Craft Production and Exchange in the Pre-Hispanic Andes: LA-ICP-MS and pXRF Analyses of Tiwanaku Ceramics

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CRAFT PRODUCTION AND EXCHANGE IN THE PRE-HISPANIC ANDES: LA-ICP-MS AND PXRF ANALYSES OF TIWANAKU CERAMICS

by

COLETTE VALE GABLER

Under the Direction of Nicola Sharratt, PhD

ABSTRACT

The development and expansion of political states is often accompanied by specialized craft production and long-distance trade networks. One of the earliest states in Andean South America was Tiwanaku, a polity that developed near the shores of Lake Titicaca, Bolivia, and dominated the south central Andes during a period called the Middle Horizon (AD 500-1000). In this paper, I report compositional data derived from laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) and portable X-ray fluorescence (pXRF) analyses of Tiwanaku pottery sherd s from a number of sites across the region. I then draw on these data to examine a) whether pottery production was a centralized activity and b) the circulation of ceramic vessels around the Tiwanaku realm.

INDEX WORDS: Tiwanaku, Archaeology, Production, Exchange, Ceramics, Chemical Analysis
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COLETTE VALE GABLER

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May 2017
DEDICATION

This thesis is dedicated to my mother and father who have supported all of my aspirations. I would not be where I am today if it was not for your love and guidance.
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1 INTRODUCTION

1.1 Background

Tiwanaku was a polity that emerged near the shores of Lake Titicaca in what is now modern-day Bolivia. One of the earliest states in Andean South America, Tiwanaku dominated the south-central Andes economically, politically, and culturally during the Middle Horizon (AD 500-1000). The emergence of Tiwanaku began around AD 250 in the Titicaca Basin (Janusek 2004, 2008). After its development, Tiwanaku expanded into a powerful stratified state that was characterized by large urban centers, regional settlement hierarchies, and influential ideology that brought together diverse groups of people (Janusek 2008). State expansion started in the Titicaca heartland, and then further stretched through the south-central Andes where the state established long-distance exchange and long-term connections in lowland Bolivia, Peru, and northern Chile (Anderson 2013; Goldstein 2005, 2015; Torres-Rouff 2008). Unlike many other states, Tiwanaku likely did not adopt militaristic practices as part of their expansion (Goldstein 2005, 2013; Janusek 2013). Instead, people were attracted to the flourishing opportunities and “rising religious prestige” (Janusek 2008:97) that Tiwanaku had to offer. This caused the population at Tiwanaku to increase, and eventually expanded into various communities around the state’s core in the altiplano. This thesis examines the production and exchange of Tiwanaku ceramics. By investigating how centralized and standardized ceramic production was and the complexity of exchange systems, this thesis seeks to contribute to ongoing debates about the kind of state Tiwanaku was.

1.2 The Chapters that Follow

The first half of the next chapter (Chapter 2) discusses anthropological theories about what a “state” is. This topic has been of considerable debate among archaeologists. The two
characteristics specifically discussed in this chapter are specialized craft production and long-distance exchange. Why are these two commonly found in state-like societies? To help address questions about the Tiwanaku craft production and exchange, compositional analysis was conducted for the research presented in this thesis. The various methods used to generate compositional data from archaeological material are introduced in Chapter 3. Tiwanaku is presented in Chapter 4. The three sections of Tiwanaku territory (the core, the hinterland, and the periphery) are introduced. The common styles, designs, and vessel shapes of Tiwanaku pottery are described as well as current debates about what kind of polity Tiwanaku was. Chapter 5 introduces the research design of this thesis. It provides background information about the different samples and collections, the compositional analysis methods used to generate data, and the statistical methods used to analyze data. Chapter 6 presents the results of this thesis research. The closing chapter (Chapter 7) concludes by discussing those results in the context of the theories presented in Chapter 2. According to the compositional analysis of the ceramic samples, was Tiwanaku ceramic production standardized and centrally organized? Were Tiwanaku ceramics exchanged across the various sites in the Titicaca Basin and across the south-central Andes? What can the nature of Tiwanaku craft production and exchange tell us about Tiwanaku society?
2 THEORIES OF STATES AND CIVILIZATIONS

2.1 Introduction

A central and recurrent theme in anthropology since its inception as an academic discipline is how to categorize societies. This study focuses on the category of “States.” It traces the idea of a state beginning with the 19th century social evolutionists, specifically Herbert Spencer and Lewis Henry Morgan. They asserted that societies could be categorized by their position on an evolutionary spectrum, from simple societies to complex societies. Moving into the first half of the 20th century, the chapter examines V. Gordon Childe’s criteria for states and Elman R. Service’s influential classificatory system. Turning to more recent literature, this chapter then adopts a regional approach by comparing case studies to explore how the idea of state is used by archaeologists working in different regions and on different time periods.

The second half of this chapter focuses on craft production and exchange in states. Given archaeology’s focus on the material components of human societies, the relationship between political organization and the production and circulation of goods has been examined and discussed at length in archaeology. Drawing on the work of a number of scholars, I discuss debates in archaeology about the extent to which production is centrally organized and controlled in states, and whether the emergence and spread of a state affects patterns of trade and exchange.

2.2 Anthropological and Archaeological Theories of States

2.2.1 Social Evolutionists

Influenced by Charles Darwin and other scientists working on biological evolution, 19th century social evolutionists, including Herbert Spencer and Lewis Henry Morgan, aimed to understand how societies and cultures evolved or changed throughout time (Trigger 2006:145). Spencer argued that everything, including societies, moves from simple to more complex
(Trigger 2006:145). Spencer uses an analogy to explain this simple to complex theory: societies as organisms. Atoms, the most basic unit of matter, can attach to each other to form larger molecules (Trigger 2006:145). Molecules, then, have the capability to create cells, and further, organisms. These organisms, which can be referred to as organization in this case, began as simple societies and some eventually progressed into complex states.

Lewis Henry Morgan (1877), who argued there were three stages in the evolution of society, adopted a more explicitly material approach than Spencer. Morgan (1877) defined three categories: Savagery, Barbarism, and Civilization. Both the savagery and barbarism levels are divided into three sub-periods: Lower, Middle, and Upper Status (Morgan 1877). Each of these levels, or as Morgan referred to them, “Ethnical Periods,” represented a certain condition of society and are also distinguishable by different criteria. Morgan suggested that different types of societies can be divided and identified based on the complexity of their traditions, whether it was the tools that were used or the kind of food the people ate.

According to Morgan (1877:26), the savagery period began with the “infancy of the human race” and ended with the invention of pottery. The period also included fish subsistence, the use of fire, and the invention of the bow and arrow. The period of barbarism started with the introduction of pottery production, and ended with the creation of a phonetic alphabet. The sub-periods of barbarism also included the domestication of animals in the Eastern hemisphere, the cultivation of plants and maize by irrigation in the Western hemisphere, the use of adobe-brick for building houses, and the manufacturing of iron (Morgan 1877:27-28). Finally, the period of civilization began with the creation of a phonetic alphabet and also includes the production of written records (Morgan 1877:28).
2.2.2 Culture-History and Childe’s Ten Criteria for States

Although Morgan was not an archaeologist, the idea that the type of socio-political organization has material correlates is prevalent in archaeology. For instance, in the early to mid-20th century the archaeologist, V. Gordon Childe, presented what he argued to be the criteria for civilization. His list, which has influenced later archaeological definitions of a “state” includes: (1) cities that were more densely populated than chiefdom societies; (2) full-time specialization including craft specialists, merchants, traders, agriculturalists, officials, and priests; (3) agriculture, production, and exchange of materials were centrally controlled by elites and distributed which expressed their high state organization; (4) class stratification where an elite ruling branch is present, as well as other people with no political power or prestige; (5) collection and distribution of surplus; (6) impressive monumental public buildings were created including residences, palaces, and temples; (7) long-distance exchange; (8) the invention of a writing system; (9) invention of sciences and technology such as astronomy, arithmetic, and geometry; and (10) highly developed artwork (Childe 1950-11-16).

Of these ten criteria, some of these are commonly found in state societies, including increased density within the populations of cities and social hierarchies within the society. However, other criteria are questionable depending on the case in question. For example, writing was not always present in state-like societies.

In 1978, Charles Redman suggested dividing Childe’s criteria into two groups: primary and secondary. The primary characteristics are demographic, economic, and organizational and also suggest essential changes in a society’s structure (Redman 1978). In comparison, the secondary characteristics help document the primary characteristics’ existence. The first five characteristics Childe listed (dense cities; full-time specialization; centrally controlled
agriculture, production, and exchange of materials; class stratification; and collection of surplus) are what Redman (1978) categorized as primary characteristics. Redman proposes that they are applicable to the majority of complex societies. The second group of characteristics (impressive monuments; long-distance exchange; writing; science and technology; and developed art) represent the secondary characteristics (Redman 1978). Redman proposes that unlike the primary characteristics, the secondary characteristics may not have always been present in all recognized states.

2.2.3 Service’s Classification System

About two decades after Childe wrote his *Urban Revolution* (1950), Elman Service (1975) divided societies into groups based on their complexity. Service’s descriptions of states are part of his classification system of societies based on four groups: Bands, Tribes, Chiefdoms, and States (Elman 1975). Of the four groups, states are the highest level in Service’s classifications.

States commonly include elites who have clear authority over people. It is also argued that state-like societies have a centralized government, rules, and laws set to organize and control the people, and an army (Service 1975). Craft specialization was supported through people’s accessibility to raw materials and their improved techniques and technologies. The crafts were generally controlled by the elites and the materials became standardized. For example, there were standard ceramic vessel types with a set of designs that were usually specific to the society. A society’s identity is expressed through the crafts that were produced and Service (1975) argued that long-distance exchange of craft goods existed throughout the state territory, or even with other societies. The buildings in states were impressive and elaborate compared to chiefdoms or
other simpler societies. Palaces, temples, public buildings, and residences form the cities (Service 1975).

Childe and Service’s influence on archaeological notions of socio-political organization has been considerable. In particular, Service’s four categories are still referred to extensively in textbooks that are used to teach introductory anthropology and archaeology classes. For example, Colin Renfrew and Paul Bahn’s textbook, *Archaeology: Theories, Methods, and Practice* (2012), introduces Service’s classifications. Each category is explained separately to describe the specific forms of leadership and government, if any, social organization, technologies, and other attributes of the society. Another textbook, *Images of the Past* (2008) by T. Douglas Price and Gary M. Feinman, also briefly discusses bands, tribes, chiefdoms, and states as concepts. These groups are introduced while describing various aspects of society and behavior. Lastly, William A. Haviland, Harald E. L. Prins, Dana Walrath, and Bunny McBride’s *The Essence of Anthropology* (2013) textbook also explains various systems of political organization using Service’s categories. In the following section, I briefly examine the influence these categories have had on archaeologists working in different regions and on different time periods.

### 2.3 Regional Definitions of Archaeological States

Mesopotamia was of the earliest complex states and had major cities, such as Uruk, that consisted of great complexity. Archaeologists excavating these ancient cities of the Mesopotamian state have noted several impressive attributes. The cities included attributes such as monumental architecture, a writing system, agriculture, craft specialization, production, exchange, social stratification, and political organizations. One of Mesopotamia’s cities, Uruk, was first established at around 4100-3100 BC (Rothman 2001). Within this city, there was impressive residential architecture and monumental buildings. There was an increase in intensive
irrigation agriculture which allowed for great surplus collections. The people of Mesopotamia had a writing system that was written on clay tablets and were also specialized in metallurgy, stonecutting, and the production of pottery (Rothman 2001). Further, Mesopotamia’s social stratification, political organization, and exchange economy were all highly developed at its peak.

As with scholars working in Mesopotamia, those examining Mesoamerica’s complex societies frequently note characteristics such as monumental buildings, agriculture and irrigation, writing systems, social stratification and organization, craft specialization, and exchange, as evidence for the presence of states. Many Mesoamerican societies, such as the Aztecs and Maya, developed because of the production of pottery, the domestication of various plants, and the slow emergence and growth from villages to cities in state-like societies (Blanton 1998).

Similar characteristics are also cited as evidence of states in Andean South America, with the exception of one criterion: a writing system. Even without a formal writing system, the Inca were an impressive society that expanded throughout Andean South America. Large-scale storage of surplus, extensive road systems for transport and exchange networks were created, and great monuments and residential buildings were built. A lack of any writing systems in the Inca state shows how these characteristics are applicable to many state-like societies, but they are not all universal qualifications.

In addition to regional case studies, comparative archaeological work has sought to identify characteristics of ancient states and has also highlighted limitations with relying on a fixed list of attributes. For example, in comparing Mesoamerica and South Asia, scholars challenged the notion that centrally controlled agriculture is a necessary feature of states (Kehoe 1978). More recently, highlighting the considerable range of methodological tools used by
archaeologists, Henry Wright (1989:99) argues that criteria for complex states must account for a greater diversity of complex societies, therefore, “we must diversify the roster of early civilizations” to include smaller polities. An example of this includes complex societies in Western African that are not as recognized as states when compared to societies such as the Inca, Maya, ancient Egyptians, Greeks, or Romans. These complex societies originated during the first millennium BC (Wright 1989:99), which was prior to any European contact. Many of these West African complex societies developed independently from the major civilizations, therefore Wright (1989) argues that a society does not have to be as complex and expansive as the Inca and the Maya to be considered a state, and can develop in various ways. Many of these smaller societies are capable of showing state-level characteristics such as craft production, exchange, and social organization. However, because these societies do not always have monumental architecture, writing, or class stratification and elites, they go unnoticed in the subject of states.

Wright (1989) specifically compares state-like societies in the Near East and Mesoamerica. In reference to the Near East, he notes some scholars consider decision-making and societal hierarchies to be characteristics of complex societies (Wright 1989). Further, preserved papyrus texts from Egypt and clay documents from Mesopotamia had writing that recorded information about trade, labor, decisions about crops, conflicts, and other kinds of recordings. Wright emphasizes that there is great importance in archaeologists’ increased knowledge of Mesoamerican writing systems. To clarify, writing was present in certain states but absent in others, like the Inca. The Inca polity, which dominated around 5,500 kilometers north to south (Moseley 2001) and covered about 980,000 square kilometers of territory (Earle 1987) of Andean South America in the 15th and early 16th centuries. The Inca territory covered parts of what is now Peru, Bolivia, Argentina, and Childe. The Inca society is considered a state by
Childe’s definition by many measures, but they did not have a writing system. This did not make the Inca any less of a complex state compared to the Maya in Mesoamerica. Writing was independently one of the major contributions to many Mesoamerican states’ complexity, but was not necessary in the Inca polity.

All of the state-like societies that have been mentioned included similar characteristics such as monumental buildings, social organization, craft production, long-distance exchange, agriculture, and more. This indicates how strong Childe and Service’s influence has been on how archaeologists recognize and categorize political organization. The rest of this chapter explores the relationship between production and exchange, and state organization in greater depth.

2.4 Production and Exchange in States

2.4.1 Production

Cathy Costin (1991:1) argues that it is crucial to study production because it can help reveal the kind of government and social organization in a society. Was production centrally controlled? Were there specific standardized styles or recipes used to manufacture the material goods, or did people create their own crafts using their own recipes? Generally, specialization and production are conducted through principles of economic demand, efficiency, and security (Brumfiel and Earle 1987:5; Costin 1991:2; Halperin 2008:128). The level of craft specialization can help to better reconstruct the degree of control enacted by a society’s elites. It is important to note that the relationship between the production of materials and a political system can vary from craft to craft (Sharratt et al. 2016:408; Sinopli 1988).

It has been suggested by several scholars that specialized craft production has been strongly associated with states based on the claim that it required a great amount of organization (Costin 1991; Costin and Hagstrum 1995; Earle 1981; Sinopoli 1988). However, this claim is
debated among scholars. Some scholars, such as Costin and Melissa B. Hagstrum (1995), stated that production and specialization are organized based characteristics such as skill, labor investment, and standardization. When these three characteristics are evaluated together, the level of organization of production can be better understood (Costin and Hagstrum 1995). Both production and specialization are rooted in social, economic, and/or political systems (Costin 1991). Generally, specialized craft production was common in state-like societies, but it is strongly emphasized by Costin (1991) that production and specialization are not the same. Production, according to Costin (1991:3), “is the transformation of raw materials and/or components into useable objects.” Specialization, on the other hand, refers to the organization of production (Costin 1991:3). Based off of these definitions, production may occur in a number of societies, however, specialized craft production would appear in more complex states.

There is also a clear distinction between specialization and standardization that must be clarified. While specialization may include the organization of production and “the regular, repeated provision of some commodity or service in exchange for some other” (Costin 1986, 1991), standardization “refers to homogeneity in ceramic materials, vessel shape, and/or decoration” (Costin and Hagstrum 1995:622). The standardization of specialized craft production is important to consider because it “reflects economic and social constraints within the production system” (Costin and Hagstrum 1995:662).

Specialization can be divided into different “dimensions of variation” (Brumfiel and Earle 1987:5). For example, two types of specialists can be identified: independent and attached. Independent specialists manufacture goods for an unspecified population of people and do not necessarily work under the pressure of elites. Therefore, they must have had a little more freedom in the kind of products they manufactured. According to Costin (1991:11), independent
specialists usually manufactured utilitarian goods that were used on a regular basis such as cooking and serving vessels. Attached specialists, on the other hand, are generally pressured through an arrangement with the government who controls the specialization and production of material goods (Brumfiel and Earle 1987:5). They usually produced wealth and luxury items that were not always available to everyone in the community (Costin 1991:11). The production of material goods by these two different groups of specialists can reflect the intensity, organization, and products manufactured. Specialization can also be divided into full-time or part-time specialization. Full-time specialists usually exist when there is a high demand for material goods. Full-time work is required to successfully meet that demand (Brumfiel and Earle 1987:5). Part-time specialists, in contrast, do not have that pressure of high demand for material goods.

2.4.2 Exchange

Trade and exchange are sometimes used interchangeably. However, it is important to note the distinction between the two. Exchange can be defined as “the transfer of goods from one party to another through a wide range of mechanisms, from ritualized gift exchange to the negotiated transactions of barter and markets and the one-way exchange of coercion and piracy” (Agbe-Davies and Bauer 2010:15). On the one hand, trade can be categorized as a type of exchange. Rahul Oka and Chapurukha M. Kusimba (2008:340) defined trade “as the material-economic component of exchange.” Another definition given by Anna S. Agbe-Davies and Alexander A. Bauer (2010:15) describes trade as “a more specific category of activity in which the exchange is more formalized and market based.” Trade assists in maintaining social bonds that help hold societies together (Agbe-Davies and Bauer 2010:15).

Complex exchange networks have been evident within state-like societies around the world (Brumfiel and Earle 1987; Oka and Kusimba 2008; Sharratt et al. 2015). It is further
suggested that most societies may have participated in exchange, but only complex societies had trade and exchange that was controlled by governments and elites (Polanyi et al. 1957; Oka and Kusimba 2008). As discussed, Childe (1950) included long-distance exchange as a characteristic of state, and exchange continues to feature in archaeologists’ identification of states in the past as seen in Mesopotamia, Inca, and Mesoamerica, to name a few. Understanding the movements of material goods in trading and exchange systems better ascertain the society’s political and social organization (Sharratt et al. 2015). How much control did the elites have over exchange? How accessible was the material to obtain for the common people compared to the elites? Did exchange take place only within a given society or with other states? What were the motives behind the exchange, or what were the elites hoping to gain from the exchange?

