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**Black Sea Change:**  
A Revision of the Sinop Ceramic Chronology Using Luminescence Dating

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## **Abstract**

Fifty-nine ceramic sherds from eleven archaeological sites within the Sinop promontory of the Turkish Black Sea coast were dated by luminescence to establish a regional ceramic chronology. This absolute chronology was used to evaluate existing assumptions about the occupational history of the promontory and its relationship to the greater region, in both prehistoric and postcolonial periods. Lastly, the efficacy of the luminescence method was explored and advanced through the implementation of new and emerging techniques for dating pottery using luminescence and then for systematically determining the objective value and reliability of each date.

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At a moment's notice, I would require her to fill the role of psychologist, coach, or accountant. In many ways, Catherine, more than anyone else, was my guide through this process and I thank her sincerely. Finally, I thank Shivaun Corry, who—when it became clear that I needed one final push—provided unconditional love and support when I needed it most.

## **Dedication**

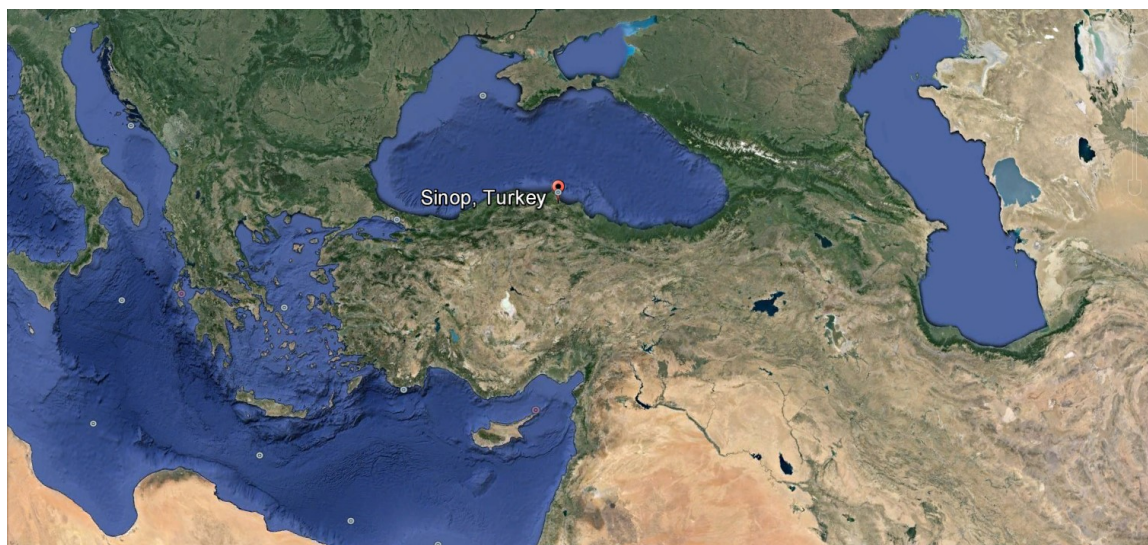
To my parents, Drs. Ronald William Casson and Banu Özertuğ Casson,  
the real anthropologists in the family.

## Chapter One: Problem Statement and Introduction

“Time and tide wait for no man.”—St. Marher (1225 CE)

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Turkey is home to some of the world’s most well-known and significant archaeological sites and regions. No introductory archaeological textbook is complete without mention of the early settlement of Çatalhöyük, animal domestication at Çayönü, early religious practices at Göbekli Tepe, Paleolithic occupations at Üçağızlı, the architectural wonders of Cappadocia, or any number of Classical Period sites along the Turkish Mediterranean and Aegean coasts. Curiously under-represented in the public and international coverage of Turkey’s archaeological bounty is the Black Sea region of the country (Figure 1.1), particularly in relation to its prehistoric patterns of settlement. Until recently (e.g., Bauer, 2006a), this lack of coverage accurately reflected the state of archaeological knowledge of the region’s prehistory. Research conducted by the Sinop Regional Archaeological Project (SRAP), which I joined in 2003, has actively engaged in efforts to remedy this situation.



**Figure 1.1: The Black Sea, Turkey, and Sinop (Google Earth)**

SRAP commenced archaeological survey within the Sinop promontory in the summer of 1996 and, at this writing in 2013, has operated a survey or excavation project in the region during 10 different summers (1996-2000, 2003, 2006, 2010-12). These endeavors, of which this thesis is one contribution, have added significantly to our understanding of one region—Sinop—within the greater Black Sea regional complex.

So, why is it that our knowledge of this region's past has lagged behind our understanding of the archaeology of Anatolia, Thrace, the Southeast, the Mediterranean and Aegean coasts, and the Lakes regions? Said another way, there has been a bias toward archaeological research along two main lines within Turkey: national governmental promotion of coastal historic (i.e., Greek and Roman) sites for purposes of tourism along the Aegean and Mediterranean coasts, and in the Anatolian plateau, Thrace, and the Southeast, with a focus on the emergence of complex civilizations. Again, why might this be? There are several possibilities in play here, including the relative geographic isolation of the Black Sea region, separated from the development of civilizations to the south in Anatolia by the Pontic mountains. Historical factors may also be partly responsible—e.g., funding decisions to promote tourism in other parts of the country at the expense of similar investment in archaeological research along the Black Sea. Lingering effects of the Iron Curtain may also explain why we know so much less about this region than, say, the Mediterranean.

As noted by Bauer (2006a, 2006b), archaeological research within the Black Sea region—including not just the Turkish coast (my focus) but the entire Black Sea basin—has focused more on the inland populations than on coastal populations, particularly

during prehistoric periods (Bauer and Doonan, 2012). Features of coastal communities, they argue, have been reduced in previous analyses to peripheral variants of inland cultures. By marginalizing the Black Sea basin as peripheral to other regional cores (e.g., Europe, the Mediterranean, Mesopotamia) the region has been framed archaeologically as a border zone between areas, rather than as a coherent “interacting and integrated” region (Bauer and Doonan, 2012: 15). This is, as mentioned above, partly explainable by geophysical and geopolitical reasons, emphasizing the physical isolation of the region and the fractured nature of research in the area, where the archaeological cultures of each country with a Black Sea coast have been evaluated independently.

As archaeological research in the area has lagged behind other regions, it is not surprising that region-specific chronologies are still in the developmental stages. The norm in the region is of poorly defined chronologies of regional archaeological sites and materials where reliable dating (e.g., of ceramic assemblages) had been largely non-existent (Işın, 1998). Framing the Black Sea as its own region of analysis requires the development of reliable absolute chronologies. Bauer (2006a) has argued, citing the work of Sherratt (1997), that regional syntheses should continue, even in the absence of clearly defined chronologies. The difference in perspective is largely semantic here, as Bauer’s reasons for not ceasing archaeological research in the Black Sea while we all wait for an established chronology to be presented are sound. Chronologies can be imprecise and they are often adjusted to reflect new data. Moreover, human behaviors operate on multiple scales across time and space; despite our craving for chronologies of maximal refinement, chronological construction should serve to resolve specific research

questions. From this perspective, chronology development is a “working construct”, part of the general process of archaeological investigation (Bauer, 2006a: 137-38). This, however, undersells the importance of anchoring events in time on a scale which allows one to make intra- and inter-regional comparisons.

Specifically, as I argue in this thesis, techniques of chronology development that create relative chronologies through qualitative analysis and/or comparisons of form or style to other regions do not provide the chronological resolution or accuracy needed for understanding the occupational history of a region. That is, prior to this study and the results generated from this analysis, efforts to determine chronological relationships—i.e., periods of site occupation, and abandonment—were based largely on analogical inference. Chronology development instead should be the product of rigorous quantitative analysis of collections *from the region* that produce an absolute chronology *for that region*.

This dissertation research provides a step toward the production of that absolute regional chronology by beginning the process of creating an absolute luminescence-based chronology for the Sinop Promontory along the Turkish coast of the Black Sea based on dating a representative sample of local pottery. The resultant chronology will permit an evaluation of existing qualitative and comparative chronological systems for the region and allow for the evaluation, more generally, of theories regarding the relationship of Black Sea settlement patterns to other cultural centers in the larger Near Eastern cultural network. Additionally, as many of the techniques deployed in this process are relatively novel, the research concomitantly refines ceramic luminescence dating protocols that

have the potential to improve the precision and resolution of resultant chronologies not just in the Black Sea, but globally. Fundamentally, though, this thesis is Black Sea-centric, though the power of this chronology will be a product of the degree of precision made possible by improved luminescence dating techniques.

What follows in the subsequent chapters is the creation and examination of the results of luminescence dates from 59 ceramic sherds from eleven sites on the Sinop Promontory, spanning a nearly 8000-year occupational history. The result is the first comprehensive absolute chronology for an area within the greater Black Sea region of Turkey. These new data offer a means of analyzing the relationship between an absolute chronology and previous existing typologies used in the area to form a revised ceramic chronology for the region.

This thesis is organized around two parallel themes: first, understanding the cultural history of the Turkish Black Sea region as seen in the Sinop promontory through the creation of a framework for an absolute chronology via dating local pottery and, second, the pursuit of improved luminescence dating protocols aimed at increasing the precision of the technique as an analytical tool. While entire chapters are devoted to one theme or the other, the complementarity of these issues in addressing the fundamental questions of this research requires some overlap in their presentation and discussion.

In Chapter Two, I present the regional cultural history of the Sinop promontory, reviewing the archaeological research done in the area and its surroundings. Here I will include some discussion of the environment, settlement histories, and previous efforts at dating. In Chapter Three, I conduct a review of the current state of knowledge of the use

of luminescence dating as a tool for chronology development. These two chapters represent the “literature review”, the foundation upon which original research contained in subsequent chapters is based.

Chapter Four defines the archaeological sample and how it was acquired and presents the research questions explored in this research. In Chapter Five, as the “methods” chapter, the focus is on the technical and laboratory methods used in producing the data of this thesis; detailing the various processes (and decisions) used to generate the dates presented in the next chapter. Here, the discussions are entirely methodological and detail the process of sample preparation, laboratory techniques (i.e., protocols of analysis), and the analysis of the data generated by laboratory techniques. Chapter Six is the “results” chapter, wherein the data are presented in their raw form (continuing the discussion of date production from Chapter Five) and presented as final ages, sorted by region and/or site and ware type, when possible.

Interpretation of the data occurs in Chapter Seven, where I discuss the implications of the dates, both individually (when relevant) and by category (region/site, ware type, etc.). Here, a comparison to previous efforts at chronology construction is evaluated most clearly. How similar, for example, is the understanding of the age of a site or pottery type when we compare the luminescence ages to the previous qualitative efforts? In what ways does our understanding of the regional pattern of occupation change? Here, as will be shown, surprising patterns emerge. The chapter ends with a consideration of the main points of the research, a summary of the implications of the results presented, and a discussion of areas where further research is needed.

## Chapter Two: Regional Culture/History of the Sinop Promontory

“I am a citizen of the world.”—Diogenes of Sinop (412-323 BCE)

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### *Environmental Characteristics*

The Black Sea coast of Turkey differs from the rest of Turkey as a cultural region for reasons that can largely be explained in terms of the isolating effects of the Pontic Mountains (Figure 2.1). The extent to which the Pontic Mountains create a physical barrier from Anatolia to the south isolates the people of the coast. The prehistoric and early historic populations would have had to travel a distance of over 160 kilometers east to Samsun to cross the Pontic Mountains south to the Anatolian Plateau. Crossing the Pontics to the west is less difficult, but either scenario would have taken a journey of several days at the minimum. As Doonan (2004a: 8-9) notes, “Poorly defined tracks, dizzying valleys, and unpredictable weather make the Pontic mountains treacherous even in the best of seasons.”



**Figure 2.1: Turkish Black Sea, highlighting the Pontics (Google Earth)**

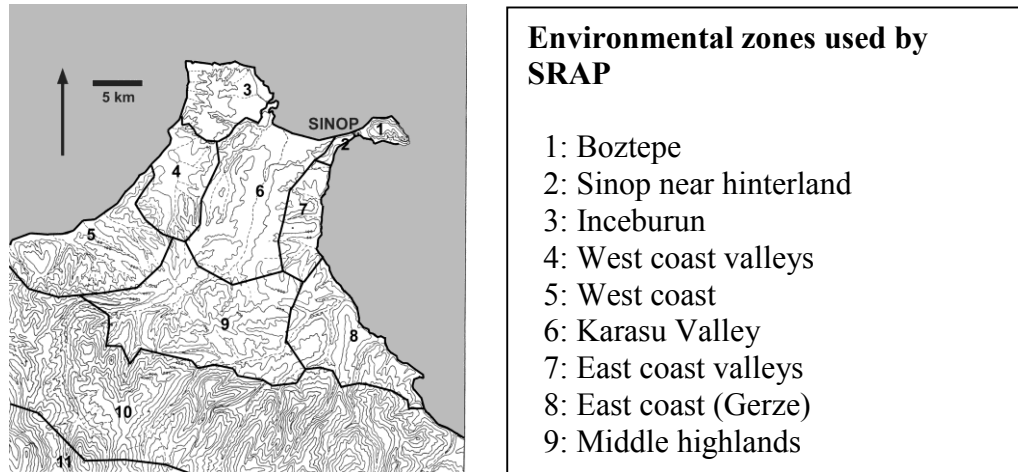
The separation of the Black Sea coast of Turkey from the Anatolian plateau extends beyond a physical barrier. The coastal climate is distinct from the plateau, as one would expect. The Black Sea coast is generally moist and mild (temperate) whereas the inland plateau is significantly more arid.

Within the Sinop promontory the landscape is characterized by a diverse set of environmental, geological, and climatic conditions, reflecting the diversity of the regional habitat. Places are more than just location (Doonan, 2004a:12; Hordon and Purcell, 2000:77-80). The landscape is a combination of physical, topographic, and human contexts. Places are meaningful for the people who inhabit them through their perception and consumption of the disparate realities of the various physical, geographic, ecological, historical, cultural, and social components they encounter (Doonan, 2004a: 12-22; Wilkinson, 2003: 15-33).

Physically, the promontory is separated from the Anatolian plateau to the south by the Pontic mountain chain. Jutting into the Black Sea, the promontory is roughly 18 x 25 km, or 450 km<sup>2</sup>, with a varied geology and climate which create an ecological system rich in flora and fauna. The diversity of the promontory's geological features provides a way to further subdivide the region into main zones: the coast, the valleys, and the highlands, each with its own characteristics (Figure 2.2). The coast, itself diverse, varies from steep cliffs to open drainage valleys that permit landings via boat. The valleys represent relatively open landscapes with terraced forests and, currently, agricultural fields. The hinterland, in many ways a continuation of the valley systems further inland, include rolling hills (suitable for agriculture), forested mountain gorges, and high

plateaus, used for pasturage, agriculture, and communication between the valley systems.

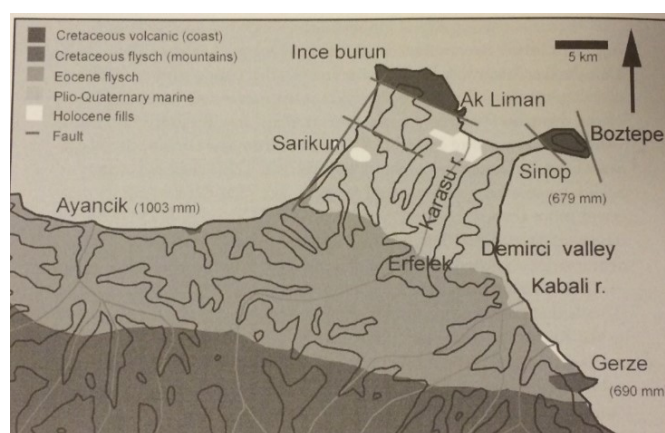
Each of these zones was surveyed systematically by SRAP.



**Figure 2.2: Environmental zones of Sinop promontory (from Doonan, 2004a)**

Geologically, the promontory can be sub-divided into four main zones (see Figure 2.3). Working from the interior to the coast, the first zone is that of the high mountains, an east-west belt of Upper Cretaceous flysch which receives the highest rainfall in the promontory and acts as the watershed for the area's principle rivers. Closer inland runs a belt of Eocene flysch, west from the coast at Ayancık through the interior of the promontory to Gerze on the eastern coast of the promontory. Like the high mountains, this zone is mountainous, consisting of impassable valley systems and upland plateaus. Beyond the highland flysch zones, the third zone—beginning with the modern town of Erfelek—is defined by rolling hills more typical of the coastal plain. The geology here is a series of mixed Plio-Quaternary marine deposits: sandstone, marls, and limestone outcrops that support diverse agricultural practices. The fourth zone, at the extreme north of the promontory, is defined by the twin Cretaceous volcanic outcrops of Boztepe and

Inceburun. It is from this zone that the iconic pyroxene, or “black sand”, temper (BST) of Sinop originates. Alternating among the volcanic outcrops are coastal valleys, which provide access points for beach landings for fisherman and merchant ships. The primary ports are found along the south side of the Boztepe promontory (NE Sinop). Lastly, as seen in Figure 2.3, the valleys within the interior lowland valley systems have pockets of Holocene soil formation. These erosional clays, plentiful in certain locations, were extensively sampled for pottery manufacture. Mineral resources are evenly distributed throughout the region, with the exception of the volcanic deposits.



**Figure 2.3: Major geological regions of the Sinop promontory (from Ketin, 1962)**

Ecologically, what distinguishes the Pontic coast, and Sinop, from interior Anatolia is the amount of rainfall the area receives. The amount of rainfall varies along the coast from west to east, as a function of the interaction between prevailing winds, ocean currents, and the local features of the Pontic mountain chain. West of Sinop, there is less rainfall; east there is significantly more rainfall, reaching tropical levels 460 miles to the east at Rize. In Sinop specifically, the high mountains trap significant rainfall on the order of 800 mm/year (Steinhauser, 1970, in Doonan, 2004a). There is a slight east-

west bias in rainfall within the promontory, as the prevailing winds from the west create a condition in which western rainfall on the promontory (1200 mm/year) exceeds that of the eastern part of the promontory (650-700mm/year) (Doonan, 2006). The floral regime is rich and varied, manifest most noticeably in the nature of the vast forests, varying with elevation and climate. Over 50% of Sinop province is classified by the Turkish government as forest, making it the most heavily forested province in the country today (Doonan, 2004b). The forests of the coastal plains include many broadleaf trees, including species that yield fruit and nuts, including: oak, laurel, elem, plane, beech, boxwood, pine, hazelnut, cherry, and chestnut. The low elevation highland forests (zone 2) include: fir, pine, beech, oak, plane, poplar, linden, and chestnut. The high elevation forests (zone 1) include fir scrub, to the exclusion of other species. Ecological patterns are reflected in zones of historic economic production as well. Areas with drier open plains support agricultural development; the highlands surrounding Gerze were the principle source of timber through the Ottoman and Republican periods; and the coastal lowlands feature cash crops, from olives in antiquity to tobacco more recently.

These conditions have been largely constant from the Late Pleistocene to the present. Theories of dramatic sea level change in the Early Holocene, related to a purported Black Sea Flood (see for example, Ryan et al., 2003) have since been shown to be inaccurate. The consensus (first reported by Yanko-Hombach et al., 2007, confirmed by Fouache et al., 2012) is now that between 16 and 13 ky BP what was then the Black Sea rose rapidly to about 50 meters below the present level of the Black Sea and then gradually rose to within 20 meters of current levels at about 11 ky BP. After a brief drop

of sea level at 10 ky BP during the Younger Dryas, it was not until about 9.5 ky BP that the Black Sea re-connected with the Sea of Marmara via the Bosphorus Straits, gradually bringing the Black Sea to its current depth, salinity, and biota. Furthermore, available archaeological and paleoenvironmental evidence from the Pontic region do not support any measurable changes in population size between 14,000 and 6,000 BP that would be linked to the previously hypothesized large-scale inundation (Dolukhanov and Shilike, 2006). During the last 10,000 years, the level of the Black Sea has risen in a gradual (~3cm/year) and oscillating manner to its present level, insufficient to force a massive migration of human populations from Europe ca. 8.4-7.2 ky BP (Yanko-Hombach, 2007).

#### *Proposed Regional Connections*

The Sinop promontory represents one of the few coastal plains on the Turkish Black Sea coast amenable for large human settlement (the river deltas of the Yeşilirmak and Kızılırmak represent the other possibilities). As such, it is not surprising that the promontory has long represented a critical node in the greater Black Sea region and beyond, providing a hub for communications, production and exchange of material goods, and political development, since as early as 2500 BCE (Hiebert et al., 1997). Since the Bronze Age, ca. 3<sup>rd</sup> millennium BCE, Sinop's seaport has served as an access point for all subsequent maritime, lowland, and mountain cultures in the local and greater regional networks. The port at Sinop represents the safest deep water natural landing on the entire southern coast of the Black Sea, covering an area of over 1000 km, making it an essential port of call for east-west traffic (Doonan, 2004a: 10; Doonan, 2006: 49). As such, the promontory's ability to serve as a greater regional node is largely a product of

its unique situation on the coast. Drawing on the work of the Romanian historian Bratianu (1969), Doonan notes that the Black Sea served as a *placque tournant*, or “turntable”, upon which the civilizations of Eurasian, the Mediterranean, and the Near East have revolved. To quote Doonan (2004a: 11):

The Black Sea is the arena in which the people of these distinctive regions have clashed and cooperated for millennia. Sinop, the pivot of Black Sea communications, mediated the economic and political relationships of these wider cultural and economic regions.

It is this concept of the community that represents the best way to place the Black Sea, and Sinop in particular, into a framework for understanding the importance of the area within a larger multi-regional framework. Doonan (2006) notes that the concept of community has seen a surge in its application to a variety of regional-level groupings of archaeological phenomena (e.g., Knapp, 2003) as it represents a less rigid alternative to potentially artificial categories like “archaeological culture”. Communities are rarely territorially discrete in the way that modern political states are as they are more a product of social categories than externally created political borders. The SRAP represents an attempt to place this region into the context of different communities, as they change over time.

In framing the Sinop community, Bauer (2006a) draws upon the work of Yaeger and Canuto (2000) who suggest that notions of community represent a productive way for archaeologists to approach social interaction in the past and define the community as a “socially constituted institution” wherein interaction builds and maintains communities

(Yaeger and Canuto, 2000: 5). For Yeager and Canuto (2000) communities are tightly bounded to space and limited in scale. Bauer (2006a: 39-40) expands this notion to posit that not only does spatial proximity nurture community relationships, but communities themselves can construct space on the basis that communities also include transitional spaces and the landscapes through which human activity pass. Communities, in this framework, are more fluid; they are composed of socially-interacting groups whose members recognize each other as members of the same fluctuating community. This discourse-centered approach to community, argues Bauer (2006a: 41), is useful for archaeologists because it places the focus on interaction and the interpretation of social patterning as opposed to the standard cultural-historical practice of viewing archaeological “cultures” as discreet entities, finite in time and place.

Of course, to be a useful concept, communities must be observable archaeologically. Mac Sweeney (2011: 3) notes the “recent comeback” of the term “community” in disciplines like archaeology but laments the lack of an archaeological specific definition of the term. Like Bauer, she also notes the need for the concept to be understood as a form of social identity that is actively constructed across space and at various scales. While the research presented in this thesis is not explicitly an effort to understand community from this perspective, the extent to which a community existed archaeologically in the Sinop promontory is measured here in the material record by the interaction documented by the sharing of specific ceramic types, described in Chapter Four. In Chapters Four specific questions of community interaction are framed and addressed again in Chapter Seven.

The role of the research presented in subsequent chapters—the luminescence dating of ceramics—provides the chronological anchor for these analyses. The dating protocols and results obtained from these efforts cannot resolve these issues independently but can be used to disambiguate issues inherent in surface survey and data collection.

Continuing the discussion of community and regional connections, the Sinop promontory is the northernmost point in Anatolia located due south of the Crimean Peninsula across the Black Sea, making it a convenient and logical crossing point from the north. The surface currents (see Figure 2.4) of the Black Sea, in fact, flow in this north-south direction from the Crimea to Sinop and from the south to the north just west of Sinop, at the Cape of Karambis, to the Crimea (Doonan, 2006). Not coincidentally, the Greek settlement at Sinope founded a satellite colony of Kytoros, just west of Karambis. Underwater archaeological research conducted off the coast of the Sinop promontory in 2000 give an indication of the nature of these connections, finding multiple Byzantine shipwrecks stocked with “carrot” amphorae made in Sinope west of the promontory, indicating knowledge of the south-north currents off of Karambis (Ballard et al., 2001). These same “carrot” amphorae are excavated by the hundreds in archaeological sites along the northern Black Sea coast (Doonan 2006).



**Figure 2.4: Currents of the Black Sea (from King, 2004)**

The earliest evidence for human settlement in the region was documented by Dolukhanov (2007), in what is now northern Armenia, his survey team located multiple Acheulean and Mousterian sites. Though Neolithic patterns are less clear, since at least the Early Bronze Age (mid-3<sup>rd</sup> millennium BCE) ceramics found within the Sinop region illustrate connections between the western and northern coastal shores of the Black Sea (Doonan 2006). Dönmez (2010) confirms this initial reading of the promontory's prehistory and offers a good summary of the current state of knowledge into the promontory's prehistory. He conservatively places the earliest dated settlements in the greater provincial area to the Late Chalcolithic period with the settlement process perhaps beginning in the Early Chalcolithic or Neolithic. The Early Bronze Age in Sinop was marked by an increase in population and in the number of settlements, a period that Dönmez refers to as very active in the province. Middle Bronze Age finds suggest that Sinop was at this point part of the commercial network of the Assyrian Trade colonies,

with a center south at Kültepe, based on excavations from the cemetery at Gerze.

Dönmez notes a lack of an Early Iron Age center at Sinop and in fact along the entirety of the Turkish Black Sea coast at this time. Settlements become more frequent after the Early Iron Age again during Middle to Late Iron Age.

The pattern observed in Sinop is mirrored in many ways by that of Cide, site of regional surveys from 2009-2011 (Düring and Glatz, 2010; Düring et al., 2012).

Settlements at Cide, about 250 km west of Sinop along the Black Sea coast, are documented from the Chalcolithic through postcolonial periods. Neolithic sites have not been recorded during these surveys. Interestingly, the survey at Cide has chosen to reject the application of luminescence dating (B. Düring, personal communication, May 20, 2009) on grounds that it is not suitable to dating of ceramics from surficial contexts. This criticism is addressed in Chapter Five.

Featuring most prominently in regional studies is the site at Ikiztepe, located near Bafra west of Samsun, and excavated at various times over the last three decades. Data published by Alkım et al. (1988, 2003) and Bilgi (1999) reveal a site chronology that spans the Chalcolithic to Middle Bronze Ages (see also, Ivanova, 2013). The material culture—particularly aspects of the ceramics, as noted by Bauer (2006a)—suggests clearer regional connections along the coasts of the Black Sea than to Anatolia, in the interior. Among the evidence is the “Karanovo VI/Gumelitsa” type (Alkin et al. 1988; Thissen, 1993) though possible links also exist between Ikiztepe’s Chalcolithic pottery and the pottery from sites like Büyük Güllücek in northwestern Anatolia and the Marmara region. Bauer (2006a: 143) also notes that the later period Ikiztepe burials are

similar to burial practices in the north Pontic steppe region, at sites like Dobrogea and the Odessa region: shallow, rectangular cist-graves with supine bodies with flexed knees and burial gifts including daggers and spearheads and ochre (Comşa, 1979; Panayotov and Dergacev, 1984; Yakar, 1985). Connections like these led researchers to use the collections from the Ikiztepe excavations as points of reference for regional assemblages, often arguing that stylistically similar ceramics from other sites in the greater Black Sea region dated to the same time periods as their broadly defined Ikiztepe analogs. At Sinop, SRAP chose to use luminescence dating to, in part, challenge these assumptions. The degree to which the luminescence dates reshape the Sinop chronology is in some way a response to the lack of a pure analog to Ikiztepe.

Evidence for inter-regional connections becomes clearer during the Iron Age (Summerer, 2007) in the region of the Halys basin (Kızılırmak River) between Sinop and Samsun on the coast. Excavations in this area unearthed a number of early Greek vases and Greek style clay roof tiles, thought to date to the late Archaic Period. Summerer posits that some of the architectural terracottas—locally made—represent an adoption of Greek styles. She goes on to suggest that the presence of Greek architectural elements, from what were likely monumental palaces, within indigenous settlements is best explained by a Greek economic interest in the region's natural resources, including cinnabar, interestingly called *sinopis* by the Greeks. Likewise, Demir (2007) provides evidence of trade from the southern Black Sea coast to the Aegean Sea of salted small-fry (*hamsi*) during the Archaic and Classic periods. These small fish (which, incidentally,

represent one of the favorite foods of this thesis's author) would have represented an important component of the diet of lower working classes.

Throughout antiquity into the Middle Ages these patterns of trade and exchange continued to reflect the social, economic, and political dynamics of the greater Black Sea, Aegean, and Mediterranean regions. What follows is just a small sample of recent work that illustrates this point. Peacock (2007) provides evidence for trade between the Islamic world and northeastern Europe (Russia and the Crimea) between the ninth and early 13<sup>th</sup> centuries CE. His evidence suggests that the Black Sea represented a major route of long-distance trade (including, perhaps, that of human slaves), linking east and west, across important commercial lines, supported by the presence of "large hoards of Islamic silver coins" in Russia in the ninth century CE. Güneş-Yağcı (2007), likewise, notes that with the decline of the Byzantine Empire in the beginning of the 13<sup>th</sup> century CE that Italian city-states began to create colonies along the Black Sea coast to establish trade centers. These Italian colonies would become influential in the slave trade until the Ottoman empire took control of the region in the mid-15<sup>th</sup> century CE.

The Sinop seaport and hinterland networks certainly played an integral role in the maintenance of widespread networks and, conceivably, were sensitive to patterns of cultural change in these same networks for much of the last 8000 years. One pattern that has emerged is that the connections are much more apparent and clear to other Black Sea coastal areas (north, west, and east) than to the interior of Anatolia (Doonan, 2006: 48). To understand this pattern and seek out other patterns, the SRAP team has invested

heavily in efforts to understand these connections by studying the distribution of sites and characteristics of the material record in the promontory.

The original research presented in this thesis is designed to provide the chronological control to clarify the nature of these relationships, by dating pottery sherds found within the promontory at a series of sites identified through regional survey. As the region has been colonized and contested by a series of different cultural groups since potentially as early as the Neolithic, the constructed landscape is best conceived of as a palimpsest of superimposed features that represent this diverse past (Doonan, 2004b; Wandsnider, 1998). One method of resolving the material culture palimpsest is to establish reliable information about the ceramic assemblages, assigning them to categories of identity, and using luminescence to explore the processes of interaction between the areas on the local and regional landscape (Doonan, 2004b). The focus of the dating regimen was on sites thought to be prehistoric, though as will become readily apparent, this was not a straightforward process. Before presenting those data in Chapter Six and discussing their significance in Chapter Seven, I will end this chapter with a review of the current state of knowledge regarding the local archaeology of the promontory including an effort to contextualize it within the greater region.

*Archaeological Evidence for Human Settlement of the Sinop Promontory and Environs*

Doonan (2004a: xix) provides a detailed and exhaustive timeline of the major archaeological periods, evidence for occupation and settlement, and cultural trends on the Sinop promontory. That work and subsequent additions to the regional chronology are summarized here in Table 2.1.

**Table 2.1: Major Archaeological Periods for the Sinop Promontory (Doonan, 2004a)**

<b>Period</b>	<b>Dates</b>	<b>Cultural Trends</b>	<b>Major Sites</b>
Neolithic	c a. 8000- 4000 BCE	Pre-ceramic and Ceramic	İnceburun, Mezarlıktepe
Chalcolithic	c a. 4000- 2700 BCE	-	Maltepe, Kayanın Başı
Early Bronze	c a. 2700- 2000 BCE	Widespread settlement in Sinop and Samsun regions Parallels to Bulgaria, north- western Anatolia and Ukraine	Kocagöz, İkiztepe, Güllüavlu
Middle-Late Bronze	c a. 2000- 1000 BCE	Limited contacts with Central Anatolia	Güllüavlu
Iron	c a. 1000- 600 BCE	Establishment of Coastal Settlements Connections between Sinop and northern Black Sea coast; Intensification of settlement along Kırkgeciçay drainage	Köşk Hüyük Sinop Kale, Tıngır Tepe (Tingiroglu)
Archaic	7 <sup>th</sup> -early 5 <sup>th</sup> c. BCE	Foundation of Sinope by Miletus Sinopean colonies in the eastern Black Sea	Sinop kale
Classical	5 <sup>th</sup> -4 <sup>th</sup> c. BCE	Mass production of Sinope amphorae with distribution around the Black Sea	
Hellenistic	4 <sup>th</sup> -early 1 <sup>st</sup> c. BCE	Sinope made capital of the Pontic Kingdom Expansion of coastal settlement	Kecioglu—Demirci, Altinoglu (Lala), Cakiroglu
Roman	Early 1 <sup>st</sup> c. BCE- 3 <sup>rd</sup> c. CE	Conquest of Sinope by the Romans Agricultural villas in the hinterland	Karapınar, late
Late Roman/ Early Byzantine	4 <sup>th</sup> c. CE-7 <sup>th</sup> c. CE	Widespread agricultural industry Expansion of suburban settlement Building of churches in the hinterland Expanded road system	Demirci, Kıraztepe, Çiftlik, Erfelek, Cakiroglu, Kırkgeciçay Drainage

Table 2.1 continued

<b>Period</b>	<b>Dates</b>	<b>Cultural Trends</b>	<b>Major Sites</b>
Middle/Late Byzantine	8 <sup>th</sup> c. CE— 13 <sup>th</sup> c. CE	Arab invasions Struggle between Byzantium and Trebizond for control of the central Black Sea Declining Hinterland settlement	Sinop town
Seljuk	13 <sup>th</sup> c.—15 <sup>th</sup> c. CE	Repair of city walls Building in Sinop town Isolation of the port from the hinterland	Pervane Medrese Alaatin Mosque Lala Kervanserai (Taş Hanı)
Ottoman	15 <sup>th</sup> c.—20 <sup>th</sup> c. CE	Conquest in 1461 Increased ship building in 1570 Cossack sack of Sinop in 1614 Russian sack of Sinop 1853 Recovery of town in hinterland in the late 19 <sup>th</sup> c.	Sinop town, Çakıroğlu
Republican	1923— current	Population exchange 1920s Expansion of agriculture along south coast Suburban and industrial expansion on Boztepe Hinterland settlements depend on external income	-

By presenting these sites in table form, a slightly artificial sense of order is suggested. There is, in fact, some disagreement about the nature of this classification, as I've learned in a series of conversations with SRAP co-directors Doonan and Bauer (personal communication, April 28, 2007). The placement of Mezarlıktepe, for example, in the Neolithic has received significant debate within SRAP. It could be that the site was occupied during the Late Neolithic or Early Chalcolithic, based on some similarities to Ilıpınar (Bauer, 2006a). Similarly, Kayanın Başı may have been a site straddling the Late Chalcolithic to Early Bronze Age. A third example is the site of Köşk Hüyük in Gerze. Doonan's classification puts the site in the Iron Age, but Bauer (2006a) sees aspects of

the Middle Bronze Age in the ceramic collection, based on the presence of red burnished teapot spout, or to the Early Bronze Age, based on similarities to Kocagöz (2006a) This ambiguity highlights the degree to which chronological control, provided by luminescence dating, is needed in this case. Ceramics from Köşk Hüyük, Mezarlıktepe, and Kayanın Başı are part of the luminescence analysis discussed in future chapters, so this disagreement will receive further attention in later chapters.

Regardless, there was almost certainly a Paleolithic component to the occupation of the promontory, supported by the finds of chipped stone artifacts at Ince Burun. Results from SRAP survey since 1996, however, indicate that the primary periods of expansion and, later, contraction of human population as a regional community on the promontory and beyond begins with the Late Chalcolithic Age and continues to the present. Spatially, of course, the nature of these connections varied over time, but Doonan (2006: 51) has identified periods of “maximum cohesion” during the Hellenistic, Late Roman and late Ottoman/Republican periods in particular. During these periods, the economic and social structure of the promontory centered on the port, supported by a network of secondary centers which would have served to concentrate political power, provide structure for industrial activities (e.g., Ottoman ship building) and distribute locally produced goods to external markets. Additionally, Doonan (2006: 51) writes that the small-scale household-based activities would also have been scattered throughout the hinterland, including: agriculture, fishing, industry, forest products, and facilities supporting religious practices, lodging, and exchange practices. Conversely, during times of reduced regional cohesion, the hinterlands were more isolated from the port and its

political network, though the port itself remained connected to the greater Black Sea community and region throughout these periods.

