RECONSTRUCTING THE BATTLES OF HIMERA:

BIOARCHAEOLOGICAL PERSPECTIVES ON ANCIENT MILITARY FORCES

by

KATHERINE L. REINBERGER

(Under the Direction of Laurie J. Reitsema)

ABSTRACT

This study explores mobility and military construction in the Mediterranean using multiple isotope analysis of human remains buried in mass graves associated with the Battles of Himera in Sicily, Italy during the 5th century BCE. Isotopic analysis was performed on teeth and bone samples of Greek soldiers who died in the two battles, one in 480 BCE and the latter in 409 BCE at the Greek colony site of Himera between armies of Greeks and Carthaginians. This study explores where the soldiers were from through oxygen, strontium, and lead isotopic analysis on their teeth, and the soldiers' diet through carbon and nitrogen isotopes on their bones. Place of origin and diet were used as proxy indicators of identity, recognizing that where someone is from, and their cultural dietary practices reveal aspects of an individual's life.

The data was interpreted through a theoretical framework that considers how social, political, and cultural factors are embodied in our skeletons and how political structures shape human bodies and lives. The study of mortuary assemblages from ancient battles allows for a more direct view into how warfare contributed to the connectedness and mobility of the Mediterranean by looking at the composition of armies.

The isotopic analysis revealed a diverse group of soldiers in the first Battle of Himera, supporting ancient historical texts and illuminating the collective action of mercenary soldiers fighting alongside citizens of the town they were defending. Alternatively, the later battle had a much more homogenous fighting force, with soldiers having similar isotopic values to the local citizens, indicating a homegrown army. This study supports the use of ancient historical texts to interpret the past, suggests different political structures had an important impact on the construction of ancient military forces, and indicates that mobility and connectedness in the Mediterranean was not uniform; there were fluctuations in who was traveling, how far, and for how long. This study suggests that mercenary soldiers played a profound role in the movement of people across the Mediterranean, likely forming a series of smaller migrations amongst larger, more permanent movements of colonization.

INDEX WORDS: Bioarchaeology, stable isotope analysis, radiogenic isotope analysis, embodiment, body politic, warfare, Classical Greece, Sicily, Italy

RECONSTRUCTING THE BATTLES OF HIMERA:

BIOARCHAEOLOGICAL PERSPECTIVES ON ANCIENT MILITARY FORCES

by

KATHERINE L. REINBERGER

B.A., University of North Carolina at Chapel Hill, 2014

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILSOPHY

ATHENS, GEORGIA

2022

RECONSTRUCTING THE BATTLES OF HIMERA:

BIOARCHAEOLOGICAL PERSPECTIVES ON ANCIENT MILITARY FORCES

by

KATHERINE L. REINBERGER

Major Professor:	Laurie J. Reitsema
Committee:	Susan Tanner
	Naomi Norman
	Britney Kyle

Electronic Version Approved:

Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
The University of Georgia
May 2022

DEDICATION

"For the whole world is the sepulchre of famous men, and it is not the epitaph upon monuments set up in their own land that alone commemorates them, but also in lands not their own there abides in each breast an unwritten memorial of them, planted in the heart rather than graven on stone." (Funeral oration of Pericles - Thucydides 2.43)

For Avadna

ACKNOWLEDGEMENTS

This research was funded by the National Science Foundation Research Experience for Undergraduates (NSF REU) award numbers 1560227 and 1560158 through the University of Georgia (UGA) and the University of Northern Colorado, the UGA Graduate School Integrative and Interdisciplinary Research Grant, the UGA Graduate School Dean's Award, the UGA Willson Center for Humanities and Arts, and the UGA Center for Archaeological Sciences Norm Herz Award.

This research would not have been possible without my collaborators and supporters in Italy, especially Stefano Vassallo and the Soprintendenza Archeologica di Palermo, Sicily, Norma Lonoce, Giorgia Vincenti, Matteo Valentino, Pier Francesco Fabbri, Università del Salento, and Lorenzo and everyone at la Casa Vacanze Sosta dei Garibaldini.

An incredible thank you to my major professor, Laurie Reitsema, for your continuous support. You provided me with so many opportunities to mentor, teach, and grow as a scholar. Through multiple drafts and research trips across the country and the world, thank you for being a stellar example of an academic and a colleague. Another special thank you to the co-PI on the REU and my committee member, Britney Kyle. I want to also recognize my other amazing committee members: Susan Tanner and Naomi Norman for being important sources of support when I hit roadblocks in this dissertation. Thank you to the other professors and researchers at UGA who provided feedback, lively discussions, and ideas. I also want to thank the supportive staff throughout the years at UGA's Department of Anthropology: Brenda, Clark, Ryan, Maxine, and Margie.

I want to thank all the students on the NSF REU Site: Immersive Research in the Bioarchaeology of Greek Colonization, Sicily, Italy. They say one learns best by teaching others and it was an absolute joy working with these students and teaching them about lab methods and conducting research. A special thank you to my Department of Anthropology undergraduate mentees-turned-colleagues, Rachel Horton and Chelsea Batchelder. It has been a pleasure going from weekly reading discussions to publishing together.

Thank you to everyone at the Center for Applied Isotope Studies, both those who provided me with assistantships and those who helped analyze my dissertation samples: Carla Hadden, Alex Cherkinsky, Doug Dvoracek, Emmy Deng, Shirley Sheng, Thomas Maddox, and Bekah Lee. Thank you to John Krigbaum and George Kamenov at the Department of Anthropology and the Department of Geological Sciences at University of Florida for running my strontium and lead samples for this dissertation.

To my friends and colleagues, thank you for the camaraderie, solidarity, and overall great times: Julie Worley, Megan Conger, KC Jones, Christina Crespo, Sammantha Holder, Carey Garland, Edgar Alarcón, April Smith, Kristen Morrow, Christina Lee, Matt Colvin, Travis Jones, Alex Edwards. Thank you to my support network, especially Amanda and Jenny. And to my friends, co-performers, and teachers at Canopy Studios.

Thank you to my favorite travel companion, isotope sample collector, and collaborator, Elijah Fleming. I also want to thank my partner, Alec Nelson, for all of his support; for shouldering me when I needed it the most and for being a light in a dark place when all other lights go out. And to my family: my sister, Kristen, and my parents, Mark and Margaret.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

1.1 Introduction to the context and problem

Greek military history has been a source of public and scholarly interest for thousands of years, with a plethora of literature on the training, weapons, strategies, and leaders. The anthropology of warfare goes beyond the tactical details to consider why political communities participate in warfare and the individual levels of engagement with the violence of war. Anthropological research on soldiers allows for understanding the complex social, economic, and political factors that bring soldiers into situations that increase their risk of death. Bioarchaeological research, the study of human skeletal remains from archaeological contexts, has the unique opportunity to study the lived experiences of ancient soldiers. However, there are limited available skeletal collections to explore questions about soldiers' lives in general and especially in the Mediterranean. Preservation of human remains from the Mediterranean is inconsistent because of the fluctuating wet and dry seasons and there is historical and archaeological evidence that many soldiers would have been cremated. While this dissertation focuses on soldiers fighting in Greek Sicily, there are limited skeletal collections of soldiers globally and so this study also aims to provide an important case study in how to directly study the lived experiences of soldiers. The individuals studied in this dissertation are an exceptional occasion to learn more about soldiers fighting in the Greek world and military construction more broadly.

The aim of this dissertation is to see if there is a relationship between globalization, resulting political structures, and the daily lives and movement of soldiers. This dissertation uses evidence from stable and radiogenic isotope analysis of skeletons in mass graves associated with two of the Classical world's greatest organized, violent conflicts – the Battles of Himera in 480 BCE and 409 BCE between the Carthaginian army and Greeks on Sicily – to understand how soldiers were assembled for organized warfare. Briefly, according to historical sources (Diod. 11.20-25; Hdt. 7.165-167), the battle of 480 BCE was victorious for the Greeks with the assistance of a large, allied force, while the battle of 409 BCE ended in a siege and complete destruction of Himera when there were few assisting forces (Diod. 13.59-62).

1.1.1 Greek warfare in a connected Mediterranean world

This dissertation explores the role that soldiers played in a mobile and connected Mediterranean world. Military campaigns provide opportunities for mobility, either in short stints as part of an individual campaign, the long-term settlement of soldiers after the conquering of an area, or the expulsion of the losing side. Using isotopic analysis to look at place of origin of the soldiers will reveal how mobile military forces were or if soldiers were generally recruited from the surrounding area. We know certain Greek military campaigns involved extensive travel, such as Xenophon's Anabasis taking place in Babylon (401 BCE), but this study explores the mobility of the soldiers fighting in the armies defending Greek cities.

The movement of people across the Mediterranean and the creation of new settlements abroad has been extensively studied (Dietler 1998, 2007; Osborne 2009; Hodos 2006; Hornblower 2008; van Dommelen, 2009, 2012). Horden and Purcell (2000) described the fragmented microregions and climate unpredictability of the Mediterranean. Osborne (2009)

claims that the variety of environmental conditions was one of the factors enabling the Greeks to easily move around the Mediterranean and settle outside of Greece. Changes in settlement pattern and movement were only possible in a world where many people were constantly moving across the seas, creating a rich knowledge of the shores and distant areas of the Mediterranean, their peoples, and what those peoples' cultures were, including Iberians, Phoenicians, Etruscans, Greeks, among many others (Osborne, 2009). The motivations for these movements, both micro- and macro-migrations, were economic, political, social, in nature with a variety of outcomes: setting up trade-posts, creating permanent colonies, or joining existing groups and their settlements (Osborne, 2009).

The necessity to trade overseas for raw materials, especially copper and tin for making bronze, predestined the Greeks very early in their history to take to the sea and mingle with people from foreign soils (Horden and Purcell 2000; Pomeroy et al., 1999). The 8th century BCE was a time when communities were spreading themselves across the local landscape, establishing settlements and activity centers through the territory to which they laid increasingly formal claim (Osborne, 2009).

Sicily provides one of the best stages to investigate cultural interaction in the Mediterranean because Greeks and Phoenicians established colonies around the same time and added to a complex system of exchange and interaction (Hodos 2006; Osborne 1997, 2009). This was one of the largest movements of people across the Mediterranean that included the establishment of permanent colonial settlements, overseas military expeditions, and territorial occupations (van Dommelen 1997, 2012). The military expeditions led to land disputes between Carthaginians and Greeks in Sicily in the Late Archaic-Early Classical period. The history of Sicily is characterized by the mobility of its peoples, both large scale in the foundation of

colonies by Phoenicians and Greeks (Osborne 1997; van Dommelen 2012) and small scale in the movement of people between colonies (Lomas 2006).

1.1.2 Military construction during the 5th century BCE

While warfare and ancient militaries are popular to study, much of the research on Greek warfare comes from mainland Greece with focus on Athens and Sparta, particularly in relation to the Persian War and the Peloponnesian War. This dissertation explores the important differences between warfare in a Greek colonial setting on Sicily and mainland Greece. The tyrants who ruled over Sicily enacted significant departures from Classical Greek military practices, including the larger scale employment of mercenaries and focusing attentions on the elite social classes for support (Griffin 2005; Lomas 2006). Briefly, Classical Greek military practices generally followed a model of militias of soldiers from similar homelands joining together within larger armies, while Sicilian tyrants began to create large armies of a mix of citizen-soldiers and mercenaries from outside the communities (van Wees 2004; Griffin 2005). Greek mainland military tradition also relied on the use of citizen-soldiers who were expected to participate in warfare as part of their citizenship duties, while Sicilian tyrants used military service as a mechanism to become a citizen of the colonies tyrants ruled (Griffin 2005).

The political and economic changes, and movements of people in the Classical period would have had profound effects on all members of a community, but soldiers and civilians would have embodied these circumstances in different ways. Soldiers play a unique role in society by becoming specialized in violence, similar to the ways merchants are specialized in a particular craft. As noted above, the presence of burials of soldiers available for study is limited for all regions and time periods. This study not only illuminates military construction in Sicily

but is also one of a few examples of isotopic research on soldiers in the Mediterranean. The isotopic data presented here will increase our understanding of potential differences in diet and mobility between civilians and soldiers.

1.1.3 Bridging multiple disciplines to evaluate ancient texts

The study brings together information from bioarchaeology, geology, geography, Classics, and archaeology. The multiple methods and perspectives from these fields allows for an anthropological nuanced and multi-scalar discussion of warfare, focused on the lives of the individual soldiers as well as considering the larger, sociopolitical forces, especially in regards to the Sicily's tyrants compared to mainland city-state democracies. It is imperative to make connections between these disciplines to make knowledgeable interpretations about ancient peoples, their lives, and the structures around them. Using evidence from other historical records on ancient warfare, this dissertation situates the isotopic data in the historical tradition of a fascination with Greek military practices, bridging a gap between Classical research and anthropological techniques.

This dissertation relies heavily on ancient historical texts for the predictions and hypotheses, specifically the writings of three ancient historians: Thucydides, Herodotus, and Diodorus Siculus. However, ancient texts are considered incomplete and subjective because they are highly fragmentary and often conditioned by the personal biases of the ancient writers (James 2013). This study provides an important opportunity to assess the use of these ancient texts as sources of information about the past using bioarchaeological and isotopic data. The use of scientific methods to investigate the accuracy and significance of these classical works is unique. While recognizing the bias of historical texts is an important part of archaeological research, the

use of written documents has been a valuable tool as a jumping off point for more nuanced discussions about the past. The written records of these historians are used to form hypotheses about the lived experiences of these soldiers before the battles in which they lost their lives. Diodorus Siculus provides a detailed account of some of these soldiers being allied forces from neighboring communities, specifically Syracuse and Agrigento, and later mentions the use of foreign mercenaries in the Gelon's armies who he later granted citizenship rights (Diod. 11.72). This research suggests that our understanding of Greek communities and military forces in the Classical period (5^{th}-4^{th} centuries BCE) based on ancient texts should be explored and further tested.

1.2 Overview of theoretical orientation

This dissertation uses two main theoretical frameworks to situate the isotopic data in a way that explores the lived experiences of Greek soldiers who died in the Battles of Himera: embodiment and the "three bodies" framework (Scheper-Hughes and Lock 1987). Embodiment describes the means in which bodies incorporate the physical, social, and cultural worlds around them in a way that affects their biology (Krieger and Smith 2004). This framework has often been used in social epidemiology but has grown in bioarchaeological research as a way for those studying ancient human remains to explore the biological consequences of the political, social, cultural, and physical situations their bodies have had to negotiate. While traditionally used to look at the health of populations (Goodman 2010), this study utilizes the concept of embodiment to describe how the isotopic values of human skeletal tissues are reflective of the larger social and political environments in which the people live and grow.

Moving forward, because the bodies of interest in this study are those of ancient soldiers, I will be using the "three bodies approach" and, in particular, the "body politic" to describe the ways in which soldiers' bodies are impacted by their political environments. Scheper-Hughes and Lock (1987) described the three-body approach and define the body politic, referring to the regulation, surveillance, and control of individual and collective bodies. We understand the tasking nature of military service on the body and the body politic provides a lens to understand how political structures contribute to these pressures on soldiers' bodies. The political structures and those in charge of military forces shape soldiers' bodies to benefit the larger goals and outcomes of the state or political system.

Diet shows the relationship between humans and their physical and social environments. In this way, our interactions with the social environments that impact our diet are incorporated into our tissues during life and can be measured using isotopic analysis. Geographic place of origin, or birthplace, similarly reveals the connections between an individual soldier and the greater world around them. Where an individual or a soldier is able to travel or find work in military service is dependent on political relationships and social connections. Human migration creates new avenues for exchange and interaction between populations.

The body politic allows for a consideration of how the political structures shaped ideal soldier bodies, in addition to the ways that individual soldiers respond to economic issues, social norms, and political power. The people who made up a military unit were recruited, trained, and organized according to political standards. This dissertation will explore how the body politic shapes what types of people joined military service, inferred by using isotopic analysis that reflects the embodied dietary customs and place of origin.

1.3 Study samples and method overview

This research uses human skeletal remains from mass graves thought to be associated with the Battles of Himera. One mass grave context is associated with the first Battle of Himera in 480 BCE where a victorious, allied army of Greeks defeated the Carthaginians. A second mass grave context is associated with the later Battle of Himera in 409 BCE in which the Carthaginians defeated the Greek army, who had little assistance, and destroyed the city. The two mass grave contexts revealed dozens of adult men who died in some violent encounter outside the city walls of Himera. In this dissertation, I conducted isotopic analysis on 54 soldiers from 480 BCE and 31 soldiers from 409 BCE. I also analyzed samples from 120 non-soldier individuals buried in the western necropolis at Himera, where the mass graves were located. These citizen burials represent a sample of the general populace as a comparison to the soldiers.

This study explores the diet and geographic place of origin of these soldiers, revealing aspects of their lived experiences not apparent from only the archaeology or the historical records surrounding the Battles of Himera. This dissertation measures extracted bone collagen from 69 of the soldiers (38 from 480 and 31 from 409) to explore diet through the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic values of individuals. The soldiers were compared to 95 civilians for carbon and nitrogen analysis. Carbon is useful for determining what kinds of plants the soldiers may have been eating and nitrogen can be used to estimate animal protein consumption. Both are useful for estimating fish consumption. Bone collagen represents an aggregate of the last many years of an individual's life (5-25 years), so would not necessarily represent their diet immediately before death, but their average consumption patterns across their whole life. In addition to offering information on how humans exploited their environments via subsistence,

isotopic evidence can reveal whether individuals shared similar diets, and by extension, similar cultural and geographic backgrounds.

To investigate place of origin, this dissertation uses tooth enamel from 62 of the soldiers (51 from 480 and 11 from 409) to measure oxygen, strontium, and lead isotopes. The soldiers were compared to 120 civilians for oxygen, 33 for strontium, and 5 for lead. Tooth enamel is formed during childhood and does not modify overtime, so the isotopic values present in ancient tooth enamel reflects where a person lived during childhood. Oxygen isotopes reflect a person's water source, dependent on altitude, latitude, proximity to the coast, precipitation, and temperature of the local environment, as well as storage and treatment of the water. Both lead and strontium are reflective of the local geology, coming from the underlying bedrock of the site. Variations in these isotopic values allow researchers to investigate if individuals are local or non-local to an area, if they come from many different areas, and sometimes with enough contextual research, which site or region they came from if they are not local.

1.4 Study objectives: questions and hypotheses

The main study objective of this dissertation is to address how military bodies were constructed in the 5th century BCE in Greek Sicily. To explore this issue, I examined whether solders who died in battles lived characteristically different lives than civilians, or whether the differences between a soldier and a civilian were minimal. I predict that soldiers are more likely to have disparate geographic places of origin compared to civilians, as evidenced by their strontium, lead, and oxygen isotope ratios. I also predict that soldiers from 480 BCE battle were more likely to be non-local than soldiers from the Battle of 409 BCE, supporting historical accounts of Diodorus Siculus and Herodotus. Both Diodorus Siculus and Herodotus emphasized

that the Himeran army had support from Agrigento and Syracuse in 480 BCE, but little to no support in 409 BCE, so there are more likely to be soldiers not local to Himera in the earlier battle.

I also predict that soldiers would exhibit carbon and nitrogen isotope ratios indicative of different diets from the civilian population, representing differences in social class, and resource acquisition and provisioning between soldiers and civilians. Moreover, I predict that soldiers who were determined to be local to Himera would have different dietary isotopic values than civilians, further supporting the hypothesis that soldiers would have been provisioned differently than civilians, even if they were from the same area. While smaller city-states (*poleis*) relied on citizen militias, larger *poleis* had more formal unit organization with a more defined soldier class (Lee 2013). Himera was one of the largest *polis* on Sicily (est. 18,000 to 26,000 total population), with Syracuse's population ranging from 7,500 to 20,000 and Agrigento's ranging from 30,000 to 40,000 (De Angelis 2016). These three colonies could have supported more defined soldier classes, especially with the predominance of tyrants.

1.5 Outline of dissertation

In this dissertation, I will first give a brief overview of what the literature and previous research says about Greek warfare. In this section, my aim is to answer the question: What does a typical soldier in a Greek army look like? And how does a traditional Greek army come together? This will provide points of comparison for the next part where I will describe the diverse traditions in the armies of tyrants in Sicily and briefly explain ways that the tyrants diverged in traditional warfare practices that would not become canon in Greek military craft

until about a century later. I will also provide a brief description of the Carthaginians and the related Phoenicians.

The heart of Chapter 2 will be to explore my theoretical frameworks: the body politic and embodiment. I will provide an overview of the concept of the body politic amongst Scheper-Hughes and Lock (1987) three bodies approach, focusing on the ways that political aspects of the world shape how certain types of bodies, in this case, soldiers' bodies are created. The idea of embodiment also focuses on ho bodies "tell stories" about warfare. I will explain other examples of the ways that warfare becomes embodied that has impacts on our health and diet, and sometimes even our bones, through bioarchaeological and bioanthropological case studies. Chapter 2 will also provide an overview of Greek warfare and the practices relevant for this study, including food acquisition and recruitment.

In Chapter 3, I will provide a detailed overview of isotopic analysis, moving through each isotopic system employed in this dissertation: stable carbon and nitrogen isotopes to study diet, and stable oxygen and radiogenic strontium and lead to study migration. Beyond the basic chemistry and physics of these isotopic systems, I will also describe various biological and physical conditions that create variation, including but not limited to the environmental factors that affect oxygen isotopes and how strontium and lead vary based on geology.

Chapter 4 will provide an overview of the biocultural context of Himera and Sicily on a wider basis. I will describe the history of Himera and Sicily, as well as the local geologies and environments. This will provide the foundation for expected isotopic values of the soldiers and civilians who are local to Himera or Sicily. I will also discuss the unique political atmosphere of Sicily, specifically the tyrants and their emergence out of Greek colonization. I will also provide

background information about the economic and social relationships between Himera and surrounding groups, including fellow Greeks, indigenous populations, and Phoenicians.

In Chapter 5, I will describe my research design, including sample selection and sample descriptions of the soldiers from both battles and the civilians selected for comparisons. I will also explain the detailed methods for each isotopic system and which data analyses I used. Finally, I will present the predictions and hypotheses I had while constructing my project design. The sixth and seventh chapters will be dedicated to presenting my results and providing discussion and explanation on the findings. I will provide alternative explanations for where non-local soldiers may have come from, including presenting published data from previous isotopic work and predictions of isotopic values based on the geological and environmental conditions. There will also be discussion of the potential motivations men had for becoming mercenary soldiers and how the body politic played a role in these individuals' recruitment. This dissertation strives to understand the lived experiences of soldiers, not just during their campaigns and battles, but also what led them into their profession. The eighth and final chapter will conclude this dissertation and describe areas for future directions for this project.

CHAPTER 2:

THE BODY POLITIC AND GREEK WARFARE

2.1 Introduction

This dissertation builds on the broad literature of Greek warfare scholarship by including anthropological frameworks designed to consider how individuals' bodies are shaped by the social and political world around them: embodiment and the "three bodies" framework. It is necessary to outline the main tenets of the body politic to be able to draw connections between the ways warfare and political organizations shape bodies. I will then discuss one of the ways bioarchaeologists have proposed the body politic can be used in research involving human skeletal remains, which leads into a discussion of the bioarchaeology of warfare and the ways that warfare can be embodied by both victims and perpetrators. This chapter situates this dissertation in the larger body of work that connects human beings to the social and political world around them.

To better understand the nature of warfare in Sicily, it is necessary to first describe the mainland practices of Greek warfare. There is variation among Greek warfare, both within and between Sicily and mainland Greece, in terms of motivations to serve in the military. These differences are important to explore moving forward to recognize who became soldiers and how they fit into the larger and highly mobile Mediterranean. This study will focus on the lived experiences of soldiers before death at the Battles of Himera and investigate how the central political institutions, and more specifically the tyrants of Sicily, operated in the 5th century BCE

in Sicily. Specifically, this dissertation will focus on areas of interest including the recruitment of soldiers, military life, and diets.

2.2 Body politic

The body politic forms the core of this dissertation's theoretical framework and has traditionally been used to challenge the underlying assumptions of Western biomedicine, including the body-mind dualism which considers the body and the mind separate entities (Scheper-Hughes and Lock 1987). More recently, medical anthropology has considered how the body is as affected not only by biological factors, but also by the social constructions in which the body is formed (Scheper-Hughes and Lock 1987).

