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Lithic Technology and Obsidian Exchange Networks in Bronze Age Sardinia, Italy (ca. 1600-850 B.C.)

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by

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of the requirements for the degree of
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ABSTRACT

The Sardinian Bronze Age (Nuragic period) and the factors which created and maintained an island-wide identity as seen through the presence of its distinctive *nuraghi* have received considerable attention; however the amount of research directly related to the stone tools of the era has been relatively limited despite the wealth of knowledge it is capable of yielding. This thesis hopes to contribute to Sardinian archaeology through the study of ancient technology, specifically obsidian lithic technology, by combining typological information with source data gleaned from the use of X-ray fluorescence spectrometry (XRF). These data are integrated with statistical analyses breaking down the spatial distribution of nuraghi across the island through the use of distance-based methods, including k-means and kernel density analyses, which create a more comprehensive understanding of the island-wide political and social structure. This research will test the hypothesis that changes in the acquisition of obsidian raw materials were coupled with corresponding changes in how the obsidian was used. The results provide precedence for future work in Sardinia and create a model for integrating two types of analyses, sourcing and typological. By combining these results, it is possible to investigate how obsidian influenced the ancient economy as well as assess its cultural significance for people of the past.

Chapter 1: Introduction

Sardinia is located in the Mediterranean Sea off the western coast of Italy and occupies an area of approximately 24,000 square kilometers (Figure 1.1). The Sardinian Bronze Age Nuragic period (ca. 1600-850 B.C.) is named after the approximately 7,000 truncated cone-shaped residential stone structures called nuraghi which are found throughout the island. These structures are usually corbelled domes made of cut granite and basalt; they average approximately 12 m in diameter and originally rose to around 15-20 m high, although there is a wide range of variation (Balmuth 1984). Two types of nuraghi are present, “simple” (Figure 1.2) and “complex” (Figure 1.3). These likely represent a chronological progression with an increase in complexity over time. Simple towers had low doors, interior stairways and one or two chambers. Additional stories, chambers, and walls were added as time progressed. This is likely related to a concomitant outgrowth of social and economic stratification (Dyson and Rowland 2007).

Nuragic obsidian lithic technology and the exchange networks which created and maintained an island-wide identity as seen through the presence of its distinctive nuraghi have received little attention despite the wealth of knowledge it is capable of yielding. The relative isolation of the island from outside influences compared to contemporaneous communities elsewhere in the Mediterranean provides a great opportunity to study indigenous Sardinian cultural developments. Islands are truly fascinating places which raise issues of identity, isolation, connectivity, power, and resources (Pearson 2004). Several lines of inquiry are integrated in this thesis to test the hypothesis that changes in

Figure 1.1. The Italian island of Sardinia (outlined in red) (adapted from United States Geological Survey 2010)

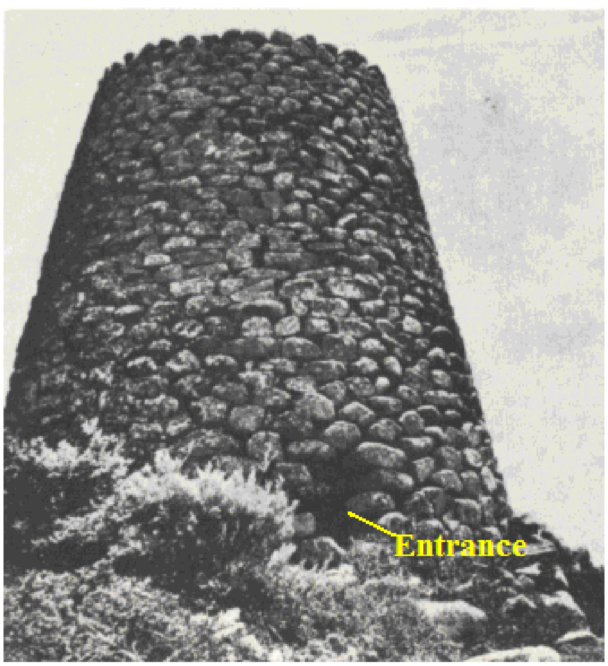

Figure 1.2. The simple tower of Nuraghe Madrone in Silanus (adapted from Balmuth and Rowland 1984:31)

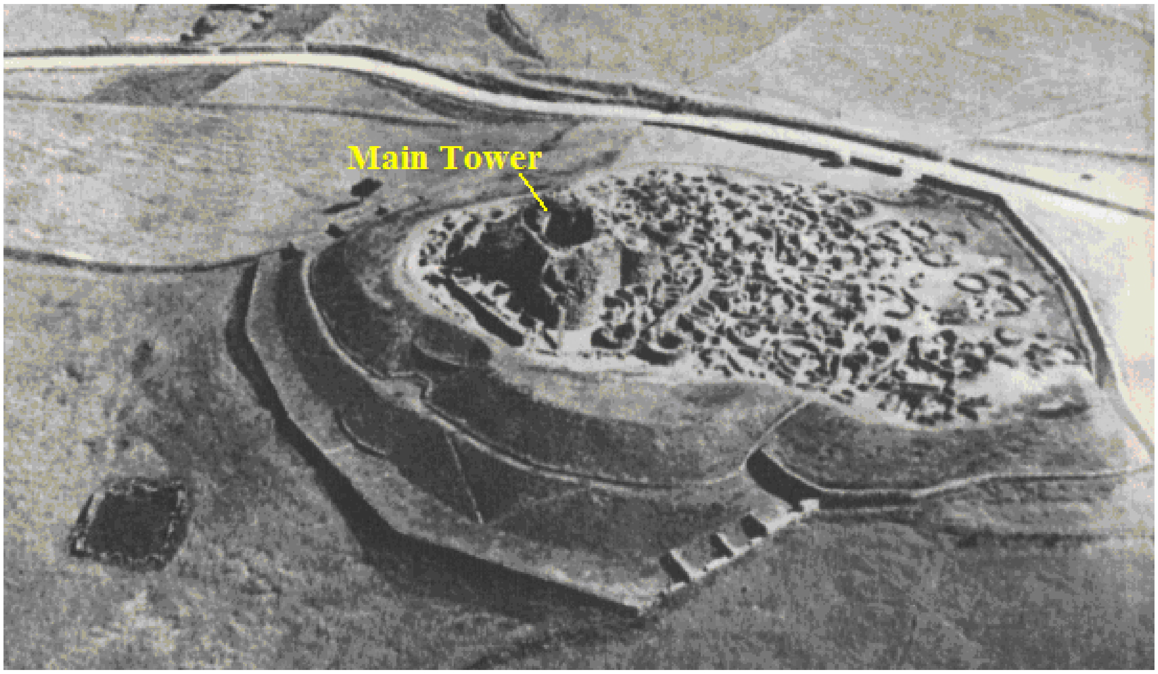

Figure 1.3. The complex nuraghe Su Nuraxi in Barumini (adapted from Balmuth and Rowland 1984:32)

the acquisition of obsidian raw materials during the Chalcolithic and Nuragic in Sardinia are coupled with corresponding changes in how the obsidian was used. It will be shown that marked technological changes occurred over these time periods and possible explanations for such variation will be explored. It is undeniable that stone technology was integrated into larger systems of interaction, which themselves can be analyzed to understand cultural change. A combination of theoretical paradigms will be evaluated, resulting in a new theoretical criterion which provides precedence for future work in Sardinia and creates a model for integrating two types of analyses, sourcing and typological. By combining these results, it is possible to investigate ancient economies, exchange networks, and cultural values.

Outline

This thesis begins with a discussion of the geographic and cultural background of the Mediterranean as a whole, consequently setting the stage for a more in-depth analysis of Sardinian prehistory and an overview of the relevant sites for this study. Chapter 3 uses two statistical techniques, k-means and kernel density estimation, to examine Nuragic settlement behavior. These techniques are used to quantify the distribution of an archaeological point-pattern of Nuragic sites on Sardinia to test whether or not there is evidence for the presence of separate polities or regional centers during the Nuragic. This is significant because it expands the relevance of GIS software in archaeology as well as sets the stage for further examination of the Nuragic economic and political landscape under which obsidian exploitation is addressed.

This research provides one of the first comprehensive studies of Nuragic obsidian artifacts by combining typological analyses with source data gleaned from the use of X-ray fluorescence spectrometry (XRF). Sourcing analysis was conducted to determine if obsidian exploitation during the Nuragic differred from that of earlier time periods. Obsidian sourcing methods, specifically XRF analysis, is addressed in Chapter 4, followed by a chapter discussing sourcing results obtained from an analysis of lithic artifacts from five sites on the island of Sardinia. This chapter outlines current theories of obsidian acquisition and trade in the Neolithic, Chalcolithic (Copper Age), and Bronze Ages. Such a combination of data is able to track the movements of ancient peoples and goods across the landscape during resource procurement, whether it is directly from a quarry site in the Monte Arci region or through trade with neighboring villages through reciprocation. It will be shown that down-the-line trade was the dominant mode of exchange during both Neolithic and Nuragic times, capable of reproducing and maintaining cultural solidarity.

Typological analysis and the methods used in this research are explained in Chapter 6. Chapter 7 considers the typological results and juxtaposes them against earlier assemblages from the Neolithic and Chalcolithic. The results from the spatial, sourcing, and typological analysis are combined in Chapter 8.

Chapter 2: Geographic and Cultural Background

This section provides the background data and chronologies necessary for the interpretation of the research, beginning with a broad overview of Mediterranean prehistory and ending with a survey of the relevant Sardinian archaeological sites.

The Mediterranean is a vast area comprising the land and islands bordering the Mediterranean Sea (Figure 2.1). The Mediterranean Sea begins in the west at the Strait of Gibraltar and ends in the east near modern day Israel. For purposes of this survey, the Mediterranean will be considered the lands on the north side of the Mediterranean Sea as well as the various islands such as Cyprus, Crete, Sicily, Sardinia and Corsica. North Africa and the southern Levant have been excluded as they do not directly relate to the covered topics.

The climate is characterized by hot, arid summers and cool, wet winters. The topography is multifarious, ranging from mountains to plains. Vegetation consists of evergreen forests, shrublands and grasslands. Today, much of the natural vegetation has been modified by humans as a result of agriculture, which includes crop plantation as well as livestock grazing. The natural vegetation has also undergone changes as a result of climate fluctuation. An important period of climate fluctuation occurred during the end of the Pleistocene and the beginning of the Holocene. The study of foraminifers suggests that the influx of Atlantic waters into the western Mediterranean Sea increased during periods of deglaciation in the last 18,000 years (Bolling/Allerid warm events) and decreased during periods of climate degradation (Younger Dryas cool event) before

Figure 2.1. The Mediterranean (adapted from United States Geological Survey 2010)

emerging as what is seen today (Abrantes 1988). These climate fluctuations are important because of the concomitant emergence of agriculture in the Mediterranean.

The traditional prehistory of the Old World is divided into several broad time periods: the Palaeolithic, Mesolithic, Neolithic, Chalcolithic (Copper Age), and Bronze and Iron Ages. In the East Mediterranean however, there is very little evidence for pre-farming adaptations distinct from the Late Palaeolithic; in only a few areas have Mesolithic horizons been recognized (Price 1983). Because the relatively rapid introduction of agriculture and domestication reduces the visibility of the Mesolithic, it is common to designate pre-farming adaptations in the East Mediterranean as Epipalaeolithic.

Sardinian Prehistory

In general, Sardinia is composed of extensive granites, schists, volcanic rocks, and limestone with thin layers of topsoil (Rowland 2001). The soil matrix consists of the ubiquitous brown soils and scattered rocky soils which cover the island. These xerochrepts support ample deciduous forest cover, although the effects of agriculture have altered most of the landscape (Pietracaprina 1980). Sardinia's geography is varied with a large range in elevation. In general, there is a lack of natural rivers and lakes.

Evidence of Palaeolithic occupation first took form in 1979 (Cornaggia Castiglioni and Calegari 1979). Based on an analysis of lithic evidence as well as the geomorphological and pedological context from 10 sites, the earliest Sardinian occupation has been dated to the Lower Palaeolithic. The lithics are characterized by tools with large striking platforms, unsophisticated retouch, and an overall lack of bifacial flaking (Martini 1992). Such claims of antiquity are not without scrutiny. Cherry (1992) points out how unusual these dates are in that they do not fit with everything that is known about early human migration patterns. However, a well-excavated site at Corbeddu Cave does provide evidence of an Upper Palaeolithic presence. Sondaar et al. (1991) have dated Corbeddu Cave to as early as 14,000-12,000 B.P. The lithic industry is characterized by very elementary technology which lacks the complexity of assemblages found elsewhere in Europe during the same period (Martini 1992). Moreover, geomorphological evidence indicates that the island of Corsica and Sardinia were connected at the time, thus making the possibility of Palaeolithic island habitation more plausible if a migration occurred across the narrow channel between Italy and Corsica. Whether or not these Palaeolithic/Mesolithic people were the ancestors of later Neolithic cultures is not clear, but current Neolithic diffusion models seem to negate such a claim (Sondaar 1987). More evidence is needed to complement these findings and create a more comprehensive picture of early Sardinian peoples.

The Sardinian Mesolithic (ca. 11000-6000 B.C.) was aceramic and is characterized by coastal communities occupying seasonal camps and exploiting local marine resources. New types of wild fauna were hunted as a result of large-scale climatic changes at the end of the Pleistocene. The stone tool repertoire mostly consists of scrapers, although blades, microliths, and other retouched flakes have been recovered (Dyson and Rowland 2007). There is a general lack of Mesolithic archaeological evidence as these sites are ostensibly underwater as a result of sea-level fluctuations at the start of the Holocene.

The appearance of agriculture marks the transition into the Neolithic. Agriculture began in the Near East around 10,000 B.C. and was transferred to the Mediterranean through two alternative demographic scenarios. In the demic diffusion model, the spread of agriculture involved a massive movement of people, which implies a significant genetic input of Near Eastern genes (Ammerman and Cavalli-Sforza 1984). Under the cultural diffusion model, the transition to agriculture involved the movement of ideas and practices rather than people. This model would not be accompanied by major changes at the genetic level. Studies involving genetic information from extant populations in the Mediterranean and Near East intimate that the demic diffusion model most closely resembles the data, although a combination of cultural and demic diffusion is certainly possible, if not probable (Chikhi et al. 2002). It must be mentioned that there are limitations of DNA testing on modern populations, especially when making interpretations about ancient mobility. These include the fact that living Mediterranean inhabitants may not be descended from those of ancient times.

Evidence suggests that the transmission of agriculture to the western Mediterranean occurred over water instead of land. By using population equations created by Ammerman and Cavalli-Sforza (1984), and assuming an annual rate of population growth of 1 percent, one can calculate a rate of spread of 10 km/year, 30 times greater than the maximum observed ethnographically. These results support demic diffusion by implying that agriculture could not have advanced by short distance settlement expansion whereby populations slowly moved further into peripheral lands (Zilhão 2001). The punctuated nature of agricultural development as well as the littoral proclivity seems to provide additional evidence to support this hypothesis. Assuming that the demic diffusion model is correct does not necessarily imply that agricultural diffusion was a package deal which included the diffusion of pottery, architecture, grindstones etc. In fact, differences in environment, mobility and foraging economies led to various agricultural practices being adopted.

An important aspect of Mediterranean prehistory regarding the diffusion of agriculture is insular populations. The Grotta Filiestru provides evidence of Neolithic peoples in Sardinia. The cave has preserved botanical and faunal remains remarkably well. Domesticated plants and animals include emmer, einkorn, sheep, pigs and cows, all from the Early Neolithic. It is hypothesized that people here practiced mixed agriculture while still collecting wild plants and hunting local fauna (Trump 1983). The Sardinian Neolithic is usually divided into several time periods based on an analysis of its pottery. The chronology is based on calibrated radiocarbon dates as published by Tykot (1994). The earliest Neolithic phase is the Cardial (ca. 5800-5300 B.C.), which is characterized by an impressed ware with geometric designs in the form of bowls and jars. There is not a large variety of vessel shapes, and diagnostic pieces can be identified either by decoration or handle type. Cardial handles are best described as pierced lugs. The second phase of the Neolithic is the Filiestru (ca. 5300-4700 B.C.). These levels usually contain an undecorated ware often with a red ochre slip or wash. Handles are large and horizontal. The Bonu Ighinu (ca. 4700-4000 B.C.) phase is delineated by decorated pottery with both small and vertical, or large and horizontal handles. Flat bases are virtually absent. The Ozieri (ca. 4000-3200 B.C.) is the last Neolithic phase and includes distinctive curvilinear decoration of repeated stab lines, heavy incision with ochre incrustation, and recessed handles (Trump 1984). Although this overview describes diagnostic pottery types, it does not do justice to the complex variety of pottery found in all periods of the Neolithic.

The Chalcolithic (ca. 3200-2200 B.C.) in Sardinia is marked by the introduction of copper and includes two phases, Abealzu-Filigosa and Monte Carlo. Abealzu-Filigosa pottery is heavy, unrefined, and undecorated, which is in stark contrast to the relatively ornate Ozieri ware. At this time, there is evidence of large-scale changes in habitation behavior in that previously dispersed populations seem to nucleate in larger settlements. Lilliu (1988) has suggested that this relates to an economic shift away from cultivation and towards pastoralism, although current dietary evidence does not support the claim. Recent trophic analysis carried out by Lai (2008) using stable isotope analysis of human remains has shown that, “The long-held opinion that local Copper Age and especially Early Bronze Age societies relied more on herding than the Neolithic ones is not supported by the data.” Lai (2008) goes further by suggesting that the contribution of plant foods actually increased during these periods. Changes in settlement behavior are more evident in the later Monte Carlo phase, whose diagnostic pottery has a large variety of forms, with a litany of ornate decorations (Webster 1996). This corresponds to the development of stone architecture such as *hypogea* (oven-shaped tombs) and seemingly fortified settlements in four distinct territorial facies: Campidano, Oristanese, Nuorese, and Sassarese (Lo Shiavo 1986). These socio-political changes are likely precursors to later Bronze Age developments.

The Sardinian Early Bronze Age begins with the Bonnanaro culture and is divided into two phases, A and B. Bonnanaro A (ca. 2200-1900 B.C.) shares cultural affinities with earlier Chalcolithic phases both in material culture as well as in ritual behavior (Tykot 1994). Collective secondary burials from the Late Neolithic and Chalcolithic were reused by these peoples, which suggests an absence of elites if not a completely egalitarian political and social structure.

The Middle Bronze Age Bonnanaro B (ca. 1900-1600 B.C.) saw the rise of the first proto-nuraghi, low stone platforms with internal corridors and chambers (Webster 1996). These structures predate similar architecture in the Aegean region. The Middle Bronze Age marks the beginning of a significant shift in the way in which people interacted with their physical environment. However, it is not until the beginning of the Nuragic that these changes take full effect.

The beginning of the Nuragic period dates to around 1600 B.C., roughly contemporaneous with the Middle Bronze Age of southern France, the Torrean culture of Corsica, and the Talayots of the Balearics (Tykot 1994). Early interpretations as to the beginning of the Nuragic dealt with large-scale migrations and conquering foreigners (Lilliu 1966). More recent approaches to the introduction of the Nuragic culture focus on a decentralization of previous hierarchies and a subsequent localization of authority. Lewthwaite (1986) suggests that agricultural depletion of the land as a result of intensive over-use caused a new emergent elite class to take control of capital investments including plow technology and livestock.

The Nuragic I period (ca. 1600-1300 B.C.) saw the proliferation of nuraghi throughout the island. This was concomitant with a decrease in the use of caves and other open-air settlements (Lilliu 1988). It is crucial to recognize that these structures did not arise out of a vacuum, but were part of much wider emergence of monumental stone architecture which is seen in Greece (tholoi), Corsica (torri), and the Balearics (talayots) (Figure 2.1). These architectural affinities do not necessarily imply a diffusion of ideas, but such parallel developments do have some relation to one another. The purpose of these nuraghi has been difficult to ascertain. Based on the material evidence, it is clear that they are residential dwellings and not ritual or mortuary structures. However, any theory describing these structures as residences for an elite aristocracy is not supported by the evidence. They were likely fortified nuclear family homesteads which took on a variety of roles ranging from a residence, territorial marker, watchtower, and symbol of status and prestige for the entire community (Gallin 1991). The rise of Giants' Tombs also occurred at this time. These are slab-lined, rectangular funerary chambers with characteristic megalithic architecture, usually fronted by stone-lined semicircular entrance courts. While they contained communal burials, the number and capacity of these tombs suggests that they were only burial places for the elite, with ordinary residents being interred elsewhere (Dyson and Rowland 2007). The latter part of the Nuragic I saw the development of complex nuraghi with the concomitant expansion of encompassing villages. Complex nuraghi were constructed from scratch or as remodeling efforts of more simple ones. Webster (1996:29) implies that this increasing centralization marks the introduction of local chiefs who constructed and reified their power through regional exchange and monumental architecture. Because of the broad similarities in Nuragic architecture and culture, it is certain that these communities interacted with surrounding villages and felt some sense of common identity.

