption patterns at Yaasuchi will reveal the scale of the exchange network that it participated in, and provide insight into the horizontal and vertical integration of that network. This network may not be coterminous with the entire Valley of Oaxaca, but the scale of Yaasuchi's exchange network will by itself provide valuable insight into the political and economic integration of the Valley, informing our view of how these factors conditioned rural economic behavior.

In the next chapter, I will discuss research design, methods and materials, and the results of Yaasuchi ceramic provenance determinations in detail. These data will provide a foundation for subsequent discussion of ceramic production, consumption, and exchange at Yaasuchi, as well as the scale and structure of its exchange network.

CHAPTER IV: MATERIALS AND METHODS

Research Design

To explore rural ceramic production, consumption, and exchange in Late Classic Oaxaca, a large sample of Yaasuchi ceramics and natural clays were submitted for compositional analysis at OSU. The elemental composition of an archaeological material may be used to identify a geographic provenance or "source" for that material given an adequate comparative database (Glascock 1992; Minc and Sterba 2014; Neff 2002). Compositional analyses of Yaasuchi ceramics were undertaken to determine the proportion of the Yaasuchi assemblage that was produced locally vs. imported from other sites in the Valley of Oaxaca. Insofar as the relative abundance of these goods at Yaasuchi is strongly indicative of the community's participation in regional markets and access to or dependence on imported goods, Yaasuchi's ceramic consumption patterns may be used to evaluate urban/rural exchange relations in Late Classic Oaxaca. The diversity of imported goods and the relative abundance of materials from major sites such as Monte Albán, Jalieza, and Zaachila, as well as smaller sites and more distant centers, will reflect the structure of the regional exchange network, allowing us to address questions regarding Late Classic political and economic integration.

The principal analytical method employed in this thesis was Instrumental Neutron Activation Analysis (INAA). INAA is an ideal method for the characterizing the bulk elemental composition of heterogeneous materials such as ceramics because of its high precision, accuracy, and its ability to measure large quantities of a sample (Glasock 1992; Glascock and Neff 2003; Minc 2008; Minc and Sterba [in press]). Over 300 samples of Yaasuchi ceramics and 30 natural clays were analyzed using INAA to determine their elemental composition. These data were used to estimate the geographic source of the ceramics through statistical comparisons with similar data for a large corpus of Late Classic ceramics from other sites in the Valley of Oaxaca, including production wasters, as well as well as over 300 natural clays collected during the Oaxaca Clay Survey.

An assumption of this approach is that the clays used to produce each group were unmodified by potters prior to firing. To address the possibility that the bulk compositional signature of some Yaasuchi ceramics may have been altered through the addition of temper, a subset of ceramics were submitted for analysis using Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS) at OSU's W.M. Keck Collaboratory for Plasma Spectrometry to determine whether the composition of the clay matrix differed geochemically from the sample's bulk elemental composition.

In addition to compositional analysis, measurements of vessel diameter and thickness were recorded for rim sherds of all vessel types in the Yaasuchi sample to facilitate discussion of the formal variability of locally produced goods. A detailed discussion of sample selection criteria, sherd classification and measurement, analytical protocols for INAA and LA-ICP-MS, and statistical procedures is provided below.

Sample Selection at Yaasuchi

Yaasuchi Ceramics

In the summer of 2012, the Instituto Nacional de Antropología e Historia (INAH), Centro Oaxaca generously granted access to collections of ceramics from Yaasuchi from Sherman's (2005) survey and excavation of the site held in its repository in Cuilápan de Guerrero, Oaxaca. A total of 305 archaeological ceramics were selected for analysis at OSU and exported in December of 2012.

The Yaasuchi sample was drawn from four contexts: Feature 1, Structure 6, Structure 5B, and surface collections taken elsewhere at the site. The majority of this sample was taken from Structures 5B and 6 to explore similarities and differences in household consumption patterns within the community; 97 samples were selected from Structure 5B and 104 were selected from Structure 6. To help define local compositional groups, a sample of 61 ceramics was taken from contexts in the vicinity of Feature 1, including 22 from Feature 1 proper. To provide a more general view of community consumption patterns relative to those of the two households, 42 sherds were selected from those surface collections taken outside the vicinity of Structures 5B and 6 that

Table 4.1: Summary of ware by context for the Yaasuchi ceramic sample submitted for INAA relative to frequencies of *gris* and *café* wares recovered by Sherman (2005).

Submitted for INAA

	Feature 1		Structure 6		Structure 5B		Surface		Total	
Ware	n	%	n	%	n	%	n	%	n	%
Café	32	48%	55	51%	48	48%	0	0%	135	43%
Gris	34	52%	53	49%	51	52%	42	100%	180	57%
Total	66	100%	108	100%	99	100%	42	100%	315	100%

Recovered by Sherman (2005)

	Feature 1		Structure 6		Structure 5B		Surface		Total	
Ware	n	%	n	%	n	%	n	%	n	%
Café	60	20	201	12	184	22	0	0	900	32
Gris	236	80	1449	88	639	78	71	100	1940	68
Total	296	100	1650	100	823	100	71	100	2840	100

Sherman (2005: Table B.1) identified as having a high abundance of Late Classic ceramics (collections in Areas C and D). Comparisons of ceramic consumption patterns between these contexts will facilitate discussion of (1) the prevalence and intensity of ceramic production and product specialization, (2) community reliance on locally-produced vs. imported goods, and (3) the diversity of household economic behavior. Our observations at each of these levels may be used to address the larger questions of market structure, political integration, and rural economic dependence.

To ensure a low probability of accidental selection of wares from the Late Formative Period, samples were only taken from lot bags that contained fewer than 10% diagnostic wares from the Formative Period for Structure 6 and Feature 1. Since Structure 5B was built adjacent to a Formative Period structure (Structure 5A) and was significantly disturbed by modern plowing, it was necessary to increase this threshold to 15% Formative diagnostics for the Structure 5B sample. To prevent the accidental selection of earlier ceramics from surface collections, this sample was restricted to the most common Late Classic ware: the G.35 conical bowl. Within Feature 1, Structure 5B and Structure 6 contexts, the sample was divided evenly between reduction-fired gray-ware (*gris*) and the more oxidized brown-ware (*café*) ceramics. The surface collection sample was restricted to *gris* wares due to a lack of diagnostic *caf□* wares in these collections. To ensure representative sampling of materials throughout each context, ceramics in lot bags collected from each context were first quantified in terms of frequencies of *gris* and *caf□* sherds per lot bag. A random sample was then taken from each lot bag in proportion to the frequency of each ware within that lot. Frequencies of *gris* and *caf□* wares in the Yaasuchi sample are summarized by context relative to frequencies of *gris* and *caf□* wares recovered by Sherman (2005) in Table 4.1.

No attempt was made to stratify sample selection by vessel form. This biases the sample toward the more common vessel types, but ensures that the sample more accurately reflects consumption patterns at the household and community level. Following sample selection, rim and base sherds were classified by vessel form following the Xoo Phase ceramic typology outlined by Martínez López *et al.* (2000). The most common vessel forms include *cajetes conicos* [conical bowls] (60%), *ollas* [jars] (10%), *comales* [griddles] (5%), *c□ntaros* [water jars] (2%), and *cajetes semisf□ricos* [semispherical bowls] (2%). Uncommon categories (< 2%) include *□asos* [cylindrical jars], *chirmoleras* [salsa-grinding bowls], *tlec□iles* [floor basins], and *cajetes con sil□etas com□□estas* [bowls with composite silhouettes]. Non-diagnostic body sherds were classified as *indeterminado* [non-diagnostic] (18%). These frequencies are relatively proportional to those recorded for Late Classic contexts at Yaasuchi by Sherman (2005: Tables 4.2 and 4.3).

Of the 305 ceramics exported to OSU in 2012, 4 were identified as Formative Period wares during laboratory analysis, bringing the total Late Classic sample down to 301. However, compositional data for another 10 samples of Late Classic Yaasuchi ceramics previously analyzed were also available for analysis. This sample included 6 ceramic production wasters: 5 from Feature 1 in Structure 6; 1 from Structure 5B. The other 4 samples were conical bowls from Structure 6. This brings the total Late Classic sample from Yaasuchi to 311. Frequencies and percentages of each vessel type by context are summarized in Table 4.2.

Table 4.2: Vessel form by context in the Yaasuchi ceramic sample.

	Feature 1		Structure 5B		Structure 6		Surface		Total	
Vessel Form	n	%	n	%	n	%	n	%	n	%
Cajete cónico	28	42.4	49	50.0	66	60.6	42	100.0	185	58.7
Olla	5	7.6	13	13.3	12	11.0	0	0.0	30	9.5
Comal	4	6.1	11	11.2	0	0.0	0	0.0	15	4.8
Cajete semiesférico	1	1.5	3	3.1	2	1.8	0	0.0	6	1.9
Cántaro	0	0.0	5	5.1	0	0.0	0	0.0	5	1.6
Sahumador	2	3.0	1	1.0	0	0.0	0	0.0	3	1.0
Vaso	2	3.0	1	1.0	0	0.0	0	0.0	3	1.0
Chirmolera	0	0.0	2	2.0	0	0.0	0	0.0	2	0.6
Silueta compuesta	0	0.0	0	0.0	1	0.9	0	0.0	1	0.3
Tlecuil	1	1.5	0	0.0	0	0.0	0	0.0	1	0.3
Waster	5	7.6	0	0.0	1	0.9	0	0.0	6	1.9
Indeterminado	17	25.8	13	13.3	24	22.0	0	0.0	54	17.1
Formative	1	1.5	0	0.0	3	2.8	0	0.0	4	1.3
Total	66	100	98	100	109	100	42	100	315	100

Yaasuchi Clay Survey

To facilitate the identification of locally-produced wares at Yaasuchi, a clay survey was conducted within a 2 km radius of the site during the summer of 2012. For the purposes of this study, a field clay is defined as a soil or sediment with sufficient clay content to be highly plastic (as determined by the ribbon method) and thus potentially suitable for forming ceramic vessels, although it may contain a significant fraction of grains or inclusions larger than clay particles. The intent of this survey was twofold: to determine the current extent of locally-available field clays and to collect a group of samples encompassing the full range of textural and morphological variability in the area. The survey was conducted in two parts: (1) a gross coverage survey of soil profiles along accessible roads and stream-banks, and (2) an intensive pedestrian survey within the immediate vicinity of the site with the permission of the land-owner.

A total of 30 clay samples were collected over the course of this survey from 22 sampling locations. The majority of the clay samples collected (22) were located during the pedestrian survey in an area less than half a kilometer southwest of the site where a dark

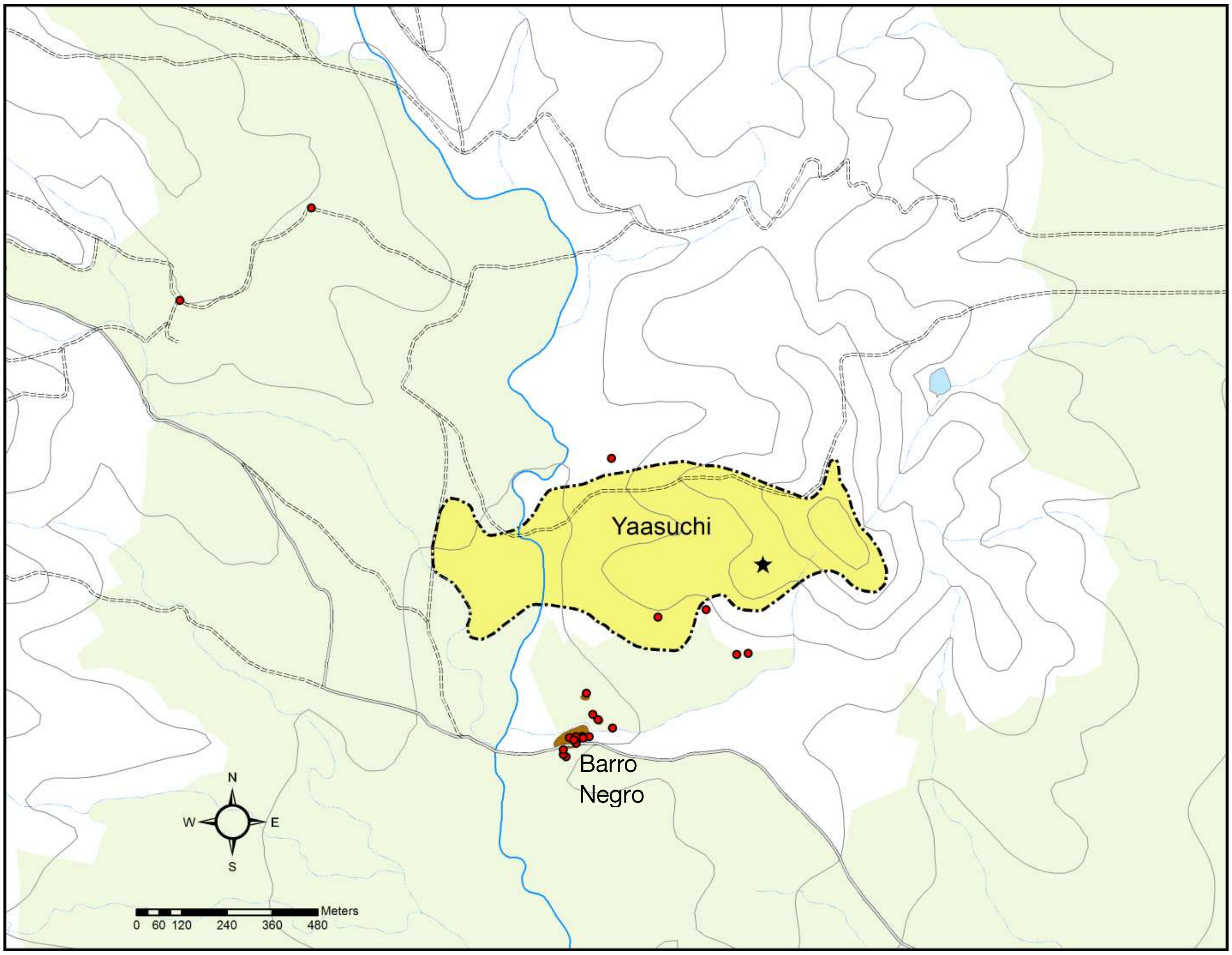

Figure 4.1: Yaasuchi Clay Survey sampling locations relative to the site of Yaasuchi. Approximate site boundaries are shown in yellow. Areas that are currently under agricultural production are shown in green.

bed of *barro negro* (black clay) was exposed at the surface in a maize field on either side of a small creek. This clay bed was sampled at semi-regular intervals using a soil auger to depths of 30". Augering showed that the clay bed varied in texture with depth from clay to sandy clay. Samples were collected from multiple depths when the clay appeared to vary substantially in texture. Samples were not collected in areas or from depths where the texture approached too sandy to be considered pottery quality. The clay bed was very limited in extent; its total estimated area was only about 5000 m^2. Equivalent deposits could not be located elsewhere in the vicinity of the site.

The remaining clay samples were collected from cut-banks up to 1.5 km from the site in the surrounding foothills. Generally speaking, steeper slopes in the area tended to be devoid of soil (due to erosion) and thus lacked clay-rich sub-surface horizons. Valley floors were generally congested with alluvial deposits of silt and sand and also lacked clay-rich soils or sediments. All field clays collected from outside the *barro negro* deposit were red-to-yellow in color and tended to be somewhat sandy in texture. All were collected from clay-rich horizons within residual soils developing on the native bedrock. These exposures were of limited extent and typically occurred on the foot-slopes or side-slopes of hills. Figure 4.1 shows the distribution of clay sampling locations relative to the site of Yaasuchi.

Comparative Data

The Yaasuchi data are part of a larger, collaborative study focusing on Late Classic ceramic production and exchange. As part of this project, this study benefits from access to compositional data from two larger, regional data sets: a large sample of Late Classic ceramics from 7 sites in the Valley of Oaxaca; and a large sample of natural clays collected from throughout the region during the Oaxaca Clay Survey. Each of these data sets is described below.

Oaxaca Clay Survey Database

The Oaxaca Clay Survey was conducted over two field seasons in 2007 and 2012 with the goal of acquiring a spatially representative sample of geologic clays from across the Valley of Oaxaca in order to establish a robust basis for ceramic provenance determinations (Minc and Sherman 2011; Minc 2013). Samples were collected from a total of 328 locations and exported to the OSU-RC for compositional analysis through INAA. Sample preparation and analysis followed the procedures described for the Yaasuchi Clay Survey samples described above and yielded major, minor, and trace-element data comparable to that available for the Yaasuchi ceramics.

Clay geochemistry is driven by several factors, including weathering, erosion, and redeposition, but it is largely a product of parent material. The Valley of Oaxaca is a diverse geologic landscape that may be classed into three main complexes (Minc 2013:1-2; Minc and Sherman 2011):

(1) Metamorphic complexes of Precambrian dioritic gneiss, meta-granite, and meta-anorthosite. Dioritic gneisses dominate the geology of the western side of the valley from the Etla Subvalley to Ejutla while meta-anorthosites and granites outcrop more locally in the Etla Subvalley west of Atzompa and Loma del Trapiche.
(2) Cretaceous sedimentary complexes of limestones, conglomerates, sandstones, and fine-grained calcareous mudstones or calcilutites. Spatial distribution of these units is discontinuous, but they are primarily found in the hills dividing the Tlacolula and Zimatlán Subvalleys, the Northern Etla Subvalley, and the southern Tlacolula Subvalley.
(3) Tertiary volcanics, including rhyolite tuffs at the eastern side of the Tlacolula Subvalley and andesites in the Tlacolula Subvalley and eastern side of the Ocotlán Subvalley.

During the Oaxaca Clay Survey, samples were collected on an opportunistic basis from exposures of natural clays in surface deposits and cut-banks along roads, streams, and quarries. Sampling was conducted with the dual intent of establishing a representative database of material associated with each bedrock type and obtaining clays from the vicinity of potential production areas and major Late Classic sites. Figure 4.2 is a map showing the OCS sampling locations relative to regional geology and archaeological sites included in the OSU-RC Late Classic ceramic database.

In order to create a continuous model of clay composition throughout the Valley of Oaxaca, compositional data from 320 sampling locations were used to generate a smoothed surface of geochemical data for 29 elements. Twenty-eight samples were excluded from calculation of smoothed surfaces as outliers or poor-quality clays, and chemistry was averaged for locations where more than one sample was available. Interpolation was conducted using the minimum curvature spline method, which maintains a relatively exact fit while compensating for irregularly spaced data. Interpolated values for each element

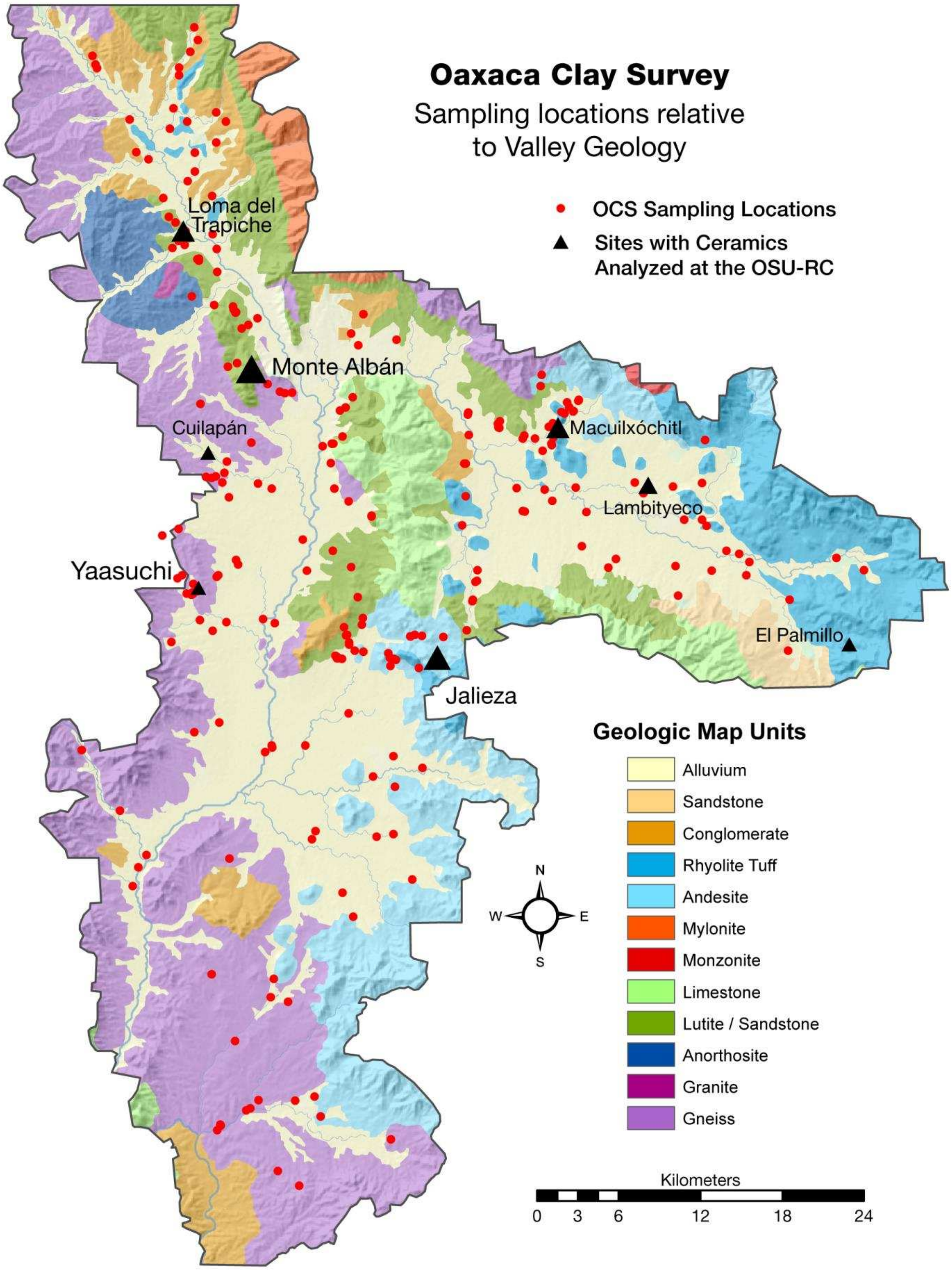

Figure 4.2: Oaxaca Clay Survey sampling locations relative to regional geology.

were then projected onto a series of points spaced at 1 km intervals and cropped to the Valley of Oaxaca Settlement Survey Boundary (for details see Minc and Sherman 2011).

Use of the OCS spatial model offers a number of clear advantages for provenance estimates. The model may be used to map the spatial patterning of elemental variation at a regional scale, facilitating the identification of regional trends, spatial correlations between elements, associations with geologic units, and areas of unique chemistry (Minc and Sherman2011). Moreover, it provides estimates of the probable chemistry of areas with low sample representation. When compared with compositional data for ceramic reference groups, these factors may contribute to finer resolution in provenance determinations or identify areas of broadly similar chemistry.

Figure 4.3 shows the relative (low to high) regional distribution of 12 elements important in discriminating differences between the Late Classic reference groups as mapped using the OCS spatial model. The regional distribution of some element groups strongly reflects the influence of clay parent materials. Concentrations of the rare earth elements (only La is shown) appear highest along the western edge of the Valley and Ejutla where the bedrock is dominated by dioritic gneiss. These elements are depleted farther east in the Tlacolula Subvalley, where volcanics are most abundant. Concentrations of some transition metals (Fe and Sc) echo this regional trend, while others (Cr and V) are more regionally variable. Concentrations of the alkali metals, particularly Cs and Rb, are highest in areas with volcanic geology and lowest in areas where metamorphic rocks are most abundant. This is not the case for Na however, which has elevated concentrations in all three sectors of the Valley but is generally depleted in alluvial areas. The distribution of sedimentary bedrock units is most closely reflected in Ca concentrations, which are highest in the hills separating the Tlacolula and Zimatlán Subvalleys, in the northern Etla Subvalley, and in the hills between the Ejutla and Ocotlán Subvalleys.

Late Classic Ceramic Database

To identify Yaasuchi samples that were imported from other sites, compositional data for the Yaasuchi ceramics were compared to reference groups of Late Classic ceramics from elsewhere in the Valley of Oaxaca previously defined by the OSU-RC (Minc 2013;

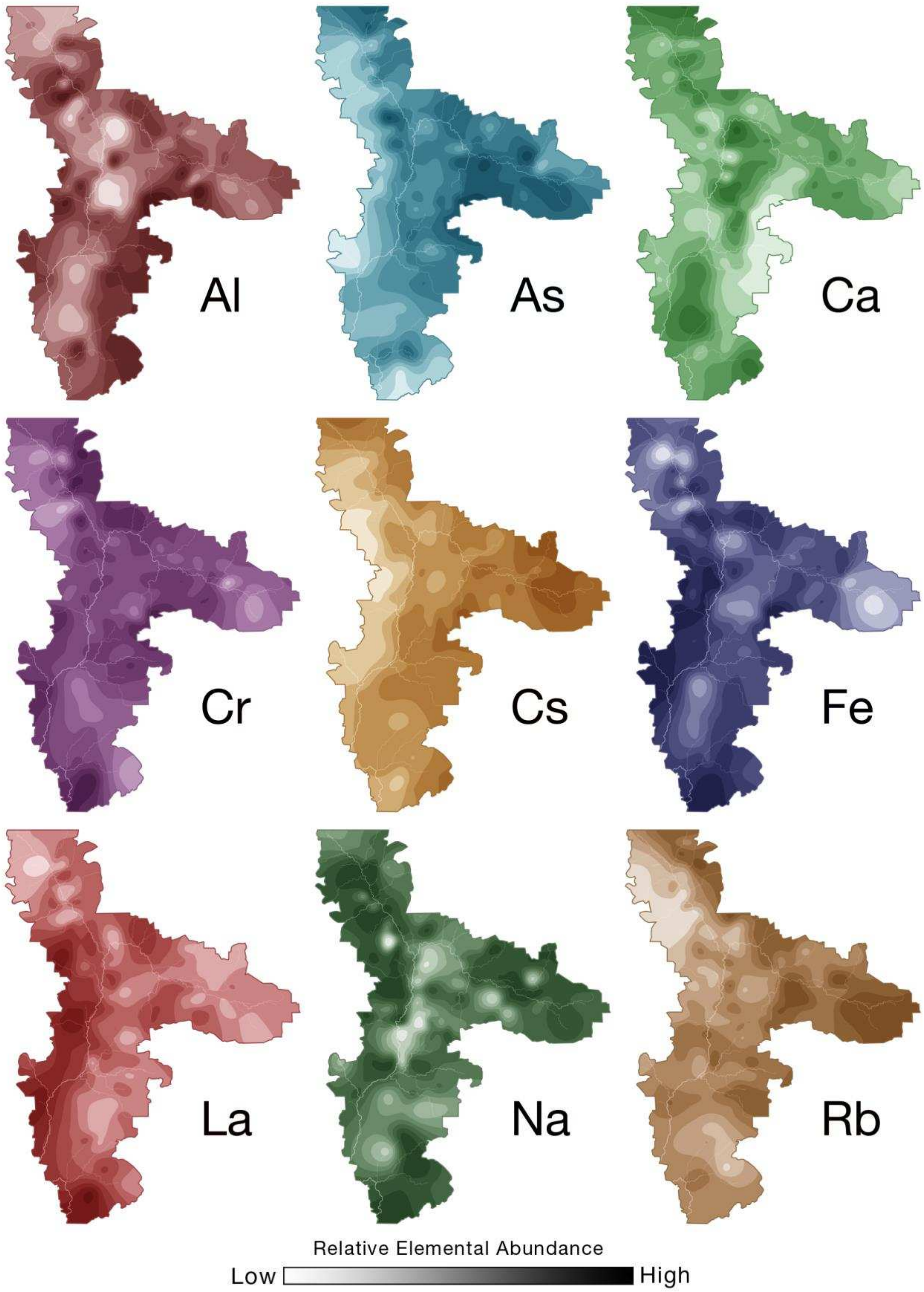

Figure 4.3: Smoothed relative abundances of nine elements in natural clays from the Valley of Oaxaca. Values were interpolated using trace-element data from the Oaxaca Clay Survey.

Minc and Pink 2014). These groups were defined using a database of over 1300 ceramic samples from key sites throughout the Valley of Oaxaca, including Monte Albán, Jalieza, Macuilxóchitl, Lambityeco, El Palmillo, Cuilapán and San Agustín de las Juntas, and Yaasuchi. To date, ten different compositional groups have been defined for elsewhere in the valley, and each reference group has been assigned a probable provenance based on the principal of local abundance and its similarity to clays associated with particular bedrock units and different regions of the valley (Figure 4.4; Minc 2013; Minc and Pink 2014).

Photography and Sherd Measurements

Prior to compositional analysis, all ceramic samples were photographed and measured in the OSU Archaeometry Laboratory. Three artifact photos were taken of each sherd: 1 interior view, 1 exterior, and 1 of the profile. These were used to record attributes of vessel form for future reference. In addition, three paste micro-photographs were taken on fresh breaks using a Keyence digital microscope at 50x, 100x, and 200x magnification. These were used as a visual record of paste attributes (such as oxidation, texture, and grain-size and roundness) of potential use in the interpretation of compositional data.

To evaluate the degree to which Yaasuchi potters standardized the production of common vessel forms or imported vessels in particular size classes, two basic measurements were recorded for diagnostic rim sherds: rim diameter and thickness. Diameter was estimated by comparing each rim sherd to a diameter chart of arcs corresponding to a range of diameters. Variability in rim manufacture required a somewhat more complex protocol for the measurement of rim thickness. The most common vessel type in Late Classic Oaxaca and Yaasuchi are *cajetes cónicos* or conical bowls. During measurement of these samples, it was noticed that three distinct methods of rim construction were used in the manufacture of these vessels (Figure 4.5). Some had simple, direct rims with no apparent modification. Others had bolstered rims where the clay was folded over the exterior, resulting in a more robust rim. Still others had wiped rims where the edge of the vessel was considerably narrower than the vessel body. Of the 93 *cajete cónico* rims in the Yaasuchi sample, 55 had simple rims, 37 had wiped rims, and 3 had folded rims.

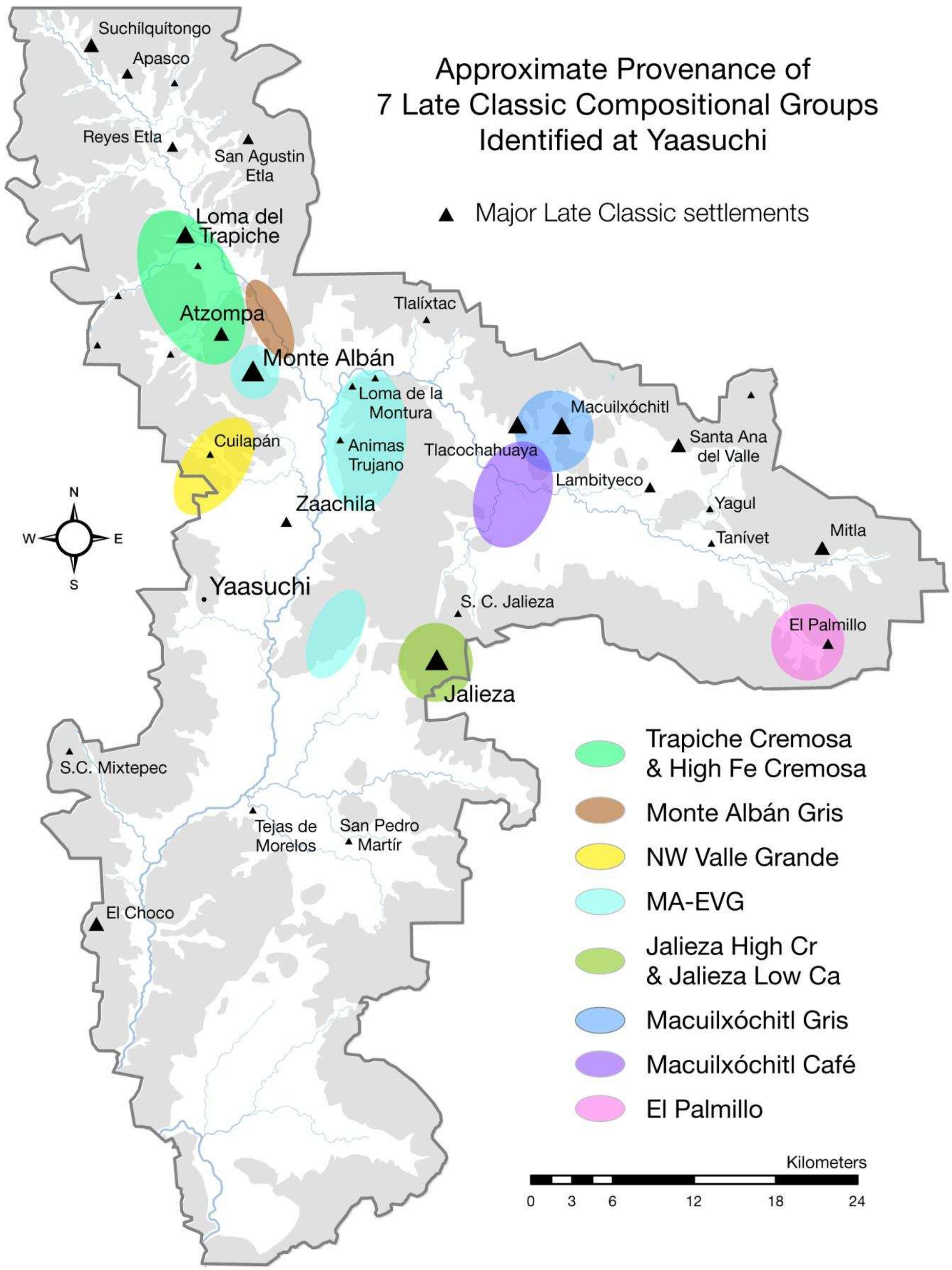

Figure 4.4: Approximate provenance of Late Classic reference groups in the OSU-RC database.

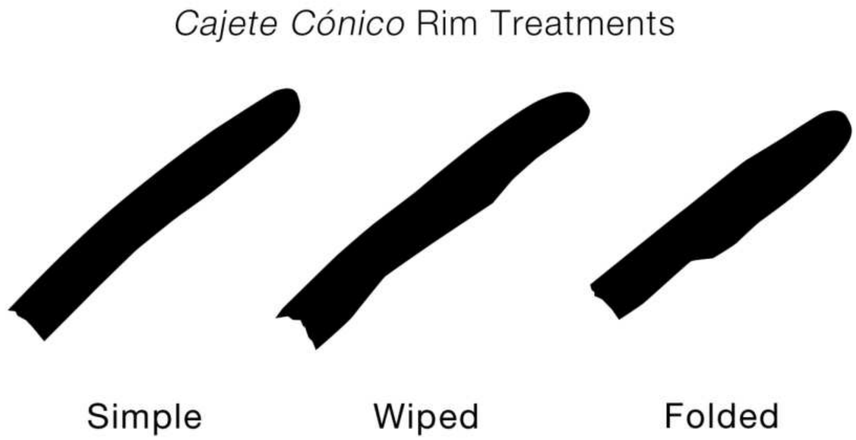

Figure 4.5: Profile views of three rim treatments observed on *cajetes cónicos* in the Yaasuchi ceramic sample.

To account for these differences in rim treatment, sherds were first classified according to rim type (simple, wiped, or folded) and then measured according to a variable protocol. The thickness of sherds with simple rims was measured 2 cm below the lip of the vessel. To obtain measurements comparable to those recorded for simple rims, folded rims were measured below the fold. Wiped rims tended to have a small ridge below the wiped portion of the rim. The thickness of these vessels was therefore recorded below this ridge to obtain measurements comparable to those of the simple rims.

In addition, two paste attributes were recorded for each sample: color and texture. Caso, Bernal, and Acosta (1967) identified four basic ware types for Prehispanic Oaxaca: *gris* [gray-ware], *café* [brown-ware], *amarillo* [Yellow-ware], and *crema* [cream-ware]. *Crema* ceramics, identified based on the presence of distinctive plagioclase inclusions and fine slips, were largely produced in the Formative Period. During the Classic period, these were replaced by un-slipped *gris cremosa* wares. *Amarillo* ceramics continued to be produced, but in much lower frequencies. As noted above, the Yaasuchi sample was evenly divided between *gris* and *café* wares. These classifications were confirmed for each sample in the laboratory during paste photography. Qualitative assessments of paste texture were recorded as an additional measure of paste attributes. Samples were classified as having either a *coarse* or *fine* paste, based purely on the relative abundance and visible presence of sand-sized inclusions. While these classifications are not a rigorous, quantitative measure of paste texture, they nevertheless provide a rough view of the relative texture of ceramics belonging to each group.

INAA

Sample Preparation

All ceramic samples were prepared for INAA using standard laboratory procedures (Glascock 1992; Minc 2012:7-8; Minc and Sherman 2011:292-293). After being photographed, a portion was clipped from each sherd and then the slip, residual soils, and surface contamination were removed using a tungsten-carbide bit. Samples were then rinsed in deionized water and oven-dried overnight before being pulverized with an agate mortar and pestle. An approximately 250 mg portion of each sample was then encapsulated in a high-purity polyethylene vial for irradiation.

Prior to compositional analysis, all clay samples were made into clay tiles and fired to mimic any potential effects of pottery manufacture on clay chemistry. This procedure followed standard laboratory protocols for natural clays described by Minc and Sherman (2011). Raw clays were first dried overnight and then pulverized with an agate mortar and pestle. They were then rehydrated using deionized water and shaped into a series of roughly 2 x 4 cm tiles that were again dried for a few days before firing. Firing was conducted in an oxidizing environment for 1 hour at 800° C to remove organic matter and surface absorbed water. Following firing, sample preparation followed the procedure described above for archaeological ceramics.

Irradiation

Major, minor, and trace elemental compositions of all ceramic and clay samples were determined for a suite of 32 elements using INAA at the OSU TRIGA reactor. To quantify data for elements with short-lived radioactive isotopes, all samples were first transferred to the reactor core via pneumatic tube for 20 second irradiations at a thermal neutron flux of 10^{13} n · cm^{-2} · s^{-1}. These were then subjected to an initial gamma count of 540 seconds (real time) using a 30-40% efficiency HPGe detector 22 minutes after irradiation to quantify elemental concentrations for 7 short-lived isotopes (Al, Ca, Ti, V, Dy, Mn, and K). After one week, they were irradiated again for 14 hours in a rotating rack around the reactor core at a lower neutron flux of 10^{12} n · cm^{-2} · s^{-1} to activate isotopes with longer half-lives. After allowing the shorter-lived isotopes to decay for 5 days, each sample was subjected to a 5000s (live time) gamma count to estimate elemental abundances for 7 medium half-life isotopes (As, La, Lu, Na, Sm, U, and Yb). Four weeks after irradiation, they were subjected to a final gamma count of 10,000s (live time) to estimate elemental abundances for 18 isotopes with longer half-lives (Sb, Ba, Ce, Co, Cr, Cs, Eu, Fe, Hf, Nd, Rb, Sc, Sr, Ta, Tb, Zn, Th, and Zr). Four of these elements (Sr, Zr, U, and Nd) are generally below detection limits.

Data Reduction and Quality Assurance

All elemental concentrations were calculated using direct comparisons with two certified standard reference materials: the NIST1633a coal fly ash and the NIST688 basalt. Three replicates of NIST1633a and one sample of NIST688 were included in each batch of 30 samples. The NIST688 standard was used as a calibration standard for Ca during the first gamma count, and served as a check standard thereafter. The NIST1633A standard was used to calculate the abundance of all other elements. Standard constants (reflecting the amount of activity per mg of element) were calculated for each element using consensus values for these standards as reported by Glascock (2006: Table 36) and applied to gamma counts for each sample to determine their elemental composition. Two additional standard reference materials were included as check standards in each batch to verify the accuracy and precision of results: NIST1633b (coal fly ash) and New Ohio Red Clay (NORC). Comparisons of elemental estimates for these standards to published values (Glascock 1996: Table 6) served as a check on the precision and accuracy of INAA measurements.

Ceramic Provenance Determinations

Following trace-element analysis, a series of statistical procedures were conducted to identify locally-produced and imported ceramics at Yaasuchi. First, samples were classified into compositional groups using multivariate statistical analysis of trace-element data. Individual samples were then compared to reference groups defined for a large corpus of ceramics from other Late Classic sites also analyzed at the OSU-RC to determine their similarity to ceramics produced elsewhere in the Valley. Once group membership was established, each group was statistically compared to trace-element data for clays from the region Oaxaca Clay Survey, and to the resulting interpolated spatial model of Valley clay chemistry. Each of these steps is described in detail below.

Group Definition and Refinement

The primary goal of group definition was to identify groups of ceramics with compositional signatures that are at once internally consistent and distinct from other groups, under the assumption that these groups represent the product of a distinctive clay source or production location. As a rule, the most prevalent compositional group at a given site generally represents local production (Rice 1987:413), but comparisons with data for ceramic production wasters and natural clays are necessary to confirm this interpretation. A secondary goal of group definition was to provide a statistical basis for comparisons with data from other sites, natural clays, and the spatial model of regional clay chemistry.

Group definition followed the now standard analytical sequence for ceramic provenance determination. First, preliminary groups were defined through an exploratory evaluation of univariate and bivariate plots, as well as multivariate techniques such as hierarchical cluster analysis. Clear outliers and major divisions between groups were identified, as were elements important in discrimination between groups. Samples with multiple possible affiliations were given a best-fit classification pending group refinement. Following preliminary definition, groups were refined using jack-knifed Mahalanobis distances to create statistically homogenous core groups, which were then used to re-evaluate group membership for all samples.

Glascock (1992:18) defines the Mahalanobis distance as "the measure of the squared Euclidean distance between a group centroid and a specimen, divided by the group variance in the direction of the specimen".

It may be mathematically defined as:

$$D^2 = (X_i - \overline{X})' S^{-1} (X_i - \overline{X})$$

where ▯*i* is a multivariate vector for sample *i* in group ▯, and S^{-1} is the inverse of the variance-covariance matrix (Glascock 1992:18-19; Neff 2002:29-30). Unlike simple Euclidean distances, the Mahalanobis D^2 statistic accounts for correlations between variables and the decreasing density of sample points from the group centroid toward the sample of interest in multivariate space. Mahalanobis distances also follow a Chi-square distribution, which permits significance tests using Hotelling's T^2, the multivariate equivalent of Student's T test (Glascock 1992:18-19).

Ideally, the number of samples in a group must be several times that of the number of variables in calculations of Mahalanobis distances in order to limit the influence of individual cases (Glascock 1992:19). Unfortunately, this is rarely the case when working with trace-element data for archaeological ceramics. A common method for reducing the number of variables used in calculation of Mahalanobis distances is the use of Principal Components rather than raw elemental data (Glascock 1992; Neff 2002). To this end, a Principal Components Analysis (PCA) was conducted prior to group refinement in order to reduce the dimensionality of the dataset and transform correlated elements. To define a group of variables that described the regional variability of clays from the Valley of Oaxaca rather than merely that of the Yaasuchi ceramics, a robust PCA was calculated on the covariance matrix of data for over 300 clay samples collected during the Oaxaca Clay Survey using log10 transformations of 26 elements (Al, Ba, Ca, Ce, Co, Cr, Cs, Dy, Eu, Fe, Hf, K, La, Lu, Mn, Na, Rb, Sc, Sm, Ta, Tb, Th, Ti, V, and Yb). Clay samples identified as outliers (in the upper 5^{th} percentile) based on a jack-knifed Mahalanobis distance distribution were excluded from calculation of PCs, as were 28 samples identified in the laboratory as being of insufficient quality for pottery production.

Eigen-values from this PCA show that it takes as many as 10 PCs to describe 95% of the variability in the OCS clays – an indication of just how variable clays are within the valley. The majority of this variation (82%) is described in the first 5 PCS, however, and

Table 4.3: Elemental loadings on OCS Principal Components on covariances shown in terms of eigen-vectors. Values in red represent strong positive loadings. Values in blue represent strong negative loadings. The percentage of OCS variance accounted for by each PC is shown at the head of each column.

Element	PC1 35.7% Eigen vector	PC2 19.7% Eigen vector	PC3 12.5% Eigen vector	PC4 8.6% Eigen vector	PC5 6.6% Eigen vector	PC6 4.0% Eigen vector	PC7 3.5% Eigen vector
Al	0.04	0.07	-0.06	0.07	0.04	-0.06	0.10
Ca	-0.24	**-0.64**	**0.63**	0.13	0.17	0.27	0.01
K	0.00	0.09	0.05	-0.14	0.17	-0.03	0.05
Na	0.13	-0.07	**-0.44**	0.35	0.37	**0.62**	0.31
Fe	0.19	0.08	0.07	0.16	-0.07	-0.02	0.06
Ti	0.07	0.06	-0.01	0.00	-0.23	0.27	-0.09
Sc	0.19	0.09	0.14	0.13	-0.13	-0.01	0.17
V	0.08	0.10	0.18	0.15	-0.28	0.13	0.09
Cr	0.09	0.15	0.19	0.25	**-0.48**	0.12	0.17
Mn	0.18	0.14	0.11	**0.40**	0.23	0.02	**-0.76**
Co	0.22	0.11	0.09	0.35	-0.12	0.04	-0.10
Zn	0.16	0.07	0.16	0.15	0.13	-0.12	0.25
Rb	-0.11	0.25	0.16	-0.13	0.16	0.06	0.05
Cs	**-0.57**	**0.52**	0.17	0.26	0.28	-0.03	0.10
Ba	0.13	-0.05	-0.07	-0.13	0.20	0.01	-0.14
La	0.18	0.08	0.08	-0.17	0.20	0.01	0.04
Ce	0.18	0.07	0.08	-0.12	0.17	0.02	-0.02
Sm	0.21	0.06	0.09	-0.07	0.16	-0.01	0.06
Eu	0.21	0.02	0.01	-0.02	0.13	-0.06	0.01
Tb	0.23	0.07	0.15	-0.07	0.18	-0.01	0.10
Dy	0.22	0.07	0.17	-0.08	0.10	-0.01	0.08
Yb	0.24	0.06	0.23	-0.12	0.10	-0.01	0.10
Lu	0.22	0.08	0.22	-0.12	0.07	0.01	0.11
Ta	0.06	0.05	-0.02	-0.34	-0.14	0.39	-0.28
Hf	-0.05	0.16	0.07	-0.18	-0.10	0.37	-0.07
Th	-0.13	0.30	0.16	-0.25	-0.01	0.35	-0.03

these are strongly correlated with particular groups of elements that have geologic significance. PC1 is positively loaded on all of the rare earth elements and several of the first order transition metals and negatively loaded on Cs and Ca. High values on this component are spatially correlated with the metamorphic complex in the western Valle Grande; low values correspond to the rhyolite complex in the eastern Tlacolula Subvalley. PC2 is positively loaded on Cs and Th and negatively loaded on Ca; high values on this PC correspond to clays derived from andesite complexes in the Eastern Valle Grande and Southern Tlacolula Subvalley, while negative values correspond to the dioritic anorthosite complex in the western Etla Subvalley. Together, these two PCs account for as much as 53% of the variance in the OCS clays. Formulas for the first 7 PCs, accounting for 90% of the variability in the sample, were projected onto the data for the Yaasuchi ceramics and used to calculate Mahalanobis distances for group refinement and sample classification. Additional PCs were loaded on less reliable or redundant elements and had little utility in determining group membership. Elemental loadings and eigen-values for the first 7 PCs are summarized in Table 4.3. The geographic distributions of principal component scores for PC1 through PC4 are shown in Figure 4.6.

In the jack-knifing procedure used for group refinement, each sample is first removed from the group and compared to the remaining samples in the group to test its individual probability of membership and group homogeneity using the Mahalanobis D^2 statistic. If the group is homogenous, the removal of a single sample does not strongly affect group structure and the sample shows a high Mahalanobis distance probability of membership. Samples with low probabilities of membership are iteratively removed until group structure stabilizes and compositional homogeneity is achieved (Minc 2013:9).

Those samples remaining in each group following the jack-knifing procedure were classified as *Core* members of that group. These were used to re-evaluate the group membership of all samples, again using the Mahalanobis D^2 statistic calculated using 7 PCs. Unclassified samples that exhibited significant probabilities of membership ($p > 0.05$) in a given group were classified as belonging to that group, but designated ⍰*oncore* members. Those samples that remained unclassified were tested for most likely group membership using a canonical discriminant analysis calculated on all elements, but these classifications

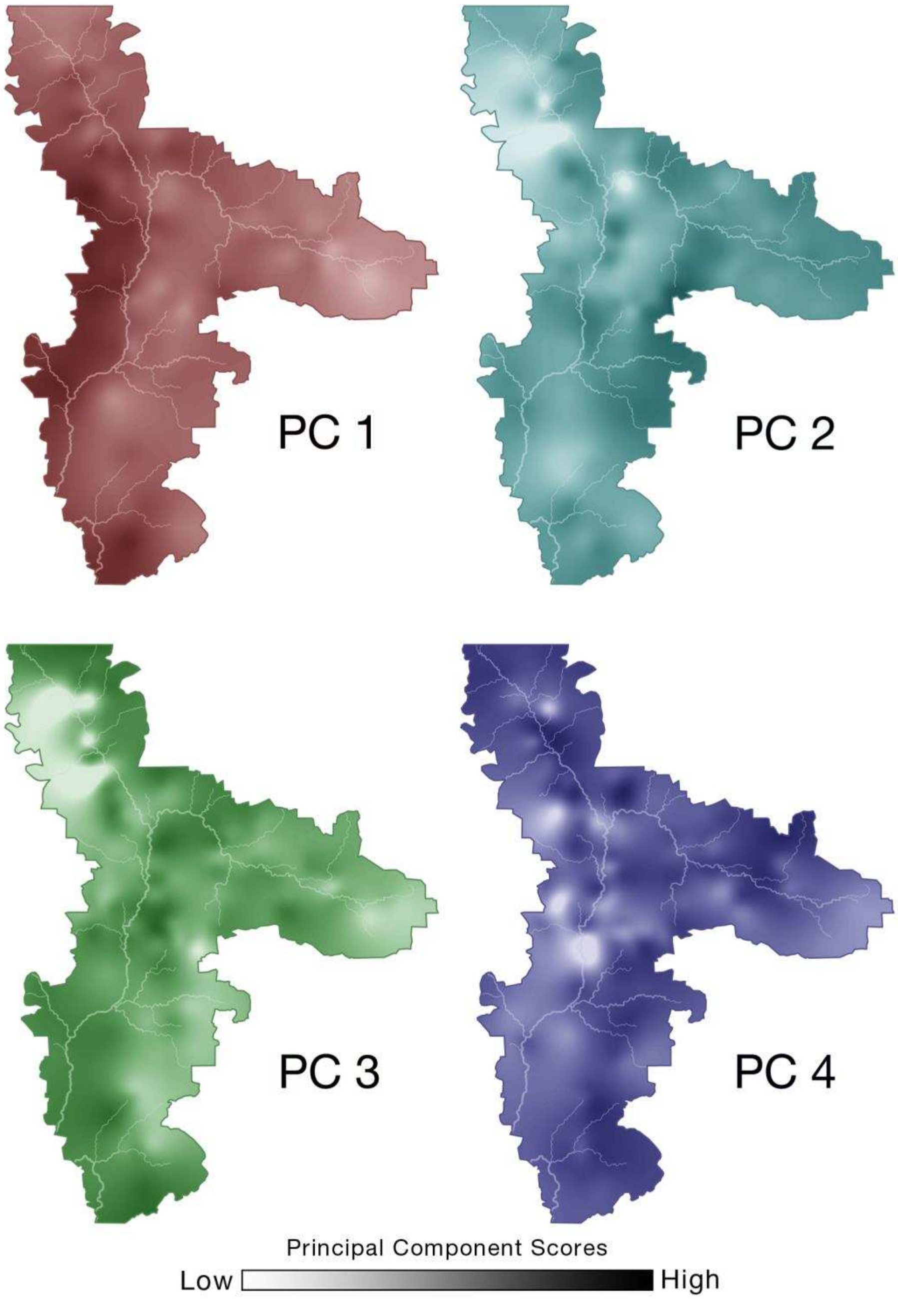

Figure 4.6: Smoothed principal component scores for PC1-PC4. Positive values for PC1 are spatially correlated with metamorphic complexes in the Western Valle Grande; negative values correspond to rhyolite complexes in the Eastern Tlacolula Subvalley. Positive values for PC2 correspond to andesite complexes near Jalieza while negative scores correspond to the anorthosite complex in the Etla Subvalley. Negative values on PC3 are spatially correlated with the anorthosite complex as well. Subsequent PCs, such as PC4, describe more localized variability useful in distinguishing between clays within each geologic province.

were verified through examination of compositional profiles before final group assignment. All samples classified in this way were designated *assigned.* Those samples that did not strongly match any group were classified as *unassigned* or *outliers* pending comparison with reference groups from other Late Classic sites.

Comparisons with the [illegible]C Late Classic Ceramic database

To date, ten compositional reference groups have been defined for other Late Classic sites (Minc 2013; Minc and Pink 2014). Two compositionally distinct *cremosa* wares, likely originated in the Southern Etla area near Monte Albán, Loma del Trapiche, and Atzompa. Two groups, one with elevated concentrations of Cr and another with low values for Ca, were most abundant at Jalieza. Another four groups could be traced to the Tlacolula arm of the Valley, including two from the Macuilxóchitl area and one from El Palmillo. Relatively few ceramics were compositionally similar to clays in the western Valle Grande, but high concentrations of the rare earth elements show that a small group, primarily found at Monte Albán and Cuilápan, likely came from the Northwest Valle Grande. Finally, compositional similarity to limestone-derived clays showed that another small group likely was likely produced in the Eastern Valle Grande or Monte Albán (Minc 2013; Minc and Pink 2014). To identify Yaasuchi samples that belonged to these various groups, Mahalanobis distance probabilities of membership were calculated for all samples in the Yaasuchi database relative to core and noncore members of each group using the 7 OCS PCs described above. Samples that exhibited significant probabilities of membership in a single group ($p > .05$) were classified as members of that group following verification of similarity using elemental bi-plots and compositional profiles. Those samples that exhibited a significant probability of membership in multiple groups were classified as belonging to the group in which they showed the highest probability of membership, but only after verification of best fit using compositional profile plots.

Comparisons with the Oaxaca Clay Survey Database

After the Yaasuchi ceramics were classified into compositional reference groups, multivariate statistical comparisons were made between each group and the Oaxaca Clay

Survey database to identify natural clays with geochemical signatures similar to those of ceramics from each group.

To identify clay samples with a high probability of similarity to the compositional groups identified at Yaasuchi, Mahalanobis D^2 probabilities of membership were calculated for all clay samples in each reference group using Core and Noncore members of that group from all sites in the OSU database. Mahalanobis D^2 probabilities were again calculated using PCs derived from the OCS clay database and projected onto the ceramic data. Calculations were made twice for each group: once using seven PCs and again using only five PCs. The use of seven PCs provided fairly conservative estimates of the probability that each clay sample was compositionally identical to a given ceramic group, but has the potential of introducing (and giving equal weight to) unimportant dimensions of variability, leading to false negative matches with the OCS clays. The use of five PCs provides a less constrained view of possible group membership, but has the potential to be less accurate if crucial dimensions of variation are missing, leading to false positives. Calculation of Mahalanobis distance probabilities using both a high and a low number of PCs provides a balanced view of possible matches between the OCS clays and the compositional groups represented at Yaasuchi. Probabilities exceeding 5% were considered fair matches between individual clays and each group under both estimation parameters.

Comparisons with the OCS Spatial Model

To complement provenance estimates made using comparisons with the OCS clays and Late Classic ceramic groups, reference groups identified at Yaasuchi were compared to an interpolated spatial model of Valley of Oaxaca clay chemistry generated using the Oaxaca Clay Survey data. Statistical comparison of the ceramic reference groups represented at Yaasuchi to the OCS spatial model largely followed the procedure used in comparisons with individual clay samples. Mahalanobis D^2 probabilities of similarity to each reference group were calculated for each 1 km grid cell using 5 OCS PCs. These probabilities were then mapped as continuous distributions using an exact splining method and cropped to the regional survey boundary. Probabilities exceeding 5% were considered fair matches between individual grid cells and each group.

Provenance Results

Using the group definition and refinement procedures described above, 95.5% of Yaasuchi ceramics (n=297) could be classified into seven compositional groups. Three of these groups were found almost exclusively at Yaasuchi and account for 83.3% of the total sample. These three groups (Atoyac/Zaachila, Yaasuchi, and Yaasuchi High REE) have chemical signatures reflecting the local geology of the western Valle Grande (i.e., enriched in the REE), but can be separated based on differences in concentrations of the REEs and Cs (Figure 4.7).

