Bioarchaeological Analysis of Isolated Crania from the Elizabeth Site in the Lower Illinois River Valley

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BIOARCHAEOLOGICAL ANALYSIS OF ISOLATED CRANIA FROM THE ELIZABETH SITE IN THE LOWER ILLINOIS RIVER VALLEY.

by

DANIEL SCOTT JONES

Under the Direction of Bethany L. Turner, PhD

ABSTRACT

This thesis explores the life history of six isolated skulls interred in Mound 3 of the Elizabeth site, a Middle Woodland site in the lower Illinois valley. This study employs analyses of osteological features, stable and radiogenic isotopes, and biodistance for a cross-section of the Mound 3 population (n=15), including the isolated crania. Isotopic results reveal significant variation in lead isotope ratios in enamel, and interpretively meaningful variation in strontium values. However, bone carbonate oxygen values are not significantly different. Carbon isotope values from bone carbonate revealed only sex-based dietary differences. Biodistance data indicate relatively genetic homogeneity at the site, although significant variation was present in two of the isolated crania. Ultimately, data indicate that two of the six isolated skulls likely originated from elsewhere in the valley, but that the population likely resided in the Elizabeth site vicinity in the decade preceding death, and were not outsiders.

INDEX WORDS: Middle Woodland, Lower Illinois River Valley, Multi-isotope analysis, Carbon, Lead, Strontium, Oxygen, Elizabeth Mound, Trophy heads, Isolated crania
BIOARCHAEOLOGICAL ANALYSIS OF ISOLATED CRANIA FROM THE ELIZABETH SITE IN THE LOWER ILLINOIS RIVER VALLEY.

by

DANIEL SCOTT JONES

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Arts in the College of Arts and Sciences Georgia State University 2015
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1 INTRODUCTION

The lower Illinois River valley is a large, diverse area of roughly 2,800 square miles that encompasses nearly 70 miles of lower river drainage. The productive environment and diverse ecosystems of the valley have enabled a lengthy history of human presence in the region, which spans several millennia beginning around 10,000 B.C. Since this area has remained relatively free from the urbanization and resultant site destruction that has plagued many parts of the New World. The lower Illinois valley provides an unparalleled natural laboratory in which to conduct long-term, systematic, archaeological research on prehistoric human existence and biocultural evolution. As a result, research on prehistoric human occupation of the region, itself a smaller portion of the greater “Eastern Woodlands” complex, has been extremely active since the late nineteenth century, contributing to an immense collection of data and anthropological interpretations that have shed new light on the once-flourishing cultures of the region. However, despite the idyllic conditions and a compendium of research, many questions regarding the prehistoric civilizations of the American Midwest remain.

One question that has gone largely unaddressed in previous research stems from a unique feature in a single mound at one of the many hundreds of sites in the greater valley area. During excavations of Mound 3 at the Elizabeth site, a multi-mound Middle Woodland mortuary site located on a bluff top knoll, researchers uncovered a slot-trench beneath the earthen apron that blanketed the central portion of the burial mound. Enclosed inside were six isolated skulls that had been aligned neatly and interred with a wooden cover over the top; such a cache of skulls has never been observed in any of the numerous excavated sites throughout the lower valley. Because these individuals are interred in this unique fashion, and because these individuals
represent a minority of “secondary burials” at the site, it is clear that these individuals, either by status during life or in death, are of some importance. The life histories, social identities, and residential origins of the individuals represented by these six skulls are the focus of this thesis.

The majority of previous research in the lower Illinois River valley has focused on the treatment of the dead as inferred from mortuary context (Asch 1976; Buikstra 1976, 1977; Charles 1985, 1992; Charles and Buikstra 2002; Charles et al. 1988; Henderson 1882; King et al.
analyses of human skeletal remains (Beehr 2011; Buikstra 1976; Charles et al. 1988; Hedman et al. 2009; Henderson 1882; Lambert et al. 1979; Rose 2008; Seeman 1988; Tainter 1980), and analyses of spatial distribution, cultural and social complexity, and trade networks (Buikstra and Charles 1999; Charles 1995; Charles et al. 2004; Farnsworth and Asch 1986; Fie 2008; Fortier 2008; Ruby et al. 2005; Yerkes 1988). The type, frequency, and spatial and temporal distributions of mortuary sites are perhaps the most important characteristic of prehistoric life in the region and are thus the foci of many research agendas.

The Middle Woodland period (ca. 150 B.C.-A.D. 250) was a time of increasing social complexity and widespread change in the lower valley, and across much of the Eastern Woodland. During the Middle Woodland period, both population densities and the number of mortuary sites increased sharply over those of the Late Archaic (Buikstra 1988; Buikstra and Charles 1999; Charles 1992; Charles and Buikstra 1983; Charles and Buikstra 2002; Charles et al. 1988; King et al. 2011; McGregor 1959). Both burial mound construction and mortuary ritual increased in complexity during the Middle Woodland period, leading many researchers (Buikstra 1972, 1976; Buikstra and Charles 1999; Charles 1985, 1992, 1995; Charles and Buikstra 2002) to hypothesize that the lower valley area was “(re)colonized” by new or different cultural groups that had migrated into the valley area from elsewhere in the region. While this hypothesis is supported by the marked absence of human populations between c.a. 200-50 B.C., this has not yet been directly tested. Therefore, a secondary focus of this research is an analysis of population movement in the lower valley, but specifically at the Elizabeth site. In essence, the research design surrounding the isolated skulls also serves as a pilot project examining the
efficacy of methods amenable to analyses of residential origins, migration patterns, and genetic heredity in the lower valley region.

1.1 Research Questions

This research seeks to answer a single overarching question: who were the individuals that are represented by the six isolated skulls interred in Mound 3 of the Elizabeth site? In order to answer this question, this thesis will address five auxiliary questions:

1. What are the demographics of the six isolated skulls? What do the demographic parameters suggest about the geographic origin and/or intended meaning(s) of the isolated skulls?

2. Is there variation in isotopic proxies for diet and mobility in early life? Is there variation in these proxies for late life? Do these values suggest that the six skulls are “local” or “non-local” individuals?

3. Is there variation in isotopic parameters for diet between the individuals represented by the six skulls and the remainder of the Mound 3 population? If so, what might have caused these variations in diet and what does this suggest about the status of the six individuals represented by the isolated skulls?

4. Are the six skulls genetically similar to the remainder of the Mound 3 population, or are they genetically different? What might similarity or difference suggest in terms of the statuses of these individuals during life, or the intended meaning(s) of their skulls in death?

5. Are biogeochemical analyses useful in elucidating residential origins and modeling paleomigration in the Lower Illinois River valley? If so, can the current
study be modified and expanded for future research? What are the limitations of such a study?

These questions will be answered through the characterization and analysis of strontium and lead isotope values of tooth enamel, as well as carbon and oxygen isotope values of bone from individuals (n=15) interred in Mound 3 of the Elizabeth site. Isotopic values in skeletal material reflect the isotopic composition of consumed foods, water, and dust particulates that in turn reflect environmental values in the area where an individual resides (Bowen and Wilkinson 2002; Price and Burton 2010; Schoeninger and Moore 1992). Since permanent tooth enamel is formed during childhood, isotope ratios in permanent tooth enamel reflect the geochemistry of an individual’s locale during dental crown formation (Bowen and Wilkinson 2002; Price and Burton 2010; Schoeninger and Moore 1992). Accordingly, characterizing isotope values in skeletal remains permits the differentiation between geologically “local” versus “nonlocal” individuals (Bowen and Wilkinson 2002; Price and Burton 2010; Schoeninger and Moore 1992). Additionally, an analysis of dental metric traits is used here to assess the biological affinities of the Mound 3 population. The analysis of “biological distance,” in this case dental cervicometric analysis, has demonstrated efficacy in elucidating genetic measures of heritability, thus allowing for an assessment of genetic similarity between individuals and/or groups (Hillson et al. 2005; Pilloud and Hillson 2012; Stojanowski 2007; Stojanowski and Buikstra 2004; Stojanowski and Schillaci 2006).

The proposed study represents the first attempt to analyze the cache of skulls interred at the Elizabeth site and has the potential to explain aspects of cultural practices, mortuary ritual, conflict, and social identity during the Middle Woodland period. This is also the first study to model migration in the lower Illinois River valley using biogeochemistry, as well as the first
study to utilize dental cervicometrics as an alternative measure for assessing biological distance. Ultimately, the goal of all archaeological research, regardless of regional focus, is to develop a more thorough understanding of the people and places in the past. In that spirit, this multifaceted analysis has the potential to alter understandings of the prehistoric Midwestern United States.

1.2 Overview of Chapters

Chapter 2 of this thesis presents the cultural development and context of the lower Illinois River valley region organized by chronological period. This chapter also provides the reader with an overview of the geography of the lower valley, and the geography specific to the Elizabeth site. The discussion then transitions to the Elizabeth site with a focus on the history of the site and the archaeological excavations previously conducted. Following the history of the site, the ecology and subsistence of the lower valley is presented, with emphasis on climate, ecological conditions, and the diet and subsistence of lower valley populations throughout time. This chapter thoroughly summarizes the historical background of the indigenous cultures that occupied the region, the physical geography of the area, the Elizabeth site, and the subsistence methods utilized by prehistoric peoples that resided there.

Chapter 3 presents the physical environment and ecology of the lower Illinois River Valley. This chapter specifically discusses the physical geography of the greater valley area, as well as the geography in the immediate vicinity of the Elizabeth site. Following the introduction of the physical environment, the ecological setting of the study area is discussed. This discussion includes a brief review of the local climate, and a thorough discussion of local fauna and flora.

Chapter 4 discusses the ways in which isolated crania have been contextualized in archaeological and cultural contexts around the globe. This chapter summarizes previous
research on isolated crania and trophy skulls, and focuses on the specific interpretations that researchers have drawn using a variety of methodologies and theoretical approaches. Chapter 4 also details the two main hypotheses surround the occurrence of isolated crania in archaeological contexts and provides a foundation for methodological approaches that can be used in contextualizing these enigmatic objects in a broader cultural context.

Chapter 5 broadly covers the bioarchaeology of the Elizabeth site, beginning with a broad overview of bioarchaeology, and proceeding to a discussion of isotopic and osteological analyses. This chapter briefly reviews the historical developments leading to the present state of bioarchaeology. This chapter also includes a discussion of the theoretical perspectives of bioarchaeological analyses and the contextualization of social and cultural identity in the archaeological record. The chapter includes a review of the osteological methods and theories used to reconstruct demographics in archaeological populations. Finally, Chapter 5 focuses heavily on the use of isotopic analysis of human remains in order to assess human paleomobility and diet in prehistoric populations. The specific methods and laboratory preparation of human samples for isotopic analyses are discussed, as are clean lab procedures and mass-spectrometer characterization of samples.

Chapter 6 presents the isotopic data used as a proxy for paleomobility and residential origins for the Elizabeth Mound 3 population. The chapter begins with a brief discussion on the use of isotopic analysis in studies of paleomobility, then the study objective, research questions, and hypotheses are stated and examined. Chapter 6 also presents the geological information on the lower valley and discusses how this information is used in the interpretation of isotopic data. Finally, the chapter presents the results of isotopic analysis of strontium, lead, and oxygen, and discusses the interpretation of this data with regard to the research questions and hypotheses.
Chapter 7 presents the carbon isotopic data that is used as proxy for diet and subsistence for the Elizabeth Mound 3 population. The chapter begins with a brief discussion of the utility of carbon isotopic analysis in paleodietary studies. Chapter 7 also presents faunal archaeobotanical data from the Elizabeth site, Smiling Dan site, and Napoleon Hollow site in order to further elucidate the diet and subsistence utilized by the prehistoric populations residing in the Elizabeth site vicinity. The chapter then presents and discusses the study objectives, research questions, and hypotheses. Finally, the carbon isotope data from bone carbonate are presented and discussed.

Chapter 8 summarizes the use of dental cervicometric analysis in order to assess biological distance for the population interred in Mound 3 of the Elizabeth site. The chapter discusses the use of biological distance research in bioarchaeology, including detailed information on the development of alternative methods of analysis. The objectives of the biological distance study are set forth, including biodistance-specific research questions and hypotheses. The methods utilized in the biodistance study are discussed in detail, including an analysis of intra-observer error. Finally, the results are presented and discussed, and the conclusions of this aspect of the study are detailed.

Chapter 9 presents an overall summary of the study findings. The original research question and auxiliary research questions previously detailed are revisited and discussed, as are the study hypotheses. The chapter then provides a discussion of future research, and provides commentary and conclusions.
2 CULTURAL EVOLUTION AND ARCHAEOLOGICAL CONTEXT

2.1 Cultural Evolution

Numerous archaeological sites in the lower Illinois River valley and greater Midcontinental United States have been studied since the late 19th Century. As a result, a wealth of data exists spanning from the Paleo-Indian Period (ca. 10,000-8000 B.C.) through the modern era (Henderson 1882; King et al. 2011; Thomas 1890). Previous research covers a variety of foci, including the origins of the mound-building tradition in the valley, regional interaction and trade networks, biological affinities of resident populations, paleodemography, diet, and health and lived experiences. In this chapter I provide a chronological summary of cultural development in the lower valley region, discussing the key developments and trends that have been identified.

<table>
<thead>
<tr>
<th>Cultural Period</th>
<th>Approximate Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleo-Indian</td>
<td>10,000-8000 BC</td>
</tr>
<tr>
<td>Early Archaic</td>
<td>8000-6000 BC</td>
</tr>
<tr>
<td>Middle Archaic</td>
<td>6000-2500 BC</td>
</tr>
<tr>
<td>Late Archaic</td>
<td>2500-600 BC</td>
</tr>
<tr>
<td>Early Woodland</td>
<td>600-50 BC</td>
</tr>
<tr>
<td>Middle Woodland</td>
<td>50 BC-AD 400</td>
</tr>
<tr>
<td>Late Woodland</td>
<td>AD 400-1000</td>
</tr>
<tr>
<td>Mississippian</td>
<td>AD 1000-1300</td>
</tr>
</tbody>
</table>

2.1.1 Paleo-Indian Period (10,000-8000 B.C.)

The earliest human occupation of the valley region occurred c.a. 10,000 B.C.; however, sites during this period are rare and therefore data are sparse (Henderson 1882; King et al. 2011; Thomas 1890; Winters 1959b). During the Paleo-Indian Period and for much of the subsequent Early Archaic Period (c.a. 8000-6000 B.C.), populations in the lower Illinois River valley and
across much of the broader region are characterized as small familial groups or bands of nomadic Hunter-Gatherers that engaged in widespread geographic movement and utilized short-term encampments (Carlson 1979; Charles and Buikstra 1983; Cook 1976; Goodyear 1979; Meyers 1970; Winters 1959b). Population density during the Paleo-Indian period was extremely low, perhaps in part due to the expansive and unoccupied geographic areas of the greater region, as well as an abundance of biotic resources (Goodyear 1979; Meyers 1970). Both the diversity and availability of these resources enabled communities to occupy a greater portion of the valley rather than limiting them to resource-rich areas, thereby resulting in increased population density. Winters (1959b:7) suggests that regional Paleo-Indian culture ceased over time, perhaps as a result of the merging of cultures during a transitional phase spanning the late Paleo-Indian and Early Archaic Periods. However, the lack of habitation sites in this region during Archaic period constrains a more in-depth examination of the cultural context, and much of what has been postulated is conjecture based on analogous cultures elsewhere in the United States (Winters 1959b).

2.1.2 Archaic Period (8000-600 B.C.)

At or around 8000 B.C., the Continental Archaic culture developed across the lower portion of North America (Winters 1959a). Of the two distinct branches that constitute the Continental Archaic, the Eastern Archaic branch encompasses both the cultures and the geographic area extending from the western plains to the Atlantic Coast, including the numerous regional cultural groups therein (Winters 1959a). While high rates of mobility and opportunistic exploitation of seasonal resources continued during the initial phases of the Archaic Period, archaeological evidence suggests that semi-permanent settled communities emerged around 7000 B.C. (Brown and Vierra 1983; Buikstra 1988; Buikstra and Charles 1999). Winters (1959a:13)
states that the artifacts recovered from encampments and surface surveys are temporally associated with the early “Foraging Stage” (8000-6000 B.C.) and include weapons (side-notched contracting stem projectile points) and domestic-use tools (grinding stones, slabs, flake side scrapers, choppers, bone awls). Limited evidence also suggests that fabricating tools were also present, including drills, hammerstones, and flakers, as well as simple stone pendants, which were likely ornamental objects (Winters 1959a:13). Researchers have uncovered limited evidence of burials within the middens of these Early Archaic sites (Brown and Vierra 1983; Buikstra 1988; Buikstra and Charles 1999; Charles and Buikstra 2002). However, by most accounts, burials were rather unremarkable, with only a few containing any grave goods, and most representing the unfortunate necessity of disposing of a deceased community member (Charles and Buikstra 2002).

During the Middle Archaic Period (c.a. 6000-2500 B.C.), both sedentism and economic intensification began in the region (Brown and Vierra 1983; Buikstra 1988; Buikstra and Charles 1999; Charles 1995; Charles and Buikstra 2002; King et al. 2011). Brown and Vierra (1983:190) suggest that, in response to the increasing availability of staple resources, strategic long-term encampments began arising near areas with abundant, highly productive resources, indicating both a reliance on specific resources and increasing economic intensification. Researchers further postulate that the shift toward sedentism and resource reliance during the Middle Archaic was prompted, at least in part, by the evolution of a productive slack-water environment of the lower valley area, making sedentism more efficient than the previous hunting and gathering subsistence model (Brown and Vierra 1983; Buikstra and Charles 1999). Clear changes in cultural practices and material culture occur beginning around 6000 B.C., including the emergence of new tool preparation techniques and tool types (Winters 1959a). During the
transition between the preceding Foraging Stage and the later “Exploitive Stage” (Winters 1959a:13), stylistic changes due to the implementation of a new woodworking toolkit results in the development of pecked and polished stone tools and ornaments, further indicating an increase in leisure time. Around 5000 B.C. tools and ornaments fashioned from the native copper of the region are evident, as is the sharp increase in the number and variety of weapons, domestic implements, and fabricating tools (Winters 1959a). Concurrent with the punctuated increase in material culture is a surge in both the number of encampments and the amount of cultural debitage found within such sites. Winters (1959a:13-14) has interpreted these increases as indicative of an expansion in population due to resource availability, though he is quick to acknowledge three factors that distort interpretations: 1) early sites may simply be more stratified and thus less frequently encountered than more recent sites; 2) small sites may be incorrectly interpreted as more recent due to the absences of diagnostic artifacts; and 3) the lengthier persistence of the Exploitive Stage may have simply resulted in a greater accumulation of artifacts and a greater number of occupied sites. Regardless, the resulting long-term settlements and exploitation of ecological niches appears to have propelled cultural development. One particularly remarkable development is the utilization of formal areas for the disposal of the dead, which begins to occur around 6000 B.C. (Buikstra 1988; Buikstra and Charles 1999; Buikstra et al. 1998; Charles 1995; Charles and Buikstra 1983; Charles and Buikstra 2002; Charles et al. 1986; King et al. 2011; Winters 1959a).

Interment of the dead during the Middle Archaic progressed beyond the simple midden interments of Early Archaic habitation sites, to the construction of formal cemeteries (Buikstra 1988; Buikstra and Charles 1999; Charles and Buikstra 2002; King et al. 2011). In addition to the continued utilization of habitation site middens for burials, two new mortuary-site patterns
emerge during the Middle Archaic: burials located near the terminal edges of bluff crests, and burials in the raised sand ridges of the valley floor in association with seasonal encampments (Buikstra 1988; Buikstra and Charles 1999; Charles and Buikstra 2002). During this time, midden burials are most often utilized for the very young and very old, as well as individuals that appear to have been ill; adults, adolescents, and older children were instead interred in bluff crest mortuaries (Charles and Buikstra 2002; Charles et al. 1988). One of the most intriguing aspects of this trend toward formal cemeteries is the emergence of the mound building tradition that has come to exemplify the cultural expression of the lower Illinois valley populations of the period. Through the addition of bodies and the deposition of earthen caps, what initially began as modest burial knolls eventually grew into relatively prominent burial mounds (Buikstra and Charles 1999). Charles and Buikstra (1983; 2002) have noted that the mortuary tradition established during the Middle Archaic arose during a time of decreased mobility and is perhaps linked to increasing territoriality. By and large, this mortuary tradition remained in use in the valley for some 5000 years (Charles and Buikstra 2002).

During the Late Archaic Period (ca. 2500-500 B.C.), cemeteries were being constructed exclusively on bluff crest mounds at the valley periphery, and also expanded beyond the proximity of the main river valley to encompass elevated points along nearby tributaries, perhaps reflecting a population expansion into adjacent areas of the valley (Buikstra and Charles 1999; Charles et al. 1988; King et al. 2011). The development of mound and mortuary complexity (i.e., overall size of mounds; formal organization; central log crypts) throughout the Archaic period suggests increased social intricacy amongst the lower valley populations, a trend that did not continue (Buikstra 1972, 1976; Buikstra 1988; Buikstra and Charles 1999; Buikstra et al.)
1998; Charles 1995; Charles and Buikstra 1983; Charles and Buikstra 2002; King et al. 2011; Ruby et al. 2005).

2.1.3 Woodland Period (600 B.C.-A.D. 1000)

In stark contrast to researchers’ assumptions regarding the trajectory of cultural development in the valley, the Early Woodland period (ca. 600-50 B.C.) is marked by a sharp decrease in population densities and a relative absence of mortuary sites in comparison to the relative abundance of such during the preceding Archaic period (Buikstra and Charles 1999; Charles 1985, 1992, 1995; Charles et al. 1986; Farnsworth and Asch 1986; King et al. 2011; Winters 1959b). In fact, very few burials and scattered occupation sites exist from the Early Woodland period (e.g., The Peisker Site, Pete Klunk Mound 7), suggesting the presence of only a few highly mobile groups, and rendering human presence during the period “nearly invisible” (Buikstra and Charles 1999:212). Interestingly, the few individuals recovered were once again interred in middens in similar fashion to those of the Early Archaic. Through the interpretation of ceramics and radiocarbon dates, Farnsworth and Asch (1986) confirm that a period of broad abandonment occurred between the latter part of the Early Woodland and the early Middle Woodland periods. However, around 50 B.C., a clear shift in material culture and the construction of bluff crest tumuli mark the re-colonization of the lower valley by “new” groups (Buikstra and Charles 1999; Charles and Buikstra 2002; Farnsworth and Wiant 2006; King et al. 2011).

The re-colonization of the lower valley area during the latter part of the Early Middle Woodland appears to be the impetus for change throughout the valley, as both mound construction and mortuary ritual increase in complexity during this time. During the Middle Woodland Period (ca. 50 B.C.-A.D. 400), population densities and the number of mortuary sites
both increase sharply over those of the Late Archaic (Buikstra 1988; Buikstra and Charles 1999; Charles 1992; Charles and Buikstra 1983; Charles and Buikstra 2002; Charles et al. 1988; King et al. 2011; McGregor 1959). Buikstra (1972; 1976:28) estimated that population density during the Middle Woodland was approximately 0.46 individuals per square mile, or approximately 1,288 individuals within the 2,800 square mile research area. The material culture and mortuary patterns exhibited subsequent to the Middle Woodland re-colonization event are characteristic of the Hopewell Interaction Sphere, a “panregional phenomenon” involving the exchange of exotic materials and characterized by elaborate mortuary ritual (Charles and Buikstra 2002:19). Many researchers (Buikstra 1972, 1976; Buikstra and Charles 1999; Charles 1985, 1992, 1995; Charles and Buikstra 2002) interpret this renewed fluorescence and change in cultural practices signaling the re-colonization of the valley by new or different groups (either biologically or culturally) that migrated to the valley from adjacent areas or elsewhere in the broader region. The Middle Woodland “mortuary religious complex” (Buikstra 1972, 1976; Caldwell 1959) consisted of multiple sites of formally organized community cemeteries, which eventually progressed into the construction of large, linear organizations of multiple mound complexes perched upon prominent bluff crests (Buikstra and Charles 1999; Charles and Buikstra 2002; King et al. 2011). Middle Woodland burial mounds were relatively elaborate structures, measuring seven 7m high and 35m in diameter (on average), typically built in a single construction phase, and often consisting of elevated ramps and central log tombs with roofs (Buikstra 1988; Buikstra and Charles 1999; Charles et al. 1986). The process of interment likely involved a period of public viewing as the body decomposed in the tomb, which was followed by the bundling of the remains for burial in the pit, or elsewhere in the ramp area (Buikstra 1988; Charles and Buikstra 2002; Charles et al. 1986).
Mound type and material culture suggest these the ‘new’ residential groups recolonizing the valley may have immigrated to the lower valley from the central Illinois valley to the north (Bullington 1988; Farnsworth and Asch 1986). Studenmund and Farnsworth (2000) suggest that, while movement trended in a north-to-south direction, radiometric data did not support a southward migration model. Recent research by King et al. (2011) analyzed published radiocarbon data and conducted new radiocarbon assays of both skeletal bone collagen and Middle Woodland mound and habitation sites to develop a more thorough model of intra-site mound chronologies and to further assess the temporal and spatial dynamics of valley settlement. The data presented by King et al. (2011) support the hypothesis that reoccupation of the lower valley occurred in a north-to-south trajectory, and further indicate that the most likely sites for the initial re-colonization of the valley are those near the mouth of the Blue Creek at the northern section of the lower valley.

