Etruscan Trade Networks: Understanding the Significance of Imported Materials at Remote Etruscan Settlements through Trace Element Analysis Using Non-Destructive X-Ray Fluorescence Spectrometry

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Etruscan Trade Networks: Understanding the Significance of Imported Materials at Remote Etruscan Settlements through Trace Element Analysis Using Non-Destructive X-Ray Fluorescence Spectrometry

by

Patrick T. Woodruff

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts Department of Anthropology College of Arts and Sciences University of South Florida

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DEDICATION

This research paper is dedicated to my lovely wife and family. Their support, sacrifices, and constant encouragement provided the motivation that kept me focused on completing this research. Without their love and understanding, I would not have the opportunity to fulfill my goals of becoming an archaeologist.
I would like to thank Dr. Nancy de Grummond, Dr. Jane Whitehead, Dr. Robert Tykot and Randall Stratton in providing the support necessary to conduct this research. Dr. Nancy de Grummond is a professor at Florida State University and the current field director for the Cetamura archaeological field school. Dr. Jane Whitehead is a professor at Valdosta State University in Georgia. She was the site director for the excavations at the La Piana archaeological site. Both Dr. de Grummond and Dr. Whitehead provided access to the Etruscan ceramic artifacts on which this thesis is based. Randall Stratton is the property manager and board member at Tenuta di Spannocchia, an 1100-acre organic agricultural estate in central Tuscany where the ceramics excavated from La Piana have been securely stored for the past 10 years. Dr. Robert Tykot was not only my academic advisor, he also generously provided the equipment necessary to complete this project.
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ABSTRACT

The Etruscan civilization was rich in local and interregional trade. Its exchange networks were vital in establishing relationships with other societies, importing exotic materials and goods, as well as disseminating and assimilating information. However, there is little understanding of the participation of smaller inland settlements in the act of exchange. This research answers questions pertaining to the purpose of trade within these self-sustaining communities, the reliability of identifying geographic locations of the clay used in ancient ceramics through the use of non-destructive X-ray Fluorescence (XRF) spectrometry without sampling current regional clay sources, and the materiality of the ceramics being exchanged in order to establish major forms of production for each settlement. The analyses of trace elements contained within the ceramic materials previously excavated from two remote Etruscan sites (La Piana and Cetamura) can provide a greater understanding of both the trade practices of the Etruscan culture and the reliability of the sourcing methods.

Over 100 ceramics ranging from storage containers, bricks and roofing tiles, amphorae, loom weights, and tableware (including red and black gloss) from Cetamura and La Piana were selected to represent a sample base for local and non-local crafted ceramics. The artifacts were analyzed non-destructively using a Bruker Tracer III-SD portable X-ray fluorescence spectrometer (pXRF), which has been shown to be highly successful in other archaeological studies. Six trace elements (rubidium, strontium, yttrium, zirconium, niobium and thorium) of each artifact were recorded and analyzed using principal component analysis to create a comparable data set. The
results confirm that while these Etruscan settlements were self-sustaining, they were still participating in long-distance exchanges.
CHAPTER ONE
INTRODUCTION

The pre-Roman Etruscan civilization (900–300 B.C.) was rich in local and interregional trade. Its exchange networks were vital in establishing relationships with other societies, importing exotic materials and goods as well as disseminating and assimilating information. But how extensive were the trade networks established by the Etruscans? Preserved documents from outside historians such as Livy and Herodotus have provided a foundation of Etruscan mercantilism, but the cities they refer to are limited to large metropolitan centers near or around major waterways. The inland cities of Fiesole and Arezzo in the northern region of Etruria were positioned near the Arno River. Volterra was situated on the Era River, which drains into the Arno. To the south, Veii and Vulci rest along the Tiber River. The waterways were used for transporting goods to and from these major centers (Grant 1980:17-20). Inland settlements were limited which trade can be conducted and would have to travel to the major port cities to exchange exotic goods.

The purpose of this thesis is to provide benchmarks in distinguishing between locally sourced ceramic artifacts and imported wares and to identify a supportive method in characterizing specific production concentrations. If successful, these techniques can be utilized by future researchers in determining exchange practices and specialized production systems. This research will examine the historical background of the Etruscan civilization, the scientific methodologies used, the analysis of the ceramic artifacts, and a theoretical interpretation based on the results followed by a conclusion. The historical background will help support the hypothesis that while
culturally the Etruscans maintained unified beliefs, each settlement was an independent entity. The methodology chapter discusses various types of scientific methods that are capable of performing this analysis and why X-ray Fluorescence (XRF) was selected as the preferable method. Chapter Four analyzes the artifacts tested within each ceramic category and provides statistical and visual support based on the data collected. A combination of scientific data and theoretical frameworks produce interpretative explanations of the practices of these Etruscan settlements.

The archaeological record, both in Etruria and abroad, indicates expansive trade networks in which the Etruscans participated, though there is little understanding of smaller inland settlements in the act of exchange. From excavations of remote Etruscan settlements such as Cetamura, La Piana, Poggio Civitate and Podere Funghi (Bon-Harper 2011; de Grummond 2000; Tuck 2000; Whitehead 2000) crafting workshops of various types were commonplace. Evidence of kilns, metal slag, and loom weights located in or around the workshop zones suggests that individual settlements would have been able to create and maintain their infrastructure without relying on outside trade.

This study will look into answering these important questions: “Did the trade practices in smaller settlements resemble the practices in major city-centers?”; “Can ancient ceramics be sourced using non-destructive XRF spectrometry without sampling current clay sources in the region?” and “Was the scale of production for ceramics similar at each settlement or was it more dependent on the surrounding geographic landscape?” The analysis of trace elements contained within the ceramic materials previously excavated from two remote Etruscan sites (La Piana and Cetamura) can illustrate a greater understanding of trade practices within the Etruscan culture, the reliability of the sourcing methods and the production systems used within each settlement. Discovering imported material artifacts in remote settlements throughout Etruria adds to the
significant importance placed on interregional and international trade as well as determining each settlement’s primary production focus. This focus can be identified based on which artifacts were imported and which were crafted locally.

For this study, two Etruscan settlements from within the central region of Etruria were selected (Figure 1). La Piana, a Late Etruscan settlement within the ancient territory of Volterra, is located approximately seven km west of the modern town of Siena, Italy. Classified as an agricultural site, La Piana overlooks the river Merse’s flood plains and was only inhabited from mid fourth century B.C. to the end of the third century B.C. (Whitehead 1994). Further evidence based on the archaeological excavations at La Piana indicates that re-habitation did not take place after the settlement was abandoned. The timeframe, location between major city-centers and the capability of self-sustainability of the infrastructure through workshops and sustenance through agriculture makes the La Piana site an ideal candidate for the comparative analysis planned for this study.

The archaeological site of Cetamura lies approximately 18 km northeast of the modern town of Siena near the border of the ancient territory of Arezzo. In contrast to La Piana, Cetamura was sporadically inhabited from the 7th century B.C. to the 16th century A.D. with evidence of the presence of Middle Paleolithic hunters as far back as 40,000 years ago. However, during a repopulation of the site from the mid-4th century B.C. during the Etruscan Hellenistic period an artisan work zone was established (de Grummond 2000). This timeframe aligns with the La Piana site, allowing comparable ceramics to be analyzed.
In 1999, geophysical surveys were conducted in the northeastern portion of the La Piana complex revealing a large rectangular structure (Figure 2). This structure runs in a southwest to northeast direction with the entrance on the northeast side (Whitehead 2000). The position of this structure’s entrance is directly aligned with the sun’s position on the summer solstice. Although later excavations were unable to positively identify the purpose of this structure, it is possible that the structure may have been used as a temple, as indicated by its position (Jannot 2005:12). A structure of this size could have also been used as a community center (Banti 1973:31-32). In addition to the large rectangular structure found in the northeast portion of the site, numerous quantities of both adult and fetal faunal remains belonging to sheep, goats and pigs were discovered.
in the southwest center of the archaeological site plan (Whitehead 1996). Though there is evidence of metal, stone, ceramic, and textile crafting, the capacity of these facilities indicate a possible specific support structure for the crop and livestock production. If this is the case, we should see a pattern in the types of ceramic ware being produced at La Piana. Local ceramic production would probably focus more on infrastructure related construction materials and coarse ware ceramics such as storage containers rather than fine gloss ware or other ceramic items produced specifically for trade purposes.

A completely different structural layout of the archaeological site at Cetamura is evident when compared to La Piana. Cetamura is positioned on the top of a plateau that arcs easterly from

Figure 2: La Piana archaeological site plan (Whitehead 2000:146)
the southwest to the northwest. The buildings do not face northeast as found at La Piana, but are positioned along the contour of the site with the southernmost structures running southwest to northeast and the northernmost structures positioned southeast to northwest (Figure 3). In the northwest section of the site lies a workshop zone (Zone II). Excavations have uncovered several
buildings containing evidence of specific crafts (de Grummond 2006). Finds here including spindle whorls, metal slag and a large amount of ceramics sherds (that include various forms of fine ware pottery) would suggest that Cetamura was a production center unlike La Piana. Expectations of locally diverse ceramic types excavated at Cetamura would support a disparate production focus from La Piana.

The differences in elevation between La Piana and Cetamura and within each of the sites can suggest that the primary production focus may be linked to the geographic landscape at these two settlements. The elevation at La Piana was somewhere between 200-500 meters above sea level (Figure 4) overlooking the flood plain of the Merse River (Whitehead 1994). The overall site was level with a one meter variance over the 110 meter length of the site. Cetamura is located above the 500 meter mark as indicated in figure 3. The highest point of elevation on the site is 695 meters and fluctuates over 11 meters throughout the 120 meter length of the settlement in an almost terraced design. This could suggest that Cetamura was constructed around the existing terrain whereas La Piana may have been constructed to overlook the plain. Major differences between the clay sources as shown in the geomorphological and mineral map of Etruria (Figure 5) between La Piana and Cetamura should be evident when localized ceramic samples are analyzed with a portable XRF (pXRF) spectrometer. The area surrounding La Piana contains sediments from Mesozoic calcareous rock and marine Pliocene clays that contain strontium. Though the sandstone and calcareous marl deposits around Cetamura also contain strontium, higher concentrations of thorium are found in carbonatites and quaternary deposits (Barthel and Dahlkamp 1992:105-106).

Strontium is a soft silver-white element, which commonly occurs in nature. The metal turns yellow when it is exposed to air and has physical and chemical properties similar to calcium and barium. Strontium is the 15\textsuperscript{th} most abundant element on Earth and has an estimated average of
approximately 360 parts per million (ppm) in the Earth’s crust, though much higher strontium values have been recorded (up to 2000 ppm) in carbonate-rich deep-sea sediments (Turekian and Wedepohl 1961:186-187).

Figure 4: Land elevation map of Etruria (Settis and Bonamici 1985:2)
Thorium is a soft, paramagnetic, radioactive actinide metal and only one of three radioactive primordial elements that is naturally abundant. It is commonly found in carbonatites, sandstones, limestone, granitic and volcanic rocks and can range from 10-1000 ppm (Barthel and Dahlkamp 1992:105-106). The ceramics made from the clay around La Piana that contain Pliocene marine deposits would be expected to contain higher ratios of strontium to thorium than the alkaline-rich sources near Cetamura.
Analysis in variations of the other trace elements such as niobium, rubidium, yttrium and zirconium may identify ceramic artifacts not sourced from either Cetamura or La Piana. Niobium and zirconium are commonly found with thorium ranging from 10-30 ppm and 100-200 ppm respectively. Rubidium occurs most frequently in volcanic and illitic muds containing concentrations of approximately 500 ppm. Yttrium is found in most vegetation in concentrations of 20-100 ppm and much smaller amounts in sea water (Emsley 2001:495-497). Volterra lies approximately 20 km west-northwest of Siena and is surrounded by a marine Pliocene zone and alluvial plains. The Etruscan city of Arezzo, 30 km northeast of Siena, is located near the continental quaternary and alluvial plains. Chiusi to the southeast is positioned near marine Pliocene and sandstone deposits while Populonia on the west coast is on the alluvial plains near sandstone and Mesozoic calcareous rock outcroppings. Arezzo, Chiusi and Volterra are in close proximity to both La Piana and Cetamura and could possibly be additional production centers or conduits for interregional exotic ceramic wares.

In Chapter Two, a general overview of the Etruscan civilization explaining political, social and exchange practices may resemble a world economic system, according to Wallerstein (1974). A world economic system is defined as a unit with a single division of labor and multiple cultural systems with little political structure that relies on exchange with others for provisioning the needs of an area (Wallerstein 1974:390). However, most of what is known about the Etruscans involve the large metropolitan cities. It was only recently, from the last quarter of the 20th century on, that data from smaller inland settlements, such as La Piana and Cetamura, have been collected. With this information, studies into the exchange practices of the settlements can be examined and tested to determine if the Etruscan’s form of inter- and intraregional trade conforms to the world-system model.
In addition to the types of exchanges, social practices surrounding the physical artifacts can be understood through the concept of materiality. Materiality “encompasses the view that material or physical components of the environment and social practices enacted in that environment are mutually reinforcing” (Jones 2004:330). The research conducted in this thesis examines the ceramic materials at each site to determine whether certain types of ceramics were crafted locally or imported. This information can be used to interpret divisions of labor and whether the scale of production for ceramics was generalized or specialized (Costin 1991:4-6). These theoretical concepts spawned the research questions in this thesis and the answers can be attained through the archaeometric methodologies associated with XRF spectrometry.
CHAPTER TWO

HISTORICAL BACKGROUND OF THE ETRUSCAN CIVILIZATION

There are ongoing discussions regarding the genesis of the Etruscan civilization. Some argue that the people migrated from Lydia through the north; others believe the Etruscans were indigenous to the west central portions of Italy in which their settlements were established. There are ancient writings that indicate the Etruscans had ties to Lydia (Anatolia) and sailed away to establish a new colony due to the over-population.