So if we take the Late Chalcolithic Age as our starting point for the development of “community” in and around the promontory, we can begin to summarize its important characteristics. Whatever Neolithic settlements preceded the formation of the Sinop community will be interesting to identify, but their placement in the community must first be established. The Bronze Age, generally, was characterized by small settlements where people practiced subsistence agriculture and by ceramics suggesting a dispersed network of connections.

Doonan also (2006: 51-2) notes that the evidence from the SRAP survey from ceramic analysis suggests that, from this time onward, people of the promontory were connected to the western half of the Black Sea—despite the lack of direct evidence of overseas trade or intensive seafaring. He speculates that it was small-scale wide-ranging fishing practices that kept the populations connected as part of a larger community. As fisherman ranged far from home, following the seasonal migrations of economically important fish species, they came into contact with one another. This contact may have been the basis of gift exchanges and other alliance building strategies arising from contact, cooperation, and competition.

This pattern continued through the Late Bronze Age and Iron Age, but during the early first millennium BCE coastal settlement patterns began to change, marked by the establishment of a settlement bearing clear similarities to pre-Greek settlements of the greater North Pontics (Doonan, 2004a). He writes that it may have been a small colony

(e.g., a fishing camp) but that it, nonetheless, marks the commencement of increased settlement density on the coast of the promontory, suggesting a period of coastal-oriented settlement (Doonan, 2007). The movement of the population from the hinterlands to the coast during this period suggests an economy with reduced reliance on inland agriculture and increased reliance on fishing and/or trade.

The Archaic period commences with the establishment of the Milesian colony at Sinope in the 7<sup>th</sup> c. BCE which quickly led to the creation of colonies stretching to the eastern Pontics and remaining closely allied with Sinope (Doonan, 2006). Despite the growth of these coastal settlements, connections to the hinterland by the Greek settlers appear weak until the 4<sup>th</sup> c. BCE. During this period, Sinope becomes disconnected from its eastern colonies and re-invested in local networks, marked by a dramatic increase in amphora production on Boztepe (Garlan and Tatlican, 1997) and expansion of Hellenized settlements in the hinterland in the 3<sup>rd</sup> c. BCE, reflecting a possible origin of the olive industry for which Sinope is known in later times (Doonan, 2006). This interpretation is supported by the extensive production and distribution of Sinop amphorae in the late Classical/ early Hellenistic Periods, 4<sup>th</sup>-3<sup>rd</sup> c. BCE (e.g., De Boer, 2001). Survey work by the SRAP supports this interpretation by documenting an increase in settlement density during the Late Classical and Hellenistic periods along the coasts of the promontory, the establishment of contacts between inland, coastal, and overseas communities, as well as through the establishment of Greek influenced sanctuaries in the hinterlands. Doonan (2006:52) refers to the origins of the integrated community in the Sinop promontory.

Late Roman and early Byzantine periods are marked by an expansion of the integrated regional economy. Hinterland settlement density increases to levels only matched in modern times and a suite of specialized sites, including for industrial, maritime, agriculture, and religious purposes, are in evidence (Doonan, 2004a). The rescue excavation at Çiftlik, 10 km southeast of Sinop, is a fine example of the late Roman/early Byzantine church (Hill, 1998). Amphora production, too, grows, marked by the development of a second port and production facility at Demirci Plaj, 15 km south of Sinope in the Demirci Valley that would have served the growing regional agricultural community (Kassab Tezgor et al., 2010). Amphora with the “black sand” pyroxene temper are found in significant quantity during these periods throughout the north and west Black Sea regions. SRAP surveys in the highlands, too, show evidence for an intensified expansion of the greater Sinop “community”, as the presence of large settlements in the hinterlands contain imported ceramics from the coast and/or overseas (Doonan, 2006). With later Arab and Turkish invasions into the region in the 9<sup>th</sup>-11<sup>th</sup> c. CE the port continued its role as a critical node in the Black Sea region but the port’s relationship with the hinterland weakened. This pattern continued with the subsequent Ottoman Empire into the 20<sup>th</sup> c. CE, though in later periods of the empire’s rule the need for tobacco and timber for ship building increased, indicating a more widely dispersed series of settlements with subsistence agriculture (Doonan, 2004b).

Prior to the work of the SRAP, Işın (1998) pioneered survey work in the Sinop promontory from 1987-1990. These surveys represented an effort to understand and document the distribution of prehistoric sites over the littoral (shore) areas of Black Sea

and Pontic Mountains. He noted significant differences between coastal and highland sites in architectural practices beginning in prehistoric periods, with coastal construction using wattle and daub and highland construction of stone. He also suggested that mound distribution tracked trade routes, one along the coastal plain and one south through the mountains into Anatolia. The SRAP is currently evaluating these trends with a systematic survey.

Providing further context for developments in Sinop is the multicomponent occupation of İkiztepe, a major settlement located about 90 km east of Sinop in the Kızılırmak river delta near Bafra, consisting of four distinct mounds. The settlement, with occupations in the Chalcolithic (late 5<sup>th</sup>-4<sup>th</sup> millennium BCE), Early Bronze (3<sup>rd</sup> to early 2<sup>nd</sup> millennium BCE), Late Iron (mid-first millennium BCE), and Hellenistic (4<sup>th</sup> to early 1<sup>st</sup> c. BCE) spans a similar duration of occupation to the sites at nearby Sinop (Alkım et al., 1988; Bilgi 1999). It is not surprising, therefore, that ceramics from İkiztepe are often compared to ceramics from the Sinop region. As both Bauer (2006a) and Dönmez (2010) note, however, there are reasons to be dubious about a straightforward comparison between the two regions: the potters of the İkiztepe sites, located along the Kızılırmak delta were much more connected to the Anatolian plateau to the south by way of the pass through the mountains formed by the river. Sinopian potters lack this access point to the central Anatolia and are instead in greater contact with influences from the Black Sea regions of the west and north. As will be shown in Chapters Five and Six, using the İkiztepe ceramics as a source for direct comparison of ceramic styles and ages will not necessarily yield an accurate typology or chronology.

*Chronology of Pre-Colonial Ceramic Types in Sinop, Turkey*

A lack of reliable stratigraphic excavations in the Sinop region, combined with the region's isolation from other better-dated regions inland from the coast, has presented a challenge for drawing conclusions regarding its early periods. Conventional chronologies for the Sinop promontory (e.g., Işın, 1998) are based on uncertain typological parallels to material from other regions. Concurrent research at Cide (Düring and Glatz, 2010), a region just over 250 km west of Sinop, is currently operating under the same unclear chronological framework. Even the stratigraphic excavations at the prehistoric mounds of İkiztepe (Alkim et al., 1988; 2003) have not mitigated the chronological problems for dating in this region: work at İkiztepe has generated only a few C-14 dates and an early attempt at quartz-inclusion luminescence dating (Göksu-Ögelman and Ukav, 1986), and the excavators prefer to leave the radiocarbon dates uncalibrated in order to better fit the conventional chronology (Thissen, 1993). Bauer's (2006a, 2011) impressive study of the Sinop pottery from a ware type/manufacturing perspective represents an attempt to move beyond this style-based approach. Initial efforts to calibrate those studies with luminescence dating were explored in a recent collaboration (Casson et al., 2012) and are subject to future research. While helpful in many regards (and the subject of discussion in Chapter Four), Bauer's ware type studies still suffer from a lack of clear chronological anchoring as they do not rely upon stylistic attributes. In this context, the luminescence studies undertaken so far at Sinop, in addition to the research proposed here, serve to revise and improve substantially our understanding of the pre-Colonial periods in the region.

In cases where there is an absence of stratigraphic or comparative data for chronology construction, direct luminescence dating of ceramics collected through surface survey is an effective strategy (Dunnell and Feathers, 1995; Feathers, 2000). Luminescence dating of ceramic sherds is not subject to deficiencies in association-based dating because of the correspondence of the dated event and the archaeological target event; luminescence is the dating method of choice for surface samples, as the method generates a regional view of chronology without the expense of excavation. These issues will be discussed in further detail in Chapter Three.

### **Chapter Three: Archaeology and Chronology Development**

“Time is but the stream I go a-fishing in.”—Henry David Thoreau (1817-1862)

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This thesis is fundamentally about evaluating the potential for luminescence dating to create or revise an absolute chronological framework for the Sinop promontory. One of the primary advantages of using luminescence dating to develop a chronology is that it allows you to date individual artifacts where the resultant date is of human behavioral significance. In this case, the method derives luminescence ages for the manufacture of individual ceramic sherds. By compiling a series of dates from different sherds from a series of sites in the Sinop promontory, one can begin to get a realistic representation of when certain forms were being manufactured in different parts of the landscape.

This chapter argues that luminescence dating is the ideal way to provide chronological control for the research questions framed by the SRAP. Not only is luminescence the best fit for the nature of the data (i.e., surface collected ceramic sherds) but it provides the right kind of chronological data for the scale of analysis associated with understanding the issues of community and connections as outlined in Chapter Two. This chapter will be divided into four parts: a consideration of the usefulness of archaeological chronologies, the advantages and applications of luminescence dating, a close look at a few key examples of luminescence, and, finally, building a ceramic chronology with luminescence.

#### *The Usefulness of Archaeological Chronologies*

Chronologies are tools to create a usable framework with which to categorize

time. Chronological units are conceptual, defined, and imposed on the continuum of time (Ramenofsky, 1998: 75). As such, chronology and time are not synonymous terms.

Time is a nebulous dimension whose meaning is debated by philosophers and scientists (Bardon and Dyke, 2013). Chronological units are created by humans (e.g., archaeologists) to measure time in ways that are meaningful. Chronological units are highly specific tools and should conceptually fit to specific temporal research questions. This is the perspective of Ramenofsky (1998) and forms the basis for the way research presented herein has been framed, as embracing ontological materialism.

Ontological materialism implies that real temporal divisions do not exist, at least not at any measurable scale. Some scientists think there are real units of time and space, *quanta*, but of such short intervals that time and space appear infinitely divisible (Bardon and Dyke, 2013). Archaeological units are of much longer duration. These measured durations of time are not pre-packaged as a set of units that scientists can discover; rather, time is arbitrarily divisible into units of our choosing. So, for our purposes, time is abstract. This is contra to an essentialist framework, wherein chronological units are thought to be real and discoverable. The essentialist framework is marked by an over-reliance on culture historical units as real, which can lead to a tendency to circular logic in which units undergo continual “chronological redefinition” (Ramenofsky, 1988: 83). This process reifies types by maintaining, adjusting, and redefining culture historical units to accommodate current research interests, all the while assuming the units are real. Ramenofsky (1998: 75) also notes that archaeologists can recover through standard methods “temporal indicators” from archaeological deposits and estimate their duration

in common sense intuitive categories, but this, too, does not mean that those units are in any way real. They are merely conceptual categories, made by human minds to serve human minds. Time, after all, is a continuous variable at all practical scales. It is linear (except at very large scales) and nonreversible.

Archaeologists study time primarily as a linear phenomenon following Gould's (1987) metaphor of "time's arrow" and use various chronometers to track the progress of the arrow (Lyman and O'Brien, 2006). The only requirements for a chronometer, according to Gould (1987: 157) are that it tracks changes in an observable and irreversible way through time and, add Lyman and O'Brien (2006: 121), irrespective of where in geographic space it is used. Data generated from luminescence dating fulfill these standards by measuring the accumulation and storage of electric charge that becomes trapped in defects of crystalline materials (Aitken, 1985). When the chronometer is artifact-based, as with luminescence dating of ceramic artifacts, it can be called a direct-dating technique, meaning that the *target event* is equivalent to the *dated event* (Dean, 1978; Lyman and O'Brien, 2006: 286). These terms will be explored in greater detail in the following section, as this feature of luminescence dating represents one of its most significant advantages. In terms of this discussion of chronometers, their resolution will be a product of analytical techniques and the fit to the research question. Traditionally, this has been seen as a potential limit to luminescence dating, because of lower precision due to cumulative error from many measured variables. This, too, will be discussed in later chapters: first, as a limit (below, in Chapter Three) and then as an area of methodological improvement developed in the course of this research (Chapter Four).

Returning to the more general discussion of time and chronology, let us consider the way that archaeologists must reconcile the creation of chronological units with the abstract nature of time. How do archaeologists extract “chunks of time” from the material record? As Ramenofsky (1998: 78) states, it is not sufficient for archaeologists to simply state that time elapses continually; rather, archaeologists must construct chronologies that measure the temporal dimension. As noted above, this is best achieved through a materialist perspective in which conceptual categories are imposed on the continuum of time. Because there are no necessarily “right” categories or divisions between the categories, it is critical that the selection of units be the product of logical continuity to the research questions under investigation. The degree of temporal resolution required of analysis, for example, should be sufficient to address the research question. An examination of the fit between temporal goals and chronology is largely a measure of *reliability* and *validity* (Ramenofsky, 1998).

Reliability and validity are used to assess the adequacy of units (Ramenofsky, 1998: 8-10). Reliability is a measure of the consistency or reproducibility of a measurement instrument and describes the ability of units to be precise and accurate—the empirical qualities of a unit. Validity addresses the relevance of units to the goals of archaeological research. Validity and reliability are not synonymous with precision and accuracy; the reliability of a measure is a *product* of the analysis conducted, whereas the validity of a measurement reflects the *decisions* made during analysis—the relationship between what you are measuring and your research question. *Precision* is a function of the reproducibility of the measurement instrument; *accuracy* refers to the how close one

is to the “right” answer. In a sense, reliability includes aspects of both precision and accuracy, *i.e.*, the likelihood of a date to withstand further research, which is likely a function of both precision and accuracy. Precision is linked with random error (the more precise, the less random error); accuracy is linked with nonrandom, or systematic, error (bias).

To increase the reliability of the luminescence dates, I will be using multiple lines of evidence, so that if/when ages agree (from thermoluminescence, optically stimulated luminescence, and/or infrared stimulated luminescence) it will become reasonable to have more confidence in a date, and also increase the precision and accuracy of the results. In Chapter Four, I will discuss the use of multiple lines of evidence (calculations of equivalent dose derived from three different luminescence stimulations) as a way of increasing the reliability of luminescence dates. The validity of chronological units can be assessed by analyzing the conceptual fit between the units and the research goals. In this research, the validity of the chronology is largely a product of sample selection: which ceramics were included in the dating protocol and why. Validity is also a product of the kind and quality of the temporal information used to address research questions, in particular the time scale and resolving power of the technique (Ahlstrom, 2008). This, too, will be discussed in the next chapter.

Two additional components of validity and reliability assessment are *resolution* and *scale* (Ramenofsky, 1998: 79-81). Resolution is the ability to distinguish different temporal events, enough to address the research question? If, for example, you wish to learn whether or not a kiln was used in the year 1050 CE or 1055 CE, luminescence will

not be able to *resolve* that question, as it cannot produce ages with sufficient precision to distinguish between such a narrow temporal margin. Relatedly, the product of temporal measurement, or *estimate*, can be either ordinal (a measure of relative chronology, with no numerical specificity of age) or interval (a measure of absolute chronology, with fixed numerical values). Ordinal and interval estimates differ in regards to the scale of resolution of the measurement—interval scale operates at higher resolution. Though interval measures also operate on a relative scale (only ratio scale data is absolute, with a fixed zero point), it differs from ordinal in that the time between events is quantified. Researchers, however, must be wary not to confuse the finer resolution (precision) provided with interval scale data with an assessment of accuracy (a component of reliability) or validity, as falsely assumed precision. Consider, for example, a situation in which wood from the floorboards of an early pioneer home are dated with dendrochronology, a technique which provides an age for the death of the tree from which that wood came with precision to one year. But, as the sample that was dated did not have its outermost growth rings and may or may not have been cut soon before its use as a floorboard, its temporal relationship to the pioneer home may be significantly different from its highly precise dendrochronological date. Ordinal level dating reduce the possibility of error, though at the sacrifice of greater resolution.

#### *Advantages and Applications of Luminescence Dating*

As noted above, a justification of luminescence dating must be made in terms of the way the technique creates chronological units that can be used to address the research questions of specific archaeological questions. Following Feathers (1997: 3-4), for any

technique to address a chronological problem, archaeologists must demonstrate the ability to: one, define in unambiguous terms the event of interest, called the *target event*; two, select the dating method that best measures the target event; and three, develop a dating strategy that maximizes precision. Within this framework, luminescence dating has three clear advantages (Feathers, 1997: 4):

- The dating event and the target event are the same when the dating event is the manufacture of the pottery. This avoids the problem of association,
- It provides dates for materials that are ubiquitous in archaeological contexts, *i.e.*, pottery,
- It covers an archaeologically important age range (from the very recent to well over 100,000 years).

The chief disadvantage of the luminescence dating technique is its reliance on numerous analytical steps, each of which carries an error calculation, which when propagated can decrease the precision of the resultant date. As for the advantages listed above, the first two are easily understood. The dated event is the last exposure to sufficient heat or light. It works best on crystalline materials, particularly quartz and feldspar, which are common components of the material record. The manufacture of the ceramic exposed the material to high heat. If this is the last time the ceramic was exposed to high heat (often the case), then luminescence provides a direct date of manufacture. This is the primary way luminescence can provide archaeological chronological information with high validity—a well-formed conceptual fit between chronological units and research questions. As not all events from the past can be

directly dated, the discussion here will continue with an examination of how luminescence fares in this regard.

The terms *dated event* and *target event* have been mentioned several times already and have a long history within archaeological research (originating with Dean 1978; see also Dunnell and Readhead, 1988). Here they will be expressly defined and discussed in more detail. Dated events represent those events for which date estimates are generated by a dating technique, *i.e.* the event that is actually dated. Target events are the events of archaeological interest. The dated event is not always the same as the target event; when this is the case, to address the target event, archaeologists must rely on bridging arguments. Consider again the pioneer home described above: if a building event is to be dated by dendrochronology, a bridging argument is necessary to link the death of the tree to the construction of the building. But, when an artifact-based chronometer is also a direct-dating technique, as is usually the case with luminescence dating of pottery, the target event is also the dated event when what you want to know is the time of manufacture. For ceramics, the dated event is the most recent exposure to temperatures high enough to reset the stored luminescence energy to zero. This happens during ceramic manufacture, at temperatures over 500°C. (It may also happen during ceramic use, for example cooking ware—but usually the difference in time between the manufacturing event and the use event is negligible.) As this event is also the target event, this represents a significant advantage for using luminescence to create chronometric units. As Lyman and O'Brien (2006: 286) note, most absolute chronometers are indirect-dating techniques, where the target event is only indirectly

dated by association to the dated event. This is most true for radiocarbon dates, which date the death of living cells. When archaeologists use radiocarbon dating to date by association the age of an archaeological site or deposit, for example, it becomes an accuracy problem unique to association-based dating. As Feathers (1997: 4; 2000: 160) argues, indirect dating lowers validity and potentially accuracy; this uncertainty is rarely specified in the reporting of dates, perhaps because it is so difficult to quantify. In general, the validity of the application of a technique for a given problem can be assessed based on the link between the dated event and the technique and the information generated about the time of occurrence of those events (Ahlstrom, 2008).

There is some nuance to the issue of target events, as they can occur at different scales: as discrete artifacts and as groups of artifacts (Dunnell, 1981). For discrete artifacts, the target event is the manufacture or, occasionally, the use of the artifact, e.g., the manufacture or use of a pottery vessel. For groups of artifacts, the target event is the occupation, i.e., the set of events when artifacts came together over some duration. For depositional events resulting from occupation at a site, luminescence dating of sherds is not a direct dating method, because the sherd may have been manufactured (dated event) long before deposition, as in the pioneer home above. To address deposition/occupation requires a bridging argument. Luminescence does, however, provide direct dates for the duration of types, which can be used to discuss the temporal element of particular sites and loci. That is, a quantity of manufacturing dates does not equal occupation, but can serve as a bridging argument to understand the span of occupation. In Sinop, our goals

were to identify both discrete events—the age of specific sherds—but also to understand changes over time through entire human landscapes.

Regional studies often rely on data collected from the surface, where association-based data may be susceptible to weaknesses in validity. A valid bridging argument must take into account the age of the surface: the shorter the duration of the surface, the stronger the temporal association. The occupational landscapes from which samples are collected by archaeologists are palimpsests, created by long periods of occupation, re-occupation, and post-depositional factors that can make establishing patterns of historical relatedness difficult (Beck, 1994; Feathers, 2000). Until recently, the luminescence community, and thus archaeologists as well, mistakenly recommended against dating surface ceramics because of perceived concern over uncertainties about gamma and cosmic radiation dose rates for artifacts exposed on the surface. As Dunnell and Feathers (1994) showed, however, this perspective fails to consider that all buried sites were once surface sites. Barnett (2000a) showed that large pits, in fact, have many of the same features of a surface palimpsest, in that they are likely to have materials of different ages. Furthermore, the dose rate calculation of buried sites can also be less stable than surface contexts, not to mention changes in dose rate due to changing burial depths and therefore the uncertainty of the dose rate on a surface may be less than for buried samples (Dunnell and Feathers, 1994). Feathers (2003: 1499) suggests, in fact, that the accuracy of dating surface ceramics by luminescence has been validated to the degree that any uncertainties in the dose rate are no greater than from buried sites.

Even in well understood regions, with major sites of known age there will be parts of the landscape dotted with small sites with nondiagnostic artifacts and no other datable material. Only direct dating of the ceramics with luminescence can determine the relationship between small scatters and large sites. Similarly, the duration of site occupation is susceptible to the problems of association—the creation of high uncertainty from the lack of control over too many variables (Feathers, 2003: 1499). Luminescence results for ceramics collected from surface survey from the Sinop promontory are presented in Chapter Six.

It was mentioned above that reduced precision represents the biggest “weakness” of luminescence dating. A further consideration of that statement is warranted here, in terms of the often paired concepts of *accuracy* and *precision*. As noted above, luminescence requires the measurement of a large number of analytical variables, each with their own error term, which accumulate in the production of a single cumulative error. This propagated error lowers the precision of the technique. But, the power of a dating technique is not a function of precision alone. It is also a product of its accuracy and precision. Accuracy is increased if the dated event and target are the same event, which is the case for luminescence. Association-based techniques, like radiocarbon, may be less accurate. So, radiocarbon, while often quite precise, is often not accurate and is only a direct dating method for organics (Feathers, 1997: 5). Interestingly, there has been a recent surge in the popularity of dating ceramic residues by radiocarbon (e.g., Bertan et al., 2008, Zarillo et. al., 2008) as it provides a method with which to use radiocarbon as a direct dating technique, though of course the problem of association may persist if the

residues dated do not relate to ceramic use. Additionally, efforts to increase the precision of the luminescence technique have increased in recent years (e.g., Feathers et al., 2012) routinely producing luminescence dates with less than 8% error—the best example of this are the data presented in this thesis, in fact, in Chapter Six.

Two final notes on the effectiveness of luminescence: the dating of long-duration events (occupations) and the lack of a need for calibration. The precision and accuracy of long-duration events can be improved by simply increasing sample size. That is, to understand the distribution of dates from a site or region, as with the research at Sinop, the addition of more sherds for luminescence analysis increases the resolution of occupation: the distribution of individual dates defines the temporal range of occupation and any multimodality indicates multiple occupations (Feathers, 1997: 7; Lipo et al., 2005). Secondly, luminescence—unlike radiocarbon dating—produces calendrical dates. Radiocarbon requires additional comparison with the tree-ring calibration curve. Because of temporal variation in the cosmic production of carbon isotopes, radiocarbon dates require calibration before they can be compared globally as calendar dates. When the calibration curve (for the Holocene generated from dendrochronological sequences) is flat, then radiocarbon ages can represent multiple (and different) calendar ages. Precision is significantly worsened in these conditions.

In sum, luminescence dating techniques are increasingly being used to answer archaeological questions that had previously been addressed only with radiocarbon or other dating methods (Feathers, 1997, 2000, 2003; Liritziz et al., 2013.). This trend is the result of several attractive advantages of the luminescence technique. First, luminescence

can be applied to materials commonly found at archaeological sites, including ceramics, burned lithics (fire-cracked rock), and buried sediments. Second, luminescence directly dates archaeologically relevant events. Third, because luminescence can directly date assemblages, it can help resolve mixed assemblages, help define temporal ranges of types, and help determine site durations. Fourth, luminescence has been successfully applied to dating materials found on the surface. This makes it particularly attractive to regional survey projects like the SRAP, which depend on surface outcrops of artifacts. Fifth, luminescence provides calendar dates with no need for further calibration, as with radiocarbon. These advantages make luminescence an appropriate choice for chronology development in the Sinop promontory.

*Key Examples of Luminescence: Three Case Studies*

Problems with association-based dating extend into several other arenas. First, association-based dating is not very useful for measuring rates of change (Feathers, 1999, 2000). An example that illustrates this point is Feathers (2009) study explaining the rise of in frequency of shell-tempered pottery in the American eastern woodlands.

Archaeologists have long known that shell-tempered pottery replaced other tempers during the Late Prehistoric, but there was little resolution to this interpretation.

Feathers identified the reason for the lack of resolution as related to a disparity between the chronological units and the research question. By using traditional dating methods, like seriation and radiocarbon, early efforts to understand the changing dynamics of ceramic manufacture could not be resolved. Specifically, a reliance on association-based dating provided only average dates, grouped into culture-historical

units, which suppressed the variation present over time. From seriation, three “periods” were derived: Period A, marked by grog temper; Period B, marked by with both grog-tempered and shell-tempered pottery; and Period C, with mostly shell-tempered pottery. Radiocarbon dates were associated with period, not artifact type, so it was unclear if the dates from Period B reflected the presence of both tempers concurrently or one before the other. These early efforts identified broad trends but lacked resolution: was the change gradual with a clear overlap, indicating an internal source of shell-tempered innovation, or sudden and without overlap, indicating a rapid replacement in technology (external)? A luminescence-based direct-dating methodology could address that problem by matching the chronometer—individual artifacts—with the research question. As described by Feathers, simply dating a large sample of sherds from Period B of each temper type produces a temporal distribution of ages. The rate of change can be measured by noting how many dates for each temper type occurred in a given length of time. His results showed strong chronological overlap between temper types and suggested that shell-tempered pottery was present in the area, in low frequency, much earlier than previously assumed. That is, association-based dating could not resolve the chronology of change because it could not provide data able to distinguish between possible interpretations of cultural change. Direct dating of ceramics, represented here by luminescence, was able to resolve alternative explanations. The methodological limits of association-based dating are revealed in comparison with high resolution luminescence dates (Feathers, 2000).

A second example of the ability for luminescence to resolve certain questions of chronology comes from Ramenofsky and Feathers (2002) and serves to illustrate how luminescence data can supplement other lines of evidence and illuminate, in this case, issues of site abandonment in the Rio Chama region of northern New Mexico.

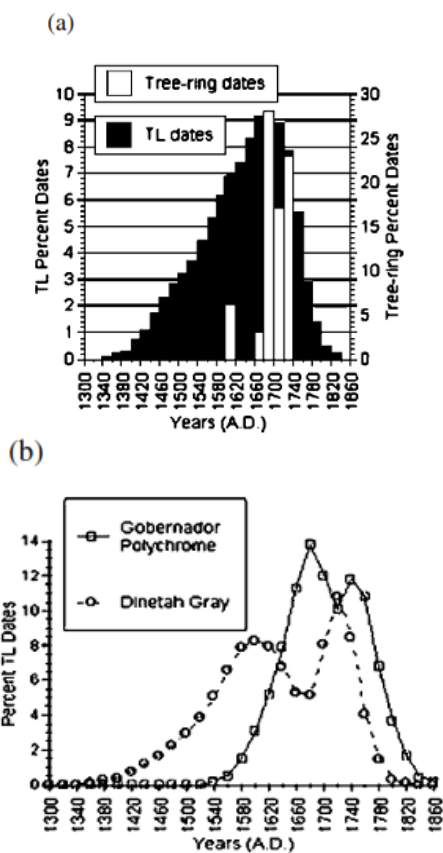
Traditional methods, in this case ceramic seriation, dendrochronology, and historical documentation of abandonment, estimated final native abandonment of their large pueblos at between 1550 to 1650 CE, a range with insufficient precision to resolve temporal issues of the effect of Spanish colonization where regional abandonment is more commonly given as around 1670 CE. Was abandonment a rapid and singular event? Was it really that early? Or, alternatively, might it have been more complex, including, perhaps a re-occupation by the natives?

Here, as with the previous example, the traditional chronological resolution is too imprecise and the authors turn to luminescence dating to supplement and help resolve the various issues of chronology, assuming that the use-life of ceramic artifacts was short. The standard advantages of luminescence dating were also a good fit in this context, including the ability to get direct dates of surface artifacts and provide dates that are independent of any interpretive bias inherent in relating documentary evidence to ceramic style. (Ramenofsky and Feathers, 2002: 151). Results from luminescence (in agreement with the most recent efforts at dendrochronology in the area) suggest that the native populations did not leave as early as had been previously assumed. The luminescence dates suggest that they used the Lower Rio Chama through the first half of the 17<sup>th</sup> c. and perhaps used it continuously until the Pueblo Revolt (in 1688), though issues of sample

size preclude the authors from claiming this with high reliability. Again, with a more valid chronological system, resolution increases and research questions can be more adequately addressed. Claims about temporal events in the past can be seen as without validity if the wrong dating technique is employed, for the evidence is misleading (Ahlstrom 2008).

The third example is provided by Dykeman et al., (2002) who also report on a luminescence application from northern New Mexico, from roughly the same time period, though here the focus will be on using luminescence to establish accuracy. Tests for accuracy involve a comparison of dates from different dating techniques for the same target event. Complications can arise when the dated event is slightly different. In this study, the authors present efforts to evaluate the accuracy of the chronology for short-term occupation in a series of Navajo sites from New Mexico by comparing luminescence to dendrochronology. The results here are quite informative. While few individual dates from the two methods are in statistical agreement, the distribution of their probable ranges is very similar, with a primary mode at 1700 CE (see Figure 3.1a and 3.1b).

A finer look at the distributional data for the dendrochronological dates suggests a mode, coincident with the luminescence data if the sherds are sorted by type and graphed separately. That is, the bimodality of one of the types matches the bimodality of the dendrochronological dates, and both types contribute to the main mode. Additionally, the main mode is in good agreement with estimates from radiocarbon for the range of production for the both ceramic types (Dykeman et al., 2002).



**Figure 3.1: Comparison of tree-ring dates with luminescence dates from northern New Mexico (from Feathers, 2003)**

Here, the complexity of the information recovered from the independent dating techniques is best understood in terms of the different dated events revealed by each. The dendrochronology dates address the death of the trees dated; cut-dates for house construction in the best-case scenario. The luminescence dates address ceramic manufacture. They date different components of regional occupation. A direct comparison of individual dates yields lower correspondence because they are dating different events and the gap between the dates can be considered, partly, a measure of occupation duration. The distributional aggregated data, on the other hand, change the scale of analysis and make the differences between dates for house construction and

ceramic manufacture meaningful; zooming out from individual dates, they reflect instead the regional activities over a greater period of time (Dykeman et al., 2002). Interestingly, this further supports the notion that many luminescence dates are needed in chronology, as we saw with the example for Southeast American shell-tempered pottery.

These three examples illustrate the potentially powerful role of luminescence in establishing a chronology and in answering research questions that are temporal in nature. Luminescence can resolve uncertainties about cultural change (origins of shell-tempered pottery in the American Southeast), provide clarity about site abandonment (Rio Chama), and can add a degree of accuracy and resolution to issues of site use (duration of occupation of Navajo sites through ceramic manufacture and house construction) when used as part of a system of multiple independent dating techniques.

Ahlstrom (2008) notes a similar feature in his work on integrating multiple lines of evidence: select the evidence (e.g., chronometer) most appropriate for the problem at hand. This is generally sound logic, and it addresses some of the concerns with both accuracy and validity described above. When multiple lines of dating evidence can be brought to the same research question, it also often increases the precision with which interpretation can be made.

In sum, the dating protocol used for chronology development in Sinop applies the lessons learned from these case-studies to construct a chronology that is:

- Sensitive to cultural change by sampling and dating sherds of different temper types throughout the promontory and looking for patterns in the data,

- Precise enough to resolve issues of uncertainty in site use and abandonment, from a collection of surficial material, and
- That employs several lines of quasi-independent chronological information for each sherd, through the simultaneous dating by thermoluminescence (TL), optically stimulated luminescence (OSL), and infra-red stimulated luminescence (IRSL).

Here the discussion will transition from an examination of specific problems of chronology to a discussion of how to build regional-level chronological systems using luminescence.

#### *Using Luminescence to Build a Ceramic Chronology*

As scientific archaeology has increasingly developed in method and theory beyond the basics of doing simple culture historical research of regions, those of us collecting data and offering chronological control for those data have had to continually improve upon and refine chronological techniques to fit growing data requirements (Lipo et al., 2005). With more sophisticated hypotheses, we need fully valid and high resolution chronometers. For example, as we think about the Sinop promontory, it is no longer sufficient to merely provide a scattering of dates to match the scattering of sites; instead, a successful research agenda must be able to link these sites and together as part of a pattern. This, of course, requires a regional chronology with precision and accuracy sufficient to not just say what is “early” and what is “late”, but to say how much things differ from each. That is, seriation of ceramic types based on style is insufficient (though it has uses in identifying, for example, sample size problems). An absolute chronology,

with direct dates of ceramic artifacts is required. And for that, the best tool is luminescence.

The need for chronological sophistication requires an appreciation for the importance of validity in the selection of technique. The data requirements necessary for chronological control must be carefully addressed. This is true for the discussion of target and dated events and for the benefits of direct dating as opposed to association-based dating, but it is also important as we consider issues of sampling in the field and the development of improved laboratory techniques. Chronological methods must be improved, yes, but so too must better efforts be made to relate the material record to the continuum of time in ways that add clarity to our understanding of the past (Lipo et al., 2005).

When coupled with a sound sampling strategy, luminescence dating can provide the chronological resolution required to properly understand regional connections and measure community patterning in human populations in the Sinop promontory. To show the validity of this perspective, I will discuss some issues inherent in dating ceramic assemblages and then summarize a similar research program, from eastern North America.

The most apparent point in favor of luminescence dating in this context is that it provides direct dates of ceramic manufacture, as here the dated and target events are the same. The last heating of the ceramics is both what is measured and what is of interest: the manufacture by prehistoric potters of ceramic vessels. This has the added importance of being the case when ceramic samples are collected from surface contexts, where

stratigraphic control cannot be used to tease apart the relative order of an archaeological deposits (though of course, stratified sites remain vulnerable to problems of association dating). As shown above, luminescence dating is a firmly established method that clearly satisfies concerns of validity present in association-based dating.

The luminescence method is based on the measurement of a latent signal that over time accumulates in the form of an absorbed dose within crystalline minerals like those found in ceramics. The luminescence signal can be measured by stimulating, by heat or by light, the sample in controlled conditions and then calibrating the released signal to laboratory irradiation and deriving the dose rate to determine the amount of time passed since last firing to sufficient temperature (on the order of 450—500 °C). The method has been used successfully to resolve mixed assemblages of surface artifacts and a wide suite of other dating issues (see Feathers, 2003 for a complete discussion).

As will be discussed in greater detail in Chapter Five, the research presented here goes beyond what had until recently been standard use of thermoluminescence (TL) to date ceramics from their last heating during manufacture. This research was amongst the first to also employ optically-stimulated luminescence (OSL), a relatively new approach at the commencement of the research reported in this thesis. Heat also empties energy from the OSL signal, so it is likely that OSL is also dating the last exposure to heat, more than the last exposure of the interior matrix of the ceramic to sunlight during pottery manufacture. Together (and occasionally supplemented by infra-red stimulated luminescence [IRSL]) these techniques can improve the precision of the resultant date by providing multiple quasi-independent equivalent dose data for each sherd (ages produced

from these separate measures use the same dose rate data, so are not fully independent). Lastly, the use of OSL dating for ceramics may also improve the accuracy of luminescence as it addresses the problem of anomalous fading and a topic of discussion in Chapter Five).