2.2 The Elizabeth Site: History and Excavation

The Elizabeth site (11PK512; Figure 2.1) is a multicomponent site located in the northern section of the Illinois valley on the western bluff just adjacent to the Illinois River. The site was excavated under the direction of Jane Buikstra (PI) and co-directors Douglas Charles and Steven Leigh as part of the Northwestern University Archaeological Field School over multiple field seasons between 1979 and 1985 (Charles et al. 1988). The entire site consists of 14 mounds and three knolls, with cemeteries that date to the Archaic (ca. 8000-600 B.C.), Middle Woodland (ca. 50 B.C.-A.D. 400), and Late Woodland (ca. A.D. 400-1000) periods (Charles et al. 1988). Mounds 1, 3, 4, 6, and 7 date to the Middle Woodland period, while other mounds are likely Late Woodland structures (Charles et al. 1988). Both Middle and Late Woodland mounds appear to have been erected Archaic period structures and debris scatters (Leigh et al. 1988).
The focus of this research is Elizabeth Mound 3 (hereafter Mound 3; Figure 2.1), a modest Middle Woodland mound located in the northeastern section of the site near the termination of a small ridge to the north of Mound 1 (Leigh et al. 1988). Mound 3 is constructed atop Archaic-period debris with little-to-no modification of the ground surface (Leigh et al. 1988). Mound 3 is located entirely on the north-facing slope and consists of a central pit, a rectangular log crypt (2.7 m x 1.4 m) oriented NNW-SSE (Leigh et al. 1988:45). The crypt contained the extended remains of one adult male and one adult female (Burial 2, Skeletons 1 and 2); traces of niter on top of the remains and the pit floor suggest a log roof was likely placed on the tomb during or after the ‘final’ interment (Leigh et al. 1988). Buikstra and Charles (1999:213) note that similar to Mound 1, Mound 3 is an uncomplicated structure that is representative of an early Hopewellian community cemetery. Although Mound 3 included a
central feature and encircling burials, it did not consist of the elevated earthwork ramp that is characteristic of Middle Woodland Hopewellian structures (Buikstra and Charles 1999:214). However, the mound did have an apron that was placed around the central feature after the interment of Burial 2, which is typical of mounds constructed during the Middle Woodland period (Leigh et al. 1988).

![Figure 2.2: Elizabeth site Mound 3 (adapted from Leigh et al. 1988:46)](image)

Following the apron construction, a small trench measuring 1.4m x 0.5m, approximately 40 cm deep, was cut into the mound, penetrating through the apron approximately 50 cm north of the burial crypt (Burial 2), and into the A horizon beneath (Leigh et al. 1988). Six adult male skulls were interred in the trench, aligned relatively perpendicular to the NNW-SSE orientation of the central crypt (Leigh et al. 1988). The skulls were found in various stages of preservation, some with articulated cervical vertebrae and mandibles, some with only mandibles, and some
that consisted of only crania, suggesting all were likely curated for some period of time prior to the final interment (Leigh et al. 1988:46). Additionally, no cut marks were found on the skulls (Leigh et al. 1988:47). The interment of the six skulls in Mound 3 is an anomaly in the lower valley region, and no similar events have yet been documented. Accordingly, this likely represents an event of great significance, the nature of which is currently unknown.

Radiocarbon dating for Mound 3 of the Elizabeth site has been conducted on skeletal materials (Buikstra et al. 1998; King et al. 2011). Buikstra et al. (1998) tested EZ3 individual 7-1 (an achrondroplastic dwarf) and obtained a calibrated radiocarbon date range of A.D. 132-388, while King et al. (2011:502) tested EZ3 individual 2-1 and obtained a calibrated radiocarbon date range of A.D. 72-211. Given that Burial 2 appears to represent the initiating event for Mound 3, we can assume the Middle Woodland component of Mound 3 was constructed sometime around c.a. A.D. 72-211. As the Feature 1 burials occurred sometime after this event, the six skulls can also be temporally associated with the Middle Woodland period. This temporal association, along with the anomalous nature of the interment of the skulls, makes the event unique in the context of the re-colonization of the lower valley.
3 PHYSICAL ENVIRONMENT, GEOLOGY, AND ECOLOGY

3.1 Geography of the Lower Illinois Valley

It is important to note here that there is a geographical area and a research focus area that are both referred to as the lower Illinois River valley or lower Illinois valley (or some variant thereof), both of which are important to the research conducted herein. The geographic term refers to the entire lower valley area described below, while the research area refers to a specific area was the focus of archaeological research conducted by Northwestern University, the Center for American Archaeology, and others. The “Lower Illinois River Valley” archaeological research area encompasses the 70 miles of the lower river drainage beginning at approximately 39°49’ north latitude, near the modern town of Meridosia, IL (Struever 1968:291). This research area stretches southward to the confluence of the Illinois and Mississippi rivers, roughly 2,800 square miles, which includes both the expansive floodplains and the adjacent uplands extending some 20 miles to either side of the river valley (Struever 1968).

In general, Illinois is an unassuming and relatively flat prairie plain, with elevations ranging from a minimum of 268 feet above sea level (ASL) to a maximum of 1,065 feet ASL with few notable physiographic distinctions (Leighton et al. 1948). The southern portion of Illinois is distinguished by its warmer climate, and more rugged topography, a result of glacial and fluvial modification spanning many millennia. Three primary features characterize the geography of Illinois River valley: the Illinois River, the expansive flood plain on the valley floor, and large bluffs that define the eastern and western limits of the valley. The river begins at the junction of the Des Plaines and Kankakee rivers in the northeastern area of Illinois and flows 273 miles across the state (Turner 1936). The 215 miles of the “lower” portion of the Illinois
River begins at the “Great Bend,” a turning point some 63 miles from the river’s head where the direction of flow transitions from westerly to southerly and the lower valley begins (Sauer 1916:17-18). The lower valley sits between several physiographic divisions of the landscape. The majority of the valley is within the Central Lowland Province in the Till Plains section, although the southernmost portion of the valley (near the confluence of the Illinois and Mississippi rivers) sits on easternmost the periphery of the Ozark Plateaus Province (Leighton et al. 1948). The valley itself is located on the ancient Illinois floodplain, with the Galesburg plain occupying the area to the northwest, and the Springfield plain to the southwest (Leighton et al. 1948). The area immediately west of the lower valley (located in the aforementioned Ozark Plateaus Province) is different in the northern and southern sections of the valley: in the northern section is the Griggsville plain, while the Lincoln Hills section abuts the western margin in the southern portion of the valley (Leighton et al. 1948).
Figure 3.1: Physiographic Divisions of Illinois (adapted from ISGS)
This lower valley area is characterized by floodplains between 2 and 7 miles wide, periodic narrowing and expansion of the valley walls, the absence of the rocky bluffs that characterize the narrower northern valley, prominent gravel terraces, a modest fluvial gradient, and a meandering river course amenable to navigation (Sauer 1916; Turner 1936). The geological age, stability, navigability, and availability of resources all made the natural environment of the lower valley extremely amenable to human occupation.

In comparison to the upper valley, the lower Illinois River valley has been filled with a greater amount of silt, differentially deposited by the flow of the river and resulting in high riverbanks and poorly developed natural levees (Struever 1968; Turner 1936). These high banks and levees cause the impounding of seasonal floodwaters, creating a variety of permanent and seasonal catchment lakes in the forested and wet prairie areas in the levee backwater zones (Struever 1968; Turner 1936). Whereas the permanent lakes are deep, temporary lakes are often shallow as a result of frequent silt deposits (Turner 1936). Smaller areas of water accumulation such as ponds or sloughs also occur with some regularity due to the small springs and tributaries that abound in the valley bottom (Turner 1936). During the late summer, or during drought cycles, the water catchment areas and shallow lakes evaporated, yielding extensive mud-flats that provided an ideal habitat for local seed-bearing plants (Struever 1968). In the lower valley area the river gradient is gradual, causing a sluggish flow that winds about the valley floor, but generally remains close to the western bluff (Struever 1968). On the eastern side of the valley bottom is a broad alluvial plain that once would have supported a forest of water-tolerant trees and other flora (Struever 1968). The alluvial bottomland is made even more productive by the
frequent flooding of the river, a result of water backlogs from the adjoining Mississippi River in the southernmost portion of the lower valley (Struever 1968).

At the base of the looming bluffs, begins the talus slope zone, a hillside transition that is covered in oak-hickory forest (Struever 1968). The talus slope zone gives way to the bluff face, an inhospitable environment characterized by perpendicular limestone bluffs covered in windblown loess and residuals where few plants grow (Turner 1936). The bluffs themselves tower up to several hundred feet over the valley floor and a landscape of “heavily dissected terrain” persists (Struever 1968:291). The entire area from the talus slope zone and extending several miles outward from the valley is littered with natural springs and tributary streams that cut through the bluffs and talus slope toward the valley floor below (Struever 1968; Turner 1936).

3.1.1 Geography at the Elizabeth Site

The geography in the immediate vicinity of the Elizabeth site generally adheres to the geography typical of the lower valley. In this portion of the valley, the Illinois River remains close to the western bluffs, resulting in a floodplain of nearly 6.5 km in width (Charles et al. 1988). The site is located on the finger of a western bluff in the northern portion of the lower valley on a large, erosional ridge oriented roughly WNW-ESE (Charles et al. 1988; Fisher 1988). The mound group sits on the northern corner of the bluff, which towers 50 meters above the valley floor below, offering sweeping views of the expansive valley, the opposing bluffs, and the Illinois River below (Charles et al. 1988). As is typical for the valley, the vertical face of the bluffs is composed of limestone; eroded loess overburden and a steep talus slope provide an abrupt transition to the valley floor below (Charles et al. 1988). Atop the bluff, the interior
uplands are gentle and rolling with peak elevations around 190-195 m above sea level (Fisher 1988).

The bluff upon which the Elizabeth site is constructed breaks to the south where a permanent stream flows through the bluff and adjoining talus slope zone, then into the hollow below (Charles et al. 1988). The ridge slopes gently at approximately 4° toward the end of the bluff, narrowing slightly as it progresses easterly (Fisher 1988:9). The slopes on both sides of the ridge are moderate and occasionally steep, while the crest of the ridge is gentle (Fisher 1988). Three gullies extend to near the top of the south slope, resulting in accelerated erosion (Fisher 1988:10).

On the eastern end of the ridge, there is a bifurcation that branches to the north and the south. The northern segment eventually melds with the erosional topography at a lower tier, while the southern segment continues easterly and eventually slopes downward to the limestone on the bluff face (Charles et al. 1988). Mounds 1-4 are all positioned within the primary section of the ridge prior to the bifurcation, whereas Mounds 1-2 are on the southern segment, and Mound 3 is on the northern segment (Charles et al. 1988). An additional ridge originating at the midpoint of the main ridge extends southward and protrudes into Napoleon Hollow, an Archaic and Late Woodland site located on the valley floor below, just adjacent to the river (Charles et al. 1988). Mounds 8-12 of the Elizabeth site are located on this the secondary ridge, while Mound 13 (and several burials) were located on two smaller ridges to the west of the secondary ridge (Charles et al. 1988).

3.2 Geology of the Study Area

The geology of the study area is of fundamental importance in biochemical analyses as regional geochemical signatures from bedrock directly influence the chemical composition of
human and faunal skeletal remains. Considerations important to biochemical analysis include local soil composition and conditions, composition of geological bedrock, sources of fresh water, elevation, climactic conditions, and subsistence patterns. Additionally, the efficacy of isotopic analyses as proxies for geographic origins and paleomobility is largely dependent on sufficient regional geological variation to allow measureable differences in isotope values (Knudson and Price 2007; Price 1989; Price and Burton 2010; Price et al. 1985).

For the purposes of biochemical analyses, ascertaining the composition of bedrock layers is of primary importance given the associated variations in geochemical values. The geology of the broader study area is varied, with underlying bedrock composed of various types and ages of sedimentary rock, including dolomite, siltstone, and shale, which range in age from the Lower Paleozoic to the Middle Cenozoic (Kolata 2005). Within the northern portion of the lower river valley, the local geology consists largely of eroded Pennsylvania shales, Meramec-Osage and Mississippian limestone, with glacial deposits of chert and oolitic (egg stone) material extending to depths of approximately 150 feet (Horberg 1950; Turner 1936). The bluffs that bound the valley bottomland are generally of the same composition, though in the southern areas of the lower valley (Calhoun County), the bluffs also contain outcrops of Devonian and Silurian limestone, which overlay deep beds of Ordovician limestone and shale (Turner 1936:690). In the immediate vicinity of the Elizabeth site are bedrock formations of sedimentary rock dating to the Middle Paleozoic (Silurian, Devonian, and Mississippian) and Upper Paleozoic (Pennsylvanian and Permian), with formations of Meppen Limestone, Burlington-Keokuk Limestone, and the Fern Glen Formation of limestone, shale, and chert (Hedman et al. 2009). Deposited over the surface of these varied bedrock layers are assorted glacial deposits and loess (see below), remnants of the large and expansive glaciers that once blanketed the upper Midwestern United
States. The numerous sediments uplifted, transported, and subsequently deposited by the glacier along the glacial path constitute these glacial deposits. Glacial deposits in Illinois are largely comprised of Paleozoic bedrock of carbonate rock and shale. Of this conglomeration, the sediments native to the local area represent the preponderance of the composition, with transported sediments making up comparably less (Hedman et al. 2009).

Surficial Quaternary deposits in the immediate vicinity of the Elizabeth site stem from the Hudson glacial episode, the period between the present and approximately 10,000 years ago. Deposits include the Cahokia Formation, alluvium ranging from clay and silt to medium sand and ranging from approximately 15 to 40 feet in thickness, with the upper 5-30 feet composed of silt and clay (McKay 2005). Additionally, river sand, gravel, and silt deposits are present in the areas adjacent to the Illinois River, including the natural flood plain and valley floor.

Loess is an important Quaternary sediment that results from the accumulation of wind-blown dust (Jacobs et al. 2012). Loess deposits consisting of alluvium (clay, silt, sand, and gravel) cover the Illinois area, including the lower Illinois River valley. These deposits are the result of the predominate easterly paleowinds that caused loess accumulations of up to 30 meters along the eastern uplands, especially in valleys with a north/south orientation, such as the lower Illinois River valley (Muhs et al. 2001). Following glacial activity in the region, loess deposition also stopped, and soil formation processes began to modify the upland loess mantle. Given erosion and topographic change, loess thickness has varied over time, especially in source valleys where loess tends to thin rapidly. However, the local landscape has remained generally stable over the past several thousand years, thus these minor alterations should not be an issue for the relatively recent Woodland period. Loess thickness in the immediate vicinity of the Elizabeth site varies between one and five meters, with areas on the eastern bluffs of the valley
(those opposite the site) averaging greater than 5 meters of loess deposit (Kohfeld and Harrison 2001; Muhs et al. 2001). According to the Illinois Loess Thickness data from the Illinois State Geological Survey, the western bluffs on the southern periphery of the site have loess accumulations of approximately 15-20 feet in thickness.

In much of Illinois, as well as many of the adjacent states, loess has higher levels of smectite than do the underlying glacial deposits, which are enriched in both ilite and chlorite (Kohfeld and Harrison 2001; Muhs et al. 2001). Consequently, where loess thickness is sufficient enough to constitute the soil parent material, the \(^{87}\text{Sr}/^{86}\text{Sr}\) values of underlying bedrock are not a reliable predictor of the strontium isotope values of the overlying loess (Hedman et al. 2009). However, \(^{87}\text{Sr}/^{86}\text{Sr}\) values of loess do vary based on the underlying bedrock material. Loess that overlays shales, which have higher \(^{87}\text{Sr}/^{86}\text{Sr}\) values than loess, will be higher than loess which overlays carbonates, which have \(^{87}\text{Sr}/^{86}\text{Sr}\) values similar to those in loess (Kohfeld and Harrison 2001; Muhs et al. 2001). According to the “Loess Thickness” data from the Illinois State Geological Survey, loess thickness in the immediate vicinity of the Elizabeth site is minimal, if existent. Additionally, the Paleozoic formations of shale, sandstone, and carbonate that characterize the bedrock of the Illinois valley all have generally lower \(^{87}\text{Sr}/^{86}\text{Sr}\) values than do the Precambrian formations of Wisconsin, Ohio, Kentucky, and Tennessee (Kohfeld and Harrison 2001; Muhs et al. 2001).

Two modern residential wells have been drilled in the general vicinity of the Elizabeth site and provide additional insight into the geologic formations that underlay the area. Both wells are registered with and reported by the Illinois State Geological Survey and are located in Pike County, Illinois, in the Griggsville Quadrangle. The first well (Pike API #121492128900) is approximately 193 meters WSW of the Elizabeth site and was drilled in March of 1986 to a
depth of 19 feet. In the top layers (less than 10 feet deep), engineers encountered moist brown silt loam, reddish-brown clay loam (glacial till), and sandstone pieces. Below 10 feet, the matrix was composed of brown silty clay with pieces of broken chert and limestone, with white chert and medium grey crystalline limestone and chert fragments occurring below 16 feet. The second well (Pike API #121492129600), located approximately 900 meters NNW of the site was drilled in April of 1986 to a depth of 47 feet. At depths less than 20 feet, the matrix was composed of moist brown silt, with silt loam occurring between 20-35 feet. Below 38 feet, the matrix was silty clay loam with chert pieces and clay; below 43 feet, the matrix transitioned to medium grey crystalline limestone with chert pieces and intermittent layers of secondarily deposited chert limestone. Layers of limestone continued to a depth of 47 feet. While the collection, documentation, and reporting of these wells is by no means scientifically rigorous, the information provided does coincide with other data on the area.

Due to the highly varied geology of the Elizabeth site, as well as the position of the site nearby the Illinois River, and because it has been hypothesized that prehistoric populations throughout the valley resided on the valley floor (Buikstra 1972, 1976; Buikstra and Charles 1999; Buikstra et al. 1998; Charles 1992; Charles and Buikstra 2002; Farnsworth and Asch 1986; Farnsworth and Wiant 2006; Fowler 1959; Leigh et al. 1988; Tainter 1980; Yerkes 1988), lead, strontium, and oxygen isotopes could be heavily influenced by alluvial deposition and meteoric water variation (Knudson et al. 2009; Price 1989; Price et al. 1985; Turner and Armelagos 2012; Turner et al. 2009; Turner et al. 2005). While this expansive section of bedrock would seem incompatible to analyses that require sufficient geologic variation, the glacial till and loess contribute to greater geologic variation across the broader region (Horberg 1950).
Research using strontium isotope analysis has been limited in the Midwestern United States due to the concerns regarding the relative homogeneity of bedrock signatures throughout the region. However, in a recent study, Hedman et al. (2009) assessed the geologic variation of the broader region and ultimately concluded that sufficient variation of $^{87}\text{Sr}/^{86}\text{Sr}$ values exists. Furthermore, similar research (Ambrose et al. 2003; Gregoricka 2013; Slater et al. 2014) has been successful in the analysis of strontium isotope values in analogous or nearby regions. $^{87}\text{Sr}/^{86}\text{Sr}$ values have previously been reported for the geological sequences in Illinois (Stueber et al. 1987), including carbonates (limestone and dolomite), shales, and sandstones, which are summarized in Table 3.1.

Table 3.1: $^{87}\text{Sr}/^{86}\text{Sr}$ Values of geological layers

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>$^{87}\text{Sr}/^{86}\text{Sr}$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate (limestone, dolomite)</td>
<td>0.7076-0.7098</td>
</tr>
<tr>
<td>Shales</td>
<td>0.7279-0.7547</td>
</tr>
<tr>
<td>Sandstones</td>
<td>0.7106-0.7276</td>
</tr>
</tbody>
</table>

Lead isotope values for the study area also vary, but can be compared to the Mississippi Valley-Type (MVT) ore values, a global, descriptive mineral deposit model created by the U.S. Geological Survey Mineral Resources Program. This type collection is based, at least in part, on the geological formations observed in the Ozark Plateau, an expansive geological conglomeration located to the southeast of the Illinois sedimentary basin (Leach et al. 2010). The lead ore values corresponding to the geological formations of the lower Illinois River valley are summarized in Table 3.2 and are based on Leach et al. (2010).

Table 3.2: Lead Values for MVT ore

<table>
<thead>
<tr>
<th>Lead Ratio</th>
<th>MVT ore Range (min, max)</th>
<th>Mean MVT ore Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{206}\text{Pb}/^{204}\text{Pb}$</td>
<td>19.526-23.910</td>
<td>21.5317</td>
</tr>
<tr>
<td>$^{207}\text{Pb}/^{204}\text{Pb}$</td>
<td>15.724-16.28</td>
<td>15.9869</td>
</tr>
<tr>
<td>$^{208}\text{Pb}/^{204}\text{Pb}$</td>
<td>39.216-43.55</td>
<td>40.9991</td>
</tr>
</tbody>
</table>
Based on data sourced from the International Atomic Energy Agency-World Meteorological Organization Global Network for Isotopes in Precipitation (GNIP) and the model derived by (Bowen and Revenaugh 2003), water oxygen values were estimated for the coordinates of the Elizabeth site using the Online Isotopes in Precipitation Calculator (OPIC), which yielded a mean annual value of -7.00‰ (Bowen 2015).

3.3 Lower Valley Ecology and Subsistence Strategies

The ecological setting of the lower Illinois valley is one of immense variation across a small geographical area which provided a relatively stable, lush environment for prehistoric groups (Buikstra 1977). The geography of the lower valley, which is characterized by the Illinois River, the lush river valley including the expansive flood plain, and the uplands, provides ample space and rich, productive, natural resources on which to base human subsistence. The following briefly summarizes the ecological setting and subsistence strategies of the prehistoric inhabitants of the lower valley area.

3.3.1 Climate of the LIRV

The climate of the lower valley is humid and temperate, with cold and relatively dry patterns dominating during the winter, and warm, wet summer patterns (Talkington 1991). Three air masses are present in the region, each of which affects the local climate. A cold, dry air mass emanating from Canada is most common in the winter, while a warm, humid air mass from the Gulf of Mexico is most common during the summer. This summer air mass is the source of most of the precipitation in the valley region. The final air mass, which originates over the Pacific Ocean, brings mild, dry air to the Illinois area. Although certain air masses are “most common” during a particular season, any of these three masses can be found over Illinois during any season; this results in a wide day-to-day variation in both precipitation and temperature, with
temperatures averaging 50°-55°F, and annual precipitation between 35-38 inches (Talkington 1991).

3.3.2 Ecological Setting of the LIRV

The geography of the lower valley has produced a number of diverse ecological environments that Struever (1968:291) describes as “a narrow biome differentiated internally into a number of small-scale plant associations cutting through a vast prairie landscape.” The flora of the valley can best be categorized according to the physical relationship of the species with the river and backwaters, including aquatic, moist-soil, and upland vegetation, all of which have life cycles that are closely linked to the waters (Talkington 1991).

As a result of the shallow grade and the slow meandering of the Illinois River, along with the natural levees and broad flood plain, the valley bottom is frequently flooded and covered in natural sediments transported by the river. Additionally, these seasonal floods resulted in pooling water that varied directly with seasonal flooding and drought cycles, resulting in captive fish populations (Struever 1968). A wet prairie covered a narrow corridor of higher ground just adjacent to the bluff line at the eastern limit of the valley bottom. The catchbasins of the valley bottom matured and withered throughout the course of the season, providing expansive mud-flats where seed-bearing plants such as Chenopodium (goosefoots), Polygonum (knotweed/knotgrass), Iva (marshelder), and Amaranthus (amaranth) thrived (Struever 1968). The aquatic vegetation of the lower valley ecosystem grows in water, either entirely beneath the surface, emerging from the water, or floating on the surface, and includes the lotus or water lily (Talkington 1991). Similar to the aquatic vegetation, moist-soil vegetation grows in and around the mudflats at the periphery of backwater lakes and in dried-up lakebeds. Moist-soil plants, which depend on year-round cycles of specific water levels, are the most abundant form of vegetation in the lower
valley and include arrowleaf, cocklebur, and species of millet, smartweed, nutgrasses, rice cutgrass, Spanish needles, teal grass, and water hemp (Talkington 1991). Forests of black willows, cottonwoods, and soft maples, all water-loving species, are most common in the bottomland forests that flank the river and include slack water lakes (Talkington 1991). These bottomland forests give way to a forest comprised of mixed soft-woods, including silver maple, American elm, swamp privet, red mulberry, box elder, green ash, sycamore, and river birch, all of which provide much more hospitable environment than do the water-loving species (Talkington 1991). Further from the river and toward the talus slope zone, species diversity increases with a mix of softwoods, sugarberry, hackberry, hawthorn, honey locust, bur oak, persimmon, and dogwood (Talkington 1991).