Atys divided the population into two groups and determined by drawing lots which should emigrate and which should remain at home. He appointed himself to rule the section whose lot determined that they should remain, and his son Tyrrenhus to command the emigrants. The lots were drawn, and one section went down to the coast at Smyrna, where they built vessels, put aboard all their household effects and sailed in search of a livelihood elsewhere. They passed many countries and finally reached Umbria in the north of Italy, where they settled and still live to this day. Here they changed their name from Lydians to Tyrrenians after the king’s son Tyrrenhus, who was their leader (Herodotus 1.94).

Many support a migration hypothesis for the Etruscans by referencing their non-Indo-European language, the archaeological evidence of a cultural shift in burial practices from cremation to inhumation during the Late Bronze Age to Early Iron Age and cultural similarities found in artistic design and symbolism depicted on artifacts excavated in these burial tombs. Although the language difference between the Etruscans and the other inhabitants of Italy could support evidence of a migration, the difference could also be related to trade practices. Since there is a distinct shift in several cultural practices, researchers have classified these periods as
Villanovan and Etruscan respectively. However, it is not to say that the Etruscan and Villanovan are one and the same, though in comparing material culture and social organization there are similarities. Other influences from Greece and the eastern Mediterranean are also evident, but those influences are mainly from commercial contact rather than settlements (Ward-Perkins 1959:13).

The Etruscans established small villages in close geographical proximity to natural resources and waterways. These resources, for the most part, were mineral in nature as the Tolfa and Apennine mountain regions contained metal ore, copper, lead, iron, alum, mercury and small traces on tin. The landscape of mountain ridges, dense forest, and river valleys also provided protection from neighboring villages. These localized villages, often located on high plateaus with sharp cliffs on three sides for defensive purposes, formed centers for regional commerce. The centers grew and later amalgamated the surrounding villages into independent cities (Grant 1980:17-18). Archaeological evidence from the Tuscania site suggests that the critical phase of settlement shift from a system of small independent villages to a more hierarchical system that was dominated by the major commercial centers such as Tarquinia and Vulci lasted less than one hundred years (Barker and Rasmussen 1988). City-States were formed with their pseudo boundaries established around the geographical areas being resourced. Tarquinia, located approximately 65 km northwest of the Tiber River and 8 km inland from the west coast, was the first to undergo urbanization. Other cities such as Luni sul Mignone, Caere, Vulci, Rusellae, Vetulonia, Chiusi, Volterra, Veii, Cortona, Arrezzo, and Faesule soon followed (Figure 5, on p. 9). All of these cities were formed inland but close to waterways that led to the Tyrrhenian Sea. Populonia, a center located on the coast that had its own port is the only exception. The design of Populonia differs from the other cities which may indicate outside influence. Populonia was also
not as old as the other city-states in Etruria which suggests that it was initially a market or (emporia) constructed by the Mycenaean, who were well known for establishing trading outposts on foreign soil (Grant 1980:27-30).

**Politics**

The pre-urban Etruscan villages of the 9th century B.C. were broadly uniform. With the exception of descendants of the villages founding families (clans), these villages were egalitarian and classless. It is suggested that in the following centuries when initial contact with foreign merchants, who were attracted by the quality of locally crafted products, a whole new wealthy class emerged.

This new class of nobles was the foundation of a feudal system, eventually morphing into oligarchic governments, incorporating artisans, clients, freedmen and slaves (Grant 1980:117-123). Although the Etruscan regions were completely autonomous, leaders from each region, referenced by modern scholars as a “League”, consulted annually at the Fanum Volumnae near Orvieto (Haynes 2005:135-137). The “Etruscan League” consisted of a representative (possibly a king or political leader) from each of the twelve cities of Veii, Cerveteri, Tarquinia, Vulci, Volsinii, Roselle, Vetulonia, Populonia, Chiusi, Perugia, Volterra, and Arezzo (Figure 6). Little is known about the “Etruscan League” however, ancient literature by Livy suggest that the League of Twelve Cities were a loose confederation of Etruscan city-states oriented more towards religious aspects than military alliances (Livy 4.61). Livy based his conclusion on the fact that the “League” was unable to agree on joining in the defense of Veii when the Romans attacked. Though the “League” was not mentioned, a brief unification of the city-states allowed Etruria to expand south of the
Tiber River along the coast and northeast across the Apennine Mountains into the Po valley. Nonetheless, the “League” was not a united front for the Etruscans and each city-state was
independent from the others. Wall paintings in the François tomb at Vulci date to the 4th century B.C. and possibly document an Etruscan interpretation of historical events. These paintings depict a man and his brothers from Vulci, fighting other figures from other Etruscan cities including Volsinii, Sovana, Falerii and Rome (Gillett 2010:5-6). There were also rivalries between Caere and Tarquinia related to merchant agreements with Rome indicating that the Etruscan states were focused more on economic trade than political unification.

**Military**

Based on the ancient documents of the Greeks and Romans and archaeological materials excavated at various home sites, the Etruscans did not seem to have a unified defense system. The military units were typically owned and controlled by the individual elite families or clans. These units were primarily designed to protect the families and their properties and also to acquire additional resources. The numerous amounts of warrior representation in Etruscan art would lead one to believe that an evolution from that of lightly armored to heavy infantry, similar to the Greek hoplite, expanded all through Etruria. However, the only actual evidence comes from Dionysius’ documentation of two Etruscan families that mentioned Etruscan-made hoplite shields and weapons (Snodgrass 1965:116-119). A tomb of an elite Etruscan warrior in Orvieto that dated from the first half of the fourth century contained a round hoplite shield, greaves, muscled cuirass, and a Montefortino helmet, standard heavy infantry equipment. The Montefortino or ‘jockey-cap’ style helmet was first introduced by the Celts to the north of Etruria near the 4th century B.C. (Burns 2003:64). Since testing has not been conducted on these items, it is uncertain whether they were actually used in combat or were ceremonial. An excavation near Vetulonia provides evidence of a clan-based army in Etruria. One hundred and twenty helmets, dated to the early 5th century.
B.C., were discovered in a deposit near the arch of Vetulonia. The majority of these helmets were inscribed with the name ‘Haspnas’, meaning ‘of the family of Haspa’ (Maggiani 1990:47-48) (Figure 7). There were also rare times when several of these clan-based armies collaborated on larger efforts. An example of one of these occasions was when units from Tarquinia and Veii combined forces to conquer Rome in order to control the natural river crossing connecting their territories in Campania and the South, although they could not sustain their control and were expelled (Ward-Perkins 1959:24). Although there was occasional collaboration between the Etruscan regions did occur, more commonly there was confrontation. Rivalries between Tarquinia and Caere prompted many conflicts over resources. Wall paintings and stucco reliefs in elite family tombs discovered in Caere (Tomb of Reliefs) and Tarquinia (Giglioli Tomb) show visible signs of conflict both between families and with Rome (Haynes 2005:333).

Social Status

Interregional trade with the Greeks, Near East, and neighboring territories increased the wealth in the city-states of Etruria, which created a stratified class system. Evidence of this wealth
increase can be seen by the existence of artisan and mercantile artifacts in the tombs at Volsinii as well as in the excavated houses in Vetulonia, San Giovenale and Veii (Torelli 1974; Grant 1980). Tombs of the elite class also have contained elaborate bronzes, ivory and silverworks of Urartian influence as well as Greek pottery, displaying the wealth of the owners (Maxwell-Hyslop 1956:165). Greek authors have linked Etruscan wealth and women and slave’s freedom with barbarian luxury, since it was unfamiliar to the Greek culture (Bonfante 1981:166). Other tombs of non-elite persons in the same area contain utilitarian earthenware of local origin that provides additional evidence of a stratified class system.

From the archaeological record and ancient writings of the Greeks and Romans, we can determine the city-states of Etruria were not just patrilineal. Women also exhibited social influence in the Etruscan societies. Evidence of both patronymics and matronymics has been found on a multitude of burial goods, pottery, mirrors, and wall paintings in contrast to the Roman and Greek cultures as indicated by ancient classical authors writing about the foreign cultural practices that women had in Etruscan aristocratic society. Depictions of Etruscan art portrayed both men and women reclining together at banquets and other ceremonial events (Bonfante 1981:159). Sarcophagi also support this theme with sculpted lids of couples embracing and funerary images along the sides. The focus on families or clans rather than the individual male was an important facet of the Etruscan culture that distinguished them from other societies of that time.

Tomb excavations have played a large role in understanding the Etruscan culture. A common theme among the elite was the amount of detail that was placed in the construction of these funerary sites. The interior of each tomb was crafted to represent the interior of the homes including roof beams that were either painted or sculpted into the ceilings. This theme seems to be widespread throughout Etruria. The Tomb of the Shields and Swords in Vulci has hand carved
chairs and footrests with raised circular disks on the wall above the chairs to represent shields. Rock carvings in the interior of Campana Tomb 1 in Cerveteri show three baskets on a shelf overhanging a bed (Haynes 2005:87). It appears that only the tombs of the elite families maintain this design style and usually resided on the families’ property. Other objects that indicated status such as bronze mirrors were popular within the Etruscan middle and elite classes. These items displayed a high quality of skill in bronze working with engraved pictorials on the back and intricate designs on the handles (Figure 8). The mirrors also contained inscriptions written in the Etruscan language above the figures. Larissa Bonfante believes the images on the back of these mirrors are representation of Greek plays which gives insight to the level of education of Etruscan women. It also shows the level of craftsmanship, literacy, art and culture of the Etruscan societies (Bonfante 1980:152-153). Of the 252 mirrors currently at the Museo Claudio Faina in Orvieto and Museo Nazionale Archeologico in Viterbo, 36 show evidence of having been repaired, indicating the mirrors were used in daily life and not just as grave goods (de Grummond 2002:309).

Social status can also be determined by examining the Etruscan architecture. The Etruscans incorporated elaborate designs on roofing tiles to delineate social or religious prominence (Tuck 2000:111). An excavation at Poggio Civitate in Murlo revealed similar elaborate roofing tiles associated with a building that has been identified as a crafting workshop (Nielsen 1998:97-98).

**Maritime Trade**

The advanced skill that the Etruscans employed in crafting their products was not enough to explain the dramatic economic growth; they needed an effective way to get their raw minerals and bulk goods into the hands of the consumer. Distribution over land, based on the geography and the regional layout of other Etruscan city-states, was slow and ineffective. A better solution
was to transport goods over the seas, using ships that could carry tons of cargo. Populonia was the first port city of Etruria, and with its logistical success it is not surprising that other city-states followed suit. Tarquinia and Caere both expanded their limits to incorporate port cities, Garvisca and Pyrgi respectively, in order to secure effective distribution of their goods. By reviewing the archaeological evidence of these port cities and various shipwrecks off the southern coast of France and Spain, we can gain an understanding of the goods and information exchanged.
Etruscan shipbuilding was different than the traditional ships of Greek or Levantine design. Etruscan shipwrights had adapted a traditional technology of ‘sewn’ craft to the requirements of large-scale hauling and defense (Turfa and Steinmayer Jr. 2001:123-126). Instead of using nails, boat planks were sewn together with rope which helped minimize the effects of the heavy surf and impacts of beaching near coastal areas. The Etruscans also incorporated a foresail as depicted on a painted Caeretan White-on-Red pyxis (a box of a usually cylindrical shape having a lid with a knob in the center), currently on display at the Louvre, dating to the mid-7th century B.C., which is the oldest representation of this type of seafaring sail (Turfa and Steinmayer Jr. 1999:293-295; Turfa 2000:113-114). Adding a foresail in conjunction with rowers increased speeds along the Mediterranean waters and the ‘sewn’ ship design model that allowed more flexibility to the hull corroborates this suggestion.

The responsibility for foreign policy and interactions appeared to have been owned by the Etruscan merchants. Evidence of foreign outposts within the coastal ports of Etruria and of Etruscan outposts in foreign regions shows bidirectional exchange systems. Excavations at Gravisca, the harbor of Tarquinia, have yielded information on the various cultures once present there. Evidence of this contact comes from a number of Greek sanctuaries located around the port (Haynes 2005:172-174). Additionally, a few Etruscan merchants and elites may have had stronger relations to Phoenician merchants as indicated by the rarely exported Phoenician ceramics placed as grave goods in a tomb at Populonia (di Bona et al. 2010:4).