The Nuragic II period (ca. 1300-1150 B.C.) is an era of increasing complexity and competition. The complex nuraghi which took form in the later Nuragic I began to expand, giving rise to the first Sardinian urban centers acting as regional foci of trade and exchange. Extra-insular trade also began to manifest itself on coastal sites as can be seen by the Mycenaean pottery and Cypriot oxhide ingots which found their way into archaeological deposits. This probably occurred as occasional long-distance trade, with artifacts making it as far as Spain (Dyson and Rowland 2007). Early interpretations used core-periphery models to emphasize the role that Sardinia played in providing the raw materials for state-level societies of the east (Rowland et al. 1987). However it was later discovered through isotopic analysis that people of Sardinia were actually importing these materials for their own use (Atzeni 1998).

Metals are increasingly common at archaeological sites during the Nuragic III (ca. 1150-850 B.C.). They usually come in the form of bronze weapons and votive figurines, or *bronzetti* (Figure 2.2). Curiously, there is little evidence of actual physical conflict or warfare. It is likely that these bronze artifacts represent an increasingly competitive landscape occupied by regional elites vying for territorial power (Webster 1996).

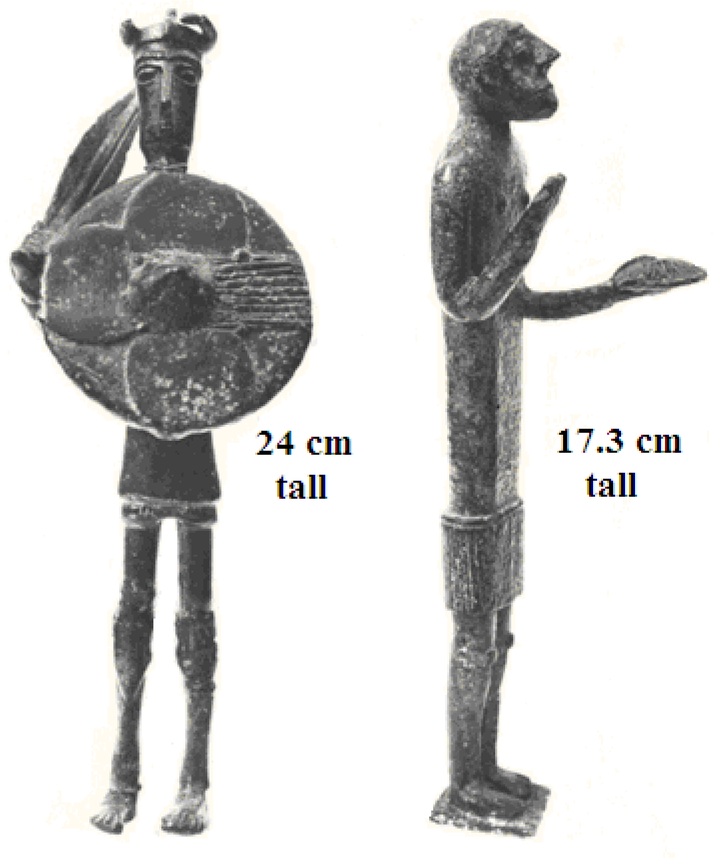

Figure 2.2. Late Bronze Age votive figurines, or bronzetti (adapted from Balmuth and Rowland 1984:45)

The Nuragic IV (ca. 850-510 B.C.) period as defined by Tykot (1994) refers to the beginning of the Iron Age, a dynamic era of profound change. As the name implies, the introduction of iron technology occurred during this period. Unlike cultures farther east, iron technology did not displace bronze and copper in Sardinia; iron was quite rare (Webster 1996). What is perhaps more important is the increasing East Mediterranean Phoenician influence. The Phoenicians began establishing coastal settlements on the southern coasts of Sardinia by around 750-650 B.C., slowly extending their dominion inland as time passed. Port settlements such as Cagliari, Sulcis, Nora, and Tharros became major centers of trade not only during the Nuragic IV, but continuing into Punic and Roman times (Dyson and Rowland 2007). Despite the foreign presence, Nuragic culture continued to flourish. The relationship between the Phoenicians and the indigenous Sardinians is somewhat ambiguous. Although the Phoenicians maintained a standing military force, there is no evidence of conflict. Considering this, in addition to the presence of native materials in Phoenician contexts (Ugas and Zucca 1984), it is reasonable to assume that the Nuragic-Phoenician interaction was peaceful, stimulated by mutual benefit through trade and exchange. Indigenous Sardinian cultural interaction was not limited to the Phoenicians since artifacts from mainland Italy are found in many Nuragic deposits. Overall, the Nuragic IV was an influential time as residents became exposed to the outside world on a scale not seen in previous generations. All of the relevant time periods are compiled into one table in Appendix A.

Although the Nuragic saw numerous social and political developments, four types of raw material were continually used for tools in Sardinia during the Bronze Age: copper, chert, quartz, and obsidian. For this study, only the obsidian will be considered. Obsidian is an igneous rock and a type of volcanic glass which is usually black in color (Le Maitre 1989:97). It was named after the Roman consul, Obsidius, who was an avid collector of the material (Middlemost 1997:33). Igneous rocks are those rocks that have solidified from a molten state either within or on the surface of the Earth (Le Maitre 1989).

The introduction of metals such as copper and bronze during the Bronze Age also occurred at this time. They were mined from indigenous deposits found throughout the island in the Sarcidano, La Nurra, Anglona, and Iglesiente regions. However, it has been shown that the introduction of metals did not drastically alter the predominance of stone technology for carrying out daily activities (Balmuth 1984). Although bronze axe heads are found, the use of metal technology principally served other defensive and ritual functions as can be seen in the bronze swords and bronzetti characteristic of the Late Bronze Age. Early Bronze Age metals are usually recovered in tomb deposits and not in normal residences (Webster 1996). Nevertheless, the introduction of metals could have altered the perception of stone in the ancient mind.

Obsidian Sources and Archaeological Sites

There are a number of obsidian sources and archaeological sites which are relevant for my research and must be discussed in some detail (see Figure 2.3). First, the region which contains the obsidian raw material utilized by ancient peoples is explained. The Marghine Region is examined next. This region contains four of the five analyzed archaeological sites. An additional site outside of the Marghine Region is discussed last.

Monte Arci

Monte Arci is a region in west-central Sardinia which contains the obsidian raw material used for stone tools from the beginning of the Neolithic period and continuing into the Nuragic era. Researchers have identified four subsources located in the Monte Arci area (Figure 2.4) and include SA, SB1, SB2, and SC (Tykot 1997; Lugliè et al. 2006). Secondary SC obsidian deposits have also been identified by Lugliè et al. (2006) south of the main SC conglomerate. This region of Sardinia is by no means the only source of obsidian in the western Mediterranean. Additional obsidian sources are found

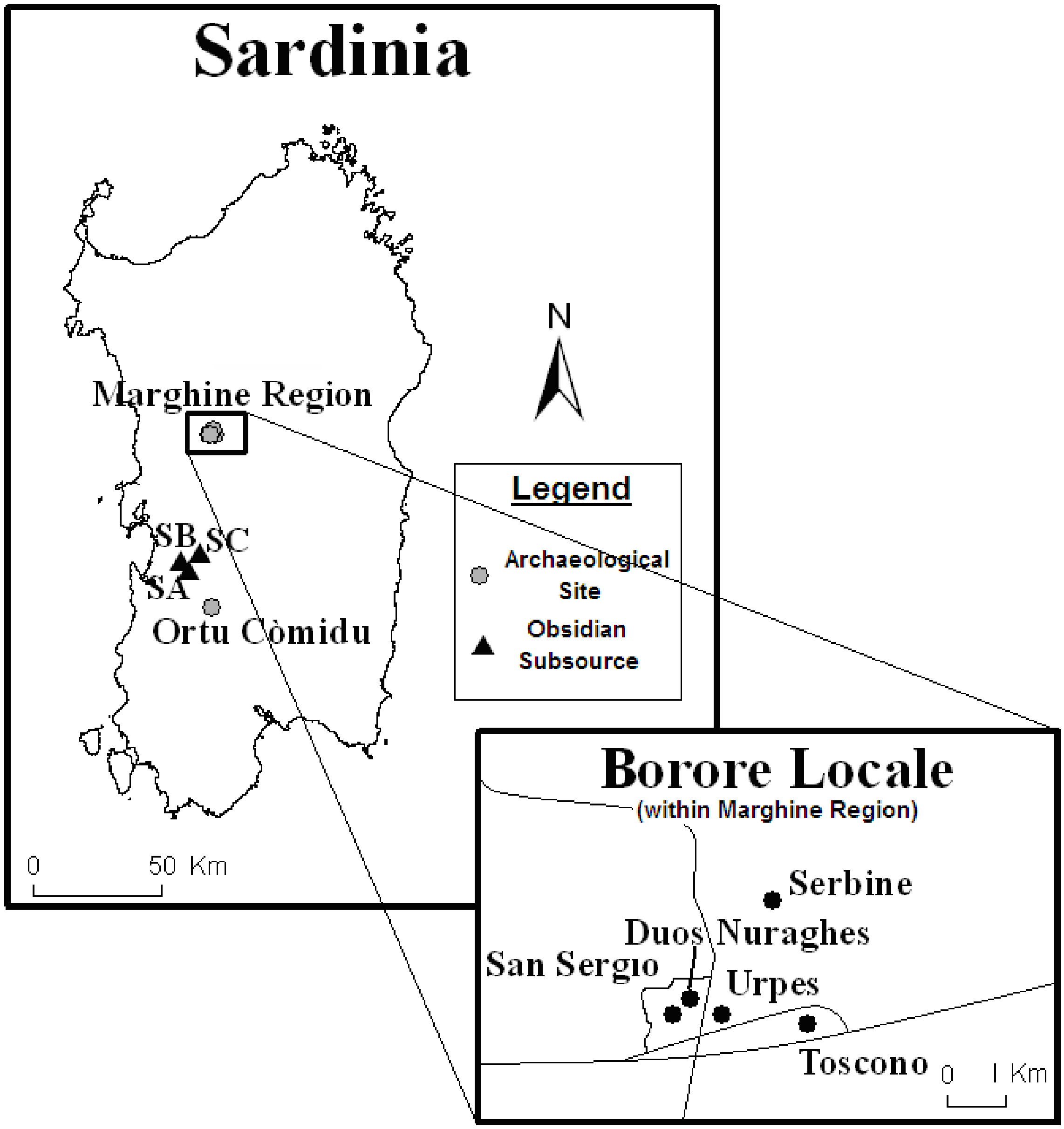

Figure 2.3. Map showing all of the relevant sites

on the islands of Lipari, Palmarola, and Pantelleria. On Sardinia, however, only the obsidian from Monte Arci is known to have been exploited (Tykot 1996).

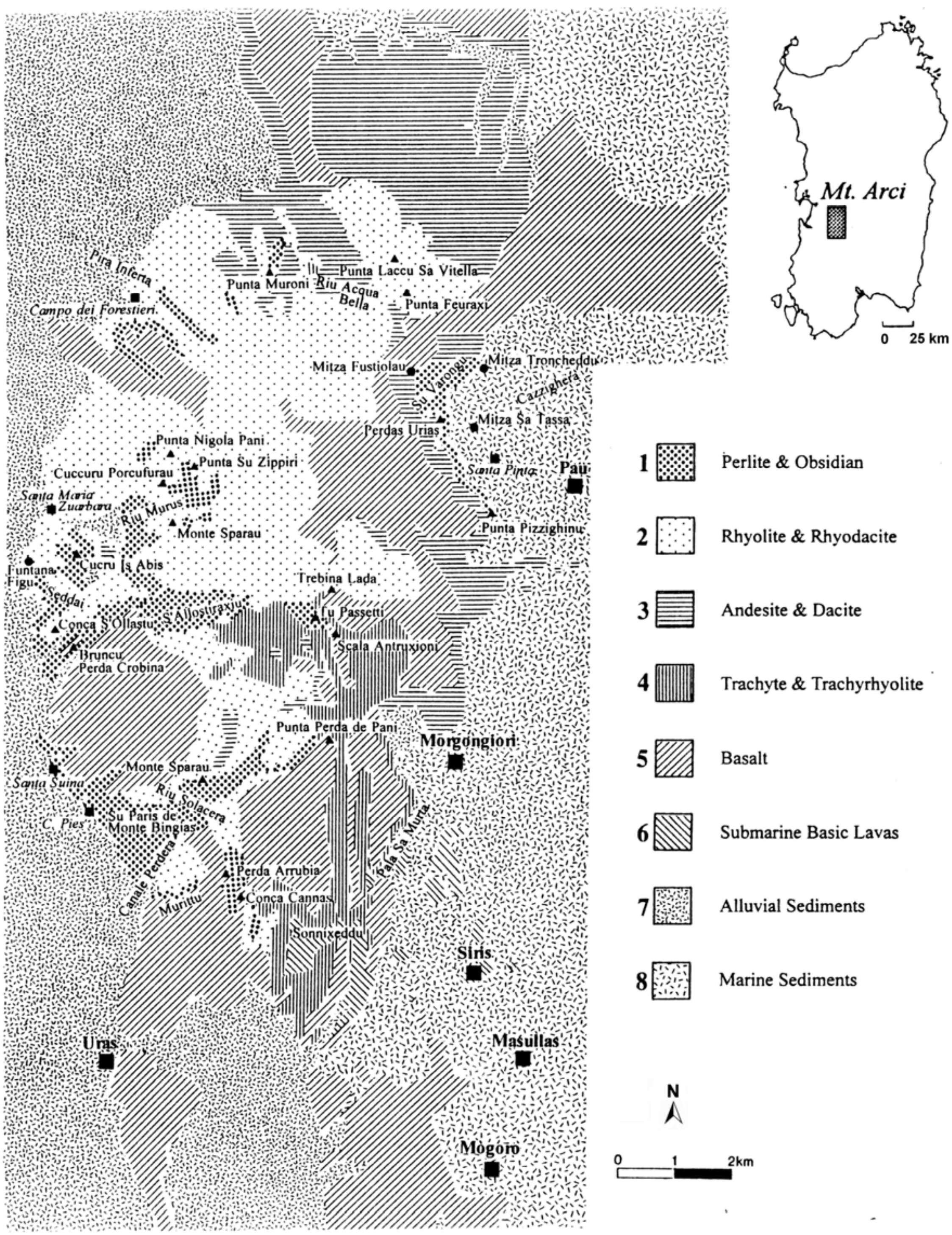

Figure 2.4. Map of subsources at Monte Arci (adapted from Tykot 1997:469)

Marghine Region

The Marghine region covers approximately 400 square kilometers of basaltic upland plateau and is bordered on the north by the Goceano Mountains and the south by the Abbassanta Plain. To the east lies the Tirso River valley and to the west lie the uplands of Planargia (Figure 2.5). The climate is characterized by mild winters and hot dry summer, not unlike the rest of the Mediterranean. Rainfall is moderate, although summer droughts are common (Webster 2001). The current vegetation consists of thinly covered scrub which is conducive to modern-day pastoralism, although in the past the plateau supported extensive oak forests. During the Nuragic, this region supported one of the largest clusters of nuraghi and their associated burial tombs (Webster 2001). This entire region is separated from similar areas by a 2 km buffer zone in which there are no nuraghi, only megalithic tombs. Buffer zones such as this may be a common feature on the island, reflecting territorial boundaries (Webster 1991). For my research, a cluster of nuraghi in the Borore locale (Figure 2.6) has been analyzed. The Borore locale is a roughly elliptical area of pasture and mixed farmland which slopes gently to the southeast. The following sites were excavated as part of a larger regional survey carried out from 1980 through 1996, and the recovered materials were analyzed for my research.

Duos Nuraghes (Borore)

The west-central Sardinian site of Duos Nuraghes (Figure 2.7) is located in the Marghine region on a low knoll in the Borore locale at 400 m elevation (Webster 1996). It typifies a little-studied but important element of Nuragic culture, a simple nuraghe village. Occupation at the site spanned from ca. 1600 B.C.–A.D. 1000. It is a Middle-

Figure 2.5. Regional topography of Sardinia (adapted from Pracchi et al. 1971:47)

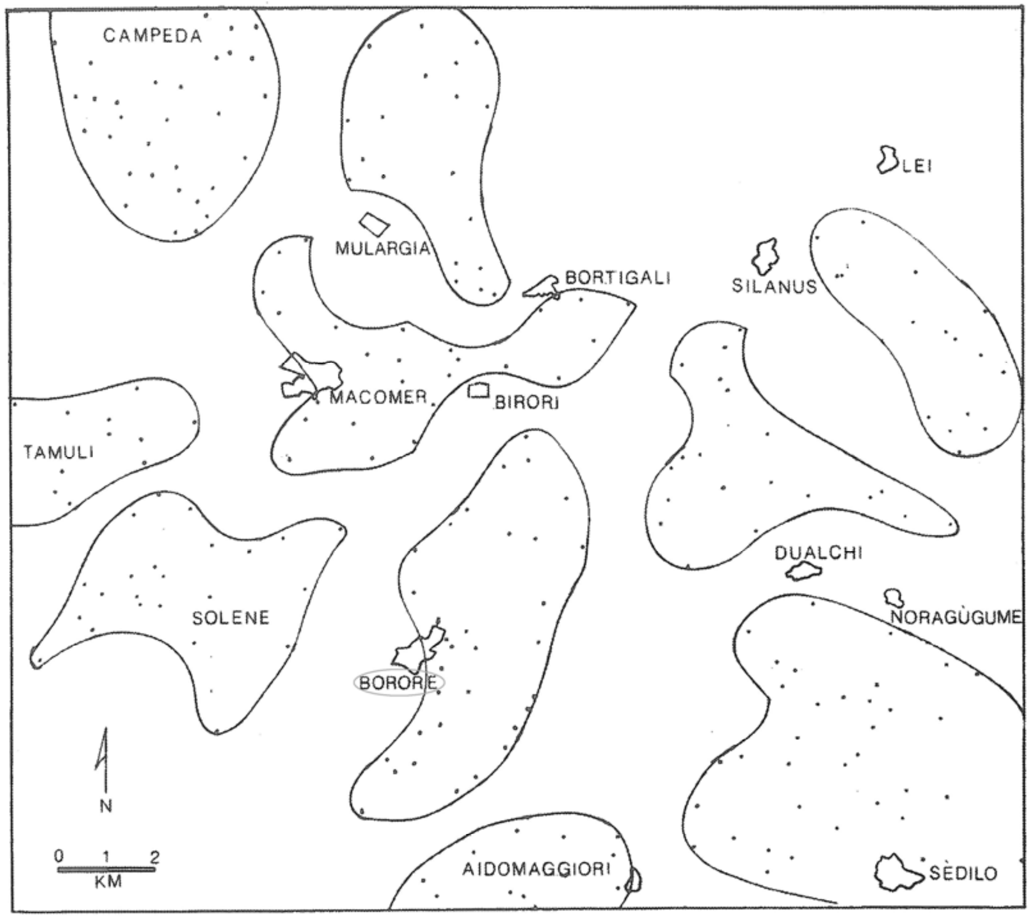

Figure 2.6. Nuraghi aggregates and named megalithic tombs in the Marghine region (adapted from Webster 2001:3)

Late Bronze Age residential complex composed of two centrally located tholos nuraghi. Tower A is a single story "simple" nuraghe with some cultural remnants up until Medieval times. Tower B is a more complex two-story nuraghe, constructed somewhat later than Tower A. Residential stone structures are located to the east and west of the nuraghi. In general, the West Village has suffered more from post-depositional erosion than the East Village perhaps due to the eastern circuit wall protecting against down-slope erosion. Therefore, the East Village has been extensively excavated by digging 38 2-x-4 m trenches, thus revealing a cistern, circuit wall, and 14 buildings with foundations

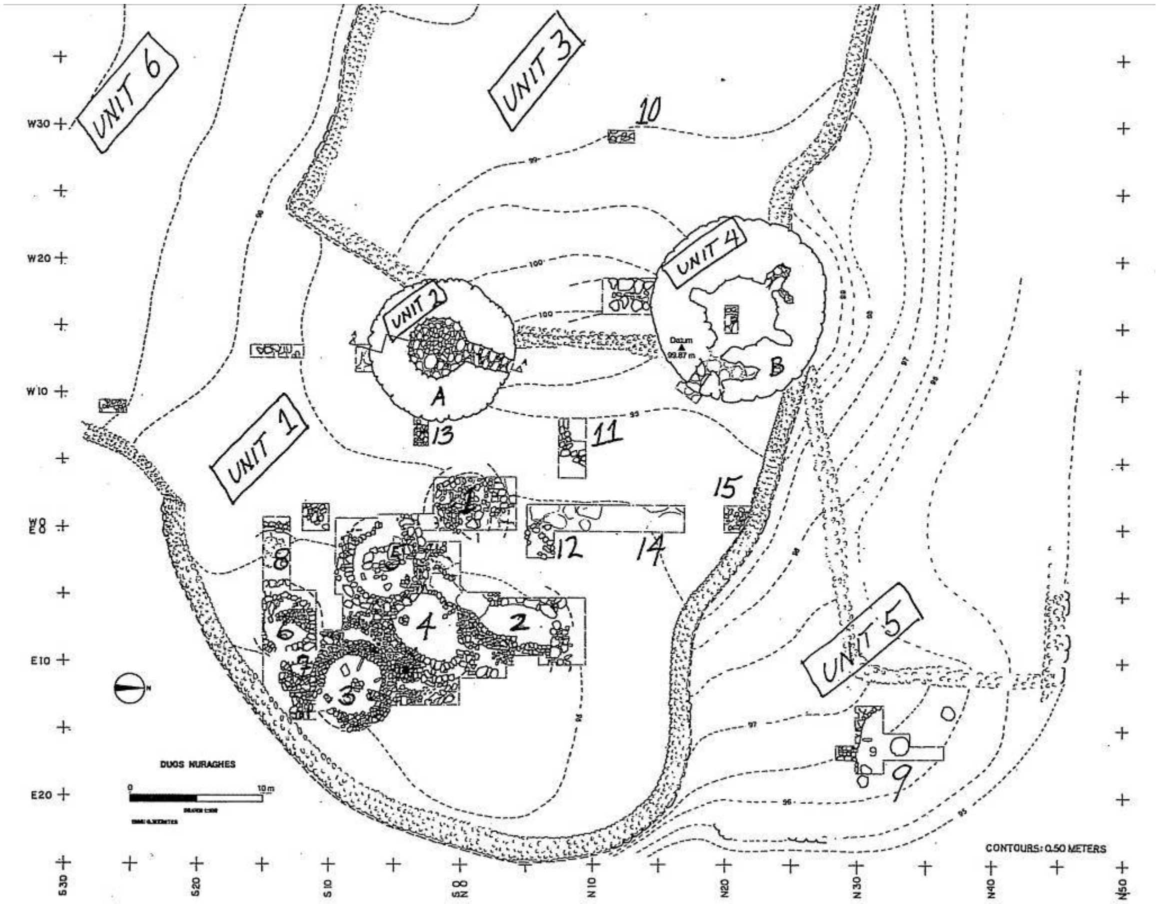

Figure 2.7. Plan of Duos Nuraghes (adapted from Webster 2001:7)

containing artifacts spanning the site's occupation. Approximately 12 m northeast of the East Village wall, a carved stone stela was also uncovered within a large stone structure with features suggesting a civico-ritual function (Webster 2001). Since lithic remains are present throughout the site, a spatial analysis of technology is possible.