The uplands, which extend between several hundred meters to many miles away from the bluff edge, are covered in a verdant heavy oak-hickory forest that slowly gives way to a high grass prairie beyond the forest belt (Struever 1968; Talkington 1991). The upland forest consists of many species of oak and hickory, as well as red and sugar maples, and black walnuts (Talkington 1991). The prairie ecosystem predominates across the greater region, extending south and west from the Great Lakes (Struever 1968).
4 CONCEPTUALIZING THE SOCIAL IDENTITIES OF ISOLATED CRANIA

4.1 Introduction

The display of human bodies and body parts can serve a multitude of functions and may be interpreted in a variety of ways. However, beyond the intended function or perception, such a display makes a very clear, profoundly powerful statement by the group that has commissioned their exhibition. Numerous anthropological researchers across the globe have been confronted with interpreting the display of the dead and/or disembodied remains in both extant and archaeological cultures. Conceptualizing this intriguing manifestation of social identity has required the implementation of diverse theoretical perspectives and methodologies (Browne et al. 1993; Carmichael 1988; Drusini and Baraybar 1991; Forgey 2005; Forgey and Williams 2005; Giles et al. 2010; Kellner 2002; Knudson et al. 2009; MacDowell 1991; Proulx 1971; Proulx 1989; Tung 2007; 2008; Tung and Knudson 2008; Verano 1995). One of the most powerful images portrayed by such displays is that of the “trophy head.” Here and throughout I utilize the term “trophy head” which has numerous interpretations and implications; however, my use of the term is defined simply as “isolated crania (or skulls) that through mortuary treatment or burial context is of some perceived importance.” Through interpretation, data analysis, and the development and application of regionally specific paradigms, the importance of isolated crania has been summarized as representing three potential scenarios: the display of vanquished adversaries, the display of venerated ancestors, or the display of warriors who were killed and beheaded by their enemies.

In North America, the existence of trophy heads is less common than in other regions (e.g., Peru), though some examples do exist (Chacon and Dye 2007; Dunnel and Greenlee 1999; Dye
More often in the literature, the emphasis seems to be on the taking of any body part as a trophy, typically in association with conflict and warfare between rival groups (Brown and Dye 2007; Lovisek 2007; Mensforth 2007; Owsley et al. 2007; Schaalma 2007). In addition to human trophies associated with conflict, there have also been numerous instances of isolated crania being found in mortuary contexts, as well as instances of headless bodies, hands, feet, and various other human skeletal components (Chacon and Dye 2007; Dye 2009; Giles et al. 2010; Jacobi 2007; Lovisek 2007; Mensforth 2007; Owsley et al. 2007; Seeman 2007). Often, either due to the context, personal preference, or the ambiguity of the circumstances, isolated body parts receive very limited attention in most analyses. For this reason, there have been very few attempts to thoroughly elucidate the identity of the individuals represented by trophy heads, and even fewer that strive to contextualize and conceptualize the existence of these representations within a given society. The following reviews the various ways in which previous researchers have attempted to explain these enigmatic symbols in order to orient the present study within the broader literature and to provide a theoretical basis for the interpretation of such symbols.

4.2 Isolated Heads as Vanquished Enemies or POWs

The suggestion that isolated heads represent a prize (i.e., “trophy head”) taken from an individual of a rival group symbolizing success in conflict, or from a prisoner of war subsequent to imprisonment, is substantiated by both archaeological data and ethnohistoric accounts from around the globe. In the pre-Hispanic Andes and elsewhere in the Americas, both ethnohistoric and skeletal analyses indicate that human trophies were taken from the corpses of rival groups following battle (Bourget 2001; Chacon and Dye 2007; Tung and Knudson 2008; Verano 2001). Often the trophy heads found throughout Peru had been modified after death, suggesting they
were mounted for display (Browne et al. 1993; Carmichael 1988; Drusini and Baraybar 1991; Forgey and Williams 2005; Knudson et al. 2009; Neira and Coelho 1972; Proulx 1989; Tung 2008; Tung and Knudson 2008). Trophy heads linked to conflict have also been associated with the Wari empire (600-1000 CE), which underwent a period of imperialism and expansion spurred by religious indoctrination and militaristic campaigns (Tung and Knudson 2008). In a study of trophy heads from the site of Conchopata in the Wari hinterland, Tung and Knudson (2008) propose that the standardized appearance of trophy heads is indicative of state oversight of trophy preparation, and note that isotopic data suggest that the heads represented foreign enemies taken as part of the broader imperial agenda. Trophy heads dating to the Inca Period (ca. A.D. 1438-1532) are also associated with conflict, which is well-documented by the archaeological and skeletal records, as well as ethnohistoric accounts which recall “gruesome and brutal” warfare at the behest of Inca emperors, military leaders, and elite (Ogburn 2007).

In the Arctic and Sub Arctic regions of North America, there are many examples of dismembered bodies, especially crania, which were collected following conflict and appear to have been modified in various ways, perhaps as a way of “dehumanizing an enemy” (Maschner and Reedy-Maschner 2007:37). In the American Southwest, evidence for the taking of human heads as trophies comes from Basketmaker and Freemont rock art which depict both head-taking and scalping with great detail (Schaafsma 2007). The interpretation that these heads represent trophies of successful conflict is based on the depiction of skulls either exhibiting the face paint or hairstyles of rival groups (Schaafsma 2007). Furthermore, rock art also depicts the modification of skulls with carrying straps, as well as shamans carrying the skulls (Schaafsma 2007). In the Southeastern United States, images of decapitated heads serve to further support the connection between conflict and the taking of heads as trophies (Brown and Dye 2007).
Examples also exist from the Eastern and Southeastern United States. During the Archaic Period in eastern North America, scalping, dismemberment, and decapitation often occurred in the course of conflict, which Mensforth (2007:223) suggests mimics hunting behavior where the success of a hunt is followed by the ritual processing of the kill. The Rogan copper repoussé plates from Etowah Mound C in Georgia depict decapitated heads in the left hand of a dancing warrior, while the right hand holds a mace that is depicted elsewhere in scenes showing the ceremonial decapitation of enemy warriors (Brown and Dye 2007). Numerous trophy skulls have also been associated with the Ohio Hopewell. Trophy heads from various sites throughout the region were analyzed by Seeman (1988, 2007), who, based on postmortem modification and evidence for inter-group hostility, concludes that the skulls are trophies of warfare. This interpretation is strengthened by the fact that the demographic distribution of the Hopewell trophy skulls favored young adult males, as well as the presence of drill-holes, cut marks, and cleaning striations, which suggests the cleaning and preparation of skulls for use as symbolic decoration (Seeman 1988:567).

Mensforth (2007:224) references ethnohistoric accounts which suggest that trophy taking behavior manifests most often in tribal societies and occurred “almost exclusively” in the context of conflict and/or warfare. In every instance where isolated crania have been linked to conflict there is ample evidence for inter-group warfare and/or persistent violence, either from the archaeological record or ethnohistoric documentation. Additionally, this evidence is often further supported by evidence of skeletal trauma, or overt evidence of interpersonal conflict.

4.3 Isolated Heads as Revered Ancestors

Isolated crania might also represent the revered ancestors of the group with which they have been interred, serving not as representations of success in warfare but as symbols in an
ancestor-veneration ritual. Aside from an association with ritualistic activities, the notion that trophy heads represent revered ancestors can also apply to the curation of the remains of honored relatives (Seeman 1988). These practices have been referred to as ancestor veneration, the removal and retention of skeletal elements as keepsakes of the dead (Andrushko 2011; Rakita et al. 2005). As Duncan (2005:207) explains, ancestor veneration denotes honoring the memory of the dead, which may also include supporting the soul in negotiating a final resting place. According to Andrushko (2011:265), skulls used in veneration ritual are typically buried, and then later disinterred following the decomposition of the soft tissue. This is an important distinction to draw when considering the archaeological context of suspected trophy skulls. Also, because of this initial period of interment and the subsequent disinterment, bones that have been engaged for the purpose of veneration ritual do not bare the cut marks indicative of flesh processing (Andrushko 2011). Furthermore, the demographic profile of human remains used in ancestor veneration tends to favor older adults of both sexes (Andrushko 2011; Seeman 1988, 2007; Verano 1995). Archaeological, ethnohistorical, and ethnographic examples of the many activities related to ancestor worship and veneration ritual exist around the globe. Of the many examples of veneration ritual, the occurrence and temporal perseverance of trophy heads is perhaps most ubiquitous in the area encompassed by modern-day Peru. Despite the assortment of meanings ascribed to them, the Nasca trophy heads of Peru have been generally characterized as representing either trophies of warfare, or as cultural symbols and objects representing fertility, religion, or sacrifice (Forgey and Williams 2005). Given that the skulls are demographically inclusive of men, women, and children of various ages, as well as the shared Nasca cranial deformation pattern, some have adamantly described them as symbols and items of ancestor worship (Forgey and Williams 2005). Carmichael (1988, 1995) argues that the
Nasca trophy heads represent revered ancestors, suggesting that postmortem manipulation of the
dead, which included the reopening of tombs and removal of body parts, indicates human
remains were used as objects in veneration ritual. During subsequent cultural periods,
ethnohistoric documents describe the preservation (i.e., mummification) of the bodies and/or
body parts of Inca lords for both elaborate public veneration and private meetings (Guamán
Poma De Ayala and GY 1980 [1615]). During public events, the mummified body was paraded
through public spaces; the immediate kin of the deceased were left to curate the portion of
remains discarded during the preservation process (Salomon 1995; Tung 2008). Gose (2003) has
described the disinterment of bodies and/or body parts of kin by the indigenous Peruvians of
Colonial Peru for use in ancestor-veneration rituals.

In the Marquesan archipelago of the Pacific (French Polynesia), caches of isolated skulls
can been divided into either trophies or ancestral relics based on contextual information
(Bonogofsky 2011). While decorated skulls are interpreted as war trophies, those skulls that are
modestly preserved and wrapped in a tapa (ceremonial cloth) are instead indicative of the
individual’s status as chief, and are thus used in ancestral worship activities (Bonogofsky 2011).
Ethnohistoric documents from the time corroborate this interpretation, noting that decorated
skulls were those of war captives and served as status items, not as items of ancestor worship
(Bonogofsky 2011).

Unfortunately, some examples of trophy skulls lead to interpretive ambiguity. In
Melanesia, the broad region that encompasses Indonesia, Papua New Guinea, the Solomon
Islands and the Torres Strait Islands, skulls that represent war trophies and those of ancestors are
treated in a similar manner as both are viewed as important (Bonogofsky 2011). Both enemy
and ancestor skulls are often decorated with feathers, flowers, paint, and shells, and modeled
with clay, then kept in a basket of palm fibers for use in fertility rituals (Bonogofsky 2011:83). In Melanesia, both the skulls taken as trophies of war and the skulls of revered ancestors were seen as bringing strength and propagation to the community, as well as honoring the dead.

Examples of trophy skulls that are representative of ancestor worship and veneration in the Midcontinental United States do exist, though interpretations remain juxtaposed. The most preeminent collection of trophy skulls in the region comes from the Ohio Hopewell, a culture closely associated with the Middle Woodland groups of the lower Illinois River valley. In the 1920s, Earnest A. Hooton conducted the earliest laboratory analyses on trophy skulls excavated from Turner Mound 3 in the Turner Group of earthworks near modern day Cincinnati, OH, noting that most belonged to middle-aged or old adult males, and thus were likely ancestors or belonged to individuals interred elsewhere in the mound (Seeman 1988, 2007; Willoughby and Hooton 1922:61). Hooton noted that 13 of the 16 skulls bore cut marks, and five of the skulls had between one and four perforations of approximately 1/8” diameter in various locations on the cranial vault (Willoughby and Hooton 1922:61). Hooten posited that cut marks were the result of postmortem processing and that the perforations were likely to facilitate the placement of suspension rope or adornment with feathers or other decorations (Willoughby and Hooton 1922:61). Subsequent analysis concluded similarly, noting that demographics were biased towards adult males (Webb 1988). Webb (1988) further notes the presence of cut marks on the crania, also suggesting that they were likely the result of processing the remains for burial and not an indication of decapitation or mutilation, a hallmark of trophy heads acquired through violence. However, as noted above, Seeman (1988, 2007) interprets the Turner Group isolated skulls as trophy heads.
4.4 Summary

Discerning the meaning, symbolism, or events that surround isolated heads is an extremely complex process that requires not only theorizing social circumstances, but also synthetic analysis of the contextual information regarding the skulls both individually and collectively. To date, there is not a universal set of criteria that has been developed that can adequately address the contextualization of trophy heads, nor any other aspect of ancient culture. Instead, when such scenarios are encountered, it is necessary to utilize an array of analytical techniques and rely on the various interpretations set forth in the literature in order to draw sound and reasonable conclusions. Clearly, demographic variables, signs of skeletal trauma/violence, and modification play an important role in assessing the use of trophy heads. In addition, biological affinity, proxies of diet and residential origin, and material culture can further explicate the meaning, significance, and social identity of those represented by isolated crania. Finally, archaeological context, especially the mortuary treatment of such objects, is critical to the analysis and conclusions ascribed to these enigmatic symbols.
5 BIOARCHAEOLOGY OF THE ELIZABETH SITE: PRINCIPLES AND METHODS

5.1 Introduction

Since the term “bioarchaeology” was coined in the late 1970’s (Buikstra 1977), the discipline has come to serve as a bridge between physical and biological anthropology and archaeology. Specifically, bioarchaeology moves beyond the descriptive nature of archaeology by incorporating analyses of the human remains discovered during archaeological excavation, thereby orienting bioarchaeological research with the cultural and historical processes of ancient human groups (Agarwal and Glencross 2011; Buikstra and Beck 2006; Knudson and Stojanowski 2009; Larsen 1997; White et al. 2011; Wright and Yoder 2003). In that respect, bioarchaeological research is driven more by the anthropological and archaeological research questions than simply the biological (Wright and Yoder 2003). The two disciplines are thus intertwined through the implementation of interdisciplinary methods and theories in an effort to assess the greater context of the population (Buikstra and Beck 2006; Knudson and Stojanowski 2008; 2009; Larsen 1999). It is important to note that, although individuals and small groups of human skeletal remains are the direct elements of inquiry, bioarchaeological analysis is truly concerned with broader social interpretations (Agarwal and Glencross 2011; Beck 2006; Buikstra and Beck 2006; Knudson and Stojanowski 2008; 2009; Konigsberg and Buikstra 1995; Larsen 1997). This approach is critical for understanding conditions such as the social, economic, and political constructs of a society, inter- and intra-group interactions, daily activities, divisions of labor, social and/or gender stratification, demography, residential origin, migration, genetic affinity, diet, and disease (Buikstra and Beck 2006; Knudson and Stojanowski 2008; Knudson and Stojanowski 2009; Larsen 1999).
5.2 Bioarchaeology: Methods and Theories

Until more recently, the analysis of human skeletal remains had largely been limited to visual and metric analyses, which were later synthesized into charts and tables and placed inconspicuously in the appendices of archaeological reports (Buikstra 1977, 1991). However, following the advent of Lewis Binford’s “new archaeology” in the 1960s, and the focus on cultural ecology during the 1970s, osteological research transitioned from a technical skill to the foundation of a new sub-discipline of archaeological inquiry dubbed “bioarchaeology” (Buikstra 1977). As a discipline, bioarchaeology can more clearly elucidate characteristics of demography, social organization and interaction, genetic heredity, population mobility, diet, and health and disease (Buikstra 1977; Buikstra and Beck 2006).

Of fundamental importance within bioarchaeological research is osteological analysis. Skeletal analysis has developed over the course of many centuries, with the most notable and influential work occurring as recently as the 18th and 19th century. Early work on craniology, a method of description based on (racial) types, was conducted by Blumenbach, Morton, and Warren during the late 18th and early-to-mid 19th centuries, and focused on classification at the expense of variation (Cook 2006). During this time, the primary focus of skeletal analysis was the skull, and assessing both the origins and diversity of indigenous North American groups was of prime importance. The focus on typology dominated the field for several decades until, in the mid-20th century, the concept of human biological variation, and the emergence of the disciplines of population genetics and statistics, became foundational tools and concepts for analyzing prehistoric populations (Cook 2006).

Paleodemography, the assessment of population composition based on age-at-death and biological sex, has become an integral component in osteological, and thus bioarchaeological,
research. During the early half of the 20th century, at a time when standards for estimating the age-at-death and biological sex of skeletal remains were in their infancy, Earnest A. Hooton created mortality profiles for remains excavated at Pecos Pueblo (Beck 2006). In the course of laboratory research, Hooton examined cranial deformation, craniometrics, morphological attributes, and estimated stature, before resolving to create “types” through visual sorting (Beck 2006). Although assigning typology has not been of concern to the research in the lower Illinois River valley, the depth of Hooton’s analysis of demographics, variation, and cranial modifications, has undoubtedly influenced current research methodologies. In the time since Hooton’s work, a corpus of anthropological research on the lower Illinois valley has been amassed (Asch 1976; Buikstra 1972, 1976, 1977; Charles 1992; Charles and Buikstra 2002; Dong et al. 2010; Dye 2009; Goodman et al. 1984; King et al. 2011; Konigsberg and Buikstra 1995; Lambert et al. 1979; McGregor 1959; Mosher et al. 2013; Perino et al. 2006; Raff 2008; Raff et al. 2011; Rose 2008; Rose et al. 1978; Schurr 1992; Seeman 1988; Steadman 1998; Struever 1968; Tainter 1980)

In order to accurately assess population demographics of lower Illinois Valley populations, Buiksta (1972, 1976) utilized both qualitative and metric methods to determine biological sex of individuals, and a suite of assessments of the dentition, cranial sutures, and pubic symphyseal surfaces to determine age-at-death for individuals. Beyond individual assessments, Buikstra (1972, 1976) also incorporated burial demographics into her research, including assumptions regarding intra-regional burials, extent of burials, decreased representation as a result of cremation, lack of habitation site burials, un-mounded cemeteries (both outside the scope of mound-site excavations and elsewhere), and above-ground exposure and decomposition. By incorporating aggregated considerations of the aforementioned issues
into her analyses, Buikstra (1972; 1976:22-23) succeeded in constructing life tables and mortality curves for the Gibson, Klunk, and Gardens of Kampsville sites, as well as utilizing site data in order to project population statistics at the regional level. This demographic analysis continues to represent one of the most comprehensive studies in the entire Eastern Woodland region.

In addition to demographic information, understanding the inter- and intra-population genetic affinity, or biological distance, is highly informative in assessing migration, population origin, evolution, and social interaction. Buikstra (1972, 1976) also conducted a thorough study of biological distance between individuals and groups at the Klunk and Gibson mound sites using non-metric (discrete) traits. The results of the study suggest that Middle Woodland groups were relatively stable communities that occupied sites over long periods of time as indicated by “significant epigenetic differences with spatially distinct mound groups,” as well as similar morphological variation between the skeletal series from neighboring mounds (Buikstra 1976:57). These results also suggest that Middle Woodland groups in the lower valley had lineage-linked status positions, and that social groups were endogamous (Buikstra 1972, 1976).

5.3 Isotopic Analysis

Studies of stable and radiogenic isotopes have proven utility in testing hypotheses related to diet and nutrition, residential origin and mobility, and general lifestyles of the past. As various environmental signatures are deposited in human tissue through metabolic processes, isotopic analyses are well suited to testing hypotheses related to diet and subsistence, nutritional ecology, geologic region of origin, and residential movements (Ambrose and Krigbaum 2003; Larsen 1999, 2002; Price 1989; Price et al. 1985; Turner and Armelagos 2012; Turner et al. 2009; Turner et al. 2005). Identifying residential origins and prehistoric migration patterns
allows for an interpretation of broader cultural processes and, ultimately, refined conclusions regarding past human lifeways, including the social, economic, and political relationships within and between groups (Ambrose and Krigbaum 2003; Gregoricka 2013; Larsen 1999; Price et al. 2002b; Price et al. 1985; Turner et al. 2009; Turner et al. 2005). Characterization of oxygen, strontium, and lead isotopes from skeletal materials is central to investigating the residential origins and migration patterns of prehistoric human groups.

The basis of isotopic analysis is the measure of differences in isotope abundances. These differences can be measured between isotopes of a single substance, or between two substances or phases (Ambrose and Krigbaum 2003; Price 1989; Price and Burton 2010; Price et al. 1985). Fractionation refers to the fluctuations of isotope ratios as a result of chemical or physical processes. In other words, assuming isotopes begin in a state of equilibrium distribution, fractionation occurs when one isotope is enriched relative to another. Fluctuations in the incorporation of elements into a biological organism are caused by variations in an organism’s biochemical processes (e.g., biochemical signaling, metabolism). In the analysis of stable isotope fractionation, values are measured relative to a standard value and, because the resulting ratio is minute, are reported in parts per mil (‰), and often relative to a geological or environmental standard using delta (δ) notation.

Previous uses of biogeochemistry in the lower Illinois River region have largely been limited to investigations of diet through the use of various trace elements and stable isotopes. In order to investigate dietary differences between Middle and Late Woodland groups, zinc and strontium concentrations have been analyzed and have revealed status-related dietary differences in Middle Woodland groups; in Late Woodland groups, higher levels of zinc and lower levels of strontium specifically in female skeletal remains suggest gender-based dietary differences.
In addition, research has shown that while zinc levels, which indicate the consumption of animal protein, remained relatively stable, strontium levels decrease during the Late Woodland period as maize agriculture began to flourish (Buikstra 1988). Studies of lead support the common issue of age-accumulation (e.g., older individuals have higher lead concentrations), although age-accumulation has little bearing on the lead isotope ratios as the geographic etiology and type of lead are independent of concentration. Also, male remains had significantly higher lead concentrations than did their female counterparts, perhaps in response to the use of galena, the mineral form of lead sulfide, which was often used as a ceremonial pigment (Buikstra 1988; Emerson and Hughes 2000). Bone collagen carbon isotopes have been characterized in the central and southeastern U.S. in order to assess the consumption of maize, which is known to have intensified in the Mississippian period (ca. A.D. 1000-1300); however, studies have shown that maize consumption occurred around AD 600 (just prior to the Mississippian period) and gradually increased over time (Buikstra 1988).

More recently, Rose (2008) analyzed the bone biochemistry of skeletal remains excavated from sites in west-central Illinois. Isotopic analyses suggest that maize was eaten in small quantities during the Middle Woodland and was likely linked to ritual activity (Rose 2008). However, the results also indicate that maize agriculture was intensified by the early Late Woodland period, perhaps even as early as ca. A.D. 400, during which time maize consumption varied drastically within communities (Rose 2008:434). Additionally, nitrogen isotope values were higher in male skeletal remains, which suggests that males had inequitable access to protein, or perhaps is simply the result of physiological differences between males and females (Rose 2008).
Strontium isotopes have been used in the broader region as a proxy for residential mobility, most notably at the Mississippian site of Cahokia, and at sites in northern Illinois (Slater et al. 2014). The study by Slater et al. (2014) indicated that immigrants at the site migrated from across the region and were seemingly integrated into the greater Cahokia community as was indicated by a lack of burial (and thus social status) differences, suggesting that immigrants were perhaps common in the community or that they assimilated without notable difficulty. Although temporally different, a regional study by Beehr (2011) concluded that a high degree of residential mobility was present in northern Illinois during the Woodland period, especially in comparison to the rates of mobility in the Hopewell Mound Group in Ohio.

5.3.1 Stable Light Isotopes and Migration

Oxygen has 20 total isotopes, three of which ($^{16}$O, $^{17}$O, and $^{18}$O) are stable. Out of the three stable isotopes, $^{16}$O has a natural abundance of 99.762% and, along with $^{18}$O, is expressed as $\delta^{18}$O in parts per mil (‰) relative to the Standard Mean Ocean Water (V-SMOW), which has a composition similar to central Pacific sub-surface water.