The other four groups (Monte Albán/Eastern Valle Grande, Northwest Valle Grande, Trapiche Cremosa, and High Fe Cremosa) had been previously defined using Late Classic ceramics from other sites in the OSU-RC database. Combined, these account for 12.2% of the total sample. The remaining 4.5% of the Yaasuchi sample could not be assigned to any of the Late Classic reference groups and were classified as outliers. Results of provenance determinations for each of these groups are discussed in detail below, in order of group abundance at Yaasuchi. Total group frequencies in the Yaasuchi sample are summarized by ware in Table 4.4.

Table 4.4: Frequencies and percentages of 7 compositional groups of ceramics identified in the Yaasuchi sample by ware.

	Gris		Café		Total	
Compositional Group	n	%	n	%	n	%
Atoyac/Zaachila	93	52	44	33	137	44
Yaasuchi	31	17	52	39	83	27
Yaasuchi High REE	35	20	5	4	40	13
MA-EVG	13	7.3	0	0.0	13	4.2
NW Valle Grande	2	1.1	9	6.8	11	3.5
High Fe Cremosa	0	0.0	11	8.3	11	3.5
Trapiche Cremosa	1	0.6	4	3.0	5	1.6
Outlier	3	1.7	8	6.0	11	3.5
Total	178	100	133	100	311	100

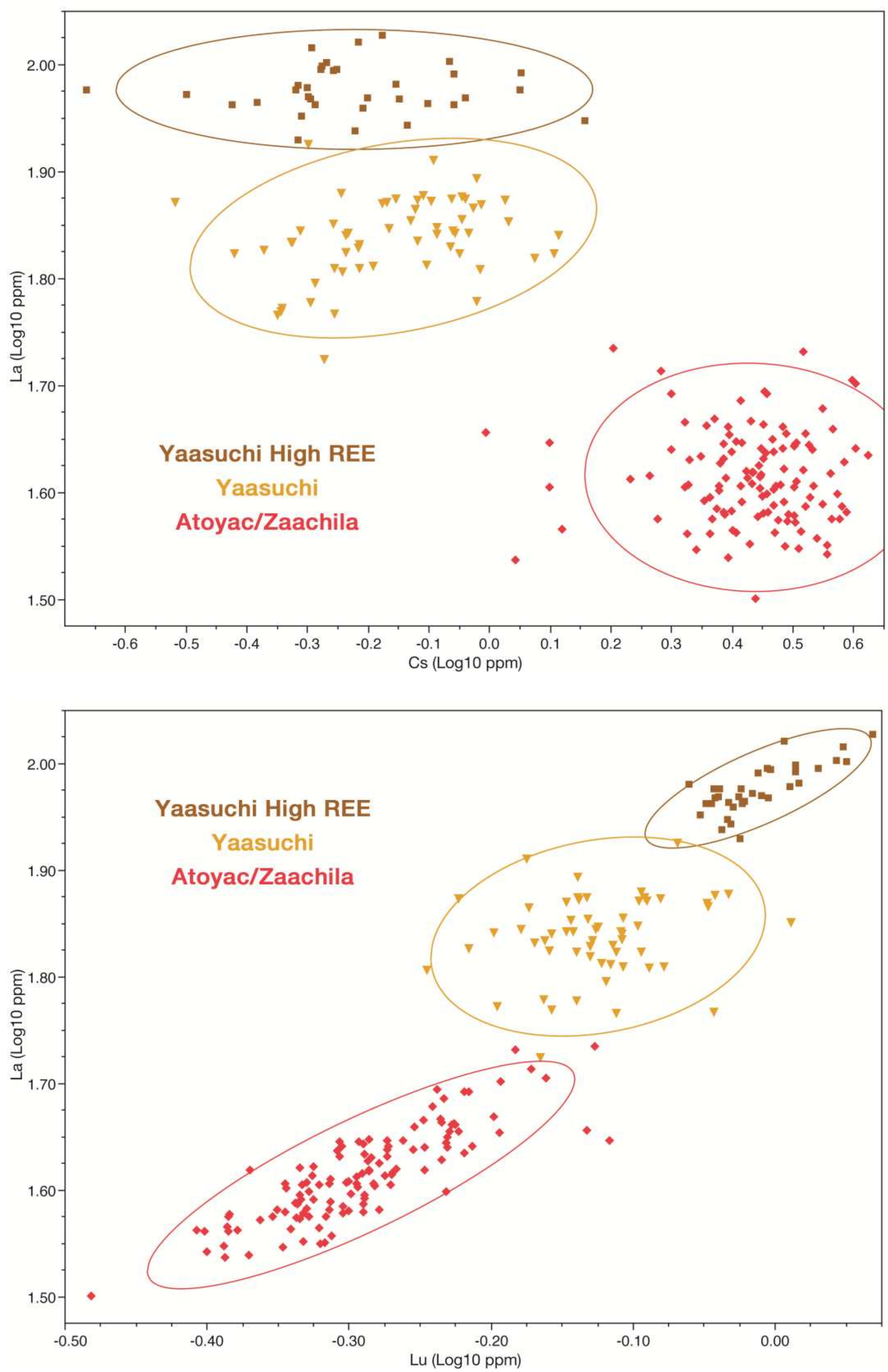

Figure 4.7: Bivariate plots of La vs. Cs and La vs. Lu for three locally-abundant compositional groups at Yaasuchi.

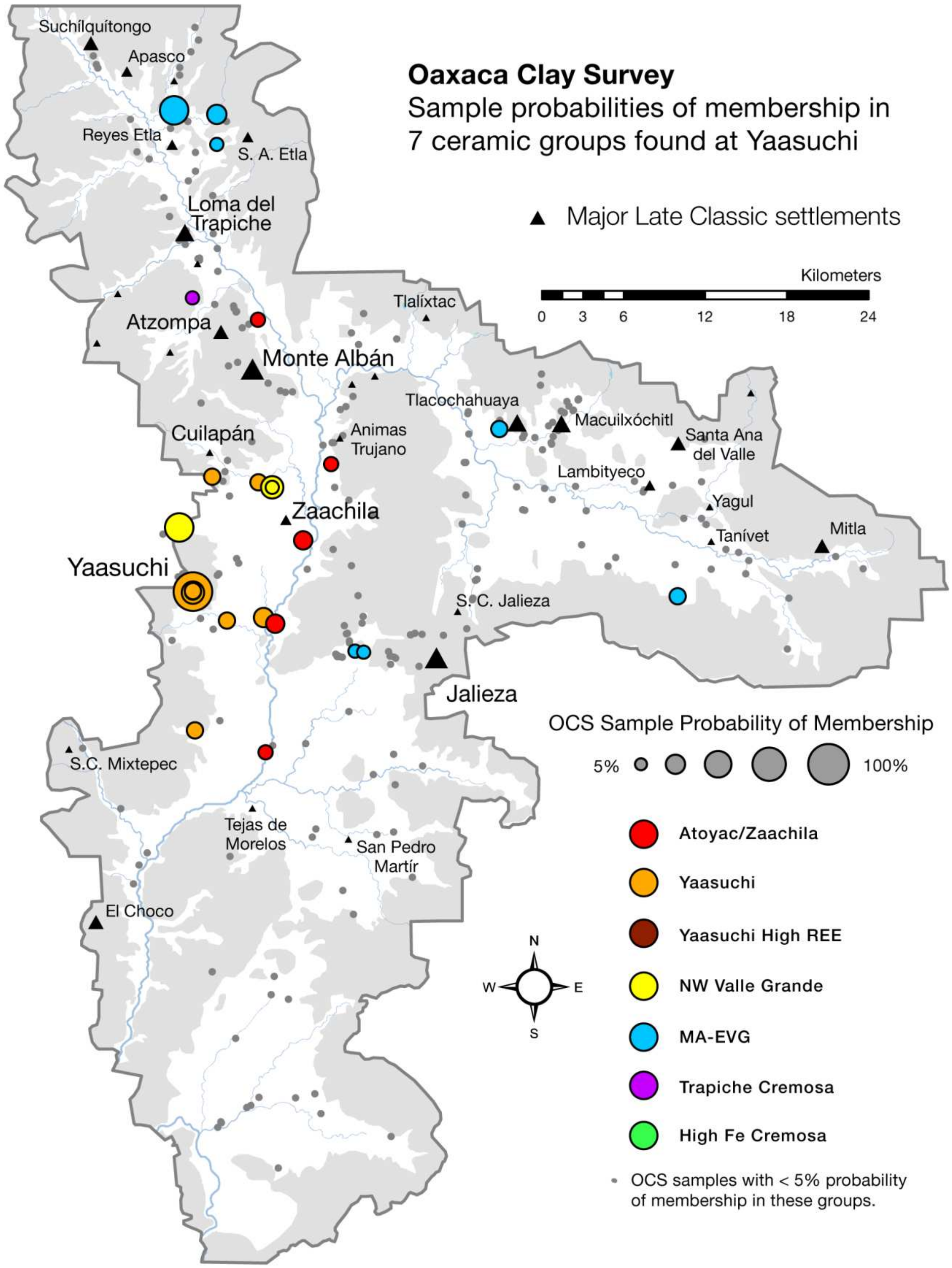

Figure 4.8: Oaxaca Clay Survey sample probabilities of membership in 7 ceramic compositional groups found at Yaasuchi. Probabilities were calculated using 5 PCs for core and noncore members of each group from all sites in the OSU-RC database.

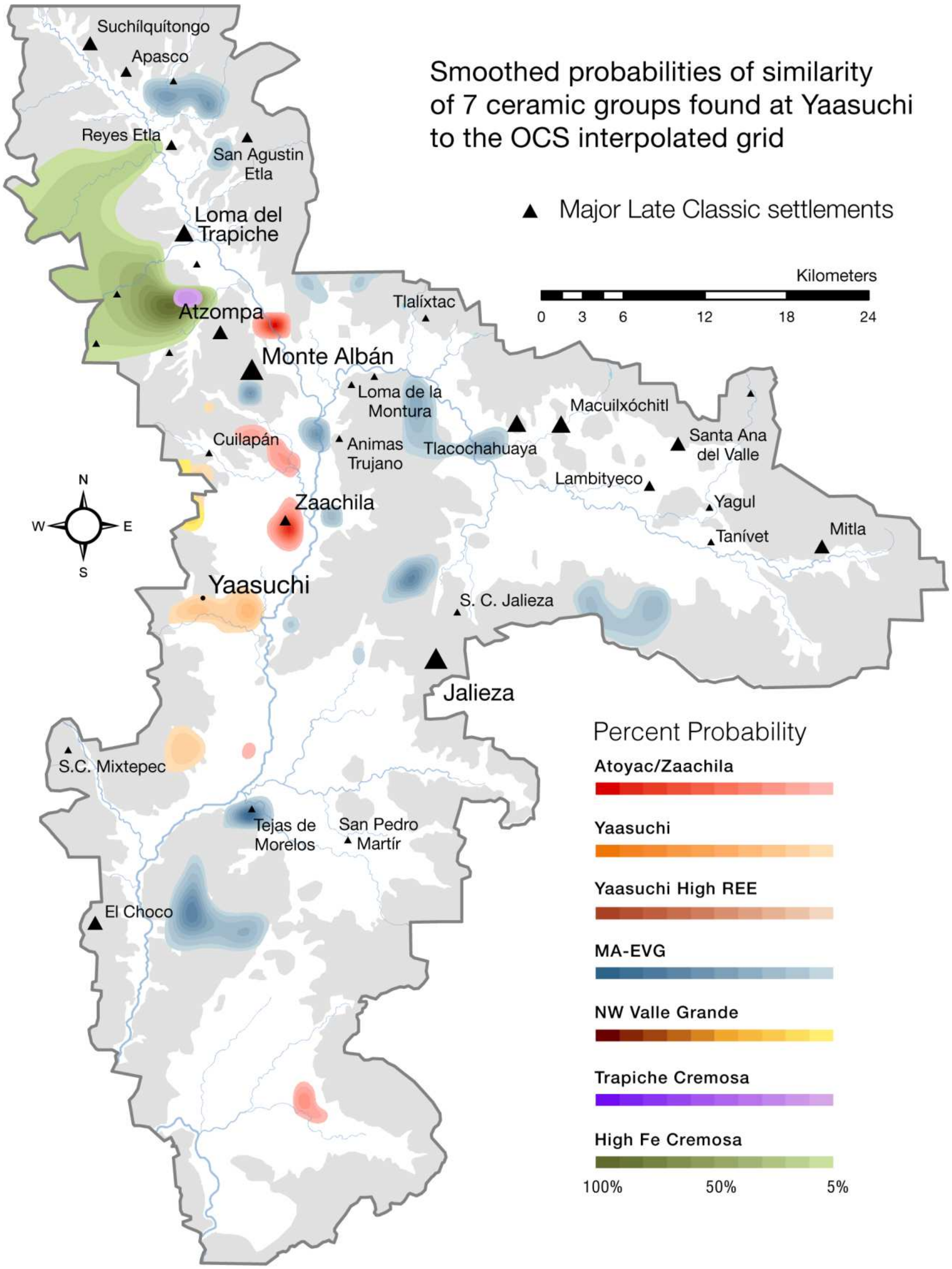

Figure 4.9: Smoothed probabilities of similarity of 7 ceramic compositional groups to the Oaxaca Clay Survey interpolated grid. Probabilities were calculated using 5 PCs for core and noncore members of each group from all sites in the OSU-RC database.

Results of Mahalanobis distance comparisons of each of these groups to the OCS clay database and the OCS spatial model using 5 PCs are shown in Figures 4.8 and 4.9, respectively.

Atoyac-Zaachila

The single most abundant compositional group at Yaasuchi accounted for 44% of the total sample (n=137), yet did not match clays within the immediate vicinity of the site. Mahalanobis distance comparisons of this group to the OCS database using 5 PCs showed that the clays with significant ($p > 0.05$) probabilities of belonging to this group were alluvial clays collected near the middle stretch of the Río Atoyac in the Southern Etla and Northern Valle Grande. These included OCS 038 (7 km east of the site), OCS 057 (1 km southeast of Zaachila), OCS 279 (across the river from El Cerrito, a site near Yatzeche), OCS 052B (5 km northeast of Zaachila), and OCS 186B (On the Atoyac below Atzompa). Comparisons with the OCS spatial model showed a similar distribution of high probability matches near Zaachila, El Cerrito, and below Atzompa. Figure 4.10 shows the compositional profile of the Middle Atoyac group relative to OCS 038, OCS 057, and OCS 279.

Given the high probability matches with alluvial clays from the middle stretch of the Atoyac, we might conclude that this compositional group represents imported goods from Zaachila, the closest Late Classic center on the Atoyac. However, half (n=3) of the Yaasuchi production wasters belonged to this group, and it was by far the most abundant in contexts most directly associated with Feature 1, suggesting that these ceramics were locally-produced. The parsimonious explanation for this discrepancy is that some or all ceramics belonging to this group were produced at Yaasuchi using clays procured near the Atoyac. At its closest point, the Atoyac is 7 km from Yaasuchi. The clay sample with the highest probability of belonging to this group (OCS 038; $p = 0.20$) was collected from this area. Yet, insofar as an abundant clay source was located less than 0.5 km from Yaasuchi, this apparent reliance upon clays located at least 7 km away warrants additional inquiry.

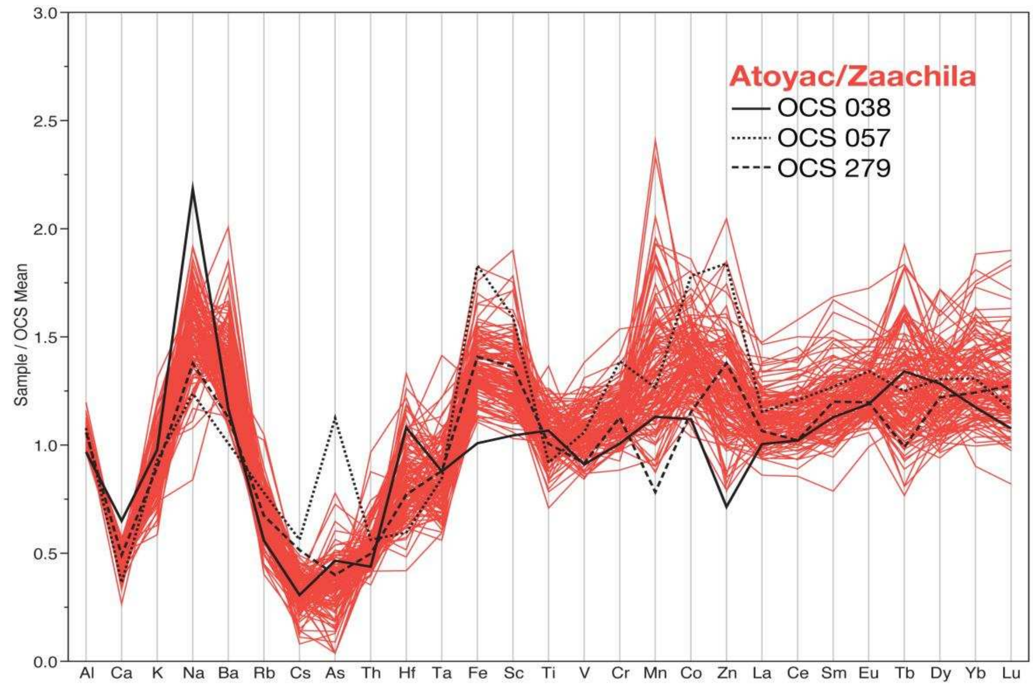

Figure 4.10: Compositional profile of the Atoyac/Zaachila group relative to the 3 clay samples with the highest probability of similarity. All were collected from the banks of the Atoyac.

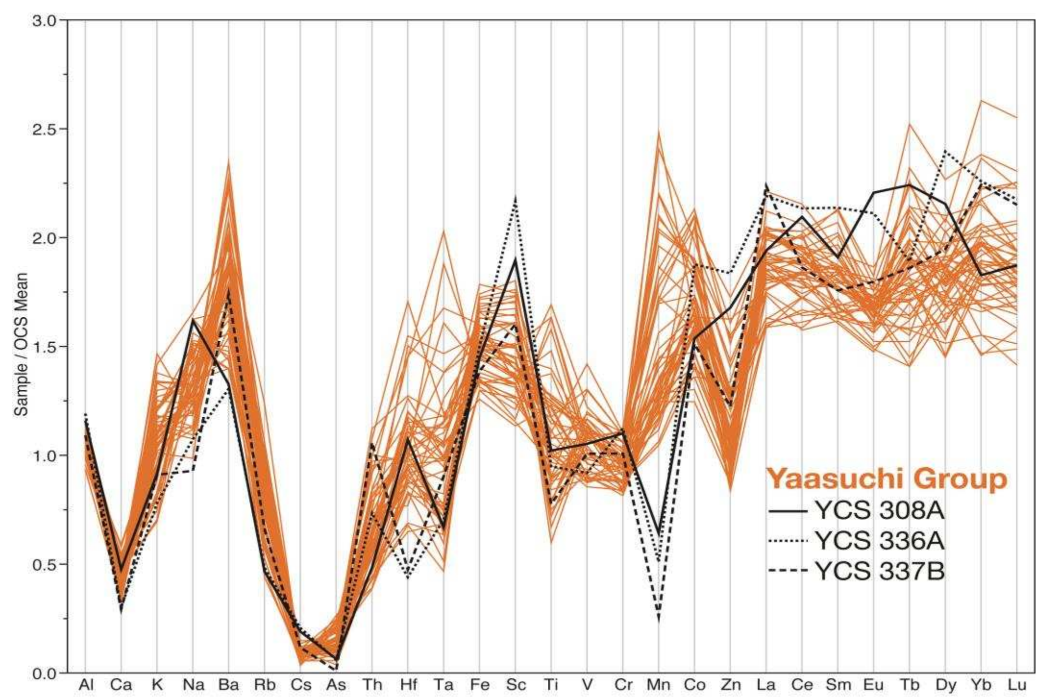

Figure 4.11: Compositional profile of the Yaasuchi group relative to the 3 clay samples with the highest probability of similarity. All 3 were collected in the vicinity of Yaasuchi.

The most significant compositional differences between the Atoyac/Zaachila group and the other locally-abundant groups at Yaasuchi (discussed below) and the YCS clays were that it had lower concentrations of REEs and higher concentrations of Cs. This compositional signature is consistent with alluvial clays near the Río Atoyac where REE-rich, gneiss-derived sediments from the Western Valle Grande are mixed with Cs-rich volcanic sediments from upstream in the Tlacolula Subvalley. Alternatively, this compositional signature could be achieved through the dilution effects of temper addition, most likely alluvial sand from the Atoyac. To address these alternative possibilities, a subset of ceramics from this group were subjected to microscale analysis using LA-ICP-MS at the W.M. Keck Collaboratory for Plasma Spectrometry to determine whether the clays used to manufacture this group had been altered through the addition of temper. Details of this analysis are summarized in the next section of this Chapter.

□aas□chi

The second-most abundant compositional group at Yaasuchi (n=82; 26%) closely matched clays from the Western Zimatlán Subvalley near Yaasuchi. Using 5 PCs, 13 clay samples exhibited significant ($p > 0.05$) probabilities of belonging to this group; 8 of these samples were collected during the Yaasuchi Clay Survey from the *barro negro* deposit less than 0.5 km from the site, demonstrating that the most likely source of these ceramics was Yaasuchi itself. Comparisons with the OCS spatial model yielded similar results. Grid cells with the highest probability of belonging to this group were located near Yaasuchi or elsewhere on the western margin of the Zimatlán Subvalley. The compositional signature of this group strongly reflects that of gneiss-derived clays from the Western Valle Grande; it is relatively high in the REEs, low in Cs and Rb, and high in Fe and Sc. Figure 4.11 shows the compositional profile of samples belonging to the Yaasuchi group relative to the three clay samples with the highest probability of similarity: YCS 308A, YCS, 336A, and YCS 337B.

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A total of 40 ceramic samples (13%), including a production waster, belonged to a third locally-abundant compositional group. This group was broadly similar in composition to the Yaasuchi group described above and YCS clays, but had higher concentrations of the rare earth elements. None of the OCS clays, YCS clays, or spatial model grid cells exhibited significant probabilities of membership in this group using 5 PCs. However, elevated concentrations of the rare earths strongly suggest that these ceramics were produced in the Western Valle Grande. The most similar clay sample (OCS 046B) was compositionally similar across most elements, but had lower concentrations of the heavy rare earths, and higher concentrations of Th and As. This sample was collected from a buried clay deposit exposed in a road-cut about 1.5 km northeast of Yaasuchi. Figure 4.12 shows the compositional profile of samples belonging to the Yaasuchi High REE group relative to OCS 046B.

The principal of local abundance and group membership of a ceramic production waster suggest that the High REE group was manufactured at Yaasuchi, despite the lack of local clay samples with a significant probability of membership. The absence of a significant match between this group and any of the OCS or YCS clays could be due to (1) clay modification during production or (2) inadequate sampling of clays within the vicinity of the site. Again, a subset of samples from this group was analyzed using LA-ICP-MS to address the first hypothesis.

Monte Albán/Eastern Valle Grande

Thirteen samples of Yaasuchi ceramics (4.2%) had significant probabilities of membership in the Monte Albán/Eastern Valle Grande reference group (MA-EVG). This group is principally distinguished based on its high concentrations of Ca and shows strong affinities to calcareous clays derived from sedimentary complexes that outcrop discontinuously in the Eastern Valle Grande, at Monte Albán, and in the Northern Etla Subvalley (Minc 2013; Minc and Pink 2014). Comparisons of this group to the OCS clays and spatial model using 5 PCs yielded significant matches in all parts of the Valley with sedimentary complexes. To narrow the provenance of this group to areas with the highest probability of similarity, Minc and Pink (2014) re-calculated Mahalanobis distances using 27 elements rather than PCs. The results of this analysis showed that the areas with the highest probability of similarity to this group were at Monte Albán, and in the Eastern Valle Grande near the Late Classic sites of Animas Trujano and Loma de La Montura.

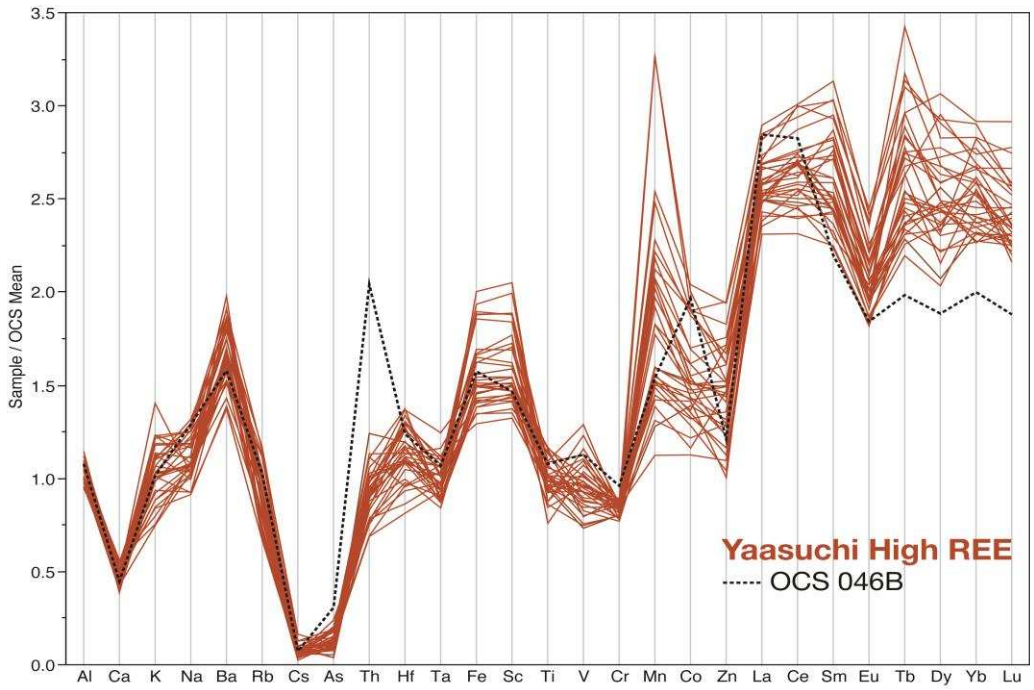

Figure 4.12: Compositional profile of the Yaasuchi High REE group relative to OCS 046B, which had the highest probability of similarity. OCS 046B was collected 2km downstream from the site.

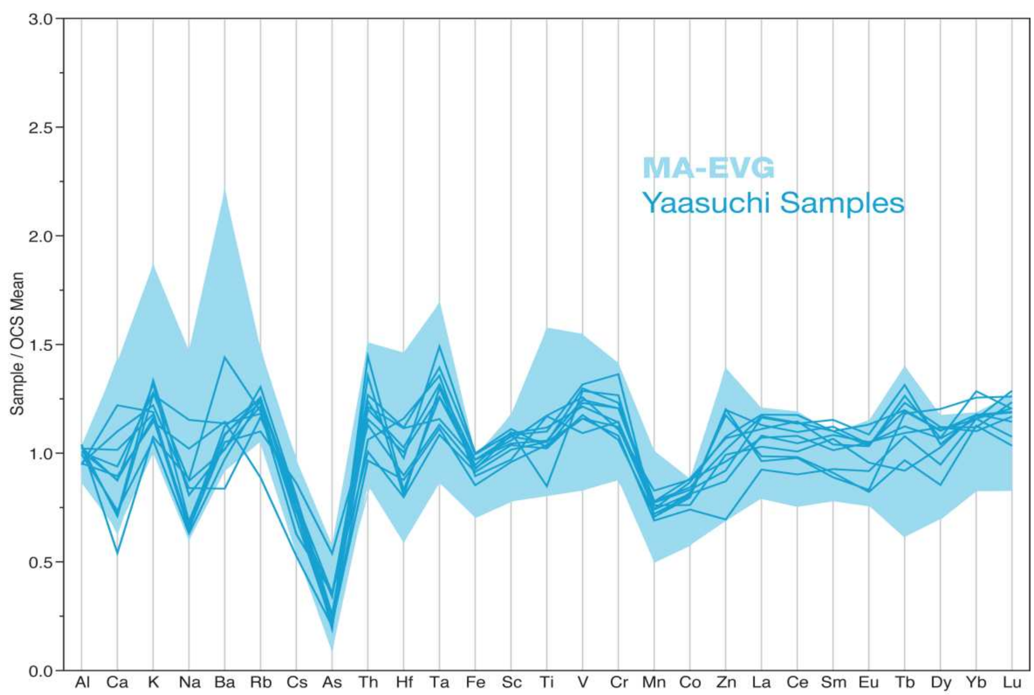

Figure 4.13: Compositional profile of the MA-EVG group relative to Yaasuchi ceramics with a significant probability of membership. Shaded area represents the compositional range of core and noncore members of the Eastern Valle Grande group.

Significantly, 16 Late Classic production wasters from Monte Albán belong to this group. A number of Formative wasters from San Agustín de las Juntas and samples from the modern potting community of San Bartolo Coyotepec (both located near Animas Trujano) exhibit high probabilities of membership as well (Minc 2013:10-11), suggesting a roughly triangular source region stretching from MA, east to SAJ, and south to Coyotepec. Figure 4.13 shows the compositional profile of the MA-EVG group relative to Yaasuchi ceramics with a significant probability of membership.

Northwest Valle Grande

Eleven samples of Yaasuchi ceramics (3.5%) had significant probabilities of membership in the Northwest Valle Grande group. Like the Yaasuchi groups, ceramics belonging to this group have relatively high concentrations of the rare earth elements, but have higher concentrations of Sc and lower concentrations of Rb and Th (Minc 2013; Minc and Pink 2014). Clays that have significant probabilities of membership in this group (using 5 PCs) are located in the northwest Valle Grande near the site of Cuilapán, including OCS 263, OCS 058, and OCS 060. Comparisons with the OCS spatial model reflected these results, indicating that ceramics belonging to this group were likely manufactured in this area. Figure 4.14 shows the compositional profile of the Northwest Valle Grande group relative to Yaasuchi ceramics with a significant probability of membership.

High Fe Cremosa

Ten samples of Yaasuchi ceramics (3.2%) had significant probabilities of membership in the High Fe Cremosa reference group. This group, like the Trapiche Cremosa group described below, is characterized by high concentrations of Al and Na, due to the presence of plagioclase inclusions, but has higher concentrations of the rare earths and Fe (Minc 2013; Minc and Pink 2014). Minc (2013) has suggested that this group may reflect a difference in paste recipe rather than a discrete production source. Specifically, its elevated concentrations of the rare earths may reflect the use of gneiss-derived clay, tempered with the plagioclase inclusions characteristic of *cremosa* wares. None of the OCS clays exhibited a significant ($p > 0.05$) probability of membership in this group using 5 PCs, but those with the highest affinity (OCS 190C and OCS 064B) were collected on the western

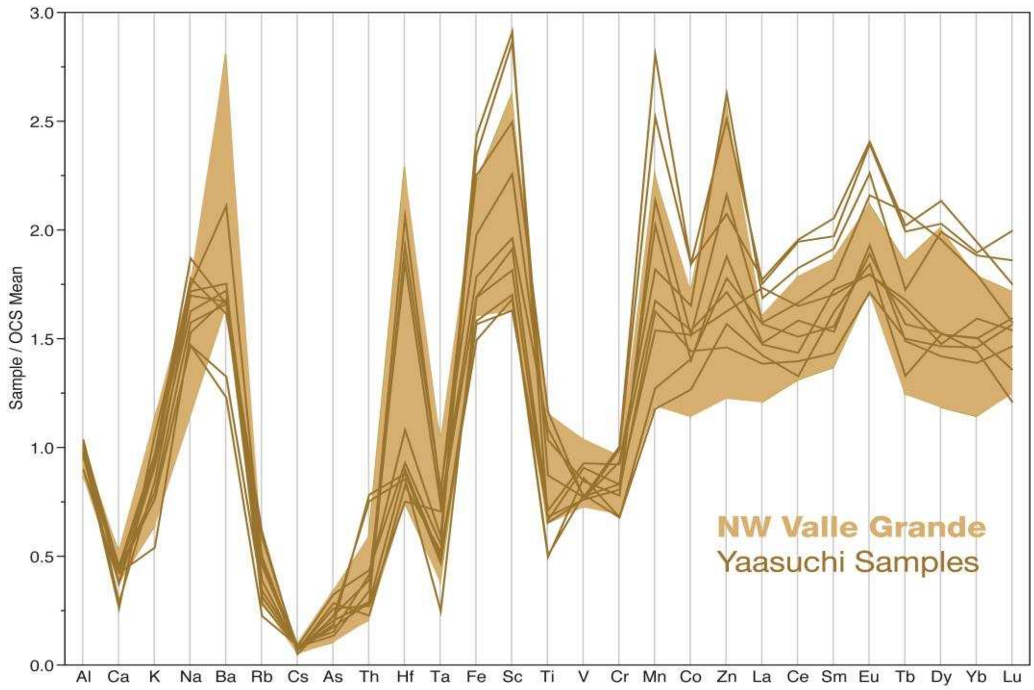

Figure 4.14: Compositional profile of the NW Valle Grande group relative to Yaasuchi ceramics with a significant probability of membership. Shaded area represents the compositional range of core and noncore members of the NW Valle Grande group.

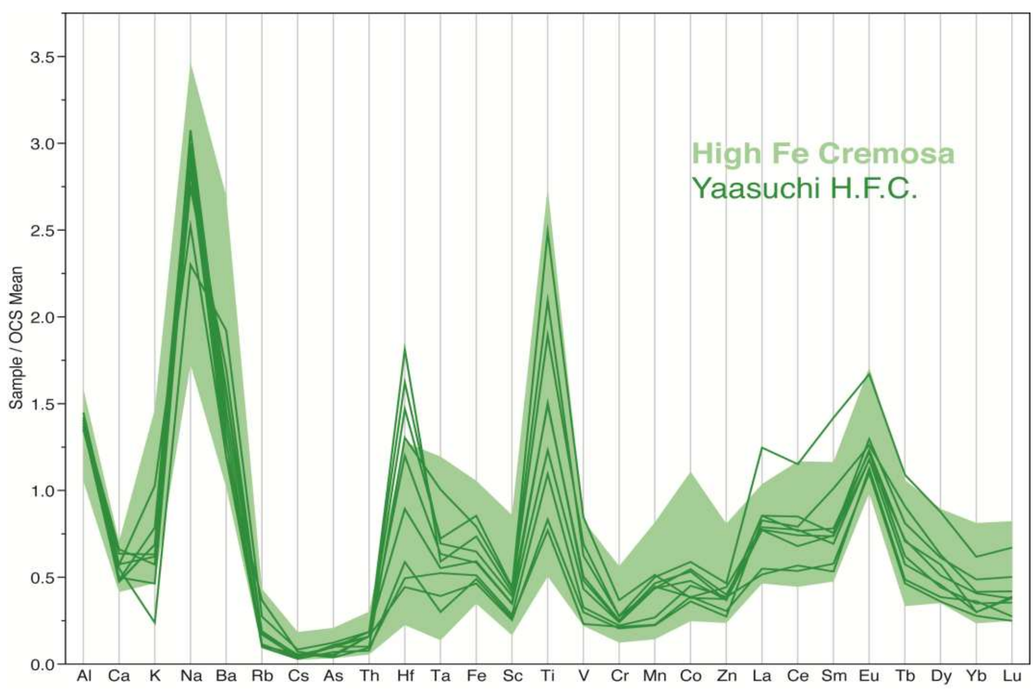

Figure 4.15: Compositional profile of the High Fe Cremosa group relative to Yaasuchi ceramics with a significant probability of membership. Shaded area represents the compositional range of core and noncore members of the High Fe Cremosa group.

side of the Etla Subvalley near Atzompa and Loma del Trapiche. In contrast, a number of grid cells in this area did exhibit significant probabilities of similarity. Figure 4.15 shows the compositional profile of the High Fe Cremosa group relative to Yaasuchi ceramics with a significant probability of membership..

Trapiche Cremosa

The smallest reference group represented at Yaasuchi is the Trapiche Cremosa group. Four Yaasuchi ceramics (1.3%) exhibited significant probabilities of membership in this group. This group includes a large number of production wasters from Loma del Trapiche, a site located a few kilometers northwest of Atzompa. These two sites flank a plagioclase-rich anorthosite deposit that is still mined for clay and temper by the modern potting community of Santa Maria Atzompa (Shepard 1967; Stolmaker 1976). Ceramics belonging to this group however, have a wide range of paste texture and often do not have visible inclusions. This suggests that these ceramics are not tempered, but manufactured

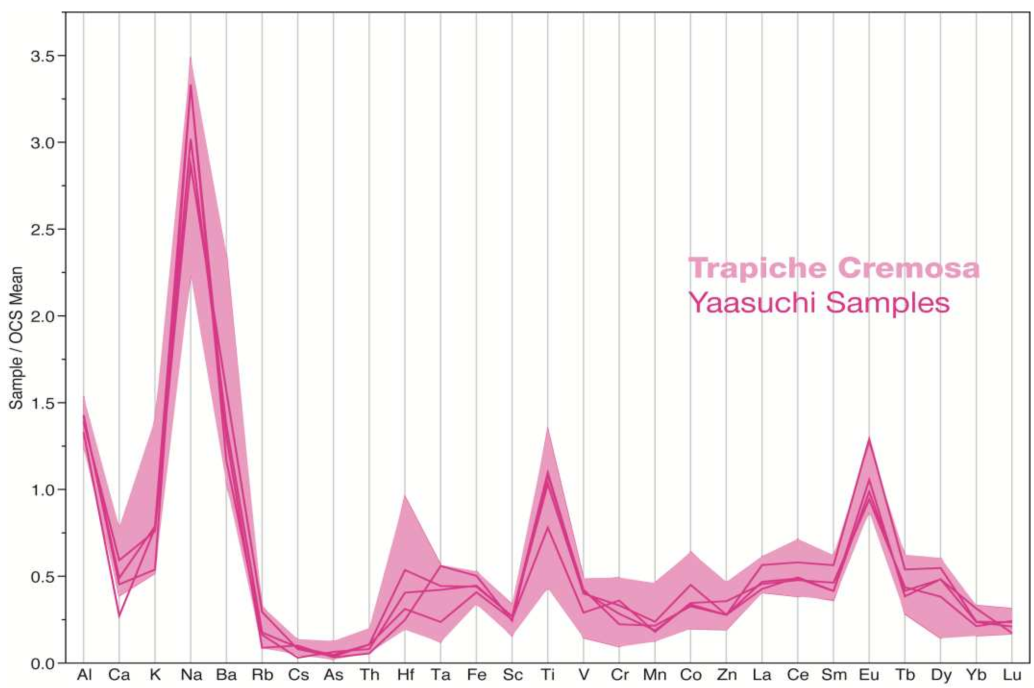

Figure 4.16: Compositional profile of the Trapiche Cremosa group relative to Yaasuchi ceramics with a significant probability of membership. Shaded area represents the compositional range of core and noncore members of the Trapiche Cremosa group

using raw-clay derived from this bedrock unit. Indeed, the only OCS clay sample with a significant probability of membership in this group (OCS 064A) was collected from the Atzompa area. Comparisons with the OCS spatial model isolated this area as having a significant probability of similarity as well. Figure 4.16 shows the compositional profile of the Trapiche Cremosa group relative to Yaasuchi ceramics with a significant probability of membership.

Outliers

Finally, 14 samples of Yaasuchi ceramics could not be classified into any of the groups discussed above or previously defined by the OSU-RC (Minc 2013; Minc and Pink 2014). Compositional dissimilarities between these samples also showed that they could not be readily classified into one or more proto-groups. However, 11 of the 14 outliers have concentrations of the rare earths, Al, Ca, K, Rb, and Cs comparable to the Yaasuchi group and YCS clays. These samples principally differ from each other and from the Yaasuchi ceramics in terms of Na and the transition metals; they are wildly variable in terms of these elements. Clay samples collected near Yaasuchi also had highly variable concentrations of the transition metals. It is thus likely that the majority of Yaasuchi outliers were produced locally rather than imported from an unknown site or sites. In any case, high concentrations of the rare earths in these 11 outliers indicate a production source in the western Valle Grande. The remaining three outliers had aberrantly low concentrations of numerous elements, suggesting errors in their measurement or calibration. All attempts to identify the source of these errors have been unsuccessful.

LA-ICP-MS

While the majority of Yaasuchi ceramics could be classified into three groups matching production debris from the site (the Atoyac/Zaachila group, the Yaasuchi group, and the Yaasuchi High REE group), only the Yaasuchi group showed strong affinity with clays collected in the immediate vicinity of the site during the Yaasuchi Clay Survey. The Atoyac/Zaachila group appeared more similar to clays collected near the Río Atoyac, while the Yaasuchi High REE group did not exhibit significant similarity to any natural clay samples. To address the possibility that the bulk elemental signatures of these two groups were the product of clay modification through temper addition or clay refinement, a subset of all three groups matching production debris from Yaasuchi were submitted for further analysis using LA-ICP-MS.

LA-ICP-MS, like INAA, is a high precision method for estimating the elemental composition of a material. Unlike INAA, it is a microscale analytical technique used to sample the composition of very small areas of a material rather than its bulk chemistry. For this reason, it is an ideal method for determining whether differences in the bulk chemistry of an archaeological ceramic are due to temper addition or are the product of use of geochemically distinct clays. LA-ICP-MS has been used in conjunction with INAA as a method of temper detection in numerous studies of archaeological ceramics (Cochrane and Neff 2006; Stoner and Glascock: 2012; Wallis and Kamenov 2013). A common approach is to use LA-ICP-MS to target the clay matrix of the sample, avoiding or analyzing inclusions separately. If a sample is un-tempered, the chemical signature of the clay matrix as measured through ICP-MS should mimic the sample's bulk chemistry as measured through INAA. If however the sample is tempered, the bulk chemistry of the sample will show dilution effects and/or elemental spikes not evident in analysis of the clay matrix. This generalization should hold for alluvial clays derived from mixed parent material because the clay, silt, and sand fractions of the sample should all be derived from multiple parent materials. Similarly, if clay has been refined to remove inclusions, its bulk elemental composition may exhibit higher concentrations of elements more abundant in the clay fraction of the material.

Sample Selection

To address the possibility that the bulk chemical signature of the Atoyac/Zaachila and Yaasuchi High REE groups could be the product of clay modification through tempering or refinement, 3 samples were selected at random from core members of each of the 3 Yaasuchi compositional groups. Although this sample size is small, the samples included for analysis are compositionally representative of the Yaasuchi reference groups. Samples of all three groups were included under the reasoning that if the Atoyac/Zaachila and High REE groups were manufactured using a local clay altered by temper addition or refinement, analysis of the clay matrix would yield results similar to those of ceramics belonging to ceramics belonging to the Yaasuchi group. If, on the other hand, the bulk compositional signature of the Atoyac/Zaachila group was the result of alluvial admixture of gneiss-derived and volcanic sediments, analysis of the clay matrix of the these samples would yield results similar to those obtained through INAA – lower rare earths and higher Cs. Similarly, if the bulk compositional signature of the Yaasuchi High REE group was not a product of clay refinement, we would expect the clay matrix of these samples to exhibit higher concentrations of the rare earths than those of the Yaasuchi group.

Analytical Protocols

Prior to compositional analysis, a roughly 0.5 x 0.5 cm portion of each sherd was removed using a rock saw, rinsed in deionized water and dried in an oven overnight. Samples were then embedded in high-purity epoxy discs and polished to 1μm for analysis. Three samples were embedded in each disc and analyzed as a group during three separate laser acquisition sequences. LA-ICP-MS was conducted using a Themo Scientific X-Series 2 plasma mass spectrometer coupled to a Photon Machines, Inc. Eximer laser with a wavelength of 193 nm. A total of 25 ablations were conducted on each sample using a spot size of 65 μm and a laser rep rate of 7 hz for approximately 32 seconds per ablation. Prior to each ablation, background counts were collected for approximately 36 seconds. Following each ablation, counts were collected for a washout period of approximately 33 seconds. Ablation spots were spaced at semi-regular intervals across the sample surface in areas of clay matrix free of sand-size inclusions (>62.5 μm). Counts were collected for 30 isotopes, including: ^{29}Si, ^{43}Ca, ^{45}Sc, ^{47}Ti, ^{51}V, ^{52}Cr, ^{55}Mn, ^{57}Fe, ^{59}Co, ^{60}Ni, ^{66}Zn, ^{85}Rb, ^{88}Sr, ^{89}Sr, ^{89}Y, ^{133}Cs, ^{137}Ba, ^{139}La, ^{140}Ce, ^{141}Pr, ^{146} Nd, ^{147}Sm, ^{153}Eu, ^{157}Gd, ^{159}Tb, ^{163}Dy, ^{165}Ho, ^{166}Er, ^{169}Tm, ^{172}Yb, and ^{175}Lu.

To calibrate isotope counts to elemental abundances, a GSE-1G basalt glass standard was analyzed using identical acquisition parameters 10 times during each acquisition sequence. To assess the accuracy of calibrated measurements, 10 ablations of a NIST612 glass standard were conducted in a similar manner. These ablations were spaced evenly throughout the sequence to help control for instrumental drift over the course of the run.

Data Processing and Calibration

Initial data processing was conducted using LaserTram, an in-house visual basic software running in Microsoft Excel. Raw time-resolved counts for each ablation were first imported into the LaserTram program to define background and analysis count rates and to calculate normalized count ratios for each isotope. Because the duration of background count collection and washout varied with travel time as the laser moved between pre-defined ablation areas, it was necessary to manually define representative periods of background and analysis counts for each sample. Background corrections were calculated by subtracting the average background count rate for each isotope from each count interval. Corrected counts for ^{29}Si were then used as an internal standard to calculate normalized count rates for all other isotopes (Humayun *et al.* 2010; Wallis and Kamenov 2012). Finally, average ^{29}Si-normalized ratios and standard errors were calculated for each ablation using normalized corrected ratios within the defined analysis periods for each ablation. Detection limits were calculated as three standard deviations above background ratios. Individual analyses yielding elemental abundances below detection limits were excluded from quantification of mean sample compositions.

To estimate elemental abundances in each ablation, calibration curves were generated using data from the GSE-1G basalt standard ablations. Observed NIST612 ^{29}Si-normalized ratios were first averaged and then compared to known abundance/SiO_2 concentrations to generate calibration curves for each element. The GSE-1G basalt has a known SiO_2 content of 53.7% (Jochum *et al.* 2007). To calculate elemental abundances in each sample ablation, ^{29}Si-normalized count ratios were multiplied by calibration gradients for each element and SiO_2 estimates for each sample, derived using its INAA data. Data for SiO_2 was not collected directly using INAA, but we may assume that it accounts for most of the remaining fraction of the sample unmeasured by other element oxides. SiO_2 was estimated by first converting all major and minor element concentrations to oxide abundances for each sample, totaling concentrations in parts per million and subtracting this amount from a million. Elemental abundances were calculated for the NIST612 check standard in the same manner using a known SiO_2 content of 70.9% (Jochum *et al.* 2007). After mass counts were calibrated to elemental abundances for each ablation, these were screened for multivariate outliers and averaged to obtain mean elemental abundances for each sample.

Results and Discussion

Because of the small sample size for this portion of the study, statistical comparisons of data from samples belonging to the three compositional groups were not possible. Interpretation of the results of LA-ICP-MS analysis was thus restricted to qualitative comparisons using multivariate compositional profile plots. To assess whether elemental abundances differed in the clay matrix of samples belonging to the three groups, data for 19 elements measured using both LA-ICP-MS and INAA for were normalized to mean concentrations from the Oaxaca Clay database and plotted as compositional profiles. These were then compared to bulk compositional profiles of INAA data for the same samples to reveal similarities and differences in clay matrix composition relative to the bulk composition of each sample. Our discussion is focused on those elements with the highest discriminatory power in separation of the three groups using their bulk chemistry: Cs and the REEs (La, Ce, Sm, Eu, Tb, Dy, Yb, and Lu).

Comparisons of the composition clay matrix of each sample as measured using LA-ICP-MS (Appendix C) relative to bulk compositional profiles for the same samples as measured using INAA (Appendix B) show much higher concentrations of most elements (especially the transition metals and REEs) in the clay matrix of all samples relative to bulk elemental concentrations. The significance of this observation is difficult to assess however, as it could be the product of either differences in the analytical accuracy of LA-ICP-MS and INAA or a real difference in bulk elemental and clay matrix composition. Our discussion is thus restricted to relative differences in the composition of the three groups, as measured using each method.

Comparisons of the compositional profiles of the clay matrix (Figure 4.17) to bulk elemental profiles (Figure 4.18) show similar differences in the abundances of the REEs and Cs in the Atoyac/Zaachila group relative to the other two groups. Concentrations of Cs in the clay matrix of the Atoyac/Zaachila group are higher than those of samples belonging to the Yaasuchi group and Yaasuchi High REE group; while concentrations of the REEs are

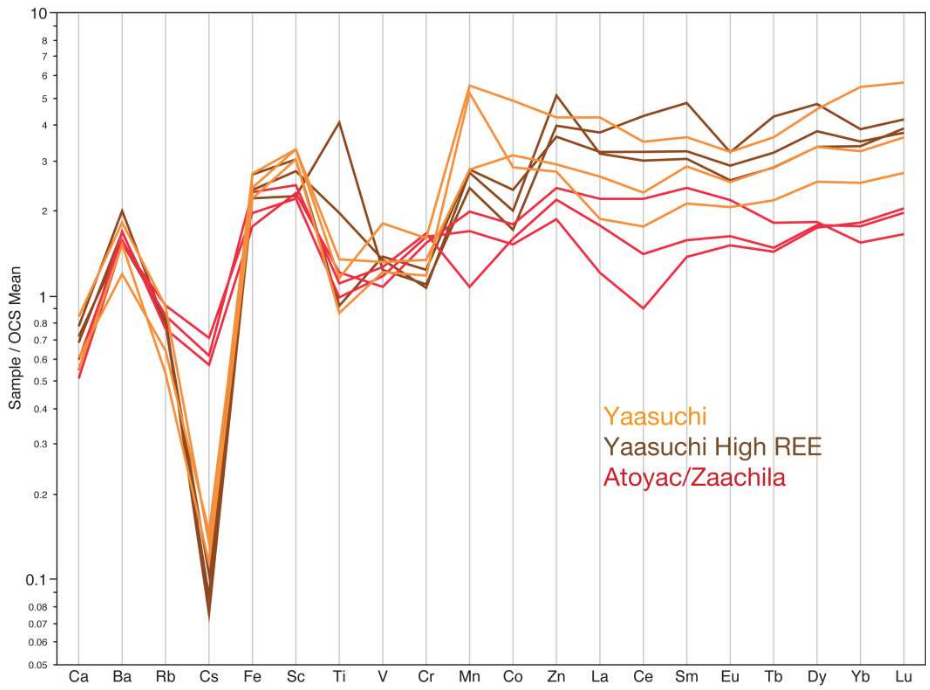

Figure 4.17: Mean compositional profiles of the clay matrix of 9 samples of Yaasuchi ceramics as measured using LA-ICP-MS.

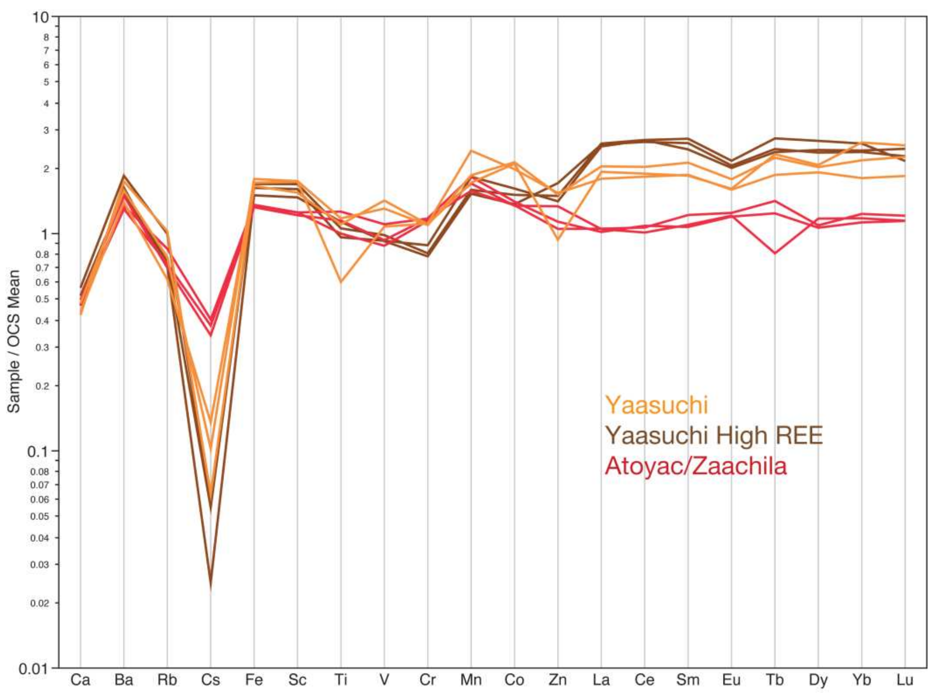

Figure 4.18: Bulk compositional profiles of 9 samples of Yaasuchi ceramics, as measured using INAA.

generally lower. There is substantial overlap in concentrations of the light REEs (La, Ce, Sm, and Eu), but samples belonging to the Atoyac/Zaachila group have slightly lower concentrations of the heavy REEs (Tb, Dy, Yb, and Lu). When analytical uncertainty and sample variance is taken into consideration, there is substantial overlap in concentrations of the REEs in the clay matrices of the three groups, even in terms of heavy REEs such as Lu (Figure 4.19; Table C.1). However, concentrations of Cs in the clay matrix of the Atoyac/Zaachila group are substantially higher than in the other two groups, even when sample variance is taken into account (Figure 4.20; Table C.1). This suggests that differences in the bulk elemental composition of the Atoyac/Zaachila group relative to other groups at Yaasuchi are not due to the addition of temper. As in the bulk compositional data obtained through INAA, the higher Cs concentrations in the clay matrix of the Atoyac/Zaachila group imply that the clay used to manufacture this group was derived from multiple parent materials, including REE-rich gneiss sediments from the western Valle Grande and Cs-rich volcanic sediments from the eastern arm of the Valley. As discussed above, the most likely source of such clay is alluvial deposits along the Río Atoyac in the northern Valle Grande. Given that half of the production wasters from Yaasuchi belong to this group and its abundance in Feature 1, these analyses suggest that a significant proportion of Yaasuchi pottery was produced using clays procured near the Río Atoyac, at least 7 km from the site.