2.2.1 Anthropology of body politic

Scheper-Hughes and Lock (1987) consider the multiple lenses that can be used to think about the body, creating three bodies that overlap and represent different components of humans' lives. This framework challenges dualistic ideas that are common in medicine, such as the nature vs nurture, and the mind vs body divide. The individual body, or "body-self," is a reflection of the lived experiences related to age, sex, ancestry, and occupation. This first corporeal body reveals the biological realities that are influenced by specific social customs and recognizes that our own bodies exist apart from other individual bodies (Scheper-Hughes and Lock 1987). The second body is the "social body," which is a symbolic representation of broader social influence and situates the body within the larger population or social collective. An approach that uses the social body is more focused on the context in which the body is positioned, rather than the biological features.

The third body, or the "body politic," is shaped by political forces, such as those present in military and warfare situations, and involves the political identity of individuals and the collective group. The body politic refers to the regulation, surveillance, and control of individual and collective bodies (Scheper-Hughes and Lock 1987). Scheper-Hughes and Lock (1987) argue that Western assumptions about the mind and body affect research in many fields, including anthropology and medicine. At the core of their argument is that the ways that we understand the body in Western societies influences how health care is planned and distributed, which can lead to negative health outcomes if not all aspects of the body are considered. While their original intention was to use their (de)constructions of concepts about the body for medical anthropology, I argue that it is just as important to look at the past with a similar lens. Bioarchaeological research is directly in contact with bodies from the past and the three-body system allows us to consider all possible conceptualizations of the body without falling back on traditional Western assumptions.

The body politic and embodiment appreciates how humans actively engage with the world around them and that their skeletal remains embody these biocultural and political actions and experiences. This theoretical framework utilizes the information embedded in human remains, such as isotopic signatures of foods and geographic origins, as data for interpreting behavior of the individuals and organization of the political structures. Below, I will explain how bioarchaeologists have used the body politic to interpret other types of bioarchaeological data.

2.2.2 Body politic used by bioarchaeologists

Traditionally, the body politic framework has been used by a handful of bioarchaeologists to study occupational patterns which are delegated based on cultural decisions

from social arrangements. Martin and colleagues (2013) use Scheper-Hughes and Lock (1987)'s framework to study the "idea of humans having simultaneously multiple bodies that reflect different spheres of influence in which all humans live" (p. 152). Martin goes on to describe how the individual body includes the self-identification of individuals by their age, sex, and/or gender, ancestry or kinship, congenital anomalies, and employment or occupation. The social body is the more symbolic representation of the larger spheres of social influence and evidence of the social body can be studied by looking at the mortuary context, body modification, and gender expression (Martin et al., 2013).

When Martin and colleagues (2013) look at the body politic, they consider the ways that politics and other coercive social structures impact humans. This last body is of most interest, Martin argues, because it offers insight into a person's social status, health, and risk of early death (2013: 153). Warfare is included in her list of culturally sanctioned violence in pre-state and state societies, as well as slavery, enforcement of punishment for crimes, and more (Martin et al., 2013). Culturally sanctioned violence includes socially created categories that place individuals at risk for trauma, poor health, and early death. Martin argues that the body politic provides a way to think about power and the use of force, and how power disparately impacts perpetrators of violence and the victims of violence. The body politic provides an avenue to frame questions about social order and social control created in ancient societies and what these might mean for individual bodies.

Martin and colleagues (2013) points to other studies where Tung (2007) and Walker (2001) argued that warriors use interpersonal conflict as a means of attaining and maintaining higher status. Bioarchaeologists are often reliant on this evidence being revealed on the skeletons and in the mortuary context. Martin outlines three methods for reconstructing activity: finding

evidence of degenerative processes of articular surfaces (osteoarthritis and degenerative-joint-disease), measurements of the size and shape of long bones (robusticity) and evaluating the presence of body growths and their size (entheses or musculoskeletal stress markers).

This dissertation is unique because it is working with a skeletal sample where one potential occupation of the individuals, i.e. soldiers, is already suggested through mortuary evidence and historical record. Therefore, I am able to go beyond the physical aspects of the bones and how they reveal occupational hazards of soldiers, to consider the more minute lived experiences. Here I can interpret how political forces impacted the diet and movement patterns of the individuals they control, and concurrently, how the soldiers themselves are exerting their own power over an economic system based on their bodies' ability to perform.

Additionally, this study will use the body politic in a unique way, recognizing soldiers as both the perpetrators and victims of violence. Soldiers have the complicated role in having agency and power to enact violence on others to achieve economic gain, while also being subject to the control of political leaders (tyrants) and generals who ultimately have the most power over soldiers' bodies by defining campaigns and controlling how bodies are prepared for battle.

2.2.3 Body politic in different political regimes

The body politic contributes to our understanding of why and how certain kinds of bodies are socially and politically produced, understanding that the human body is constrained by cultural and social features in our daily lives. The two Battles of Himera, occurring under very different political regimes, a more connected group of tyrants in the first and a looser alliance of tyrants and more democratic *poleis* in the latter period, may illuminate how different political structures influence military construction and the lives of the soldiers themselves. By situating

the body politic in a broader sphere of changing political forces, we are able to see if and how violent human interaction changes in different societal conditions.

Scheper-Hughes and Lock (1987) described the body politic as the ways that politics and society control sexuality, reproduction, work, etc. in ways that institutionalize a population for collective stability and well-being, as defined by those in power. This type of regulation is extremely prevalent in military situations, where the success of the Greek phalanx is dependent on the cohesiveness of the bodies that form Greek hoplite soldiers had a variety of different options for armor, but there was a standard hoplite shield (*hoplon*), a concave disk approximately a meter in diameter (Lee 2008). Hoplites fought in densely packed infantry formations, also known as the phalanx. The phalanx allowed each soldier to stand in close order where the large hoplite shield would protect not only the individual, but also the soldier immediately to their left. By moving together in an organized fashion, all hoplites were able to be relatively protected as long as they operated on open, level terrain, and in relative sync.

Because political forces shape the body politic, it stands to reason that the body politic of an individual or population living under a tyrannical regime would be different than a more democratic society. However, this dissertation will only focus on how power and political organizations influence individual soldiers' and civilians' bodies. The body politic in a world that is rife with political tension and frequent warfare would be vastly different than one in times of peace. For example, the body politic of the soldiers in Himera leading up to the first Battle of Himera in 480 BCE would be different than the one right before the second battle in 409 BCE. The first era had strong connections between the several Greek tyrants on Sicily, the latter era formed after many years of prosperity and peace was disturbed by a simultaneous breakdown among former alliances.

Similarly, an army made up of allies from across the Mediterranean would differ from that of an army of only local men. The way that the bodies in the first Battle of Himera were controlled would have been different than the second battle. The first Battle of Himera was likely fought using the traditional soldier community in Greek warfare based on regional or familial affiliation with an arguably strong sense of togetherness to protect each other as you would your town (van Wees 2004). The phalanx is a strong symbol of unity, free from the Homeric concepts of individual triumph. The phalanx was only as strong as the sense of connection between each member to keep everyone protected and moving forward (Sekunda 2013). In the original phalanx, this connection may have been more automatic as soldiers may have been fighting alongside family members or friends from the same town. Even in later hoplite battles in mainland Greece (4th century BCE), military units were still regionally based, and wars were waged with common causes such as territory disputes (van Wees 2004). This sense of unity and community differs in situations where soldiers are brought together from far off regions. The "natural" familial community in original hoplite warfare would have to be fabricated to create a similar sense of unity and purpose to keep everyone protected on the battlefield. Mercenaries were paid soldiers, often with the promise of land attached to their military service, and, in later periods, monetary payment (Trundle 1996). The promise of citizenship in the Greek communities post-service would have been a significant draw for many soldiers and may have created a hopeful sense of community where the soldiers you are fighting next to may become future neighbors and fellow-citizens (Griffin 2005).

While every military organization, in both modern and ancient contexts, would have had exerted different influences on individual soldiers' bodies, they also would have interacted differently with local communities. Soldiers were dependent on each other and the local peoples

for food acquisition, especially if a military campaign lasted several days or even weeks. Additionally, the promise of citizenship and land for mercenaries would have meant a large influx of citizens, and potentially citizens who would not have been given traditional access to citizenship, i.e. “barbarians” or non-Greek speakers.

2.3 Bioarchaeology of warfare

Bioarchaeology, the study of human skeletons in archaeological contexts, examines the responses of the human body to environmental and social pressures, illuminating human behavior from scientific analysis of archaeological remains. The bioarchaeology of warfare has traditionally focused on patterns of trauma (Tung 2012; Walker 2001) and evidence for disease on the skeletal remains of soldiers and victims of war (Kyle et al., 2018). More recent research has expanded to include research on the diet of soldiers (Walker 2001; Holder et al., 2017).

The study of warfare using human skeletal remains is difficult because of the numerous burial practices in different cultures: many victims of war and soldiers are buried in more uncommon practices, away from traditional cemeteries and with different burial conditions. Knusel and Smith (2014) remarked that “the often non-normative nature of the casualties of conflict make their recovery more difficult than for normative burials of the same date and place” (p. 95).

Most bioarchaeological research has to rely on finding evidence of trauma before researchers can begin theorizing on how that trauma occurred. Evidence of trauma is not always visible on bones because many injuries only affect the soft tissue. However, when it is visible, it provides a direct source for the study of warfare and violence and the ways violence becomes part of the cultural landscape (Martin and Harrod 2015). Bioarchaeological data on trauma

provides information on the social relationships between the perpetrators and victims of violence; whether violence was part of intergroup warfare and raiding or intragroup violence against inner members of the society can be gleaned from where the trauma was present on the bones, burial treatment, and other biocultural information (Martin and Harrod 2015).

Soldiers provide opportunities to understand how political and social organizations operate. Within different historical and archaeological contexts, soldiers are often the best evidence for what the political situation was in the past and how that affected social status and economies (Sparacello et al., 2015). Bioarchaeological research on soldiers has revealed changes in recruitment practices over time due to larger political interactions (Archaic to Hellenistic northern Italy, Sparacello et al., 2015) and migration patterns through isotopic evidence of diet and mtDNA (Eerkens et al., 2016).

Soldiers are intricately linked to the political, social, and economic circumstances of their communities in ways that civilians are not, while also being some of the most mobile people in the ancient world. For example, a study in Italy analyzed how social status played a role in determining who was a soldier and how that could reveal the changes in larger military organization from the Archaic to the Hellenistic period (Sparacello et al., 2015). In this study, the researchers analyzed grave goods as evidence of status and compared cross-sectional asymmetry of the humerus across individuals. They argued that asymmetry was evidence of training with weapons for war in adolescence, where the upper limbs used in battle would have had different roles (one arm might have held a shield, while the other arm wielded a sword, etc.). The researchers found that in the earlier period, social status was positively correlated with humeral asymmetry, where those with high status grave goods and weaponry had higher frequency of asymmetry (Sparacello et al., 2015). Alternatively, the later period saw no correlation. Their

conclusion was that the early period was marked by small armies of high-status, elite individuals, but in the later period, when political interactions with other groups increased, there was a need to create conscription armies of men from all social statuses to have a constant standing army. Through the analysis of possible soldiers, the researchers were able document how political pressure and military organization structure were reflected in soldiers' lives and bodies.

Additionally, analysis of soldiers is useful for understanding how social relationships are formed and expressed through political or familial alliances. A study of a mass grave of prehistoric soldiers in California used isotopic and mtDNA evidence to evaluate where the individuals came from and what the motivations for engaging in battle were (Eerkens et al., 2016). Using dietary isotopic indicators, they found that the soldiers had been eating locally in the last years of their life, but the isotopic indicators of migration showed that they were all non-local. Additionally, the mtDNA evidence proved that there were at last four matrilines represented in the group (Eerkens et al., 2016). This research suggests that multi-family alliances were used to fight away from home, most likely in warfare between groups, not within groups. The analysis of soldiers revealed that social alliances during war may not have been as clearly understood if only civilian remains were studied with the limited contextual evidence available.

The anthropological study of soldiers is also an important avenue to examine motivation and agency. Soldiers are victims in war, as well as the perpetrators. Anthropological research on soldiers allows for understanding the complex social, economic, and political factors that bring soldiers into a situation that increases their risk of death. There are many motivating factors for soldiers to join armies that gives them agency such as economic gain and glory (van Wees 2004). However, there are also plenty of situations that take away the agency of individuals to join in war, such as conscription and coercion, a more common practice in later periods in

Mediterranean history and more modern warfare (Holder et al., 2017). Research on the effects of conscription are important for understanding the costs of modern and past wars. Additionally, understanding how soldiers engage in warfare and resulting consequences provides a new opportunity to study resilience and risk, such as outlined in Panter-Brick (2010).

A main critique of research on soldiers has been on the consideration of soldiers only in the analysis of how they died, not in investigating how they lived or who they were before and after the war. Anthropology is able to study the after effects of warfare, in particular, the social cost of soldiers who survived the war (Panter-Brick 2010). This research on soldiers expands our understanding of how soldiers lived, rather than just focusing on how they died. This study contributes to anthropological research on how social environments impact health and well-being. Warfare is a socially embedded phenomenon, and often soldiers are the best line of evidence to understand the symbols and motivations behind why political communities engage in warfare.

2.4 A biocultural approach and the embodiment of warfare

Biocultural theory is the consideration of human remains as both biologically and socially constructed (Agarwal and Glencross 2011). Biocultural research came from an ecological and evolutionary perspective that recognized that humans were able to adapt to environmental conditions, especially marginal environments, through various biological and cultural responses (Wiley 1992). Additionally, biocultural research considers the interactions and ways that human culture modifies environments. Human adaptability was at the forefront of the origins of a biocultural framework (Zuckerman and Armelagos 2011). Livingstone (1958) was one of the first to notice this relationship when they were looking at sickle-cell mutation as an adaptive

response to a long relationship between the population and malaria. Biocultural research with a bioarchaeological approach often employs the term embodiment, which recognizes that bodies incorporate the social and cultural world around them in a way that affects their biology (Krieger and Smith 2004). Bioarchaeology came out the concept of human adaptation and processual archaeology which aimed to use scientific methods to understand human adaptation in the past (Agarwal and Glencross 2011). Bioarchaeologists are able to interpret human remains in the framework that the bodies we study are the result of biological signatures from the political, social, and cultural situations they endured (Zuckerman and Armelagos 2011). This basic framework assists us as we make broader interpretations of the social world individuals lived in based on the skeletal remains, especially when looking at how large changes in ecological and social relationships may impact health (Armelagos 1990).

There are many strengths to using a biocultural framework, including its holistic approach to understanding the many different factors that affect health and other biological outcomes (Zuckerman and Armelagos 2011). It also avoids static ideas of health as just an outcome, highlighting the constantly changing factors that underscore life as a process, and the ability of humans to modify environments in response. Additionally, with the growth of political economy in anthropological research, the biocultural framework has been able to consider the political factors that affect biological outcomes (Goodman and Leatherman 1998; Roseberry 1998; Scheper-Hughes and Lock 1987). For some, the biocultural framework also allows bioarchaeologists to consider the materiality of human remains in archaeological contexts (Sofaer 2006). This approach considers human remains as biological beings that are imbued with social meaning and symbols that can be studied.

This dissertation will primarily use a biocultural approach by focusing on the embodiment of soldiers' lived experiences into biologically meaningful evidence, specifically isotope values that reflect diet and place of origin. Humans are influenced by the environments in which they live and move, and therefore humans embody these experiences in many different ways. This study considers the isotopic analysis of human skeletal remains as biological evidence for the cultural, social, and political impacts on the body. Migration is a socially and politically controlled event or process with biological consequences, in this case the change isotopic composition of an individuals' tissues. Similarly, diet is a culturally embedded experience where the isotopic values of a persons' food become embodied in their isotopic values.

2.5 Warfare in the Greek world

As one of the earliest, well-documented examples of organized warfare, Greek warfare has captured the fascination of centuries of scholars. This section will outline some of the basic understanding of Greek military practices and explore the many debates in the current scholarly record. First, I will discuss a general background of the Greek world leading up to the conflicts of 5th century BCE, before moving into a more general discussion of Greek warfare.

In a broad sense, beyond the descriptions of the specific events and family conflicts leading up to the battles (Hdt. 7.165), the Battles of Himera occurred because of interactions between two colonial powers, the Phoenicians from Carthage and the Greeks on Sicily. Understanding the role of these colonial powers on Sicily is fundamental for examining the connectedness of the Mediterranean during the 5th century BCE. "One of the most conspicuous characteristics of the Greeks… is and always has been their mobility" (Hornblower, 2008). The

movement of Greeks overseas created new human-environment interactions, exposing people to new regions, landscapes, and, most importantly, new people. The 8th century BCE was a time when communities were spreading themselves across the local landscape, establishing settlements and activity centers through the territory to which they laid increasingly formal claims (Osborne, 2009).

Colonies respond differently to colonization so focusing on local responses is a fundamental part of understanding expansion and contraction of world-systems (Hodos 2006; Morris 1999). Conceptually, there are two groups of agents in this interaction: the Greeks, and the "non-Greeks." Greek colonization had many forms: in some cases, Greek colonists originated from a mother city (*metropolis*) that established a colony under its support (Pomeroy et al., 1999); while in other cases, enterprising individuals organized movements for private gain (Osborne, 1998). The colonial situation in the Mediterranean is a complex contingent mix of shifting desires and perceptions, forms of adaptation and opposition, and space and structures of power (Dietler, 1998). The material culture we understand to be Greek is a combination of influences from around the Mediterranean to which colonies and local populations contributed (Gosden, 2004). Greekness during this time was most likely fluid and changeable (Gosden, 2004).

Geographic origins of soldiers can provide insight into social and political identity, or where a society draws the line between "us" and "others." Geopolitically, "Greece" was actually a series of city-states with varied dialects, traditions, and ethnicities. Greeks tended to divide the world into Greeks and barbarians, specifically tied to language, where in the Hellenic mindset barbarians, those who could not speak Greek, are non-Greeks (Zacharia 2008) and Greeks share a unified Mediterranean cultural identity (Gosden 2004; Hodos, 2006). This unified cultural

identity may have been formed because of interactions with the "other" during colonization of the 8th-6th century BCE, military conflicts such as the Persian Wars in the 5th century BCE, and the movement of people during Mediterraneanization – described as the increasing process of interconnectedness from the 8th to the 4th century BCE (Morris 2003; Smith 2003). Importantly, this unified identity would not have been static in all regions and would certainly have fluctuated with political and social influences in the colonies and surrounding areas.

Greek identity in this area was forming as a result of contact with outside groups of people. Smith (2003) argues that concepts of Greek identity were formed through communication links from Sicily to Athens, and Greeks on Sicily interacted with both indigenous groups and Phoenicians. These communication links were likely decentralized and made up a network of Greek people that considered themselves unified with a similar cultural identity. Malkin (2011) has argued that, as Greeks moved further away from Greece, they began to recognize how similar they were with other Greek populations and not as similar to the non-Greek populations that they were now interacting with. In his decentralized network of Greek people, Malkin (2011) argues that the "convergence by divergence" created an understanding of Greekness, or a unified Greek identity. This may ultimately have led to how alliances operated on Sicily during the Battles of Himera.

2.5.1 Greek warfare

The purpose of this research is to explore the identities of the soldiers at Himera, including geographic place of origin and cultural background through diet. The focus on place of origin and diet provides an avenue that look at the lived experiences of warfare, and Greek warfare more specifically. To establish the necessary context for this study, I will review what is

known about the origins of soldiers in armies, the composition of armies, and how they changed over time, and where information is available, where these practices stood in the 5th century BCE. I review key ancient authors, historical literature, and archaeology.

There have been extensive studies of patterns in Greek warfare, especially focusing on hoplites, the traditional heavily armored soldier primarily armed with spears and shields, in *polis* armies, specifically Athens and Sparta. The *polis* is the administrative and city center of ancient Greek city-states. However, as Lee (2013) points out, there is much more diversity in military practices, across regions and time. There is a general movement through time from tribal war bands to small *polis* citizen militias and then to large *polis* armies that are not just made up of citizens. Unit organizations of large *polis* armies often emulated the political structures of the time (Lee 2013). For example, Athens organized its hoplites, as well as its cavalry, in ten regiments which paralleled its ten civic tribes (Xen. *Hell.* 4.2.19). Many scholars suggest that most Greek states had poor finances to support large armies in the Archaic period and most campaigns were supported by soldiers paying for their own rations and equipment (Rawlings 2013; Sekunda 2013; van Wees 2004). However, in the western Greek world, including Sicily, more resources were concentrated in the hands of the state through tyrants, increasing the ability of the state to hire mercenaries and raise larger armies to include those who would not normally afford to go to war (Sekunda 2013). This trend would continue for other states in the Greek world into the Classical and Hellenistic periods (van Wees 2004). Warfare also brought about significant demographic consequences for certain areas through death or translocations (Sekunda 2013).

Traditional interpretations of ancient military construction have relied on historical and literary narratives by ancient authors such as Aristotle, Thucydides, and Homer. *The Histories* by

Herodotus, written in 440 BCE and regarded as the founding, earliest work of history in western literature, was largely an account of clashes among ancient peoples, focusing particularly on the Persian War, which occurred during Herodotus' lifetime (Asheri 2007). Such ancient histories are invaluable for our recognition and descriptions of how people and societies are formed and function today and, in the past, but also are incomplete and carry the biases of individual authors (James 2013). For example, writing at a time of ongoing warfare, Herodotus' descriptions augment a distinction between Greeks and "barbarians," deliberately glorifying Greek citizens (Asheri 2007; Lavelle 1986).

During the Archaic and Classical periods, armed Greek forces chiefly comprised hoplite soldiers: heavily armored, self-funded citizens who served their own *poleis* and allies. Most hoplites in Classical mainland Greece would have been part of small militias of neighbors and relatives defending their land, rather than professional, paid soldiers (Bintliff 2012; Lee 2008). Hoplites have been seen as the archetype of Greek ideals of honor, citizenship and democracy (Arist. Nic. Ethics 3 1116b15) (Lee 2008; Trundle 1996).

2.5.2 Recruitment and training

Greek soldiers were predominantly farmers, as hoplite warfare developed in the context of an agricultural society. At first, part-time militias resolved conflicts over fertile land (Bardunias and Ray 2016). Later in the 5th and mid-4th centuries, the political and economic interests escalated to be between individual states or even alliances. Military units would still have likely been groups of related men or at least those from the same town or region. Over time, phalanxes became dominantly mercenaries and the roles of the citizen soldier and paid fighters merged (Bardunias and Ray 2016). Regardless of the political structure under which the armies

served, hoplites were citizen-soldiers. Especially in mainland Greece, most free citizens were expected to perform military service. Citizen-hoplites were organized into tribes based on territory and politico-military groups of equal size (Sekunda 2000). Traditionally, tribes were further divided into *phratries* or "brotherhoods" which called for its unrelated members to remain close during battle, often under the protection of a deity.

Different city-states varied in their methods for recruitment and preparation of male children for military service. In most states, military training began at the age of 18 and would last for two years. The young men (now known as *epheboi* or "youths") would undergo a program of physical and military training. Sources suggest the Archaic period programs would have been haphazard and more rudimentary but became increasingly organized over time. Much of this training was based on creating strong military units of men to fight together. Sekunda (2000:8) notes "the hoplite was not a warrior who fought individually." Units composed phalanxes where soldiers were drawn in ranks with a wall of shields through which they stabbed their opponents. Xenophon (Mem. 3.1.8) compared the arrangement of the hoplite line to the construction of a house, where the strongest men were used at the front and the rear (the roof and the foundations), while the weaker men were "drawn forward by the bravery of the front rank and pushed forward by the pressure of those in the rear" (Sekunda 2000: 8). The majority of ephebic training was focused on group tactics rather than individual weapon skills. The concentration on group dynamics and the simultaneous rise of hoplite warfare and democracy has made historians draw parallels between the increase of the non-elite class in society, the importance of hoplites, and in collective decision-making in political areas. However, before the 4th century BCE, most hoplites were expected to provide their own food, equipment, and servants, something not possible for most simple farmers. Greek hoplites were more likely

professionals who could afford the expensive hoplite armor, not part-time amateurs, though there were places for light-armed soldiers which could have comprised the poorest citizens (Hale 2013).