Although many scholars associate long-distance exchange with state organization, it is important to understand that exchange networks may have acted independently from state authority (Parkinson and Galaty 2009). A society that acts independently from governments and elites can reveal various aspects of the society. For example, without elites controlling exchange, who regulates the organization of the exchange networks in their place? Without the government, how large of a scale are the exchange networks? Studying exchange in a society with no centralized control by the elites can explain how the commoners organized the exchange networks.

Elizabeth Brumfiel and Timothy Earle (1987) proposed three different models to study and understand the specialization and exchange of material goods. These three models include a commercial development model, an adaptationist model, and a political model (Brumfiel and Earle 1987:1). First, in a commercial development model an increase in specialization and exchange are crucial in a society’s economic growth (Brumfiel and Earle 1987; Halperin 2008).
This kind of economic system incorporates three main characteristics: (1) a division of labor; (2) extensive exchange system to distribute material goods to elites and commoners; and (3) an economy that is free of any political administration (Brumfiel and Earle 1987:1; Halperin 2008). The labor and land are treated as commodities within this model. It has been argued that although commercial development models tend to promote social complexity within a society (Jacobs 1984), it has also been suggested that the model can decrease the social complexity present in peripheral communities (Wolf 1982).

In the second model, the adaptationist model, elites are involved and intervene in the economy. Within this model, the organization of exchange reflects the power and capabilities of the elites (Brumfiel and Earle 1987:2). A centralized leadership is beneficial because the elites create the networks for exchange. Further, the redistributive exchange that is present in this model awards considerable benefits including increased “productivity, diversify subsistence, and provide insurance against food failures” (Brumfiel and Earle 1987:2). The Aztec state, for example, has been examined using the adaptationist model. Certain expectations about changes in production and exchange are generated using the adaptationist model (Brumfiel 1987). The first expectation is that the changes in production and exchange involve subsistence goods. The second expectation is that stability, efficiency, and the capacity of the economic system are improved by political integration (Brumfiel 1987:116). However, according to Brumfiel (1987), the Aztec only partially fulfill these expectations. When the Aztec society was a fully-developed state was the only time when full-time specialists were present. Before state formation and after the state’s collapse, only part-time specialists were around (Brumfiel 1987:116). Further, the exchange of goods between specialist producers was not undertaken. Instead, the rural producers who marketed food to attain certain material goods or products were involved with the exchange.
In other words, Aztec exchange networks did not circulate specialist goods, but rather farmers and agriculturalists traded food necessities for material goods. As a result, people of lower social statuses were able to obtain certain non-local subsistence goods like salt and obsidian (Brumfiel 1987:116). Overall, the Aztec state did not have stable market conditions which affected the kind of economy the Aztecs had.

Lastly, in the political model, similar to the adaptationist model, elites have a significant role in exchange networks. The main difference between the two models is that within the political model, the elites are considered the primary recipients of these exchanges, instead of the general population where commoners and elites alike receive these material goods (Brumfiel and Earle 1987:3). It has been suggested by Brumfiel and Earle (1987) that this occurs within the political model so the elites can create and maintain social stratification. Therefore, elaborate specialization is caused by political complexity in order to intensify both economic and political control (Earle 1987:67). This increased the control the political elites had over the commoners in the society. An example of a political model would be the Inca from Andean South America. The Inca polity originally began as a smaller community in Peru’s southern highlands. During the 1400s, the polity greatly expanded to a population of 8 to 14 million people and controlling an estimated territory of 980,000 square kilometers (Earle 1987:65). The Inca polity was mainly based on subsistence production control. The Inca had impressive roads that were used for trade and exchange, government messengers, Inca military, and more (Moseley 2001). However, exchange routes and travel roads could not be used without permission from the elite government. Instead of a writing system, the Incas used quipus. Quipus were used to record information on these exchanges, city populations, and other government matters. To avoid any elite interference or government control, some societies, such as the Late Classic Maya, have
depended on direct reciprocal exchange (Brumfiel and Earle 1987:7) where there is an even exchange between two people or groups.

These different models that Brumfiel and Earle discussed are only a few examples of types of exchange systems. Elites and political governments are common criteria for state-like exchange systems, but as Brumfiel and Earle presented, some exchange models are free of any political administration (commercial development model) and others include political control (adaptationist model and political model). This illustrates the possible differences between various exchange systems in state-like societies. A similarity between most models is the extent of organization required. This organization can be established by the elites or the commoners, or even control from the core outward toward the peripheral cities.

### 2.5 Conclusion

Since Morgan in the late 1800s, material components of human society have been the core of anthropological definitions of social organization. Categorizing various societies is necessary in anthropology and archaeology because it helps address questions about human organization using comparative examples. Therefore, a number of material correlates have been recurrently associated with states. However, some have argued, such as Charles Redman (1978), that these correlates do not have to be present in all examples of ancient states. Redman suggested that the secondary characteristics (impressive monuments; long-distance exchange; writing; science and technology; developed art) may not always be present in a recognized state.

Two recurring characteristics of states are craft specialization and long-distance exchange. Studying craft production, standardization, and specialization can help reveal information about what kind of government a particular past society may have had. Further, the
level of craft specialization can also help determine the degree of control the elite may have had over the production of material goods. However, the relationship between the government and the production of material goods can vary depending on the craft in question (Sharratt et al. 2015), as well as the society itself. Understanding the levels of craft production, standardization, and specialization can ascertain the social and political limitations within a society’s production and economic systems (Costin and Hagstrum 1995). In many cases, craft production is a centralized activity, but this is not always the case, as seen in the commercial development model.

Specialists can be divided into various categories including independent and attached specialists, and full-time and part-time specialists (Brumfiel and Earle 1987). The presence of independent specialists reflects a lesser degree of government control in craft production. Attached specialists, on the other hand, generally produce what the elites and government demand, minimizing the freedom the specialists had to produce their crafts. Full-time specialists exist in societies where there are high demands for material goods and crafts. Part-time specialists are usually found in societies where the demand is much lower (Brumfiel and Earle 1987). These societies may be smaller in size with less social complexity.

Long-distance exchange is another characteristic commonly found in state-like societies. Unlike craft production and specialization, long-distance exchange is one of Redman’s (1987) “secondary” characteristics, meaning it may not always be present within states. However, how complex and how long-distance exchange need to be in order for it to be considered on the state level? Scholars such as Oka, Kusimba, Agbe-Davies, and Bauer argue that trade and exchange are different kinds of acts. Trade can be considered a more specific action (Agbe-Davies and Bauer 2010) or a material-economic component to exchange (Oka and Kusimba 2008).
Exchange is market-based, formalized, and conducted through a wide range of mechanisms (Agbe-Davies and Bauer 2010). Although there are differences in definitions, can Childe’s list of state-like characteristics include long-distance exchange as well as trade?

Since there are a number of different exchange systems, there are a number of different exchange models that are associated with different kinds of state-like societies. Three of the models that have been introduced include: the commercial development model, the adaptationist model, and the political model. Each of these models may or may not incorporate elites or a government. Further, each model shows different levels of social complexity, hierarchy, and organization. For instance, the commercial development model has an exchange system that is free of any government control and both elites and the common people had access to material goods such as ceramics. The political model, on the other hand, had more restrictions to who had access to material goods and also had elites that controlled the exchange systems. These models show how exchange systems can be organized at different levels of complexity. Regardless of the different levels of complexity in exchange systems within a society, exchange is a state-like characteristic that is crucial to understanding a society’s social organization and interactions.

Understanding a society’s material production and craft specialization can contribute to understandings of the society’s level of control over the community and their political system. A number of states from Mesopotamia, Mesoamerica, Andean South America, West Africa, and other regions have been discussed. The various characteristics that have been mentioned were observed in the descriptions of a number of states, including craft production and long-distance exchange. The rest of this thesis examines evidence for centralized craft production and long-distance exchange in the Tiwanaku state, one of the earliest states in Andean South America.
3 METHODS

3.1 Introduction

As discussed in Chapter 2, craft production and long-distance exchange have been topics of considerable interest to archaeologists and anthropologists. Examining the trade and exchange of goods in the past can be undertaken in a number of ways. These include visual analysis and ethnoarchaeology. Another approach, that which has been adopted in this thesis, relies on compositional analyses of archaeological material culture. Compositional analyses in archaeology draw on techniques from analytical chemistry and have been utilized for studying, among other things, ceramic, metal, obsidian, and other lithic tools. This chapter first describes how visual analyses are utilized in studies of trade and exchange and the limitations of such an approach. It considers what visual analyses and ethnoarchaeological studies of production can add to our understandings of craft in the past. It then examines different compositional techniques appropriate to reconstructing production and exchange in the archaeological record, focusing in particular on the techniques utilized in this thesis study.

3.2 Visual Analyses in Archaeology

In visual analyses of ceramic vessels, physical characteristics are analyzed including size, form, surface treatments, design, iconography, and use wear. All of these characteristics can be used to organize ceramic vessels into like-groups (Janusek 2003). This kind of analysis is useful for obtaining primary data on a group of artifacts.

Visual analysis can help gain a better understanding about craft production and exchange within a society. Specialized craft production of material goods, such as ceramics, has been commonly found in states. The process of production was usually controlled and highly standardized. In some states-like societies, elites, or another form of authority, controlled the
design, techniques used, and recipes, but this was not the case in every state. If specialized and
standardized craft production was present within a state, this would be discernible through visual
analysis. The ceramics produced would show consistent styles, shapes, iconography and designs,
and so on.

When examining exchange through visual analysis, style is an important consideration.
Within a state, the style of an artifact may be similar throughout the different communities that
were affiliated with the society. However, slight alterations may be observed in certain regions.
For example, various ceramic vessels found in Tiwanaku and surrounding communities differed
in style. Lukurmata’s distinctive style included modeled llama-effigy and feline incensarios and
tan-wares (Janusek 2008:2014). The tan-ware serving wares are considered strictly Lukurmata-
style. Lukurmata ceramic vessels were generally painted a lighter red pigment than other
Tiwanaku-style pottery (Janusek 2003:80), and ceramic pastes were derived from local clay
sources. Therefore, if tan-ware vessels are found at the Tiwanaku capital, it can be argued that
Lukurmata exchanged with the capital.

Visual analyses are commonly used to study archaeological materials, such as pottery.
However, the degree to which trade, exchange, and interaction patterns in the past can be
reconstructed through visual analyses alone is limited (Golitko 2011). Visual analyses can help
ascertain levels of centralization and standardization through the visual styles, designs, temper
inclusions, and more. Although, even more information can be established using compositional
analysis.

Compositional analysis, which is addressed below, compliments visual analyses, and also
can provide answers to questions that visual analysis cannot. For example, the visual analysis of
ceramic vessels cannot determine the chemical composition of the ceramics, which can
determine which ceramics were produced using the same clays and paste recipes. Although visual analyses can help notice factors such as temper inclusions, it cannot definitively determine whether or not ceramic vessels with the similar visual characteristics were produced by the same craftsman or at the same site. Therefore, visual analyses cannot establish if ceramic vessels were locally manufactured or imported from other areas. The use of techniques from compositional analysis provides an alternative understanding of archaeological materials that would be inaccessible strictly with visible analyses alone. However, it is important to note this does not all imply that visual analyses should be dismissed completely. Rather, integrating visual and compositional analyses can be beneficial in archaeological research.

3.3 Ethnoarchaeology and Ceramic Production

Ethnoarchaeology is the “study by archaeologists of regularities in living cultures” (Trigger 2006:399). This particular research practice came about because some scholars, such as Lewis Binford, suggested studying ancient societies by analyzing patterns produced by modern societies. Binford observed that although archaeologists had progressed greatly in gaining knowledge on techonomic behavior, or the practice uses of artifacts (Trigger 2006:399), there was a lack of knowledge on the correlations between material culture and social behaviors. Binford suggested that studying living culture where their actions and behaviors can be observed would help better interpret the social and ideological information in an archaeological context (Trigger 2006:399).

By analyzing modern-day potters and their techniques, ethnoarchaeologists can use analogies to attempt to understand the behaviors of past people. For example, Dean Arnold (1993) studied ceramic production in Quinua villages. The purpose of his study was to understand the series of choices potters make when they manufacture their ceramic vessels. This
has helped to better understand the production of ceramics in Andean societies within the area in the past. Arnold stated (1993:73) that prior to collecting raw materials to create pottery, the potter must first choose what vessel they plan to make. This is because there is a difference in clay sources that are used in the process when making cooking vessels versus making non-cooking vessels. In Arnold’s study area, ceramic vessels that are made for cooking are made using a special clay that have small “gold-like” particles in it (Arnold 1993:73). The clay that has these “gold-like” particles can only be procured from one site near one of the villages. Clay that is used for holding food, carrying water, and rituals, however, is much more commonly found in various locations (Arnold 1993). For both the cooking and non-cooking vessels, people did not have to travel far to procure the clay.

Compositional analysis was conducted on clay samples with the gold particles to determine what the material was. Through X-ray diffraction patterns, Arnold (1993:74) was able to ascertain that the gold particles were actually flecks of gold-colored mica mineral phlogopite. It has been noted by Quinua potters that the gold particles in the clay were needed for cooking vessels so they would not crack under heat. These laboratory results proved to be very valuable because “micaceous pottery is technologically superior to non-micaceous pottery for cooking” (Arnold 1993:74). This is because micaceous pastes are more resistant to thermal fracture compared to non-micaceous pastes which makes them great for cooking vessels. Further, “the places of mica reduce crack propagation and deflect the energy of crack initiation,” therefore making micaceous pastes stronger than non-micaceous pastes (Arnold 1993:74).

Arnold’s observations and interactions with the villages in Quinua have provided archaeologists with greater knowledge about how past societies in Andean South America may have produced their ceramics. Theories about how far potters may have traveled to procure raw
materials, what affects the types of clay used, if there are reasons why they choose different materials over others, have all been obtained through ethnoarchaeological research, including Arnold’s. Further, Arnold (1991:70) argues that the chemical composition of materials, such as pottery, “is difficult to relate to potters’ behavior because the relationship between the chemical elements in the pottery and the potters’ behavior is not obvious.” Therefore, Arnold suggests ethnoarchaeological research can help fill those gaps. However, ethnoarchaeology does have its limitations. The use of analogy in ethnoarchaeology can cause some issues. The world is different than it was a thousand years ago. Technology has greatly improved, the population of people have increased, and cities have become bigger and denser. Industrial cities have become the new state capitals of the world and factories have allowed for mass production. Many commodities are rarely hand-made or produced without machines today. Therefore, in the modern world, where there is a market economy and rapid transportation networks, can ethnoarchaeology really allow scholars to access contexts of organization similar to those in the past?

Comparing archaeological states to modern-day “states” would be difficult. In the case of production, the modes and means of production would have been on different levels in ancient states compared to modern-day. Thus, can ethnoarchaeology only be applied to smaller villages or communities? Some of these smaller communities, such as the Quinua villages that Arnold observed (1993), do not have the major factories and markets the modern industrial cities have. The technology that was available in the past cannot compare to many civilizations today. Therefore, a great deal of initial research should be conducted on the modern-day community to determine if such a parallel analogy can be possible. Ethnoarchaeology is not beneficial if the two societies being compared do not reflect each other. Just like visual analysis,
ethnoarchaeology can be used as a primary or additional approach when researching craft production and exchange. The rest of this chapter focuses on compositional analysis, its significance in archaeological research on craft production and exchange, and the various methods that can be used to measure an artifact’s elemental composition.

3.4 Compositional Analysis

Compositional analysis can identify the chemical elements in material culture. Other than ceramics, compositional analyses can be performed on obsidian, metal, glass, and other archaeological materials. In the case of ceramics, compositional analyses have been undertaken to investigate the production and exchange of pottery, as well as for conservation purposes (Pollard et al. 2007:5). In general, archaeologists are increasingly relying on compositional analysis to research social, political, and economic patterns in past societies (Niziolek 2011:222). Compositional analysis is undertaken using techniques from analytical chemistry, which is used to distinguish and evaluate inorganic and organic elements, as well as isotopic measurements, in the samples that are being studied (Pollard et al. 2007:5).

The remainder of this chapter discusses the use of compositional analysis in archaeology. Then, different methods of compositional analysis, such as instrumental neutron analysis (INAA), inductively coupled plasma-mass spectrometry (ICP-MS), X-ray fluorescence (XRF), proton-induced X-ray emission (PIXE), and atomic absorption spectrometry (AAS) will be introduced. PIXE and AAS are briefly introduced. INAA will be assessed in greater depth because of its popularity and significance in compositional analysis within archaeology. Finally, this chapter discusses ICP-MS and XRF in depth because the research presented in this thesis utilized those two particular methods. Examples of archaeological research utilizing these
various approaches are discussed. Although this thesis study focuses on ceramics, these techniques have been applied to other materials, such as obsidian.

### 3.5 Compositional Analysis in Archaeology

Compositional analysis can be used to determine provenance, not to be mistaken for “provenience,” which is the vertical and horizontal position within the material in which an artifact is found (Renfrew and Bahn 2012:50). According to Mark Pollard and colleagues (2007:5), provenance is the “systematic relationship between the chemical composition of an artifact and the chemical characteristics of one or more of the raw materials involved in the manufacture.” Using analytical chemistry techniques, various elements in a sample are measured which can help determine what parent source the raw material came from. This kind of analysis can contribute to studies of craft production and the movement of material, including pottery, obsidian, metals, glass, in the past (Rice 1987; Sharratt et al. 2009; Sharratt et al. 2015:401). The “Provenance Postulate” and “Criterion of Abundance” are concepts relevant to making the connection between chemical compositions and the production and exchange of materials. The “Provenance Postulate” states that “there exist differences in chemical composition between natural sources that exceed, in some recognizable way, the differences observed within a given source” (Weigand et al. 1977:24). In other words, there are chemical differences that exist between different sources of raw material (Bishop et al. 1982:301). The differences are specifically in the concentration of chemical elements or in the relationship between concentrations of two or more elements (Weigand et al. 1977:24). Therefore, using ceramics as an example, if two ceramic samples are chemically characterized as the same, then, theoretically, both ceramic samples came from the same natural source of clay. However, it is important to
take into consideration the temper and other inclusions that may have been added to the clay during production because these can alter the chemical composition of the pottery.

The “Criterion of Abundance” states that “in its simplest form a ceramic unit strongly represented at a site is presumed to be of local manufacture, scarcely represented pieces of being of non-local origin” (Bishop et al. 1982:301). Thus, if a large quantity of chemically similar ceramic materials is present at a site, and then they are assumed to be locally manufactured. On the other hand, if the quantities are few then the artifacts or materials are interpreted as non-local or imported from another site. Both the “Provenance Postulate” and “Criterion of Abundance” are critical concepts in archaeological applications of chemical analysis.