On the whole, clay matrices of samples belonging to the other two groups exhibit a degree of similarity not evident in the bulk compositional data (Figure 4.17). In terms of their bulk composition, samples belonging to the Yaasuchi High REE group have higher concentrations of the light REEs relative to samples belonging to the Yaasuchi group and lower concentrations of Cr and Co (Figure 4.18). These differences are much less apparent in the clay matrix of each sample. In general, the clay matrix of samples belonging to the High REE group is comparable in composition to samples belonging to the Yaasuchi group. Significantly, there is considerable overlap in concentrations of the REEs and similar ratios in the abundances of the light REEs to the heavy REEs (Figure 4.17). Concentrations of Co remain lower in the High REE group, but measurements of the transition metals in the clay matrix of both groups are highly variable. These results suggest that the two groups were

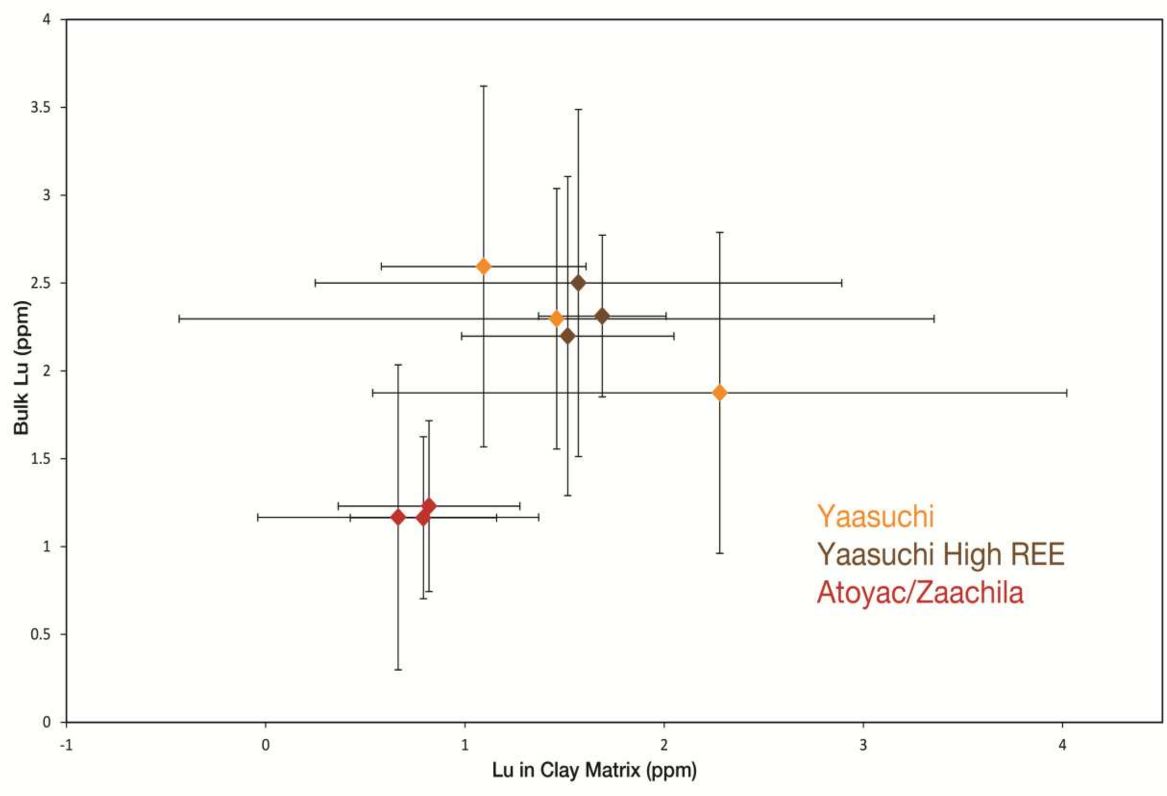

Figure 4.19: Bulk Lu concentrations of nine Yaasuchi ceramics relative to Lu concentrations in their clay matrices. Bulk Lu was measured using INAA; Lu in clay matrices was measured using LA-ICP-MS. Error bars represent one standard deviation for clay matrix data and one standard error for bulk compositional data.

manufactured using a similar clay source, but that the composition of one group was altered through clay modification. Insofar as numerous clay samples collected in the vicinity of Yaasuchi have a significant probability of membership in the Yaasuchi group, this group was likely manufactured using raw clay, while clay used to manufacture the High REE group may have been altered.

Conceivably, REE enrichment in the bulk composition of the High REE group could have been achieved through clay refinement and the removal of coarse inclusions. Comparisons of paste texture between the three groups (Table 4.5) confirm that a higher percentage of samples belonging to the Yaasuchi High REE group were made using a fine paste (87%). By comparison, only 28% of the Yaasuchi group was manufactured using a fine paste. Visual assessment of thin-section photographs of samples submitted for LA-ICP-

MS (Figure 4.21) provide additional confirmation that samples belonging to the High REE group have generally smaller inclusions than samples belonging to the Yaasuchi and Atoyac/Zaachila groups. These analyses suggest that the both the Yaasuchi group and Yaasuchi High REE group were produced using locally available clays at Yaasuchi, but that clays used to produce the High REE group may have been refined during pottery production.

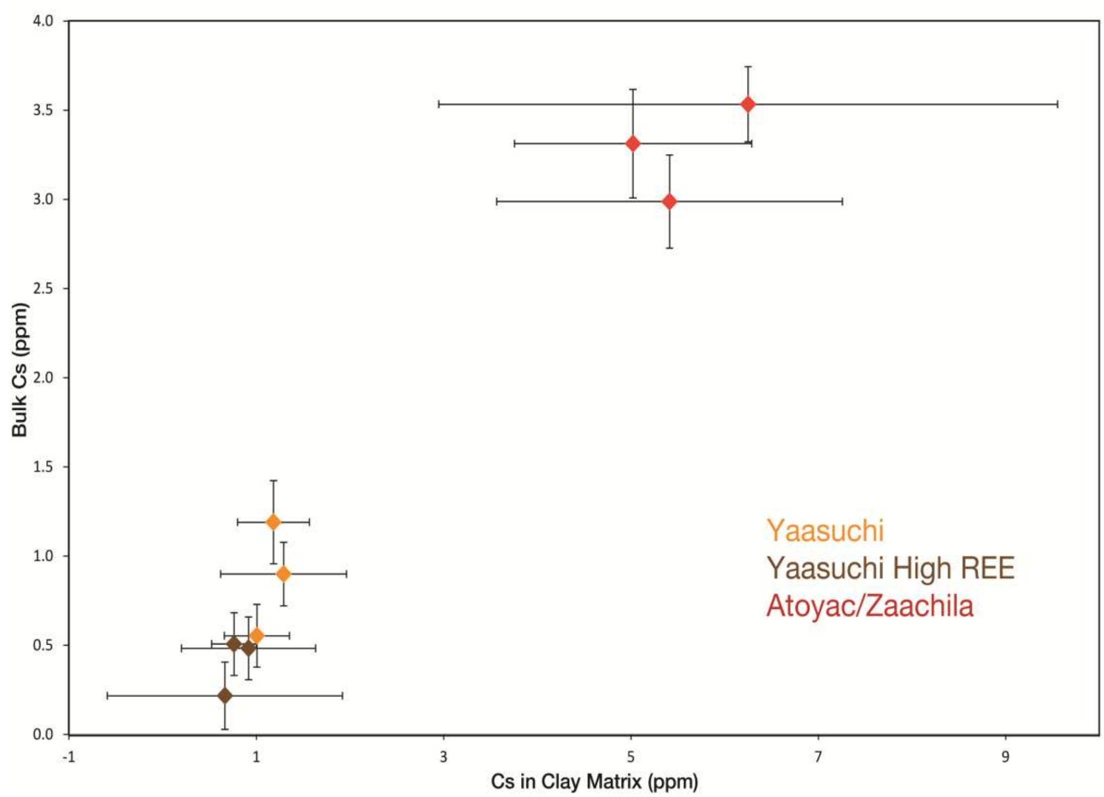

Figure 4.20: Bulk Cs concentrations of nine Yaasuchi ceramics relative to Cs concentrations in their clay matrices. Bulk Cs was measured using INAA; Cs in clay matrices was measured using LA-ICP-MS. Error bars represent one standard deviation for clay matrix data and one standard error for bulk composition data.

Table 4.5: Frequencies of coarse and fine-textured ceramics belonging to three-locally abundant groups at Yaasuchi.

	Coarse		Fine		Total	
	n	%	n	%	n	%
Yaasuchi	58	71.6	23	28.4	81	100
Yaasuchi High REE	5	13.2	33	86.8	38	100
Atoyac/Zaachila	62	47.3	69	52.7	131	100

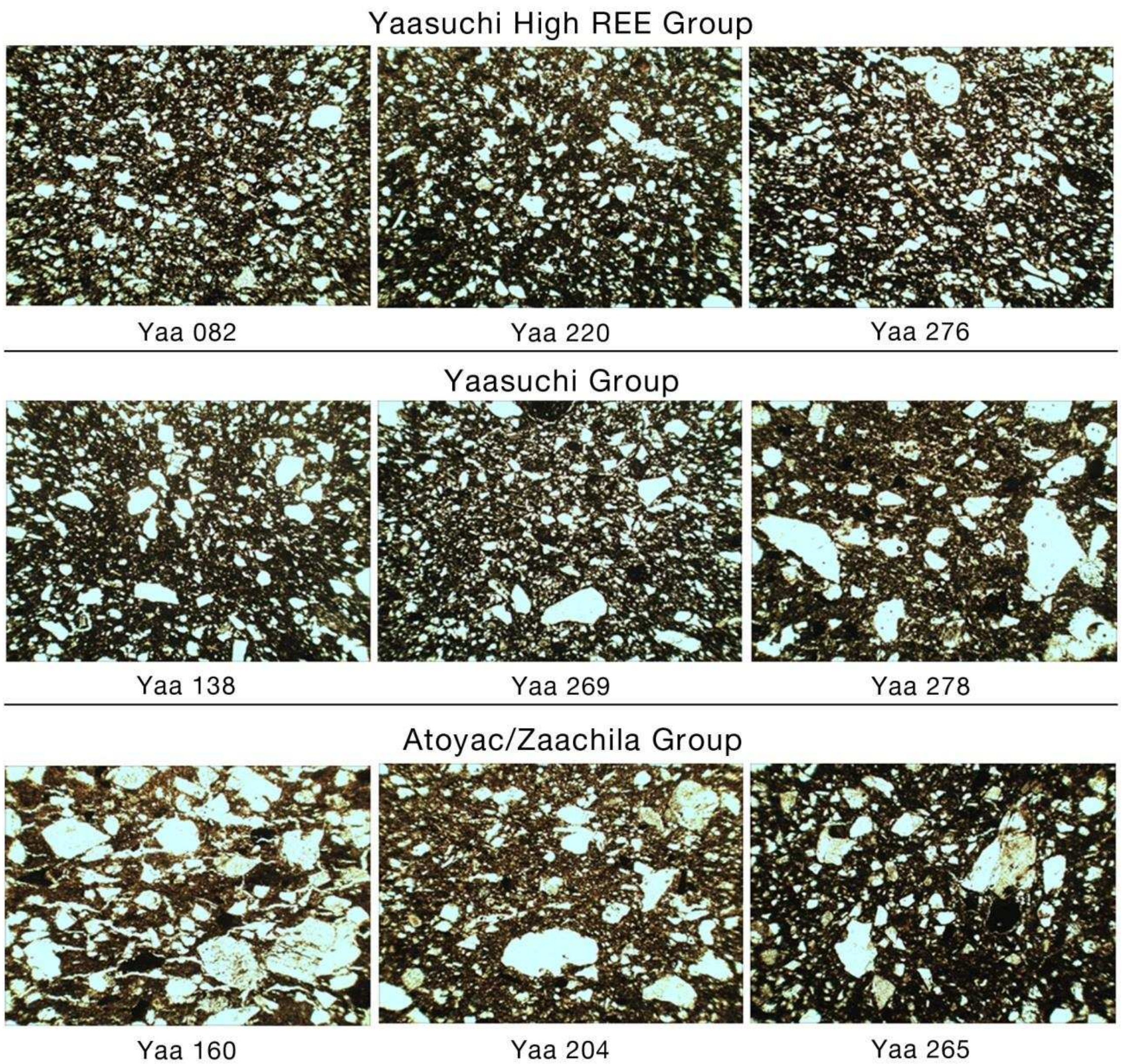

Figure 4.21: Thin-section photographs of nine samples submitted for analysis using LA-ICP-MS. Samples belonging to the Yaasuchi High REE group were generally made using a finer paste than samples belonging to the Yaasuchi and Atoyac/Zaachila groups. Photos were taken at 40x magnification.

Summary

A large sample of Yaasuchi ceramics were selected from collections taken from two households, a firing feature, and village-wide surface collections. Elemental analysis of these sherds using INAA at the OSU-RC facilitated statistical comparisons with compositional data for a growing database of Late Classic ceramics from the Valley of Oaxaca, clay samples collected during the Oaxaca and Yaasuchi Clay Surveys, a regional model of clay chemistry, and previously-analyzed production debris from Yaasuchi. Results of these analyses showed that Yaasuchi ceramics could be classified into seven compositional groups, including three locally abundant groups that matched ceramic production debris from the site. A subset of samples was then analyzed using LA-ICP-MS to determine whether the compositional signature of two locally abundant groups had been affected through clay modification during production. Each of these analyses contributed to the identification of a likely production local or geographic source of clay used in the manufacture of each vessel, facilitating discussion of Yaasuchi's exchange relations with other Late Classic communities. Classification and measurement of morphological aspects of each vessel such as form, diameter, thickness, rim treatment, and paste color and texture will contribute to discussion of product specialization, standardization, or diversity among those compositional groups produced at Yaasuchi, facilitating discussion of rural household production strategies. Implications of these analyses for rural craft production, consumption, and exchange will be discussed at length in the next chapter.

Chapter V: Rural Market Participation at Yaasuchi

Results of provenance determinations detailed in the last chapter showed that Yaasuchi ceramics could be classified into 7 compositional groups corresponding to multiple clay resource areas in the Valley of Oaxaca (Figure 5.1). The majority of ceramics in the Yaasuchi sample (up to 87%), were produced locally including ceramics belonging to the Atoyac/Zaachila, Yaasuchi, and Yaasuchi High REE groups, although the provenance of ceramics belonging to the Atoyac/Zaachila group is problematic.

In contrast, perhaps as little as 13% were imported from other sites, principally located in the northern Valle Grande and southern Etla Subvalley. The largest group of imported ceramics in the Yaasuchi sample was the MA-EVG group (4.1%). Ceramics from the Northwest Valle Grande group formed 3.5% of the Yaasuchi sample; these were likely produced north of Yaasuchi near Cuilapán. Another 5.1% of ceramics in the Yaasuchi sample matched two *cremosa* groups (Trapiche Cremosa, and High Fe Cremosa) produced using material found near Loma del Trapiche or Atzompa; sites that were almost certainly affiliated with Monte Albán. While the proportion of ceramics imported to the site was small, access to material from these sources indicates a degree of market integration between communities in the northern Valle Grande. At a minimum, this shows that Yaasuchi households did participate in exchange in regional markets, but were not dependent upon market exchange for access to ceramics.

In this chapter I will discuss patterns of rural craft production, consumption, and exchange at Yaasuchi in more depth to provide a more detailed view to rural market participation and market structure in the northern Valle Grande during the Late Classic. First, I will evaluate whether Yaasuchi potters were manufacturing goods solely for local or domestic consumption or for regional exchange by assessing the relative degree of product specialization and standardization evident in the three compositional groups identified as locally-produced wares: Yaasuchi, Yaasuchi High REE, and Atoyac/Zaachila. I will then discuss patterns of ceramic consumption at Yaasuchi at both the household and community scale, with particular focus on similarities and differences in consumption patterns

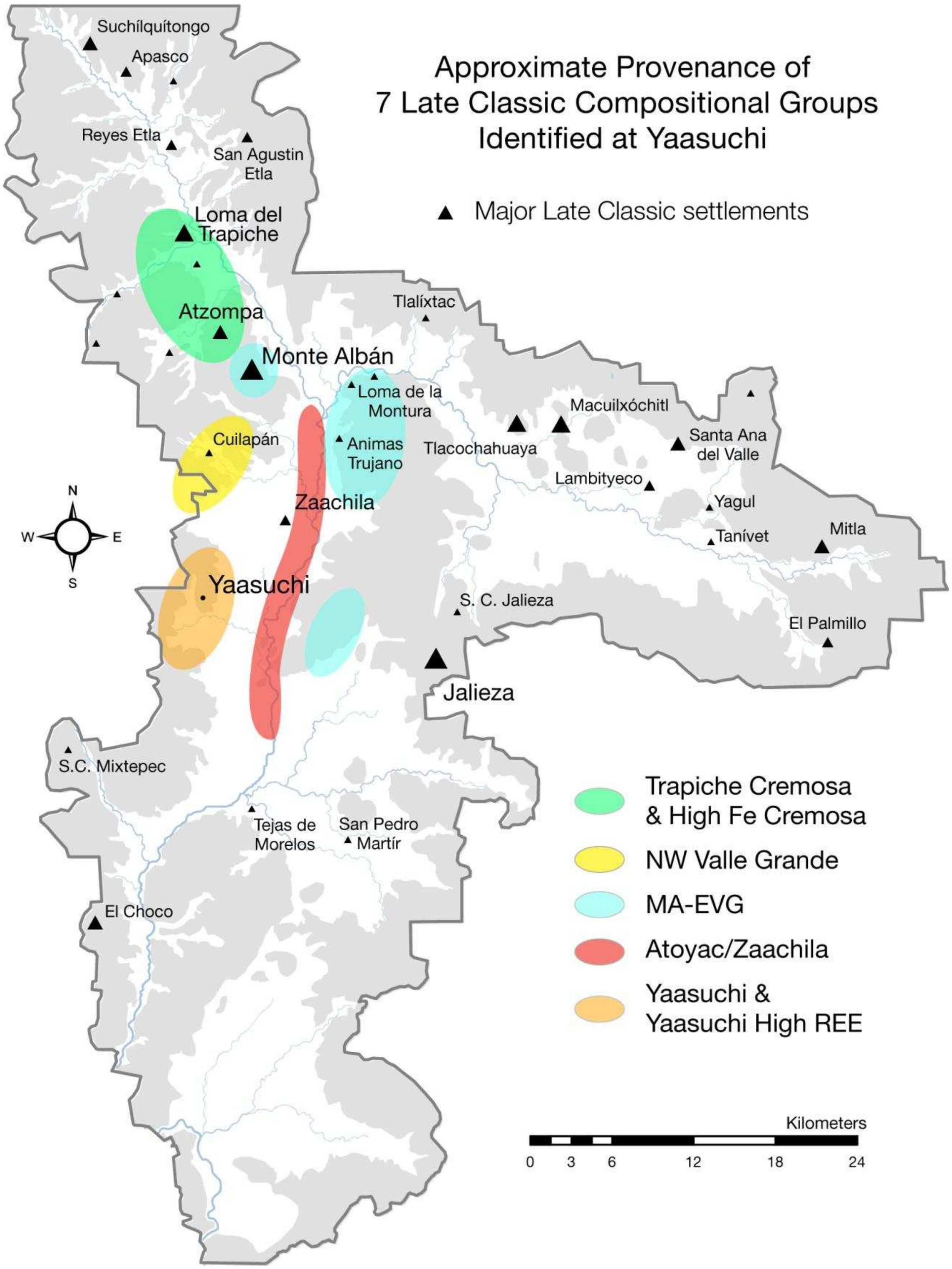

Figure 5.1: Approximate provenance of 7 compositional groups identified at Yaasuchi.

between households and reliance on imported goods from other sites. Finally, I will discuss evidence for exports from the Yaasuchi area at other sites during the Late Classic.

Sample Bias Correction

In order to make a more thorough examination of ceramic production and consumption patterns between contexts at Yaasuchi it is necessary to weight group abundances by ware to provide a more accurate view of group representation within assemblages from each context. Sampling of the Yaasuchi assemblage was stratified at two levels: (1) sampling was divided between Structure 5B, Structure 6, Feature 1, and Surface Collections; and (2) the sample was divided evenly between *gris* and *café* wares within excavated contexts, and restricted to G.35 conical bowls in surface collections. *Gris* and café wares were not, however, equally represented in the Yaasuchi assemblage. Sherman (2005: Table 5.4) reports that *gris* ceramics outnumbered *café* ceramics at a ratio of over 5:1 within Structure 5B and Structure 6 assemblages. Equal sampling of the two wares was conducted to increase sample representation of uncommon groups, but this has the effect of overestimating the abundance of groups that were primarily manufactured as *café* wares and underestimating the abundance of groups that were principally manufactured as *gris* wares. To correct for this bias, group frequencies were re-weighted by context according to the relative abundance of Late Classic *gris* and *café* wares recorded in each context by Sherman (2005).

Calculation of correction factors required a number of steps. First, total frequencies of *gris* and *café* ceramics were recorded for all excavation contexts for Structure 5B, Structure 6, Feature 1, and surface collections identified as having a large proportion of Late Classic ceramics. Next, excavation contexts that were not sampled for this study due to proximity to the surface or high frequencies of Formative ceramics were eliminated from totals for each area. Frequencies of Formative *gris* and *café* ceramics were then tabulated for each context and subtracted from totals for each area. Finally, the remaining frequencies of each ware were totaled by area and used to calculate the relative percentage of Late Classic *gris* and *café* ceramics (Table 5.1). To estimate the relative assemblage abundance of each compositional group in each area, sample frequencies of *gris* and *café*

Table 5.1: Frequencies of Late Classic *gris* and *caf*�wares collected by Sherman (2005: Tables B.1, B.3, and B.4) from Yaasuchi contexts sampled in this study.

	Gris		Café		Total	
Context	n	%	n	%	n	%
Feature 1	199	83	42	17	241	100
Structure 6	657	90	77	10	734	100
Structure 5B	323	75	109	25	432	100
Surface	188	97	5	3	193	100
Total	1367	85	233	15	1600	100

Table 5.2: Frequencies of gris and café ceramics assigned to each compositional group represented in the Yaasuchi sample by context.

	Feature 1						Structure 6					
Compositional	Gris		Café		Total		Gris		Café		Total	
Group	n	%	n	%	n	%	n	%	n	%	n	%
Atoyac/Zaachila	23	68	11	35	34	52	34	67	18	33	52	50
Yaasuchi	2	6	9	29	11	17	4	8	18	33	22	21
Yaasuchi High REE	3	9	1	3	4	6	9	18	2	4	11	10
MA-EVG	4	12	0	0	4	6	2	4	0	0	2	2
Northwest Valle Grande	0	0	5	16	5	8	1	2	4	7	5	5
High Fe Cremosa	0	0	2	6	2	3	0	0	9	17	9	9
Trapiche Cremosa	1	3	3	10	4	6	0	0	1	2	1	1
Outlier	1	3	0	0	1	2	1	2	2	4	3	3
Total	34	52	31	48	65	100	51	49	54	51	105	100

	Structure 5B						Surface					
Compositional	Gris		Café		Total		Gris		Café		Total	
Group	n	%	n	%	n	%	n	%	n	%	n	%
Atoyac/Zaachila	16	31	15	31	31	31	20	48	0	0	20	19
Yaasuchi	15	29	25	52	40	40	10	24	0	0	10	10
Yaasuchi High REE	12	24	2	4	14	14	11	26	0	0	11	10
MA-EVG	6	12	0	0	6	6	1	2	0	0	1	1
Northwest Valle Grande	1	2	0	0	1	1	0	0	0	0	0	0
High Fe Cremosa	0	0	0	0	0	0	0	0	0	0	0	0
Trapiche Cremosa	0	0	0	0	0	0	0	0	0	0	0	0
Outlier	1	2	6	13	7	7	0	0	0	0	0	0
Total	51	52	48	48	99	100	42	100	0	0	42	100

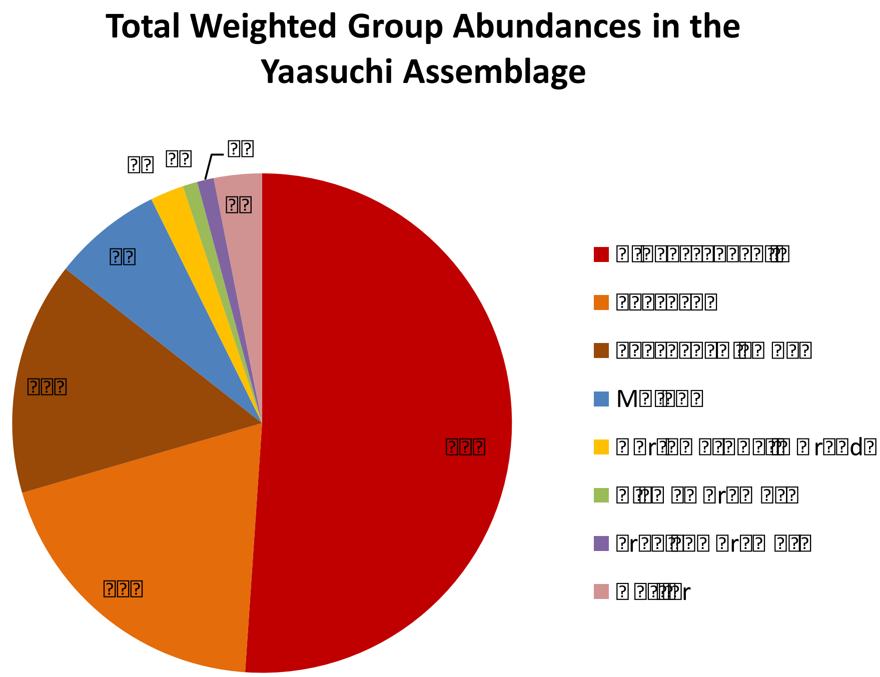

Figure 5.2: Total weighted abundance of ceramics belonging to each compositional group in the Yaasuchi assemblage.

wares belonging to each group were then simply multiplied by the percentage of the appropriate ware recovered in each assemblage to create weighted frequencies of each group. Ratios of weighted frequencies to totals were then calculated to estimate the assemblage abundance of each group. Un-weighted frequencies of *gris* and *café* ceramics belonging to each compositional group in the Yaasuchi sample are reported in Table 5.2. Weighted estimates of group abundance by ware are reported in Table 5.3.

After reweighting group abundances by ware, I estimate that as much as 89% of the Yaasuchi assemblage[2] was manufactured locally and that only 11% of the assemblage was imported (Figure 5.2). At a site level, the single most abundant group was the Atoyac/Zaachila group, constituting a full 51% of the assemblage. This was followed by the Yaasuchi group and Yaasuchi High REE group, which constituted an estimated 20% and

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[2] Surface collections were excluded from estimates of group abundance at the site level because they were restricted to a single Late Classic diagnostic (G.35 conical bowls), both in the INAA sample and in the original collections.

Table 5.3: Estimated assemblage abundances of each compositional group represented in the Yaasuchi sample by context. Estimates for the total Yaasuchi assemblage to not incorporate data from surface collections.

Compositional Group	Feature 1 Gris Est. %	Feature 1 Café Est. %	Feature 1 Total Est. %	Structure 6 Gris Est. %	Structure 6 Café Est. %	Structure 6 Total Est. %
Atoyac/Zaachila	67.6	35.5	62	67	33	63
Yaasuchi	5.9	29.0	10	8	33	11
Yaasuchi High REE	8.8	3.2	8	18	4	16
MA-EVG	11.8	0.0	10	4	0	3
Northwest Valle Grande	0.0	16.1	3	2	7	3
High Fe Cremosa	0.0	6.5	1	0	17	2
Trapiche Cremosa	2.9	9.7	4	0	2	0
Outlier	2.9	0.0	2	2	4	2
Context Total	83.9	16.1	100	89	11	100

Compositional Group	Structure 5B Gris Est. %	Structure 5B Café Est. %	Structure 5B Total Est. %	Surface Gris Est. %	Surface Café Est. %	Surface Total Est. %
Atoyac/Zaachila	31	31	31	48	0	48
Yaasuchi	29	52	35	24	0	24
Yaasuchi High REE	24	4	19	26	0	26
MA-EVG	12	0	9	2	0	2
Northwest Valle Grande	2	0	1	0	0	0
High Fe Cremosa	0	0	0	0	0	0
Trapiche Cremosa	0	0	0	0	0	0
Outlier	2	13	5	0	0	0
Context Total	76	24	100	100	0	100

Compositional Group	Total Yaasuchi Assemblage: Gris n	Gris %	Café n	Café %	Total n	Total %
Atoyac/Zaachila	61	55	8	33	69	51
Yaasuchi	16	15	10	42	26	19
Yaasuchi High REE	20	17	1	4	20	15
MA-EVG	10	9	0	0	10	7
Northwest Valle Grande	2	1	1	6	3	2
High Fe Cremosa	0	0	1	6	1	1
Trapiche Cremosa	1	1	1	3	1	1
Outlier	2	2	2	7	4	3
Total	112	83	23	17	135	100

15% of the total assemblage respectively. Of the imported ceramics, the MA-EVG group was most abundant (7%). Estimated abundances of all other imported groups were significantly impacted by group weighting. Only 2% of the assemblage belonged to the Northwest Valle Grande group, while abundance estimates for the Trapiche Cremosa and High Fe Cremosa group dropped to just 1% each. Outliers accounted for an estimated 3% of the site assemblage. As discussed in the last chapter, it is likely that a proportion of ceramics belonging to the Atoyac/Zaachila group were produced at Zaachila or other communities on the Atoyac floodplain. While we cannot distinguish these compositionally from ceramics belonging to this group that were produced locally, it is likely that these ceramics were imported in frequencies comparable to other sources in the northern Valle Grande. Insofar as the Northwest Valle Grande and MA-EVG groups account for an estimated 7% and 2% of the total site assemblage respectively, it is likely that the total site assemblage was imported from Zaachila was fairly low, perhaps in the range of 5%.

These weighted group abundances do not significantly alter our view of ceramic consumption patterns at the site level, but carry implications for our understanding of variation in production and consumption strategies between households at Yaasuchi. Before discussing ceramic consumption patterns between contexts, production strategies used to manufacture each of the locally produced compositional groups are discussed in detail.

Ceramic Production at Yaasuchi

Our understanding of the organization of ceramic production at Yaasuchi is greatly enhanced by excavation data from the site. The direct association of a surface firing feature with a commoner residence implies that the scale of production at Yaasuchi was small and not directly controlled by elites. Yet important questions remain about the concentration and intensity of production. An unexpected finding of this study was that Yaasuchi potters used multiple clay resources to manufacture their wares, allowing us to examine differences in production strategies between groups. The Yaasuchi and Yaasuchi High REE groups were both produced using clays procured from the vicinity of the site, but those used to produce the High REE group were either refined or intentionally selected to produce a subset of wares with a finer paste texture. In contrast, the Atoyac/Zaachila group was produced using clays procured nearly 7km from the site on the Río Atoyac floodplain. This reliance on multiple clay sources and manufacturing techniques raises the question of whether these compositional groups represent the labor of a single household, separate households during the same period, or a change in clay resource use over time. To address this question, we will revisit the relative abundance of the three groups between contexts at the site.

A separate issue is whether Yaasuchi potters were manufacturing primarily for domestic use, for intra-community exchange, or for export to regional markets. To address this question, we will evaluate the degree of product specialization evident within each group and assess the intensity of production through comparisons of compositional and morphological variance. I will argue that higher levels of product specialization and standardization within groups suggests production for exchange, while a more generalized production strategy reflects production for domestic use or exchange within the community.

Concentration of Production

While it seems clear that Yaasuchi ceramics belonging to the Atoyac/Zaachila, Yaasuchi, and Yaasuchi High REE groups were largely produced on site, it is not clear whether all three groups were the product of a single household, multiple households, or a change in clay resource use over time. Comparisons of compositional group frequency by context (discussed in the next section) showed that the Atoyac/Zaachila group was by far the most abundant in both Feature 1 and Structure 6, strongly suggesting a continuity in household production between the household associated with Feature 1 and Structure 6. The Atoyac/Zaachila group is also represented in both the Structure 5B, and surface collection assemblages, but at a lower level. This reduces the likelihood that the presence of the three groups represents a diachronic change in clay resource use, but also suggests that this group was not manufactured in all households at Yaasuchi. Rather, it seems likely that much of the community obtained pottery from Structure 6 and the household that preceded it.

Less clear is which household produced pottery belonging to the Yaasuchi and Yaasuchi High REE groups. While 1 waster matched each group in Feature 1 deposits, frequencies of the Yaasuchi and High REE groups were lower in Feature 1than in any other context. This suggests that while the household that preceded Structure 6 may have used clays from the vicinity of the site to produce a minor portion of its goods, it was not the primary producer of these groups. The same is true for Structure 6, where representation of the two groups was nearly as poor. Insofar as these two groups were much more abundant in Structure 5B and in surface collections, it seems likely that other households produced ceramics belonging to these groups in greater frequency. Yet there is no convincing evidence for ceramic production at Structure 5B. One ceramic production waster matching the Yaasuchi group was recovered from Structure 5A – that is, from the earlier, Formative portion of Structure 5, but no wasters or firing features similar to Feature 1 were encountered in Structure 5B. This household therefore seems to have acted as a consumer of local ceramics rather than a manufacturer of any of the three locally produced compositional groups.

In summary, the varying abundances of the three locally-produced groups between Yaasuchi households and surface contexts suggest that multiple households engaged in ceramic production and that disparate production strategies were employed to manufacture each group. While evidence for production of all three groups is limited to Structure 6 and the household that preceded it, the low abundance of ceramics belonging to the Yaasuchi and Yaasuchi High REE groups suggests that these ceramics were produced in greater abundances at another household at the site. Some households, such as Structure 5B, relied on exchange within the community to obtain the majority of their ceramics. Others, such as Structure 6 and the household that preceded it, may have engaged in production for domestic use, as well as local or regional exchange. The specific production strategies used to manufacture each group are discussed in more detail below.

Product Specialization

As discussed in Chapter 3, one strategy for discerning whether ceramics were produced for exchange is assessing the degree to which production was restricted to a particular range of goods. To evaluate product specialization at Yaasuchi, the diversity of goods produced within each compositional group were compared by vessel form and ware. A higher diversity of vessel forms and ware types were taken to indicate a more generalized production strategy consistent with production for domestic use. Lower diversities of vessel forms and wares were taken to indicate a greater degree of product specialization, implying that goods belonging to these groups were produced for exchange.

Table 5.4: Frequencies of *gris* and *café* wares by compositional group for ceramics produced at Yaasuchi.

	Atoyac/Zaachila		Yaasuchi		Yaasuchi High REE	
Ware	n	%	n	%	n	%
Café	43	33	52	64	3	8
Gris	88	67	29	36	35	92
Total	131	100	81	100	38	100

Comparisons of each group by ware (Table 5.4) show that of the three compositional groups produced on site, the Yaasuchi High REE exhibited the highest degree of product specialization. Nearly all (92%) ceramics belonging to the High REE group were manufactured in a *gris* paste while only 8% were *cafés*. In contrast, about two thirds (67%) of ceramics belonging to the Atoyac/Zaachila group were *gris* ware and only one third *café*. When compared with the overall percentage of *gris* ceramics in recovered from Structures 5B and 6 (~85%), this figure indicates a lower degree of product specialization by ware in this group. Percentages of each ware belonging to the Yaasuchi group were reversed: about two thirds of this group (64%) were made using café paste and only about one third (36%) were manufactured in *gris* pastes, again indicating a more generalized production strategy.

Comparisons of each group by vessel type reflect these results (Figure 5.3). Again, product specialization was most evident in the Yaasuchi High REE group. Only two ceramics (5%) belonging to this group were not classified as *cajetes cónicos,* and one of these was a waster. Of the 116 diagnostic ceramics belonging to the Atoyac/Zaachila group, 81% were classified as *cajetes cónicos*. These were also the most common vessel type in the

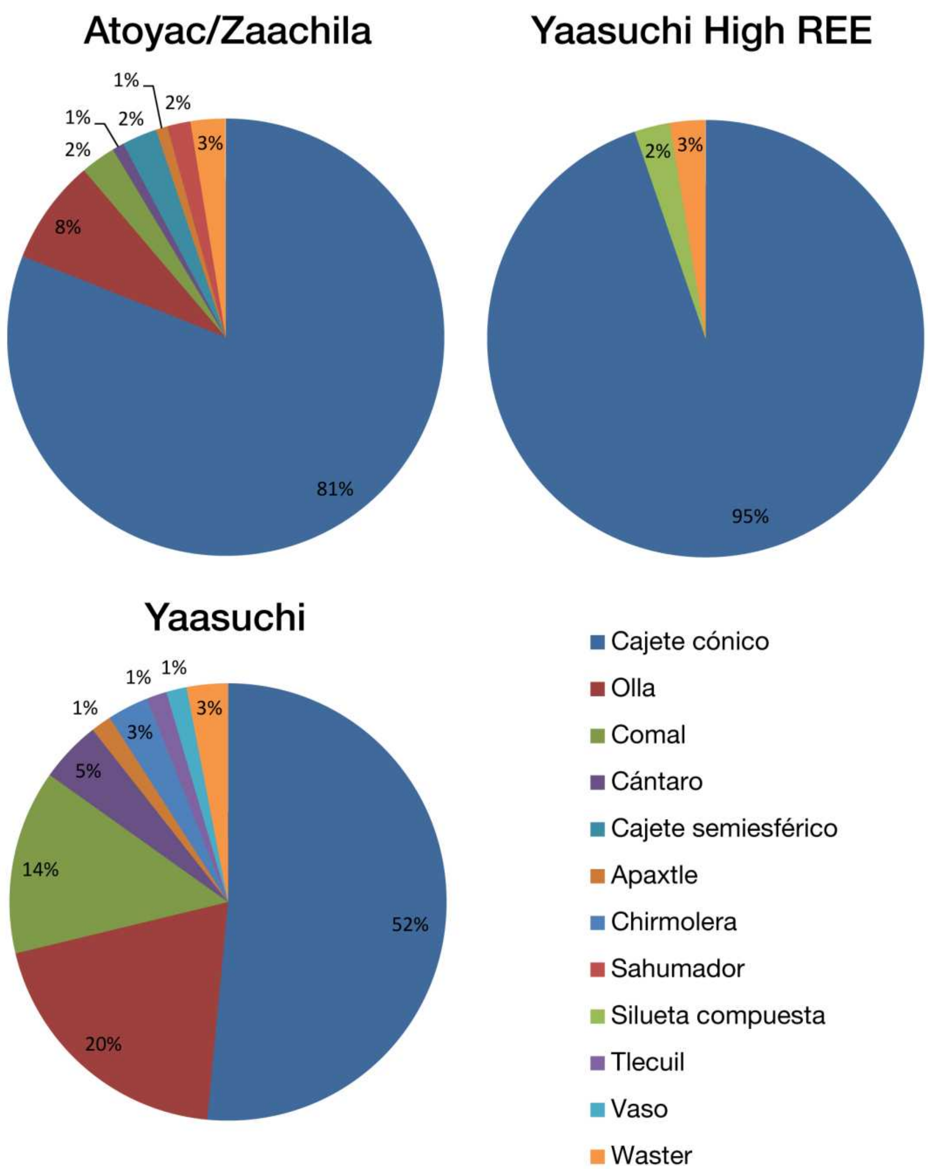

Figure 5.3: Percentages of vessel types belonging to each compositional group manufactured at Yaasuchi.

Yaasuchi sample, but only constituted 71% of diagnostic wares. The slightly higher figure of 81% may therefore represent a narrow degree of product specialization in this group. The other 19% of the Atoyac/Zaachila group was divided between a range of vessel forms, including *ollas*, *comales*, *cántaros*, *cajetes semiesféricos*, *apaxtles*, and *sahumadores*. Production of the Yaasuchi group was most generalized. Only half (52%) of this group were classified as *cajetes cónicos*. The remaining sample was divided between *ollas* (20%), *comales* (14%), *cántaros* (5%), an *apaxtle* (1%), *chimoleras* (3%), a *tlecuil* (1%), and a *vaso*

(1%). The majority of goods belonging to all 3 groups are utilitarian wares associated with the serving or preparation of food, the only possible exceptions being *sahumadores*, *vasos* and *tlecuiles* [floor basins].

Overall, comparisons of vessel form and ware by compositional group reveal varying degrees of product specialization. The Yaasuchi High REE group was limited almost entirely to G.35 conical bowls, indicating a high degree of product specialization and possible production for exchange. A greater focus on production of *gris* wares and conical bowls in the Atoyac/Zaachila group indicated a degree of product specialization, but a broad range of other forms belonged to this group as well, suggesting that this group was produced both for domestic use and exchange. The Yaasuchi group was by far the most diversified, reflecting a generalized production strategy consistent with manufacture for domestic use.

Intensity of Production

If product specialization indicates production for exchange, we would expect the intensity of production to have been higher among those groups exhibiting a higher degree of product specialization. As discussed in Chapter 3, one approach to evaluating the intensity of production is to compare the degree of standardization with each group, on the assumption that a more uniform or standard product reflects greater production intensity. If the High REE group was produced in significant quantities, we would expect this intensity of production to result in more standardized goods. Both the relative morphological and compositional variability within each group reveal that this is the case.

Standardization of Vessel Dimensions

Comparisons of morphological variability between the three groups were limited to G.35 *cajetes cónicos*, the most common vessel form in all groups. Insofar as our primary measures of variability within this form are rim diameter, rim thickness, and rim treatment, these analyses were further restricted to rim sherds. Comparisons of rim treatment between groups revealed that the majority of *cajetes cónicos* produced at Yaasuchi were manufactured with either simple or wiped rims; only 2% were

Table 5.5: Variation in rim treatments between three compositional groups produced at Yaasuchi.

Compositional	G.35 Rim Treatment							
	Simple		Wiped		Folded		Total	
Group	n	%	n	%	n	%	n	%
Yaa High REE	13	76	4	24	0	0	17	100
Atoyac/Zaachila	22	44	27	54	1	2	50	100
Yaasuchi	10	71	3	21	1	7	14	100
Total	45	56	34	42	2	2	81	100

Table 5.6: Rim diameters and thickness of *cajetes cónicos* belonging to three compositional groups produced at Yaasuchi.

	Atoyac/Zaachila n = 94		Yaasuchi n = 34		Yaasuchi High REE n = 36	
Rim Measurements	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Diameter (cm)	25.3	7.9	29.6	9.0	22.4	5.3
Thickness (mm)	8.4	1.3	9.2	1.8	7.6	1.0

manufactured with folded rims (Table 5.5). The proportion of simple vs. wiped rims varied considerably between groups as well. Over 70% of *cajetes cónicos* belonging to the Yaasuchi and Yaasuchi High REE groups were manufactured with simple rims. In contrast, over half (54%) of the Atoyac/Zaachila group was made with wiped rims, while just 44% were simple.

The greater variability in rim treatment in the Atoyac/Zaachila group may reflect less standardized production. On the other hand, it could also represent a difference in production practice between households or over time. Nearly 70% (n = 22) of *cajetes cónicos* belonging to the Atoyac/Zaachila group in Feature 1 and Structure 6 had wiped rims, while 60% of rims belonging to this group in Structure 5B (n = 6) and 88% in surface collections (n = 7) were simple. This implies that either multiple households produced ceramics belonging to the Atoyac/Zaachila group, or that there was some chronological separation between Structure 6 and other parts of the site. Regardless, within Feature 1 and Structure 6, the variability in rim treatment of the Atoyac/Zaachila group was comparable with that of the other two groups.

Metric comparisons of *cajetes c⍰nicos* belonging to the Atoyac/Zaachila, Yaasuchi and Yaasuchi High REE groups showed that there were significant differences in both rim diameter and thickness between the three groups (pairwise Student's t-tests; $\alpha = 0.05$). Samples belonging to the Yaasuchi High REE group (n = 36) were generally smaller in diameter and thinner than samples belonging to the Atoyac/Zaachila (n = 94) and Yaasuchi groups (n = 34) (Table 5.6). More importantly, the variability in rim diameter and thickness of the High REE group was also significantly lower (Welch's t-test of unequal variances; $\alpha = 0.05$). The coefficient of variation ($s/\bar{x} \cdot 100$) of rim diameter for the High REE group was 18.7, while those of the Atoyac/Zaachila and Yaasuchi groups were 31.0 and 30.6.

While these differences in metric variability may reflect differing intensities of production, they may also be due to varying degrees of product specialization within groups and a focus on different size classes of vessels. Martínez López *et al.* (2000:254-255) have argued that Late Classic G.35 conical bowls were produced in 3 standard dimensions: large bowls between 23 and 40 cm in diameter; medium-sized bowls between 16 and 23 cm; and miniature bowls (*miniat⍰ras*) with diameters less than 16 cm. A histogram of rim diameters for close to 250 complete or nearly complete *cajetes c⍰nicos* measured by Martínez López *et al.* clearly shows this tri-modal distribution (Figure 5.4).

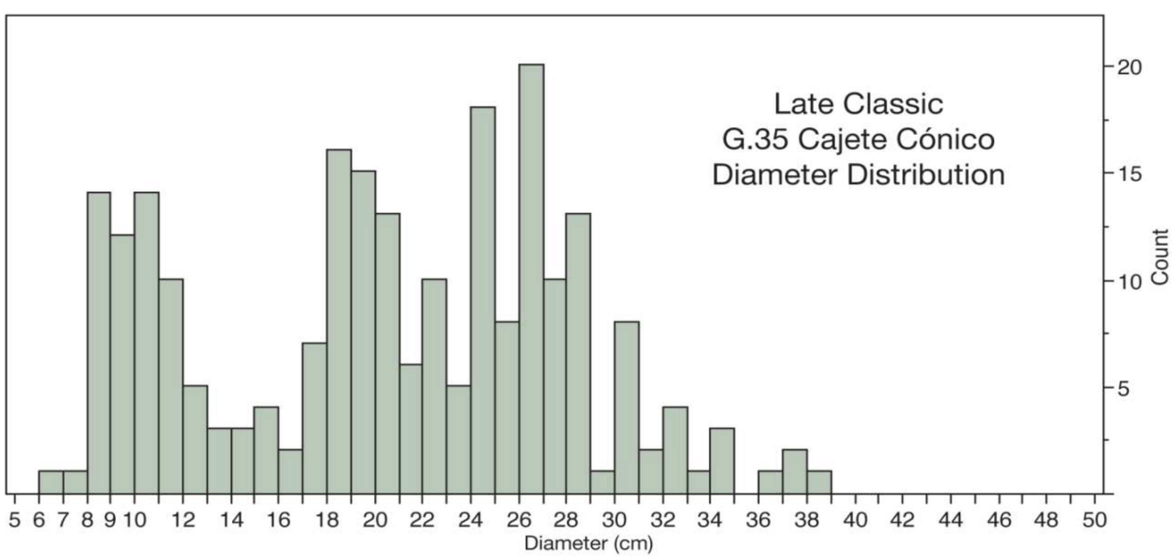

Figure 5.4: Late Classic G.35 *cajete c⍰nico* diameter distributions reported by Martinez Lopez *et al.* (2000:255).

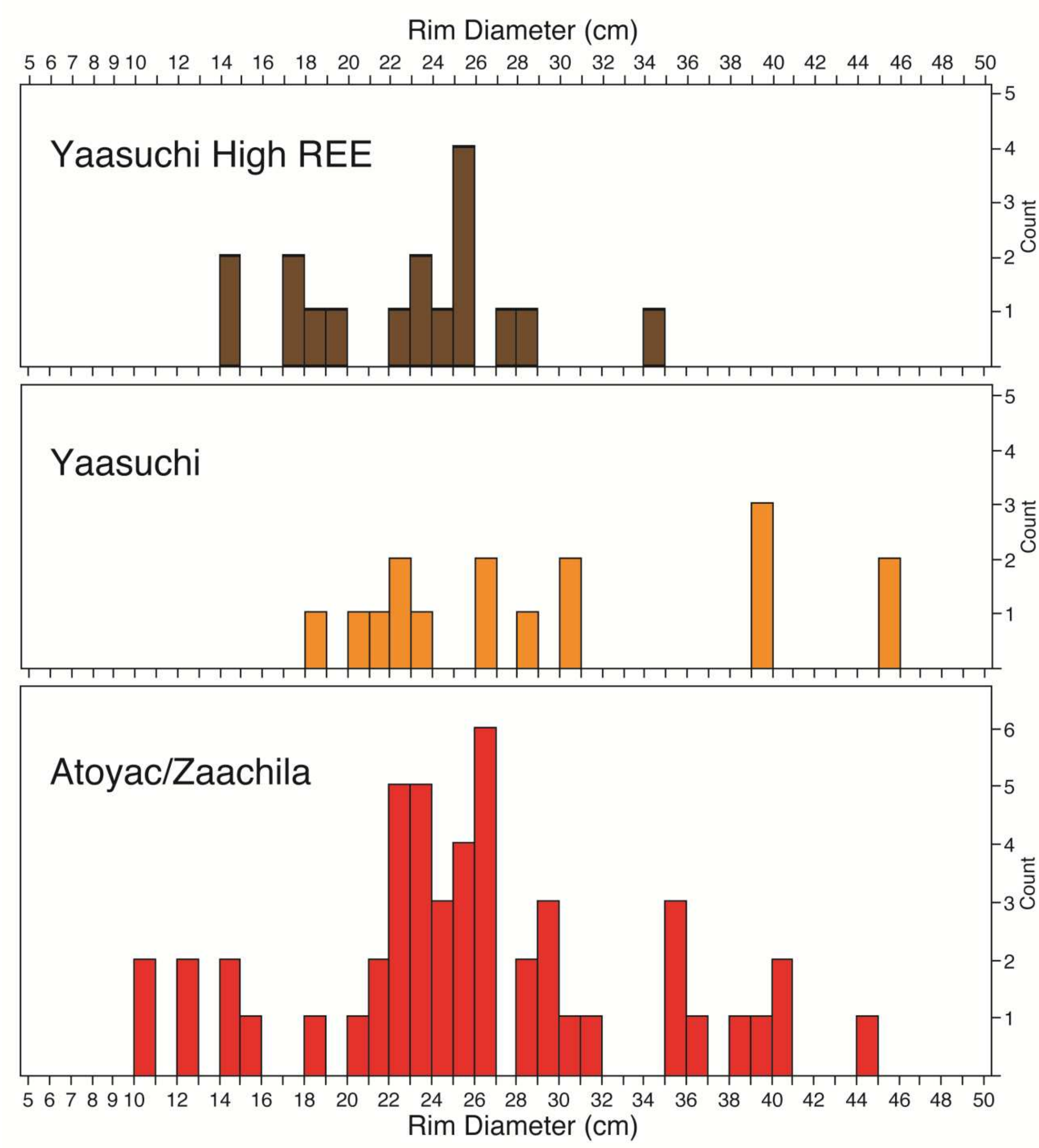

Figure 5.5: *Cajete c�nico* diameter distributions for three compositional groups produced at Yaasuchi.

Histograms of rim diameters for vessels produced at Yaasuchi (Figure 5.5) show that the majority of cajetes cónicos belonging to the Yaasuchi High REE group fall within the range of diameters for medium and large bowls. In comparison, the distribution of rim diameters for the Atoyac/Zaachila and Yaasuchi groups is much broader. Notably, all groups exhibit multi-modal diameter distributions, but the size classes differ from those observed by Martínez López *et al.* (2000). *Cajetes cónicos* at Yaasuchi were produced in a large size of 32 to 46 cm, a much broader medium size class of 16 to 32 cm, and a small size of 10 to 16 cm. Nearly all samples belonging to the High REE group fell within the middle size class, while the Yaasuchi group included both medium and large bowls and the Atoyac/Zaachila group encompassed all three size classes. Thus, the lower variance in vessel size in the High REE group may reflect an additional degree of product specialization rather than a higher intensity of production.

Compositional Standardization

The degree of standardization may also be assessed through comparisons of compositional variability (Costin and Hagstrom 1995). To examine the relative compositional variability of ceramics belonging to the three compositional groups produced at Yaasuchi, comparisons were made between coefficients of variation for 27 elements between the three groups (Figure 5.6). Remarkably, these comparisons yielded similar results to those obtained through examination of variability in vessel size between groups. The Yaasuchi High REE group had the least variable paste composition relative to the other two groups; coefficients of variation for the High REE group were lower than both other groups across 13 elements (K, Na, Ti, Cr, Rb, Ba, La, Ce, Yb, Lu, Hf, Ta, and Th) and higher than the other two groups for only 5 elements (Ca, Fe, Sc, Mn, and Co). The Atoyac/Zaachila group had the next lowest range of variability, with lower coefficients of variation than the other two groups across 7 elements (Al, Ca, V, Co, Zn, As, and Cs) and higher coefficients of variation for the 7 REEs that were measured (Ce, Sm, Eu, Tb, Dy, Yb, and Lu). The Yaasuchi group had the broadest range of variability across elements, with higher coefficients of variation than the other two groups for 15 elements (Al, K, Na, Ti, V, Cr, Zn, As, Rb, Cs, Ba. La, Hf, Ta, and Th) and lower coefficients of variation for just 7 (Fe, Sc, Mn, Sm, Eu, Tb, and Dy). Results of Levene's tests of equality of variances confirmed that

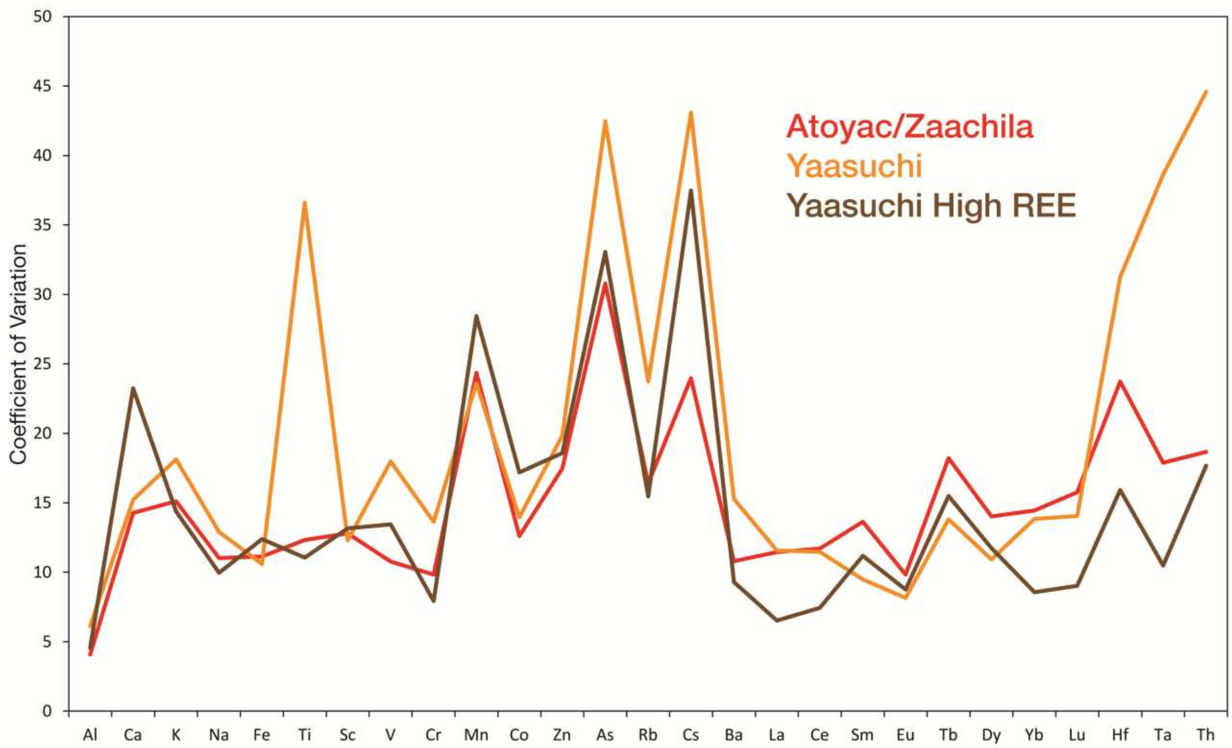

Figure 5.6: Coefficients of variation for 3 compositional groups produced at Yaasuchi across 27 elements.

the differences in variability observed between the three groups were significant ($p < 0.05$) for 19 elements, the exceptions being K, Na, Sc, Mn, Zn, Sm, Eu, and As.

Discussion

Based on multiple measures of intensity and standardization, widely different production strategies were used to manufacture ceramics belonging to each of the three compositional groups produced at Yaasuchi. Of the three, production of the Yaasuchi group was the most generalized. This group was manufactured using unmodified clays from the immediate vicinity of the site and encompassed a much broader range of vessel forms than ceramics of the other two groups. Furthermore, the compositional and morphological variability of this group was higher than any other, suggesting a lower intensity of production for domestic use or limited exchange within the community.

At the other end of the spectrum, the Yaasuchi High REE group exhibited the highest degree of morphological and compositional standardization, was restricted to a single vessel form, and was produced using clay that was either refined or selected to create a finer paste. In spite of the lower frequency of this group at the site, this pattern of production is more consistent with intensive production for regional exchange. Identification of Yaasuchi exports belonging to this group at other sites would validate this hypothesis.

The Atoyac/Zaachila group appears to represent a combination of production for domestic use and exchange. Its greater abundance, both at the site level and in Feature 1 and Structure 6, indicate a fairly high intensity of production, an interpretation supported by its lower compositional variance relative to the Yaasuchi group. Furthermore, the vast majority of ceramics belonging to the Atoyac/Zaachila group were *cajetes cónicos,* indicating a higher degree of product specialization than was evident for the Yaasuchi group. The dominance of this group in the Feature 1 and Structure 6 assemblages indicate a continuity of production in this area. The lower abundance of this group in Structure 5B and surface collections (discussed below) suggests that this group was not produced in all households, but obtained through intra-site exchange with Structure 6 or its predecessor.

Together, these results show that the paste recipes used to manufacture Yaasuchi ceramics co-vary with alternative strategies of production, suggesting that multiple households engaged in pottery production at Yaasuchi. This is not to say that each group represents the labor of a separate household – the presence of ceramic wasters belonging to all three groups in Feature 1 suggests otherwise – only that multiple households were producing pottery and that these relied to greater and lesser degrees on separate clay sources. Significantly, the abundance of ceramics belonging to the Yaasuchi and Yaasuchi High REE groups were much lower in Feature 1 and Structure 6 relative to Structure 5B and surface collections, strongly suggesting that Structure 6 and the household that preceded it were not the principal producers of these groups. Nor was ceramic production necessarily a ubiquitous household task. Some households may have produced a significant quantity of pottery, both for domestic use and exchange, while others, such as Structure 5B relied on exchange within the community. These multiple production strategies reflect differential engagement with local and regional markets, some households acting as pottery suppliers within the community and exporting to regional markets, while others acted as pottery consumers, ostensibly focusing to a greater degree on agricultural production.