Oxygen isotopes are metabolized into human tissues from environmental drinking water and thus $\delta^{18}$O values reflect the isotopic composition of consumed water (Iacumin et al. 1996; Luz et al. 1984; Price et al. 1985; Schoeninger and Moore 1992). The variation in terrestrial drinking water is linked to numerous components, including latitude, elevation, and soil aridity, but especially climatic and meteoric conditions (Bowen and Revenaugh 2003; Iacumin et al. 1996; Larsen 1997; Luz et al. 1984; Price et al. 1985; Schoeninger and Moore 1992). Terrestrial water $\delta^{18}$O values decrease as distance from the sea increases, as well as with increases in elevation and decreasing temperatures (Bowen and Revenaugh 2003). Temperature and humidity are primary sources of water variation with evaporation causing variable loss of $^{16}$O,
and precipitation leading to a progressive loss of $^{18}\text{O}$ (Bowen and Revenaugh 2003; Iacumin et al. 1996; Luz et al. 1984; Price et al. 1985; Schoeninger and Moore 1992; Turner and Armelagos 2012). Accordingly, there is a marked difference between the life history information indicated by oxygen isotope ratios in comparison to carbon and nitrogen ratios. While carbon and nitrogen ratios are indicative of dietary consumption, oxygen ratios, which are heavily influenced by and indicative of the local environment, enable an assessment of geographic origins and paleomobility.

The oxygen isotope composition of carbonate and phosphate, the foundation of the mineral fraction of teeth and bone, is directly influenced by the isotopic composition of body water ($\delta^{18}\text{O}_{bw}$). This is the result of the phosphate, which is located within the hydroxyapatite of bone, maintaining equilibrium with the oxygen pool in body water at a constant temperature of 37°C (White et al. 1998). In mammals, the $\delta^{18}\text{O}$ values in bone enamel carbonate ($\text{Ca}_{10}(\text{CO}_3)_{6}(\text{OH})_2$) has a linear relationship with the $\delta^{18}\text{O}$ value of environmental water, though the two are not in isotopic equilibrium (Luz et al. 1984). Although body water can be modified via in- and out-fluxes of oxygen-containing compounds from the body (e.g., water loss and/or vapor), $\delta^{18}\text{O}_{bw}$ values reflect the oxygen isotope composition of meteoric drinking water (Iacumin et al. 1996; Luz et al. 1984; Turner et al. 2009; White et al. 1998). By comparing an individual’s $\delta^{18}\text{O}$ with the $\delta^{18}\text{O}$ values for local terrestrial water sources, it is possible to use intra-population analyses to reconstruct patterns of geographic movement (i.e., local vs. non-local), establish provenance of human skeletal remains, reconstruct paleoclimate change (using stationary populations), and characterize variations in growth environments (Bowen and Revenaugh 2003; Iacumin et al. 1996; Luz et al. 1984; Turner and Armelagos 2012; Turner et al. 2009; White et al. 1998).
5.3.2 Heavy Isotopes and Migration

Strontium (Sr) is an alkaline earth metal with 31 isotopes, three of which ($^{84}\text{Sr}$, $^{86}\text{Sr}$, and $^{88}\text{Sr}$) are naturally occurring and stable. Another strontium isotope ($^{87}\text{Sr}$) is both radiogenic and stable, as it formed through radioactive decay of rubidium ($^{87}\text{Rb}$), another alkali metal. The ratio of ($^{87}\text{Sr}/^{86}\text{Sr}$) has long been utilized in geoscience research involving rocks and minerals primarily because strontium substitutes for calcium in minerals (as well as bone) due to its similar electron configuration. In general, stable strontium isotopes exhibit little variation in atomic mass, resulting in minimal (measurable) fractionation (Ambrose and Krigbaum 2003; Knudson and Price 2007; Price 1989; Price and Burton 2010; Price et al. 2002b; Turner and Armelagos 2012; Turner et al. 2009; Turner et al. 2005; van der Merwe et al. 1996).

Additionally, biological processes do not fractionate strontium isotopes, allowing them to pass unadulterated through the food web; they therefore reflect the isotopic ratios of local bedrock that enter into trophic food webs (Price 1989; Price and Burton 2010; Price et al. 2002b; Turner and Armelagos 2012; Turner et al. 2009). As a result, biological anthropologists have utilized strontium stable isotope analysis to infer residential origins and migration patterns of ancient humans.

Strontium isotope analyses are comparative studies that examine the differences between strontium isotope ratios of a given sample measured against strontium baselines of “bioavailable” strontium ratios obtained from water, bedrock, soil, plants, or fauna (Price et al. 2002a). Alternatively, sample ratios can also be compared against a regional database of strontium isotope values, or “isoscapes” (Hodell et al. 2004). The results can detect local and non-local individuals, as well as general temporal and spatial constraints (Turner et al. 2012). However, in order to determine migration and mobility, strontium isotope ratios of regional
bedrock must be distinct from other nearby areas (i.e., of different ages/signatures), otherwise the analysis will be inconclusive (Ambrose and Krigbaum 2003; Hedman et al. 2009; Hodell et al. 2004; Knudson and Price 2007; Knudson and Tung 2011; Price and Burton 2010; Price et al. 2002b).

Specific samples of individual skeletal and dental material are essential to conducting strontium isotope analyses. Since tooth enamel forms during early childhood, the strontium isotope ratio of a given tooth incorporates isotope ratios from the local geochemistry during the period in which the dental enamel was formed. For example, various aspects of growth of a mandibular first premolar (P1) could represent a period from approximately 2-13 years of age, depending on the individual. Therefore, strontium ratios from dental enamel reflect local geochemistry during the period from 2-13 years of age. As bone is subject to constant remodeling throughout life, strontium isotope values obtained from bone samples represent the period of (approximately) 10-20 years before death. As a result of the differing characteristics of bone and tooth formation, isotope ratios from bone and teeth of an individual can also be used to detect migration. Provided the strontium isotope signature is not contaminated postmortem, a comparative analysis between tooth and bone samples (or early vs. late formed teeth) can yield information on migratory and sedentary behaviors throughout life (Knudson and Price 2007; Price and Burton 2010; Price et al. 2002b; Turner and Armelagos 2012; Turner et al. 2009).

Lead (Pb) is a soft and heavy post-transitional metal belonging to the carbon group which often occurs in ore along with copper, silver, and zinc. The element is composed of three radiogenic isotopes ($^{206}$Pb, $^{207}$Pb, and $^{208}$Pb) and one non-radiogenic isotope ($^{204}$Pb), all of which are observationally stable. $^{206}$Pb is a product of the decay of $^{238}$U (uranium), $^{207}$Pb a product of $^{235}$U decay, and $^{208}$Pb is produced via the decay of $^{232}$Th (thorium). Rocks, minerals, ores, and
soils tend to vary in Pb isotopic composition based on initial Pb, U, and Th amounts, as well as by the time that has elapsed since their formation. The isotopic ratios of underlying rocks are subsequently passed on to local soils and biota resulting in geologically-linked geographical isotope signals (Kamenov and Gulson 2014). In areas where the underlying geology is old and high in U/Pb and Th/Pb, the ratios of radiogenic Pb ($^{206}$Pb/$^{204}$Pb, $^{207}$Pb/$^{204}$Pb, and $^{208}$Pb/$^{204}$Pb) are higher; conversely, in areas where the underlying geology is equally old but has lower U/Pb and Th/Pb, lower ratios of radiogenic Pb will result (Kamenov and Gulson 2014).

In human bones and teeth, as well as those of similarly composed species, lead substitutes for calcium (Ca). As with nearly all other elements, lead isotope levels in tooth enamel are representative of an individual’s geological environment during the period of enamel formation, while lead isotopes in bone are circulated in blood, and thus present a lifetime average of lead values from the environment (Kamenov and Gulson 2014). Furthermore, the exchange of lead in the oral cavity (i.e., from enamel to saliva and visa versa) is extremely unlikely given the comparably low lead concentrations in saliva (Costa de Almeida et al. 2011; Kamenov and Gulson 2014). Lead isotope ratios in enamel can be extremely effective at tracing geographic origins and paleomobility in early life, especially when multiple teeth from the same individual are utilized, or a comparison of early versus late life is drawn using intra-individual variation in bone and enamel isotope values.

5.3.3 Stable Light Isotopes and Diet

Carbon has 15 known isotopes, although only two ($^{12}$C and $^{13}$C) are stable, with $^{12}$C being the most abundant at 98.9% and $^{13}$C at 1.1%. The bulk of the Earth’s carbon exists in the oceans in a non-biological form in the aforementioned ratio and, during the carbon transfer cycle, atmospheric carbon dioxide (CO$_2$) is depleted of $^{13}$C relative to oceanic carbon (Schoeninger and
Carbon abundance in skeletal remains is expressed as a ratio ($^{13}\text{C}/^{12}\text{C}$) of parts per mil (‰) relative to the $\delta^{13}\text{C}_{\text{VPDB}}$ carbon standard (value “PDB” for Peedee Belemnite), which was established using a marine carbonate fossil from the Peedee formation in South Carolina (Katzenberg 1992). In animals, stable carbon isotope ratios in enamel reflect carbon intake during the enamel crown formation, while bone carbonate values reflect carbon intake from all diet sources (terrestrial/marine animals, plants) in the (approximately) ten years preceding death, with ratio values reflecting the photosynthetic pathway of consumed items (Larsen 1997; Turner and Armelagos 2012; Turner et al. 2005). This $\delta^{13}\text{C}$ value is representative of the dietary intake spectrum of carbohydrates, fats, and proteins (Katzenberg 1992; Turner and Armelagos 2012:3129).

Plants can generally be divided into three groups based on their method of photosynthesis, or carbon dioxide (CO$_2$) fixation. Of the three groups, two are primary photosynthetic pathways, the C$_3$ or “Calvin-Benson” pathway and the C$_4$ or “Hatch-Slack” pathway (Katzenberg 1992). In 1962, Calvin and Bassham described a CO$_2$ fixation process by which the CO$_2$ is converted from a 6-carbon compound to a 3-carbon, 3-phosphoglyceric acid compound, deriving the term “C$_3$ plants.” Alternatively, in 1966, Hatch and Slack identified a CO$_2$ fixation method where CO$_2$ is incorporated in 4-carbon compounds, then subsequently transferred into sugars via 3-phosphoglycerate; the 4-carbon compound incorporation is led to “C$_4$ plants” (Waller and Lewis 1979). The third photosynthetic pathway, Crassulacean Acid Metabolism (CAM), has also been identified in cacti and other similar succulents, though it is rarely consumed by humans and is thus of minimal consequence to dietary reconstruction, but nevertheless can overlap C$_3$ and C$_4$ pathways depending on environment (Jackson et al. 2012; Katzenberg 1992; Larsen 1997; Osborne and Sack 2012; Saugier et al. 2012; Turner and
Armelagos 2012; Waller and Lewis 1979). In general, C₃ plants are more common in both tropical forests and the temperate climates found in higher latitudes and include various (non-tropical) grasses, trees, shrubs, and tubers or other underground storage organs (Freeman et al. 2011; Jackson et al. 2012; Larsen 1997). Likewise, most C₄ plants are typically better adapted to tropic climates and include tropical grasses, some amaranths (annuals or short-lived perennials, e.g., amaranth seed), chenopods (e.g., spinach, beet), and setarias (tufted grasses), with the most notable crops in the Americas being maize (Jackson et al. 2012; Larsen 1997; Osborne and Sack 2012; Saugier et al. 2012; Schoeninger and Moore 1992) and amaranths, although these species grow in temperate climates as well (Freeman et al. 2011; Jackson et al. 2012; Osborne and Sack 2012; Saugier et al. 2012; Turner et al. 2009). It is important to note here that the dichotomy of temperate versus tropical plants is complicated and various species utilizing all forms of photosynthetic pathway are found in a variety of tropical and temperate contexts (Freeman et al. 2011; Jackson et al. 2012; Osborne and Sack 2012; Saugier et al. 2012).

Atmospheric CO₂ is the primary source of carbon for terrestrial plants and is thus used in determining plant δ¹³C values (Schoeninger and Moore 1992). Because C₃ and C₄ plants discriminate differentially against ¹²C and ¹³C, which is isotopically heavier, δ¹³C values falling between -22‰ and -38‰ range fit the C₃ plant profile, while δ¹³C values from -9‰ to -21‰ range fit the profile for C₄ plants (Larsen 1997). As bone collagen is composed of over 30% glycine, an amino acid with relatively high δ¹³C values, researchers have identified a fractionation factor of approximately +5‰ between diet and bone collagen, as well as approximately +1‰ fractionation between carnivores and herbivores (Katzenberg 1992). By combining the knowledge of fractionation factors with δ¹³C values for various consumable items, researchers can infer dietary consumption.
5.3.4 Confounding Issues with Isotopic Analyses

Analysis of bone chemistry is not without inherent issues and challenges, though some are more problematic than others. There are numerous questions regarding inter- and intra-individual variability, paleodemography, and bone diagenesis. However, as methods and technology continue to develop, and researchers focus equally on fundamental methodological improvements and research hypotheses, many challenges are being overcome; still, others remain.

Inter- and Intra-individual variability remains a major concern and questions abound. Variation within a population can be particularly high, with coefficients of variation (c.v.) reported as high as 20-30%, as a result of age, sex, and metabolism (Price et al. 2002b; Price et al. 1985). Numerous studies have shown that strontium concentrations (PPMs) vary by age. Despite high variation in strontium concentration for sub-adults, general trends show that strontium levels decrease in childhood, stabilize between approximately age 20 and age 50, then slightly increase with age (Price et al. 2002b; Price et al. 1985). Studies of various regional populations have yielded a range of results regarding sex-related variation in isotope levels; as of yet there is no clear connection between sex and isotope concentration (Price et al. 2002b; Price et al. 1985).

Bone diagenesis is the post-mortem alteration (contamination, leaching) of the chemical composition of bone in response to the macroenvironment of the soil in which it is deposited (Baxter 2004; Price 1989; Sandford 1992; Weiner 2010). Upon interment in soil, the homeostatic conditions maintained by bone during life are supplanted by the geochemical conditions of the soil, resulting in numerous changes. Microbial and chemical diagenesis of the organic matrix of the bone results in increased porosity, enhancing the diagenic process by
mineral phases including calcite ($\text{CaCO}_3$) and barite ($\text{BaSO}_4$) (Weiner 2010). The ions of the skeletal hydroxyapatite lattice exchange with soluble soil ions, and recrystallization and/or growth of apatite crystals may occur, and cations and anions exchange elements in the biogenic apatite (Sandford 1992). Diagenesis is influenced by a number of factors, including the chemical composition of soil (texture, mineralogy, organic content), temperature, microorganisms, groundwater, and precipitation (Baxter 2004). However, tooth enamel is extremely resilient to post-depositional diagenesis due to its dense crystal structure, which has demonstrated efficacy in preserving the composition of biogenic strontium and lead isotopes (Kamenov and Gulson 2014; Turner et al. 2009).

5.4 Sample Selection

Individuals from the skeletal assemblage of Elizabeth Mound 3 were included in the study population based largely on the availability of permanent dentition, as well as the availability of bone fragments amenable to isotopic analysis. The availability of fragments was important in this case so as to eliminate any invasive sampling, both per the request of the Illinois State Museum and out of respect for the remains. In addition to availability, sample selection was based on spatial location within the mound, individual age, biological sex, and availability of sample material. The study population consists of 27 individuals, comprised of 18 adults, one sub-adult (10-16 yrs. at death), one child (5-8 yrs. at death), five children (0-3 yrs. at death), and two fetuses (Bullington 1988; Charles et al. 1988; Leigh et al. 1988).

Table 5.1: Population of Elizabeth Mound 3 utilized in study

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>Age at Death</th>
<th>Burial Location</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>27-38</td>
<td>Feature 1</td>
<td>M</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>35+</td>
<td>Feature 1</td>
<td>M</td>
</tr>
<tr>
<td>F1-Sk 3</td>
<td>22-30</td>
<td>Feature 1</td>
<td>M</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>25-35</td>
<td>Feature 1</td>
<td>M</td>
</tr>
<tr>
<td>F1-Sk 5</td>
<td>22-30</td>
<td>Feature 1</td>
<td>M</td>
</tr>
</tbody>
</table>
In order to provide a comprehensive isotopic profile spanning approximately birth through 13 years of age, the ideal sampling model would utilize an individual’s first, second, and third molars. However, in the skeletal population at the Elizabeth site, as is typical of prehistoric populations, ante- and post-mortem tooth loss all serve to complicate this sampling model. As a result, sampling of dental enamel primarily focused on the mandibular and maxillary permanent molars when available. In two cases (individuals 2-1 and 5-1), these sampling points were not available and the maxillary pre-molar and mandibular canine (respectively) were substituted instead. Although this scenario is not ideal for either continuity or comparative analyses, it was a necessary adjustment given the circumstances. These sampling points can be divided into three broad dental developmental groups with first-molars representing “infancy/early childhood” (IEC), canines, second pre-molars, and second molars representing “middle childhood” (MC), and third molars representing “adolescence” (AD) (Buikstra and Ubelaker 1994; Hillson 1996;
These groups are summarized in Table 4.2. This sampling strategy is effective given the situation, as it allows the categorization of teeth by developmental category while maximizing the tooth types available for sampling.

<table>
<thead>
<tr>
<th>Tooth Type</th>
<th>Years of Crown Development</th>
<th>Developmental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.3-7.0</td>
<td>MC</td>
</tr>
<tr>
<td>P1</td>
<td>1.0-7.5</td>
<td>MC</td>
</tr>
<tr>
<td>P2</td>
<td>2.0-8.5</td>
<td>MC</td>
</tr>
<tr>
<td>M1</td>
<td>0.0-3.5</td>
<td>IEC</td>
</tr>
<tr>
<td>M2</td>
<td>2.5-8.0</td>
<td>MC</td>
</tr>
<tr>
<td>M3</td>
<td>8-15</td>
<td>AO</td>
</tr>
</tbody>
</table>

5.4.1 Contextual Parameters

Numerous contextual parameters were included for analysis based on the osteological data gathered both by the author, and the published osteological and archaeological data recorded during the original excavation (Charles et al. 1988). Contextual data collected by the author includes age, biological sex, skeletal inventory, skeletal metrics, and the type of bone/tooth sampled for isotopic analysis. Contextual data that was included in analyses but acquired from the published reports includes burial location (within the mound), burial position (placement of the body), and burial orientation (cardinal direction of head). Additional contextual parameters assigned for the purpose of analysis include: buried as pair (individuals buried in a pairing of two adults), buried with child (individuals or groups buried with an individuals of 20 years or less), buried in apron (individuals buried within the original apron of the mound), isolated skull/full burial, and bone type (individuals that were sampled and analyzed using bone carbonate). These additional contextual data were used for the purpose of inter- and intra-group comparisons of isotopic data in order to identify patterns in juxtaposed groups.
5.5 Osteological Analysis

Skeletal remains are an indispensable component of anthropological inquiry, especially as a source of information for testing hypotheses and promoting comprehensive knowledge related to mortuary ritual, residential patterns, biodistance, diet, disease, trauma, physical activity and lifestyle, and paleodemography. Not surprisingly, demographic data such as age-at-death and biological sex are critical to the study of ancient cultures given their ability to elucidate the various complexities of population structure and cultural behaviors (e.g., White et al. 2011).

While biological sex and age-at-death inform various aspects of research, the two components also form the cornerstone to studies of sex, gender, and paleodemography (e.g., Buikstra and Beck 2006; White et al. 2011). In light of the importance placed on the creation of a thorough and accurate biological profile, estimating the biological sex and age-at-death of human skeletal remains is fundamental to bioarchaeological research.

Standard osteological analyses were conducted on the skeletal remains from the Elizabeth site, including skeletal inventory, assessment of age-at-death, and estimation of biological sex. The osteological analyses were conducted as discussed herein, per standard osteological procedures (Buikstra and Ubelaker 1994; Katzenberg and Saunders 2011; White et al. 2011). It should be noted, however, that many of the remains are fragmentary and as such were not suitable for detailed osteological analyses. Furthermore, the condition of the six skulls associated with Mound 3, Feature 1, were extremely fragmented and thus the conclusions drawn regarding age and biological sex are limited (Leigh et al. 1988).

For the purposes of this research, data on skeletal paleopathology was not collected as it was beyond the scope of this analysis. However, if data collection (e.g., measurements, sampling) was inhibited or affected as a result of pathological conditions on bone or teeth, such
issues were noted in the raw data. Published paleopathological data exists for the entirety of the Elizabeth population (Charles et al. 1988).

5.5.1 Estimating Biological Sex

The methods of sex estimation utilized in bioarchaeological analysis are based on sexual dimorphism, or the differences between male and female skeletons, which are known to vary in both shape and size. Within the broader category of sexual dimorphism, sex estimation techniques are generally divisible into two groups: measurements (e.g., cranial and post-cranial metrics), and attribute morphology (e.g., morphological differences of the cranium and pelvis). By comparison, female skeletal remains generally present with smaller and lighter (“gracile”) features than do males (White et al. 2011). With regard to accuracy, it is important to distinguish that all methods of sex estimation are based on reference populations (i.e., “known samples”) and thus any estimation is only relatively accurate (Buikstra and Beck 2006; Buikstra and Ubelaker 1994; White et al. 2011). Additionally, model populations are often unreliable when assessing skeletal remains that are temporally or spatially isolated, such as indigenous North American remains. Observer error and biases also confound estimation, as does the tendency for the identification of seemingly “positive features”; in identifying features as positive (or present), estimations tend to favor male estimation (Buikstra and Ubelaker 1994; White et al. 2011). While seriation of the entire skeletal sample remains an effective means of discerning morphology in aggregate, the logistics challenges and inefficiency of doing so often precludes such endeavors. Additionally, estimating biological sex in juvenile individuals is complicated by a lack of sexual dimorphism and is not advisable in the absence of preserved soft tissues.
5.5.2 Estimating Age-at-death

Estimations of age-at-death are a critical component to bioarchaeological research given their importance in demographics, and thus the broader methodological, theoretical, and practical applications of the discipline. Regardless of the application, estimations of skeletal age-at-death are fundamental to any osteological analysis. Although several methods exist for estimating age-at-death from skeletal remains (Baker 1984; Brooks and Suchey 1990; Buikstra and Ubelaker 1994; Katz and Suchey 1986; Lovejoy et al. 1985a; Lovejoy et al. 1985b; Mann et al. 1987; Meindl and Lovejoy 1985; Todd 1920; Todd and Lyon 1924), as of yet there is no single, infallible method of estimation with demonstrated accuracy. Accordingly, a host of methods should be utilized in multifactorial fashion so as to establish a range of values that are adequately representative of the individual’s potential age (Buikstra and Beck 2006; Buikstra and Ubelaker 1994; White et al. 2011). While the agreement of methods based on markedly different criterion has the potential to skew estimates, the multifactorial approach aids in avoiding the biases of any single method, and combines the accuracy of all methods.

The Todd system (Todd 1920) is a scoring system for the pubic symphysis that requires the observer to critically evaluate a variety of features of the symphyseal face (Buikstra and Ubelaker 1994). The association of developmental stage and age are reliant upon a model population, and thus age estimates are ultimately dependent on the morphological characteristics present in that model population. While the method exhibits ongoing utility in estimating biological age of skeletal remains, the reference sample renders it problematic, especially when used on samples of indigenous North Americans, such as those examined in this study.

The Suchey-Brooks system is based largely on the Todd system, with statistical modifications aimed at broadening confidence intervals (Brooks and Suchey 1990; Katz and
Suchey 1986). Additionally, the reference population for the Suchey-Brooks system is a modern sample of forensic cases from Los Angeles, CA; biases for the method should consider the relative modernity of this sample, as well as the socio-economic backgrounds represented by the individuals in the collection. The Suchey-Brooks system is based on scoring phases of postcranial development based on evaluation of symphyseal topography and is thoroughly described in Buikstra and Ubelaker (1994:21).

The method established by Lovejoy et al. (Lovejoy et al. 1985a; Lovejoy et al. 1985b) uses the auricular surface of the ilium in lieu of the pubic symphysis, capitalizing on the fact that the auricular surface is more often preserved in archaeological contexts (Lovejoy et al. 1985a; Lovejoy et al. 1985b). Additionally, auricular surface changes are discernable beyond the age of 50, and equally as accurate (Lovejoy et al. 1985a:15). However, age-associated changes to the auricular surface are complex and there is no “delayed epiphysis” stage (as in pubic symphyses), making accurate scoring difficult (Lovejoy et al. 1985a:16). Model ages for the Lovejoy method were developed through observation of modern individuals and are thus limited in their application and efficacy (Lovejoy et al. 1985a; Lovejoy et al. 1985b). The method is described thoroughly in Buikstra and Ubelaker (1994).