All trenches were excavated following natural layers, although in especially thick strata arbitrary levels were maintained in 10 cm intervals. The majority of the deposits were recovered using trowels and hand picks. The matrix was screened through a 7 mm mesh.

Additional sites in the Borore locale have also been included. They are Nuraghe Urpes, Nuraghe San Sergio, and Nuraghe Serbine. Of these three sites, only at Nuraghe Urpes has there been excavation conducted outside of the nuraghe, hence these sites do not exemplify a representative sample like that of Duos Nuraghes. Nonetheless, they provide a comparative sample from which interpretations can be made.

Nuraghe Urpes

The site of Nuraghe Urpes includes a complex nuraghe which rests 600 m to the southeast of Duos Nuraghes. It is comprised of a central tower with four small corner towers and a bastion (Figure 2.8). There is a village to the northwest which contains a partially-intact stone wall surrounding the settlement. A total of 33 1-x-1-m test units was opened in the village (Figure 2.9). Additional units were also excavated within the nuraghe (Webster 2001). The site likely dates to the Nuragic III and into the Iron Age, although additional occupational levels were found which extend to A.D. 900.

Nuraghe San Sergio

This site’s nuraghe is the closest to Duos Nuraghes and has suffered from modern destructive procedures. It is a simple nuraghe with an adjacent village. A 2-x-2-m unit was excavated in the nuraghe which revealed a highly disturbed stratigraphy with a rich collection of artifacts (Webster 2001). Dating the site is difficult, but because of the simple architecture, it likely dates to the earlier portion of the Nuragic.

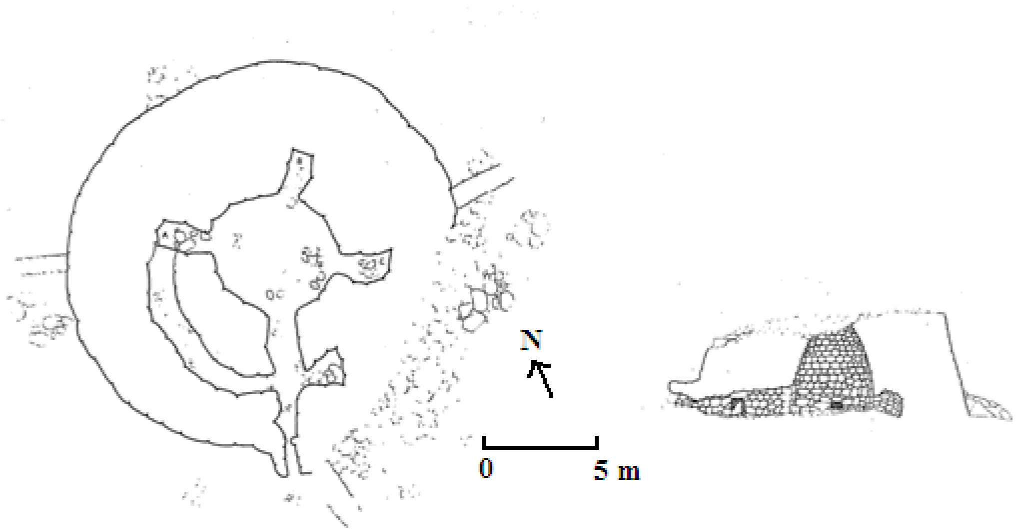

Figure 2.8. Plan and artistic rendering of Nuraghe Urpes (adapted from Michels and Webster 1987:29)

Nuraghe Serbine

The site of Nuraghe Serbine is located 2 km northeast of Duos Nuraghes and is an early example of Nuragic architecture. This proto-nuraghe has several chambers and is adjacent to a small village with a surrounding wall. Test units were excavated in several of the chambers. Based on architectural analysis, this site likely dates to the Nuragic I period (Webster 2001). This is the last of the relevant sites in the Marghine region. An additional site is included called Nuraghe Ortu Còmidu.

Nuraghe Ortu Còmidu (Sardara)

The excavation of Nuraghe Ortu Còmidu, located near the Pixina River, south of Monte Arci in the province of Cagliari, took place in 1975, 1976, and 1978 as part of a project which explored early Sardinian metal working (Balmuth and Phillips 1986), and followed early work done at this site by Taramelli (1918). Ortu Còmidu likely dates to

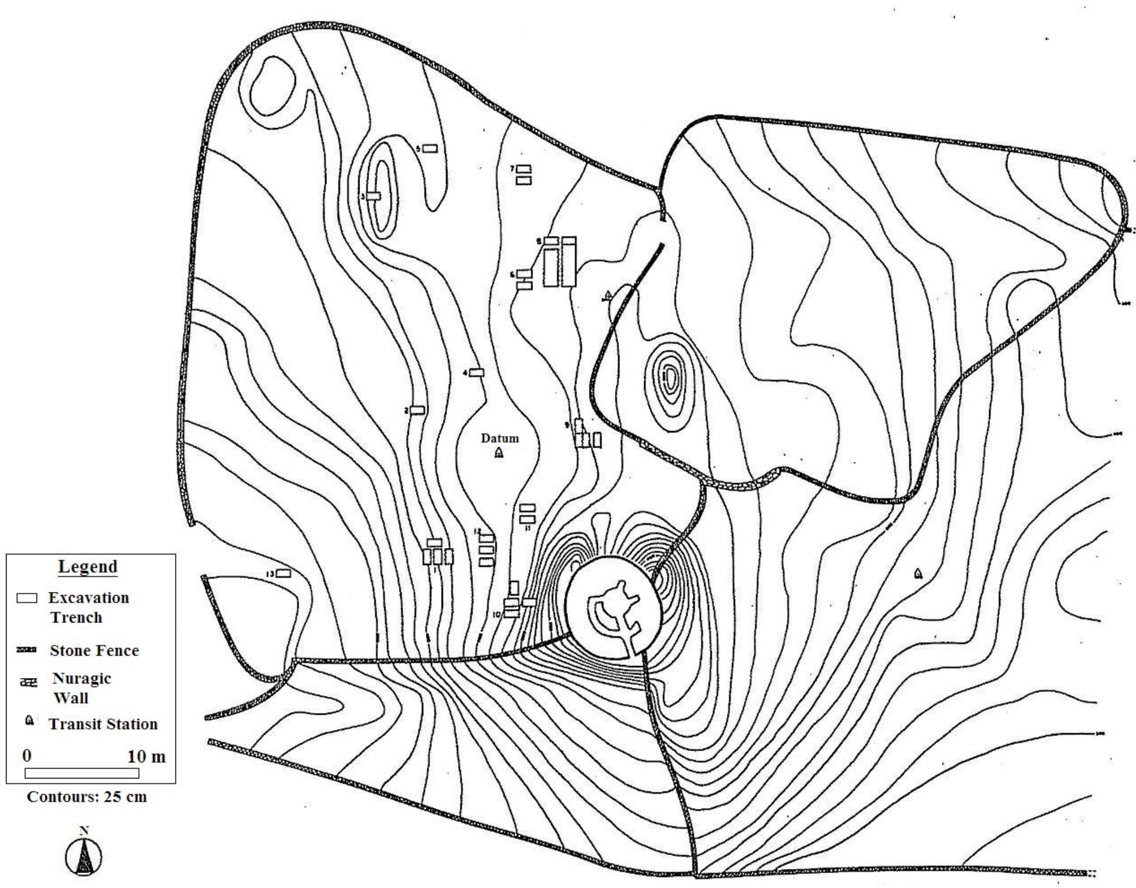

Figure 2.9. Map showing the location of excavation units at Nuraghe Urpes (adapted from Michels and Webster 1987:30)

the early phase of the Nuragic period and is a “complex” nuraghe 12 m in diameter. Figure 2.10 shows that it has a central tower, a courtyard with a well, and at least three subsidiary towers attached to the central one (Balmuth and Phillips 1986). The recovered artifacts come from both within and outside of the nuraghe. The excavators divided the site into 5- x-5-m grid units and excavated following 10 cm levels. A concise table with information about each site is includes in Appendix B.

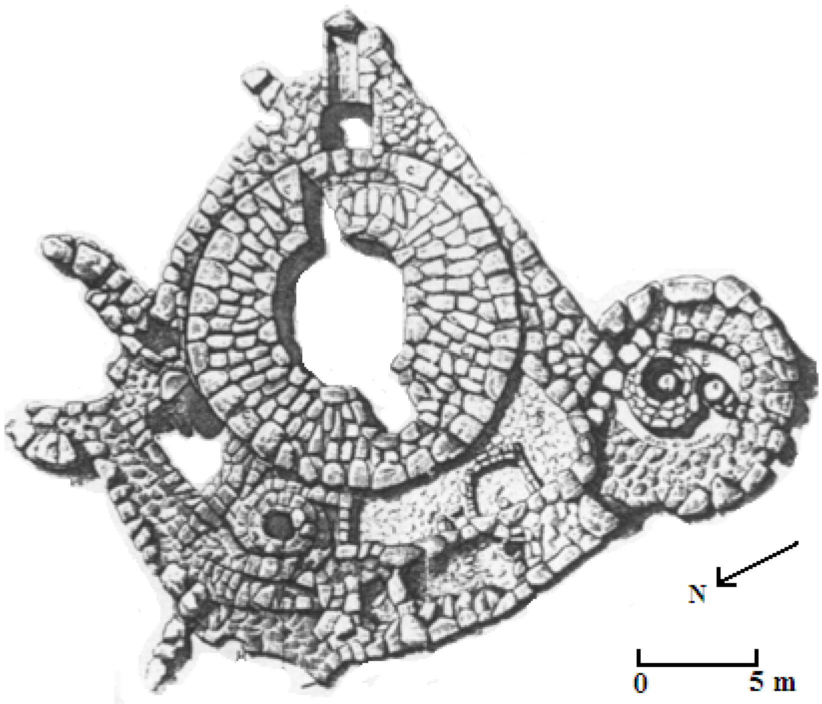

Figure 2.10. Plan of Nuraghe Ortu Còmidu (adapted from Balmuth and Phillips 1986:356)

Chapter 3: Spatial Analyses

This chapter provides further insight into the geographic and cultural background of Nuragic Sardinia through a settlement pattern analysis. It specifically tests whether or not there is evidence for the presence of separate polities or and regional centers during the Nuragic. The landscape is studied through an examination of the locations of a majority of the nuraghi on the island. Using several statistical techniques to identify clusters, it is shown that Nuragic settlements are patterned in ways which have wider political implications, especially when it comes to the rising complexity and elite status. This provides precedence for later hypotheses which are put forth regarding changes in obsidian exploitation.

The accession of Geographic Information Systems (GIS) in archaeology is an outgrowth of its ever-increasing availability and ease of use (Kvamme 1999). It is by no means a new technology as it has been around since the 1970s, but this past decade has seen a sharp increase in the number of applications capable of being incorporated into archaeological research (Chapman 2006). This section describes ways to integrate GIS into archaeological research and discusses the theoretical implications that such developments can have for the analysis of the political landscape of Nuragic Sardinia. By combining analyses in the R Statistical Package and GIS software, k-means cluster detection and kernel density estimation are used to demonstrate the suitability of these techniques for researchers in all areas of archaeology. A discussion of the statistics is followed by an analysis of Bronze Age Sardinia which will be used to address settlement patterning as well as document the presence or absence of emerging polities, site catchments, and regional centers.

The study of archaeological space has always been a relevant topic for archaeologists and has usually taken two forms, intra-site and inter-site analyses (Kroll and Price 1991). Intra-site analysis has typically used ethnographic evidence to study the distribution of material artifacts (Roberts and Partiff 1999), while inter-site analysis has been used to study settlement patterning and site distribution. Both types of studies can benefit from k-means and kernel density analyses, although only inter-site differences are examined here.

These statistical techniques are not new, but their prevalence in the field of archaeology has been limited likely due to the difficulty of obtaining the necessary data needed to run the analyses as well as the knowledge of how to move between two software environments. For example, R was used to run the statistical part of the study, while GIS portrayed the data in a way that was easy to understand and interpret. R is a command line statistical program which offers users numerous options to create and edit scripts. Scripts are sheets which contain a chain of commands which can be edited to fit the input data and are used to run complex sets of functions.

Methods

K-means and kernel density functions are cluster analyses which use point-pattern data to categorize and quantify the distribution of points across a surface. The k-means function is a partitioning technique which assigns every point membership to one of a number of optimum clusters. Determining the optimum number of clusters requires an examination of the within-cluster sum of squares over a range of possible solutions. This necessitates an understanding of the nature of the data being examined to determine a range of possible optimum solutions which can be further narrowed down by looking for an “elbow” in the resulting curve (Everitt and Hothorn 2006). This will be illustrated later. After the optimum number of clusters is determined, the k-means function initially determines cluster centers through the selection of random points from the distribution which act as seeds. As new points are added to the cluster, the center is recalculated (Conolly and Lake 2006).

Kernel density estimation is a non-parametric technique which places a probability density function, or kernel, over every point and is capable of locating areas of statistically high and low point density (Conolly and Lake 2006). The user defines the radius of the kernel, or bandwidth, based on previous knowledge of the data being analyzed. This technique, like others, suffers from scalar issues in which different results can be obtained based on different bandwidth definitions. It is therefore necessary to understand the nature of the data, the relevant research questions, and experiment with several definitions to obtain accurate results (Wand and Jones 1995).

For this study, points represent archaeological sites on the island of Sardinia (Figure 3.1). Each point marks the location of a nuraghe. Of the approximately 7,000 known nuraghi on the island (Lilliu 1988), 5,132 will be used in this study. The locations of the nuraghi were determined by using a map from Webster and Teglund (1992). The map did not distinguish between “simple” and “complex” nuraghi, thus it lumps two distinct construction types together. Moreover, the locations of known nuraghi could be biased because of preservation issues related to both ancient and modern-day

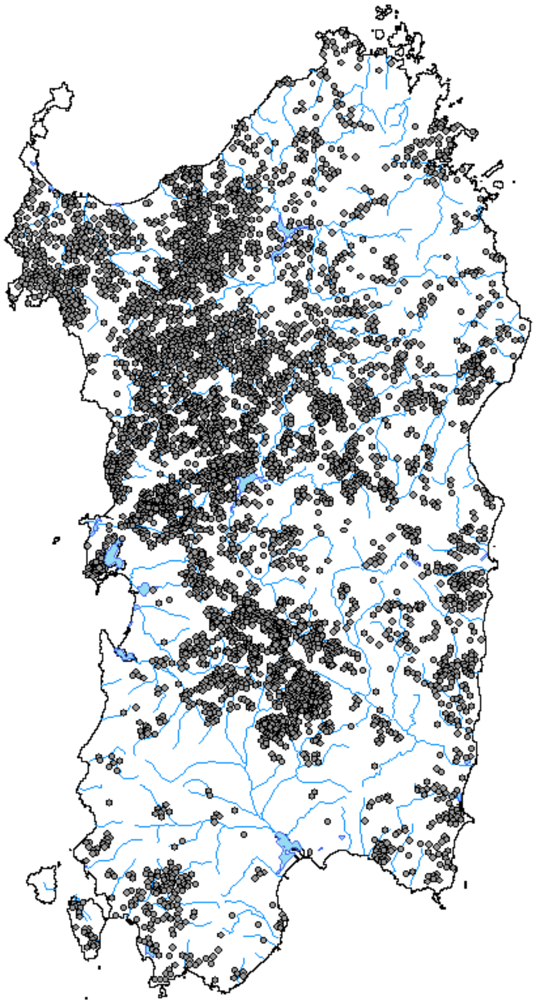

Figure 3.1. Map of known nuraghi on the island of Sardinia

construction as well as urban sprawl. While it is true that Nuragic architecture changed over time, there is no evidence to suggest a significant abandonment of nuraghi as a result of new construction. Hence it is possible to assume that most of the structures were occupied, at least sporadically, throughout most of the Nuragic period (ca. 1600-510

B.C.). For these reasons this study is still capable of making inferences about ancient behavior.

Results

The map was scanned and subsequently brought into GIS by georeferencing the image (Figure 3.1). Georeferencing refers to defining the physical space a map occupies, and giving it coordinates. The attribute table of the points and their coordinates was exported as a text file and brought into R for a k-means analysis. The optimum number of island-wide clusters was determined by examining Figure 3.2, which shows the within-cluster sum of squares over a range of possible solutions from one to fifteen. This range is displayed because it best illustrates where there is a deviation, or elbow, in the rate of change in the sum of squares at the number seven, thus indicating that this is the optimum number of clusters (Everitt and Hothorn 2006). Each point was assigned membership to one of the clusters using the “kmeans” function in R, and GIS was used to portray the results (Figure 3.3). However, it must be noted that point patterns characterized by a number of high-density clusters interspersed between empty space may not be the most appropriate for the k-means function (Conolly and Lake 2006). It is difficult to determine if this is the case for the Nuragic period, although with a cursory examination of the points it is clear that there are areas with few to no points which delineated cluster boundaries.

Kernel density analysis provided further insight by identifying regions of significantly high and low point density using a 95 percent confidence interval. The entire island was used as the study area since this is the extent of the distribution of the nuraghi and would thus be the relevant area in which to address archaeological questions.