Ceramic Consumption at Yaasuchi

Feature 1

Within the surface firing feature designated Feature 1, over 90% of the assemblage could be classified into one of the three locally produced compositional groups (Figure 5.7). Ceramics in Feature 1 were overwhelmingly dominated by the Atoyac/Zaachila group, which formed as much as 62% of the assemblage and included 3 wasters. Of the other 2 wasters in the Feature 1 sample, 1 could be classified to each of the other two locally produced compositional groups, but these were far less abundant in the Feature 1 assemblage. Only 10% of the assemblage was classified as belonging to the Yaasuchi group and just 8% belonged to the Yaasuchi High REE group. As a ceramic production feature, it is perhaps not surprising that a single group would dominate the assemblage, but it is also important to note that the proportion of imported wares in Feature 1 was much higher than in any other context (18%). These included ceramics from four source compositional groups, including MA-EVG (10%), NW Valle Grande (3%), Trapiche Cremosa (4%), and High Fe Cremosa (1%). Another 2% of the assemblage were outliers.

The majority of locally produced diagnostic ceramics in the Feature 1 assemblage were utilitarian wares such as *cajetes cónicos* and *ollas*, but 2 *sahumador* incense burners were classified as belonging to the Atoyac/Zaachila group. By contrast, diagnostic ceramics belonging to the imported groups included a much higher frequency of less-common vessel forms (Table 5.7). Samples belonging to the MA-EVG group included a *vaso*, the Northwest Valle Grande group included 2 *comales,* and the Trapiche group included another *vaso.* Only 3 of the 15 samples belonging to one of the imported groups could be classified as *cajetes cónicos.* Significantly, one third of imported wares belonged to one of the *cremosa* groups, implying participation in Monte Albán's exchange network.

The diversity and abundance of imported materials in the Feature 1 assemblage suggests that our sample included a substantial amount of domestic debris in addition to

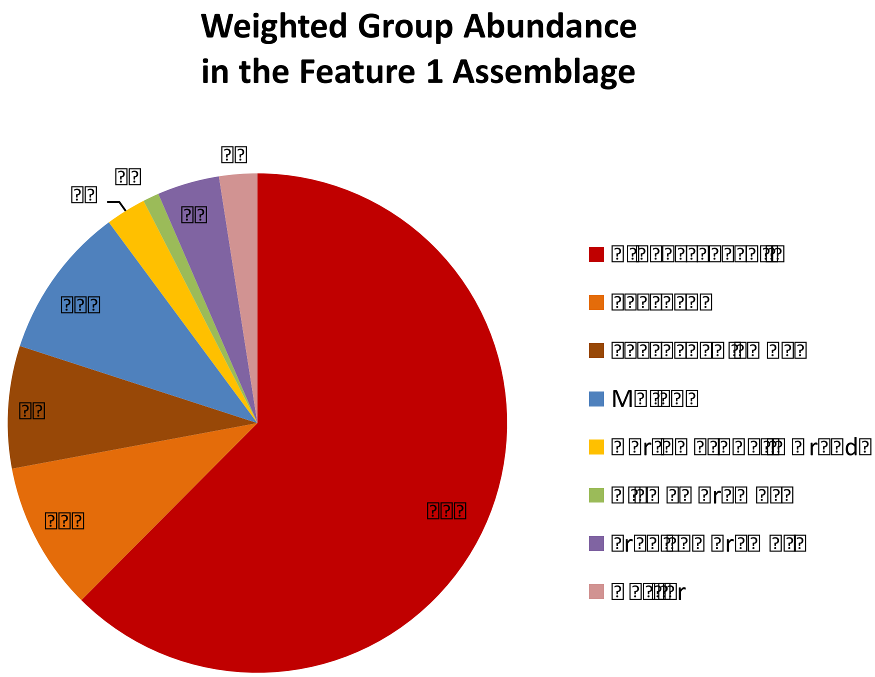

Figure 5.7: Weighted compositional group abundance in the Feature 1 assemblage.

Table 5.7: Frequencies of vessel form by compositional group in the Feature 1 sample.

	Atoyac/ Zaachila	Yaasuchi	Yaasuchi High REE	MA-EVG	High Fe Cremosa	NW Valle Grande	Trapiche Cremosa	Outlier	Total
Cajete cónico	19	3	3	0	0	1	2	0	28
Olla	2	1	0	2	0	0	0	0	5
Comal	0	2	0	0	0	2	0	0	4
Sahumador	2	0	0	0	0	0	0	0	2
Vaso	0	0	0	1	0	0	1	0	2
Cajete semiesférico	0	0	0	0	0	0	0	1	1
Tlecuil	0	1	0	0	0	0	0	0	1
Waster	3	1	1	0	0	0	0	0	5
Indeterminado	8	3	0	1	2	2	1	0	17
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

production debris. This does not negate the value of this portion of the sample for our understanding of ceramic production at Yaasuchi. Rather, because the stratigraphic position of Feature 1 indicates that it predated Structure 6, the presence of domestic material in this sample provides an opportunity to examine continuity and change in ceramic consumption patterns over time in the Structure 6 area. The high representation of uncommon vessel forms belonging to imported groups suggests that the household that predated Structure 6 relied on domestic production to supply the majority of utilitarian wares, but had access to less common vessel forms through regional exchange. The sources of these materials were either in the northern Valle Grande (MA-EVG and Northwest Valle Grande groups) or in the southern Etla area (Trapiche Cremosa and High Fe Cremosa groups), suggesting that at this time, Yaasuchi households were participants in Monte Albán's market zone.

Structure 6

In the low status residence (Structure 6) associated with the firing feature, estimated compositional group abundances were remarkably similar to those of Feature 1, suggesting a substantial continuity in household production and exchange patterns between Structure 6 and the household that preceded it. However, the ratio of locally-produced to imported wares in the Structure 6 assemblage was higher than that of earlier Feature 1 and the number of vessel forms in the Structure 6 assemblage was lower.

Combined, the Atoyac/Zaachila, Yaasuchi, Yaasuchi High REE, and outliers formed 92% of the assemblage. Only 8% belonged to groups that were definitively imported from other sites (Figure 5.8). Again, the Atoyac/Zaachila group formed an estimated 63% of the assemblage, suggesting that this group continued to be produced at Structure 6. Other groups produced at Yaasuchi were also well represented: 16% of the assemblage belonged to the Yaasuchi High REE group, and 11% were members of the Yaasuchi group. The overall abundance of imported goods was only about half that observed in Feature 1, but the sources represented remained the same. Both the MA-EVG group and Northwest Valle Grande group constituted 3% of the assemblage. Both *cremosa* groups were represented as well, but their relative abundances were reversed. Whereas the Trapiche Cremosa group

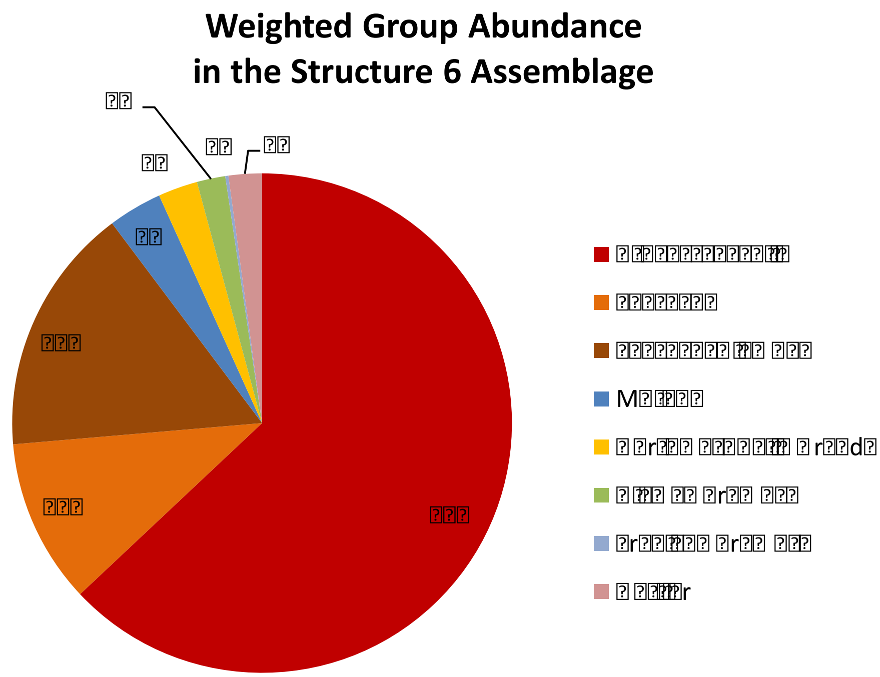

Figure 5.8: Weighted compositional group abundance in the Structure 6 assemblage.

Table 5.8: Frequencies of vessel form by compositional group in the Structure 6 sample.

	Atoyac/ Zaachila	Yaasuchi	Yaasuchi High REE	MA-EVG	High Fe Cremosa	NW Valle Grande	Trapiche Cremosa	Outlier	Total
Cajete cónico	42	9	9	1	2	2	0	1	66
Cajete semiesférico	1	0	0	0	0	1	0	0	2
Olla	5	4	0	0	3	0	0	0	12
Silueta compuesta	0	0	1	0	0	0	0	0	1
Indeterminado	4	9	1	1	4	2	1	2	24
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	105

was four times as abundant as the High Fe group in Feature 1, in Structure 6 the High Fe Cremosa group formed 2% of the assemblage while the Trapiche Cremosa group accounted for less than 1% (n = 1).

Another striking difference between the Stucture 6 assemblage and those of other contexts is the low number of vessel forms represented in the sample. Only four diagnostic forms – all utilitarian wares – were represented in the Structure 6 sample: *cajetes cónicos* (n = 66), *cajetes semiesféricos* (n = 2), *ollas* (n = 12), and a single *cajete con silueta compuesta* (Table 5.8). Examination of vessel frequencies reported by Sherman (2005: Table 4.2) suggests that this is not a product of sampling error; ceramics recovered from Structure 6 were largely restricted to utilitarian wares. The most common vessel form in all compositional groups represented in the Structure 6 sample is the *cajete cónico,* but the proportion of this form varies by group. Nearly all ceramics belonging to the Yaasuchi High REE group are *cajetes cónicos.* The distribution of vessel forms belonging to the Atoyac/Zaachila and Yaasuchi groups was slightly more generalized; each group also included a few *ollas*. As in the local groups, the majority of imported ceramics were *cajetes cónicos.* Only the High Fe Cremosa group had a larger frequency of another vessel form; *ollas* (n= 3) outnumbered *cajetes* (n = 2) in the sample.

In summary, as in Feature 1, the Structure 6 assemblage was dominated by the Atoyac/Zaachila group, indicating a continued reliance on domestic production for most goods. Four groups of imported ceramics were represented within the Structure 6 assemblage. These groups were identical to those represented in Feature 1, indicating some continuity in market access and participation, but the diversity of vessels acquired from these sources was far lower. This may suggest that, in contrast with the household associated with Feature 1 and Structure 5B, residents of Structure 6 may have had less access to or ability to purchase these goods.

Structure 5B

As noted in Chapter 3, only a small portion of Structure 5B was excavated, constraining our view of consumption patterns in this household. Furthermore, as much as 70% of sherds recovered from Structure 5B came from construction fill and were thus likely to have been re-deposited from other contexts (Sherman 2005:Table 4.3). Fortunately, fill contexts were largely avoided by limiting the Structure 5B ceramic sample to only those contexts with less than 15% Formative ceramics; only 20% (n = 21) of the 5B sample was taken from fill contexts (*Lotes* 2182, 2238, and 2241; see Appendix A). The remaining ceramics in the 5B sample were taken from excavation contexts above the *banqueta* surface or in the patio area. We may thus be confident that group frequencies observed in the Structure 5B sample largely reflect the consumption patterns of this household.

Consumption patterns at Structure 5B differed radically from those at Structure 6 in three important respects: (1) locally produced ceramics were more evenly divided between groups; (2) imported ceramics were obtained from far fewer sources; and (3) the diversity of vessel forms represented in the sample was much higher (Figure 5.9; Table 5.9). Overall, the relative abundance of locally produced wares was consistent with those observed at Feature 1 and Structure 6. Ninety percent of the Structure 5B assemblage could be classified as belonging to the Atoyac/Zaachila, Yaasuchi, or Yaasuchi High REE groups or were high REE outliers. In contrast with other areas of the site however, the Yaasuchi group was most abundant. At 35% of the 5B assemblage, the Yaasuchi group was slightly larger the Atoyac/Zaachila group (31%). The remainder of the locally-produced ceramics belonged to the Yaasuchi High REE group (20%) or were outliers (5%). Ceramics belonging to the Yaasuchi and Atoyac/Zaachila groups encompassed a broad range of vessel forms, including *comales*, *cántaros*, *chimoleras*, *apaxtles*, and *vasos*. In contrast, the Yaasuchi High REE group was restricted to *cajetes cónicos*.

Imported ceramics in the Structure 5B assemblage were classified into just two groups. Nearly all ceramic imports belonged to the MA-EVG group (9% of the 5B assemblage; n = 6) while just 1 sample (1%) was classified as belonging to the Northwest Valle Grande group. All imported ceramics in the sample were *gris* wares. Over half were *cajetes cónicos*. Other imports included a *cajete semiesférico*, a *cántaro,* and a *sahumador*. The latter was the only ritual item in the Structure 5B sample and the sole member of the Northwest Valle Grande group. Significantly, neither *cremosa* group was represented in the Structure 5B sample. Overall, the proportion of imported wares in the Structure 5B

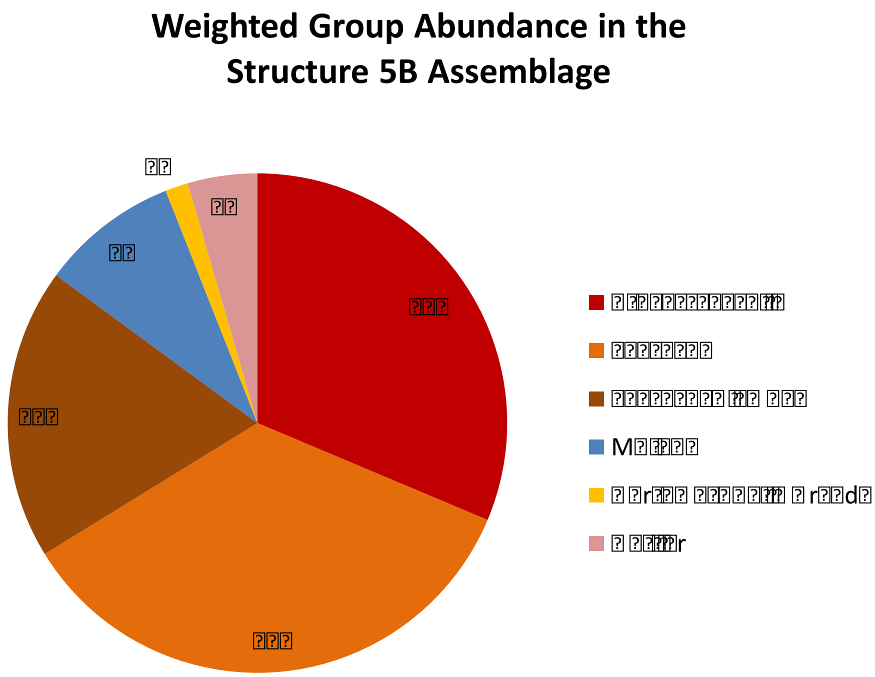

Figure 5.9: Weighted compositional group abundance in the Structure 5B assemblage.

Table 5.9: Frequencies of vessel form by compositional group in the Structure 5B sample.

	Atoyac/ Zaachila	Yaasuchi	Yaasuchi High REE	MA-EVG	High Fe Cremosa	NW Valle Grande	Trapiche Cremosa	Outlier	Total
Cajete cónico	16	13	14	4	0	0	0	1	48
Olla	2	8	0	0	0	0	0	3	13
Comal	3	7	0	0	0	0	0	1	11
Cántaro	1	3	0	1	0	0	0	0	5
Cajete semiesférico	2	0	0	1	0	0	0	0	3
Chirmolera	0	2	0	0	0	0	0	0	2
Apaxtle	1	0	0	0	0	0	0	0	1
Sahumador	0	0	0	0	0	1	0	0	1
Vaso	0	1	0	0	0	0	0	0	1
Waster	0	1	0	0	0	0	0	0	1
Indeterminado	6	5	0	0	0	0	0	2	13
Total	31	40	14	6	0	1	0	7	99

assemblage is comparable to those of Structure 6 and Feature 1, but the diversity of sources in the Structure 5B assemblage was much lower. This suggests that either Structure 5B did not have access to the same exchange networks, or chose not to participate in those networks in the same way. This problem will be discussed at greater length below.

Surface Collections

To obtain a view of ceramic consumption patterns at Yaasuchi beyond Structures 5B and 6, 42 samples from surface collections were submitted for compositional analysis. In order to ensure that this sample dated to the Late Classic, sampling was restricted to G.35 *cajetes cónicos*, the most common Late Classic diagnostic vessel. Results of provenance determinations showed that as much as 98% of *cajetes cónicos* in this sample belonged to one of the three locally produced compositional groups (Figure 5.10). The Atoyac/Zaachila group accounted for nearly half of the surface collection assemblage (48%). The Yaasuchi High REE and Yaasuchi groups each accounted for about a quarter of the assemblage (26% and 24% respectively). Only one sample (2%), belonging to the MA-EVG group, was imported from another source area.

The low frequency of imported wares in surface collections is somewhat surprising when compared with frequencies from the other three sampling contexts (Table 5.10). About 10% of *cajetes cónicos* in the Feature 1, Structure 6, and Structure 5B samples were imported from other sites; frequencies consistent with broader consumption patterns in each context. Given that frequencies of this vessel form from each context are more or less comparable to that of the surface collection sample, it seems doubtful that the low frequency of imported goods is a sampling error. Rather, households in Areas C and D seem to have relied predominantly on local ceramic production, importing a minimal number of goods from few sources. This pattern of consumption is more consistent with consumption patterns observed at Structure 5B than Structure 6 or Feature 1. The higher abundance of the Atoyac/Zaachila group likely reflects contributions from the Feature 1 household or Stucture 6, but the greater parity in abundances between local groups suggests that Structure 6 was not the sole pottery producing household.

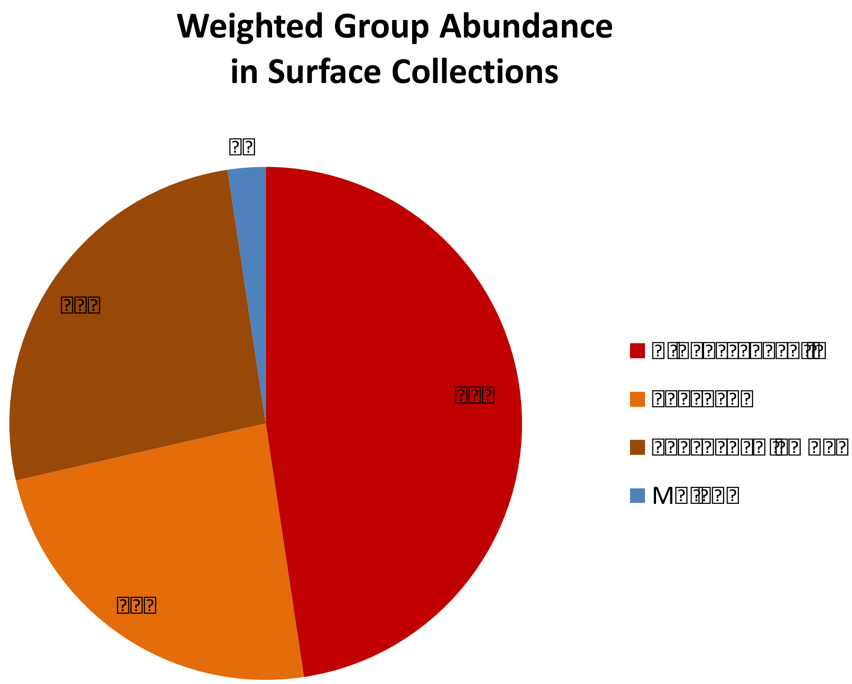

Figure 5.10: Weighted compositional group abundance in surface collections.

Table 5.10: Frequency and abundance of *cajetes cónicos* belonging to each compositional group by context.

Compositional	Feature 1		Structure 6		Structure 5B		Surface	
Group	n	%	n	%	n	%	n	%
Atoyac/Zaachila	19	67.9	42	63.6	16	33.3	20	47.6
Yaasuchi	3	10.7	9	13.6	13	27.1	10	23.8
Yaasuchi High REE	3	10.7	9	13.6	14	29.2	11	26.2
MA-EVG	0	0.0	1	1.5	4	8.3	1	2.4
High Fe Cremosa	0	0.0	2	3.0	0	0.0	0	0.0
NW Valle Grande	1	3.6	2	3.0	0	0.0	0	0.0
Trapiche Cremosa	2	7.1	0	0.0	0	0.0	0	0.0
Outlier	0	0.0	1	1.5	1	2.1	0	0.0
Total	28	100	66	100	48	100	42	100

Discussion

In general, households at Yaasuchi relied on local production for 90% of their ceramics, only importing about 10% of their wares from other communities. This implies that regional market access or participation at Yaasuchi was limited, yet there was substantial variation in ceramic consumption between households within the site. While households at Feature 1 and Structure 6 relied predominately on domestic production for the majority of their goods, they imported ceramics from a range of sources in the Northern Valle Grande and Southern Etla area. In contrast, Structure 5B had access to a much broader range of vessel forms than Structure 6, but obtained the majority of its goods within the community. Those ceramics that it did import were dominated by a single compositional group, suggesting that suggesting this household's access to or participation in regional exchange was more constrained than at Structure 6 or the household that preceded it.

Without a firmer understanding of the chronological relationship between Structure 5B and Structure 6, the contrast in consumption patterns between the two households is difficult to interpret. It is tempting to speculate that Structure 5B post-dated Feature 1 and Structure 6 and that the lack of *cremosa* imports in the 5B assemblage reflects growing barriers to exchange with Monte Albán in the Northern Valle Grande during the Late Classic. However, the lack of a firm date for Stucture 6 requires that we consider alternative explanations for this variability in household economic behavior, as well.

One of the other striking differences in consumption between Structure 5B and Structure 6 is the more even representation of local compositional groups. No single composition group dominated the 5B assemblage, suggesting that while this household may have produced some of its own ceramics, it relied on other households within the community for a large proportion of its ceramics. Given the lower abundance of the Atoyac/Zaachila group in the 5B assemblage, it seems likely that ceramics from this group were not produced domestically by this household, but obtained through exchange with another household. As producers of the Atoyac/Zaachila group, Structure 6 and the household that preceded it are strong candidates. If Structure 5B was contemporaneous with Structure 6, we must seek an explanation for their differences in ceramic consumption that is not political.

Sherman (2005:296) has suggested that the larger size of Structure 5B may indicate that it was an elite residence. Its greater access to a diversity of vessel forms relative to Structure 6 substantiates this hypothesis. However, it may be significant that the majority of the least common vessel types in the 5B assemblage were produced locally. If Structure 5B was an elite residence, it seems that its occupants were able to realize a higher standard of living without acquiring goods through regional exchange. In contrast, consumption patterns at Structure 6 show that this household imported ceramics from a higher diversity of sources, but only had access to the most utilitarian vessels forms. This consumption pattern is consistent with Sherman's interpretation that Structure 6 was a commoner residence. If the two households were contemporaneous, differences in consumption patterns between the two may simply reflect status related differences in economic behavior. Lower access to resources may have required households at Feature 1 and Structure 6 to supplement income from agricultural production with craft production for exchange, both within the community and in regional markets. If so, the greater diversity of imported ceramics in these households may simply reflect their higher dependence on regional markets as a source of income. If Structure 5B enjoyed superior access to agricultural land or other resources and was able to acquire the goods that it needed within the community, it may not have been as dependent on regional markets, either as a source of income or craft goods.

Yaasuchi Ceramic Exports

Examination of ceramic production and consumption patterns at Yaasuchi has suggested that some households at the site may have engaged in production for export to regional markets. Of the three groups produced at Yaasuchi, the Yaasuchi High REE group exhibited the highest degree of both product specialization and morphological and compositional standardization, strongly suggesting that this group was produced for exchange beyond the community. A low degree of product specialization was evident in the Atoyac/Zaachila group as well, suggesting that it may have been produced both for domestic use and exchange. Production of the Yaasuchi group was most generalized, suggesting low intensity production for domestic use. We may evaluate these interpretations by identifying whether Late Classic ceramics from other sites represented in the OSU database show a high probability of membership in those groups produced at Yaasuchi.

Analysis

In order to identify possible exports from Yaasuchi at other sites in Valley of Oaxaca, Minc and Pink (2014) calculated probabilities of group membership for nearly 1000 ceramics in the Yaasuchi, Yaasuchi High REE, and Atoyac/Zaachila groups using compositional data for each sample obtained through INAA at the OSU-RC. These samples came from a number Late Classic centers, including Monte Albán, Jalieza, El Palmillo, and Macuilxóchitl (Table 5.11). Probabilities were computed using 5 principal components calculated on the covariance matrix for the Oaxaca Clay Survey database and projected onto compositional data for each ceramic. Matches between ceramics from these sites and groups produced at Yaasuchi (as determined through the multivariate Mahalanobis distance between samples and group centroid) will allow us to further explore the structure of the exchange network Yaasuchi participated in and allow us to explore differences in the flow of goods to and from the Yaasuchi area.

Table 5.11: Frequencies of Late Classic ceramics from other sites in the OSU-RC database. Analysis of samples from Lambityeco was in process at the time of writing.

Site	Late Classic Ceramics
Monte Albán	188
Jalieza	245
El Palmillo	259
Dainzu	148
Lambityeco	114
Loma del Trapiche	25
Cuilápan	9
San Agustín de las Juntas	6
Total	994

Results

Results of these analyses showed that 21 samples had a significant ($p > 0.05$) probability of membership in groups produced at Yaasuchi (Table 5.12). Of these, 18 samples matched the Atoyac/Zaachila group, 3 samples matched the Yaasuchi group, and none matched the Yaasuchi High REE group. One additional sample had a probability of membership in the Yaasuchi group that was very near significant (at $\alpha = 0.05$).

Of the 18 samples matching the Atoyac/Zaachila group, 14 were recovered from the site of Jalieza, 3 came from Monte Albán, and 1 from Macuilxóchitl. Nearly all samples matching the Atoyac/Zaachila group at Jalieza were large utilitarian vessels. Four samples from Jalieza were classified as *apaxtles* [very large bowls]; two of these had composite silhouettes. Another 6 samples were classified as *cajetes*: 2 were *cajetes con siluetas compuestas*; 2 were *cajetes cónicos grandes*, and 1 was a *cajete grande*. Four samples from Jalieza were classified as *comales* and 1 was classified as a *tlecuil* [floor basin]. Of the three samples from Monte Albán, one was a *cajete cónico grande*, while the other two were classified as *indeterminate form*. The sole sample belonging to the Atoyac/Zaachila group from Macuilxóchitl was classified as an *olla sencilla* [simple jar]. Two thirds of the samples matching this group were manufactured in a *gris* paste, the other third were *café*.

All 4 samples matching the Yaasuchi group were from Jalieza. Two of these were classified as *comales*, one was classified as a *cajete semiesférico*, and another was classified as an *apaxtle*. All four were manufactured in a *café* paste.

Discussion

Insofar as the Atoyac/Zaachila group was manufactured using clays obtained from the floodplain of the Río Atoyac in the center of the Valle Grande, attributing ceramics from other sites that match this group to Yaasuchi is problematic. While some households at Yaasuchi used clays from this area to manufacture pottery, it is likely that many communities on the Atoyac floodplain, such as Zaachila, did as well. Thus, it is much more likely that the 18 ceramics from Monte Albán, Jalieza, and Macuilxóchitl were obtained from the much larger community of Zaachila than obtained through exchange with

Table 5.12: Late Classic ceramics from other sites in the OSU-RC database with a significant probability of membership in the Yaasuchi and Atoyac/Zaachila compositional groups.

INAA ID	Site	Ware	Vessel Type	Group	Prob. (%)
MA 094	Monte Albán	Gris	Cajete cónico grande	Atoyac/Zaachila	62.6
MAX 036	Monte Albán	Café	Indeterminado	Atoyac/Zaachila	29.1
MAX 056	Monte Albán	Gris	Indeterminado	Atoyac/Zaachila	64.5
JAL 001	Jalieza	Gris	Cajete con silueta compuesta	Atoyac/Zaachila	29.9
JAL 004	Jalieza	Gris	Cajete con silueta compuesta	Atoyac/Zaachila	22.9
JAL 007	Jalieza	Gris	Cajete cónico grande	Atoyac/Zaachila	67.0
JAL 021	Jalieza	Gris	Cajete cónico grande	Atoyac/Zaachila	37.4
JAL 058	Jalieza	Gris	Apaxtle con silueta compuesta	Atoyac/Zaachila	12.5
JAL 069	Jalieza	Café	Tlecuil	Atoyac/Zaachila	43.7
JAL 072	Jalieza	Café	Comal	Atoyac/Zaachila	25.5
JAL 114	Jalieza	Gris	Cajete grande	Atoyac/Zaachila	72.0
JAL 134	Jalieza	Café	Comal	Atoyac/Zaachila	48.6
JAL 135	Jalieza	Café	Comal	Atoyac/Zaachila	14.7
JAL 148	Jalieza	gris	Apaxtle	Atoyac/Zaachila	15.0
JAL 186	Jalieza	gris	Comal	Atoyac/Zaachila	55.1
JAL 211	Jalieza	gris	Apaxtle con silueta compuesta	Atoyac/Zaachila	12.3
JAL 229	Jalieza	gris	Apaxtle	Atoyac/Zaachila	85.9
DAN 011	Macuilxóchitl	café	Olla sencilla	Atoyac/Zaachila	17.9
JAL 223	Jalieza	café	Cajete semiesférico	Yaasuchi	04.6
JAL 225	Jalieza	café	Comal	Yaasuchi	06.6
JAL 228	Jalieza	café	Apaxtle	Yaasuchi	92.1
JAL 233	Jalieza	café	Comal	Yaasuchi	32.7

households at Yaasuchi. Nevertheless, the fact that both Monte Albán and Jalieza were obtaining ceramics from this area is significant. This demonstrates that communities in the northern Valle Grande participated in exchange with both Monte Albán and Jalieza, with the implication that any political tensions between the two did not create hard barriers to exchange within the northern Valle Grande.

Identification of four ceramics at Jalieza that match the Yaasuchi group was especially surprising given that production of this group at Yaasuchi appeared to low-intensity generalized production for domestic use or exchange within the community. Again however, significant probabilities of membership in the Yaasuchi group only imply that these ceramics were manufactured from clays obtained in the same source area as those produced at Yaasuchi. Figure 5.1 shows that this area includes Yaasuchi, but also encompassed a 6 to 8 km long section of piedmont on the western margin of the Zimatlán Subvalley. Insofar as Yaasuchi is not the only community in this area, it is possible that another village produced the Jalieza ceramics belonging to this group. This is not to say that ceramics produced at Yaasuchi would not have been available through exchange to households in Jalieza, but the generalized production strategy used to manufacture this group at Yaasuchi is inconsistent with production for exchange.

Nevertheless, the presence of ceramics matching the Yaasuchi and Atoyac/Zaachila groups at Jalieza is important. By itself, evidence from consumption patterns at Yaasuchi suggested little contact through exchange with Jalieza, implying barriers to exchange between communities in the western Valle Grande and this important center. The presence of even a few ceramics matching the Yaasuchi group at Jalieza indicate that exchange did take place between Jalieza and communities in this area, with important implications for our interpretation of regional political and economic integration during the Late Classic.

Conclusion

Evidence from production and consumption patterns at Yaasuchi suggest that during the Late Classic, rural households in the northern Valle Grande were not dependent upon urban craft producers, as has been often assumed in many models of Late Classic economic organization. Nor however, was Yaasuchi an economically independent community. Rather, the evidence from Yaasuchi indicates that rural households in this area obtained the vast majority of their ceramics through domestic production or intra-community exchange, but imported at least 10% of goods from other communities.

Moreover, household economic behavior was not uniform at Yaasuchi. Households exhibited a range of economic behavior encompassing multiple strategies of production, consumption, and exchange. Households at Feature 1 and Structure 6 produced the majority of their ceramic goods domestically, but also produced for exchange within the community and possibly in regional markets. These households had access to ceramics produced in a number of Late Classic communities in the northern Valle Grande and the southern Etla Subvalley, including Monte Albán. In contrast, there is no evidence for ceramic production at Structure 5B. This household obtained the majority of its goods from other households within the community and those ceramics that it did import came from a limited number of sources, implying that this household's market access or participation was more constrained. While this study is hampered by our lack of knowledge regarding the fine-scale chronological relationship between these households, it is clear that Yaasuchi households employed multiple strategies of production, consumption, and exchange during the Late Classic.

In this chapter I have suggested that the differences in economic behavior observed between households at Yaasuchi could be accounted for either through reference to status or the changing political dynamics of the Late Classic. It would be easy to speculate that the differences in production and exchange observed between Structures 5B and 6 could be due to the decline of Monte Albán during the Late Classic and its withdrawal from regional market networks. However, it is equally plausible that households tailored their individual strategies of consumption and exchange to their particular economic needs given differential access to resources. In the final chapter of this thesis, I will discuss the implications of this research for rural market participation, market structure, and political integration during the Late Classic in more depth.

CHAPTER VI: DISCUSSION AND CONCLUSIONS

> *"Peasants diversify and retain an element of self-sufficiency not because markets are absent but because markets are unreliable".*
>
> – Overton *et al.* (2004:3)

Rural Market Participation at Yaasuchi

Results of compositional analyses of Yaasuchi ceramics have shown that rural households in the northern Valle Grande were not dependent on urban craft producers for the majority of their goods during the Late Classic. Nor however, were these households self-sufficient producers divorced from the regional economy. Yaasuchi households consistently relied on local production and exchange within the community to supply as much as 90% of the ceramics they consumed, but imported the remaining portion of goods from other communities. The diversity of goods consumed by some households suggests that exchange was not tied exclusively to a single community, but articulated with a broader, regional system integrating flows of goods between communities. In addition, evidence suggests that some households at Yaasuchi engaged in production for regional exchange.

Craft production at Yaasuchi was not limited to ceramics; evidence from excavations suggests that some households, such as Structure 6, may have produced textiles for exchange as well. This pattern is consistent with the strategy of multi-crafting described by Balkansky and Croissier (2009) for Prehispanic Oaxaca, wherein households would have sought to buffer agricultural risk by diversifying production to include a variety of craft activities. Export of these goods to regional markets would have provided a secondary source of income in times of agricultural scarcity, and improved access to goods not available locally. And yet, within Yaasuchi, patterns of production, consumption and exchange varied considerably between households. Understanding this variability in household economic behavior requires consideration of how household craft production was articulated with exchange, both within the community and at a regional scale.

Compositional analyses showed that multiple production strategies were employed to manufacture Yaasuchi ceramics. Locally produced wares could be divided into three internally consistent but distinct compositional groups: the Atoyac/Zaachila, Yaasuchi, and Yaasuchi High REE groups. At a site level, the Atoyac/Zaachila group was most abundant. This group was manufactured using clays obtained from the Río Atoyac floodplain, while the Yaasuchi and Yaasuchi High REE groups were manufactured using clays obtained in the vicinity of the site. Clays used to produce the High REE group were either refined or intentionally selected to produce a finer paste. Differences between these groups were not limited to paste composition; each group represented a distinct production strategy, as indicated by differences the degree of product specialization and standardization between groups. The Yaasuchi High REE group exhibited a high degree of product specialization and standardization relative to the other two groups, a pattern consistent with production for exchange beyond the community. By contrast, the Yaasuchi group was less standardized and encompassed the full range of Late Classic vessels forms. This generalized strategy is more consistent with production for domestic use and exchange within the community. Production of the Atoyac/Zaachila group was dominated G.35 *cajetes cónicos*, indicating a degree of product specialization, but a range of other types belonged to this group as well, suggesting an intermediate strategy of production both for domestic use and exchange. Variations in the relative abundance of these groups between contexts suggested that they were not produced in all households. Rather, these groups likely represent variation in production strategies between households at Yaasuchi, some engaging in limited, generalized production for domestic use, while others sought to supplement agricultural income through more intensive production for exchange.

Compositional data from ceramics recovered from Structure 6 and Feature 1 demonstrated substantial continuity in economic behavior between Structure 6 and the household that preceded it. In both contexts, at least 60% of the assemblage belonged to the Atoyac/Zaachila group. Though the clays used to produce this group were obtained from the Río Atoyac floodplain, nearly 7 km from the site, their abundance in these contexts and match with a number of production wasters from Feature 1 indicate that they were produced locally by these households. Ceramics belonging to the Yaasuchi and Yaasuchi

High REE groups were also present in Feature 1 and Structure 6 assemblages, but at much lower frequencies than in the Structure 5B or surface collections, suggesting that Structure 6 and the household that preceded it were not the primary producers of ceramics belonging to these groups, despite the presence of a ceramic production waster matching each group in Feature 1. Rather, households at Structure 6 and Feature 1 appear to have focused production on ceramics belonging to the Atoyac/Zaachila group, producing lower abundances of ceramics belonging to the Yaasuchi and Yaasuchi High REE groups. The majority of ceramic production at these households was likely intended for domestic use, but Structure 6 and its predecessor also acted as suppliers of ceramics to other households at Yaasuchi and exported to regional markets.

In addition to locally produced wares, there was diversity of imported goods in the Feature 1 and Structure 6 assemblages. The Feature 1 assemblage boasted a higher proportion of imported wares than any other context, and included goods belonging to the MA-EVG, Northwestern Valle Grande, Trapiche Cremosa, and High Fe Cremosa compositional groups. The percentage of imported goods in the Structure 6 assemblage was somewhat lower, but the same sources of ceramics were represented.

In contrast, Structure 5B's involvement in the regional economy appears to have been more constrained. Like Structure 6, this household obtained about 90% of its ceramics locally, but divided its consumption more evenly between the three locally produced groups. There was no evidence for ceramic production at Structure 5B; rather this household appears to have obtained the majority of ceramics through exchange with other households within the community. Another notable difference in consumption between households was the lower diversity of imported wares in Structure 5B. Nine out of ten of the ceramic samples that matched compositional groups manufactured outside of Yaasuchi belonged to the MA-EVG group, while just one matched the Northwest Valle Grande group. Significantly, none of the ceramics from the Structure 5B sample matched the Trapiche Cremosa or High Fe Cremosa groups. This suggests that while Structure 5B participated in regional market exchange to the same *degree* as Structure 6, its involvement in regional exchange was very different.

Our interpretation of this variability in patterns of production, consumption, and exchange between households at Yaasuchi is to some extent hampered by our lack of knowledge concerning the chronological relationship between Structure 5B and Structure 6. As noted in the last chapter, it is tempting to speculate that the lack of *cremosa* ceramics in the Structure 5B assemblage indicates that this household post-dated Structure 6 and signifies a withdrawal of communities in the northern Valle Grande from Monte Albán's exchange network. Insofar as the radiocarbon date obtained from Structure 5B returned a date of AD 660 -770, this would support the view that Monte Albán's political and economic dominance of the Valley of Oaxaca had begun to wane early in the Late Classic. However, there is little to no evidence to suggest a substantial difference in age between Structure 5B and Structure 6. Indeed, the presence of a minority of wares belonging to the Atoyac/Zaachila group in the 5B assemblage suggests ceramic exchange between the two households. This requires consideration of alternative explanations for this variability in economic behavior between households.

Another potential factor affecting the economic behavior of each household is status. Structure 6 was a small, patio-oriented residence consistent with the commoner households described by Winter (1974), while Structure 5B was considerably larger, suggesting that its occupants enjoyed higher status than those of Structure 6 (Sherman 2005:296-297). This interpretation is supported by the higher diversity of vessel forms in the Structure 5B assemblage relative to that of Structure 6. If Structure 5B was a higher status residence, we need not rely on a temporal/political argument to explain the differences in production and consumption between the two households. Indeed, even if Structure 5B was occupied before or after Structure 6 and its predecessor, status is a worthy consideration in our interpretation of household economic behavior.

Overton *et al.* (2004:3-4) have argued that "Where land quality is poor or in short supply, households diversify into craft production with the aim of selling into the market, as another strand in their production activities." They argue that peasant households diversify production and engage in market exchange not to maximize income, but to buffer economic hardship given inadequate or inconsistent resources. However, if markets are unreliable and resources are adequate, households may seek to retain an element of self-sufficiency. In this light, it may be significant that of the two households represented in our sample, it is the lower status, commoner household that appears to have both engaged in more intensive ceramic production, and participated in broader exchange networks. Structure 5B's lesser involvement in craft production may reflect superior access to land or other resources. If markets were unreliable, and this household was able to supply the majority of its needs through exchange within the community without engaging in craft production as a secondary source of income, it would have had lesser incentive to participate in regional markets. Structure 5B participated in extra-local exchange to the same *degree* as Structure 6, but did not obtain goods from as distant of sources. It is plausible that this difference in consumption patterns reflects Structure 6's greater involvement in exchange with more distant or numerous communities as it sought additional opportunities to market its wares.

In short, I have suggested that the diversity of economic behavior observed at Yaasuchi likely reflects alternative responses to an unreliable market system between households with differential access to land, labor, or other resources. This raises the question of how or why markets were unreliable. Addressing this issue requires that we consider broad patterns of economic behavior observed at the site level. Despite numerous differences between households, we can make a number of generalizations about craft production, consumption, and exchange at Yaasuchi:

(1) Households were not dependent upon craft production in urban centers for a significant proportion of their goods; the majority of ceramics consumed at the household level were produced domestically or acquired through intra-community exchange;
(2) Pottery producing households engaged in multiple production strategies, manufacturing goods both for domestic consumption, as well as for exchange within the community and in regional markets;
(3) Ceramic imports were not dominated by goods acquired from a single source, but from multiple sources in the northern Valle Grande or southern Etla Subvalley near Monte Albán;

Combined, these patterns of ceramic production, consumption, and exchange provide a view toward the structure of the market network that Yaasuchi participated in, with implications for regional political integration. Each of these topics is briefly discussed below.

Implications for Market Structure

As discussed in Chapter 3, one of the most factors critical factors affecting rural economic behavior is market structure. Of the four idealized market types outlined in Chapter 3, patterns of consumption, production and exchange at Yaasuchi are most consistent with an overlapping market system. In such a system, horizontal integration facilitates exchange between adjacent market zones, undermining urban monopolies by introducing a degree of competition between centers. However, the lack of strong vertical integration limits the flow of goods and price information between zones, inhibiting the development of a strong division of labor. Because markets are an unreliable source of goods and income, rural households maintain a degree of self-sufficiency, but may diversify production, engaging in a variety of craft activities to supplement goods acquired through the market and as a secondary source of income. Goods acquired through the market are not dominated by a single source, nor are the sources of material strongly correlated with particular products. Consumption of imported goods is limited however, and the majority of household needs are supplied through domestic production or intra-community exchange. This is exactly the pattern of market participation observed at Yaasuchi.

Several lines of evidence support this interpretation: (1) the diversity of sources of ceramics imported to Yaasuchi; (2) the concentration of these sources in the northern Valle Grande and southern Etla Subvalley near Yaasuchi; (3) a limited flow of goods between Monte Albán and Jalieza's market zones; (4) Yaasuchi's reliance on local production and intra-community exchange; and (5) the production of ceramics for exchange as a secondary source of income for low status households. Below I will discuss each of these lines of evidence in additional detail. This will be followed by a brief discussion of the evidence against interlocking, dendritic, and solar market networks.

Evidence for an Overlapping Market Network

There are two primary lines of evidence supporting the interpretation that Yaasuchi participated in an overlapping market network during the Late Classic. The first of these is the diversity of sources of ceramics imported to the site. The second is evidence for the consumption of ceramics from the Yaasuchi area at both Monte Albán and Jalieza. This evidence is complemented by patterns of production, consumption, and exchange observed at the household level at Yaasuchi.

In general, Yaasuchi households only imported about 1 in 10 vessels from other sites, but those ceramics imported to the site could be classified into four compositional groups corresponding to as many source areas: the Northwest Valle Grande group; the MA-EVG group; the Trapiche Cremosa group; and the High Fe Cremosa group. Significantly, the two *cremosa* groups were produced outside of the Valle Grande at Trapiche, Atzompa, or perhaps even Monte Albán. This indicates contact through exchange between Yaasuchi and sites affiliated with Monte Albán, demonstrating that Yaasuchi was within Monte Albán's broader market zone. Yet ceramics belonging to these two groups did not dominate imported wares at Yaasuchi and were even absent from the Structure 5B assemblage. The only compositional groups represented in Feature 1, Structure 6, and Structure 5B were the Northwest Valle Grande and MA-EVG groups. The Northwest Valle Grande group was produced north of Yaasuchi near the site of Cuilapan, while the MA-EVG group could have been produced either on the eastern margin of the Valle Grande near Animas Trujano or at Monte Albán. Notably, these source areas flank the site of Zaachila in the northern Valle Grande. Insofar as Zaachila is the closest major Late Classic center to Yaasuchi, it seems likely that Yaasuchi obtained a majority of imports through exchange in Zaachila – despite the fact that we cannot readily discern Zaachila ceramics from Yaasuchi goods belonging to the Atoyac/Zaachila group. In an overlapping market system, Zaachila would have been well positioned geographically to moderate the flow of goods between communities in the northern Valle Grande, including Monte Albán and Jalieza.

Significantly, none of the ceramics in the Yaasuchi sample belonged to either of the two compositional groups produced at Jalieza. By itself, this may suggest that barriers to exchange between Jalieza and Monte Albán inhibited any flow of goods between Jalieza and communities in the western Valle Grande. However, ceramics matching the Atoyac/Zaachila group were identified in samples of ceramics from both Jalieza and Monte Albán, suggesting that both centers were involved in exchange with communities on the Río Atoyac floodplain. In addition, a small number of ceramics from the Jalieza sample matched the Yaasuchi group, demonstrating contact through exchange between Jalieza and the Yaasuchi area (if not Yaasuchi itself). The lack of Jalieza ceramics in the Yaasuchi assemblage therefore does not indicate a complete barrier to exchange between Jalieza and communities in the western Valle Grande. Rather, it suggests that either Jalieza was not a major exporter of ceramics, or that exchange linkages between Jalieza's market zone and those in the northern Valle Grande, although present, were weaker than those between other communities in the northern Valle Grande. The latter is consistent with an overlapping market system. Insofar as market structure carries implications for the organization of production and exchange within communities, patterns of economic behavior observed at the site level may be used to validate or invalidate this interpretation.

As discussed above, ceramic consumption at Yaasuchi was overwhelmingly dominated by goods produced locally either for domestic use or intra-community exchange, suggesting Yaasuchi's need or ability to retain self-sufficiency. Households employed multiple strategies of production to manufacture craft goods, but it was lower status households such as Structure 6 that engaged in more intensive craft production. Structure 6 produced the majority of its own ceramics, acted as a supplier of ceramics to other households in the community, and probably exported goods for regional exchange. Higher status households such as Structure 5B, acted as net-consumers of ceramics, but obtained the majority of their goods through exchange within the community and imported ceramics from a lower diversity of sources. This contrast in economic behavior suggests that those households with resources sufficient to retain self-suffiency did so, while households with lower resources engaged in craft production for exchange, not to maximize income, but to buffer risk and supplement income from agricultural production.

This pattern of production, consumption, and exchange is consistent with a market structure that is both an unreliable source of goods and income. An overlapping network is one such system, but diversified production and low market participation may be observed in communities at the periphery of solar and dendritic networks as well. For this reason, it is necessary to briefly discuss the evidence from Yaasuchi against the other types of market structure.

Evidence Inconsistent with a Solar Market System

Solar market networks are principally characterized by substantial barriers to exchange between adjacent market zones. Under such a system, we would expect exchange at Yaasuchi to be tied exclusively to a single political center such as Monte Albán, Jalieza, or Zaachila. Rural communities would primarily act as agricultural producers, exporting staple goods to the market center in exchange for craft products. Unfavorable terms of exchange would encourage rural communities to engage in craft production for domestic use, but these would not be exported for exchange in the market center. Consumption at the site level would thus be divided between ceramics produced locally using a generalized production strategy and ceramics produced by craft specialists in a single nearby center. The evidence against Yaasuchi's participation in such a system may be summarized as follows:

(1) ceramic imports to Yaasuchi were not obtained from a single community, but from numerous sources in the northern Valle Grande and southern Etla Subvalley;
(2) Yaasuchi engaged in ceramic production for export to regional markets, as well as domestic use and intra-community exchange; and
(3) there is evidence for exchange between Yaasuchi and both Monte Albán and Jalieza, including import of cremosa ceramics from the Monte Albán area and export of ceramics from the Yaasuchi area to Jalieza.

Evidence Inconsistent with a Dendritic Market System

A dendritic exchange system is principally characterized by strong vertical integration between communities at a range of scales and weak horizontal integration between communities of equivalent scale. This form of exchange relations is consistent with an administrative view of the Late Classic economy, with Monte Albán serving as both an administrative and commercial center over an integrated regional economy. In such a system, administrative controls on production and exchange would serve to channel staple goods from the hinterland toward Monte Albán's urban core. Rural market participation would be incentivized through provision of craft goods produced at Monte Albán or perhaps secondary wholesaling centers such as Zaachila. Rural communities would export staple goods in exchange for these products, but would not have access to goods produced in other sectors of the exchange system due to the directionality of trade. Unfavorable terms of exchange and would isolate communities at the periphery of the exchange system, encouraging rural communities to engage in generalized craft production for domestic use, but exchange of these goods beyond the community would be inhibited. The evidence against Yaasuchi's participation in a dendritic exchange network may be summarized as follows:

(1) ceramic imports to Yaasuchi were not dominated by goods produced at Monte Albán, but included ceramics produced in other sectors of Monte Albán's exchange network, namely *cremosa* ceramics produced in the southern Etla Subvalley at Trapiche and Atzompa, as well as goods produced in smaller communities in the northern Valle Grande;
(2) Yaasuchi households engaged in production for regional exchange as well as production for domestic use; and
(3) ceramics matching the Yaasuchi group were identified at Jalieza, implying that exports from the Yaasuchi area were not channeled solely toward Monte Albán, but available to multiple centers.

Evidence Inconsistent with an Interlocking Market System

An interlocking market system is characterized by both strong vertical and horizontal linkages between communities at a variety of scales in a commercially integrated regional network. This is consistent with a commercial model of the Late Classic economy where market efficiency encourages product specialization and a strong division of labor between communities. Communities of all scales would be able to capitalize on local comparative advantage to focus production on a limited range goods, confident that others could be obtained through the regional market. Insofar as Yaasuchi both imported ceramics from a number of communities at a range of scales, engaged in production for regional exchange, and even engaged in production specialization to manufacture the Yaasuchi High REE group, this is perhaps the most difficult model of the regional economy to refute. However, a number of lines of evidence suggest that Yaasuchi households were not able to rely on market exchange as either a reliable source of income or goods, indicating low market efficiency and weak articulation of exchange:

(1) Yaasuchi households predominately relied on generalized domestic production and intra-community exchange for the majority of their ceramics;
(2) craft production for exchange was principally undertaken by low status households not to maximize income, but as part of a diversified production strategy intended to buffer economic risk and supplement agricultural income;
(3) higher status households maintained independence from the regional market by relying on local craft producers rather than exchange beyond the community; and
(4) Yaasuchi's access to goods that could not be produced locally, such as chert and obsidian, was very limited.

Summary

Ceramic production, consumption, and exchange patterns observed at Yaasuchi are most consistent with those predicted for an overlapping exchange network. Overall, access to craft goods produced in other communities, including ceramics, obsidian, chert, and groundstone, was limited. Ceramics that were imported from other sites were not dominated by materials produced in a single center, but were acquired from a number of sources in the northern Valle Grande and southern Etla Subvalley. This suggests that to the extent that Yaasuchi households engaged in regional exchange, they largely participated in a market zone encompassing Monte Albán and Zaachila. A few ceramics from Jalieza matched the Yaasuchi group, indicating some exchange between communities in the western Valle Grande and this important center, but a lack of imported ceramics at Yaasuchi from Jalieza and more distant sectors of the Valley suggest a division of the Valley into overlapping market zones with poor linkages between them. An effect of this poor integration would be limited flow of goods and price information between centers, inhibiting the development of a strong division of labor between communities. As a result, markets would have been an unreliable source of goods and income, encouraging rural communities to maintain economic independence through reliance on local production and intra-community exchange.

Implications for Regional Political Integration

An overlapping market system is consistent with the view that political authority in the Valley of Oaxaca was increasingly decentralized during the Late Classic, but that political divisions between sub-regional polities were not substantial enough to completely inhibit exchange between market zones. Insofar as this study is confined to material from a single rural site, our view of political and economic relations between centers is limited. Nevertheless, Yaasuchi's near equal distance to both Jalieza and Monte Albán offers a view toward how communities situated between these polities responded to changing political dynamics within the Valley.

As discussed above, ceramic imports to Yaasuchi show that it primarily engaged in exchange within a market zone centered at Monte Albán but encompassing the southern Etla Subvalley and northern Valle Grande. Monte Albán did not exercise direct control over the production or exchange of ceramics within this zone. Rather, numerous communities, including Yaasuchi, engaged in ceramic production for exchange within this area. While the number of ceramics imported to Yaasuchi was low, its access to *cremosa* ceramics from the Trapiche-Atzompa area as well as those from more proximal sources in the Valle Grande suggests that exchange linkages between communities in this market zone were fairly strong. It thus seems likely that communities in this area – including Yaasuchi – maintained political as well as economic ties to Monte Albán. Other communities in Monte Albán's immediate political and network would have likely included Zaachila, Loma del Trapiche, Atzompa, Cuilapan, and Animas Trujano.

In contrast, there is less direct evidence for interaction between Yaasuchi and Jalieza. Yaasuchi did not import any ceramics from Jalieza, initially suggesting a barrier to exchange between Jalieza and communities in the western Valle Grande. However, a number of ceramics belonging to the Atoyac/Zaachila group were found at both Jalieza and Monte Albán, indicating that both centers engaged in exchange with communities on the Río Atoyac floodplain. As the largest Late Classic center in this sparsely populated area, Zaachila is the most likely candidate. In addition, a small number of ceramics matching the Yaasuchi group were identified at Jalieza, but not at Monte Albán. As noted elsewhere, this may not indicate direct interaction with Yaasuchi per se, but it does show that Jalieza had access to goods produced in the Yaasuchi area, perhaps through exchange with Zaachila. This demonstrates that while there may have been growing political divisions between Jalieza and Monte Albán, there was substantial overlap between their respective economic networks in the northern Valle Grande.

In summary, while Jalieza and other urban centers may have begun to exercise a degree of autonomy during the Late Classic, political divisions within the Valley were not sufficient to completely inhibit exchange between communities affiliated with each polity. In the northern Valle Grande, Monte Albán would have faced competition from Jalieza for market power and political influence, presenting rural communities and smaller centers in this area with a choice of market zones to participate in. Evidence from ceramic consumption patterns at Yaasuchi suggests that it maintained political and economic ties to Monte Albán, probably through Zaachila. Yet Jalieza's access to ceramics produced near the Río Atoyac and in the western Valle Grande suggests that communities in this area participated in exchange with both centers. We may thus conclude that to the extent that the Valley of Oaxaca was politically divided during the Late Classic, its market networks were not coterminous with political boundaries. In this scenario, direct economic interaction between Jalieza and Monte Albán would have been limited, but the boundaries of their respective market zones would have remained fluid and each would have maintained economic ties with smaller centers situated between them, such as Zaachila. Thus, the economic consequence of increasing political autonomy was not barriers to exchange between sectors of the Valley, but the development of an overlapping market network linking adjacent market zones.