Finally, the use of cranial suture closure is also an effective means of estimating age-at-death. Cranial sutures fuse with increasing age and, despite variability, the degree of closure can serve as a proxy for estimating skeletal age at death (Buikstra and Ubelaker 1994; White et al. 2011). This integrated methodology is described in Buikstra and Ubelaker (1994:32-37).
5.6 Isotopic Analysis: Laboratory Methods

5.6.1 Isotopic Sample Selection

Due to both the expense and the invasive and destructive nature of isotopic analysis, the total number of individuals included in isotopic analysis was limited to 15. The total population of individuals interred in Elizabeth Mound 3 (n=27) was considered for potential isotopic analysis. Of these individuals, those lacking permanent dentition (n=8) were excluded. As the primary focus of this research is the six isolated crania located in Feature 1 (F1-Sk 1-6), these individuals were automatically included in the study sample of 15. Additionally, because of the prominence displayed by their burial in the central feature of the mound, individuals 2-1 and 2-2 were included in the analysis. The remaining seven individuals for the isotopic analysis sample were chosen at random. The final sample consists of 15 adult individuals between 22-55+ years of age (mean= 40.43), comprised of eight males and seven females.

5.6.2 Sampling

Sampling took place at the Illinois State Museum Research and Collections Center in Springfield, Illinois, May 28-30, 2014. Each tooth was catalogued and photographed, then cleaned with acetone. Once clean a vinyl polysiloxane impression was created using 3M ESPE Imprint™ II Garant™ Light Body impression material (ISO 4823 Type 3) in order to cast a replica of the tooth, thereby preserving the original tooth surface and condition of the tooth for reference and potential future research. The enamel surface was then abraded using a Dremel 100 Series Single-Speed Rotary Tool (F0130100AE 100-N/7) equipped with a burr attachment in order to remove all surface contaminants. An enamel sample of approximately 10-30 mg was cut from the largest cusp of the tooth using the Dremel tool equipped with a tungsten carbide diamond cutting blade. Enamel samples spanned the cemento-enamel junction (CEJ) to the
occlusal margin, or the maximum height where teeth were heavily worn. Samples were placed in individually labeled, sterile, 15mL centrifuge tubes for storage and transport.

5.6.3 Preparation of Isotopic Samples

Preparation for isotopic analysis took place at the Georgia State University Bioarchaeology Laboratory under the supervision of Dr. Bethany Turner. The initial preparation for analysis of carbon, oxygen, lead, and strontium isotopes generally follows the same procedure for both bone and enamel samples. For the isolation of bone apatite, the bone sample was cut using a dental drill equipped with a diamond cutting blade, and then the outer layer of bone was mechanically removed using a dental drill equipped with a burr tip in order to remove contaminants from the sample. The inner trabecular bone was then removed using the burr tip, leaving only the cortical portion of bone for analysis. During the cutting and cleaning phase, the burr tip and diamond blade were cleaned using acetone and rinsed with ddH₂O between each sample in order to avoid contamination. Once trabecular bone and contaminants were removed, the samples were soaked in an ultrasonic bath of ddH₂O for three 10-minute cycles, with fresh ddH₂O added for each cycle. Once the bone samples were dry, they were crushed using an agate mortar and pestle and screened using 120 mesh (125 microns) and placed back in sterile centrifuge tubes. Between the processing of each sample the mortar and pestle were cleaned with acetone and rinsed with ddH₂O in order to avoid contamination. After all samples had been crushed and screened, samples were soaked in a 3:1 solution of bleach (2% NaOCl) and ddH₂O for a period of 48 hours at approximately 6°C. Once the samples ceased to produce bubbles (indicating no exogenous carbonates remain), samples were rinsed to neutral using ddH₂O. Samples were then soaked in a 2% acetic acid solution for 4 hours at approximately 6°C. Samples were then rinsed to neutral pH using ddH₂O. At this point the bone samples were
freeze-dried and stored in sterile centrifuge tubes pending further preparation and mass spectrometer analysis.

Enamel samples were first mechanically cleaned using a dental drill equipped with a burr tip in order to remove surface contamination; the burr tip was cleaned with acetone and rinsed with ddH₂O between each sample to avoid contamination. Following the mechanical cleaning, enamel samples were crushed using an agate mortar and pestle until powdered, then placed in sterile centrifuge tubes. Again, the mortar and pestle were cleaned using acetone and ddH₂O between each sample to avoid contamination. At this point the preparation of enamel followed the same process as that used to prepare the bone samples. Once completed, the enamel samples were also freeze-dried and stored in sterile centrifuge tubes pending further preparation and mass spectrometer analysis.

5.6.4 Lead (Pb) Isotope Separation

Separation of lead (Pb) was conducted in October of 2014 in a Class 1000 clean laboratory, equipped with class 10 laminar flow hoods, at the University of Florida, Department of Geosciences under the supervision of Dr. George Kamenov. The following is a summary of the procedures utilized to separate and measure lead isotopes by Tl (thallium) spiking.

Since samples were prepared for analysis and freeze-dried, samples were weighed and then transferred to acid-cleaned Teflon containers along with approximately 3 drops of 4xH₂O to stabilize sample and prevent static cling of powdered sample. Samples were then dissolved in 2.5ml of 50% HNO₃ solution in capped Teflon beakers on a hot plate for approximately 2.5 hours in the laminar flow hood; samples were then uncapped and remained on the hot pad for 8-10 hours to allow evaporation to complete dryness. Once dry, the samples were dissolved in 100-200µl of Seastar 1N HBr. The resin bed stems (approximately ~100µl) of columns were
then packed with 100-200µl of Dowex 1X-8 mesh (100-200 mesh) resin. The resin was washed with 2ml of optima grade 6N HCl, after which the samples were loaded into the column resin. Once the samples were loaded, the columns were washed thrice with 1ml Seastar 1N HBr. After progressing through the columns, the samples were collected in a wash of 1ml of 20% optima grade HNO₃, then placed on the hot plate for approximately 3 hours in order to allow the solution to evaporate to dryness. Just prior to mass spectrometer analysis, 300 µl of HNO₃ spiked with Tl was added to the dry samples.

5.6.5 Strontium (Sr) Isotope Separation

During the lead elution step described previously, the wash was collected and evaporated to dryness on a hot plate in a laminar flow hood in order to conduct strontium separation. This process is not inhibited by lead elution, as the strontium is not absorbed in the Dowex resin. The dried residual samples were dissolved in 100µl of clean 3.5N HNO₃. The ~100µl resin bed stems of columns were packed with Strontium Spec resin (EI Chrom Part # SR-B100-S) in order to separate the strontium in the sample from all other elements. After packing with resin, columns were washed with 1ml 4xH₂O and equilibrated using 2ml of 3.5N HNO₃. The samples were then loaded into the columns in 100µl of 3.5N HNO₃. Columns were then washed thrice with 100µl of 3.5N HNO₃, before a final wash of 1ml of 3.5N HNO₃. Strontium was then collected in sterile Teflon containers using 1.5ml of 4xH₂O. Once collected, the samples were evaporated to dryness on a hot plate in the laminar flow hood. Immediately prior to mass spectrometer analysis, 300µl of 2% HNO₃ was added to the samples.

5.7 Mass Spectrometer Characterization of Sr and Pb Isotopes

Mass spectrometer characterization of lead and strontium were conducted at the Department of Geological Sciences, University of Florida, using a “Nu-Plasma” multiple-
collector inductively coupled-plasma mass spectrometer (MC-ICP-MS). The time-resolved analysis method of Kamenov et al. (2006) was utilized for all analyses.

For lead analysis, Tl normalization technique was used on the fresh mixtures in order to prevent thallium oxidation to Tl$^{3+}$ (Kamenov et al. 2004). NBS-981 Pb standard analyses conducted in dry plasma mode (~5.1 and ~3.2 volts, respectively) yielded the following results:

$^{206}$Pb/$^{204}$Pb = 16.9377 (+/-.0038 2σ), $^{207}$Pb/$^{204}$Pb=15.4864 (+/-.0014 2σ) and $^{208}$Pb/$^{204}$Pb= 36.6936 (+/-.0077 2σ).

For strontium analysis, isobaric interferences that are caused by krypton (Kr) impurities in the argon (Ar) carrier gas are corrected by determining the on-peak zero prior to introducing each sample. Mass bias in the $^{87}$Sr/$^{86}$Sr values is corrected using exponential law, where $^{86}$Sr/$^{88}$Sr=0.1194. The presence of Rb (rubidium) is corrected in measurement of $^{87}$Sr by monitoring $^{85}$Rb intensity levels, which are then subtracted from the $^{87}$Rb intensity levels in $^{87}$Sr using the value $^{87}$Rb/$^{85}$Rb = 0.386, as well as the mass-bias correction factor determined from $^{86}$Sr/$^{88}$Sr values (Turner 2008). The average $^{87}$Sr/$^{86}$Sr value measured in the NBS-987 Sr standard using time resolved analysis (TRA) is 0.710246 (2σ = 0.000030), while the value using long-term thermal ionization (TIMS) analysis is 0.710240 (2σ = 0.000023). In essence, these values are virtually indistinguishable.
6 RESIDENTIAL ORIGINS AND PALEOMOBILITY AT THE ELIZABETH SITE

6.1 Introduction

As discussed, studies of stable and radiogenic isotopes have proven utility in analyzing the residential origins and mobility of human populations. Elucidating potential geographic places of origin and identifying prehistoric migration can inform interpretations of individual social identities, thereby informing the broader human lifeways, including the complex social, economic, and political relationships both within and between prehistoric groups. For the purposes of conceptualizing the nature of the isolated crania from Mound 3 of the Elizabeth site, identifying patterns and both “local” and “non-local” individuals in the population is critical to help contextualize the potential meaning(s) and social identities of the individuals represented by the isolated crania. In this study, lead and strontium isotopes from tooth enamel are characterized, as are oxygen isotopes from bone carbonate.

6.2 Study Objectives

The objective of this research is to assess the life history of the six skulls from Feature 1 of Mound 3 of the Elizabeth site. More specifically, this study will employ analyses of heavy and light isotopes from bone and enamel samples in order to explicate variation in geographic locations during early and late life. Additionally, the study serves as a pilot project evaluating the efficacy of using stable isotope analysis in order to test hypotheses regarding residential provenience and migration in the lower Illinois River valley.
6.3 Research Questions and Hypotheses

Question 1: What are the demographics of the six isolated skulls? What do the demographic parameters suggest about the possible etiology or purpose of the isolated skulls? Given the fact that the demographic profiles and trends of trophy heads greatly influence the interpretations of such phenomena, an accurate profile of age at death and biological sex is an essential first step to assessing the life history of these individuals, and evaluating the symbolic meaning of their interment in Mound 3.

Question 2: Is there variation in isotopic proxies for mobility in early life? Is there variation in these proxies for late life? Do these values suggest that the six skulls are “local” or “non-local” individuals? Further understanding the residential origins of these six individuals may allow for an assessment of how they came to be interred at the Elizabeth site. By assessing whether these individuals are “local” or “non-local,” it may be possible to further speculate, or at least contextualize, their interment at the site.

Question 3: From where did the cultural groups that recolonized the lower Illinois valley during the Early Middle Woodland period originate? While there is no question that new or different cultural groups moved in to the valley following a period of relative abandonment during the Early Woodland period, there is no clear indication as to where these groups may have come from. As many researchers have stated, the most likely point of origin for the migrants into the lower valley is the central Illinois valley area north of the lower valley, although this model has not yet been tested (Bullington 1988; Farnsworth and Asch 1986). However, as King et al. (2011:524) note, as of yet there have been no studies aimed at modeling migration into the lower valley, thus necessitating a multiregional and temporally sensitive approached directed toward analysis of population genetics, demography, and archaeological
data. This research serves as a pilot project, evaluating the efficacy of using isotopic analysis in order to model migration and deduce residential origins in the lower Illinois River valley.

Despite the small-scale of the proposed research, addressing issues such as residential origin, mobility, and biological distance of possible migrant populations has implications for current understandings of the lifeways in the lower valley, as well as the broader research issues of the region.

6.4 Hypotheses

Two primary hypotheses have been formulated to steer the focus of this research. In addition to the primary hypotheses, sub-hypotheses that frame various scenarios within the primary hypotheses have also been generated. Finally, in addition to the primary and sub-hypotheses, a secondary hypothesis has also been generated based on the goals of the pilot study portion of this research. All hypotheses are stated and discussed below.

**H₁:** The isolated crania represent individuals that are/were not part of the Elizabeth community (i.e., “outsiders). If the isolated crania represent outsiders, then the isotopic proxies for residential origin and late life paleomobility (i.e., Sr, Pb, O) will be notably different from the “average” values for the remainder of the Elizabeth population.

**H₁a:** The isolated crania represent trophies taken following inter-group conflict

**H₁b:** The isolated crania represent the (beheaded) remains of outsiders taken during conflict and killed following subsequent imprisonment (i.e., POWs).

**H₁c:** The isolated crania serve as talismans, protecting the individuals interred in the mound from the groups that they represent.

**H₂:** The isolated crania represent individuals that, either through birthright or inclusion, are/were part of the Elizabeth community (i.e., kin, “insiders”). If the isolated crania represent
kin/community members, then the isotopic proxies for residential origin and late life paleomobility (i.e., Sr, Pb, O) will be relatively homogenous across the Elizabeth population, especially O from bone carbonate, which is indicative of late life geographic residence.

**H2a:** The isolated crania represent individuals that were ancestors/kin that were intentionally transported from their place(s) of origin and reburied at the Elizabeth site by the community.

**H2b:** The isolated crania represent kin sacrificed during ritual

**H2c:** The isolated crania serve as talismans, protecting the individuals interred in the mound.

**H2d:** The isolated crania are objects used in veneration ritual and thus represent an act of homage toward deceased community members.

**H3:** The isotopic proxies of paleomobility and residential origins (O, Sr, Pb) are sufficiently specific and sensitive to be used in the lower valley region as a means for deducing residential origins and reconstructing population movement in antiquity. If there is sufficient and specific variation in isoscape values across the lower valley region, then discernable differences in individual isotopic proxies of residential origin and paleomobility will be present.

### 6.5 Results and Discussion

Results for all isotopic parameters (Pb, Sr, O) for the Mound 3 samples are presented in Table 6.1 and discussed below. The table also details parameters of interest, including age-at-death and biological sex. Given that isotopic parameters serve as proxies of distinct climatological and geological contexts, I first discuss the data for each element individually, before proceeding into a synthetic discussion of the collective isotopic data. The statistical analyses presented herein include both parametric and non-parametric analyses of variance and
correlations, factor analysis, and hierarchical cluster analysis, and were performed using SPSS 21.0 and Excel 2013.

Table 6.1: Summary of demographic and isotopic data by individual

<table>
<thead>
<tr>
<th>Burial</th>
<th>Age-at-Death (years)</th>
<th>Sex</th>
<th>δ¹⁸O PDB</th>
<th>δ¹⁸O SMOW</th>
<th>⁸⁷Sr/⁸⁶Sr</th>
<th>²⁰⁶Pb/²⁰⁴Pb</th>
<th>²⁰⁷Pb/²⁰⁴Pb</th>
<th>²⁰⁸Pb/²⁰⁴Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>27-38</td>
<td>M</td>
<td>-4.8</td>
<td>25.5</td>
<td>0.70976</td>
<td>19.221</td>
<td>15.677</td>
<td>38.764</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>35+</td>
<td>M</td>
<td>-4.3</td>
<td>25.9</td>
<td>0.71012</td>
<td>21.516</td>
<td>15.920</td>
<td>41.109</td>
</tr>
<tr>
<td>F1-Sk 3</td>
<td>22-30</td>
<td>M</td>
<td>-4.1</td>
<td>26.1</td>
<td>0.71016</td>
<td>20.362</td>
<td>15.800</td>
<td>40.013</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>25-35</td>
<td>M</td>
<td>-3.9</td>
<td>26.4</td>
<td>0.71017</td>
<td>19.969</td>
<td>15.760</td>
<td>39.510</td>
</tr>
<tr>
<td>F1-Sk 5</td>
<td>22-30</td>
<td>M</td>
<td>-4.1</td>
<td>26.2</td>
<td>0.70985</td>
<td>20.539</td>
<td>15.815</td>
<td>39.976</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>30-51</td>
<td>M</td>
<td>-4.3</td>
<td>25.9</td>
<td>0.71119</td>
<td>20.580</td>
<td>15.825</td>
<td>40.111</td>
</tr>
<tr>
<td>1-1</td>
<td>40-50</td>
<td>F</td>
<td>-3.5</td>
<td>26.7</td>
<td>0.70989</td>
<td>22.331</td>
<td>15.999</td>
<td>41.817</td>
</tr>
<tr>
<td>2-1</td>
<td>50+</td>
<td>F</td>
<td>-4.1</td>
<td>26.2</td>
<td>0.70985</td>
<td>21.179</td>
<td>15.872</td>
<td>40.518</td>
</tr>
<tr>
<td>2-2</td>
<td>45-50</td>
<td>M</td>
<td>-3.9</td>
<td>26.4</td>
<td>0.71006</td>
<td>21.938</td>
<td>15.948</td>
<td>41.425</td>
</tr>
<tr>
<td>3-1</td>
<td>50+</td>
<td>F</td>
<td>-4.3</td>
<td>26.0</td>
<td>0.70981</td>
<td>20.720</td>
<td>15.833</td>
<td>40.184</td>
</tr>
<tr>
<td>3-2</td>
<td>45+</td>
<td>F</td>
<td>-3.6</td>
<td>26.6</td>
<td>0.71056</td>
<td>20.711</td>
<td>15.834</td>
<td>40.198</td>
</tr>
<tr>
<td>5-1</td>
<td>40-55</td>
<td>F</td>
<td>-3.6</td>
<td>26.7</td>
<td>0.7114</td>
<td>21.781</td>
<td>15.930</td>
<td>40.979</td>
</tr>
<tr>
<td>5-2</td>
<td>30-45</td>
<td>M</td>
<td>-5.0</td>
<td>25.3</td>
<td>0.71032</td>
<td>21.477</td>
<td>15.910</td>
<td>40.932</td>
</tr>
<tr>
<td>12-1</td>
<td>45-55</td>
<td>F</td>
<td>-4.7</td>
<td>25.5</td>
<td>0.70991</td>
<td>22.122</td>
<td>15.977</td>
<td>41.574</td>
</tr>
<tr>
<td>13</td>
<td>47+</td>
<td>F</td>
<td>-4.1</td>
<td>26.2</td>
<td>0.71026</td>
<td>19.918</td>
<td>15.745</td>
<td>39.444</td>
</tr>
</tbody>
</table>

6.5.1 ⁸⁷Sr/⁸⁶Sr Results and Discussion

Strontium analysis of enamel apatite was successful for all 15 individuals in the sample population. Of these 15 individuals, two (F1-Sk 4; 5-1) exhibited a weak strontium signal, indicating potential contamination of the sample either in situ or in the laboratory, or possibly that the ⁸⁷Sr/⁸⁶Sr ratio was not substantial enough to yield high signal levels (Hedman et al. 2009). Although the ⁸⁷Sr/⁸⁶Sr values associated with these samples still have merit, the issue of weak signal is important for considerations of specificity.

Strontium results indicate a relatively small variation in early-life strontium isotopic composition in the population from Mound 3 of the Elizabeth site, which ultimately serves as a proxy for local strontium geology, assuming local foods were consumed. ⁸⁷Sr/⁸⁶Sr values range from 0.70976‰ to 0.7114‰, with a mean of 0.71022‰ and a standard deviation of .00048‰.
There are no significant differences in Sr isotope values by age, biological sex, or burial location, or burial context (for contextual information, see section 4.4.1). Furthermore, analysis of Sr isotope values between the isolated skulls of Feature 1 and the rest of the Mound 3 population using a t-test were not significant ($p=.940$). These data suggest that, during the period of enamel crown formation (i.e., early life), the individuals represented in this sample were likely residing in close geographic proximity, or consuming foods sourced from non-distinct geological contexts. However, this interpretation could be confounded by a lack of discernable variation in environmental Sr values, which would result in the normalization of Sr values despite varied residential origins. Four outliers are present in the strontium data set: individuals 3-2, 5-1, and isolated skull F1-Sk 6 all exhibited $^{87}\text{Sr}/^{86}\text{Sr}$ values well above the normal range, with the latter two exceeding two standard deviations of the mean. Additionally, isolated skull F1-Sk 1 exhibited a $^{87}\text{Sr}/^{86}\text{Sr}$ value well below the normal range. While these values are not statistically significant, they are interpretively meaningful and suggest that these individuals may have lived in geologically different areas or consumed non-local foods during early life.
6.5.2 $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ Results and Discussion

Lead isotope values were analyzed using enamel carbonate to estimate each individual’s geological place of residence during the period of enamel formation. Given the samples utilized in this study, the enamel formation period varies between crowns formed in utero, and ranges up to a maximum (relative) age of seven years. It is important to note here that while modernization is resulting in the anthropogenic alteration of global Pb isotopic composition, prehistoric Pb isotope levels in the New World, especially during the Middle Woodland period, were a reflection of complex geological variation and not anthropogenic factors (Kamenov and Gulson 2014).

Wide variation is evident in all three lead isotope ratios (Figure 6.2). $^{206}\text{Pb}/^{204}\text{Pb}$ values range between 19.221‰ and 22.331‰, with a mean of 20.958‰ and a standard deviation of
0.90138‰. The mean error for $^{206}\text{Pb}/^{204}\text{Pb}$ values is 0.003912‰. $^{207}\text{Pb}/^{204}\text{Pb}$ values range between 15.677‰ and 15.999‰, with a mean of 15.856‰ and a standard deviation of 0.09134‰. The mean error for $^{207}\text{Pb}/^{204}\text{Pb}$ values is 0.001532‰. Finally, $^{208}\text{Pb}/^{204}\text{Pb}$ values range from 38.764‰ to 41.817‰, with a mean of 40.437‰ and a standard deviation of 0.86335‰. The mean error for $^{208}\text{Pb}/^{204}\text{Pb}$ values is 0.001938‰.

Figure 6.2: Isoplot of lead $^{206}\text{Pb}/^{204}\text{Pb}$ and $^{207}\text{Pb}/^{204}\text{Pb}$ values by individual

The lead species analyzed share a common etiology and therefore should be highly correlated. Statistical analyses of correlation were conducted using Spearman’s Rank Order Correlation to verify this relationship and to assess abnormalities in the data; all lead species were highly correlated and no abnormalities were found. One individual (F1-Sk 1) exhibited a
$^{208}\text{Pb}/^{204}\text{Pb}$ value noticeably lower than the other individuals in the sample population ($^{208}\text{Pb}/^{204}\text{Pb} = 38.764$). Still, the data indicate very little overall variation in lead ratios for all three lead types. The mean values for all lead isotopes between the isolated crania from Feature 1 are significantly different than those for the remainder of the study sample when analyzed using a t-test ($p = .033; p = .047; p = .05$, respectively). This suggests that the individuals represented by the six crania interred in Feature 1 likely resided in a geologically similar area during their respective early lives. Similarly, the data also suggest that the remaining nine individuals from the Mound 3 isotope sample appear to originate from a similar geographic origin during their own early lives. Not surprisingly, all lead isotope ratios representing Elizabeth Mound 3 are indicative of underlying bedrock that is geologically old and high in U/Pb and Th/Pb. These values are consistent with published data (Kamenov and Gulson 2014; Turner et al. 2009), suggesting an absence of anthropogenic alteration of lead isotopes during the time period; these values further indicate that the Elizabeth population did not engage in mining activities.

6.5.3 $\delta^{18}O$ Results and Discussion

The isotopic ratios of oxygen ($\delta^{18}O$) in bone carbonate reflect those of consumed drinking water during the approximately 10 years preceding the death of the individual. Isotopic ratios of imbibed water are subject to environmental and climactic factors, including temperature, humidity, and elevation, as well as other local climate conditions. Variations in $\delta^{18}O$ values across populations suggest variation in drinking water sources and, indirectly, variation in local climate. Oxygen isotope ratios are expressed in parts per mil (‰) relative to standard marine ocean water (vSMOW). Values of $\delta^{18}O$ relative to the PeeDee Belemnate (vPDB) are converted to values relative to SMOW using the following equation:
Bone carbonate $\delta^{18}$O values vary only modestly, ranging from 25.3‰ to 26.7‰, with a mean of 26.1‰ ± 0.4‰. Of these values, none are significant; this indicates that during the latter 10 years of their lives, individuals in the study population resided in the same general geographic area and/or consumed water from the same (or similar) source.