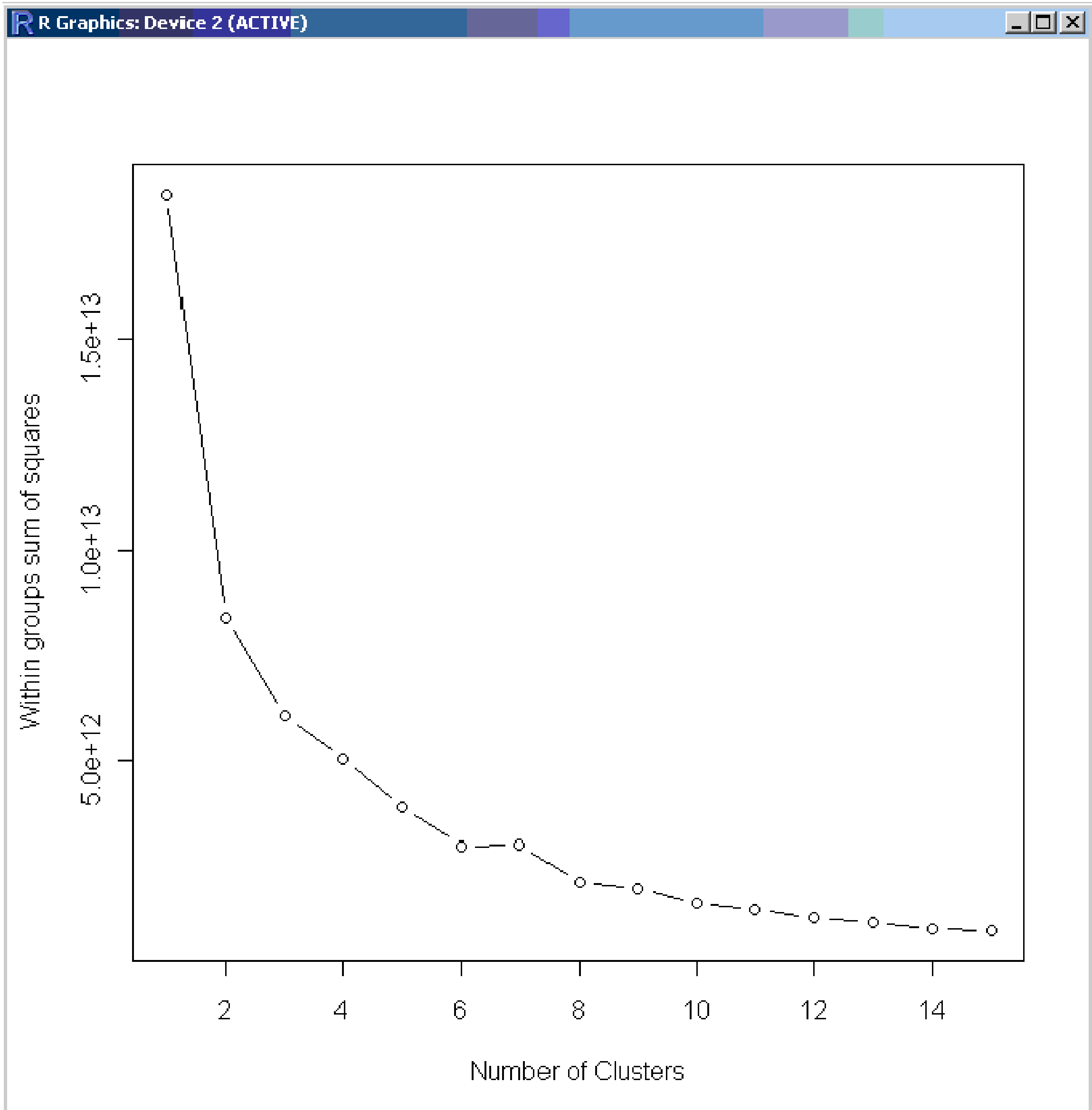

Figure 3.2 The k-means within-cluster sum of squares over a range of possible solutions

Although the study area is relatively large, a bandwidth of 5 km was used. This means that areas of high or low point density are determined based on a 5 km radius surrounding each point. This complements the relatively large cluster detection area of the k-means

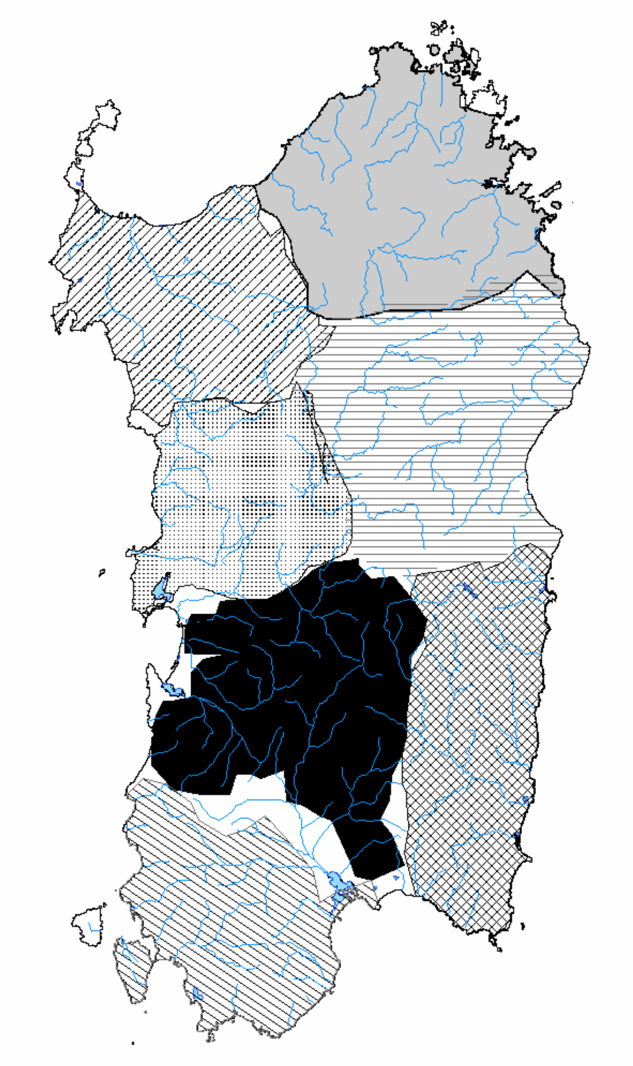

Figure 3.3. Distribution of the seven optimum clusters (colors are arbitrary)

analysis. The results are shown in Figure 3.4 where the high density hot zones are darkly shaded and the low density cold zones are lightly shaded.

It is possible that the hot and cold areas are distributed based on geographic features such as elevation or slope. For example, areas with a steep slope might contain fewer sites; hence the cold areas might reflect the underlying geography and not other

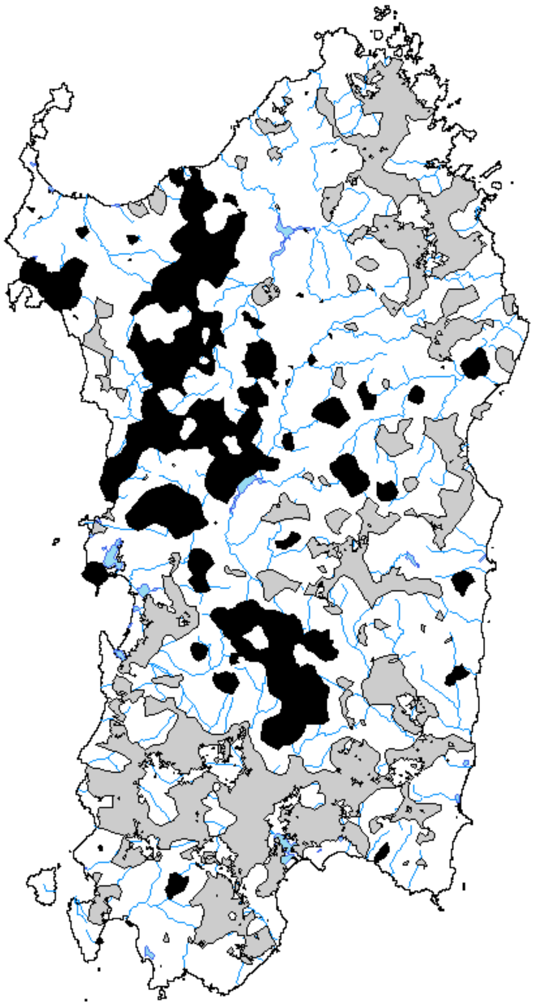

Figure 3.4. The kernel density analysis showing high (dark) and low (light) density areas

factors which would be archaeologically relevant. Kernel density estimations can control for these factors by using logistic regression to control for topographical features. Two regressions were run to see if the elevation (m) and/or slope (degrees) at all of the points could account for site distribution. Elevation and slope were determined using a 30 m digital elevation model (DEM). Since both these variables were not normally distributed, a logarithmic transformation was computed. The dependent variable was a point's status as a site. A random set of points was created using GIS, and their elevations were used as a dependent variable category. It was discovered that neither of these factors affected the distribution of the hot and cold areas based on an analysis of the coefficient of determination and a rejection of the null hypothesis at a significance level of 0.05. The p-values for slope and elevation were 0.664 and 0.636 respectively. Despite this fact, it is possible that other ecological and geographic factors could affect the distribution of hot and cold areas, and further research is necessary to truly understand the complex relationship between topographical constraints and cultural choices.

Discussion

Many elements must be considered when explaining settlement patterning, and not all of them are easily identifiable. Environmental variables that affect known site locations range from basic issues like fresh water sources, topography, agricultural productivity, and access to raw materials. On Sardinia, the lack of natural fresh water sources such as rivers and lakes made the creation of wells a necessity. The efficacy of this analysis lies in its flexibility to control for independent variables such as environmental constraints, thus allowing a researcher to more acutely hypothesize about the cultural significance of site distribution. In this study, elevation and slope were shown to have a negligible effect on the distribution of known nuraghi. Therefore, site selection was not statistically biased toward higher or lower elevation and slope. Moreover, the selection of sites was likely not biased toward fresh water sources since Sardinia's lack of natural rivers and lakes made the creation of wells a necessity

The kernel density analysis shows that the areas of highest point distribution are located in the west-central and northwestern parts of the island. This includes the area of Monte Arci, where known raw material sources, specifically obsidian, are located (Tykot 1997). Furthermore, k-mean's clusters around the Monte Arci region contained the most number of points per cluster, which corroborates with results obtained from the kernel density analysis. Access to raw materials was likely an important part of ancient site distribution.

Cultural choices unrelated to the physical environment must also be considered. Blake (2001) highlights the ideological significance of the arrangement of nuraghi and their associated burial tombs. Burial evidence seems to suggest that Nuragic peoples had at least some class structure as stated by Dyson and Rowland (2007:82), "Given their size and limited number the Giants' (burial) tombs were probably only burial places for the elite." However, the material evidence must be placed into a larger context. Human agency employs material culture meaningfully, thus architecture orders the environment into a landscape with meaning (Vavouranakis 2006). Therefore, burial tombs could have been seen as the conceptual and physical boundaries of ancient territories. If these boundaries changed over time, one would expect the earliest proto-nuraghi of the Middle Bronze Age to be patterned differently than the later complex multi-towered nuraghi and their associated defensive structures (Webster 1996). Future studies would benefit from an analysis which distinguishes between simple and complex architecture. Moreover, an additional k-means analysis in each of the seven regions would bring the scale of clustering down to a level more in line with burial placement. This would allow more context-specific interpretations to be formulated.

Territoriality is commonly regarded as a characteristic feature of the Nuragic period and has been suggested to be evidence of the beginning of a chiefdom-level society (Bonzani 1992). Moreover, Webster (1996) has suggested that the Nuragic political landscape was composed of a three-tier hierarchy of control based on ethnographic correlates and an analysis of the size and complexity of nuraghi. The site clustering identified in this research supports the possible presence of separate polities and regional centers, and/or a localized distribution of resources (Roberts 1996). The political and economic structure of the Nuragic likely consisted of a number of loosely structured polities or economic centers controlled by emerging elites. While such claims may be too simple to explain a complicated entanglement of features, these results provide precedence for a more in-depth analysis of island-wide political and social relationships, which will be addressed later through an analysis of one aspect of the Nuragic economy, specifically obsidian exchange.

Chapter 4: Obsidian Sourcing Methods

This chapter introduces the methods utilized by archaeologists to determine the provenance (source) of obsidian artifacts. Determining the source of raw material used in the creation of artifacts is useful for archaeologists interested in reconstructing ancient human mobility, trade networks, and economic systems. A number of artifacts from several Nuragic sites are analyzed to determine if obsidian exploitation during the Nuragic differred from earlier time periods.

Determining Provenance

To identify the source of obsidian artifacts, several methods are available. The most cost-efficient method is visual inspection. Some obsidian sources can be distinguished based on an artifact's color, transparency, and presence of phenocrystic inclusions. Additional methods include calculating the artifact's density and comparing it with known measurements. Figure 4.1 shows an example of how density measurements can distinguish between several western Mediterranean obsidian sources. Non-elemental analyses such as fission tracking and isotope analysis have also been shown to be effective in obsidian sourcing (Badalian et al. 2002; Gale 1981). The fourth option is elemental analysis. This method is the most precise and accurate, but several assumptions must be tested. One or more of the elements tested must be homogenous within the source as well as statistically different from any other source (Tykot 2003). If these

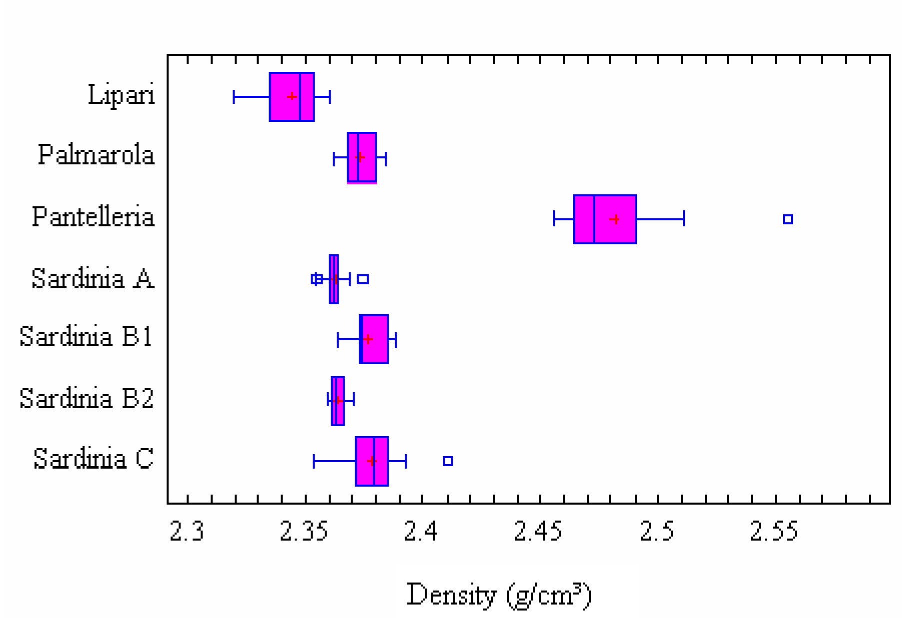

Figure 4.1. Density measurements capable of distinguishing between several western Mediterranean obsidian sources (adapted from Tykot 2004:31)

prerequisites are met, then a choice must be made as to the appropriate type of analysis to be used. Factors such as time, cost, size of the artifact, and destructiveness of the analysis must be considered. A variety of elemental analysis options are available including instrumental neutron activation analysis (INAA), proton induced X-ray/gamma ray emission (PIXE/PIGME), inductively coupled plasma spectroscopy (ICP-S), ICP mass spectrometry (ICP-MS), scanning electron microscope (SEM) with energy dispersive spectrometry (EDS), electron microprobe with wavelength dispersive spectrometry (WDS), and a variety of XRF instruments.

X-ray Fluorescence

At the heart of XRF technology is the principle that primary X-rays shot at a sample create vacancies in the atoms on the surface of the material which produce secondary, or fluorescent, X-rays which are characteristic of the elements of which it is composed (Pollard et al. 2007). Figure 4.2 shows an atom with its various electron shell layers. This is where these vacancies are created. It differs from other elemental analyses in that it is capable of recognizing trace elements, a distinction critical to the sourcing of obsidian since different obsidian sources contain different trace elements related to its initial volcanic formation. However, XRF is by no means limited to obsidian sourcing; it is also useful in the study of metals, glass, and ceramics. Since it is non-destructive, it is especially useful for archaeologists.

For this study, a Bruker Tracer III-V portable XRF machine (Figure 4.3) was used to source 344 artifacts from the Marghine region: 242 from Duos Nuraghes and 102 from Nuraghe San Sergio, Nuraghe Serbine, and Nuraghe Urpes. An additional 144 artifacts from Ortu Còmidu were also sourced. These artifacts are owned by the archaeological superintendency of Sardinia and were analyzed in the archaeological lab on the University of South Florida campus in the spring of 2009. Permissions for analysis were granted to Dr. Robert Tykot. Previous destructive analyses, specifically obsidian hydration dating, were conducted on the artifacts from the Marghine region by Stevenson and Ellis (1998) as can be seen in Figure 4.4.

A filter placed directly into the machine enhanced results for certain trace elements (Rb, Sr, Y, Zr, Nb) already shown to be significant in Mediterranean obsidian sourcing (Tykot 2010). The artifacts were placed on the top of the machine and x-rayed for a period of three minutes. While the immediate display on the computer screen (Figure 4.5) showed obvious differences between samples, the raw analytical data were calibrated against standard reference materials to come up with actual concentrations.

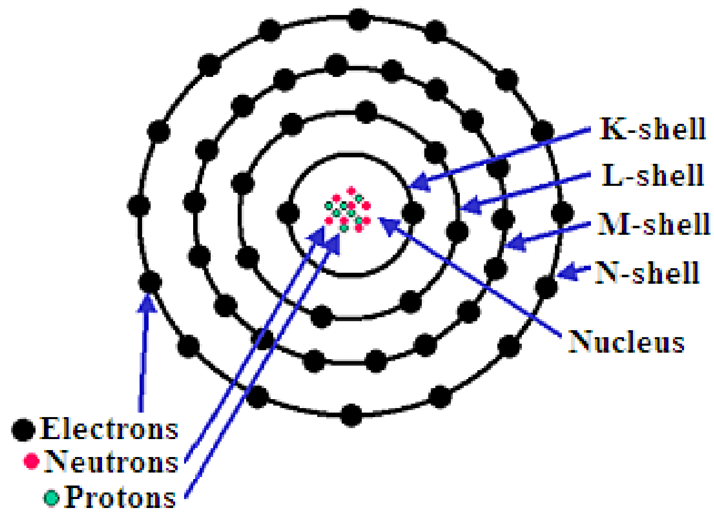

Figure 4.2. An atom with multiple electron shell layers (adapted from Griffiths 2003)

Figure 4.3. A Bruker Tracer III-V portable XRF machine (photo by Robert Tykot)

Figure 4.4. Some examples of Nuragic obsidian artifacts from Duos Nuraghes (note sections missing as a result of obsidian hydration dating (Stevenson and Ellis 1998)) (photos by Robert Tykot)

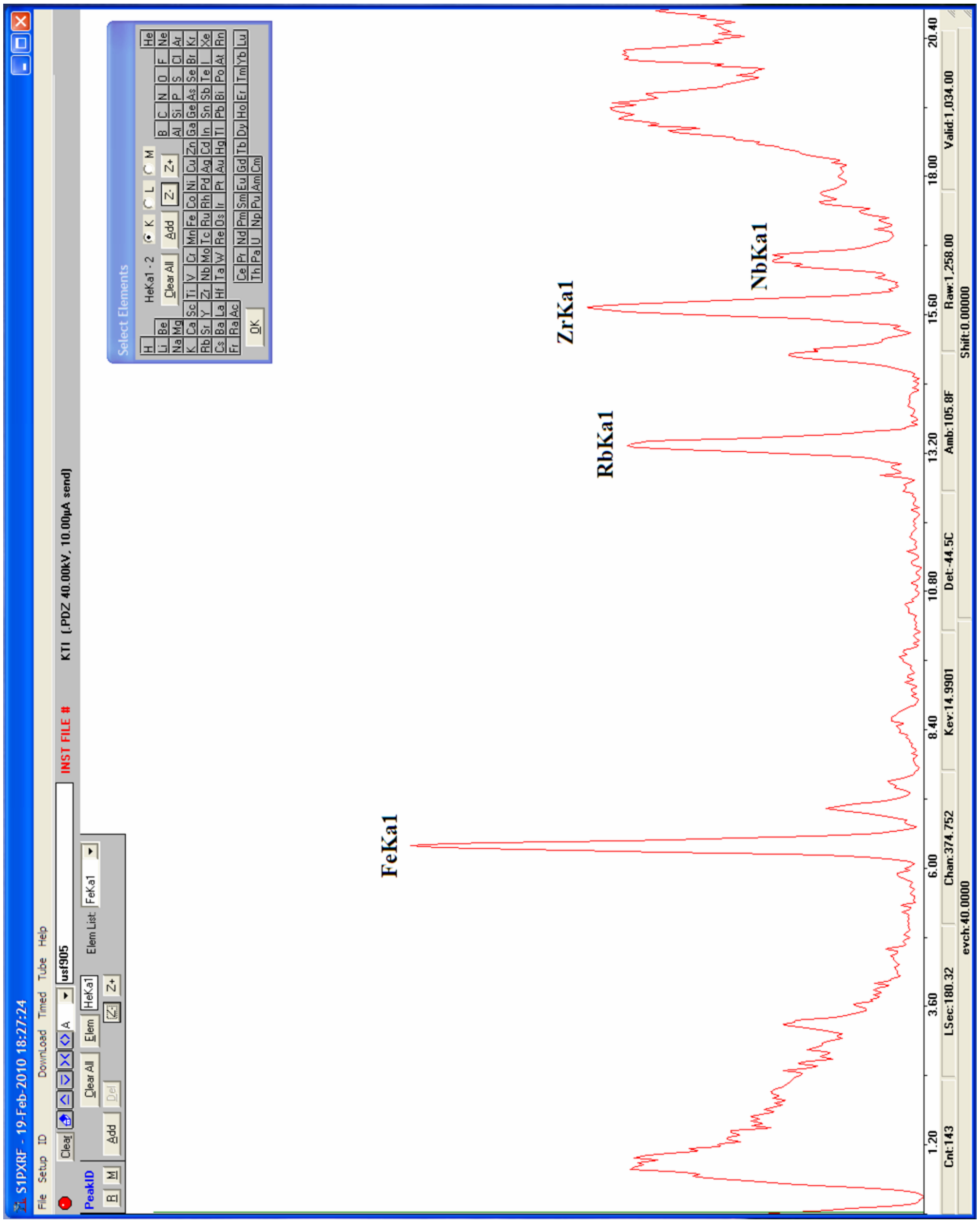

Figure 4.5. Sourcing results showing the peaks for the various elements present in sample USF 905

The results were ultimately compared with known geological samples by creating graphs depicting the elemental ratios of rubidium and strontium to niobium, just one way to "visually" match obsidian artifacts with geological samples.