Regarding sampling and sample size, if we consider a surface assemblage of artifacts as evidence for past occupations of the landscape, then dating any single artifact from that assemblage will not necessarily produce an accurate estimate for the formation of that assemblage, because the ceramic may have been manufactured long before its deposition (Lipo et al., 2005: 538). In order to accurately understand the formation/use/abandonment of the site, a large sample is required. But how large is large enough? Here we enter into a topic that is guaranteed to drive funding agencies and project directors mad, for the answer to that seemingly simple question is inherently complex. The absolute number of samples (e.g., sherds) needed to get a representative sample is completely dependent on the nature of the chronological data that they generate as they relate to the research question. Any distribution of artifacts present in an assemblage or site is the product of past human behaviors, some of which were simple and short-term others may have been complex and/or long-term. If, after producing dates for a small subset of an assemblage, researchers observe that their chronological distribution is tightly bunched about a single chronological period, then that sample is likely sufficient to argue for a single-component site. If, on the other hand, the data are non-normal or multi-modal in their distribution, the sample requires additional sherds be added to fully understand the nature of their distribution (Lipo et al., 2005). One example

of this that we have already seen is the evidence from Dykeman et al., (2002) described above. Put simply, sample size is problem and context specific. There is no way around this.

A second sampling-related issue is scalar: can comparisons be made between sites or assemblages from the same landscape? That is, can one kind of sherd be a proxy for a “set”, such that by dating that kind of sherd one can date a larger set (Lipo et al., 2005)? The key here is certainty about the nature of any “set”, or type. If sets can clearly be demonstrated to represent a culture historical type, (that is, be limited in time and place) then this is a good strategy of reducing sample size and beginning the comparative process between sites. One proposed way of maintaining tight control over site occupation and/or formation is to limit pottery for proxy use from smaller shorter-lived contexts (Barnett, 2000a). By way of caution, however, as was learned in the process of conducting the initial stages of the analyses of pottery from Sinop, when the culture historical types are not sufficiently defined then they may be artificially conflating multiple types (Casson, 2007). Specifically, low-fired sherds of mixed temper that were “brownish” in color were identified as “Early Bronze Age”. This category quickly revealed significant chronological variability. In this case, the “set” proxy is not useful. Phrased another way, a chronological evaluation of sherd types provides a way of assessing hypotheses of contemporaneity between proposed types and assemblages. Eventually, we hope to create a chronology for Sinop that uses luminescence dating of ceramic ware types to identify potential types that operate as good chronological markers, and therefore, more precise dating of assemblages. It should be noted here, however, that

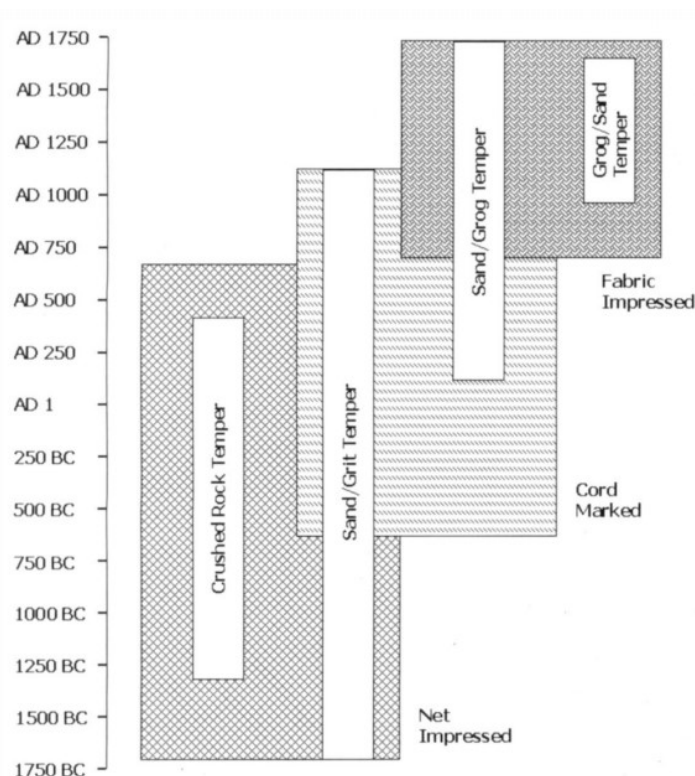
these types are not stylistic types as discussed, for example, by Dunnell (1978), where units are a product of non-functional attributes that may vary stochastically over time. Rather, the “techo-types” of Bauer (2006a) are instead a product of functional attributes. This represents a key component of luminescence research at Sinop going forward.

Finally, the discussion turns to an exploration of the use of luminescence dating to build a regional ceramic chronology, a case study from the North Carolina Sandhills (Herbert et al., 2002). The study presents preliminary results of their efforts to develop an absolute chronology, though for the purposes of this thesis a demonstration of truth in concept, or validity is sufficient.

Prehistoric pottery in the Carolina Sandhills had typically been classified by analogy to other regions, a story reminiscent of the situation in Sinop. Environmental challenges to organic preservation made the traditional method of using radiocarbon to create the chronology unrealistic and luminescence was identified as an alternative method (Herbert et al., 2002). And, of course, luminescence provides the added advantage of providing direct dates, in this case, for excavated pottery remains.

In this study, luminescence methods were run in conjunction with petrographic analyses of sherds in the analytical sample. Samples were sorted and identified based on a range of different tempers and surface treatments and then dated by luminescence. In this way, a full battery of information would be produced for each sherd, the results of which form the basis of a taxonomic series of pottery and a cohesive regional sequence (Herbert et al., 2002).

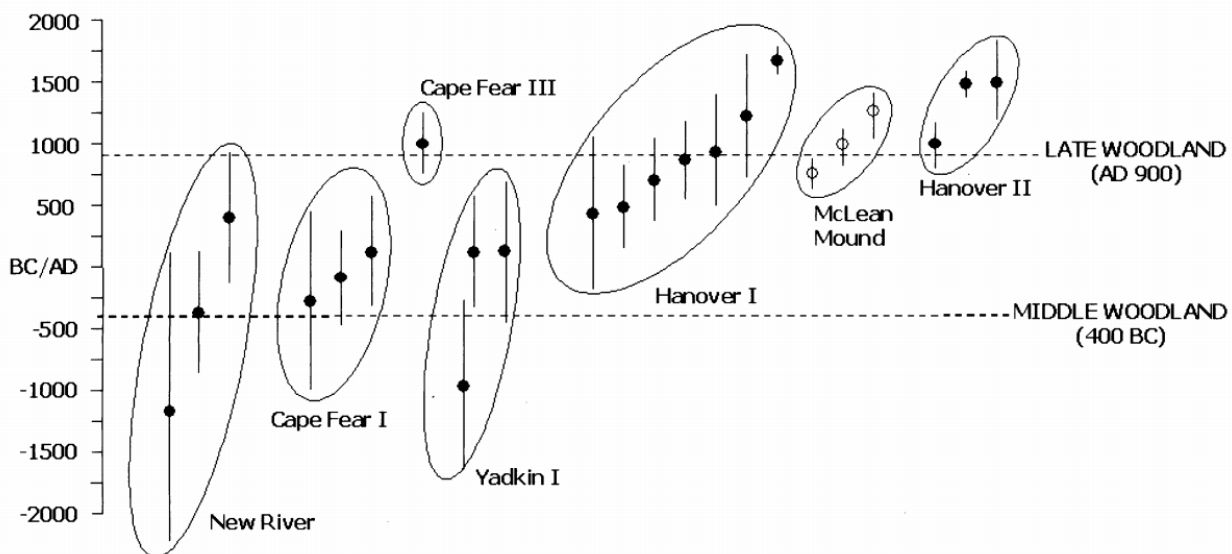
Using the categories of tempering technique and vessel treatment as categories of analysis, the researchers sorted these categories by time to develop the preliminary chronology. Acknowledging the arbitrariness of unit formation in this regard, it nonetheless led to some very interesting interpretations (see Figure 3.2). Surface treatments showed clear transitions, with some overlap, from net impressed to cord marked to fabric impressed over time. The temper categories were much more variable.



**Figure 3.2: Temporal relationships of temper and surface treatment attributes, Carolina Sandhills (from Herbert et al., 2002)**

The findings from this analysis were used to assign sherds to taxonomic series (see Figure 3.3), where filled circles represent TL means and open circles represent calibrated radiocarbon intercepts. The taxonomic series were then placed into a regional

sequence illustrating notable changes in ceramic characteristics occurring in the period of about 900—1000 CE, with distinctive periods on either side of this transitional time.



**Figure 3.3: Carolina Sandhills taxonomy (from Herbert et al., 2002)**

This kind of research protocol is precisely what was attempted at Sinop, though with some differences which will be addressed in succeeding chapters. Material from Sinop, for example, was collected from surface survey. Second, the link between ware type, or petrographic analysis, and luminescence was not always explicit in Sinop, a problem of poor communication between project team members during the formative part of the research project. But, nonetheless, the research presented here by Herbert and colleagues (2002), despite its small sample, provisional results, and potential for not fully representing the region's ceramic richness establishes the validity of the dating technique for regional ceramic chronology development. As they argue, these problems are all addressed by increasing sample size. Increasing the sample size of the dating agenda will

maintain the validity of the project and add resolution to the sequence, perhaps indicating ways in which it was more complex in certain parts of landscape during certain periods. One final thought on this project as it relates to the dating work at Sinop: the luminescence data from the Carolina Sandhills had higher than expected error ranges, due perhaps to heterogeneity of the ceramic paste (Herbert et al., 2002: 105). This has not been a problem with the ceramic pottery at Sinop. In fact, precision of dates from Sinop, as will be shown in Chapter Five, is one of the strengths of this particular research.

As we approach a consideration of the specifics of dating at the Sinop promontory, one further note on methodological problems of association-based dating is necessary. As mentioned in Chapter Two, dating (radiocarbon and luminescence) at İkiztepe has in the past been used as a source of analogy to understanding chronology at Sinop. When one assumes that the association between pottery and radiocarbon dates in one place can be extrapolated to similar pottery in other places, then association problems are again manifest. As is apparent with Feathers' (2009) discussion of shell-tempered pottery in the American Southeast, this can lead to problems of circularity and lack of validity. When a temper type becomes associated with a chronological age in one part of the landscape and is found in another part of the landscape it is not necessarily the case that the chronological relationship is consistent. Similarly, as shown by Barnett (2000b) in her luminescence analysis of Late Bronze and Iron Age ceramics from Eglad, chronologies based on technological aspects of pottery (fabric, temper, etc.) lack good resolution. This further supports the need for direct dating of the pottery from Sinop in order to understand the chronology of the pottery at Sinop.

## Chapter Four: The Sample and Research Questions

“On the surface, an intelligible lie; underneath, the unintelligible truth.”—Milan Kundera

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### *The Sample: Location, Procurement, and Selection*

A total of 59 ceramic sherds from the Sinop promontory were analyzed over the course of this research, from four principle survey regions within the promontory: the Demirci Valley, the Karasu Valley, the Highlands, and Gerze. Dividing the promontory into these zones is one way in which SRAP is attempting to employ a *multi-sited approach* to understand the social, cultural, and economic links between the coasts and the inland valleys and highlands of the hinterland (Doonan, 2004b: 40). The multi-sited approach goes beyond simply looking at multiple places and instead targets the processes that connect distant physical and conceptual locations. The processes that would have connected past communities on the Sinop landscape, argues Doonan (2004b: 41) include: communication, interaction, production, consumption, and identity formation. The establishment of an absolute chronology cannot address each of these aspects of “connectedness” independently, but as the dating protocol described herein also functions as part of the greater SRAP, samples for luminescence analysis have been selected from loci in each of these regions as part of a broader effort to determine connectedness.

The SRAP actuated the multi-site approach to fieldwork through a nested program of extensive and systematic archaeological field survey that links site-level studies with intensive systematic survey of large areas (See Table 4.1, from Doonan 2004b: 48). Sites, or more accurately, *loci*, are subjectively identified as dense clusters of archaeological evidence (Dunnell and Dancey, 1983; Dunnell, 2002).

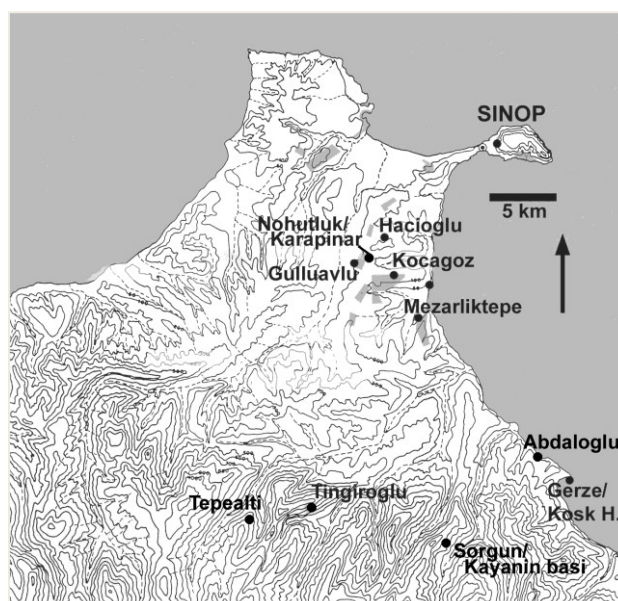
**Table 4.1: SRAP Nested Research Design (from Doonan, 2004b: 48)**

<b>Investigative Method</b>	<b>Data Analysis</b>	<b>Objectives</b>	<b>Processes Explored</b>
Small-scale Excavation	Collection of in-site evidence	Define economic and chronological data	Production Consumption
Field Survey (continuous full coverage)	Spatial analysis of site distribution and non-site features	Settlement pattern, Density, diversity and intensity of usage	Communications Interaction Production Identity
Field Survey (non-contiguous sampling)	Spatial analysis of assemblage variation (on and off site)	Distribution of ceramic types (on and off site); functional definition	Production Consumption Identity
Geomorphology and Palynology	Evaluate landscape development, impact of human occupation through time	Define local ecological and landscape changes, including anthropomorphic aspects	Production
Geophysics and Geochemistry	Site Definition, function, and specialization	Defines site extent and structure, specialized use of space	Production Communications
Ceramic and Floral Analysis	Site function, distribution and spread of local and imported products	Identify economic patterns	Production Consumption Identity
Historical and Ethnographic	Land-use and specialization, customs registers	Define land use, infrastructure, and resource procurement	Communications Interaction Production Consumption Identity

Each locus is a cluster of archaeological material (pottery, tile, daub, etc.) with enough physical discretion to infer past human activity at the location. In this way, “sites” may contain multiple loci. In any case, once a locus is identified during survey, the team decides in the field if that locus warrants additional close analysis of, for example, the ceramics. Standard SRAP protocol includes digital photography of all recovered samples (often sorted by transect) and preliminary typological characterization

according to gross physical characteristics (including hardness, color, inclusions, etc.). All luminescence dates are from samples from recorded loci. Luminescence dating of ceramics from loci identified during field survey assists in resolving issues of not just chronology but distribution of ceramic types in time and space, and the patterns of economic interaction. In terms of the processes explored in the multi-sited approach, luminescence dates can be used to explore the themes of Production, Consumption, and Identity. The multi-sited research design connects loci within and between regions. A sampling program designed to fit research questions, including the development of the absolute chronology presented here, can produce meaningful results. As will be seen in this and subsequent chapters, the better the dating protocol matched research questions (e.g., by sampling ware types from each locus), the more meaningful the results.

In total eleven loci were sampled for analysis. What follows is a description of the key features of each locus, sorted by region. See Figure 4.1 for a map of all loci.



**Figure 4.1: Sinop promontory, all sampled loci (prepared by O. Doonan)**

### Demirci Valley

The archaeology of the Demirci valley, 15 km south of Sinop, is dominated by a Roman industrial landscape, with the remains of settlement and industry present throughout the valley, marked by extensive scatters of roof tiles, storage vessels (including amphora), and kiln debris (Doonan, 2004a: 101-03). The focus of the Roman industry was a large center devoted to amphora production at the site of Demirci *plaj* (beach). The production center dates to the Roman/early Byzantine period (ca. 2nd to 7th centuries CE), as determined by excavations directed by Kassab-Tezgör in collaboration with the Sinop Museum (Kassab-Tezgör, 1996, Kassab-Tezgör and Tatlican, 1998). The site extends 0.5 km inland from a terrace overlooking the valley outlet from the north and about 1 km along the coast. Kilns from the site date to the Imperial and Late Roman periods (late 2nd to 6th centuries CE). The site was later used as an oil production facility during the 6th to 7th centuries CE (Kassab-Tezgör, 1996).

SRAP surveys along the coastal zone of the valley (excluding the site of Demirci *plaj*, not surveyed by SRAP) yielded the greatest density of settlement during the Hellenistic and Roman periods. The ceramic assemblages are dominated by medium to coarse black-sand-tempered (BST) wares (an indicator of local production, as the “black sand”, or pyroxene, is sourced from a local volcanic beach, Karakum) of varied forms, with dense clusters of fine wares and large storage vessels (Doonan, 2004a: 104). The highest proportion of fine wares were documented in the valley at Keçioğlu (not part of the luminescence sample), indicating that the population there consumed imported and

high-quality goods, a trend continued in later Roman periods, though with fewer imported fine wares (Doonan, 2004a: 104).

The interior of the valley was also extensively settled during Roman times, with ceramic production occurring at the local level. The SRAP documented over a dozen loci with on-site ceramic production away from the coastal industry, characterized by tile, pithos, and the occasional amphora sherd in association with kiln debris (Doonan, 2004a: 105).

Doonan (2004a: 107-08) proposes an industrial agricultural model to best characterize the relationship between the coast and the interior of the valley during Roman periods. During the Hellenistic period fine wares were present at significant frequency as much as 3 km inland; during the Roman periods fine wares are limited to the coasts. The absence of fine wares in inland contexts suggests that inland loci were largely farmsteads, lacking high status residential components. One possibility is that these farmsteads existed, in part, to supply olives or other agricultural products to be shipped from the coast. Fine wares, present at high-status sites near the coast and inland during Hellenistic times, may reflect local consumption of local industry. In this model, the Demirci valley is seen as an interface between coastal places with wealth from maritime and industrial opportunities and interior places focused on low-intensity terrestrial exploitation. Luminescence dating of pottery from select loci within the Demirci valley will be used to evaluate the chronological aspects of this model.

***Demirci Valley loci: Kocagöz and Mezarlıktepe.*** Kocagöz is an Early Bronze Age settlement located on a ridge overlooking the sea in the Demirci Valley. Excavations

conducted in the 1950s (unpublished, mentioned briefly in Erzen, 1956; Akurgal and Budde, 1956) yielded a ceramic assemblage, including black burnished pottery (Bauer, 2006a), typologically more similar to sites in the North and West Black Sea (Erzen, 1956) or to the western Anatolian-Pontic area than to Ikiztepe (Burney, 1956). Bauer (2006a: 192) also notes the presence of a distinctive type of cup with a pointed bottom (perhaps related to an Aegean *depas*-type cup), indicative of the EBA, though with similar forms found at sites including Dereivka in the Dneiper basin of the north Pontic steppe (dating to the later 4th mill. BCE [Rassamakin, 1994: 41]) and at Colchis, an Iron Age site in Georgia (Lordkipanidze, 1991). Also identified at Kocagöz were a number of dark-burnished, small globular juglets similar to known samples from EBA coastal sites in Bulgaria referred to as *askos-type* juglets (Bauer, 2006a: 192-93). The site at Kocagöz is currently under cultural cultivation (corn, primarily), which has disturbed the surface layers of the settlement. Samples analyzed during this research were taken from the surface of the cornfield. Eight samples were dated from Kocagöz.

Mezarlıktepe is a small coastal settlement and industrial site on the lower slopes of a coastal ridge overlooking a small estuary, which has been used to suggest evidence for settlement near the coast of Sinop in the sixth/ fifth millennia BCE (Neolithic-Chalcolithic). Neolithic period phases are suggested by the presence of incised lug-handled ceramics stylistically similar to 6<sup>th</sup> millennium BCE settlements in the Marmara region of northwest Turkey, such as Ilıpınar and Yarımburgaz. Chalcolithic occupation is inferred from the presence of tripods, convex and bi-convex spindle whorls, and hole-mouthed jars, known throughout the Sinop promontory. A concentration of ceramic

wasters and a prehistoric kiln (Doonan, 2004a: 59) suggests pottery may have been produced on this site. Bauer (2006a: 179) states that the ceramic assemblage includes sherds decorated with distinctive incised designs not common to the Sinop region, with greatest similarity to Late Neolithic/Early Chalcolithic (6<sup>th</sup> to the early 5<sup>th</sup> mill. B.C.E.) Ilıpınar (Roodenberg, 1995), located 600 km to the west, near the Sea of Marmara, and from Yarımburgaz Cave (Özdoğan et al., 1991) in Turkish Thrace, over 700 km to the west. Additional diagnostic features of the Mezarlıktepe ceramics include attributes more consistent with Late Chalcolithic Black Sea pottery, such as the firing cores manipulated to have an oxidized red interior surrounded by reduced black exterior surfaces (Bauer, 2006a: 180). Nine samples were dated from Mezarlıktepe.

### **Karasu Valley**

In contrast to the colonial and postcolonial industrialization of the Demirci valley coast, the Karasu valley coast, or delta, was sparsely populated in Hellenistic and Roman times. SRAP identified just one locus, the site at Gerna, marked by a fragment of a monolithic marble column associated with a 17m brick and stone masonry structure (Doonan, 2004a: 108-09). Gerna is thought to be late Roman/early Byzantine (4<sup>th</sup>-7<sup>th</sup> centuries CE) based on typological characteristics of the ceramics.

SRAP survey did, however, document extensive settlement inland, in the central and outer Karasu valley, especially during the Roman periods. One example from the interior is the locus at Karapınar (described below). Doonan observes (2004a: 112), in contrast to the pattern in the Demirci valley, that the fine wares at Karapınar are of very high quality and suggest an owner-occupied settlement with local inland control of the

farmstead, as opposed to absentee ownership, as part of a self-sufficient village or large villa. The Roman central Karasu valley was inhabited as densely as the Demirci valley, indicating widespread agriculture through this period. Was this shift a temporal one, marking the transition from Imperial to later Roman times, or part of a broader spatial trend?

Finally, Doonan (2004a: 89) notes that settlement in the Karasu river valley shows a break in occupation between the broader valley of the outer promontory and the rougher topography of the highlands. Loci in the middle elevations are characterized by limited open agricultural fields with simple local pottery (difficult to date by typology alone). The hypothesis being evaluated by SRAP—and by the luminescence dating protocol—is the extent to which these sites were temporary as opposed to long-term occupations (Doonan, 2004a: 90).

***Karasu Valley loci: Güllüavlu, Karapınar, Maltepe Hacıoğlu, and Nohutluk.***

Güllüavlu is a small (ca. 0.5 hectare) multi-phased mound in the Nohutluk district of the Karasu Valley with evidence of human burials and settlement, with at least two phases of occupation: Bronze Age (marked by red daub floors similar to İkiztepe) and middle second millennium (marked by surface pitting and burnished red wares similar to those of Central Anatolia) (Doonan, 2004a: 63). Like Kocagöz in the Demirci Valley, Güllüavlu would have been a highly visible settlement along land and sea communication routes, taking advantage primarily of terrestrial resources. Bauer (2006a: 189) also notes that pottery features suggest multiple phases of occupation, from the Late Chalcolithic/Early Bronze Age, based on the presence of black burnished and incised ceramics, to the

Middle Bronze Age, based on the presence of red-slipped pottery and a “teapot spout” similar to a type of Old Assyrian *entrepot* from Kültepe-Kaneş. Two ceramics were dated from Güllüavlu.

Karapınar is a large (ca. 5 hectare) multi-period site showing unusual continuity with Bronze and Iron Age (Phrygian) ceramics, with additional Archaic, Hellenistic and Roman period pottery, suggesting one of the most complete late prehistoric (second to early first millennium) stratigraphic sequences in the region away from the coast. The Roman period is also quite extensive, including several domestic clusters and a production area marked by extensive kiln debris and high quality fine wares (Doonan and Bauer, 2005). Doonan (2004a) notes that the diverse functions represented at the settlement are consistent with a self-sufficient village or perhaps a large villa. Prehistoric pottery recovered from the locus, described by Bauer (2006a: 195), includes slipped and burnished wares and pots, some with “rope”-like modeling around the neck. Bauer notes similarities to this rope-like modeling to the “banded” ceramics of Eastern Europe and the North Pontic from the 3<sup>rd</sup> to the 2<sup>nd</sup> mill. B.C.E. The locus called Nohutluk (below) is likely to be from the same site, with different phases observed on the opposite side of a modern street. Three ceramics were dated from Karapınar.

Maltepe Hacıoğlu is an inland settlement in a small side valley of rolling hills below the eastern ridge of the Karasu Valley. Unlike Kocagöz, with a commanding view of the sea, Maltepe Hacıoğlu has no clear viewshed to known contemporary settlements or lines of communication nor is it situated to take advantage of coastal resources (Doonan, 2004a: 63). The site is a large and complex Chalcolithic settlement and

industrial site where the SRAP has documented extensive production of polished limestone bracelets and chipped stone tools adjacent to a settlement (Doonan, Casson, and Gantos, 2007). The ceramic assemblage at the site suggests widespread parallels in western Anatolia and the west Black Sea region. The site contains significant quantities of finely polished oyster-grey pottery (Bauer's Type V) thought to be unique to the site (though Bauer [2006a:182] notes the possibility of one sherd at Güllüavlu and another at Kayanın Başı). Six samples were dated from Maltepe Hacıoğlu, taken from two main areas: the upper mound (associated with the limestone bracelet industry) and from the lower terrace, which contains most of the evidence for a settlement.

The Nohutluk locus is likely a continuation of Bronze Age Karapınar, perhaps also including remnants from a Roman villa (see above). SRAP surface surveys identified five sample areas within the locus containing Hellenistic pottery and tile as well as handmade sherds and daub (Doonan and Bauer, 2005: 135). Nohutluk and Karapınar are considered key sites for luminescence dating because of the presence of ceramic material that could not be typologically dated. Four samples were dated from Nohutluk.

### **Highlands**

Highland loci are large postcolonial (Greek) settlements found on the upper part of the Kabalı River overlooking deep gorges. SRAP investigations have thus far concentrated on the area above the Karasu and Kabalı rivers, on the eastern side of the promontory. Unlike the lower elevation loci of the Karasu valley, highland loci along ridge tops offer potential for long-range communication and viewshed and are often of

medium to large size, occasionally exceeding 5 hectares (Doonan, 2004a: 90). Highland villages, to the extent that they have been identified by SRAP survey, may have been settled in small widely dispersed villages. Doonan (2004a: 137-38) hypothesizes, based on ethnographic analogy, that a modicum of seasonal transhumance may have existed in the postcolonial settlements, increasing the population of the highlands in the summer. If correct, this would imply that valley systems were connected to the highlands on a seasonal basis, perhaps based on kinship and political alliances.

Highland loci included Hellenistic, Roman, and early Byzantine settlements, with evidence of coastal connections, including documentation of Roman milestones (i.e., a road system). Doonan (2004a: 114-15) references literature (e.g., French, 1988) that identifies “nearly a dozen” milestones indicating the existence of a road system through the 3rd century CE, some of which with clear indication of distance to Sinope, indicating its connection to the Roman port. SRAP survey data suggest that the highlands were much less densely settled in later periods—Byzantine Selcuk, and Ottoman, from the 9th to the early 20th centuries (Doonan, 2004a: 136).

SRAP has yet to conduct extensive systematic survey in the highlands. As such SRAP hypotheses about economic and cultural patterns are tentative and luminescence dating represents a key early step in framing the issues. Nonetheless, Doonan (2004a: 154) offers some preliminary hypotheses for evaluation. Early (pre-Hellenistic) and late (post-Roman) settlements tend to be small and (materially) isolated, during which time the coastal port was looking outward, through the Black Sea. Connections between the

coast and the highlands are more apparent between these periods, during the Hellenistic and Roman (and in the modern), maintained perhaps by a Roman road system.

***Highland loci: Kayanın Başı, Maltepe Tepealtı, Tıngır Tepe (aka Tıngıroğlu).***

Kayanın Başı is a highland Chalcolithic settlement in the uplands west of Asar Tepe that has been excavated illegally by neighboring villagers. The ceramic scatter covers approximately 0.2 hectares but is primarily due to the wash from the illegal excavations. Bauer (2006a: 183) describes the pottery from the locus as “unparalleled” in Sinop, with a variety of incised patterns on black burnished pottery. In his description, Bauer also notes the appearance of the “hanging triangle” motif, distinctive to the *Dolmen* Culture of the northern Caucasian Black Sea Coast. Bauer (2006a: 186) suggests a date for the locus, based on these characteristics, to the Late Chalcolithic to Early Bronze Ages, approximately the early to middle 4<sup>th</sup> mill. BCE. Nine samples were dated from Kayanın Başı.

Maltepe Tepealtı is a site about which little is known, as there is scant evidence on the surface in present time. Işın (1998) describes it as an “indigenous” settlement presumed to be from the early first millennium BCE, based on typological factors (see also Doonan, Casson, Gantos 2007). 3 samples were dated from Maltepe Tepealtı.

A surface ceramic scatter at Tıngır Tepe, or Tıngıroğlu, was also documented by Işın (1998) and later shown by SRAP in 2006 to be part of a *kale*, or castle/fortress with a lower settlement (Doonan, Casson, and Gantos, 2007). This multi-period locus overlooks the gorge of the Kabalı River, with rolling hills to the east and the river to the west. The site includes standing walls, a central stone tower, and a 6 hectare ceramic scatter (with

looting pits) characterized by Sinopean Hellenistic stamped amphoras, which Doonan identifies as locally made, indicating a connection to the coast from the 3<sup>rd</sup> century BCE onward (Doonan, 2004a: 90). Bauer (2006a: 198) also notes a significant representation in the ceramic assemblage of buff-colored ware and Late Bronze Age forms (e.g., faceted handles and carinated bowls), which he took to indicate a Late Bronze to early Iron Age date for the site. Five samples were dated from Tıngır Tepe.

### **Gerze Coast**

Gerze, a port located on the southeastern coast of the promontory, about 25 km from Sinop. The site of Gerze is one of a few documented coastal settlements that illustrate the maritime orientation of life on the promontory. The harbor, naturally protected by a battery to the north, was a center for ship building and repair during the Ottoman period (Doonan, 2004a: 129). This is likely due to the availability of quality timber in the highlands behind the port.

*Gerze loci: Abdaloğlu and Köşk Höyük.* Abdaloğlu is a major coastal settlement just north of Gerze spanning Bronze Age and Greco-Roman cultural horizons. Two phases of occupation were noted (Doonan and Bauer, 2005): a Bronze Age settlement (about 0.2 ha in extent) indicated by a compact scatter of prehistoric pottery at Gol Dağ, including hand-made grey and brown wares with chaff temper and horizontal bands of decoration, and a later dispersed scatter of Hellenistic-Roman ceramics across a wider area of at least 20 ha. Distinct clusters of pottery and architectural debris suggest a more dispersed settlement plan than recorded in areas closer to Sinop port. Typological estimates of the pottery (based on comparison to İkiztepe pottery 60 km to the east) place

the age of the site in the early third millennium BCE. Seven samples were dated from Abdaloğlu.

Köşk Höyük is a threatened mounded settlement on a small coastal spur jutting out into Gerze harbor. A lighthouse was installed on the site in the mid-20th century and much of the mound covered in a concrete cap. In the 2003 season SRAP recorded exposed scarps exhibiting well-preserved architecture at Köşk Höyük. Material from the site includes dark burnished wares suggestive of the Early Bronze Age as well as what Bauer (2006a: 195) refers to as distinctive Early Hittite forms, including a “teapot spout” (similar to Güllüavlu). Three samples were dated from Köşk Höyük. In the summer of 2014 the SRAP has plans to conduct a salvage excavation at the site.

*Hypothesis Derived from Regional Sampling*

By partitioning the Sinop promontory into environmental zones, corresponding to past seasons of archaeological survey and sampling, it becomes possible to formulate specific hypotheses about the use of different parts of the landscape over time. Of course, it is important to note (again) here that the pottery ages do not necessarily correspond directly to occupation (when discrete objects were brought together), but to individual manufacturing events (the dated event). At loci with a large sample of luminescence dates, a series of manufacturing events may be used as part of a bridging argument to infer time of occupation.

Sample selection for luminescence dating followed two (occasionally diverging) agendas. The first, driven by a need to fill in the culture-history of the prehistoric occupation of the Sinop promontory, focused on sample selection from loci thought to be

from the Bronze Age and earlier (based on efforts of typological identification by SRAP team members). The second agenda was a product of seasonal SRAP project goals, primarily focused on clarifying issues of site occupation during postcolonial periods. As such, the research questions explored through this project clustered around these two sets of related data. Specifically, the following research questions will be evaluated in terms of derived luminescence ages of pottery:

- What was the temporal pattern of *prehistoric* occupation throughout these different regions of the Sinop promontory?
  - Is prehistoric occupation a significant part of Sinop's past?
  - Do loci occupied prehistorically continue to be occupied in postcolonial times?
- To what extent did *postcolonial* sites from the inland valleys operate in isolation from the coast?
  - Were sites in the Karasu valley short-term (temporary) or long-term occupations?
  - Were there times during which the Karasu valley locus at Karapınar existed independently, without coastal connections?
  - Do dates from fine-wares and handmade pottery support the hypothesis that Demirci valley was an interface between the coasts and hinterland during the Roman period?
- Are highland sites *postcolonial*, only occupied during the Hellenistic, Roman and Early Byzantine periods?

- At a higher degree of resolution, is postcolonial occupation of the highlands most apparent in the middle of this temporal range (during the later Hellenistic and Roman periods, reflecting use of a Roman road linking the highlands to the coast), with greater isolation from the coast (and smaller sites) in the pre-Hellenistic and post-Roman. That is, do connections between the highlands and the coasts/valleys oscillate through time?
- Is the coastal site of Köşk Höyük an Iron Age locus, as Doonan believes, or is it Early/Middle Bronze Age, as Bauer has hypothesized?

These questions will be evaluated and addressed based on the results of luminescence dating for pottery manufacture (of specific ceramic ware types, when applicable) at each locus. Small sample size may be an issue at each locus, but in this type of project there is no one-size-fits-all sample size requirement to determine the span of pottery manufacture at a locus. Each dated sherd represents a single episode of manufacture; as additional sherds are dated from each locus, the nature of the temporal span of site occupation gains resolution and clarity. For some loci, for example, three sherds with tight chronological correspondence may indicate a sufficient sample. For other loci, five or more sherds with dates spread over many thousands of years may indicate an insufficient sample. This is just one example of the ways in which decision-making in this project is path dependent—*an iterative process*—where the dating of additional sherds may or may not be required to adequately produce chronological resolution. Each of these scenarios (and many more) will be discussed in Chapter Six.

The results of luminescence dating will also be used to evaluate the merits of reliance on typological dating within the promontory to non-local pottery traditions. Just how much divergence is there between analytically derived luminescence dates and typologically derived age estimates? Will the Sinop chronology be fundamentally rewritten as a result of the addition of luminescence dates? How will the dates help to clarify issues of community in the promontory? Additionally, the results of the dating project can also be used to evaluate the efficacy of the technique in the area and the potential for fine-tuning the analytics of the technique to resolve specific problems of regional chronology.

#### *Sample Selection*

Ceramic sherds analyzed by luminescence dating were procured in both haphazard and systematic ways. This is the result of the unique conditions under which this research project came to be. Pilot studies of the efficacy of luminescence dating in Sinop were conducted in 2004 from sites surveyed by the SRAP in 2003 without my direct involvement. Subsequent samples, from ensuing seasons following the pilot studies, were more systematically selected for inclusion in the luminescence dataset according to specific research goals.

But, as funding for this research was split between SRAP and University of Washington graduate funding, sample selection was often of “two minds”, reflecting the SRAP need for dates from specific loci to address ongoing research questions in the postcolonial history of the promontory and my interest in expanding chronological knowledge of the prehistoric occupation of the promontory. Phrased differently, the

rationale behind sample selection was often modified by logistical concerns. As such, the final sample of 59 dated sherds is not an “ideal sample”, systematically sampled from an infinite population of ware-identified sherds evenly dispersed across each of the identified sites/loci. It is, instead, a practical opportunistic sample, reflecting a series of individual decisions and availability of samples of sufficient size, with adequate locational and contextual information.