Two temples and smaller sanctuaries discovered nearby attest to the presence of Greek and Punic inhabitants. Two temples have also been partially excavated at Pyrgi, the harbor of Caere. The first was erected in the early 6th century B.C. and was dedicated to Etruscan Uni/Phoenician Astarte. In 1964, excavations uncovered three inscribed gold tablets and one partial bronze tablet.
near this temple, two in Etruscan and one in Phoenician. The tablets were commemorating the dedication of the temple by Thefarie Velianas, “King of Kirsy” (Haynes 2005:176), Kirsy being the Phoenician word for Caere. Having discovered the two tablets in close proximity archaeologists were hopeful that the Phoenician texts would assist in deciphering the Etruscan texts. Unfortunately, the tablets were not direct translations of one another.

Other archaeological excavations in France as well as maritime excavations off the coast of France and Spain support extensive trading of goods. The occurrence of Etruscan and other Greek amphorae and other objects associated with wine consumption around Iron Age sites near Provence, Languedoc and Roussillon in southern France support evidence of a flourishing exchange (Riva 2010:3). Additionally, Etruscan amphorae associated with local ceramics and grey ware found at other indigenous settlements such as Saint-Blaise, France, may show evidence of physical places of contact between local and foreign traders.

Shipwrecks of both Greek and Etruscan origin found off the coast of France provide additional evidence of expanded trade relations with Europe. The Grand Ribaud F shipwreck (Figure 4) is the remnants of an Etruscan merchant vessel loaded with nearly 700 amphorae stacked in layers of five, stacked bronze basins and disks with beaded rims, coarse Etruscan ware and high-quality Greek ceramics (Drap and Long 2001:21-23). The remains of a Greek vessel off the southern coast of France at Cap d’Antibes (Figure 9) also contained Etruscan amphorae as part of its cargo. A trove of 40 bucchero kantharoi both painted and plain bolstered stylistic patterns inimitable to Vulci (Daniel 2009:45-46).

Trade relations with southern Europe made sense for the Etruscans considering the Iberia peninsula was the closest geographical source of tin (Fawns 1907:5-9). Although early evidence of small traces of tin in Etruria is supported, the Etruscan metal workers would have exhausted
that resource rather quickly, prompting a search for a replacement in order to continue bronze production. Etruscan artifacts have been discovered in Europe, northern Africa and southwest Asia as well as throughout the Mediterranean region, showing the depth and knowledge of the Etruscan seafaring merchants.

Figure 9: Map of shipwrecks off the coast of France containing Etruscan and Greek wares (Daniel 2009:44)
Archaeological Sites

La Piana

Just 7 km west of Siena, Italy lies the rich, fertile soil where the settlement known as La Piana was formed (Figure 10). The site rests on an elevated plot of land overlooking the river Merse’s flood plain, which is believed to have been drained by the Etruscans to create an area suitable for crop and livestock production (Whitehead 1994:123). This settlement survived a little over 100 years, originating in the mid-4th century B.C. and lasting to the end of the 3rd century B.C., where it likely met an abrupt and brutal demise. The general understanding is that the region surrounding Siena became widely depopulated in 79 B.C., shortly after the destruction of Volterra.

Figure 10: Image of the La Piana settlement and surrounding area. Photo courtesy of Jane Whitehead
at the hands of the Roman dictator Sulla (de Grummond et al. 1994; Whitehead 1994). Evidence at the La Piana site indicate that this settlement was uninhabited long before Sulla’s reign and that invading Gauls may have laid siege on their way to Rome. La Piana did not repopulate after its destruction.

Archaeological excavations were conducted at La Piana through a span of almost 30 years beginning in 1974 under the direction of Professor Enzo Mazzeschi of Siena. In 1982, Dr. Jane Whitehead continued Enzo’s work on the site and continued to direct excavations throughout the 1990s and into the early 2000s (Whitehead 1994; 1996; 2000; 2000a). The initial excavations were focused around a large, multi-room structure, positioned southwest to northeast of the southern portion of the site (Field A) (Figure 11) (Whitehead 1994:127).

The eastern most room of the main structure in Field A has been identified as a storeroom based on the large number of storage containers found. One of the storage jars discovered in the southeast corner of the storeroom contained hand worked knobs to support a rope for suspension

Figure 11: La Piana Site Plan for multi-room structure (Whitehead 1994:126)
Soil samples previously taken from this room provided evidence of the types of perishable materials, such as grapes, millet and barley that were stored in the northwest corner of the room (Whitehead 1994:135).

Later excavations that were conducted revealed evidence of multiple living quarters, domestic textile manufacturing, metalworking, stoneworking, ceramics and animal butchering. Though skills working with ceramics, textiles, metals and stone were evident, the occurrence of these trades suggest a more supporting role in the daily production of the site. In one of the center rooms of the structure excavated in Field A (Figure 13), charcoal remains of what was identified as a loom were discovered next to a tight group of seven glass beads (Figure 14) and an overturned child-size bowl. The bowl still contained remnants of a porridge like substance and the beads were probably worn by the individual working the loom. In an earlier excavation in 1982, a femur and

Figure 12: Knobbed storage jar (Whitehead 1994:135)
Figure 13: Site plan of La Piana after the 1995 excavation season (Whitehead 1996:107)

Figure 14: Glass beads in situ, grouped as if still strung together (adapted from Whitehead 1996:116)
ischium of a female were found in close proximity to where the loom remains were discovered (Whitehead 1996:114-116). In the adjacent room to the west, scorching in the southwest corner along with some animal remains suggest a possible hearth. Several more human remains were also found in this room; a lunate and metacarpal of a human adult male and the proximal end of a juvenile femur and epipheasal head. These two rooms, contained within the multi-room structure, appear to be part of a residence. Perimortem cut marks on the shaft of the juvenile femur indicate an abrupt and violent death for these individuals (Whitehead 1996:117). The room contained in Field C (Figure 13) revealed similar evidence of another residency. A hearth was identified as well as multiple types of pottery that would be expected inside living quarters. Along with storage containers, cups and bowls more elaborate fine ware including some red and black gloss ceramics were also recorded. Though similar ceramics were discovered in the living quarters of the multi-room structure, no evidence of red or black gloss fine ware were discovered. This could be explained by a stratified class system as typically found throughout the Etruscan civilization.

An area approximately 11 meters wide east of Field B and south of Field C (Figure 13) was a cobbledstoned paved surface. The area could be described as a work zone, judging by the finds from the surface of the pavement. In a 2-x-3-m rectangular area, several deposits of slag related to bronze working were found. A multitude of stone sherds were unearthed on this cobbled surface near where the slag was found (Whitehead 1996). The type of sherds suggests that the stone work was conducted for producing tools. The fact that none of the stones used in the structures found in Fields A, B and C were shaped point more toward a knapping process and not full scale masonry. Along with the slag and stone sherds, massive quantities of faunal remains were also discovered in this area. Most of the remains were from domesticated animals such as sheep, cows and pigs, though there were a few belonging to deer, turtles and dogs. It is difficult to
determine if this area was used dump site, a corralled pen, or a butchery (Whitehead 1996). A dump site of these remains so close to the living quarters would have been unsanitary and given the nature of the violent destruction of this site, a reasonable conclusion would be one of the latter two.

Excavations and geophysical surveys conducted at the La Piana site in 1999 revealed two structures that may provide further evidence to support an agricultural production focus. A large cistern connecting the structures from Field A and Field C was uncovered during the excavation (Figure 15). The cistern’s diameter of the inner vat was measured at approximately 4.5 meters. Dr. Whitehead describes this feature as having been “constructed of dry-laid field stones in two concentric cylindrical rings with a meter-wide cylinder of dense clay packed between them” (Whitehead 2000a:117). She further explains that the roof was systematically constructed to channel rain water into the cistern while screening the vat from pollutants and minimizing evaporation. In fact, she believes that the entire roof structure from Fields A and C was designed to direct rain water into the cistern as depicted in the reconstructive drawing in Figure 16.

To the north of Field A, the surface of a large 30-x-15-m structure was found (Figure 15). This structure runs in a southwest to northeast direction with the entrance on the northeast side (Whitehead 2000). The alignment of entrance to the sun’s rising position on the solstice may suggest a possibility that the structure could have been used as a temple (Jannot 2005:12). During the 1999 field season, ground truthing was conducted on four areas of the structure, area A in the northwest corner, area B in the structure’s center, area C in the northeast entrance and area D in the southwest corner (Figure 17). The structure’s foundation appeared to be raised forming a low, flat mound. Surveying the southern corners in areas A and D the team expected to uncover the structure’s foundations but instead the bedrock emerged between 30 and 50 cm below the surface.
Interestingly, the bedrock formed two lines producing right angles at the corners (Whitehead 2000:148). Several roof tiles and a few nails were found suggesting some form of building or perhaps a covered pavilion. If this feature was an enclosed structure, a ridge beam of the roof,

Figure 15: La Piana 2000 site plan showing location of the cistern and rectangular structure (adapted from Whitehead 2000:146)
typical in Etruscan temples, would run through the center (Whitehead 2000). This was the expectation of the field team upon surveying an area in the center of the feature (Area B). What was found was the continuation of the bedrock approximately 7 cm below the surface. Area C produced similar results where the bedrock again was taking on an architectural form (Whitehead 2000). Though is still remains uncertain what, if any, structure was located in this area. Could it be just a natural phenomenon where the bedrock resembles a large rectangular structure, or did the inhabitants of this site use the bedrock as the foundation for some communal area? Without further excavations the answer remains unknown.

Figure 16: Reconstruction drawing of the cistern as La Piana (Whitehead 2000a:119)
Cetamura

The ancient Etruscan site of Cetamura resides approximately 30 km northeast of Siena, Italy on top of a hill 695 meters above sea level in the Chianti Mountains. Unlike La Piana, the peak on which Cetamura lies has a long history of habitation, ranging from the Upper Palaeolithic (40,000 B.C.) to the mid-16th century A.D. Though evidence has been found that Palaeolithic hunters visited this area, post pits carved into the sandstone bedrock and a nearby well consistent...

Figure 17: Ground truthing plan of the large structure in La Piana (Whitehead 2000:147)
with the Etruscan Archaic Period (7th century B.C.) were the first indications of a sedentary settlement (see Figure 3 – Area G, Zone I) (de Grummond et al. 1994:90-93).

Cetamura was first discovered in September of 1964 by Alvaro Tracchi. Tracchi, a public accountant and archaeology enthusiast, was mapping Roman and Etruscan roads and identifying archaeological sites in the Chianti-Valdarno region (de Grummond et al. 1994; 2000). After several sessions of collecting and recording artifacts and clearing and surveying the site, Tracchi concluded that Cetamura was the most significant Etruscan/Roman settlement in the Chianti region. He published his discovery including a surveyed map of the site in Studi Etruschi (1966) and later in his book Dal Chianti al Valdarno in 1978. His book was released a year after his untimely death (de Grummond et al. 2000:6). His map has provided useful information in developing a foundation for the current site plan on Cetamura (Figure 18). A permit to excavate Cetamura was issued to the Department of Classics at Florida State University (FSU) by the Soprintendenza Archeologica della Toscana in Florence in 1973, under the direction of John J. Reich (de Grummond et al. 2000). Reich continued as site director until 1983 when Nancy T. de Grummond assumed the role. Dr. de Grummond is a professor in the Classics department at FSU and is responsible for establishing and administering an archaeological field school through FSU at the Cetamura site in 1978 (de Grummond 2000:6). Excavations and the field school at Cetamura are currently ongoing.

The layout of Cetamura is analogous to a fortified hilltop settlement, a design common in the uneven mountainous terrain of the Chianti region (Cresci and Viviani 1995). These settlements are defined by the foundation walls constructed around the perimeter hilltops. This type of fortification was a typical practice during the Hellenistic Period (325-175 B.C.) and a number of settlements near Cetamura in the Chianti region such as Montecastelli, Poggio La Croce, La
Pietraia and Montemoggino display similar construction techniques (Cresci and Viviani 1995:142-143). Cresci and Viviani (1995:142) further hypothesize “…that fortified hilltop settlements have a stable habitational function; are characteristic of the Hellenistic Period; are linked to agricultural
and breeding activity as part of a distribution system of goods for exchange; have a spatial
distribution that corresponds to the periphery of the city-state’s territory; and make up a part of the
territorial services organized around centers whose function it is to regulate production and
commerce.” Though Cetamura is most certainly a fortified hilltop settlement as depicted in Figure
18, I disagree with some of the requirements Cresci and Viviani set forth in identifying this
typology. There has been no evidence at Cetamura suggesting a surplus of agricultural goods nor
the exchange of such goods. Evidence that has been found suggests that a surplus of production
goods were used in exchange for agricultural goods.

Tracchi initially segmented the site at Cetamura into four zones (A, B, C, and D) which
have since been consolidated into two zones by the FSU field team. Zone I (Figure 19) represents

![Figure 19: Zone I map of Cetamura (adapted from Hargis 2007:54)](image)
the living area of the site and corresponds to Zone A (Figure 18). Zone II (Figure 20) is the artisan work area and is the equivalent to Zone B (Figure 18).

Zone I is located on the highest point of the hilltop 5-6 m above the structures located in Zone II. Evidence of occupation as described by the structural features in Zone I range from the Archaic Etruscan Period (7th-6th century B.C.) to the Medieval Period (9th-16th century A.D.). The post pits suggesting Archaic Etruscan wooden structures, the hypocaust flooring of Roman baths, and the Medieval fortress or castrum as described in documents dating from 1172-1177 A.D. archived at Badia a Coltibuono all show evidence of being constructed in close proximity to the well. The well, which is centered in the main area of Zone I, must have been in place or constructed no later than the first recorded occupiers 2,600 years ago (de Grummond 2000:11). Since this research is specific to Etruscan production and trade during the Hellenistic Period, this study will focus more on Zone II which was constructed and used solely during that time.