Chapter 5: Sourcing Results and Discussion

This chapter presents the results obtained from XRF analysis and integrates these data within the larger picture of Sardinian prehistory. It also expands on previous Nuragic obsidian sourcing by Michaels et al. (1984). It will be shown that Nuragic obsidian exploitation differs from that of earlier time periods, a conclusion which has broader economic and social implications.

Nuragic Period Obsidian Results

Overall, the pattern of obsidian acquisition is roughly similar at all of the observed sites. At Duos Nuraghes, type SA obsidian accounts for 14.5 percent of the assemblage, type SB1 is represented by just one artifact (0.4 percent), type SB2 7.9 percent, while type SC dominates at 77.2 percent (Figure 5.1). This pattern reemerges at the other sites in the Marghine region, with type SA accounting for 13.7 percent of the assemblage, type SB2 is represented by 10 artifacts (9.8 percent), while type SC dominates at 76.5 percent (Figure 5.2). At Ortu Còmidu, type SA actually accounts for more of the overall assemblage at 33.1 percent, type SB2 is represented by just one artifact (0.7 percent), while type SC dominates at 66.2 percent (Figure 5.3). One must note Ortu Còmidu's close proximity to the SA subsource which could explain its larger abundance. Moreover, secondary SC obsidian deposits identified by Lugliè et al. (2006) are in close proximity to Ortu Còmidu. However, it is difficult to assume that the SC

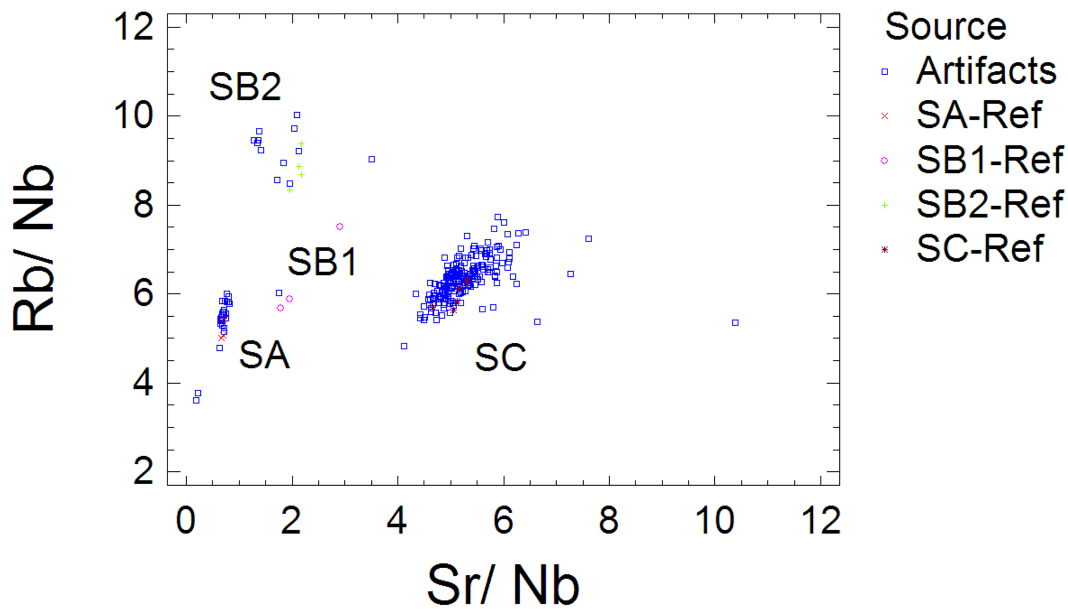

Figure 5.1. Plot of Rb/Nb versus Sr/Nb at Duos Nuraghes (geological reference materials shown)

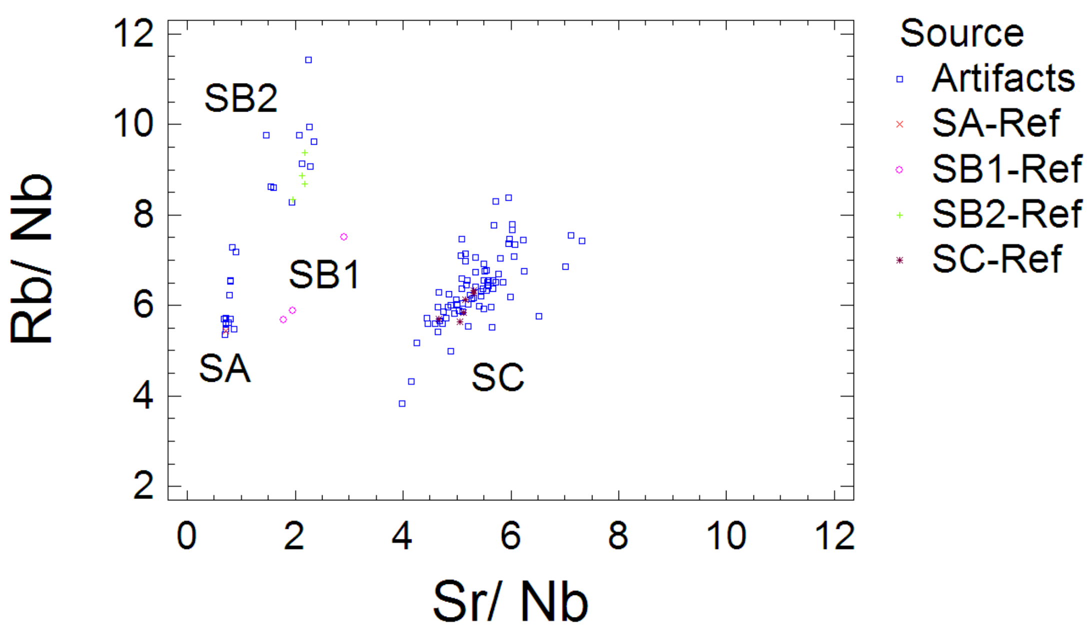

Figure 5.2. Plot of Rb/Nb versus Sr/Nb at Nuraghe San Sergio, Nuraghe Serbine, and Nuraghe Urpes (geological reference materials shown)

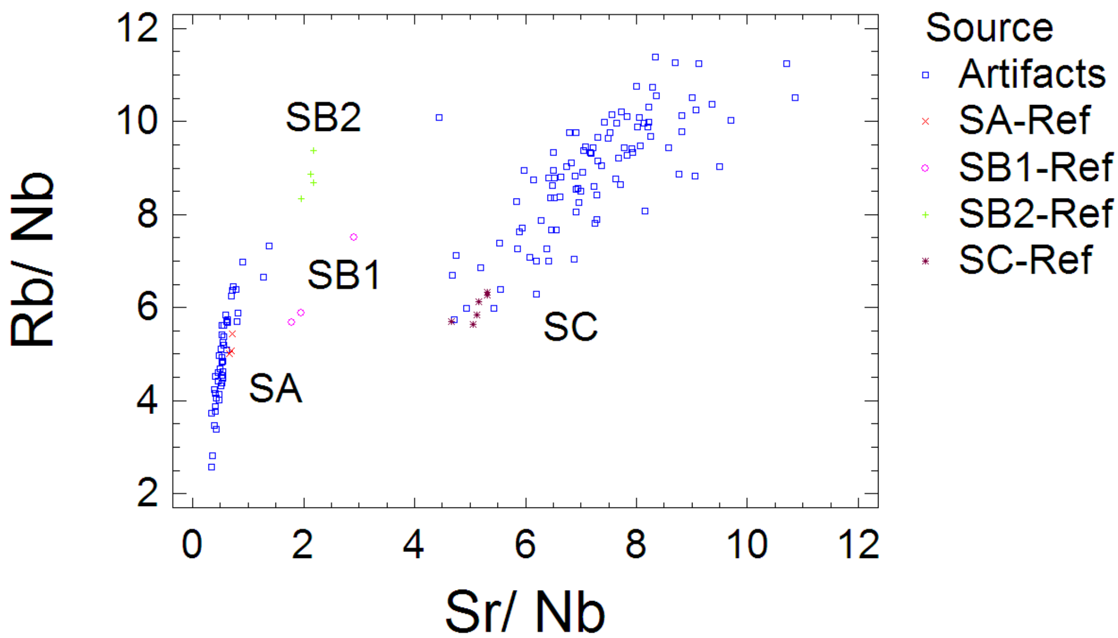

Figure 5.3. Plot of Rb/Nb versus Sr/Nb at Nuraghe Ortu Còmidu (geological reference materials shown)

subsource dominates the assemblage only because of its location, not when all other Nuragic sites in this study display the same pattern.

In general, type SC obsidian overshadows other subsources in the composition of these Nuragic assemblages. Type SB1 and SB2 were not a significant source of raw material while type SA is the second most common, comprising upwards of one-third of an entire assemblage. Similar studies on obsidian at other Nuragic sites carried out by Michels et al. (1984) support these findings (Figure 5.4), but one must note the low number of artifacts sourced at these other sites.

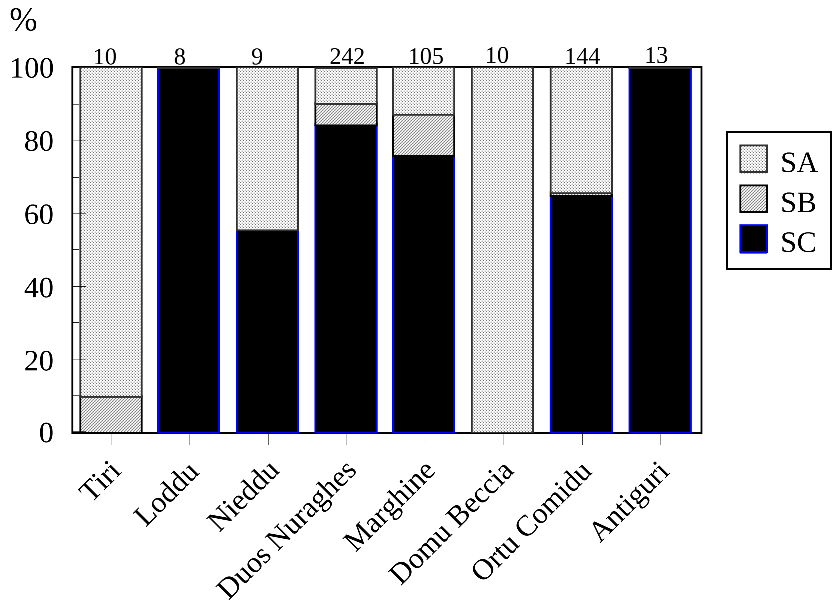

Figure 5.4. Obsidian source distribution at other Nuragic sites (adapted from Michaels et al. 1984)

Pre-Nuragic Obsidian Exploitation

During the Neolithic, trade of Sardinian obsidian extended throughout the central-western Mediterranean (Figure 5.5) and was an important part of the ancient economy (Tykot 2002). The degree to which obsidian exportation was controlled by Sardinian residents is open for debate. It must certainly be expected that residents in the vicinity of Monte Arci were those mainly responsible for acquisition and primary reduction of the obsidian, followed by transport and exchange outside of the Monte Arci region. There is also no evidence that trade with the mainland was frequent enough to significantly affect local economies. What is curious is that these external obsidian trade networks did not continue into the Bronze Age. Regardless, the general pattern of Early to Middle Neolithic obsidian exploitation on Sardinia, and the nearby island of Corsica, demonstrates a larger variety of obsidian sources being used than during the Chalcolithic

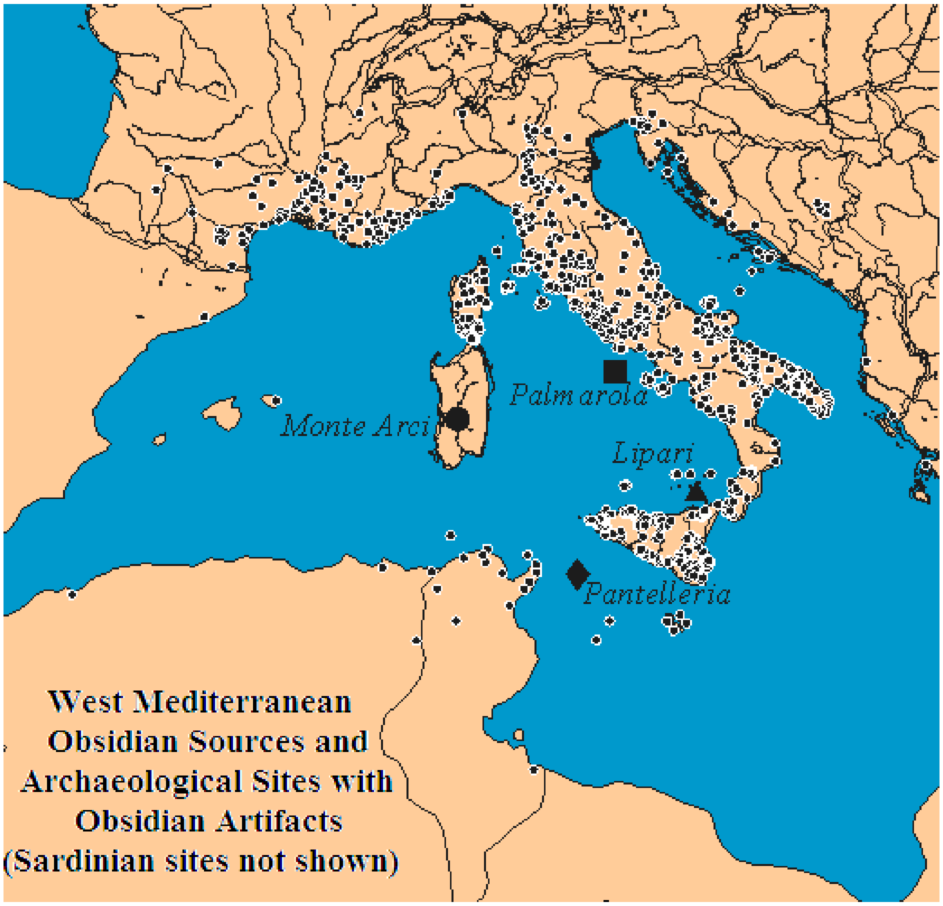

Figure 5.5. Mediterranean sources (polygons) and Neolithic archaeological sites (dots); Sardinian sites not shown (adapted from Tykot 2002:619)

and Nuragic. In particular, the SB subsources were utilized in much greater abundance, while type SA was also much more common (Tykot 1996). Figure 5.6 shows the distribution of Early Neolithic obsidian exploitation at archaeological sites throughout Sardinia. By the Late Neolithic, type SC obsidian begins to predominate at many archaeological sites, although it is not until Chalcolithic and Nuragic times that the SC subsource shows up in statistically higher quantities (Tykot 1996).

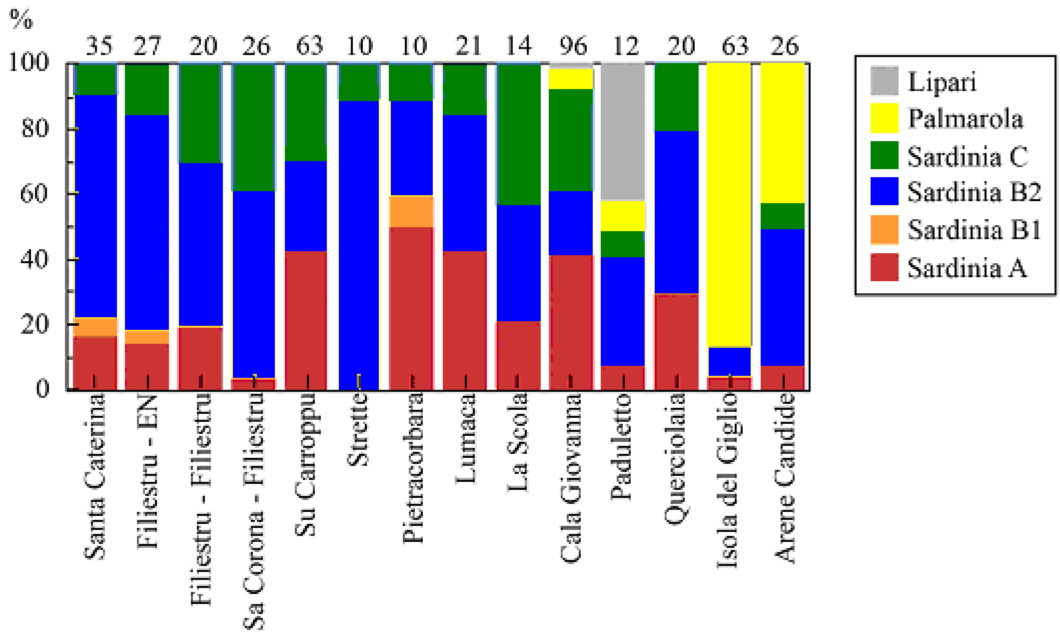

Figure 5.6. Early Neolithic obsidian exploitation in Sardinia (adapted from Tykot 2007:220)

Exchange Networks

It has been argued that down-the-line obsidian trade was the dominant mode of raw material acquisition for Neolithic peoples in Sardinia because of the broad geographic similarity in the purposes of obsidian usage and in the socio-economic circumstances in which it occurred (Tykot 1996; 2003; Tykot et al. 2008). Down-the-line trade is defined as a mode of exchange in which residents close to a raw material source traded goods with those within their immediate contact zone, thus passing these goods through several hands before the artifacts are eventually discarded (Smith 1987). Since this model necessitates cultural interaction, the exchange of obsidian can be seen as a unifying mechanism which maintained an insular cohesiveness embedded in reciprocal trade. This does not mean that residents of a particular village had any knowledge of people elsewhere on the island or even a knowledge of where the obsidian quarry was located. It is just that those residents close to the quarry, who were responsible for primary reduction, were engaged in activities which resulted in the pattering of the archaeological record. There appears to be no evidence that this model of obsidian acquisition changed from Late Neolithic to Nuragic times. There is, however, a change in the quantitative distribution of the obsidian subsources, resulting in the dominance of the SC subsource towards the end of the Neolithic and continuing into Nuragic times. This corresponds with the development of SC reduction workshops located at the quarry, which can be seen by the high levels of standardized primary reduction (Figure 5.7) revealed by survey and excavation in the Sennixeddu area on the east side of Monte Arci (Tykot et al. 2006). These reduction workshops created standardized core blanks (Figure 5.7) which could be easily transported and reduced later. Stone tool standardization has been shown to indicate a competitive industry, possibly requiring a regulatory control over the raw material (Torrence 1986:44). It is therefore plausible that an increased control of access at the quarry site, as seen at Sennixeddu, could have led to a trickle-down effect into larger spheres of interaction, thus resulting in the widespread dominance of one type of obsidian.

Similar situations have been analyzed at sites such as Teotihuacan in Mexico. Santley (1980) outlines a multi-step process of increasing economic and political complexity beginning with local elites managing part-time craft specialty activities, and then increasingly limiting access to the quarry site, eventually leading to a state-managed, vertically integrated monopoly. This model addresses the issue from a formalist perspective using Marxist principles (Marx 1977). While it is true that material culture relates to the rise of ideological configurations, fields of discourse, attendant and

Figure 5.7. Primary reduction revealed by survey and excavation in the Sennixeddu area on the east side of Monte Arci (photos by Robert Tykot)

contingent upon structured economic principles (Foucault 1979), this model fails to account for the fact that non-western societies operate under different economic principles than traditional western societies (Sahlins 1972).

Instead of arguing for any predetermined relationship between structures of power and particular contexts of action, namely controlling obsidian distribution, it is more appropriate to examine how the relationship between structure and context is set in motion by human action (Hodder 1989). It is plausible that emerging elites in the vicinity of Monte Arci used obsidian exchange as a way to create, solidify, and reify their power.