An ideal sample would be a systematic collection of sherds from the different regions of the promontory, covering a range of temper and surface treatment characteristics (or types) and vessel forms found in the study area. This is how the sample was selected in the study by Herbert et al. (2002) described in Chapter 3. The sample reported here, as noted above, is an opportunistic sample, reflecting the realities of sample procurement and the subsequent selection of sherds to date from the larger collection of procured sherds. Additionally, the sample reported herein also differs from the Herbert et al. (2002) sample in that typological information of individual sherds varies in its degree of resolution. For loci and sherds thought to be prehistoric, sherds have been classified according to Bauer’s (2006a) typological classification system, a product of analysis via microscopy and an examination of microstructural and compositional information, forming methods, and original firing temperature and atmosphere. All of the prehistoric sherds are handmade. Bauer’s (2006a) system produced eight types, plus the category of BST, or black-sand (pyroxene) temper noted above, a locally occurring temper from the Late Roman and Early Byzantine periods, which I’ve included here (see Table 4.2, Figure 4.2). The postcolonial sherds do not fit

into this system and have instead been classified according to a more general system of temporal classification (e.g., Roman, Byzantine, etc.).

**Table 4.2: Prehistoric Types (following Bauer, 2006a)**

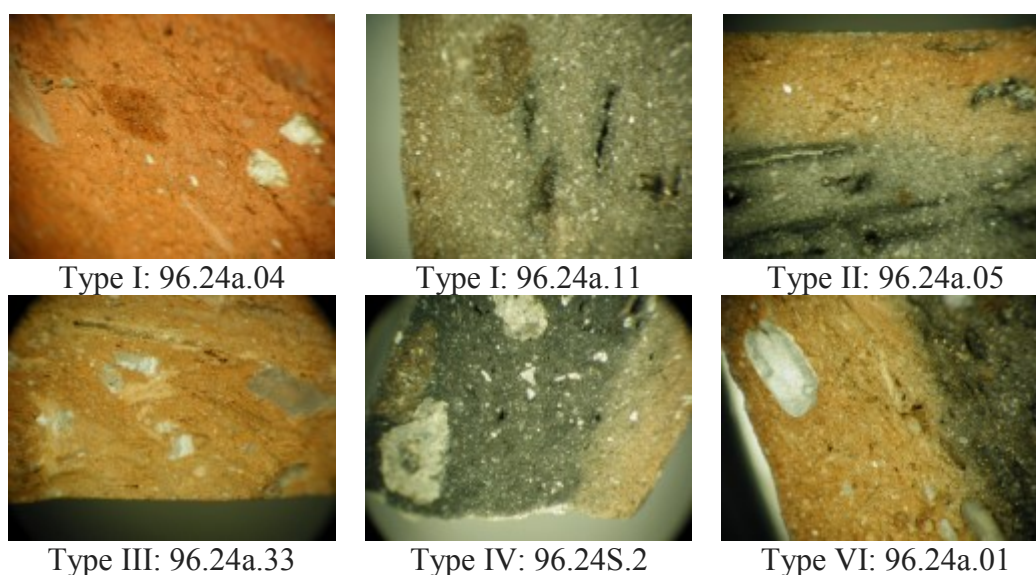
<b>Sinop Type</b>	<b>Description</b>
Type I: “Sandy Ware”	Most common type; illitic clay matrix; particle size between 1 and 2 $\mu$ in diameter; 10-20% quartz and calcite inclusions at 0.1-0.25 mm diameter; variable firing temperature and atmosphere; sequential slab construction; decorative treatments include incision, modeling, and slip.
Type II: “Chaff-tempered Ware”	Found throughout Sinop region; moderate abundance (10-20%) of medium-coarse (1-2mm long) chaff fibers as temper to add plasticity; matrix otherwise like Type I; variable firing temperature and atmosphere; sequential slab construction; decorative techniques include slip and burnish, incision, and modeling.
Type III: “Quartz-tempered Ware”	High percentage (20-30%) of coarse (>0.5mm diameter) quartz inclusions as a tempering material; base matrix similar to Types I and II (fine-particle illite clay with mixed sand); relatively low fired (at or below 800°C); sequential slab manufacture; decorative techniques include incision.
Type IV: “Shell-tempered Ware”	Found throughout region at all time periods; identifiable by high percentage (10-20%) of coarse (0.5-2mm long) crushed shell in matrix; fired to approximately 800°C); sequential slab manufacture.
Type V: “Fine Grey Ware”	“Unusual” ware with limited appearance in Sinop region, most plentiful at Maltepe Hacıoğlu, though also found at Güllüavlu and Kayanın Başı; aka “Maltepe Grey Ware”; Late Chalcolithic and perhaps earliest Bronze Age; fine-grained clay with few inclusions; smoothed burnished surface with “pearly, satin-like glossy appearance”; similar clay matrix as in Type I; moderately reducing firing atmosphere; fired at higher temperatures than other types (900°C); sequential slab manufacture; finishing techniques include burnishing, to reduce porosity.
Type VI: “Pebble Ware”	Infrequent type; similar paste to other types (sandy paste, fine-particled clay); distinguished by inclusion of a low-moderate percentage (5-10%) of coarse (0.5-1mm diameter) rounded river pebbles in matrix; present only at inland sites like Güllüavlu and Kocagöz; maximum firing temperature of 800°C;

Table 4.2 continued

<b>Sinop Type</b>	<b>Description</b>
Type VIII: “Coarse Sandy Ware”	Very coarse matrix, composed of high percentage (30% or more) of medium sized (0.25-0.5mm diameter) sand inclusions; appears at Köşk Höyük and Karapınar.
BST*	Black Sand Temper, locally occurring temper. Typical of Late Roman, Early Byzantine wares.

\*BST, or black sand temper, is less a ware type than a reference to a tempering material with origins conservatively in the Hellenistic period and perhaps earlier. Earlier examples from the Classical-Hellenistic tend to have a “yellowish” paste with a high percentage of fine to medium BST with few other inclusions, while the later Roman-Byzantine material tends to be “redder/oranger” with BST and other mixed sand (Bauer, 2006a).

These types are largely the product of functional characteristics and would typically be classified as wares by processual archaeologists, as stylistic attributes do not contribute significantly to the attributes. The dating program will test whether or not the types have temporal meaning. Bauer (2006a, 2011) observes that, in rough terms, four of his eight types are generally conservative (Types I: Sandy, II: Chaff, III: Quartz, IV: Shell) and Types V (Fine-Grey) and VI (Pebble) are older in occurrence, while Types VII (Sandy Limestone) and VIII (Coarse Sandy) are more recent in occurrence.



**Figure 4.2: Macrophotos of selected ware types from Kocagöz (from Bauer, 2006a)**

The obtained sample, from which the dated sample was selected, was the product of ceramic collection from multiple SRAP field seasons. A subsample of ceramic sherds were exported from Turkey and eventually sent to the University of Washington's Luminescence Laboratory. Of the more than 100 sherds sent to the laboratory, 62 were eventually selected for dating, in three distinct stages. The first stage, noted above, consisted of thirteen sherds from five loci for analysis as part of 2004's pilot study. The second stage of analysis in 2005-06, an addition of eleven sherds, increased the sample size of two of the sites in the pilot study (to address questions raised by the pilot study, e.g., site duration, multiple single occupations vs. a single long-term occupation) and added a sixth locus. These sherds were the product of surveys in earlier seasons as well, with 9 collected during survey in 2003 in and in each in 1996 and 1998. Each of these first two stages was purely opportunistic in selection of sherds for luminescence analysis; sherds selected for dating were sampled from already existing collections that had been exported from Turkey for non-luminescence based analysis. This kind of opportunistic sampling biased the sample toward dating of sherds from sites and loci thought to be postcolonial and did not represent a systematic selection of sherds for dating across types or vessel forms. Samples were dated to address specific issues of regional culture-history being formulated by the directors of the SRAP and based on which samples were available for analysis.

The third stage of sample selection, completed in 2008-09, was significantly more systematic in nature, as samples were chosen for dating primarily from prehistoric sites surveyed in 2006 from which samples could be assigned to one of the Sinop ceramic

types described in Bauer's (2006a) dissertation research on prehistoric handmade pottery from the Sinop promontory. 34 samples in this third stage were taken from the 2006 surveys and four additional samples (three from 1998 and 1 from 1996) were dated. The full list of sherds dated in this thesis research is listed in Table 4.3 a-c, sorted by stage of analysis and locus, and includes relevant typological information. The season during which the sample was collected via survey can be identified from the SRAP designation number, e.g. T03.01.2 is from 2003, L98.29.13 is from 1998, and Sin06-1-1 is from 2006.

**Table 4.3a: Stage 1: 2004 Pilot Study**

UW #	SRAP #	Locus/Site	Region	Type	Typological Age Estimate
U1120	T03.01.1	Kayanın Başı	Highlands	VII	EBA, 3 <sup>rd</sup> Mill BCE
U1121	T03.01.2	Kayanın Başı	Highlands	II	EBA, 3 <sup>rd</sup> Mill BCE
U1122	T03.02.1	Kayanın Başı	Highlands	I	EBA, 3 <sup>rd</sup> Mill BCE
U1123	T03.02.2	Kayanın Başı	Highlands	V	EBA, 3 <sup>rd</sup> Mill BCE
U1124	T03.02.3	Kayanın Başı	Highlands	I	EBA, 3 <sup>rd</sup> Mill BCE
U1125	T03.02.4	Kayanın Başı	Highlands	BST	EBA, 3 <sup>rd</sup> Mill BCE
U1126	L03.07.1	Abdaloğlu	Gerze	VI	EBA, 3 <sup>rd</sup> Mill BCE
U1127	L03.07.2	Abdaloğlu	Gerze	I	EBA, 3 <sup>rd</sup> Mill BCE
U1128	L03.08.1	Kocagöz	Demirci Valley	II	EBA, 3 <sup>rd</sup> Mill BCE
U1129	L03.08.2	Kocagöz	Demirci Valley	II	EBA, 3 <sup>rd</sup> Mill BCE
U1130	L03.09.1	Karapınar	Karasu Valley	I	Late Chalc., EBA, Pre-3000 BCE
U1131	L03.11.1	Köşk Höyük, Upper	Gerze	II	Late Bronze – Early Iron Age, 1600-1700 BCE
U1132	L03.11.2	Köşk Höyük, Lower	Gerze	I	Late Bronze – Early Iron Age, 1600-1700 BCE

**Table 4.3b: Stage 2: 2005-06 Opportunistic Additions**

UW #	SRAP #	Locus/Site	Region	Type	Typological Age Estimate
U1483	L03.08 #1	Kocagöz	Demirci Valley	IV	EBA, 2800-2200 BCE
U1484	L03.08 #2	Kocagöz	Demirci Valley	III	EBA, 2800-2200 BCE
U1485	L03.08 #3	Kocagöz	Demirci Valley	I	EBA, 2800-2200 BCE
U1486	L03.04 #1	Kayanın Başı	Highlands	I	EBA, 3rd Mill BCE
U1487	L03.04 #2	Kayanın Başı	Highlands	III	EBA, 3 <sup>rd</sup> Mill BCE
U1488	L03.04 #3	Kayanın Başı	Highlands	VIII	EBA, 3 <sup>rd</sup> Mill BCE
U1489	T03.07	Kocagöz	Demirci Valley	VIII	EBA, 2800-2200 BCE
U1490	T03.14	Kocagöz	Demirci Valley	VIII	EBA, 2800-2200 BCE
U1491	L03.08 (from sed)	Kocagöz	Demirci Valley	I	EBA, 2800-2200 BCE
U1516	L98.29.13	Maltepe-Hacıoğlu	Demirci Valley	V	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1517	96.74.78	Köşk Höyük	Gerze	IV	LBA/Iron 1600-700 BCE

**Table 4.3c: Stage 3: 2008-09 Systematic Sample of Prehistoric Sites**

UW #	SRAP #	Locus/Site	Region	Type	Typological Age Estimate
U1549	Sin06-1-1	Abdaloğlu	Gerze	VI	EBA, 3 <sup>rd</sup> Mill BCE, or 4 <sup>th</sup> c. BCE
U1550	Sin06-2-1	Abdaloğlu	Gerze	II	EBA, 3 <sup>rd</sup> Mill BCE, or 4 <sup>th</sup> c. BCE
U1572	Sin06-2-3	Abdaloğlu	Gerze	I	EBA, 3 <sup>rd</sup> Mill BCE, or 4 <sup>th</sup> c. BCE
U1573	Sin06-2-4	Abdaloğlu	Gerze	BST	EBA, 3 <sup>rd</sup> Mill BCE, or 4 <sup>th</sup> c. BCE
U1988	Sin06-1-2	Abdaloğlu	Gerze	NA	EBA, 3 <sup>rd</sup> Mill BCE, or 4 <sup>th</sup> c. BCE
U1603	L98.25.82	Güllüavlu	Karasu Valley	II	Mid Bronze, 2100-1700 BCE
U1604	L98.25.86	Güllüavlu	Karasu Valley	V	4 <sup>th</sup> Mill. BCE
U1551	Sin06-1-1	Karapınar	Karasu Valley	I	Late Chalco./EBA

Table 4.3c continued

<b>UW #</b>	<b>SRAP #</b>	<b>Locus/Site</b>	<b>Region</b>	<b>Type</b>	<b>Typological Age Estimate</b>
U1574	Sin06-1-4	Karapınar	Karasu Valley	I	Late Chalco./EBA
U1989	96.74.41	Köşk Höyük	Gerze	NA	LBA/Iron, 1600-700 BCE
U1547	Sin06-1-1	Maltepe-Hacıoğlu	Demirci Valley	NA	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1568	Sin06-1-2	Maltepe-Hacıoğlu	Demirci Valley	VIII	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1569	Sin06-1-4	Maltepe-Hacıoğlu	Demirci Valley	IV	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1570	Sin06-2-2	Maltepe-Hacıoğlu	Demirci Valley	I	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1571	Sin06-2-3	Maltepe-Hacıoğlu	Demirci Valley	V	Late Chalco., 4 <sup>th</sup> Mill. BCE
U1552	Sin06-1-1	Maltepe-Tepealtı	Highlands	II	Early 1 <sup>st</sup> Mill. BCE
U1575	Sin06-1-2	Maltepe-Tepealtı	Highlands	VIII	Early 1 <sup>st</sup> Mill. BCE
U1986	Sin06-1-3	Maltepe-Tepealtı	Highlands	NA	Early 1 <sup>st</sup> Mill. BCE
U1542	Sin06-1-1	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1544	Sin06-3-1	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1545	Sin06-4-1	Mezarlıktepe	Demirci Valley	BST	5 <sup>th</sup> Mill. BCE
U1546	Sin06-5-1	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1563	Sin06-2-3	Mezarlıktepe	Demirci Valley	IV	5 <sup>th</sup> Mill. BCE
U1564	Sin06-4-2	Mezarlıktepe	Demirci Valley	I	5 <sup>th</sup> Mill. BCE
U1567	Sin06-5-3	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1567	Sin06-5-3	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1590	Sin06-1-5	Mezarlıktepe	Demirci Valley	I	5 <sup>th</sup> Mill. BCE

Table 4.3c continued

<b>UW #</b>	<b>SRAP #</b>	<b>Locus/Site</b>	<b>Region</b>	<b>Type</b>	<b>Typological Age Estimate</b>
U1557	Sin06-1-1	Nohutluk	Karasu Valley	BST	Early 1 <sup>st</sup> Mill. BCE
U1567	Sin06-5-3	Mezarlıktepe	Demirci Valley	II	5 <sup>th</sup> Mill. BCE
U1590	Sin06-1-5	Mezarlıktepe	Demirci Valley	I	5 <sup>th</sup> Mill. BCE
U1557	Sin06-1-1	Nohutluk	Karasu Valley	BST	Early 1 <sup>st</sup> Mill. BCE
U1559	Sin06-3-1	Nohutluk	Karasu Valley	II	Early 1 <sup>st</sup> Mill. BCE
U1581	Sin06-2-2	Nohutluk	Karasu Valley	IV	Early 1 <sup>st</sup> Mill. BCE
U1584	Sin06-5-4	Nohutluk	Karasu Valley	I	Early 1 <sup>st</sup> Mill. BCE
U1987	Sin06-4-4	Nohutluk	Karasu Valley	NA	Early 1 <sup>st</sup> Mill. BCE
U1555	Sin06-3-1	Tıngır Tepe	Highlands	III	7 <sup>th</sup> - 4 <sup>th</sup> c. BCE
U1576	Sin06-1-2	Tıngır Tepe	Highlands	II	7 <sup>th</sup> - 4 <sup>th</sup> c. BCE
U1577	Sin06-1-3	Tıngır Tepe	Highlands	IV	7 <sup>th</sup> - 4 <sup>th</sup> c. BCE
U1578	Sin06-2-2	Tıngır Tepe	Highlands	VI	7 <sup>th</sup> - 4 <sup>th</sup> c. BCE
U1579	Sin06-2-3	Tıngır Tepe	Highlands	VIII	7 <sup>th</sup> - 4 <sup>th</sup> c. BCE

Bauer (2006a: 229) lists the occurrence of these ware types by locus/region. That data is presented here, recreated from the original, in Table 4.4a-b.

**Table 4.4a: Ware Types in Sinop by Site/Period (from Bauer, 2006a)**

Period, from Typology	Site/Locus	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII
Chalcolithic	Mezarlıktepe	X	X		X				
	Maltepe Hacıoğlu	X	X		X	X			
	Kayanın Başı	X	X	X	X	X			
Early Bronze	Güllüavlu	X	X	X	X	X	X		
	Kocagöz	X	X	X	X		X		
	Karapınar	X	X		X			X	X
	Nohutluk	X	X		X			X	X
	Köşk Höyük	X	X	X				X	X
Middle to Late Bronze	Tıngertepe	X	X	X				X	

In the dated sample (which includes two postcolonial sites: Maltepe-Tepealtı and Abdaloğlu), the occurrence of ware types varies slightly (and includes BST), as shown in Table 4.4b, below. The ‘X’ denotes types identified by Bauer (2006a) and ‘D’ indicates presence in the dated sample. The differences between the two tables are a product of sample size. Future research, to be discussed in the final chapter, will address the ways in which the dating program will coincide with the classification of ware types.

**Table 4.4b: Ware Types in Sinop by Site/Period, as Seen in Dated Sample**

Period, from Typology	Site/Locus	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII	BST
Chalcolithic	Mezarlıktepe	X D	X D		X D					D
	Maltepe Hacıoğlu	X D	X		XD	X D			D	
	Kayanın Başı	X D	X D	X	X	X D		D		D
Early Bronze	Güllüavlu	X	X D	X	X	X D	X			
	Kocagöz	X D	X D	X	X		X		D	
	Karapınar	X D	X		X			X	X	
	Nohutluk	X D	X D		X D			X	X	D
	Köşk Höyük	X D	X D	X	D			X	X	

Table 4.4b continued

<b>Period, from Typology</b>	<b>Site/Locus</b>	<b>Type I</b>	<b>Type II</b>	<b>Type III</b>	<b>Type IV</b>	<b>Type V</b>	<b>Type VI</b>	<b>Type VII</b>	<b>Type VIII</b>	<b>BST</b>
Middle to Late Bronze	Tingertepe	X	X D	X D	D		D	X	D	
Postcolonial	Abdaloğlu	D	D				D			D
	Maltepe- Tepealti		D					D		

One final note on the sample and sample selection deserves mention here, as its significance to efforts at understanding temporal variability of ware types is relevant to the following discussions. Most of the sherds included in the dated sample were selected from amongst their respective assemblages for dating because they lacked established temporally defining characteristics. That is, nondiagnostic samples were selected for dating in order to evaluate the merit of diagnostic sherds described by Bauer (2006a). For example, take the locus of Tingertepe, thought to be Late Bronze to perhaps Iron Age (mid 1<sup>st</sup> mill. B.C.E.) based on the presence in the assemblage of some 4<sup>th</sup> c. amphora handles. Rather than date the amphora handles, nondiagnostic sherds were selected for analysis, were ware-typed, and then dated by luminescence. What follows in the presentation of results (Chapter Six) and interpretation (Chapter Seven) reflects these decisions.

In subsequent chapters, data from these three episodes of sample selection will be combined and analyzed by region and locus.

## Chapter Five: Luminescence Methods

“You can’t have a light without a dark to stick it in.”—Arlo Guthrie (1947)

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### *Luminescence Dating: The Application*

The application of luminescence dating techniques to archaeological research questions can be traced back to the 1960s in America and Europe (e.g., Ralph and Han, 1966, Aitken et al., 1968), when it was used as a method for dating heated materials like archaeological ceramics (Feathers, 2003). Despite a period of skepticism toward the value of the technique for dating pottery in the 1980s and 1990s, it has, in the last decade or more, gained in acceptance and popularity to the point that it is now relatively routine to date archaeological materials, particularly pottery, with luminescence (Feathers, 2009).

Part of the skepticism about the technique can be traced to an inaccurate conception of the limits of the technique and a lack of understanding of geological formation processes, particularly as they relate to surface sites. As discussed by Dunnell and Feathers (1994), and described in Chapter Three, the preference for analysis of materials from buried contexts rather than from surficial contexts was in large part due to the perceived lack of context provided by surficial finds. This bias against surficial sites is both unfounded and proved to be detrimental to the application of luminescence dating, by its association to use in surficial sites.

The fear from the luminescence community was that dating surface samples would suffer from too much uncertainty in the gamma and cosmic dose rate, and the possibility of radon fall-out from the atmosphere. These fears have been shown to be unfounded (Dunnell and Feathers, 1994) because all archaeological contexts, buried or

otherwise, at one point existed as a surface. Samples that have always been on the surface are in fact preferable because there is less uncertainty about the duration and rate of burial. Sediment samples from the surface, of course, will be emptied of their luminescence signal from sunlight, but with ceramics mineral grains from the interior of the fabric have not been exposed to sunlight and, thus, are not affected by the sun. Finally, the lack of stratigraphic context on the surface in no way works to the detriment of the luminescence technique to derive an accurate date, as the date is a direct measure of the last time the artifact was heated to a temperature sufficient to “zero” any stored luminescence energy. Buried sites run the risk of giving a sense of false security through an over-reliance on stratigraphic information, as all artifacts recovered from the strata are often simplistically viewed as having the same age. And, as mentioned, the recovery of artifacts from the surface makes calculations of environmental radioactivity (the external Dose Rate) much more straightforward.

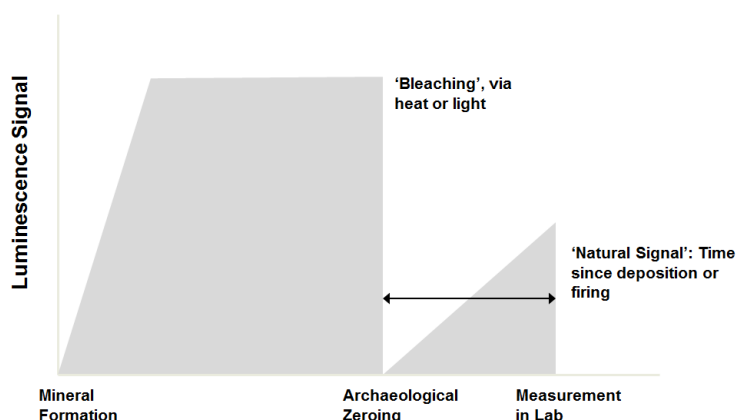
With advances in method and instrumentation, luminescence dating is becoming more and more accurate and precise and can be applied to a greater range of archaeological research questions. In this chapter and the next I will describe the ways in which the research conducted in the dating of ceramics from Sinop both reflect these advances and themselves have served to further the field of luminescence dating. Methodologically, this research represents an effort to date pottery manufacture not just by thermoluminescence, but also by optically-stimulated and infrared-stimulated luminescence. Secondly, as part of this research I developed a method of qualitatively evaluating, or “grading”, the quality of dates of each sherd in such a way that a collection

of dates for a site or locus is not viewed simply as a distribution of dates but as a distribution of dates with varying degrees of reliability. The grading system will be explained in Chapter 6.

What follows in the remainder of this chapter is a detailed description first of principles of luminescence dating and then the specific methods used in the laboratory to derive dates for set of samples described in Chapter 4.

#### *Luminescence Dating: Defined*

Luminescence dating is based on the emission of light from commonly occurring crystalline materials, principally quartz and feldspar, after the release of stored energy that had been absorbed from an external source, which for dating is naturally occurring radioactivity—alpha, beta, gamma—as well as cosmic radiation (Chen and McKeever, 1997). The intensity of this light, or luminescence, whose signal can be measured in controlled laboratory settings, is proportional to the amount of energy absorbed, which in turn is proportional to the amount of time elapsed since energy accumulation began, what I'll call here the “time zero”. The time zero is the last time energy was released from a metastable state via stimulation from sufficient heat or light, which often coincides to events with anthropological significance, e.g., the firing of ceramics by prehistoric potters. By calibrating the luminescence signal with laboratory irradiation and taking into consideration the dose rate, a date from time zero can be derived. Luminescence stimulated by heat is called Thermoluminescence; that stimulated by light Optically Stimulated Luminescence (a generic term that includes by stimulation by infrared as well as visible light). The “life cycle” of luminescence energy is modeled in Figure 5.1:

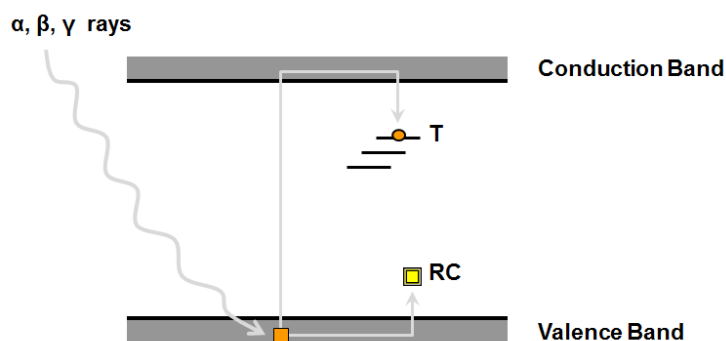


**Figure 5.1: The luminescence life cycle**

As is illustrated above, after formation minerals accumulate a latent luminescence signal over geological time. This signal eventually reaches saturation levels if not stimulated by heat or light. In the example of ceramic manufacture, with the gathering of clay and temper for ceramic production, potters subject these materials to light and heat, during the manufacturing process. During the modeling of the ceramic vessel, mineral grains (quartz and feldspar) stored within the interior of the ceramic object have been bleached by light for the final time. During the firing of the ceramic object in a kiln or firepit, all of the grains are zeroed via heat exposure. These events represent archaeological zeroing, after which the luminescence begins to accumulate anew, until zeroed again, in this case in a controlled laboratory setting.

To understand how luminescence works, one must look to the underlying physics, specifically to the energy band theory of solids (McKeever, 1985). Atoms consist of nuclei surrounded by a cloud of electrons at different energy levels. In crystalline materials atoms are arranged in a symmetrical lattice in which electrons occupy discrete energy states, called bands. Two bands are important in crystalline materials: the valence

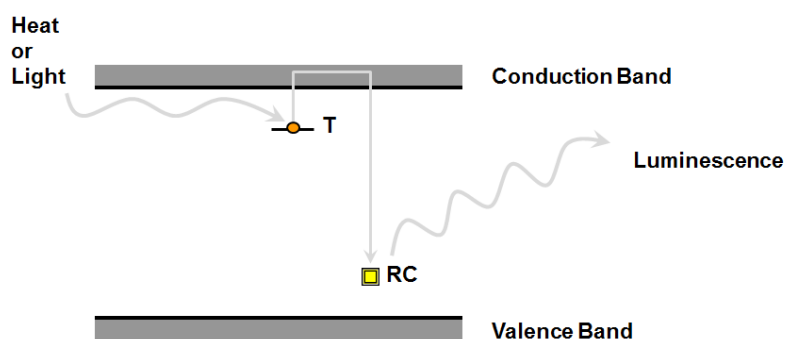
band and the conduction band (See Figure 5.2a). The valence band is at the lowest energy band, or the ground state, where electrons are tied to the parent atom. The conduction band is the next highest band that electrons can occupy when excited by energy. In ceramics, the gap between the valence and conduction bands is referred to as the “forbidden zone”, which can be occupied by electrons in insulators, like ceramics, at localized energy levels because of the presence of structural defects in the lattice arrangement. These defects, marked “T” for trap, allow for the occupation of energy levels within the forbidden zone, where electrons continue to get trapped in defects over time. When, for example, an electron moves from the valence band to the conduction band and encounters a trap with negative charge deficiency it can be trapped.



**Figure 5.2a: Energy diagram of the luminescence model**

Luminescence occurs during recombination. The absorption of energy from an external source frees an electron from the valence band. It then becomes trapped for an indefinite period of time. Heat or light stimulation can release the trapped charge, after which they can recombine with other trapped charge, normally not emptied by heat or light, and conveniently called “recombination centers”, marked “RC” (See Figure 5.2b).

Luminescence occurs during recombination: the paired charges are first in an excited state and then during a drop to a steady state, energy is released as heat and luminescence.



**Figure 5.2b: Recombination centers**

Applying these physical properties to dating requires four sets of conditions (Feathers, 1997: 16).

1. *A natural dosimeter and a source of radioactivity.* A dosimeter is any material that accumulates luminescence charge as a function of radiation exposure. Most luminescence research has focused on quartz and feldspars, as they are effective dosimeters and are ubiquitous in nature, and therefore ubiquitous in clays used in ceramic production.
2. *A zeroing event at an anthropologically relevant target event.* Energy stored in traps must be emptied to begin the dating clock (See Figure 5.2a). Heat and light are standard zeroing mechanisms. Temperatures of 450°C are required to zero pottery. Light is more variable, dependent on the wavelength of light, degree of shade, the type of trap, and the presence of filters, e.g., water.

3. *The traps cannot be saturated.* So much time should not have elapsed since the target event that all of the electron traps are full, because once traps are all full, luminescence signal will no longer be proportional to time. Resultant dates will only give a minimum age. This limit to saturation is dependent on dose rate and attributes of the material. High dose rates can produce saturation in as little as 100,000 years, or even less.
4. *Accumulated luminescence signal must be stable over time.* If traps lose charge, like an inefficient battery cell, the signal measured in the laboratory will represent an underestimate of the sample's age since firing, in the case of ceramics. This is referred to as thermal fading, the loss of luminescence signal at ambient temperatures (well below 450°C). Thermal fading involves emptying shallow, unstable electron traps, and can affect some quasi-stable traps in older samples, especially in hotter climates. Anomalous fading, on the other hand, is more of an obstacle to accurate dating, as deep traps in some materials fade at ambient temperatures, primarily in feldspars—a material often used in dating ceramics. Anomalous fading in feldspars is explained by quantum tunneling (e.g., Visocekas et al., 1994), in which an electron may escape from a trap and recombine as a result of small but finite probability of “tunneling” through its energy barrier. Comparing the luminescence of similarly dosed samples after varying storage times is the best way to detect anomalous fading. This research relied upon the fading correction developed by Huntley and Lamothe (2001).

When these conditions are met, luminescence data can be recovered in the laboratory and used to calculate the age of artifacts, like the ceramics from Sinop to their time of manufacture (firing). The age equation is a simple one, though the simplicity of the equation hides the complexity of the components. The age equation is:

$$\text{Age (years)} = D_E \text{ (Gy)} / D_R \text{ (Gy/year)}$$

Where  $D_E$  is the equivalent dose and  $D_R$  is the dose rate.  $D_E$  is the amount of absorbed radiation dose that is necessary to account for the measured luminescence signal,  $D_R$  is the amount of radiation absorbed per unit time, and 1 gray (Gy), the metric (SI) measurement unit for radiation absorbed dose, is equivalent to the absorption of one joule of ionizing radiation by one kilogram of matter (1J/kg). Luminescence dates are reported as calendrical dates with error terms that reflect the propagation of errors from each stage of data measurement, usually expressed as 1-sigma.

The steps specific to the calculation of ages for the Sinop material are described below. First, though, a quick note about the analytical process as it relates to the generated data. At some points in the analysis, the outcome of one stage in the analysis determined the next step to be taken. This path dependency, or the relationship of future decisions to past outcomes, is an important component of analytical work and is part of the laboratory design from the very beginning, starting with the determination of whether or not the Sinop ceramic samples had a luminescence signal that corresponded to the correct time scale and that the traps were not saturated; i.e., that I was not measuring a deep geological age.

Once this was established, the methods specific to thermoluminescence (TL), optically-stimulated luminescence (OSL), and infrared-stimulated luminescence (IRSL) were carried out. At specific points in each of these processes, previous outcomes determined the future course of analysis, at times necessitating additional methodological steps and data collection. A prime example of this path dependency references condition four, described above: anomalous fading. Analysis showed that, as some of the TL signal was produced from feldspars, anomalous fading was a concern. Despite applying the Huntley-Lamothe (2001) fading correction, it was sometimes not possible to correct for fading, at least with very good precision. Anomalous fading, though, may not be a problem for the OSL signal, as the initial infrared exposure of samples during analysis (part of the Double SAR method, described below) may remove the feldspar signal (responsible for fading) from the OSL measurement, circumventing the problem of anomalous fading. OSL measurements are then, theoretically, derived purely from quartz, as only feldspar is sensitive to infrared. So, in this example, the presence of anomalous fading in the TL signal re-directed the focus of analysis to the OSL signal. As will be described in the section on OSL methodology below, however, an examination of the OSL data suggested that the story was not that simple, that the quartz signal, too, had an interesting characteristic, which also led to further analysis.

The fact that laboratory protocols are not rote is no surprise to anyone who has worked with materials with diverse and varying physical properties. That path dependency existed to the degree that it did was at times challenging, as with the case of the OSL data, for example, where I was forced to develop a novel combination of

methods. It is a strength of the technique, though, that luminescence dating allows such flexibility of protocol, enabling the analyst to follow the case-specific characteristics of data as they are generated, ultimately leading to dates that are precise and accurate.

Each of the steps in the analytical process, or forks in the road, specific to the calculation of ages for the Sinop material are described below.

### *Laboratory Analysis*

The above catalog of ceramic samples, totaling 59 sherds, represents only those sherds that were dated via luminescence. These 59 sherds are the samples that were selected for analysis based on a number of factors: in Stages 1 and 2 described, all samples sent to the lab were dated, but in stage 3, samples were selected from a bigger pool, based on more systematic sampling targeting those loci thought to be prehistoric. Stage 3 sampling also occurred in waves: as results were generated, filling in the chronological range of loci, additional samples were added to the loci that were thought to require additional chronological resolution. When possible, in Stage 3, efforts were also made to select samples from the 2006 field season, from which ware typology was available.

Additionally, practical matters of sample selection were considered. Notably, sherds for dating had to be at least 5mm thick in order to leave a minimum of 1 mm in the center of the sherd, in cross-section, beyond the 2mm penetrating capacity of beta radiation from the depositional environment, which would complicate the dose rate measurements. Furthermore, some samples, especially those collected by SRAP prior to

2006 lacked a sample of associated sediment, needed to calculate the environmental dose rate. These sherds were rarely included in analysis.

As discussed in Chapter 3, the benefits of luminescence dating in survey contexts are clear: the dated event corresponds to a target event, namely the manufacture of the ceramic artifact; calendar dates are generated, and mixed assemblages can be resolved with adequate sample size. The goals of this research seek to take advantage of these strengths. The discussion will now turn to the methods of analysis used in the Luminescence Laboratory at the University of Washington, under the supervision of Dr. James Feathers, thesis advisor and director of the laboratory. The descriptions of the steps used in this analysis are modified from a laboratory template developed and written by Dr. Feathers.

### **Procedures for Thermoluminescence Analysis of Pottery**

*Sample preparation—fine grain.* Each sherd was first processed as part of a general intake protocol, including: qualitative descriptions of each sherd (color, temper, firing, etc.), entered into the laboratory sample logbook, and then placed in a beaker of water to reach moisture saturation. After at least one week, samples are removed from water and weighed to record a “wet weight”, equivalent to the maximum weight the sample could reach in a fully saturated environment. The sherds are then placed in a 50°C oven for a minimum of one week and then weighed a second time. This “dry weight” is subtracted from the wet weight and this sum is divided by the wet weight, yielded a moisture percentage that is used in later radioactivity calculations.