Conclusion

The increasing autonomy of many Late Classic centers in the Valley of Oaxaca did not created a series of discrete, bounded market zones, but an overlapping market network facilitating exchange between adjacent centers. At the same, vertical integration between centers was limited, inhibiting the overall flow of goods and the development of a strong regional division of labor. Households at Yaasuchi responded to the opportunities and constraints posed by the structure of this exchange system in different ways. Those households with sufficient resources to fulfil their needs through exchange within the community limited participation in regional markets, while those with lower resources engaged in market exchange as a supplementary source income. Lower status households such as Structure 6 and its predecessor employed multiple production strategies, manufacturing ceramics both for domestic use and exchange within the community and regional markets. Households that enjoyed higher status, such as Structure 5B, relied on intra-community exchange to fulfil most domestic needs and did not produce pottery for exchange in regional markets. The differential involvement of Yaasuchi households in craft production and regional exchange suggests that market participation was an unreliable source of income and goods during the Late Classic. Markets were not absent, but rural market participation was strongly conditioned by market structure and relative access to resources.

Insofar as this study is limited to analysis of material from a single rural site, these interpretations remain speculative. Defining the structure of the regional exchange system requires consideration of material from a large number of sites on a scale of rural to urban from across the region. The view from Yaasuchi suggests that it participated in exchange with overlapping market zones centered at both Monte Albán and Jalieza, but the structure of the exchange system may have differed in other parts of the Valley. Ongoing analysis of material from Monte Albán, Jalieza, and other important Late Classic centers at the OSU-RC will clarify the overall structure of regional exchange and political integration. Nevertheless, this study has provided a critical view of how rural households may have responded to the changing political and economic climate of the Late Classic.

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APPENDIX A:

Sample Descriptions

Table A.1: Yaasuchi Ceramic Sample Descriptions

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA013	Feature 1	B	2007	*Indeterminado*	G35	*Gris*	Fine	Rim	9.75	38	Wiped	Atoyac/Zaachila	Core
YAA014	Feature 1	B	2007	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Atoyac/Zaachila	Noncore
YAA015	Feature 1	B	2007	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.2	14	Wiped	Yaasuchi High REE	Assigned
YAA016	Feature 1	B	2007	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.91		Wiped	Atoyac/Zaachila	Core
YAA017	Feature 1	B	2007	*Cajete semiesférico*	G3?	*Gris*	Fine	Body/base				Outlier	
YAA018	Feature 1	B	2007	*Cajete cónico*	---	*Café*	Coarse	Body/base				Trapiche Cremosa	Assigned
YAA019	Feature 1	B	2007	*Indeterminado*	---	*Café*	Coarse	Body				Trapiche Cremosa	Assigned
YAA020	Feature 1	B	2019	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.52	10	Simple	Atoyac/Zaachila	Core
YAA021	Feature 1	B	2019	*Indeterminado*	---	*Gris*	Fine	Body				MA-EVG	Core
YAA022	Feature 1	B	2019	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.46	15	Wiped	Atoyac/Zaachila	Core
YAA023	Feature 1	B	2019	*Cajete cónico*	G35	*Gris*	Coarse	Base				Atoyac/Zaachila	Assigned
YAA024	Feature 1	B	2019	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.51	24	Simple	Atoyac/Zaachila	Core
YAA025	Feature 1	B	2019	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA026	Feature 1	B	2019	*Olla*	---	*Café*	Coarse	Body				Yaasuchi	Assigned
YAA027	Feature 1	B	2019	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Noncore
YAA028	Feature 1	B	2019	*Comal*	---	*Café*	Fine	Body				NW Valle Grande	Core
YAA029	Feature 1	B	2030	*Indeterminado*	---	*Café*	Coarse	Rim				NW Valle Grande	Assigned
YAA030	Feature 1	B	2032	*Cajete cónico*	G35	*Gris*	Coarse	Rim	9.89	26	Wiped	Atoyac/Zaachila	Core
YAA031	Feature 1	B	2125	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.47	28	Wiped	Yaasuchi	Noncore
YAA032	Feature 1	B	2125	*Olla*	---	*Gris*	Fine	Neck				Atoyac/Zaachila	Core
YAA033	Feature 1	B	2125	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.57	24	Wiped	Atoyac/Zaachila	Core
YAA034	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA035	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				NW Valle Grande	Assigned
YAA036	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				High Fe Cremosa	Noncore
YAA037	Feature 1	B	2125	*Comal*	---	*Café*	Coarse	Body				Yaasuchi	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA038	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Assigned
YAA039	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Noncore
YAA040	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Core
YAA041	Feature 1	B	2125	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Assigned
YAA042	Feature 1	B	2128	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi High REE	Core
YAA043	Feature 1	B	2128	*Olla*	---	*Gris*	Coarse	Rim	4.82	12		MA-EVG	Core
YAA044	Feature 1	B	2128	*Olla*	---	*Gris*	Fine	Neck				MA-EVG	Core
YAA045	Feature 1	B	2128	*Comal*	---	*Café*	Coarse	Rim	12.35	44		Yaasuchi	Core
YAA046	Feature 1	B	2128	*Vaso*	---	*Café*	Coarse	Body/base				Trapiche Cremosa	Assigned
YAA047	Feature 1	B	2143	*Cajete cónico*	---	*Gris*	Coarse	Body				Trapiche Cremosa	Assigned
YAA048	Feature 1	B	2143	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA049	Feature 1	B	2143	*Indeterminado*	---	*Café*	Coarse	Body				Yaasuchi	Assigned
YAA050	Feature 1	B	2143	*Indeterminado*	---	*Café*	Coarse	Body				High Fe Cremosa	Noncore
YAA051	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA052	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA053	Feature 1	B	2209	*Olla*	---	*Gris*	Coarse	Body				Atoyac/Zaachila	Core
YAA054	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Coarse	Base				Atoyac/Zaachila	Assigned
YAA055	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.37	21	Simple	Atoyac/Zaachila	Core
YAA056	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.52	14	Wiped	Atoyac/Zaachila	Core
YAA057	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.15	14	Simple	Yaasuchi High REE	Core
YAA058	Feature 1	B	2209	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.37	12	Wiped	Atoyac/Zaachila	Noncore
YAA059	Feature 1	B	2209	*Cajete cónico*	---	*Café*	Coarse	Rim	9.75	30		Yaasuchi	Assigned
YAA060	Feature 1	B	2209	*Sahumador*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Assigned
YAA061	Feature 1	B	2209	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Assigned
YAA062	Feature 1	B	2209	*Sahumador*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Noncore

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

INAA ID	Context Information			Sample Description								Group Assignment	
	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA063	Feature 1	B	2209	*□lec□il*	---	*Café*	Coarse	Rim	23.59	45		Yaasuchi	Core
YAA064	Feature 1	B	2209	*Cajete cónico*	---	*Café*	Coarse	Rim	6.46	38	Wiped	Atoyac/Zaachila	Assigned
YAA065	Feature 1	B	2209	*Formative*	---	*Café*	Coarse	Rim					Formative
YAA066	Feature 1	B	2209	*Cajete cónico*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Core
YAA067	Feature 1	B	2211	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.85	18	Wiped	Atoyac/Zaachila	Core
YAA068	Feature 1	B	2211	*Cajete cónico*	G35	*Gris*	Coarse	Base				Atoyac/Zaachila	Core
YAA069	Feature 1	B	2211	*Vaso*	---	*Gris*	Fine	Rim	4.7	9	Simple	MA-EVG	Assigned
YAA070	Feature 1	B	2211	*Comal*	---	*Café*	Fine	Body				NW Valle Grande	Core
YAA071	Feature 1	B	2211	*Cajete cónico*	---	*Café*	Coarse	Rim	7.35	18	Simple	Yaasuchi	Core
YAA072	Feature 1	B	2211	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Core
YAA073	Feature 1	B	2211	*Cajete cónico*	---	*Café*	Coarse	Rim	6.8	23		NW Valle Grande	Core
YAA074	Structure 6	B	2054	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.98	22	Simple	Yaasuchi	Core
YAA075	Structure 6	B	2054	*Indeterminado*	---	*Café*	Coarse	Rim	11.15	25		Yaasuchi	Core
YAA076	Structure 6	B	2054	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA077	Structure 6	B	2054	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA079	Structure 6	B	2062	*Cajete semiesférico*	G3	*Gris*	Fine	Body/base				Atoyac/Zaachila	Core
YAA080	Structure 6	B	2062	*Indeterminado*	---	*Café*	Coarse	Body				Outlier	
YAA082	Structure 6	B	2074	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.56	25	Wiped	Yaasuchi High REE	Core
YAA083	Structure 6	B	2074	*Indeterminado*	---	*Café*	Fine	Rim				Outlier	
YAA084	Structure 6	B	2078	*Cajete cónico*	G35	*Gris*	Coarse	Rim	9.47	35	Simple	Atoyac/Zaachila	Core
YAA085	Structure 6	B	2078	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Assigned
YAA086	Structure 6	B	2079	*Cajete semiesférico*	---	*Café*	Fine	Rim	6.94	30	Simple	NW Valle Grande	Assigned
YAA087	Structure 6	B	2084	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA088	Structure 6	B	2084	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi High REE	Core
YAA089	Structure 6	B	2084	*Indeterminado*	---	*Gris*	Fine	Rim				MA-EVG	Assigned

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA090	Structure 6	B	2084	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA091	Structure 6	B	2084	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Assigned
YAA092	Structure 6	B	2084	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi High REE	Assigned
YAA093	Structure 6	B	2096	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Atoyac/Zaachila	Assigned
YAA094	Structure 6	B	2110	*Cajete cónico*	G35	*Gris*	Fine	Rim				Atoyac/Zaachila	Core
YAA095	Structure 6	B	2110	*Indeterminado*	---	*Café*	Coarse	Base				Trapiche Cremosa	Core
YAA096	Structure 6	B	2111	*Formative*	---	*Gris*	Fine	Rim					Formative
YAA097	Structure 6	B	2113	*Cajete cónico*	G35	*Gris*	Fine	Rim				Atoyac/Zaachila	Core
YAA098	Structure 6	B	2113	*Indeterminado*	---	*Café*	Coarse	Rim				High Fe Cremosa	Core
YAA099	Structure 6	B	2141	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA100	Structure 6	B	2141	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.05	25	Simple	Atoyac/Zaachila	Core
YAA101	Structure 6	B	2141	*Cajete cónico*	G35	*Gris*	Coarse	Rim	8.46	25	Wiped	Atoyac/Zaachila	Core
YAA102	Structure 6	B	2141	*Indeterminado*	---	*Café*	Coarse	Rim				High Fe Cremosa	Core
YAA104	Structure 6	B	2156	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.32	17	Simple	Yaasuchi High REE	Core
YAA105	Structure 6	B	2156	*Olla*	---	*Gris*	Fine	Rim				Atoyac/Zaachila	Core
YAA106	Structure 6	B	2156	*Indeterminado*	---	*Café*	Coarse	Neck				NW Valle Grande	Assigned
YAA107	Structure 6	B	2161	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.47	20	Wiped	Atoyac/Zaachila	Core
YAA108	Structure 6	B	2161	*Olla*	---	*Café*	Coarse	Rim				High Fe Cremosa	Noncore
YAA109	Structure 6	B	2173	*Silueta compuesta*	---	*Gris*	Coarse	Body				Yaasuchi High REE	Core
YAA110	Structure 6	B	2173	*Cajete cónico*	G35	*Gris*	Coarse	Rim	8.96	40	Simple	Atoyac/Zaachila	Core
YAA111	Structure 6	B	2173	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA112	Structure 6	B	2173	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.72	22	Wiped	Atoyac/Zaachila	Core
YAA113	Structure 6	B	2173	*Olla*	---	*Café*	Coarse	Rim	12.22	32		Yaasuchi	Assigned
YAA114	Structure 6	B	2173	*Olla*	---	*Café*	Coarse	Neck				High Fe Cremosa	Core
YAA115	Structure 6	B	2173	*Cajete cónico*	K14	*Café*	Coarse	Rim	12.04	44	Wiped	Atoyac/Zaachila	Assigned

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA116	Structure 6	B	2173	*Indeterminado*	---	*Café*	Coarse	Base				Atoyac/Zaachila	Core
YAA117	Structure 6	B	2173	*Olla*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Core
YAA118	Structure 6	B	2173	*Olla*	---	*Café*	Coarse	Base				Atoyac/Zaachila	Core
YAA119	Structure 6	B	2180	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.54	23	Simple	Atoyac/Zaachila	Assigned
YAA120	Structure 6	B	2180	*Cajete cónico*	---	*Gris*	Fine	Base				Yaasuchi High REE	Core
YAA121	Structure 6	B	2180	*Olla*	---	*Café*	Coarse	Rim	12.6	46		Atoyac/Zaachila	Noncore
YAA122	Structure 6	B	2180	*Indeterminado*	---	*Café*	Fine	Rim				Yaasuchi	Noncore
YAA123	Structure 6	B	2180	*Cajete cónico*	K14	*Café*	Coarse	Base				High Fe Cremosa	Core
YAA124	Structure 6	B	2186	*Cajete cónico*	G35	*Gris*	Fine	Rim	5.76	23	Simple	MA-EVG	Core
YAA125	Structure 6	B	2186	*Formative*	---	*Café*	Fine	Body					Formative
YAA126	Structure 6	B	2186	*Cajete cónico*	K14	*Café*	Coarse	Base				High Fe Cremosa	Assigned
YAA127	Structure 6	B	2194	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.92	26	Wiped	Yaasuchi	Noncore
YAA128	Structure 6	B	2194	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.96	25	Wiped	Atoyac/Zaachila	Core
YAA129	Structure 6	B	2194	*Cajete cónico*	G35	*Gris*	Coarse	Rim	9.06	48	Simple	NW Valle Grande	Core
YAA130	Structure 6	B	2194	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.9	25	Wiped	Yaasuchi High REE	Core
YAA131	Structure 6	B	2194	*Cajete cónico*	---	*Café*	Coarse	Base				Yaasuchi	Core
YAA132	Structure 6	B	2194	*Olla*	---	*Café*	Coarse	Rim	10.09	28		Yaasuchi	Core
YAA133	Structure 6	B	2194	*Indeterminado*	---	*Café*	Coarse	Body	9.59	15		Yaasuchi	Core
YAA134	Structure 6	B	2194	*Indeterminado*	---	*Café*	Coarse	Rim	10.01	24		NW Valle Grande	Core
YAA135	Structure 6	B	2194	*Olla*	---	*Café*	Coarse	Rim	7.22	18		Yaasuchi	Noncore
YAA136	Structure 6	B	2194	*Cajete cónico*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Core
YAA137	Structure 6	B	2197	*Formative*	---	*Gris*	Fine	Rim					Formative
YAA138	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.98	39	Simple	Yaasuchi	Core
YAA139	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.15	22	Wiped	Atoyac/Zaachila	Core
YAA140	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.32	29	Wiped	Atoyac/Zaachila	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA141	Structure 6	B	2197	*Cajete cónico*	---	*Gris*	Fine	Body/base				Atoyac/Zaachila	Assigned
YAA142	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.57	26	Wiped	Atoyac/Zaachila	Core
YAA143	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.21	25	Simple	Yaasuchi High REE	Core
YAA144	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA145	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA146	Structure 6	B	2197	*Indeterminado*	---	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA147	Structure 6	B	2197	*Cajete cónico*	G35	*Gris*	Fine	Rim	10.93	29	Simple	Atoyac/Zaachila	Core
YAA148	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Fine	Base				Yaasuchi	Assigned
YAA149	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Rim				Yaasuchi	Core
YAA150	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Rim	10.84	30	Wiped	Atoyac/Zaachila	Noncore
YAA151	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Body/base				Atoyac/Zaachila	Core
YAA152	Structure 6	B	2197	*Indeterminado*	---	*Café*	Coarse	Rim	10.26	24		High Fe Cremosa	Core
YAA153	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Base				Atoyac/Zaachila	Core
YAA154	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Base				Atoyac/Zaachila	Core
YAA155	Structure 6	B	2197	*Cajete cónico*	K14	*Café*	Coarse	Rim	10.77	20	Simple	Yaasuchi	Core
YAA156	Structure 6	B	2197	*Cajete cónico*	K14?	*Café*	Coarse	Rim				Yaasuchi	Assigned
YAA159	Structure 6	B	2204	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.66	35	Wiped	Atoyac/Zaachila	Core
YAA160	Structure 6	B	2204	*Cajete cónico*	K14	*Café*	Coarse	Rim	9.89	40	Folded	Atoyac/Zaachila	Core
YAA161	Structure 6	B	2204	*Cajete cónico*	K14	*Café*	Fine	Rim	7.92	26		Atoyac/Zaachila	Core
YAA162	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Assigned
YAA163	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.73	23	Simple	Atoyac/Zaachila	Core
YAA164	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Atoyac/Zaachila	Core
YAA165	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.78	34	Simple	Yaasuchi High REE	Core
YAA166	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.42	30	Simple	Outlier	
YAA167	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.32	28	Wiped	Yaasuchi High REE	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA168	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.81	28	Wiped	Atoyac/Zaachila	Core
YAA169	Structure 6	B	2205	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA170	Structure 6	B	2205	*Indeterminado*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Core
YAA171	Structure 6	B	2205	*Cajete cónico*	K14	*Café*	Coarse	Rim				Atoyac/Zaachila	Core
YAA172	Structure 6	B	2205	*Indeterminado*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Noncore
YAA173	Structure 6	B	2205	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA174	Structure 6	B	2205	*Indeterminado*	---	*Café*	Coarse	Rim	10.51	26		High Fe Cremosa	Core
YAA175	Structure 6	B	2221	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.45	28	Wiped	Atoyac/Zaachila	Core
YAA176	Structure 6	B	2221	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.32	22	Wiped	Atoyac/Zaachila	Core
YAA177	Structure 6	B	2221	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.29	35	Wiped	Atoyac/Zaachila	Core
YAA178	Structure 6	B	2221	*Olla*	---	*Café*	Coarse	Rim	18.97	60		Yaasuchi	Assigned
YAA179	Structure 6	B	2221	*Cajete cónico*	K14	*Café*	Fine	Body/base				NW Valle Grande	Core
YAA180	Structure 6	B	2221	*Olla*	---	*Café*	Coarse	Rim	7.94	30		Atoyac/Zaachila	Noncore
YAA181	Structure 6	B	2221	*Olla*	---	*Café*	Coarse	Rim	10.25	34		High Fe Cremosa	Noncore
YAA182	Structure 6	B	2221	*Cajete cónico*	G35	*Café*	Coarse	Base				Atoyac/Zaachila	Core
YAA183	Structure 5B	B	2070	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Assigned
YAA184	Structure 5B	B	2070	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Yaasuchi	Core
YAA185	Structure 5B	B	2070	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA186	Structure 5B	B	2070	*Vaso*	---	*Café*	Coarse	Body/base				Yaasuchi	Core
YAA187	Structure 5B	B	2070	*Cántaro*	---	*Café*	Coarse	Rim	11.27	18		Yaasuchi	Core
YAA192	Structure 5B	B	2170	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Core
YAA193	Structure 5B	B	2170	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.2	30	Simple	MA-EVG	Core
YAA194	Structure 5B	B	2170	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.2	30	Simple	MA-EVG	Core
YAA195	Structure 5B	B	2170	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.72	23	Simple	Atoyac/Zaachila	Core
YAA196	Structure 5B	B	2170	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

INAA ID	Context Information			Sample Description								Group Assignment	
	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA197	Structure 5B	B	2170	*Indeterminado*	---	*Café*	Coarse	Body				Atoyac/Zaachila	Core
YAA198	Structure 5B	B	2170	*Indeterminado*	---	*Café*	Coarse	Body/base				Atoyac/Zaachila	Assigned
YAA202	Structure 5B	B	2176	*Comal*	---	*Café*	Coarse	Rim	11.45	31		Yaasuchi	Core
YAA203	Structure 5B	B	2176	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA204	Structure 5B	B	2182	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.97	29	Simple	Atoyac/Zaachila	Core
YAA205	Structure 5B	B	2182	*Comal*	---	*Café*	Coarse	Rim				Yaasuchi	Noncore
YAA206	Structure 5B	B	2182	*Comal*	---	*Café*	Coarse	Rim				Yaasuchi	Core
YAA207	Structure 5B	B	2216	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.32	21	Simple	Atoyac/Zaachila	Core
YAA208	Structure 5B	B	2216	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.43	30	Simple	Yaasuchi	Core
YAA209	Structure 5B	B	2216	*Olla*	---	*Gris*	Coarse	Rim	12.01	23		Yaasuchi	Assigned
YAA210	Structure 5B	B	2216	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Yaasuchi High REE	Core
YAA211	Structure 5B	B	2216	*Indeterminado*	---	*Café*	Fine	Body/base				Atoyac/Zaachila	Core
YAA212	Structure 5B	B	2216	*Comal*	---	*Café*	Coarse	Rim	8.17			Yaasuchi	Noncore
YAA213	Structure 5B	B	2216	*Olla*	---	*Café*	Coarse	Rim	13.69	44		Yaasuchi	Assigned
YAA214	Structure 5B	B	2216	*Cántaro*	---	*Café*	Coarse	Rim	10.44	20		Yaasuchi	Core
YAA215	Structure 5B	B	2216	*Indeterminado*	---	*Café*	Coarse	Rim				Yaasuchi	Assigned
YAA216	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.56	26	Simple	Atoyac/Zaachila	Core
YAA217	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim				MA-EVG	Core
YAA218	Structure 5B	B	2231	*Chirmolera*	---	*Gris*	Coarse	Rim	10.01	45		Yaasuchi	Core
YAA219	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA220	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.62	18	Simple	Yaasuchi High REE	Core
YAA221	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim				Yaasuchi High REE	Core
YAA222	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	*Soporte hueco*				Yaasuchi	Core
YAA223	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.66	25	Folded	MA-EVG	Core
YAA224	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.65	17	Simple	Yaasuchi High REE	Assigned

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

INAA ID	Context Information			Sample Description								Group Assignment	
	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA225	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.39	24	Simple	Yaasuchi High REE	Core
YAA226	Structure 5B	B	2231	*Indeterminado*	---	*Gris*	Coarse	Body				Yaasuchi	Core
YAA227	Structure 5B	B	2231	*Cajete semiesférico*	G3	*Gris*	Fine	Rim				Atoyac/Zaachila	Core
YAA228	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Noncore
YAA229	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Coarse	Rim				Atoyac/Zaachila	Core
YAA230	Structure 5B	B	2231	*Sahumador*	---	*Gris*	Fine	Base				NW Valle Grande	Assigned
YAA231	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Core
YAA232	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Fine	*Soporte hueco*				Yaasuchi	Core
YAA233	Structure 5B	B	2231	*Cajete cónico*	G35	*Gris*	Coarse	Base				Yaasuchi High REE	Core
YAA234	Structure 5B	B	2231	*Cántaro*	---	*Café*	Fine	Rim	10.26	30		Yaasuchi	Core
YAA235	Structure 5B	B	2231	*Comal*	---	*Café*	Fine	Rim	8.29	34		Outlier	
YAA236	Structure 5B	B	2231	*Comal*	---	*Café*	Coarse	Rim	8.21	34		Atoyac/Zaachila	Noncore
YAA237	Structure 5B	B	2231	*Comal*	---	*Café*	Coarse	Rim	14.1	38		Yaasuchi	Core
YAA238	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	11.37	34		Yaasuchi	Core
YAA239	Structure 5B	B	2231	*Comal*	---	*Café*	Coarse	Rim	8.25	35		Atoyac/Zaachila	Noncore
YAA241	Structure 5B	B	2231	*Indeterminado*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Noncore
YAA242	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	11.57	18		Outlier	
YAA243	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	10.32	22		Atoyac/Zaachila	Core
YAA244	Structure 5B	B	2231	*Indeterminado*	---	*Café*	Coarse	Rim	10.89	26		Outlier	
YAA245	Structure 5B	B	2231	*Cántaro*	---	*Café*	Coarse	Rim	9.18	19		Atoyac/Zaachila	Core
YAA246	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	8.39	31		Yaasuchi	Core
YAA247	Structure 5B	B	2231	*Indeterminado*	---	*Café*	Fine	Rim	7.7	27		Outlier	
YAA248	Structure 5B	B	2231	*Cajete cónico*	K14	*Café*	Fine	*Soporte conico*				Yaasuchi High REE	Core
YAA249	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Body/base				Atoyac/Zaachila	Core
YAA250	Structure 5B	B	2231	*Cajete cónico*	K14	*Café*	Fine	Rim	10.64	26	Simple	Atoyac/Zaachila	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA251	Structure 5B	B	2231	*Indeterminado*	---	*Café*	Coarse	Rim				Atoyac/Zaachila	Noncore
YAA252	Structure 5B	B	2231	*Comal*	---	*Café*	Coarse	Rim	11.59	25		Yaasuchi	Core
YAA253	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	11.48	31		Outlier	
YAA254	Structure 5B	B	2231	*Olla*	---	*Café*	Coarse	Rim	10.11			Yaasuchi	Assigned
YAA255	Structure 5B	B	2233	*Cajete semiesférico*	---	*Gris*	Fine	Rim	6.65	16		MA-EVG	Core
YAA256	Structure 5B	B	2233	*Cántaro*	---	*Gris*	Fine	Rim	8.16	11		MA-EVG	Core
YAA257	Structure 5B	B	2236	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Assigned
YAA258	Structure 5B	B	2238	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.91	19	Simple	Yaasuchi High REE	Core
YAA259	Structure 5B	B	2238	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.23	39	Wiped	Atoyac/Zaachila	Noncore
YAA260	Structure 5B	B	2238	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.57	23	Wiped	Atoyac/Zaachila	Assigned
YAA261	Structure 5B	B	2238	*Olla*	---	*Café*	Coarse	Rim				Outlier	
YAA262	Structure 5B	B	2238	*Olla*	---	*Café*	Coarse	Rim	11.37	31		Yaasuchi	Core
YAA263	Structure 5B	B	2238	*Apaxtle*	K14	*Café*	Coarse	Rim	7.82	64	Wiped	Atoyac/Zaachila	Core
YAA264	Structure 5B	B	2238	*Indeterminado*	---	*Café*	Coarse	Rim	8.27	30		Yaasuchi	Core
YAA265	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.97	36	Wiped	Atoyac/Zaachila	Core
YAA266	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.32	31	Wiped	Atoyac/Zaachila	Core
YAA267	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA268	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi High REE	Core
YAA269	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.04	45	Simple	Yaasuchi	Core
YAA270	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.09	14	Simple	Atoyac/Zaachila	Noncore
YAA271	Structure 5B	B	2241	*Cajete semiesférico*	---	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA272	Structure 5B	B	2241	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi High REE	Core
YAA273	Structure 5B	B	2241	*Comal*	---	*Café*	Coarse	Rim	9.67	37		Yaasuchi	Assigned
YAA274	Structure 5B	B	2241	*Comal*	G35	*Café*	Coarse	Rim	6.71	34	Wiped	Atoyac/Zaachila	Assigned
YAA275	Structure 5B	B	2241	*Olla*	---	*Café*	Coarse	Rim	11.11	37		Yaasuchi	Assigned

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA276	Structure 5B	B	2243	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.72	27	Simple	Yaasuchi High REE	Core
YAA277	Structure 5B	B	2243	*Cajete cónico*	G35	*Gris*	Fine	Rim				Atoyac/Zaachila	Core
YAA278	Structure 5B	B	2243	*Cajete cónico*	G35	*Gris*	Coarse	Rim	7.86	26	Simple	Yaasuchi	Core
YAA279	Structure 5B	B	2243	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.55	25	Simple	Outlier	
YAA280	Structure 5B	B	2243	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.38	25	Simple	Yaasuchi High REE	Core
YAA281	Structure 5B	B	2243	*Cajete cónico*	K14	*Café*	Coarse	Rim	11.79	39	Simple	Yaasuchi	Core
YAA282	Structure 5B	B	2243	*Cajete cónico*	K14	*Café*	Coarse	Rim				Atoyac/Zaachila	Core
YAA283	Structure 5B	B	2243	*Olla*	---	*Café*	Coarse	Rim	17.55	28		Yaasuchi	Core
YAA284	Structure 5B	B	2243	*Cajete cónico*	---	*Café*	Coarse	Rim	13.67	45		Yaasuchi	Core
YAA285	Structure 5B	B	2243	*Cajete cónico*	K14	*Café*	Fine	Body/base				Yaasuchi High REE	Core
YAA286	Structure 5B	B	2243	*Chirmolera*	---	*Café*	Coarse	Body				Yaasuchi	Core
YAA287	Structure 5B	B	2244	*Cajete cónico*	G35	*Gris*	Fine	Body				Yaasuchi High REE	Core
YAA288	Structure 5B	B	2245	*Cajete cónico*	G35	*Gris*	Coarse	Base				Yaasuchi	Core
YAA289	Surface	C	1020	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA290	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA291	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Base				Atoyac/Zaachila	Core
YAA292	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi High REE	Assigned
YAA293	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Base				Yaasuchi	Core
YAA294	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	*Soporte*				Atoyac/Zaachila	Core
YAA295	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA296	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA297	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	11.33	39	Folded	Yaasuchi	Assigned
YAA298	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Yaasuchi High REE	Assigned
YAA299	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Atoyac/Zaachila	Core
YAA300	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	*Soporte*				Atoyac/Zaachila	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

INAA ID	Context Information			Sample Description								Group Assignment	
	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA301	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Rim	9.51	24	Simple	Atoyac/Zaachila	Core
YAA302	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Base				Atoyac/Zaachila	Core
YAA303	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.9	23	Simple	Yaasuchi	Assigned
YAA304	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Rim	7	23	Simple	MA-EVG	Core
YAA305	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	6.66	23	Simple	Yaasuchi High REE	Core
YAA306	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Rim	8.12	22	Simple	Yaasuchi High REE	Assigned
YAA307	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.89	23	Simple	Atoyac/Zaachila	Core
YAA308	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	9.21	22	Simple	Atoyac/Zaachila	Core
YAA309	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Body/base				Yaasuchi	Core
YAA310	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	7.88	25	Simple	Atoyac/Zaachila	Core
YAA311	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Body/base				Atoyac/Zaachila	Assigned
YAA312	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Fine	Rim	8.52	22	Wiped	Yaasuchi	Noncore
YAA313	Surface	C	1021	*Cajete cónico*	G35	*Gris*	Coarse	Rim	7.78	23	Simple	Yaasuchi High REE	Core
YAA314	Surface	C	1022	*Apaxtle*	G35	*Gris*	Coarse	Rim	9.41	60	Simple	Yaasuchi	Noncore
YAA315	Surface	C	1022	*Cajete cónico*	G35	*Gris*	Coarse	*Soporte*				Atoyac/Zaachila	Noncore
YAA316	Surface	C	1022	*Cajete cónico*	G35	*Gris*	Coarse	*Soporte*				Atoyac/Zaachila	Core
YAA317	Surface	C	1022	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA318	Surface	C	1023	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Yaasuchi High REE	Core
YAA319	Surface	C	1045	*Cajete cónico*	G35	*Gris*	Coarse	Body/base				Atoyac/Zaachila	Noncore
YAA320	Surface	C	1045	*Cajete cónico*	G35	*Gris*	Coarse	Soporte				Yaasuchi	Assigned
YAA321	Surface	C	1045	*Cajete cónico*	G35	*Gris*	Coarse	Body/base				Atoyac/Zaachila	Core
YAA322	Surface	C	1045	*Cajete cónico*	G35	*Gris*	Coarse	Rim	8.53	22	Simple	Atoyac/Zaachila	Core
YAA323	Surface	C	1045	*Cajete cónico*	G35	*Gris*	Coarse	Rim	7.09	26	Wiped	Atoyac/Zaachila	Core
YAA324	Surface	C	1046	*Cajete cónico*	G35	*Gris*	Coarse	Rim	6.68	12	Simple	Atoyac/Zaachila	Noncore
YAA325	Surface	C	1046	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Atoyac/Zaachila	Core

Table A.1: Yaasuchi Ceramic Sample Descriptions (Continued)

	Context Information			Sample Description								Group Assignment	
INAA ID	Context	Site Area	Lot No.	Vessel Form	CBA Type	Paste Type	Paste Texture	Description	Rim Thickness (mm)	Rim Diameter (cm)	Rim Treatment	Compositional Group	Group Status
YAA326	Surface	C	1046	*Cajete cónico*	G35	*Gris*	Fine	Rim				Yaasuchi	Assigned
YAA327	Surface	D	1024	*Cajete cónico*	G35	*Gris*	Coarse	Rim	8.14	21	Simple	Yaasuchi	Core
YAA328	Surface	D	1025	*Cajete cónico*	G35	*Gris*	Fine	Body/base				Yaasuchi	Core
YAA329	Surface	D	1025	*Cajete cónico*	G35	*Gris*	Coarse	Rim	9.08	10	Simple	Atoyac/Zaachila	Core
YAA330	Surface	D	1025	*Cajete cónico*	G35	*Gris*	Fine	*Soporte*				Atoyac/Zaachila	Noncore
YAA331	Clay	B	2111	[illegible]	---	---		Tierra quemada				Yaasuchi	Assigned

Table A.2: Yaasuchi Clay Survey Sample Descriptions. Texture determined using the hydrometer method (Bouyoucos 1962).

	Sample Location					Color		Organic Matter	Texture			
INAA ID	UTM Zone	Northing	Easting	Elevation (m)	Depth (cm)	Pre-firing	Post-firing	% Loss on Ignition	% Sand	% Silt	% Clay	USDA Class
YCS283	14T	1870508	734183	1580	40 - 60	7.5 YR 4/6	2.5 YR 4/8	4.7	42.3	12.8	44.9	Clay
YCS288A	14T	1870511	734213	1585	0 - 30	7.5 YR 4/6	2.5 YR 4/8	3.5	35.8	6.4	57.8	Clay
YCS289	14T	1871445	732709	1610	35	7.5 YR 5/6	2.5 YR 4/6	5.7	32.6	12.8	54.5	Clay
YCS290	14T	1871027	733851	1579	20 - 35	7.5 YR 5/6	2.5 YR 4/8	8.8	16.5	22.5	61.0	Clay
YCS294A	14T	1870314	733854	1555	15 - 30	10 YR 3/3	5 YR 4/4	7.1	13.3	19.3	67.5	Clay
YCS294B	14T	1870314	733854	1555	30 - 45	10 YR 4/2	5 YR 4/4	5.8	29.4	16.0	54.5	Clay
YCS294C	14T	1870314	733854	1555	45 - 60	10 YR 4/2	5 YR 4/4	5.6	16.5	16.1	67.4	Clay
YCS308A	14T	1870350	733802	1561	15 - 45	10 YR 3/2	5 YR 4/6	7.1	3.8	32.1	64.2	Clay
YCS308B	14T	1870350	733802	1561	45 - 75	10 YR 3/3	5 YR 4/4	18.2	3.7	25.7	70.6	Clay
YCS309A	14T	1870336	733816	1562	15 - 30	10 YR 3/2	5 YR 4/6	6.2	10.2	19.2	70.6	Clay
YCS309B	14T	1870336	733816	1562	60 - 75	10 YR 4/2	5 YR 4/6	6.2	0.5	19.3	80.2	Clay
YCS310A	14T	1870406	733785	1562	15 - 30	10 YR 3/3	5 YR 4/6	3.8	42.3	16.0	41.7	Clay
YCS310B	14T	1870406	733785	1562	45 - 75	10 YR 4/2	5 YR 4/6	12.2	10.1	25.7	64.2	Clay
YCS320	14T	1870265	733719	1562	60 - 75	10 YR 3/1	5 YR 4/6	22.6	0.6	19.2	80.2	Clay
YCS321	14T	1870238	733731	1566	45 - 75	10 YR 6/8	2.5 YR 4/8	8.5	16.6	16.0	67.4	Clay
YCS334	14T	1870256	733724	1564	15 - 45	2.5 YR 5/6	5 YR 5/8	5.6	32.6	22.5	44.9	Clay
YCS336A	14T	1870292	733775	1563	0 - 25	10 YR 3/1	5 YR 4/6	9.7	6.9	22.5	70.7	Clay
YCS336B	14T	1870292	733775	1563	30 - 60	10 YR 3/1	5 YR 4/4	2.6	29.4	12.8	57.8	Clay
YCS337A	14T	1870291	733757	1564	0 - 30	10 YR 3/1	5 YR 4/6	10.1	10.1	12.8	77.1	Clay
YCS337B	14T	1870291	733757	1564	30 - 45	7.5 YR 3/0	5 YR 4.6	5.0	10.1	16.0	73.8	Clay
YCS337C	14T	1870291	733757	1564	45 - 75	10 YR 3/1	5 YR 4/6	5.8	23.0	16.0	60.9	Clay
YCS338	14T	1870288	733740	1565	0 - 15	10 YR 3/1	5 YR 4/6	6.3	23.0	16.0	61.0	Clay
YCS342	14T	1870273	733758	1569	15 - 40	10 YR 3/2	5 YR 4/6	5.7	19.8	19.3	61.0	Clay
YCS344	14T	1870287	733776	1570	0 - 30	10 YR 3/1	5 YR 4/6	3.3	29.4	16.0	54.5	Clay
YCS346	14T	1870282	733752	1565	15 - 30	10 YR 3/1	5 YR 4/6	9.7	16.5	16.0	67.4	Clay
YCS348A	14T	1871689	733057	1607	50 - 100	7.5 YR 5/4	2.5 YR 3/6	3.3	13.3	19.3	67.4	Clay
YCS348B	14T	1871689	733057	1607	250 - 265	10 YR 5/6	2.5 YR 3/6	9.4	7.0	28.9	64.2	Clay

APPENDIX B:

INAA Compositional Data

Table B.1: INAA Compositional Data for Yaasuchi Ceramics. Negative values are below minimum detection limits.

INAA ID	YAA013		YAA014		YAA015		YAA016		YAA017		YAA018		YAA019		YAA020	
Batch No.	RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06	
	□□□	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89203	573	93029	595	89036	619	89753	577	103413	651	132749	715	125841	720	93538	602
Ca	19521	1241	16551	1052	18798	1628	19640	1320	11002	927	19606	1653	20700	1479	19039	1224
Na	15457	311	15015	304	11611	241	15240	307	9290	197	26765	525	33672	657	14800	301
K	17035	2215	19946	2222	24160	2829	17697	1811	23979	2758	14359	1833	11201	1525	18081	2348
Fe	61197	796	67233	870	68440	868	63862	829	84623	1064	22329	320	20950	305	72393	916
Ti	5071	436	5197	430	5352	478	4934	435	4347	453	4882	369	5735	413	5720	458
Sc	22.00	0.37	24.06	0.40	24.22	0.40	22.86	0.38	27.99	0.47	3.47	0.06	4.40	0.08	25.55	0.43
V	130.42	13.52	149.49	15.36	122.79	12.83	128.21	13.09	196.71	19.87	39.83	5.50	52.29	7.12	149.72	15.41
Cr	72.86	2.89	79.44	3.39	64.38	3.06	75.67	3.10	101.23	3.40	13.25	1.05	19.18	1.60	84.48	3.24
Mn	993	31	1018	32	1643	51	934	29	1765	55	140	5	161	5	1225	38
Co	20.86	0.36	22.21	0.38	24.51	0.41	21.49	0.37	34.99	0.56	4.40	0.11	5.77	0.14	25.89	0.43
Zn	130.93	7.89	142.81	7.98	140.10	7.96	136.60	7.64	159.83	8.97	35.68	3.52	31.60	3.37	174.80	8.89
As	11.76	0.48	12.15	0.48	4.35	0.42	12.58	0.59	14.24	0.54	0.36	0.25	1.71	0.40	10.37	0.54
Rb	41.52	6.78	50.14	7.42	77.77	8.82	57.62	9.25	76.65	9.29	16.23	4.38	13.74	4.10	44.14	7.33
Cs	2.26	0.28	1.84	0.23	0.45	0.22	2.12	0.24	3.00	0.30	0.10	0.09	-0.27	0.01	2.09	0.25
Ba	890.40	90.87	918.22	92.97	1206.77	101.45	950.91	90.39	901.98	89.38	992.38	84.80	904.18	80.95	965.53	91.27
La	39.09	0.32	41.31	0.34	90.38	0.63	40.47	0.34	54.98	0.42	10.40	0.16	17.25	0.22	46.33	0.38
Ce	87.47	1.40	89.90	1.45	194.38	2.33	84.89	1.48	110.44	1.67	22.47	0.67	36.82	0.78	100.33	1.58
Sm	9.06	0.07	9.41	0.07	17.07	0.12	9.03	0.07	11.18	0.08	2.25	0.03	3.29	0.03	10.21	0.08
Eu	2.50	0.06	2.53	0.06	3.77	0.08	2.42	0.06	2.55	0.07	1.54	0.04	2.03	0.05	2.85	0.07
Tb	1.16	0.19	1.85	0.23	2.68	0.26	1.63	0.21	2.01	0.23	0.48	0.09	0.39	0.10	1.51	0.20
Dy	7.95	0.75	7.55	0.67	15.02	0.85	8.24	0.65	11.28	0.89	-1.05	0.03	2.66	0.56	7.65	0.64
Yb	3.78	0.19	3.90	0.19	7.21	0.22	4.02	0.15	6.32	0.21	0.47	0.08	0.69	0.10	4.65	0.18
Lu	0.51	0.02	0.51	0.03	0.89	0.03	0.50	0.02	0.77	0.03	0.07	0.01	0.08	0.01	0.56	0.03
Hf	5.70	0.30	5.24	0.26	8.15	0.34	5.83	0.31	3.89	0.26	3.94	0.17	2.77	0.15	7.32	0.32
Ta	0.48	0.07	0.49	0.08	0.66	0.08	0.48	0.07	0.49	0.08	0.31	0.05	0.26	0.05	0.75	0.08
Th	3.34	0.18	3.26	0.18	6.46	0.20	3.04	0.18	5.15	0.20	0.35	0.07	0.54	0.08	4.27	0.20

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA021		YAA022		YAA023		YAA024		YAA025		YAA026		YAA027		YAA028	
Batch No.	RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	88420	571	89012	578	94110	584	93292	625	87886	577	89839	605	84991	567	89766	643
Ca	42806	1904	21064	1187	18602	1253	20081	1315	20490	1312	22055	1375	25791	1443	19976	1308
Na	8659	181	12274	251	14193	287	14353	293	12269	251	11824	244	16648	334	14636	299
K	26562	2599	17530	2104	20760	2073	24923	2727	21613	2343	22240	2372	22778	2170	15634	2634
Fe	46871	624	70381	907	64810	842	66321	846	67530	874	70849	914	52729	698	113741	1436
Ti	5380	393	4358	437	5885	459	6007	585	5326	478	4515	464	6206	481	3382	438
Sc	18.19	0.30	23.78	0.40	21.42	0.36	23.02	0.38	22.84	0.38	23.96	0.40	18.52	0.31	47.59	0.79
V	156.51	15.81	147.49	14.91	150.84	15.36	154.95	15.88	136.38	13.93	143.20	14.67	111.17	11.55	95.81	10.96
Cr	81.69	2.79	84.12	3.05	82.85	3.06	95.95	3.48	79.75	3.24	67.74	2.89	66.37	2.69	66.52	3.51
Mn	665	21	1033	32	724	22	1598	49	1094	34	1360	42	1023	32	2146	66
Co	15.02	0.27	24.38	0.41	21.66	0.37	25.34	0.43	24.97	0.41	28.40	0.47	20.35	0.35	31.27	0.52
Zn	121.95	6.97	170.29	8.63	135.83	7.50	149.23	8.26	156.49	8.20	146.11	8.10	128.42	7.45	235.37	11.77
As	6.75	0.45	12.14	0.59	10.82	0.65	10.39	0.60	13.34	0.68	7.38	0.62	5.19	0.62	3.78	0.76
Rb	109.94	8.72	51.23	7.92	43.62	7.70	49.99	7.25	64.96	10.52	58.24	8.00	58.78	7.14	28.07	6.78
Cs	7.03	0.30	3.06	0.25	1.63	0.27	3.18	0.29	2.79	0.26	1.27	0.23	2.43	0.24	-0.74	0.02
Ba	787.30	78.37	1245.26	95.78	1038.40	86.60	1021.87	85.14	1252.12	94.42	1271.81	101.09	1118.02	84.10	1020.85	100.09
La	40.97	0.33	41.85	0.35	37.74	0.32	44.15	0.37	41.18	0.35	61.63	0.46	44.13	0.35	64.98	0.49
Ce	86.59	1.37	86.80	1.43	81.90	1.40	93.35	1.51	85.15	1.40	128.38	1.75	91.61	1.47	146.87	2.11
Sm	8.26	0.06	9.21	0.07	8.42	0.06	9.77	0.07	9.26	0.07	12.48	0.09	9.47	0.07	16.26	0.12
Eu	1.98	0.06	2.53	0.06	2.30	0.06	2.59	0.07	2.43	0.07	3.03	0.07	2.29	0.06	4.61	0.10
Tb	1.28	0.18	1.41	0.20	1.45	0.19	1.10	0.19	1.10	0.19	2.12	0.23	1.63	0.20	2.05	0.26
Dy	5.87	0.55	8.11	0.62	6.25	0.53	8.90	0.73	6.86	0.63	9.58	0.75	7.71	0.68	11.68	0.91
Yb	3.79	0.17	3.90	0.13	3.67	0.17	4.34	0.18	3.81	0.16	6.63	0.22	3.84	0.12	5.71	0.22
Lu	0.48	0.02	0.47	0.02	0.46	0.02	0.49	0.02	0.54	0.02	0.83	0.03	0.51	0.02	0.70	0.03
Hf	6.67	0.29	4.85	0.27	6.50	0.31	7.38	0.34	4.76	0.25	5.04	0.28	8.30	0.33	7.31	0.41
Ta	0.92	0.07	0.56	0.08	0.56	0.07	0.70	0.07	0.59	0.08	0.39	0.06	0.48	0.06	0.36	0.07
Th	8.20	0.21	3.60	0.18	3.29	0.18	3.81	0.19	3.21	0.18	4.19	0.19	6.40	0.21	2.70	0.22

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA029		YAA030		YAA031		YAA032		YAA033		YAA034		YAA035		YAA036	
Batch No.	RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06		RC1983-05/06	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	86910	600	94502	600	93476	630	90317	602	91013	586	90648	588	84877	567	119517	684
Ca	19225	1363	21110	1314	17949	1319	20328	1297	21332	1442	19266	1174	18518	1129	25096	1491
Na	17498	352	16456	331	12687	263	15375	311	15548	313	13050	265	17077	342	22474	444
K	19540	2356	16125	2578	16897	2688	16461	2318	17362	2003	16831	2111	21796	2225	4959	1271
Fe	92573	1160	66308	860	77825	1000	66712	866	65533	852	74106	938	73868	951	30382	422
Ti	5366	503	6041	493	5354	552	4993	453	5107	392	6555	438	2592	395	7817	476
Sc	36.82	0.61	21.92	0.37	28.20	0.47	21.93	0.37	23.18	0.39	25.22	0.42	27.76	0.46	6.42	0.11
V	106.35	11.37	139.45	14.32	149.72	15.34	129.48	13.39	125.18	12.93	121.09	12.58	98.60	10.55	64.30	7.45
Cr	52.14	3.28	78.11	2.88	72.14	3.17	77.94	2.97	73.75	2.97	63.31	2.85	45.30	2.63	17.05	1.38
Mn	1818	56	1278	40	1761	54	1357	42	887	28	836	26	1082	34	398	12
Co	25.71	0.43	25.91	0.43	30.40	0.49	24.75	0.41	22.09	0.38	24.62	0.41	23.84	0.40	9.08	0.19
Zn	245.32	11.74	130.24	7.53	174.33	9.26	141.84	7.77	157.60	8.20	171.28	8.98	201.86	10.66	41.99	4.54
As	5.18	0.83	10.66	0.85	9.74	0.92	11.82	0.83	9.19	0.94	3.93	0.80	4.67	0.97	3.22	0.66
Rb	22.91	6.96	51.77	7.60	51.72	8.81	64.15	9.72	49.60	8.05	52.23	8.96	39.69	7.25	23.01	5.08
Cs	-0.65	0.02	2.56	0.25	2.41	0.26	2.94	0.28	2.60	0.33	0.57	0.20	-0.57	0.01	0.74	0.14
Ba	1351.67	115.10	1007.37	84.15	1100.31	93.97	1114.85	83.26	1095.55	87.01	1391.17	103.08	1627.54	115.62	1488.54	91.80
La	57.62	0.45	44.37	0.36	55.31	0.46	43.50	0.38	44.23	0.39	75.84	0.59	57.42	0.48	31.49	0.30
Ce	125.08	1.96	89.19	1.48	113.44	1.71	90.25	1.48	90.37	1.57	155.59	1.95	113.33	1.65	64.07	1.25
Sm	14.01	0.11	9.62	0.07	12.20	0.09	9.52	0.07	10.22	0.08	15.49	0.12	12.32	0.09	6.00	0.05
Eu	4.13	0.09	2.42	0.06	3.02	0.07	2.54	0.06	2.56	0.07	3.60	0.08	3.61	0.08	2.49	0.06
Tb	2.11	0.26	1.35	0.19	1.87	0.24	1.22	0.19	1.39	0.22	2.08	0.23	1.59	0.22	0.83	0.11
Dy	10.70	0.85	7.72	0.68	9.34	0.82	5.94	0.74	7.29	0.60	11.90	0.68	8.34	0.78	3.37	0.50
Yb	5.26	0.22	4.28	0.17	5.23	0.19	4.22	0.16	4.54	0.18	6.48	0.17	4.23	0.19	1.44	0.10
Lu	0.63	0.03	0.52	0.02	0.67	0.02	0.53	0.02	0.55	0.02	0.81	0.03	0.48	0.02	0.20	0.01
Hf	13.08	0.49	6.02	0.29	8.37	0.39	4.51	0.26	7.03	0.31	8.36	0.35	5.94	0.32	11.08	0.38
Ta	0.49	0.08	0.54	0.07	0.61	0.08	0.54	0.08	0.52	0.09	0.73	0.08	0.28	0.06	0.43	0.06
Th	1.88	0.20	3.42	0.20	3.89	0.21	3.40	0.19	3.69	0.20	13.48	0.27	5.12	0.24	1.23	0.12

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA037		YAA038		YAA039		YAA040		YAA041		YAA042		YAA043		YAA044	
Batch No.	RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	94746	608	86842	578	88353	612	95431	630	89049	570	91524	597	87723	555	84039	539
Ca	21686	1404	19895	1554	21595	1620	18418	1282	20644	1437	21239	1504	33545	2037	50233	2282
Na	12749	263	19732	396	15924	326	18914	380	18786	378	13106	270	6272	138	8793	185
K	23948	2324	21933	2090	22058	2783	21285	2479	21244	2179	25252	2677	22011	1803	25355	2269
Fe	71812	922	50325	662	60278	779	51902	679	50934	657	72437	915	44343	593	43452	580
Ti	4119	421	5221	405	5383	539	5310	422	5908	454	5178	473	4435	378	5758	427
Sc	23.62	0.39	16.71	0.28	19.54	0.33	16.88	0.28	17.11	0.29	25.27	0.42	17.95	0.30	17.74	0.30
V	144.65	14.72	124.04	13.01	122.12	12.74	129.34	13.39	116.73	12.07	123.16	12.96	163.82	16.47	167.49	16.77
Cr	68.51	2.72	68.73	2.51	78.99	2.77	66.24	2.52	67.76	2.53	57.76	2.55	85.73	2.77	92.24	2.84
Mn	1128	35	794	25	2062	64	772	24	770	24	1368	42	604	19	606	19
Co	31.19	0.50	18.31	0.32	24.08	0.40	19.04	0.33	18.03	0.32	25.09	0.42	13.94	0.26	13.56	0.25
Zn	124.83	7.53	103.48	6.32	126.58	6.97	113.16	6.49	123.54	6.57	171.01	9.40	133.92	6.86	136.99	6.89
As	3.51	0.40	7.36	0.43	9.33	0.44	8.46	0.46	8.26	0.47	3.24	0.46	4.96	0.41	6.25	0.50
Rb	71.72	8.44	54.99	6.26	55.56	6.48	59.64	6.78	42.83	6.43	88.55	8.61	105.36	8.06	98.14	7.24
Cs	0.74	0.23	2.87	0.25	3.60	0.29	2.75	0.25	2.91	0.27	0.62	0.20	6.91	0.34	6.87	0.34
Ba	1310.12	103.65	1003.80	85.38	1007.72	80.97	896.42	81.56	976.85	85.14	1236.25	95.37	753.90	68.17	649.37	65.61
La	71.42	0.53	30.68	0.27	34.87	0.30	31.69	0.28	31.65	0.28	91.30	0.66	36.33	0.30	35.48	0.30
Ce	152.00	1.84	66.12	1.16	75.64	1.27	64.55	1.17	64.38	1.22	204.57	2.33	74.08	1.24	73.85	1.24
Sm	13.18	0.10	5.93	0.05	7.50	0.06	6.25	0.05	6.66	0.05	18.23	0.13	7.22	0.06	7.06	0.05
Eu	3.23	0.08	1.93	0.05	2.16	0.06	1.91	0.05	1.87	0.05	3.92	0.09	1.58	0.05	1.60	0.05
Tb	2.02	0.19	0.85	0.13	1.34	0.17	1.12	0.16	0.91	0.14	2.45	0.21	0.98	0.13	1.20	0.14
Dy	10.84	0.60	4.92	0.54	6.22	0.74	6.74	0.83	5.25	0.51	13.52	0.78	4.69	0.52	6.60	0.53
Yb	5.90	0.19	2.46	0.12	3.11	0.15	2.65	0.14	2.85	0.15	7.46	0.23	3.32	0.14	3.70	0.12
Lu	0.74	0.03	0.29	0.02	0.40	0.02	0.33	0.02	0.31	0.02	0.93	0.03	0.42	0.02	0.51	0.02
Hf	7.01	0.31	6.25	0.27	5.55	0.25	5.83	0.26	5.56	0.26	7.61	0.31	5.66	0.27	5.49	0.24
Ta	0.40	0.07	0.39	0.06	0.41	0.06	0.44	0.06	0.53	0.07	0.59	0.07	0.78	0.07	0.80	0.07
Th	5.35	0.21	2.68	0.16	5.81	0.19	2.59	0.16	2.72	0.15	5.95	0.20	9.57	0.23	8.98	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA045		YAA046		YAA047		YAA048		YAA049		YAA050		YAA051		YAA052	
Batch No.	RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	92044	598	117150	666	124980	707	91314	581	81990	552	127087	718	88800	589	86471	566
Ca	20220	1420	23782	1671	22362	1686	21862	1427	19287	1259	18937	1369	21811	1386	22741	1518
Na	13153	270	31026	612	33919	667	14926	304	11956	247	27858	552	15604	318	16360	332
K	23426	2146	16152	1698	16362	1794	25135	2396	22782	2474	13857	1871	17902	2328	19707	1926
Fe	67480	873	20666	299	23603	332	69615	898	76988	985	30544	418	69713	884	59252	772
Ti	4644	429	5391	437	5650	433	6473	482	11101	640	4932	441	4788	452	4861	491
Sc	22.55	0.38	4.39	0.08	3.99	0.07	22.41	0.37	21.79	0.36	5.69	0.10	24.95	0.42	20.03	0.33
V	130.95	13.46	50.89	6.78	53.85	6.93	141.98	14.67	165.72	16.69	43.75	6.20	133.67	13.73	136.54	14.03
Cr	61.38	2.87	22.47	1.33	15.14	1.15	63.29	2.80	69.32	2.83	13.24	1.34	76.35	3.07	70.62	2.55
Mn	1056	33	204	7	184	6	1033	32	1158	36	465	15	1142	35	1090	34
Co	29.18	0.47	7.67	0.17	5.57	0.13	26.72	0.44	26.30	0.43	17.91	0.31	24.22	0.40	21.93	0.37
Zn	116.41	7.18	31.69	3.37	31.62	4.29	124.90	7.74	128.59	7.32	57.06	4.40	153.93	8.02	136.62	7.63
As	2.82	0.44	1.26	0.38	0.87	0.35	3.80	0.54	2.67	0.60	2.35	0.44	7.00	0.66	10.92	0.72
Rb	68.63	8.10	14.82	3.59	7.41	3.80	62.22	7.54	64.80	8.06	13.99	3.59	48.55	7.10	57.94	6.68
Cs	0.90	0.25	0.79	0.14	0.89	0.16	0.68	0.21	0.66	0.22	0.36	0.13	2.23	0.31	2.95	0.28
Ba	1477.84	104.73	1061.88	80.19	1007.51	75.93	1452.97	105.51	1603.00	106.80	1184.39	77.75	949.95	76.81	1273.83	88.67
La	71.65	0.54	15.75	0.20	20.78	0.23	70.23	0.51	68.22	0.53	22.81	0.24	43.02	0.37	38.71	0.34
Ce	151.39	1.82	37.20	0.76	43.72	0.85	148.37	1.82	135.56	1.74	58.16	0.98	92.05	1.46	82.30	1.35
Sm	13.14	0.10	3.30	0.03	4.48	0.04	13.39	0.10	13.22	0.10	5.22	0.04	9.57	0.07	8.33	0.07
Eu	3.34	0.08	1.90	0.05	2.48	0.06	3.33	0.08	2.95	0.07	2.40	0.06	2.66	0.07	2.25	0.06
Tb	1.93	0.18	0.42	0.08	0.55	0.08	1.92	0.18	1.73	0.18	0.66	0.09	1.47	0.18	1.03	0.15
Dy	10.31	0.62	2.65	0.49	3.01	0.48	9.82	0.65	9.43	0.66	2.83	0.50	7.90	0.61	6.12	0.59
Yb	6.08	0.19	0.92	0.10	0.70	0.08	5.78	0.19	5.48	0.15	1.49	0.10	3.78	0.15	3.70	0.16
Lu	0.78	0.03	0.07	0.01	0.09	0.01	0.75	0.03	0.72	0.03	0.20	0.01	0.51	0.02	0.46	0.02
Hf	5.87	0.28	3.66	0.16	1.70	0.11	7.05	0.31	9.68	0.38	23.62	0.74	5.63	0.27	3.85	0.23
Ta	0.44	0.07	0.27	0.04	0.35	0.06	0.68	0.08	1.24	0.09	0.23	0.04	0.44	0.06	0.53	0.07
Th	3.99	0.18	0.71	0.08	0.37	0.07	4.64	0.19	4.82	0.19	0.57	0.11	2.87	0.17	3.58	0.16