The entire situation corresponds well with the results obtained from the spatial analysis, which demonstrates the possible existence of multiple Sardinian territories controlled by local elites. Obsidian exchange could have been just one context in which these elites established power. If Bronze Age obsidian exchange was the only context for establishing power, then one would expect to find the most extravagant nuraghi in the proximity of Monte Arci, if it can be assumed that elites expressed their power through architecture. This is not the case; there are multiple regional cores with multiple peripheries likely with a variety of economic and social structures.

Regardless of the structure of the Nuragic economy, this changeover to the dominance of SC obsidian could have led to changes in the reduction strategies employed throughout the island which can be quantified by typological analysis, although causal relationships may be difficult to determine. It may be better to consider this relationship as a dialectic between raw material acquisition and its ultimate reduction for use. Nevertheless, this can be studied through typological investigation.

Chapter 6: Typological Methods

This chapter introduces the methods which were utilized to classify and analyze the same artifacts which were sourced using XRF. The measured attributes are capable of determining the reduction strategies employed on the artifacts. In this way, it is possible to correlate an artifact's provenance with how it was knapped.

For this study, a total of 413 obsidian artifacts were classed into types and then analyzed. This included 228 artifacts from Duos Nuraghes and 71 from the other sites in the Marghine region. An additional 114 artifacts were analyzed from Ortu Còmidu. It must be pointed out that the number of artifacts which were chemically sourced is larger than the number of artifacts being typologically analyzed. This is due to the fact that some artifacts were too destroyed to be properly measured as a result of undergoing obsidian hydration dating. This destruction may have prohibited a typological analysis, but it did not preclude analysis using XRF.

Artifact classification is a necessary component of archaeological investigation. In lithic studies, it has usually taken the form of typology creation. Archaeologists must invariably create typologies which allow pertinent questions relevant to their research to be answered. Dibble (2008:87) defines a typology as "a classification of lithic objects according to various criteria, most often morphological ones." Morphological classification schemes are easy to create and are based on the recognition of certain attributes common to all forms. The choice of attributes can be related to the perceived function of the artifact or they can be value-free measurements predicated on the recognition of certain features. Lithic assemblages are typically composed of two material types: tools which display some sort of intentional shaping or retouch and the debitage fashioned during the process of knapping. Often, the presence of highly formalized tools characteristic of many hunter-gatherer societies has left many archaeologists unaware of the explanatory potential of debitage analysis. Indeed, many sedentary communities have used stone in an ad hoc manner, expediently producing large amounts of debitage and informal retouched tools. This should not deter researchers from attempting to examine the social and functional components of these artifacts (Andrefsky 2001). The sites for this study offer an exceptional opportunity to examine Nuragic lithic assemblages with suitable provenience, thus making it possible to use debitage analysis to explore a myriad of issues. For purposes of this survey, only the obsidian artifacts have been analyzed because of the ability to correlate morphological attributes with source data gleaned from the use of XRF technology.

Relevant Typology

The process of debitage analysis described in Sullivan and Rozen's (1985) article has been utilized to reconstruct ancient residential patterns, socio-political organization, and to identify typological changes through time and space. These data have been subsequently incorporated into the broader understanding of cultural, social, and political aspects of Nuragic culture. This typology attempts to avoid a priori presumptions about the artifacts in order to reduce any biases introduced by the researcher. The crucial conceptual power of this typology is the ability to distinguish between core reduction and tool production based on the varying proportions of debitage categories, thus allowing comparisons to be formulated. Tool production refers to the manufacture of tools through flaking, while core reduction refers to the process of flake removal for the purpose of the acquisition of the detached pieces (Andrefsky 2009:66). Tool production is recognized archaeologically by the presence of a large percentage of broken flakes and flake fragments compared to the number of cores and complete flakes. The inverse is true of core reduction (Sullivan and Rozen 1985). Assemblages were divided into several categories: retouched tools, proximal flakes, medial flakes, distal flakes, and angular waste. Retouched tools were further subdivided into shaped and unshaped tools, backed tools, and blades. Unshaped tools were distinguished from shaped tools by the recognition of a striking platform as well as by evidence of the original shape of the flake from which it came. The shape of a flake becomes indistinguishable when there is a significant amount of retouch, and thus a significant energy output into the fashioning of a tool. One will note that the debitage categories are slightly different than those outlined by Sullivan and Rozen (1985), and further classify flake fragments into medial and distal categories (Figure 6.1). Broken flakes are classified as proximal flakes, thus allowing for additional analyses which can account for post-depositional processes such as flake breakage as a result of trampling. A complete list of attributes which were measured for purposes of this study are included in Appendix C. One will note the subjectivity of some of the attributes with regard to an artifact’s shape, but they were included to give a general description of the morphology of an artifact. Additional site formation processes must also be considered.

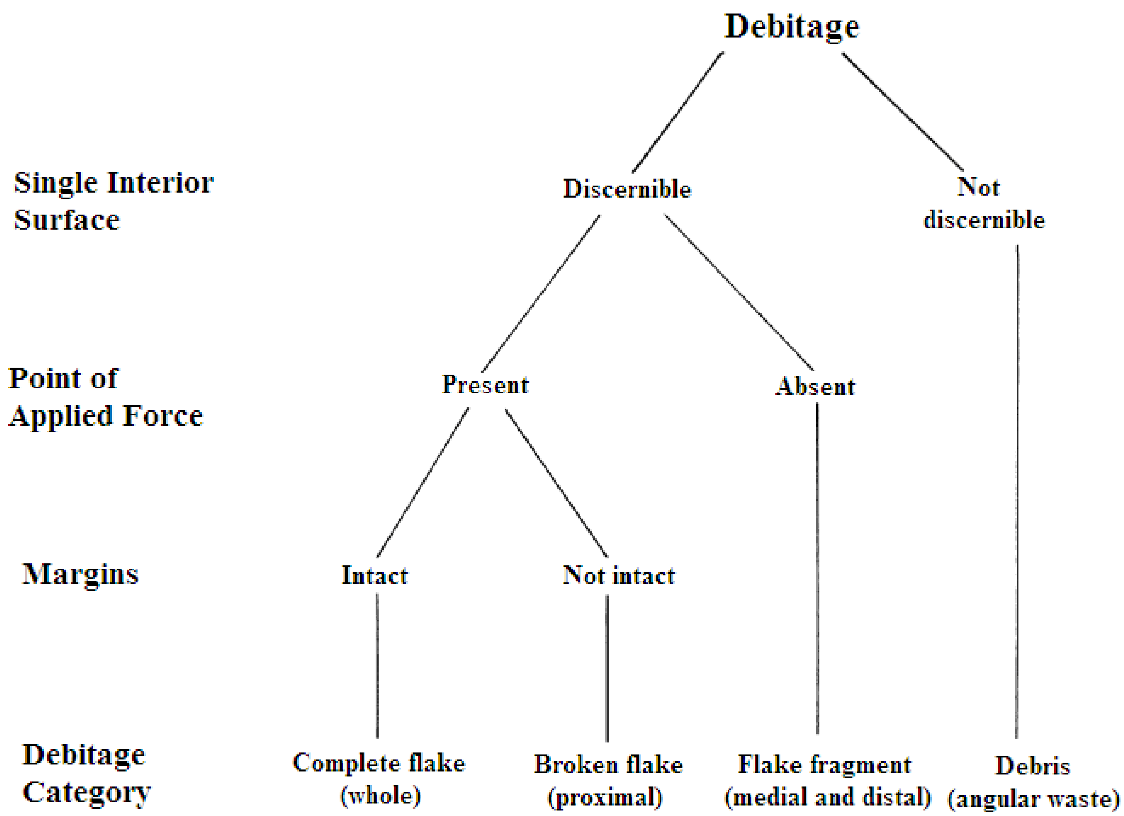

Figure 6.1. Debitage classification scheme (adapted from Sullivan and Rozen 1985:759)

Chapter 7: Typological Results and Discussion

This section presents the results obtained from typological analysis and integrates these data with obsidian source information obtained through XRF. Appendix D displays the raw data from the pieces that were both sources and classified. It is shown that the reduction strategies employed by Nuragic peoples are quite different from those of earlier time periods. These typological differences correspond with changes in the obsidian sources being exploited. Several theories are put forth as to the causes of these modifications.

Depositional Processes

All archaeological sites are influenced by depositional processes which affect the overall constitution of recovered material. This is certainly the case for Nuragic sites in Sardinia. The abandonment of an area is a crucial factor to acknowledge when discussing artifacts from an archaeological site. The nature of the abandonment event and the reasons behind it can be numerous, but two issues must be considered: whether or not the event was expected and whether or not return was anticipated. These two factors can affect the types of artifacts which are recovered. If abandonment occurred unexpectedly or return was anticipated, one is likely to find artifacts of social and sentimental importance, not just the refuse left behind as would be expected under planned abdication (Deal 2008). Additionally, the cleanup of lithic material by past peoples is an important part of ancient life. It should not be a surprise that people of the past cleaned up the garbage which accumulated over time. Intensely used domestic areas are more likely to undergo cleaning than elsewhere. The size of a tool will also affect its probability of entering the record; smaller pieces are more likely to elude clean up (Keeley 1991). Regardless, these factors do not preclude one from making accurate interpretations about the makeup of a lithic assemblage, nor should it deter one from using this information to draw conclusions.

Integration with Previous Analyses

To appreciate Nuragic lithic technology, it is useful to juxtapose it against the comparatively formalized lithic assemblages and large-scale trade networks typical of the earlier Neolithic. Studies indicate that the Neolithic saw a shift in reduction strategies more oriented towards blade and microlith production. Arrowheads, axes, and a small number of lunates are also found (Trump 1984). Geometric retouched pieces in the form of burins and scrapers dominated the assemblages (Lugliè et al. 2006a; 2006b; 2008). These types of artifacts were created using a tool production strategy, a subtractive process in which a core eventually becomes one tool. Although the debitage from the creation of these tools has not been analyzed, the presence of tools not created from flakes inherently makes their creation the result of a tool production strategy.

The number of studies examining Chalcolithic lithic technology is especially low. This is ostensibly due to the lack of carefully dated sites with a suitable number of Chalcolithic obsidian artifacts which would warrant a typological analysis. Based on the few descriptive analyses that have been conducted, it is known that Chalcolithic assemblages were dominated by the presence of blades and leaf-shaped arrowheads, a pattern which is not significantly different from that of Neolithic times (Melis 2000). However, another artifact is also prevalent, the lunate. Melis (2000) does not use the term lunate, but describes an artifact which is elliptical in shape, with a plano-convex or trapezoidal cross-section.

A study of Nuragic lithic technology at Ortu Còmidu was carried out by Hurcombe (1992) and is one of the few analyses of its kind. Morphological divisions initially separated the retouched tools into several categories including lunates (Figure 7.1). Use-wear analysis on the lunates, which I shall refer to as backed tools, indicated that the ultimate function of these tools was the scraping of plant material. Interestingly, both the backed edges and the acutely angled edges opposite the backing also displayed traces of use-wear. This would seem to run counter to previous interpretations which suggested that these artifacts were hafted, and thus indicative of the presence of composite tools. Andrefsky (2005) defines backing as the intentional dulling of an edge either by chipping, grinding, or abrading. Interestingly, 11 of the 12 backed tools at Ortu Còmidu contain their backing on either the distal or lateral margins. This differs from sites in the Marghine region in which nearly all backed tools contain backing on the proximal end. Regardless, it is clear that this tool form was common throughout the island in the Nuragic period. All of the studied lithic assemblages are also similar in the lack of blades. Under the traditional definition of blade technology, an artifact's length perpendicular to the striking platform must be twice as long as its width (Bar-Yosef and Kuhn 1999). Only two retouched blades were discovered from Duos Nuraghes, one from Serbine, and one from Ortu Còmidu.

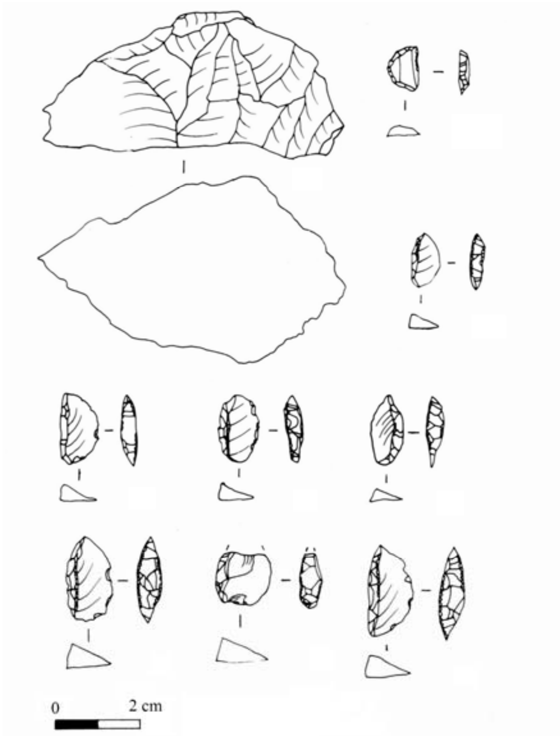

Figure 7.1. Examples of lunates from Ortu Còmidu (adapted from Balmuth and Phillips 1986:388)

At Duos Nuraghes, there is a broad distribution of backed tools. Nine of the 17 structures, including the nuraghi, contain backed tools, and 14 of 17 contain unshaped tools. This would seem to negate the existence of lithic craft specialization. Additional evidence for the lack of craft specialization is expressed by the distribution of artifacts throughout the site (Figure 7.2). All of the structures display a broadly similar collection of artifacts. None of the structures contain an inordinate amount of debitage, cores, or other artifacts which would indicate specialization. The residents of Duos Nuraghes, including those of the nuraghi, seem to be responsible for their own lithic needs. Moreover, the reduction strategies employed throughout the sites are generally consistent

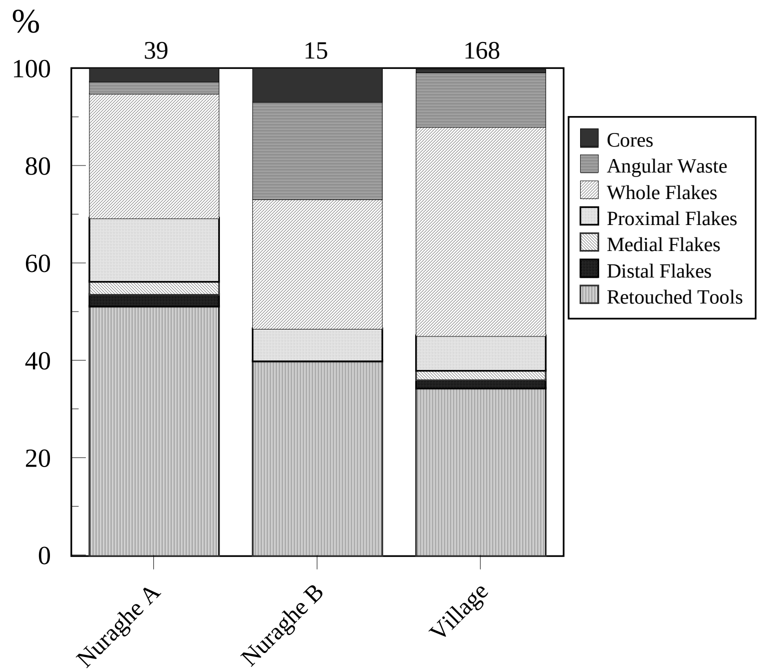

Figure 7.2. The distribution of artifacts at Duos Nuraghes

(Figure 7.3). Core reduction seems to be the preferred reduction strategy at all of the sites, with complete flakes making up an average of 40 percent of the assemblages. The relatively low number of cores may also indicate that primary reduction occurred at the quarry site or else depositional processes such as the throwing out of used cores may have affected the makeup of the assemblages.

Another study from Nuraghe Urpes and Nuraghe Toscono suggests that obsidian artifacts were used for a range of cutting and scraping activities (Michels 1987). Michels goes as far as to classify these artifacts into categories such as rasp-end, concave, and straight-edged scrapers. It is, however, overly simplistic to classify artifacts as concave or straight-edged when in fact many artifacts from all of the sites display retouch on multiple edges of different shapes. The diversity of morphological attributes at Duos

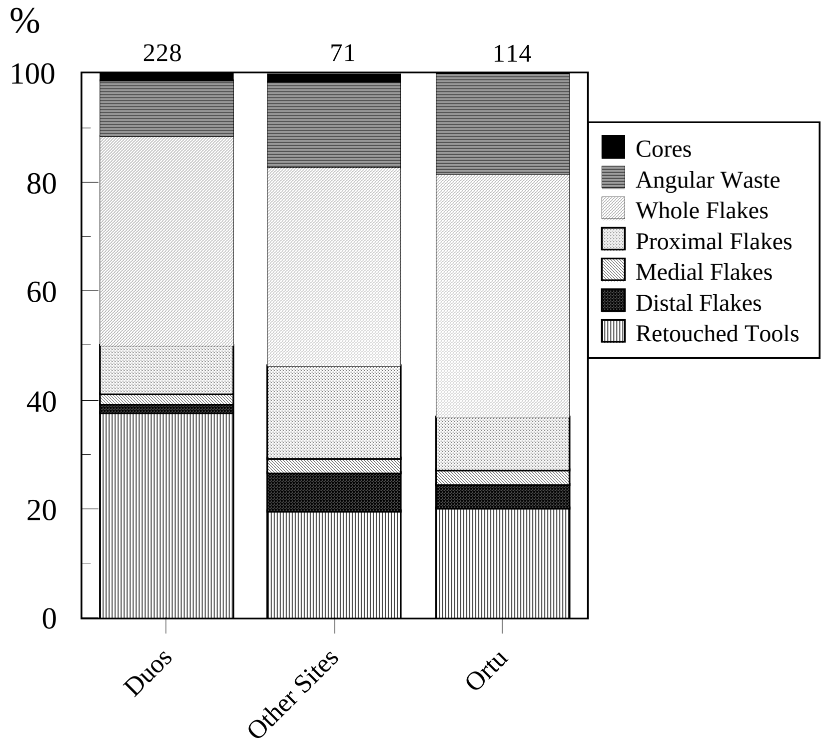

Figure 7.3. The distribution of artifacts at all sites

Nuraghes does support Michel's (1987) conclusion that obsidian was used for a number of scraping and cutting activities. Figure 7.4 displays the frequency of different retouch locations on Duos Nuraghes artifacts. Unifacial retouch is the predominant class while parti-bifacial and bifacial classes are secondary. When combined, parti-bifacial and bifacial retouch frequency is nearly identical to that of the unifacial category. Platform retouch is indicative of the backed tools as discussed earlier. Retouch angles are just as diverse and range from steep to acute, likely indicating a variety of processing endeavors. This is supported by a more recent, detailed use-wear study of the obsidian assemblage from Duos Nuraghes (Setzer and Tykot 2010).

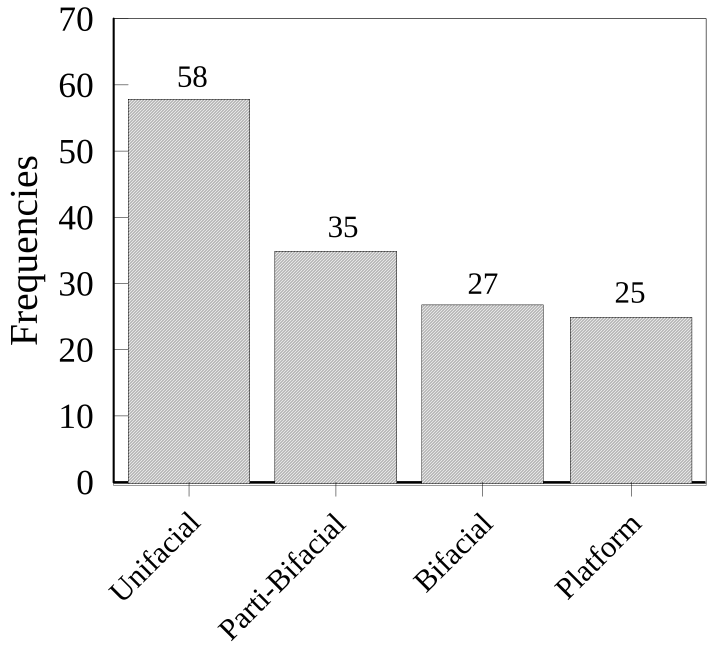

Figure 7.4. Frequency of different retouch locations on Duos Nuraghes artifacts

Unshaped tools comprise the bulk of the retouched category and were defined as tools in which the initial flake category was recognizable, whether that be a whole flake, medial flake, etc. For the comprehensively excavated sites, there are a larger percentage of unshaped tools at Duos Nuraghes (38 percent), than at Ortu Còmidu (20 percent). Moreover, the invasiveness of the retouch was measured in 2 mm increments from marginal to invasive and is shown in Figure 7.5. The decreasing frequency of retouch invasiveness is characteristic of a reduction strategy where re-sharpening and tool maintenance was not a predominant activity. It seems that cores were expediently reduced, and the resulting debitage was retouched for the task at hand.