### 3.6 Methods of Chemical Analysis

A number of compositional analysis techniques have been introduced to archaeology in order to reconstruct craft production and exchange in the past. These include proton-induced gamma ray/X-ray emission (PIGM-PIXE), atomic absorption spectroscopy (AAS), instrumental neutron activation analysis (INAA), inductively coupled plasma-mass spectrometry (ICP-MS), X-ray fluorescence (XRF) (Mallory-Greenough et al. 1998; Pollard et al. 2007; Rice 1987; Sharratt et al. 2009; Sharratt et al. 2015). Each technique differs in their capacity to detect and measure elements in the samples (Rice 1987:390). Each also has advantages and disadvantages, which are further discussed below. It is important to use the technique that is best suited for the research, the type of material that will be measured, the state of preservation the artifacts are in, what elements are going to be measured, and also the availability of the equipment (Niziolek 2011:241). The choice could also be affected by the cost of use (Mallory-Greenough et al. 1998; Pollard et al. 2007; Rice 1987; Sharratt et al. 2009; Sharratt et al. 2015).
3.6.1 Proton-Induced X-ray Emission and Atomic Absorption Spectroscopy

Proton-induced X-ray emission, or PIXE, uses protons, instead of X-rays or electrons, “to create the initial vacancies in their inner electron shells” (Pollard et al. 2007:116). When used in archaeology, the proton beam that is produced can be focused on a sample that is outside of the accelerator (Pollard et al. 2007:117). This eliminates the requirement of sampling if the artifact is too big for the chamber. Another advantage of PIXE includes sensitivity to a number of elements (Rice 1987:398). However, the technique is very expensive to use and also not widely available (Golitko 2011; Rice 1987). As such, PIXE is not one of the most commonly used techniques in archaeology.

Another less-commonly used technique in compositional analysis is atomic absorption spectroscopy (AAS). This technique identifies elements by their absorption instead of energy emission (Rice 1987:395). In the 1980s, AAS replaced optical emission spectroscopy (OES) in archaeological chemistry (Pollard et al. 2007:48). AAS has some advantages. The technique has generally high precision and sensitivity, and can have high accuracy if standards are carefully prepared. AAS is also affordable and requires little training to use and interpret data (Rice 1987:396). However, AAS is not meant for multiple element analysis. This technique unfortunately only measures one element at a time and is referred to as a “sequential analytical technique” (Pollard et al. 2007:49; Rice 1987). Therefore, all of the samples are analyzed for only one element, then reanalyzed for the next element, and this continues until the process is done (Pollard et al. 2007:49). This is problematic because the amount of time required to fully analyze each sample would be substantial. In other words, if each element is measured individually, it would take a longer period of time for one sample to be assessed completely than if all elements in one sample are measured at the same time. Further, sample preparation is time-
consuming and requires the samples to be diluted in acid (Rice 1987:396), which makes it a destructive technique. Although AAS is still used in research, it is not as commonly as it used to. Today, AAS has been largely replaced by ICP-MS techniques, which will be discussed later.

### 3.6.2 Instrumental Activation Analysis

Since the start of analytical chemistry and compositional analysis, instrumental neutron activation analysis, or INAA, has been one of the most popular techniques in archaeological research because of its advantages. INAA is “an analytical technique that relies on irradiating a portion of the artifact with neutrons” (Moholy-Nagy et al. 2013:76). Chemically speaking, the technique irradiates the element with neutrons and transforms the atoms within the elements present in a sample into artificial radioactive isotopes (Pollard et al. 2007:123). Unlike other compositional analysis methods discussed in this chapter, INAA reconstructs the nucleus in the atoms and changes the nucleus’ energy levels (Pollard et al. 2007:123). Other methods target the electron levels instead. INAA was first used in the 1930s, but was introduced to archaeological research in the late 1950s (Pollard et al. 2007; Rice 1987).

INAA can be used to analyze pottery, obsidian, faience beads, coins, flint, glass, and jade (Pollard et al. 2007). A number of studies have been undertaken on such materials using INAA. For example, INAA has been used in studying pottery production because it can correlate ceramic products to “geographically restricted raw-material sources” (Neff et al. 1994:334).

INAA has a number of advantages, which contribute to the technique’s popularity. First, INAA is very sensitive (Dussubieux et al. 2007:350). It can detect a wide range of elements (Rice 1987:397), and can measure low and high concentrations with high precision (Moholy-Nagy et al. 2013: 763; Pollard 2007:132). There have been, however, inconsistencies with how wide the elemental range actually is for INAA. Some scholars propose that 30-40 elements per
sample can be measured (Mallory-Greenough et al. 1988), others mention 40-50 elements per sample (Pollard 2007:132), lastly, some claim as many as 75-92 elements (Rice 1987:397).

Another advantage of INAA is the low sample preparation requirements (Bishop et al. 1982; Dussubieux et al. 2007; Mallory-Greenough et al. 1998; Pollard et al. 2007; Rice 1987; Vaughn et al. 2011). In other words, bulk analysis can be done on a large number of elements at one time (Rice 1987:390). Low sample preparation is indeed a great advantage, if it is possible. However, the low sample preparation advantage is only available if the sample is already small enough. Samples such as a coin or a bead may be small enough where any preparation is not required (Pollard et al. 2007:129; Rice 1987:397). However, if the artifact is too large for the equipment, a small sample has to be removed from the artifact (Pollard et al. 2007; Rice 1987).

One disadvantage of INAA concerns the generation of data. Generally, INAA can generate and record data in a short amount of time (Bishop et al. 1982:292; Rice 1987). However, depending on the elements present, it can take a long time to generate the data because the radionuclides need to decay (Little et al. 2004; Rice 1987). Depending on the half-life of the elements being measured, generating data can take up to weeks or months. This could put a long pause on the ongoing research. Additionally, interpreting the large quantities of analytical data can be long and challenging.

INAA also requires a nuclear reactor. This can severely impede the availability of this technique (Rice 1987:398), because nuclear reactors in laboratories have become difficult to find. The loss of neutron irradiation facilities is one of the reasons INAA is being replaced by other techniques (Pollard et al. 2007:134). The cost to use the equipment in the few facilities left can be relatively high (Rice 1987), however it is still comparable to some other techniques. Until recently, INAA was the standard method and technique of choice for detecting elements and
measuring the composition of artifacts (Mallory-Greenough et al. 1998:94; Pollard et al. 2007). However, in the 1980s, alternative methods such as ICP-MS were developed and were found to be comparable to INAA for analyzing archaeological materials.

### 3.6.3 Inductively Coupled Plasma-Mass Spectrometry

Inductively coupled plasma-mass spectrometry (ICP-MS) was first developed in 1983 (Pollard et al. 2007). The technique works by using inductively coupled plasma to ionize the sample and mass spectrometry is then used to measure the ions that were created (Pollard et al. 2007: 160). Like INAA, ICP-MS has been used in archaeology principally to help determine the provenance of artifacts, including pottery. ICP-MS, in general, has incredibly low detection limits, a high accuracy rate, and is very precise (Golitko 2011; Mallory-Greenough et al. 1998; Sharratt et al. 2009; Sharratt et al. 2015). It is important to note that accuracy and precision are not the same when techniques are evaluated. As Rice (1987:390) explains, accuracy can be defined as “how close the result is to the true figure.” Precision refers to the method’s reproducibility when detecting and measuring elements in a sample (Rice 1987:390). The extreme sensitivity, accuracy, and precision of ICP-MS allows for a great number of elements to be measured simultaneously at an accelerated rate (Golitko 2011; Little et al. 2004). Unlike INAA where the data cannot be produced until all elements are measured, a process which can take up to months, data are generated instantly when using ICP-MS.

The initial installation of ICP-MS equipment can be expensive; however, the technique is very cost-effective for day-to-day running (Sharratt et al. 2009, 2015). Laboratories with ICP-MS are also easier to locate because a nuclear reactor is not required (Little et al. 2004). This is one of the reasons why ICP-MS has become more popular compared to INAA. Some research has been conducted to compare the two techniques with the aim to see how compatible ICP-MS
is to INAA (Pollard et al. 2007). In such research, the data are generated from both techniques on the same samples, and then are compared. Determining whether or not ICP-MS is consistent with INAA is necessary because if ICP-MS becomes the “industrial standard,” which Pollard and colleagues (2007:35) suggest it will, a lot of past research that used INAA databases can be used for comparing future ICP-MS research.

There are a number of ways of introducing a sample for analysis using ICP-MS. Each has its own benefits and limitations (Pollard et al. 2007:195). The sample is introduced to the plasma either as a solution or a solid. Some early ICP-MS had a weak acid extraction method which proved to be problematic because of the long sample preparation, and inaccuracy where the sample may not have been truly represented (Dussubieux et al. 2007:350). Other forms of ICP-MS include microwave digestion (MD) and laser ablation (LA) (Pollard et al. 2007), the latter is increasingly preferred in archaeology.

3.6.4 Microwave Digestion

Microwave digestion (MD-ICP-MS), is a form of ICP-MS that introduces a liquid to the plasma (Kennett et al. 2001:22). Samples such as ceramics and obsidian, are solubilized by microwave digestion. Golitko (2011) explains the microwave digestion process in simple terms: microwave digestion “involves dissolving a sample in acid under pressure and heat created by bombarding the sample with microwaves.” Although MD-ICP-MS is a useful method, especially with its bulk characterization (Golitko 2011), it does come with a number of disadvantages. The high-purity acids that are required for MD-ICP-MS are very expensive and also dangerously corrosive (Golitko 2011; Kennett et al. 2001; Little et al. 2004). Furthermore, the sample preparation not only takes a long time (Little et al. 2004), the method can possibly contaminate the sample with reagents (Golitko 2011; Kennett et al. 2001) and it is destructive which creates
great limitations. Because of this, MD-ICP-MS would not be a method of choice when working with museum collections (Kennett et al. 2004).

### 3.6.5 Laser Ablation

ICP-MS has been a favorable method for compositional analysis since its introduction to the analytical chemistry world. However, when it became possible to use solid samples through laser ablation instead of liquid solutions (Niziolek 2011), ICP-MS became more useful, popular, and convenient. Laser ablation “uses a laser to vaporize a small amount of a sample, which is then swept into the mass spectrometer by a gas” (Golitko 2011:253). Unlike INAA, which measures bulk composition, laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) uses a point sampling technique (Dussubieux et al. 2007: 350) which helps target specific materials in a sample. In ceramic production, the three main categories of raw materials include clay, temper, and other minerals for any coloring or glaze (Niziolek 2011: 226). Using LA-ICP-MS, specific materials in each sample can be targeted. This means that only the clay, temper, glazes, or paints can be measured if desired. The laser can be altered to target the material of interest (Niziolek 2013:2828). Since INAA is a bulk analysis technique and cannot target specific parts of the samples, its data could possibly differ from the data generated by LA-ICP-MS (Vaughn et al. 2011). If a study is comparing data from both methods, this difference must be taken into consideration.

LA-ICP-MS has a number of other advantages. One of the most appreciated benefits of the technique, for archaeological applications, is that it is minimally destructive (Pollard et al. 2007; Vaughn et al. 2011). Some scholars refer to LA-ICP-MS as non-destructive. However, “minimally destructive” is more accurate for two reasons. First, the laser does leave a mark on the solid sample, but it is so small it is almost invisible to the naked eye (Sharratt et al. 2009:796;
Second, if the artifact is not small enough to fit in the chamber, a sample must be taken from the artifact.

Sharratt and colleagues (2015) used LA-ICP-MS on Tiwanaku pottery from the Moquegua Valley in Peru. The goal of the study was to examine the production and regional exchange of pottery before and after the collapse of the Tiwanaku state. Previous to this study, research that has been pursued in the past regarding pottery production and exchange patterns in the Tiwanaku domain had relied on visual analysis (Sharratt et al. 2015). The visual analyses have helped identify the likely presence of non-local materials in some ceramic assemblages at the city of Tiwanaku and in the state’s provinces (Sharratt et al. 2015:400). As discussed earlier in this chapter, visual analysis cannot, however, confirm the presence of imports as opposed to the spread of style. With the use of LA-ICP-MS, Sharratt and colleagues (2015:409) were able to determine that Tiwanaku in Moquegua used local clays in ceramic production and that most pottery used by the community was produced with Moquegua Valley resources. However, about 10% of the analyzed sample was not produced from locally available clays but had been imported into the Moquegua Valley. Further, the non-local ceramics had likely come from multiple places (Sharratt et al. 2015:409).

3.6.6 X-ray Fluorescence

Another technique used to generate compositional data is X-ray fluorescence (XRF). When using XRF, “a specimen is irradiated with primary X-rays from an X-ray tube or from radioactive sources” (Rice 1987). The elements that have been detected and measured by their wavelengths and the intensity of the X-rays are measured quantitatively (Pollard et al. 2007; Rice 1987: 393). XRF is used only for solid samples, such as ceramics and obsidian (Shackley 2010:...
This technique also has a number of advantages. Analysis can be done using XRF without any sampling (Pollard et al. 2007: 107), and is considered non-destructive (Palumbo et al. 2015: 61). XRF is also very cost-effective, precise, has a multi-element system, performs rapid analyses, and is widely available (Bishop et al. 1982; Golitko 2011; Rice 1987).

XRF does, unfortunately, come with some disadvantages. First, one of the main problems that XRF can cause is the limitation in how deep the X-rays can penetrate the sample. XRF is a “surface sensitive technique” which means the X-rays cannot penetrate far into the samples (Bishop et al. 1982; Golitko 2011; Pollard et al. 2007; Rice 1987). This is why it is important to know what materials are being analyzed and the technique that will be used. If this is not taken into consideration then the surface may be dirty and cause contamination, or the wrong part of the sample could be analyzed by mistake (Pollard et al. 2007: 107). This makes XRF, however, great for analyzing surfaces on artifacts such as paints, glazes, or slips on ceramic samples (Rice 1987: 394). The method can also cause slight discoloration on the sample, but this is usually temporary and disappears after a short period of time (Rice 1987: 394).

### 3.6.7 Portable X-ray Fluorescence

A new addition of XRF includes a portable X-ray fluorescence technique, or pXRF. Many archaeologists find pXRF very useful. Overall, pXRF is cost-effective, non-destructive, and fast (Golitko 2011; Moholy-Nagy et al. 2013; Palumbo et al. 2015). However, there have been reports of inaccuracies when using pXRF. When comparing XRF to pXRF, there have been statistical differences in the measurements of individual elements (Moholy-Nagy et al. 2013: 93).

It is understandable why archaeologists are drawn to a portable XRF instrument. Not only is it affordable so any individual, laboratory, or university can obtain it (Shackley 2010:18), but the ability to bring a machine to an excavation where analysis can be done on site is very
convenient. This makes research where artifacts and samples cannot leave a country less complicated.

However, as Shackley (2010) discusses, there are problems with using pXRF. He acknowledges the technique as “an emerging and rapidly changing technology that has the potential to make very real changes” in archaeology (Shackley 2010: 18). He recognizes the capability pXRF has to become a great analytical technique, but urges archaeologists to slow down and consider the positives and negatives (Shackley 2010: 18). Not a lot of training is required to use the pXRF technology and almost anyone to get one. The pXRF equipment can cost around $50,000. Shackley (2010:18) describes how “an archaeologist can go in the field or in the lab and start shooting at any number of substances and get ‘real’ numbers.” As described above, the accuracy, protocols, and standardization for pXRF is questionable. Without fully knowing the evaluation of the technique, there is no guarantee that the generated data accurately represent the samples being measured. In the case of pXRF, until its strengths and limitations are fully understood, caution must be taken when using it for compositional analysis and research. Therefore, ideally, additional techniques should be used in the same study and on the same samples to help assure the correct data are generated. If there are considerable differences when comparing the results, then it is known there are inaccuracies in at least one method.

Firoozeh Forouzan and colleagues (2012) report the use of pXRF, and some stylistic analysis, on three different types of artifacts from Chogha Gavaneh, Iran. The authors used pXRF on zoomorphic figurines, “tokens,” and sling bullets to further understand the social and economic functions of these material goods (Forouzan et al. 2012:3534). They discovered that there were a number of outliers that were present in the collection of samples. Further, it was revealed that “the population of the area actually traded further into India and southern
Mesopotamia” than previously thought (Forouzan et al. 2012:3539). The groupings of these artifacts and outliers would have never been discovered with visual analysis alone. Forouzan and colleagues (2012:3534) also emphasize the importance of source databases in this kind of research. Such geological databases are useful because the chemical composition of artifacts can be compared to the source materials to determine if that was the place of procurement. However, Forouzan and colleagues (2012) acknowledged in their research that they did not have access to any such geological database. Although a database would be beneficial to the research, it is not detrimental to the study if there is none available because Forouzan and colleagues were still able to determine groupings of artifacts with similar chemical compositions. A database would be able to determine where the procurement of materials may have taken place, but this could be done for future research as an addition.

3.7 Overview

A number of techniques are now used by archaeologists to analyze the elemental composition of artifacts. Each has benefits and limitations. Bishop and colleagues (1982:275) urge how important it is for archaeologists to have a good understanding of the chemical analysis techniques, including their strengths, weaknesses, and how they work.

Another important point to be made refers to the use of multiple techniques. If possible, the use of multiple techniques in one study will increase the accuracy of the generated data (Golitko 2011: 259; Piscitelli et al. 2015). If certain elements cannot be detected or measured properly for any reason, the use of an additional method will be able to fill in the gaps within the generated data. For example, if pXRF is used in research, the use of another technique will help prevent possible inaccuracies since pXRF is still relatively new and the limitations are still not fully understood.
An example of a study that uses multiple techniques involves the analysis of obsidian samples using pXRF. Moholy-Nagy and colleagues (2013) analyzed 2,235 obsidian artifacts from Tikal, Guatemala. An additional 55 samples that had already been published were also included. These additional samples had been analyzed using XRF and INAA (Moholy-Nagy et al. 2013). Emphasis was placed on how compositional analysis does the work that visual analyses cannot. A trained analyst can distinguish an unusual-looking mineral in a ceramic sample, then the sample can be fully analyzed using compositional analysis techniques (Moholy-Nagy et al. 2013: 92). Visual analyses are great for initial assessments, such as style, color, texture, and so on. But the only way to know the composition of the samples is to use the chemical analysis methods. In visual analysis, it is not possible to see the elements present in the sample, so without the methods that have been discussed, compositional analysis is not possible with only visual analysis. Further, researching and deciphering trade and exchange of craft goods would not be possible with visual analysis alone.

Moholy-Nagy and colleagues (2013:92) also explained how certain elements could not be distinguished by pXRF if the level of those elements were too low to be detected. Therefore, according to Moholy-Nagy and colleagues (2013), these samples should also be analyzed by INAA, or another method. Therefore, INAA could measure more elements that pXRF may have missed because INAA is much more sensitive when detecting elements. Although this may be true, the data would be more reliable if INAA was used as a secondary method to compare generated data with the pXRF results (Moholy-Nagy et al. 2013). Due to the cost of INAA, it is understandable why this is not always possible, however, it must be considered. If pXRF is a method of choice, its limitations must be better understood and an appropriate research design should be planned accordingly. The possibility that the data resulted from pXRF are not accurate
or precise can severely alter any concluded findings. The use of additional method, such as INAA or the laboratory XRF, would help diminish any inaccuracies.