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA053		YAA054		YAA055		YAA056		YAA057		YAA058		YAA059		YAA060	
Batch No.	RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08		RC1983-07/08	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89747	591	92163	607	88342	578	93319	587	87610	583	91960	583	87657	578	87868	582
Ca	20830	1388	19921	1421	22717	1494	22848	1517	22052	1450	18398	1209	19450	1259	20434	1448
Na	16177	328	14559	299	17033	345	14744	301	10450	221	11448	237	9056	193	18369	370
K	19269	2126	19187	2324	17738	2285	21191	2326	29199	3213	20637	2074	21213	2416	21436	1951
Fe	59720	779	66689	849	58512	749	70455	909	68612	871	71468	923	73208	943	54516	716
Ti	4173	433	5549	506	4782	426	5292	428	6080	513	6317	550	12233	650	4241	407
Sc	19.91	0.33	22.29	0.37	19.76	0.33	25.35	0.42	24.45	0.41	24.03	0.40	20.68	0.34	18.16	0.30
V	125.15	13.02	154.12	15.86	133.45	13.74	138.28	14.16	128.91	13.43	152.70	15.56	185.15	18.70	107.71	11.73
Cr	68.35	2.74	84.02	3.02	70.90	2.68	82.17	3.23	58.43	2.76	83.39	3.20	63.65	2.62	65.66	2.89
Mn	1257	39	1300	40	1150	36	1131	35	1646	51	1123	35	1363	42	764	24
Co	23.93	0.40	24.89	0.42	21.93	0.37	23.80	0.40	24.42	0.41	25.49	0.42	35.34	0.56	19.95	0.34
Zn	112.22	6.68	136.10	7.48	141.55	7.63	169.54	8.56	149.83	8.01	166.26	8.37	105.33	6.93	125.42	6.78
As	11.19	0.83	11.12	0.78	8.56	0.83	10.61	0.91	4.85	0.89	13.05	1.16	3.41	0.85	10.22	1.09
Rb	75.66	8.60	61.83	7.66	60.69	7.80	61.17	8.26	76.98	8.31	72.43	9.28	69.51	8.10	45.30	6.36
Cs	3.18	0.30	3.76	0.30	3.02	0.29	3.40	0.27	0.87	0.23	3.84	0.30	0.83	0.22	2.68	0.28
Ba	1246.39	94.43	1037.73	79.81	1196.54	87.65	922.99	77.65	1431.28	105.65	1243.92	89.55	1510.95	100.94	1099.28	77.50
La	43.99	0.38	47.73	0.41	40.42	0.36	43.67	0.39	91.75	0.71	42.47	0.38	67.70	0.55	35.75	0.34
Ce	89.68	1.39	96.45	1.48	83.02	1.37	93.84	1.55	184.69	2.27	86.60	1.39	153.32	1.84	76.39	1.25
Sm	8.88	0.07	9.88	0.08	8.90	0.07	9.96	0.08	18.50	0.14	9.49	0.07	13.70	0.10	7.79	0.07
Eu	2.44	0.06	2.35	0.06	2.21	0.06	2.56	0.07	3.59	0.08	2.44	0.06	2.63	0.07	2.15	0.06
Tb	0.82	0.14	1.28	0.16	1.42	0.16	1.25	0.16	2.30	0.19	1.63	0.20	1.86	0.19	1.18	0.15
Dy	5.42	0.54	7.21	0.77	7.59	0.64	9.44	0.71	12.95	0.77	7.69	0.62	8.13	0.64	5.29	0.51
Yb	3.83	0.15	4.07	0.17	3.54	0.14	4.42	0.16	7.71	0.24	4.45	0.17	4.98	0.15	3.33	0.16
Lu	0.51	0.02	0.54	0.02	0.47	0.02	0.57	0.02	0.95	0.03	0.58	0.03	0.64	0.03	0.43	0.02
Hf	4.94	0.28	7.07	0.31	6.27	0.29	4.84	0.27	8.71	0.35	4.22	0.25	12.02	0.45	4.95	0.23
Ta	0.56	0.07	0.61	0.08	0.46	0.07	0.52	0.08	0.56	0.07	0.55	0.08	1.10	0.08	0.33	0.06
Th	3.22	0.17	5.21	0.21	3.28	0.17	3.51	0.18	6.10	0.21	3.53	0.17	17.21	0.30	2.90	0.17

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA061		YAA062		YAA063		YAA064		YAA065		YAA066		YAA067		YAA068	
Batch No.	RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	84452	562	90168	619	85998	602	85746	597	91894	609	89790	604	92215	602	92461	622
Ca	21698	1244	20539	1408	21967	1163	17622	1163	22242	1222	20240	1344	16856	1309	22941	1333
Na	14725	299	14213	292	13796	283	16782	342	11538	239	15441	313	16000	324	15583	317
K	20856	2001	15561	2310	27859	2589	18940	2752	-3755	164	19323	2310	19052	2712	23438	2294
Fe	39302	531	71545	919	64564	837	54138	711	77359	994	61856	792	67772	877	62033	809
Ti	6200	479	8558	655	9183	628	6053	547	9115	560	5091	448	5796	526	5756	522
Sc	14.66	0.25	23.05	0.38	20.62	0.34	18.18	0.30	26.87	0.45	21.47	0.36	22.66	0.38	20.85	0.35
V	105.05	11.33	148.62	15.16	143.24	14.85	118.86	12.57	194.91	19.64	125.28	12.84	138.27	14.16	139.91	14.46
Cr	67.01	2.49	98.15	3.52	61.00	2.55	76.77	2.88	216.34	5.19	76.28	2.95	83.93	3.00	77.75	2.96
Mn	725	23	1572	49	1189	37	1688	52	882	27	1009	31	947	29	1159	36
Co	13.15	0.25	26.66	0.44	23.56	0.40	20.99	0.36	29.05	0.47	23.77	0.40	25.73	0.43	26.83	0.44
Zn	106.85	6.16	156.50	8.28	134.69	8.00	128.92	7.35	64.39	6.08	157.38	8.08	164.29	8.47	155.45	8.12
As	6.89	0.52	10.36	0.70	2.56	0.53	9.63	0.78	9.81	0.86	8.37	0.78	8.42	0.83	5.00	0.74
Rb	71.15	8.11	62.14	9.55	83.01	9.73	59.95	8.54	17.48	6.55	69.66	9.60	86.08	9.97	72.53	10.10
Cs	2.79	0.22	3.75	0.26	0.61	0.19	2.65	0.23	1.26	0.22	2.60	0.23	3.41	0.26	3.38	0.24
Ba	1002.59	76.86	974.86	78.89	1506.56	97.81	1072.07	82.90	878.42	78.40	1072.22	79.12	865.53	77.69	927.19	74.48
La	31.91	0.29	39.66	0.35	64.46	0.51	31.87	0.28	18.65	0.20	39.04	0.34	40.35	0.36	39.34	0.35
Ce	68.94	1.28	92.99	1.49	141.79	1.75	71.39	1.22	40.68	1.30	82.03	1.34	88.11	1.40	96.45	1.48
Sm	6.75	0.05	8.93	0.07	11.95	0.09	7.15	0.06	5.46	0.05	8.43	0.07	8.73	0.07	8.54	0.07
Eu	1.78	0.05	2.39	0.06	3.04	0.07	2.03	0.06	1.57	0.05	2.30	0.06	2.42	0.06	2.46	0.06
Tb	0.89	0.14	1.18	0.17	1.35	0.17	1.17	0.16	0.74	0.15	0.94	0.15	1.32	0.17	1.13	0.15
Dy	5.36	0.60	5.98	0.68	7.99	0.69	5.50	0.87	5.89	0.53	5.79	0.62	6.52	0.61	7.02	0.65
Yb	3.11	0.14	3.91	0.16	5.64	0.20	3.18	0.14	3.54	0.14	3.27	0.14	3.71	0.17	3.80	0.17
Lu	0.40	0.02	0.59	0.02	0.78	0.03	0.44	0.02	0.46	0.02	0.47	0.02	0.51	0.02	0.51	0.02
Hf	9.39	0.33	13.98	0.50	14.52	0.50	6.98	0.30	4.25	0.26	4.41	0.24	5.32	0.27	5.09	0.26
Ta	0.74	0.07	0.71	0.08	0.96	0.10	0.53	0.06	0.74	0.07	0.41	0.07	0.51	0.07	0.48	0.07
Th	5.68	0.17	4.48	0.18	4.75	0.21	3.25	0.16	1.61	0.16	3.84	0.18	3.64	0.19	3.24	0.17

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA069		YAA070		YAA071		YAA072		YAA073		YAA074		YAA075		YAA076	
Batch No.	RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	83501	558	88831	642	88084	589	89506	600	78454	557	86424	620	93007	601	91448	614
Ca	45903	1920	19118	1670	16625	1253	20322	1402	16938	1349	23967	1705	20172	1352	16851	1405
Na	7733	165	14882	308	9637	203	15137	308	17213	348	15235	313	13282	272	12931	267
K	19013	1794	15701	2536	21036	2043	16798	2309	19343	2448	15476	2422	19532	2237	20049	1923
Fe	43151	580	109636	1368	65817	855	63256	822	83408	1068	70442	896	71034	920	69802	904
Ti	6298	449	4520	612	7196	606	5151	526	5642	508	6138	559	5645	482	6372	479
Sc	16.22	0.27	46.76	0.78	21.80	0.36	20.86	0.35	31.99	0.53	24.60	0.41	24.46	0.41	23.28	0.39
V	153.08	15.45	96.95	10.59	125.08	12.95	128.80	13.30	97.49	10.69	125.58	13.05	136.19	14.13	145.65	15.07
Cr	66.85	2.54	67.47	3.57	63.77	3.23	80.33	2.79	55.66	3.03	67.99	3.08	67.82	2.94	56.05	2.71
Mn	689	21	2391	74	1047	32	1253	39	1722	53	2123	66	1026	32	1076	33
Co	12.79	0.24	31.29	0.51	25.03	0.42	26.40	0.43	23.72	0.40	27.86	0.46	29.24	0.48	26.97	0.44
Zn	104.54	6.15	285.25	13.14	112.92	7.21	144.69	7.71	213.29	10.14	185.56	9.75	116.86	7.56	108.35	7.33
As	7.31	0.78	8.28	1.03	3.88	0.86	10.56	1.06	5.81	1.09	5.96	0.99	6.51	1.08	4.35	0.97
Rb	69.09	7.81	18.30	6.73	74.81	9.76	68.92	9.29	50.98	9.45	55.46	9.00	76.77	9.00	85.46	11.45
Cs	3.36	0.25	-0.70	0.02	0.58	0.20	3.47	0.22	0.36	0.19	0.79	0.22	0.97	0.21	0.70	0.20
Ba	1218.52	79.61	945.68	93.03	1606.28	103.88	1129.95	80.57	1244.33	92.26	1127.15	89.22	1436.98	98.62	1389.28	93.73
La	40.24	0.35	64.33	0.53	66.75	0.54	36.07	0.34	54.21	0.46	64.98	0.54	73.94	0.60	74.87	0.61
Ce	80.47	1.28	146.16	2.06	135.83	1.78	77.92	1.33	118.81	1.74	138.81	1.84	147.77	1.84	153.27	1.93
Sm	8.19	0.06	15.59	0.12	12.93	0.10	8.09	0.06	12.09	0.09	13.97	0.11	14.88	0.11	14.72	0.11
Eu	1.97	0.05	4.58	0.10	3.08	0.08	2.18	0.06	3.69	0.09	3.21	0.08	3.41	0.08	3.48	0.08
Tb	1.07	0.15	2.02	0.24	1.61	0.18	1.24	0.17	1.51	0.20	1.98	0.20	1.67	0.20	1.81	0.20
Dy	5.89	0.52	11.09	0.89	8.87	0.63	6.62	0.70	7.75	0.81	9.75	0.79	10.55	0.68	10.33	0.63
Yb	3.98	0.16	5.56	0.23	5.35	0.18	3.48	0.15	4.06	0.17	5.57	0.17	6.57	0.22	5.83	0.22
Lu	0.50	0.02	0.80	0.03	0.69	0.03	0.49	0.02	0.59	0.03	0.75	0.03	0.89	0.03	0.74	0.03
Hf	8.26	0.31	6.28	0.35	6.75	0.31	5.23	0.27	12.56	0.46	6.57	0.30	5.24	0.27	8.69	0.35
Ta	0.71	0.07	0.34	0.08	1.17	0.09	0.50	0.07	0.45	0.07	0.44	0.07	0.78	0.08	0.73	0.09
Th	6.48	0.19	2.83	0.23	5.45	0.19	3.46	0.18	2.54	0.19	3.83	0.20	4.86	0.20	7.42	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA077		YAA079		YAA080		YAA082		YAA083		YAA084		YAA085		YAA086	
Batch No.	RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10		RC1983-09/10	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	82463	566	89145	592	79287	622	83454	582	74637	521	87180	580	88776	570	88444	611
Ca	15662	1224	23662	1384	19754	1362	25699	1394	7783	871	19052	1392	25712	1402	19814	1788
Na	12211	252	14584	297	12001	252	10699	225	2419	69	16165	328	14124	289	16686	339
K	21863	2180	17751	2197	19050	3149	15672	2339	20949	2093	13556	2146	30423	2517	17376	2087
Fe	61637	806	64990	843	113438	1412	76183	981	52892	698	60730	792	65084	846	105138	1335
Ti	8262	523	6415	522	18952	1043	5038	483	13652	732	6568	504	5449	463	6056	545
Sc	19.81	0.33	21.33	0.36	29.10	0.48	26.22	0.44	14.92	0.25	20.08	0.34	23.19	0.39	40.77	0.68
V	129.09	13.44	138.46	14.07	313.91	31.01	118.10	12.59	125.91	12.88	140.53	14.55	95.88	10.34	96.63	10.66
Cr	59.10	2.68	83.00	3.10	128.53	4.15	59.78	2.94	59.21	2.59	81.18	3.03	53.42	2.67	62.70	3.38
Mn	1075	33	1172	36	2279	70	1562	48	1020	32	1059	33	1001	31	1549	48
Co	23.17	0.39	23.29	0.39	33.67	0.54	27.46	0.45	19.90	0.34	22.28	0.38	23.39	0.40	27.97	0.47
Zn	107.49	7.46	153.36	8.02	164.10	9.04	160.73	8.84	94.44	6.09	155.52	7.88	160.91	8.34	298.87	13.60
As	1.51	0.93	13.31	1.20	6.62	1.37	6.35	1.43	2.89	0.04	6.63	1.29	2.70	1.16	3.35	1.40
Rb	104.21	12.66	63.53	9.25	54.41	9.80	84.21	9.75	75.67	9.16	56.23	9.35	53.04	8.37	-25.78	1.39
Cs	-0.49	0.01	2.87	0.25	0.41	0.21	0.51	0.18	1.19	0.20	2.51	0.24	1.05	0.23	-0.66	0.02
Ba	1568.51	98.43	1286.43	85.39	1171.07	95.27	1430.74	97.93	1160.80	80.96	1168.43	80.34	1464.95	97.16	1287.40	106.70
La	69.89	0.58	38.11	0.37	53.39	0.48	92.97	0.75	54.89	0.49	36.66	0.37	59.61	0.53	61.83	0.56
Ce	144.06	1.91	81.51	1.37	102.44	1.69	203.05	2.27	122.82	1.60	79.80	1.34	115.56	1.62	137.11	2.03
Sm	13.95	0.11	8.35	0.07	11.38	0.09	19.39	0.15	10.76	0.09	8.00	0.07	13.01	0.10	15.13	0.12
Eu	3.27	0.08	2.28	0.06	2.51	0.07	3.85	0.09	2.13	0.06	2.18	0.06	3.38	0.08	4.33	0.10
Tb	1.73	0.18	1.05	0.16	1.64	0.20	2.42	0.22	1.31	0.16	1.20	0.16	1.81	0.19	1.75	0.26
Dy	9.93	0.67	6.59	0.64	8.89	0.83	13.32	0.78	7.01	0.57	5.73	0.67	10.63	0.70	10.88	0.81
Yb	5.54	0.20	4.03	0.19	5.97	0.23	7.11	0.20	4.94	0.14	3.61	0.16	6.03	0.21	5.52	0.20
Lu	0.75	0.03	0.49	0.02	0.76	0.03	0.99	0.03	0.72	0.03	0.48	0.02	0.79	0.03	0.74	0.03
Hf	9.86	0.37	5.58	0.26	9.26	0.37	7.40	0.33	12.27	0.42	8.07	0.32	5.96	0.27	14.01	0.53
Ta	1.26	0.09	0.53	0.07	1.44	0.10	0.63	0.08	1.89	0.11	0.53	0.07	0.33	0.07	0.48	0.07
Th	4.96	0.20	3.65	0.19	3.58	0.22	5.14	0.22	10.96	0.23	3.00	0.18	2.14	0.17	2.20	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA087		YAA088		YAA089		YAA090		YAA091		YAA092		YAA093		YAA094	
Batch No.	RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	95091	1261	94883	1346	94263	1116	95023	1247	86102	1201	91231	1140	99319	1427	105449	1384
Ca	18442	900	25093	1021	37387	1242	22151	916	12226	733	14603	695	16964	873	20066	890
Na	15207	310	13239	273	8719	183	17198	348	10176	213	11319	233	16721	339	15393	313
K	19679	2562	23095	2671	26498	2229	29477	2805	19869	2794	21704	2146	24926	2692	17021	2323
Fe	64075	835	63100	825	43750	593	60902	797	58451	767	68164	883	67875	883	72827	942
Ti	5061	412	5984	452	6033	364	5242	419	5693	463	6541	440	5012	474	5527	493
Sc	21.49	0.36	22.51	0.38	18.33	0.31	20.67	0.35	20.43	0.34	21.75	0.36	23.79	0.40	24.37	0.41
V	138.10	14.75	105.27	11.65	195.47	19.73	113.48	12.28	98.15	10.96	127.49	13.20	153.06	16.46	145.91	15.23
Cr	82.60	2.98	52.13	2.67	93.76	3.01	59.29	2.74	56.03	2.55	63.03	2.90	75.59	2.93	83.09	3.06
Mn	1144	35	1187	36	492	15	896	27	1332	41	661	20	1275	39	1274	39
Co	24.49	0.41	19.83	0.35	11.17	0.22	23.91	0.40	24.96	0.42	21.87	0.37	23.73	0.40	26.31	0.44
Zn	168.02	8.55	167.61	8.96	155.49	7.91	111.57	7.00	147.84	8.39	105.86	7.01	174.61	9.40	199.08	9.38
As	11.68	1.12	2.49	0.04	3.78	0.84	3.34	0.88	4.42	1.04	2.90	0.05	9.20	1.25	6.92	1.31
Rb	49.53	7.99	57.15	7.62	76.77	8.13	50.22	8.46	86.76	8.88	70.73	8.88	51.77	9.15	51.77	7.70
Cs	3.17	0.27	0.38	0.20	5.59	0.29	0.87	0.19	1.23	0.21	0.86	0.25	2.57	0.27	3.07	0.28
Ba	1059.73	66.28	1437.26	84.01	757.67	57.29	1511.46	81.87	1446.51	78.17	1483.81	82.93	996.11	70.33	1119.37	70.35
La	37.88	0.32	91.82	0.66	42.65	0.35	69.90	0.52	69.13	0.52	77.08	0.57	46.21	0.38	45.23	0.38
Ce	82.95	1.38	192.72	2.15	84.69	1.49	141.75	1.82	139.35	1.74	180.70	2.11	95.48	1.49	93.02	1.56
Sm	9.05	0.09	19.97	0.18	8.70	0.10	13.97	0.13	14.98	0.14	15.12	0.14	11.41	0.11	10.79	0.10
Eu	2.33	0.06	3.74	0.09	1.69	0.05	3.28	0.08	3.25	0.08	3.47	0.08	2.71	0.07	2.81	0.07
Tb	1.18	0.19	2.59	0.26	1.30	0.19	1.95	0.22	1.46	0.20	1.71	0.21	1.29	0.21	1.61	0.21
Dy	5.90	0.37	12.64	0.47	5.54	0.31	9.26	0.44	9.58	0.45	8.58	0.37	7.29	0.43	6.84	0.40
Yb	3.66	0.13	6.91	0.18	3.66	0.14	5.00	0.14	5.41	0.15	5.91	0.18	4.43	0.14	4.21	0.15
Lu	0.47	0.02	0.89	0.02	0.51	0.02	0.66	0.02	0.72	0.02	0.72	0.02	0.60	0.02	0.60	0.02
Hf	4.94	0.26	9.14	0.36	7.36	0.30	7.01	0.31	7.98	0.32	10.77	0.40	7.42	0.33	5.50	0.29
Ta	0.61	0.09	0.62	0.07	0.93	0.09	0.41	0.07	0.61	0.08	0.71	0.09	0.55	0.07	0.43	0.06
Th	3.32	0.19	5.88	0.20	11.42	0.25	3.88	0.20	3.78	0.18	7.53	0.23	3.83	0.20	3.27	0.20

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA095		YAA096		YAA097		YAA098		YAA099		YAA100		YAA101		YAA102	
Batch No.	RC1983-21/22		RC1983-21/22		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	122344	1361	93634	1231	91917	1248	122559	1442	95816	1243	100728	1312	91117	1245	120891	1408
Ca	27041	1124	19415	860	21132	930	21613	1015	22777	993	21891	916	19067	896	22131	1057
Na	29792	591	11657	239	15683	321	29447	590	16475	336	15149	311	14860	304	30105	602
K	15791	2176	19328	2005	21942	2554	14337	2029	12161	2172	16035	2376	16922	2041	16320	2331
Fe	19122	287	45010	605	61433	770	34550	449	60600	759	66786	833	56341	712	37118	478
Ti	4085	345	6992	413	5085	391	9915	519	5916	392	6184	461	4970	389	13043	614
Sc	4.13	0.07	17.33	0.29	20.72	0.34	6.77	0.11	21.97	0.36	23.30	0.39	19.38	0.32	7.15	0.12
V	37.02	5.34	136.38	14.09	132.48	14.07	88.20	9.68	135.51	14.49	138.12	14.35	120.53	12.82	107.55	11.73
Cr	24.36	1.45	81.12	2.85	76.01	2.35	18.59	1.15	69.94	2.17	83.21	2.58	65.94	2.14	24.94	1.34
Mn	154	5	506	16	1077	33	373	11	968	30	1101	34	910	28	439	14
Co	5.90	0.14	10.89	0.22	23.15	0.37	8.16	0.16	21.79	0.35	23.42	0.37	21.70	0.35	6.49	0.13
Zn	40.65	3.89	119.07	6.76	153.77	7.43	42.12	3.42	135.15	6.44	161.81	7.79	118.20	5.96	42.80	3.40
As			4.68	1.32	11.68	0.52	2.91	0.39	6.99	0.49	6.11	0.45	11.55	0.57	2.66	0.47
Rb	24.80	3.91	53.74	7.26	54.25	6.50	14.45	3.26	55.10	6.51	62.45	7.18	62.75	6.95	-9.62	0.40
Cs	0.70	0.14	1.61	0.22	3.05	0.23	-0.32	0.01	2.14	0.21	2.70	0.23	2.70	0.21	0.34	0.11
Ba	1212.19	60.67	841.04	57.03	1113.10	74.56	1222.29	75.43	899.00	67.02	895.32	68.69	1051.21	69.55	1065.33	67.30
La	16.79	0.19	36.86	0.33	39.00	0.29	28.50	0.24	42.65	0.32	46.47	0.35	40.54	0.31	31.45	0.26
Ce	36.06	0.82	73.53	1.34	80.23	1.09	55.92	0.81	86.98	1.14	92.58	1.19	78.15	1.07	57.86	0.83
Sm	3.68	0.04	8.03	0.10	9.30	0.09	5.84	0.06	10.49	0.10	11.17	0.11	9.52	0.09	6.21	0.06
Eu	1.81	0.05	1.83	0.05	2.39	0.06	2.26	0.05	2.51	0.06	2.64	0.06	2.21	0.05	2.34	0.05
Tb	0.44	0.09	1.12	0.16	1.02	0.15	0.73	0.10	1.33	0.15	1.40	0.15	1.33	0.15	0.63	0.09
Dy	2.10	0.24	5.80	0.32	6.20	0.39	2.80	0.30	7.89	0.39	7.96	0.41	6.61	0.35	2.43	0.28
Yb	0.63	0.07	3.85	0.15	3.73	0.12	1.20	0.09	3.96	0.12	4.24	0.13	3.82	0.12	1.03	0.08
Lu	0.10	0.01	0.49	0.02	0.46	0.02	0.15	0.01	0.52	0.02	0.58	0.02	0.50	0.02	0.14	0.01
Hf	2.13	0.12	9.40	0.34	4.64	0.22	12.37	0.36	6.19	0.26	6.08	0.25	4.60	0.22	8.89	0.28
Ta	0.15	0.05	0.85	0.08	0.48	0.06	0.37	0.05	0.48	0.06	0.65	0.07	0.51	0.07	0.62	0.06
Th	0.71	0.10	8.62	0.23	3.02	0.13	1.05	0.08	3.37	0.13	3.93	0.13	3.02	0.14	0.66	0.09

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA104		YAA105		YAA106		YAA107		YAA108		YAA109		YAA110		YAA111	
Batch No.	RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	94430	1248	93282	1203	90629	1159	94144	1206	127672	1388	91431	1498	92978	1309	95788	1272
Ca	20633	904	20275	947	16723	801	21707	893	26222	1046	22911	1010	20923	939	21773	959
Na	13154	271	15942	325	16396	335	15836	324	29472	589	10155	219	14559	299	15296	313
K	22925	2402	15991	2273	18798	2354	19255	2090	12840	1726	18383	2443	14254	1906	23796	2804
Fe	63169	792	63858	800	69676	871	58956	741	22944	310	70001	874	61623	773	63786	801
Ti	5323	402	5979	458	2553	333	4900	376	4028	302	5045	491	4852	364	5356	472
Sc	22.15	0.37	21.54	0.36	27.43	0.45	21.11	0.35	4.37	0.07	24.03	0.40	19.98	0.33	21.55	0.36
V	111.41	12.37	145.64	15.05	108.31	11.58	132.77	13.87	29.37	4.62	124.84	13.51	132.56	13.85	144.48	15.15
Cr	57.38	2.16	83.07	2.47	45.44	1.97	74.05	2.30	14.52	0.94	58.28	2.34	76.11	2.29	82.60	2.39
Mn	962	29	945	29	1001	31	752	23	194	6	1764	54	1084	33	1125	34
Co	19.18	0.31	25.58	0.40	21.43	0.35	20.47	0.33	6.61	0.14	26.45	0.41	21.60	0.35	24.84	0.39
Zn	125.10	6.29	154.63	7.51	177.73	8.01	132.57	6.65	34.82	2.86	183.60	8.40	149.80	7.25	165.66	7.59
As	5.36	0.61	4.92	0.56	7.29	0.69	8.63	0.68	1.81	0.45	2.02	0.63	11.04	0.82	8.03	0.78
Rb	79.33	7.54	67.58	6.64	41.25	5.87	47.86	6.90	-8.31	0.35	74.17	7.05	54.17	6.21	58.24	6.19
Cs	-0.49	0.01	3.04	0.23	-0.53	0.01	2.09	0.19	-0.26	0.01	-0.51	0.01	2.71	0.22	3.28	0.23
Ba	1406.04	88.25	849.81	64.79	1328.26	81.27	974.86	67.14	996.47	58.71	1304.76	77.84	1183.66	73.18	890.24	61.91
La	89.61	0.62	43.76	0.34	52.08	0.39	40.30	0.32	20.23	0.19	91.80	0.64	41.61	0.33	41.75	0.33
Ce	180.77	1.75	89.10	1.15	99.51	1.26	84.31	1.13	40.48	0.66	185.98	1.80	79.41	1.13	86.38	1.14
Sm	19.32	0.18	10.14	0.10	12.81	0.12	9.61	0.09	4.60	0.05	19.73	0.18	9.12	0.09	9.62	0.09
Eu	3.77	0.08	2.41	0.06	3.52	0.08	2.49	0.06	2.11	0.05	3.66	0.08	2.20	0.05	2.40	0.06
Tb	2.35	0.19	1.32	0.14	1.34	0.15	1.23	0.15	0.47	0.07	2.68	0.21	1.36	0.15	1.66	0.17
Dy	12.83	0.43	6.92	0.35	8.30	0.38	6.52	0.36	1.98	0.24	11.82	0.51	6.35	0.39	6.34	0.37
Yb	7.46	0.19	4.16	0.12	4.41	0.14	3.47	0.12	0.82	0.06	7.52	0.19	3.50	0.12	3.49	0.11
Lu	0.89	0.02	0.50	0.02	0.54	0.02	0.46	0.02	0.10	0.01	0.90	0.02	0.43	0.02	0.46	0.02
Hf	8.88	0.32	5.89	0.23	5.57	0.25	5.38	0.23	4.01	0.15	7.53	0.28	4.73	0.22	4.64	0.21
Ta	0.63	0.07	0.61	0.07	0.32	0.05	0.46	0.06	0.19	0.04	0.55	0.07	0.46	0.07	0.46	0.07
Th	6.47	0.15	3.44	0.14	1.45	0.14	3.43	0.14	0.51	0.07	6.00	0.16	2.79	0.13	4.00	0.15

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA112		YAA113		YAA114		YAA115		YAA116		YAA117		YAA118		YAA119	
Batch No.	RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-23/24	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	93641	1328	82150	1220	123863	1382	88235	1332	91524	1306	88309	1459	95405	1313	98772	1300
Ca	23519	1029	21881	1009	30193	1172	24026	1034	21647	1055	24110	1119	17000	875	18153	899
Na	14424	296	10640	225	30001	600	15990	327	14251	294	16030	329	15719	322	15686	321
K	19739	2322	18683	2514	11907	1832	30461	2923	18469	2183	21717	2732	20747	2657	19717	2422
Fe	60963	767	55988	707	21760	295	54024	683	63174	793	53136	674	62588	787	64875	813
Ti	5672	450	7050	584	4351	313	4651	410	5267	447	5036	480	5454	438	5606	453
Sc	19.49	0.32	19.49	0.32	4.16	0.07	17.80	0.30	21.76	0.36	17.33	0.29	21.14	0.35	21.88	0.36
V	122.08	13.31	116.23	12.67	38.03	5.30	106.54	11.65	133.03	14.22	121.90	13.56	138.89	14.59	157.58	16.39
Cr	76.27	2.36	69.69	2.13	13.87	1.01	65.28	2.09	84.46	2.62	65.57	1.97	73.04	2.45	78.20	2.58
Mn	1262	39	1518	46	191	6	1238	38	1137	35	1391	43	1217	37	1150	35
Co	21.92	0.35	22.46	0.36	6.15	0.13	21.50	0.35	23.50	0.37	20.88	0.33	24.75	0.39	24.24	0.38
Zn	139.66	7.08	90.40	5.30	31.25	3.03	147.17	6.88	166.39	7.76	130.84	6.66	140.19	6.86	153.86	7.45
As	10.51	0.81	1.88	0.03	1.43	0.02	10.14	0.92	9.76	0.98	9.23	0.94	20.32	1.56	14.30	1.44
Rb	46.22	6.11	65.49	6.96	15.97	3.95	64.87	6.69	54.77	6.84	53.99	6.18	49.12	6.52	59.16	8.29
Cs	2.43	0.21	-0.46	0.01	0.43	0.10	3.06	0.20	2.86	0.20	2.30	0.19	3.20	0.23	1.56	0.19
Ba	1058.88	68.49	1295.91	75.49	1127.10	64.47	1207.61	72.56	1098.46	71.05	1077.65	67.82	987.62	68.30	901.10	67.36
La	38.23	0.31	49.10	0.38	30.45	0.27	37.91	0.32	39.65	0.34	36.36	0.31	40.74	0.35	41.62	0.36
Ce	76.54	1.08	92.32	1.16	59.74	0.81	74.28	1.06	82.36	1.14	70.23	1.02	81.80	1.22	81.52	1.20
Sm	8.81	0.09	11.57	0.11	8.03	0.08	8.95	0.09	9.54	0.10	8.28	0.08	9.44	0.09	10.15	0.10
Eu	2.20	0.05	2.47	0.06	2.42	0.05	2.15	0.05	2.33	0.06	2.06	0.05	2.26	0.06	2.45	0.06
Tb	1.10	0.14	1.79	0.16	0.92	0.09	1.15	0.14	1.19	0.15	1.34	0.15	1.19	0.15	1.52	0.17
Dy	5.49	0.38	8.64	0.45	3.46	0.28	5.62	0.39	6.32	0.37	5.34	0.43	5.89	0.38	6.99	0.35
Yb	3.30	0.11	5.76	0.15	1.22	0.08	3.57	0.12	3.72	0.12	3.25	0.11	3.68	0.13	3.91	0.14
Lu	0.45	0.02	0.73	0.02	0.17	0.01	0.45	0.02	0.47	0.02	0.41	0.02	0.49	0.02	0.52	0.02
Hf	6.42	0.25	6.42	0.24	3.03	0.13	5.78	0.23	6.17	0.25	5.82	0.22	5.04	0.24	4.67	0.22
Ta	0.50	0.06	0.76	0.08	0.24	0.04	0.37	0.06	0.49	0.08	0.51	0.06	0.45	0.07	0.45	0.08
Th	3.51	0.14	3.77	0.14	1.06	0.08	2.80	0.13	3.30	0.15	2.81	0.13	3.11	0.16	3.22	0.16

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA120		YAA121		YAA122		YAA123		YAA124		YAA125		YAA126		YAA127	
Batch No.	RC1983-23/24		RC1983-23/24		RC1983-23/24		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	93460	1233	94161	1290	95095	1396	125263	1373	91540	1174	78622	1063	131196	1459	96959	1231
Ca	21668	943	19619	911	18761	947	26053	1075	24636	942	11190	609	27806	1114	18690	846
Na	11735	244	17974	366	14083	291	25553	502	8808	181	9215	183	28869	568	11007	225
K	25655	2544	15636	2410	21520	2567	21346	2182	22321	2025	25704	2805	20742	3094	13536	2120
Fe	64795	813	52368	662	74475	929	27417	359	42888	545	41075	523	27571	361	85352	1053
Ti	4858	408	5562	417	4728	434	6435	387	5507	337	8079	439	5496	382	5053	432
Sc	23.59	0.39	17.60	0.29	27.51	0.46	5.67	0.10	16.62	0.28	15.31	0.25	4.93	0.08	28.70	0.48
V	118.30	12.91	127.46	13.97	123.88	13.43	55.05	7.11	147.53	15.31	120.51	12.50	45.63	5.91	178.86	18.57
Cr	56.22	2.28	65.63	2.20	67.11	2.56	16.31	1.36	75.86	2.43	60.11	2.25	12.17	1.20	82.66	2.98
Mn	1121	34	1012	31	1521	47	374	12	634	19	529	16	345	11	1264	39
Co	20.73	0.33	17.71	0.29	25.78	0.40	9.31	0.17	13.85	0.23	13.89	0.23	7.63	0.14	30.45	0.46
Zn	147.23	7.28	113.47	6.17	191.60	8.71	45.65	2.75	99.37	4.44	80.40	3.94	49.71	3.19	180.11	7.53
As	3.35	0.05	11.58	1.31	7.62	1.43	1.20	0.24	9.32	0.39	3.67	0.34	1.16	0.29	5.08	0.46
Rb	88.74	7.60	50.12	6.61	47.59	7.11	30.95	4.32	100.42	7.89	98.17	7.79	19.41	3.66	66.24	7.82
Cs	0.71	0.16	1.10	0.17	1.39	0.19	0.62	0.12	5.51	0.25	2.60	0.19	0.63	0.11	0.97	0.19
Ba	1238.94	81.28	989.90	63.97	1196.90	78.58	926.55	80.63	1117.04	80.13	1165.04	87.03	884.33	75.82	1007.16	85.96
La	92.86	0.69	34.42	0.31	53.23	0.44	28.46	0.23	39.84	0.29	61.87	0.43	39.75	0.30	64.34	0.45
Ce	189.01	1.84	67.10	1.01	108.93	1.36	51.31	0.86	78.98	1.17	125.28	1.52	68.46	0.97	126.71	1.65
Sm	19.87	0.19	8.00	0.08	12.69	0.12	5.88	0.06	8.60	0.09	11.13	0.08	6.07	0.05	14.65	0.14
Eu	3.73	0.08	2.03	0.05	3.01	0.07	2.37	0.05	2.02	0.05	2.11	0.05	2.53	0.05	2.79	0.06
Tb	2.58	0.20	0.78	0.11	1.60	0.17	0.72	0.09	1.11	0.12	1.46	0.13	0.59	0.08	1.93	0.17
Dy	13.04	0.45	5.95	0.38	8.34	0.46	3.15	0.31	6.13	0.32	7.88	0.32	2.75	0.29	11.36	0.45
Yb	7.61	0.20	3.19	0.12	5.08	0.15	0.88	0.10	3.24	0.12	5.37	0.15	1.04	0.09	6.11	0.18
Lu	0.91	0.02	0.41	0.02	0.64	0.02	0.16	0.01	0.47	0.02	0.74	0.03	0.13	0.01	0.82	0.02
Hf	8.67	0.31	6.23	0.24	6.14	0.25	8.18	0.24	5.45	0.20	20.33	0.56	8.57	0.25	6.50	0.26
Ta	0.56	0.07	0.57	0.07	0.57	0.07	0.39	0.04	0.67	0.06	1.22	0.08	0.34	0.04	0.45	0.06
Th	7.02	0.17	2.86	0.13	4.73	0.17	1.07	0.10	6.67	0.17	14.97	0.24	0.89	0.10	6.19	0.22

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA128		YAA129		YAA130		YAA131		YAA132		YAA133		YAA134		YAA135	
Batch No.	RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	92513	1217	83327	1344	88511	1310	94124	1232	92355	1197	89818	1179	88506	1372	99918	1310
Ca	22379	982	18941	1016	23849	972	21791	911	19202	873	21164	969	19542	899	19176	899
Na	14837	297	15367	309	13075	266	13578	275	13512	273	14068	283	16044	322	13627	275
K	16439	2200	11035	2058	21450	2386	27830	2417	27739	2365	24990	2833	16345	2388	16949	2200
Fe	68368	849	78991	978	66747	831	60971	761	62602	780	63104	787	78859	975	79957	987
Ti	4951	406	3671	407	5002	410	5060	387	5318	410	5202	410	3447	395	5684	421
Sc	24.07	0.40	31.17	0.52	23.19	0.38	18.86	0.31	20.30	0.34	20.69	0.34	29.60	0.49	27.71	0.46
V	135.87	14.11	117.00	12.69	107.63	12.08	119.01	12.68	111.19	12.03	108.99	11.84	114.26	12.35	143.23	15.50
Cr	77.53	2.78	61.77	3.01	57.15	2.67	56.77	2.59	62.34	2.32	56.84	2.39	55.54	2.65	68.58	2.66
Mn	971	30	1427	44	1240	38	1076	33	1034	32	999	31	1309	40	1245	38
Co	23.95	0.37	26.06	0.40	22.47	0.35	35.08	0.52	26.95	0.41	24.28	0.38	25.70	0.40	25.11	0.39
Zn	149.54	6.04	194.53	7.42	154.94	6.22	101.83	4.90	108.52	5.05	113.43	5.10	184.47	7.13	161.14	6.53
As	10.92	0.51	6.56	0.56	4.56	0.46	3.28	0.45	2.51	0.47	2.98	0.46	5.64	0.59	4.51	0.59
Rb	56.16	7.27	31.99	6.47	87.38	8.62	79.98	8.67	75.59	7.37	85.62	9.63	48.74	6.95	43.62	8.38
Cs	2.28	0.20	-0.55	0.01	0.73	0.16	0.82	0.16	1.07	0.16	-0.47	0.01	-0.54	0.01	-0.53	0.01
Ba	962.23	83.17	1296.92	95.78	1444.29	99.46	1737.94	107.81	1765.26	109.92	1470.67	99.29	1280.06	95.39	1243.12	93.50
La	45.89	0.33	53.92	0.39	87.69	0.60	69.32	0.48	71.27	0.49	68.22	0.48	63.55	0.45	52.99	0.39
Ce	93.27	1.44	107.55	1.59	191.89	2.05	138.19	1.62	139.76	1.64	129.67	1.59	124.02	1.63	106.15	1.53
Sm	11.66	0.11	13.65	0.13	19.45	0.19	14.10	0.14	14.90	0.14	14.72	0.14	13.44	0.13	13.32	0.13
Eu	2.63	0.06	3.42	0.07	3.79	0.08	3.24	0.07	3.26	0.07	3.18	0.06	3.44	0.07	3.05	0.06
Tb	1.26	0.14	1.70	0.17	2.38	0.18	1.74	0.16	1.80	0.15	1.93	0.16	1.67	0.16	1.67	0.16
Dy	7.60	0.39	8.30	0.41	12.21	0.46	9.63	0.41	9.47	0.41	9.24	0.38	8.05	0.40	8.78	0.43
Yb	4.22	0.14	4.40	0.14	6.69	0.19	4.30	0.14	5.03	0.15	5.58	0.17	4.67	0.15	4.70	0.15
Lu	0.59	0.02	0.64	0.02	0.93	0.03	0.63	0.02	0.72	0.02	0.74	0.02	0.62	0.02	0.68	0.02
Hf	6.47	0.25	5.06	0.24	8.02	0.29	6.77	0.25	6.53	0.24	7.72	0.26	5.77	0.25	11.59	0.37
Ta	0.46	0.06	0.43	0.07	0.54	0.06	0.46	0.06	0.60	0.06	0.70	0.07	-0.15	0.01	0.62	0.07
Th	4.64	0.19	1.74	0.19	6.50	0.20	3.69	0.16	4.23	0.18	4.10	0.19	4.93	0.20	3.21	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA136		YAA137		YAA138		YAA139		YAA140		YAA141		YAA142		YAA143	
Batch No.	RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-25/26	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	98513	1360	92164	1117	98624	1350	97329	1292	96585	1285	91378	1140	93488	1144	89136	1210
Ca	20192	945	41061	1322	21772	1005	21581	921	21503	977	25954	1052	20323	887	20390	970
Na	16621	333	9834	202	12724	261	13723	279	16278	327	15119	302	14144	285	10945	228
K	19665	2438	19279	1800	21907	2802	15223	2127	16903	2246	16189	1763	19030	2253	20957	2563
Fe	63850	796	44819	569	83785	1032	69848	871	67289	839	41769	533	68311	852	70375	874
Ti	4470	419	5691	334	6150	485	5301	407	4908	402	5987	384	5843	446	5278	455
Sc	20.77	0.34	17.73	0.29	28.61	0.47	23.29	0.39	22.33	0.37	16.10	0.27	22.27	0.37	24.75	0.41
V	159.31	16.49	168.75	17.12	165.96	17.27	154.09	16.49	139.85	14.60	138.48	14.38	153.86	16.28	101.80	11.48
Cr	76.71	2.69	91.13	2.85	74.13	2.96	87.28	2.98	82.47	2.83	77.66	2.56	84.15	2.94	57.87	2.81
Mn	1341	41	510	16	1590	49	1197	37	1139	35	535	16	1288	39	1519	47
Co	24.80	0.38	11.52	0.20	36.31	0.54	26.49	0.41	25.99	0.40	12.18	0.21	25.29	0.39	25.34	0.39
Zn	129.70	5.48	138.99	5.66	172.66	6.89	166.17	6.90	138.97	5.77	106.56	4.51	148.67	5.95	139.79	6.01
As	12.14	0.66	2.82	0.50	2.15	0.60	9.21	0.76	12.88	0.88	5.84	0.67	14.22	0.89	3.00	0.70
Rb	51.05	7.18	70.66	7.38	65.75	8.48	45.92	6.71	71.99	8.40	55.21	6.74	56.47	8.15	82.84	8.47
Cs	2.46	0.21	3.04	0.19	0.90	0.18	2.65	0.22	3.67	0.23	1.21	0.17	3.18	0.23	-0.50	0.01
Ba	1025.80	79.31	709.91	60.18	1224.43	93.98	994.23	77.86	1011.01	78.61	920.93	70.30	1112.28	83.58	1399.99	99.85
La	41.03	0.31	33.07	0.26	75.12	0.53	41.66	0.32	45.65	0.35	33.26	0.27	40.30	0.32	93.22	0.65
Ce	84.81	1.36	66.66	1.16	152.96	1.83	85.54	1.34	91.15	1.38	64.37	1.13	82.86	1.34	190.20	2.10
Sm	9.72	0.10	7.44	0.10	16.86	0.16	10.45	0.11	10.91	0.11	7.79	0.09	9.89	0.10	21.91	0.21
Eu	2.38	0.06	1.58	0.04	3.42	0.07	2.50	0.06	2.58	0.06	1.84	0.04	2.40	0.05	3.77	0.08
Tb	1.14	0.13	1.12	0.14	2.28	0.20	1.38	0.15	1.49	0.14	0.92	0.12	1.05	0.13	3.01	0.20
Dy	7.68	0.43	6.12	0.31	11.13	0.48	6.91	0.38	6.61	0.38	5.65	0.34	6.21	0.38	13.68	0.52
Yb	3.55	0.13	3.33	0.12	6.41	0.19	3.60	0.13	3.86	0.13	3.04	0.11	3.67	0.14	6.66	0.17
Lu	0.53	0.02	0.46	0.02	0.91	0.03	0.54	0.02	0.56	0.02	0.47	0.02	0.54	0.02	0.98	0.03
Hf	4.27	0.20	5.72	0.22	8.17	0.30	5.62	0.23	5.53	0.24	7.19	0.25	5.83	0.23	6.80	0.27
Ta	0.49	0.06	0.92	0.07	0.65	0.06	0.63	0.06	0.39	0.05	0.76	0.06	0.55	0.06	0.52	0.06
Th	3.40	0.17	7.61	0.19	4.08	0.19	3.51	0.17	3.15	0.18	5.42	0.17	3.84	0.18	5.83	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA144		YAA145		YAA146		YAA147		YAA148		YAA149		YAA150		YAA151	
Batch No.	RC1983-25/26		RC1983-25/26		RC1983-25/26		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89833	1217	90753	1256	90458	1291	89642	1283	91556	1356	98936	1295	91738	1293	88743	1274
Ca	23700	970	22922	965	19251	937	21584	907	20005	943	17539	845	19989	954	23456	963
Na	15824	317	15935	319	15249	307	17303	356	14473	302	11393	240	19920	409	18214	375
K	14747	1771	20495	2454	18808	2238	21532	2480	21894	2713	21186	2311	20916	2597	20725	2674
Fe	62707	783	59510	746	60830	764	60187	785	75327	972	72008	930	54734	720	57768	758
Ti	4963	420	4435	360	5818	429	6208	441	5378	439	6604	464	5739	426	4860	391
Sc	20.65	0.34	19.49	0.32	20.53	0.34	19.79	0.33	26.88	0.45	24.42	0.41	18.01	0.30	19.22	0.32
V	137.43	14.40	123.40	13.16	139.22	14.91	130.98	13.87	134.39	14.33	143.39	15.07	123.45	13.22	125.74	13.97
Cr	77.65	2.81	69.30	2.70	77.23	2.85	76.54	2.83	70.23	2.84	67.39	2.91	62.72	2.59	73.16	2.95
Mn	1137	35	1085	33	1357	42	981	30	1571	48	1197	37	1269	39	1134	35
Co	24.38	0.38	22.80	0.35	22.66	0.35	21.64	0.37	25.69	0.43	26.88	0.45	20.24	0.35	21.99	0.38
Zn	136.60	5.55	119.95	5.22	119.25	5.22	132.25	8.30	196.62	10.22	120.63	7.94	146.73	7.93	124.38	7.47
As	9.93	0.90	11.30	0.82	8.68	0.92	9.16	0.52	8.95	0.68	4.41	0.59	7.80	0.65	4.75	0.50
Rb	56.01	8.17	70.98	8.26	57.25	7.97	51.78	7.82	52.46	8.36	74.81	9.39	62.05	8.82	65.17	9.71
Cs	3.17	0.21	2.72	0.22	2.36	0.18	2.12	0.21	1.32	0.25	0.56	0.19	1.32	0.21	2.50	0.24
Ba	1106.03	79.46	1292.13	86.72	1058.14	76.13	1012.17	89.59	979.81	89.66	1463.49	109.70	992.63	85.45	1003.52	84.47
La	37.80	0.31	41.56	0.33	38.49	0.31	36.41	0.29	49.36	0.40	64.38	0.49	36.69	0.32	38.32	0.31
Ce	76.41	1.28	81.67	1.28	78.59	1.29	79.25	1.42	107.97	1.57	123.90	1.68	78.64	1.34	82.44	1.32
Sm	9.19	0.09	9.55	0.10	9.55	0.10	7.96	0.07	11.08	0.09	13.14	0.11	7.87	0.06	8.43	0.07
Eu	2.22	0.05	2.40	0.05	2.40	0.05	2.31	0.06	2.91	0.07	3.21	0.08	2.32	0.06	2.31	0.06
Tb	1.22	0.13	1.05	0.13	1.40	0.16	1.45	0.19	1.74	0.24	2.16	0.24	1.10	0.18	1.49	0.20
Dy	6.69	0.40	6.51	0.39	6.25	0.42	5.80	0.35	9.00	0.43	10.21	0.43	6.37	0.39	6.46	0.37
Yb	3.51	0.14	3.69	0.14	3.57	0.13	3.34	0.16	4.93	0.21	6.03	0.20	2.98	0.15	3.42	0.16
Lu	0.50	0.02	0.52	0.02	0.50	0.02	0.40	0.02	0.67	0.03	0.84	0.03	0.41	0.02	0.47	0.02
Hf	5.12	0.22	4.21	0.20	5.23	0.22	5.52	0.27	7.42	0.34	8.14	0.34	6.43	0.28	5.37	0.25
Ta	0.41	0.05	0.35	0.05	0.51	0.06	0.38	0.06	0.43	0.08	0.66	0.08	0.54	0.07	0.49	0.07
Th	3.23	0.17	3.24	0.17	3.32	0.18	2.88	0.17	3.23	0.19	3.80	0.19	2.99	0.16	3.07	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA152		YAA153		YAA154		YAA155		YAA156		YAA159		YAA160		YAA161	
Batch No.	RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	120893	1331	90972	1197	94135	1351	89879	1197	80783	1191	91295	1229	95816	1323	88545	1169
Ca	22797	1004	21453	969	20175	968	15046	818	14169	736	22307	975	22652	997	21239	893
Na	28680	582	17583	362	17566	363	13059	274	11454	241	15504	321	16695	347	16856	347
K	9644	1513	22506	2171	18935	2448	22398	2346	25432	2397	18781	2208	21580	2434	16357	1927
Fe	23980	342	59160	776	63793	833	68692	892	68867	893	61425	788	62027	810	63244	828
Ti	5725	365	5291	397	5209	399	5817	428	10754	533	5043	403	6008	460	5447	409
Sc	4.64	0.08	19.60	0.33	21.81	0.36	23.31	0.39	20.24	0.34	20.08	0.34	19.93	0.33	20.65	0.35
V	41.63	6.08	122.73	13.06	125.31	13.54	112.59	12.25	121.87	13.10	126.50	13.56	118.76	12.87	131.22	13.95
Cr	15.02	1.30	78.06	2.82	79.74	2.91	60.03	2.70	55.83	2.58	79.09	2.78	79.60	3.13	74.81	2.89
Mn	229	7	900	28	1094	34	1149	35	1057	32	1048	32	1564	48	960	29
Co	7.69	0.17	23.08	0.39	21.25	0.37	27.67	0.46	24.19	0.41	23.37	0.40	23.94	0.41	22.65	0.39
Zn	44.08	3.81	138.05	7.85	143.13	8.17	143.73	8.96	110.47	7.32	100.20	6.54	129.31	8.09	143.41	8.58
As	1.01	0.01	7.55	0.69	6.76	0.60	3.45	0.67	3.51	0.54	13.21	0.74	10.41	0.73	6.89	0.72
Rb	8.83	3.92	60.39	7.63	62.73	8.52	89.58	9.74	93.56	11.46	55.13	8.67	58.69	8.41	58.60	8.17
Cs	0.51	0.11	3.26	0.30	2.66	0.28	0.64	0.22	0.91	0.23	2.83	0.27	2.99	0.26	2.68	0.26
Ba	923.70	76.93	982.12	82.95	1182.63	92.30	1447.36	109.43	1535.88	108.05	1148.36	87.84	1154.78	92.63	1103.30	87.03
La	19.03	0.22	36.52	0.32	41.03	0.36	64.67	0.51	62.37	0.49	38.00	0.33	37.52	0.34	35.65	0.31
Ce	42.86	0.83	81.30	1.32	96.23	1.50	139.43	1.79	125.73	1.85	79.24	1.33	82.05	1.41	77.65	1.46
Sm	4.24	0.04	8.00	0.07	9.48	0.08	12.91	0.11	11.73	0.10	8.75	0.07	8.52	0.08	8.33	0.08
Eu	2.16	0.06	2.19	0.06	2.60	0.07	3.26	0.08	3.09	0.08	2.31	0.06	2.30	0.06	2.16	0.06
Tb	0.50	0.09	1.31	0.20	1.60	0.21	2.30	0.26	1.54	0.20	1.46	0.20	1.26	0.19	1.12	0.19
Dy	2.12	0.24	5.82	0.32	6.62	0.38	10.03	0.43	7.76	0.37	6.35	0.36	5.85	0.42	6.31	0.38
Yb	1.07	0.11	3.41	0.17	3.68	0.16	5.47	0.20	4.86	0.18	3.80	0.17	3.32	0.15	3.34	0.14
Lu	0.11	0.01	0.46	0.03	0.47	0.02	0.77	0.03	0.67	0.03	0.50	0.02	0.46	0.02	0.47	0.02
Hf	3.37	0.16	4.86	0.24	6.88	0.31	7.56	0.33	10.05	0.39	4.45	0.23	6.12	0.28	6.23	0.29
Ta	0.32	0.05	0.58	0.07	0.57	0.06	0.61	0.07	1.67	0.11	0.50	0.07	0.66	0.07	0.49	0.07
Th	0.62	0.09	2.65	0.18	4.22	0.19	4.28	0.21	3.64	0.18	3.44	0.19	3.15	0.17	2.90	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA162		YAA163		YAA164		YAA165		YAA166		YAA167		YAA168		YAA169	
Batch No.	RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-27/28	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	99414	1434	95979	1379	94930	1384	86253	1212	72149	1124	96193	1325	91188	1179	92181	1236
Ca	21983	1022	19122	872	22189	958	19955	947	9476	595	19452	899	22446	950	24013	1033
Na	12984	273	15876	329	15668	325	10646	226	4768	112	12648	265	15470	321	16300	338
K	26390	3149	22406	2469	18824	2203	21255	2253	13864	2239	21326	2437	21171	2522	18068	2171
Fe	81235	1029	69894	889	67970	883	64920	850	41905	573	70131	894	69087	882	65807	860
Ti	5278	457	6244	439	5697	437	4508	376	4472	389	5594	396	6051	421	5629	393
Sc	27.69	0.46	24.05	0.40	23.75	0.40	23.11	0.39	15.31	0.26	24.44	0.41	24.64	0.41	23.49	0.39
V	160.98	16.93	154.14	16.07	153.05	16.33	94.99	10.54	60.15	7.51	113.94	12.33	149.69	15.85	140.93	14.86
Cr	75.69	3.33	79.93	2.83	80.68	3.31	54.34	2.84	54.61	2.35	59.24	2.81	73.96	3.08	77.23	3.07
Mn	1742	53	1168	36	1047	32	1323	41	1430	44	1298	40	1018	31	1029	32
Co	37.24	0.60	24.95	0.42	23.92	0.41	24.19	0.41	23.02	0.39	24.81	0.42	23.94	0.41	23.58	0.40
Zn	148.94	9.20	169.46	9.37	152.31	8.54	165.85	8.87	136.46	7.93	170.39	9.18	140.67	8.27	148.91	8.35
As	3.58	0.85	8.68	0.89	7.35	0.80	3.22	0.86	1.80	0.68	2.56	0.03	8.46	1.09	6.95	1.15
Rb	68.86	10.02	66.55	10.11	71.40	9.52	95.03	11.07	75.61	8.80	85.63	10.41	70.89	10.35	59.01	8.76
Cs	0.45	0.23	2.83	0.28	2.50	0.26	0.60	0.23	1.49	0.21	0.63	0.21	2.48	0.26	2.48	0.31
Ba	1197.80	104.12	922.45	80.70	1019.63	87.76	1301.60	96.74	1247.38	86.64	1246.29	105.54	1043.28	84.93	1058.59	85.28
La	84.55	0.63	46.10	0.40	43.44	0.38	86.73	0.67	58.55	0.48	93.17	0.72	45.10	0.40	45.85	0.41
Ce	173.02	2.27	97.27	1.62	91.34	1.47	185.33	2.20	113.32	1.54	192.97	2.39	94.46	1.58	93.73	1.55
Sm	16.39	0.14	10.50	0.09	9.72	0.09	17.77	0.15	11.57	0.10	18.79	0.15	10.41	0.10	10.79	0.09
Eu	3.58	0.09	2.72	0.07	2.51	0.07	3.49	0.08	2.63	0.07	3.77	0.09	2.62	0.07	2.60	0.07
Tb	2.56	0.28	1.60	0.24	1.35	0.19	2.48	0.28	1.81	0.19	3.23	0.34	1.66	0.23	1.67	0.20
Dy	11.22	0.47	6.87	0.38	7.00	0.37	12.17	0.46	8.81	0.40	14.71	0.52	7.27	0.40	7.33	0.40
Yb	7.10	0.24	4.06	0.17	4.10	0.17	6.84	0.23	6.09	0.19	7.42	0.23	4.04	0.17	4.30	0.18
Lu	0.94	0.04	0.58	0.02	0.56	0.03	0.92	0.03	0.79	0.03	0.94	0.03	0.64	0.03	0.59	0.02
Hf	7.16	0.32	8.11	0.34	7.75	0.33	7.37	0.32	5.95	0.27	7.95	0.35	6.78	0.31	6.65	0.31
Ta	0.61	0.08	0.58	0.08	0.44	0.08	0.54	0.07	0.62	0.07	0.69	0.08	0.53	0.07	0.76	0.07
Th	5.72	0.23	3.69	0.20	3.65	0.19	6.64	0.21	5.68	0.18	6.03	0.21	2.93	0.19	3.59	0.19