2.5.3 Mercenaries and slaves

Mercenaries, or paid soldiers, were used in foreign armies across the Mediterranean especially after the spread of coinage in the Archaic period (Hdt 7.165) (Vassallo 2014; Tagliamonte 1994). Mercenaries are known to have aided both Greek *poleis* (Trundle 1996) and foreign polities (helping Persia; Hdt. 8.26.52; Thuc.I.60.). Early mercenaries (8th-7th centuries BCE) were often small groups of specialists brought in to support citizen-based armies and could be of Greek or other cultural backgrounds (Trundle 1996). Some of these specialized troops may have been intentionally recruited from areas known for their military prowess, such as archers from foreign Scythia (Lee 2008).

Tyrants were known to forcefully relocate segments of the populace, and hire bodyguards for protection, including foreign mercenaries (Diod. 11.49; Hdt. 7.156; Thuc. 6.4.6) (Lomas 2006; Harris 2020). Tyrants were city leaders not necessarily from the cities themselves who rose to power by populism or force. While some tyrants were supported by the populace, others were not, and had to work strategically to maintain tenuous control (Luraghi 1994). Sicily's military practices and political organization diverge from mainland Greece in the predominance of tyrannies, with only small interludes of democracy (Lomas 2006). Importantly, Greek tyrants pursued territorial expansions across Sicily, leading to the division of the island into pro-Carthaginian (Selinunte, Himera), and anti-Carthaginian (Syracuse, Agrigento) tyrannies (Vassallo 2005).

Greek mercenaries are well attested to have fought for foreign leaders. Lee (2007) elaborates the "To the citizens of Ionia's coastal cities at the end of the fifth century BC, the sight of mercenaries in the streets was nothing new. For decades, the Persian satraps of western Asia Minor had been employing Greek professionals, Arcadians especially, in their personal guards, and urban garrisons" (p. 43). Xenophon describes the different assembly places of Cyrus' army before his expedition into the Persian interior, including soldiers from all parts of Greece: Aeniania, Dolopia, and Thessaly of northern Greece, Achaea and Arcadia of the Peloponnese, and Boetia and Attica of central Greece. The many generals participating in the campaign would have had several contingent assembly locations before reaching Anatolia, according to Lee (2007). While it is unclear where Greek generals and armies would have assembled soldiers from, it is clear that by the end of the 5th century BCE professional Greek soldiers were willing to travel great distances and fight alongside soldiers from other regions.

There are many reasons why someone would become a mercenary. Some may have been motivated by the Greek virtue of prowess in warfare, where it is seen as a way to prove courage and bravery (*andreia*). It was also a way towards self-enrichment or financial prosperity as Thucydides (4.59) describes "nobody is deterred by fear of war if they expect to gain by it." Additionally, mercenaries were able to be employed consistently as long as there was work. Mercenaries could be used to guard fortified positions year-round while citizen troops traditionally only fought in the good season of the year when the weather permitted travel and time away from farms or other work.

Becoming a mercenary was very accessible, especially in Greek city-states. A soldier did not need any special skills outside of ones already characteristic of city-state life. Greek men were already being trained for their citizen military duty. Other non-agrarian wage-earners

needed special skills to be successful. For example, traders needed capital to sell and practical skills to know how to sell. There was likely some variation in the level of commitment to mercenary service. Certainly, some citizens were entirely settled farmers and others could become full-time wandering soldiers. However, it is more likely that people were both and that circumstances pushed them in one direction or the other at various points in their lives (McKechnie 1989: 80).

An additional group of people who may have sought mercenary employment, or who were forced into it, were enslaved peoples. Hunt (1998) outlines that the role and importance of slaves in Classical period warfare was likely greater than usually discussed by the ancient historians. Similar to general feelings towards paid mercenaries, ancient historians may have wanted to downplay the avenue to citizenship afforded to enslaved peoples if they participated in war. Herodotus connected freedom to success in military pursuits and adds to the general link between military and civic responsibility (Hunt 1998: 122). The pressure of military success may have strained these oppositions, and certainly did in a few cases when slaves participated as infantry, rowers, and other supporting roles for the hoplites (Paus 1.32.3, 7.15.7, 10.20.2; Hunt 2007). It is important to acknowledge the role these groups of people could have contributed to military success of armies in the Mediterranean, and likely globally.

2.5.4 Military life

While hoplites likely appeared in the 8th to 7th centuries BCE, there is no description of hoplite battle before the Classical period with the first written accounts from the Persian Wars (Sekunda 2000). The Peloponnesian War (431-404 BCE) covered mostly by Thucydides' has a heavy focus on Spartan and Athenian military systems which includes descriptions of hoplite

warfare. The Classical period, beginning with the battle of Salamis in 480 BCE and ending with the death of Alexander the Great in 323 BCE, coincides perfectly with the timeline of the Battles of Himera. Therefore, it is likely much of the mainland Greek military practices would have been known, if not practiced with a few significant variations.

Much of what we know about the daily lives of Greek soldiers before Alexander the Great comes from Xenophon's Anabasis or The Expedition of Cyrus. While taking place about 79 years after the first Battle of Himera, and 8 years after the second Battle of Himera, the account of Cyrus' quest across the Persian empire is the most contemporary example of battle and military life that touch on more than the leaders, strategies, and weaponry. In 401 BCE, Cyrus enlisted more than 10,000 Greek mercenaries to conquer the Persian empire. Xenophon, an Athenian aristocrat, was among the troops, but took charge after the assassination of Cyrus and other Greek officers. His account covers the day-to-day lives of the soldiers as they travel from Babylon to the Greek cities of Turkey. In the discussion of Xenophon's Anabasis, I will refer to the Greek soldiers who accompanied Cyrus as they are in other literature, the Cyreans, though they are thought to have come from many different parts of Greece (Xen. Anab. 1.2).

By the Classical period, the hoplites were increasingly joined by other military units, such as cavalry and light infantry. There was increased specialization with certain men becoming more skilled in archery or javelin throwing. These highly skilled soldiers would often be brought in to support the traditional hoplite phalanxes and provided more opportunities for those who could not necessarily afford the expensive hoplite gear.

This specialization also allowed for certain regions and political units to be recognized for their skill. The Scythians, for example, a nomadic people in the Pontic steppe, north of the Black Sea stretching into Russia, from the 7th to 3rd centuries BCE were known for their

equestrian and archery skills, creating strong armies against Persia in the 6th century as well as many becoming mercenaries later for other groups, including Athens and Sparta (Cernenko 1983). Another group, the Thracians from the Balkans region, were well-known peltasts or javelin throwers, who were hired by both Persians and Greeks.

The 6th and 5th centuries were generally very tumultuous in the Mediterranean, so it is not surprising that warfare begets soldiers begets more warfare. Adcock (1957) argues that "the use of mercenaries and their leaders tended to slow down the tempo of Greek warfare, for they were not inclined to seek decision by battle, for fear peace might break out" (p. 24).

2.5.5 Soldiers' diet

Soldiers who were chosen for duty, either as farmers to be amateur fighters, or mercenaries, would be expected to gather at designated locations (*syllogon*) and to bring whatever supplies, including food, gear (*panoplia*), and people (personal attendants, *hyperetes*) they needed. Food would need to last several days in the field, but soldiers would forage and plunder nearby towns and fields if the campaign continued.

The Athenian citizen hoplites were given orders to bring three days' rations (Lee 2007), but Xenophon describes varying amounts of food being carried depending the circumstances. Soldiers were expected to carry food, water, firewood, camping gear such as tents, and any cooking gear. There does not seem to be a standardized military mess gear, but soldiers likely carried a personal mess kit which included a drinking cup, a spit, and a small bowl (Lee 2007). There is some historical evidence of large cooking vessels such as deep cauldrons (*chytrai*) or shallow pans (*lopades*) (Lee 2007), which would have been coarse ceramics, relatively watertight, and fire-resistant.

Because of the weight of these cooking vessels, firewood, and other heavier supplies, it is likely hoplites would have cooked in small groups. In Anabasis, the Cyreans were members of a *suskenia*, informal 'mess groups' of 10-15 members, and there was no evidence of centralized food prep for the whole army. Archaeological evidence from Euboea corroborates the theory that soldiers cooked in small groups (Sapouna-Sakellaraki et al., 2002). Xenophon's Anabasis provides the most detailed account of dietary lifestyles of hoplite soldiers. This large army of Greek mercenaries were hired by Cyrus the Younger to seize Persia in 401 BCE. While slightly later and in a different region than Himera, Sicily 5th century BCE, it is an important case study in understanding some of the ways mercenary soldiers would have provisioned themselves away from home and likely reflects dietary preferences of soldiers during this time period.

Grain through cereals was the predominant part of the soldiers' diet. In Anabasis this mostly included barley and wheat, similar to the diet of Himera and other Sicilian sites. The Cyrean soldiers were given a choenix (0.84kg) measure of grain per day (~2800 calories) (Lee 2007). Grain was cooked four ways: 1) parching or roasting, which was the simplest and quickest, 2) making a simple maza cake of roasted barley meal kneaded with water or oil without further baking, 3) baking the maza cake, basically unleavened bread, though leavened bread was mentioned once with Anabasis at a banquet with officers, and 4) porridge (Lee 2007). Each kind of preparing grain had its advantages and disadvantages so would be dependent on the situation. Bread took the longest to prepare, but was the most portable, while porridge could easily be made quickly in the field without access to built hearths. Porridge, however, was more subject to spoilage and difficult to transport. Similar maza cakes could be made with acorn or nut meals if grain cereals were not available, but tended to be tough, especially if too thick (Lee 2007).

It seems the Cyreans, like many Greek citizens at home, enjoyed a variety of relishes (*opsa*). In mainland Greece, traditional additions were cheese, olives, garlic, and onions, but soldiers' diets would have depended on the location and provisioning from the land and nearby communities if the rations they brought from home ran out. According to Xenophon, some Cyreans experimented with dates and palm hearts, and in Anatolia, with legumes or winter bulbs. In some cases, soldiers would have had more freedom plundering local stores of beans, lentils, and wild vegetables (Lee 2007). Xenophon has reports of relying on the local knowledge of their captives and companions. Oil was likely not used in cooking or consumption for soldiers because it was too valuable as a fuel.

The most desirable *opson* was likely meat, however, the Classical Greek diet contained relatively little of it. By the 4th century and likely earlier, Athenians ate most of their meat at public sacrifices, in addition to small amounts from home raised poultry, hunting, fish, and snails. On the other hand, meat eating appears prominently in the Anabasis, especially when grain was hard to come by, though there is some suggestion that soldiers were morally opposed to meat consumption. According to Lee (2007: 222), "Greek cultural prejudices associated meat eating with barbarism and nomadism, and the Cyreans were sometimes reduced to consume anything available, including their pack animals to survive." However, there is some evidence that soldiers hunted when they did not need to so it is unclear how accurate this assumption is. Wine and water consumption is well attested, as it is in the Greek mainland. It is unclear from the Anabasis if soldiers would have mixed the two, a common Greek practice.

The different dietary patterns of soldiers are important to note when considering how and when these individual came to be a part of the military campaign. Some of the soldiers may have been career soldiers as mercenaries, having left their homes when they were younger and

traveled around amongst different military campaigns for economic gain (Hale 2013). Their diets would be indicative of the available foodstuffs along their travels, with variation depending on what rations were available and what region they were fighting in. Younger soldiers may have come straight from their homeland. Many Greek hoplites were in charge of supplying their own food, at least for the beginning of military campaigns, and then would have foraged along the way. Diet reflects nutritional needs, environmental constraints, as well as a connection to their cultural background so the bones of soldiers may have carbon and nitrogen isotopic signatures that represent the diet of their home community and/or their cultural background.

2.6 Conclusion

In this chapter, I have outlined the main theoretical framework of my dissertation: the body politic and the way it shapes the embodiment of warfare in human bodies. All soldiers act as political agents of the state and the political system they serve benefits from their labor and shapes their lives. Additionally, soldiers play a unique role in society by becoming specialized in violence and battle, similar to the ways merchants are specialized in a particular craft. The battles of Himera occur in a colonial context, with a mobile world of changing identities as different groups encounter each other. This would set the stage for the many different military practices outlined in this chapter. Understanding the lives of soldiers in a traditional sense, with a majority coming from mainland-centric locations and sources, allows us to later explore the variations in practices employed by tyrants in Sicily. Additionally, this chapter has aimed to provide background for potential isotopic variation, investigating the possible regions soldiers came from and possible contributions to their diet which will be contextualized to the general populace of Himera in Chapter 4.

The dialectical relationship between soldiers and the political regime is best understood in the frame of the body politic and the embodiment of warfare. Both frameworks allow for soldiers to have agency while also acknowledging the pressures of society and politics that constrain their lived experiences. I am combining these frameworks with the traditional understanding of Greek warfare, the ways that tyrants challenged these models by creating coercive population movements and an early use of mercenaries, and how mercenary soldiers become specialized in their craft. This combination allows me to consider a model where tyrants exert control over soldiers' bodies and the soldiers respond to that control with a form of craft specialization where their body is their "craft" and these interactions shape the body politic, both of the individual soldiers and the collective military force. Soldiers' bodies are influenced by the political and social environment, but also contribute to forming that political environment. The body politic is enforced and expressed through embodiment and incorporated into the soldiers' bodies through isotopic analysis that represents their place of origin and diet.

CHAPTER 3:

ISOTOPE ANALYSIS

3.1 Introduction

Stable isotope analyses of human and faunal skeletal remains are fundamental in archaeological interpretations of the lived experiences of people in the past (DeNiro and Epstein 1978; Katzenberg 2008). The methodology of isotope ratio analysis is based on the premise that the isotopic composition of an individual's tissues reflects the composition of the consumed foods (van der Merwe and Vogel 1978; Vogel and van der Merwe 1977). The goal of this section is to review how isotope analyses are used to reconstruct the diet and migration patterns of past populations. The elements considered are stable carbon and nitrogen isotopes used for dietary reconstruction, and stable oxygen isotopes and strontium and lead for local and migratory reconstruction. This section will also highlight some of the isotope analysis work already directed in the Mediterranean context to situate the research conducted for this dissertation and the possible causes of variation in our sample population from Sicily.

Isotopes are atoms of the same element that contain the same number of protons in their nuclei, but different numbers of neutrons. Most elements have isotopes and the differences in atomic weight that occurs is measurable through mass spectrometry. Stable isotope values are expressed as a permil (‰) ratio of an element's isotopes in relation to a known abundance standard. Stable carbon, nitrogen, and oxygen stable isotope ratios are reported according to the equation [$\delta=(R_{sample}-R_{standard})/R_{standard}x1000$]. The delta notation in analysis provides a convenient

way of expressing the small relative differences measured by isotope ratio mass spectrometry between samples and standards (Katzenberg 2008; Schoeninger 2011).

Bone is a plastic tissue that remodels throughout life, which makes it a useful tool for interpreting the lived experiences of people in the past. Bone modeling adapts structure to loading by changing bone size and shape, removing damage to maintain bone strength (Hedges et al., 2007). Mature bone tissue is removed through bone resorption by osteoclasts and the new bone is formed by osteoblasts. This modeling and remodeling is an important factor when considering the isotopic values of bone. Depending on the remodeling rate of the particular bone, the sample's isotopic values represent an average over several years.

3.1.1 General fractionation

Fractionation is the event that occurs between a reactant and a product where an isotope is either added or lost, creating a difference between the food that an organism eats and its tissues. Stable isotope relative abundances of an element change as the element is transferred from the food that a consumer eats to its tissues, called fractionation. This process occurs because the bonds that incorporate lighter isotopes are weaker than the bonds that incorporate heavier isotopes, breaking more readily during events like diffusion and evaporation (Fry 2006). Fractionation creates the diet-tissue spaces that are measurable and allow researchers to interpret past diet (Schoeller 1999). Consumers have different isotope values than the food they eat, especially nitrogen isotope values that differ based on trophic levels in the ecosystem (Steele and Daniel 1978; Minagawa and Wada 1984).

3.1.2 Diagenesis

Diagenesis, literally meaning “across generations,” is a general term for any alteration or change to the original mineral matrix of bone. Issues of diagenetic alteration are important to understand because the isotopes from collagen and bioapatite provide reliable dietary and environmental information and it is important to know *if* there is a lack of alteration from exchange with the environment, and if there is, then is there a way to remove deposits of these contaminants through cleaning and other pretreatment methods. Diagenesis through chemical deterioration or microbial contamination can affect the isotope ratios.

3.1.2a Collagen

Bone tissue can be viewed as a hierarchical structure consisting of two general fractions: mineral and organic. Within this structure, organic (predominantly collagen) molecules form fibrous layers that are interspersed with plate-like crystals of carbonate apatite (mineral fraction) Weiner and Traub (1992). These two components are the most common for interpreting diet and migration in the past. Bone collagen makes up a majority of protein and organic component of bone, and its isotope values are representative of those of the protein source of the diet (Ambrose and Norr 1993; Tieszen and Fagre 1993). Bone collagen is made from amino acids, which are often essential and formed from ingested protein (Schoeller 1999).

Collagen can be degraded when the bonds between its amino acids break down, especially in acidic burial environments (Collins et al., 2002). The organic collagen fraction of bone typically degrades before the mineral content. When collagen proteins leach out, it allows other components to come in (contamination). The first major process in collagen degradation is chemical deterioration of the collagen through hydrolysis and infilling by non-native mineral

content (i.e. fossilization) (Collins et al., 2002). This process is dependent on time, pH, and temperature, which is why older bones and those coming from hot and acidic environments have more collagen degradation. The second process of collagen degradation is from microbial attack. One example are humic contaminants such as bacteria and fungi. The mineral content of bone can act as a buffer against microbial attack on collagen. However, over time as the mineral degrades, through contamination and recrystallization of apatite, it becomes more susceptible. Both processes, chemical deterioration and microbial contamination, can cause diagenesis of the collagen which affects the isotope ratios.

There are some methods to test the quality of collagen after pretreatment, including the measurement of overall carbon content (% Carbon), nitrogen content in collagen (% Nitrogen), collagen yield in the sample (% Collagen), and the atomic ratio of carbon to nitrogen (C:N). These quality measures compare archaeological collagen to modern collagen, a much more well-preserved substance. Many studies have provided acceptable ranges for these collagen quality indicators: %Carbon=13-47%, %Nitrogen=5-17%, C:N Ratio=2.9-3.6, and collagen yield (%Collagen=5-28%) (Ambrose 1990; DeNiro 1985; Van Klinken 1999).

Schwarcz and Nahal (2021) have further concluded that C:N ratios are affected differently by particular contaminants, with contamination by humic matter increasing C:N ratios and selective loss of amino acids decreasing the C:N ratio. The most observed variation in C:N is due to contamination with organic material, which increases C:N ratios (Schwarcz and Nahal 2021). When C:N ratios are lower than 3.2, the C:N ratio is more likely to be caused by loss of non-glycine amino acids which could signify more alteration of $\delta^{13}C$ and $\delta^{15}N$ values – non-glycide amino acids are one of the few contaminants with lower C:N ratios. However, Schwarcz and Nahal (2021) find that the majority of the time when collagen is lost, parts of the entire

molecule is lost, not particular components (such as amino acids), therefore degradation is less likely to affect the $\delta^{13}C$ and $\delta^{15}N$ values.

Some alterations of collagen can often be corrected with proper sample preparation including a demineralization in weak HCl to remove the original mineral content of the sample and any non-native carbon contaminants. Additionally, lipids and humic contaminants can be removed with methanol and sodium hydroxide (NaOH) respectively. Alkali solutions, most commonly NaOH in collagen extraction, dissolve base-soluble humic and fulvic acids, leaving the insoluble residue of collagen remaining (Håkansson 1976). The quality checks listed above should be used in addition to the sample pretreatments because there are cases for samples to be too degraded or contaminated to use for analysis.

3.1.2b Carbonate

The mineral component of bone and enamel is hydroxyapatite, ($Ca_{10}(PO_4)_6(OH)_2$), also called a calcium phosphate. In some hydroxyapatite, the OH- is replaced with a carbonate (CO3), creating a carbonated apatite. Carbonate, within dental enamel or bone bioapatite, is a molecule containing carbon isotope values that represents the values of the whole diet energy intake because it derives carbon from all three dietary macronutrients (Krueger and Sullivan 1984; Schwarcz 2000). Carbonate is more susceptible to diagenetic changes than collagen, but in different ways. While collagen alteration is usually addition or loss of components, carbonate diagenesis is often the substitution of atoms which can be more difficult to measure and pretreat. This alteration occurs during contamination by sedimentary carbonates in the burial environment and recrystallization of apatite during post-mortem processes and sample preparation (Koch et al., 1997). However, carbon isotopes from carbonate in enamel have been found to remain intact

because of the high crystallinity and low porosity of enamel and therefore are a reliable measure of diet after a long time (Lee-Thorp and van der Merwe 1991; Wood et al., 2016). There are multiple ways in which biogenic and diagenetic subfractions of bone and tooth mineral can be differentiated (e.g., solubility, crystallinity, and density), but often the local burial conditions must first be well understood.

Pretreatment of hydroxyapatite has one main goal: to remove all contaminants that would release CO_2 when the sample is reacted with phosphoric acid (H2PO4). In some cases, this requires the removal of organic contaminants (usually NaOCl), followed by removing secondary carbonates adsorbed either from the burial environment or from atmospheric CO2 during exposure to NaOCl (Koch et al., 1997; Garvie-Lok 2004; Snoeck et al., 2016). The use of acetic acid has been very successful in removing some of the effects of diagenetic alteration without affecting the biogenic carbonates (Krueger 1991; Sealy et al., 1991; Wright and Schwarcz 1996). Acetic acid is used to remove secondary carbonates which often are present as calcite minerals (CaCO3). Calcite minerals are more susceptible to dissolution in acetic acid while the older and well-crystallized original bioapatite is more resistant (first proposed by Haynes 1968; Hedges et al., 1995). Acetic acid can sometimes cause recrystallization of the samples so that they become brushite ($CaHPO_4 \cdot 2H_2O$), which affects more modern samples and enamel more than older bioapatites (Koch et al., 1997; Lee-Thorp and van der Merwe 1991; Wood et al., 2016). This recrystallization happens more often with higher concentrated acetic acid (1M vs. 0.1M) (Koch et al., 1997), however, it seems to only become an issue for soaks longer than 24 hours (Zazzo and Saliège 2011). Carbonate has been shown to be difficult to yield accurate and precise measurements, especially when different pretreatment methods are used (Pestle et al., 2014). The general consensus is that a weak acetic acid solution (0.1N or a buffer solution) allows for the

removal of external carbonates if treated for no more than four hours. This is especially important for oxygen isotopes that are very susceptible to change with recrystallization of samples, often occurring in well preserved bone (Koch et al., 1997).

There are a variety of methods to test diagenesis and the preservation of bone and tooth apatite, including FTIR, weight % CO2 from apatite, phosphate peak splitting crystallinity indices, etc. (Wright and Schwarcz 1996). Measuring the evidence of diagenetic alteration allows us to remove samples from analysis if necessary. This study only uses tooth enamel for carbonate analysis because of the poor preservation of the bone. Tooth enamel is less susceptible to diagenetic alteration because it has higher crystallization and is a less porous material (Wood et al., 2016). Though there are some issues to address in pretreatment, tooth enamel and carbonate in bone continue to be a useful measure for bulk diet and for understanding place of origin.

3.2 Isotope analysis of migration

The main bioarchaeological methods for studying migration and the movement of people include isotopic analysis and the examination of biological relatedness. Both of these broader methods can be used to identify regional and site-specific trends in the percent of people who are locals and non-locals that contribute to our understanding of how people move around. Isotope values in tooth enamel mimics the region in which a person lived in early childhood because tooth enamel does not remodel like bone. Isotopic measurements from bones, however, indicate the geographic region in which an individual lived in the most recent years of their life leading up to death.

This isotopic information is useful in migration studies and understanding how humans have moved across different landscapes, as well as understanding dietary changes throughout the

life of an individual and between populations through time. Differentiating between locals and non-locals can define subgroups of the population that may reveal inequalities as well as other factors that influence identity (Price et al., 2002). Identifying locals from non-locals creates a greater understanding of local and regional population dynamics (Beard and Johnson 2000; Ezzo 1994). Exploration of how non-locals were perceived in society through access to resources or burial practices may reveal the agency of certain people and how that might affect their selfhood and overall identity (Turner et al., 2012).