Moholy-Nagy and colleagues (2013:93) suggest that the elemental measurements were statistically different for pXRF when compared to previous XRF results. They argue, however, that the pXRF has a lot of potential because of its portable convenience, affordable cost, and swiftness. Regardless of its potential, pXRF should be used cautiously and the data Moholy-Nagy and colleagues obtained should not necessarily be declared definitive, but an initial assessment that should be continued in future research. Moholy-Nagy and colleagues (2013: 94) concluded that pXRF is great for rapid initial evaluations, but methods like INAA, or ICP-MS, should be included in the research to confirm measurements because of their low detection limits, high precision, and accuracy. Also, the use of these methods with visual analysis assessments will ensure dependable data.

This thesis utilizes two of the techniques discussed in this chapter to analyze ceramics sherds from Andean South America that have been visually identified as Tiwanaku. This state-like polity was a complex society that, many scholars claim, participated in specialized craft production and long-distance exchange. This thesis discusses data generated through compositional analysis on Tiwanaku ceramics to help reconstruct where the ceramics may have been produced and how they may have been distributed. The Tiwanaku state is introduced in the next chapter.
THE HISTORY AND CULTURE OF TIWANAKU

4 4.1 Introduction

This chapter focuses on the Tiwanaku state which emerged preeminent among a number of polities at the end of the Late Formative 2 period (AD 300-500) near the shores of Lake Titicaca in what is now Bolivia (Janusek 2008:1). Tiwanaku’s precursors as well as the environment in which the states are developed will be briefly introduced. The chapter then examines Tiwanaku’s city, hinterland, and peripheries. Given the topic of this thesis, this chapter also focuses on the production and exchange of Tiwanaku pottery.

4.2 Geography

Tiwanaku was an early state society that developed in the Titicaca Basin in Andean South America. The capital city (also Tiwanaku) was located only about 10 kilometers from the shores of Lake Titicaca in what is now modern-day Bolivia (see Figure 1) (Janusek 2004, 2008). The Tiwanaku state core was in an area of high altitude plains, called the altiplano which spans altitudes of 3,800 to 4,00 meters above sea level and is characterized by a cold and challenging climate (Goldstein 2005; Vranich 2013:2). Lake Titicaca is located at the lowest point of the altiplano.
Living in the altiplano is a difficult task because it is characterized by high altitudes, intermittent rainfall, hail, frost, a short growing season, and poor soils (Moseley 2001:41). Only the most specialized and hardy of crops grow in the altiplano, including various tubers and domesticated grains. Tubers include over 60 varieties of potatoes, oca, and ulluco, and some of the grains include quinoa and cañihua (Moseley 2001:41). Llamas and alpaca were useful for the transportation of goods, wool, food, and fertilizer (Moseley 2001:41).

4.3 Precursors of Tiwanaku

Prior to its emergence, Tiwanaku was only one of a number of polities within the Titicaca Basin (Vranich 2013:2). During the Late Archaic Period (5000-1500 BC) nomadic bands of people occupied the region. Sedentism was accompanied by the emergence of a subsistence economy based on agropastoralism (Janusek 2008:18). During the Archaic, villages were small
and temporary, and people began crafting pottery for cooking, serving, and storing food (Janusek 2008:18). By the Early Formative Period (1500-800 BC) the first non-nomadic villages were established in the Lake Titicaca Basin (Janusek 2008:18).

During the Middle Formative Period (800-200 BC) two regional cultural complexes developed, which Janusek considers (2004:18) the first complex societies in the region. One was Chiripa, named after the Chiripa site which is found on the Taraco Peninsula. The site included ceremonial buildings and monumental platform with sunken courts (Hastorf 2003; Janusek 2008:18). Inhabitants of Chiripa sites crafted elaborate pottery and had diversified local economies that included hunting, farming, and herding (Janusek 2008:18). Another Middle Formative Titicaca Basin polity was Qaluyu, located in the northern basin. Like Chiripa, inhabitants had elaborate pottery and platforms with sunken courts.

During the Late Formative 1 period (200 BC-AD 250), another society, called Pukara, emerged from the Qaluyu society and dominated the northern basin of the Lake Titicaca area (Janusek 2008:20). Trading expanded during the period and Pukara had a number of interactions with other communities throughout the Titicaca Basin to obtain goods they originally did not have access to. On the southern side of Lake Titicaca, on the other hand, many different polities developed out of the Chiripa polity. However, Janusek argues (2008:21) that until AD 200 there were no polities comparable to Pukara. At approximately this time, the Pukara polity began to diminish. After both Pukara and Chiripa collapsed, a number of what Janusek refers (2008:21) to as “ritual-political centers,” emerged. Some of these include Lukurmata, Palermo, Kala Uyuni, Khonkho Wankana, and Tiwanaku.

It was at the end of the Late Formative 1 that Tiwanaku emerged out of these “networks of interacting and fluid polities” (Janusek 2004, 2008) and became the main political, economic,
cultural, and ceremonial center in the Titicaca Basin. Janusek suggests (2008:22) that “Tiwanaku’s early success, in great part, was its ability to incorporate geographical and social diversity through a flexible, elegant cosmology and prestigious goods and practice.” This encouraged more surrounding communities and polities to ally with Tiwanaku. Consequently, Tiwanaku expanded into an early state that endured for centuries until its collapse around AD 950-1000. The core, hinterland, and peripheries of Tiwanaku during state apogee are briefly introduced in the next section.

4.4 Tiwanaku Core

For the research presented, the core represents the Tiwanaku capital region. Drawing on recent research and excavations, many scholars have referred to the site of Tiwanaku as a metropolis, symbolic center, and cosmopolitan city. Some scholars, such as Alan Kolata (1993) argue that Tiwanaku’s core was a highly centralized state. The Tiwanaku site itself consisted of great monuments, residences, plazas, and other forms of architecture. The city was characterized by social stratification indicated by a neighborhood or residence’s distance from the core (Janusek 2004, 2008). Higher status households are located closer to the core than those of lower status. Higher status households are also identified by the material used in the construction, the size of the residence, the infrastructure, and the assemblages (Janusek 2004, 2008).

During Tiwanaku IV (AD 400-800), many great monumental complexes were either repurposed from existing ceremonial space or constructed anew (Janusek 2008:109; Sharratt 2011). Some of these monuments include the Pumapunku and Akapana temples. The Pumapunku temple was an independent ritual complex that was attached to a large plaza and was located some hundred meters southwest of the Akapana temple. Its construction began during early Tiwanaku IV. The impressive monument included superimposed floors with vibrant green
plaster for theatrical performances and ceremonies (Vranich 1999). The construction occurred during three major phases. Although some scholars find Pumapunku to be very similar to the Akapana (Kolata 1993), Pumapunku’s had different spatial configurations (Janusek 2008:118). The Akapana temple was also constructed in early Tiwanaku IV. The Akapana had seven superimposed terraces that concluded in a high platform (Janusek 2008; Manzanilla 1992). Although it was constructed in early Tiwanaku IV, there is evidence that the building may have been renovated around AD 800 (Janusek 2004). There is also evidence for a number of offerings of llamas, humans, and smashed ceramic vessels (Janusek 2004; Sharratt 2011). Other than monumental buildings, the ceremonial core at Tiwanaku also incorporated other structures. For example, plazas were major features within the Tiwanaku landscape (Janusek 2008). Many plazas were associated with major Tiwanaku constructions such as Pumapunku and Akapana.

Portals and ritual movement were also crucial in Tiwanaku’s ceremonial core. Unlike other polities in Andean South America, the Tiwanaku temples, ceremonies, and rituals were open to a great number of people, not just a select group (Janusek 2008). Portals, such as the Sun Portal, had great importance. The portals “opened into narrow chambers, instilling a sense of mystery, disorientation, and esoteric power as a person entered increasingly sanctified and intimate spaces” (Janusek 2008:127-128). In other words, portals were entrances to temples, such as Pumapunku, and the passage ways that people walked through had created movement in such a way that it gave people a realistic spiritual experience.

Extensive research and excavations has been conducted at Tiwanaku’s temples. Research on Tiwanaku residential areas has increased over two decades (Janusek 2004, 2008). According to Janusek (2002, 2003, 2004, 2008), the core city of Tiwanaku grew in great part due to the construction of residential compounds. The compounds were uniformly aligned, enclosed, and
grouped together to create smaller communities. Each residence individually had a patio, refuse pits, storage bins, wells, kitchen, animal pens, and refuse dumps (Janusek 2008:155).

4.5 Tiwanaku’s Hinterland

Both Kolata (1993, 1996) and Ponce Sanginés (1989) “describe a highly hierarchical four-level Tiwanaku settlement system corresponding to the state agricultural investment and a quadripartite division of administrative and production functions” (Goldstein 2005:82). Kolata suggests (1993) that settlement within the Tiwanaku core region is directly connected with the development of raised field systems because smaller polities would have wanted to be part of the centralized agriculture rather than build and organize their own raised fields somewhere else. Within Tiwanaku’s hinterland there were second tier settlements such as Lukurmata, Khonko Wankane, and Pajchiri (Kolata 1993; McAndrews et al. 1997). Lukurmata showed significant similarities in daily and ritual practices to the Tiwanaku core. Tiwanaku-style ceramics were also present at Lukurmata, as well as in residential homes (Sharratt 2011). However, ceramics that were specific to Lukurmata, as briefly mentioned in Chapter 2, are known for their tan ware pastes and a red paint that is lighter than the traditional red used for most Tiwanaku ceramics. Lastly, excavations at Lukurmata showed evidence of substantial storage facilities (Kolata 1993). These storage facilities were used for storing excess food or materials that may have been distributed to the people.

Agriculture was an important part of the hinterland. Agriculture production intensified during Tiwanaku IV and raised field systems were moved into marshy areas (Janusek 2008). During his excavations in Lukurmata, Kolata (1993:207) noted that “Lukurmata is linked directly to the raised field complexes of the Pampa Koani by elevated roadbeds.” There were also roadbeds that connected to another hinterland site, Pajchiri, and to Tiwanaku.
Agriculture was even more complex in Pajchiri compared to Lukuramata. Pajchiri had raised fields on artificial, stepped terraplots, aqueducts, and a large freshwater reservoir that was connected to the aqueduct by a canal (Orloff and Kolata 1989). Kolata (1993:209) argues that “the entire system may have functioned to mitigate the problem of hypersalinization in lake-edge fields, and thereby maintain optimal production for the support of this pivotal administrative center.” Both Pajchiri and Lukurmata exemplify the extensive agriculture and technology that was present in the Tiwanaku communities.

4.6 Tiwanaku’s Peripheries

Beyond the hinterland, Tiwanaku maintained relationships with communities across the south-central Andes. Provinces have been identified in the Moquegua Valley (Figure 2) and Cochabamba (Goldstein 2005; Anderson 2013). Bio-archaeological data confirm that at least in the case of Moquegua, provinces include migrants from the Tiwanaku core, including sites such as Lukurmata. Material styles, ritual practices, and residential households have been found in the Moquegua Valley that are similar to those in the Tiwanaku core (Goldstein 2005), implying the people identified as Tiwanaku in the hinterland and periphery (Bennett 1936; Goldstein 1993; Sharratt 2011). Similarly, Tiwanaku-style ceramics have been found at Cochabamba, which is illustrated in Figure 3 (Anderson 2013; Janusek 2008). The Tiwanaku elites utilized their connections with these peripheral communities to access desired resources such as coca and maize from lower elevations (Janusek 2008).
Figure 2 Map of Peru showing peripheral sites (redrawn from Williams 2013)
Portable material culture, including ceramic vessels, were important tools in Tiwanaku expansion, serving as media for sharing styles and ideology across the Tiwanaku realm and
acting as emblems of both Tiwanaku wide and regionally specific identities (Janusek 2008:141; Sharratt et al. 2015). The appearance of Tiwanaku ceramics began around AD 500 and “marked the appearance of new religious iconography that developed out of formative themes but was strikingly different in execution and meaning” (Janusek 2008:141). Tiwanaku ceramics have been the subject of numerous studies, which have identified an array of forms and decorative repertoires (Bennett 1934, 1936; Goldstein 1985; Janusek 1999, 2002, 2003, 2004a, 2004b; Korpisaari, Oinonen and Chacama 2014).

### 4.7.1 Tiwanaku Ceramic Vessel Classes and Types

According to Janusek (2003:57), Tiwanaku ceramics include a wide range of forms, surface treatments, and iconography. In order to categorize Tiwanaku pottery, Janusek (2003) divided them into broad functional classes such as cooking and storage vessels, serving vessels, and ceremonial vessels. Some cooking and storing vessels include *ollas* and *tinajas*. *Ollas* varied greatly in size and were generally large, large bulbous vessels with restricted necks (Janusek 2003). *Ollas* were primarily used as cooking vessels, but were also used as storage vessels. *Tinajas* also came in different varieties. They generally had a sloping shoulder, curved neck with a neck handle or two opposing body handles (Janusek 2003:59). They were specifically used for transporting and storing liquids and beverages such as water and chicha (maize beer). Visually, *tinajas* and *ollas* can be difficult to distinguish, particularly if working only with fragmentary material (Janusek 2003).

Another functional class, the serving vessels, consisted of vessel types including *keros* and *tazones*. *Keros* were the classic Tiwanaku drinking goblet. They are also regarded as the most distinctive emblem of Tiwanaku ceramics (Janusek 2003:60). This form was very popular among the communities and were produced and distributed on a major scale. *Tazones* were the
classic Tiwanaku serving and eating bowls (Janusek 2003:63). *Incensarios* constitute Janusek’s final functional class. These were elaborate ceremonial vessels and often display evidence that substances were burned in them. Many were found in Lukurmata accompanying offerings and burials (Janusek 2003:71). *Incensarios* usually had a zoomorphic head and tail to represent a llama, condor, or feline.

### 4.7.2 Tiwanaku Ceramic Iconography

The Tiwanaku-style emerged out of the Qeya-style and involved a considerable expansion in the range of depicted iconography (Janusek 2003:75). Janusek (2003:75) further explains “the new repertoire of decorative and iconographic images constituted a corporate style, a standardized and temporally conservative repertoire of techniques and material patterns that expressed Tiwanaku state political and religious ideology.” Stylized iconography depicted animals such as birds, felines, serpents, and llamas, however, felines were central symbols of power (Janusek 2003:75-76). A great number of geometric designs were also painted on the ceramic vessels (Figure 4).
4.8 Pottery used for Chronology

According to Janusek (2003:31), “in pottery, style is not simply expressed in a set of decorative attributes; it is crafted into a vessel through specific techniques of production.” Therefore, pottery embodies affiliations, intentions, and ideas. Understanding style within a society is important because it plays an active role in the community. Style can reflect the identities of the community, as well as their traditions and ideologies. For example, in the case of Tiwanaku, if ceramics were found in other periphery sites and recognized as Tiwanaku-style, it can be argued that those communities identified as Tiwanaku. The style, as well as ideologies, affiliations, and technology, can change over time in a society. Therefore, ceramic styles have been used by archaeologists to construct chronologies based on the changes in these styles.
4.8.1 Tiwanaku Chronologies

A number of chronologies have been proposed for Tiwanaku. Between 1932 and 1934, Wendell Clark Bennett excavated the site of Tiwanaku and hinterland sites such as Chiripa and Lukurmata (Bennett 1934, 1936; Janusek 2008:11). After excavating numerous test pits at these sites, Bennett (1934, 1936) created a chronological sequence divided into Early, Classic, and Decadent phases. Each was characterized mostly by undecorated pottery sherds (Bennett 1934, 1936; Janusek 2004:84). Both Classic and Decadent Tiwanaku are characterized by more elaborately decorated pottery sherds. As Bennett stated (1934:403), “it is the style of decoration which most clearly marks the division” between Classic and Decadent phases. To distinguish between the two, Bennett describes (1934:404-406) the various groups of traits that characterize the Classic and Decadent Tiwanaku styles. He further argued that these traits must be viewed in groups rather than individually. In other words, the characteristics of the design style, vessel shape, and type of vessel, to name a few, seen together may classify a specific type of Tiwanaku-style pottery. Vessel shape, for example, may be the same in the Classic and Decadent Tiwanaku style. However, the Classic vessel shape may have a different artistic design on it compared to the Decadent vessel with the same shape. Therefore, Bennett refers to decoration as a criterion for dividing similarly shaped vessels.

According to Bennett (1934:404-405), Classic Tiwanaku pottery designs are generally restricted to the exterior of the vessel: “A scallop or a wavy line may adorn the inner rim of a vessel, but the principal design area is on the outside” (Bennett 1934:404). Further, the designs usually cover the whole exterior of the vessel rather than only parts of it. These designs were usually zoomorphic drawings which were outlined in dark lines. The zoomorphic figures were colored in with decorative details and various colors (Bennett 1934:404). Human figures only
had heads depicted while the zoomorphic figures had both head and body. Bennett argues (1934:404) that there were no vessels that did not follow this “rule” during Classic Tiwanaku. Pumas did not have four legs depicted, the proportions of the figures were true, and the figures were meant to be realistic (Bennett 1934:404). Generally, scenic compositions were very uncommon, therefore, the figures were repeated around the vessel.

In comparison to Classic Tiwanaku styles, according to Bennett, Decadent Tiwanaku vessels still had the designs on the exterior, but instead of the designs covering the entire exterior of the vessel, Decadent designs cover only some areas (Bennett 1934:405). Figures are still outlines with dark colors, but there are also figures filled in black as well. There is a lesser variety of detail and color in the designs which, for Bennett, implies simplification compared with Classic styles (Bennett 1934:405). The figures are also slightly altered during Decadent Tiwanaku. For example, Bennett explains (1934:405-406) that rather than realism in human figures during Classic Tiwanaku, the Decadent Tiwanaku human figures had elongated heads, “in which the profile and the back of the head are separated from the eye and by abnormally long distance”. An eye of the human figure may become the focus of the vessel’s design. Lastly, the heads may even be depicted upside down or have other unique placements.

Bennett’s chronology was explicitly based on his observations of stylistic changes in the decorative repertoires found on pottery. Although his chronology and interpretations were subjective, he was the first scholar to attempt to develop a reference timeline for Tiwanaku. He was also the first archaeologist to conduct systematic excavations at Tiwanaku.

Following Bennett, Carlos Ponce Sanginés developed a chronology for Tiwanaku based on three stages and five epochs (Janusek 2004:85). Ponce Sanginés was an archaeologist and politician who aimed to reconstruct “Tiwanaku as the pre-Columbian symbol of Bolivian
national identity” (Vranich 2013:5). He strongly insisted that Tiwanaku had been insufficiently studied by foreigners and, therefore, should be researched from a “Bolivian perspective.” He argued that Tiwanaku was just as powerful and expansive as any ancient civilizations in the Old World (Vranich 2013:5). However, when Ponce Sanginés started his excavations in the 1950s, he noted that the site was not as monumental and magnificent as it first appeared. Ponce Sanginés attempted to reconstruct the Tiwanaku core monuments in hopes of attracting visitors to witness the site. However, his attempts failed in part because visitors found it challenging to explore the monument. Therefore, Ponce Sanginés stopped his project and ended up taking down part of the reconstructed parts of the monuments (Vranich 2013).