Figure 20: Zone II map of Cetamura (adapted from Hargis 2007:54)
Zone II is commonly called the artisan’s zone (de Grummond and Ewell 1999). This zone is easiest to explain by breaking it into three sections, the workshop area (C, J and K), the cistern (A, B, and D) and the temple or sanctuary (L) (Figure 20). Structure C (Figure 21) has an interior of approximately 5 x 8 m consisting of well-laid floor of irregular flat stones. Found within and around this structure were numerous amounts of loom weights, spindle whorls and spools which may suggest the location of a textile workshop (de Grummond and Ewell 1999:103; de Grummond 2000:18). The smaller rectangular structure east of Structure C is comprised of irregular sandstone blocks consistent with other Etruscan kilns discovered in Italy (Figure 22). It is hypothesized that this kiln was mainly used for producing bricks, roof tiles, and loom weights since there has been no evidence found within the structure of pottery production (de Grummond 2000:19-20). A stone

Figure 21: Structure C, Zone II at Cetamura (de Grummond 2000, Plate IIIc)
platform (Structure J) (Figure 23) between Structures C and K shows evidence of ash, carbon and numerous by-products of ceramic activity (de Grummond 2000:20). The rectangular area containing the platform suggest a possible second, smaller kiln specific to the production of pottery. Though previous excavations have not uncovered a forge, metal slag has been recovered in the artisan’s work zone. Wall features extending north of the two kilns (Structure H) may provide clues to other forms of manufacturing, including metalworking.

An example of ingenuity of the Etruscans in water management is the cistern (Structures A, B, and D) adjacent to the artisan’s zone and south of Structure C. The structure was a three-tier terraced system designed to effectively store large quantities of water (Figure 24) dedicated to the
artisan’s work area. Structure B was built with an aperture in the west wall to allow for runoff into Structure A. Structure A has a similar aperture to allow drainage into Structure D, where the water was then collected by the artisans (de Grummond 1994:99-107). To allow for maximum rain water collection, the cistern was not covered nor was the water being filtered. This supports the hypothesis that the water was allocated for craft production and not for consumption. The well in Zone I which was covered to minimize contamination would have been the only potable water supply (de Grummond 1994:93).

Figure 23: Structure J containing a possible second kiln (de Grummond 2000, Plate IIIb)
Figure 24: The cistern for the artisan’s work area at Cetamura (image courtesy of Nancy de Grummond)
Figure 25: Plan of the sanctuary and courtyard at Cetamura (Structure L) (de Grummond 2009:40)
Structure L in Zone II has been identified as a sanctuary combining both elements of a temple and a sacred area (Figure 25). The trapezoidal plan of the sanctuary contains several small rooms, a rustic altar and a ritual cavity carved into the bedrock. Adjoining the sanctuary is an interior open-air courtyard (de Grummond 2009:39). Both the sanctuary and courtyard feature a beaten earth floor. Though the plan is not orthodox to a typical Etruscan temple, seven votive features helped establish its identity (de Grummond 2009:41). One of the votives contained over 50 items or gifts including a miniature brick, a gemmed iron ring, a broken bronze grater, broken ceramic beakers, bronze nail caps and iron nails (Gleba 2009:111).

All three areas in Zone II are connected by function. The artisan work area provided space capable of producing a large quantity of quality items which may or may not have been for local domestic use. The cistern water management system was created to support the artisans and the temple structure area provided a ritual space for the artisans to offer gifts to their deities in return for infallible finished products. When comparing Cetamura to La Piana, there is a sharp contrast in the motivation of production specialization. The settlement at La Piana shows every indication that husbandry was the primary focus in which a surplus could be accumulated for the purpose of trade. Cetamura shows every indication that the settlement was engaged in producing a surplus of manufactured products for internal use and very possibly for exchange.
CHAPTER THREE

METHODOLOGY

From what has been discovered of the Etruscan civilization, indications are that the Etruscans were highly proficient in politics, diplomacy, mercantilism and trade skills in the form of agriculture, metallurgy, carpentry, textiles, shipbuilding and ceramics. This understanding can help in interpreting the analytical results when studying Etruscan artifacts such as pottery. Artisans, like chefs, often create their products using recipes. Though each artisan may add their own artistic creativity to the product, the majority of the process is the same (Grocock and Grainger 2006:23). Major and minor elements can be added to adjust the color of the final product or to modify the consistency in the form of temper. A major element is defined as an element dominant throughout the crust of the Earth that has a concentration greater than 1.0%, notably Si, Al, and Fe (Herz and Garrison 1998; Munita et al. 2001). A trace element is an element where its composition consists of less than 1000 parts per million (ppm). Though there are no standard reference materials (SRMs) published to date for studying the compositional make-up in ceramic artifacts, Mexico’s Centro Nacional de Metrología (CENAM) has identified 14 trace elements (Rb, Sr, Ba, Y, Zr, Nb, V, Cr, Co, Ni, Cu, Zn, Th and Pb) that can be used in the analysis of ancient ceramic provenance (Lozano and Bernal 2005:390). In order to evaluate the quantitative significance of trace elements in relation to provenance studies, XRF is one of many geochemical methods that can be used to gather the appropriate data.
XRF and Elemental Analysis

XRF provides elemental composition for a ceramic sample when atoms interact with radiation. Once the materials are excited with X-rays they become ionized. The energy of the radiation can dislodge an inner shell electron causing the atom to become unstable. An electron from an outer shell replaces the missing inner electron releasing energy because the inner shell electron is more strongly bound compared with an outer one. The released energy is lower than the primary X-rays which is called fluorescent radiation. Energy differences between electron shells are known and fixed and the resulting secondary fluorescent X-rays can be used to detect the abundances of elements that are present (Shackley 2011:16-21).

There has been some discussion as to whether XRF is a viable method for analyzing trace elements for the purpose of clay sourcing of ancient ceramics (Glascock 2011; Johnson 2014; Speakman et al. 2011). Though neutron activation analysis (NAA) is still the preferred method for this type of analysis, archaeologists turn to the pXRF when samples cannot be transported or damaged by sampling. NAA is capable of detecting elements to parts per billion (ppb) whereas XRF can only detect part per million, allowing for higher precision for trace and rare earth elements. Since trace elements are studied to identify clay sourcing and fall within the range of less than 1000 ppm, XRF is capable of providing such data.

Other XRF factors that are beneficial when compared to NAA include cost per sample, processing time, sampling accessibility and destructiveness. A nuclear reactor is required for conducting NAA and only a handful of facilities worldwide have the capability to conduct this analysis. NAA requires specialized training for handling radioactive materials and waste and is reflected in the cost per sample, which averages $100.00 per sample. This analysis, though highly accurate and precise, is destructive to the artifact and can take up to several weeks to generate
results (Glascock 2011:171). XRF requires minimal training and does not require special facilities. Portable units of XRF are becoming more common and allow the testing of previously inaccessible artifacts in countries where international transport is restricted. Most portable units can be used at a commercial cost of approximately $500.00 per day. The preparation and sampling process using a pXRF on ceramics requires an average of 5 minutes. In an eight hour period, 80-100 samples can be analyzed at a low cost per sample.

There is still hesitation by researchers for using pXRF in lieu of NAA in analyzing trace elements for sourcing due to questions pertaining to accuracy, precision and homogeneity of the samples. Several case studies have addressed these concerns and support the use of pXRF spectrometers. Jack Johnson (2014) expresses concerns and identifies potential internal and external errors that can affect the results of elemental analyses when using a pXRF.

Internal errors pertaining to the fluctuation of pXRF spectrometers performance can be easily identified by conducting multiple assays of a single point on an object. If a drift or variance of the results is visible, a simple re-calibration of the instrument can be performed by the manufacturer (Johnson 2014:569). At the time of my research, there was no indication of internal errors associated with the Bruker Tracer III-SD pXRF spectrometer that was used to sample ceramic artifacts from the La Piana and Cetamura collections.

External errors such as heterogeneity, software calibration, sample preparation and user error are more common and if not addressed could lead researchers to draw conclusions based on inaccurate data (Johnson 2014:565). Heterogeneity is always a concern when conducting geochemical sampling on manufactured products such as ceramics. A solution to minimize errors when analyzing these type of materials is to ground a powder sample using a mortar and pestle constructed of a material that is outside the range of chemicals being analyzed. Unfortunately, this
will destroy all or part of the artifact being studied. In cases where an artifact cannot be destroyed, taking multiple readings from various points on the object that are clear of inclusions, paints, slips and soil can produce similar results to those obtained using a powdered sample. Sample preparation and user error are easily corrected by providing the proper training and are less of an issue compared to software calibration. Calibration is a numerical translation of the observed objects response to X-rays into elemental concentration and returns a result in parts per million (Johnson 2014:565). These translations are performed by software tools usually provided by the XRF manufacturer. Bruker, the manufacturer of the pXRF used for this thesis, provides over 250 calibration spreadsheets based on specific types of objects being analyzed such as obsidian, mud rock, glass, heavy metals, stone, oils and soils. The calibrations are based on a specific type of regression analysis known as inverse prediction. For the calibration to work, standards of known elements are measured and counted by the XRF to produce a best-fit equation based on the counts and concentrations (Johnson 2014:565-566). This process in not perfect and errors that occur are passed to the results; however, errors can be reduced when more standards are used in the calibration (Johnson 2014:565). For my study, the “Berkeley SD obsid calibration Comp 19.5 to 22” spreadsheet was used to calibrate the data collected from the research samples. This calibration tool was created by Robert J. Speakman and contains standards on 48 known elements, six of which are the trace elements used in this thesis.

Michael Glascock (2011:177-184) published a comparative analysis between XRF and NAA using obsidian artifacts collected in the central Mexico region. Linear regression models show the comparison between XRF and NAA for the trace elements of rubidium (Rb), strontium (Sr) and zirconium (Zr) with a 95% confidence level (Figures 26-28). Table 1 shows that the results for the strontium (Sr) element could not be determined below a value of 10 ppm when
sampled using NAA. When the same samples were tested with the XRF spectrometer, values as low as 1 ppm were recorded suggesting a slightly higher precision in sampling this trace element compared to neutron activation.

This comparative study provides support in regards to the accuracy and precision capabilities of XRF spectrometers, though it does not address the homogeneity of sampling. Geologically speaking, obsidian samples are generally homogeneous. Ceramics, with natural or intentional inclusions such as sediments or temper, are typically not as homogeneous and sampling specific areas of ceramic artifacts could produce inaccurate results. Therefore certain methods are taken to reduce these inconsistencies. To avoid the destructive process of grinding a portion of the artifact by mortar and pestle while still ensuring homogeneity of the sample, an alternative method

![Linear Regression Model for Rubidium (Rb)](image)

**Figure 26**: Rb linear regression model based on values collected on obsidian artifacts in central Mexico (adapted from Glascock 2011)
Figure 27: Sr linear regression model based on values collected on obsidian artifacts in central Mexico (adapted from Glascock 2011)

Figure 28: Zr linear regression model based on values collected on obsidian artifacts in central Mexico (adapted from Glascock 2011)
of analyzing multiple points on the artifact and averaging the calculated values together can be used. A minimum of two samples from a ceramic artifact, one from the inside and one from the outside, is needed to simulate a homogeneous sample, however if a cross section of the artifact is visible, additional samples should be taken from these edges.

The performance of a pXRF in analyzing non-homogeneous ceramic materials may be a little more difficult than studying homogeneous obsidian samples. A similar study using a pXRF and NAA was conducted in 2011 to compare the results of Mimbres and Jornada pottery sherds.
from the American Southwest containing varying amounts of temper (Speakman et al. 2011). Although the sherds could have been homogenized into ceramic powdered samples, the study also wanted to test the non-intrusive capabilities of the pXRF. The pXRF sampling was conducted once per sherd on flat, clean surfaces void of any slips, paints or glaze. The NAA sampling was prepared that same way with the exception of the samples being ground into a fine homogenized powder (Speakman et al. 2011:3490). The multivariate datasets for elements common to the NAA and pXRF showed no significant differences, though the pXRF dataset was not as precise as the NAA (Speakman et al. 2011:3494). While the XRF was able to distinguish between major compositional groups, NAA has the capability to analyze trace and rare earth elements needed to discriminate all compositional groups (Speakman et al. 2011:3495).

Another recent study was conducted at the Archaeological Sciences Laboratory at the University of South Florida by Hasan Ashkanani comparing trace element results taken from samples of Middle Eastern Bronze Age ceramics (Ashkanani 2014). Data from a pXRF spectrometer using multi-point sampling and crushed powder sampling was compared to crushed powder results analyzed with an inductively coupled plasma mass spectrometer (ICP-MS). Bivariate plots of the data showed similar group discrimination within each method, indicating that a pXRF spectrometer using a multi-point sampling method is a viable non-destructive solution in identifying the chemical composition of ancient ceramic artifacts (Ashkanani 2014:132-139).