Research in residence, residential change, and migration are important in anthropology and the study of living and past populations (Turner et al., 2009; Price et al., 2000). Bioarchaeology is uniquely suited to study population migration and the movement of people because of the methods and time-depth afforded by research of mortuary assemblages. This allows bioarchaeologists to study populations overtime and observe possible changes in population structure that result from large or small movements of people.

Oxygen, strontium, and lead isotope analysis allows bioarchaeologists to distinguish between locals and non-locals. This contributes to our understanding of regional population interactions and connect patterns of mobility to social, political, and cultural conditions (Price 2014; Turner et al., 2009). The variation in isotopes allows bioarchaeologists to observe important interactions in a population, such as long-distance migration and trading. Isotopes allow for a more precise description of if the individuals were local or from somewhere else. This analysis facilitates investigations of social interactions in the past that may have been influenced by people traveling across their landscapes (Knudson and Tung 2011). Previous movement and migration studies have focused on mortuary analysis and investigating the origins or meanings of certain grave goods and burial positioning (Antonaccio 2005; Vassallo 2011;

Viva 2020). While this archaeological evidence and material culture provide insight into local and regional interaction, it does not reveal long-standing population histories that affect why people or ideas move.

When bioarchaeologists relate questions concerning diet and the movement of people to each other, it is possible to combine the contributions mentioned previously to create a broader understanding of a population and the behavior of the individuals. Bioarchaeological research allows researchers to see if migration patterns and the movement of people affected dietary behaviors, or vice versa, and make inferences as to why that might have occurred. Even at the individual level, combining questions about locals and non-locals with questions about consumption can be used to describe differential access to resources (Turner et al., 2012). Humans are best understood when a researcher considers the many aspects of their identity and what makes them who they are, which includes where they are from and what they eat.

3.2.1 Oxygen

There are three oxygen isotopes that can be used to trace molecules as they circulate in the biosphere (^{16}O, ^{17}O, ^{18}O). Oxygen and its isotopes have specific dynamics dependent on the water cycle, where evaporation and condensation create predictable variations in water isotope compositions at the regional and global level. Meteoric water influences the $\delta^{18}O$ value, which is the ratio of ^{18}O to ^{16}O. Meteoric water is the water from precipitation or surface water.

Oxygen isotopes have been found to be useful in a variety of studies including research into migration and climate change. At interest in these studies are the many ways that oxygen isotopes fractionate in different conditions, causing variation. Dansgaard (1964) is one of the first studies that try to describe the global trends in oxygen stable isotopes. Previous work had

shown that fresh water has lower oxygen isotopic values than ocean water, the ocean values are consistent globally, and condensation temperature decreasing causes a decrease in isotopic values in precipitation. The latter conclusion is evident as altitude and/or latitude increase. Dansgaard (1964) describes the effects of condensation where heavy isotopes tend to condense out of vapor before the lighter isotopes (depleted air continues to move inland or upward), and evaporation where lighter isotopes evaporate more readily. Oxygen has been fundamental in our understanding the relationship between mean annual temperature and isotope ratios across the world.

Longinelli (1984) and Luz (1984) describe further oxygen fractionation effects, most specifically in the movement from meteoric water to body water and finally to bone phosphate. Both conclude that the oxygen isotopic values of body water vary linearly with values of local meteoric water, with higher values in body water compared to the ingested values. Longinelli (1984) found that there are differences between species, most likely related to diet and habit. Luz (1984) also concluded that fractionation of oxygen that creates differences between drinking water and body water is dependent on rates of drinking and respiration.

Oxygen isotope fractionation occurs with many environmental processes. Lighter oxygen isotopes are more likely to be taken up during evaporation, heavier oxygen isotopes are more likely to fall during precipitation, and oxygen isotope values tend to increase with an increase in temperature (Dansgaard 1964; Daux et al., 2005). The effects of oxygen isotope fractionation need to be considered when looking at oxygen values and especially when comparing them to different areas. There are also some human practices that effect oxygen isotope fractionation. In particular, various cooking processes such as stewing and brewing have been shown to effect oxygen isotope values anywhere from 1‰ to 10‰ (Brettell et al., 2012). Even if the meteoric

water oxygen isotope values do not change, there is the chance that the values we are measuring in humans have been fractionated through human processes. It is important to consider issues of water preparation and water storage when looking at oxygen values to determine who is local and non-local. One way to combat differences in $\delta^{18}O$ values due to water treatment as opposed to environmental factors to consider cultural practices at the time and if there were major differences in how different groups prepared food and water for consumption.

This contribution was important for our understanding of oxygen isotopic values, recognizing that the total oxygen flux through the body, including the enriched oxygen isotopic values in food, is what we are measuring. However, it has been shown that humans consume most of their water in drinking water, so their oxygen isotopic values will most likely reflect the local water source. There have been some recent studies showing that oxygen isotope fractionation occurs in various cooking processes such as brewing, boiling, and stewing (Brettell et al., 2012). It is important to consider these cultural practices when trying to interpret human migration and consumption.

Diagenetic alteration has been shown to be a large issue in oxygen isotope analysis because of the sensitivity of carbonate in bone apatite to changes in the burial environment (Koch et al., 1997). Additionally, Koch and colleagues (1997) showed that certain, common pretreatment methods can cause additional recrystallization of the apatite that especially influences the oxygen isotope values. Distinguishing between locals and non-locals is often a matter of small measurable differences that could be heavily swayed if the numbers are affected by diagenetic changes. This is why it is always important to find appropriate baselines for the region and follow correct protocols for sample pretreatment.

3.2.2 Strontium

Strontium is an alkaline earth element with a valence of +2, like calcium (Bentley 2006). It also has a similar ionic radius to calcium (strontium is slightly larger) and so it often substitutes for calcium in hydroxyapatite during the development of teeth and bones (Beard and Johnson 2000; Ezzo 1994). Tooth enamel and bone both have calcium phosphate hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$). In the environment, strontium is found in rock, groundwater, soil, plants, and animals. The different isotopes of strontium include ^{84}Sr, ^{86}Sr, ^{87}Sr, and ^{88}Sr (Faure and Powell 1972). ^{87}Sr is the only radiogeneic isotope that forms through the radioactive decay of rubidium.

The small mass differences between the various isotopes of strontium results in little to no fractionation as the elements are incorporated into hydroxyapatite and so the values in the human remains reflect the same values as the plants and animals they ate which reflect the local bedrock and soil values (Price et al., 2002). The present-day $^{87}Sr/^{86}Sr$ ratio in a rock is a function of the initial $^{87}Sr/^{86}Sr$ ratio, rubidium and strontium content (Rb/Sr), and the age of the rock (Bentley 2006). For example, continental rocks, such as granites, have a greater range of variation than ocean basalts (Ericson 1985). Rocks such as shales and granites then have high Rb/Sr and high $^{87}Sr/^{86}Sr$ ratios (typically above 0.710) (Tricca et al., 1999). In contrast, volcanic rocks such as basalts and andesites have low Rb/Sr and correspondingly low $^{87}Sr/^{86}Sr$ ratios (less than 0.706, from Rogers and Hawkesworth 1989). Because the levels of strontium isotope ratios in local bedrock, soil, water, plants, and animals are variable, strontium ratios have been incredibly useful in studies of mobility.

Strontium isotopes are utilized in prehistoric human ecology, such as in examining migration, exchange of food, and human territoriality (Ericson 1985). Human residence in the past can be examined through the tooth eruption sequences of humans, the elemental exchange

rates in bone tissue, and the geochemistry of strontium isotopes (Ericson 1985; Price et al., 2000). It is important to consider the turnover rate of bone, especially when comparing to dental enamel. Since tooth enamel does not regenerate or take in new elements after it has formed, the strontium isotopes present in tooth enamel reflect the geologic region in which a person lived in childhood, when tooth enamel forms. Bone, on the other hand, continually remodels so that the isotope ratios in bone reflect the geologic region in which an individual lived before death.

There are some recognized problems of using strontium isotopes, including geological variability, diagenesis, and the importance of defining the local area (Ericson 1985). Paleodietary studies are also possible because strontium is useful in estimating marine and terrestrial contributions to the diet (sea water has a distinct strontium isotope ratio, 0.7092, Veizer 1989).

Strontium isotopes undergo some fractionation, but it is to such a miniscule amount that it does not usually affect archaeological interpretations on human migration (Price et al., 2000). Strontium isotopes are quite heavy compared to carbon, nitrogen, and oxygen, and so the difference between the isotopes themselves are proportionally not enough to make any of them react differentially that others. The isotope ratios of strontium are mostly affected by the radioactive decay of rubidium and the age of the rock in which the strontium isotopes are found (Ericson 1985; Faure and Powell 1972). For interpretations on human migration, it is important to look at the age of the geology of an area to understand the different values of strontium present.

If humans are utilizing areas with more than one rock type that have different strontium ratios, than bone strontium isotope ratios would provide a measure of the relative importance of food from these distinct zones (Sealy et al., 1991). Marine, coastal terrestrial, and inland terrestrial, should have distinct strontium and carbon isotope ratio measurements. It is important

to compare strontium with other elemental isotopes when reconstructing diets in the past. Additionally, there is a necessity for accurate baselines from possible localities and control groups (Beard and Johnson 2000). Faunal remains provide the best line of evidence because the foods they consume are predictable. Specifically, small animals are useful because they tend not to migrate, though it is important to compare small and large animals to show the possible variation in a region (Price et al., 2002). The isotopic data of rocks, soil, or ground water can also be useful in strontium isotope analysis, but should be considered secondary to faunal remains. Animals, especially small mammals, can reflect an aggregate of isotopic values across a small area, whereas the isotopic values of a singular rock can vary depending on which part is sampled.

3.2.3 Lead

There are four naturally occurring Pb isotopes (^{204}Pb, ^{206}Pb, ^{207}Pb, and ^{208}Pb). The lightest, ^{204}Pb, is non-radiogenic. The others, ^{206}Pb, ^{207}Pb, and ^{208}Pb are radiogenic and are the decay products of ^{238}U, ^{235}U, and ^{232}Th, respectively (Dickin 2005, Faure and Mensing 2004, Malainey 2011). Lead isotopes (^{20n}Pb/^{204}Pb) are also useful indicators of movement patterns because the values in tooth enamel reflect the local geology on which a person lived, specifically the radiogenic isotopes are affected by the geologic age of the bedrock, increasing in abundance relative to ^{204}Pb as the rocks age. Different abundances of radiogenic Pb isotopes are also dependent on the original concentrations of U, Th, and Pb in the lead geology, so may provide sensitive differences in Pb isotope ratios in different areas (Samuelsen and Potra 2020). Soil or soil-born dust inhalation and ingestion are the likely pathways for Pb incorporation (Kamenov 2008).

In many cases, lead is assumed to yield biogenically meaningful results, as long as the site is in a region that would not be affected by mining practices which is especially problematic after the Roman period in Europe (Prowse et al., 2010). Italy, especially Sicily, is very low in metal resources so there was little mining in Greek towns during the 6th to 5th centuries. Therefore, lead isotopic values in individuals' enamel in this dissertation are most likely that from the local geology in which the person lived and is not affected by other sources of lead.

3.2.4 Movement in the Mediterranean

Oxygen isotopes have been useful in indicating residence and migration in a Greek colonial context (Keenleyside et al., 2011). Keenleyside and colleagues' study (2011) analyzes the oxygen isotopes of enamel from individuals interred at the ancient Greek colony of Apollonia Pontica (5th-3rd centuries BCE). The goal of the study was to distinguish between locals and non-locals. It was expected that individuals who exhibited non-local signatures would primarily come from the Aegean, reflecting historical records on the origin of the founders of Apollonia. Their results showed that five of 60 individuals yielded non-local signatures. These non-local signatures were characteristic of a location with higher $\delta^{18}O$, such as present in the Aegean. They concluded that it may be possible to distinguish between those who moved into the colonial context of the Black Sea, from other areas, especially if those places have distinct oxygen isotope ratios.

Strontium isotope analysis has been used to create an isoscape, or general map of strontium isotope distribution, in the Aegean region (Nafplioti 2011) and the movement of people in Neolithic sites of southeastern Italy (Tafuri et al., 2016). Leppard and colleagues (2020) conducted a meta-analysis of published strontium isotope ratios to quantify diachronic

Mediterranean mobility and migration. They found that rates of post-juvenile migration are relatively low with generally low non-local rates in the sites studied. They found comparatively higher levels of migration in the period of 7000-3500 BCE with decreasing levels later (Table 3.1). They argue that the Mediterranean was geological heterogeneous over small spatial scales, but do not reflect increasing mobility suggested by historical records (Leppard et al., 2020). This dissertation adds to the greater discussion of mobility in the Mediterranean by studying soldiers who are a notoriously mobile group of people.

Table 3.1 Comparative $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ isotopic data from Mediterranean sites

Site Name	Time Period	N	Average $\delta^{18}O$	Average $^{87}Sr/^{86}Sr$	Citation
Vagnari (Italy)	Roman	24	-3.95 ± 0.9	-	Prowse et al., 2010
Syracuse, Sicily	Archaic	15	-2.97 ± 0.3	-	Tanasi et al., 2018
Apollonia	Archaic	60	-5.8 ± 0.7		Keenleyside et al., 2011
NE Iberia	Iron Age	34	-	0.709348	Valenzuela-Lamas et al., 2018
Apollonia	Prehistoric-Hellenstic	16	-	0.709079	Stallo 2007
Grotta Scaloria, S Italy	Neolithic, fauna	4	-	0.708248	Tafuri et al., 2016
Settore, S Italy	Neolithic, fauna	3	-	0.708547	Tafuri et al., 2016
La Torretta/Poggio Imperiale, S Italy	Neolithic, fauna	5	-	0.70870	Tafuri et al., 2016
Crete	Modern fauna and archaeological human	23	-	0.708974	Nafplioti 2008, 2011
Argolid	Modern Fauna	11	-	0.708406	Nafplioti 2008, 2011
Corinth	Modern Fauna	3	-	0.708665	Nafplioti 2008, 2011
Euboea	Modern Fauna	8	-	0.709184	Nafplioti 2008, 2011

Attica	Modern Fauna	3	-	0.70894	Nafplioti 2008, 2011
Kea	Modern Fauna	5	-	0.708865	Nafplioti 2008, 2011
Kynthos	Modern fauna	5	-	0.709158	Nafplioti 2008, 2011
Naxos	Modern fauna and archaeological human	8	-	0.709526	Nafplioti 2008, 2011
Chios	Modern fauna	3	-	0.711162	Nafplioti 2008, 2011
Kos	Modern fauna	3	-	0.708301	Nafplioti 2008, 2011
Vagnari	Imperial Roman	43	-3.9 ± 0.8	0.708529	Emery et al., 2018
Vagnari	Modern and archaeological fauna and soil	15		0.708678	Emery et al., 2018
Tell Dothan, Southern Levant	Early Iron Age, fauna	8	1.0 ± 1.5	0.708188	Gregoricka and Sheridan 2017
Tell Dothan, Southern Levant	Early Iron Age, human	43	-2.3 ± 0.7	0.708161	Gregoricka and Sheridan 2017

3.3 Stable isotope analysis of diet

There are many methods to interpret foodways in the archaeological record that do not involve human remains. These include the analysis of plant and animal remains at a site, coprolites, and residues on pottery and tools that are used in production and consumption (Gremillion 2011; Larsen 2015). These are important for giving an assessment of what foods were consumed, but do not describe in what proportion these foods were consumed and how food was distributed across a population. The addition of bioarchaeological methods allows a more direct route to the individual diets of people in the past.

Determining past diet and foodways of the past provides context for evaluating growth and development, assessing paleopathologies, and interpreting adaptation (Katzenberg 2008). Diet is one of the routine parts of life that has the potential to reveal much about the identity of

individuals. What people eat is defined by cultural and social conditions that have implications on biological aspects of the human body (Reitsema and Kozlowski 2013). Additionally, the presence of dietary differences, as evidenced by different isotopic signatures, can provide insight on inequalities in the past and differential access to resources that may not be visible by other archaeological methods.

Isotopic analysis has improved our understanding of consumption profiles of different foods eaten by people in the past (Larsen 2015). Isotope signatures allow for a more precise identification of the diet because they reflect the relationship between dietary resources and the isotopic ratios of consumer tissues, and are an established method for understanding diet in past populations (DeNiro and Epstein 1978; DeNiro and Epstein 1981). Dietary behavior provides information on nutritional ecology and transitions in the life history of the individual such as weaning and residential change. Dietary studies using bone chemistry have contributed to an understanding of the timing and spread of maize agriculture in the New World, the spread of agriculture in Europe, comparing the relative contribution of marine and terrestrial foods in coastal settings, and understanding how food is collected and extracted locally (Vogel and van der Merwe 1977; van Klinken et al., 2000; Schoeninger et al., 1983).

3.3.1 Carbon

Stable carbon isotope ratios provide information on the ecosystem of the consumer, differentiating between amounts of C_3 and C_4 plants in the diet (Vogel and van der Merwe 1977; Schoeninger 1995) and contributions of terrestrial versus marine resources. The original carbon isotope standard was *Belemnitella americna*, Pee Dee Belemnite, from a Pee Dee formation in South Carolina, but has since been used up so now the international reference standard is VPDB,

"Vienna Pee Dee Belemnite" (USGS). Ratios of $\delta^{13}C$ can be measured in bone collagen, bone apatite, and tooth enamel.

C_3 and C_4 plants metabolize the two stable carbon isotopes differently, creating a product of either a 3- or a 4-carbon molecule. The different photosynthetic pathways reflect the different ways that plants convert the electromagnetic energy from the sun into chemical energy, in the form of glucose. C_3 plants include most human cultigens and vegetables, including wheat, barley, and rye. C_4 plants include maize, millet, and other tropical grasses. The carbon source for a terrestrial ecosystem is atmospheric CO_2, which has a $\delta^{13}C$ value of -7‰.

In the photosynthetic pathway of C_3 plants, also called the Calvin-Benson cycle, carbon is dissolved in the leaf cytoplasm and fixed by ribulose biphosphate carboxylation (Fry 2006). This reaction incorporates lighter isotopes (^{12}C), discriminating against the heavier carbon isotope (^{13}C). The resulting $\delta^{13}C$ is about 20‰ lower than atmospheric CO_2 with a range of -22‰ to -38‰, average of -26‰ (Fry 2006; Larsen 2015).

C_4 plants follow a slightly different pathway, called the Hatch-Slack pathway, which uses phophoenolpyruvate carboxylase within the mesophyll plant tissue to create a 4-carbon molecule. There is not as much discrimination against the heavier stable isotope, creating an offset of only about -5‰, and a range of -9‰ to -21‰, averaging -12.5‰ (Fry 2006). Humans who eat C_4 plants have a higher (less negative) $^{13}C/^{12}C$ value than others. People who eat more C_3 plants, such as wheat, would have a lower (more negative) value. The diet-tissue spacing shifts approximately 1‰-5‰ in experimental and field settings (DeNiro and Epstein 1978; Hare et al., 1991). This differentiation has been fundamental in analyzing the origins of agriculture and studying subsistence transitions in past populations. After metabolic fractionation, which

occurs when humans incorporate the isotopes into their tissues, the $\delta^{13}C$ value of bone collagen is about 5‰ higher than their total diet.

Additionally, carbon isotopes are useful in distinguishing between terrestrial and marine diets (Chisholm et al., 1982). Carbon isotopes in the ocean come from a variety of sources including diffusion with the atmospheric carbon and degrading sediments in the water. Carbon from the ocean has a $\delta^{13}C$ value of 0‰ (Chisholm et al., 1982). This creates a higher (less negative) $\delta^{13}C$ value for plants and animals that utilize marine resources. If humans are consuming marine plants or marine fish, the higher $\delta^{13}C$ will be reflected in their remains.

3.3.2 Nitrogen

Nitrogen in the body and from the diet is present as amino acids and protein that comes from the food we eat (Schoeller 1999). Stable nitrogen isotope ratios reflect the trophic position of an organism in the local food web. They are expressed as a ratio of ^{15}N and ^{14}N, nitrogen's two stable isotopes, in relation to the standard of atmospheric nitrogen. Nitrogen from food sources are ingested and incorporated into consumer tissues. During this process, the lighter isotope (^{14}N) is broken down more readily than ^{15}N and excreted through urea (Minawaga and Wada 1984; Schoeninger and DeNiro 1984). This results in the higher $\delta^{15}N$ values of consumers' tissues by about 3-5‰ compared to their diets. This value continues to rise through the food chain. It is useful in distinguishing between carnivores, omnivores, and herbivores. Nitrogen in our diet comes from atmospheric nitrogen that has been processed by bacteria in the soil, allowing it to be taken up by plants and passed through the food chain (Schoeninger 1995). Terrestrial plants exhibit $\delta^{15}N$ values of approximately 3‰ after the fractionation from the atmospheric air via photosynthesis. Continuing up the food chain, herbivores exhibit $\delta^{15}N$ of 6-

8‰, and carnivores have values around 9‰ (Fry 2006). $\delta^{15}N$ values are useful in evaluating the importance of animal protein, but do not successfully differentiate between meat and dairy of the same animal.

Marine and freshwater organisms typically exhibit elevated $\delta^{15}N$ ratios because of denitrification in ocean water and the great length of aquatic food webs compared to terrestrial ecosystems (DeNiro and Epstein 1981). Individuals with higher nitrogen isotope ratio values are generally thought to be eating more luxury items such as animal-derived protein, or marine resources. The conclusions depend on culturally and isotopically defined baselines of local diet.

There are several factors that affect nitrogen isotope values that are not related to specific dietary components, most notably climate, and agriculture and animal husbandry techniques may influence values in Sicily. Hot and arid climates have been shown to increase $\delta^{15}N$ values because of how animals respond to heat stress (Szpak 2014). Additionally, animal husbandry techniques such as grazing intensity and the use of animal fertilizers in crop production have been shown to raise the $\delta^{15}N$ values (Bogaard et al., 2007; Szpak 2014). Manuring in agriculture changes the source of nitrogen for plants, increasing the amount of ^{15}N. Furthermore, soils will tend to have higher $\delta^{15}N$ in areas exposed to the heat and sun, higher salinity, and where there is fire-clearing (Heaton et al., 1986).

3.3.3 Diet-tissue space

Fractionation creates diet-tissue spacing, where there are measurable differences in the diet compared to the different tissues of the body and what people excrete (Krueger and Sullivan 1984; Minagawa and Wada 1984). This is especially important when choosing which tissue to measure. The isotopic values will be discussed more below, but there are two components that

archaeologists measure in human skeletons: the organic collagen, made up mostly of protein, and the carbonate, made up by mineral.

Carbon isotope fractionation differences occur most dramatically with the type of photosynthesis a plant uses for energy. C_3 plants undergo a much greater depletion of ^{13}C during photosynthesis than C_4 plants (-19‰, -9‰ respectively Krueger and Sullivan 1984), resulting in C_3 plant ranges -34‰ to -22‰, and C_4 plants ranging -13‰ to -8‰ (Krueger and Sullivan 1984). These differences in fractionation allow anthropologists to distinguish between people and animals who consume C_3 plants or C_4 plants (van der Merwe and Vogel 1978; Vogel and van der Merwe 1977). Within the body, metabolism creates more avenues for fractionation to occur, resulting in an enrichment in ^{13}C in the human body compared to the diet (+5‰, Krueger and Sullivan 1984).

Nitrogen isotope fractionation also occurs as nitrogen enters the plant from the soil or atmosphere. When most plants do not fix nitrogen themselves, the ones that do tend to have much lower nitrogen values, such as legumes. These plants are able to use the nitrogen directly from the atmosphere which has a value of $\delta^{15}N=0‰$. Most plants receive nitrogen from nitrogen fixing bacteria which enriches the amount of ^{15}N in the plant compared to the atmosphere. Nitrogen isotope values continually increase as it goes through each trophic level, about a +3-5‰ effect (Minagawa and Wada 1984; O'Connell et al., 2012; Schoeller 1999). The greater numbers of trophic levels in an ecosystem, the greater enrichment of nitrogen that occurs, as can be seen in marine systems. Another point in the fractionation of nitrogen through the food chain is the differential fractionation of different amino acids. Because nitrogen is predominantly present in the form of protein in the body, which is made up of different values of amino acids, it

is important to consider how different amino acids may have different fractionation effects (Hare et al., 1991).