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA170		YAA171		YAA172		YAA173		YAA174		YAA175		YAA176		YAA177	
Batch No.	RC1983-27/28		RC1983-27/28		RC1983-27/28		RC1983-29/30		RC1983-29/30		RC1983-29/30		RC1983-29/30		RC1983-29/30	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	86633	1223	90159	1176	95377	1261	91109	1257	120463	1326	93622	1221	93163	1276	97118	1272
Ca	19572	988	20987	953	18693	824	19616	905	21823	962	21299	897	25130	1002	23190	1051
Na	15506	321	14444	300	15374	318	12203	251	29449	585	13019	268	14140	290	13499	277
K	18200	2220	17673	1918	18467	2228	22238	2225	14282	1822	16837	2173	13064	1971	16809	2153
Fe	59757	785	66181	863	60834	798	75238	931	27795	368	69513	866	71053	884	71941	894
Ti	5624	406	5716	415	5423	405	6525	411	7863	440	5007	409	4816	431	4932	419
Sc	18.78	0.31	22.70	0.38	20.24	0.34	22.78	0.38	5.73	0.10	23.06	0.38	22.95	0.38	23.98	0.40
V	130.27	13.58	133.84	14.16	110.51	11.73	141.53	15.05	61.26	7.46	161.18	17.25	152.89	15.86	150.82	15.79
Cr	67.00	2.77	80.14	2.94	59.82	2.87	63.55	2.15	16.66	0.97	86.52	2.45	83.32	2.49	85.07	2.47
Mn	975	30	1043	32	799	25	1215	37	382	12	1269	39	1285	39	1313	40
Co	20.64	0.36	23.52	0.40	23.50	0.40	29.45	0.45	6.58	0.13	26.63	0.41	26.78	0.41	27.96	0.43
Zn	126.13	7.40	140.25	8.04	98.26	6.86	127.61	6.74	50.51	4.09	173.63	8.03	169.59	7.62	174.57	7.86
As	12.82	1.09	10.52	1.29	3.38	0.99	5.26	0.72	2.50	0.65	17.06	0.98	10.95	0.93	11.00	0.96
Rb	42.75	7.09	61.23	9.53	57.78	8.58	73.04	7.33	15.31	3.24	46.65	6.61	58.55	6.23	52.66	6.60
Cs	3.19	0.26	2.93	0.27	0.70	0.20	0.58	0.17	0.47	0.11	2.43	0.20	2.96	0.24	3.20	0.23
Ba	1110.69	83.51	1189.98	90.72	1211.35	92.45	1608.80	112.48	1204.52	83.91	1037.44	87.79	1023.62	86.26	1030.94	86.28
La	37.30	0.36	44.65	0.41	50.96	0.45	69.57	0.55	29.05	0.28	42.71	0.37	40.41	0.36	44.28	0.39
Ce	77.82	1.44	93.34	1.54	109.74	1.61	136.03	1.49	58.31	0.78	83.64	1.18	87.45	1.14	90.85	1.17
Sm	8.90	0.09	9.87	0.10	10.28	0.10	13.45	0.11	5.51	0.05	9.57	0.09	8.99	0.08	9.84	0.09
Eu	2.24	0.06	2.54	0.07	2.50	0.07	3.22	0.07	2.26	0.05	2.56	0.06	2.50	0.06	2.68	0.06
Tb	1.06	0.17	1.96	0.25	1.45	0.18	1.47	0.14	0.58	0.07	1.17	0.13	1.14	0.13	1.47	0.15
Dy	5.70	0.35	7.81	0.39	6.93	0.36	9.20	0.40	2.51	0.27	8.18	0.42	7.17	0.39	7.53	0.40
Yb	3.21	0.13	4.07	0.17	4.18	0.17	5.26	0.21	0.88	0.08	3.93	0.14	3.57	0.15	3.99	0.16
Lu	0.43	0.02	0.59	0.03	0.60	0.02	0.72	0.03	0.15	0.01	0.53	0.02	0.52	0.02	0.53	0.02
Hf	7.08	0.32	6.10	0.30	5.26	0.28	6.62	0.25	6.10	0.20	4.21	0.21	4.91	0.22	3.91	0.21
Ta	0.87	0.08	0.59	0.07	0.51	0.08	0.66	0.07	0.34	0.05	0.51	0.08	0.42	0.06	0.47	0.07
Th	3.50	0.20	3.92	0.19	3.30	0.19	6.63	0.16	1.23	0.08	3.42	0.15	3.59	0.14	3.50	0.15

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA178		YAA179		YAA180		YAA181		YAA182		YAA183		YAA184		YAA185	
Batch No.	RC1983-29/30		RC1983-29/30		RC1983-29/30		RC1983-29/30		RC1983-29/30		RC1983-11/12		RC1983-11/12		RC1983-11/12	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	85486	1112	85699	1234	95400	1168	118864	1345	91007	1204	102340	1260	96617	1521	82206	1119
Ca	13939	789	20402	996	19484	857	29007	1103	17321	926	19031	860	21869	1111	15897	802
Na	11226	231	18183	367	13444	274	26281	524	17257	349	9447	199	16179	333	10998	229
K	21157	2098	19961	2360	18239	1966	13109	2172	21527	2464	28559	3230	18352	2920	23700	2567
Fe	54993	694	73165	909	64099	802	40076	513	59376	746	75674	964	78394	1018	62499	805
Ti	5890	413	3527	407	6383	385	10967	532	5528	467	4723	361	3765	414	6375	462
Sc	18.88	0.31	26.57	0.44	21.24	0.35	7.25	0.12	19.30	0.32	26.21	0.44	27.96	0.46	22.30	0.37
V	105.12	11.57	95.67	11.29	154.34	15.68	79.52	9.04	108.30	11.59	174.45	17.86	136.12	14.77	114.73	12.93
Cr	59.71	2.05	53.96	2.13	73.51	2.28	18.81	1.33	66.61	2.08	105.28	3.87	67.66	3.03	56.17	2.83
Mn	841	26	1383	42	792	24	428	13	1072	33	947	29	1736	53	1099	34
Co	20.20	0.32	24.41	0.38	21.15	0.34	10.03	0.18	20.45	0.33	33.48	0.54	32.38	0.53	23.93	0.40
Zn	107.75	5.94	165.43	7.66	141.45	6.53	53.06	3.76	151.28	7.10	132.48	8.56	177.21	9.37	139.54	7.82
As	2.45	0.85	4.37	0.96	7.26	0.91	2.57	0.74	7.67	0.96	4.38	0.32	6.92	0.37	2.61	0.32
Rb	71.79	6.51	37.82	6.02	48.16	6.98	14.31	3.71	52.98	6.96	87.43	10.01	44.38	9.61	56.91	8.44
Cs	0.47	0.14	-0.54	0.01	3.87	0.23	-0.33	0.01	3.07	0.22	1.05	0.26	0.38	0.24	0.61	0.23
Ba	1657.19	109.83	1278.25	98.94	847.30	78.77	1316.60	92.67	1204.42	91.13	996.19	71.52	1291.90	83.01	1433.75	86.04
La	68.12	0.55	50.71	0.44	38.17	0.35	45.94	0.41	35.52	0.34	64.98	0.44	66.59	0.46	67.92	0.46
Ce	133.59	1.40	104.75	1.32	75.63	1.07	86.82	1.02	70.53	1.03	127.87	1.97	139.14	1.88	143.02	1.86
Sm	13.60	0.11	11.33	0.10	8.43	0.08	11.28	0.09	7.73	0.08	12.26	0.09	14.61	0.11	14.71	0.11
Eu	2.95	0.07	3.27	0.07	2.23	0.05	3.21	0.07	2.26	0.05	2.70	0.07	3.44	0.08	3.12	0.08
Tb	1.64	0.14	1.52	0.14	1.28	0.13	1.11	0.10	1.00	0.13	1.88	0.20	1.77	0.20	1.92	0.20
Dy	9.48	0.38	8.00	0.44	6.32	0.35	4.81	0.32	5.90	0.36	13.08	0.46	10.50	0.52	10.16	0.42
Yb	4.84	0.15	4.28	0.17	3.69	0.17	1.82	0.12	3.21	0.13	8.98	0.18	5.78	0.14	4.94	0.13
Lu	0.70	0.03	0.63	0.03	0.53	0.02	0.27	0.02	0.48	0.02	1.26	0.03	0.77	0.02	0.68	0.02
Hf	5.35	0.21	6.07	0.25	4.68	0.21	10.01	0.30	5.87	0.23	7.54	0.36	5.67	0.30	8.01	0.34
Ta	0.67	0.07	0.30	0.06	0.71	0.09	0.45	0.06	0.57	0.08	0.76	0.09	0.43	0.09	0.64	0.08
Th	6.04	0.16	1.84	0.13	3.92	0.15	1.04	0.11	2.85	0.14	7.79	0.23	3.06	0.19	4.37	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA186		YAA187		YAA192		YAA193		YAA194		YAA195		YAA196		YAA197	
Batch No.	RC1983-11/12		RC1983-11/12		RC 1983-11		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89027	2126	96799	1246	100240	1450	90303	1073	88718	1078	92059	1204	90994	1207	91063	1279
Ca	20727	1059	20699	947	24204	1113	39862	1327	40131	1312	22786	1008	22546	925	19550	886
Na	12861	270	14023	287	16684	342	6885	148	6518	140	15470	316	18696	378	16932	344
K	22730	2821	25430	3002	19260	2824	27430	2954	24171	2317	18839	2188	16609	2158	21819	2757
Fe	75098	956	72763	949	79683	1032	45462	613	46711	634	61056	806	53295	710	56547	751
Ti	8852	635	8544	488	4084	423	5495	349	5853	368	4685	351	5935	409	4998	419
Sc	21.98	0.37	24.58	0.41	27.88	0.46	17.63	0.29	17.86	0.30	20.51	0.34	17.99	0.30	18.47	0.31
V	155.72	17.33	137.56	14.26	152.80	16.99	165.13	16.78	154.66	15.72	131.73	13.88	132.58	13.91	126.93	13.46
Cr	71.45	2.95	66.25	3.15	71.95	3.04	83.39	2.97	77.34	2.88	81.33	2.85	71.91	2.67	70.03	3.17
Mn	1099	34	1020	31	1787	55	667	20	637	20	863	26	916	28	1121	34
Co	26.76	0.45	23.18	0.40	32.18	0.52	14.34	0.27	14.74	0.28	22.20	0.38	19.95	0.35	19.90	0.35
Zn	121.63	7.65	152.23	8.40	163.13	9.14	115.88	6.70	122.84	6.94	146.34	7.78	127.40	7.14	120.48	7.13
As	2.77	0.34	4.92	0.40	3.15	0.38	9.40	0.37	8.98	0.44	10.94	0.50	4.86	0.38	9.71	0.47
Rb	81.70	9.18	61.51	10.07	56.10	8.69	103.97	9.89	105.99	10.41	54.62	8.35	49.72	8.29	47.28	7.33
Cs	0.81	0.21	0.82	0.23	0.61	0.24	6.82	0.36	6.41	0.33	2.39	0.28	2.19	0.25	2.77	0.33
Ba	1533.48	86.27	1280.32	79.65	1110.60	78.40	842.42	59.28	839.58	60.68	1086.30	68.75	1022.41	64.54	1144.11	71.67
La	81.52	0.55	70.51	0.48	67.53	0.47	43.07	0.31	43.32	0.32	40.35	0.30	35.18	0.28	37.77	0.29
Ce	162.61	2.03	141.13	1.88	133.50	1.83	86.19	1.39	88.71	1.47	84.25	1.40	76.41	1.32	78.67	1.35
Sm	15.42	0.12	15.30	0.12	14.24	0.11	8.76	0.07	8.74	0.07	8.66	0.07	7.98	0.06	7.84	0.06
Eu	3.19	0.08	3.58	0.09	3.30	0.08	1.99	0.06	2.17	0.06	2.36	0.07	2.14	0.06	2.21	0.06
Tb	1.85	0.19	2.18	0.21	1.75	0.19	1.25	0.15	1.22	0.15	1.01	0.16	1.01	0.15	0.97	0.13
Dy	8.03	0.42	11.54	0.44	9.94	0.48	6.15	0.31	6.06	0.30	6.21	0.34	5.84	0.36	5.94	0.38
Yb	5.43	0.15	6.34	0.17	5.81	0.16	3.30	0.10	3.41	0.10	3.31	0.11	3.14	0.11	3.38	0.12
Lu	0.67	0.02	0.80	0.02	0.74	0.02	0.50	0.02	0.49	0.02	0.45	0.02	0.45	0.02	0.41	0.01
Hf	9.91	0.40	10.57	0.42	5.67	0.35	7.00	0.30	7.62	0.34	4.40	0.25	7.17	0.31	5.48	0.29
Ta	1.04	0.09	0.91	0.09	0.32	0.07	0.81	0.08	0.86	0.09	0.53	0.07	0.51	0.07	0.44	0.08
Th	6.59	0.21	6.05	0.21	2.84	0.18	7.96	0.21	8.39	0.21	2.88	0.19	3.07	0.16	3.16	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA198		YAA202		YAA203		YAA204		YAA205		YAA206		YAA207		YAA208	
Batch No.	RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	90004	1161	94533	1311	94747	1255	94036	1328	101999	1293	94269	1227	95167	1226	91266	1367
Ca	19762	931	22022	902	17321	892	21517	951	19802	955	21223	944	20953	911	21184	1062
Na	18891	382	14562	298	13241	272	15992	328	14617	299	13294	273	16173	329	14858	306
K	18922	2350	24987	2518	28654	2765	22486	2661	22432	2962	26957	2633	23613	2625	14639	2471
Fe	50077	673	64776	852	67851	890	62684	810	72066	922	68345	879	61611	813	78900	1029
Ti	4816	373	4408	394	5401	421	5242	431	6835	427	6544	397	5453	426	3510	447
Sc	16.59	0.28	21.70	0.36	22.11	0.37	20.49	0.34	25.48	0.42	22.32	0.37	20.70	0.35	28.28	0.47
V	101.74	11.04	113.53	12.37	115.53	12.17	111.89	12.38	135.16	14.42	137.88	14.55	149.29	16.18	137.54	15.03
Cr	63.19	2.52	63.41	2.91	64.00	2.83	77.47	3.04	61.36	2.91	65.58	3.17	80.95	3.43	74.84	3.75
Mn	805	25	1034	32	1127	35	1454	45	1103	34	955	29	969	30	1745	53
Co	18.85	0.34	26.46	0.44	27.76	0.46	22.90	0.39	24.08	0.41	28.42	0.47	23.23	0.39	32.45	0.52
Zn	127.32	6.89	127.62	7.81	120.73	7.71	152.43	8.15	160.89	8.72	117.07	7.46	155.92	8.20	160.02	9.44
As	9.35	0.49	2.95	0.45	5.93	0.53	9.82	0.57	4.08	0.58	3.49	0.53	10.29	0.64	5.68	0.72
Rb	45.79	7.80	83.26	8.70	79.04	10.59	61.30	7.87	56.41	9.00	69.64	8.33	70.27	9.38	66.55	11.18
Cs	1.96	0.26	0.67	0.24	0.80	0.26	3.31	0.30	1.28	0.24	0.58	0.20	2.85	0.30	0.86	0.27
Ba	963.28	63.89	1547.37	86.85	1473.13	84.90	1005.79	65.47	1369.49	80.28	1449.47	82.27	952.28	63.15	1206.76	77.02
La	33.34	0.27	74.07	0.52	74.45	0.52	38.67	0.30	66.58	0.47	69.22	0.49	43.31	0.34	67.65	0.49
Ce	68.30	1.25	146.10	1.90	143.93	1.90	76.39	1.47	129.99	1.88	134.86	1.84	89.86	1.64	131.51	1.92
Sm	7.38	0.06	14.11	0.11	14.28	0.11	8.72	0.07	15.11	0.12	13.33	0.11	9.33	0.07	14.37	0.11
Eu	2.06	0.06	3.26	0.08	3.38	0.08	2.32	0.06	3.73	0.09	3.00	0.08	2.48	0.07	3.14	0.08
Tb	1.11	0.15	1.86	0.20	2.03	0.21	0.83	0.15	2.51	0.24	2.19	0.22	1.07	0.17	1.67	0.20
Dy	5.49	0.37	10.42	0.43	9.86	0.43	6.45	0.41	11.59	0.48	10.73	0.41	6.84	0.36	9.98	0.51
Yb	2.98	0.10	5.48	0.14	5.72	0.15	3.47	0.11	5.86	0.15	6.08	0.16	3.50	0.11	5.84	0.15
Lu	0.38	0.01	0.71	0.02	0.73	0.02	0.46	0.02	0.81	0.02	0.78	0.02	0.49	0.02	0.77	0.02
Hf	4.37	0.26	6.93	0.33	7.84	0.34	5.80	0.29	8.99	0.39	8.61	0.37	4.82	0.26	4.43	0.29
Ta	0.46	0.07	0.47	0.08	0.73	0.08	0.50	0.07	0.63	0.09	0.62	0.08	0.49	0.08	0.43	0.08
Th	2.28	0.16	5.21	0.22	6.13	0.22	3.19	0.18	3.58	0.21	5.60	0.21	3.77	0.20	2.95	0.20

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA209		YAA210		YAA211		YAA212		YAA213		YAA214		YAA215		YAA216	
Batch No.	RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-11/12		RC1983-13/14		RC1983-13/14	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	93965	1264	93672	1328	89449	1214	94281	1121	81829	1177	93261	1162	102907	1379	96999	1311
Ca	21047	961	23050	976	18619	827	17259	822	20739	909	19236	853	17175	855	19868	989
Na	14094	290	10716	225	16141	329	11720	242	10933	229	11945	247	11506	232	16721	330
K	22272	2420	25594	2965	27235	2794	29561	2777	17988	2484	30476	2983	25013	2543	17383	2344
Fe	70490	921	78336	1001	58624	779	64226	848	81567	1055	63884	825	75843	948	60565	766
Ti	6024	419	3973	435	4823	392	5289	377	12585	610	4611	353	6654	450	6020	431
Sc	23.99	0.40	29.00	0.48	19.02	0.32	21.36	0.36	21.75	0.36	21.46	0.36	26.70	0.44	20.24	0.34
V	157.49	16.06	131.72	14.55	133.05	14.11	116.02	12.38	216.82	21.91	118.14	12.55	143.35	14.94	130.47	13.73
Cr	69.40	3.01	59.56	3.40	71.57	2.93	58.83	2.90	72.52	3.17	59.94	3.08	94.80	3.12	79.28	2.57
Mn	1003	31	1686	52	970	30	794	24	1516	46	909	28	1086	33	1163	36
Co	29.17	0.48	27.55	0.46	20.67	0.36	24.57	0.41	26.96	0.45	24.89	0.42	27.19	0.42	22.04	0.35
Zn	137.67	8.15	195.78	9.99	125.14	7.30	118.56	7.24	135.54	8.04	124.95	7.35	104.27	5.63	121.62	5.55
As	6.49	0.69	4.97	0.77	7.71	0.74	2.25	0.63	2.38	0.60	4.11	0.78	1.70	0.35	3.88	0.42
Rb	81.81	10.17	88.37	10.78	63.21	8.89	88.95	9.93	54.02	8.48	89.20	9.64	100.35	8.80	48.81	5.74
Cs	1.59	0.27	1.12	0.27	3.67	0.28	0.91	0.23	0.62	0.23	0.87	0.21	-0.48	0.01	2.33	0.20
Ba	1268.37	78.65	1309.64	84.89	944.35	63.99	1540.68	84.66	1346.33	77.38	1663.72	88.37	1001.42	98.26	835.26	85.92
La	66.05	0.48	98.48	0.68	37.62	0.31	74.81	0.54	64.60	0.48	74.74	0.54	62.56	0.48	37.62	0.33
Ce	134.48	2.03	198.00	2.57	73.30	1.49	127.91	1.89	127.83	1.87	144.74	1.96	127.68	1.68	78.43	1.24
Sm	13.22	0.10	21.58	0.17	8.22	0.07	14.67	0.11	12.99	0.10	13.92	0.11	14.30	0.13	8.44	0.08
Eu	3.15	0.08	4.12	0.10	2.30	0.06	3.61	0.09	2.98	0.08	3.23	0.08	3.07	0.07	2.27	0.05
Tb	1.90	0.20	2.77	0.27	1.27	0.19	1.92	0.20	1.65	0.19	1.65	0.19	2.21	0.17	1.07	0.13
Dy	9.06	0.39	14.22	0.53	5.72	0.36	10.16	0.39	9.25	0.44	9.44	0.40	12.09	0.44	5.91	0.39
Yb	5.64	0.15	7.84	0.19	3.29	0.11	6.01	0.15	5.53	0.14	5.80	0.16	7.35	0.20	3.37	0.16
Lu	0.74	0.02	1.03	0.02	0.44	0.02	0.81	0.02	0.79	0.02	0.73	0.02	0.93	0.03	0.41	0.03
Hf	7.14	0.36	6.37	0.35	5.90	0.28	7.97	0.36	17.21	0.61	6.75	0.31	10.60	0.39	6.50	0.26
Ta	0.63	0.09	0.60	0.10	0.57	0.06	0.76	0.08	1.34	0.11	0.71	0.08	0.70	0.07	0.56	0.06
Th	4.94	0.23	5.09	0.23	2.65	0.18	3.51	0.18	5.40	0.20	6.44	0.21	6.84	0.19	3.53	0.17

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA217		YAA218		YAA219		YAA220		YAA221		YAA222		YAA223		YAA224	
Batch No.	RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	90389	1057	87760	1320	96680	1235	93564	1303	98657	1443	91338	1422	90028	1164	95077	1462
Ca	32779	1185	26887	1100	21418	1047	23663	1009	22898	1048	26451	1100	46335	1501	24128	1126
Na	8356	170	15564	310	13102	261	10833	221	9458	203	15443	306	6858	145	10849	223
K	27764	2335	22740	2649	24925	3461	22128	2491	17444	2738	22934	2830	24485	2147	24680	3233
Fe	45542	585	70219	881	69690	873	79420	991	93892	1163	76517	954	45474	586	85077	1060
Ti	6142	397	4703	449	5293	416	5530	434	4570	480	4518	444	5527	365	5705	516
Sc	17.35	0.29	23.78	0.39	23.50	0.39	27.65	0.46	33.59	0.56	26.24	0.44	17.08	0.28	30.46	0.50
V	159.88	16.42	139.11	15.12	145.02	15.03	125.40	13.46	147.50	15.63	138.44	14.65	158.48	16.23	147.71	16.42
Cr	74.92	2.52	67.53	2.86	80.10	2.72	54.99	2.53	57.87	2.75	70.12	2.70	81.64	2.52	58.73	2.80
Mn	709	22	1480	45	1036	32	1362	42	2172	66	1452	44	661	20	2034	62
Co	14.97	0.25	26.88	0.42	25.52	0.40	25.71	0.40	34.79	0.53	29.60	0.45	14.17	0.24	31.56	0.48
Zn	109.63	4.96	133.45	6.32	148.13	6.37	170.04	7.14	221.28	8.82	144.53	6.44	104.93	4.89	197.12	8.09
As	5.68	0.43	5.34	0.50	9.47	0.54	4.10	0.57	2.18	0.49	6.35	0.58	6.70	0.50	1.96	0.62
Rb	102.63	7.94	52.07	6.62	63.98	7.35	62.49	7.58	68.10	7.47	48.22	7.33	105.33	8.46	62.47	7.24
Cs	6.13	0.24	-0.45	0.01	2.81	0.21	-0.48	0.01	-0.53	0.01	-0.47	0.01	6.56	0.24	-0.51	0.01
Ba	790.53	74.92	1343.97	110.21	1013.45	93.47	1179.79	107.60	1075.99	107.40	1207.52	102.39	870.52	75.79	1139.45	105.53
La	39.43	0.32	58.70	0.43	43.70	0.36	95.68	0.69	99.83	0.72	68.31	0.50	42.87	0.35	105.29	0.74
Ce	81.47	1.23	125.89	1.63	88.12	1.41	203.89	2.23	226.22	2.42	138.79	1.75	85.80	1.26	228.57	2.44
Sm	8.05	0.08	12.95	0.12	10.11	0.10	21.71	0.19	23.29	0.20	14.82	0.13	9.16	0.10	24.00	0.21
Eu	2.01	0.05	3.03	0.07	2.48	0.06	4.16	0.08	4.58	0.09	3.13	0.07	2.08	0.05	4.72	0.09
Tb	1.14	0.13	1.79	0.15	1.09	0.14	2.79	0.20	3.15	0.22	1.88	0.16	1.34	0.13	2.78	0.20
Dy	5.86	0.31	8.55	0.44	7.58	0.37	14.70	0.50	16.07	0.61	11.45	0.48	5.72	0.30	15.07	0.59
Yb	3.41	0.16	5.48	0.22	4.15	0.19	7.66	0.25	8.56	0.27	5.50	0.23	3.45	0.12	7.72	0.21
Lu	0.43	0.02	0.70	0.03	0.53	0.03	0.87	0.03	1.03	0.03	0.69	0.03	0.48	0.02	1.06	0.04
Hf	7.59	0.27	7.59	0.30	4.74	0.24	8.60	0.32	6.67	0.31	6.05	0.27	6.86	0.26	9.44	0.36
Ta	0.72	0.06	0.59	0.06	0.59	0.07	0.67	0.07	0.56	0.07	0.47	0.06	0.78	0.06	0.62	0.06
Th	8.03	0.16	3.53	0.16	3.63	0.16	5.59	0.19	5.19	0.21	3.08	0.17	7.65	0.18	10.68	0.23

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA225		YAA226		YAA227		YAA228		YAA229		YAA230		YAA231		YAA232	
Batch No.	RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	96456	1413	90239	1411	97395	1367	98138	1292	89475	1187	100293	1504	95213	1380	86807	1126
Ca	23893	1045	23093	1055	23620	951	19768	881	23504	963	20874	1067	21302	1018	22856	1021
Na	10990	227	14517	291	14546	290	8524	177	17706	347	14917	302	13629	274	14523	288
K	19132	2638	16927	2482	18468	2719	15328	2286	21919	2484	11091	2453	14448	2413	22574	2913
Fe	88273	1095	69431	873	73586	919	85586	1065	57175	723	97502	1204	77840	972	62846	791
Ti	5333	458	4982	488	5298	443	4844	414	6258	431	5011	548	5632	489	5510	427
Sc	30.82	0.51	24.57	0.41	25.05	0.42	28.68	0.48	18.25	0.30	39.32	0.65	27.44	0.46	21.74	0.36
V	140.61	15.13	114.31	12.49	146.42	15.29	166.86	17.21	131.85	13.75	134.56	14.72	148.51	15.80	122.91	13.12
Cr	58.92	2.80	59.88	2.90	88.12	2.91	93.45	2.89	69.80	2.45	67.74	2.99	66.21	2.69	57.85	2.67
Mn	1814	56	1596	49	1447	44	1337	41	909	28	2512	77	1799	55	1235	38
Co	32.43	0.50	29.03	0.45	30.75	0.47	29.36	0.45	19.40	0.31	33.43	0.51	31.56	0.48	25.13	0.39
Zn	208.65	8.37	137.28	6.13	160.64	6.82	176.88	7.34	122.66	5.40	258.76	9.87	143.76	6.59	111.80	5.44
As	3.61	0.60	6.04	0.61	8.68	0.66	19.02	0.81	10.31	0.67	7.89	0.84	3.27	0.71	3.45	0.62
Rb	77.63	8.89	49.99	6.46	66.14	7.66	59.13	8.69	60.04	6.84	43.67	7.19	66.75	9.07	57.89	6.71
Cs	-0.51	0.01	-0.46	0.01	4.01	0.23	3.53	0.24	2.48	0.19	-0.56	0.01	0.92	0.18	-0.42	0.01
Ba	1109.57	104.31	1256.01	101.42	894.10	82.04	1130.57	97.42	952.38	82.56	1070.04	109.88	1083.61	91.63	1381.43	98.49
La	103.83	0.76	59.22	0.47	50.30	0.42	47.64	0.40	34.60	0.32	63.88	0.51	69.53	0.55	67.03	0.53
Ce	225.96	2.42	124.78	1.64	105.30	1.55	98.47	1.55	70.61	1.19	141.03	1.90	142.42	1.76	136.87	1.70
Sm	24.07	0.22	13.39	0.12	11.88	0.11	11.76	0.11	8.51	0.09	17.06	0.15	15.96	0.15	14.14	0.13
Eu	4.70	0.09	3.00	0.07	2.72	0.06	2.86	0.07	2.07	0.05	4.01	0.08	3.20	0.07	3.10	0.07
Tb	3.19	0.22	1.78	0.15	1.40	0.14	1.54	0.16	1.11	0.13	1.99	0.18	1.80	0.16	1.61	0.15
Dy	15.97	0.57	10.26	0.49	8.01	0.42	7.79	0.40	5.70	0.36	11.07	0.59	10.83	0.52	8.32	0.41
Yb	8.08	0.25	4.95	0.20	4.68	0.16	4.50	0.17	3.30	0.13	5.88	0.23	5.99	0.22	4.57	0.18
Lu	1.12	0.04	0.64	0.03	0.64	0.03	0.57	0.02	0.43	0.02	0.73	0.03	0.78	0.03	0.61	0.02
Hf	8.18	0.32	6.21	0.27	4.97	0.25	3.52	0.22	9.08	0.32	6.01	0.30	6.05	0.28	6.86	0.28
Ta	0.59	0.07	0.44	0.06	0.48	0.06	0.60	0.07	0.56	0.07	0.43	0.07	0.46	0.07	0.61	0.06
Th	6.31	0.20	2.59	0.15	3.95	0.18	3.97	0.17	2.97	0.15	3.12	0.19	3.82	0.21	3.49	0.16

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA233		YAA234		YAA235		YAA236		YAA237		YAA238		YAA239		YAA241	
Batch No.	RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-13/14		RC1983-15/16	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	88955	1568	89326	1281	76651	1103	94507	1358	84370	1177	102636	1272	92146	1321	85770	1219
Ca	24900	1150	21723	907	10708	652	21699	1010	21881	922	18688	886	23828	1065	24996	1011
Na	9512	200	12418	248	4079	97	16727	330	15389	305	11828	238	19761	386	16299	330
K	20973	2831	26015	2658	18196	2542	17662	2116	21393	2276	26340	2527	18637	2627	24434	2751
Fe	87029	1080	65777	828	43826	564	65944	831	68682	860	58954	746	54935	696	54708	689
Ti	4580	486	4683	388	4579	406	5066	421	7741	444	6444	419	7140	483	3709	382
Sc	30.13	0.50	21.65	0.36	15.10	0.25	23.32	0.39	22.24	0.37	18.59	0.31	18.12	0.30	20.24	0.34
V	136.37	15.02	128.21	13.53	81.13	9.00	107.11	11.59	122.04	13.04	115.31	12.48	119.10	13.30	112.80	12.71
Cr	59.11	2.80	59.61	2.35	52.95	2.11	73.48	2.71	63.82	2.57	55.22	2.37	66.05	2.30	70.24	2.33
Mn	2801	86	1032	32	1236	38	1222	37	1005	31	1068	33	1147	35	1174	36
Co	32.55	0.50	26.92	0.42	22.06	0.35	24.26	0.38	27.26	0.42	21.24	0.34	18.51	0.30	27.20	0.41
Zn	173.72	7.47	105.75	5.38	78.14	4.29	152.08	6.60	113.73	5.48	99.40	5.17	90.18	4.71	89.81	4.58
As	3.69	0.79	4.10	0.78	3.02	0.67	11.51	1.08	1.80	0.77	5.16	0.85	4.38	0.94	2.34	0.40
Rb	65.54	7.73	73.45	7.68	67.78	6.97	47.65	7.11	78.02	8.66	66.52	7.45	46.71	6.44	61.94	6.51
Cs	-0.50	0.01	0.95	0.17	1.18	0.13	2.31	0.21	0.88	0.17	0.57	0.14	1.89	0.16	0.98	0.15
Ba	1264.14	106.34	1817.90	118.34	1075.35	78.11	1107.04	86.42	1727.02	113.67	1527.72	106.36	1066.36	84.10	991.30	81.58
La	95.24	0.72	78.08	0.61	44.88	0.39	39.35	0.37	69.44	0.56	64.02	0.53	37.61	0.36	45.34	0.35
Ce	197.03	2.22	155.65	1.85	96.48	1.33	86.48	1.42	129.92	1.63	118.87	1.52	77.08	1.25	93.82	1.32
Sm	22.82	0.20	15.12	0.15	9.70	0.10	10.05	0.10	14.59	0.13	12.85	0.13	9.49	0.10	9.79	0.10
Eu	4.25	0.08	3.20	0.07	2.17	0.05	2.55	0.06	3.31	0.07	2.86	0.06	2.17	0.05	2.20	0.05
Tb	2.72	0.19	1.96	0.16	1.23	0.11	1.20	0.14	1.82	0.16	1.43	0.14	1.20	0.13	1.61	0.15
Dy	14.95	0.64	8.91	0.41	7.22	0.36	7.01	0.43	8.41	0.38	10.28	0.43	6.08	0.39	7.42	0.38
Yb	8.17	0.25	5.55	0.21	5.12	0.17	3.46	0.15	5.83	0.20	4.58	0.19	3.63	0.17	5.13	0.16
Lu	1.02	0.03	0.73	0.03	0.73	0.02	0.46	0.02	0.71	0.02	0.57	0.02	0.48	0.02	0.74	0.03
Hf	6.56	0.29	7.26	0.29	10.96	0.36	4.83	0.24	6.22	0.28	7.65	0.29	8.61	0.32	4.34	0.20
Ta	0.66	0.07	1.00	0.08	0.91	0.07	0.40	0.06	0.62	0.07	0.65	0.07	0.67	0.06	0.37	0.05
Th	4.59	0.19	5.56	0.19	5.30	0.16	2.34	0.15	4.58	0.17	4.18	0.17	2.68	0.15	3.58	0.14

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA242		YAA243		YAA244		YAA245		YAA246		YAA247		YAA248		YAA249	
Batch No.	RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	87136	1164	86435	1179	74537	1141	93760	1282	87088	1249	75961	993	92032	1368	92351	1230
Ca	20506	947	20366	946	14868	752	19403	930	20681	945	9596	597	21958	1010	20273	898
Na	8638	182	16311	329	10840	223	15879	321	12030	248	3954	94	9252	197	16832	339
K	25532	2600	20190	2155	27071	2598	17035	1983	24421	2694	13234	1780	19438	2724	15572	1948
Fe	77230	960	56963	717	47680	610	61437	769	62614	783	42915	552	89016	1102	55236	695
Ti	11005	561	6123	424	5026	350	6058	386	6139	429	4960	326	4941	497	5872	403
Sc	22.81	0.38	18.88	0.31	16.48	0.27	19.43	0.32	20.80	0.35	14.94	0.25	30.74	0.51	18.19	0.30
V	174.05	18.11	118.96	12.79	81.31	9.01	141.78	14.79	111.60	12.09	83.49	9.34	129.88	14.24	120.32	12.74
Cr	74.50	2.64	67.80	2.33	53.35	2.06	66.21	2.29	67.75	2.51	51.58	1.96	57.21	2.55	65.55	2.23
Mn	1173	36	1018	31	833	26	1084	33	1081	33	901	28	1950	60	1033	32
Co	26.47	0.41	20.48	0.32	62.76	0.89	22.67	0.35	29.21	0.44	20.16	0.32	31.88	0.48	19.80	0.31
Zn	117.22	5.50	114.53	5.05	95.17	4.96	113.43	5.11	109.11	5.12	84.64	4.18	190.52	7.60	97.06	4.64
As	4.16	0.50	9.19	0.66	3.06	0.47	11.67	0.61	2.18	0.50	3.08	0.52	3.19	0.60	9.57	0.71
Rb	57.09	7.63	50.19	5.76	79.13	7.40	58.11	6.16	56.75	6.44	62.08	6.26	56.37	7.37	48.25	5.81
Cs	-0.47	0.01	2.95	0.22	-0.41	0.01	3.23	0.21	-0.45	0.01	0.96	0.14	0.41	0.16	2.55	0.20
Ba	1145.76	94.17	964.79	78.69	1511.33	101.46	916.29	81.45	1326.38	94.97	988.83	73.49	1065.14	99.43	1077.80	83.63
La	99.71	0.71	36.44	0.32	61.34	0.48	35.25	0.32	58.39	0.46	43.66	0.36	92.28	0.69	36.48	0.31
Ce	205.72	2.12	80.16	1.19	189.46	1.92	73.83	1.15	130.09	1.55	93.24	1.28	203.50	2.18	79.85	1.23
Sm	15.87	0.15	8.34	0.08	13.13	0.12	8.22	0.08	12.75	0.12	9.94	0.10	22.14	0.20	8.53	0.09
Eu	2.88	0.06	2.23	0.05	2.90	0.06	2.21	0.05	2.83	0.06	2.10	0.05	4.04	0.08	2.24	0.05
Tb	1.86	0.16	1.03	0.12	1.72	0.15	1.12	0.13	1.73	0.15	1.30	0.13	2.89	0.21	1.15	0.13
Dy	8.78	0.42	5.16	0.36	8.99	0.37	5.86	0.39	7.96	0.41	7.24	0.35	14.21	0.53	5.29	0.36
Yb	5.05	0.17	3.17	0.15	4.88	0.18	3.49	0.15	5.29	0.15	5.17	0.17	7.88	0.24	3.06	0.13
Lu	0.76	0.03	0.39	0.02	0.62	0.03	0.41	0.02	0.77	0.03	0.65	0.02	0.95	0.03	0.42	0.02
Hf	12.74	0.41	6.17	0.25	8.18	0.29	4.09	0.21	8.21	0.29	5.61	0.22	5.55	0.26	7.49	0.27
Ta	0.98	0.07	0.47	0.06	0.59	0.06	0.42	0.05	0.61	0.06	0.80	0.07	0.58	0.07	0.47	0.06
Th	16.02	0.24	3.61	0.14	4.32	0.17	3.01	0.14	4.19	0.14	4.96	0.16	4.56	0.18	2.75	0.14

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA250		YAA251		YAA252		YAA253		YAA254		YAA255		YAA256		YAA257	
Batch No.	RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	91202	1391	86179	1288	88297	1170	76372	1064	87129	1359	83408	1030	84009	1103	96473	1197
Ca	21736	937	23299	979	20106	939	13053	724	23707	1078	55725	1627	40846	1378	20838	955
Na	14963	304	16416	333	12416	255	8152	171	12982	267	6347	136	10012	207	11336	234
K	17341	2284	20881	2258	27676	2764	26734	2577	20308	2685	24731	2368	23771	2229	23306	3210
Fe	61119	768	55362	698	63572	794	44967	573	98920	1216	43782	559	41992	538	85124	1055
Ti	6456	472	4099	424	8536	502	5431	392	15900	741	5351	326	6123	387	4904	443
Sc	19.98	0.33	20.76	0.34	19.10	0.32	16.18	0.27	27.09	0.45	16.98	0.28	15.89	0.26	28.88	0.48
V	115.98	12.79	115.01	12.92	132.83	14.11	79.06	9.15	182.64	18.69	149.70	15.15	139.00	14.34	176.65	18.15
Cr	79.19	2.51	69.14	2.40	58.59	2.22	53.10	2.13	82.69	3.04	71.77	2.37	77.39	2.56	77.94	2.73
Mn	1493	46	1295	40	1099	34	956	29	1645	50	617	19	651	20	1206	37
Co	22.80	0.35	28.70	0.43	22.18	0.34	16.37	0.27	27.40	0.42	13.71	0.23	12.96	0.22	38.50	0.57
Zn	127.11	5.41	93.67	4.70	102.33	4.93	92.36	4.51	164.09	6.79	136.88	6.60	113.14	5.09	164.02	6.82
As	12.60	0.76	3.66	0.55	2.43	0.58	4.11	0.69	5.00	0.83	14.14	0.78	5.41	0.71	6.32	1.02
Rb	57.46	6.38	50.38	5.72	72.39	6.75	86.76	6.55	54.93	7.46	92.78	6.44	74.76	6.49	64.52	7.35
Cs	3.60	0.21	1.25	0.19	0.76	0.15	0.66	0.14	0.89	0.17	7.56	0.25	4.62	0.21	1.27	0.20
Ba	1094.54	82.55	1128.15	81.42	1541.39	102.58	1439.65	96.24	1215.93	93.50	815.34	71.67	888.16	68.59	1092.31	92.52
La	35.57	0.31	44.28	0.38	74.62	0.58	91.43	0.69	62.65	0.51	41.57	0.36	37.93	0.34	83.87	0.66
Ce	77.98	1.24	95.84	1.34	146.35	1.65	143.31	1.64	126.55	1.67	82.88	1.23	75.98	1.19	173.64	1.96
Sm	8.94	0.09	9.43	0.10	14.80	0.14	18.91	0.17	15.28	0.15	8.92	0.10	8.47	0.09	17.49	0.17
Eu	2.20	0.05	2.12	0.05	3.15	0.06	4.01	0.08	3.46	0.07	2.00	0.05	1.84	0.04	3.61	0.07
Tb	1.22	0.14	1.54	0.15	2.01	0.16	2.95	0.19	2.18	0.18	1.21	0.13	0.94	0.12	2.40	0.20
Dy	6.96	0.43	6.66	0.33	9.32	0.42	13.48	0.43	10.08	0.48	6.06	0.31	5.64	0.30	11.65	0.42
Yb	3.36	0.16	5.55	0.19	4.33	0.14	7.55	0.21	5.84	0.17	3.46	0.12	3.47	0.12	7.72	0.20
Lu	0.48	0.02	0.76	0.03	0.60	0.02	0.95	0.03	0.77	0.03	0.48	0.02	0.46	0.02	1.06	0.03
Hf	5.62	0.23	4.46	0.21	11.63	0.38	8.42	0.30	16.31	0.50	6.12	0.25	7.92	0.27	5.37	0.24
Ta	0.47	0.05	0.43	0.06	0.74	0.06	0.72	0.06	1.25	0.08	0.70	0.06	0.84	0.06	0.55	0.07
Th	3.05	0.14	3.91	0.15	7.11	0.18	6.47	0.16	3.50	0.18	7.49	0.16	7.04	0.17	5.01	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA258		YAA259		YAA260		YAA261		YAA262		YAA263		YAA264		YAA265	
Batch No.	RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16		RC1983-15/16	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	92492	1382	91055	1197	94030	1561	79689	1057	87688	1207	89816	1167	91864	1244	93419	1273
Ca	22363	1098	25056	1058	21602	1120	14825	732	17218	868	21991	971	21573	924	21748	1011
Na	10539	221	13227	270	14367	298	8646	181	10692	222	16510	333	11124	229	17046	345
K	18385	2494	18129	2237	24180	3375	28041	2646	23697	2386	19995	2285	24601	2556	24796	2638
Fe	88158	1089	74663	930	67753	846	46015	588	70812	881	55226	695	71345	889	63723	799
Ti	5713	468	4318	403	5435	553	5783	380	7314	450	5104	404	6000	410	6602	449
Sc	30.88	0.51	29.17	0.48	22.56	0.37	16.73	0.28	23.79	0.39	18.56	0.31	23.27	0.39	20.53	0.34
V	164.13	17.26	120.88	12.84	143.18	16.18	82.65	9.05	139.90	14.62	108.67	11.67	141.59	14.84	140.61	14.86
Cr	56.36	2.50	71.39	2.94	90.67	2.86	52.51	2.22	56.98	2.42	67.25	2.37	64.86	2.58	79.48	2.69
Mn	1898	58	942	29	2507	77	767	24	1112	34	970	30	1158	35	1345	41
Co	32.37	0.49	25.71	0.39	28.22	0.43	16.63	0.27	28.44	0.43	20.40	0.32	27.77	0.42	23.04	0.36
Zn	184.60	7.42	162.98	6.71	137.27	5.80	89.65	4.56	125.04	5.63	110.87	4.93	122.18	5.58	120.07	5.27
As	4.64	0.94	10.42	1.07	10.84	1.06	2.69	0.91	4.03	0.96	8.83	1.14	5.23	1.12	8.66	1.21
Rb	68.26	6.94	41.45	6.62	65.20	7.30	94.89	7.91	72.19	7.24	55.89	6.23	64.29	7.87	71.72	6.76
Cs	0.86	0.20	1.92	0.21	4.24	0.24	0.74	0.16	1.06	0.17	3.11	0.20	0.30	0.14	3.53	0.21
Ba	1217.42	104.36	1044.98	83.20	1052.00	87.37	1479.18	97.35	1425.32	97.92	1139.45	79.61	1479.98	100.99	1042.29	81.78
La	100.64	0.77	51.80	0.45	41.14	0.38	96.44	0.75	74.68	0.61	37.94	0.37	74.25	0.62	38.83	0.37
Ce	216.76	2.28	104.34	1.53	85.50	1.34	143.14	1.67	147.50	1.75	78.64	1.24	144.82	1.75	80.59	1.35
Sm	23.46	0.22	13.28	0.13	10.03	0.11	19.85	0.19	15.23	0.15	9.14	0.10	15.64	0.15	9.67	0.10
Eu	4.53	0.09	3.04	0.07	2.39	0.05	4.07	0.08	3.23	0.07	2.15	0.05	3.26	0.07	2.39	0.05
Tb	3.48	0.23	1.50	0.17	1.25	0.14	3.03	0.19	2.10	0.18	1.14	0.14	1.84	0.17	1.44	0.15
Dy	15.53	0.54	8.54	0.39	6.17	0.51	14.79	0.44	9.57	0.41	5.59	0.35	9.51	0.44	5.99	0.39
Yb	8.33	0.26	5.09	0.22	4.12	0.14	7.97	0.22	5.96	0.17	3.72	0.17	5.90	0.21	3.63	0.14
Lu	1.11	0.04	0.67	0.03	0.52	0.03	1.04	0.03	0.83	0.03	0.45	0.02	0.81	0.03	0.49	0.02
Hf	7.15	0.28	2.86	0.19	5.22	0.24	9.39	0.32	7.13	0.28	5.40	0.23	6.04	0.25	7.92	0.29
Ta	0.63	0.07	0.37	0.06	0.49	0.06	0.67	0.06	0.85	0.08	0.40	0.05	0.66	0.06	0.62	0.06
Th	4.99	0.18	2.76	0.16	3.98	0.16	6.85	0.18	4.65	0.17	2.99	0.14	4.61	0.18	3.03	0.16

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA266		YAA267		YAA268		YAA269		YAA270		YAA271		YAA272		YAA273	
Batch No.	RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	94640	1314	85109	1307	93004	1566	92857	1455	91994	1259	90909	1345	87268	1299	98943	1348
Ca	19643	869	20255	869	21801	1118	19967	979	23508	993	23957	1062	21785	1015	19950	956
Na	15370	383	14392	361	10175	265	14895	376	13660	343	13279	336	10611	271	12324	258
K	21503	2553	21469	2665	17575	3091	17264	2833	16095	2378	18684	2494	20839	2979	15433	2949
Fe	63284	830	64578	848	88845	1144	80607	1045	71847	920	74380	969	76078	992	70254	917
Ti	4591	356	5085	402	4826	554	3131	433	4373	396	5332	482	4861	429	4836	428
Sc	21.29	0.36	21.73	0.36	30.74	0.51	28.38	0.47	28.14	0.47	25.02	0.42	27.90	0.46	25.72	0.43
V	126.22	16.02	120.65	15.26	125.17	16.63	136.93	17.51	131.75	16.69	138.35	17.49	139.32	17.80	119.46	15.62
Cr	77.42	2.81	74.59	2.92	52.69	2.85	75.28	2.92	66.33	3.07	79.31	2.79	53.26	2.87	62.22	3.01
Mn	900	34	1031	39	2791	105	2061	77	974	37	1648	62	1730	65	1385	52
Co	23.28	0.40	23.27	0.40	34.12	0.55	33.73	0.55	24.66	0.42	30.60	0.50	25.71	0.44	25.62	0.43
Zn	165.11	11.19	123.84	9.36	184.00	12.71	175.59	13.83	210.68	13.50	194.59	12.87	166.42	11.46	129.37	10.42
As	9.39	0.45	14.85	0.50	3.36	0.47	4.81	0.47	10.07	0.56	12.51	0.59	4.00	0.51	3.73	0.53
Rb	61.08	8.83	37.81	7.88	84.01	11.71	51.84	9.34	53.85	11.12	88.41	10.71	93.94	12.04	57.46	9.16
Cs	2.83	0.24	2.40	0.26	-0.61	0.02	1.19	0.23	1.99	0.28	3.29	0.27	0.55	0.20	0.97	0.24
Ba	1008.93	65.35	1131.67	69.04	1247.40	79.41	1081.68	75.16	997.30	65.60	1043.15	73.01	1223.06	77.06	1311.68	76.91
La	42.76	0.31	42.38	0.31	104.85	0.70	65.92	0.46	49.16	0.36	53.90	0.39	98.75	0.67	70.87	0.49
Ce	86.85	1.34	85.84	1.35	221.98	2.48	138.14	1.82	102.50	1.58	113.13	1.63	207.30	2.34	141.43	1.85
Sm	9.78	0.09	10.32	0.10	24.09	0.22	14.82	0.13	12.82	0.12	11.90	0.12	22.50	0.21	16.58	0.15
Eu	2.38	0.06	2.49	0.07	4.33	0.10	3.06	0.08	2.96	0.08	2.65	0.07	4.27	0.10	3.84	0.09
Tb	1.27	0.18	1.27	0.17	2.67	0.30	1.90	0.21	1.44	0.18	1.32	0.19	2.88	0.25	2.11	0.21
Dy	6.01	0.35	6.63	0.40	16.24	0.67	10.51	0.54	9.43	0.44	8.31	0.44	14.46	0.55	11.68	0.49
Yb	3.54	0.11	4.08	0.13	7.92	0.17	5.31	0.15	4.63	0.14	4.78	0.13	7.61	0.18	5.86	0.16
Lu	0.49	0.02	0.52	0.02	1.01	0.02	0.74	0.02	0.61	0.02	0.66	0.02	0.99	0.02	0.75	0.02
Hf	5.15	0.25	5.76	0.28	6.52	0.31	4.64	0.26	4.57	0.26	4.83	0.28	7.90	0.35	6.33	0.30
Ta	0.66	0.08	0.52	0.08	0.64	0.09	0.29	0.07	0.42	0.07	0.63	0.08	0.58	0.11	0.51	0.08
Th	3.13	0.17	3.19	0.17	7.37	0.23	2.82	0.18	3.41	0.20	4.33	0.20	5.65	0.21	5.13	0.19