Figure 6.3: Elizabeth site $\delta^{18}$O values (‰ vs. SMOW) by individual

In order to convert bone carbonate $\delta^{18}$O values to the estimated $\delta^{18}$O of consumed drinking water, I used the following formula (Turner et al. 2009:324) as adapted from Iacumin et al. (1996) and Prohaska et al. (2005):

$$\delta^{18}O_{\text{Carbonate}} - \frac{31.2}{0.78} = \delta^{18}O_{\text{Water}}$$
The resultant set of $\delta^{18}O_{\text{water}}$ values, summarized in Table 6.2, span the range of model-derived $\delta^{18}O_{\text{ppt}}$ (meteoric precipitation) values established by Bowen and Wilkinson (2002) (See also: Dupras et al. 2008; Dupras and Schwarcz 2001; Iacumin et al. 1996). Estimated $\delta^{18}O_{\text{water}}$ values for the individuals sampled herein vary between -7.6‰ to -5.7‰, with a mean of -6.5‰ ± .6‰. Because of the connection between environment, geology, drinking water, and geographic location, it is important to note here that like much of the lower valley region, the area around the Elizabeth site is served by numerous streams and natural springs, as well as the Illinois River; all such water sources are subject to an array of evaporative processes leading to notable variation in baseline $\delta^{18}O$ values. The $\delta^{18}O_{\text{water}}$ ratios calculated based on precipitation, river, and ground water at the location of the site average -7.00‰ (Bowen and Wilkinson 2002; Bowen 2015; Bowen and Revenaugh 2003). Regardless, the oxygen isotope data all suggest that during the latter decade of life, the entire population interred in Mound 3 of the Elizabeth site ostensibly resided in the same geographic area and/or consumed similar, locally sourced water.

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>$\delta^{18}O_{\text{water}}$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>-7.4</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>-6.8</td>
</tr>
<tr>
<td>F1-Sk 3</td>
<td>-6.5</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>-6.2</td>
</tr>
<tr>
<td>F1-Sk 5</td>
<td>-6.4</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>-6.8</td>
</tr>
<tr>
<td>1-1</td>
<td>-5.7</td>
</tr>
<tr>
<td>2-1</td>
<td>-6.5</td>
</tr>
<tr>
<td>2-2</td>
<td>-6.2</td>
</tr>
<tr>
<td>3-1</td>
<td>-6.7</td>
</tr>
<tr>
<td>3-2</td>
<td>-5.9</td>
</tr>
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<td>5-1</td>
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<tr>
<td>5-2</td>
<td>-7.6</td>
</tr>
<tr>
<td>12-1</td>
<td>-7.3</td>
</tr>
<tr>
<td>13</td>
<td>-6.5</td>
</tr>
</tbody>
</table>
6.6 Synthesis of Results and Discussion

The analysis of three isotopic proxies for population movement provides a basis to discuss paleomobility and potential residential origins for the individuals interred in Mound 3 of the Elizabeth site. The following synthesis of isotopic results and subsequent discussion begins by focusing on the isolated skulls from Feature 1 of Mound 3, before proceeding to a broader discussion of the individuals interred at the site. This broader discussion more directly addresses the efficacy of biogeochemical analyses in assessing paleomobility in the lower Illinois valley region.
Table 6.3: Summary of isotopic data by individual

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>Strontium</th>
<th>Lead</th>
<th>Oxygen</th>
<th>Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>Outlier</td>
<td>Outlier</td>
<td>Normal (-)</td>
<td>Normal (-)</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
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<tr>
<td>F1-Sk 3</td>
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<td>Normal</td>
<td>Normal (-)</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 5</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal (+)</td>
</tr>
</tbody>
</table>

6.6.1 Feature 1, Skulls 1-6

Skull 1 had low $^{87}\text{Sr}/^{86}\text{Sr}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ values, as well as a relatively low $\delta^{18}\text{O}$ value. The low values for $^{87}\text{Sr}/^{86}\text{Sr}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$, all of which are derived from the enamel apatite, suggest this individual likely resided in a comparably different geographic location early in life. The relatively low $\delta^{18}\text{O}$ value, which is derived from bone carbonate, suggests that this individual may have resided in comparably different area in the decade preceding death. The data indicate that the individual represented by F1-Sk 1 was likely an immigrant to the Elizabeth site area, having originated from elsewhere in the valley. Additionally, the lack of $\delta^{18}\text{O}$ value normalization suggests this individual either resided in a non-local area at the time of death, or that the individual was a relative newcomer to the Elizabeth area, thus the $\delta^{18}\text{O}$ values had not completely normalized to the local values at the time of death.

Figure 6.5: F1-Sk 1 comparison of isotopic proxies of paleomobility (individual vs. group average)
Skull 2 exhibited average $^{87}\text{Sr}/^{86}\text{Sr}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ values, while $\delta^{18}\text{O}$ values were comparably lower. The average $^{87}\text{Sr}/^{86}\text{Sr}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ are indicative of comparably similar (or shared) geographic location during early life, while the low $\delta^{18}\text{O}$ value suggests that this individual may have resided in comparably different area in the decade preceding death. Alternatively, the individual may have been a relative newcomer to the Elizabeth area, thus the $\delta^{18}\text{O}$ values had not completely normalized to the local values at the time of death. If this is the case, this indicates that either the individuals with shared geographic location during early life migrated to the Elizabeth area during life, or perhaps this individual resided elsewhere during life, returning to the Elizabeth area for a period of time before death.

Skull 3 produced average $^{87}\text{Sr}/^{86}\text{Sr}$, $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, $^{208}\text{Pb}/^{204}\text{Pb}$, and $\delta^{18}\text{O}$ values in comparison with the total sample. These results suggest that the individual represented by F1-Sk 3 originated from a comparably similar (or shared) geographic location during early life, and was also local to the Elizabeth area in the decade preceding death.

Skull 4 produced average $^{87}\text{Sr}/^{86}\text{Sr}$ values, modestly lower $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ values, and higher (but still average) $\delta^{18}\text{O}$ values, when compared with the total sample. These results suggest that the individual represented by F1-Sk 4 likely originated from a comparably similar (or shared) geographic location to the majority of the Mound 3 population during early life, and was also local to the Elizabeth area in the decade preceding death.

Skull 5 yielded comparably lower (but average) $^{87}\text{Sr}/^{86}\text{Sr}$ values, and average $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, $^{208}\text{Pb}/^{204}\text{Pb}$, and $\delta^{18}\text{O}$ values in comparison with the total sample. The results suggest that the individual represented by F1-Sk 5 likely originated from a comparably similar
(or shared) geographic location to that of the majority of the Mound 3 population during early life, and was also local to the Elizabeth area in the decade preceding death.

Skull 6 produced high $^{87}\text{Sr}/^{86}\text{Sr}$ values, while the $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ values were relatively average, as were $\delta^{18}\text{O}$ values. The comparably similar $\delta^{18}\text{O}$ values are indicative of an individual that resided in the local Elizabeth area prior to death. However, the data regarding the geographic origin of this individual is less apparent. Clearly, the high $^{87}\text{Sr}/^{86}\text{Sr}$ values suggest that the individual likely originated from a geographically different area at or around birth. While the $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ values do not seem to support this conclusion, the simple explanation could be that, because of the extensive (and relatively homogenous) loess overburden characteristic of the valley, different geographical areas could share relatively similar local lead values. If this is the case (which seems likely), then the individual represented by F1-Sk 6 likely originated from a comparably different geographic location than did the majority of the Mound 3 population, and immigrated to the Elizabeth area in sufficient time for $\delta^{18}\text{O}$ values to have equilibrated to the local values prior to death. Alternatively, if sufficient geographical variation in lead values does exist in the region, this would instead suggest an issue in $^{87}\text{Sr}/^{86}\text{Sr}$ analysis, indicating that this individual shared a geographic origin with the rest of the Mound 3 population. Given the extreme care taken in sample acquisition and preparation, strength of the Sr signal to the mass spectrometer, as well as the normalcy of the data, this would seem highly unlikely.
7 ECOLOGY, DIET, AND SUBSISTENCE AT THE ELIZABETH SITE

7.1 Introduction

The reconstruction of diet and subsistence is critical to broader archaeological analysis. Beyond the wide-ranging characterization of diet and subsistence across the Illinois area, the diet and subsistence of the Elizabeth site population, recreated using both direct and indirect methods, is an essential component of bioarchaeological inquiry. Diet functions not only as a fundamental feature of daily life, but can also provide insights into physiological well-being and health, social identity, socioeconomic circumstances, political economy, and human-environmental interaction. Accordingly, elucidating the dietary characteristics across the Elizabeth site population, which will allow for comparisons of individuals and groups, will ultimately serve to clarify the biocultural dynamics of the population, as well as the social identities of the individuals represented by the six isolated skulls.

7.2 Diet and Subsistence in the LIRV

Remains of food, animals, and botanicals recovered from archaeological sites serve as a method of directly reconstructing the diet and subsistence of indigenous groups throughout the history of the Midcontinental United States. In addition to excavation data, numerous other studies have focused on the reconstruction of diet and subsistence through stable isotope analysis (Ambrose et al. 2003; Dekker 2008; Dong et al. 2010; Dupras et al. 2008; Hanson and Buikstra 1987; Reitsema 2013; Rose 2008; Tomczak 2003; Turner and Armelagos 2012; van der Merwe et al. 1996), paleoenvironmental and paleoecological reconstruction (Asch 1976; Cleland 1976; Styles 1981; Talkington 1991), and faunal and floral surveys (Asch 1976; Styles 1981; Talkington 1991; Turner 1936).
Data from numerous Middle Woodland habitation sites in the lower valley indicate a diversity of local fauna were consumed, though white tail deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and migratory water birds such as duck (*Aas platyrhynchos* [mallard]; *Anas rubripes* [black duck]), and geese (*Branta canadensis*) occur with high frequency (Struever 1968). Of these species, white-tailed deer occur with the greatest frequency (85%), indicating the significance of this species in the subsistence economy during the Middle Woodland (Perino et al. 2006). Seventeen species of bird were identified from the Snyders site, as were the remains of various mammals, including raccoon, beaver, dog, woodchuck, and elk (Perino et al. 2006).

In addition to terrestrial species, local freshwater fish and mollusks occur with great frequency in archaeological contexts throughout the lower valley, with the Blue-Point mussel (*Amblema* spp.), being the most common species, representing 45% of all identified mussels (Perino et al. 2006). Thirty-one species of freshwater mussel were recovered and identified from the Snyders Village site, the majority of which are common in the main channel of large-rivers (Perino et al. 2006). One species in particular (*Fusconaia ebena*) is noteworthy because these muscles generally only reside in deep water (Perino et al. 2006). Thirteen species of fish are found at the Snyders site, of which the freshwater drum (*Aplodinotus grunniens*) is the most prolific, followed by catfish (*Catfish* spp.), and buffalofish and suckers (Catostomidae) (Perino et al. 2006). Finally, several species of turtle have been found associated with habitation sites, as have two specimens of aquatic snail (Perino et al. 2006).

In addition to the faunal remains, numerous species of local flora have also been recovered. Flora recovered from the Apple Creek site include over 36,000 fragments of hickory nut, and 4,200 fragments of acorn; seeds from commensal plants, such as *Polygonum*,...
Chenopodium, and Iva are also prolific at the site (Struever 1968:299). Data from the Newbridge site, another Middle Woodland habitation site in the valley, are similar to those from Apple Creek. Carbonized Chenopodium and Polygonum seeds were recovered in a large mass, which was free of leaves, stems, or plant debris, suggesting these items were burned and discarded during the cooking process (Struever 1968). While carbonized remains were not found at Apple Creek, the species recovered suggest that the seed-bearing plants Chenopodium and Polygonum were an important component of the Middle Woodland subsistence economy. Evidence from the Snyders Village site also found charred hickory nuts and acorns, as well as papaw (Asimina triloba) and persimmon seeds (Diospyros virginiana).

The archaeological record paints a clear picture of the subsistence economy of the Middle Woodland, where weed seeds, acorns, hickory nuts, mussels, fish, waterfowl, turkey, deer, and other animals constituted the bulk of the diet, and other species were procured and consumed as available (Asch 1976; Buikstra 1977; McGregor 1959; Perino et al. 2006; Struever 1968; Styles 1981). Cleland (1976:67-71) has noted that, although the Middle Woodland period seems to indicate a slow shift toward agriculture, the subsistence economy is best described as one that relies on a non-specialized multiple resource base that follows a “diffuse” (i.e., generalized) rather than focal (i.e., focused/specialized [such as maize]) pattern.

7.3 Ecology and Subsistence at the Elizabeth Site

As stated above, the archaeological record of the lower valley (in general) suggests Middle Woodland groups relied on weed seeds, acorns, hickory nuts, mussels, fish, waterfowl, turkey, and deer, opportunistically procuring and consuming species as available. This non-specialized subsistence methodology, which emphasized the exploitation of multiple resources rather than relying heavily on any one source, would have been ideal for the mobile hunter-
gatherer groups that resided in the vicinity of the Elizabeth site. Although no studies have been conducted which characterize the diet specific to the Elizabeth site across time periods, archaeological evidence in the form of faunal and paleobotanical remains exist that give general indications of the diet and subsistence at the site. In addition to the faunal and botanical data from the Elizabeth site, there is also sufficient data on faunal and botanical assemblages from both the Napoleon Hollow and Smiling Dan sites. Napoleon Hollow is a small, valley floor habitation site at the foot of the bluffs very near the Elizabeth site, while Smiling Dan is also a site located due east of the Elizabeth site near the foot of the Eastern bluff. In contrast to the Elizabeth site, both Smiling Dan and Napoleon Hollow have Middle Woodland components, thus the subsistence data from these sites may be more indicative of Middle Woodland subsistence than the assemblages from the mortuary context of the Elizabeth site.

7.3.1 Elizabeth Site Faunal Analysis

Although the faunal remains recovered during excavation come from tombs within the mortuary component of the site and date roughly to the Archaic period, these remains are nevertheless representative of species availability shortly before the Middle Woodland occupation of the Elizabeth site. Most of the faunal remains recovered had been burned or intentionally modified, making species determination (in some cases, but not all) difficult. Of the faunal remains recovered from the central tomb of Mound 6, 30 of the 38 mammal bones belong to large mammals, most likely elk (*Cervus elephus*) and possibly white-tailed deer (Leigh and Morey 1988). Also present was the left maxillary canine of a cougar (*Felis concolor*), as well as two unidentified teeth (Leigh and Morey 1988). The remains of two birds were also found at Mound 6, a turkey (*Melagris gallopavo*) and an American coot (*Fulica americana*), both of which were placed above the main floor of the tomb (Leigh and Morey 1988).
Freshwater fish and mollusks were also found in Mound 6. The remains of a black bullhead (*Ictalurus melas*) and an unknown species (represented by a burned vertebra) were recovered from the central tomb (Leigh and Morey 1988). Twenty-five fragments of *Busycon* (large, edible sea snail) shell were recovered, and two shell beads, one of which was river pearl (Leigh and Morey 1988).

Faunal analysis was also conducted at Mound 7 of the site. The faunal remains from Mound 7, which come from the central tomb, are more diverse than those in other areas of the site, which further suggests that these remains may be of symbolic nature. Regardless, the species represented are indicative of those available for consumption in the Elizabeth site vicinity. Elk predominated the faunal assemblage of the tomb and were modified and burned similarly to those from the Mound 6 tomb; one section of burned elk antler was also recovered (Leigh and Morey 1988). Bird remains were also found in the central tomb, nine elements of which are Canadian goose; another 12 elements from birds are of unknown species, but consist of polished long bones (Leigh and Morey 1988). Reptile remains are also found the Mound 7 assemblage, including both a single fragment from a box turtle (*Terrapene* spp.) and a complete box turtle, which was interred in the subfloor pit of the central tomb (Leigh and Morey 1988).

Elsewhere in Mound 7, the faunal assemblage was quite similar to both the Mound 7 central tomb and that of Mound 6. This assemblage included skeletal elements from elk (modified and unmodified), unknown large animals (modified and unmodified), turkey (modified and unmodified), Canadian goose, modified trumpeter swan (*Cygnus buccinators*), a Blanding’s turtle (*Emydoidea blandigi*), a coyote mandible (*Canis* cf.), several modified and natural bivalve shells, 130 marine-shell discs, an immature dog (*Canis* cf. *familiaris*), and the modified crania of
both grey (*Sciurus carolinensis*) and fox (*Sciurus niger*) squirrel (Leigh and Morey 1988:278-281).

The ornamental modification of the majority of the faunal assemblage, as well as the location of the assemblage in a mortuary mound, both suggest these items were used for structural and ornamental purposes rather than for subsistence. However, despite the lack of direct evidence, it can be inferred that these items could have been utilized for subsistence. As Leigh and Morey (1988:281) note, the relative abundance of elk in the Elizabeth assemblage is unusual, especially considering the utter lack of deer, which typically dominates the assemblage of most Middle Woodland sites; this further suggests that either the consumption of elk at the Elizabeth site was an anomaly, or that these animals were used for symbolic purposes and not as a food source. Regardless, the faunal assemblage of Mounds 6 and 7 is at least representative of the faunal resources common in the Elizabeth site vicinity during the Archaic period.

### 7.3.2 Elizabeth Site Archaeobotany

The recovery and identification of plant remains from beneath Mound 6 at the Elizabeth site, a Middle Archaic midden, provides a reasonable basis for assessing the flora availability and utilization at the site. However, it should be noted that the archaobotanical analysis discussed herein comes from the Middle Archaic component of the site, thus may not directly reflect the diet and subsistence of the later Middle Woodland component of the site. Therefore, data from both Smiling Dan and Napoleon Hollow, Middle Woodland habitation and ceremonial sites (respectively), are also incorporated below (see section 7.3.3) as they are most representative of the diet of the individuals interred in Mound 3.

Plant remains recovered from beneath Mound 6 were separated from the matrix and cleaned via tub flotation and chemical flotation, then analyzed using a binocular microscope at
10X magnification (Asch and Asch 1988). Samples were taken from an 8 m x 3.5 m area that resulted 176L of soil and yielded 28g of charcoal (Asch and Asch 1988). More than 80% of the total sample was black walnut (*Juglans nigra*) shell fragments, and the majority of the remainder was thick-shelled hickory (*Carya* asp.) (Asch and Asch 1988). Strangely, while acorn is typically a mainstay of contemporary sites in the valley, none is found at the Elizabeth site (Asch and Asch 1988). Two grape seeds, wood pieces, bark, grass stems and rhizomes, and various unidentifiable materials were also found in the sample area (Asch and Asch 1988). The remains of pecans (*C. illinoensis*) and hazelnuts (*Corylus americana*) were recovered, though both were rare (Asch and Asch 1988). These data suggests that hickory and black walnuts were consumed in larger quantities and higher frequencies than other items, but pecans, hazelnuts, and various grass stems and rhizomes were also consumed, perhaps depending on availability.

### 7.3.3 Napoleon Hollow and Smiling Dan Sites: Archaeobotany Assemblage

Asch and Asch (1986) analyzed wood and archaeobotanical remains from the Woodland component of the Napoleon Hollow site, the valley floor ceremonial/mortuary site at the foot of the bluffs upon which the Elizabeth site is constructed. Because the site was likely utilized for ceremonial and/or mortuary activities rather than habitation, the faunal and botanical assemblages are considered less representative of Middle Woodland subsistence (Asch and Asch 1986; Calentine and Simon 2006). Wood charcoal from oak and hickory tend to dominate the assemblage at sites near the Illinois River, suggesting the landscape was likely more open woodland composed of oaks and hickories (Calentine and Simon 2006). This modification has been interpreted as a result of the practice of slash and burn agriculture by the populations residing in the valley area, where native seeds were cultivated in order to reduce the reliance on natural flora (Calentine and Simon 2006). Relatively few nutshells (25.8% of assemblage) and
seeds (n=233; 0.1% of assemblage) were found at the site in Blocks I and IV, which were dominated by wood (Asch and Asch 1986; Calentine and Simon 2006).

Asch and Asch (1985) also analyzed wood and archaeobotanical remains from the Woodland component of the Smiling Dan site, a permanent/semi-permanent habitation site on the eastern periphery of the valley due east of the Elizabeth site. Nutshell accounts for 39.4% of the assemblage at Smiling Dan, while seeds (n=16,653; .01% of assemblage) are plentiful; wood dominates the assemblage at roughly 50.8% (Asch and Asch 1985; Calentine and Simon 2006). Calentine and Simon (1996:41) note that the botanical assemblage at Smiling Dan “exhibits an extraordinary seed assemblage, with thousands of starchy grains including erect knotweed, maygrass, little barley, and chenopod,” which comprise around 90% of the total botanical assemblage.

Calentine and Simon (1996:36) note that, in western Illinois, the occurrence of hazelnut shells during the Woodland period is much higher than in other areas and subsequent time periods, outranking hickory nuts at nearly twice as frequent. Black walnut also occurs with great frequency at both Smiling Dan and Napoleon Hollow, while acorn shells are few (Asch and Asch 1985; Asch and Asch 1986; Calentine and Simon 2006).

Faunal and botanical assemblage data for the Elizabeth, Napoleon Hollow, and Smiling Dan sites indicate that a variety of species were available between the Middle Archaic and Middle Woodland. Furthermore, these data support the aforementioned theories that the human groups residing in the lower Illinois valley during the Middle Woodland were hunter-gatherers that engaged in non-specialized foraging activities devised to maximize dietary efficiency by exploiting the full spectrum of available resources in the lower valley area. Additionally, these populations may have engaged in landscape modification in order to improve production and
foraging efficiency, including the domestication of sumpweed, and the genetic alteration (or domestication) of sunflower. During the Middle Woodland, the thick-shelled hickory and hazelnut were of importance, as were the larger fauna, migratory waterfowl, and riverine resources.

7.4 Study Objectives

As stated, the objective of this research is to assess the life history of the six skulls from Mound 3, Feature 1 of the Elizabeth site. The component of research discussed in this section focuses on the analysis of stable carbon isotopes to reconstruct and analyze diet and subsistence. By reconstructing the components of the diet that contribute to carbon levels in the human skeleton, it is possible to elucidate the broader diet patterns of the Elizabeth population. Of specific importance to the overarching objective of this study is the analysis of dietary patterns between and within groups and individuals.

7.5 Research Questions and Hypotheses

Question 1: Is there variation in isotopic parameters for diet between the individuals represented by the six skulls and the remainder of the Mound 3 population? If so, what might have caused these variations in diet and what does this suggest about the status of the six individuals represented by the isolated skulls?

Two primary hypotheses have been formulated to steer the focus of the diet and subsistence portion of this research. In addition to the primary hypotheses, sub-hypotheses that frame various scenarios within the primary hypotheses have also been generated. All hypotheses are stated and discussed below.

\( H_1: \) The isolated crania represent individuals that are/were not part of the Elizabeth community (i.e., “outsiders). If the isolated crania represent outsiders, then the isotopic
proxies for diet and subsistence (i.e., carbon) may be notably different from the “average” values for the remainder of the Elizabeth population.

**H$_1$a:** The isolated crania represent trophies taken following inter-group conflict

**H$_1$b:** The isolated crania represent the (beheaded) remains of outsiders taken during conflict and killed following subsequent imprisonment (i.e., POWs).

**H$_1$c:** The isolated crania serve as talismans, protecting the individuals interred in the mound from the groups that they represent.

**H$_2$:** The isolated crania represent individuals that, either through birthright or inclusion, are/were part of the Elizabeth community (i.e., kin, “insiders”). If the isolated crania represent kin/community members, then the isotopic proxies for diet (i.e., carbon) will be relatively homogenous across the Elizabeth population, and will adhere to patterns based on contextual analysis.

**H$_2$a:** The isolated crania represent individuals that were ancestors/kin that were intentionally transported from their place(s) of origin and reburied at the Elizabeth site by the community.

**H$_2$b:** The isolated crania represent kin sacrificed during ritual

**H$_2$c:** The isolated crania serve as talismans, protecting the individuals interred in the mound.

**H$_2$d:** The isolated crania are objects used in veneration ritual and thus represent an act of homage toward deceased community members.
7.6 Bone Carbonate \( \delta^{13}C \) Results and Discussion

Carbon isotope ratios (\( \delta^{13}C \)) in bone apatite are indicative of the diet consumed by individuals in the decade preceding death, with values representing the overall dietary contributions of marine and terrestrial animals, and plants with \( C_3 \), \( C_4 \), and CAM photosynthetic pathways. Normal \( \delta^{13}C \) values range between -5.0‰ and -25.0‰; values that are more negative are indicative of diet rich in plants using the \( C_3 \) photosynthetic pathway (e.g., wheat), while values that are less negative indicate more \( C_4 \) plants (e.g., maize). Intermediate values (\( \delta^{13}C \sim -14.4‰ \)) suggest a diet of mixed plant consumption or consumption of CAM plants, though these are extremely rare in the Midcontinental United States (Bowen and Wilkinson 2002:317). However, since \( \delta^{13}C \) values represent an average of carbon from the whole diet (i.e., from all sources), these values could also reflect the consumption of terrestrial animals that are themselves \( C_3 \) browsers or \( C_4 \) grazers (Katzenberg 1992; Katzenberg and Harrison 1997; Kingston 1999; Price and Burton 2010; Price et al. 1985; Thackeray et al. 1996; Turner 2008).