It has been determined that using XRF with a non-destructive multi-sample approach on heterogeneous ceramic pottery can provide comparable results to the destructive methods used in ICP-MS and NAA (Ashkanani 2014:132-139; Bonizzoni et al. 2010:352). All three of these methods can be used to provide a reliable working dataset that will denote variability of the chemical composition between each object, but this raises questions as to how the variability
should be interpreted and if it is plausible to associate the variability of trace elements in ceramics to determine different sources as it is used to identify different obsidian sources (Tykot 2002).

A forensic investigation was conducted recently to determine if the chemical composition of brick building materials can be traced back to specific manufacturers (Schied et al. 2009). A total of eleven bricks were sampled from various producers and production batches and compared to two other bricks found at crime scenes. The elemental data was collected using NAA, ICP-MS and XRF and was statistically analyzed using principal component analysis. This analysis further supports comparable results between the three scientific methods applied to identify the chemical composition of the brick samples. Based on the variability of the chemical composition of the brick samples, the test was able to identify the brick producers associated with the bricks that were discovered at the crime scenes (Schied et al. 2009:2131-32). Though the purpose of this study was to help with present criminal investigations, the research question and the methods that were applied are the same methods used by archaeologists in identifying local and regional clay sources of past cultures. It is therefore reasonable to associate the distance of variability with the probability of different clay source types. When there is a high variability between ceramic samples, there will be a high probability that the samples were produced using different sources of clay. It is then feasible to associate a low variability between samples with similar or identical clay sources.

A pXRF has several advantages that appeal to archaeologists, like a minimal cost per sample, portability and the ability to analyze samples without damaging or destroying the artifact. However, it should not be used as a substitute for other methods such as NAA, ICP-MS and petrography when sourcing ceramics (Speakman et al. 2011). The pXRF is a viable tool that can supply supplemental data to corroborate other geochemical methods. However, there are
conditions in which only a pXRF can be used to report the chemical composition of an artifact. These situations often occur when analyzing museum or private collections where permission to destroy or transport the artifact offsite is not permitted, in which case every precaution should be taken to minimize the risk of errors. My thesis falls under such conditions where the artifacts could not leave the facilities nor could objects be destructively sampled. Fortunately, there has been some previous research conducted using NAA and petrographic analysis on ceramic artifacts at La Piana and Cetamura as discussed later in this chapter, which can be compared to the pXRF results collected during my research to provide a more accurate analysis for the interpretation of the results.

**XRF in Archaeology**

Archaeologists are increasingly turning to XRF for their elemental analyses of sourcing lithics, obsidian, glasses, and ceramics (Johnson 2014:563; Speakman et al. 2011:3483). XRF analysis is being utilized to understand pottery and trade distribution in areas around the world such as Cyprus, Egypt, Kuwait and Southeastern United States (Frankel and Webb 2012; Morgenstein and Redmount 2005; Stremtan et al. 2014; Tykot et al. 2013).

In Cyprus, pXRF analysis was conducted on over 400 Cypriot pottery objects from the Early and Middle Bronze Age in an attempt to identify local and non-local products (Frankel and Webb 2012:1380). The pottery was categorized as Red Polished ware, Drab Polished ware and Devices. The first category consisted of highly polished red pottery most commonly known during the Early and Middle Cypriot periods (2200-1800 B.C.). Drab Polished ware is similar to the Red Polished ware except the surface is orange-brown in color. Devices pertain to any type of ceramic
that may have been used locally such as mudbricks, coarse ware basins, spindle whorls and hobs (Frankel and Webb 2012:1380-1381).

The samples originated from four archaeological sites around the island (Ambelikou-Aletri, Marki-Alonia, Bellapais-Vounous and Psematismenos-Trelloukkas) and were analyzed using a portable Thermo Scientific Niton XL3t Geometrically Optimised Large Area Drift Detector EDXRF spectrometer (Frankel and Webb 2012:1381-1382). The ED-XRF recorded 36 elemental values (Sn, Cd, Pd, Mo, Ag, Nb, Zr, Sr, Rb, Bi, As, Se, W, Pb, Sb, Rb, Re, Ta, Hf, Zn, Cu, Ni, Co, Fe, Mn, Cr, V, Ti, Ca, Cl, K, S, P, Si, Al and Mg) which were calibrated into ppm. The results were able to distinguish separate chemical compositions between the Red Polished wares and the Drab Polished wares. The results also indicate that Bellapais-Vounous was the main source of Drab Polished wares and that most of the Red Polished wares were crafted locally at each site (Frankel and Webb 2012:1383-1386).

Maury Morgenstein and Carol Redmount (2005) used a pXRF to try to identify locally produced ceramics from the Nile Valley in Egypt, specifically from the El Hibeh archaeological site. The samples used in this study (47 total) were from a collection of surface surveys near mortuary deposits. The pXRF used was a Niton XLt-793W spectrometer and the samples were taken and analyzed in the field (Morgenstein and Redmount 2005:1614). There were 11 chemical values (Sb, Sn, Ag, Sr, Rb, Pb, Zn, Cu, Co, Fe, and Mn) recorded for each sample for a duration of 240 seconds and then calibrated into ppm (Morgenstein and Redmount 2005:1617). The results successfully identified locally produced ceramic objects from nonlocal ceramics. Additionally, they were able to determine that Sr, Rb, and Fe were the main components in distinguishing specific geochemical groupings, including imported ceramics from the Aegean and Oases regions (Morgenstein and Redmount 2005:1622).
In 2012, a study was carried out analyzing the chemical composition of Dilmun and Barbar Bronze Age ceramics and raw materials from the ancient port of al-Khidr on the Failaka Island in Kuwait (Stremtan et al. 2012). The purpose of this study was to collect elemental data of the samples using a pXRF non-destructive multi-point method, X-ray diffraction (XRD), ICP-MS and petrographic analysis to identify mineral and chemical compositions and textural features in order to recreate ancient trade and exchange networks (Stremtan et al. 2012:274-278). A Bruker Tracer III-SD pXRF was used to analyze six trace elements (Ba, Rb, Y, Sr, Zr, Nb). The results indicate a clear distinction of two groups consisting of local and non-local ceramics with one outlier. The pXRF analysis was supported by a similar dataset produced by the ICP-MS showing two distinct groups with one outlier. The petrographic analysis of the outlier revealed a unique matrix when compared with the other groups of samples (Stremtan et al. 2012:278).

Another provenance study of ceramic artifacts was conducted in 2013. Chemical composition data of 500 ceramic samples were taken from eight Native American archaeological sites and private collections in northwest Florida using the non-destructive multi-point method with a Bruker Tracer III-V pXRF spectrometer (Tykot et al. 2013). Quantitative analysis of trace elements (Rb, Sr, Y, Zr, Nb) showed measurable differences between the sites, suggesting that the majority of the ceramic artifacts were locally produced. One of the samples, a clay ball, revealed a close match to clay ball artifacts found at the Poverty Point site in Louisiana (Tykot et al. 2013:241). The surface analysis conducted on heterogeneous ceramic samples in this study was successful mainly due to the type of ceramics being sampled. None of the artifacts tested contained surface paints, slips or glazes which would have affected the compositional results (Tykot et al. 2013:242-243). Additional sample preparation such as creating a homogeneous powder or abrasively removing surface decorations would be needed to recreate similar results.
These case studies are only a few illustrations of the many applications XRF has in providing valuable information pertaining to archaeological questions about ceramic provenance. Since this study is specific to provenance of Etruscan ceramics pertaining to exchange patterns and production concentrations, an examination of previous Etruscan pottery research to include, but not limited to, XRF elemental analysis is essential.

Etruscan Ceramic Studies

Over the last few decades, many types of research have been conducted in the study of Etruscan pottery. Analyses using petrography, XRD, XRF, Fourier transform infrared (FT-IR) and Mössbauer spectroscopy have produced an abundant amount of data pertaining to the geochemical composition, firing techniques, clay sources, temper, and stylistic patterns for Etruscan ceramics over multiple settlements (Gliozzo and Memmi Turbanti 2004; Maritan et al. 2005; Nodari et al. 2004; Weaver et al. 2013). Though interest in the technology of Etruscan ceramic production has increased over the years, it has diverged into two correlated methodologies. One of the methodological paths focuses on the manufacturing and firing processes by analyzing the ceramic kilns and its byproducts while the other applies archaeometric techniques to study the chemical composition of the ceramic products (Vander Poppen 2013:165-167). XRF is one of several techniques used in the latter methodology to help identify trade patterns. Though the majority of the data collected is proprietary to the individual sites, the information can collectively provide valuable insight into the production and manufacturing practices of Etruscan pottery. Currently there are no standards in place for sampling data and the data that is gathered is dependent on a specific research question such as identifying the clay sources used in the manufacturing process.
Researchers who want to determine which ceramic artifacts were produced locally at an individual site would most likely analyze the elemental composition of the ceramic to match it to local clay sources. Problems arise when trying to determine which elements should be analyzed to provide the most accurate information.

A recent provenance study of ceramic materials at Poggio Colla and Podere Funghi analyzed 14 trace elements (Ce, Cr, Cu, Ga, La, Ni, Pb, Rb, Sc, Sr, Th, V, Y, and Zn) using a Panalytical 2404 XRF spectrometer to determine geochemistry, petrography and X-ray diffraction to identify mineral content, and thermogravimetric analysis for understanding firing techniques (Weaver et al. 2013). Podere Funghi lies in a field below Poggio Colla approximately 500 meters to the east. At least four teardrop shaped kilns surrounded by residential living quarters have been located at Podere Funghi, identifying this site as a major ceramic producer during the Hellenistic Period (Warden and Thomas 2002:103-105; Weaver et al. 2013:32). The teardrop shape suggests that these were updraft kilns capable of sustaining firing temperatures up to 1000 ºC (Rice 2005:159-160). Weaver et al. (2013:32) used fine ware sherds collected from a midden at Podere Funghi as a control source for locally produced ceramics. The fine ware sherds were intermixed with kiln wasters suggesting these ceramics were produced onsite using raw clay sources local to the area. The results from the trace element analysis of the Podere Funghi fine ware and samples of coarse ware, bucchero and roof tiles collected from Poggio Colla indicate a strong relationship in the chemical composition between all of the samples. Since many types of ceramic wares are fired at different temperatures, between 500-900 ºC for the samples collected, thermogravimetric analysis was conducted to identify any impact on the trace element composition. They concluded that the firing temperatures did not affect the chemical composition of the trace elements and that
the ceramic samples from Poggio Colla were made using the same local clay source as the fine ware sherds from Podere Funghi (Weaver et al. 2013:37-40).

Another study analyzed 29 trace elements and compounds (SiO$_2$, TiO$_2$, Al2O$_3$, Fe$_2$O$_3$, MnO, MgO, CaO, Na$_2$O, K$_2$O, Sc, V, Cr, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Nd, Pb, Th, and U) using a Philips PW 2400 XRF spectrometer to collect geochemical data on 27 samples of Etruscan grey pottery or cinerognola from two archaeological sites (Este and Padova) in northeastern Italy (Maritan et al. 2005). Their study attempts to provenance the grey pottery to determine if the ceramics were created locally or were being imported. Though no evidence of ceramic production has been discovered at any of the three sites, the abundance of grey sherds suggests that the grey pottery may be crafted with local clay sources (Maritan et al. 2005:32-33).

The trace element analysis of the samples indicate that the samples from Este are chemically distinct from the samples taken from Padova. Petrographic and mineralogical tests support the dual sources of clay and that most likely the clay used in the Este sample originated near the southern region of the Veneto plain (Maritan et al. 2005:39-42).

Though the methods used at each of these sites provides data that evaluate which ceramic artifacts were locally produced, they are proprietary to the site and would be difficult to compare to data collected at other sites unless the exact same equipment and methods were used. Ideally testing a multitude of sites using the same method and equipment could provide a greater dataset to provenance studies and trade practices, though standardization of equipment and methods is not a realistic solution. Even though the raw data collected and methods used to collect the data are different and in most cases unique to an individual site or specific researcher, the end results and conclusion drawn can benefit future research and testing. Since my research was limited to
conducting non-destructive chemical analysis onsite, I compare my results to previous ceramic studies from both La Piana and Cetamura to support my findings and formulate conclusions.

There are various methods to identify ceramics besides analyzing trace elements. Macro- and microscopic analysis can provide a visual representation of the elemental structures contained within the ceramics. This can be useful for identifying inclusions contained in the clay and firing techniques that may help with provenancing ceramics. Theodore Peña at the University of California, Berkeley is currently in the process of compiling a database of elemental compositions in local clays throughout mainland Etruria. As part of his research, he analyzed red gloss ceramic wares from the Cetamura site using macroscopic examination, low-power microscopic examination, refiring, and petrographic analysis (Peña 1990:650). The sample size tested consisted of 41 ceramic sherds excavated during the 1987 and 1988 field seasons. The results of his observations identified three separate ceramic fabric classes containing distinct mineralogical bodies (Peña 1990:650). All but five pieces examined were categorized in the first fabric class, placing provenance somewhere in the northern inland area of Etruria. The second and third fabric classes contain volcanic particulates commonly found in the southern regions of Italy near Naples and Campania respectively (Peña 1990:651-657). Though these methods of provenancing are different than the methods used in my research, the data, analysis and interpretation of the results should coincide with my results.