Ponce Sanginés’s chronology was based on a ceramic sequence and consists of Tiwanaku I through Tiwanaku V. His chronology was linked to another evolutionary model that consisted of three stages (Kolata and Ponce-Sanginés 2003; Sharratt 2011). In this three-stage model, Tiwanaku I and II (200 BC–AD 200) corresponds with the social organization characterized by smaller villages (Kolata and Ponce-Sanginés 2003). Tiwanaku III (AD 200-400) is when early state-like organization began and by Tiwanaku IV (AD 400-800) the society advanced to the height of its state. In Tiwanaku IV, the Tiwanaku monumental core was built. Finally, during Tiwanaku V (AD 800–1200) Tiwanaku expanded to its limits before its decline (Kolata and Ponce-Sanginés 2003; Sharratt 2011).

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John W. Janusek’s chronology of Tiwanaku differs. According to Janusek (2003, 2004:86) “combined, stratigraphy, seriation, and radiocarbon dating reveal three major periods of regional, social, political, and religious development between 200 BC and AD 1570.” Janusek (2004:86-88) labels these three periods as Late Formative Period (200 BC–AD 500), the Tiwanaku Period (AD 500-1150), and the Pacajes Period (AD 1150-1450). The Late Formative Period is divided into two phases: Late Formative 1 (200 BC–AD 300) and Late Formative 2 (AD 300-500). Again, pottery is a critical component of chronology building for the Tiwanaku. The Late Formative Period is characterized by its undecorated wares and smaller vessels (Janusek 2004:86).

Janusek (2004) had originally been divided into four phases. These include Early Tiwanaku IV (AD 500-600), Late Tiwanaku IV (AD 600-800), Early Tiwanaku V (AD 800-1000), and Late Tiwanaku V (AD 1000-1150). However, Janusek currently argues (2008:21-22) there are only two principal phases within the Tiwanaku Period which are divided into Tiwanaku 1 and 2. Tiwanaku 1 (AD 500-800), is characterized by its elaborately decorated redware pottery (Janusek 2008:22). Generally, all households in the Tiwanaku core had access to ceramic vessels for consumption. Tiwanaku 2 (AD 800-1000) had, according to Janusek (224:23) a more centralized political economy and the people were dependent on the elite within the core. This forced Tiwanaku into a more hierarchical and stratified polity. The last period is called the Pacajes Period (AD 1150-1450) and is contemporaneous with the wider Andean Late Intermediate Period, a period characterized across much of Andean South America by stylistic variation and political instability. In the Titicaca Basin, new settlement patterns and cultural practices began in the Pacajes Period. As discussed, a number of chronological models for
Tiwanaku history have been proposed over the past 80 years (see Table 1). However, this thesis utilizes Janusek’s chronology. Bennett’s chronology is not included in Table 1 because it is based on relative chronology rather than designated years.

4.1 Interpretations of Tiwanaku

The first people who reportedly encountered the ruins of Tiwanaku were the Inca who emerged in the Cuzco region during the Late Intermediate Period (AD 1000-1470). Other people before the Inca probably confronted the Tiwanaku ruins, but there are no records or evidence pointing towards who that was. The Inca’s acknowledgement of the ruins was recorded by the Spanish after they conquered the Inca empire (Moseley 2001). The Inca state developed into an expansive empire during the Late Horizon (AD 1470-1533) and was eventually eventually conquered by the Spanish in 1533 (Moseley 2013). The Inca believed they had the right to conquer whoever they wanted because they were presumed to be the “firstborn” (Vranich 2013:3). However, when the Inca armies approached the Titicaca Basin, they witnessed the eroding monuments of a civilization that obviously pre-dated the Inca. The Inca believed that these ruins might represent an old world that was destroyed by the creator god, Viracocha (Vranich 2013:3). This old world was thought to have been inhabited by giants (Moseley 2001:13). Tiwanaku marked the end of one world and the start of the next world for the Inca civilization (Vranich 2013:3), and was where Viracocha used clay from Lake Titicaca to sculpt the first humans (Janusek 2008; Moseley 2013:11). Although this was just one of the Inca’s many origin myths, the Inca considered Tiwanaku a very special and sacred place of political authority and divine creation. From the time the Inca came across the Tiwanaku sites people have been attempting to figure out its enigmatic story.
Many archaeologists support the interpretation that Tiwanaku was a state, but there are also some who dissent. Scholars who disagree with Tiwanaku as a state do so for various reasons, all of which include characteristics from Childe’s criteria for states. No form of writing has been found at Tiwanaku, but neither did the Inca and they were an expansive and powerful state. The degree of government or elite control, if any, is unclear and surviving architectural monuments are few. Recent research on Tiwanaku that has been conducted by a number of scholars has supported Tiwanaku as a state.

The supporters of statehood will be summarized first, beginning with Max Uhle, a German archaeologist. During the late 1800s, Uhle examined historical chronicles and suggested that “ancient Tiwanaku was the origin center and capital of an advanced pre-Hispanic polity that had incorporated much of the central Andes for a relatively brief period” (Moseley 2013:12-13). However, more research had to be conducted before anyone took Uhle’s conclusion of Tiwanaku as fact. In 1922 Kroeber and some of his students worked on the Uhle collections using seriation to order the materials chronologically. By 1927, all of the materials in the collections had been published (Moseley 2013:13). Kroeber’s project and the publications “reaffirmed” the claim that Tiwanaku was an expansive state that was comparable to the Incas (Moseley 2013:13).

Charles Stanish (2013) supports the claim that Tiwanaku was a state. He argues that Tiwanaku was one of the greatest civilizations in the ancient world (Stanish 2013:151). Stanish (2013) compares Tiwanaku to well-known state societies. For example, Mycenae was considered to be about half the size of only Tiwanaku’s architectural core. As a whole, however, Tiwanaku has been estimated to be about six times larger than Mycenae, and possibly even larger (Stanish 2013:152). Therefore, the size of Tiwanaku should not be a reason for why Tiwanaku would not be considered a state. Stanish (2013:152) believes that Tiwanaku demonstrated qualities of a
state including great works of art on an immense scale, impressive architecture including temples and palaces, built roads, and more. Further, Tiwanaku also created city centers for religious, social, cultural, economic, and political activities (Stanish 2013:153). Tiwanaku also influenced many areas in the south-central Andes. A number of large-scale colonies were maintained, as well as long-distance exchange relationships with distant communities (Stanish 2013:153). Lastly, Stanish (2013) notes that a number of craft specialists existed who worked on pottery, metals, stone, and architecture.

Janusek (1999; 2002; 2008; 2013), discusses the concept of “state culture” in relation to Tiwanaku. State culture, he (Janusek 2008: 152) asserts, is “a suite of technologies, styles, practices, and ideals that was internalized and idealized by elites and commoners alike.” Some of Tiwanaku’s most important elements of state culture include ritual consumption and peaceful coexistence among people with different ideals (Janusek 2008). Janusek (2008) also includes the strong influence Tiwanaku had in the south-central Andes and its impressive trading relationships.

Paul Goldstein (2013) focuses his work on Tiwanaku’s peripheral colonies rather than the heartland. Goldstein (2013:41) argues that “Tiwanaku’s version of state expansion, as a great popular migration, differs from the expansion of many agrarian archaic states worldwide.” In other words, he argues that Tiwanaku was a state, but it is a different kind of state model than most archaeologists typically use. Generally, states require military force (Goldstein 2013) which Tiwanaku lacked, according to current archaeological research. The state concept, as Goldstein (2005, 2013) suggested, should be looked at broadly with flexibility. Although there are characteristics that are common among many state-like societies, there is no one type of a state.
“Segmentary states,” first proposed by Aiden Southall, is an example of a “unified yet less unitary early state” (Goldstein 2005, 2013). This less strict sense of a state includes partial involvement under government authority, but one that still maintains a high level of political autonomy. Goldstein (2005, 2013) suggested that this model was appropriate for Tiwanaku. There is still control, but people have more freedom in their daily lives, especially in the peripheral communities outside of the Tiwanaku core. Goldstein (2005, 2013) further envisioned Tiwanaku as a pluralistic state. In political pluralism, people are able to coexist in a society with different lifestyles, beliefs, interests, and so on (Goldstein 2013). Tiwanaku’s diversity has been one of the reasons why some scholars do not view Tiwanaku as a state. To some, diversity within a community signifies factionalism or a weak state (Goldstein 2013:59). Goldstein (2013), however, considers Tiwanaku to be “a socially diverse and politically confederate state” that was strategic and influential.

Karen Anderson (2013) suggests using another state model for Tiwanaku. She introduces Richard Blanton’s model which includes exclusionary and corporate states. Exclusionary states involve authority figures that have few restrictions on their power (Anderson 2013:87; Blanton 1998). Usually, images of the authority figure or ruler, their name, life, and achievements will be depicted on architecture and portable material culture and after death, those leaders will be buried in elaborate, ostentatious royal tombs (Anderson 2013; Blanton 1998). Indirect control over periphery communities is enacted through alliances with local elites.

In corporate states, on the other hand, there are restrictions on a ruler’s power (Anderson 2013; Blanton 1998). There are very few, if any, images of rulers or royal tombs. Both elites and commoners alike had the same access to various kinds of crafts, such as the different styles and types of ceramic vessels (Anderson 2013; Blanton 1998). Corporate states concentrate more on
including people within the society, whether it is in rituals or craft distributions, rather than overpowering and coercing them. Anderson (2013) suggests that the corporate state model fits Tiwanaku best. This is because Tiwanaku has no royal burials or images of rulers, wide distribution and availability to various kinds of material goods, and limited palaces (Anderson 2013:106).

Patrick Ryan Williams (2013) suggests that Tiwanaku was a pluralistic expansive state. By comparing Tiwanaku and Wari peripheral communities, Williams suggests that the Wari constituted an empire while Tiwanaku was more of a pluralistic state. The Moquegua Valley is the only known area in the Andes where both Tiwanaku and Wari simultaneously occupied it (Williams 2013:38). Focusing on the Moquegua area, Williams (2013) suggests that Tiwanaku lacked any centralized authority in the provincial setting. However, determining whether a society was a state or not cannot be established by examining only one area. Obtaining information from the core, hinterland, and periphery is necessary for a complete evaluation. Therefore, Williams’ research very useful when determining life and organization in the periphery, away from the core. Overall, Williams (2013: 38) argues that “Tiwanaku was a pluralistic expansive state,” but peripheral communities, such as Moquegua, were less complex and socially stratified than the Tiwanaku core. Since the Wari, however, seemed to have greater hierarchical class systems, more centralized exchange networks, and a military, they were considered to be a more complex society (Williams 2013).

Other challenges to Tiwanaku’s statehood can be seen in the debates between Erickson and Kolata. Their disagreements focus on agriculture and states. Kolata (1991) argues that raised field agriculture requires centralization and bureaucracy, and that the Tiwanaku state was involved directly in the creation and management of the fields. Erickson (1993) disagrees with
this statement and argues that raised field systems never required a state. Instead, he claims that raised field agriculture developed very early. In the Lake Titicaca Basin, Erickson (1993: 371) declares that raised field agriculture began around 1000 BC. He also undertook ethnographic work within rural communities in the region and demonstrated that raised field agriculture does not require corporate organization. However, this debate on the significance of agriculture as a requisite for statehood is still ongoing.

4.2 Conclusion

Tiwanaku was an early state society that emerged in the Titicaca Basin in Andean South America. Tiwanaku was located in the altiplano, a cold and harsh environment, where hardy crops were grown and camelids were domesticated. A number of smaller villages surrounded the Titicaca Basin area before Tiwanaku, until two regional cultural complexes, Chiripa and Qaluyu, developed and conquered their local areas. Pukara was the last complex society before the emergence of Tiwanaku. Tiwanaku became the main cultural, ceremonial, economic, and political center in the Titicaca Basin.

Tiwanaku consisted of three separate sections: the core, hinterland, and periphery. The relationship between these three sections is crucial to understanding what Tiwanaku was. This thesis focuses on Tiwanaku ceramics from each of those sections. Ceramics were significant in the Tiwanaku culture and were important tools in the expansion of Tiwanaku. The design and style of Tiwanaku ceramics are also distinct with some of their shapes and their iconography. Zoomorphic designs such as pumas and felines were very common. Tiwanaku ceramics, in general, have been subject to a great number of studies in archaeology.

There have been a number of models suggested for what kind of society Tiwanaku was. Goldstein (2013) suggests a diaspora model and that Tiwanaku was a pluralistic expansive state.
Williams also suggested that Tiwanaku was a pluralistic state. This model states that Tiwanaku started at the core and eventually people dispersed and expanded to other surrounding communities in the hinterland and the periphery. Opportunities for materials, agriculture, livestock, and more, was greater outside of the core, which allowed for people to expand towards the hinterland and periphery (Goldstein 2005). Southall also proposed a segmentary state model, which Goldstein also supported. Anderson (2013), on the other hand, suggested Blanton’s model which included corporate and exclusionary states. Many of the models that have been discussed are appropriate for the Tiwanaku state. Within a diaspora state, people migrate from the core and settle in communities that are located in the periphery, such as Moquegua for Tiwanaku. People migrated out of the heartland, but still maintained their Tiwanaku identity, traditions, and ideologies (Goldstein 2005). Another model, the pluralistic state model, can account for Tiwanaku’s diversity within its society. Within pluralistic states, different lifestyles, ideologies, and activities may occur (Goldstein 2013). Tiwanaku was a diverse society, but also had certain set values and ideologies. Tiwanaku also shares a number of qualities from Blanton’s (1998) corporate state model. For instance, Tiwanaku had a relative lack of images of rulers, however, there are some elite burials that have been excavated. Material goods were evenly distributed among the Tiwanaku population. However, some scholars, such as Janusek (2003, 2004, 2008), have argued that the general population had access to ceramics, but people who were further from the center of the core did not have access to the elaborate ceramic vessels. People who resided in the outer neighborhoods further from the center may have had cruder and more basic ceramics, and their residences were much simpler compared to those of the elites. Tiwanaku also consisted on various temples throughout the many sites, indicating integration of people into ceremonies and ritual activities.
Debate about the nature of the Tiwanaku state continues. Tiwanaku did not have a writing system, no military, and there was control administered by a government and elites. As discussed in Chapter 2, archaeologists working in diverse contexts have examined the relationship between political organization and production and exchange. By conducting compositional analysis on a sample of Tiwanaku ceramics from a number of sites, this thesis examines Tiwanaku ceramic production and exchange.

5 Research Design

5.1 Introduction

This chapter presents the research design of this thesis. It first discusses existing research on Tiwanaku ceramics before detailing the research questions addressed in this study. The collections that analyzed samples derived from are then discussed. These collections include the Bennett Collection at the American Museum of Natural History, the Tarija Collection at the Field Museum of Natural History, and material from the Moquegua Valley in Peru. Following the discussion of the samples, the specific methods used in this research are detailed. Finally, this
chapter describes the statistical procedures used to analyze the data that were obtained through compositional analysis.

5.2 Existing Research

Tiwanaku ceramics have been the subject of a number of studies. Largely based on visual analyses, this work has identified an array of forms and decorative repertoires (Bennett 1934, 1936; Goldstein 1985; Janusek 1999, 2002, 2003, 2004, Korpisaari et al. 2014), as described in Chapter 4. However, to date, there has been relatively little compositional analysis of Tiwanaku pottery. In particular, analyses and interpretations of heartland Tiwanaku pottery, such as from the capital city and from surrounding hinterland sites, depend overwhelmingly on visual analyses (Janusek 2003; Korpisaari and Parssinen 2001). Relying principally on regional differences in form and decorative style, scholars have drawn on visual analyses to argue that ceramics were moving into and out of the Tiwanaku heartland (Goldstein 2005). For example, ceramics identified, based on style, as being from Cochabamba in the eastern lowlands, were recovered from the Chiji Jawira neighborhood at the city of Tiwanaku in the altiplano (Rivera Casanovas 2003). The lack of published compositional data derived from ceramics excavated at sites in the Tiwanaku core makes it difficult to determine whether they were produced centrally at the core then distributed, or if they were made locally at each separate Tiwanaku province. It also limits attempts to determine whether ceramic vessels were circulated around the Tiwanaku realm or if styles were being shared.

The limited existing published compositional work on Tiwanaku pottery, conducted at the Field Museum’s Elemental Analysis Facility, focuses on the Tiwanaku province in the Moquegua Valley (Sharratt et al. 2009; Sharratt et al. 2015), which was discussed briefly in Chapter 4. This research revealed that about ten percent of analyzed Tiwanaku assemblages from
Moquegua was produced using non-local clays (Sharratt et al. 2009; Sharratt et al. 2015), and confirmed that Tiwanaku ceramics were moving long distances. However, the absence of published data on Tiwanaku ceramics produced in the heartland or in the lowland provinces to the east makes it difficult to assess the degree to which the Tiwanaku core participated in long-distance exchange. Further, there is currently no published database on the chemical composition of clays from the Lake Titicaca Basin. By deriving compositional data from ceramics excavated in the Tiwanaku core (the Titicaca Basin), as well as from various periphery communities, this thesis will facilitate a better understanding of Tiwanaku’s craft production and exchange networks. This research also compliments existing visual analyses of heartland and periphery ceramics as well as the existing geochemical research on the provincial Tiwanaku ceramics from southern Peru, and will examine whether pottery was being circulated between the different regions.

5.3 Research Questions

Compositional analysis was undertaken on Tiwanaku ceramics to examine craft production and exchange patterns across the state. As discussed in Chapter 2, the centralized production and long-distance exchange of material goods, such as pottery, has been associated by many archaeologists with complex states in the past. This thesis drew on the compositional derived through LA-ICP-MS and pXRF to address the following questions:

1) How tightly centralized and standardized was ceramic production in the Tiwanaku state?
   a. Is there evidence for centralized ceramic production at the capital city of Tiwanaku?
b. To what extent was ceramic production in the Tiwanaku core centralized and standardized? Were ceramics produced at one site in the Tiwanaku core and then distributed or did different sites produce their own ceramics?

c. To what extent was ceramic production in the Tiwanaku periphery centralized? Is there evidence for standardized, controlled production in provincial Tiwanaku sites?

2) How were the ceramics circulated and exchanged throughout the Tiwanaku territory?

a. Were ceramics produced at the core and then distributed to the hinterland and periphery?

b. Is there evidence for non-local ceramic material at Tiwanaku? If so, does the compositional data indicate where non-local material was imported from?

c. Is there evidence for non-local ceramic material at sites in the hinterland? If so, does the compositional data indicate where non-local material was imported from? Did different hinterland sites have differential access to non-local material?

d. Is there evidence for non-local ceramic material at provincial Tiwanaku sites? If so, does the compositional data indicate where non-local material was imported from?

e. What proportion of analyzed ceramics were non-local at the site of Tiwanaku, at the hinterland sites, and at provincial sites?

Since there is no published database on the chemical composition of clays from the Lake Titicaca Basin, my thesis relies on the “Criterion of Abundance,” which was introduced in Chapter 3. The “Criterion of Abundance” states that if a large quantity of ceramic materials that are chemically similar are present at a site, then they can be assumed to be locally manufactured.
This relies on identifying the compositional signature for ceramics from a given region or site. Therefore, this thesis begins by addressing the following:

1) Do ceramics from the Tiwanaku core, hinterland, and peripheries have distinct compositional signatures? Can they be differentiated compositionally?

2) Do ceramics from different sites within the core, hinterland, or peripheries have distinct compositional signatures?