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA274		YAA275		YAA276		YAA277		YAA278		YAA279		YAA280		YAA281	
Batch No.	RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89690	1414	91415	1338	91800	1361	93804	1254	97498	1370	93003	1114	98964	1404	93828	1323
Ca	20922	992	16469	824	21302	876	21117	931	19275	912	9342	552	17677	862	15629	835
Na	17608	439	9293	239	11988	303	15106	378	10614	269	5403	141	12559	317	12471	314
K	19218	2551	22110	2725	24666	2616	19584	2467	23170	2988	21417	2198	22839	2679	24225	2557
Fe	55528	734	83862	1083	70438	922	70594	923	77819	1008	48499	656	67132	883	71617	939
Ti	6401	511	12171	649	5934	466	5489	457	5774	446	5768	372	5304	417	3923	389
Sc	17.70	0.30	24.29	0.41	24.05	0.40	23.28	0.39	25.31	0.42	18.65	0.31	23.72	0.40	26.39	0.44
V	123.26	15.92	250.16	30.52	117.60	15.19	153.91	19.42	180.65	22.34	152.56	18.81	128.33	16.40	117.49	14.87
Cr	68.98	2.51	90.74	3.15	53.19	2.67	89.40	3.33	74.86	3.04	84.27	2.95	58.62	2.69	76.34	3.07
Mn	1649	62	1433	54	1307	49	1326	50	1467	55	538	20	1217	46	1236	46
Co	19.68	0.35	27.59	0.46	23.27	0.40	28.89	0.48	35.76	0.57	13.73	0.26	24.11	0.41	27.54	0.46
Zn	101.25	8.36	120.34	9.69	195.11	13.32	141.87	10.20	106.88	9.68	158.10	9.89	114.64	9.39	95.47	8.41
As	6.49	0.60	4.11	0.52	2.95	0.52	4.09	0.55	4.21	0.67	9.87	0.72	4.71	0.70	3.96	0.69
Rb	56.93	7.74	87.56	10.83	59.37	8.06	70.29	9.46	86.50	10.69	94.84	10.18	83.86	10.14	61.45	8.89
Cs	2.99	0.32	1.21	0.26	0.22	0.19	2.59	0.28	-0.55	0.01	3.06	0.23	0.48	0.21	-0.55	0.01
Ba	1015.30	61.37	951.86	64.96	1260.67	78.65	862.49	60.38	1350.15	80.16	748.21	51.09	1183.96	73.25	1194.00	71.78
La	35.81	0.28	55.11	0.40	94.85	0.65	48.51	0.36	71.00	0.50	42.71	0.33	94.79	0.66	58.47	0.43
Ce	74.14	1.23	108.57	1.56	199.43	2.23	101.42	1.48	142.71	1.86	90.45	1.36	206.92	2.32	121.69	1.68
Sm	8.44	0.08	11.98	0.12	20.75	0.19	11.26	0.10	14.69	0.14	9.07	0.10	19.78	0.18	13.13	0.13
Eu	2.16	0.06	2.43	0.07	3.95	0.09	2.55	0.07	3.09	0.08	2.10	0.06	3.78	0.09	2.88	0.07
Tb	0.84	0.13	1.80	0.21	2.50	0.22	1.65	0.20	2.36	0.22	1.07	0.16	2.58	0.21	1.65	0.18
Dy	5.24	0.42	10.57	0.47	12.98	0.49	7.71	0.43	11.38	0.48	6.21	0.30	13.44	0.49	10.07	0.45
Yb	2.75	0.10	6.01	0.15	7.01	0.16	4.12	0.14	7.74	0.19	3.75	0.10	6.70	0.17	6.54	0.15
Lu	0.39	0.01	0.88	0.02	0.91	0.02	0.59	0.02	1.03	0.02	0.50	0.02	0.91	0.02	0.91	0.02
Hf	6.06	0.27	8.34	0.35	9.33	0.38	6.56	0.32	6.90	0.34	7.02	0.29	9.38	0.38	7.94	0.34
Ta	0.50	0.06	0.97	0.10	0.77	0.10	0.63	0.07	0.72	0.09	0.85	0.08	0.54	0.08	0.39	0.08
Th	3.79	0.17	5.95	0.21	6.62	0.21	4.49	0.19	6.29	0.21	8.43	0.21	7.34	0.21	4.05	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA282		YAA283		YAA284		YAA285		YAA286		YAA287		YAA288		YAA289	
Batch No.	RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18		RC1983-17/18	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	91318	1487	98840	1271	89603	1276	86190	1328	87986	1353	96073	1358	87807	1320	88320	1291
Ca	19779	947	20200	926	21966	973	18364	993	19782	854	18955	911	19158	915	21042	957
Na	16251	407	13338	335	11563	293	11876	302	12314	311	12079	306	13932	350	12948	326
K	20675	2891	22927	2535	21848	2606	20400	2745	16789	2853	24480	2757	18836	2286	22106	2900
Fe	63078	813	70541	923	73777	962	77533	1011	78007	1019	70885	928	70080	922	60618	805
Ti	5830	542	6639	465	6691	505	5271	466	5171	439	6112	467	5178	451	5039	443
Sc	20.47	0.34	22.89	0.38	22.78	0.38	26.58	0.44	26.87	0.45	24.67	0.41	24.78	0.41	21.69	0.36
V	130.52	16.72	143.70	17.90	145.95	18.28	109.58	14.37	140.49	18.24	120.43	15.96	128.19	16.14	96.25	12.61
Cr	74.15	2.95	61.36	2.85	64.41	2.87	53.35	2.81	65.74	3.09	56.97	2.78	65.19	2.82	54.01	2.75
Mn	1756	66	982	37	1275	48	1775	67	1458	55	1298	49	1336	50	1272	48
Co	24.06	0.41	28.60	0.47	27.98	0.46	29.00	0.48	31.84	0.52	22.63	0.39	29.03	0.48	21.87	0.38
Zn	172.49	11.94	98.43	8.62	141.59	9.40	200.64	12.50	119.07	10.01	132.86	10.18	141.61	9.81	118.73	9.13
As	7.54	0.82	4.10	0.76	3.97	0.78	2.32	0.03	5.46	1.00	2.56	0.03	4.12	0.99	2.87	0.93
Rb	63.65	8.88	82.79	10.90	74.04	10.21	73.24	9.98	37.03	10.06	74.20	9.33	57.21	10.18	97.16	10.55
Cs	3.09	0.26	0.75	0.20	1.30	0.25	-0.56	0.01	0.68	0.21	0.91	0.19	0.95	0.20	1.44	0.23
Ba	1045.91	63.63	1371.37	77.13	1535.42	82.63	1359.27	79.94	1327.37	77.62	1285.86	78.16	1357.89	82.47	1477.21	81.64
La	37.42	0.31	73.20	0.53	69.18	0.50	99.16	0.70	74.24	0.54	93.19	0.66	60.10	0.46	88.76	0.64
Ce	79.27	1.32	147.38	1.84	143.38	1.91	208.23	2.34	146.81	1.88	194.33	2.21	119.78	1.67	181.64	2.09
Sm	8.95	0.09	14.36	0.14	14.00	0.14	22.40	0.20	16.08	0.16	20.12	0.19	13.65	0.13	19.22	0.18
Eu	2.29	0.06	3.33	0.08	3.19	0.08	4.27	0.10	3.37	0.08	3.86	0.09	2.92	0.08	3.57	0.09
Tb	1.09	0.16	1.94	0.21	1.43	0.16	2.94	0.24	2.08	0.23	2.53	0.22	1.55	0.18	2.23	0.19
Dy	5.58	0.40	10.08	0.43	9.05	0.44	13.69	0.55	9.80	0.48	13.37	0.50	9.41	0.45	11.16	0.44
Yb	3.22	0.11	5.15	0.16	5.04	0.13	7.22	0.18	5.65	0.16	6.80	0.17	4.88	0.14	7.08	0.18
Lu	0.46	0.02	0.67	0.02	0.70	0.02	0.99	0.02	0.80	0.02	0.91	0.02	0.69	0.02	0.92	0.02
Hf	6.81	0.31	7.39	0.31	10.27	0.39	8.60	0.35	6.53	0.33	7.44	0.35	5.92	0.31	8.78	0.35
Ta	0.64	0.07	0.71	0.08	0.86	0.09	0.58	0.08	0.55	0.08	0.66	0.08	0.57	0.07	0.69	0.08
Th	3.10	0.17	4.85	0.22	4.22	0.21	6.50	0.23	3.56	0.20	6.69	0.22	2.86	0.21	6.13	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA290		YAA291		YAA292		YAA293		YAA294		YAA295		YAA296		YAA297	
Batch No.	RC1983-17/18		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	91422	1303	92504	1422	96308	1401	91081	1455	92522	1306	91836	1258	95656	1582	91987	1363
Ca	23103	1008	24481	1102	25036	1035	24974	1170	24273	1033	25724	1147	23979	1115	28270	1116
Na	11389	289	16061	330	11637	244	15648	324	13925	288	10906	230	10703	228	12173	255
K	20509	2311	21513	2302	19221	2448	20068	2482	17069	2314	16550	2387	22380	2626	20378	2525
Fe	71569	938	60263	756	76047	946	74567	930	65790	822	66159	826	82985	1029	70032	875
Ti	5148	414	4878	418	4853	443	3774	408	4900	408	4419	377	5465	468	4570	421
Sc	25.32	0.42	20.29	0.34	26.28	0.44	26.37	0.44	23.33	0.39	23.83	0.40	30.71	0.51	24.15	0.40
V	118.33	15.05	131.79	14.01	148.74	15.65	140.75	15.06	153.60	16.46	122.15	12.97	139.46	15.32	135.77	14.46
Cr	57.42	2.64	73.29	2.47	70.40	2.70	71.97	2.69	85.15	2.99	59.17	2.60	57.72	2.74	67.97	2.58
Mn	1285	48	1062	33	1428	44	1678	51	1243	38	1335	41	1849	57	1469	45
Co	24.30	0.41	23.65	0.37	34.76	0.52	31.33	0.47	24.33	0.38	23.07	0.36	29.52	0.45	32.66	0.49
Zn	140.64	10.36	117.32	5.32	133.88	6.06	148.61	6.38	132.59	5.69	128.12	5.75	198.47	7.77	136.37	6.10
As	2.82	0.04	10.69	0.69	5.31	0.66	4.16	0.66	15.91	0.84	5.13	0.83	1.76	0.65	3.59	0.68
Rb	60.81	9.53	47.24	6.45	67.55	7.19	39.24	6.27	37.44	5.91	70.63	7.31	84.08	9.23	44.11	6.13
Cs	0.32	0.17	2.94	0.21	0.75	0.16	-0.51	0.01	1.99	0.20	-0.48	0.01	-0.54	0.01	-0.50	0.01
Ba	1534.24	85.50	994.34	82.55	1297.73	103.96	1160.57	96.79	1239.29	93.28	1482.86	107.89	1149.42	105.75	1498.64	104.07
La	93.66	0.67	40.12	0.34	83.16	0.63	59.91	0.48	43.66	0.37	85.10	0.65	100.40	0.75	72.34	0.57
Ce	195.59	2.21	84.96	1.30	170.82	1.95	130.25	1.67	90.64	1.35	174.62	1.92	213.99	2.27	150.78	1.77
Sm	20.54	0.20	8.85	0.09	16.93	0.16	13.08	0.12	10.05	0.09	17.85	0.17	22.20	0.21	14.52	0.14
Eu	3.75	0.09	2.38	0.05	3.77	0.07	3.06	0.06	2.48	0.06	3.53	0.07	4.31	0.08	3.30	0.07
Tb	2.55	0.22	1.24	0.14	2.37	0.18	1.81	0.16	1.39	0.14	2.40	0.17	3.54	0.24	2.07	0.17
Dy	13.42	0.49	6.30	0.37	12.44	0.45	10.33	0.49	7.28	0.42	13.46	0.47	16.30	0.55	10.01	0.46
Yb	6.91	0.17	3.91	0.15	7.37	0.23	5.25	0.19	4.01	0.17	7.33	0.22	8.61	0.26	6.09	0.20
Lu	0.96	0.02	0.51	0.02	0.90	0.03	0.72	0.03	0.59	0.03	0.94	0.04	1.12	0.04	0.81	0.03
Hf	7.50	0.32	4.64	0.21	5.67	0.25	5.58	0.24	5.81	0.23	5.89	0.24	7.04	0.28	6.97	0.27
Ta	0.60	0.08	0.46	0.06	0.58	0.07	0.48	0.06	0.44	0.06	0.60	0.07	0.53	0.07	0.53	0.06
Th	6.80	0.22	3.53	0.16	4.71	0.18	2.56	0.16	3.79	0.16	5.19	0.18	5.74	0.21	4.80	0.18

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA298		YAA299		YAA300		YAA301		YAA302		YAA303		YAA304		YAA305	
Batch No.	RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	98046	1368	93190	1282	97972	1437	91485	1425	95332	1326	95380	1247	90950	1027	93088	1402
Ca	23135	1133	26204	1051	22320	1012	23095	1049	23942	1039	24655	1035	32397	1162	21173	946
Na	9009	201	16168	333	13294	277	12636	265	13222	275	12316	255	11481	239	10003	214
K	18032	2720	18667	2282	19584	2276	15308	2559	17677	2660	19798	2139	26361	2288	23474	2885
Fe	89557	1111	60060	755	59389	748	71936	899	67233	842	76356	951	40000	516	78036	973
Ti	4899	498	5020	418	6108	487	5462	573	5004	430	3951	362	5433	357	5683	503
Sc	34.02	0.56	20.21	0.34	20.31	0.34	24.57	0.41	22.77	0.38	26.82	0.44	15.72	0.26	28.23	0.47
V	131.42	14.73	138.74	14.89	151.66	16.11	135.41	14.93	136.46	14.34	147.15	15.22	147.66	15.16	143.42	15.37
Cr	66.48	2.82	71.41	2.48	76.20	2.59	81.36	2.82	79.81	2.64	80.63	2.77	73.04	2.39	55.41	2.51
Mn	2566	79	1095	34	1603	49	1675	51	1295	40	926	28	590	18	1864	57
Co	34.17	0.51	23.44	0.36	23.28	0.36	26.87	0.41	24.13	0.37	27.12	0.41	12.61	0.21	28.82	0.44
Zn	207.74	8.20	120.45	5.36	136.29	5.65	149.81	6.25	134.42	5.83	140.21	6.11	79.31	4.03	172.52	7.08
As	2.44	0.85	9.85	0.90	6.17	0.74	8.25	0.89	12.10	1.17	6.39	1.00	5.61	0.85	1.42	0.96
Rb	78.29	8.89	47.50	6.92	62.71	6.32	66.04	6.93	61.53	6.54	60.98	6.51	99.51	7.27	73.41	7.99
Cs	-0.57	0.01	2.59	0.21	2.81	0.20	2.84	0.22	2.80	0.22	-0.51	0.01	6.45	0.25	-0.53	0.01
Ba	1198.34	98.25	1160.38	87.46	972.17	76.85	1079.28	90.06	1386.29	94.79	1271.36	91.43	881.92	71.15	1284.68	106.85
La	96.92	0.73	40.40	0.36	39.44	0.36	49.48	0.43	41.42	0.37	54.06	0.46	34.02	0.32	98.97	0.77
Ce	216.08	2.34	83.83	1.30	84.25	1.29	101.87	1.47	86.11	1.29	112.14	1.55	68.00	1.17	205.55	2.21
Sm	21.51	0.20	9.18	0.09	8.90	0.09	10.34	0.11	9.58	0.10	11.84	0.11	7.37	0.08	21.51	0.20
Eu	4.44	0.09	2.33	0.05	2.43	0.05	2.60	0.06	2.48	0.05	2.67	0.06	1.76	0.04	4.02	0.08
Tb	3.83	0.27	1.18	0.13	1.18	0.13	1.62	0.15	1.26	0.14	1.67	0.15	1.10	0.12	2.80	0.19
Dy	14.69	0.61	6.19	0.35	7.33	0.43	6.85	0.43	6.92	0.39	10.93	0.44	5.20	0.30	15.26	0.54
Yb	8.80	0.26	3.71	0.14	3.91	0.16	4.82	0.19	4.21	0.18	6.62	0.21	3.41	0.12	7.85	0.21
Lu	1.11	0.04	0.49	0.02	0.50	0.02	0.58	0.02	0.54	0.02	0.90	0.03	0.52	0.02	1.07	0.04
Hf	6.51	0.27	5.67	0.24	6.24	0.24	7.14	0.27	3.29	0.18	4.46	0.22	5.98	0.22	8.92	0.33
Ta	0.56	0.06	0.54	0.06	0.48	0.05	0.64	0.07	0.48	0.06	0.42	0.06	0.69	0.06	0.68	0.06
Th	5.58	0.20	3.30	0.16	3.01	0.15	3.83	0.17	3.69	0.17	4.06	0.17	6.40	0.17	5.99	0.19

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA306		YAA307		YAA308		YAA309		YAA310		YAA311		YAA312		YAA313	
Batch No.	RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20		RC1983-19/20	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	101761	1325	91950	1348	91174	1257	95780	1474	88584	1471	96255	1255	87884	1404	96060	1501
Ca	18884	995	23842	999	25287	1008	20947	1122	23366	990	24282	1115	25108	1141	23229	1022
Na	11486	241	16896	346	15867	325	14951	312	11817	249	18964	386	14897	309	12546	264
K	24168	2631	16527	2076	21382	2452	16640	2430	19532	2638	23090	2573	15536	2211	25506	2910
Fe	80660	1004	58532	739	60353	760	74100	926	69590	868	55182	695	75627	945	65898	826
Ti	6854	496	5838	385	4653	379	4082	471	5181	468	5596	393	2923	391	5609	493
Sc	26.60	0.44	19.67	0.33	20.12	0.33	26.28	0.44	24.67	0.41	18.86	0.31	27.45	0.45	23.42	0.39
V	164.99	17.26	130.92	13.70	133.77	14.29	148.46	16.32	147.06	15.87	120.73	12.75	132.30	14.13	112.43	12.79
Cr	75.30	2.68	72.99	2.51	75.97	2.44	69.35	2.67	79.92	2.64	70.57	2.46	65.84	2.72	56.93	2.51
Mn	1383	42	856	26	1007	31	1880	58	1571	48	927	28	1617	50	1764	54
Co	35.93	0.53	20.58	0.32	22.77	0.35	30.63	0.46	26.65	0.41	21.99	0.34	33.26	0.50	26.32	0.40
Zn	126.60	5.96	114.22	5.28	122.20	5.36	144.06	6.22	139.40	5.96	122.02	5.25	138.13	6.22	147.20	6.24
As	3.25	1.06	8.99	1.10	10.16	1.23	4.93	1.18	12.76	1.31	7.85	1.29	5.67	1.61	3.82	0.05
Rb	90.46	8.44	44.35	6.15	50.31	6.18	55.45	7.20	53.41	7.13	43.41	6.19	28.32	6.54	98.30	8.69
Cs	0.65	0.16	1.71	0.18	2.79	0.20	0.76	0.17	3.04	0.21	1.95	0.18	-0.52	0.01	1.12	0.17
Ba	1398.22	103.71	1065.26	81.21	1145.52	87.46	1145.05	93.24	1331.79	94.74	1085.26	82.62	1365.21	99.05	1387.76	101.56
La	92.35	0.73	40.90	0.38	40.14	0.38	68.32	0.58	45.76	0.42	38.58	0.38	62.48	0.55	94.92	0.77
Ce	191.63	2.09	83.53	1.30	83.75	1.31	136.45	1.70	89.54	1.40	80.11	1.27	131.27	1.69	202.49	2.14
Sm	17.65	0.17	9.12	0.10	9.27	0.10	14.54	0.14	10.48	0.11	8.76	0.10	13.72	0.14	19.32	0.19
Eu	3.91	0.07	2.30	0.05	2.36	0.05	3.23	0.07	2.55	0.06	2.33	0.05	3.06	0.06	3.87	0.08
Tb	1.97	0.16	1.22	0.13	1.31	0.13	1.90	0.16	1.40	0.14	1.25	0.13	1.82	0.16	2.35	0.18
Dy	12.57	0.47	6.23	0.35	6.30	0.36	10.26	0.48	7.46	0.42	6.55	0.38	9.30	0.48	13.60	0.51
Yb	8.04	0.26	3.76	0.17	3.71	0.17	6.41	0.24	4.59	0.20	3.68	0.15	5.67	0.20	7.07	0.20
Lu	1.00	0.03	0.51	0.02	0.52	0.02	0.78	0.03	0.60	0.03	0.50	0.02	0.76	0.03	0.95	0.03
Hf	10.83	0.35	7.35	0.26	5.16	0.22	6.46	0.26	5.22	0.24	7.18	0.28	4.48	0.23	7.74	0.28
Ta	0.77	0.07	0.58	0.05	0.51	0.06	0.37	0.06	0.46	0.06	0.49	0.06	0.34	0.05	0.68	0.06
Th	6.56	0.20	4.57	0.16	3.46	0.15	3.17	0.18	3.27	0.17	3.49	0.16	2.57	0.17	7.50	0.20

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA314		YAA315		YAA316		YAA317		YAA318		YAA319		YAA320		YAA321	
Batch No.	RC1983-19/20		RC1983-19/20		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	104806	1527	91541	1433	99309	1336	100869	1479	96580	1331	98311	1273	103113	1333	93004	1295
Ca	17723	934	16886	996	21148	966	19460	915	18935	924	15744	777	15186	771	20469	912
Na	11552	241	13131	277	14787	301	10707	226	12159	252	15247	310	13196	271	17723	357
K	24405	2347	18821	2807	18532	2350	15514	2718	23341	2543	24571	2531	16060	2174	19492	2445
Fe	72942	909	65751	824	66707	863	90686	1136	70031	905	63849	829	74602	960	61840	807
Ti	5874	450	5926	503	5276	417	4980	513	5308	484	5121	374	6452	442	6122	405
Sc	24.61	0.41	22.43	0.37	23.33	0.39	32.67	0.54	25.23	0.42	21.21	0.35	26.93	0.45	21.05	0.35
V	157.49	16.66	140.94	15.43	141.50	15.03	156.67	16.47	121.21	13.36	140.16	14.55	169.81	17.65	124.18	13.23
Cr	67.65	2.78	74.55	2.56	82.82	3.13	58.73	3.30	60.38	2.59	77.88	2.78	85.95	3.32	77.85	2.91
Mn	1125	34	1993	61	1169	36	2121	65	1563	48	747	23	994	30	855	26
Co	30.67	0.46	26.24	0.40	24.91	0.42	32.38	0.52	25.67	0.42	21.33	0.36	24.42	0.41	23.23	0.39
Zn	129.40	5.78	136.69	6.02	167.13	8.97	222.56	11.00	173.69	8.94	162.40	8.17	160.29	8.55	151.27	7.95
As	4.18	0.06	14.10	1.73	9.03	0.56	3.11	0.51	2.88	0.52	11.19	0.62	11.39	0.60	7.31	0.62
Rb	76.26	7.79	60.30	7.49	47.29	7.09	57.30	9.64	86.47	9.00	58.88	7.57	30.90	6.84	68.93	9.20
Cs	-0.50	0.01	3.32	0.22	3.37	0.27	-0.67	0.02	0.70	0.21	2.78	0.25	1.23	0.25	2.71	0.25
Ba	1600.60	110.41	1434.67	100.52	1003.92	68.31	1318.29	86.52	1352.48	80.35	1111.00	75.48	892.25	66.43	1085.96	68.76
La	84.12	0.68	45.16	0.43	44.07	0.33	106.74	0.72	95.88	0.65	42.18	0.32	50.96	0.38	41.61	0.32
Ce	167.26	1.93	91.49	1.40	90.89	1.42	227.07	2.50	202.58	2.35	83.26	1.51	105.18	1.64	88.56	1.47
Sm	16.39	0.15	10.20	0.10	10.53	0.10	24.88	0.23	20.74	0.19	9.62	0.10	12.23	0.11	9.84	0.10
Eu	3.63	0.07	2.49	0.05	2.53	0.07	4.63	0.10	4.04	0.09	2.46	0.06	2.81	0.07	2.54	0.07
Tb	2.23	0.17	1.18	0.13	1.44	0.20	3.02	0.27	2.83	0.26	1.31	0.21	1.53	0.23	1.37	0.20
Dy	11.18	0.44	7.10	0.47	7.64	0.42	16.82	0.60	12.72	0.51	6.44	0.36	9.04	0.41	7.33	0.38
Yb	6.33	0.19	4.72	0.21	4.41	0.13	8.58	0.19	8.32	0.19	3.70	0.13	4.77	0.13	3.92	0.12
Lu	0.85	0.03	0.59	0.02	0.59	0.02	1.17	0.03	1.04	0.02	0.53	0.02	0.69	0.02	0.57	0.02
Hf	5.85	0.25	6.11	0.24	5.75	0.28	7.62	0.34	7.70	0.33	6.03	0.28	6.60	0.31	7.10	0.30
Ta	0.77	0.08	0.40	0.06	0.53	0.07	0.66	0.09	0.72	0.10	0.56	0.07	0.68	0.08	0.53	0.08
Th	4.83	0.17	3.68	0.17	3.67	0.18	5.50	0.23	6.26	0.22	3.81	0.20	4.87	0.21	3.20	0.19

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA322		YAA323		YAA324		YAA325		YAA326		YAA327		YAA328		YAA329	
Batch No.	RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22		RC1983-21/22	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	102053	1331	97441	1397	102036	1375	96529	1336	102519	1405	97959	1411	98385	1407	92534	1295
Ca	19651	907	17567	850	15105	781	18493	958	15770	798	19522	958	22061	1048	18292	895
Na	15834	322	14595	298	11190	232	13644	279	12319	254	13800	285	13726	283	14421	295
K	21323	2360	16929	2142	20822	2356	22619	2351	16315	2183	21669	2510	20058	2648	18767	2715
Fe	65511	851	69398	881	77586	998	68895	876	79197	1000	80835	1039	81582	1048	77415	994
Ti	5700	452	6477	449	5859	440	4885	422	5018	412	5248	491	4715	446	6243	438
Sc	22.89	0.38	25.00	0.42	28.04	0.47	23.54	0.39	29.79	0.49	28.86	0.48	29.54	0.49	26.58	0.44
V	150.47	15.70	157.37	16.32	175.73	18.23	152.65	15.94	154.12	16.07	151.39	15.81	165.26	17.86	161.81	17.04
Cr	86.99	3.07	90.28	3.26	103.96	3.80	85.98	3.23	77.65	3.09	74.66	3.19	74.12	3.07	81.58	3.18
Mn	910	28	1216	37	1334	41	1246	38	1181	36	1543	47	1517	46	1396	43
Co	23.53	0.39	24.80	0.41	28.40	0.47	26.98	0.44	27.19	0.45	35.84	0.57	34.85	0.55	28.07	0.46
Zn	157.00	8.19	136.73	8.06	233.41	11.59	183.14	8.93	194.24	9.84	183.22	9.44	196.84	10.27	210.75	10.90
As	8.21	0.62	4.74	0.63	10.69	0.73	10.37	0.82	6.31	0.87	3.02	0.71	2.25	0.04	5.83	0.85
Rb	53.34	8.17	53.69	7.77	52.90	7.91	65.27	8.29	60.35	9.00	56.39	8.18	55.84	7.92	66.95	8.67
Cs	4.21	0.28	2.34	0.26	3.95	0.29	4.01	0.34	1.71	0.29	0.94	0.25	0.78	0.23	2.86	0.27
Ba	936.93	63.63	972.37	69.70	972.92	68.05	1205.42	73.17	985.51	67.03	1124.29	77.51	1441.59	86.50	943.27	69.70
La	43.19	0.33	46.70	0.35	50.74	0.38	43.76	0.34	53.24	0.40	73.43	0.53	75.44	0.55	49.23	0.38
Ce	87.87	1.55	99.48	1.64	106.17	1.64	89.03	1.50	106.23	1.75	150.87	1.94	150.34	1.96	105.69	1.62
Sm	10.27	0.10	11.19	0.11	12.15	0.12	10.62	0.11	13.27	0.13	16.45	0.15	16.94	0.16	11.52	0.11
Eu	2.55	0.07	2.63	0.07	2.79	0.07	2.59	0.07	2.87	0.07	3.20	0.08	3.50	0.08	2.79	0.07
Tb	1.27	0.20	1.85	0.22	1.85	0.22	1.26	0.20	1.80	0.22	2.13	0.26	2.56	0.27	1.47	0.21
Dy	7.35	0.39	7.23	0.40	8.87	0.44	7.27	0.40	9.66	0.43	10.59	0.46	12.45	0.50	7.40	0.44
Yb	4.47	0.12	4.62	0.13	5.34	0.14	4.27	0.12	5.65	0.14	6.96	0.17	7.02	0.18	4.19	0.12
Lu	0.60	0.02	0.63	0.02	0.69	0.02	0.61	0.02	0.79	0.02	0.90	0.02	0.93	0.02	0.60	0.02
Hf	5.40	0.28	7.45	0.33	5.95	0.29	4.42	0.26	5.19	0.30	5.97	0.30	6.38	0.30	6.49	0.32
Ta	0.63	0.08	0.63	0.07	0.58	0.08	0.52	0.07	0.60	0.08	0.51	0.07	0.41	0.08	0.63	0.09
Th	3.74	0.19	3.86	0.20	4.93	0.22	3.33	0.20	3.84	0.21	4.35	0.21	3.53	0.21	4.41	0.21

Table B.1: INAA Compositional Data for Yaasuchi Ceramics (Continued)

INAA ID	YAA330		YAA331	
Batch No.	RC1983-21/22		RC1983-03/04	
	ppm	± 1σ	ppm	± 1σ
Al	96255	1344	79194	574
Ca	16820	862	30488	1601
Na	14867	304	16635	340
K	14497	2154	21503	2695
Fe	82345	1039	80164	998
Ti	4637	433	16938	834
Sc	31.13	0.52	24.80	0.41
V	154.93	16.37	182.84	18.23
Cr	76.52	3.17	61.81	2.56
Mn	1330	41	1326	41
Co	27.28	0.45	26.54	0.41
Zn	181.08	9.37	138.99	6.21
As	8.16	0.96	1.71	0.02
Rb	33.88	8.18	47.40	7.18
Cs	1.60	0.25	-0.44	0.01
Ba	1107.30	75.73	1054.94	92.69
La	54.33	0.42	77.62	0.60
Ce	119.19	1.77	164.14	1.93
Sm	13.41	0.13	16.84	0.12
Eu	3.31	0.08	3.37	0.07
Tb	1.86	0.25	2.29	0.17
Dy	8.77	0.45	10.95	0.77
Yb	5.18	0.15	6.03	0.21
Lu	0.75	0.02	0.73	0.03
Hf	6.70	0.31	15.73	0.50
Ta	0.56	0.09	1.25	0.09
Th	3.35	0.21	8.34	0.20

Table B.2: INAA Compositional Data for Yaasuchi Clay Survey Samples. Negative values are below minimum detection limits.

INAA ID	YCS283		YCS288A		YCS289		YCS290		YCS294A		YCS294B		YCS294C		YCS308A	
Batch No.	RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-03/04		RC1983-03/04		RC1983-03/04	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	71457	538	81367	552	94786	607	100406	656	85290	584	86439	584	87838	592	102059	632
Ca	11851	1142	3664	389	8850	947	15978	1077	20206	2247	23564	1378	26767	1402	21732	1246
Na	8952	197	7808	174	12808	272	4488	114	14906	315	15352	315	15779	322	16471	334
K	21229	2217	34232	2466	22320	2335	9695	2285	15139	1934	17687	1849	17040	1710	19003	2061
Fe	88979	1100	60328	756	59748	754	91177	1129	80259	994	68466	857	72222	901	67960	852
Ti	30178	1336	17106	811	10352	644	14002	767	7918	532	7649	502	10384	626	5341	508
Sc	20.17	0.34	16.60	0.28	20.40	0.34	36.25	0.60	20.83	0.35	19.45	0.32	19.66	0.33	31.03	0.51
V	245.14	24.39	156.88	15.87	126.93	13.10	185.35	18.72	113.42	11.89	115.44	11.93	138.59	14.14	133.98	13.75
Cr	45.39	2.10	40.23	1.89	53.42	2.43	62.53	2.70	84.45	2.64	104.57	2.93	117.43	3.13	74.55	2.78
Mn	1346	42	801	25	755	24	1643	51	1182	37	1071	33	941	29	549	17
Co	24.08	0.37	12.85	0.22	15.78	0.26	31.36	0.48	34.04	0.51	31.46	0.47	29.94	0.45	26.21	0.41
Zn	119.34	5.54	89.09	4.46	75.47	4.29	187.34	7.78	133.82	5.98	122.92	5.64	120.56	5.61	191.29	7.66
As	0.77	0.35	1.20	0.25	5.63	0.73	0.79	0.25	1.97	0.27	1.11	0.37	1.35	0.36	1.71	0.40
Rb	70.36	7.44	92.48	7.43	59.73	6.25	21.13	5.88	68.33	8.06	60.63	7.29	47.12	6.38	39.35	6.20
Cs	-0.45	0.01	-0.40	0.01	0.44	0.13	-0.54	0.01	0.65	0.15	-0.41	0.01	-0.41	0.01	1.67	0.20
Ba	1156.07	90.15	1257.60	100.32	1238.55	81.61	836.64	90.53	920.95	92.01	794.23	80.80	817.33	75.68	1027.55	93.07
La	55.76	0.41	118.34	0.80	42.83	0.35	59.01	0.42	46.46	0.33	48.78	0.39	53.19	0.40	71.43	0.54
Ce	113.68	1.47	226.48	2.21	82.09	1.26	120.67	1.68	97.06	1.34	92.58	1.32	101.13	1.41	158.15	1.88
Sm	12.08	0.09	15.22	0.11	7.44	0.06	17.53	0.13	9.40	0.07	9.94	0.07	9.26	0.07	15.16	0.12
Eu	3.13	0.07	2.87	0.06	2.16	0.05	4.05	0.08	2.91	0.06	2.86	0.06	2.75	0.06	4.24	0.08
Tb	1.54	0.13	1.64	0.14	1.29	0.13	3.28	0.22	1.68	0.15	1.44	0.13	1.38	0.13	2.28	0.17
Dy	8.49	0.72	8.24	0.67	6.63	0.57	18.58	0.95	8.25	0.75	7.72	0.69	6.35	0.58	11.82	0.74
Yb	4.70	0.18	3.48	0.13	4.74	0.16	9.71	0.23	3.83	0.18	4.09	0.16	4.06	0.17	5.38	0.22
Lu	0.56	0.02	0.48	0.03	0.66	0.02	1.26	0.03	0.49	0.02	0.54	0.02	0.48	0.02	0.75	0.03
Hf	14.41	0.46	23.70	0.71	13.61	0.44	7.98	0.32	5.22	0.26	6.29	0.27	5.71	0.23	7.31	0.29
Ta	2.21	0.11	1.71	0.10	1.28	0.08	0.98	0.09	0.58	0.06	0.56	0.07	0.87	0.07	0.41	0.07
Th	2.85	0.15	20.76	0.29	5.85	0.17	0.83	0.13	2.08	0.14	1.99	0.14	2.06	0.14	3.20	0.17

Table B.2: INAA Compositional Data for Yaasuchi Clay Survey Samples (Continued)

INAA ID	YCS308B		YCS309A		YCS309B		YCS310A		YCS310B		YCS320		YCS321		YCS333	
Batch No.	RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-03/04	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	89960	585	87275	592	91406	596	87138	980	93522	583	110375	659	86602	588	76217	593
Ca	17480	1356	19078	1178	17788	1398	24413	1783	15663	1166	16082	4056	9195	965	26046	1633
Na	17011	354	17532	366	17667	368	22147	457	16514	345	10372	222	814	48	10129	216
K	15669	1645	19348	2228	16821	2048	27374	2470	17002	1692	15478	1610	-3995	191	28571	2203
Fe	59352	748	62148	781	66370	829	46429	592	68168	854	66577	841	73909	917	77713	979
Ti	4837	387	6671	463	5978	394	7733	710	4057	374	4685	398	5787	505	14778	749
Sc	25.01	0.41	23.23	0.39	25.24	0.42	17.33	0.29	26.53	0.44	35.67	0.59	10.38	0.17	17.93	0.30
V	109.88	11.63	122.24	12.57	126.65	13.19	112.63	12.23	129.68	13.17	268.72	26.52	54.19	6.64	129.74	13.62
Cr	58.78	2.46	61.26	2.70	60.28	2.42	49.76	2.04	59.98	2.40	82.71	3.04	14.27	1.68	164.60	4.05
Mn	502	16	732	23	610	19	674	21	506	16	345	11	1466	45	562	18
Co	21.28	0.34	21.66	0.34	23.73	0.37	13.82	0.23	20.53	0.33	36.12	0.54	9.42	0.17	33.01	0.51
Zn	152.11	6.29	134.82	5.85	154.50	6.64	92.56	4.53	150.99	6.40	193.58	7.78	173.89	6.56	213.18	8.36
As	2.61	0.40	3.62	0.65	3.47	0.57	1.08	0.33	0.48	0.55	1.60	0.50	1.95	0.40	2.42	0.59
Rb	43.01	6.47	49.09	7.18	53.61	7.88	48.32	5.91	43.59	7.02	41.62	7.07	-13.38	0.59	217.36	13.12
Cs	1.40	0.18	1.19	0.18	1.12	0.18	0.67	0.13	1.30	0.18	1.34	0.21	-0.35	0.01	3.08	0.22
Ba	1082.26	86.43	1163.23	85.62	1157.57	89.66	1286.46	89.63	1165.79	90.02	1019.19	90.89	579.96	67.76	1853.79	122.53
La	63.64	0.47	59.47	0.46	65.19	0.47	52.09	0.41	65.76	0.48	76.72	0.56	57.20	0.42	104.51	0.79
Ce	128.86	1.60	121.32	1.57	129.48	1.62	108.17	1.37	129.99	1.65	148.73	1.85	124.70	1.49	232.57	2.48
Sm	13.17	0.10	12.99	0.10	13.61	0.10	10.96	0.08	14.10	0.10	16.45	0.12	14.06	0.10	22.52	0.17
Eu	3.49	0.07	3.32	0.07	3.53	0.07	3.10	0.06	3.38	0.07	3.76	0.08	3.58	0.07	4.01	0.08
Tb	2.00	0.15	2.08	0.16	1.86	0.15	1.74	0.14	1.70	0.15	2.27	0.18	1.54	0.12	2.32	0.18
Dy	9.65	0.62	9.67	0.67	10.65	0.71	8.05	0.70	10.83	0.64	12.95	0.67	8.89	0.66	11.65	0.68
Yb	5.36	0.19	5.00	0.19	4.90	0.18	3.71	0.13	5.27	0.18	6.54	0.17	5.29	0.13	5.46	0.25
Lu	0.67	0.03	0.59	0.02	0.58	0.02	0.47	0.02	0.67	0.03	0.91	0.03	0.71	0.02	0.66	0.03
Hf	6.29	0.26	8.95	0.33	7.17	0.29	9.48	0.32	3.57	0.22	3.12	0.22	14.59	0.45	17.88	0.55
Ta	0.52	0.07	0.55	0.06	0.53	0.06	0.81	0.06	0.57	0.08	0.41	0.07	1.75	0.10	1.23	0.09
Th	2.51	0.15	2.23	0.15	2.28	0.15	2.17	0.13	2.13	0.15	3.55	0.17	39.35	0.45	7.05	0.21

Table B.2: INAA Compositional Data for Yaasuchi Clay Survey Samples (Continued)

INAA ID	YCS334		YCS335		YCS336A		YCS336B		YCS337A		YCS337B		YCS337C		YCS338	
Batch No.	RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	75296	522	68677	485	104873	640	85271	557	91843	585	96135	610	58947	389	88529	587
Ca	13597	1168	6161	1648	13731	1087	7149	759	12642	1017	13338	1231	5704	587	16082	1354
Na	9314	202	10374	222	11237	240	10232	219	12299	260	9693	209	7934	169	17361	362
K	24801	2199	33122	2102	16217	1846	36373	2252	21415	1820	18919	1774	24207	1483	27077	2387
Fe	78044	969	21993	299	70325	885	39987	516	58632	743	65029	816	24847	323	50370	638
Ti	10528	592	2708	274	4968	419	4883	396	5017	395	4065	354	2462	247	6243	498
Sc	17.83	0.30	8.80	0.15	35.50	0.59	16.10	0.27	23.80	0.39	26.23	0.43	9.36	0.16	18.98	0.32
V	130.06	13.26	63.90	6.98	117.07	12.14	90.11	9.46	126.28	12.95	128.23	13.15	48.25	5.24	110.69	11.45
Cr	104.40	3.03	31.00	1.64	76.03	2.86	43.51	1.99	58.32	2.38	68.25	2.70	26.87	1.18	52.21	2.42
Mn	455	14	107	4	437	14	280	9	366	12	222	7	102	3	516	16
Co	25.33	0.39	7.10	0.14	31.96	0.49	21.82	0.34	25.40	0.39	25.75	0.40	7.72	0.14	19.38	0.31
Zn	137.88	5.89	44.27	2.82	209.51	8.18	83.60	4.41	139.39	6.03	139.52	6.13	51.46	2.73	97.34	4.74
As	1.47	0.30	0.61	0.26	1.57	0.02	1.60	0.33	1.64	0.02	0.25	0.36	0.41	0.19	1.53	0.30
Rb	105.19	8.04	79.06	5.54	40.79	6.42	78.80	6.72	54.12	7.10	55.72	7.91	60.05	4.76	54.25	6.63
Cs	1.67	0.18	-0.28	0.01	1.82	0.23	0.67	0.15	0.90	0.17	1.03	0.18	0.41	0.09	0.78	0.16
Ba	1902.48	114.13	2123.22	119.07	1011.00	93.12	2039.82	121.33	1400.33	95.90	1348.59	96.03	1320.85	78.83	1182.72	100.02
La	65.76	0.47	92.14	0.64	80.67	0.59	81.19	0.57	82.94	0.61	82.35	0.57	57.61	0.40	60.96	0.42
Ce	137.10	1.62	147.84	1.56	161.19	1.92	137.44	1.55	144.66	1.73	140.63	1.67	88.26	1.01	128.95	1.50
Sm	11.86	0.09	8.21	0.06	16.99	0.12	11.47	0.08	14.01	0.10	13.97	0.10	7.03	0.05	10.45	0.08
Eu	3.01	0.06	2.67	0.06	4.06	0.08	3.65	0.07	3.48	0.07	3.45	0.07	2.33	0.05	3.20	0.07
Tb	1.67	0.14	0.83	0.09	1.92	0.17	1.53	0.13	1.77	0.15	1.89	0.17	1.05	0.09	1.54	0.13
Dy	7.84	0.58	5.84	0.41	13.16	0.70	8.57	0.51	10.70	0.60	10.69	0.58	5.27	0.36	8.44	0.69
Yb	3.90	0.15	3.30	0.11	6.65	0.20	5.08	0.17	6.35	0.19	6.61	0.16	4.01	0.12	4.08	0.17
Lu	0.49	0.02	0.45	0.02	0.87	0.03	0.63	0.02	0.77	0.03	0.87	0.03	0.50	0.02	0.52	0.03
Hf	6.61	0.28	3.75	0.17	3.00	0.21	7.83	0.29	6.29	0.29	3.24	0.21	3.83	0.15	9.96	0.34
Ta	0.57	0.07	0.34	0.04	0.44	0.07	0.53	0.06	0.52	0.06	0.56	0.07	0.42	0.04	0.65	0.06
Th	5.07	0.17	29.81	0.34	4.86	0.19	13.50	0.22	9.14	0.21	7.02	0.18	8.13	0.14	3.94	0.14

Table B.2: INAA Compositional Data for Yaasuchi Clay Survey Samples (Continued)

INAA ID	YCS342		YCS344		YCS346		YCS348A		YCS348B	
Batch No.	RC1983-03/04		RC1983-01/02		RC1983-01/02		RC1983-01/02		RC1983-01/02	
	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ	ppm	± 1σ
Al	83452	554	80437	547	91291	587	96860	627	114555	684
Ca	12104	1467	18600	1299	6968	878	11226	992	8174	772
Na	9980	209	10258	222	11053	236	11534	248	6409	146
K	19726	1657	37351	2598	18742	1771	25009	2463	22359	2029
Fe	62454	784	34676	453	61880	778	60904	767	91037	1127
Ti	5564	400	4043	377	5095	384	6657	548	3990	421
Sc	20.29	0.34	10.99	0.18	25.98	0.43	21.26	0.35	34.26	0.57
V	101.05	10.65	65.48	7.30	135.73	14.08	130.04	13.43	190.97	19.18
Cr	51.89	2.18	28.66	1.54	61.94	2.30	43.32	2.25	75.91	2.89
Mn	441	14	626	20	347	11	1055	33	926	29
Co	24.63	0.38	15.59	0.26	32.77	0.49	21.67	0.34	36.52	0.55
Zn	152.65	6.64	73.03	3.79	155.58	6.51	113.35	5.21	184.36	7.57
As	1.50	0.35	0.79	0.24	2.67	0.32	9.75	0.53	23.45	0.61
Rb	64.50	6.50	86.60	6.30	44.52	6.20	67.33	7.22	61.29	8.39
Cs	0.92	0.16	0.54	0.11	0.92	0.18	0.89	0.17	1.17	0.20
Ba	1177.57	93.88	2080.71	127.25	1130.68	94.39	1294.87	93.74	929.24	91.51
La	65.87	0.50	112.00	0.76	69.36	0.47	61.08	0.44	56.20	0.40
Ce	128.02	1.55	208.62	2.05	131.79	1.63	114.73	1.49	123.38	1.67
Sm	10.83	0.08	10.77	0.08	12.21	0.09	11.36	0.08	12.52	0.09
Eu	3.21	0.07	3.15	0.06	3.51	0.07	2.89	0.06	3.12	0.07
Tb	1.37	0.13	1.20	0.11	1.84	0.15	1.48	0.13	2.15	0.16
Dy	8.5	0.58	6.50	0.52	11.49	0.58	9.72	0.74	12.35	0.72
Yb	5.59	0.19	3.03	0.12	5.67	0.21	4.76	0.16	7.46	0.20
Lu	0.70	0.02	0.44	0.02	0.73	0.03	0.60	0.02	0.98	0.03
Hf	7.17	0.29	7.98	0.27	5.32	0.25	10.05	0.35	4.58	0.23
Ta	0.64	0.06	0.55	0.06	0.50	0.07	0.61	0.06	0.58	0.06
Th	6.93	0.18	60.04	0.63	4.75	0.16	6.04	0.17	4.71	0.20

Table B.3: Mean INAA Compositional data for NIST1633B and NORC Standard Reference Materials. Estimated concentrations are shown by element relative to values reported by Glascock (2006). NIST certified values are in parentheses.

Element	Gamma Count	Energy (KeV)	NIST1633B This Study; n = 15 Mean ppm	± 1s	C.V.	NIST1633B Glascock 2006 Mean ppm	± 1s	C.V.	New Ohio Red Clay (NORC) This Study; n = 15 Mean ppm	± 1s	C.V.	Ohio Red Clay (ORC) Glascock 2006 Mean ppm	± 1s	C.V.
Al	PT	1779	147945	3363	2.3	150500	2700	1.8	98483	1777	1.8	94500	2800	3.0
Ca	PT	3084	14026	2124	15.1	15100	600	4.0	1326	215	16.2	4400	290	6.6
Na	PT	1368	1935	55	2.8	2010	30	1.5	1447	37	2.6	1357	42	3.1
K	PT	1524	19857	2473	12.5	19500	300	1.5	35053	1289	3.7	34600	1100	3.2
Fe	W4	[illegible]	77831	1586	2.0	8	0	3.0	51460	1442	2.8	50480	1520	3.0
Ti	PT	320	7774	323	4.2	7910	140	1.8	6500	322	5.0	6121	281	4.6
Sc	W4	[illegible]	40.31	0.76	1.9	(41)	---	---	18.51	0.56	3.0	18.30	0.50	2.7
V	PT	1434	303.38	10.04	3.3	295.70	3.60	1.2	207.72	8.17	3.9	203.00	6.00	3.0
Cr	W4	[illegible]	197.98	4.32	2.2	198.20	4.70	2.4	92.40	3.76	4.1	90.20	1.90	2.1
Mn	PT	847	143.95	4.03	2.8	131.80	1.70	1.3	266.74	5.54	2.1	261.00	14.00	5.4
Co	W4	[illegible]	48.98	0.99	2.0	(50)	---	---	22.93	0.78	3.4	22.70	0.50	2.2
Zn	W4	[illegible]	210.71	32.40	15.4	(210)	---	---	86.62	8.49	9.8	92.80	11.00	11.9
As	W1	[illegible]	130.66	3.41	2.6	136.20	2.60	1.9	15.18	1.17	7.7	14.80	1.10	7.4
Rb	W4	[illegible]	142.53	22.33	15.7	(140)	---	---	183.98	16.36	8.9	180.80	5.30	2.9
Cs	W4	[illegible]	10.61	0.42	4.0	(11)	---	---	10.33	0.50	4.8	10.10	0.20	2.0
Ba	W1	[illegible]	637.70	62.23	9.8	709.00	27.00	3.8	634.51	53.54	8.4	612.00	33.00	5.4
La	W1	[illegible]	85.58	1.27	1.5	(94)	---	---	51.00	1.38	2.7	50.10	1.00	2.0
Ce	W4	[illegible]	182.24	5.10	2.8	(190)	---	---	113.79	4.57	4.0	112.30	2.70	2.4
Sm	W1	[illegible]	18.47	0.58	3.1	(20)	---	---	9.51	0.44	4.7	9.17	0.40	4.4
Eu	W4	[illegible]	3.94	0.12	3.0	(4.1)	---	---	1.77	0.10	5.8	1.72	0.05	2.6
Tb	W4	[illegible]	2.78	0.41	14.9	(2.6)	---	---	1.32	0.13	10.1	1.24	0.20	16.1
Dy	PT	95	15.48	0.62	4.0	(17)	---	---	7.26	0.28	3.9	6.89	0.37	5.4
Yb	W1	[illegible]	7.50	0.30	4.0	(7.6)	---	---	4.39	0.20	4.6	4.32	0.21	4.9
Lu	W1	[illegible]	1.06	0.04	4.0	(1.2)	---	---	0.62	0.02	4.0	0.59	0.02	3.6
Hf	W4	[illegible]	7.14	0.33	4.6	(6.8)	---	---	7.41	0.31	4.2	7.34	0.20	2.7
Ta	W4	[illegible]	1.89	0.10	5.4	1.04	.14	1.3	1.57	0.12	7.7	1.49	0.30	20.1
Th	W4	[illegible]	25.17	0.66	2.6	25.70	1.30	5.1	15.54	0.60	3.9	14.90	0.30	2.0

APPENDIX C:

LA-ICP-MS Compositional Data

Table C.1: LA-ICP-MS Compositional Data for 9 Yaasuchi Ceramics. Si concentrations were estimated using INAA compositional data and used as an internal standard to calculate abundances of other elements.

Group	Atoyac/Zaachila						Yaasuchi					
INAA ID	YAA160		YAA204		YAA265		YAA138		YAA269		YAA278	
	Mean ppm	± 1s	Mean ppm	± 1s	Mean ppm	± 1s	Mean ppm	± 1s	Mean ppm	± 1s	Mean ppm	± 1s
Si	297307		300019		296705		283050		294970		290576	
Ca	27222	13873	25014	8960	23377	8895	27715	29531	38649	9191	25198	8643
Fe	109185	52758	82655	20223	92127	36368	113101	23678	126924	51714	103842	30718
Sc	40.32	12.40	37.81	11.23	36.15	10.17	53.99	13.01	53.95	19.56	49.76	15.96
Ti	5799	1900	6338	6220	5178	3299	7055	7847	6053	4172	4557	2983
V	161.12	65.61	137.22	42.04	149.61	51.61	167.87	40.63	229.81	90.96	154.69	63.21
Cr	112.58	36.38	104.20	31.04	109.56	73.80	90.79	31.30	108.38	38.56	79.90	25.54
Mn	922	832	1699	1945	1450	838	2392	1296	4734	17424	4449	7152
Co	27.19	12.11	30.52	14.01	25.92	9.37	53.47	29.77	83.32	209.93	48.50	55.69
Ni	60.21	19.42	63.19	16.53	48.80	14.85	71.59	15.53	104.85	95.23	78.06	78.48
Zn	249.52	101.02	274.41	78.27	212.98	66.91	332.45	63.19	487.06	366.18	313.43	103.46
Rb	71.78	51.09	64.54	20.41	78.08	33.59	54.07	19.71	77.44	27.89	44.89	29.13
Sr	330.42	253.98	361.54	233.57	307.23	154.79	325.89	176.31	380.23	231.78	369.57	139.03
Y	52.01	23.13	46.66	32.49	50.93	29.03	95.46	44.64	143.73	107.84	71.88	35.56
Cs	5.41	1.84	5.02	1.27	6.25	3.30	1.29	0.67	1.18	0.38	1.01	0.35
Ba	1221	267	1312	1433	1184	815	927	413	1410	883	1181	893
La	65.35	53.40	81.20	205.44	44.54	24.97	97.26	94.15	157.34	89.40	68.99	37.79
Ce	106.17	78.47	166.26	438.65	68.26	30.38	174.92	176.85	264.44	116.57	132.80	127.95
Pr	15.01	10.37	21.62	53.95	11.20	6.62	23.92	23.34	35.38	15.62	17.14	10.23
Nd	63.99	44.58	97.56	242.68	50.77	31.47	111.01	107.69	156.45	74.08	78.30	44.69
Sm	12.51	7.95	19.14	44.69	10.92	6.22	22.79	17.98	28.90	17.68	16.86	9.85
Eu	3.12	1.59	4.19	8.52	2.90	1.27	4.85	3.12	6.20	3.52	3.96	1.85
Gd	11.42	6.84	16.11	33.27	10.34	6.24	21.49	13.38	26.94	17.19	16.24	8.91
Tb	1.51	0.80	1.85	2.81	1.46	0.81	2.90	1.55	3.70	2.61	2.22	1.26
Dy	9.78	4.47	10.02	9.81	9.58	4.83	18.45	9.19	25.08	18.95	13.90	7.34
Ho	1.89	0.92	1.77	1.31	1.96	1.03	3.49	1.50	5.14	4.21	2.81	1.34
Er	6.32	3.00	5.71	3.54	6.28	3.05	10.34	4.55	16.06	12.63	8.14	3.65
Tm	0.74	0.35	0.69	0.41	0.79	0.42	1.34	0.56	2.23	2.10	1.07	0.52
Yb	5.19	2.54	4.55	2.53	5.35	2.58	9.56	4.60	16.11	15.11	7.39	3.47
Lu	0.79	0.32	0.67	0.37	0.82	0.46	1.46	0.53	2.28	1.89	1.09	0.51

Table C.1: LA-ICP-MS Compositional Data for 9 Yaasuchi Ceramics (Continued). Si concentrations were estimated using INAA compositional data and used as an internal standard to calculate abundances of other elements.

Group	Yaasuchi High REE					
INAA ID	YAA082		YAA220		YAA276	
	Mean ppm	± 1s	Mean ppm	± 1s	Mean ppm	± 1s
Si	304506		290903		297541	
Ca	35696	30562	31290	20566	32851	43795
Fe	111118	38369	125944	61818	103825	73256
Sc	45.17	16.31	49.71	12.33	36.89	20.37
Ti	10279	22328	4837	1985	21429	80930
V	171.12	114.84	175.34	126.59	157.37	112.44
Cr	72.35	21.36	83.79	61.31	74.46	56.23
Mn	2332	2259	2391	2347	2058	4747
Co	34.09	17.06	40.39	37.74	29.21	16.48
Ni	47.33	19.89	42.12	16.42	38.72	23.97
Zn	582.19	191.79	416.28	212.32	455.40	190.26
Rb	67.01	34.95	67.72	31.81	70.84	117.75
Sr	382.87	281.15	312.94	179.11	472.71	795.12
Y	102.75	64.51	111.65	58.89	133.96	176.63
Cs	0.76	0.24	0.92	0.72	0.66	1.26
Ba	1549	509	1302	629	1197	1406
La	117.17	109.13	118.80	76.61	139.15	224.78
Ce	226.83	202.47	243.52	150.30	325.99	581.16
Pr	29.31	25.53	30.32	17.76	42.57	76.95
Nd	128.34	112.41	134.98	80.28	184.06	331.40
Sm	24.23	19.29	25.77	14.69	38.17	64.37
Eu	4.92	3.53	5.54	2.27	6.18	7.31
Gd	21.96	14.97	24.10	13.38	34.22	51.88
Tb	2.89	1.77	3.26	1.85	4.38	5.93
Dy	18.46	11.16	20.95	11.04	26.14	34.13
Ho	3.68	2.29	4.02	2.08	4.96	6.25
Er	11.86	8.02	12.21	6.15	15.19	18.25
Tm	1.42	0.94	1.49	0.76	1.82	1.96
Yb	9.96	6.86	10.34	4.82	11.43	12.52
Lu	1.57	1.32	1.52	0.71	1.69	1.74

Table C.2: Mean LA-ICP-MS Compositional Data for the NIST12 Standard Reference Material. Estimated concentrations are shown by element relative to literature values compiled by Jochum *et al.* (2007).

	NIST612 This Study; n = 27			NIST612 Jochum *et al.* 2007		
	Mean ppm	± 1s	C.V.	Mean ppm	± 1s	C.V.
Si	336107	---	---	336107	4675	1.4
Ca	94418	8805	9.3	85049	1429	1.7
Fe	51.9	6.2	11.9	51.0	2.0	3.9
Sc	43.8	3.3	7.5	41.0	4.0	9.8
Ti	39.1	1.5	4.0	44.0	5.0	11.4
V	38.9	2.1	5.4	39.0	4.0	10.3
Cr	39.0	1.4	3.5	36.0	3.0	8.3
Mn	38.0	12.6	33.1	38.0	1.0	2.6
Co	34.1	1.3	3.9	35.0	2.0	5.7
Ni	38.1	1.6	4.1	38.8	0.2	0.5
Zn	35.3	2.0	5.7	38.0	4.0	10.5
Rb	28.5	1.8	6.3	31.4	0.4	1.3
Sr	87.3	7.6	8.7	78.4	0.2	0.3
Y	46.8	6.5	14.0	38.0	2.0	5.3
Cs	41.4	2.5	6.0	42.0	3.0	7.1
Ba	42.5	3.2	7.5	39.7	0.4	1.0
La	40.6	4.8	11.9	35.8	0.4	1.1
Ce	39.7	1.7	4.2	38.7	0.4	1.0
Pr	40.5	3.7	9.2	37.2	0.9	2.4
Nd	40.8	4.7	11.5	35.9	0.4	1.1
Sm	43.6	5.3	12.2	38.1	0.4	1.0
Eu	39.0	4.2	10.8	35.0	1.0	2.9
Gd	46.0	6.1	13.3	36.7	0.4	1.1
Tb	42.8	5.7	13.4	36.0	3.0	8.3
Dy	43.2	6.2	14.3	36.0	0.4	1.1
Ho	45.7	6.6	14.5	38.0	1.0	2.6
Er	50.4	5.9	11.7	38.0	0.9	2.4
Tm	43.6	6.1	14.1	38.0	1.0	2.6
Yb	46.0	6.7	14.5	39.2	0.4	1.0
Lu	45.0	6.5	14.4	36.9	0.4	1.1