In the early 1990s, collaborative research between the Archaeology and Nuclear Science and Engineering departments at Cornell University was established to conduct NAA testing on ceramic artifacts from various archaeological sites. One of the sites in their research was La Piana, where chemical analysis using NAA was conducted to compare painted and unpainted ceramic objects (Whitehead et al. 1995). The process analyzed 29 elements from 89 ceramic samples.
excavated from the 1992 and 1993 field seasons. Each sample was prepared into 200 mg powdered samples and irradiated using the Cornell 500 kW TRIGA research reactor (Whitehead et al. 1995:238-239). The data produced were analyzed through principal component analysis (PCA), cluster analysis and discriminate function analysis and Mahalanobis distances. The results showed all of the statistical analyses confirmed that the unpainted and painted ceramic objects in the samples taken from La Piana were from two distinctly separate clay sources (Whitehead et al. 1995:239-242). Though it is uncertain if either of these ceramic types were produced using local clay sources, these ceramic wares bear resemblance to ceramic ware types from the Volterra area (Whitehead et al. 1995:244).

**Methods Used for this Study**

In attempting to produce analytical results specific to the research questions, a minimum sample size of 10 ceramic objects were selected from La Piana and 30 ceramic objects from Cetemura for each category (construction, coarse ware, fine ware, bucchero and impasto). The larger sample size from Cetemura was due to availability. Simple random sampling with replacement was used on stratified samples based on ceramic types. The ceramic objects from La Piana were randomly selected from storage containers specific to each category. The Cetamura samples were chosen randomly for each category from a subset of ceramics specific to the Hellenistic Period. Each artifact was assigned a numerical number and the Microsoft Excel formula “RANDBETWEEN(1,N)” was used where N equaled the total number of artifacts in each batch. This process was repeated until enough unique numbers were selected to match the sample sizes at each site.
Typical categorization of Etruscan ceramics are based on the type of ceramic fabric (e.g. CF1, CF2, CF3 and CF4) (de Grummond 2001:22). My research is focused on anthropological questions of exchange and production methods and would have overlapped certain categories if these were used. For example, thick coarse ware cooking vessels are categorized as CF1 and storage containers are categorized as CF3 along with fine table ware while other table ware such as cups are classified as CF4. To avoid confusion, the following definitions specific to the purpose of the ceramic objects were created for this research. Construction materials include bricks, roof tiles, and loom weights. Fine ware consist of plates, bowls, vases, pitchers and cups and will be categorized into sub-groups based on the type of finish that includes red gloss, black gloss and plain. Coarse ware types include storage containers, such as jars and amphorae and cooking vessels. Impasto and bucchero samples normally would be categorized as fine ware, but are being placed in separate individual categories based on manufacturing processes.

The research conducted for this study was analysis of six trace elements (Th, Sr, Y, Rb, Zr, and Nb) using a Bruker Tracer III-SD pXRF spectrometer. The X-ray analysis was performed on-site in both the laboratory at Badia a Coltibuono and the storage facility at Spannocchia. Badia a Coltibuono is the laboratory where the artifacts for Cetamura are stored. The Spannocchia Foundation, formed in February 2002 with the intent of supporting conservation, research, and education at the Tenuta di Spannocchia, is an 1100-acre organic agricultural estate in central Tuscany that has been securely storing the ceramics excavated from La Piana for the past 10 years. A multi-point sampling method was used on areas void of external coatings such as paint, slips or surface contamination for each artifact using XRF emitting X-rays to a maximum of 40 keV and a 0.006” Cu, .001” Ti, and .012” Al filter with no vacuum for 120 second durations per sample. The Bruker S1PXRF software was used to record the counts of each element for every sample.
Measurements for the samples were calibrated into ppm using the “Berkeley SD obsid calibration Comp 19.5 to 22” spreadsheet. Calibrated data for each sample were compared for integrity and then averaged together for use in statistical analysis. Principal component analysis was performed using IBM® SPSS® Statistics versions 21 and 22.
CHAPTER FOUR
ANALYSIS OF ETRUSCAN CERAMICS

All of the ceramics sampled using principal component analysis (PCA) had over 70% of their variance explained. A compilation of the data for construction, coarse ware, plain fine ware, red gloss, black gloss, and bucchero and impasto ceramic artifacts indicates two different production processes between the La Piana and Cetamura sites. Figure 29 illustrates the PCA results from all of the ceramic artifact types sampled at La Piana and Cetamura.

Results analyzed in this study are separated into seven sections, representing the categories of ceramic types (construction materials, coarse ware, plain fine ware, black gloss, red gloss and bucchero and impasto) and the final overall analysis. The first section discusses the analysis of construction materials to show that provenance is possible and how it will be used as a control source for remaining categories. Each subsequent section analyzes the different ceramic types in comparison to the construction materials from both sites. These sections provide the cumulative variance percentage explained on components that have an eigenvalue of 1 or greater. Correlation coefficients based on Pearson’s $r$ are provided for each trace element within the specific ceramic types. These sections also provide a scatter plot similar to Figure 29 displaying the placement of the ceramics sampled in relation to the construction materials. The final section ties the previous sections together providing an overall analysis and interpretation of the data and is presented in two scatter plots. The first plot groups the ceramic artifacts by type and the other groups the artifacts by clay source.
Figure 29: Scatter chart showing the principal component analysis of all the ceramic materials sampled at each archaeological site.
**Construction Materials**

A total of 27 out of 30 ceramic construction materials were used in the final analysis, 7 samples from La Piana and 20 from Cetamura. There were three artifacts omitted due to contamination or low battery levels on the Bruker pXRF spectrometer. The principal component analysis with Varimax rotation and Kaiser Normalization revealed two main components explaining 72.5% of the total variance (Table 2). There is a strong differential between the first component consisting of five of the six trace elements (thorium, rubidium, yttrium, zirconium, and niobium) and the second component containing strontium (Table 3). The ratio of strontium in the trace elements contained in the construction materials (P97-SF3-2, P97-SF3-4, P98-SE3-11 and P98-SI4-15) from La Piana (53.7%) is significantly higher than the ratio of strontium in the trace elements found in the construction materials at Cetemura (21.6%). The equation used for calculating the average ratio is:

\[ R = \frac{\sum e_i / e_t}{n} \]

where \( R \) is the average ratio of strontium at a given site, \( e_i \) is the value of strontium for an individual sample, \( e_t \) is the total value of all six trace elements for an individual sample and \( n \) is the total number of artifacts sampled. The trace element values for each sample can be found in Appendix A.

Based on a similarity matrix of the six trace elements, multi-dimensional scaling of two dimensions with a stress level of .139 confirms two distinct groups of construction material (Table 4 and Figure 30). Interestingly, three of the roof tiles sampled from La Piana (P97-SF3-1, P97-SF4-3 and P98-SE-9) appear to have been produced using clay sources from Cetamura (Figure 30 and Figure 31).
Table 2: Explained variance of the trace elements contained within the construction materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared</th>
<th>Rotation Sums of Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>3.47</td>
<td>57.91</td>
<td>57.91</td>
</tr>
<tr>
<td>2</td>
<td>0.88</td>
<td>14.63</td>
<td>72.54</td>
</tr>
<tr>
<td>3</td>
<td>0.78</td>
<td>12.99</td>
<td>85.53</td>
</tr>
<tr>
<td>4</td>
<td>0.44</td>
<td>7.42</td>
<td>92.94</td>
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<tr>
<td>5</td>
<td>0.29</td>
<td>4.92</td>
<td>97.86</td>
</tr>
<tr>
<td>6</td>
<td>0.13</td>
<td>2.14</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

Table 3: Component score coefficient matrix for construction materials

| Component Matrix |
|------------------|------------------|
| Component        | 1                | 2                |
| Nb               | .867             | -.034            |
| Th               | .820             | .154             |
| Rb               | .815             | -.069            |
| Zr               | .790             | -.358            |
| Y                | .718             | .358             |
| Sr               | -.015            | .941             |

Two components extracted
|   | 1  | 2  | 3   | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|----|----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1 | 1.000 | -  | -   | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 2 | -   | 1.000 | -   | -   | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 3 | -   | -   | 1.000 | -   | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 4 | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 5 | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 6 | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 7 | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 8 | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 9 | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 10| -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 11| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 12| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 13| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 14| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 15| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 16| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 17| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  | -  |
| 18| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  | -  |
| 19| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  | -  |
| 20| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  | -  |
| 21| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  | -  |
| 22| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  | -  |
| 23| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  | -  |
| 24| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  | -  |
| 25| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 | -  |
| 26| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 |
| 27| -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   | 1.000 |

Table 4: Similarity matrix containing the 27 samples of construction materials
Figure 30: Scatter chart showing the multidimensional scaling of the construction materials
Figure 31: Scatter chart showing the principal component analysis of the construction materials
Judging by the data analyzed for construction materials, two distinct clay source groups can be distinguished. Though only 4 of the 7 La Piana samples appear in the separate group, the results of the coarse ware ceramic samples will support that this clay source is local to La Piana. Since ancient potters generally travelled 1-3 km for raw clay and temper, a conclusion can be made that the three La Piana roof tiles (P97-SF3-1, P97-SF4-3 and P98-SE-9) were most likely created at Cetamura and entered the La Piana site as finished products (Nijboer 1998:108-135).

Coarse Ware Materials

The ceramic coarse ware materials that were sampled (8 from La Piana and 19 from Cetamura) were analyzed and compared to the construction materials. Principal component analysis of the coarse ware artifacts indicates two components allot for 87.9% of the total variance (Table 5). As with the construction materials, one component consists of strontium and the other combines the remaining five trace elements (Table 6). The majority of artifacts align with the construction materials indicating that these objects were created using the same clay sources with a few exceptions. One La Piana artifact (P97-SG3-3) shows trace elements similar to Cetamura clay sources, while two Cetamuran artifacts (C-07-274 and C-2012-214) source from La Piana (Figure 32). There are two obvious outliers from the sampling of coarse ware ceramic objects from Cetamura (C-99-182, C-99-253), which could indicate another possible clay source. Additionally, there are three other coarse ware objects (C-99-225, C-B1017P and C2012-492) that are distant from the main conglomerate of coarse ware samples correlating to the Cetamura construction materials and may belong to another clay source group. Whether these additional
sources indicate other sites in which these objects were exchanged or a different clay sources used in ceramic production at Cetamura is presently unknown.

Table 5: Explained variance of the trace elements contained within the coarse ware materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared</th>
<th>Rotation Sums of Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative</td>
</tr>
<tr>
<td>1</td>
<td>3.88</td>
<td>64.69</td>
<td>64.69</td>
</tr>
<tr>
<td>2</td>
<td>1.39</td>
<td>23.20</td>
<td>87.89</td>
</tr>
<tr>
<td>3</td>
<td>0.30</td>
<td>4.92</td>
<td>92.81</td>
</tr>
<tr>
<td>4</td>
<td>0.18</td>
<td>2.96</td>
<td>95.77</td>
</tr>
<tr>
<td>5</td>
<td>0.16</td>
<td>2.66</td>
<td>98.43</td>
</tr>
<tr>
<td>6</td>
<td>0.09</td>
<td>1.57</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

Table 6: Component score coefficient matrix for coarse ware materials

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb</td>
<td>.950</td>
<td>-.093</td>
</tr>
<tr>
<td>Th</td>
<td>.933</td>
<td>.001</td>
</tr>
<tr>
<td>Rb</td>
<td>.924</td>
<td>-.102</td>
</tr>
<tr>
<td>Zr</td>
<td>.887</td>
<td>-.179</td>
</tr>
<tr>
<td>Y</td>
<td>.676</td>
<td>.656</td>
</tr>
<tr>
<td>Sr</td>
<td>-.108</td>
<td>.954</td>
</tr>
</tbody>
</table>

Two components extracted
Figure 32: Scatter chart showing the principal component analysis of the coarse ware materials
Fine Ware (*Plain*)

There were a total of 5 pieces from La Piana and 14 from Cetamura of fine ware ceramic materials that did not contain paint, gloss, or slips. Principal component analysis of the fine ware artifacts indicates two components allot for 72.6% of the total variance when compared directly against the construction materials (*Table 7*). As with the construction materials and the coarse ware, one component consists of strontium and the other combines the remaining five trace elements (*Table 8*). Out of the five La Piana fine wares, one artifact (P96-NA2-7) may have been crafted locally, another (P96-SA2-4) is grouped with the local Cetamura sources and three do not match either La Piana or Cetamura clay sources. P96-SA2-3 and P96-SA3-7 seem to align with C-

---

**Table 7: Explained variance of the trace elements contained within the fine ware (*plain*) materials**

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared</th>
<th>Rotation Sums of Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Variance (%)</td>
<td>Cumulative %</td>
<td>Total Variance (%)</td>
</tr>
<tr>
<td>1</td>
<td>3.38</td>
<td>56.30</td>
<td>3.38</td>
</tr>
<tr>
<td>2</td>
<td>0.98</td>
<td>16.25</td>
<td>0.98</td>
</tr>
<tr>
<td>3</td>
<td>0.64</td>
<td>10.69</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.44</td>
<td>7.36</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.33</td>
<td>5.57</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.23</td>
<td>3.83</td>
<td></td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

**Table 8: Component score coefficient matrix**

*for fine ware (*plain*) materials*

<table>
<thead>
<tr>
<th>Component Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Th</td>
</tr>
<tr>
<td>Zr</td>
</tr>
<tr>
<td>Nb</td>
</tr>
<tr>
<td>Rb</td>
</tr>
<tr>
<td>Y</td>
</tr>
<tr>
<td>Sr</td>
</tr>
</tbody>
</table>

Two components extracted
99-253 and C-99-182 identified from the coarse ware samples. The remaining outlier from La Piana (P96-SA3-10) does not match any identified local clay sources. Out of the 14 ceramic pieces sampled from Cetamura, 13 appear to be locally crafted with one outlier. Though this one outlier from Cetamura (C-76-147) does not correlate with local clay sources from either site, it shows a strong association to another piece of ceramic coarse ware (C-2012-492) found at Cetamura (Figure 33).