Once this descriptive information is collected, each sherd was then broken to expose a fresh profile from which material was drilled from the center of the cross-section, more than 2 mm from either surface, using a tungsten carbide drill tip. The material retrieved was ground gently by an agate mortar and pestle, treated with HCl to disaggregate individual grains and remove carbonates, rinsed several times with water and then acetone using a centrifuge, and then settled in acetone first for 2 minutes (to remove the  $> 8 \mu\text{m}$  grains) and then for 20 minutes to remove the  $< 1 \mu\text{m}$  grains. The remaining grains should fall in size between 1-8  $\mu\text{m}$  and is placed back in an acetone solution whose density is qualitatively determined adequate to produce a single layer on stainless steel disc 1cm in diameter. This resultant solution was then settled onto a maximum 72 stainless steel discs, representing individual aliquots of a single sample. .

The luminescence from these fine-grains (1-8  $\mu\text{m}$ ) is mainly a function of quartz and feldspar. The 1-8 $\mu\text{m}$  size is small enough not to attenuate any alpha irradiation (Wintle, 1997) and large enough to exclude clay minerals which generally have no luminescence signal.

***Determination of equivalent dose ( $D_E$ ).*** Thermoluminescence is measured by heating sample aliquots, one at a time, at a steady rate to 450°C (as above) while measuring the emission of light with a sensitive photomultiplier. As the temperature ramps up, electrons become more likely to escape their traps, increasing the signal. The signal decreases as the traps are emptied. This results in a peak structure, which may be a composite of several peaks, called a glow curve. Optically-stimulated luminescence was

measured with the light source at constant power, recording luminescence against time as a decay curve, or “shine down.

Because traps have different energy depths, some of which are less stable than others, it is important to target only those traps which are stable for analysis, i.e. those traps that have not been emptied since the zeroing event. To do this a 240°C preheat was used in both TL and OSL/IRSL. In addition, for TL a *plateau*, or range of temperature over which the signal is stable, was used to determine the temperature integral for analysis. Each technique will be described here in greater detail.

TL was measured on a Daybreak reader using a 9635Q photomultiplier with a Corning 7-59 blue filter, in N<sub>2</sub> atmosphere at 1°C/s to 450°C. A preheat of 240°C with no hold time precedes each measurement. Artificial irradiation was given with a <sup>241</sup>Am alpha source and a <sup>90</sup>Sr beta source, the latter calibrated against a <sup>137</sup>Cs gamma source. Discs were stored at room temperature for at least one week after irradiation before glow out. Data were processed by Daybreak TLApplic software.

Several discs were used to test for anomalous fading. The natural luminescence was first measured by heating to 450°C, as above. The discs were then given an equal alpha irradiation and stored at room temperature for varied times: 10 min, 2 hours, 1 day, 1 week and 8 weeks. The irradiations were staggered in time so that all glow outs (second glows, because the natural was measured first) were performed on the same day. The second glows were normalized by the natural signal and then compared to determine any loss of signal with time (on a log scale). Samples that exhibited fading with signal versus time values that reasonably fit a logarithmic function, were corrected for age

following procedures recommended by Huntley and Lamothe (2001). The fading data will be addressed in greater detail below, in the context of the OSL  $D_E$ .

The equivalent dose ( $D_E$ ) is the amount of radiation (absorbed dose) required to produce a luminescence signal equivalent to the natural signal measured on the sample. The  $D_E$  is measured by calibrating the natural signal against known doses of radioactivity in the laboratory. The equivalent dose was determined by a combination additive dose and regeneration procedure called the *slide method* (Huntley et al., 1993, Prescott et al., 1993). Both additive dose and regeneration involve incremental additions of dose to several aliquots of material (based on an assessment of the magnitude of the natural signal). Additive dose involves administering incremental doses to natural material. A growth curve plotting dose against luminescence can be extrapolated to the dose axis to estimate an equivalent dose, but for pottery this estimate is usually inaccurate because of errors in extrapolation due to nonlinearity. Regeneration involves zeroing natural material by heating to 450°C and then rebuilding a growth curve with incremental doses. The problem here is sensitivity change caused by the heating. By constructing both curves, the regeneration curve can be used to define the extrapolated area and can be corrected for sensitivity change by comparing it with the additive dose curve. This works where the shapes of the curves differ only in scale (i.e., the sensitivity change is independent of dose). The curves are then combined using the “Australian slide” method in a program developed by David Huntley (Prescott et al., 1993). The equivalent dose is taken as the horizontal distance between the two curves after a scale adjustment for sensitivity change. Where the growth curves are not linear, they are fit to quadratic

functions. Dose increments (typically  $n = 5$ ) are determined so that the maximum additive dose results in a signal about three times that of the natural and the maximum regeneration dose about five times the natural. If the regeneration curve has a significant negative intercept, which is not expected given current understanding, the additive dose intercept is taken as the best fit, if not a fully reliable approximation.

Signal stability was determined for TL by conducting a plateau test. A plateau region was determined for each sample by calculating the equivalent dose at temperature increments between 240° and 450°C and determining over which temperature range the values are equivalent, i.e. within error terms. This plateau region was then compared with a similar one constructed for the b-value (alpha efficiency), and the overlap defined the integrated range for final analysis. The plateau test is also used to detect insufficient heating during zeroing, as the natural signal in a poorly heated sample (non-zeroed) will still have a component not brought to zero. For OSL, the determination of signal stability is less straightforward, as stable and unstable signals are not easily separated. A preheat is used to remove unstable signal. I used the 240°C preheat used in TL, except that the temperature was held at the maximum for 10 seconds.

As alluded to above, addressing the anomalous fading of the TL signal represented an analytical challenge. Whenever possible, TL data were corrected for fading. This is a problem inherent to dating fine-grained ceramics, as they are by nature polymineral and include a feldspar component. To supplement that data (and to clarify it, when possible), the  $D_E$  was also measured from the OSL and IRSL signals. Specifically, to eliminate the feldspar from the OSL signal, the double-SAR technique was employed.

OSL and IRSL on fine-grain (1-8 $\mu$ m) pottery samples are carried out on single aliquots following procedures adapted from Banerjee et al. (2001) and Roberts and Wintle (2001). Equivalent dose was determined by the single-aliquot regenerative dose (SAR) method (Murray and Wintle, 2000) with the addition of an IR stimulation before the OSL measurement (Zhang and Zhou, 2007; Roberts, 2007) to circumvent the problem of anomalous fading, as IR exposure may remove the feldspar signal from OSL because only feldspar is sensitive to IR. The quartz signal remains after the IR stimulation and it is this signal that is measured by OSL.

The SAR method measures the natural signal and the signal from a series of regeneration doses on a single aliquot. The method uses a small test dose to monitor and correct for sensitivity changes brought about by preheating, irradiation or light stimulation. SAR consists of the following steps:

- 1) preheat,
- 2) measurement of natural signal (OSL or IRSL), L(1),
- 3) test dose,
- 4) cut heat,
- 5) measurement of test dose signal, T(1),
- 6) regeneration dose,
- 7) preheat,
- 8) measurement of signal from regeneration, L(2),
- 9) test dose,
- 10) cut heat,

11) measurement of test dose signal, T(2),

12) repeat of steps 6 through 11 for various regeneration doses.

A growth curve was then constructed from the L(i)/T(i) ratios and the equivalent dose is found by interpolation of L(1)/T(1). Usually a zero regeneration dose and a repeated regeneration dose are employed to insure the procedure is working properly. For fine-grained ceramics, a preheat of 240°C for 10s, a test dose of 3.1 Gy, and a cut heat of 200°C were used. (Cut heat means the temperature is not held at the maximum, and the sample is allowed to immediately cool down.)

The luminescence, L(i) and T(i), was measured on a Risø TL-DA-15 automated reader by a succession of two stimulations: first 100 s at 60°C of IRSL (880nm diodes), and then 100s at 125°C of OSL (470nm diodes). Detection was through 7.5mm of Hoya U340 (ultra-violet) filters. The two stimulations were used to construct IRSL and OSL growth curves, so that two estimations of equivalent dose are available.

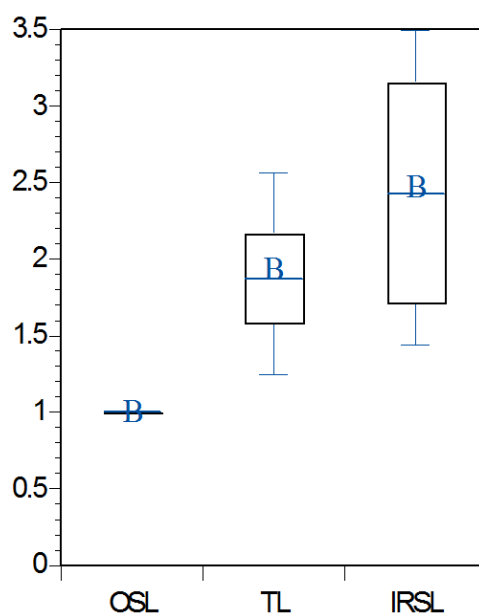
The expectation was that this double-SAR technique would circumvent the problem of anomalous fading, but it was not clear if the IR stimulation at the beginning of the protocol eliminated the entire feldspar signal, as feldspar is also sensitive to blue light (470nm). Some preliminary tests in our laboratory had suggested that the OSL signal does not suffer from fading, but this may be sample specific, as the Sinop ceramics do exhibit some characteristics of fading in the OSL signal. To test the effectiveness of the IR stimulation in eliminating the feldspar signal, a pulsed-OSL application was implemented.

Pulsed OSL takes advantage of the time between the stimulus and the emission of luminescence energy to target the quartz component of the luminescence signal. Feldspar is relatively “fast” emitting, on the order of about 10 microseconds, whereas quartz is much slower, almost entirely after 10 microseconds. So, in an effort to remove the feldspar signal and preserve the quartz signal (and thus account for anomalous fading), a 10 microsecond “pulse” of light stimulation was employed. After the pulse, mainly a quartz signal would be measured. This research was first presented at the 7<sup>th</sup> New World Luminescence Dating and Dosimetry Workshop (Casson, 2010). The pulsed data revealed an interesting pattern, as the pulsed  $D_E$  was statistically equivalent to the non-pulsed  $D_E$ . This suggests that the double-SAR technique was equally as effective in eliminating the feldspar as the pulsed technique, making pulsing redundant, at least for the samples tested. This might not be true for all Sinop samples as inspection of the b-value data suggest.

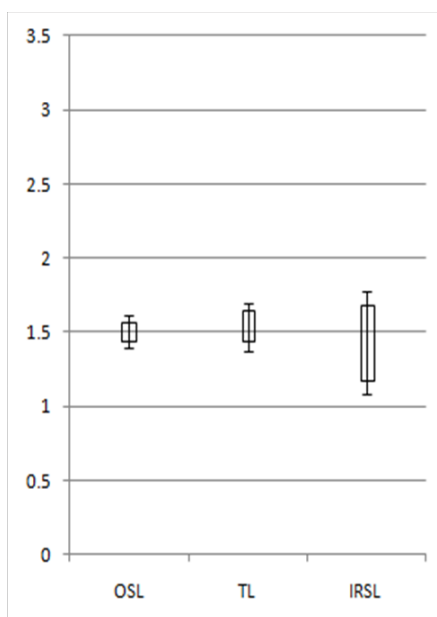
The b-value is the ratio of luminescence response from beta vs alpha irradiation ( $\beta:\alpha$ ) and is used to correct for lower  $\alpha$  efficiency, because alpha rays are less effective at producing luminescence than beta rays or gamma rays. For TL, the alpha efficiency is determined by comparing additive dose curves using alpha and beta irradiations. The slide program is also used in this regard, taking the scale factor (which is the ratio of the two slopes) as the b-value (Aitken 1985).

Alpha efficiency is predicted to differ among IRSL, OSL and TL on fine-grained materials, as it is known to differ between coarse-grained feldspar and quartz (Aitken, 1985). The b-value was measured for IRSL and OSL by adding two alpha regeneration

points to the SAR sequence. The slopes of the beta regeneration growth curve and that of the alphas are compared to determine b-value. Alpha rays are more efficient for IRSL (predominately feldspar), and TL (a polymineral combination of feldspar and quartz) than for OSL (mostly quartz). Results from a series of samples analyzed in 2006 in the University of Washington's Luminescence Laboratory from different geographic locations (not including Sinop) show that OSL b-value is less variable and centers around 1.0. IRSL b-value is more variable and is higher than that for OSL. TL b-value tends to fall between the OSL and IRSL values. Figure 5.3a shows the ideal distribution of b-values for these samples. Figure 5.3b, is the b-value data from the Sinop samples, which do not behave in this idealized way. Subsequent work has shown that b-values for OSL from ceramics where the feldspar contribution is expected to be minimal yields values in the 0.5-0.6 range, which agrees with other published data (Mauz et al., 2006).



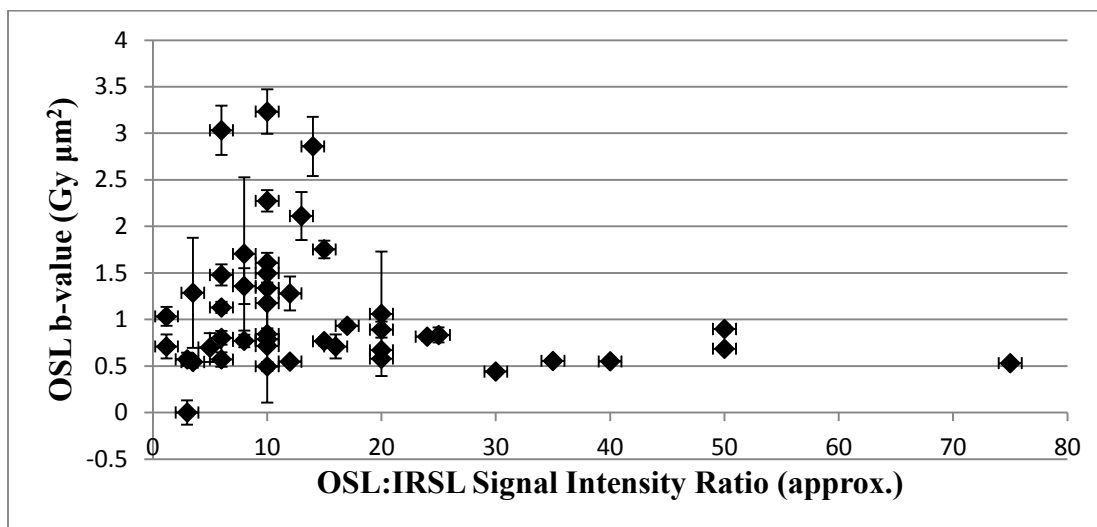
**Figure 5.3a: Measured b-value distribution, from non-Sinop dated samples**



**Figure 5.3b: Observed b-values, from Sinop pottery**

The Sinop data do not follow the prediction of  $OSL < TL < IRSL$ , reflecting increasing feldspar percentage from  $OSL \rightarrow TL \rightarrow IRSL$ . Instead, the OSL b-values (and TL, to a lesser extent) are anomalously high, approaching feldspar levels. That is, neither the pulsed-data nor the double-SAR lowered the b-value. Each technique, designed to remove the feldspar signal, produced similar results.

High b-values remain unclear. One possibility, as alluded to above, is that the OSL signal stemmed partly from feldspars and thus faded. This hypothesis was also addressed with the Sinop data. The higher than expected OSL b-values are associated with low OSL:IRSL signal ratios, as shown in Figure 5.4. This means that the high OSL b-values likely include a feldspar contribution to the OSL signal. But, the OSL might not fade, as the IRSL stimulation prior to OSL measurement preferentially removed the fading part of the feldspar signal. This is consistent with high b-value data with pulsed OSL measurements for the same samples.



**Figure 5.4: Ratio of OSL:IRSL signal sorted by OSL b-value**

Additional research into the application of infrared exposure coupled with pulsed OSL on polymineral fine-grained samples from China further clouded the issue (Feathers et al., 2012). This analysis, of which I was also a contributing author, was on sediments and not pottery, but it is worth describing the results here. Fading rates between pulsed and non-pulsed differed in these samples: fading was significant mainly with the non-pulsed signals, suggesting that the pulse removed most of the feldspar component in these samples. Comparison of the Chinese sediment samples with the Sinop pottery samples suggests that there remains work to be done in understanding the nature of the feldspar component in polymineral fine-grain samples. One possibility is that double SAR did not remove all of the feldspar signal but did remove that part of the feldspar signal that faded (J.K. Feathers, personal communication, Jan 15, 2012). Other work with feldspars has shown that a previous IRSL stimulation can remove most of the fading signal (Jain and Ankjaergaard, 2011).

The observation that the Sinop b-value data violated the assumptions of the idealized model of b-value distributions described above led to an effort to qualify the quality of the dates for each sample. In other words, in sorting through the component parts of the calculations for equivalent dose and dose rate, I was struck by the realization that despite the quantifiable nature of the age formula (and the ability to assign error terms to each component of the equation), there was a degree of subjectivity present that could not be quantified. This realization would eventually lead to the design of a grading system, which I will discuss in significant detail in Chapter 6, based on whether or not each sherd met certain standards across eight categories. One of these categories is whether or not the relative order of b-value data for the sample follows the expectation of  $IRSL > TL > OSL$ . If yes, it passes that standard; if no, it fails that standard. In this way, final dates can be assigned a grade which reflects the quality of the data and communicates the fact that some dates are based on objectively better data than other dates, with varying degrees of ambiguity. In consultation with Feathers, I am reconsidering the way that this standard is being defined, as it is not fully clear what the TL is measuring (we assume that IRSL is mainly feldspar and OSL is mainly quartz, ideally). The TL signal may be feldspar, quartz, and something else entirely. It may simply be important that the OSL b-value is less than IRSL and TL and any difference between IRSL and TL is not particularly meaningful.

Before presenting the results of the analysis and of the grading system, the denominator of the age equation—dose rate—remains to be discussed.

***Determination of dose rate ( $D_R$ ).*** Radioactivity from the U and Th decay series was measured by alpha counting in conjunction with atomic emission for  $^{40}\text{K}$ . Samples for alpha counting were crushed in a mill to flour consistency, packed into plexiglass containers with ZnS:Ag screens, and sealed for one month before counting. The pairs-technique was used to separate the U and Th decay series. For atomic emission measurements, samples were dissolved in HF and other acids and analyzed by a Jenway flame photometer. K concentrations for each sample were determined by bracketing between standards of known concentration. Conversion to  $^{40}\text{K}$  is by natural atomic abundance. Radioactivity was also measured, as a check, by beta counting, using a Risø low level beta GM multiscaler system. About 0.5 g of crushed sample was placed on each of four plastic sample holders. All were counted for 24 hours. The average is converted to dose rate following Bøtter-Jensen and Mejdahl (1988) and compared with the beta dose rate calculated from the alpha counting and flame photometer results.

Both the sherd and an associated soil sample were measured for radioactivity. For some samples collected during the first two stages of analysis, no associated sediment sample was submitted to for analysis. In these circumstances, radioactivity values for associated sediment were calculated from an average of the values of the nearest collected sediment samples. Cosmic radiation was determined after Prescott and Hutton (1988). Radioactivity concentrations were translated into dose rates following Adamiec and Aitken (1998).

***Moisture contents.*** Water absorption values for the sherds were determined by comparing the saturated and dried weights. Because of the temperate climate, moisture

in the pottery was taken to be  $80 \pm 20$  percent of total absorption. Again for temperate climates, soil moisture contents were taken from typical moisture retention quantities for different textured soils (Brady, 1974: 196).

## Chapter Six: Results

“However beautiful the strategy, you should occasionally look at the results.”  
—Winston Churchill (1874-1965)

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The results of the luminescence dating are presented as final calculated ages, sorted by locus and compared to typological age estimates. Qualitative grade values for the sherds at each site will also be considered, where dates with higher grades are considered to provide greater chronological clarity for the research questions presented in Chapter Four. As part of this discussion, I will also present the dates spatially (as ordinal-level data) and after looking at each locus by region, will look at the entire dataset sorted by ware type, to the extent that the dataset allows.

Raw data, including equivalent dose and dose rate values are provided for each sample in Appendix I and II. Appendix III describes the decision-making process for each date, as the product of specific analytical decisions, i.e., why, for example, was the equivalent dose from TL used instead of OSL in a particular circumstance. In Appendix IV I present the grading matrix used in assigning a qualitative grade for each final luminescence date.

I will begin with some descriptive metrics, starting with a comparison of the TL and OSL ages, across the entire dataset.

### *Descriptive Data Summary: TL Compared to OSL*

65% of the sample showed agreement between TL and OSL, with fading corrected TL data. Agreement between the OSL and TL ages is an indication of accurate data, where each technique is measuring the same phenomenon. Disagreement between

the TL and OSL ages, on the other hand, requires some discussion. Two scenarios are possible in the case of disagreement:  $TL < OSL$  and  $TL > OSL$ .

The first scenario, where  $TL < OSL$ , is likely a result of fading in the TL signal that was not completely corrected for. The opposite scenario, however, is less clear, and may be a result of poor firing during manufacture, i.e., incomplete bleaching, or of dominance by a slow bleaching component. This second scenario, where  $TL \text{ age} > OSL \text{ age}$ , is a mark of less reliable data and as such represents one of the ways that the quality of grade is downgraded.

Where the TL and OSL ages agreed within one-sigma error terms, a weighted average was taken as the best estimate. Agreement between these techniques are noted in the following set of tables that provide luminescence ages, under the column heading “Luminescence Method”, signifying the techniques used in final age determination.

#### *Luminescence Evaluation*

The analysis presented here includes, for the first time, an effort to make standard and explicit a system for “grading” the quality of each date. This represents a form of qualitative assessment along eight attributes of quantifiable data. Those attributes are listed and defined in Table 6.1.

**Table 6.1: Categories of Luminescence Data Evaluation**

<b>Attribute</b>	<b>Standard Required to Pass</b>
Associated Sediment	Taken from direct associated context
$\beta$ Dose Rate	Calculations from $\alpha$ -counting/flame photometry equivalent to calculations from $\beta$ -counting
OSL $D_E$ Error Term	<15%

Table 6.1 continued

<b>Attribute</b>	<b>Standard Required to Pass</b>
TL D <sub>E</sub> Error Term	<15%
TL Plateau	>70°C
b-values	IRSL>TL>OSL, or OSL b-value < 1
TL Fading	Absent or correctable
OSL Age = TL Age	Within error terms

The first two categories are a measure of the quality of the Dose Rate. Dose rate calculations in samples with an associated sediment sample taken directly from the context of the sherd's deposition is better than not. Likewise, dose rate calculations are more reliable when comparable values are generated from measurements from two different methods. The next five categories are a measure of the quality of the luminescence data. The 15% error term demarcation point is largely arbitrary, but clearly the greater the precision here, the more precise we can assume the date to be. The 70°C minimum plateau length, too, is slightly arbitrary, but the greater the length of signal stability, the more reliable the data. OSL b-values that are less than 1 mean that the OSL signal is less likely to have a problem with fading. No (or correctable) fading is the preferred outcome for any signal. Finally, the age is more reliable when the OSL and TL ages correspond within error terms.

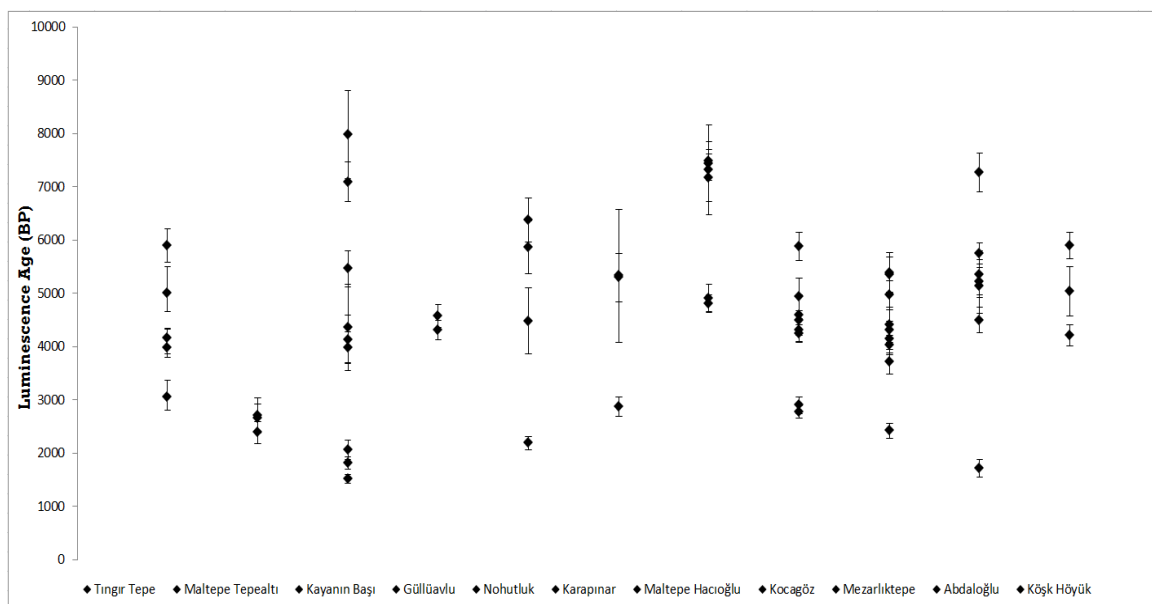
These eight categories are weighted in assigning a qualitative grade to each dated sample. The rubric is presented here in Table 6.2.

**Table 6.2: Luminescence Date Grading Rubric**

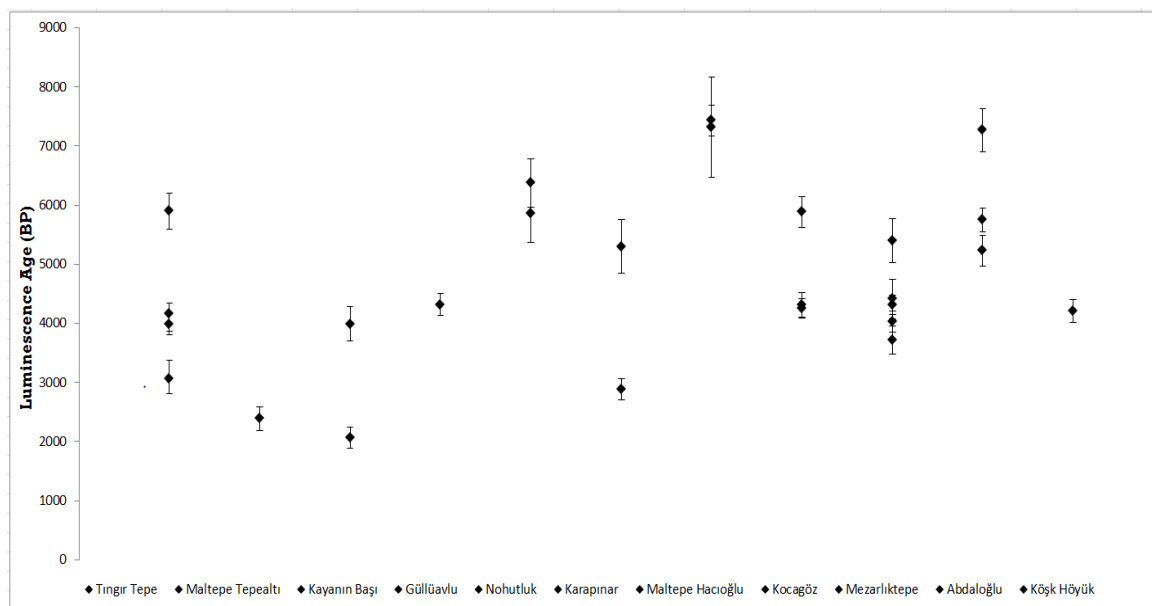
<b>Grade</b>	<b>Requirements</b>
A	OSL = TL, and TL does not fade or can be corrected, and passes all other standards
B	OSL = TL, and fails just one standard
C	OSL = TL, but fails two or more standards
D	OSL $\neq$ TL and fails more than two standards

This system of grade determination prioritizes the agreement of age calculations for OSL and TL, a requirement for a passing grade. To earn a B grade, only one standard can fall short. Grades of C and lower are seen as qualitatively worse. Data are presented here, first in table form, listing luminescence age, typological age, and luminescence method used in the calculation. Then, two sets of graphs are displayed for each locus, one with all dates (regardless of grade) for each locus, and one with only the “good grades” of A and B for each locus. In the SRAP sample, 44% (26/59) of dates graded to A or B. Tables list ages along the BCE/CE spectrum, whereas figures have been translated to BP ages (where BP means before 2010), to make typological/calendrical comparison more straightforward. The full matrix for each grade is presented in Appendix IV.

I will start by presenting all the loci, organized in rough geographic order, from highland to coast. Figure 6.1 includes all the dates. Figure 6.2 is only the “good grades”.



**Figure 6.1: All luminescence dates, from Highland to Coast, left to right**



**Figure 6.2: Luminescence dates, good grades only, from Highland to Coast, left to right**

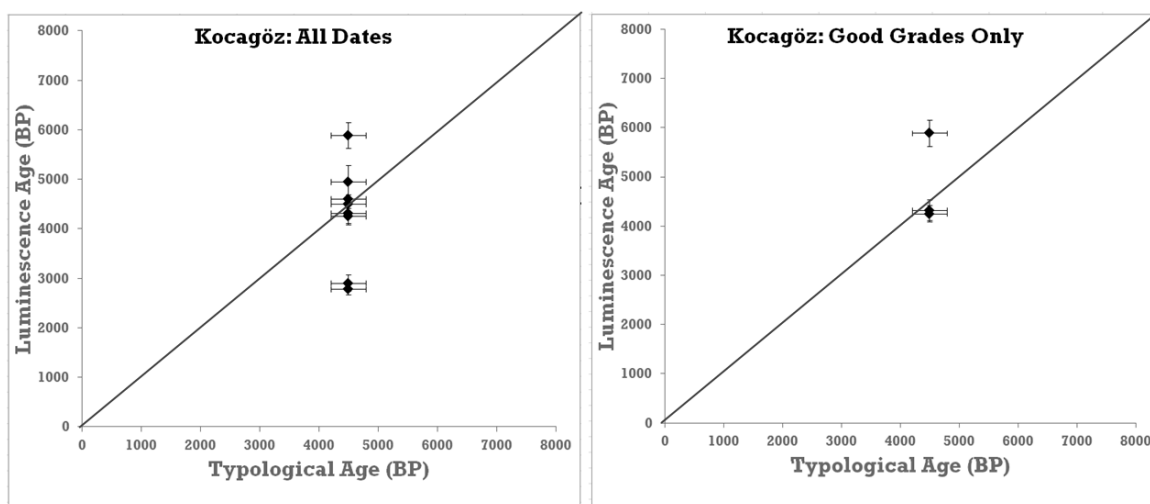
No readily apparent patterns emerge when exploring the data in this way. The highland loci of Tingir Tepe, Maltepe Tepealti, and Kayanın Başı, the valley sites of

Güllüavlu and Mezarlıktepe, and the coastal sites of Abdaloğlu and Köşk Höyük, all roughly span the period from about 3000 to 6000 years ago, roughly equivalent to the Bronze Age. The sites themselves do illustrate some basic chronological patterns: Hacıoğlu is Early Chalcolithic, perhaps even Late Neolithic and Kayanın Başı might have a similar early component. Mezarlıktepe, Tıngıroğlu, and Köşk Hüyük might extend into the MBA, while Güllüavlu might include LB material. There is, obviously, some variability in these distributions that I will explore on a site by site basis. The “good grades” do, however, suggest a slight trend toward older sites closer to the coast. The “good grades” also seem to reduce the scatter somewhat, which does indicate that the grading system is removing spurious outliers from the interpretation. This is, however, difficult to gauge, of course, because it is unclear if the scatter in age distribution is because of luminescence problems or real spread in ages, or sample size.

*Demirci Valley Loci: Kocagöz and Mezarlıktepe*

**Table 6.3: Kocagöz Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1128	L03.08.1	EBA 2800-2200 BCE	Agree	2939 ± 338 BCE	6.8	OSL	C
U1129	L03.08.2	EBA 2800-2200 BCE	Agree	2243 ± 165 BCE	3.9	TL, OSL, IRSL	A
U1483	L03.08.1	EBA 2800-2200 BCE	Agree	2309 ± 210 BCE	4.9	TL, OSL	B
U1484	L03.08.2	EBA 2800-2200 BCE	Agree	2589 ± 375 BCE	8.2	TL, OSL, IRSL	C
U1485	L03.08.3	EBA 2800-2200 BCE	Agree	2490 ± 185 BCE	4.1	OSL, IRSL	C
U1489	T03.07	EBA 2800-2200 BCE	Lum. Later	772 ± 112 BCE	4.0	TL, OSL	C
U1490	T03.14	EBA 2800-2200 BCE	Lum. Later	894 ± 163 BCE	5.6	TL, OSL	C
U1491	L03.08x	EBA 2800-2200 BCE	Lum. Earlier	3877 ± 266 BCE	4.5	TL, OSL, IRSL	A

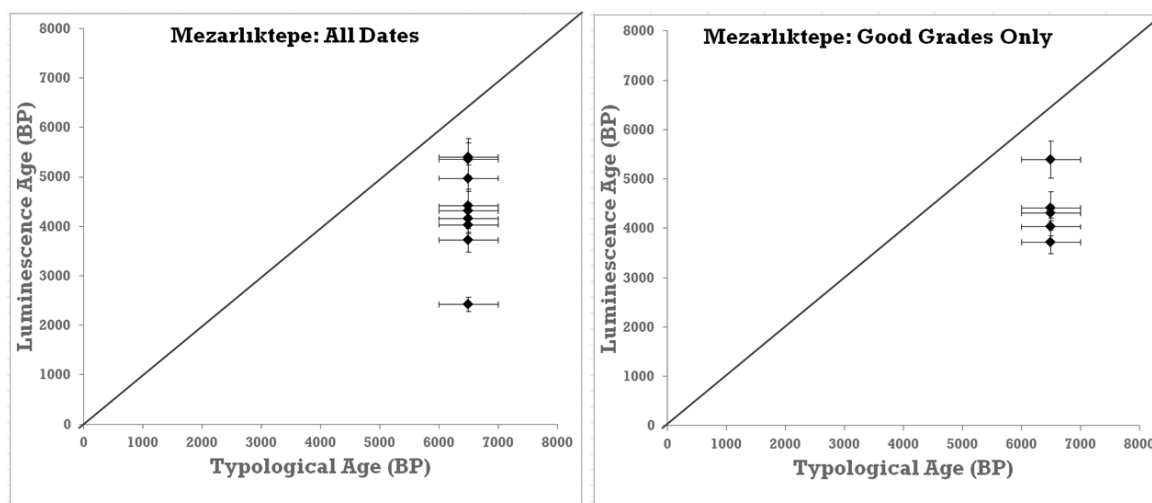


**Figure 6.3: Kocagöz luminescence vs. typological age (BP)**

The data for Kocagöz, though only 3 samples have high-quality good dates, is in general agreement with the expectations from typology of an Early Bronze Age settlement between 2800 and 2000 BCE. Two of the best dates, in fact, are in perfect agreement with this estimate. One date, among the good grades, is older than expected (Late Chalcolithic). It could be, based on Erzen's (1956) reporting of Akurgal's excavations, that the site had two distinct strata and that luminescence data are picking up these two events. This can be further confirmed with the addition of more samples for dating. Precision for each of these dates is quite good, all less than 10% error. The dates with high grades reflect this, as well, with all three "good grades" at less than 5% error. The average % error, for the entire sample at this locus, is 5.25%, a high degree of analytical precision.