All of the 15 bone apatite samples successfully yielded \( \delta^{13}C \) ratios and were included in analysis, although individual 5-2 exhibited high levels of \( CO_2 \), potentially indicating contamination of the sample either in the lab or in situ. Carbonate \( \delta^{13}C \) ratios are expressed as per mil relative to PDB.

The following formula was used to convert bone apatite \( \delta^{13}C \) to the estimated \( \delta^{13}C \) of consumed diet:

\[
\delta^{13}C \ (\%o, \text{vs. PDB}) - 11
\]
The resulting set of δ¹³C values ranges from -14.4‰ to -7.5‰, with a mean of -12.5‰ ±1.8966‰. These values all fall well below the intermediate threshold and support previous interpretations that maize was not a developed food source for the people inhabiting the Midcontinental United States during the Middle Woodland period. There is no significant variation in δ¹³C values by burial location, position, or age at death. However, there are significant differences in δ¹³C values by sex when analyzed using a t-test (p=.05), with males exhibiting mean values less negative than those of females (-12.772 vs. -13.536). Interestingly, two individuals (F1-Sk 6; 5-2) exhibited notably lower δ¹³C values (-8.7 and -7.5, respectively), though these are not statistically significant.

<table>
<thead>
<tr>
<th>Biological Sex</th>
<th>Average δ¹³C values (% vs. PDB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>-13.536</td>
</tr>
<tr>
<td>Female</td>
<td>-12.772</td>
</tr>
</tbody>
</table>

Figure 7.1: δ¹³C values (% vs. PDB) by individual
### 7.7 Discussion and Conclusions

These data indicate only minor variation in dietary carbon values for the Mound 3 population at the Elizabeth site. The data support the myriad studies suggesting that maize agriculture had not yet become a major component of the Middle Woodland diet and instead indicate that C₃ plants, such as the hickory, walnut, prairie grasses and rhizomes. Furthermore, the data also support the consumption of animals that subsist on a combination of C₃ or C₄ plants, such as deer, elk, and squirrel, as well as waterfowl, freshwater bivalves, and fish. There is a notable and significant difference in the carbon isotope values between males and females, but no distinct variation in values based on age at death, burial location, burial orientation, or burial position. The relative homogeneity of the carbon isotope values for the Mound 3 sample indicate little differentiation in access to resource, except where sex is considered. This may indicate that males and females interred in Mound 3 of the site had access to (or were excluded from) a particular food source. Finally, individual 5-2 and isolated skull 6 both had relatively low carbon isotope levels, suggesting these two individuals may have regularly consumed a diet that was high in an item(s) with a low carbon isotope value, or that they were excluded from items with a “less negative” carbon isotope value. In order to address this issue, as well as the issue of sex differentiation in diet composition, it would be necessary to characterize both carbon and nitrogen isotope values for bone collagen and carbonate, as well as enamel apatite, thus providing additional levels of analysis with which to draw more reasoned conclusions.
8 BIOLOGICAL DISTANCE AT THE ELIZABETH SITE

8.1 Introduction

Studies of phenotypic inheritance, or biological distance (hereafter “biodistance”), examine phenotypic variation of the cranium and dentition in order to assess the genetic similarity between individuals and populations (Buikstra et al. 1990; Stojanowski and Schillaci 2006). Methodologically, analysis of biodistance relies on the observation of metric and non-metric traits of the cranium and dentition as an approximation of latent genotypic information (Stojanowski and Schillaci 2006). Skeletal samples can be compared more broadly at the regional or local interpopulation level, or more specifically at the individual level within a given sample (Stojanowski and Schillaci 2006). Although research goals vary, biodistance studies examine patterns of microevolution and inheritance in humans and serve to elucidate key aspects of prehistoric lifeways.

Despite the ability of biodistance studies to examine variation and affinity at an inter-regional level, an important aspect of biodistance research is the capability to focus on temporally and geographically restricted samples (Buikstra et al. 1990; Stojanowski and Schillaci 2006). These focused studies are less concerned with the issues of population origins or patterns of genetic affinity than with population specific questions regarding demographics, migration patterns, population aggregation, and the effects of such activities on allele distribution within the population (Buikstra et al. 1990; Stojanowski and Schillaci 2006). In short, spatially or temporally focused biodistance studies examine the many lived experiences that affect the degree of biological integration within human populations.
Within small-scale biodistance research are five common research orientations, including analyses of kinship and cemetery structure, sex-specific phenotypic variation, aggregate phenotypic variation, temporal microchronologies, and age-structured phenotypic variation (Stojanowski and Schillaci 2006). These five areas of inquiry form the basis of two broader research categories. The first category examines intra-cemetery structure based on spatial, temporal, or demographic variables (Stojanowski and Schillaci 2006). Kinship and cemetery structure analysis utilizes biodistance data to identify related individuals within larger cemeteries, thus examining potential kin-structured burial systems (Stojanowski and Schillaci 2006). Temporal microchronologies are used to evaluate patterns of phenotypic variation within one site over a span of time during which microevolutionary processes or changing patterns of gene flow may have occurred (Stojanowski and Schillaci 2006). The final method of intra-cemetery investigation is age structure phenotypic variation, which examines intra-population selection processes and provides a measurement of morbidity, growth arrest, and early mortality (Stojanowski and Schillaci 2006). The second category of inquiry focuses on studies of sex-specific and aggregate phenotypic variability. Comparison of sex-specific phenotypic variation within sites and/or regions enables researchers to make inferences regarding post marital residence practices, which speak directly to the social organizations and other aspects of prehistoric life (Buikstra et al. 1990; Stojanowski and Schillaci 2006). Lastly, aggregate phenotypic variation analysis between distinct sites and/or regions is utilized to draw inferences regarding the formation of sites and cemetery areas (Buikstra et al. 1990; Stojanowski and Schillaci 2006).
8.2 Previous Biodistance Research

Biodistance data from skeletal remains can be gathered through measurement and/or observation of specific characteristics of the cranium, dentition, and, in some cases, the postcranial skeleton (although these are less frequent). The use of craniometric variables, cranial non-metrics traits, dental metrics, and dental morphological variables are all rooted in heritability studies (Buikstra et al. 1990; Stojanowski and Schillaci 2006). While there is considerable variation amongst study samples, phenotypic variance clusters around a narrow-sense heritability estimate (that is, the transmissible component of non-environmental inheritance ($h^2$)) value of 0.55 (Stojanowski and Schillaci 2006; Vitzthum 2003). Here, heritability is defined as the ratio of additive genetic variance to total phenotypic variance within a population. Heritability estimates have great utility in social sciences research, especially in the disciplines of bioarchaeology, evolutionary anthropology, and epidemiology, especially given more recent foci on examining biological, rather than cultural or behavioral, phenotypes (Vitzthum 2003). Still, the concept of heritability is often mis-interpreted (or over-emphasized), further complicating its use in research. Regardless, methods of biodistance analysis using phenotypic data from skeletal populations to infer genotype have proven utility and theoretical reliability, even when utilized for small-scale analyses (Alt and Vach 1995; Buikstra 1972; Buikstra et al. 1990; Stojanowski and Buikstra 2004; Stojanowski and Schillaci 2006).

Metric analysis can be conducted on both the cranium and dentition in order to assess (or estimate) the phenotypic similarity between populations and/or individuals. Continuous measurements of variable data are gathered, and then the data are analyzed using standard descriptive (minimum, maximum, mean, standard deviation) and inferential statistical methods (Stojanowski and Schillaci 2006). The use of cranial metric data is most common and is based
on standard inter-landmark distances (Buikstra and Ubelaker 1994). Various forms of dental metric data are also commonly used in biodistance studies; of these, the mesiodistal and buccolingual dimensions of dental crowns are the most common measurement (Buikstra and Ubelaker 1994; Stojanowski and Schillaci 2006). More recently, some researchers (Hillson et al. 2005; Pilloud and Hillson 2012; Stojanowski 2007; Stojanowski and Schillaci 2006) have advocated the use of measurements of the cervical region of the tooth (the area where the enamel meets the root) as this area accurately reflects a similar genetic signal to that of the enamel crown, yet is less subject to alteration by dental wear.

Analysis of non-metric traits can also be conducted on crania, as well as analyses of morphological traits in dentition, in order to assess inter-population and inter-individual similarity. Although non-metric traits are discontinuous in phenotypic expression, they are nevertheless assumed to have an underlying continuous mode of inheritance (Stojanowski and Schillaci 2006). The primary descriptive statistic in non-metric trait analysis is the presence of traits (e.g., shovel-shaped incisors, cingulum projections) their degrees of expression, and their respective frequencies (Stojanowski and Schillaci 2006). While this presents a relatively straightforward method of data collection, it can also result in inter-observer errors, which further complicate analysis by creating a discontinuous mode of expression (Stojanowski and Schillaci 2006). Regional or global analysis benefit from the use of polymorphic traits, or those that are found in numerous populations at moderate frequencies (Stojanowski and Schillaci 2006). Dental morphological traits include subtle variations in cusps, projections and roots, while cranial non-metric traits include variations of bone projections or foramina. For intra-site analyses, traits that represent genetic anomalies (i.e., rare characters or character expressions) are often more useful in identifying closely related individuals (Stojanowski and Schillaci 2006).
addition to cranial and dental non-metric analysis, some post cranial anomalies can also be useful in determining patterns of genetic affinity, such as sacralization of lumbar vertebrae and supracondylar processes on the humerus (Buikstra and Ubelaker 1994; Stojanowski and Schillaci 2006). Regardless of the method (or methodologies) utilized for analysis, accurate identification and recording of anomalies or traits is essential to biodistance analysis.

8.3 Study Objectives

The objective of this research is to assess phenotypic inheritance and biological affinity at Mound 3 of the Elizabeth Site during the Middle Woodland period (ca. 50 B.C.- A.D. 400). However, since this study does not analyze DNA in order to assess genetic affinity, the genetic relationships among and between individuals are simply inferred, and the extent to which epigenetic and environmental conditions affect the expression of these genetic pathways is unknown. This study specifically attempts to elucidate patterns of inter- and intra-group genetic variation in order to answer fundamental questions regarding prehistoric life in the region.

Given the apparent significance of the six skulls interred in Feature 1 of Mound 3, this research explores patterns of phenotypic variation to identify potential genetic relationships between these skulls and the rest of the Mound 3 population in an effort to both contextualize this event and explicate group dynamics, as well as address the cultural identity of the population interred in Mound 3.

8.4 Research Questions and Hypotheses

*Research Question 1:* Who were the individuals that are represented by the skulls interred in Feature 1 of Elizabeth Mound 3? In order to address this question, a secondary question emerges regarding the biological affinity of these individuals. *Research Question 2:* What degree of genetic similarity is shared between the six skulls interred in Feature 1 of Mound 3, as well as
between these individuals and the other individuals interred in Mound 3? While assessing biological affinity does not directly address the question of who these individuals were, biodistance analysis does allow for inferences to be made regarding whether or not these individuals were more likely part of the Elizabeth population, or whether they were more likely part of a biologically distinct group, one that did not experience a high rate of genetic exchange with the Elizabeth population. Through biological distance, it is also possible to further address the unusual circumstances of their interment, and elucidate affinal relationships that might inform interpretations of the skulls in Feature 1.

Despite the relatively small-scale and limited sample size of this biodistance research, addressing the degree of genetic relatedness of these populations has implications for the current understandings of the lifeways in the lower valley, as well as the broader research issues of the region.

8.5 Methods

8.5.1 Sample Selection

Individuals from the skeletal assemblage of Elizabeth Mound 3 were included in the study population based on the availability and condition of mandibular first, second, and third molars (M₁, M₂, M₃). Due to the importance of utilizing unaltered permanent dentition, the sample population available for the study was extremely limited. While the full skeletal population from Mound 3 consisted of 27 individuals, only 11 individuals were suitable for cervicometric analysis (Bullington 1988; Charles et al. 1988; Leigh et al. 1988).

Biological distance was analyzed using dental metric data. Due to the fragmentary condition of the six skulls from Feature 1, the use of cranial metric and non-metric methods was not possible. In addition, Buikstra (1972, 1976) has noted that occlusal surface attrition,
especially in individuals in excess of 30 years of age, obscures dental morphology and impedes the accurate observation and measurement of dental crown data. However, alternative measurements of dentition have been successful in assessments of biological distance (Hillson et al. 2005; Pilloud and Hillson 2012; Stojanowski 2007; Stojanowski and Buikstra 2004; Stojanowski and Schillaci 2006). One alternative method of assessment based on dental metrics involves utilizing measurements taken from the point at which the tooth crown joins the root (“cervix”), while another involves measurements taken along the diagonal axis of the molar (Hillson et al. 2005; Pilloud and Hillson 2012; Stojanowski 2007; Stojanowski and Buikstra 2004; Stojanowski and Schillaci 2006). Pilloud and Hillson (2012) have demonstrated the efficacy of cervical measurements (cervicometrics) in biological distance studies using distinct skeletal samples, including a population from Neolithic Anatolia, and a precontact population from Northern California, both with great success.

Cervicometric data were collected per the methodology established by Pilloud and Hillson (2012:300-301). Measurements were taken on the left side of the dental arcade (or the right if not available due to limited preservation, pathology, or severe attrition) using Mitutoyo Absolute Digimatic needlepoint dental calipers (by Paleo-tech concepts) calibrated to 0.01 mm. Of the 11 individuals included in the analysis, one individual (EZ3 3-11) did not have mandibular first molars.

Following data collection, the product of the buccal-lingual (B-L) and mesio-distal (M-D) measurements was calculated, giving the approximate occlusal crown area or “robustness index” (RI), as shown in Table 8.1. The relationships between measurements were then investigated using scatterplots and correlations and through the use of multivariate statistical and interpretative analyses using SPSS 24.0 and Excel 2013, per established methodologies (Alt and
Vach 1995; Buikstra 1972; Buikstra et al. 1990; Hillson et al. 2005; Larsen 1997; Pilloud and Hillson 2012; Stojanowski 2007; Stojanowski and Buikstra 2004; Stojanowski and Schillaci 2006). A major point of emphasis in these analyses is a comparison between the six skulls from Feature 1 of Mound 3, and the remainder of individuals interred in Mound 3.

Table 8.1: Summary of Robustness Index ("RI") values by individual

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>M₁ RI</th>
<th>M₂ RI</th>
<th>M₃ RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>67.816</td>
<td>71.8725</td>
<td>72.424</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>86.5389</td>
<td>90.0828</td>
<td>95.5216</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>81.054</td>
<td>79.7008</td>
<td>80.5296</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>70.0392</td>
<td>74.466</td>
<td>-</td>
</tr>
<tr>
<td>1-1</td>
<td>72.5888</td>
<td>61.593</td>
<td>63.2024</td>
</tr>
<tr>
<td>2-2</td>
<td>94.0814</td>
<td>96.614</td>
<td>100.5909</td>
</tr>
<tr>
<td>3-1</td>
<td>63.1828</td>
<td>61.9333</td>
<td>57.477</td>
</tr>
<tr>
<td>5-2</td>
<td>96.0175</td>
<td>87.5772</td>
<td>95.5643</td>
</tr>
<tr>
<td>11</td>
<td>-</td>
<td>58.2133</td>
<td>69.5232</td>
</tr>
<tr>
<td>12-1</td>
<td>68.3925</td>
<td>77.1382</td>
<td>95.004</td>
</tr>
<tr>
<td>13</td>
<td>64.8074</td>
<td>66.466</td>
<td>62.6864</td>
</tr>
</tbody>
</table>

8.5.2 Intra-Observer Error

In order to assess and account for observer error, analyses of intra-observer error were conducted using the study population following the methods described in Williams and Patterson (2010). In one assessment, 10 measurements were taken of the RM₁ of Feature 1, Skeleton 2. The following day, the 10 measurements were repeated on the same individual. The resulting data were analyzed with a t- to assess intra-observer error; the t-test (p values = 0.869-0.273) was not significant. Because the sample size for the error study was small and the statistical power low, an additional assessment of intra-observer error was also conducted. In the second assessment, both buccal-lingual (B-L) and mesio-distal (M-D) measurements were taken of a single tooth on seven individuals. Two days later, these measurements were repeated on all
seven individuals. The mean percent difference for the B-L and M-D measurements was calculated using the following equation (Williams and Patterson 2010:443):

\[
\text{Percent Difference} = 100 \times \frac{\text{Absolute Difference Between Trial 1 and Trial 2}}{\text{Mean of Two Observations}}
\]

The smallest mean percent difference for the two trials was for the B-L measurement (3.4%), while the largest was for the M-D (25.2%). The paired differences were examined using Spearman’s Rank Correlation Coefficient and were highly correlated. The percent differences were examined by a paired samples t-test and yielded insignificant differences between trials (B-L \(p=0.95\); M-D \(p=0.74\)).

8.6 Results and Discussion

It should be noted that the sample size (n=11) obtained for biodistance analysis using dental cercimetrics was extremely limited for the Mound 3 population. Of these 11 individuals, six (54.5%) were male, and five (45.5%) were female, ranging from a young adult of 26-38 years (F1-Sk 1) to old adult individuals in excess of 47 years. One tooth each for Individual 11 (M_1) and F1-Sk 6 (M_3) was missing and thus the data sets for these individuals are incomplete. Furthermore, because of dental pathology, surface attrition, and preservation, it was difficult to isolate a quadrant of the dental arcade for analysis; for this reason, only the adult mandibular dentition was used, though the side used for data collection varied.

The correlations (Table 8.2) between buccolingual and mesiodistal values do not show a consistently strong relationship between values by tooth, which mirrors the findings of Hillson et al. (2005). All correlations are positive when examined using a Pearson product moment correlation; there are significant correlations between the M-D and B-L values for the lower 3rd molar.
Table 8.2: Pearson product moment correlations between B-L and M-D dimensions

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Buccolingual-Mesiodistal Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower 1\textsuperscript{st} Molar</td>
<td>.481 (p=.134)</td>
</tr>
<tr>
<td>Lower 2\textsuperscript{nd} Molar</td>
<td>.510 (p=.09)</td>
</tr>
<tr>
<td>Lower 3\textsuperscript{rd} Molar</td>
<td>.759 (p=.007)</td>
</tr>
</tbody>
</table>

There were significant differences in $M_1$ (p=0.04), $M_2$ (p=0.007), and $M_3$ (p=0.053) Robustness Indices based on sex when examined using a t-test, which is not surprising as there is known sexual dimorphism in dental development (Hillson 1996). When data are examined using z-scores to control for sexual dimorphism, there is no discernable pattern to tooth dimensions based on sex; however, when z-scores are examined using a t-test, both the M-D (p=0.00) and Robustness Index (p=0.01) values for the $M_2$ were significantly different based on sex. There were significant differences in the $M_1$ (p=0.01) and $M_2$ (p=0.05) approximate occlusal crown values when comparing young/middle adults to old adults using a t-test. Because the $M_1$ and $M_3$ data sets are missing values for a single individual each, statistical analyses were also conducted using only the complete $M_2$ data set. While specific values did change, these changes were modest and the general trends and statistical significances persisted.
In comparing the M$_2$ values for the four isolated skulls to the remainder of the Mound 3 population, individuals F1-Sk 1 and F1-Sk 6 both exhibited Robustness Index values that were noticeably different than the remainder of the Mound 3 population, as were individuals 1-1 and 12-1. This suggests that of the 11 individuals included in this biodistance analysis, these four individuals may have a distinct biological affinity in comparison to the rest of the Mound 3 population. Furthermore, the individuals represented by isolated crania 1 and 6 and individual 1-1 are biologically similar based on the cervicometric data. However, as a group, the individuals represented by the isolated skulls are not biologically distinct from the majority of the Mound 3 population. When analyzing biodistance between individuals buried within the Mound 3 apron (i.e., the isolated skulls and the central feature burials 2-1 and 2-2) using a t-test, the M$_2$ M-D
measurements were significantly different (p=0.007), while the M\textsubscript{2} B-L values were not significantly different. Although this could indicate that the individuals interred in the apron area (including both central tomb individual 2-2 and the four isolated crania of Feature 1) are more similar than the individuals interred in the periphery of Mound 3, this could also be an issue of intra-observer error in data collection given the reduced precision in collecting the mesiodistal measurement.

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>M\textsubscript{1} Data</th>
<th>M\textsubscript{2} Data</th>
<th>M\textsubscript{3} Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>Outlier</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>1-1</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>2-2</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>3-1</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
</tr>
<tr>
<td>5-2</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>11</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>12-1</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>13</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

8.7 Conclusion

The lack of significant variation between two of the six (F1-Sk 2, F1-Sk 4) isolated crania and the remainder of the Mound 3 population suggests that these individuals share a common biological affinity (i.e., are related). However, the noticeably different M\textsubscript{2} values for F1-Sk1 and F1-Sk 6 suggests that these individuals shared a common biological affinity different from that of the majority of the Mound 3 population. While M\textsubscript{2} M-D values differed significantly between the individuals buried within the apron area and those buried outside of the apron area, this interpretation could be affected by the aforementioned shortcomings in data collection. Additionally, because the measurements of the axis for maximum buccolingual and mesiodistal
crown diameter were not collected due to dental attrition, this could further confound interpretations by limiting the factors available for analysis. Finally, the sample size for analysis of dental cervicometrics has been affected by the limited availability of adult dentition as a result of oral pathologies, attrition, and preservation. This undoubtedly affects statistical analyses and interpretation. In order to address these issues, it would be necessary to re-analyze the Mound 3 population, perhaps including additional teeth in the assessment, as well as collecting dental crown maximum and minimum values in order to more thoroughly analyze the population and include additional individuals. In addition, including the remainder of the skeletal population from the Elizabeth site in the analysis would provide a more comprehensive basis for assessing genetic variation across the population during different periods.
9 SUMMARY OF FINDINGS, CONCLUSIONS, AND FUTURE RESEARCH

9.1 Summary of Findings

The purpose of this research is to clarify the social identities of the six individuals represented by the isolated crania interred in Feature 1 of Mound 3 at the Elizabeth site. Additionally, this research also serves as pilot study exploring the efficacy of using isotopic analysis as a way to analyze paleomobility and deduce residential origins of prehistoric population in the lower Illinois River valley. This represents the first analysis of strontium and lead in enamel apatite, and oxygen and carbon analyses of bone apatite, for the Elizabeth site population. Additionally, a small-scale analysis of dental cervicometrics has been conducted in order to assess inter-individual markers of heredity and genetic relatedness. These analyses are conducted in an attempt to elucidate patterns of residential origin, model migration, and analyze biological similarity using methods that have not yet been utilized in the lower Illinois River valley.

The parameters analyzed herein are proxies of different aspects of life with varied levels of specificity. This chapter is a summary and synthetic discussion of the compendium of findings drawn from the preceding chapters. Additionally, this chapter positions the key findings of this research within a broader context and identifies potential directions for future research both on the micro- and micro-scale.
Table 9.1: Summary of isotopic and cervicometric data by individual

<table>
<thead>
<tr>
<th>Burial-Individual</th>
<th>Age at Death</th>
<th>Sex</th>
<th>Strontium</th>
<th>Lead</th>
<th>Oxygen</th>
<th>Carbon</th>
<th>Biodist. M₁</th>
<th>Biodist. M₂</th>
<th>Biodist. M₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1-Sk 1</td>
<td>27-38</td>
<td>M</td>
<td>Outlier</td>
<td>Outlier</td>
<td>Normal (-)</td>
<td>Normal (-)</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 2</td>
<td>35+</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
</tr>
<tr>
<td>F1-Sk 3</td>
<td>22-30</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F1-Sk 4</td>
<td>25-35</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>F1-Sk 5</td>
<td>22-30</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>F1-Sk 6</td>
<td>30-51</td>
<td>M</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>1-1</td>
<td>40-50</td>
<td>F</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal (+)</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>2-1</td>
<td>50+</td>
<td>F</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2-2</td>
<td>45-50</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>3-1</td>
<td>50+</td>
<td>F</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
</tr>
<tr>
<td>3-2</td>
<td>45+</td>
<td>F</td>
<td>Normal (+)</td>
<td>Normal</td>
<td>Normal (+)</td>
<td>Normal</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-1</td>
<td>40-55</td>
<td>F</td>
<td>Outlier</td>
<td>Normal (+)</td>
<td>Normal (+)</td>
<td>Normal (-)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5-2</td>
<td>30-45</td>
<td>M</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal (-)</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>12-1</td>
<td>45-55</td>
<td>F</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Outlier</td>
<td>Normal</td>
</tr>
<tr>
<td>13</td>
<td>47+</td>
<td>F</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

Finding #1: Strontium, lead, and oxygen isotope values for the Mound 3 population are varied and do not cluster based on burial location, age at death, sex, or burial context.