5.4 Ceramic Samples

Samples included in this study were drawn from the collections at the American Museum of Natural History in New York City, the Field Museum in Chicago, as well as sherds that had already been legally exported from the Moquegua Valley, Peru. The research presented in this research incorporated a total of 112 samples from five identified sites as well as two general areas areas (Tarija, Bolivia and La Paz Bolivia). Not all samples were measured using both LA-ICP-MS and pXRF. For reason that are addressed later, some samples were measured only using one technique. A total of 104 samples were measured using LA-ICP-MS and 89 total were measured using pXRF. Many were measured with both.

5.4.1 American Museum of Natural History, Archives, and the Bennett Collection

Multiple visits to the American Museum of Natural History (AMNH) were undertaken to select the samples used in this research, as well as to view the original documents from Bennett’s excavations in the museum archives. The archives consisted of of letters, documents, and field notes. Wendell Clark Bennett conducted archaeological research in Bolivia from December 1933 to September 1934 (Bennett 1936:331). Originally, Bennett was to return from his excavations in Bolivia in May or June 1934, but he received approval from the museum to extend the excavation a few months longer. 46 of the samples included in this thesis are from Bennett’s
excavations around Tiwanaku and the Titicaca Basin. Bennett brought collections from various sites in Bolivia to the United States where they are still curated at the American Museum of Natural History (AMNH) in New York City. They constitute one of the most significant collections of Tiwanaku material in the USA. The entire Bennett Collection at AMNH includes numerous ceramics and sherds, as well as other material, from Tiwanaku and surrounding provinces in the Titicaca Basin. In addition to the Tiwanaku core, the collection includes material from sites of Chiripa, Pariti, Lukurmata, and Llogheta in the Titicaca Basin Tiwanaku heartland, and the sites of Arani and Colcapirhua in the Cochabamba region. However, only sherds from Tiwanaku, Chiripa, and Lukurmata from the Bennett Collection were analyzed in this research.

After arriving and waiting in La Paz for some time (three weeks), Bennett was able to obtain his permit to excavate in Bolivia. Initially, however, all of the analysis had to be done within the country (The Papers of Wendell Clark Bennett, .B466). This issue was eventually resolved and Bennett was able to export his findings back into the United States. Bennett first visited Cochabamba because there have been an “Indian uprising” around Tiwanaku, according to Bennett’s letters to AMNH. Five pits were excavated near Cochabamba. The pits were dug in low mounds, or *moros*, which Bennett identified as habitation sites (The Papers of Wendell Clark Bennett, .B466). Working at this site for a little over a month, Bennett and colleagues mostly found fragmentary artifacts, but noted some stratigraphy present (The Papers of Wendell Clark Bennett, .B466). Once they finished at Cochabamba, Bennett and colleagues left the site and spent two weeks in Arani. There they excavated a hill in which Bennett observed was a burial site. He was not able to provide details of his work in his letter for AMNH for “various reasons” (The Papers of Wendell Clark Bennett, .B466). After this short time in the Cochabamba region, Bennett stated that much more work could be done there, but they had to move on to other sites.
On June 18, 1934, Bennett wrote to AMNH with another update on his research. Bennett and his team had spent almost two months excavating in Lukurmata and on the island of Pariti (The Papers of Wendell Clark Bennett, .B466). He stated that he discovered a small temple underground. The temple measured “9.50 meters square on the inside, and constructed of 56 well cut granite and lava blocks” (The Papers of Wendell Clark Bennett, .B466). It also had principle features that included “angle stone corners,” a stone canal that was well-cut, an elaborate gateway, and decorative ledges and niches throughout the building (The Papers of Wendell Clark Bennett, .B466). After his excavation, Bennett argued that the stonework suggested that the temple was Classical Tiwanaku (see Chapter 4 for a discussion of Bennett’s chronology). However, the temple itself, Bennett suggested, was “semi-decadent” and was composed of stones that had been brought over from another building (The Papers of Wendell Clark Bennett, .B466). Bennett also mentioned his excavation at Chiripa in this letter. He describes a “new” type of pottery that had yellow or red (The Papers of Wendell Clark Bennett, .B466). He further argued that the yellow on red fragments were stratified underneath the tombs that were also Tiwanaku-type. He makes note that he found the same style of pottery at Pariti buried under Decadent Tiwanaku-style sherds (The Papers of Wendell Clark Bennett, .B466). It was after these excavations when Bennett felt confident about his knowledge of Tiwanaku’s expansion throughout southern Titicaca Basin.

46 of the samples analyzed in this research derived from Bennett’s excavations. Eight were from Chiripa, four from Lukurmata, and 34 from Tiwanaku. Most sherds were requested as a loan from the museum. However, 18 sherds had to be sampled so they would fit in the LA-ICP-MS chamber. The sampling was done by the author and Dr. Nicola Sharratt in the Archaeology
Lab at Georgia State University. A small piece was cut off that was no larger than five millimeters.

Given curation considerations, only 46 sherds were loaned by the Bennett Collection. Therefore, in order to obtain a more robust sample size, material curated at the Field Museum in Chicago was also included.

5.4.2 Field Museum Collection

A number of Field Museum artifacts from different collections were analyzed in this research. The collections consisted of sherds from Tarija, Cochabamba, and La Paz. A total of 15 samples were from the Field Museum in Chicago: 11 samples were from Tarija, two from Cochabamba, two from Cochabamba, and two from La Paz. These sherds came from various collections and donations. The Tarija artifacts came from the “1st Captain Marshall Field Paleontological Expedition to Argentina and Bolivia. Elmer S. Riggs, Collection” (Field Museum Website 2017). The Cochabamba samples were purchased from Gunther Calvimontes on January 23, 1952 by the Field Museum (Field Museum Website 2017). The sherds that were found in La Paz, Bolivia do not have any other information other than the place of discovery. These samples were added to the Bennett Collection samples to diversify and expand the geological ranges of Tiwanaku regions. However, the limited information about where they actually came from has not been helpful.

5.4.3 Moquegua Valley Sherds

This study also included ceramic sherds from the sites of Chen Chen and and Cerro Baúl. These samples were exported from Peru by Patrick Ryan Williams, and other colleagues, and have been used in their previous research on ceramic production (Sharratt et al. 2009; Sharratt et al. 2015). The principle difference between that research and the research presented in this thesis
is that Sharratt and Williams were able to procure clay samples from around the Moquegua Valley to help designate where the clay sources actually came from. This helped strengthen the arguments that communities in the Moquegua Valley, such as Chen Chen and Cerro Baúl, produced some of their ceramics locally and used local clay sources for their recipes. No clay source database currently exists for the Tiwanaku core and hinterland.

The Chen Chen ceramic vessels that were recovered from the Moquegua Valley were crafted in heartland forms including keros and tazones (Sharratt et al. 2015: 399). These ceramic vessels were decorated with traditional Tiwanaku motifs such as pumas, trophy heads, geometric designs, and the Staff God. Other decorative motifs present in Chen Chen ceramics were felines and camelids (Sharratt et al. 2015). The Cerro Baúl samples were excavated from a Tiwanaku structure within the Wari provincial city that is located on Cerro Baúl, a terraced mountain in Unti 43, a small plaza was found and within the space was an altar (Williams et al. 2010). During the excavation of this unit, six fragments of Tiwanaku-style incensarios were discovered. Therefore, it was concluded that this structure was Tiwanaku and not Wari (Williams 2010). This is the only site found that incorporates both Tiwanaku and Wari architecture and practices in the Moquegua Valley.

These samples had previously been measured using LA-ICP-MS and pXRF, however, they were not run on the pXRF instrument utilized in this thesis study, a Niton XL3t 950 GOLDD+Mining analyzer, which is discussed later in this chapter. Therefore, in order to derive comparable pXRF data, these samples were rerun on the same instrument that was used on the AMNH and Field Museum collections. These Moquegua Valley samples were included to help obtain a better understanding of Tiwanaku’s exchange networks beyond the heartland. As do the
Field Museum samples, the Moquegua samples from Chen Chen and Cerro Baúl help expand the geographical range of the study.

5.5 Visual Analysis of Tiwanaku Ceramics

Prior to the compositional analysis, I performed my own visual analyses on the Bennett Collection. The dimensions of the sherds were recorded, and I identified what kind of sherd it was (non-diagnostic body sherds, rim sherds, base sherds, handle sherds, and so on). The majority of the samples chosen from the Bennett Collection were non-diagnostic body sherds and rim sherds. In most cases, the sherds were too small to determine the vessel type. There was a total of 23 non-diagnostic body sherds, 17 rim sherds, three base sherds, and three body sherds that each had handles.

Figure 5 Sample T002 from the Bennett Collection depicting part of the zoomorphic figure, possibly a feline
Figure 6 Sample T009 from the Bennett Collection depicting part of a zoomorphic figure, possibly a bird

With the exception of a few samples, the samples had slip on the exterior surface that was usually red, however other colors such as dark greys and browns are also present. The red also varied from light to dark. A total of 23 ceramic sherds incorporated painted designs which included the split eye, geometric designs, or zoomorphic figures. There were 16 samples from the Tiwanaku core that had geometric designs, two of which showed evidence of sections of zoomorphic designs (Figures 5 and 6) and the split eye (Figure 4). Six out of the eight ceramic vessels from Chiripa showed evidence of colorful designs or thick black geometric designs (Figures 7 and 8). One sample from Lukurmata showed evidence of a little black paint, but the sherd itself is too small to determine what kind of design was originally on the ceramic vessel. It
should be noted that the presence of only two zoomorphic figures on the sherds from the Bennett Collection does not mean there may have been more on the original ceramic vessels when they were produced. However, because of the size of most of the sherds, only a fragment of the designs on the vessel was able to be observed. This can be applied to some of the ceramic sherds that did not have any designs on them as well.

Figure 7 Sample C001 from the Bennett Collection depicting geometric designs using colored and black paints
The colors of the slips and paints (if any) as well as the pastes were observed and determined using the Munsell soil charts. The pastes were mostly various shades of red, with a few exceptions where the paste was brown. There were many instances of white and/or black inclusions in pastes. A significant number of sherds showed evidence of mica inclusions. As Dean Arnold (1993) notes, mica was used in pottery-making because it strengthened the vessel. With mica inclusions, the vessel could be used for cooking to withstand the high temperatures. Although, there have been instances were some non-cooking vessels have also had small mica inclusions in the paste. Some pastes were difficult to determine because the sample was very dirty.
Overall, some patterns that were observed through visual analysis of the Bennett Collection. For example, the majority of the Chiripa samples show evidence of painted geometric designs. Of the four samples from Lukurmata, on the other hand, only one showed any evidence of geometric designs. The Lukurmata samples, although very small in size, were very plain. Almost half of the Tiwanaku samples, however, showed evidence of painted designs. There is also a significant number of samples that have mica inclusions. All of these groups and patterns have been discovered visually are potentially interesting, although it should be noted that this is not a random sample, but one that was chosen because the sherds were appropriate for LA-ICP-MS analysis. The compositional analysis methods that were used in this research will be discussed next.

5.6 Methods

5.6.1 LA-ICP-MS

Of the different ICP-MS techniques (see Chapter 3), laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) was used because of its many advantages and because the Moquegua Valley samples had also been analyzed using the same method. For the purpose of this study, the elemental signature of ceramic pastes was the focus of analysis, rather than the decorative paints. Therefore, LA-ICP-MS was used for its point sampling technique (Dussubieux et al. 2007:350). Also, since the Moquegua Valley samples had previously been measured using LA-ICP-MS, the same methods were used in the presented research so comparable data could be possible. This particular technique is also very useful for analyzing museum collections because it is minimally destructive (Pollard et al. 2007; Sharratt et al. 2009; Sharratt et al. 2015; Vaughn et al. 2011). Since the laser leaves a mark that is nearly invisible to the naked eye, museum collection samples will not be damaged in the process. However, with permission from the
AMNH, as mentioned, sampling had to be done on some sherds, which adds to some destruction of collections. After testing was completed, the Bennett Collection sherds and the small samples taken were all returned to the AMNH together.

The general parameters and procedures for LA-ICP-MS equipment at the Field Museum EAF are explained in Dussubieux et al. (2007). However, the specific procedures that the author performed are elaborated here. To begin the LA-ICP-MS process, samples are carefully placed in the chamber. The total number of samples that can be placed in the chamber may vary based on the size of the samples. On average, about five sherds were placed in the chamber at once. The sherds that had been sampled at Georgia State University were measured first. Since the sampled were under 5 millimeters, putty was used in the chamber to hold the samples in place. The sample chamber was 5 cm in height and 6 cm in diameter (Dussubieux et al. 2007:351). Along with the samples in the chamber, three reference material standard samples are also measured to ensure accuracy and precision of the readings produced by the instrument (Dussubieux et al. 2007:352-353). The certified standard samples used in this project included: Ohio Red clay, brick clay, and N610 (glass).

Once the samples are in place and the chamber is locked into the device, the chamber must be purged. Purging ensures clean measurements of the samples and allows for a successful transmission of the ablated material to the mass spectrometry which will generate the data (Dussubieux et al. 2007). Once successfully purged, the lasers are guided to each sample. On a computer, points are selected for where the laser will penetrate the ceramic material. This is how unwanted materials such as larger inclusions and temper can be avoided. There is no way to avoid the small inclusions that cannot be seen on the screen. A total of ten ablations were performed on each sample. However, for the standards, only five ablations were conducted.
After warming for five seconds, the ablation takes about 60 seconds per selected point. The reason for such a long ablation is because the laser must go deeper than the surface of the material to avoid any surface contamination. By measuring beyond the surface, the chemical composition readings will be more accurate.

### 5.6.2 pXRF

X-ray fluorescence (XRF) uses X-rays on samples which causes the atoms in the ceramic material to emit fluorescent X-rays. These fluorescent X-rays are “characteristic of its elemental composition” (Field Museum Website; Pollard et al. 2007:101). Advancements in technology allowed for a portable X-ray fluorescent device to be made. Since using multiple techniques in research such as this project is beneficial, pXRF was also used. However, pXRF has its limitations, as was explained in Chapter 3. Data obtained through pXRF is not identical to, for instance, the LA-ICP-MS data. However, LA-ICP-MS is recognized as a more accurate and sensitive technique. Therefore, LA-ICP-MS data is expected to be more reliable. This does not argue against using pXRF, but it is best to have other methods available to determine these inaccuracies, if possible. The use of pXRF, however, is very useful when a non-intrusive method is required. For example, if samples cannot be taken from a sherd and the samples are too large to fit in the LA-ICP-MS chamber, pXRF provides an alternative approach.

Within the Field Museum’s EAF, there are two pXRF devices. The first is a Bruker Tracer II-SD and the second is a Niton XL3t 950 GOLDD+Mining analyzer. The latter was used in this project. In both devices, “it is possible to conduct surface analysis at the ppm level totally non-destructively on a wide range of materials including metals, ceramics, obsidian, and glass” (Field Museum Website 2017). The Bruker Tracer is usually used by conservation staff, where
the Niton device is used by archaeologists, curators, and other researchers (Field Museum Website 2017).

More samples could be run using pXRF than in LA-ICP-MS because there are fewer limitations in size. The lack of size limitations allowed for almost full vessels to be measured using pXRF and other samples from the Field Museum that may not have fit in the LA-ICP-MS chamber. To begin, a standard (Ohio Red clay) had to be run through the pXRF device. Like LA-ICP-MS, standards are important to ensure the accuracy of the equipment’s readings. Once this was done, the samples were run individually. Each sample took 90 seconds to run.

There were certain concerns, however, when using the pXRF device. First, pXRF takes measurements at the surface of the sample. Many sherds from the Bennett Collection were dirty on the surface. This could cause contamination and affect the elemental readings. One way to try to avoid this contamination involved the placement of the samples. Instead of placing the samples so the X-rays would penetrate the interior or exterior sides where the dirt and other contaminates are, the samples were placed on its side so the X-rays could penetrate the clay as directly as possible. Although there was still a possibility of contamination from dirt, hand oils, or other materials on the surface, it was able to penetrate closer to the interior of the clay.

Another concern involved the Cerro Baúl samples. As mentioned, the only size limitation for pXRF is that the sample must be big enough to cover the small hole where the X-rays are emitted. Some of the Cerro Baúl samples were very small and did not cover the hole. Both of these concerns were taken into consideration when analyzing the data.

5.7 Statistical Analysis

Once the LA-ICP-MS data are obtained, any outlying readings that may skew the average measurements of that sample are removed prior to statistical analysis of the data. However, out
of the ten readings per sample, only a maximum of three can be removed. Any more than three would manipulate the data. Cleaning was done on the pXRF data, but it was not as extensive. Instead of cleaning out the outlying data, samples that did not have any readings that were removed. Certain elements were so low, they were considered statistically insignificant, and therefore removed. Once the LA-ICP-MS and pXRF data are cleaned, the readings were then analyzed using the GAUSS statistical program. GAUSS was developed at the University of Missouri Research Reactor Center (MURR) by Hector Neff (Niziolek 2011:250). Once the data are imported into the program, they must be transformed to log, specifically base 10 logarithms (Little et al. 2004: 105; Niziolek 2011:250). Transforming raw data to log is necessary so that the trace elements are normally distributed (Neff 1994:117), which is required when performing principal components analysis, or PCA (Niziolek 2011:250). Logged data that are normally distributed increase the accuracy of PCA. Transforming raw data is also necessary because if the measurements of certain elements are too large, it may dwarf other elements’ measurements and control the analysis (Neff 1994:117; Niziolek 2011:250). Logged data will reduce this biased analysis. Once the raw data was logged, various analyses were conducted. To follow, Hierarchical Cluster Analysis, Principal Component Analysis, and Bi-plots will be discussed.

5.7.1 **Hierarchical Cluster Analysis**

Hierarchical Cluster Analysis, or HCA, places samples into groups of similar samples. The samples within each group are going to be more similar in elemental composition to each other than with the samples that are in other groups. HCA allows archaeologists to begin interpretations of the basic similarities and differences among the samples that were analyzed (Niziolek 2015). HCA is a useful method for obtaining preliminary results.
5.7.2 Principal Component Analysis

Principle Component Analysis, or PCA, uses the elemental information of the samples to identify the most abundant elements within the samples. This analysis is important because it reduces the amount of variability (Niziolek 2015). Instead of assuming groupings with the samples, PCA searches for any patterns within the elemental data. The most prominent elements from PCA are then used to when creating the bi-plots. Therefore, the correlates on the bi-plots are based off of the most significant elements that were present in the samples.

5.7.3 Mahalanobis Distance Measurement

The Mahalanobis distance measurement is used to test the probability of samples belonging to the group to which they have been assigned (Niziolek 2015). This measurement can be done on the principal component analyses or on specific, prominent elements. Based on the elemental similarities within the samples, the test may suggest some samples be reassigned to another group with greater similarities. This was also used to determine if any outliers belonged to other groups.