3.3.4 Routing

For both carbon and nitrogen, the issue of routing can influence the effect of fractionation. Different macromolecules are routed to different tissues and if those macromolecules have different isotopic values, it can influence what we are able to measure and interpret about human diet in the past. This process occurs during metabolism where different isotopes are preferentially excreted or absorbed. For example, ^{14}N is more likely removed during metabolism and excreted through urine and urea than ^{15}N, creating a depletion in excrements but one of the enrichments in the body that we observe (Minagawa and Wada 1984). There have been several studies on how different macromolecules are routed (Ambrose and Norr 1993; Krueger and Sullivan 1984; Tieszen and Fagre 1993). All of the studies found that collagen, which is made mostly of protein, reflected the isotopic values of the protein component in the diet. Fernandes et al, in particular, found that over 70% of the carbon in collagen was attributed to the protein component of the consumers' diet. Krueger and Sullivan (1984) described how the isotopic values of different diets were routed through the body: herbivores scrambled their macronutrient isotopic values into both collagen and carbonate; carnivores routed the isotopic values of meat protein into the collagen while the lipids from the diet made up the carbonate value; and omnivores routed protein from meat to the collagen and carbohydrates from plants into the carbonate. When possible and with good preservation, it is important to study both the collagen component and the carbonate component of human bone and teeth to reveal both parts

of the diet. Because bone carbonate often reflects the overall CO_2 in the blood and body, it is a good indicator of whole dietary energy intake (Schoeninger 1995).

3.3.5 Dietary variation in the Mediterranean

Overall, despite political and social changes throughout the Mediterranean, the types of plants and animals utilized for subsistence tends to have been continuous. Therefore, I expect a fair amount of continuity in the stable isotope values among different sites, especially Greek colonies. The major domesticates introduced in the Neolithic period, including cows, sheep, goats, wheat, olives, and grapes, continued to be the major parts of the subsistence and economy even in very recent periods.

There is a rich isotopic literature on diet in the Mediterranean, with particular focus on the Greek world. Across a long time scale, populations in the Greece show evidence of a largely terrestrial diet, with $\delta^{13}C$ values close to -19‰ (Table 3.2, and Papathanasiou and Richards, 2015). This holds true for the general populace of Himera (Reitsema et al., 2020), as well as many other sites in Italy and Greece.

Table 3.2 Comparative $\delta^{13}C$ and $\delta^{15}N$ isotopic data from Greek and Italian sites

Site Name	Time Period	n	Average $\delta^{13}C$	Average $\delta^{15}N$	Citation
Euboea, Greece	Prehistoric	11	-19.9 ± 0.4	8.3 ± 0.8	Kontopoulos and Sampson 2015
Egadi Islands, Sicily	Prehistoric	4	-18.6 ± 0.6	11.1 ± 0.4	Mannino et al., 2012
Grotta Addaura Caprara, Grotta Niscemi and Grotta della Molara, NW Sicily	Prehistoric	5	-19.7 ± 0.3	9.1 ± 1.3	Mannino et al., 2011

Sedegliano, N Italy	Early to Middle Bronze Age	2	-17.7 ± 0.1	8.3 ± 0.2	Tafuri et al., 2009
Lavello, S Italy	Middle Bronze Age	4	-19.5 ± 0.1	8.5 ± 0.2	Tafuri et al., 2009
Toppo Daguzzo, S Italy	Middle Bronze Age	14	-19.6 ± 0.2	8.2 ± 0.5	Tafuri et al., 2009
Olmo di Nogara, N Italy	Middle to Late Bronze Age	19	-15.2 ± 0.8	9.4 ± 0.8	Tafuri et al., 2009
Metaponto, Italy	7^{th}-2^{nd} c. BCE	48	-19.3	10.6	Henneberg and Henneberg 2003
Himera, Sicily	5th-2^{nd} c. BCE	90	-19.5 ± 0.4	10.3 ± 0.9	Reitsema et al., 2020
Syracuse, Sicily	Archaic	15	-19.4 ± 0.4	10.6 ± 0.4	Tanasi et al., 2018
Athens, Greece	Late Archaic/Classical	16	-19.2 ± 0.6	10.6 ± 1.0	Lagia 2015
Apollonia, Bulgaria	5th-2nd c. BCE	54	-18.5 ± 0.5	10.1 ± 0.8	Keenleyside et al., 2006
Thebes, Greece	Classical		-19.2 ± 0.4	10.7 ± 1.0	Vika et al., 2009
Athens, Greece	Hellenistic	21	-19.0 ± 0.6	9.6 ± 1.6	Lagia 2015
Velia, Italy	Imperial Roman (1st and 2nd c. AD)	119	-19.1 ± 3.6	8.6 ± 1.3	Craig et al., 2009
Athens, Greece	Imperial Roman	14	-19.1 ± 0.3	9.3 ± 1.7	Lagia 2015
Isola Sacra, Rome, Italy	Imperial Roman	17	-18.8 ± 0.2	11.0 ± 1.1	Prowse et al., 2004
Leptiminus, Tunisia	Roman and Late Roman	99	-17.7 ± 0.6	13.3 ± 2.3	Keenleyside et al., 2009
Eleuther-. Greece	6th-7th c. AD	27	-18.9 ± 0.6	8.2 ± 1.4	Bourbou et al., 2011
Messene, Greece	6th-7th c. AD	21	-19.2 ± 0.3	8.7 ± 0.6	Bourbou et al., 2011
Sourtara, Greece	6th-7th c. AD	27	-18.2 ± 0.3	9.5 ± 0.3	Bourbou et al., 2011
Kastella, Greece	11th c. AD	19	-18.8 ± 0.3	9.1 ± 1.2	Bourbou et al., 2011
Stylos, Greece	11th - 12th c. AD	10	-18.8 ± 0.7	9.4 ± 1.7	Bourbou et al., 2011
Servia, Greece	11 - 15th c. AD	15	-18.7 ± 0.3	8.7 ± 0.6	Bourbou et al., 2011
Nemea, Greece	12th - 13th c. AD	11	-19.0 ± 0.3	8.7 ± 0.5	Bourbou et al., 2011
Petras, Greece	12th - 13th c. AD	12	-19.2 ± 0.3	9.5 ± 0.7	Bourbou et al., 2011

There is some variation in $\delta^{13}C$ values, with some sites having slightly elevated $\delta^{13}C$ values (~ -15‰), such as Omo di Nogara in Northern Italy. Papathanasiou and Richards (2015) attest this variation to the consumption of C_4 plants because the corresponding $\delta^{15}N$ values are not elevated. As mentioned previously, there is very little fluctuation in the environmental conditions and utilized subsistence resources through much of the Iron Age to Roman periods in the Mediterranean, so variations within and between populations are likely due to cultural and socioeconomic shifts and differences.

3.4 Isotopic analysis in the context of warfare

There is limited isotope research focused on soldiers or in contexts of war, but this limited research has shown promise to identify soldiers from civilians in burials, investigate geographic origin of soldiers, and understand the diets of soldiers. Eerkens and colleagues (2016) used multiple isotopes to explore the origins of soldiers in hunter-gatherer communities in Central California (approx. 1400-600 BP), finding early evidence for intergroup warfare in North America. Holder and colleagues (2017) used carbon and nitrogen isotopes to explore diet of Napoleon's army during the Russian Campaign of 1812. They found great variation in the isotopic values, with both C3 and C4 diets as well as a mix of soldiers consuming terrestrial, freshwater, and marine animal protein, indicating a multiethnic and socially stratified military.

Huelga-Suarez and colleagues (2016) studied the cemetery at a 13th and 14th centuries Spanish monastery and used strontium isotope ratios in tandem with entheseal changes. Using historical records, they concluded that some of the non-local individuals buried at the site may have been soldiers, using the monastery and surrounding villages as a final refuge, buried amongst local craftsmen and laborers. Colleter and colleagues (2021) conducted several isotopic

studies on a mass grave from 15th century in northern France, including $\delta^{13}C$, $\delta^{15}N$, $^{87}Sr/^{86}Sr$, $\delta^{18}O$, and $\delta^{34}S$, as well as DNA, to identify the individuals who were buried. Their multidisciplinary approach allowed for more discussion of soldiers from distant regions being buried together. Similar to the goals of this dissertation, their data improved historical records by focusing on the individual lives of soldiers rather than just the leaders.

As of now, there have been no isotopic studies of soldiers from the Mediterranean region near the time period at focus in this dissertation. This is in part because of the rarity of finding burials that have enough evidence to suggest they were soldiers. As is the case at Himera, Greek soldiers were often buried in the battlefield. Uniquely, the battlefield at Himera also happened to be one of three necropoleis at the site and was used decades before and after the battle to bury civilians in the same place as the war dead. If soldiers are buried away from the battlefield, it is often unclear if they are soldiers unless there is evidence of trauma, weapons, or a grave marking. An example of a marked soldiers' grave is the located in the Kerameikos cemetery in Athens, Greece, honoring four Lacedaemonian (Spartan) soldiers (van Hook 1932). Other Greek sources show that soldiers may have often been cremated, leaving behind little to no sample for isotopic analysis (Iliad Book I, l. 52).

CHAPTER 4

BIOCULTURAL CONTEXT OF HIMERA

4.1 Introduction

This section will outline the important background information needed to understand the social, cultural, political, and physical environments of Sicily and Himera during this time period. While Chapter 2 provided some of the background for the soldiers' lived experiences, this chapter focuses on the environments affecting the everyday lives of people living in Sicily and general populace at Himera. This section will also provide environmental information that elucidates some of the expected isotopic values of the regions of interest, especially $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ isoscapes.

4.2 History

This section will provide a brief history of Sicily, followed by a brief history of Himera. Additional sections in this chapter provide more details on the historical events as they relate to politics, economics, and interactions with other groups of people.

4.2.1 Sicily

Sicily's strategic location in the center of the Mediterranean and its available agricultural land has made it an attractive location for many groups of people across time. Ancient Greek and Roman historians were drawn to writing about the island's physical characteristics and so much

of the history of Sicily after the 8th century is relatively well known. These sources, especially Thucydides and Diodorus Siculus, will be used as important pieces of data to provide an overview of the history of Sicily leading up to the Battles of Himera. While ancient sources should be used cautiously because of the ways authors have biased worldviews or often embellished their works to appeal to the audience, they still provide the opportunity to understand social, political, and economic contexts that may not be archaeologically visible. The core questions of this dissertation, related to Greek military recruitment practices, will be evaluated also by archaeological and isotopic data, where the historical texts will provide the foundation of the study. The history of Sicily, however, is not the main focus and so use of the historical sources is appropriate to provide a brief overview.

Greeks began forming colonies in Sicily in the late 8th century BCE, with the first Greeks coming from Euboea, Megara, and Corinth (Hodos 2006) (Figure 4.1). The earliest permanent Greek colony was Naxos, founded by Chalcidians approximately 734 BCE (Dunbabin 1948:8). After Naxos, Corinthian and Megarian colonists covered the eastern and southeastern costs of Sicily. During the first wave of settlement, the Euboean Chalcidians founded Zankle, a coastal town on the northeast tip of Sicily, modern day Messina. Notably, the Greek presence on Sicily comprised different ethnic Greeks on the island, particularly those from Chalcidian (rooted in Ionian) and Doric cultural backgrounds, both Greek speaking but with different ritual and cultural practices, as well as a different dialect (Chalcidian and Doric). By the 7th century BCE, several Greek colonies along the eastern coast begin to expand westward, founding secondary colonies, such as Himera and Selinunte, along the north and southern coasts of western Sicily.

Figure 4.1. Map of Sicily with labeled Greek and Phoenician sites.

The Greek colonies in Sicily mirrored political alliances of their founding *poleis*. For example, Megara and Corinth in Greece were hostile rivals, so their colonies, Megara Hyblaea and Syracuse respectively, would have been considered rivals (De Angelis 2002:48). The political relationships between *polis* and colony affected the political decisions of the colonies, regardless of the autonomy that colonies often have. Syracuse was founded as a Dorian colony of Corinth in 734 BCE (Thuc. 6.3). Syracuse would continue to found its own colonies, including Camarina (598 BCE) along the coast, and Akrai (664 BCE) in the interior, northeast of modern day Ragusa (Thuc. 6.5). Agrigento was founded as a colony along the southwestern coast in 580 BCE, which had developed from a trading-post established by the primary Greek colony of Gela, originally founded by colonists from Rhodes and Crete (Dunbabin 1948:137). These cities are the most relevant to the Battles of Himera because of their role in the alliance, especially in the first Battle of Himera, as well as the continued relationships between the tyrants who ruled over Syracuse, Himera, and Agrigento.

4.2.2 Himera

The Greek city of Himera was founded around 648 BCE by culturally Greek settlers from the colony of Zankle, modern day Messina, and commanded the sea routes along the northern coast of Sicily and a major land route across the island (Figure 4.2). Most of the colonists were Chalcidians from Zankle, but they were also joined by exiles from Syracuse which was engaged in a civil war at the time. These two groups were different ethnically, with the primary ethnic group from Syracuse being Doric. The language at the colony was a mixture of Chalcidian and Doric, but the cultural institutions that prevailed were Chalcidian (Thuc. 6.5).

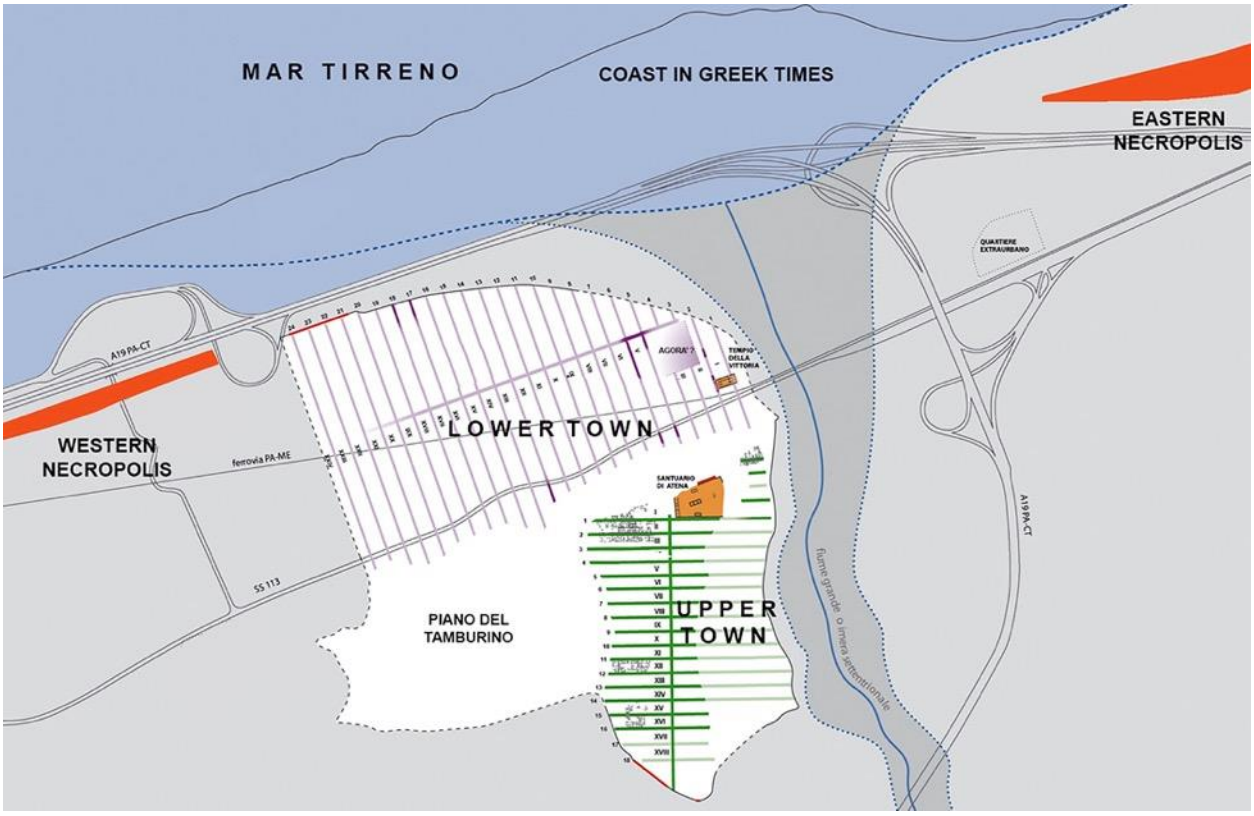

Figure 4.2. Plan of Himera. The plan of Himera shows the relation of the Upper and Lower towns to the river and the Western necropolis where the Battles of Himera were fought along the western fortifications (produced by Stefano Vassallo, from Reinberger et al., 2021).

4.2.3 The sources

Much of our knowledge of the Battles of Himera is from the historical texts of Herodotus and Diodorus Siculus. Herodotus (c. 484 – 425/413 BCE) lived in Asia Minor and documented his travels during the Persian Wars and the first Battle of Himera. Herodotus emphasizes the Greek-barbarian dichotomy, often focusing only on conflicts between these groups, while also being wary of empires and tyrants, and completely against wage-earning mercenaries (Asheri et al., 2007; Lavelle 1986). Diodorus Siculus lived in the 1st century BCE Roman period in Sicily. Although he is credited with putting together an immense composite history of the Mediterranean world, his work is criticized for copying what other historians already had written, and for amplifying Sicily's importance (Griffin 2005). Both Herodotus and Diodorus Siculus assert and emphasize that the first Battle of Himera in 480 BCE occurred on the same day as other Greek victories in the Battle of Thermopylae and the Battle of Salamis "as though heaven had deliberately arranged for the finest victory and the most famous of defeats to take place simultaneously" (Diod. 11.24, translated by Green 2010; Hdt. 7.166) (Green 2010), a possible exaggeration of the exploits of the colonial Greek West (Green 2010; Griffin 2005).

4.3 Geology and water

Understanding the surrounding geology and water systems in place in a region supports isotopic interpretations. First, I will describe the geology of Sicily and the modern water details, such as annual precipitation, all factors that affect the $^{87}Sr/^{86}Sr$, $\delta^{18}O$, and $^{20n}Pb/^{204}Pb$ of a particular region. The geologic and hydrologic characteristics of Himera are then described.

4.3.1 Sicily

Sicily's geology is varied, with bedrock deposited at different geological periods (Catalano 2004) (Figure 4.3). Sicily developed along the African-European plate boundary in the western central Mediterranean. Its segment links the African Maghrebides with Southern Apennines across the Calabrian accretionary wedge (Catalano 2004). The chain is located between the Sardinia block, the Pelagian-Ionian section, and beneath the central southern Tyrrhenian sea (Catalano 2004). See Figure 4.4 for a chart of the geologic time scales. The African rock units, or sedimentary successions form the main tectonic units in the area and are Mesozoic-Lower Miocene carbonates and cherts, and Meso-Cenozoic shelf carbonates (Catalano 2004: 36). Sicilian geology is dominated by Meso-Cenozoic formations (Triassic-Tertiary deposits), mostly composed of carbonate and siliciclastic sediments (Catalano 2004). Limited outcrops of Paleozoic and Precambrian rocks are exposed in the northeastern tip of the island (Figure 4.5). Quaternary volcanic rocks are associated with Etna volcano outcrop in the eastern part of the island (Catalano 2004). The area around Himera is characterized by a mix of deposits, ranging from Upper Mesozoic to Late Miocene formations.

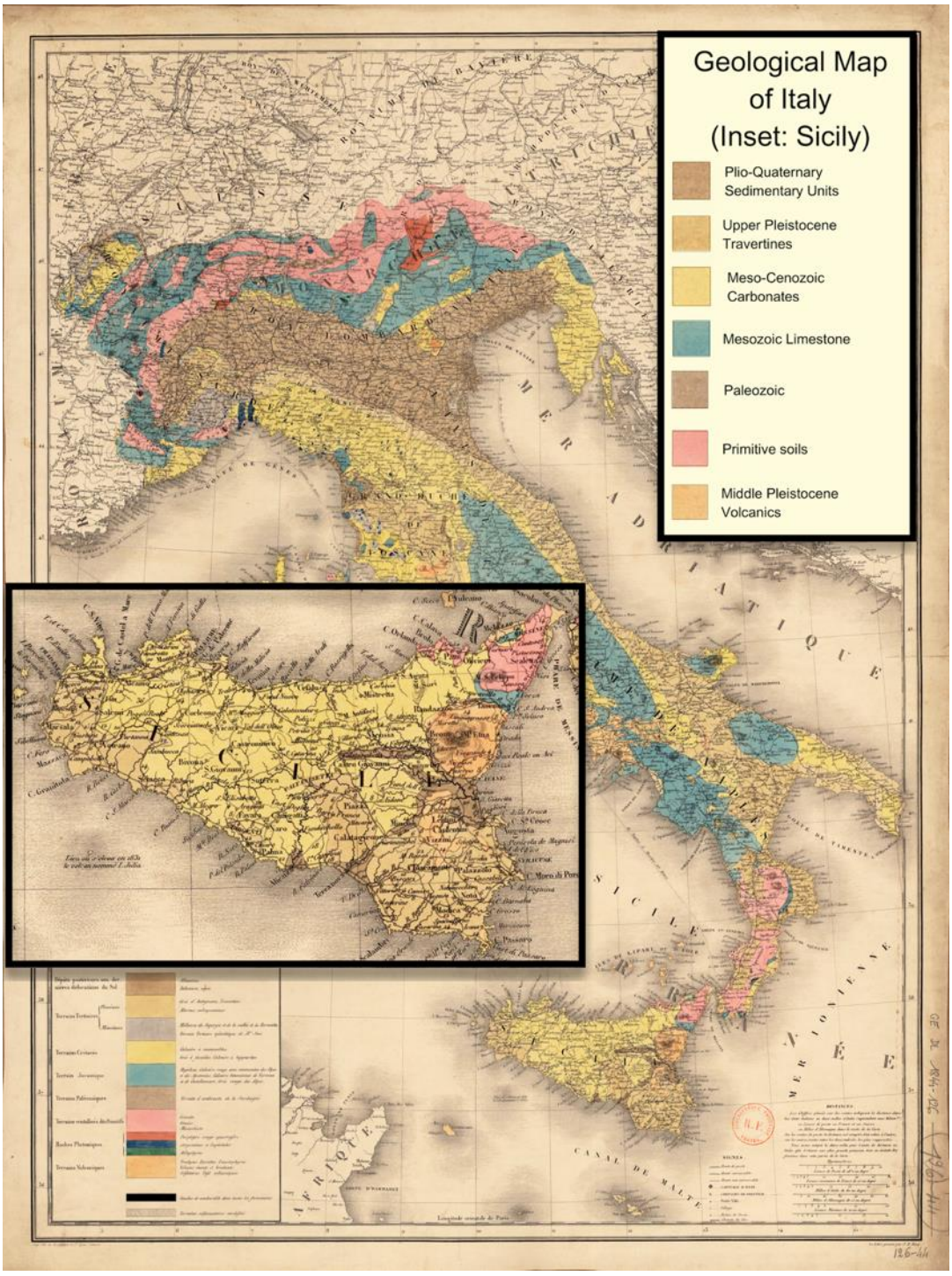

Figure 4.3. Geological Map of Sicily. Public domain image of the geological map of Italy by H. de Collegno, 1844. Bibliothèque nationale de France, dèpartment Cartes et plans, GE DL 1844-126, modified to include an inset of Sicily and a legend for the geology.

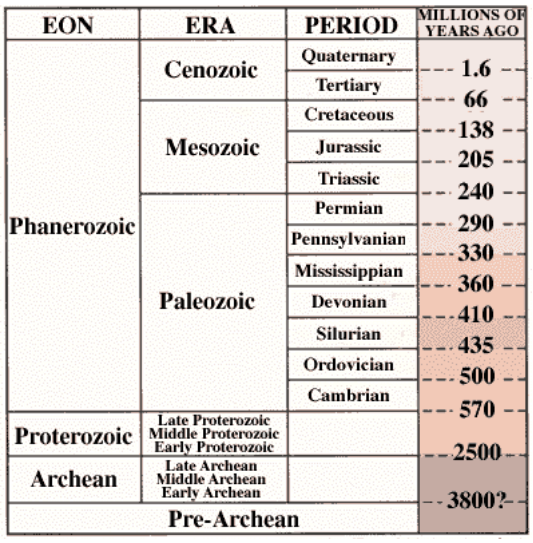

Figure 4.4. Geologic time scales used in this dissertation. Wikicommons.