The average size and weight of the Nuragic material also supports the core reduction interpretation. Not including the cores, the average flake length to thickness

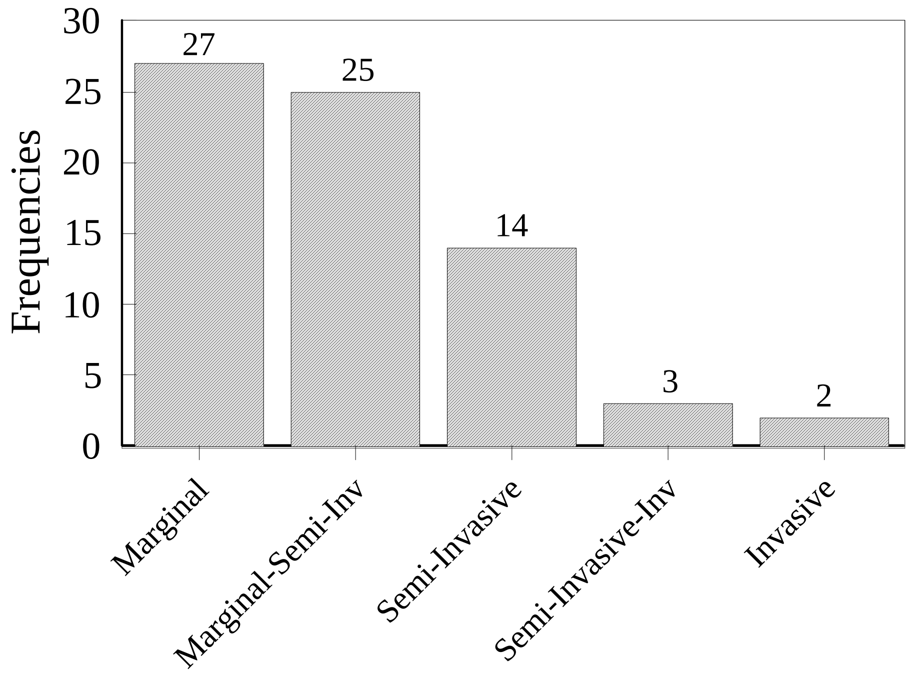

Figure 7.5. Frequency of retouched tool invasiveness at Ortu Còmidu

ratio is 3.9 while the average weight is 1.0 g. When compared to flake length to thickness ratios of formalized assemblages from Upper Paleolithic France, which range from 4 to 8, it is clear that 3.9 is rather small (Blades 2003). The lack of cores and the relatively small size and weight of the artifacts seem to support a gradual abandonment event. There is nothing to indicate that the recovered artifacts are more than refuse; no artifacts which appear to be of social or sentimental value are present. It is possible that the clean-up of domestic areas took place, which inadvertently left behind many of the smaller pieces, but the diversity of artifact types found throughout the site indicates that the lithic assemblage is a relatively complete collection of artifacts from a number of knapping and reduction events.

Explaining the causes of typological differences over time is slightly more difficult. The abundance of workable obsidian from the Monte Arci region presented ancient peoples with a choice in raw material. The art of tool production appears to have been phased out as obsidian became a secondary aspect of life, something to think about when a task needed to be completed.

The topic of causation has been addressed in a variety of ways and is central to many debates at the core of archaeological thought. While it is true that multivariate causation cannot be quantified in an absolute sense as many processualists have hoped, it should not discourage archaeologists from making inferences which are supported by the data. Renfrew (1978) provides an intriguing analysis of causation which provides the lens though which causation will be addressed in this context. Renfrew examines discontinuity in the archaeological record through an understanding of the initial conditions which set cultural change in motion. While the use of equations to quantify cultural change is premature if not outright naïve, an understanding of the initial conditions under which cultural change occurs is central to any examination of causation. This analysis attempts to recognize possible initial conditions which created social and cultural discontinuity in Sardinia. They will be divided according to direct and indirect factors.

Direct Causation

The first explanation as to the cause of the changeover to a core reduction strategy in the Nuragic relates to the quality of raw material. It is possible that the prevalence of SC obsidian required users to adapt to different reduction strategies because of its knapping quality. However, this model tends to portray individuals as unthinking in their response to outside influences. It is perhaps more appropriate to view culture change not as an unthinking response to environmental factors, but as a dialectic between an ancient understanding of the material world, conscious human agency, and the unintended consequences of human choices (Robb 2005). It is very possible that the demand for SC obsidian increased, thus coercing those near the quarry to increase its distribution, not the other way around. Moreover, the chronology does not support the notion that that the prevalence of SC obsidian required users to adapt to different reduction strategies because of its knapping quality. During the Chalcolithic, lithic assemblages still contained artifacts which were very similar to those of the Neolithic. If the increasing dominance of SC obsidian required users to adapt to different reduction strategies, then Chalcolithic assemblages should be more similar to those of the Bronze Age.

It is more plausible that an increase in plant use during the Chalcolithic and Early Bronze Age (Lai 2008) led to changes in the types of tools needed to fulfill users' needs. SC obsidian may have been preferred for the creation of backed lunates, a tool which became prevalent in the Chalcolithic and has been shown to be used for plant processing (Hurcombe 1992). This would certainly be supported by the source data from Duos Nuraghes. Twenty-four of the 25 backed tools at Duos Nuraghes come from the SC subsource. Figure 7.6 displays the breakdown of retouched artifacts by source at Duos Nuraghes.

These previous models stress the importance of materialistic conditions on the behavior of individuals and have introduced some hypothetical direct causes of lithic variation. However indirect influences must also be addressed.

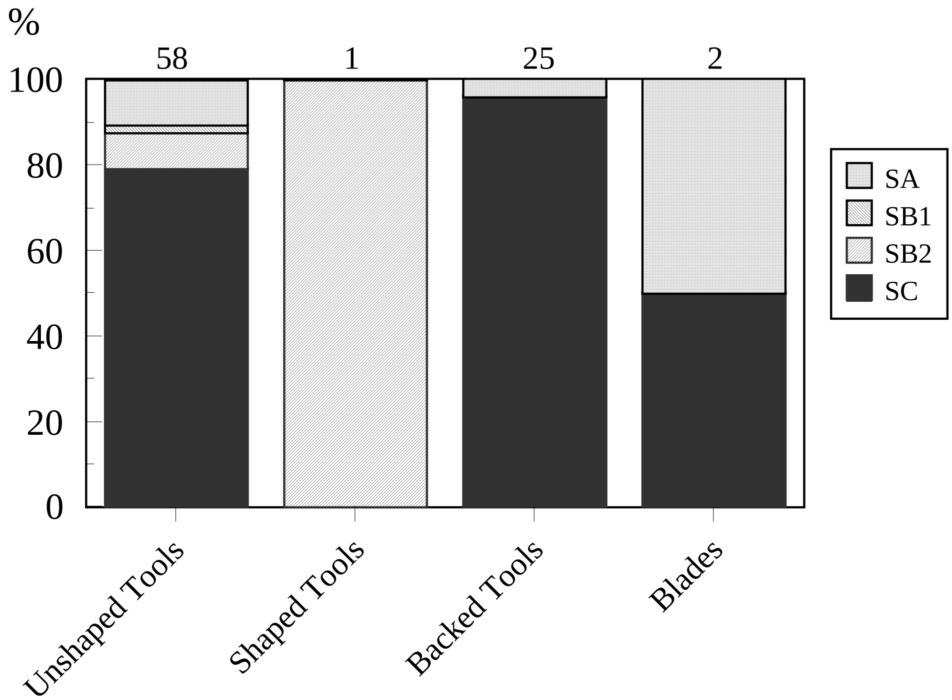

Figure 7.6. Breakdown of retouched artifacts by source at Duos Nuraghes

Indirect Causation

It must not be forgotten that the Chalcolithic is so-named because of the introduction and proliferation of metal technology. The existence of copper deposits on Sardinia is well known, however their history of exploitation is not. It is probably not until the later half of the third millennium that metallurgy becomes a part of the cultural landscape (Lo Schiavo 2000; Muhly 1973). Even then, extensive use of copper for utilitarian purposes is not supported by the material evidence and is highly unlikely. The introduction of bronze technology and the concomitant growth of metal foundries at sites such as Santa Barbara di Bauladu (Gallin and Tykot 1993) did affect how work was carried out. While metal was usually reserved for non-utilitarian purposes, there is evidence that bronze was used to create tools such as axe heads. Therefore, the introduction of a new tool medium could have led to changes in the social and cognitive importance of obsidian in the ancient mind. This is temporally supported by the less dramatic changes in obsidian assemblages when metal was not extensively utilized during the Chalcolithic. As metal was further integrated into daily life during the Nuragic, then obsidian assemblages began to be modified. Considering the offhand way in which obsidian was reduced during the Nuragic compared with the more structured lithic production of earlier time periods, it seems that obsidian became less socially important, a medium which did not warrant the extra effort required to produce elaborate bifaces and arrowheads. Metals, not obsidian, increasingly became the channel through which artistic, ritual, and some utilitarian representations manifested themselves. While obsidian did not become obsolete, it lacked its former status and ambience.

Several theories have been put forth with regard to cultural change related to obsidian typologies in prehistoric Sardinia. It must be expected that any monocausal explanation falls short of this goal in light of the complex set of circumstances which drives social change. Regardless, this research establishes a theoretical criterion capable of contributing to Sardinian archaeology.

Chapter 8: Conclusions

This research began with an introduction to the prehistory of Sardinia followed by a spatial analysis of a number of Bronze Age nuraghi found throughout the island. It was shown that both k-means cluster detection and kernel density estimations can be used in conjunction to address a variety of issues regarding the spatial distribution of points. In this study, the points represented archaeological sites, but this does not preclude an analysis of intra-site spatial distributions where artifacts represent points. It was demonstrated that the distributions of known nuraghi were affected by both environmental constraints as well as cultural choices. After controlling for environmental variables, several hypotheses were put forth as to the nature of Nuragic political and economic structure. The densest clusters were located on the west side of the island and encompassed the Monte Arci area. Access to raw materials was likely an important part of site selection. It is also likely that the clustering of sites was related to the emergence of territories, perhaps controlled by emerging elites.

This analysis was followed by an examination of obsidian lithic artifacts from five Nuragic (ca. 1600-850 B.C.) sites on the island of Sardinia. The geological sources of these artifacts were determined using XRF technology, with the results showing that the SC subsource was the dominant obsidian type which comprised all of the assemblages. This pattern of acquisition has its roots in the Late Neolithic and Chalcolithic time periods, when it is likely that part-time workshops began to emerge which were capable of supplying the entire island with raw materials through down-the-line exchange. It is possible that emerging elites used this increased control of access to obsidian as a means of solidifying and reifying their power.

Typological analysis was used to test whether this change in the composition of lithic assemblages was accompanied with corresponding changes in how the obsidian was used. It was demonstrated that Chalcolithic assemblages were very similar to those of the Neolithic, however they differed from earlier times in the abundance of backed lunates, a tool used for plant processing (Hurcombe 1992). During the Nuragic, blade technology greatly diminished as assemblages became dominated by the presence of backed lunates and expediently produced unshaped tools. Core reduction strategies were utilized as cores were flaked and the resulting debitage was selected for and further reduced according to the immediate needs. Additional evidence for ad hoc core reduction is seen in the high number of unshaped tools compared with shaped tools. These unspecialized tools were used for a wide range of activities, which is seen in the high degree of variability in the retouch locations and angles. Interestingly, there is an even distribution of lithic types throughout Duos Nuraghes, which supports the assumption that both the residents of the nuraghi as well as those of the village were responsible for their own technological demands. This also negates the presence of lithic craft specialization. Slight typological differences were evident across the island, but this could be due to the lack of comprehensive excavations conducted at sites other than Duos Nuraghes. In general however, Nuragic lithic technology is similar at all of the studied sites. It is therefore possible to accept the null hypothesis which states that changes in the acquisition of obsidian raw materials during the Chalcolithic and Nuragic in Sardinia are coupled with corresponding changes in how the obsidian was used.

The causes for this change in obsidian usage were explored on two levels, directly and indirectly. The most plausible direct cause of this change relates to changes in diet with greater emphasis on agricultural products at the beginning of the Chalcolithic and continuing into the Nuragic. This could have led to changes in the types of tools needed to fulfill users' needs, namely lunate technology. Indirect causes relate to the introduction of metal technology which could have led to changes in the social and cognitive importance of obsidian in the ancient mind.

In the future, archaeologists must develop new theoretical models for interpreting results obtained from lithic analyses. This includes viewing material as behavior (Fletcher 1995). It must be remembered that archaeologists deal with the remains of human behavior. Therefore, it must be an archaeologist's goal to address the decision-making processes behind the archaeological record. It is certainly true that new technologies are changing the face of archaeological research, but they are nonetheless limited by the interpretive potential of the people analyzing the data.

Further studies would benefit from an analysis of non-obsidian artifacts, not necessarily limited to lithics. Nevertheless, this study provides precedence for future work in Sardinia as well as provides a model for integrating two types of analyses, sourcing and typological. By combining these results, it is possible to investigate ancient economies, exchange networks, and cultural values. This project promotes a new set of economic theories capable of investigating the complex histories which typify Nuragic Sardinia as well as creates a model of cultural change able to investigate emerging complexity in a variety of situations.

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Appendix A. Table of Sardinian Prehistory (adapted from Tykot 1994:129)

<table>
<tr><td rowspan="3">UPPER PALAEOLITHIC</td><td>LOWER</td><td colspan="2">CLACTONIAN?</td><td>> 150,000 BC</td></tr>
<tr><td>MIDDLE</td><td colspan="2"></td><td></td></tr>
<tr><td>UPPER</td><td colspan="2" rowspan="2">GROTTA CORBEDDU</td><td>15,000 - 11,000 BC</td></tr>
<tr><td colspan="2">MESOLITHIC</td><td>11,000 - 6000 BC</td></tr>
<tr><td rowspan="4">NEOLITHIC</td><td rowspan="2">EARLY</td><td colspan="2">SU CARROPPU</td><td>6000? - 5300 BC</td></tr>
<tr><td colspan="2">FILIESTRU - GROTTA VERDE</td><td>5300 - 4700 BC</td></tr>
<tr><td>MIDDLE</td><td colspan="2">BONU IGHINU
- - - - - - (SAN CIRIACO) - - - - - - -</td><td>4700 - 4000 BC</td></tr>
<tr><td>LATE</td><td colspan="2">OZIERI</td><td>4000 - 3200? BC</td></tr>
<tr><td rowspan="3">CHALCOLITHIC (COPPER AGE)</td><td>INITIAL</td><td colspan="2">SUB-OZIERI
FILIGOSA
ABEALZU</td><td>3200? - 2700? BC</td></tr>
<tr><td>FULL</td><td rowspan="2">MONTE CLARO</td><td rowspan="2">BEAKER A</td><td rowspan="2">2700? - 2200? BC</td></tr>
<tr><td>FINAL</td></tr>
<tr><td rowspan="5">BRONZE AGE</td><td>EARLY</td><td>BONNANARO A</td><td>BEAKER B</td><td>2200 - 1900 BC</td></tr>
<tr><td rowspan="2">MIDDLE</td><td colspan="2">BONNANARO B</td><td>1900 - 1600 BC</td></tr>
<tr><td colspan="2">NURAGIC I</td><td>1600 - 1300 BC</td></tr>
<tr><td>LATE</td><td colspan="2">NURAGIC II</td><td>1300 - 1150 BC</td></tr>
<tr><td>FINAL</td><td colspan="2">NURAGIC III</td><td>1150 - 850 BC</td></tr>
<tr><td rowspan="3">EARLY IRON AGE</td><td>GEOMETRIC</td><td rowspan="3">PHOENICIAN</td><td rowspan="3">NURAGIC IV</td><td>850 - 730 BC</td></tr>
<tr><td>ORIENTALISING</td><td>730 - 580 BC</td></tr>
<tr><td>ARCHAIC</td><td>580 - 510 BC</td></tr>
<tr><td rowspan="3">LATE IRON AGE</td><td colspan="2">PUNIC</td><td rowspan="3">NURAGIC V</td><td>510 - 238 BC</td></tr>
<tr><td rowspan="2">ROMAN</td><td>REPUBLICAN</td><td>238 - 1 BC</td></tr>
<tr><td>IMPERIAL</td><td>1 AD - 476 AD</td></tr>
</table>

Appendix B. Table with concise information about relevant sites used in this thesis

Site	Notes
Duos Nuraghes	• 1600 B.C.–A.D. 1000 • Comprehensive excavation • Two nuraghi (simple and complex) • Village with 14 structures
Nuraghe Urpes	• 1150 B.C.–A.D. 510 B.C.? • Extensive excavation • Complex nuraghe • Village with stone wall
Nuraghe San Sergio	• 1600–1300 B.C.? • Poorly known • One 2-2-m unit excavated inside nuraghe • Simple nuraghe • Adjacent Nuragic village
Nuraghe Serbine	• 1600–1300 B.C.? • Poorly known • Several units opened within nuraghe • Proto-nuraghe • Adjacent Nuragic village
Nuraghe Ortu Còmidu	• 1600–850 B.C.? • Comprehensive excavation • One complex nuraghe • No known village

Appendix C. List of attributes used in typological analysis

Cores

1. Site
2. USF Number
3. Trench Number
4. Unit Number
5. Structure Number
6. Feature
7. Level
8. Phase

1. Early Bronze Age
2. Middle Bronze Age
3. Late Bronze Age
4. Iron Age
5. Punico-Roman
7. Roman
8. Medieval
9. Modern

9. Raw Material
10. Type

1. Unidirectional Core
2. Bidirectional Core
3. Bifacial Core
4. Multidirectional Core

11. Weight (In Grams)
12. Source
13. Maximum Length (Perpendicular to Platform Physically or Not)
14. Maximum Breadth (Perpendicular to Max Length)
15. Max Thickness
16. Plan

1. Short Quadrilateral
2. Quadrilateral
3. Short Trangular
4. Long Triangular
5. Short Irregular
6. Long Irregular
7. Elliptical
8. Indeterminate

17. Cross Section

1. Irregular
2. Biconvex
3. Lenticular
4. Plano Convex
5. Triangular
6. Sub-Triangular

7. Thirty-Sixty-Ninety Degree Triangle
8. Trapezoid
9. Circular
10. Rhomboid
11. Polygon

18. Cortex Present (In Percentages)

1.1 to 20
2. 20 to 40
3. 40 to 60
4. 60 to 80
5. 80 to 100

19. Flake Shape

1. Elongate
2. Intermediate
3. Expanding

20. Length of Longest Flake
21. Maximum Platform Length
22. Maximum Platform Breadth
23. Average Platform Angle

Shaped/ Unshaped Tools

1. Site
2. USF Number
3. Trench Number
4. Unit Number
5. Structure Number
6. Feature
7. Level
8. Phase

1. Early Bronze Age
2. Middle Bronze Age
3. Iron Age
4. Punico-Roman
5. Roman
6. Medieval
7. Modern

9. Raw Material
10. Type

1. Unshaped Tool
2. Bi-Polar Unshaped Tool
3. Backed
4. Haft Point

Appendix C (Continued)

5. Hydration Dated

11. Weight (In Grams)

12. Source

13. Maximum Length (Perpendicular to Platform Physically or Not)

14. Maximum Breadth (Perpendicular to Max Length)

15. Max Thickness

16. Plan

1. Short Quadrilateral
2. Quadrilateral
3. Short Trangular
4. Long Triangular
5. Short Irregular
6. Long Irregular
7. Elliptical
8. Indeterminate

17. Cross Section

1. Irregular
2. Biconvex
3. Lenticular
4. Plano Convex
5. Triangular
6. Sub-Triangular
7. Thirty-Sixty-Ninety Degree Triangle
8. Trapezoid
9. Circular
10. Parallelogram
11. Polygon
12. Half Trapezoid

18. Termination

1. Feather
2. Hinge
3. Step
4. Overshoot
5. Bi-Polar

19. Cortex Present (In Percentages)

1.1 to 20
2. 20 to 40
3. 40 to 60
4. 60 to 80
5. 80 to 100

20. Dorsal Scar Pattern

1. Cortical
2. Irregular
3. Parallel

Appendix C (Continued)