5.8 Conclusion

Tiwanaku ceramics have been the subject of a number of studies involved with craft production and exchange. However, there has been relatively little compositional analysis on Tiwanaku pottery. The only compositional analysis that has been done on Tiwanaku ceramics was done in the Moquegua Valley, but to date there has been none in the Tiwanaku capital or hinterland. Some of the ceramic sherds that were discovered during the previous excavations of the Moquegua Valley were used in this presented research. Other than samples from Moquegua, ceramic sherds from the Bennett Collection at the American Museum of Natural History in New York City and the Tarija Collection from the Field Museum of Natural History in Chicago.
These resulted in a sample size that included ceramics from the core, hinterland, and peripheries of Tiwanaku, allowing for an analysis of a number of different Tiwanaku territories. By using LA-ICP-MS and pXRF, compositional analysis was conducted on the ceramic sherds to examine Tiwanaku ceramic production and exchange patterns. The next chapter discusses the results of the compositional analysis of Tiwanaku ceramics.
6 RESULTS

6.1 Introduction

The elemental data obtained through LA-ICP-MS and pXRF analyses of the samples detailed in Chapter 5 were processed using statistical procedures in the GAUSS program. Results from the LA-ICP-MS data shows the samples divided into two major compositional groups with some consistent outliers. The results from the pXRF data shows less distinct groups, but still supports the LA-ICP-MS results.

6.2 Statistical Results: LA-ICP-MS

Since the samples from Chen Chen and Cerro Baúl were previously measured when the Field Museum’s LA-ICP-MS instrument had slightly different parameters from those in 2016 (when the AMNH samples were analyzed), certain elements had to be removed from both Sharratt and colleagues (2015) and the author’s research prior to running the data through GAUSS in order to ensure consistency across the entire analyzed sample. The elements that were removed from the author’s LA-ICP-MS data include: Mo, Ta, W, and Au. The elements that the author removed from Sharratt and colleague’s data include: Na, Mg, Al, Si, K, and Ca.

6.2.1 LA-ICP-MS Bi-Plots

Bi-plots were constructed using different groups of samples based on the comparison of two prominent elements, as well as of the principle component samples. Significant elements were determined through Principal Component Analysis, which is discussed later. Initially, the data were analyzed in groups based on site affiliation. In other words, all of the samples that were from the Tiwanaku core were in one group, all of the samples from Chen Chen were in another group, and so on. Certain groups overlapped when plotted, so new groups were created based on the bi-plot groupings.
The samples from Tarija and La Paz proved to be complicated. The Tarija Collection samples from the Field Museum have limited provenience information because they were acquired through donation, as mentioned in Chapter 5. Unfortunately, artifacts that are donated to museums sometimes have unknown contexts. People who donate artifacts are not always the same people who excavated the artifact. Therefore, the exact provenience for certain artifacts included in this thesis is unknown.

There is limited information about the specific archaeological context of the Tarija Collection’s artifacts. Some of the artifacts were noted in the museum’s accession record as being from Tarija, while others were from Cochabamba. Tarija is a little more than 900 kilometers southeast of Tiwanaku and Cochabamba is about 300 kilometers southeast of Tiwanaku (Figure 3). This makes it difficult to conclude where these artifacts fit within Tiwanaku’s geography. Analysis of the compositional data indicated that the Tarija (Figure 9) does not correlate with major group that was identified. Although, the three outliers from Chen Chen (M43, M44, and M45) fall closed with Tarija sample TA004. This could indicate that some ceramics in the Moquegua Valley were imported from the same site that produced the Tarija sample. Without additional clay source databases and more detailed provenience information (for the Tarija samples), the origin of these outlying samples will remain unclear. The Tarija Collection is characterized by greater heterogeneity in chemical signatures. However, without more information on the provenience of the Tarija artifacts, where they fit in the Tiwanaku realm is still unclear. When the Tarija samples were included in the bi-plots, it made it difficult to analyze the other samples because the bi-plot is too clustered. Therefore, for the rest of the analysis the Tarija samples were considered outliers and were not included in the bi-plots. This problem also applies for the samples from La Paz. Like Tarija, the Tiwanaku-style ceramics from
La Paz are assumed to be from the La Paz region or city, based on the provenience provided by the Field Museum. La Paz is only about 70 kilometers east of Tiwanaku, which can be observed in Figure 1 in Chapter 4. The one La Paz sample that was measured using LA-ICP-MS was grouped with the Tarija samples (Figure 9). For the same reasons as for the Tarija Collection, it was also not included in any other bi-plots.
Figure 9 Bi-plot of logged P and Ba concentrations showing the groupings of all samples

Bi-plots were utilized to plot the principal components obtained through Principal Component Analysis (PCA) to identify significant elements. Bi-plots that are based on PCA can be very informative because they can identify group memberships (Niziolek 2011:251). Specifically, bi-plots of RQ-mode PCA can help determine “which elements are the most variable between groups” (Niziolek 2011:251; Neff 1994:119). Figure 10 illustrates bi-plots of principal components 1 and 2 to determine which elements are significant in differentiating the chemical composition of Tiwanaku ceramics. Figure 11 displays a bi-plot of principal components 1 and principal components 3. Overall, principal components 1 (PC01) through principal components 8 (PC08) were compared. The principal components that were used were
determined based on the cumulative percent variance after Principal Component Analysis (PCA) was done. PC01 was positively loaded on Ba, Sr, Ce. PC02 was positively loaded on As. PC03 was positively loaded on Nb and Dy. PC04 was positively loaded on Cl. PC05 was positively loaded on Th. PC06 was positively loaded on Co. PC07 was positively loaded on As. Lastly, PC08 was positively loaded on P. Since these elements existed at higher levels in the sherds, they were used when plotting the samples in bi-plots. The bi-plots that display the LA-ICP-MS results of the ceramic sherds are measured using various combinations of these prominent elements.

Figure 10 Bi-plot of logged Principal Component 1 (PC01) and Principal Component 2 (PC02) showing the prominent elements
Figure 11 Bi-plot of logged Principal Component 1 (PC01) and Principal Component 3 (PC03) showing the prominent elements

Bi-plots were constructed using 90% confidence ellipses. In Figure 12, samples from Tarija and La Paz, as well as the two outliers from Tiwanaku and three outliers from Chen Chen, were not included. Once the Tarija and La Paz samples and outliers were no longer included in the bi-plots, it was easier to comprehend which samples were in which group. Three distinct groups were determined when only samples from Tiwanaku, Lukurmata, Chiripa, Chen Chen and Cerro Baúl were measured (Figure 13).
Group 1 consisted of samples from Chiripa, Lukurmata, Cerro Baúl, and Tiwanaku. With the exception of two samples, the Chiripa samples remained tightly grouped with samples from other sites. C005 and C007 do not correlate closely with Group 1. Instead, C005 correlates more closely with Group 2 and C007 is plotted within Group 3. There is one sample from Lukurmata (L003) that does not correlate with the group, however, this is the only Lukurmata sample that showed evidence of paint on the sherd. However, it still remains unclear of where this outlying sherd was produced. This supports the argument that Lukurmata received imported ceramics from other sites. Two of the four Cerro Baúl samples (CB02 and CB04) correlate closely with
Group 1. The others are grouped together further outside of the larger group. Lastly, about half of the Tiwanaku samples correlated with Group 1. The second half of the Tiwanaku samples correlate with Group 2 instead. The bi-plot shows that there is a distinction in the composition of the Tiwanaku ceramic samples. Although Group 1 shows greater levels of homogeneity than Group 2, the samples in Group 2 still display significant homogeneity (Figure 14). This implies that wherever Group 2 was produced, there was some form of standardization.

Figure 13 Bi-plot of logged Cl and Nb concentrations illustrating three distinct groups
Figure 14 Bi-plot of logged P and Cl concentrations displaying a divide between the Tiwanaku ceramic samples

Group 3 consists of ceramic samples from Chen Chen. With the exception of some samples, there is significant homogeneity within Group 3. There is also one sample from Group 1, a Tiwanaku sample (T017) that overlaps with Group 3. This can indicate that Chen Chen were producing ceramics that were imported into the core. The Chen Chen outliers (M43, M44, and M45) were the same in Sharratt and colleagues’ research (2015). Since the outliers do not correlate with any other samples or groups, their origin still remains undetermined. The outliers were not compositionally similar to the large cluster of samples which prevented a closer view of
the samples that are grouped together. Therefore, some bi-plots were also created without including the outliers.

Figure 15 Bi-plot of logged P and Dy concentrations showing heartland ceramic samples not including outliers

Figure 15 illustrates Groups 1 (except Cerro Baúl) and Group 2 (except outliers T033 and T034). Although there is a clear distinction between the two groups in the heartland, this bi-plot was created because it had to be established if there was standardization within the heartland. Based off of Figure 15, many of the Tiwanaku samples from the core appear to correlate very closely, implying a high level of homogeneity. In this bi-plot, the Lukurmata samples also correlate closely together with the Tiwanaku samples. This differs from Figure 13, where L003
appeared to have a different chemical composition. It has been established that the inclusion of the Tiwanaku outliers, T033 and T034, affected the placement of some samples. Lastly, the Chiripa samples from Group 1 are not as closely correlated as the Tiwanaku and Lukurmata samples. In comparison, the Tiwanaku samples from Group 2 show less homogeneity within the samples indicating there was less standardization within the ceramics from Group 2.

Two other bi-plots were required to determine if Cerro Baúl was more compositionally similar to the heartland or periphery. Figure 16 shows samples from Tiwanaku, Chiripa, Lukurmata, and Cerro Baúl. Since Cerro Baúl samples were found in a peripheral site, they were
originally plotted with the Chen Chen samples, but the Cerro Baúl samples appeared to be compositionally similar to the heartland samples. Compared to Figure 17, Figure 16 shows how the samples from Cerro Baúl overlap with the heartland more so than they did with Chen Chen.

Figure 17 Bi-plot of logged Ba and Ce concentrations showing periphery ceramic samples not including outliers
Hierarchical Cluster Analysis (HCA) measures the levels of dissimilarities of, in this case, the compositional data of the samples and creates a dendrogram. Samples that are grouped closer together show greater similarities than the samples that are further apart. Figure 18 shows the HCA of all the samples that were measured using LA-ICP-MS. In some cases, the HCA showed similar results as the bi-plots. The same outliers (T034, T033, M43, M44, M45) can be identified, as well as one of the Tiwanaku groups from Figure 18. Further, the Tarija samples and La Paz sample were grouped together and shown as outliers compared to the remainder of the samples from other sites. There are some similarities in the groupings of the Chen Chen samples.
and the heartland samples as well. The Cerro Baúl samples, which correlated more with the heartland, were grouped close together in the HCA, but were displayed closer to the Chen Chen samples in the chart. However, as previously discussed in Chapter 5, HCA is useful as an additional source of analysis to compare data, but does not display the data as accurately as bi-plots do.

6.2.3 LA-ICP-MS Mahalanobis Distance Measurement

Once groups had been identified based on the HCA and bi-plots, Mahalanobis distance measurements were conducted. Initially, the prominent elements (mentioned above) were going to be specifically used to measure the samples. However, this proved difficult in the first Mahalanobis distance measurement conducted because of Lukurmata’s sample size. GAUSS only allows two less variable than there are samples in each group. Therefore, since there are only four total samples from Lukurmata, only a maximum of two samples could be measured. Therefore, for the first measurement, all elements were applied. At first, each group was measured against each other, so each group included Tiwanaku, Lukurmata, Chiripa, Chen Chen, Cerro Baúl, and La Paz. When compared, many samples were already in the correct group according to the measurement. For example, with the exception of a few samples, Mahalanobis distance measurements indicated that most of the samples in the Chen Chen group belonged together. Those that did not correlate well were suggested they be grouped with either Chiripa or Tiwanaku groups. Tiwanaku samples were mostly compositionally similar, so they were correctly associated in the same group except for some samples that were recommended they associated better with Chiripa samples and some Chen Chen samples. The rest of the samples in the other groups, such as Chiripa, Cerro Baúl, and Lukurmata, did not correlate well with their own groups. Only one Chiripa sample correlated with the Chiripa group. The rest of the Chiripa
samples were suggested they were more compositionally similar to samples in Tiwanaku and Lukurmata. Interestingly, Cerro Baúl’s samples correlated mostly with the Chen Chen group as well as Chiripa. Lastly, Lukurmata’s samples were compositionally similar to Tiwanaku and Chiripa. Only one of the four Lukurmata samples correlated with the Lukurmata group.

Since there was a significant number of samples that did not belong in their group based on provenience, two groups based on the bi-plot were formed. The second Mahalanobis distance measurement could rely on prominent elements (based off of PCA) because the groups were much bigger. This Mahalanobis distance measurement used the prominent elements Ba, Sr, Ce, As, Nb, Dy, Cl, Th, Co, and P. In the updated Mahalanobis distance measurement, the same groups (Group 1, Group 2, and Group 3) determined by the bi-plots were measured. According to the measurement, Group 1 only had three samples that were considered compositionally similar to Group 3, which were the samples from Chen Chen. This was also able to be established in the bi-plots discussed earlier. Group 2 only had two samples that were more similar in composition to the Chen Chen samples in Group 3 as well. This implies that Chen Chen may have imported a significant number of ceramics to the core. This is further supported because Group 3 also had two samples that correlated with Group 1 when measured. Therefore, ceramics may have been exchanged between the core and periphery.

Like HCA, the Mahalanobis distance measurement is an additional analysis in compositional research. It should not be solely relied on to create like-groups because the groupings can be altered based on the elements that are measured. Measuring using a different group of elements can slightly alter a few samples depending on whether or not they have a much higher or lower level of that element. In other words, slight variations in elements can
make a significant difference when measured using the Mahalanobis distance measurement. The second Mahalanobis distance measurement reflected many of the bi-plots accurately.

6.3 Statistical Results: pXRF

A number of elements had to be removed from the data prior to using GAUSS because certain elements had readings that were so low they are below the limits of detection. Therefore, the data were limited to only 24 elements.

6.3.1 pXRF Bi-Plots

Before bi-plots of the samples were created, principal components were generated and plotted to determine the significant elements for the pXRF data. Although sulfur (S) and manganese (Mn) are displayed on the bi-plots, other combinations of prominent elements were incorporated during the analysis to compare and determine any differences between the bi-plots. The principal components that were used were determined based on the cumulative percent of variance after Principal Component Analysis (PCA). Similar to the LA-ICP-MS data, PC01 through PC08 were compared. PC01 was positively loaded on S and P. PC02 was positively loaded on Pb. PC03 was positively loaded on Ca. PC04 was positively loaded on Cl. PC05 was positively loaded on Sr, Mn, and Nb. PC06 was positively loaded on Ba and Mn. PC07 was positively loaded on Ti, P, and Ca. Lastly, PC08 was positively loaded on Cu.
Once the prominent elements were determined, a bi-plot of the pXRF measurements for all the samples was created to get a general picture of how the samples’ chemical compositions related to each other. At a first glance, the pXRF bi-plots appeared to be somewhat similar to the LA-ICP-MS data, but do not exactly replicate those plots. Figure 20 displays a large cluster of samples rather than three distinct groups, however, there is one similar outlier (T034). Unlike in Figure 9, Figure 20 shows the Tarija and La Paz samples in the pXRF data appear to correlate with the heartland sites.
When examined more closely, a similar pattern can be established in Figure 20 that was present in the LA-ICP-MS bi-plots. Two different groups were visible, but still unclear. This was because there were various groups represented by different colors so it was difficult to ascertain exactly what samples were where. Therefore, Groups 1 and 2 were created. Group 1 included samples from Tiwanaku, Chiripa, Lukurmata, Tarija, and La Paz. Group 2 consisted of the Chen Chen and Cerro Baúl samples. When Group 1 and Group 2 were plotted the pattern became much more evident. The results were slightly similar to the LA-ICP-MS, however, only two groups were able to be established through pXRF data rather than three. Further, pXRF data
showed that the Tarija and La Paz samples correlated with heartland samples. This was not the case in the LA-ICP-MS results. Another major difference involved the Cerro Baúl samples. Unlike in the LA-ICP-MS results, the Cerro Baúl ceramics were more compositionally similar to the Chen Chen samples compared to the heartland samples.

These inconsistencies are some of the issues that are encountered when using multiple techniques. LA-ICP-MS has been noted to be more accurate and precise in its measurements and it can access the sample deeper than the surface eliminating chances of surface contamination, as discussed in Chapter 3. When using pXRF, not only are there increased chances of surface contamination, but its levels of accuracy and precision are much lower when compared to LA-ICP-MS (Pollard et al. 2007; Rice 1987). However, the use of multiple techniques is beneficial because certain samples may not be able to be measured using certain techniques. For example, some samples were unable to be measured using LA-ICP-MS, but were measured using pXRF. Without the use of pXRF, certain samples may not have been incorporated in this research.

### 6.3.2 **pXRF Hierarchical Cluster Analysis**

HCA for the pXRF data derived from all the samples indicated two major compositional groups. From the bi-plots, two major groups were able to be established (Group 1 and Group 2). Very similar results are indicated by the HCA of the pXRF samples (Figure 21).
According the HCA, Group 1 consists of mostly Tiwanaku, Lukurmata, and Chiripa, and La Paz samples, however a few outlying samples from Chen Chen and Tarija appear as well. Group 2 contains mostly samples from Chen Chen and Cerro Baúl, as well as some from Tiwanaku, Chiripa, Tarija, and Lukurmata. With the exception of some samples, Group 1 and 2 shown in the HCA are similar to Group 1 and 2 exemplified in the bi-plots.

6.3.3 pXRF Mahalanobis Distance Measurement

When Mahalanobis distance measurements were run on the pXRF data using the prominent elements that were listed above. Groups 1 and 2 from the pXRF bi-plots were measured. Only a few samples were out of place in the Mahalanobis distance measurement. For
instance, sample T002 from Tiwanaku was originally in Group 1, the measurement established that it closely correlated with Group 2 instead. Samples CB003 from Cerro Baúl and M009 and M013 from Chen Chen were originally in Group 2 but were similar in composition with Group 1.

6.4 Visual Analysis Results

Figure 22 Map of Bennett’s excavation site in Tiwanaku (redrawn from Bennett 1934)

The visual analyses that were conducted on the Bennett Collection were compared to the ceramics’ proveniences and their compositional data. In Bennett’s monograph of his excavations in Tiwanaku (1934), he recorded the different pits and levels in which he excavated (Figure 22). The pit numbers only referred to Tiwanaku sherds and not Lukurmata and Chiripa. Of the 34
Tiwanaku samples, 31 had the pit number and level written on them. The sherds that showed evidence of mica inclusions were compared to the pit numbers. Most of the ceramic sherds that showed evidence of mica inclusions were excavated in Pits I, IV, and X. These three pits were excavated close in proximity in the southwest corner of the site.

The iconography that was observed during visual analysis was also compared to the provenience provided by Bennett. Out of the 46 total samples from the Bennett Collection, 22 showed some evidence of painted designs. Some designs preserved better than others. When compared to the LA-ICP-MS data which showed two groups (Group 1 and Group 2) in the heartland, it appeared that the 22 sherds with iconography were evenly distributed between the two subgroups. Therefore, visual style was not a factor in determining any patterns or groupings that were ascertained using compositional analysis.

The pastes were also examined and were compared to the pit numbers, but other than the mica inclusions, no other patterns were able to be established. Many of the pastes were various shades of red, with some browns as well, which made it difficult to determine definite groups. Thus, other than the mica inclusions, the color and other inclusions in the pastes were not helpful in determining groups similar to those obtained through LA-ICP-MS and pXRF.