**Table 6.4: Mezarlıktepe Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1542	Sin06-1-1	5 <sup>th</sup> Mill. BCE	Lum Later	3388 ± 371 BCE	6.9	TL, OSL	B
U1544	Sin06-3-1	5 <sup>th</sup> Mill. BCE	Lum Later	3342 ± 336 BCE	5.0	TL, OSL	C
U1545	Sin06-4-1	5 <sup>th</sup> Mill. BCE	Lum. Later	1712 ± 237 BCE	6.4	TL, OSL, IRSL	A
U1546	Sin06-5-1	5 <sup>th</sup> Mill. BCE	Lum. Later	2403 ± 336 BCE	7.6	TL, OSL	B
U1563	Sin06-2-3	5 <sup>th</sup> Mill. BCE	Lum. Later	2304 ± 159 BCE	3.7	TL, OSL, IRSL	A
U1564	Sin06-4-2	5 <sup>th</sup> Mill. BCE	Lum. Later	2143 ± 264 BCE	6.4	OSL, IRSL	D
U1566	Sin06-5-2	5 <sup>th</sup> Mill. BCE	Lum. Later	2023 ± 181 BCE	4.5	TL, OSL	B
U1567	Sin06-5-3	5 <sup>th</sup> Mill. BCE	Lum. Later	2962 ± 270 BCE	5.4	TL, OSL	C
U1590	Sin06-1-5	5 <sup>th</sup> Mill. BCE	Lum. Later	415 ± 145 BCE	6.0	OSL, IRSL	C

**Figure 6.4: Mezarlıktepe luminescence vs. typological age (BP)**

For Mezarlıktepe the dates of ceramic manufacture all point to a calendar age younger than expected by typological estimates. All the luminescence dates are younger than expected. Conversations with SRAP team members suggest that typological estimates may have been inaccurate, with a more likely typological estimate in the 4<sup>th</sup> millennium

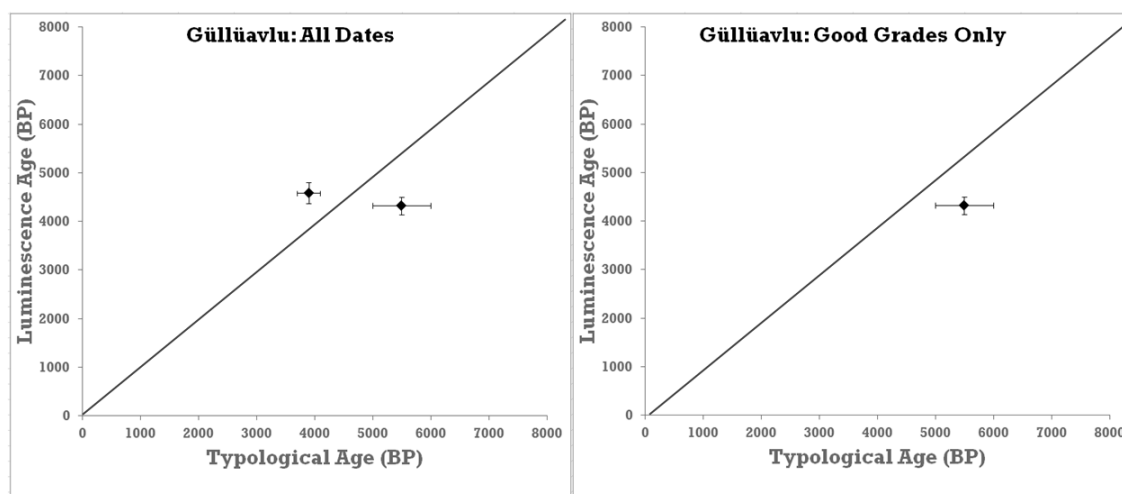
BCE, more in line with the luminescence dates. This pattern is true of the good dates, in isolation, as well, with a good cluster of ceramic manufacturing dates in the Early Bronze Age, during 3<sup>rd</sup> millennium BCE. Precision for each of these dates is quite good, all less than 10% error, and many of the “good grades” at less than 5%. Like Kocagöz, the average % error is quite low here, too, at 5.7%.; again this represents very high analytical precision.

In summary, 17 dated sherds from the Demirci Valley, covering two loci, produce dates most often from the EBA, with the dates from Kocagöz exhibiting a greater span in potential occupation, conceivably from the Neolithic to postcolonial periods.

*Karasu Valley Loci: Güllüavlu, Karapınar, Maltepe Hacıoğlu, and Nohutluk*

**Table 6.5: Güllüavlu Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1603	L98.25.82	Middle Bronze 2100-1700 BCE	Lum. Earlier	2568 ± 214 BCE	4.7	TL, OSL, IRSL	C
U1604	L98.25.86	4 <sup>th</sup> Mill. BCE	Lum. Later	2311 ± 181 BCE	4.2	TL, OSL, IRSL	B



**Figure 6.5: Güllüavlu luminescence vs. typological age (BP)**

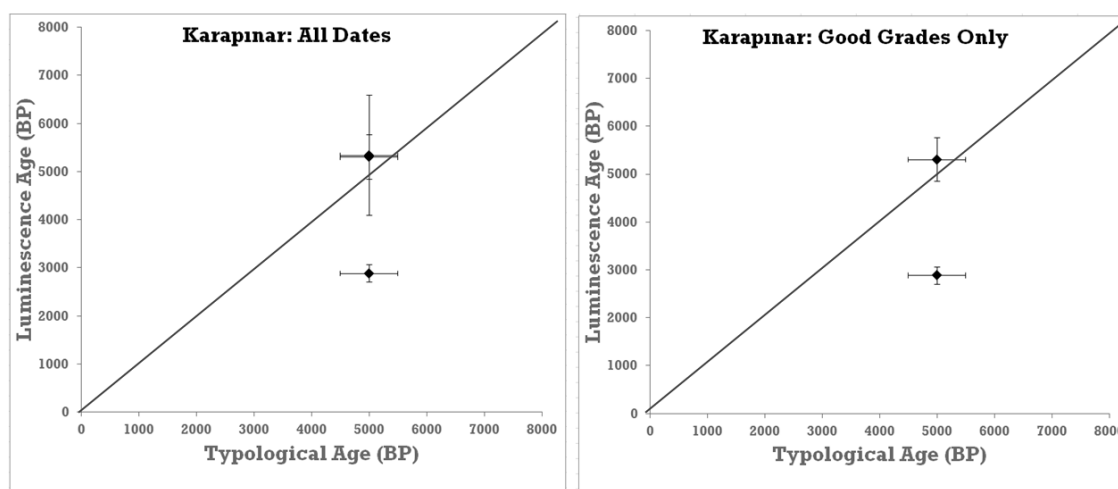
The two samples from Güllüavlu represent a very small sample size, yet neither of them agree (within error terms) with the expectations from typology, one older sample and one younger sample. The good date is younger than expected. It could be argued that the expected ages, between the Late Chalcolithic and the Middle Bronze Age, represent a wide spread in time, and as such, these dates are not wholly unexpected. Both samples give an Early Bronze Age date, within the 3<sup>rd</sup> millennium BCE. No strong conclusion can be offered from such a small dataset here, but these initial results indicate that additional dating of this locus could be beneficial to clarifying the relationship between expectations of site occupation and calendar dates from ceramic manufacture. Both dates have high precision.

**Table 6.6: Karapınar Luminescence Results**

UW#	SRAP #	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1130	L03.0 9.1	Late Chalcolithic/ EBA, 4000 - 2100 BCE	Agree	3294 ± 457 BCE	8.6	TL, OSL	B

Table 6.6 contined

UW#	SRA P#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U155 1	Sin0 6-1-1	Late Chalcolithic/ EBA 4000 - 2100 BCE	Lum. Later	871 ± 181 BCE	6.3	TL, OSL	A
U157 4	Sin0 6-1-4	Late Chalcolithic/E BA 4000 - 2100 BCE	Agree	3329 ± 1249 BCE	23.4	TL	C



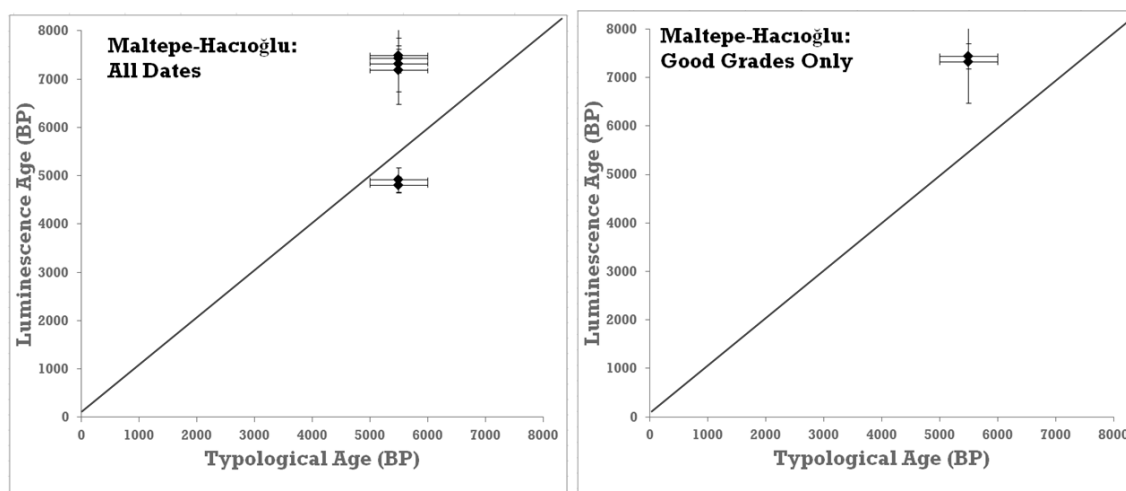
**Figure 6.6: Karapınar luminescence vs. typological age (BP)**

Two of three samples dated from Karapınar are in statistical agreement with typological estimates of age, and in such close agreement with each that they are difficult to resolve from each other on the left-hand graph. A third, with a high quality date and very good precision, is younger than expected. Again, sample size issues are at play here, but it is possible that this, too, could be a multicomponent site, with ceramic manufacture during the Late Chalcolithic/Early Bronze and then in the Iron Age. As discussed in Chapter Four, survey and previous work has indicated that this is a multi-

component site (with clear Iron Age material). Sherds dated here, thought in the field to be handmade EBA may simply have been mis-typed in the field, and were actually handmade Iron Age, supported by the luminescence dates. Two of the three samples have precision better than 10%, the third—and only C-level grade—suffers from very poor precision.

**Table 6.7: Maltepe Hacıoğlu Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1516	L98.29.13	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Earlier	5171 ± 445 BCE	6.2	TL, OSL, IRSL	C
U1547	Sin06-1-1	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Later	2903 ± 253 BCE	5.1	OSL, IRSL	D
U1568	Sin06-1-2	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Earlier	5476 ± 364 BCE	4.9	OSL, IRSL	C
U1569	Sin06-1-4	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Earlier	5428 ± 259 BCE	3.5	TL, OSL	B
U1570	Sin06-2-2	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Earlier	5311 ± 847 BCE	11.6	TL, IRSL	B
U1571	Sin06-2-3	Late Chalc, 4 <sup>th</sup> Mill. BCE	Lum. Later	2800 ± 171 BCE	3.6	TL,OSL,IRSL	C



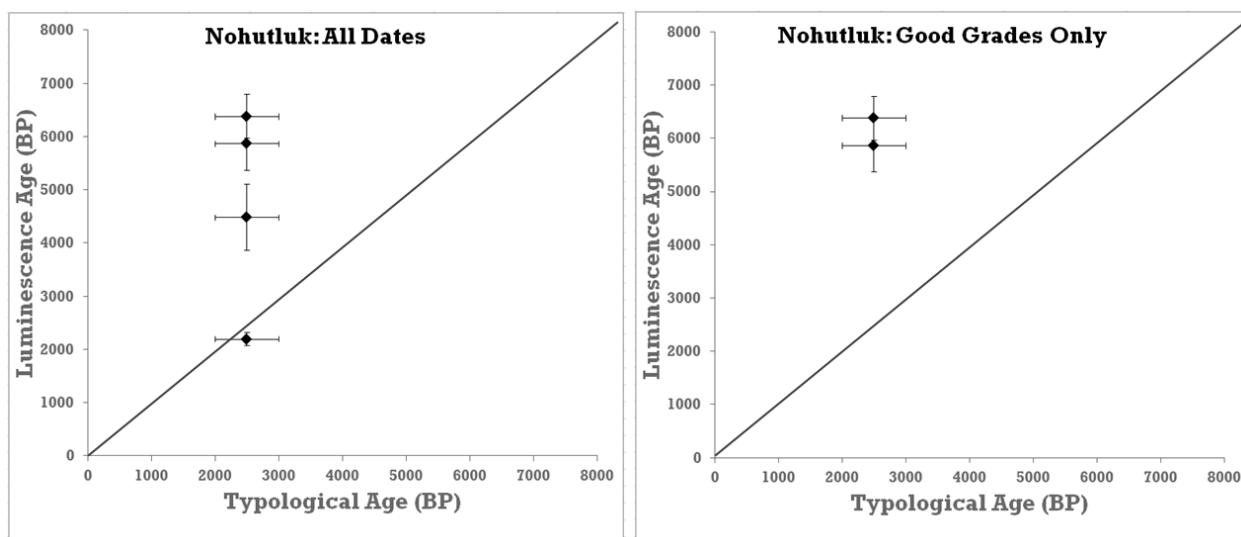
**Figure 6.7: Maltepe Hacıoğlu luminescence vs. typological age (BP)**

Dates for Maltepe Hacıoğlu cluster in two groups: one, about a millenium older than the expected ages from typology and a second, slightly younger than the expected age. The “good grade” dates, though, come exclusively from the older than expected dates, in the Neolithic. This done not mean, necessarily, that ceramic manufacture did not also occur at about 5000 years ago, in the Early Bronze Age. Again, greater sample sizes are required for greater clarity on that issue, but it is a clear possibility that Maltepe Hacıoğlu is a multi-component site, based on these results. Six of the seven dates have good precision, with error terms less than 10%. Four of those are very precise, at or below 5% error. The “good grades” are not consistently precise: one sample better than 5% error and one sample worse than 10% error. This runs counter to the expectation that good grades would generally have greater precision. The errors cited here are mainly (though not entirely) measurement, or random, error. Grading generally involves systematic error (excepting the criteria for size of the error). For example if one problem is dose rate issues, that probably will not affect precision. But high errors on equivalent dose will. It

is also possible that high-precision TL dates and high-precision OSL dates may be generated for a sample and that they do not agree.

**Table 6.8: Nohutluk Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1557	Sin06-1-1	Early 1 <sup>st</sup> Mill. BCE	Agree	186 ± 125 BCE	5.7	OSL, IRSL	C
U1559	Sin06-3-1	Early 1 <sup>st</sup> Mill. BCE	Lum. Earlier	4369 ± 411 BCE	6.5	TL, OSL	B
U1581	Sin06-2-2	Early 1 <sup>st</sup> Mill. BCE	Lum. Earlier	3856 ± 500 BCE	8.5	TL, OSL	A
U1584	Sin06-5-4	Early 1 <sup>st</sup> Mill. BCE	Lum. Earlier	2472 ± 620 BCE	13.8	OSL, IRSL	D



**Figure 6.8: Nohutluk luminescence vs. typological age (BP)**

The dates for Nohutluk span a significant range of time, from 2400 to 4400 BCE spanning the Early Bronze to Middle Chalcolithic, indicating another potentially multi-component site in the Karasu Valley. The dates with the highest grades are older than expected by several millenia, putting the typological estimates in question. The young, poorly graded, date, though is consistent with typological expectations. In terms of

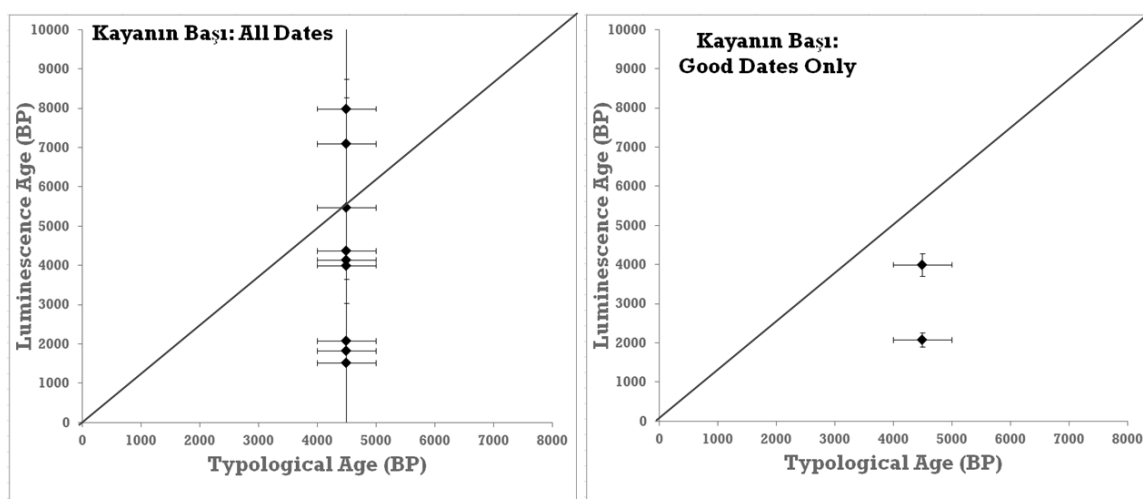
precision, the Nohutluk samples, with one notable exception, are adequately precise, with error terms at 8.5% or lower.

In summary, the Karasu Valley analysis covers a smaller sample of dated sherds, numbering 15 in total, covering 4 loci. As such, the temporal resolution is less clear than at loci in the Demirci Valley. Nonetheless, the distribution of ceramic manufacture dates suggests a series of multi-component occupations in the valley, from a potentially late Neolithic/early Chalcolithic occupation at Maltepe-Hacıoğlu, a Late Chalcolithic presence at Karapınar, an Early Bronze Age presence at Güllüavlu and Nohutluk and again at Maltepe-Hacıoğlu, with Late Bronze Age/Iron Age signatures at Karapınar and Nohutluk.

*Highland Loci: Kayanın Başı, Maltepe Tepealtı, and Tıngır Tepe (aka Tıngıroğlu)*

**Table 6.9: Kayanın Başı Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1120	T03.01.1	EBA, 3rd Mill. BCE	Lum. Later	61 ± 180 BCE	8.7	TL, OSL	B
U1121	T03.01.2	EBA, 3rd Mill. BCE	Agree	1984 ± 290 BCE	7.3	TL, OSL	B
U1122	T03.02.1	EBA, 3rd Mill. BCE	Lum. Earlier	5976 ± 825 BCE	10.3	OSL	C
U1123	T03.02.2	EBA, 3rd Mill. BCE	Lum. Earlier	3456 ± 339 BCE	6.2	OSL, IRSL	C
U1124	T03.02.3	EBA, 3rd Mill. BCE	Lum. Earlier	5086 ± 373 BCE	5.3	OSL, IRSL	C
U1125	T03.02.4	EBA, 3rd Mill. BCE	Agree	2128 ± 456 BCE	11.0	OSL	C
U1486	L03.04.1	EBA, 3rd Mill. BCE	Agree	2356 ± 818 BCE	18.8	OSL	D
U1487	L03.04.2	EBA, 3rd Mill. BCE	Lum. Later	492 ± 84 CE	5.6	OSL, IRSL	D
U1488	L03.04.3	EBA, 3rd Mill. BCE	Lum. Later	186 ± 116 CE	6.4	OSL, IRSL	C

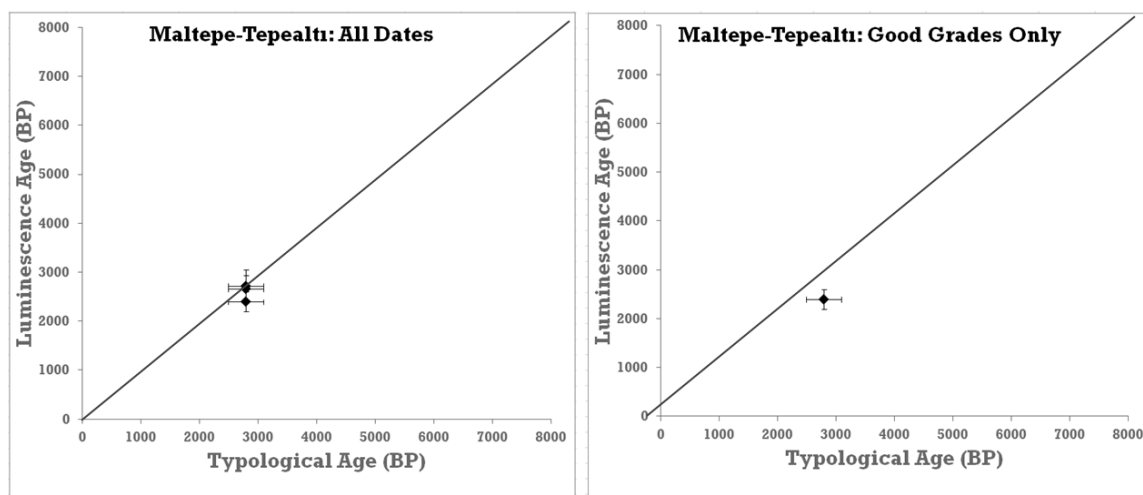


**Figure 6.9: Kayanın Başı luminescence vs. typological age (BP)**

Luminescence dates for Kayanın Başı strongly suggest a multi-component occupation, based on a wide temporal spread of luminescence dates for ceramic manufacture, including dates that are graded highly. Just one of the nine dates corresponds to the estimate of an Early Bronze Age date in the 3rd millennium BCE. Two of the samples are significantly younger than expected (one Hellenistic and one Middle Bronze Age) and two samples are significantly older than expected (Early Chalcolithic), all with high grades. Sample size makes it difficult to determine if this site was occupied consistently from 8000 to 2000 years ago or if it was periodically abandoned and re-colonized. If all of the dates are considered (including the lower grades), the site has two strong clusters of manufacture, both younger than expected: one, at about 4000 years ago and one at about 2000 years ago. Both of the “good grades” are younger than expected. Precision for the majority of these dates is quite good, all but two with less than 10% error (two are just above 10%, and the one with high error term [18%] received a failing grade).

**Table 6.10: Maltepe Tepealtı Luminescence Results**

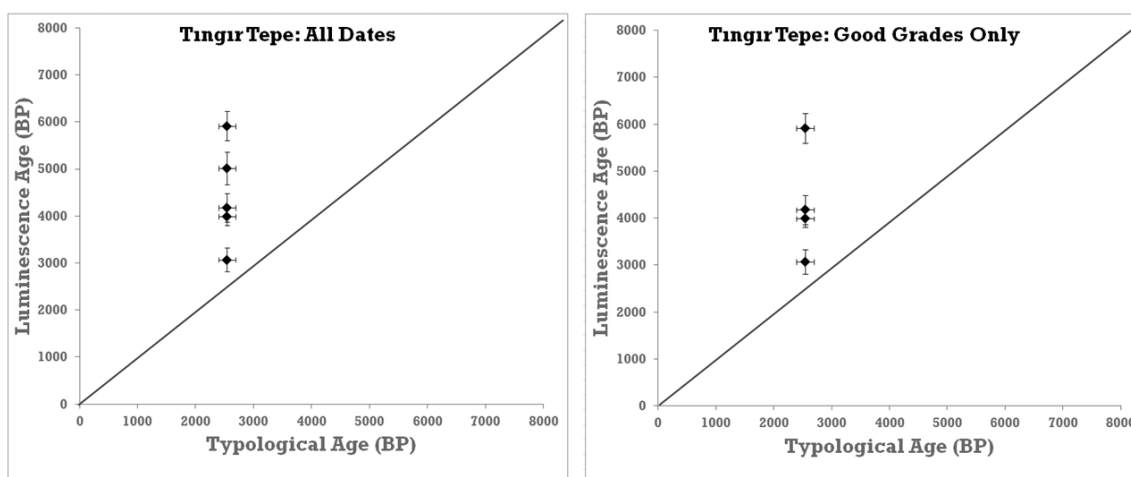
UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1552	Sin06 1-1	Early 1 <sup>st</sup> Mill. BCE	Agree	650 ± 271 BCE	10.2	TL, IRSL	C
U1575	Sin06-1-2	Early 1 <sup>st</sup> Mill. BCE	Agree	382 ± 204 BCE	8.5	TL, OSL	C
U1986	Sin06-1-3	Early 1 <sup>st</sup> Mill. BCE	Agree	701 ± 336 BCE	12.4	IRSL	D

**Figure 6.10: Maltepe Tepealtı luminescence vs. typological age (BP)**

The dates from Maltepe Tepealtı represent the best case scenario for agreement between typological estimates and luminescence dates. Despite this agreement, the data are not excellent, with low precision and generally poor grade values. In fact, the one “good grade” is the C from U1575, but as the OSL = TL, I have elected to highlight this value in the right graph. Nonetheless, the agreement between dating methods here is encouraging, in that the typological estimates are supported by luminescence with dates in the Iron Age.

**Table 6.11: Tıngır Tepe Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1555	Sin06-4-1	7 <sup>th</sup> -4 <sup>th</sup> cen. BCE	Lum. Earlier	3001 ± 343 BCE	6.9	OSL	C
U1576	Sin06-1-2	7 <sup>th</sup> -4 <sup>th</sup> cen. BCE	Lum. Earlier	1975 ± 182 BCE	4.6	TL, OSL	A
U1577	Sin06-1-3	7 <sup>th</sup> -4 <sup>th</sup> cen. BCE	Lum. Earlier	2161 ± 304 BCE	7.2	TL, OSL	A
U1578	Sin06-2-2	7 <sup>th</sup> -4 <sup>th</sup> cen. BCE	Lum. Earlier	3899 ± 313 BCE	5.3	TL, OSL	B
U1579	Sin06-2-3	7 <sup>th</sup> -4 <sup>th</sup> cen. BCE	Lum. Earlier	1055 ± 254 BCE	8.3	TL, OSL	B

**Figure 6.11: Tıngır Tepe luminescence vs. typological age (BP)**

Four of the five grades for Tıngır Tepe are “good grades” which span a period from 3000 to 6000 years ago, equivalent to the Middle Chalcolithic to the Iron Age. Of course, these dates for ceramic manufacture, at this sample size, cannot resolve whether the locus is a single component or multiple components. The entire range of dates is older than the expected typology of 7<sup>th</sup>-4<sup>th</sup> c. BCE. Each of the samples has good precision, with error terms all below 10%.

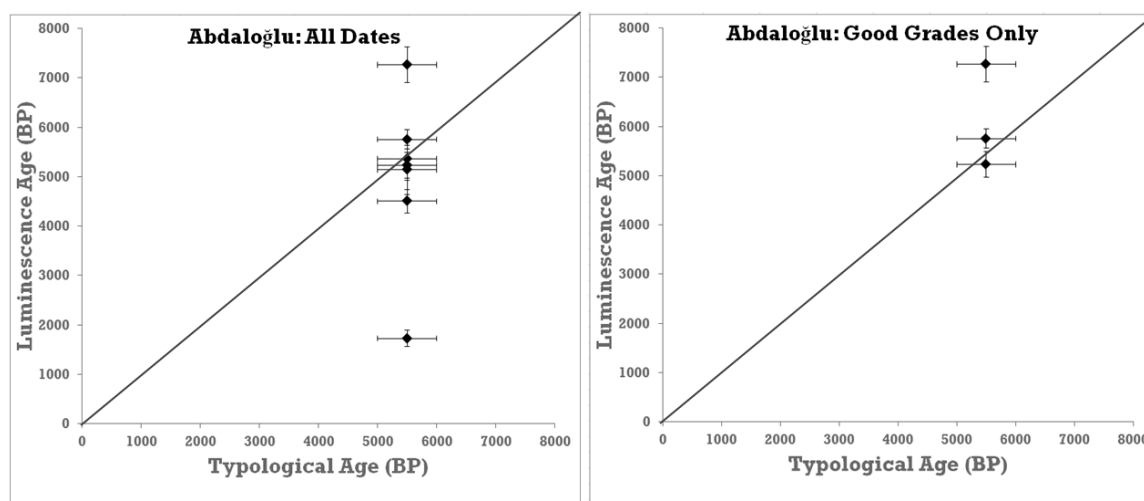
In summary, these three highland loci, from which 17 sherds were dated, reveal a

clear Iron Age component and then, at Tıngır Tepe, some evidence for much earlier occupations, perhaps as far back as the Middle Chalcolithic. The data from Kayanın Başı encompass greater temporal spans, ranging from postcolonial dates to a suggestion of manufacture as old as 8000 years ago (U1122 from Kayanın Başı, a date that does not grade well, as a “C”).

*Gerze Coast Loci: Abdaloğlu and Köşk Höyük*

**Table 6.12: Abdaloğlu Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1126	L03.07.1	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Agree	3223 ± 256 BCE	4.9	TL, OSL	B
U1127	L03.07.2	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Agree	3354 ± 433 BCE	8.1	OSL	C
U1549	Sin06-1-1	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Agree	2493 ± 242 BCE	5.4	TL, OSL	C
U1550	Sin06-2-1	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Lum. Earlier	3747 ± 199 BCE	3.5	TL, OSL	B
U1572	Sin06-2-3	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Agree	3128 ± 505 BCE	9.8	TL, OSL	C
U1573	Sin06-2-4	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Lum. Later	283 ± 166 CE	9.6	OSL, IRSL	C
U1988	Sin06-1-2	3 <sup>rd</sup> Mill. BCE or 4 <sup>th</sup> cen. BC	Lum. Earlier	5040 ± 366 BCE	7.3	OSL, TL	A

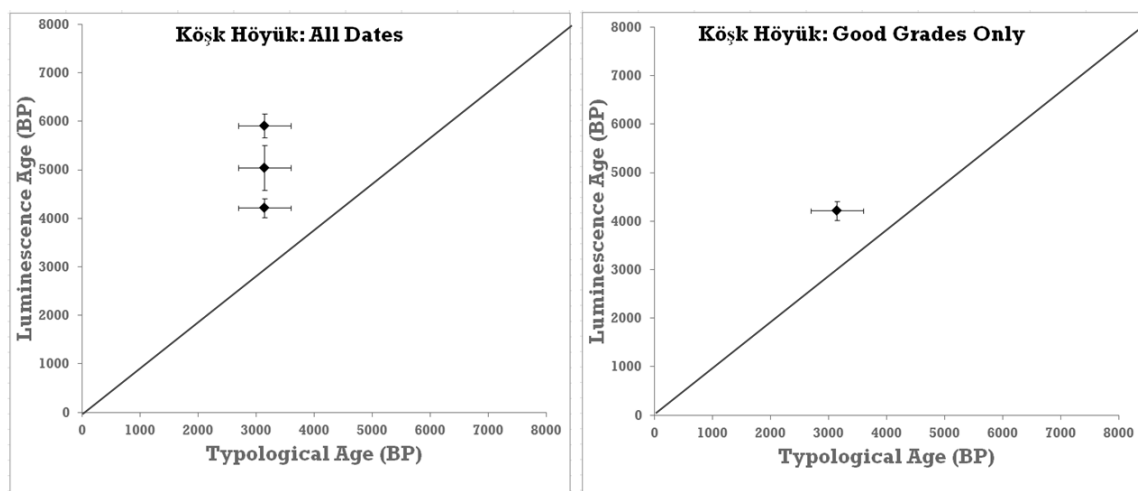


**Figure 6.12: Abdaloğlu luminescence vs. typological age (BP)**

Dates for Abdaloğlu are in general agreement with typological estimates, falling in the 3rd millennium BCE (Early Bronze Age to Late Chalcolithic), with three exceptions: one significantly older than expected age, one slightly younger and one significantly younger than expected age (Hellenistic). This younger than expected age may not actually be “unexpected”, as SRAP documented a Hellenistic component to the site at Abdaloğlu. When only the “passing grades” of A or B are considered, two dates fall within typological expectancy and one date is several thousand years too old, in the Early Chalcolithic. Interesting, this old outlier is has the highest grade of the Abdaloğlu samples. Precision for each of these dates is quite good, all less than 10% error. The dates with high grades reflect this, as well, with two of the three “good grades” with less than 5% error.

**Table 6.13: Köşk Höyük Luminescence Results**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1131	L03.11.1	LBA/Iron 1600-700 BC	Lum. Earlier	3033 ± 460 BCE	9.1	TL, OSL	C
U1132	L03.11.2	LBA/Iron 1600-700 BC	Lum. Earlier	2200 ± 198 BCE	4.7	TL, OSL	A
U1517	96.74.78	LBA/Iron 1600-700 BC	Lum. Earlier	3897 ± 249 BCE	4.2	TL, OSL	C



**Figure 6.13: Köşk Höyük luminescence vs. typological age (BP)**

Köşk Höyük, expected to be Iron Age by Doonan and Early to Middle Bronze Age by Bauer (see discussion in Chapter Two) yielded luminescence dates slightly older than expected, ranging from 2000 BCE (the sample with the best grade) to roughly 4000 BCE, spanning the Middle Bronze Age to the Late Chalcolithic. As above, small sample size warnings apply, but at the least, this locus likely has a longer occupation history than previously believed, based on ceramic manufacture. Dates are all precise to better than 10% error, with two of the three samples less than 5% error. The SRAP is planning a salvage excavation at the site as early as Summer 2014, as much of the site is eroding into the Black Sea.

These two sites on the Gerze coast, from which ten sherds were dated, cluster in age to the third and fourth millennia B.C.E. Greater samples and the addition of sites from which samples have been collected and dated will add to this picture.

*Summary*

59 sherds from 11 loci were dated via luminescence and compared to typological estimates of age. Examination of these results shows that typological estimates are very often significantly different from luminescence ages, and not in a systematic way. Three possibilities exist to explain these discrepancies: the luminescence results are inaccurate, the typology is inaccurate, or both methods are inaccurate. The fact that the samples with the high grades do not agree with the typology any better than all samples with good and bad grades, is a convincing argument that the problem is not with the luminescence dates. This indicates that an over-reliance on typological data is not only insufficient but leads to erroneous chronological interpretations which can be remedied by luminescence dating.

Though sample size issues remain for many of the loci described above, the results from this chapter will be used to discuss the contributions of the study to regional culture-history, to questions of connectedness and isolation on the Sinop promontory, and to the use of luminescence dating to regional level chronological development. This is the topic of the final chapter.

## Chapter Seven: Implications, Significance, and Future Research

“I never felt interpretation was my job.”—Mary Leakey (1913-1996)

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This project owes its inception to the insight of Owen Doonan (2004a: 54), who noted that:

The dating of prehistoric ceramics in Sinop is problematic because of the lack of stratified settlements to date. There is a tradition of assigning dates to the handmade ceramics from the area but these typologies are not grounded by any chronometric or even relative stratified sequences.

The research and data presented here is the first effort to remedy that situation, applying the strengths of luminescence dating to the particular situation in Sinop, while also simultaneously advancing aspects of the luminescence dating method. The implications of the results presented in Chapter Six are discussed here in three main sections, followed by a discussion of future research.

### *Implications—Part I: Local Culture/History*

SRAP survey has sought to address a general research problem aimed at clarifying occupational patterns within the promontory, seeking to identify connections within and between regions from the coasts to the highlands. A significant part of this research has been the clarification of the region’s ceramic chronology, a problem due to the stylistically conservative nature of the pottery which lacks *comparanda* with stratified dated sites in the area. Ceramic assemblages were recovered during the course of surface survey, across a fragmented landscape, likely consisting of single and multi-period sites, including perhaps sites that were abandoned and then resettled. Without chronological resolution, the SRAP team was limited in its ability to interpret the use of the landscape

from an examination of the pottery alone. The addition of an absolute chronology produced by luminescence, of individual dates of ceramic manufacture, represents a first step toward providing the requisite chronological resolution.

Prior to the work of SRAP the conventional Sinop chronology identified nearly all handmade ceramics as Early Bronze Age, or in some cases Late Chalcolithic, restricting the chronology to the 4<sup>th</sup> to 3<sup>rd</sup> millennium BCE (Burney, 1956; Işın, 1998; Yakar, 1975, 1985). This led to the questionable result that there were no sites along the entire Black Sea coast of Turkey dated to the second millennium, a problem some have attributed to changing sea levels (Ozdogan 2003). Such a situation makes little sense as the region is both rich in natural resources and well-positioned geographically, characteristics not lost on the Greek colonists of the 7<sup>th</sup> and 6<sup>th</sup> centuries BC. At the time, few sites had been assigned dates earlier than the Late Chalcolithic, thus restricting the prehistoric sequence to the 4<sup>th</sup> and 3<sup>rd</sup> millennia. SRAP proposed to expand this chronology through a more rigorous ware-based typology (e.g., Bauer, 2006a), but it remained untested and based on typological similarities with other sequences. The results presented here test the SRAP typology and dramatically enhance the clarity of the conventional chronology, adding significant depth and clarity to the story of Sinop's prehistoric occupation.