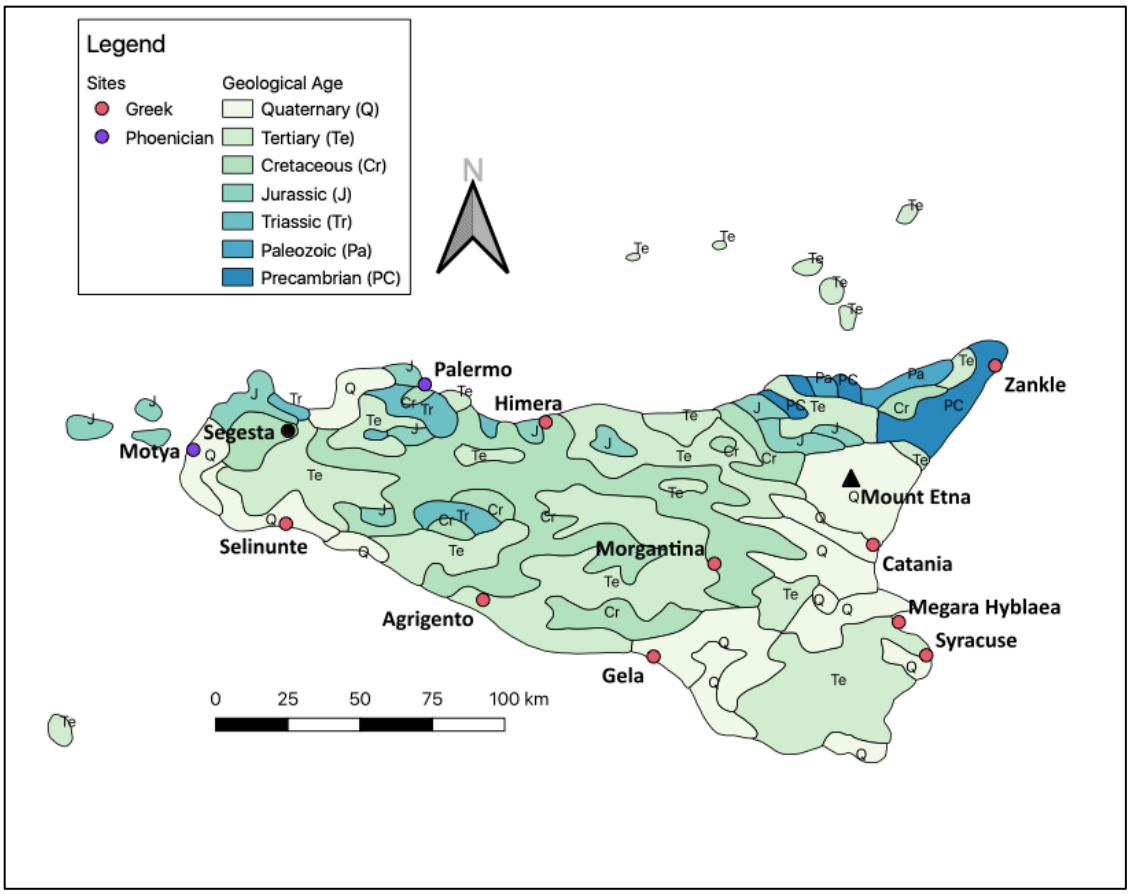

Figure 4.5. Map depicting geologic ages of the underlying bedrock in Sicily. Youngest deposits are represented by the lightest color and get darker with older geologic ages. Created in QGIS using DataSource: USGS by KLR (Reinberger et al., 2021).

Estimated $^{87}Sr/^{86}Sr$ values for the Mediterranean are presented in Figure 4.6. Agrigento, one potential source of allied soldiers in the battle of 480 BCE, has slightly younger deposits, comprising the Late Miocene to the Pleistocene. The sedimentary layers at Agrigento consist of a top layer of calcarenite and a base of the Early Pleistocene marl, surrounded by plains that likely yielded oil, sulfur, salt, and iron (Crouch 2003). Syracuse, another source of allied soldiers during 480 BCE, located on the Hyblean Plateau, has the widest range, with deposits from the Triassic to the Pleistocene (Catalano 2004). The plateau bedrock is dominated by carbonate

rocks, ranging in age from Oligocene-Miocene to Pliocene-Pleistocene. The estimated $^{87}Sr/^{86}Sr$ range from local geology for Syracuse is 0.70800 – 0.70900, based on expected Sr isotopic compositions of Oligocene to Pleistocene carbonate rocks (Howarth et al., 1997) (Figure 4.7). Agrigento values are likely slightly higher due to the younger rocks, but there will be some overlap.

The $\delta^{18}O$ values of the Mediterranean are estimated in Figure 4.8 and vary based on average precipitation rates, temperature, altitude, and latitude. Today, the annual precipitation rate in Sicily is 500-600mm, with Agrigento averaging around 500mm, Himera at 550mm, and Syracuse at 590mm (Mitchell and Millard 2009). The mean annual temperature at Himera (15.9°C) is slightly lower than Agrigento (17.3°C) and Syracuse (17.6°C). This suggests that $\delta^{18}O$ will not differ dramatically between the sites, though Syracuse may have slightly higher $\delta^{18}O$ values than Himera because of higher temperatures, and Agrigento may have lower $\delta^{18}O$ values, being situated at a higher altitude (~84m versus Syracuse at ~15m, Himera's Upper City at 72m and Lower City at 9m) (Figure 4.9). About 95% of annual rainfall occurs in fall, winter, and spring, especially between October and May, while the summer only receives about 20-50mm of rain (De Angelis 2016). The southern half of Sicily receives 40 to 60 days of rain, compared to 60 to 100 days in the northern half, and mountainous parts getting over 100 days of rain a year.

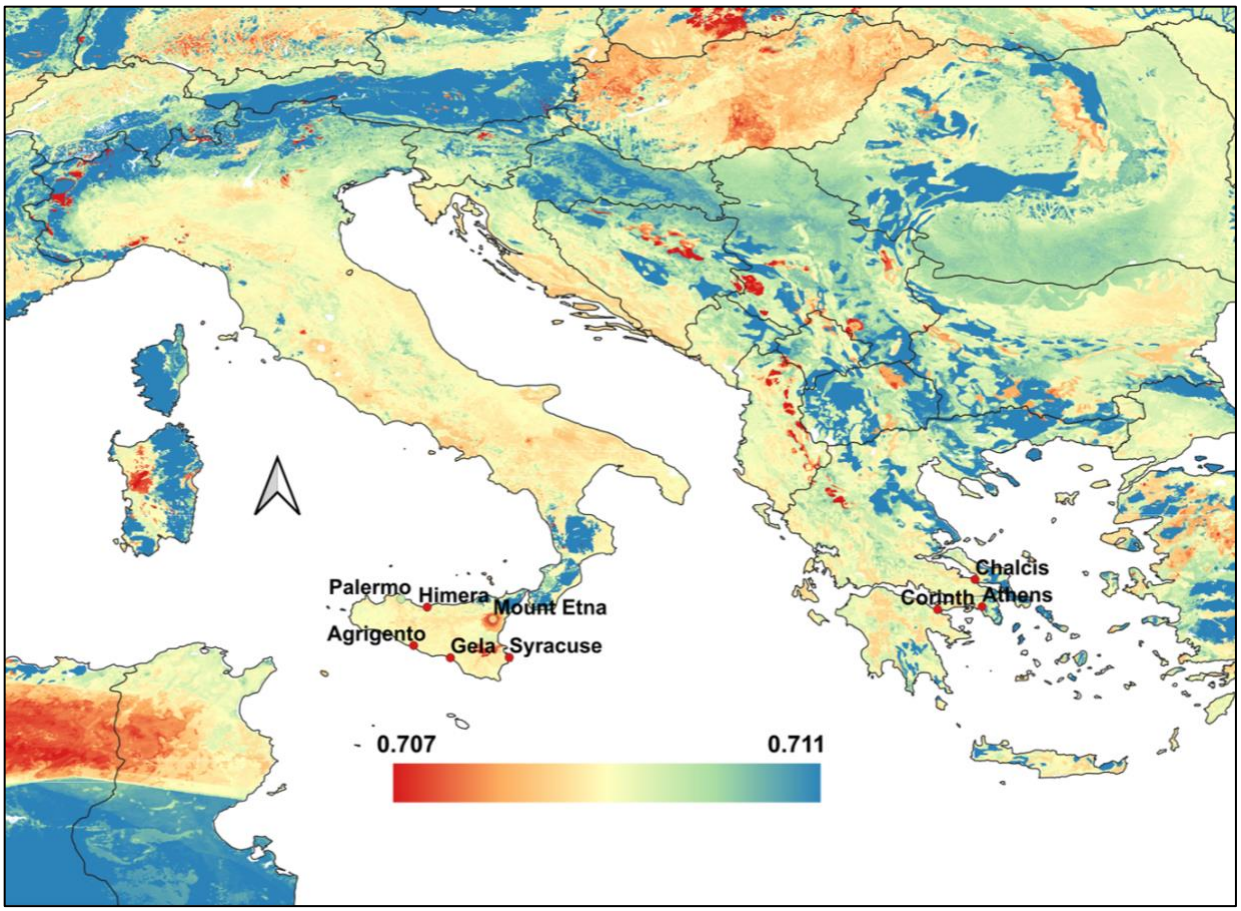

Figure 4.6. Map of predicted $^{87}Sr/^{86}Sr$ variability in the Mediterranean. Map was created in QGIS using open-source raster data from Bataille and colleagues (2020).

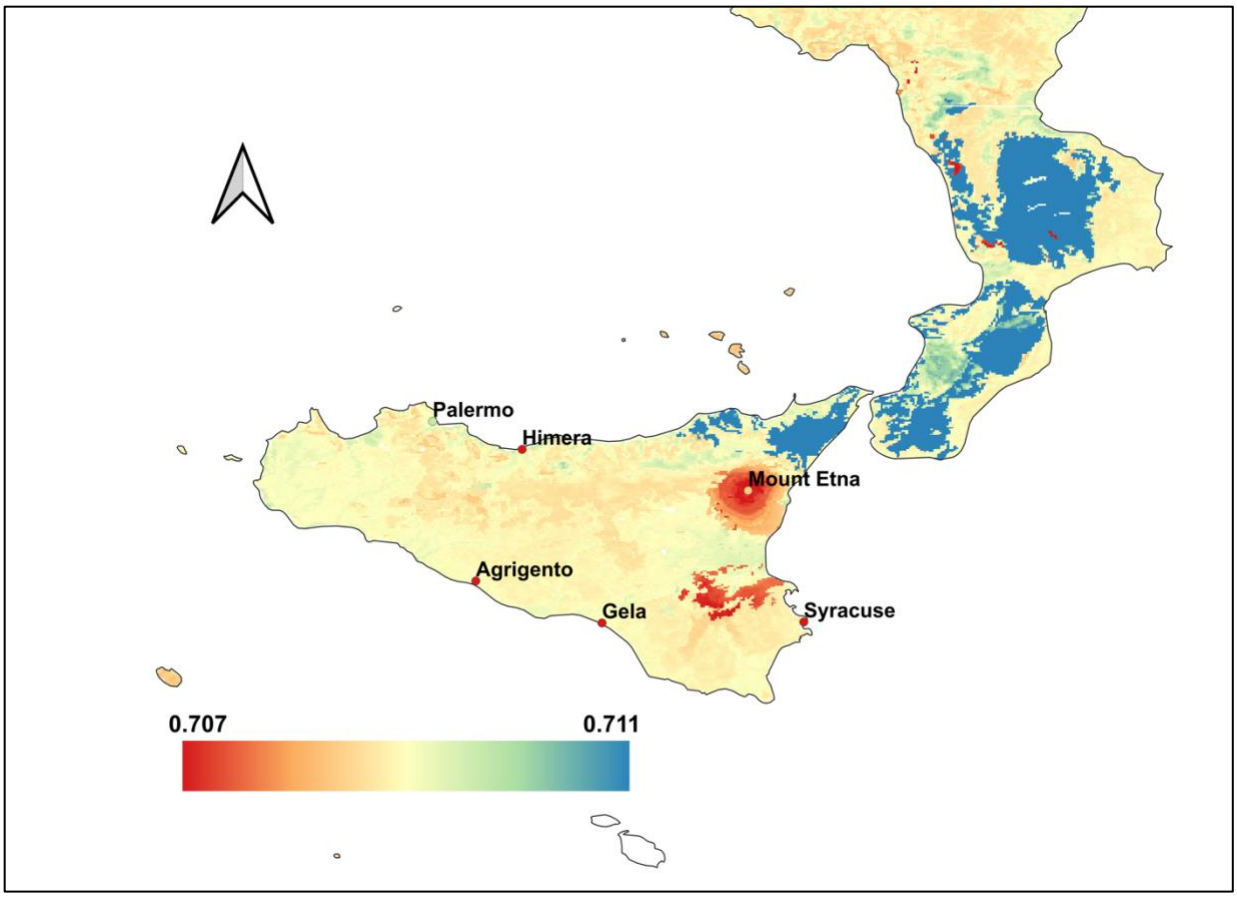

Figure 4.7. Map of predicted $^{87}Sr/^{86}Sr$ variability in Sicily. Map was created in QGIS using open-source raster data from Bataille and colleagues (2020).

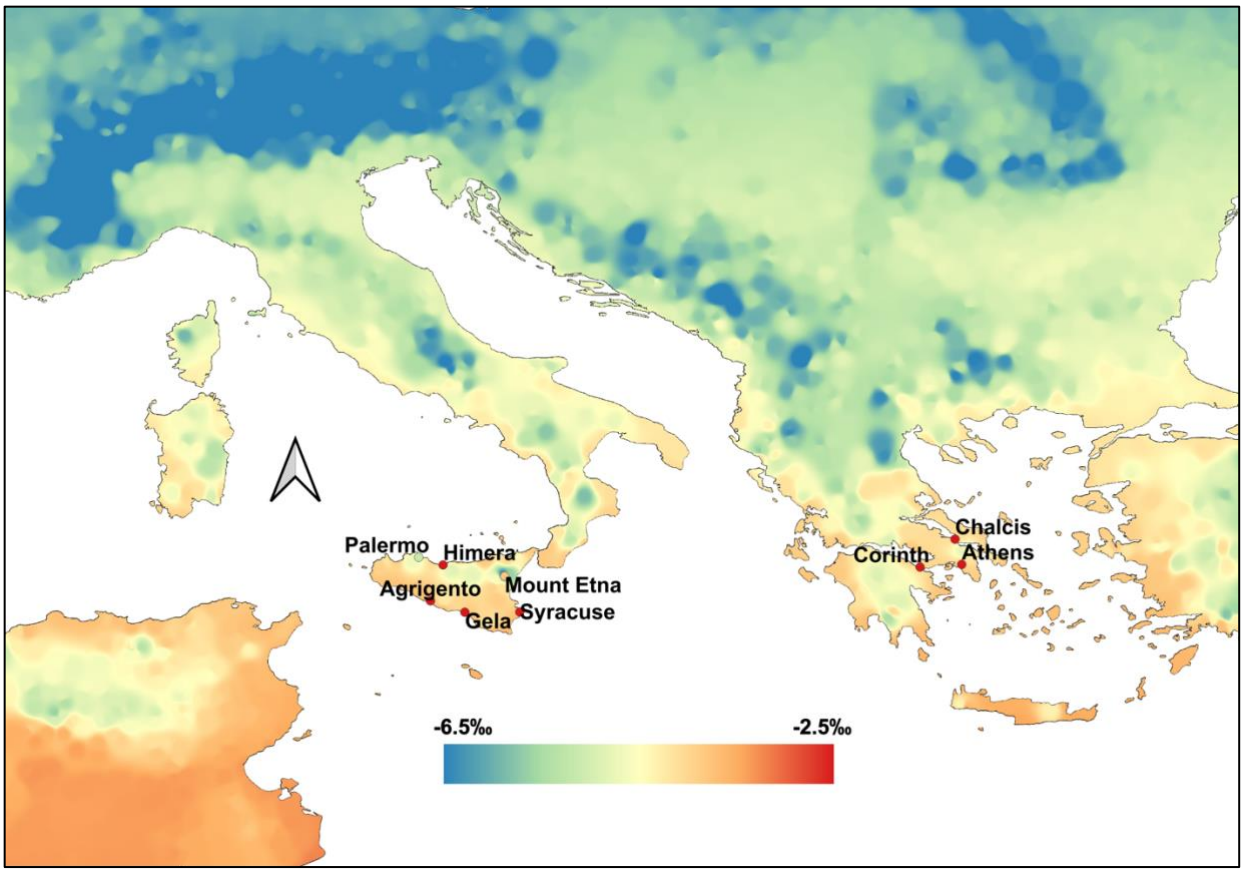

Figure 4.8. Map of predicted $\delta^{18}O_{VPDB}$ variability in the Mediterranean. An Inverse Distance Weighting (IDW) Interpolation was created in QGIS from calculating the $\delta^{18}O$ from the latitude and elevation of each point using an equation from (Bowen and Revenaugh 2003). Values of water $\delta^{18}O_{VSMOW}$ were converted to predicted enamel values of $\delta^{18}O_{VPDB}$ (Coplen 1988; Chenery et al., 2012).

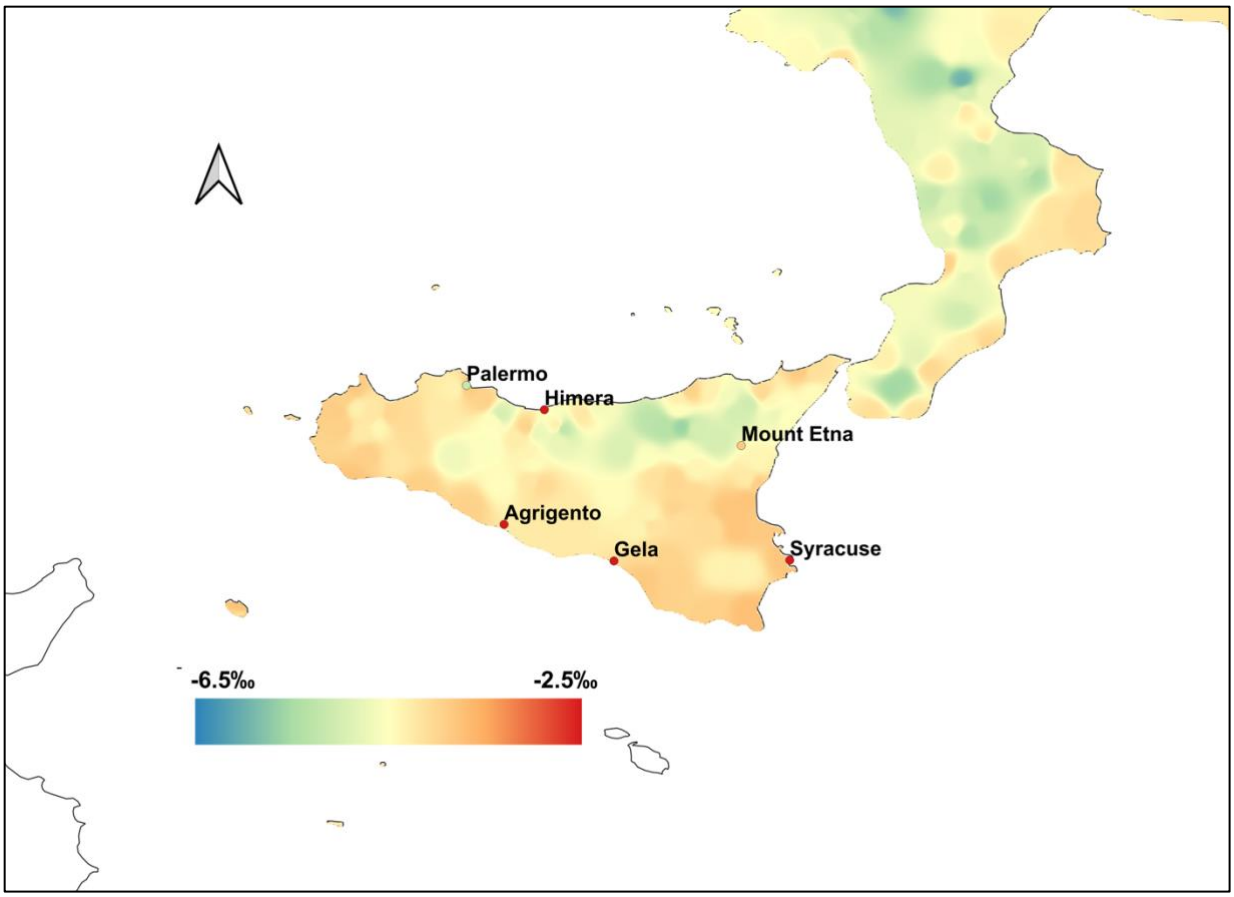

Figure 4.9. Map of predicted $\delta^{18}O_{VPDB}$ variability in Sicily. An Inverse Distance Weighting (IDW) Interpolation was created in QGIS from calculating the δ18O from the latitude and elevation of each point using an equation from (Bowen and Revenaugh 2003). Values of water $\delta^{18}O_{VSMOW}$ were converted to predicted enamel values of $\delta^{18}O_{VPDB}$ (Coplen 1988; Chenery et al., 2012).

As at many Greco-Roman sites, there was a variety of water supply including long-distance aqueducts, wells, cisterns, and local springs. At Agrigento, water was tapped by cutting into limestone to clay and marl units, similar to constructions at Rhodes (Crouch 2003). There are large quantities of groundwater stored under Agrigento, but the several impermeable limestone-clay layers made it difficult to form a large aquifer. However, the same discontinuous

layers create several smaller water tables to supply springs and wells (Crouch 2003). In the early 5th-century, an aqueduct was constructed to supply long-distance water from the northern hills and Theron, tyrant of Agrigento, was said to have used Carthaginian prisoners from the Battle of Himera in 480 BCE to create more networks of aqueducts (Collin-Bouffier 1987). A mix of passages delivered aqueduct water as well as collected and delivered water from urban springs for human and animal use (Crouch 2003).

Morgantina is an inland site which would have had to rely on many different water storage methods. Therefore, it is an important source of information for the potential water storage methods in the upper city of Himera which was not as accessible to the river as the lower city. Drinking water was likely collected from springs and private cisterns that collected rainwater. There were some pipelines from reservoirs and springs that fed the site, including public fountains along the main road and in the agora. Within the site water was distributed via terracotta or lead tubes. Finally, there were many cisterns, but wells were few, likely because of the receding water table (Crouch 2003). Selinunte had access to two nearby rivers, in addition to long-distance waterlines that fed public fountains, and cisterns for other domestic usage.

Syracuse has a unique geology, with permeable rocks creating a succession of layers between impermeable marl and clay, creating many springs along the Anapos River. The water from these springs and the river is stored in the alluvium (Collin-Bouffier 1987). These formations create the conditions necessary for several notable springs, including the spring of Arethusa on the western edge of the old site of Syracuse which had already been built up as a fountain in the 5th-century BCE (Crouch 2003).

4.3.1 Himera

The area around Himera is characterized by a mix of deposits, ranging from Upper Mesozoic to Late Miocene formations (Contino 1988). The Imerese succession, part of the Meso-Cenozoic basinal carbonate successions, consists of Triassic to Oligocene limestones and cherts, with Jurassic-Eocene carbonate flows (Boschian 1988; Catalano 2004).

The civilians living in the upper city of Himera likely consumed water that was stored from retained rainwater in cisterns, while those living in the lower city had more access to the river, in addition to artesian wells to collect from the local aquifer (Vassallo 2005, 2019). Himera installed terraces on its eastern slope which would have limited loss of rainwater (Collin-Bouffier 2009). These different sources may result in slightly lower $\delta^{18}O$ values in the upper city because cisterns were less susceptible to evaporation.

4.4 Environment

In addition to information about geology and precipitation, it is important to consider environmental effects of a region, which will be discussed for Sicily and Himera in this section. The environment can impact $\delta^{18}O$ meteoric water values, as well as indicate which resources were available for dietary contributions of the people studied in this dissertation which contribute to $\delta^{13}C$ and $\delta^{15}N$ values.