**Conclusion**

At a first glance, it was difficult to determine if the LA-ICP-MS data and pXRF data were similar. However, once Groups 1 and 2 were determined for both data sets, similar patterns were able to be recognized. It can be ascertained from the presented data that there is a clear distinction between the heartland sites (Tiwanaku, Lukurmata, and Chiripa) and one of the peripheral sites (Chen Chen). Cerro Baúl proved to be complicated. In the LA-ICP-MS data, the Cerro Baúl samples appeared to correlate with the heartland rather than the periphery. However,
when measured using pXRF, Cerro Baúl shared similar compositions with the Chen Chen samples. Since the Cerro Baúl samples are sherds from *incensarios* that were found in a Tiwanaku temple in the periphery (see Chapter 5), this debate on where they were produced required more analysis. The next chapter discusses the results and analyzes how they contribute to discussion about what kind of state Tiwanaku was.
7 DISCUSSION

As discussed in Chapter 2, archaeologists and anthropologists often associate centralized and specialized craft production as well as the long-distance exchange of goods with state political organization. It was previously demonstrated in Chapter 4 that the debate continues about the kind of state Tiwanaku was. Given the potential for reconstructing the organization of the production and circulation of craft goods through compositional analyses (discussed in Chapter 3) this thesis project generated compositional data on Tiwanaku ceramics in order to examine Tiwanaku ceramic production and exchange and to contribute to debates about the kind of state Tiwanaku was. The following questions, detailed in Chapter 5, guided this thesis.

1) How tightly centralized and standardized was ceramic production in the Tiwanaku state?
   a. Is there evidence for centralized ceramic production at the capital city of Tiwanaku?
   b. To what extent was ceramic production in the Tiwanaku core centralized and standardized? Were ceramics produced at one site in the Tiwanaku core and then distributed or did different sites produce their own ceramics?
   c. To what extent was ceramic production in the Tiwanaku periphery centralized? Is there evidence for standardized, controlled production in provincial Tiwanaku sites?

2) How were the ceramics circulated and exchanged through the Tiwanaku territory?
   a. Were ceramics produced at the core and then distributed to the hinterland and periphery?
   b. Is there evidence for non-local ceramic material at Tiwanaku? If so, does the compositional data indicate where non-local material was imported from?
c. Is there evidence for non-local ceramic material at sites in the hinterland? If so, does the compositional data indicate where non-local material was imported from? Did different hinterland sites have differential access to non-local material?

d. Is there evidence for non-local ceramic material at provincial Tiwanaku sites? If so, does the compositional data indicate where non-local material was imported from?

e. What proportion of analyzed ceramics were non-local at the site of Tiwanaku, at the hinterland sites, and at provincial sites?

Through LA-ICP-MS and pXRF, the chemical compositions of ceramic samples from a number of sites, including the Tiwanaku capital, sites in the hinterland, and sites in the state periphery, were established. This thesis relies on the Provenance Postulate, which states that since the chemical composition of ceramic paste is constituted by the clays, pastes, and other inclusions, those with similar chemical compositions likely were made by the same producers. Further, according to the Criterion of Abundance, if a large quantity of ceramic materials that are compositionally similar are present in the same site, then it can be assumed that they were produced locally. Both the Provenance Postulate and Criterion of Abundance have been crucial assets to analyzing the data presented.

The first question asked how tightly centralized and standardized ceramic production in the Tiwanaku state was. If ceramic production in the Tiwanaku state was tightly centralized and standardized, compositional data would show great homogeneity among the ceramics from all of the sites. In other words, ceramics from the core (Tiwanaku), hinterland (Chiripa and Lukurmata), and periphery (Chen Chen and Cerro Baúl) would all show similar chemical compositions. This implies that the ceramics would have been produced in one single location
(for example, in the capital), and distributed to other sites. In Chapter 6, various bi-plots were presented that display the data from the LA-ICP-MS and pXRF compositional methods, however, data from the LA-ICP-MS and pXRF differed. The bi-plots created with the LA-ICP-MS data showed three distinct groups (Group 1, Group 2, and Group 3). On the other hand, the pXRF data only displayed two groups (Group 1 and Group 2). Since pXRF is less accurate and precise (Chapter 3), this discussion draws principally on the LA-ICP-MS data. Group 1 consisted of ceramic samples from the heartland including half of the Tiwanaku samples, Lukurmata, and Chiripa, as well as Cerro Baúl samples from the Moquegua Valley, approximately 300km away. Group 2 consisted of the second half of the Tiwanaku samples. Lastly, Group 3 only had samples from Chen Chen.

The samples from Tarija and La Paz did not fall into either group, however, Chen Chen outliers M43, M44, and M45 showed similar composition to Tarija and La Paz samples. The provenience of the samples from Tarija and La Paz is unclear which made it more difficult to know which Tiwanaku site they represented. This limitation with the Tarija and La Paz samples highlights the importance of obtaining accurate provenience for archaeological materials. Further, this situation also illustrates the difficulties that can be encountered when working with museum collections, especially those that have been donated from various parties. Although, if the Chen Chen outliers correlate with Tarija or La Paz samples, that may indicate that Chen Chen was receiving imports from wherever the Tarija and La Paz ceramics were produced. Until more clay source databases are created and accurate provenience for Tarija and La Paz ceramics are obtained, however, this will remain unclear.

When analyzing all three groups, it was determined that Group 1 and Group 3 were more tightly grouped together compared to Group 2. This implies that ceramics that were produced in
the core and at Chen Chen in the Moquegua Valley were standardized in their production. In other words, during the production process of ceramics in Tiwanaku, similar clays and paste recipes are used. While the origin of the ceramics in Group 2 are still uncertain, it cannot be determined why there was less homogeneity and standardization. Since Group 1 consisted of samples from Tiwanaku, Lukurmata, Chiripa, and Cerro Baúl, the group contained samples from the core, hinterland, and a peripheral site, one which as discussed, is an unusual context because the Tiwanaku temple from which these sherds were recovered is located in an otherwise Wari site. This proved interesting, especially for the Cerro Baúl samples because of its location in the periphery. From the data provided, the incensarios at Cerro Baúl may have been imported from the core.

One interpretation of these data is that there was a centralization and standardization in the production of ceramic vessels. The Tiwanaku samples in Group 2 do not correlate with the other Tiwanaku samples in Group 1. Similarly, Group 2 samples do not share similar composition as those in Group 3. If they do not share the same chemical composition as the other groups, who created them and where did they come from? This emphasizes the great need for raw clay source databases. Since Subgroup 1B does not seem to share similar compositions as the Chen Chen samples, then they were not produced using the raw materials from the Moquegua Valley. Without other clay source databases from other areas, such as the heartland, will remain unclear if the Tiwanaku samples in Group 2 were produced in the core using different clays and recipes or if they were produced and distributed from somewhere else.

To further explore the groups that have been established, the visual analyses on the Bennett Collection from AMNH were integrated with the compositional data to determine if the ceramic sherds could be grouped based off of their physical characteristics. One of the main
physical attributes of the samples that was examined was the presence of painted designs on the surface. Of the 46 total samples from the Bennett Collection, 22 included some form of geometric or zoomorphic design. No patterns were found when referring to the designs because they were almost evenly distributed between Group 1 and Group 2. Therefore, it was determined that visual style was not a characteristic to help ascertain any patterns or groupings. Rather than style, composition may reflect the recipes and clay sources used. However, pastes were also done to determine any patterns similar to bi-plots, but none were established.

The compositional groups were then compared to the provenience of the samples provided by Bennett during his excavations. He included a map of the Tiwanaku site based on Posnansky’s work. From the AMNH samples, 31 had the pit and level in which they were excavated written on them. The pits were only provided for the Tiwanaku core samples. Since a great number of samples had mica inclusions, all of the ceramics that visually included mica were compared with their provenience. Interestingly, with the exception of a few samples, the majority of the ceramics that had mica inclusions were excavated in Pits I, IV, and X. All three pits were close in proximity and located on the southwest side of the map near the railroad. Since mica has been noted to have been good inclusions for cooking vessels, it was interesting they had similar proveniences. One sample (L003) from Lukurmata also had mica inclusions, which was also an outlying sample when Subgroup 1 was plotted. This visual observation alone set sample L003 separate from the three other Lukurmata samples, but compositional analysis also helped confirm it. Lastly, the heartland samples from the groups that were determined using bi-plots (Group 1 and Group 2) were compared to the pits, however, no similar patterns were able to be established.
Visual analysis was able to help in some ways compositional analysis could not. In the case of the style of ceramics, compositional analysis cannot determine style. With the assistance of visual analysis of the Bennett Collection, the sherds that had painted iconography on them could be compared to the bi-plot groups. Unfortunately, there were no patterns that were able to establish them from this, but in other research where groups may be possibly determined, this technique could help recognize patterns or groups that may not have been obvious in compositional analysis. Further, without the observations of the mica inclusions, their relations to the excavation pits would not have been possible.

The Cerro Baúl samples were the most interesting in Group 1 because of their location. Cerro Baúl is over 300 kilometers away from the Tiwanaku core. Based off of the bi-plots discussed in the previous chapter (Chapter 6), it can be argued that some Cerro Baúl incensarios may have been produced in the core and then distributed to the temple near Cerro Baúl. There also seems to be some similarities in composition between Cerro Baúl and Chen Chen samples as well. Although, only one Cerro Baúl sample showed similar composition to the Chen Chen samples. As mentioned in previous chapters, the Cerro Baúl samples were excavated from a Tiwanaku temple near a Wari provincial city. If the incensarios were imported from the core, it can be argued that the temple was regarded as a very important site in the eyes of the Tiwanaku people. This is because such ceramics were created specifically for the purpose of that particular temple despite the long distance between the two sites.

Group 3 consisted of only the Chen Chen samples, with a few outlying samples from Tiwanaku. It can be established by the level of homogeneity within the group that production was standardized and centralized at Chen Chen. Since there was overlap between some Chen Chen and Tiwanaku samples, it is argued that both sites produced their own ceramics using
different clay sources, but still exchanged between each other. The composition is not very
different between Group 1 and Group 3. One interpretation of this is that potters at Chen Chen
had access to their own raw clay sources, but they still shared similar paste recipes as the core.

Overall, ceramic production in the Tiwanaku state was centralized and standardized. There
is also evidence for centralized ceramic production particularly in the core. Many of the ceramics
from Tiwanaku, Chiripa, Lukurmata, and some from Cerro Baúl, were tightly grouped together
implying homogeneity in the composition. These samples were likely produced in the core.
However, until clay sources can be officially matched, it is impossible to directly associate
ceramics in Group 1 and Group 2 with natural resources. Once produced in the core, the
ceramics were distributed to the hinterland sites, such as Lukurmata and Chiripa, and som
peripheral sites like Cerro Baúl. If there was no centralization in the core, the plotted groups
would not be as tightly clustered on the bi-plots because the chemical compositions would not be
the same throughout all of the ceramic vessels produced in the core. This would indicate that the
craftsmen possibly used their own recipes and collected their own clays to produce their vessels.

All of this evidence also supports that craft production was standardized and centralized.
The core shows evidence standardized set of clays and recipes that craftsmen would follow to
create their ceramic vessels, established by the bi-plots and other statistical techniques discussed
in the previous chapter. Since the Tiwanaku sherds were divided into two groups (Group 1 and
Group 2), there may have been two different recipes involved in the production. If the Tiwanaku
samples in Group 2 prove in future research to be produced at other sites, however, then it can be
argued that there was one standardized set of recipes used to manufacture ceramics. Therefore,
until the origin of where Group 2 ceramics were produced, it may remain undetermined if there
was more than one standardized recipe used to produce Tiwanaku ceramics. It was also argued
that the ceramics were produced at the core and then distributed to the surrounding sites, including Lukurmata and Chiripa. If each site produced their own ceramics, the data would have shown the samples clustered in multiple smaller groups. This was not the case in the heartland.

The samples from Chen Chen were displayed as one large group and the same outliers were identified as those reported by Sharratt and colleagues (2015). Since Chen Chen is located over 300 kilometers from the core seeing differences between the two groups made sense. The variations between the Chen Chen and heartland ceramics are likely related to the clay sources that they had access to. Perhaps, temper inclusions might have a very similar composition through various regions in the area, although, confirming this requires future investigation. This could imply that Chen Chen has access to a local clay source, but still used similar clay to temper inclusion ratios in their recipes to make their ceramics. This establishes how standardized ceramic production was in the periphery, as well as how far the Tiwanaku production techniques had traveled. The Chen Chen samples also suggested centralized ceramic production because of the level of homogeneity in the compositional data. The recipes used to produce the ceramic vessels were very similar throughout the majority of the group, indicating similar clay sources.

Overall, craft production in the Tiwanaku state was centralized and standardized. However, until more clay source databases are generated, questions still remain unanswered. Did a different workshop produce the distant Tiwanaku samples in Group 2 or were they produced in other sites in the hinterland or periphery? Where did the Tarija and La Paz ceramic sherds come from? This will remain unclear until further research with clay sources is conducted. What can be supported is that the core produced the ceramic vessels and distributed them to the hinterland.

In Chapter 4, a number of different models for Tiwanaku suggested by various scholars were discussed. The compositional data indicates that ceramic production was mostly
standardized and centralized in the heartland and the peripheral cities were controlled separately by their own people. However, until the origin of Group 2 ceramics is established, it is difficult to determine if there was another standardized recipe that was used in the core other than the recipe used for Group 1. Therefore, even though the core did not seem to control the ceramic production in the periphery, there was still some form of organization present in the provincial sites. This was established by the tightly grouped samples on the bi-plots. There is standardization also present in both the heartland and the periphery, established by the similar compositions in each group. This supports Goldstein’s diaspora model. As mentioned in Chapter 2, within a diaspora state people who originated in the core eventually migrate and settle in communities that are located further away, such as in the Tiwanaku periphery. The migration away from the core does not eliminate their culture’s identity, ideologies, and traditions, but it may slightly alter because they are no longer in full control over the core. These alterations may include the production processes used to manufacture ceramic vessels. This reflects Tiwanaku’s periphery because the core was strongly connected with the hinterland sites, but did less so with the provincial sites, determined through the variations in compositions. There are, however, slight similarities in the clay-temper ratios which is why there was some overlap shown on the bi-plots. Craft production supports the Goldstein’s diaspora model which describes Tiwanaku as a state.

Ceramic vessels were circulated through the Tiwanaku heartland, and minimally to and from the periphery. This is because most of the ceramics in Chen Chen were locally produced and were distributed among their own community. However, since there are some Tiwanaku samples that associated with Group 3 and some Chen Chen samples that correlated with Group 1, it can be argued that Tiwanaku and Chen Chen exchanged ceramics. In the heartland, it is argued
that ceramic vessels were produced in the core, circulated throughout the capital, and distributed out to the hinterland sites, including Lukurmata and Chiripa. It was interesting when visual analyses revealed that the majority of the Chiripa ceramics showed evidence of iconographic art painted on it, but Lukurmata samples proved to be plain without any iconographic designs. One Lukurmata sample (L003) showed little evidence of paint, although the sherd was too small in size to determine more. Did the Tiwanaku core produce more elaborate ceramic vessels for Chiripa? Unfortunately, until more research can be conducted, this remains unclear. Other than the imports from the core, Chen Chen also had outliers (M43, M44, and M45) that showed similar composition as some Tarija samples. This implies that the outliers were imported to Chen Chen from wherever some of the Tarija samples were manufactured. Sharratt and colleagues (2015) note that Chen Chen had access to imported ceramics based on non-local sherds that were excavated in two separate cemeteries. However, until better provenience is obtained for the Tarija samples, it will be difficult to determine where they actually were produced.

There was evidence of non-local ceramics in both the Tiwanaku core and periphery. There were no consistent outliers from either Chiripa or Lukurmata. Further, all of the samples from Chiripa and Lukurmata were grouped together indicating that there were no non-local ceramics present in the hinterland sites. However, the total sample size for both Lukurmata and Chiripa ceramics included in the research presented was very small. The two Tiwanaku core outliers, T033 and T034, did not correlate with any other sample or group. The origin of these two samples remains unclear. Another uncertainty involves the distant Tiwanaku group (T018-T032). They were not considered outliers because they were clustered tightly together. Without more clay source databases, this will not be able to be answered beyond theory. As previously mentioned, outlying samples, M43, M44, and M45 from Chen Chen did not correlate with any
major groups, but did show similar composition with some Tarija samples. Sharratt and colleagues (2015) were, at the time, unable to determine their origin. However, it can now be argued that they were not made in the core, Lukurmata, Chiripa, or Chen Chen. Determining the origin of the Tarija samples will help to better understanding where the three outlying Chen Chen ceramics were produced. Since the two Tiwanaku outliers are grouped closely together and the three Chen Chen outliers are also clustered, it is suggested that each group of outliers were produced in other sites that have not yet been identified using compositional analysis.

Overall, the core had two out of 34 sherds that were not locally produced. Therefore, 5.9 percent of the Tiwanaku sherds were not locally made in the core. In the periphery, there were three outlying sherds out of 45 from Chen Chen. In other words, only about 6.7% of the sherds from Chen Chen were not locally produced. The low percentage of imported ceramics indicates Chen Chen may have been a close-knit community separate from the core, but still identified as Tiwanaku, which also supports the diaspora model.

Richard Blanton’s corporate state model also supports Tiwanaku as a type of state based on its craft production and exchange. Within the Tiwanaku society, all people, elites and commoners, had access to ceramic vessels, however, the people of different social classes had access to different kinds of ceramics. The elite and other people in the wealthier classes may have had access to more elaborate and painted forms of vessels, where those of lower status obtained simpler ceramics. Further, there were wide distribution patterns that provided a wide number of people to obtain Tiwanaku ceramics in different surrounding heartland sites.

Until more data and clay source databases are obtained, the evidence supports a commercial development model that was discussed in Chapter 2. Within this model there is an extensive exchange system that distributes goods to the elites and commoners and division of
labor. Although different classes of people may have had access to different kinds of ceramic vessels, people were still able to obtain some form of ceramics. As discussed, the Tiwanaku core not only circulated ceramics to elites and the common people, but they also distributed the ceramics across the heartland and into the periphery, like the temple in Cerro Baúl. The slight inconsistencies in composition in the LA-ICP-MS data could have also been a result of multiple workshops indicating a division of labor throughout the core.

Tiwanaku was a complex state that consisted of a core, hinterland, and periphery. Heartland and provincial ceramics can clearly be distinguished compositionally. The results show that the sherds from Chen Chen in the periphery are compositionally distinct from the heartland sherds, but are close enough together where it could be ascertained that Chen Chen used similar recipes as the heartland, but had access to different clay sources. Within the core and hinterland, craft production was mostly centralized and standardized. The periphery also included centralized and standardized craft production, but within its own community. Exchange and distribution of ceramic vessels occurred throughout the heartland. Sites in the periphery had access to non-local ceramics from Tiwanaku and from wherever the Tarija ceramics were produced. All of the evidence presented in this thesis supports Goldstein’s diaspora model, Blanton’s corporate state model, and Blumfiel and Earle’s commercial development model for exchange, which argue that Tiwanaku was an expansive complex state that thrived in the south-central Andes.
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## APPENDICES

### Appendix A

#### Appendix A.1

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Appendix B

Figure 23 Sample T004 from the Bennett Collection which displays the pit and level it was excavated from in Tiwanaku
Figure 24 T003 from the Bennett Collection which displays the pit and level it was excavated from in Tiwanaku