The samples dated in this study reveal a period of occupation in Sinop beginning as early as 9000 years ago in Kayanın Başı (from dates with relatively poor grades) and from nearly 8000 years ago at Maltepe Hacıoğlu (from good grades) and spanning the prehistoric and postcolonial periods in each of the regions sampled by the SRAP. The

dating program severely strains the conclusion that hand-made pottery falls only within the 4<sup>th</sup> to 3<sup>rd</sup> millennium BCE.

Ceramic manufacture in the Demirci Valley of handmade wares was not limited to the EBA, as high-quality luminescence dates were derived that are younger and older than this general expectation. At Kayanın Başı, a locus with typological expectations limited to the EBA, dates suggest a range of manufacture from the Iron Age to the Middle/Late Bronze (and into the Neolithic if lower graded dates are included in the interpretation). Dates from Kocagöz, while in general agreement with the expectation of EBA occupation, extend that period of expected occupation back into the Neolithic (based on a date with a good grade) and later into the Middle to Late Bronze Age, though that interpretation is based on dates with lower grades. The expanded range of dates suggests a multi-component or long duration period of occupation at Kocagöz.

The dates for Abdaloğlu, like Kocagöz, are generally in agreement with typological expectations of an EBA date, but here, too, the period of ceramic manufacture extends beyond this single period. One high quality date was derived with a Neolithic age and another date, with a lower grade, falls within the Classical/Archaic age range. The interpretation here, too, is that Abdaloğlu was a multi-component site, consistent with survey data, wherein the Early Bronze Age site Abdaloğlu includes a Hellenistic component referenced as Göl Dağ. Mezarlıktepe tells a slightly different and perhaps more straightforward story: all the dates are younger than expectations from typological dating. Contra the conventional typology, SRAP's hypothesis for Mezarlıktepe is that it contained a Neolithic-aged presence, but ceramic manufacture dates here are consistently

younger. Good dates place Mezarlıktepe at Middle Bronze to Late Chalcolithic. This range expands to the Hellenistic if poorer grades are included in the analysis.

In sum, the Demirci Valley luminescence chronology expands notions of prehistoric presence beyond an EBA world, to include a significant signature before and after this now clearly questionable estimation. Each of the loci from which sherds were analyzed from the Demirci Valley consist of a robust sample. While dates from additional sherds may help to add some degree of clarity to these interpretations, they are unlikely to fundamentally alter the general trends discussed here. This is less true of the Karasu Valley, the Highlands, and the Gerze Coast, from which the sample sizes at many of loci are relatively small.

The Karasu Valley luminescence dates, like those of the Demirci Valley, deviate significantly from typological expectations. Typological estimates here were more diverse, with loci ranging in expected age from the early 1st millennium BCE at Nohutluk to the Late Chalcolithic at Maltepe Hacıoğlu and Karapınar. Dates for Nohutluk were generally older than expected, ranging from the Chalcolithic (or Middle Bronze, if dates with poor grades are included) to the Neolithic. One date did agree with the typological estimate of the early 1<sup>st</sup> millennium, though the date did not earn a good grade. As a result, if only the good grades are considered, Nohutluk presents as a single-component locus. Here, as with most of the analysis from the Karasu Valley, the quality of interpretation will increase with additional samples. Analysis of Karapınar also suffers from small sample size, though here the luminescence dates agree somewhat with typological estimates of period. Of the three dated samples from Karapınar, two agree

(one of them a highly graded date) with typological estimates of a Late Chalcolithic/EBA age, though the third sample (with a good grade) is significantly younger than expected, falling in the Late Bronze Age, indicating the possibility of longer site duration.

The two samples dated from Güllüavlu were thought to represent two different periods of occupation—the Middle Bronze and Chalcolithic—based on typology, but luminescence dates suggest a single period of ceramic manufacture, during the Chalcolithic only. Clearly, sample size issues exist here, despite the fact that both dates are highly precise and one has a good grade. The fourth Karasu Valley locus, Maltepe Hacıoğlu, does not suffer the same problems with sample size, though the luminescence dates still diverge from typological expectations. Typological estimates from this locus were from the 4th millennium BCE, during the Late Chalcolithic, but luminescence dates with good grades clustered consistently around 7000 years ago, during the Neolithic. A second period of manufacture at Maltepe Hacıoğlu is suggested by a cluster of two dates that do agree with the typological expectation but lack good grades.

The Karasu Valley sample, though quantifiably smaller than that from the Demirci Valley, reveals a pattern of site use (as seen through ceramic manufacture) more complex than expected from typological estimates. Typological estimates simply do not identify the range or variability in possible age that direct dating of the ceramics with luminescence is able to do. At each of the four loci described from Karasu Valley, the luminescence dates highlight the complexity of the temporal dimension of landscape use. In some cases, small sample size prevents clear interpretation, but in all cases, the dates

serve to raise questions for additional testing and illustrate the typological estimates are insufficient, if not inaccurate.

The highlands loci, Maltepe Tepealtı and Tıngır Tepe (aka Tıngıroğlu), continue the trend of clarifying and redrawing chronological lines with the addition of luminescence dates, though small sample sizes are at issue here. The case of Maltepe Tepealtı is a rarity in this analysis, as the typology and luminescence methods for dating are in strong agreement. All the luminescence dates match the typological expectation of the early 1st millennium BCE. Dating of sherds from Tıngır Tepe, expected to date to the 7th-4th c. BCE from typological identification, suggested an earlier presence at the locus based on ceramic manufacture. All of the luminescence dates were older than expected, ranging from the Late Iron Age (8th c. BCE) to the Chalcolithic. The range is unchanged if analysis focuses on the entire sample or just the dates with good grades, though there is a cluster of dates with good grades during the Early/Middle Bronze Age. Sample size for Tıngır Tepe is fair, though additional samples may resolve the nature of duration at this potentially multi-component locus.

Finally, the solitary coastal site from Gerze, Köşk Höyük, with a typological age estimate of the Late Bronze to Iron Age, dated consistently older than expected with luminescence. All luminescence dates were earlier than expected, ranging from the Early/Middle Bronze to the Early Chalcolithic. The best date from Köşk Höyük is roughly 4000 years old, dating to the Early/Middle Bronze Age. Additional dated samples are needed from this site to confirm this result.

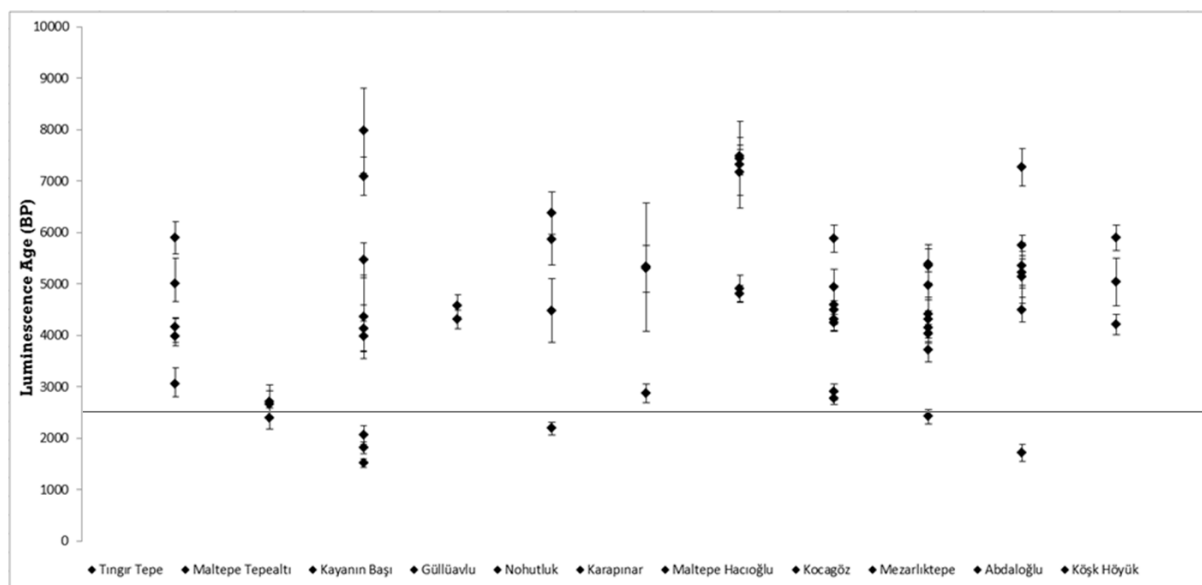
By luminescence dating 59 ceramic sherds, the research described in this project has refined and, in some cases, established the chronology of specific sites and loci of the Sinop promontory. The dates also serve a heuristic purpose, identifying additional research questions to explore and highlighting the ways that methodology of this sort can be used to construct regional-level chronologies. The implications are significant: not only will archaeologists be able to compare, on an absolute scale, dates from Sinop to dates from other sites along the Black Sea coast and to other regions in the Near East, but these dates serve as the basis for exploring questions of connectedness within the promontory, the topic of the part two.

*Implications—Part II: Regional Hypotheses*

In Chapter Four, four sets of regional level hypotheses (derived from Doonan, 2004a) were posed for consideration based on the luminescence results. The discussion will return to these questions here.

The first set of research questions focused on clarifying the prehistoric occupation of Sinop. Specifically, research and analysis sought to identify the temporal pattern of prehistoric occupation throughout these different regions of the Sinop promontory and to determine whether or not prehistorically occupied loci continued to be occupied in postcolonial times. Defining the prehistoric occupation of Sinop as spanning the Neolithic to the Iron Age places our date for the transition from prehistoric to postcolonial at roughly the 7<sup>th</sup> c. BCE, with the founding of Sinope by Miletus and the spread of Sinopean colonies in the eastern Black Sea, marking the commencement of the

Archaic Period (Doonan, 2004a: xix). This transition is marked by the horizontal line in Figure 7.1.



**Figure 7.1: All ceramic luminescence dates, prehistoric to postcolonial transition at 7<sup>th</sup> c. BCE highlighted**

Ten of the eleven loci have ceramics manufactured in prehistoric periods, with only Maltepe Tepealtı as a postcolonial aged locus (though, to be fair, the dates from this locus straddle the transition from the Late Iron Age to the Archaic Period). This strongly supports the hypothesis that prehistoric occupation was a significant part of Sinop's past, in each of the valleys and from the coast to the highlands. It is worth reiterating here, though, that sample selection (described in Chapter Four) included a preference for loci and sherds thought to be prehistoric, so these results may simply be confirming that bias. Though, as illustrated in Chapter Six, agreement between expected age from typology and luminescence age could not be assumed.

Of the remaining ten loci, four more have a postcolonial aged ceramic date: Abdaloğlu, Kayanın Başı, Mezarlıktepe, and Nohutluk, both Karapınar and Kocagöz approach the postcolonial, with dates in the Late Iron Age. In total, five of the eleven loci include a postcolonial aged date, including Maltepe Tepealtı, though only the four with clear prehistoric period occupation are relevant to this research question.

Abdaloğlu appears to be a multi-component site, as described above in Part I, with a bias toward the Early Bronze Age. One date (U1573) from Abdaloğlu, lacking a good grade, does date to the postcolonial (Late Roman,  $283 \pm 166$  CE) which leaves open the possibility that the site was occupied into the postcolonial periods. Kayanın Başı, like Abdaloğlu, appears to be a multi-component site, though in this case one of the two samples with a good grade has a date within the postcolonial, dating to the Hellenistic or Roman period (U1120,  $61 \pm 180$  BCE). The third of the Demirci Valley samples to have a prehistoric and postcolonial aged ceramic is Mezarlıktepe. The fact that Mezarlıktepe had a postcolonial aged sherd was quite a surprise, as typological expectations were that the site was Neolithic. The sherd (U1590) does not have a good grade, but dates to  $415 \pm 145$  BCE, within the Classical or Hellenistic period. The fourth and final site with both prehistoric and postcolonial aged ceramics is Nohutluk, from the Karasu Valley. The postcolonial aged sherd (U1557), though not a good grade, was the only date to confirm the typological estimate and falls within the Hellenistic period.

In sum, to answer the first research question, yes, Sinop has a clear prehistoric period of occupation, throughout each region of analysis, and at four of the ten prehistoric loci occupation extends into the postcolonial period, from sites within the valley from

varying distance to the coast. The extent to which those four loci represent continuity of occupation across time periods is unclear for two primary reasons: sample size precludes that degree of resolution, and, two, luminescence dates provide ceramic manufacture dates, not occupation dates, so arguments of occupation require additional information or bridging arguments. It could be, for example, that a locus is multi-occupational. Alternatively, it could be that some of the ceramics were not deposited where they were manufactured; i.e., “old” ceramics do not necessarily mean that the site was occupied during that earlier period. This second explanation is likely less plausible, but due to the non-equivalency of manufacture and occupation, it cannot be ruled out.

The second set of research questions posed in Chapter Four referenced the extent to which postcolonial sites from the inland valleys operated in isolation from the coast. The relationship between the coast and the inland valleys is best understood as a product of the degree to which inland sites possess ceramics with postcolonial ages.

Three specific questions were offered:

- Were sites in the Karasu valley short-term (temporary) or long-term occupations?
- Were there times during which the Karasu valley locus at Karapınar existed independently, without coastal connections?
- Do dates from fine-wares and handmade pottery support the hypothesis that Demirci valley was an interface between the coasts and hinterland during the Roman period?

The first of these questions can be answered straightforwardly. The Karasu Valley loci are relatively short-term occupations, in comparison to the dates from the Demirci

Valley. Table 7.1 provides the range of ceramic manufacturing dates at each locus, sorted by grade quality of the dates.

**Table 7.1: Age Range for Valley Loci**

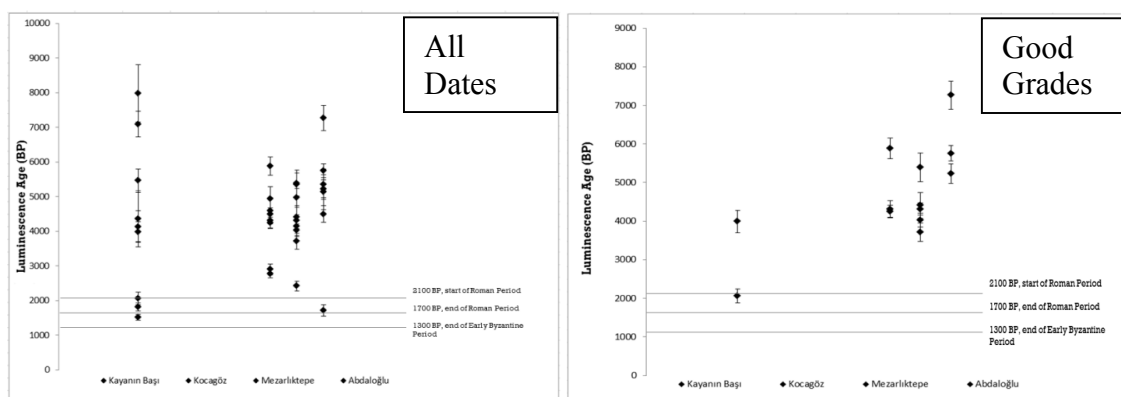
Region	Site	Age Range (All Dates)	Age Range (Good Grades)	Region	Site	Age Range (All Dates)	Age Range (Good Grades)
<b>Karasu Valley</b>	Güllüavlu	2782-2130 BCE	2492-2130 BCE	<b>Karasu Valley</b>	Nohutluk	4780-61 BCE	4780-3356 BCE
<b>Karasu Valley</b>	Karapınar	4578-690 BCE	3751-690 BCE	<b>Demirci Valley</b>	Kocagöz	4143-660 BCE	4143-2099 BCE
<b>Karasu Valley</b>	Maltepe Hacıoğlu	6158-2650 BCE	6158-4464 BCE	<b>Demirci Valley</b>	Mezarlik-tepe	3759-270 BCE	3759-1475 BCE

Güllüavlu is the shortest term occupation, at over 350 years using the good dates only. By any measure, each of the sites dated from these two valleys qualifies as long-term occupation, with all other loci spanning a minimum of over 1,000 years. As noted above, the extent to which those loci represent continuity of occupation across time periods is unclear. It is also possible that there could be a number of short-term occupations that together look like a long-term occupation. Short of being able to distinguish between many short-term and one long-term occupation, all that can be said is that the sites in the Karasu Valley have a shorter range of occupation than those in Demirci Valley.

The second question references the locus of Karapınar specifically. If we assume that a pre-colonial range of dates implies that the locus existed independently of the coast, then the answer to that question is yes. But the assumption that pre-colonial dates imply independence is difficult to prove empirically and requires information beyond an absolute chronology. In this case, the resolution of analysis needs to extend beyond simply treating all dated ceramics as equal units. By adding to our analysis the additional category of ware types, one could potentially determine connections to other regions in

the promontory. Unfortunately, in the case of Karapınar, each of the three ceramics was classified as Ware Type I: Sandy Ware, the most common ware on the promontory. Here again the implications are based on a sample size of just three ceramics. The data do permit an answer to the question of whether or not Karapınar was occupied at times when the coast was not. Two of the three Karapınar dates are firmly within the expected age range, falling within the 3rd millennium BCE (Early Bronze Age to Late Chalcolithic). These dates are consistent with occupations at both coastal sites (Abdaloğlu and Köşk Höyük). The third date, however, at  $871 \pm 181$  BCE does not have an equivalent from the coastal sites. Again, keeping sample size issues in mind, this does suggest an occupation at Karapınar when the coast was not occupied.

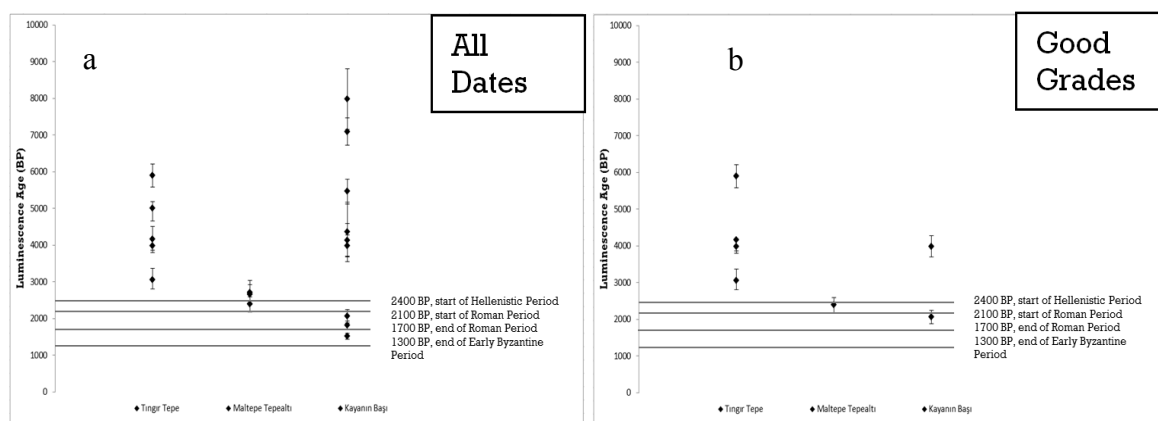
The final postcolonial research question focuses on Demirci Valley. Is there evidence of Roman influence on the inland valley sites? To answer this question, we simply look for Roman period dates within the inland sites of Kocagöz and Mezarlıktepe. Here I've included data from the nearest coastal site (Abdaloğlu) and highlands site (Kayanın Başı) to add some clarity. Figure 7.2 charts these four loci, ordered and spaced to indicate distance to the coast (closer to the coast on the right of the chart), with Roman and Late Roman/Early Byzantine dates marked.



**Figure 7.2: Demirci Valley and nearby sites, Roman period dates**

Neither of the Demirci Valley sites (of Kocagöz and Mezarlıktepe) have a Roman or Late Roman/Early Byzantine ceramic date. Yet, when we include nearby sites from outside of the valley, we see a relationship to the coast: at Abdaloğlu (but not when only the good grades are considered) and Kayanın Başı. This suggests some degree of isolation in the Demirci Valley at this time period. As noted numerous times already, though, sample size issues may explain the gap between the late prehistoric dates and the postcolonial dates. Sample size may also explain the lack of Roman dates from Kocagöz and Mezarlıktepe.

The third set of research questions posed in Chapter Four relate to highland postcolonial sites. Were they, as hypothesized in Chapter Four (based on Doonan, 2004a), only occupied during the Hellenistic, Roman, and Early Byzantine periods? As with the previous question, the analysis requires a graphical examination of the dates from the three highland loci: Kayanın Başı, Maltepe Tepealtı, and Tıngır Tepe (aka Tıngıroğlu). Those dates are presented in Figure 7.3a-b.



**Figure 7.3a-b: Highland loci: Hellenistic, Roman, and Early Byzantine dates**

Both Maltepe Tepealtı and Kayanın Başı have a postcolonial signature in the highlands, based on the sample dated here, with dates in the Hellenistic and Roman Periods, with one date with a good grade from each of those two sites. The data here do not allow for further analysis at a higher degree of resolution, as proposed in Chapter Four. Doonan (2004a) hypothesized that the Roman road, perhaps in use during the middle of this temporal range (from the later Hellenistic to the Roman periods) may have linked the highlands to the coast, with greater isolation characteristic in the pre-Hellenistic and post-Roman periods. There is strong indication, at both Tıngır Tepe and Kayanın Başı of a pre-Hellenistic presence, but beyond that it is difficult to extrapolate any further.

A fourth question, this one also specific in nature, can be addressed here briefly.

Is the coastal site of Köşk Höyük an Iron Age (1000-600 BCE) locus, as Doonan believes, or is it Early/Middle Bronze Age (3000-2000 BCE), as Bauer has hypothesized? The data are clear on this point: Köşk Höyük is an Early/Middle Bronze Age site, as shown in Table 7.2.

**Table 7.2: Köşk Höyük Luminescence Dates**

UW#	SRAP#	Typological Age Estimate	Agreement	Luminescence Age	% Error	Luminescence Method	Grade
U1131	L03.11.1	LBA/Iron 1600-700 BC	Lum. Earlier	3033 ± 460 BCE	9.1	TL, OSL	C
U1132	L03.11.2	LBA/Iron 1600-700 BC	Lum. Earlier	2200 ± 198 BCE	4.7	TL, OSL	A
U1517	96.74.78	LBA/Iron 1600-700 BC	Lum. Earlier	3897 ± 249 BCE	4.2	TL, OSL	C

Here, the round goes to Bauer, who saw aspects of the Middle Bronze Age in the ceramic collection, based on the presence of red burnished teapot spout, or to the Early Bronze Age, based on similarities to Kocagöz (Bauer, 2006a). Here, the luminescence data resolve the ambiguity present in a purely stylistic-based estimate of age.

*Implications—Part III: Luminescence Methodology*

In their discussion of chronometers, Lyman and O'Brien (2006: 288) suggest that better alignment of the resolution of chronometers with their application may eventually lead to “innovative improvements” to one or more chronometers. Among these improvements, they include the principle of overlapping (Lyman and O'Brien, 2006: 104, 288), a form of linkage between archaeological phenomenon. Though Lyman and O'Brien are using this term in their discussion of archaeological seriation of assemblages, the work here extends the concept of linkage and the principle of overlapping to include age determination by luminescence from multiple luminescence signals, from the same sample.

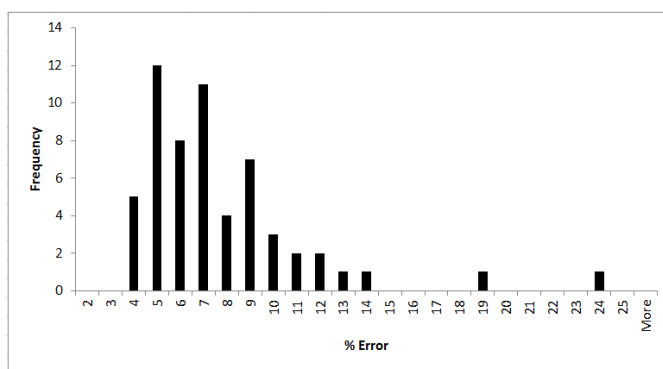
By measuring as many as three aspects of the luminescence signal (TL, OSL, IRSL) and calculating independent equivalent dose data from each of these forms of measurement, it is possible to produce three different ages for each ceramic. If the equivalent dose data (and b-values) derived from the various methods produce statistically equivalent ages—i.e., if they overlap—then a weighted average of overlapping ages can be calculated. Weighted averages increase statistical precision. In addition to this, when multiple techniques provide the same age, then confidence in the accuracy of the age is bolstered. Figure 7.4 illustrates the benefits of this method, as applied to U1491, from Kocagöz.

<b>Sample</b>	uw1491 Kocagoz L03.08 #4		Gy	error	b-value	error
<b>type</b>	fine tempered pottery		OSL	13.288	0.383	0.67
<b>context</b>	site		IRSL	13.409	0.897	0.979
<b>burial dep</b>	0		TL	17.7	1.12	1.185
<b>grain size</b>	1-8µm		TL does not fade			
<b>method</b>						
	<b>TL</b>		<b>OSL</b>			
	technique slide		SAR			
	plateau °C 250-390		1 sec			
			<b>dose rates (Gy/ka)</b>			
	value	error	fit	value	error	
<b>De (Gy)</b>	17.7	1.12	quadratic	<b>alpha</b>	0.979088	0.079789
<b>scale</b>	1			<b>beta</b>	1.148608	0.068573
<b>b-value (Gy µm<sup>2</sup>)</b>	1.185	0.053		<b>gamma</b>	0.350816	0.024824
				<b>cosmic</b>	0.278026	0.056355
				<b>total</b>	2.756538	0.121904
<b>moisture</b>						
<b>pottery</b>	0.1001	0.042923				
<b>sediment</b>	0.06	0.03				
	<b>TL</b>		<b>OSL</b>			
<b>Age (ka)</b>	6.421098	0.509265	5.700491 0.318275			
<b>calendar</b>	4415.098	509.2655 BC	3694.491 318.2746 BC			
<b>% error</b>	<b>7.931127</b>		5.583284			
<b>Weighted Average TL/OSL/IRSL</b>			<b>IRSL</b>			
	5.883803	0.26629	5.18456 1.633432			
	3877	266 BC	3178.56 1633.432 BC			
	4.525806		31.5057			

**Figure 7.4: Age calculation for U1491**

Equivalent dose data is in the upper right of the figure, listed by Greys (Gy). The strongest data (lowest error) is the OSL and IRSL data the least strong, given the high error term. But the TL age does overlap, largely due to the relatively large error term for the equivalent dose and the high b-value. It is also worth noting that, although no fading

test was done on the TL, the agreement of the IRSL with the TL and OSL suggests there is no fading. Because each calculated age (bottom of the figure) thus overlaps, a weighted average was used. Error terms decrease from their individual values—5.5 % (OSL), 31.5% (IRSL), and 7.9% (TL)—to a weighted average of 4.5%, resulting in much better precision. For the entire data set, the mean % error is 7.24 %; the median is 6.30 %; and a primary mode at about 5%. These data are presented in Figure 7.5.



**Figure 7.5: Distribution of error terms, entire dataset**

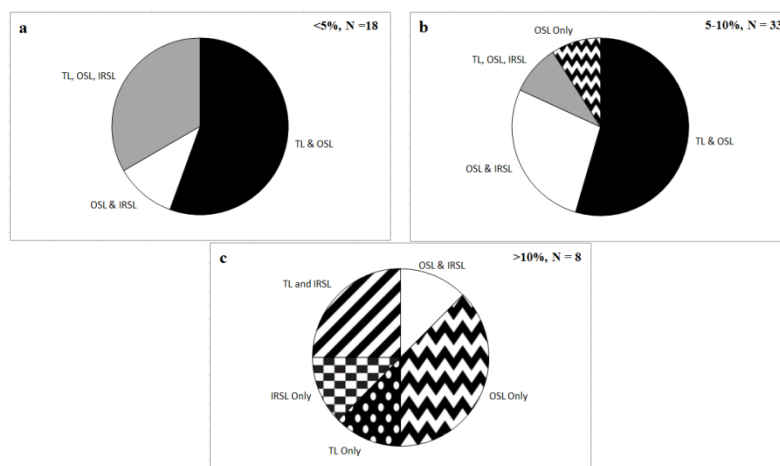
In total, the precision values for the 59 samples dated in this sample are presented in Table 7.3.

**Table 7.3: Precision Values for Dataset, by Method and Grade**

% Error			Method							Grade			
	#	%	TL only	OSL only	IRSL only	TL & OSL	OSL & IRSL	TL & IRSL	TL, OSL, IRSL	A	B	C	D
< 5 %	18	30	-	-	-	10	2	-	6	5	6	7	-
5-10 %	33	56	-	3	-	18	9	-	3	5	9	17	3
>10 %	8	14	1	3	1	-	1	2	-	-	1	4	2
<b>Total</b>	<b>59</b>	<b>100</b>	<b>1</b>	<b>6</b>	<b>1</b>	<b>18</b>	<b>12</b>	<b>2</b>	<b>3</b>	<b>10</b>	<b>16</b>	<b>28</b>	<b>5</b>

By sorting the error terms into these three categories (<5 %, 5-10%, and >10 %), clear trends in the data are readily apparent. 18 of the 59 samples, or 30%, have precision at

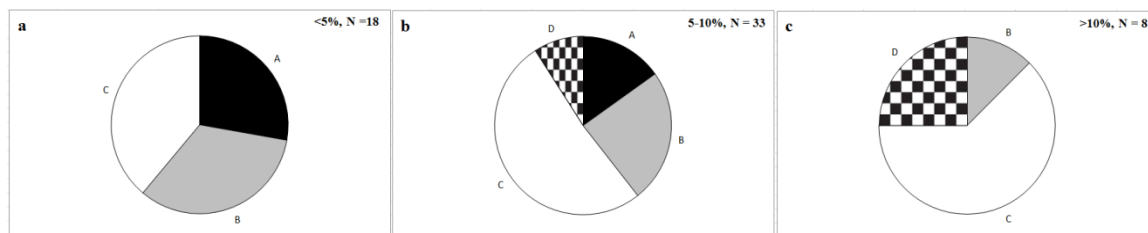
less than 5% error. All of these dates are derived from multiple measurements of the luminescence signal, where 16 of those 18 have equivalent TL and OSL, as shown in Figure 7.6a. The percentage of samples with  $Tl = OSL$  decreases as the percentage error increases. All of the 18 samples with the highest precision, furthermore, have an OSL component to the age calculation. Not surprisingly, the samples with the lowest error have the highest rate of A-grades (28%) and of A- and B-grades combined (61%), as shown in Figure 7.6a-c.



**Figure 7.6a-c: Method used for age calculation, sorted by % error**

For the samples with error between 5 and 10 %, the data tell a similar story. The majority of samples (33, or 56%) fall within this range, encompassing the mean, median, and mode. Again, all have the OSL signal as part of the age calculation (see also Figure 7.6b), suggesting that there is a very strong relationship between measuring and using the OSL signal and increasing precision, because of the SAR procedure and reduced chances of significant fading (though this is also, of course, partly a systematic error consideration). A majority of the luminescence samples (3 of 5) where only one signal was used for age, were calculated from OSL. This relationship extends, naturally, to grade determination,

as 15% (5) of the samples received an A-grade and 40% (13) received an A- or B-grade combined (see Figure 7.7a-c).



**Figure 7.7a-c: Qualitative grades, sorted by % error**

The remaining eight samples, representing just 14% of the sample, had error terms greater than 10%. Five of the samples have dates derived from just one kind of luminescence (see Figure 7.7c) and the best grade is single B, as seven of the eight samples did not earn a good grade. Of significant interest, again, is the role of OSL. Zero of the samples with high error had coincidence between the TL and OSL signal, and are increasingly reliant upon a single line of evidence. Lastly, and not surprisingly, high error terms coincide with poor qualitative grades, as they are each the product of relatively poor data.

By examining the quality of the luminescence dates in this way, it further emphasizes the degree to which a dating protocol that extends the fine-grained dating of heated ceramics to include OSL and IRSL can improve the quality of results. The OSL signal, especially when it coincides in age with the TL signal, is the best generator of high-quality and high-precision dates. As Figures 7.6a-c and 7.7a-c demonstrate, the higher the precision the date, the more fundamental the OSL signal. When the OSL signal is equivalent to the TL signal, high quality, high precision dates are the result.

When this relationship does not hold true, the opposite result is more likely: lower precision, lower quality dates.

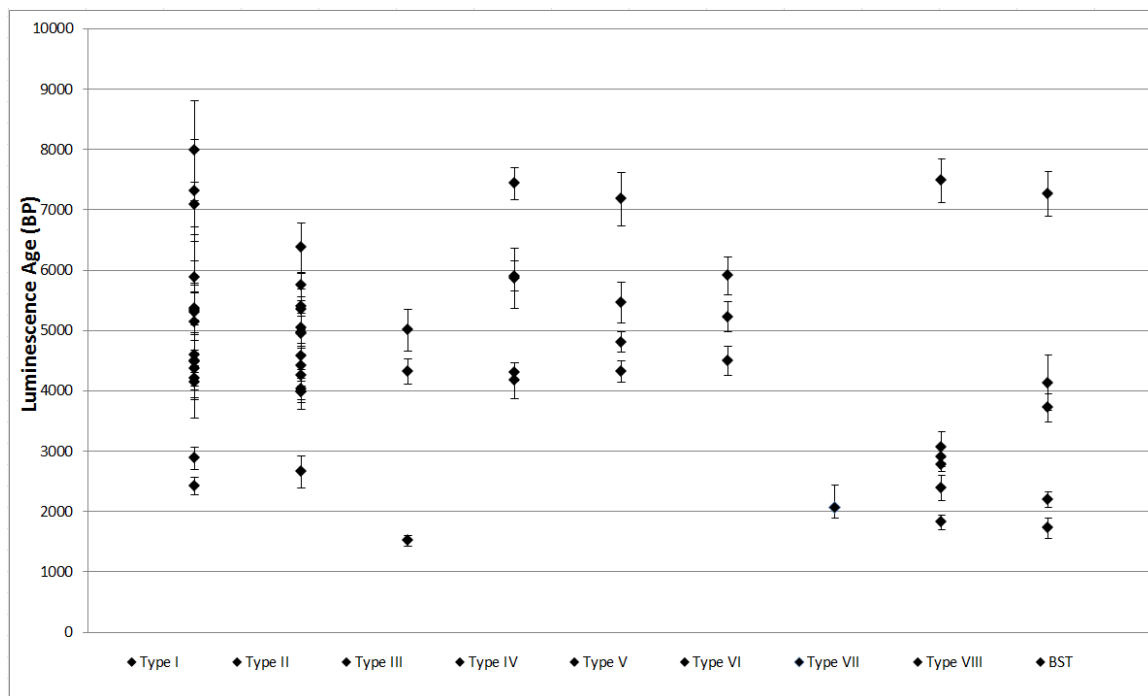
As laboratory protocols increasingly are able to isolate the quartz component of polymineral fine-grain materials, through the Double SAR and pulsed methodologies described in Chapter Five, and as the nature of unexpected b-value data are better understood, luminescence results will continually improve in their ability to provide chronological resolution for specific archaeological events. And, with the advent of the grading techniques described in Chapter Six, the interpretations generated from the luminescence data will be able to emphasize results from the most reliable data.

I further examined each of the C-grades to see which of the measures produced the low grade, to see if some C-level grades could be considered “good grades”, as not all the criteria are equal, some are more important than others. Specifically, if any of the C-grades were determined exclusively by the lack of a sediment sample (radioactivity from the associated sediment only represents 25% of the dose rate calculation, so high external dose rate makes only a minor difference in age calculation) and disagreement between alpha and beta calculations of dose rate and the OSL was equivalent to TL age, then those could be deemed acceptable. No C-grades were produced in this way. Fine-tuning of the grading system is one of the areas where additional research will be conducted.

#### *Future Research*

Three primary areas of future work are presented here: systematic sampling, by locus, of ware types; increase in sample size, generally; and, continued investigation of b-value data.

The lack of systematic sampling for wares at the level of loci prevents any coherent analysis of the temporal distribution of ware types at that scale. Instead, the age of each ware type is presented here, across the entire dataset in Figure 7.8.