4.4.1 Sicily

Sicily consists of three major, physical subregions. The first is a continuation of the Apennines on the Italian mainland and covers the north coast with three non-continuous mountain ranges, at a maximum height of 2000m, which has been predominantly forested and

with the highest precipitation (1000mm in some areas) (De Angelis 2016: 65). The mountains often go all the way to the sea, but in some coastal plains human settlements developed, such as Himera. The second major subregion is south of these mountains and includes central and southwestern portions of the island between Marsala and the ancient Himera river (Salso). This subregion has rolling hills, generally under 1000m above sea level, and valleys that slope from the interior toward the coast, facing North Africa. This subregion receives the least amount of rainfall with annual averages of 500mm. The third subregion forms the southeastern corner of the island but touches the northeastern corner of the island where Mt. Etna is located at a 3300m altitude. South of Mt. Etna is the alluvial Plan of Catania of volcanic and limestone soils (De Angelis 2016).

According to the sedimentary record, including pollen and charcoal data from Gorgo Basso, a coastal lake in south-western Sicily, the island had a diverse environmental history. Around 8000 BCE, the landscape was characterized by an open grassland, until the expansion of *Pistacia* shrubland when there was increased moisture. Olive trees expanded around 6500 BCE for a short period that ended with drier climatic conditions. Due to increased precipitation, evergreen broadleaved forests expanded around 6000 BCE with a decline in local Neolithic agriculture characterized by figs and cereals. The floral and vegetational conditions in Sicily remained stable starting around 5050 BCE until a coastal forest collapse occurred around 850-650 BCE (Tinner et al., 2009). The pollen record shows a clear decline in forest species at the same there is an increase in crops and weeds, in addition to microscopic charcoal remains that suggest fire activity. These patterns continue into the Roman period around 200 BCE, suggesting human activity played a role in the forest destruction, starting with Greek colonization in Sicily in the mid-8th century (Tinner et al., 2009).

Paleoclimatology evidence from Sicily matches other Mediterranean and temperature Europe patterns in antiquity. This includes the emergence of a cool, wet weather period around 800 BCE, moving into a warmer, drier phase in the Hellenistic period (De Angelis 2016). This evidence suggests continuity of climate, diet, and technology during the Archaic and Classical periods (De Angelis 2016). Greek settlement during this time would have benefited from less interannual variability in rainfall and predictable moisture for farmers.

Even across the island, there was diverse vegetation. For example, deciduous trees were important vegetation in the uplands, whereas coastal forest vegetation was mostly evergreen trees and shrubs. This can be explained by differences in precipitation, where the southern coast of Sicily has an average 600 mm annual precipitation in the northwest compared to 350 mm in the southeast (Gorgo Basso and Biviere di Gela, respectively) (Tinner et al., 2009).

A major difference between ancient Sicily and modern conditions is the extensive marshlands and watercourses which are no longer present due to natural processes and human interventions to eradicate malaria (De Angelis 2016). Lagoons are attested along Syracuse's coastline that were used as salt pans, including one at Camarina (Traina 1992).

Plant foods in Sicily would have been dominated by cereals, such as barley, wheat, and lentils (Dalby 1996). Selinunte, along the southwestern coast, had evidence of free-threshing wheat as the dominant cereal and bitter vetch as the most common legume (Stika et al., 2008). Barley was likely the most dominant grain in indigenous communities, such as the Elymian site of Monte Polizzo (Morris et al., 2004) Acorns may have replaced cereal grains in very poor communities, while stored grain was more common in the urban diets than those who lived in the chora (Dalby 1996; Erdkamp 2015).

4.4.2 Himera

The wetter climate and landscape at Himera during its establishment created the needed conditions for forests, for which we have direct evidence of paleoecological research at Himera. Surface surveys and associated geoarchaeological investigation show that the river valleys in Himera's territory were cleared and being exploited when Greek settlers arrived in the mid-7th century (Belvedere 2001; De Angelis 2016; Vassallo 2005). Sandy and marshy coastlines existed at the site of Himera's foundations (Belvedere 2001).

4.5 Economy

Another important factor in determining diet is the economy of a region. This section will describe the economic conditions, including farming activities, in Sicily and Himera. Additionally, the economy can impact social status, another vital factor in peoples' access to resources for diet or health.

4.5.1 Sicily

The land under cultivation in Sicily had decreased since the Late Bronze Age and was heavily vegetated with many wild animals, such as red deer, when Greeks were establishing permanent settlements (De Angelis 2016). Cities in Greek Sicily were frontier establishments with groups of elites who controlled the distribution of land. Grain exports were the main economic activity on the island, as there was a large demand in Greece, and Sicily had both an ideal environment and grain had a relatively low labor requirement (De Angelis 2016). Additionally, cereals form the basis of the traditional ancient Greek diet, contributing roughly 65 to 70% of daily consumption (De Angelis 2006). From the establishment of the Greek colonies

into about 600 BCE, Sicily was thinly populated and there was an abundance of available land (about 3-4% of Sicily's carrying capacity according to De Angelis 2016).

Arable farming evidence includes evidence of soil erosion, the mentioned increase in fires, and archaeological evidence of agricultural tools. Agricultural iron tools have been found at sites all over the island, including Himera, Gela, Agrigento, and Selinunte (De Angelis 2016). By the 6th century, there is direct archaeological and epigraphic evidence of grain production. This includes carbonized grain at tombs in Megara Hyblaea (De Angelis 2002: 302) and barley and spelt seeds at Monte San Mauro di Caltagirone (Costantini 1979).

Other economic activities included mining, fishing, and olive and vine agriculture. The easternmost mountain range of the northern subregion, the Peloritani, contains mineral resources such as copper, iron, and tin, while the central and southwestern subregion contains sulfur resources (De Angelis 2016). Additionally, the sea between the southwestern coast and Africa is shallow with not much movement, allowing for the exploitation of sea salt (Braudel 2001:24; Epstein 1992: 226).

Evidence of vine cultivation is found at Syracuse, Gela, and Naxos. Hyppis of Rhegion (FGrH 554 F4) explains that the Argive Pollis introduced wine to Syracuse and Archaic farmsteads at Gela were known to produce wine in Classical times (Adamesteanu 1958: 300, 366-67). Other arboriculture is attested by cultivation of olive and chestnut, such as at a cemetery in Camarina where olive, fir/spruce, and yew trees were in use (Costantini 1983).

A variety of domesticated and wild animals were exploited in Greek Sicily, including sheep, goat, pig, and cattle (De Angelis 2016). Bones of these animals have been found in sanctuary and settlement contexts throughout the island, suggesting consumption, in addition to

secondary products such as wool. Deer was the most common exploited wild animal, while fish and mollusks were likely harvested from the sea (De Angelis 2016).

4.5.2 Himera

Evidence of arable farming at Himera includes archaeological finds of agricultural tools, including four plowshares, two hoes, one hatchet, and two double-headed axes, that are broadly dated to the occupational period of Himera (648 to 409 BCE) (Allegro 2000; Belvedere 2001; Vassallo 2005: 131).

Non-agricultural production at Himera includes extensive terracotta and architectural sculpture production (Vassallo 2005). Additionally, metal products are found from the 7th century onward and include bronze and gold (Vassallo 2005). These products would have been sold at the agora of the city. The agora was located in the lower city at the river mouth, but was decentralized compared to the rest of the town's geography. There is evidence that sections of the city were abandoned after 480 BCE to ensure protections within the wall of the city, so the layout of the agora was likely strategically placed compared to other functions of the *polis* (Vassallo 2012).

There is a lot of evidence from material remains of trade and exchange on Sicily between indigenous populations and Greeks. Relations between Himera, a Greek colony founded in 648 BCE, and the indigenous populations nearby were relatively beneficial with evidence of trade and possible intermarriage by the archaeological findings of indigenous goods in domestic houses, sanctuaries, and necropoleis at Himera (Vassallo 2010, 2014; Vassallo and Valentino 2012). The sheer amount and distribution of the indigenous remains or hybrid remains at the site of Himera suggest that (1) the people who established Himera did not have to displace

indigenous groups as there were no material remains found before the colony was founded, and (2) Himerans interacted with indigenous people often and in many different ways, with possible evidence of cohabitation (Vassallo 2010; Vassallo 2014). Vassallo (2014) has even suggested that because of Himera's location between the outside world, relatively isolated from other Greek cities, and proximity to indigenous populations, they would have had to interact and establish somewhat good relationships with the indigenous population for economic prosperity.

4.5.3 Mediterranean diet

The Mediterranean has been marked by constant trade which has connected groups of people to a wide variety of plant and animal food from both local and imported sources. While there is some regional variation, the ancient Greek diet follows a few patterns, including the presence of a grain (*sitos*, or dietary staple), relishes (*opson*), and wine (*oinos*) (Dalby 1996). Grain was the most common dietary staple for both urban and rural communities, including barley, wheat, and lentils (Erdkamp 2015). Wheat was preferred for making breads and porridge-like dishes (Garnsey 1999). Less common cereals were spelt and millet, while acorns may have replaced cereals for the very poor (Dalby 1996). Lentils, beans, peas, and chickpeas were available as legumes (Dalby 1996; Hanson 2000). In Sicily, there is archaeobotanical evidence from Selinunte, a Greek site, of wheat as the dominant cereal, with some evidence of barley and bitter vetch as the most common legume (Stika et al., 2008). An Elymian site of Monte Polizzo, approximately 50km north of Selinunte, however, had more evidence of barley as the dominant grain and fava beans as the dominant legume (Morris et al., 2004).

Relishes were used as side dishes to accompany the main grain. They included vegetables, greens, cheese, fish, eggs, and occasionally meat (Dalby 1996:23). Desserts consisted

of fruits and nuts. Nuts available in Sicily during Himera's occupation included chestnuts, walnuts, pistachios, and acorns, according to lake core pollen (Sadori et al., 2013). Olive oil was very common for thousands of years (in Sicily, see Mercuri et al., 2006; Sadori et al., 2013), whereas olives were likely only eaten as appetizers (Dalby 1996). Olives were found at Selinunte, but not Monte Polizzo, and grapes and figs were found at both sites, according to the archaeobotanical evidence at both sites (Stika et al., 2008 and Morris et al., 2004, respectively). For lower class individuals, relishes were either absent or would have been foraged from wild foods, including asparagus, capers, chervil, and mustard (Dalby 1996: 25-26; Sarpaki 1992).

Although not as common to the general public, meat and secondary animal products mainly came from sheep, goats, and pigs, and less commonly from cattle, geese, chicken, and guinea fowl. Vassallo (2005) explains that some food animals could have been raised within household courtyards, including pigs. Even less meat was sourced from wild fauna such as hare, boar, and deer (Dalby 1996: 52l; Kron 2015: 176-177). Milk and butter were rarely eaten (Dalby 1996); but cheese was very common (Chandezon 2015: 140).

For the majority of the general populace, terrestrial animal meat likely came from communal feasting and sacrifices (Chandezon 2015). The meat was often fresh and eaten the day of the event, but offal and sausages could be purchased from markets afterwards (Dalby 1996: 23). Occasions for sacrifices of animals occurred approximately 40 times per year with the most commonly sacrificed animals being goats, sheep, and pigs (Hitch 2015). Depending on the ritual event, smaller animals could have been sacrificed within the household or smaller shrines, or in larger public areas, where cattle would have been preferred. Large cuts of meat would have been burned for the gods' sacrifice, while viscera and meat were distributed to the community (Hitch 2015).

As discussed in Chapter 2, soldiers' diet would have been remarkably similar to the general populace, with grain as the predominant part of both soldiers' and citizens' diets. Preparation of grain may have varied depending on where the soldiers' were in the campaign but would not likely affect their isotopic values. A notable difference is that soldiers likely would not have consumed as much olive oil as it was necessary for fuel during their travels. There is some question of whether meat consumption was common among soldiers, likely as much if not a little less than the general populace. The main difference between a citizen's diet and a soldier's was dependent on how long the campaign was and if a soldier still had rations brought from home. Soldiers were traditionally expected to provide their own rations until later periods (i.e. 4th century BCE) (Lee 2007). If a military campaign was short lived, or the soldier's success in the campaign was short lived, and they had packed enough from their home, it is possible the soldier's diet would reflect a different diet than the local populace. However, if the campaign had dragged on, and original rations had run out, a soldier would have been more reliant on the local environment for their diet, potentially sharing the same diet with the general populace.

4.6 Politics

While briefly described in the history section above, much of the historical accounts of the Battles of Himera are heavily reliant on the political situations leading up to these battles. In this section, I describe more detailed issues surrounding the politics of Sicily, and the uniqueness of tyrants, as well as the specific instances of Himera and relevant cities of Sicily, followed by a detailed description of the Battles of Himera as we understand them from the ancient texts.

4.6.1 Sicily

Much of Greece before the 5th century was based on a tribal system and the democratic system appeared later (Griffin 2005). During the 5th century, the *polis* system developed during which public rule became more popular, especially in Athens. Sicily's political organization diverges from mainland Greece in the predominance of tyrannies, with only small interludes of democracy, though still operating within a Greek *polis* system (Lomas 2006). Tyrants were city leaders not necessarily from the cities themselves who rose to power by populism or force. While some tyrants were supported by the populace, others were not, and had to work strategically to maintain tenuous control (Luraghi 1994). Tyrants were known for aggressive expansion, control of other cities by selective expulsion of all or some of the elite class, and the use of mercenary soldiers to enforce policy and possible to replace the displaced population (Lomas 2006). Tyrants generally formed during class-conflict, where the general population rallied around an individual who promises change (Griffin 2005). This is often the case in situations where the lower classes hope to break the dominance of the aristocracy in political life (Griffin 2005). The tyrant is able to seize power through alliance with the masses. This pattern was particularly common in tyrants in mainland Greece (Griffin 2005).

Tyrants on Sicily, on the other hand, displayed an alternative organization where they appealed to the aristocracy. In the case of Syracuse, Gelon from Gela overtook the tyranny of the previous tyrant during a citizen uprising, and one of his first moves as tyrant was to reestablish the old elite class (Griffin 2005). Gelon had a particularly interesting pattern of continuing to transplant elite classes from nearby cities, maintaining an aristocracy that felt somewhat indebted to him. People from lower classes in these nearby cities were often sold into slavery, so the elites could have interpreted Gelon's actions as generous. Archaic and Classical tyrants in Sicily often

caused large demographic changes by exiling the elite groups of conquered areas and replacing them with elite families from other towns.

Tyrants were known to forcefully relocate segments of the populace, and hire bodyguards for protection, including foreign mercenaries (Diod. 11.49; Hdt. 7.156; Thuc. 6.4.6) (Lomas 2006; Vassallo 2005). Sicily was in an advantageous position beyond economic pursuits. Sicilian tyrants would have had more access geographically to groups of people in the western Mediterranean that were traditionally outside the range of Greek warfare. In general, Greek tyrants were known to hire mercenaries specifically as bodyguards, but the scale at which they were hired in Sicily was not seen in mainland Greece until the 4th century (Griffin 2005). It is thought that the Sicilian tyrants were first able to come to power as a result of populations wanting protection from nearby native populations (Sicels, Sicans, or Elymians). The first tyrant in Syracuse (Hippocrates), for example, was able to form large civilian forces to campaign against the Sicels (Griffin 2005). This would eventually become problematic, as Hippocrates' sons would force citizens to fight in long campaigns against Sicels, as well as Chalcidian cities (another ethnic group on the island). This could have been viewed as greed for power and influence in Eastern Sicily and not beneficial to the overall city-state. Gelon was able to come to power in Syracuse by usurping the tyranny in the resulting citizen uprising (Griffin 2005).

Greek tyrants pursued territorial expansions across Sicily, leading to the division of the island into pro-Carthaginian (Selinunte, Himera), and anti-Carthaginian (Syracuse, Agrigento) tyrannies (Green 2010). A summary of historical events in the Mediterrnean, Sicily, and Himera is presented in Table 4.1.

4.6.2 Himera

The Greek colony of Himera was founded around 648 by settlers from Zankle (originally from Chalcis) and exiles from Syracuse who were currently undergoing a civil war (Diodorus Siculus; Thucydides Bk 7). Himera was a relatively isolated colony with Phoenician settlements in the nearby west, including Panormus, and a large hinterland full of indigenous populations (Vassallo 2014). Himera's position on the north coast was an advantageous position as a middle-man between outside traders, including Etruscans, other Greeks, and Phoenicians, and connecting them to the indigenous populations and Greek colonies on Sicily (Balco 2012).

In the early 6th century BCE, there was an indigenous uprising against the Himerans, resulting in a diminishment of indigenous goods at Himera, and beginning an active relationship with Agrigento and its tyrant Phalaris (Vassallo 2005). This relationship continued until a tyrant of Agrigento, Theron, took over rulership from Terillus, Himera's tyrant at the time. Theron was strongly allied to Gelon of Syracuse and Gela (Diod. Sic Bk11). These two tyrants created two strong territorial states where Selinunte and Messina maintained relative independence with some assistance from the nearby Carthaginians in North Africa. Unfortunately, Terillus had connections with Carthage and appealed to the Carthaginians for aid in re-taking Himera, leading to the first Battle of Himera in 480 BCE.

4.6.2a The 480 BCE Battle of Himera

Diodorus Siculus writes of the battle in 480 BCE between a victorious alliance of Greeks from all over Sicily, especially Syracuse and Agrigento, and a Carthaginian force (Diod. 11.20-22). The Carthaginians allegedly conspired with the Persians to conquer Greek Sicily at the same time Persia was preparing for the Persian Wars (Diod. 11.20.1). Hamilcar, the chosen

Carthaginian general, built a large naval and land army of "not less than three hundred thousand men and a fleet of over two hundred ships of war, not to mention many cargo ships for carrying supplies, numbering more than three thousand" (Diod. 11.20.2). These soldiers are described as Phoenicians, Libyans, Iberians, Ligyes, Elisyci, Sardinians, and Cyrnians (Hdt. 7.165). Unfortunately for the Carthaginians, a great storm destroyed a large number of these ships including the ones carrying horses and chariots. Hamilcar rested for three days in Panormus (modern day Palermo) and then marched along the coast towards Himera where he set up a camp for the land army and one for the naval force. The remaining warships were brought up on land and a palisade was built around the camps, taking control of the entire west side next to the city. Himerans attempted to defend the city on the first attack from Hamilcar, but many were killed. Theron, the new tyrant of Himera, with a large force from Agrigento, called for aid from Gelon.

Upon the call from Theron, Gelon set out for Himera with "fifty thousand foot-soldiers and over five thousand cavalry" (Diod. 11. 21). His arrival "inspired boldness in the hearts" of the Himerans. After setting up camp, Gelon, the whole of the cavalry was sent to explore the countryside for enemy forces, capturing thousands of prisoners. This great act caused Theron to open up the city gates for Gelon and gave him more power over the military action in the coming days. Serendipitously, the cavalry also came across a letter-carrier who was bringing messages between Selinunte and Hamilcar. Selinunte had offered to send a cavalry force to aid the Carthaginians. With this message intercepted, Gelon decided his plan was to set fire to the ships of the enemy, with his own cavalry arriving to the naval camp as if they were the allies from Selinunte. Scouts were sent to overlook the city and were ordered to raise the signal when the cavalry had made it inside the camp.

At sunrise, the cavalry rode up to the Carthaginian naval camp and successfully tricked the guards into thinking they were allies. Hamilcar was busy with setting up a sacrifice, so was unprepared when the cavalry came in to kill him and set fire to the ships (Diod. 11.22). There is some disagreement of the account of Hamilcar's death, Herodotus reporting that Gelon was unable to find him and adding that Carthaginians claim he sacrificed himself (Hdt. 7.166-167). The scouts raised the signal and Gelon advanced the rest of his army against the Carthaginian camp. A pitched battle followed, with both lines of Carthaginians and Sikeliotes pushing back and forth against each other. When the flames of the ships began to rise higher in the sky and the news of Hamilcar being slain was reported, the Greeks were "emboldened and with spirits elated at the rumors and by the hope of victory they pressed with greater boldness" on the Carthaginians, while the enemy turned in flight. Gelon slaughtered a huge number of Carthaginians (Diodorus Siculus reports 150,000) and those who were captured as prisoners were distributed among Himera, Syracuse, and Agrigento where they used the captives for building their public works (Diod. 11.25), such as the Temple of Victory in Himera and the Temple of Athena in Syracuse, which were built around the same time. Only a few Carthaginians made it back to Carthage after the small number who fled on ship were lost in the storm and they reported everyone who had gone to Sicily had perished (Diod. 11.24).

Diodorus Siculus reports that Gelon won his victory on the same day that Leonidas and fought Xerxes at Thermopylae, making a divine connection between the victory at Himera and the defeat taking place at the same time (Diod. 11.24). Herodotus adds that Sicilians tell the tale of when Gelon and Theron defeated the Carthaginian general Hamilcar in Sicily on the same day that the mainland Greeks defeated the Persians at Salamis (Hdt. 7.166).

This mirrors the general situation of Himera's population in 480 BCE, which underwent a boosting in population around this time period by the tyrant Theron who encouraged, and possibly forced, Greeks to settle in the area (Diod. 11.49).

4.6.2b The 409 BCE Battle of Himera

The successful battle in 480 BCE is contrasted with the more chaotic situation in the battle of 409 BCE when the city was under siege with little assistance from others (Diod. 13.62). Hannibal, the grandson of Hamilcar, first destroyed the walls of Selinunte, then brought his entire army and some additional Sikeli and Sikani soldiers to Himera. Hannibal set up siege-engines and wore down the Himeran defenders over many waves of attacks, including undermining the walls. After an initial success of the Himerans forcing out the Carthaginians, Syracusans from Agrigento and troops from other allies came to their aid under the command of Diocles the Syracusan. The second day, Himerans stationed guards on the walls and led out of the city many of the soldiers and allies, inspired by their daring skill and the single hope of safety laying in their success in the battle. The Carthaginians were confused by this strategy and clashed with each other more than with the Greeks. As the Himerans and allies pushed further towards the camp, Hannibal caught them in disorder, where three thousand Himerans were killed.

Chaos ensued when first a report came out that the Syracusans and more allies were marching to the aid of Himerans and that Sicilian Greeks had sent twenty-five triremes. Closely following was the news that Hannibal was preparing triremes in Motya to sail to Syracuse to seize the city while the best soldiers were at Himera. Diocles, in charge of the allied forces at Himera, advised the Greek triremes to go to the aid of Syracuse, abandoning Himera. Half of the

populace of Himera was embarked on the triremes to get them beyond Himeran territory, while the other half stayed to keep guard until the triremes could return. The Himeran citizens, mostly women and children, were loaded onto the boats by night and taken as far as Messina. Diocles took his own soldiers and left the city, including many Himerans with women and children who could not fit on the triremes (Diod. 13.61).

After two days of attacks, the walls at Himera began to fall and the Carthaginians and Iberian allies would pour in. Most of the defenders were killed and many were taken as prisoners, the temples were looted and burned, and the city was razed to the ground "two hundred and forty years after its founding" (Diod. 13.62). Any women and children that were left were distributed among the Carthaginian army, but the men who were taken captive, reported as three thousand, were ordered by Hannibal to be tortured and killed on the where his grandfather Hamilcar had been slain by Gelon (Diod. 13.62).

Table 4.1 Timeline of relevant events in Himera, Sicily, and Greece.