![Figure 33: Scatter chart showing the principal component analysis of the fine ware (plain) materials](image-url)
Fine Ware (*Black Gloss*)

Out of the 14 fine ware samples containing a black gloss finish, 2 were sampled from La Piana. The principal component analysis indicated more variation than the other fine and coarse wares. The PCA was run comparing the black gloss fine ware to the construction materials, of which 71% of the total variance is explained within the first two components (Tables 9 and 10). The results of these values were charted on a scatter plot (Figure 34). There is no evidence that the elemental make-up in the black gloss wares match either Cetamura or La Piana. However, the majority of the black gloss samples produced comparable values to the three coarse ware samples (C-99-225, C-B1017P and C-2012-492) (Figure 31). There are two outliers, one (C-94-119) does

<table>
<thead>
<tr>
<th>Total Variance Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

Table 9: Explained variance of the trace elements contained within the fine ware (*black gloss*)

**Component Matrix**

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>.814</td>
<td>.400</td>
</tr>
<tr>
<td>Nb</td>
<td>.798</td>
<td>.079</td>
</tr>
<tr>
<td>Th</td>
<td>.734</td>
<td>.394</td>
</tr>
<tr>
<td>Rb</td>
<td>.716</td>
<td>-.163</td>
</tr>
<tr>
<td>Zr</td>
<td>.698</td>
<td>-.477</td>
</tr>
<tr>
<td>Sr</td>
<td>-.259</td>
<td>.882</td>
</tr>
</tbody>
</table>

Two components extracted
not match any of the materials sampled and may be from a completely different clay source and another (C-88-63) closely matches the variability of two coarse ware samples from Cetamura (C-99-253 and C-99-182) and two plain fine ware samples from La Piana (P96-SA3-7 and P96-SA2-3).

Figure 34: Scatter chart showing the principal component analysis of the fine ware (black gloss) materials
Fine Ware (*Red Gloss*)

A total of 76.3% of the variance is explained when comparing the red gloss fine ware to the construction materials (Tables 11 and 12). Like the black gloss fine ware, the red gloss does show remarkably similar patterns, including one outlier (C-2013-45). C-2013-45 and C-94-119 may have been produced using the same clay source. Interestingly, one red gloss artifact sampled

Table 11: Explained variance of the trace elements contained within the fine ware (*red gloss*)

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared</th>
<th>Rotation Sums of Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>3.23</td>
<td>53.89</td>
<td>53.89</td>
</tr>
<tr>
<td>2</td>
<td>1.34</td>
<td>22.38</td>
<td>76.27</td>
</tr>
<tr>
<td>3</td>
<td>0.61</td>
<td>10.18</td>
<td>86.45</td>
</tr>
<tr>
<td>4</td>
<td>0.37</td>
<td>6.10</td>
<td>92.54</td>
</tr>
<tr>
<td>5</td>
<td>0.26</td>
<td>4.39</td>
<td>96.94</td>
</tr>
<tr>
<td>6</td>
<td>0.18</td>
<td>3.06</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

Table 12: Component score coefficient matrix for fine ware (*red gloss*) materials

<table>
<thead>
<tr>
<th>Component</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb</td>
<td>.874</td>
<td>.186</td>
</tr>
<tr>
<td>Th</td>
<td>.824</td>
<td>.363</td>
</tr>
<tr>
<td>Y</td>
<td>.819</td>
<td>.245</td>
</tr>
<tr>
<td>Rb</td>
<td>.807</td>
<td>-.221</td>
</tr>
<tr>
<td>Zr</td>
<td>.656</td>
<td>-.458</td>
</tr>
<tr>
<td>Sr</td>
<td>-.197</td>
<td>.926</td>
</tr>
</tbody>
</table>

Two components extracted
(C-78-1582) showed values comparable to the Cetamura clay source. There is a strong correlation between the red gloss artifacts sampled and the majority of the black gloss. These samples may have been produced using the same clay source as the black gloss wares (Figure 35).

**Figure 35:** Scatter chart showing the principal component analysis of the fine ware (red gloss) materials
Fine Ware (*Bucchero and Impasto*)

There were 20 samples of bucchero and impasto taken from the Cetamura site, and none from La Piana. The principal component analysis shows two components, with Nb, Th, Rb, Y, and Zr as component 1, and Sr as component 2, comprising of 73.6% of the total variance explained (Tables 13 and 14). Charting the values in comparison to the construction materials places five bucchero (C-90-74, C-01-362a, C-01-363, C-01-478c and C-2010-699) and two impasto samples (C-95-171 and C-05-147) in the clay source group used in producing Cetamura ceramics. In fact,

**Table 13: Explained variance of the trace elements contained within the fine ware (*bucchero and impasto*) materials**

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared</th>
<th>Rotation Sums of Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
<td>Total</td>
</tr>
<tr>
<td>1</td>
<td>3.26</td>
<td>54.38</td>
<td>54.38</td>
</tr>
<tr>
<td>2</td>
<td>1.15</td>
<td>19.18</td>
<td>73.56</td>
</tr>
<tr>
<td>3</td>
<td>0.60</td>
<td>10.06</td>
<td>83.63</td>
</tr>
<tr>
<td>4</td>
<td>0.41</td>
<td>6.85</td>
<td>90.48</td>
</tr>
<tr>
<td>5</td>
<td>0.35</td>
<td>5.76</td>
<td>96.24</td>
</tr>
<tr>
<td>6</td>
<td>0.23</td>
<td>3.76</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis

**Table 14: Component score coefficient matrix for fine ware (*bucchero and impasto*) materials**

<table>
<thead>
<tr>
<th>Component Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Nb</td>
</tr>
<tr>
<td>Th</td>
</tr>
<tr>
<td>Rb</td>
</tr>
<tr>
<td>Y</td>
</tr>
<tr>
<td>Zr</td>
</tr>
<tr>
<td>Sr</td>
</tr>
</tbody>
</table>

Two components extracted
the majority of the bucchero and impasto show values similar to clay sources from Cetamura, but there is too much variability to conclusively provenance these materials to Cetamura (Figure 36). Two outliers of bucchero and impasto (C-2011-95 and C-88-102) are distant from both Cetamura and La Piana source groups which could suggest these objects were crafted elsewhere. Another

Figure 36: Scatter chart showing the principal component analysis of the fine ware (bucchero and impasto) materials
piece of bucchero showed similar variation to the construction materials sourced from La Piana, though it is difficult to conclude with any certainty that this object was produced at La Piana using local clay sources.

**Final Analysis**

Using construction materials as a control source does provide reliable data and can be used to draw interpretive conclusions. Such interpretations conclude that mercantile exchange was active within these remote settlements, both between settlements and with major city-centers. The evidence of the Cetamura produced roof tiles sampled from La Piana and the coarse ware crafted at La Piana discovered at Cetamura supports that direct exchanges were taking place within these communities.

Various forms of plain fine ware, red gloss, black gloss and bucchero and impasto were present at both archaeological sites (Figure 37). We also know that during this time Volterran red gloss ware was apparent at both La Piana and Cetamura and that other pieces of fine ware were collected from multiple unknown sources, with the exception of C-78-1582, which appears to be crafted with clay associated with local sources around Cetamura. Several artifacts such as C-84-212 and C-91-330 have previously been identified as Volterran red gloss (Cristofani and Cristofani 1972:499-514; de Grummond et al. 1994:105-107). The red gloss ware examined from the La Piana site also showed a close relationship to the Pleistocene types of marine clay surrounding the area of Volterra (Whitehead et al. 1995:224). The marine Pleistocene clays, as with the marine calcareous clays used at La Piana, also have a slightly higher strontium content. The strontium values contained within the red gloss ceramic wares ranged from 300-400 ppm, whereas the values contained in the La Piana samples ranged from 100-250 ppm. The Cetamura samples rarely contained more than 100 ppm.
The smaller variations of the remaining five trace elements could explain the differences in the group of ceramic artifacts not sourced from either Cetamura or La Piana. Volterra lies approximately 20 km west-northwest of Siena and is surrounded by a marine Pliocene clays and
alluvial plains. The Etruscan city of Arezzo, 30 km northeast of Siena, is located near the continental quaternary and alluvial plains. Chiusi to the southeast is positioned near marine Pliocene and sandstone deposits while Populonia on the west coast is on the alluvial plains near sandstone and Mesozoic calcareous rock outcroppings.

Though the La Piana archaeological site contains a large collection of fine ware, red gloss, and black gloss ceramic artifacts, none of these artifacts were crafted using local clay sources. A piece of plain fine ware that was sampled may be an exception. P96-NA2-7 showed similar results to locally crafted ceramics, though the artifact fell outside the group of locally sourced construction artifacts it does show a closer variance to the local ceramic coarse wares. The overall ceramic production at La Piana was focused mainly on construction materials (e.g. bricks and roof tiles) and coarse ware, specifically storage containers and jars which would suggest that ceramic production was used in a support role for the local agricultural production and not as a way to create a surplus for exchange purposes. Other evidence discovered at La Piana, such as the 27 meter rectangular feature in the northeastern part of the complex may provide additional clues in supporting the site’s main source of production.

The Cetamura site shows evidence of a specialized production center where a large portion (50 total) of the ceramics sampled were produced locally. La Piana, on the other hand, had very few in comparison, 10 objects from La Piana and 2 from Cetamura that consisted of construction materials and coarse ware. The lack of locally crafted ceramic materials would indicate a different focus on production such as agriculture, in which they relied heavily on imported ceramic goods.

Though this research can only positively identify clay sources from the sites researched with any certainty, the previous scatter plots indicate multiple other potential clay sources. Archaeological evidence of Etruscan black gloss production has been discovered at sites near
Volterra, Populonia, Arezzo, and Chiusi-Marcianella (Gliozzo et al. 2004). Both Volterra and Arezzo are in closer proximity to La Piana and Cetamura than Populonia and Chiusi-Marcianella, and Volterra is well known for its red gloss pottery production (de Grummond 2000). This gives a high probability that the majority of red gloss ceramics were produced with clays originating near Volterra. A final scatter plot of the clay source type locations show the ceramic products crafted locally at both La Piana and Cetamura as well as red gloss ceramics identified as Volterran products (Figure 38). There are many other ceramic wares that overlap some of the known sources, but there is not enough information to definitively classify them as such. Appendix A lists all of the ceramic wares tested with the known clay source locations.
Figure 38: Scatter chart showing the principal component analysis of all the ceramic materials sampled by clay source
CHAPTER FIVE

CONCLUSION

The objective for this project was to determine production methods and exchange practices for the two Etruscan settlements of La Piana and Cetamura. A secondary objective was to determine the plausibility of using ceramic construction materials as a control for identifying localized clay sources.

Analyzing ceramics at both Cetamura and La Piana reveals two distinct priorities in producing ceramic objects, one for surplus and another for use. The chemical composition and stylistic designs also show differences. Andrew Jones (2004) argues that material qualities of artifacts can help interpret social relations, symbolization, and physical interactions within the environment and Schiffer (1988:469) states, “artifacts are the medium through which we come to know (through inference) the cultural past and they also furnish a unique focus for the discipline.” Understanding the artifacts and the chaîne opératoire from provenance of production to the point of discovery will help provide additional interpretation of Etruscan life within La Piana and Cetamura.

It is apparent that labor resources were distributed differently at La Piana and Cetamura with a focus on the best resource that complemented the landscape. Though both of these settlements had the capability to sufficiently sustain their communities, evidence shows that higher priorities were given to certain types of production, agriculture for La Piana and manufacturing for Cetamura. When production priorities shift, deficiencies can occur and must be supplemented
in order to maintain or grow the community. These supplements can only be acquired through the act of exchange. Determining how exchanges were managed can provide further insight on how the Etruscan communities interacted.

There are many theoretical frameworks focused on trade and exchange such as the world-system model, down-the-line distribution and centralized marketplaces (Wallerstein 1974; Shannon 1989; Chase-Dunn and Hall 1997). An issue with focusing on any single framework pertaining to trade is the assumption that all exchanges occur the same way throughout a certain civilization. This is seldom the case when dealing with complex societies. Archaeological evidence and previous research shows that the Etruscans were an extremely complex society and therefore, we should consider the possibility that complex exchange systems may incorporate multiple theoretical frameworks.

Determining the type of exchange practices conducted by the Etruscans is difficult to interpret and practically impossible without knowing all of the variables associated with exchange networks. At best, certain trade practices can be eliminated based on what is known of the Etruscan civilization.