4. Convergent
5. Radial
6. Bi-Direction Proximal Distal
7. Bi-Directional Lateral Lateral
8. None

21. Platform Type

1. Cortical
2. Plain
3. Complex
4. Point
5. Abraded

22. Maximum Platform Length

23. Maximum Platform Breadth

24. Platform Ventral Angle

25. Platform Dorsal Angle

26. Primary Blank Type

1. Whole Flake
2. Proximal Flake
3. Distal Flake
4. Bipolar
5. Angular Waste
6. Core

27. Bulbar Thinning

1. Absent
2. Marginal (75% of Bulb Remaining)
3. Marginal to Semi-Invasive
4. Semi-Invasive
5. Invasive

28. Retouch Class

1. Unifacial Dorsal
2. Unifacial Ventral
3. Parti-Bifacial
4. Bifacial
5. Platform

29. Retouch Type

1. Simple
2. Step Stepped
3. Parallel
4. Pressure

30. Invasiveness of Retouch

1. Absent
2. Marginal (2 mm or Less)
3. Marginal to Semi-Invasive

4. Semi-Invasive
    5. Invasive

31. Retouch Location

32. Edge Form

1. Straight
2. Convex
3. Concave
4. Notched
5. Denticulate
6. Serrated
7. Irregular

33. Retouch Angle Left

34. Retouch Angle Right

35. Retouch Angle Proximal

36. Retouch Angle Distal

37. Backing Type

1. Obverse
2. Inverse
3. Bi-Directional Obverse
4. Bi-Directional Inverse
5. Natural
6. Indeterminate

38. Edge Opposite Backing

1. Straight
2. Convex
3. Concave
4. Denticulate
5. Serrated
6. Irregular

Flakes

1. Site

2. USF Number

3. Trench Number

4. Unit Number

5. Structure Number

6. Feature

7. Level

8. Phase

1. Early Bronze Age
2. Middle Bronze Age
3. Iron Age

Appendix C (Continued)

4. Punico-Roman
5. Roman
6. Medieval
7. Modern

9. Raw Material

10. Type

1. Whole Flake
2. Proximal Flake
3. Medial Flake
4. Distal Flake
5. Longitudinal Flake
5. Hydration Dated

11. Weight (In Grams)

12. Source

13. Maximum Length (Perpendicular to Platform Physically or Not)

14. Maximum Breadth (Perpendicular to Max Length)

15. Max Thickness

16. Plan

1. Short Quadrilateral
2. Quadrilateral
3. Short Trangular
4. Long Triangular
5. Short Irregular
6. Long Irregular
7. Elliptical
8. Indeterminate

17. Cross Section

1. Irregular
2. Biconvex
3. Lenticular
4. Plano Convex
5. Triangular
6. Sub-Triangular
7. Thirty-Sixty-Ninety Degree Triangle
8. Trapezoid
9. Circular
10. Parallelogram
11. Polygon

18. Termination

1. Feather
2. Hinge
3. Step
4. Overshoot
5. Bi-Polar

Appendix C (Continued)

19. Cortex Present (In Percentages)

1.1 to 20
2. 20 to 40
3. 40 to 60
4. 60 to 80
5. 80 to 100

20. Dorsal Scar Pattern

1. Cortical
2. Irregular
3. Parallel
4. Convergent
5. Radial
6. Bi-Direction Proximal Distal
7. Bi-Directional Lateral Lateral
8. None

21. Platform Type

1. Cortical
2. Plain
3. Complex
4. Point
5. Abraded

22. Maximum Platform Length
23. Maximum Platform Breadth
24. Platform Ventral Angle
25. Platform Dorsal Angle

Angular Waste/Shatter

1. Site
2. USF Number
3. Trench Number
4. Unit Number
5. Structure Number
6. Feature
7. Level
8. Phase

1. Early Bronze Age
2. Middle Bronze Age
3. Iron Age
4. Punico-Roman
5. Roman
6. Medieval
7. Modern

Appendix C (Continued)

9. Raw Material

10. Type

1. Unshaped Tool
2. Bi-Polar Unshaped Tool
3. Backed
4. Haft Point
5. Hydration Dated

11. Weight (In Grams)

12. Source

Appendix D. Raw data from the artifacts that were both sources and classified

Site	USFNum	Type	Source
Duos	854	Retouched	SA
Duos	855	Retouched	SC
Duos	858	Retouched	SB2
Duos	859	Retouched	SC
Duos	860	Retouched	SC
Duos	861	Retouched	SC
Duos	864	Retouched	SC
Duos	870	Retouched	SC
Duos	877	Retouched	SB2
Duos	878	Retouched	SC
Duos	881	Retouched	SC
Duos	883	Retouched	SC
Duos	884	Retouched	SC
Duos	885	Retouched	SC
Duos	886	Retouched	SC
Duos	889	Retouched	SC
Duos	897	Retouched	SC
Duos	902	Retouched	SA
Duos	907	Retouched	SC
Duos	908	Retouched	SC
Duos	914	Retouched	SC
Duos	915	Retouched	SC
Duos	917	Retouched	SC
Duos	918	Retouched	SC
Duos	919	Retouched	SC
Duos	941	Retouched	SB2
Duos	941.2	Retouched	SC
Duos	945	Retouched	SC
Duos	947	Retouched	SC
Duos	949	Retouched	SB2
Duos	950	Retouched	SC
Duos	952	Retouched	SC
Duos	953	Retouched	SA
Duos	955	Retouched	SC
Duos	957	Retouched	SC
Duos	960	Retouched	SC
Duos	962	Retouched	SC
Duos	963	Retouched	SC
Duos	965	Retouched	SC
Duos	971	Retouched	SC
Duos	980	Retouched	SC
Duos	982.2	Retouched	SC
Duos	984	Retouched	SC
Duos	986	Retouched	SC
Duos	987.2	Retouched	SC

Appendix D (Continued)

Duos	991.1	Retouched	SC
Duos	993	Retouched	SC
Duos	996	Retouched	SA
Duos	997.1	Retouched	SB2
Duos	997.3	Retouched	SA
Duos	999	Retouched	SC
Duos	1000.1	Retouched	SC
Duos	1004.3	Retouched	SC
Duos	1004.4	Retouched	SC
Duos	1005.1	Retouched	SA
Duos	1007.2	Retouched	SC
Duos	1008	Retouched	SC
Duos	1009	Retouched	SC
Duos	1011	Retouched	SC
Duos	1013	Retouched	SC
Duos	1014	Retouched	SC
Duos	1015.3	Retouched	SC
Duos	1017.2	Retouched	SC
Duos	1018	Retouched	SC
Duos	1019.1	Retouched	SA
Duos	1020	Retouched	SC
Duos	1022	Retouched	SC
Duos	1023.2	Retouched	SC
Duos	1027	Retouched	SC
Duos	1042	Retouched	SC
Duos	1045	Retouched	SC
Duos	1053	Retouched	SC
Duos	1056	Retouched	SC
Duos	1060	Retouched	SC
Duos	1061	Retouched	SC
Duos	1064	Retouched	SC
Duos	1087	Retouched	SC
Duos	1090.1	Retouched	SC
Duos	1090.2	Retouched	SC
Duos	1092	Retouched	SB1
Duos	1093	Retouched	SC
Duos	1094	Retouched	SB2
Duos	847 (a)	Retouched	SC
Duos	866 (a)	Retouched	SA
Duos	866 (b)	Retouched	SC
Duos	887 (a)	Retouched	SC
Duos	845	Whole Flake	SC

Appendix D (Continued)

Duos	849	Proximal Flake	SC
Duos	850	Proximal Flake	SC
Duos	852	Medial Flake	SC
Duos	863	Whole Flake	SC
Duos	865	Whole Flake	SC
Duos	867	Whole Flake	SC
Duos	868	Whole Flake	SC
Duos	873	Whole Flake	SC
Duos	874	Whole Flake	SC
Duos	876	Whole Flake	SC
Duos	879	Whole Flake	SC
Duos	880	Whole Flake	SC
Duos	882	Whole Flake	SC
Duos	888	Whole Flake	SC
Duos	890	Whole Flake	SC
Duos	891	Whole Flake	SC
Duos	892	Whole Flake	SC
Duos	893	Whole Flake	SC
Duos	894	Distal Flake	SC
Duos	895	Proximal Flake	SC
Duos	898	Whole Flake	SC
Duos	899	Whole Flake	SC
Duos	903	Whole Flake	SA
Duos	904	Whole Flake	SC
Duos	913	Whole Flake	SC
Duos	923	Whole Flake	SC
Duos	924.1	Whole Flake	SC
Duos	927	Whole Flake	SC
Duos	931	Whole Flake	SC
Duos	933	Proximal Flake	SC
Duos	936	Whole Flake	SB2
Duos	937	Proximal Flake	SA
Duos	940	Whole Flake	SB2
Duos	942.1	Whole Flake	SB2
Duos	942.2	Whole Flake	SA
Duos	943	Whole Flake	SC
Duos	944	Whole Flake	SC
Duos	946	Proximal Flake	SC
Duos	948.1	Whole Flake	SC
Duos	948.2	Whole Flake	SC
Duos	951	Proximal Flake	SC
Duos	954.1	Distal Flake	SC

Appendix D (Continued)

Duos	954.2	Whole Flake	SC
Duos	956	Whole Flake	SC
Duos	959	Whole Flake	SA
Duos	961	Whole Flake	SA
Duos	964	Proximal Flake	SC
Duos	966	Whole Flake	SC
Duos	967	Whole Flake	SC
Duos	969	Distal Flake	SC
Duos	970	Whole Flake	SC
Duos	972	Whole Flake	SC
Duos	978	Whole Flake	SC
Duos	979	Whole Flake	SC
Duos	981	Proximal Flake	SA
Duos	987.1	Whole Flake	SC
Duos	989	Whole Flake	SC
Duos	992.1	Whole Flake	SC
Duos	992.2	Whole Flake	SC
Duos	994	Whole Flake	SC
Duos	995	Whole Flake	SC
Duos	998	Whole Flake	SC
Duos	1001	Whole Flake	SC
Duos	1002	Medial Flake	SC
Duos	1003	Whole Flake	SC
Duos	1004.2	Whole Flake	SC
Duos	1005.2	Distal Flake	SC
Duos	1005.3	Whole Flake	SC
Duos	1006	Whole Flake	SC
Duos	1007.1	Whole Flake	SA
Duos	1007.3	Whole Flake	SC
Duos	1010	Medial Flake	SC
Duos	1012	Whole Flake	SC
Duos	1015.1	Whole Flake	SC
Duos	1015.2	Whole Flake	SC
Duos	1015.4	Whole Flake	SC
Duos	1015.5	Whole Flake	SC
Duos	1015.6	Whole Flake	SC
Duos	1016	Whole Flake	SA
Duos	1017.1	Whole Flake	SC
Duos	1019.2	Proximal Flake	SC
Duos	1023.1	Medial Flake	SC
Duos	1024.2	Proximal Flake	SC
Duos	1029	Whole Flake	SC

Appendix D (Continued)

Duos	1036.1	Proximal Flake	SC
Duos	1036.2	Proximal Flake	SC
Duos	1038	Whole Flake	SC
Duos	1039	Whole Flake	SA
Duos	1040	Whole Flake	SC
Duos	1041	Whole Flake	SC
Duos	1044	Whole Flake	SC
Duos	1046	Proximal Flake	SC
Duos	1047	Whole Flake	SC
Duos	1048	Proximal Flake	SC
Duos	1051	Whole Flake	SC
Duos	1052	Proximal Flake	SC
Duos	1055	Whole Flake	SC
Duos	1058	Whole Flake	SC
Duos	1065	Proximal Flake	SC
Duos	1066	Whole Flake	SC
Duos	1088.2	Whole Flake	SC
Duos	1091	Whole Flake	SC
Duos	1097.1	Whole Flake	SC
Duos	1097.2	Whole Flake	SC
Duos	1098	Whole Flake	SC
Duos	1100	Whole Flake	SB2
Duos	1101	Whole Flake	SC
Duos	1102.1	Whole Flake	SA
Duos	1103	Proximal Flake	SC
Duos	846 (a)	Whole Flake	SC
Duos	846 (b)	Whole Flake	SC
Duos	847 (b)	Proximal Flake	SC
Duos	875 (a)	Proximal Flake	SC
Duos	875 (b)	Whole Flake	SC
Duos	887(b)	Whole Flake	SC
Duos	848	Angular Waste	SC
Duos	853	Angular Waste	SC
Duos	856	Angular Waste	SC
Duos	857	Angular Waste	SC
Duos	869	Angular Waste	SA
Duos	872	Angular Waste	SC
Duos	896	Angular Waste	SA
Duos	905	Angular Waste	SB2
Duos	906	Angular Waste	SC
Duos	932	Angular Waste	SC
Duos	958	Angular Waste	SC

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Duos	968	Angular Waste	SB2
Duos	982.1	Angular Waste	SC
Duos	988	Angular Waste	SC
Duos	991.3	Angular Waste	SC
Duos	997.2	Angular Waste	SC
Duos	1000.2	Angular Waste	SC
Duos	1000.3	Angular Waste	SC
Duos	1021	Angular Waste	SC
Duos	1024.1	Angular Waste	SA
Duos	1026	Angular Waste	SA
Duos	1089	Angular Waste	SC
Duos	1099	Angular Waste	SC
Duos	851	Core	SC
Duos	922	Core	SC
Duos	985	Core	SC
Ortu	11731	Retouched	SC
Ortu	11735	Retouched	SC
Ortu	11737	Retouched	SC
Ortu	11739	Retouched	SA
Ortu	11742	Retouched	SC
Ortu	11752	Retouched	SA
Ortu	11775	Retouched	SC
Ortu	11776	Retouched	SC
Ortu	11782	Retouched	SC
Ortu	11789	Retouched	SC
Ortu	11791	Retouched	SC
Ortu	11793	Retouched	SC
Ortu	11794	Retouched	SC
Ortu	11797	Retouched	SA
Ortu	11806	Retouched	SC
Ortu	11808	Retouched	SA
Ortu	11810	Retouched	SC
Ortu	11823	Retouched	SC
Ortu	11824	Retouched	SC
Ortu	11837	Retouched	SC
Ortu	11844	Retouched	SC
Ortu	11851	Retouched	SC
Ortu	11857	Retouched	SC
Ortu	11725	Medial Flake	SC
Ortu	11727	Distal Flake	SC
Ortu	11730	Whole Flake	SC
Ortu	11733	Whole Flake	SC

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Ortu	11736	Whole Flake	SC
Ortu	11738	Whole Flake	SC
Ortu	11740	Whole Flake	SC
Ortu	11743	Whole Flake	SC
Ortu	11744	Proximal Flake	SC
Ortu	11745	Whole Flake	SC
Ortu	11746	Proximal Flake	SA
Ortu	11750	Proximal Flake	SC
Ortu	11751	Whole Flake	SC
Ortu	11753	Whole Flake	SC
Ortu	11756	Whole Flake	SC
Ortu	11757	Whole Flake	SC
Ortu	11758	Whole Flake	SC
Ortu	11760	Whole Flake	SC
Ortu	11761	Distal Flake	SC
Ortu	11763	Medial Flake	SA
Ortu	11764	Whole Flake	SA
Ortu	11765	Whole Flake	SA
Ortu	11767	Whole Flake	SA
Ortu	11769	Proximal Flake	SA
Ortu	11770	Whole Flake	SA
Ortu	11771	Proximal Flake	SC
Ortu	11772	Whole Flake	SC
Ortu	11773	Proximal Flake	SB2
Ortu	11774	Whole Flake	SC
Ortu	11777	Proximal Flake	SC
Ortu	11778	Whole Flake	SC
Ortu	11779.1	Whole Flake	SA
Ortu	11779.2	Whole Flake	SC
Ortu	11780	Whole Flake	SA
Ortu	11781	Whole Flake	SC
Ortu	11785	Whole Flake	SC
Ortu	11786	Whole Flake	SC
Ortu	11792	Whole Flake	SA
Ortu	11795	Proximal Flake	SA
Ortu	11796	Whole Flake	SA
Ortu	11798	Whole Flake	SA
Ortu	11799	Whole Flake	SC
Ortu	11800	Whole Flake	SC
Ortu	11801	Medial Flake	SA
Ortu	11802	Distal Flake	SC
Ortu	11803	Whole Flake	SC

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Ortu	11811	Whole Flake	SA
Ortu	11815	Distal Flake	SC
Ortu	11817	Whole Flake	SA
Ortu	11819	Whole Flake	SC
Ortu	11822	Whole Flake	SA
Ortu	11825	Whole Flake	SA
Ortu	11828	Whole Flake	SA
Ortu	11829	Whole Flake	SC
Ortu	11830	Whole Flake	SA
Ortu	11832	Whole Flake	SC
Ortu	11834	Whole Flake	SC
Ortu	11839	Whole Flake	SA
Ortu	11843	Whole Flake	SA
Ortu	11846	Proximal Flake	SC
Ortu	11848	Whole Flake	SA
Ortu	11849	Distal Flake	SC
Ortu	11850	Whole Flake	SC
Ortu	11852	Whole Flake	SC
Ortu	11853	Whole Flake	SC
Ortu	11855	Whole Flake	SC
Ortu	11858	Whole Flake	SC
Ortu	11859	Whole Flake	SC
Ortu	11860	Proximal Flake	SC
Ortu	11861	Whole Flake	SC
Ortu	11724	Angular Waste	SC
Ortu	11728	Angular Waste	SC
Ortu	11732	Angular Waste	SC
Ortu	11741	Angular Waste	SC
Ortu	11762	Angular Waste	SC
Ortu	11787	Angular Waste	SC
Ortu	11788	Angular Waste	SC
Ortu	11804	Angular Waste	SC
Ortu	11809	Angular Waste	SC
Ortu	11812	Angular Waste	SA
Ortu	11814	Angular Waste	SC
Ortu	11820	Angular Waste	SA
Ortu	11821	Angular Waste	SC
Ortu	11826	Angular Waste	SC
Ortu	11831	Angular Waste	SC
Ortu	11833	Angular Waste	SC
Ortu	11835	Angular Waste	SA
Ortu	11842	Angular Waste	SC

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Ortu	11845	Angular Waste	SC
Ortu	11847	Angular Waste	SC
Ortu	11854	Angular Waste	SC
San Sergio	1067	Distal Flake	SC
San Sergio	1068	Whole Flake	SA
San Sergio	1069	Whole Flake	SA
San Sergio	1070	Proximal Flake	SC
San Sergio	1071	Whole Flake	SC
San Sergio	1072	Proximal Flake	SC
San Sergio	1073	Whole Flake	SC
San Sergio	1074	Proximal Flake	SC
San Sergio	1075	Whole Flake	SA
San Sergio	1076	Distal Flake	SC
San Sergio	1079	Whole Flake	SC
San Sergio	1082	Whole Flake	SC
San Sergio	1084	Distal Flake	SC
San Sergio	1086	Medial Flake	SC
San Sergio	1078	Retouched	SC
San Sergio	1081	Retouched	SC
San Sergio	1080	Angular Waste	SC
San Sergio	1083	Angular Waste	SC
Serbine	813	Whole Flake	SB2
Serbine	815	Proximal Flake	SB2
Serbine	820	Proximal Flake	SC
Serbine	821	Whole Flake	SA
Serbine	824	Distal Flake	SA
Serbine	825	Whole Flake	SC
Serbine	826	Whole Flake	SC
Serbine	828	Whole Flake	SB2
Serbine	829	Proximal Flake	SC
Serbine	835	Proximal Flake	SC
Serbine	836	Proximal Flake	SB2
Serbine	837	Proximal Flake	SA
Serbine	838	Whole Flake	SC
Serbine	839	Proximal Flake	SC
Serbine	840	Proximal Flake	SC
Serbine	841	Whole Flake	SA
Serbine	842	Whole Flake	SC
Serbine	844	Whole Flake	SC
Serbine	818	Retouched	SC
Serbine	823	Retouched	SA
Serbine	831	Retouched	SC

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Serbine	833	Retouched	SC
Serbine	834	Retouched	SB2
Serbine	1037.1	Retouched	SC
Serbine	1037.2	Retouched	SC
Serbine	817	Angular Waste	SC
Serbine	822	Angular Waste	SC
Serbine	827	Angular Waste	SC
Serbine	830	Angular Waste	SC
Serbine	832	Angular Waste	SC
Serbine	843	Angular Waste	SC
Serbine	819	Core	SC
Urpes	781	Whole Flake	SC
Urpes	786	Proximal Flake	SA
Urpes	790	Whole Flake	SB2
Urpes	795	Whole Flake	SC
Urpes	796.1	Whole Flake	SC
Urpes	796.2	Distal Flake	SC
Urpes	796.3	Whole Flake	SC
Urpes	797.1	Whole Flake	SC
Urpes	797.3	Whole Flake	SC
Urpes	797.5	Medial Flake	SC
Urpes	799	Whole Flake	SB2
Urpes	801	Whole Flake	SC
Urpes	810	Whole Flake	SC
Urpes	788	Retouched	SC
Urpes	794	Retouched	SC
Urpes	797.4	Retouched	SC
Urpes	798	Retouched	SC
Urpes	800	Retouched	SB2
Urpes	782	Angular Waste	SC
Urpes	784	Angular Waste	SC
Urpes	785	Angular Waste	SC