**Figure 7.8: Luminescence age, sorted by ware type**

Ceramic types are conservative over time in this crude analysis. Fixing any one type is a difficult process, but one to pursue in future efforts. Types I (Sandy Ware) and II (Chaff Tempered) span the range of ceramic manufacture on the promontory. This may also be true of Types VIII (Coarse Sand) and BST (Black Sand Tempered), though here the sample size makes the continuity of this temporal distribution unclear. Likewise, Types III (Quartz Tempered Ware) and VII (Sandy Limestone Ware) are relatively recent in appearance in Sinop, though this may simply be a product of sample size. Types IV (Shell Tempered Ware), V (Fine Grey Ware), and VI (Pebble Ware) have older temporal distributions, relatively well clustered within the Early Bronze Age and earlier periods.

The continuity of types over time in the promontory, as revealed in this initial analysis, is itself a meaningful part of the Sinop story, marking it as a defined region. One future research goal will be to attempt to increase our resolution through spatial sampling of ware types. Another goal will be to see if other variables in the assemblage, such as form and decoration, are chronologically more restricted than ware type. As part of the SRAP, I am actively seeking funding to conduct a systematic dating protocol, increasing our sample size, to address these outstanding questions.

The second area of targeted research is a natural offshoot of the first. As noted throughout this chapter and those preceding it, an additional area in which this research can gain clarity and explanatory power is through an increase in sample size of dated sherds from sites identified in this chapter as well as in Chapters 5 and 6. Toward that end, the SRAP contracted the Luminescence Laboratory at the University of Washington to date additional samples. As I was not directly involved in their analysis, those dates will be presented here to illustrate their potential for additional research in the Sinop promontory. Twelve samples from two Demirci Valley loci, Kocagöz and Mezarlıktepe, and 19 samples from two Karasu Valley loci, Güllüavlu and Maltepe Hacıoğlu, were analyzed in 2012, with results generated in 2013 (Feathers 2013). They are presented here in Tables 7.4 and 7.5.

**Table 7.4: Demirci Valley Samples, Dated by UW Laboratory 2012-13**

<b>UW #</b>	<b>Locus</b>	<b>SRAP #</b>	<b>Date (BCE)</b>	<b>% Error</b>
<b>U2247</b>	Kocagöz	96.24a.31	2380 ± 475	9.4
<b>U2248</b>	Kocagöz	96.24a.33	10630 ± 1420	11.2
<b>U2289</b>	Kocagöz	96.24a.01	2570 ± 250	5.4
<b>U2268</b>	Mezarlıktepe	T99080.01	3490 ± 380	7.0
<b>U2269</b>	Mezarlıktepe	T99.80.04	4000 ± 380	6.4
<b>U2270</b>	Mezarlıktepe	T99.80.04	1570 ± 200	7.7

Table 7.4 continued

UW #	Locus	SRAP #	Date (BCE)	% Error
U2271	Mezarlıktepe	T99.80.13	1950 ± 260	6.6
U2272	Mezarlıktepe	T99.80.20	3080 ± 290	5.7
U2273	Mezarlıktepe	T99.80.22	1990 ± 240	5.9
U2274	Mezarlıktepe	T99.80.30	1510 ± 360	9.1
U2275	Mezarlıktepe	T99.80.32	2080 ± 230	5.6
U2276	Mezarlıktepe	T99.80.43	1530 ± 320	9.2

My analysis of Kocagöz supported the typological expectation of an EBA period occupation, though the luminescence dates reported in Chapter Six and discussed above suggested a greater spread of ceramic manufacturing into the Chalcolithic and Archaic. Two of the three Kocagöz samples dated in 2012-13 support the typological estimates which were also supported by for an EBA period occupation. In this case, additional samples support and clarify existing data.

Typological expectations for Mezarlıktepe were for a Neolithic period occupation, in the 5<sup>th</sup> millennium BCE. My analysis suggested a later occupation, mostly around 2000 BCE, with a less clear temporal signature at about 3000 BCE. The 2012-13 samples listed above also present clusters of dates at these intervals and add an additional late component, at 1500 BCE. Again, additional samples continue to clarify the chronological picture of ceramic manufacture and, in this case, identify a potential later period of manufacture.

**Table 7.5: Karasu Valley Samples, Dated by UW Laboratory 2012-13**

UW #	Locus	SRAP #	Date (BCE)	% Error
U2249	Güllüavlu	L98.25.05	2860 ± 260	5.3
U2250	Güllüavlu	L98.25.07	1180 ± 380	11.9
U2251	Güllüavlu	L 98.25.08	2320 ± 240	10.8
U2252	Güllüavlu	L98.25.12	3880 ± 780	13.2
U2253	Güllüavlu	L98.25.28	2850 ± 360	7.4
U2254	Güllüavlu	L98.25.31	3300 ± 350	6.7
U2255	Güllüavlu	L98.25.35	2540 ± 270	5.9

Table 7.5 continued

UW #	Locus	SRAP #	Date (BCE)	% Error
U2256	Güllüavlu	L98.25.41	5460 ± 660	8.8
U2257	Güllüavlu	L98.25.76	2490 ± 420	9.4
U2258	Güllüavlu	L98.25.81	2860 ± 260	5.8
U2259	Maltepe Hacıoğlu	L98.29.7	1640 ± 220	6.2
U2260	Maltepe Hacıoğlu	L98.29.23	5470 ± 360	4.8
U2261	Maltepe Hacıoğlu	L98.29.28	2050 ± 280	6.8
U2262	Maltepe Hacıoğlu	L98.29.33	7010 ± 560	6.3
U2263	Maltepe Hacıoğlu	L98.29.37	2970 ± 340	6.9
U2264	Maltepe Hacıoğlu	L98.29.39	4440 ± 510	7.9
U2265	Maltepe Hacıoğlu	L98.29.60	5000 ± 330	4.7
U2266	Maltepe Hacıoğlu	L98.29.90	1440 ± 220	6.3
U2267	Maltepe Hacıoğlu	L98.29.92	4790 ± 450	6.6

At Güllüavlu, the expectation from typology had been for a multi-component occupation during the MBA (2100-2700 BCE) and the 4th mill. BCE Chalcolithic. My data indicated a distribution of ages with the EBA, from 2000-27000 BCE. The 2012-13 data support the earlier luminescence data, with a strong cluster of dates between 2300-2800 BCE and a scatter of older dates, as well. Here, the additional data continue to refute the typological hypothesis, support the first set of luminescence dates, and point to potential additional periods of ceramic manufacture.

At Maltepe Hacıoğlu, the expectation from typology had been a Late Chalcolithic period set of dates, in the late 3rd to early 4th mill. BCE. My data indicated an earlier cluster of dates, between 5100 and 5500 BCE (Neolithic) with good grades and some poorly grades dates that matched the typology, at between 2800-2900 BCE. The 2012-13 data, too, indicate a cluster of dates between 4400-5400 BCE and one date within the typological prediction. Other, younger, dates are also present. The additional dates from this locus support the first set of luminescence dates, adding strength to the chronological interpretation, and suggest additional periods of ceramic manufacture.

In each of the four loci, across these two valleys, additional dates support interpretations first offered in Chapter Six. This helps to reduce some of the concerns of small sample size. The dates also indicate the potential for additional periods of ceramic manufacture, consistent with the general interpretation that loci within the promontory were occupied for multiple periods, spanning multiple centuries, if not millennia.

The final area in which additional research is warranted is in addressing the underlying nature of the unexpected Sinop b-value data. OSL b-values, as discussed in Chapter Five, were higher than expected, often higher than values for TL or IRSL despite the assumption that the OSL signal should simply be a product of quartz emission. Despite efforts to correct these higher than expected values with the Double SAR technique and the addition of a pulsed signal to the measurement protocol, the Sinop material continued to present unexpected b-value relationships. I admit to being thoroughly puzzled by this result but remain interested in further pursuit of clarity on the issue, as seen by the recent publication by Feathers et al. (2012).

### *Conclusions*

The research presented in this thesis furthers archaeological knowledge in three primary ways:

- It provides clarity to the regional culture history of the Sinop promontory and its community,
- It addresses specific research questions posed by the SRAP, and
- It furthers the development of luminescence methods of analysis and presentation.

Beyond these important contributions, it is my hope that the research presented here illustrates the extent to which a reliable chronometer, when thoughtfully applied to an appropriate dataset, can provide the temporal framework upon which archaeological investigations can proceed. In many ways, the formation—or in this case, the revision—of a regional chronology represents the first step in providing the context for past behaviors.

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## Appendix I: Equivalent Dose Calculations

Sample	Equivalent Dose (Gy)			b-value (Gy $\mu\text{m}^2$ )		
	TL	IRSL	OSL	TL	IRSL	OSL
UW1120	3.361±0.233	4.692±0.618	4.843±0.429	1.001±0.182	1.267±0.214	0.541±0.028
UW1121	5.762±1.000	11.892±1.151	10.333±0.313	1.019±0.156	1.739±0.316	0.591±0.030
UW1122	24.306±2.085	16.265±0.905	17.202±0.693	1.445±0.333	No Data	0.909±0.511
UW1123	18.554±1.256	20.900±1.157	24.781±0.844	1.246±0.077	1.123±0.139	1.531±0.086
UW1124	12.905±2.893	21.645±3.666	14.783±0.393	2.193±0.273	1.275±0.306	0.761±0.038
UW1125	4.050±0.317	6.229±1.172	12.187±1.128	1.496±0.122	1.620±0.337	1.189±0.154
UW1126	12.865±0.939	No signal	9.890±0.343	1.754±0.119	No Data	0.651±0.045
UW1127	46.346±4.338	No signal	29.084±1.515	1.400±0.128	No Data	1.077±0.084
UW1128	23.393±1.015	12.417±0.933	13.492±0.589	2.012±0.147	1.743±0.224	1.407±0.070
UW1129	31.871±4.093	30.017±1.643	28.373±0.824	1.443±0.097	0.922±0.090	0.653±0.029
UW1130	21.389±1.378	13.202±0.912	15.960±1.715	2.630±0.191	1.863±0.167	1.378±0.184
UW1131	15.550±0.326	No signal	12.255±3.204	1.623±0.094	No Data	2.179±0.574
UW1132	11.272±0.634	No signal	9.846±0.474	1.257±0.089	No Data	0.777±0.048
UW1483	15.003±1.520	10.297±1.012	11.577±0.255	1.093±0.452	1.179±0.188	0.815±0.043
UW1484	9.880±0.983	14.348±1.515	13.896±1.524	0.516±0.313	1.179±0.188	1.339±0.138
UW1485	12.759±0.807	12.247±0.650	12.647±0.285	1.850±0.127	1.169±0.146	0.933±0.046
UW1486	7.420±1.060	5.299±0.570	10.933±1.926	1.388±0.186	No Data	0.710±0.130
UW1487	3.667±0.331	4.833±0.307	3.696±0.125	1.906±0.121	2.881±0.386	1.287±0.591
UW1488	2.934±0.262	4.981±0.442	4.988±0.148	1.620±0.132	1.475±0.465	0.710±0.130
UW1489	8.460±0.281	5.873±0.384	7.196±0.172	1.164±0.091	1.784±0.344	3.233±0.240
UW1490	8.232±0.599	4.513±0.621	6.492±0.271	1.950±0.233	1.679±0.674	1.752±0.093
UW1491	17.700±1.12	13.409±0.897	13.288±0.383	1.185±0.053	0.979±0.891	0.670±0.032
UW1516	20.213±3.620	16.586±1.102	17.602±0.536	2.333±0.733	0.970±0.902	1.060±0.669
UW1517	12.961±0.785	18.500±1.797	12.983±0.290	1.254±0.042	1.141±0.131	0.716±0.036
UW1542	11.871±0.514	12.316±0.913	13.285±0.565	1.600±0.096	1.136±0.230	1.611±0.104
UW1544	12.180±3.013	11.791±0.380	15.534±0.491	2.558±0.772	1.175±0.076	0.788±0.681
UW1545	7.689±0.299	13.296±1.769	10.042±0.497	1.670±0.155	1.330±0.338	0.543±0.060
UW1546	14.420±0.750	11.927±0.544	13.237±0.289	2.388±0.269	1.889±0.151	1.176±0.291
UW1547	13.981±1.235	12.838±0.963	10.231±0.204	2.134±0.118	1.097±0.063	0.549±0.013
UW1549	11.410±0.468	11.519±0.812	12.955±1.584	0.923±0.051	No Data	0.710±0.130
UW1550	34.302±1.500	20.206±0.934	28.840±0.656	1.399±0.076	1.450±0.187	2.224±0.089
UW1551	7.280±0.654	6.656±0.517	8.047±0.291	1.348±0.154	1.187±0.073	0.579±0.036
UW1552	5.175±0.279	9.342±0.672	18.992±2.744	1.591±0.100	1.391±0.243	0.699±0.155
UW1555	8.704±0.820	11.506±0.496	13.724±0.666	1.972±0.194	1.249±0.134	2.112±0.258
UW1557	4.789±0.411	6.598±0.874	6.171±0.243	0.907±0.057	1.240±0.390	0.497±0.048
UW1559	19.451±0.650	17.393±1.735	18.221±0.704	1.661±0.169	1.219±0.135	2.274±0.116
UW1563	10.668±0.681	11.401±0.663	10.070±0.170	1.231±0.066	1.148±0.145	0.531±0.021
UW1564	10.0775±0.301	13.690±1.266	10.316±0.320	1.533±0.072	1.565±0.455	3.032±0.266
UW1566	11.6188±0.597	7.722±0.642	9.434±0.254	1.226±0.142	1.065±0.154	2.859±0.317
UW1567	16.965±0.845	10.970±0.351	11.699±0.313	1.941±0.272	1.584±0.147	1.704±0.822

Sample	Equivalent Dose (Gy)			b-value (Gy $\mu\text{m}^2$ )		
	TL	IRSL	OSL	TL	IRSL	OSL
UW1568	6.637±0.693	18.959±1.537	17.084±0.308	0.934±0.096	0.840±0.148	0.686±0.038
UW1569	20.529±0.437	17.179±1.273	22.018±0.695	1.047±0.063	1.038±0.158	1.129±0.061
UW1570	16.33±2.385	18.006±2.855	22.983±0.523	0.935±0.142	0.932±0.213	0.440±0.018
UW1571	14.299±0.479	15.369±0.981	14.841±0.482	0.677±0.063	1.285±0.203	1.478±0.113
UW1572	23.697±1.250	16.767±1.030	24.667±1.858	1.27±0.146	1.245±0.159	1.280±0.183
UW1573	4.078±0.501	3.886±0.829	4.314±0.369	2.228±0.262	1.212±0.460	1.359±0.192
UW1574	10.959±0.301	7.310±0.621	6.752±0.121	2.082±0.139	1.872±0.223	0.898±0.042
UW1575	5.484±0.511	6.654±0.729	8.476±0.463	1.160±0.100	1.000±0.227	0.572±0.070
UW1576	13.723±1.025	10.590±0.500	13.143±0.441	1.781±0.227	1.514±0.219	1.497±0.102
UW1577	6.785±0.372	8.656±0.953	13.075±0.602	1.532±0.149	1.693±0.335	0.570±0.077
UW1578	16.128±0.952	13.442±0.642	16.194±0.655	0.648±0.111	0.820±0.071	0.770±0.067
UW1579	7.5945±0.717	8.785±0.771	9.594±0.983	0.720±0.066	2.642±0.798	0.834±0.082
UW1581	11.343±0.797	12.049±0.945	16.933±1.365	1.304±0.115	1.165±0.161	0.802±0.074
UW1584	6.708±0.394	12.985±2.050	17.181±3.571	1.486±0.054	1.023±0.115	0.891±0.086
UW1590	11.693±0.600	9.141±0.507	7.742±0.646	0.435±0.043	1.273±0.139	1.033±0.102
UW1603	14.492±1.367	11.404±0.601	10.045±0.273	1.249±0.010	0.857±0.080	0.555±0.024
UW1604	16.480±0.900	11.198±1.011	11.283±0.366	2.521±0.269	0.903±0.165	0.766±0.047
UW1986	4.794±0.193	8.232±0.842	29.981±2.330	0.927±0.085	0.962±0.085	0.547±0.033
UW1988	12.484±0.929	11.843±1.130	14.971±1.375	0.907±0.060	1.042±0.035	0.843±0.061

## Appendix II: Radioactivity and Dose Rate Calculations

Sample	<sup>232</sup> Th (ppm)	<sup>238</sup> U (ppm)	K (%)	Beta dose rate (Gy/ka)	
				β-counting	α-counting/ flame photometry
UW1120	5.990±0.897	2.320±0.164	1.309±0.063	1.630±0.120	1.550±0.061
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1121	8.770±1.118	2.900±0.207	1.355±1.025	1.750±0.120	1.750±0.050
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1122	5.760±0.862	1.250±0.115	1.173±0.037	1.410±0.110	1.280±0.042
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1123	18.500±1.872	2.170±0.245	2.110±0.040	2.410±0.200	2.510±0.070
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1124	9.540±1.170	1.990±0.181	0.726±0.016	1.120±0.090	1.160±0.060
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1125	7.290±1.111	2.830±0.199	1.626±0.023	1.850±0.160	1.920±0.050
Sed	4.540±0.825	0.700±0.090	0.578±0.026		
UW1126	8.630±1.167	0.860±0.135	0.940±0.009	1.060±0.230	1.120±0.040
Sed	7.440±1.002	1.090±0.122	1.050±0.024		
UW1127	36.060±2.697	2.640±0.376	2.813±0.075	3.420±0.270	3.630±0.110
Sed	7.440±1.002	1.090±0.122	1.050±0.024		
UW1128	5.870±1.000	2.870±0.190	1.457±0.031	1.698±0.110	1.748±0.046
Sed	6.880±1.080	2.360±0.190	1.254±0.058		
UW1129	49.590±3.670	4.190±0.530	2.741±0.048	4.010±0.240	4.165±0.132
Sed	6.880±1.080	2.360±0.190	1.254±0.058		
UW1130	18.780±1.870	1.600±0.220	1.034±0.036	1.442±0.110	1.576±0.067
Sed	6.880±1.080	2.360±0.190	1.254±0.058		
UW1131	8.590±1.200	2.590±0.200	1.604±0.014	1.734±0.125	1.900±0.045
Sed	4.550±0.776	1.640±0.124	1.326±0.016		
UW1132	8.480±1.170	1.450±0.140	1.229±0.014	1.390±0.090	1.429±0.040
Sed	4.550±0.776	1.640±0.124	1.326±0.016		
UW1483	6.470±1.050	2.780±0.193	1.357±0.014	1.642±0.122	1.671±0.041
Sed	8.890±1.120	1.940±0.177	1.195±0.040		
UW1484	7.670±1.040	2.410±0.179	1.620±0.025	1.839±0.118	0.691±0.043
Sed	8.890±1.120	1.940±0.177	1.195±0.040		
UW1485	5.090±0.869	2.780±0.181	1.361±0.014	1.626±0.114	1.637±0.037
Sed	8.890±1.120	1.940±0.177	1.195±0.040		
UW1486	8.640±1.110	2.060±0.169	1.533±0.042	1.969±0.170	1.969±0.180
Sed	5.450±0.921	0.940±0.111	0.770±0.043		
UW1487	4.060±0.741	1.950±0.135	1.671±0.061	1.904±0.177	1.736±0.057
Sed	5.450±0.921	0.940±0.111	0.770±0.043		
UW1488	4.960±0.864	1.820±0.138	1.481±0.010	1.860±0.157	1.590±0.032
Sed	5.450±0.921	0.940±0.111	0.770±0.043		
UW1489	10.740±1.330	1.010±0.148	1.140±0.022	1.389±0.138	1.355±0.046

Sample	<sup>232</sup> Th (ppm)	<sup>238</sup> U (ppm)	K (%)	Beta dose rate (Gy/ka)	
				β-counting	α-counting/ flame photometry
Sed	5.450±0.921	0.940±0.111	0.770±0.043		
UW1490	6.910±1.050	1.310±0.130	1.197±0.009	1.554±0.138	1.340±0.035
Sed	8.200±1.160	1.500±0.150	0.950±0.019		
UW1491	11.080±1.050	2.400±0.202	0.797±0.006	1.284±0.111	1.292±0.041
Sed	8.890±1.120	1.940±0.177	1.195±0.040		
UW1516	4.400±0.796	2.310±0.155	0.945±0.026	1.389±0.123	1.216±0.038
Sed	8.145±1.069	1.398±0.146	1.108±0.028		
UW1517	4.160±0.807	1.865±0.136	1.429±0.028	1.619±0.139	1.539±0.140
Sed	8.145±1.069	1.398±0.146	1.108±0.028		
UW1542	8.580±1.090	2.250±0.177	1.178±0.049	1.586±0.290	1.508±0.056
Sed	9.162±0.869	1.470±0.110	1.397±0.011		
UW1544	8.110±1.200	3.080±0.220	1.436±0.032	1.844±0.160	1.823±0.053
Sed	9.162±0.869	1.470±0.110	1.397±0.011		
UW1545	4.720±0.910	3.050±0.190	1.780±0.017	2.020±0.187	2.002±0.040
Sed	8.300±1.175	1.780±0.169	1.390±0.013		
UW1546	8.660±1.230	2.820±0.208	1.240±0.013	1.685±0.151	1.643±0.046
Sed	10.200±1.290	1.220±0.150	1.410±0.018		
UW1547	12.070±1.320	2.070±0.190	0.554±0.088	1.105±0.099	1.077±0.084
Sed	10.240±1.270	1.220±0.150	1.024±0.025		
UW1549	7.920±0.697	1.490±0.134	1.597±0.018	1.765±0.158	1.715±0.031
Sed	7.250±1.060	0.720±0.400	0.968±0.018		
UW1550	26.570±2.352	7.750±0.053	3.002±1.046	4.158±0.363	4.265±0.103
Sed	8.490±1.089	1.046±0.025	1.046±0.025		
UW1551	4.520±0.810	3.380±0.200	1.626±0.112	1.991±0.168	1.921±0.097
Sed	8.320±0.510	2.070±0.170	1.131±0.014		
UW1552	9.380±1.190	2.950±0.214	1.640±0.012	2.123±0.190	2.002±0.046
Sed	11.450±1.148	2.070±0.201	1.666±0.065		
UW1555	5.580±0.950	1.690±0.140	1.579±0.007	1.744±0.120	1.666±0.033
Sed	10.200±1.290	1.220±0.150	0.918±0.043		
UW1557	7.610±1.150	3.090±0.210	1.572±0.042	2.017±0.181	1.920±0.055
Sed	9.840±1.296	2.040±0.182	1.303±0.041		
UW1559	8.420±1.230	3.570±0.240	1.111±0.026	1.627±0.150	1.642±0.053
Sed	9.840±1.296	2.040±0.182	1.303±0.041		
UW1563	4.800±0.924	3.360±0.290	0.998±0.024	1.393±0.220	1.422±0.044
Sed	9.162±0.869	1.470±0.110	1.397±0.011		
UW1564	11.600±1.430	2.500±0.214	0.897±0.011	1.397±0.130	1.401±0.051
Sed	8.300±1.175	1.780±0.169	1.390±0.013		
UW1566	4.420±0.791	2.460±0.161	1.417±0.021	1.797±0.150	1.617±0.036
Sed	10.200±1.290	1.220±0.150	1.410±0.018		
UW1567	4.270±0.740	2.050±0.140	1.242±0.026	1.627±0.135	1.412±0.036
Sed	10.200±1.290	1.220±0.150	1.410±0.018		

Sample	<sup>232</sup> Th (ppm)	<sup>238</sup> U (ppm)	K (%)	Beta dose rate (Gy/ka)	
				β-counting	α-counting/ flame photometry
UW1568	6.330±0.909	3.850±0.233	0.633±0.015	1.085±0.084	1.243±0.044
Sed	10.240±1.273	1.220±0.154	1.024±0.025		
UW1569	5.360±0.850	2.040±0.150	1.695±0.044	1.893±0.180	1.804±0.048
Sed	10.240±1.273	1.220±0.154	1.024±0.025		
UW1570	2.840±0.630	2.210±0.140	0.794±0.011	1.223±0.092	1.037±0.028
Sed	14.350±1.579	1.230±0.181	1.292±0.022		
UW1571	8.130±1.100	2.600±0.191	1.450±0.025	1.834±0.170	1.765±0.046
Sed	14.350±1.579	1.230±0.181	1.292±0.022		
UW1572	17.160±1.852	2.909±0.027	2.909±0.026	3.782±0.315	3.227±0.055
Sed	8.490±1.090	0.960±0.120	1.046±0.025		
UW1573	6.110±1.020	2.740±0.190	1.076±0.007	1.481±0.157	1.430±0.040
Sed	8.490±1.090	0.960±0.120	1.046±0.025		
UW1574	8.690±1.290	4.460±0.280	1.427±0.018	2.115±0.190	2.033±0.056
Sed	8.320±0.510	2.060±0.168	1.131±0.014		
UW1575	6.100±0.990	1.840±0.150	1.972±0.059	2.319±0.205	2.017±0.059
Sed	11.450±1.418	2.070±0.201	1.666±0.065		
UW1576	4.330±0.844	2.560±0.169	1.631±0.064	2.020±0.183	1.800±0.060
Sed	8.530±1.142	1.880±0.173	1.306±0.044		
UW1577	4.170±0.680	1.970±0.130	1.500±0.090	1.853±0.158	1.853±0.158
Sed	7.900±1.080	1.460±0.150	0.932±0.032		
UW1578	6.000±0.980	2.280±0.170	1.519±0.091	1.809±0.161	1.715±0.082
Sed	5.610±0.860	1.690±0.140	0.945±0.022		
UW1579	4.080±0.732	1.850±0.131	1.608±0.013	2.024±0.160	1.672±0.030
Sed	5.610±0.865	1.690±0.145	0.945±0.022		
UW1581	7.420±1.020	2.610±0.185	1.341±0.062	1.770±0.169	1.660±0.063
Sed	12.990±1.500	1.100±0.175	1.182±0.015		
UW1584	5.370±0.950	2.530±0.180	1.624±0.114	2.174±0.193	1.819±0.099
Sed	11.420±1.400	1.570±0.180	1.242±0.028		
UW1590	7.750±1.140	2.150±0.173	2.241±0.067	2.491±0.204	2.323±0.067
Sed	9.162±0.869	1.470±0.110	1.397±0.011		
UW1603	7.080±1.130	3.250±0.270	1.124±0.007	1.393±0.120	1.570±0.050
Sed	8.153±1.071	1.410±0.150	1.110±0.030		
UW1604	10.480±1.330	2.420±0.200	0.991±0.014	1.393±0.130	1.435±0.048
Sed	8.153±1.071	1.410±0.150	1.110±0.030		
UW1986	5.430±0.940	2.280±0.160	2.031±0.147	2.265±0.185	2.110±0.123
Sed	11.450±1.418	2.070±0.201	1.666±0.065		
UW1988	8.740±1.210	1.940±0.170	1.552±0.134	1.896±0.156	1.767±0.115
Sed	7.250±1.060	0.720±0.400	0.968±0.018		

### Appendix III: Decision-Making Rationales

Sample	Rationale
U1120	OSL = TL; good b-value data* from non-pulsed OSL in particular
U1121	OSL = TL = IRSL; but used just OSL and TL (fade corrected) as IRSL barely within error terms and likely fades
U1122	OSL data only; TL data problematic: fading correction places age over 12 ka
U1123	OSL and IRSL; pulsed agrees with non-pulsed and no fading; no TL fading test
U1124	OSL and IRSL; TL (fading correction) nearly within error terms
U1125	OSL only; TL with high fading; IR data very young; Used OSL because of potential of feldspar fading with TL and IR
U1126	TL = OSL; No IR signal supports no fading in TL, use non-fade corrected TL with OSL as fade-corrected data had high error term based on few data points
U1127	OSL only; TL problematic: too old for reasons unclear, poor data
U1128	OSL only; TL too old and problematic, though the non-fading TL is near OSL age
U1129	OSL = TL = IRSL; Good data**, including b-values
U1130	TL = OSL; OSL agrees with TL fading data, IR too young (likely because it fades)
U1131	TL = OSL; OSL agrees with TL fading data; good data
U1132	TL = OSL; TL fading not correctable; good data
U1483	TL = OSL; pulsed and non-pulsed agree with TL, high precision
U1484	OSL = TL = IRSL; relatively poor OSL data (low precision) but agree with TL fade-corrected and IRSL
U1485	OSL = IRSL; good OSL data (b-value, pulsed, non-pulsed)
U1486	OSL only; problematic date, as TL very young but did not fade and OSL data with poor precision; Additional OSL measurements did not resolve OSL scatter. TL data alone would make this date roughly 2000 years younger and significantly different than expectation from typology. Given low grade.
U1487	OSL = IRSL; TL too young and fading can't be corrected
U1488	OSL = IRSL; TL younger but could be explained by fading; good data
U1489	TL = OSL; pulsed and non-pulsed OSL data used
U1490	TL = OSL; non-pulsed OSL shows better agreement with TL, though poor precision OSL data
U1491	OSL = TL = IRSL; excellent data, strong agreement among all measurements
U1516	OSL = TL = IRSL; good data, agreement among all measures
U1517	TL = OSL; good data and agreement
U1542	TL = OSL; TL fading with non-pulsed b-value (high error); IR too young, likely fades

<b>Sample</b>	<b>Rationale</b>
U1544	TL = OSL; pulsed and non-pulsed OSL agree and have good b-value; agree with TL
U1545	OSL = TL = IRSL; good data, agreement among all measures
U1546	TL = OSL; Pulsed and non-pulsed OSL agree with TL fading corrected data. Good data.
U1547	OSL = IRSL; TL fading data is poor; Low IRSL signal suggests minimal fading.
U1549	TL = OSL; poor b-value and pulsed data, but fading not significant; otherwise equivalent dose data are good.
U1550	TL = OSL; poor OSL b-value, but general agreement with TL data
U1551	TL = OSL; TL fading corrected agrees with pulsed OSL
U1552	TL = IRSL; OSL data is problematic: likely too old, as IRSL agrees with TL and stylistic estimates of age
U1555	OSL only; IR nearly agrees; TL with significant fading
U1557	OSL = IRSL; TL fades with very poor precision
U1559	TL = OSL; Problematic b-values; TL fading corrected agrees with pulsed OSL
U1563	OSL = TL = IRSL; Good data, all methods agree
U1564	OSL = IRSL; TL fades and when corrected is statistically meaningless
U1566	TL = OSL; Poor data, high b-values, but OSL agreement with TL
U1567	TL = OSL; Poor data; TL (uncorrected) agrees with poor b-value OSL
U1568	OSL = IRSL; Very poor TL data; Good pulsed OSL data in agreement with IRSL
U1569	TL = OSL; Good OSL b-value and uncorrected TL (fading yields unreasonable age)
U1570	TL = IRSL; OSL too old (unbleached?); good TL and IRSL data with insignificant fading
U1571	OSL = TL = IRSL; problematic data, but measures agree when fading assumed not significant
U1572	TL = OSL; TL fading with OSL non-pulsed, though OSL data is low precision
U1573	OSL = IRSL; TL data in near agreement
U1574	TL Only; Gives best agreement with other samples from site and TL fading data has best data; Higher b-value in OSL caused by feldspar content.
U1575	TL = OSL; Lots of scatter in IRSL signal; TL fading agrees with non-pulsed OSL
U1576	TL = OSL; Very close agreement with OSL (good b-value) and TL
U1577	TL = OSL; Fading corrected TL in close agreement with single high-precision OSL non-pulsed data point.
U1578	TL = OSL; Good data, TL (no significant fading) close agreement with OSL
U1579	TL = OSL; Good data, TL (no significant fading) close agreement with OSL
U1581	TL = OSL; Good data, TL fading-corrected in close agreement with OSL

<b>Sample</b>	<b>Rationale</b>
U1584	OSL = IRSL; TL data cannot be fading corrected
U1590	OSL = IRSL; All data are good, though TL does not agree with OSL and IRSL; Interesting note that TL alone is in decent agreement with other samples from site, but TL b-value is too low
U1603	OSL = TL = IRSL; Good data, all methods agree
U1604	OSL = TL = IRSL; Good data, all methods agree
U1986	IRSL only; poor TL data (fading not correctable) and OSL data (very high equivalent dose)
U1988	TL = OSL; Good data; IRSL young but likely fades

\*Here “good b-value data” means that the OSL b-value was near 1.0 or lower and that the b-values follow the expectation of IRSL>TL>OSL

\*\*Here “good data” are a measure of signal precision and low scatter

## Appendix IV: Grading Pass/Fail Data

Sample	Loc us/ Site	Assoc Sed	OS = T	OS D Prec < 15 %	Plateau > 70 ° C	T D Prec < 15 %	T F adin g	$\alpha$ = $\beta$	b - Value	Grad e
U1120	Kayanın Başı	+	+	+	+	+	-	+	+	B
U1121	Kayanın Başı	+	+	+	+	-	+	+	+	B
U1122	Kayanın Başı	+	-	+	+	+	+	-	+	C
U1123	Kayanın Başı	+	-	+	+	+	+	+	-	C
U1124	Kayanın Başı	+	-	+	+	-	+	+	+	C
U1125	Kayanın Başı	+	-	+	+	+	-	+	-	C
U1126	Abdaloğlu	+	+	+	+	+	-	+	+	B
U1127	Abdaloğlu	+	-	+	+	+	+	+	-	C
U1128	Kocagöz	+	-	+	+	+	+	+	-	C
U1129	Kocagöz	+	+	+	+	+	+	+	+	A
U1130	Karapınar	+	+	+	+	+	+	+	-	B
U1131	Köşk Höyük	+	+	-	+	+	+	+	-	C
U1132	Köşk Höyük	+	+	+	+	+	+	+	+	A
U1483	Kocagöz	+	+	+	+	+	-	+	+	B
U1484	Kocagöz	+	+	-	+	+	+	+	-	C
U1485	Kocagöz	+	-	+	+	+	-	+	+	C
U1486	Kayanın Başı	+	-	-	-	+	+	+	-	D
U1487	Kayanın Başı	+	-	+	-	+	-	+	-	D
U1488	Kayanın Başı	+	-	+	+	+	+	-	-	C
U1489	Kocagöz	+	+	+	-	+	+	+	-	C
U1490	Kocagöz	+	+	+	-	+	+	-	-	C
U1491	Kocagöz	+	+	+	+	+	+	+	+	A
U1516	Hacıoğlu	-	+	+	+	-	+	-	-	C
U1517	Köşk Höyük	-	+	+	+	+	-	+	+	C
U1542	Mezarlıktepe	+	+	+	+	+	+	+	-	B
U1544	Mezarlıktepe	+	+	+	+	-	+	+	-	C
U1545	Mezarlıktepe	+	+	+	+	+	+	+	+	A
U1546	Mezarlıktepe	+	+	+	+	+	+	+	-	B
U1547	Hacıoğlu	+	-	+	+	+	+	+	-	D
U1549	Abdaloğlu	+	+	+	-	+	+	+	-	C
U1550	Abdaloğlu	+	+	+	+	+	+	+	-	B
U1551	Karapınar	+	+	+	+	+	+	+	+	A
U1552	Tepealtı	+	-	+	-	+	+	+	+	C
U1555	Tıngır Tepe	+	-	+	+	+	-	+	-	C
U1557	Nohutluk	+	-	+	-	+	+	+	+	C



### **Vita**

Trained as an archaeologist and anthropologist, Dr. Aksel Casson has focused his research on the prehistory of the Middle East and the Mediterranean with an emphasis on issues of chronology development and heritage management within Turkey. He has traveled and worked widely in the Middle East and Europe and lectures on the history, politics and culture of the region. His educational background is in evolutionary biology, with dual bachelor's degrees from Grinnell College in Biology and Anthropology. Dr. Casson, who earned his PhD from the University of Washington's Department of Anthropology, worked for eight years in the Luminescence Laboratory, where he was mentored by his thesis advisor, Dr. James Feathers.

His fields of publication and expertise include luminescence dating, the archaeology of Turkey, the Neolithic period, and human transitions, as well as the creation and management of archaeological datasets. Dr. Casson has conducted archaeological fieldwork in Alaska and the Pacific Northwest, the Ohio Valley of the eastern United States, the Jordan Valley, the Turkish Black Sea Coast, the Mugello Valley of northern Italy, and the Federsee Valley of southern Germany. He has also consulted on projects in Syria, Mongolia, western China, and southeastern Turkey. Throughout his research, Dr. Casson applies an explicitly evolutionary framework to his analysis of the human past and present.