Looking at the ‘world-system’ model we must consider the Etruscan political influence, define a division of labor, and make a distinction between sustenance and luxury exchanges. Wallerstein (1974:390) defines division of labor as “areas that are dependent upon economic exchange with others for the smooth and continuous provisioning of the needs of the area.” Renfrew (1993:7) adds to this by stating a consideration should be made to “whether various regions are so tightly coupled together in their trading networks that their economies can no longer be considered separately, but should rather be considered as a single functioning whole.”
Another option is to look at down-the-line trading. This form of exchange is defined as surplus moving through reciprocal exchange successively from one group to another and continuing until the goods are diminished. Figure 39 depicts an intricate network of major routes surrounding Cetamura and La Piana, connecting the four major city-centers of Populonia, Arezzo, Volterra and Chiusi. These routes combined with the possibility that some trade goods may have been perishable suggests that this form of exchange was not taking place, at least not on a large scale. Besides, as Renfrew (1993:9-11) stated, people like to travel and they do so as a social activity.

The phenomena of social networking is evident based on artifacts from a multitude of archaeological sites around the world, supporting the theory that social interaction and the exchange of material objects were an integral part of past cultures (Wilson 2010). The various ceramic types potentially produced at Cetamura, specifically bucchero, impasto and one piece of

![Figure 39: Major Etruscan routes near La Piana and Cetamura (Whitehead 1994:124)](image)
red gloss, would suggest communication or interaction with potters outside the community that are experienced with intricate techniques required to make these ceramics. This could lead one to argue that an exchange of ideas could be accompanied with the act of trading merchandises. Through the successful use of XRF analysis, there is solid evidence of the distribution of imported ceramic artifacts at both sites based on clay sources identified from Volterra and other unknown source groups. However, it is still unclear as to how the exchange was practiced. The imported ceramics tested at both the La Piana and Cetamura sites show the same variability in clay sources. The red gloss artifacts from both La Piana and Cetamura that came from Volterra and plain fine ware samples from La Piana along with a few coarse ware and black gloss samples from Cetamura that originated from the same unknown source advocates interaction with the same outside sources. It is quite possible that these exchanges were a series of independent, direct interactions with merchants from each of the remote sites where the ceramics were being produced. The location of La Piana to the major trade routes would have required little effort for the transportation of goods to and from the site. Cetamura, on the other hand, is situated on the edge of the Apennines Mountain range 695 m above sea level. The steep undulating and winding roads that led to Cetamura would have made the transportation of goods more difficult.

With several major city-centers within the general vicinity and the majority of smaller settlements encompassing the town of Siena, it could be plausible that a centralized market system was in place and located around Siena. Some of the evidence found by analyzing the ceramic artifacts from both La Piana and Cetamura could support a centralized exchange system. A centralized marketplace would allow merchants from all of the major city-centers and smaller settlements to display and trade their goods as well as exchange ideas and techniques. Having a
common area can also remove distance restrictions allowing for greater availability of goods from various locales.

As discussed in Chapter Two, the Etruscan political structure was not unified. It was loosely governed territorially by major city-centers. Restrictions on trade do not seem to be in place based on the variation of clay sources discovered at each site within this research. It is however difficult to determine what types of exchange were taking place and for what purpose. Only an assumption can be made that the surplus needed to partake in an exchange, whether for luxury or subsistence, was based on each site’s major form of production. Though the ‘world-system’ model may have some merit when observing the Etruscans as a whole for inter-cultural exchanges, it lacks cohesion when studying individual settlements within Etruria.

Using the assumption that the ceramic artifacts used for the purpose of construction originated from local clay sources, a solid foundation can be established for provenancing other ceramic types found at these two sites. Hans Mommsen from the Helmholtz-Institut für Strahlen- und Kernphysik Universität Bonn, Germany had performed a similar study where clay sources were not available in identifying the provenance of Mycenaean ceramic wares. His study worked under the assumptions; that raw clay was not traded, ceramic wares were from homogenized clay but mixing of clays from different sources may occur, and ceramic sherds and wasters found near pottery workshops were produced from local sources (Mommsen 2001). An XRF spectrograph overlay of two roof tiles (Figure 40), one from La Piana (P98-SE3-9) and the other from Cetamura (C-2012-484), confirms that these objects were produced using the same clay source even though the style, color and texture are different. Working with Mommsen’s assumption that raw clay was not traded narrows the interpretation to craft specialization and customization. Though I agree this
interpretation is highly probable and most likely in the case of the Cetamura site, there is still a slight possibility that small amounts of raw clay may have been exchanged between artisans.

Historical literature explains that trade and exchange were vital to the success and growth of the Etruscan culture. The practices within these small settlements seem to confirm the ancient texts and a centralized marketplace where they could exchange goods, trade ideas and socially network with similar communities. This compliments the Etruscan mercantile paradigm. Even after Etruria merged with the Roman Empire, the Romans continued to seek the expertise of the master craftspeople of the Etruscans. Livy recorded that the Etruscans promised to help supply

Figure 40: Spectrograph overlay of a La Piana and Cetamura roof tile
Scipio during the Second Punic War (218-201 B.C.) with Arezzo providing “...a sum total of 5,000 light javelins, long javelins and long spears, with an equal number for each kind---also axes, shovels, sickles, vessels and hand mills, as many as were necessary for forty long ships, and 1,200 measures of wheat…” (Livy 28.45).

These interpretations tend to lead to more questions. One in particular is the difference in longevity of these two settlements. There is still some uncertainty as to why La Piana was abandoned only after a century of occupation when it had direct access to two actively used routes (Volterra-Chiusi and Populonia-Arezzo) connecting major city-centers while Cetamura, which was not on the direct trade routes shows evidence of occupation through the middle 16th century A.D. This could be related to the primary form of production at each site or other factors such as the hypothesized violent invasion of La Piana by the Gauls. The data and analysis presented is sufficient to stimulate discussion pertaining to the daily life of the Etruscan civilization and to help minimize the skepticism of performing clay sourcing analysis using XRF. The first step in doing so is to provide this information to the public.

Over the past year, I have presented my findings at two open conferences. The first presentation, in Chicago at the Archaeological Institute of America conference, focused on identifying trade practices between Etruscan settlements (Woodruff et al. 2014). In Los Angeles at the International Symposium on Archaeometry, hosted by the Getty Museum and the University of California Los Angeles, I presented my findings that support the validity of using XRF for clay sourcing (Woodruff and Tykot 2014). I am also scheduled to speak at another open forum hosted by the Polk County Archaeology Group in December this year. Along with publicly speaking on this subject, I will be providing my data, analysis and results to the Cetamura archaeological site director, Nancy de Grummond from Florida State University; the La Piana archeological site
director, Jane Whitehead from Valdosta State University; and Theodore Peña from the University of California Berkeley who is currently organizing compositional data (both mineralogical and chemical) relating to ceramic clays in Italy. Mapping the clay sources used in pottery production can lay a foundation upon which other questions pertaining to mercantilism, religious, social and political growth, and sustainability can be addressed.

With additional data on this subject, a fuller understanding of the trade practices and production methods performed in remote Etruscan settlements could be achieved. Using the reliable archaeometric methods discussed in this research, future sampling of multiple sites in the area will provide a more detailed map. These findings and interpretations present only a small fragment of what is needed to fully comprehend the inferences of trade and the various scales of production on these remote Etruscan settlements.
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Whitehead, J., T. Z. Hossain, and A. S. Verman

Woodruff, P., R. H. Tykot, N. de Grummond and J. Whitehead

Woodruff, P., and R. H. Tykot
## Appendix A: Compiled Data of Trace Elements (PPM)

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APPENDIX B: IMAGES OF CERAMIC ARTIFACTS ANALYZED

Construction Materials

*Cetamura*

C-WT-1
Coarse Ware Materials

_Cetamura_

C-B1017P
C-2013-21

C-2013-348
Fine Ware Materials (Plain)

*Cetamura*
La Piana

P96-NA2-7

P96-SA2-3

139
Fine Ware Materials (Black Gloss)

*Cetamura*

2.5NWAcropolis
La Piana

P96-SA2-6

P96-SA2-33
Fine Ware Materials (Red Gloss)

_Cetamura_

C-78-1582

C-84-212
La Piana

P96-SE4-1

P96-SE4-2

P96-SE4-7

153
Fine Ware Materials (Bucchero and Impasto)

_Cetamura_

C-90-74
APPENDIX C: PERMISSIONS

Permission for Figures 2, 10, 11, 12, 13, 14, 15, 16, 17 and 39

Patrick Woodruff <pwoodruff@mail.usf.edu>  Mon, Nov 10, 2014 at 10:41 AM
To: Jane Whitehead <jwhitehe@valdosta.edu>

Dr. Whitehead,

I am writing to request permission to use the attached image of yours in my master's thesis.

Thank you,
Patrick Woodruff
MA Student
Anthropology Department
University of South Florida

La Piana.jpg
94K

Jane Whitehead <jwhitehe@valdosta.edu>  Mon, Nov 10, 2014 at 11:02 AM
To: Patrick Woodruff <pwoodruff@mail.usf.edu>

Yes, Patrick, you may use it. I am looking forward to seeing your thesis.

Jane Whitehead

Patrick Woodruff <pwoodruff@mail.usf.edu>  Wed, Nov 19, 2014 at 9:03 AM
To: Jane Whitehead <jwhitehe@valdosta.edu>

Dr. Whitehead,

Would it also be possible to get your permission to use the following images from your articles in the Etruscan Studies journal?

Volume 1 Issue 1

   Figure 1
   Figure 5
   Figure 15
**Volume 3 Issue 1**
New researches at La Piana 1992-95. pp. 105-146
Figure 2
Figure 13

**Volume 7 Issue 1**
The structure and function of the cistern at La Piana. pp. 117-124
Figure 2

Figure 1
Figure 2

Thank you,
Patrick Woodruff

---

**Jane Whitehead** <jwhitehe@valdosta.edu>  
To: Patrick Woodruff <pwoodruff@mail.usf.edu>  

Yes, that would be fine.

---

**Permission for Figure 8**

**Patrick Woodruff** <pwoodruff@mail.usf.edu>  
To: larissa.bonfante@nyu.edu  

Dr, Bonfante,

I am finishing up my master's thesis and would like to request your permission to use the following image.

Figure 1 on page 148 in the article "An Etruscan mirror with "Spiky Garland" in the Getty Museum" from Volume 8 of The J. Paul Getty Museum Journal.

Thank you,
Patrick Woodruff  
MA Student  
Department of Anthropology  
University of South Florida
You have my permission to use the image.

best wishes,

larissa bonfante

Permission for Figures 18, 21, 22, 23, 24 and 25

Dr. de Grummond,

I am finishing up my master's thesis and would like to request your permission to use the following images.

From:

*Cetamura Antica: Traditions of Chianti; Catalogue of the Exhibition, Summer-Fall, 2000 (Opening July 19, 2000), Gaiole-in-Chianti, Centro di Informazione Turistica.* Department of Classics, Florida State University, FL.

Images: Plates Illa, Illb and Illc

From:

2009 *The Sanctuary of the Etruscan Artisans at Cetamura Del Chianti: The Legacy of Alvaro Tracchi.* Edifir, Florence, Italy.

Image: The Zone II, Phase II, NW Complex site plan featuring Structure L.

Thank you,
Patrick Woodruff
MA Student
Department of Anthropology
University of South Florida
**De Grummond, Nancy** <ndegrummond@fsu.edu>  
**To:** Patrick Woodruff <pwoodruff@mail.usf.edu>  
**Mon, Nov 17, 2014 at 6:27 PM**

Dear Patrick,

You have my permission to use the images listed below in your master’s thesis. I would appreciate it if you will inform me of the title of the thesis and provide access to it, presumably electronic, when it is finished.

Good luck and best regards,

Nancy de Grummond  
Director of Excavations at Cetamura del Chianti  
Professor of Classics  
Florida State University

---

**Patrick Woodruff** <pwoodruff@mail.usf.edu>  
**To:** “De Grummond, Nancy” <ndegrummond@fsu.edu>  
**Wed, Nov 19, 2014 at 8:59 AM**

Dr. de Grummond,

Thank you. I will definitely e-mail you a copy of my thesis, once everything is finalized. The title of my thesis is “Etruscan Trade Networks: Understanding the Significance of Imported Materials at Remote Etruscan Settlements through Trace Element Analysis using Non-Destructive X-Ray Fluorescence Spectrometry.”

On another note, would it be possible to additionally use figures 3 and 16 from *Excavations at Cetemura del Chianti, 1987-1991*?

Thank you,

Patrick Woodruff

---

**De Grummond, Nancy** <ndegrummond@fsu.edu>  
**To:** Patrick Woodruff <pwoodruff@mail.usf.edu>  
**Wed, Nov 19, 2014 at 10:43 AM**

Dear Patrick,

Thank you for the information about your thesis. As for the permissions requested, there are certainly some problems, as those maps are quite out of date. You should know that there is a particular problem with figure 3. It was mislabeled by the editors and is actually the map made by Tracchi in the 1970’s that was supposed to be Figure 2 in that article!

If you are planning to use a plan of Cetamura in 1991, the one in Fig. 2 is actually the correct one. But I actually don’t particularly recommend that you use that outdated map. Attached are two of my newest maps, and you have permission to use these instead of the two you asked for. Fig. 1 is
the general site map and Fig. 2 is a map of the same area as was reproduced in the old 1991 map (Fig. 16)

Good luck,

Nancy de Grummond

2 attachments

- **Fig. 1.pdf**
  - 529K

- **Fig. 2.pdf**
  - 1162K