The isotopic proxies for paleomobility and residential origins (Pb, Sr, O) at Mound 3 of the Elizabeth site suggest variation across the population. While none of the values for strontium or oxygen were statistically significant, the values are interpretatively meaningful. There were significant differences in lead isotopes between the isolated crania and the rest of the Mound 3 population, specifically for individual F1-Sk 1. The strontium and lead data indicate that two individuals (F1-Sk 1 and F1-Sk 6) originated from outside the Elizabeth site vicinity. While
oxygen isotope values for the population generally fell within a range of normal variation, individual F1-Sk 1 had lower oxygen isotope values than those of the local area, suggesting perhaps this individual’s oxygen isotope values were equilibrating to the local drinking water values of the area. Variation in isotopic values is to be expected in any population. However, in light of migration and/or matrilocal/patrilocal practices, patterns would be expected in isotopic values, especially those serving as proxies for paleomobility and residential origins.

**Finding #2: Carbon isotope values for the Mound 3 population are varied and cluster based on biological sex, but not based on burial location, age at death, or burial context.**

Carbon isotope values in bone carbonate for the Mound 3 population, which are indicative of the full-spectrum of dietary carbon consumed by individuals, vary across the population without regard for demographic or contextual parameters, except for biological sex. Individuals F1-Sk 1 and F1-Sk 3 exhibited values on the high end (i.e., less negative) of the scale of variation, while individual F1-Sk 6 exhibited a carbon isotope value toward the low end (i.e., more negative) of the scale. None of the individual carbon isotope values were statistically significant. When analyzing carbon isotope variation by sex, there is a statistically significant difference between values for males and females. This significant difference likely speaks to a social schema whereby males and females have differential access to certain resources, though it is unclear whether this is preferential or limited access to an item (or items) with low or high carbon isotope values. In order to more thoroughly analyze this scenario, it would be necessary to analyze carbon and nitrogen isotopic values in bone carbonate, bone collage, and enamel carbonate, thereby increasing the specificity and sensitivity of dietary analysis.
Finding #3: No pattern emerges when comparing the isotopic values for mobility and diet for the Feature 1 skulls to the rest of the Mound 3 population.

None of the isotopic proxies for paleomobility and residential origin formed a pattern based on a comparison between the isolated crania and the remainder of the Mound 3 population. It was expected that, if the skulls represented members of the Elizabeth population or relative outsiders, the isotopic proxies for paleomobility and residential origin would cluster together, indicating a shared geographic origin. While the oxygen isotope levels generally conform to this cluster hypothesis, this is strictly an indication of shared geographic location during the 5-10 years preceding death. Since no pattern is formed with lead or strontium values, these data suggest that the isolated crania originate from a variety of geographic areas. Together with the oxygen isotope values, the suite of strontium, lead, and oxygen data elucidate a scenario where individuals from varied residential origins during early life converge and live in a shared location in the decade preceding death. These individuals from varying origins are later interred together in a location and/or act of symbolic importance to the greater group. Similarly, there is no discernable pattern in the dietary carbon isotope values amongst the isolated skulls from Mound 3. One might expect to find carbon isotope values that cluster together, or at least a lack of general variation amongst the group. However, the data are varied and do not form a pattern or cluster based on comparison between the isolated skulls and the remainder of the Mound 3 population.

Finding #4: Analysis of biological distance using dental cervicometrics indicates that two of the six skulls may have a different (but mutually shared) biological affinity.
Of the six isolated skulls analyzed in this study, only four (individuals F1-Sk 1, 2, 4, and 6) could be included in the biodistance study. Only 11 (41%) of the 27 individuals from Mound 3 exhibited present, permanent dentition sufficient for cervicometric analysis based on the study methodology. Furthermore, due to missing data points, only the cervicometric data for the M2 were used in the final analysis. Of the four individuals from Feature 1, two (F1-Sk 1 and F1-Sk 6) exhibited cervicometric data that were notably different than the rest of the individuals in the study. Interestingly, these two individuals are more similar to each other, as well as individual 1-1. These data suggest that while the majority of the individuals interred in Mound 3 that were analyzed in the biodistance study seem to have shared a common genetic affinity, F1-Sk 1 and F1-Sk 6 (which are genetically similar) likely share a different genetic affinity than the rest of the Mound 3 individuals. Given the seemingly shared symbolic importance of the six individuals interred in Feature 1, one might expect for the genetic affinity of the individuals to cluster together, match the majority of the Mound 3 population, or exhibit a great deal of variation. However, the data instead suggest that of the four isolated skulls included in the study, two populations appear to be represented.

Finding #5: Isotopic proxies for paleomobility exhibit sufficient specificity and sensitivity to discern geographic origins and migration of human populations in the lower valley area.

Although the lower valley area lacks a sufficient isotopic baseline for proxies of mobility, the isotopic values for strontium and oxygen appear to be both specific and sensitive enough to elucidate migration patterns and identify residential origins. Recent research detailed herein has concluded that strontium isotopes and, to a lesser extent, oxygen isotopes are sufficient at identifying both local ranges and atypical individuals. While the lead data may be affected by
the loess overburden in the area, which could have a homogenizing effect on local lead values, the lead data do correspond with both strontium, oxygen, and biodistance data in identifying most, though not all, of the atypical individuals in Mound 3. These results thus indicate that the analysis of stable and radiogenic isotopes, specifically strontium, lead, and oxygen, serves as an adequate indicator of paleomobility and residential origins for human populations in the lower Illinois River valley, and perhaps across the Midwestern United States.

9.2 Conclusions

The osteological, biochemical, and biodistance data gleaned during this study allow for the conceptualization of the social identities of the six skulls interred in Feature 1 of Elizabeth Mound 3, as well as the potential symbolic significance of their interment in the mound. Although no analogous circumstances have yet been identified in the lower valley region, ample archaeological data from around the globe is of great utility in interpreting the potential cultural significance of this deposit (or offering).

Osteological analysis has provided information on the demographics of the Mound 3 population, including the six skulls. Though the skulls were found in fragmentary condition, the context of these burials has been preserved both through documentation of the burial excavation, and the meticulous curation by various institutions. During osteological analysis, the six skulls and their respective skeletal elements were all examined with special attention paid to the condition of the skulls, especially skeletal indicators of trauma and postmortem processing. The initial excavators and skeletal biologist that analyzed the Elizabeth site skeletal remains noted an absence of abnormal markings (cut marks, signs of processing, trauma, lethal trauma) on both
the skulls and the associated cervical vertebrae. Upon analysis, the surfaces of the bones were found to be of normal condition for the population in the area.

I caution, however, that the absence of skeletal markings linked to processing or lethal trauma, especially on the cervical vertebrae, does not preclude the possibility that these individuals were killed and/or subsequently processed. Marks of scalping, which typically are found on the temporal or frontal bones may not have occurred in this area during the Middle Woodland period. Additionally, it is possible to remove the head from the body without leaving a trace on the first several cervical vertebrae. This could be accomplished by careful cutting with a sharp implement, typically by an experienced individual. Alternatively, simply cutting lower (distally) on the neck would leave the first few cervical vertebrae unmarked; after some period of decomposition, vertebrae with marks indicative of cutting and/or processing could simply be discarded, lost, or not well preserved. Finally, the removal of the head from a corpse during the later stages of decomposition could readily be accomplished without implements, thus leaving no discernable skeletal indicators.

With regard to skeletal trauma, Buikstra (personal communication, 2015) notes that two of the individuals show evidence of trauma, an extreme rarity for the region. While four of the six show no signs of trauma, the absence of cut marks or skeletal indicators of trauma does not necessarily indicate that these events did not take place, although the lack of evidence suggesting such activities did occur is clearly lacking. The osteological analyses generally support the hypothesis that the isolated skulls were not the result of inter-group conflict, though this cannot be ruled out based on skeletal evidence alone.

Isotopic data have provided evidence of variation in geographic origin and potential migration patterns, as well as basic dietary information. Both the strontium and lead isotopes are
characterized for enamel apatite and are thus markers of residential origin during early life while enamel crowns are forming. Strontium isotope values for the population indicate that two of the six isolated skulls produced values falling outside of the normal range. The lead isotope values are varied, but indicate that one of the six skulls exhibits values outside of the normal range. Of these values, there was significant variation in the isotope values between the isolated skulls and the remainder of the Mound 3 population. Together, the isotopic data indicate that two of the individuals (F1-Sk 1 and F1-Sk 6) potentially originated from a different location than did the rest of the Feature 1 skulls, and the majority of the Mound 3 population.

Oxygen isotope values from bone carbonate, which are indicative of geographic residence in the decade preceding death, are less varied with only minor outliers in the data. In particular, individual F1-Sk 1 had an oxygen isotope value that falls near the low end of the normal range. However, the oxygen isotope values were relatively homogenous across the sample population. This suggests that the majority of the Mound 3 population was residing in the same vicinity in the decade preceding death. Furthermore, individuals on the low or high end of the normal range may represent individuals who were relatively new to the area, thus values are still in the process of equilibrating to the oxygen isotope values of local drinking water. It is possible that individual F1-Sk 1 was a more recent migrant to the Elizabeth vicinity, while the remainder of the Mound 3 population represents long-term residents in the vicinity.

Carbon isotope data from bone carbonate represent the carbon isotope composition of the comprehensive diet, including the plants and animals consumed, as well as the diet consumed by the animals these individuals were eating. There is considerable variation amongst the sample population and the only significant values are linked to sex-based differences between males and females. There are no significant differences between the isolated crania and the remainder of
the Mound 3 population, although there are specific individuals that exhibit values outside the normal range at the site. Isolated skulls F1-Sk 1 and F1-Sk 3 exhibited lower carbon isotope values, while isolated skull F1-Sk 6 exhibited a value on the high side of the normal range. However, these values have little value in discerning the identity of these individuals, especially without additional isotopic data, including nitrogen isotope values and isotopic characterization using bone carbonate, bone collagen, and enamel apatite.

Biological distance analysis using dental cervicometrics elucidated potential patterns in the genetics underlying the Elizabeth population. While the data set is limited and thus statistical analyses are less than ideal, there were notable differences amongst the population. Most notably, of the four isolated crania included in the study, there was no overlying homogeneity of biodistance data suggesting that these individuals come from different populations. Isolated skull F1-Sk 6 is an outlier in both the M1 and M2 data sets, but the M3 data for this individual were unavailable. Similarly, isolated skull F1-Sk 1 is an outlier in the M2 data set, but not in the M1, M3 or robustness indices. Isolated skull F1-Sk 4 is an outlier in the M1 data set, but not in the M2, M3, or robustness indices. Finally, individual F1-Sk 2 was an outlier in only the M3 data set. Given that the M2 data set was the most complete (i.e., had no null values), the statistical significance of these data are given the most weight. Based on the biological data generated using the cervicometrics of the M2, individuals F1-Sk 1 and F1-Sk 6 appear to share a common genetic affinity which is not shared by the majority of the individuals interred in Mound 3.

While these data are intriguing in their own right, the synthesis of multiple lines of evidence is inherently important to this bioarchaeological study. Combining these data yields more refined and specific assessment of the social identities of the six individuals represented by the isolated crania interred in Mound 3. Lead, strontium, and carbon isotope values, as well as
biological distance data all clearly indicate that individuals F1-Sk 1 and F1-Sk 6 are atypical in the Mound 3 population. However, these same data (with the exclusion of biodistance data for isolated skulls 3 and 5) all suggest that isolated skulls 2, 3, 4, and 5 all conform to the pattern of “typical” members of the Elizabeth community. The relative homogeneity of the oxygen isotope values suggests that, despite originating in different areas and sharing less biological similarity, the Mound 3 sample population of 15 individuals likely resided in the Elizabeth vicinity prior to death.

Given only two instances of osteological indicators of trauma, and the lack of ante- or perimortem processing, together with the indications of shared geographic residence prior to death, these data ultimately suggest that the six isolated skulls represent kin, either through birth or through later inclusion in the community. While the interment of six isolated crania in an invasive slot-trench adjacent to the central tomb of a burial mound is itself of some perceived importance, this importance is not explicitly linked to a shared residential origin or biological affinity. Instead, the importance of these six individuals likely stems from either their status in life or the nature of their death, neither of which are clear in the data collected and analyzed throughout the course of this study.

Ultimately, the data seem to support, and it is my opinion, that the individuals interred in Feature 1 of Elizabeth Mound 3 were likely kin, either through genetic relation or other inclusive practices, and were not outsiders. This is supported by the lack of skeletal trauma indicating a violent death, the absence of cut marks suggesting trophy taking or processing of the body, the presence of cervical vertebrae indicating the curation of bodies, and the lack of highly variable isotope values, especially the oxygen data, which indicates a shared geographic residence in the decade preceding death. This is further supported by the relative homogeneity in genetic
provenience of the Mound 3 sample, with explainable differences in genetic data based on variation in geographic residence in early life. The data here paint a picture of individuals that were likely used in symbolic veneration ritual, having been buried, exhumed, and interacted with over a course of time, before final interment in a slot trench near the primary tomb of the burial mound.

9.3 Future Research

Due to the success of this study, future research on both the Elizabeth Mounds population and the other similar populations throughout the lower valley region appears promising. My hope is that the study design can be modified to include additional components of analysis (such as isotopic characterization of C, N, O, Sr, Pb in bone carbonate, collagen, and enamel) can be utilized for the purpose of a large-scale assessment of biogeochemistry and genetic similarity for populations throughout the broader region. In order to most accurately explicate residential origins and migration, future research must include an assessment of archaeological fauna and plant remains throughout the valley, which could be used in order to construct an isotopic baseline map for the region. My hope is that by amalgamating these data, human remains throughout the region could more easily be conceptualized, and patterns of migration, residential origins, diet, social context, and social interaction could be more readily evaluated and characterized based on extensive networks of movement and interaction both spatially and temporally.

Based on the efficacy of utilizing dental cervicometrics for biodistance analyses, future research should be conducted which implements and expands this biodistance methodology in order to analyze biological similarity in regional populations. Finally, in concert with the
aforementioned isotopic data, analyses of the correlation between the prevalence and patterning of pathological conditions in the skeletal population (both temporally and spatially) with the dietary information could help explicate the biocultural consequences associated with the valley environment. The goals of such research would be improved specificity and sensitivity in the analysis of pathological etiologies, as well as a more synthetic understanding of the richness and complexity of life in the lower Illinois River valley region.
REFERENCES


Baker RK. 1984. The relationship of cranial suture closure and age analyzed in a modern multi-racial sample of males and females: California State University, Fullerton.


MacDowell N. 1991. The Mundugumor: From the Field Notes of Margaret Mead and Reo Fortune: Smithsonian Institution Press.


Turner BL, Kingston JD, and Milanich JT. 2005. Isotopic evidence of immigration linked to status during the Weeden Island and Suwannee Valley periods in north Florida. Southeastern Archaeology 24(2).


APPENDICES

Appendix A: Statistical Outputs for Isotopic Analyses

**Appendix A.1: Descriptive Statistics for Strontium Analysis**

**Descriptive Statistics**

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
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<td>.71140</td>
<td>.7102207</td>
<td>.00048995</td>
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<td></td>
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</tr>
</tbody>
</table>

**Appendix A.2: Descriptive Statistics for Strontium Analysis: Independent Samples t-test (mean isotope values by Sex)**

**Independent Samples Test**

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<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>Host for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
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<td>Sig</td>
<td>t</td>
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<td>Equal variances not assumed</td>
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<td>Equal variances not assumed</td>
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<td>Equal variances assumed</td>
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<td>.9999</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
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<td>.9999</td>
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**Appendix A.3: Independent Samples t-test (mean isotope values; isolated crania vs. other)**

**Independent Samples Test**

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<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>Host for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Sig</td>
<td>t</td>
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<tr>
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<td>Equal variances not assumed</td>
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<td>Equal variances not assumed</td>
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<td></td>
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<td>667</td>
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Appendix A.4: Independent Samples t-test (mean isotope values; in apron burial vs. peripheral)

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<th>Independent Samples Test</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-Test for Equality of Means</th>
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</thead>
<tbody>
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<td>.063</td>
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<td>10.056</td>
</tr>
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<td>.063</td>
</tr>
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<td>107F6988</td>
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<td>.063</td>
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<td>23924</td>
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<td>.619</td>
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<td>10.056</td>
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<td>23924</td>
<td>0.247</td>
<td>.619</td>
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</tbody>
</table>

Appendix A.5: Independent Samples t-test (mean Sr and Pb isotope values; by enamel period)

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<th>t-Test for Equality of Means</th>
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<td>10.056</td>
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<td>@23924</td>
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<td></td>
<td>1048</td>
<td>10.056</td>
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<td>@23924</td>
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<tr>
<td></td>
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<td>10.056</td>
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</table>
Appendix A.6: Independent Samples t-test (mean O water, PDB, and SMOW; isolated crania vs. other)

<table>
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<tr>
<th>Independent Samples Test</th>
<th>Levene's Test for Equality of Variances</th>
<th>Hotelling's Test for Equality of Means</th>
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<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
<td>t</td>
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<td>d18O Water</td>
<td>Equal variances assumed</td>
<td>1.119</td>
<td>.309</td>
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<td>d18O PDB</td>
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<tr>
<td>d18O SMOW</td>
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Appendix A.7: Descriptive Statistics (All types of Pb)

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<td>0.901381</td>
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<td></td>
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<tr>
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<td>20.95769</td>
<td>0.901381</td>
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Appendix A.8: Proximity Matrix of Correlations between Vectors of Values (Pb species; by individual)

<table>
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<th>Proximity Matrix</th>
<th>Correlation between Vectors of Values</th>
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<tbody>
<tr>
<td></td>
<td>2F1-Sk 1</td>
</tr>
<tr>
<td>2F1-Sk 1</td>
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</tr>
<tr>
<td>3F1-Sk 2</td>
<td>.998</td>
</tr>
<tr>
<td>4F1-Sk 3</td>
<td>.999</td>
</tr>
<tr>
<td>5F1-Sk 4</td>
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<tr>
<td>6F1-Sk 5</td>
<td>.999</td>
</tr>
<tr>
<td>7F1-Sk 6</td>
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<tr>
<td>81-1</td>
<td>.996</td>
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<tr>
<td>11-1-1</td>
<td>.998</td>
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<td>11-2-2</td>
<td>.996</td>
</tr>
<tr>
<td>12-3-2</td>
<td>.996</td>
</tr>
<tr>
<td>13-3-1</td>
<td>.996</td>
</tr>
<tr>
<td>14-3-2</td>
<td>.996</td>
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<td>15-3-1</td>
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<td>16-3-2</td>
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<tr>
<td>17-5-2</td>
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This is a similarity matrix.
Appendix A.9: Descriptive Statistics (O vPDB and SMOW)

<table>
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<tr>
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<td>---</td>
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<td>d18OPDB</td>
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Appendix A.10: Independent Samples t-test (mean O water value; isolated crania vs. other)

<table>
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<th>Independent Samples Test</th>
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<td>d18OPWater</td>
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</table>

Appendix A.11: Descriptive Statistics for carbon isotope values

<table>
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<tr>
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<tr>
<td>d13C</td>
</tr>
<tr>
<td>d13CFood</td>
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<tr>
<td>Valid N (listwise)</td>
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Appendix B: Statistical Outputs for Biodistance Analyses

Appendix B.1: Spearmans rho test for paired differences (percent differences, intra-observer error)

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<td>PerDiffBL</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Spearman's rho</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>PerDiffBBL</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td>N</td>
</tr>
</tbody>
</table>
Appendix B.2: Paired Samples t-test (percent differences, intra-observer error)

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 BLCervical1 - BLCervical2</td>
<td>.0036571</td>
<td>.0097586</td>
<td>.0030788</td>
<td>-1.825629 - 1.825671</td>
<td>.068</td>
<td>8</td>
<td>.949</td>
</tr>
<tr>
<td>Pair 2 MDCervical1 - MDCervical2</td>
<td>.0228671</td>
<td>.0074165</td>
<td>.0063015</td>
<td>-1.381045 - 1.381090</td>
<td>.347</td>
<td>6</td>
<td>.740</td>
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</tbody>
</table>

Appendix B.3: Pearson Correlation for BL and MD Cervicometric Data

<table>
<thead>
<tr>
<th>Correlations</th>
<th>BLCervical1</th>
<th>BLCervical2</th>
<th>MDCervical1</th>
<th>MDCervical2</th>
</tr>
</thead>
<tbody>
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<td>.991**</td>
<td>.382</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
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<td>.398</td>
<td>.351</td>
<td></td>
</tr>
<tr>
<td>N</td>
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<td>7</td>
<td>7</td>
<td>7</td>
</tr>
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<td>BLCervical2</td>
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<td>1</td>
<td>.392</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.384</td>
<td>.315</td>
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<td>N</td>
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<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>MDCervical1</td>
<td>Pearson Correlation</td>
<td>.382</td>
<td>.392</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.398</td>
<td>.384</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
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<tr>
<td>MDCervical2</td>
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<td>.446</td>
<td>.978**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.351</td>
<td>.315</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
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<td>7</td>
<td>7</td>
<td>7</td>
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</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix B.4: Group statistics for Z-scores (male vs. female) for M2 cervicometric data

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<tr>
<th>Group Statistics</th>
<th>Sex</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zscore (M2BL)</td>
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<td>.41632073</td>
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<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>-.3808465</td>
<td>.924256852</td>
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</tr>
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<td>Zscore (M2MD)</td>
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<td>Zscore (M2Robustness)</td>
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<td>5</td>
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<td>.58263928</td>
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</table>
Appendix B.5: Independent Samples t-test for z-scores (male vs. female) for M₃ cervicometric data

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variance</th>
<th>Student's t for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
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<td>Sig.</td>
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<tr>
<td>Zscore(MDBL)</td>
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Appendix B.6: Nonparametric Correlations for BL and MD Cervicometric Data

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<th>Correlations</th>
<th>BL_Cervical1</th>
<th>BL_Cervical2</th>
<th>MD_Cervical1</th>
<th>MD_Cervical2</th>
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<tbody>
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<td>Sig. (2-tailed)</td>
<td>.</td>
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<td>.453</td>
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<td>BLCervical2</td>
<td>Correlation Coefficient</td>
<td>.714</td>
<td>1.000</td>
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<tr>
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<td>Sig. (2-tailed)</td>
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<td>.816</td>
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<td>-.048</td>
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<td>Sig. (2-tailed)</td>
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<td>.453</td>
<td>.816</td>
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<tr>
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<td>N</td>
<td>7</td>
<td>7</td>
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</tr>
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<td></td>
<td>MD_Cervical2</td>
<td>Correlation Coefficient</td>
<td>.143</td>
<td>.238</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.</td>
<td>.652</td>
<td>.453</td>
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<td>.482</td>
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</tr>
<tr>
<td></td>
<td>BLCervical2</td>
<td>Correlation Coefficient</td>
<td>.857</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
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<td>.014</td>
<td>.819</td>
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<td>MD_Cervical1</td>
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* Correlation is significant at the 0.05 level (2-tailed).
Appendix B.7: One-way ANOVA of $M_2$ cervicometric data (by sex)

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<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2 B-L</td>
<td>Between Groups</td>
<td>.684</td>
<td>1</td>
<td>.684</td>
<td>1.445</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>4.258</td>
<td>9</td>
<td>.473</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4.942</td>
<td>10</td>
<td></td>
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</tr>
<tr>
<td>M2 M-D</td>
<td>Between Groups</td>
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<td>7.582</td>
<td>38.231</td>
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<tr>
<td></td>
<td>Within Groups</td>
<td>1.785</td>
<td>9</td>
<td>.198</td>
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<td></td>
<td>Total</td>
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<td>10</td>
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<tr>
<td>M2 Robustness</td>
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<td>915.013</td>
<td>12.117</td>
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<td></td>
<td>Within Groups</td>
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<td>9</td>
<td>75.515</td>
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Appendix B.8: One-way ANOVA of $M_2$ cervicometric data (isolated crania vs. other)

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<td>1</td>
<td>.684</td>
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<tr>
<td>M2 M-D</td>
<td>Between Groups</td>
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<tr>
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<td>915.013</td>
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<td>679.634</td>
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<td>75.515</td>
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Appendix B.9: One-way ANOVA of M₂ cervicometric data by location (apron vs. peripheral)

<table>
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<tr>
<td>M₂ M-D</td>
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