Date	**Historical Events in Greece**	**Historical Events in Sicily**	**Historical Events in Himera**
7th century BCE		- Greeks and Phoenicians establish numerous colonies on Sicily - Original colonies begin to establish their own colonies	- Foundation of colony, 648 BCE
6th century BCE			- Conflict with indigenous groups - Increase in goods and products from major Greek cities and Etruscan and Phoenician cities - Begins to print silver Himeran money, 2nd half of century
500-480 BCE	- Persian Wars, 497-479 - Battle of Thermopylae (Persians vs Spartans), 480 - Battle of Salamis (Persians vs Athenian navy), 480	- Theron rules at Agrigento, 488-472 - Gelon rules at Syracuse, 485-478 - Half of Gela's population moved to Syracuse under Gelon (Hdt. 7.156), 488-484 - 10,000 mercenaries made citizens of Syracuse by Gelon (Diod. 11.72-78), 488-484 - Gelon makes elite classes (*Aristoi*) of Megara Hyblaea and Euboea citizens of Syracuse while selling the lower classes (*demos*) into slavery, 488-484	- Gelon and Theron defeat the Carthaginians (led by Hamilcar) at the Battle of Himera, 480
479-466 BCE	- Defeat of Persians at the Battle of Plataea, 479	- Death of Gelon, 478 - Hieron I becomes tyrant of Syracuse, 478-466 - Death of Theron, 472	- Temple of Victory is built - Himera repopulated by invitation from Theron to Dorian colonists to settle there (Diod. 11.49)

461-416 BCE	- Peloponnesian War, 431-404 - Plague of Athens, 430	- Riots in Syracuse lead to oligarchic government - Birth of Dionysius I of Syracuse, 430	- Himera mint creates bronze and silver coins
415-413 BCE	- Sicilian Expedition: Athens responds to call for aid from Segesta and invades Sicily, 415	- Syracuse defeats Athens at the Assinaros River, 413	- Himera allied with Syracuse against the Athenians
411-400 BCE	- Alcibiades promotes oligarchic regime in Athens, 411-411 - Democracy restored in Athens, 403	- Carthaginians invade Sicily for the 2nd time, destroying Selinunte, Himera, Agrigento, Gela, and Camarina 409-406 - Dionysius I takes power in Syracuse, 405	- Battle of Himera, Himera is destroyed by Carthaginians (led by Hannibal, Hamilcar's grandson), 409

Information from Lomas (2006), Rosalia Pumo from Lyons et al., (2013), Vassallo (2005)

4.6.3 Relationships with other groups

Himera is the most isolated Greek colony with Punic settlements to the west and a large hinterland to the south and east full of indigenous settlements. As Vassallo (2014) claims, Himeran citizens had to interact with indigenous people, which shows in the presence of indigenous goods in the town, sacred areas, and necropoleis. Vassallo (2014) suggests that when the Greeks came to Himera they did not displace any local communities and were open to relations with indigenous groups that included trade and intermarriage. It is very likely that Himera's influence created a strong system of relationships in the hinterland that increased its social development for the first half of its presence.

The local, indigenous Sicilians have been traditionally divided into three groups in the historical literature, the Sikels, the Sikans, and the Elymians (Hodos 2006; Serrati 2000). Diodorus Siculus describes the Sikels as "autonomous," which is similar to the way Greek *poleis* themselves were organized (Diod Sic 14.7.5; see also Hodos 2006). There is evidence that the

Elymians had complex political structures and Thucydides describes their power and influence in the region (Hodos 2006; Thuc 6.6.2). Evidence of indigenous influence and power is found in the material culture and architectural remains of sites such as Morgantina (a Sikel site). It should be noted that these separate groups are hard to distinguish archaeologically. However, these local, indigenous populations are not Hellenized, and while their material culture may be similar amongst the three groups (Sikels, Sikans, Elymians), they are distinct from Greek material culture.

Currently, there is a lot of evidence of trade and exchange on Sicily between indigenous populations in the material remains. Relations between Himera and the local populations nearby were relatively beneficial with evidence of trade and possible intermarriage by the archaeological findings of indigenous goods in domestic houses, sanctuaries, and necropoleis (Vassallo 2010, 2014; Vassallo and Valentino 2012). The sheer amount and distribution of the indigenous remains or hybrid remains at the site of Himera suggest that (1) the people who established Himera did not have to displace indigenous groups as there were no material remains found before the colony was founded, and (2) Himerans interacted with indigenous people often and in many different ways, with possible evidence of cohabitation (Vassallo 2010; Vassallo 2014). Vassallo (2014) has even suggested that because of Himera's location, relatively isolated from other Greek cities and proximity to indigenous populations, they would have had to interact and establish somewhat good relationships with the indigenous population for economic prosperity. These relations would change in the 6th century BCE after the uprising mentioned above and a corresponded with diminishment of indigenous goods at Himera.

Contact between the foreign Greeks and the local populations would have varying results. Some interactions resulted in conflict, including the indigenous uprising in the 6th c. at Himera.

Eventually, the interactions between the groups would lead to Thucydides using the term *sikeliotai* in reference in Sicilian Greeks, which suggests a formation of regional identity that formed within the context of Greek colonization (Thuc. 4.64.3). This formation of regional identity demonstrates some separation between the Sicilian Greeks and the mainland Greeks.

Himera would have also been influenced through economic interaction and trade, by the nearby Phoenicians, who had notable presence in western Sicily (Balco 2012; Hodos 2006). There are traces of Phoenician influence in the material culture at Himera in addition to indigenous and Greek styles (Balco 2012; Serrati 2000).

4.7 Conclusion

The information above will be useful for understanding the results of this dissertation, providing social, political, and physical context for the relationships between the groups of people of interest. Additionally, the environmental and geological contexts described will offer a base for interpreting the isotopic values. Bringing together the many facets of individuals' biocultural context, in tandem with isotopic evidence, will reveal potential geographic places of origin and dietary variation.

CHAPTER 5:

RESEARCH DESIGN

5.1 Samples

This section will describe why the samples chosen for this dissertation are well suited to study the effect of warfare on soldiers. I will first explain the evidence that suggests these samples come from mass graves associated with the Battles of Himera including location and burial arrangement. I will then outline sample selection within the larger burial context and provide more details on each set of mass graves, as well as the civilians sampled from the western necropolis and baseline sampling to calculate local signatures for the isotopic systems analyzed.

The mass graves (FC for *fossa comune*, plural: *fosse comuni*) were found in the Western Necropolis of Himera, the likely location of the Battles of Himera (Vassallo 2010; Viva et al., 2020). I will use "FC" to refer to the individual *fossa commune* or mass grave designations. Historical records describe that the battles took place outside the western walls of the city and near the western necropolis, close to the beach where the Carthaginians had set up camp (Diod. 11.20). It may have been a matter of convenience that the soldiers were buried in the western necropolis where the Battle of Himera took place.

The burial of Greek war dead varied by city-state and there does not seem to be any set standards of burial until the mid-5th c. in Athenian practices (Pritchett 1985). This standardization arguably occurred in response to observing the poor treatment of the dead in the

Persian Wars (Veale 2019). There are numerous examples of battles where soldiers were cremated and their ashes were returned to their homes, such as at the Battle of Eurymedon in 468 BCE and thereafter in Athenian practice, while there are equal examples of the burial, sometimes of cremated remains, on the battlefield, especially before the 5th century BCE (Pritchett 1985; Vaughn 1991). Most evidence from the Persian wars suggests burial on the battlefield and the Oath of Plataea dictated the dead were to be buried on the battlefield (Diod. 11.29; Pritchett 1985). It was seen as honorable starting from Homeric times and into the Classical Period (Pritchett 1985; Vaughn 1991). Additionally, the treatment of war dead, including if and when the defeated party would be able to collect their dead (or if it would be done by the victors), would be dependent on the leaders of the victorious army, in this case Gelon (Pritchett 1985; Vaughn 1991).

Logistically, it would have been difficult to repatriate the war dead. Individuals would have to first be located and identified, a challenge depending the season in which the battle took place – if the Battle of Himera was in fact on the same day as the Battle of Salamis and the Battle of Thermopylae, then it would have been sometime in August or September, some of the hottest months of the year. High temperatures, humidity, and any delays in the burial of war dead could horribly impact the identifiable features of the soldiers, especially if soldiers were already stripped of armor, shields, and other identifying material goods (Vaughn 1991). The commemoration and humanitarian treatment of the war dead was important in Greek society (Veale 2019; Vaughn 1991), however, the funeral orations, ritual practices, and monument building for the dead did not seem to be exclusive to only those soldiers who were able to be brought home.

For the reasons outlined above, the soldiers buried in the mass graves at the Battles of Himera are almost certainly a mix of locals, those of Agrigento and Syracuse, and soldiers from much more distant lands. It is likely that some of the local Himerans would have been buried separately by their family and possible that some of the soldiers from Syracuse and Agrigento could have been repatriated if they were able to be identified. The plausibility that single interments at Himera also contain soldiers is bolstered by the presence of weapons and weapon wounds in some individual graves (Vassallo 2010). However, it is unlikely survivors would have been able to identify all of their war dead to be able to send them home and, as described, completely repatriating soldiers was not as common a practice until after the Persian Wars.

The mass graves are likely the result of warfare, and not another cause such as an epidemic or natural disaster. There were weapons embedded in the bones and bone trauma in several individuals (Vassallo 2010). Additionally, all of the individuals are adult males (Kyle et al., 2018; Lonoce et al., 2018; Vassallo 2010). If the mass grave was the result of an epidemic or natural disaster, it would be expected to find variety in the grave demographics, such as females and subadults. The presence of only military-aged males with evidence of violent deaths indicate this is likely the result of warfare.

5.1.1 Protocols for sample selection

Sample selection was done as part of a larger Bioarchaeology of the Mediterranean Colonies Project (BMCP) and its associated field school, the National Science Foundation Research Experience for Undergraduates Site (NSF REU): Immersive Research in the Bioarchaeology of Greek Colonization, Sicily, Italy. Samples were taken from individuals from mass graves and the general populace and first sent to the Bioarchaeology and Biochemistry

Laboratory at the University of Georgia (UGA) in Spring 2015 to facilitate pilot isotopic work. Dr. Pier Francesco Fabbri of the Università del Salento sampled rib and long bone fragments and either second molars or premolars from 56 individuals (n=48 from FC1-7, n=8 from FC8+9) that were shipped to UGA. Further sample collection for the individuals from the mass graves was performed during the first season of the NSF REU. Samples from non-soldiers were in the first batch of Spring 2015 (n=8) and were continued to be collected during all NSF REU field seasons (2016-2018), in addition to 17 individuals from FC1-7 and 23 individuals from FC8+9.

The fragmented nature of the individual bones during excavation from the ground allowed for minimal additional destruction in sampling bone fragments. Bone fragments approximately 2 inches in length were selected for collagen extraction. Rib samples were preferentially selected because they represent the last 5-10 years of an individual's life (Hedges et al., 2007), but long bone fragments were chosen if 1) rib fragments seemed too poorly preserved at time of sample collection or 2) collagen extraction was attempted with a previously sent rib sample that did not yield collagen and a second attempt with a new bone sample was necessary. Bone samples were determined to be well preserved in the field if they had a thick layer of cortical bone and were hard, not easily fragmented.

For individuals from the mass graves, second molars were preferentially sampled because of their robust size for available sample of enamel and dentine. Additionally, second molars are formed after infancy and so incorporation of the mother's isotopic signatures or any effects of weaning would not affect enamel isotopic signatures (Wright and Schwarcz, 1998). Premolars were sampled if second molars were not available or poorly preserved. Regardless of tooth type, teeth were sampled by the NSF REU team based on perceived preservation of the enamel,

meaning the enamel was hard and not chalky, did not have considerable staining from the burial environment, and were not too worn from dietary and other habits during the person's lifetime.

As part of the BMCP, civilians of Himera were sampled. Individuals were considered civilians if they were not included in the mass graves and if they did not contain any grave goods indicating activity in battle, i.e. weapons embedded in the bones (Vassallo, 2010). Citizen individuals were sampled according to the research questions of the Bioarchaeology Mediterranean Colonies Project and associated NSF REU field school, and sometimes differed from the sampling protocol of the individuals in buried in the mass graves. For example, canines were preferentially selected for the civilians because of an interest in not only the isotopic signatures, but also dental histology to look at childhood stress. Canines are more hypoplastic than other types of teeth and are more readily used to study when and how severe childhood stress episodes occurred (Lukacs 1991). Only teeth with intact isomers were sampled to permit one isomer to remain with the skeleton.

5.1.2 480 BCE mass graves

The six mass graves that are thought to be from 480 BCE consist of FC 1-7. The mass graves 1-7 are dated to the 480 BCE battle because of late 6th to early 5th-century grave goods and ceramic intrusions from ancient tombs destroyed during the constructions of the mass graves in the western end of the necropolis (Viva et al., 2020). All of the graves are oriented north-south and the individuals buried in each are oriented east-west with their heads oriented east (Figure 5.1).

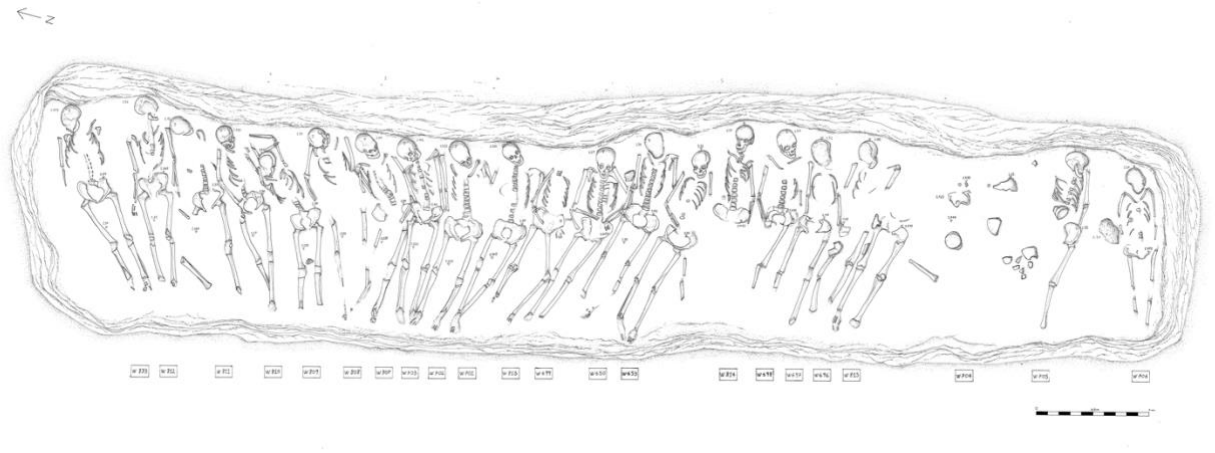

Figure 5.1. Map drawing of FC3

Previous researchers have completed archaeology and osteological analysis of the mass graves (Vassallo 2010). Archaeological and osteological evidence suggest differences between soldiers buried in FC1-4 and soldiers buried in FC5-7 (Viva et al., 2020). FC1 and FC2 are now considered the same grave after excavation and so have been grouped in the results section. The mean age of soldiers from FC1-4 was 29.6 years, compared to 45.0 years in FC5-7. The number of individuals per grave in graves FC5-7 was much lower than FC1-4 (3 and 18.3, respectively) and the bodies in FC5-7 were not as overlapped, showing less evidence of dragging (Viva et al., 2020) (Figure 5.2). Additionally, grave goods were found in FC5 and FC6, unlike in the other mass graves. Archaeological evidence indicates that these two sets of graves were dug at the same time (Vassallo 2010), but there seems to be more care observed in the deposition of the bodies from FC5-7 (Viva et al., 2020).

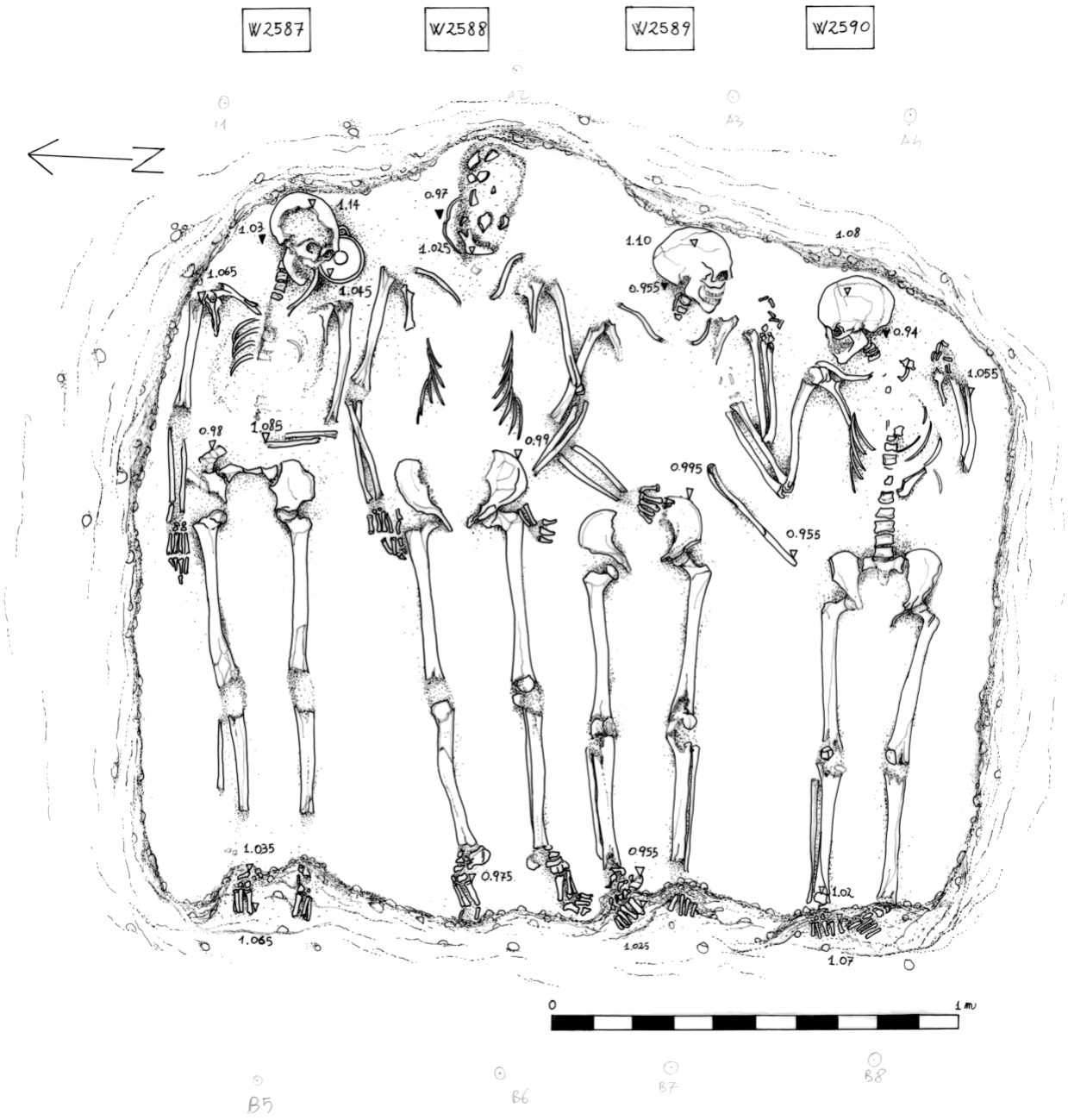

Figure 5.2. Map drawing of FC5

A total of over 65 individuals were recovered from FC 1-7 (Vassallo 2010; Viva et al., 2020). Bone samples from 53 of these individuals and tooth samples from 51 individuals were collected, resulting in 50 paired bone and tooth samples. The teeth samples consisted of four

premolars and 47 second molars, depending on what was available and in good condition for sampling. Premolar crowns form between five and eight years of age and second molar crowns form between six and eight years of age (Gustafson and Koch 1974). For both tooth types, early childhood is represented, well before the critical age period for men in Greek military training (van Wees 2004).

5.1.3 409 BCE mass graves

The mass graves FC 8-9 were located in the most eastern part of the necropolis and are oriented east-west with an estimated number of individuals over 71 (FC8 with >12 and FC9 with >59, see Vassallo 2010) (Figure 5.3). The graves FC 8+9 were originally numbered as separate mass graves but are now thought to represent a single mass grave (Viva et al., 2020). Mortuary analysis of FC8+9 has shown the presence of at least four layers of deposition (Viva et al., 2020). The first layer of body deposition followed the pattern observed in FC1-7 with bodies deposited from the eastern end of the trench and proceeding westward with heads to the south. The second layer was laid over the first, but in the same orientation with skulls of the second layer on the chests of the first layer. The third layer were laid in the opposite orientation with heads to the north, but set on top with their feet on the shoulders of individuals in the second layer. The fourth layer of bodies was placed perpendicular with the heads to the east and set on the northern and southern sides of the trench. The final layer is a number of bodies covering the others diagonally (Viva et al., 2020). The presence of ceramic grave goods from the end of the 5th century, specifically a black-figure *skyphoi,* dated these graves to the 409 BCE battle (Vassallo 2010).

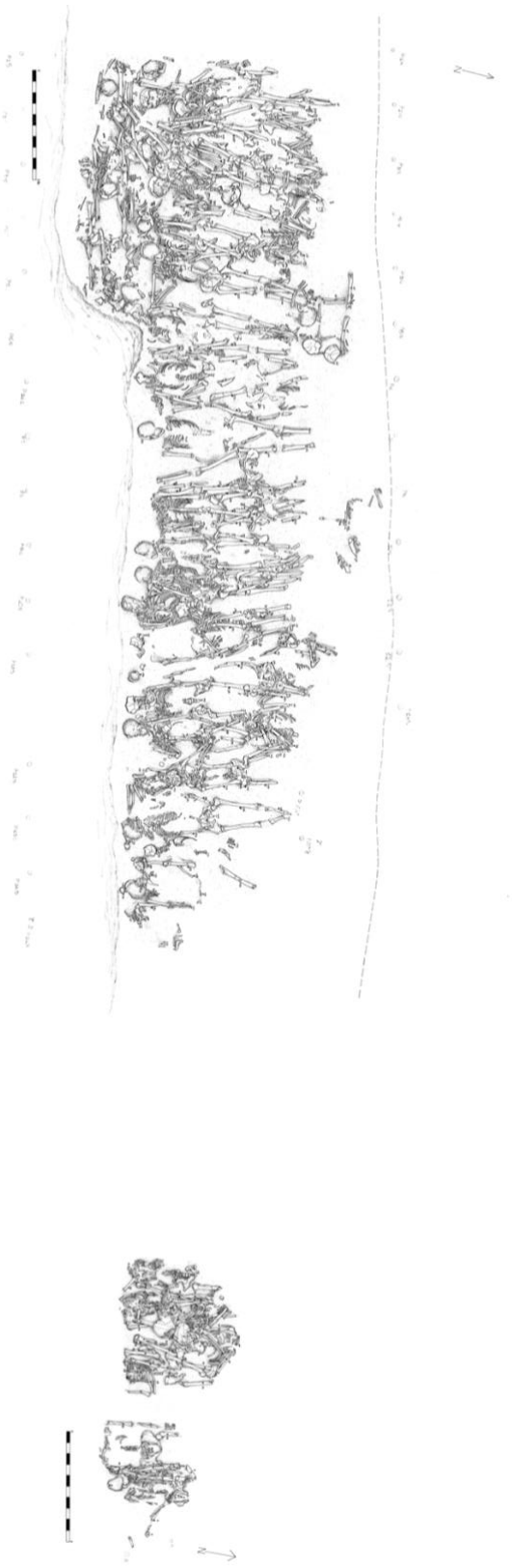

Figure 5.3. Map drawing of FC8+9

Bone samples from 31 individuals were sampled for this dissertation, while 12 individuals had teeth sampled to create 12 paired bone and tooth samples. The teeth samples consisted of one premolar and 11 second molars. Due to the nature of preservation of FC 8-9, many individuals did not have teeth available for sampling: teeth were either completely absent for some individuals from the grave or there was difficulty removing samples that would compromise the preservation of the individual. For example, delicate skull and skull fragments were sometimes excavated with surrounding soil to allow for observation and removal of the remains from the grave without destroying the bone in an attempt to clean them. In other cases, it was not possible to pair teeth remains with a particular set of bones due to the commingling of remains in this large mass grave.

5.1.4 Civilians

This study will compare soldier data to data from civilians buried in the western necropolis (n=131). The western necropolis was used throughout the Greek occupation period of Himera, so represents a sample of people who lived, and died, at Himera during all of time periods in the colony's lifespan. Isotopic data on civilians was collected as part of the 2016, 2017, and 2018 field seasons of the Bioarchaeology of Mediterranean Colonies Project. Previous publications showed no statistical differences were found for $\delta^{13}C$ and $\delta^{15}N$ ratios between civilians based on burial style (simple pit and tile graves), body position (flexed or supine), age, and sex so all civilians will be pooled to represent the general populace of Himera (Reitsema et al., 2020).

Bone samples from 72 individuals were sampled for collagen extraction and teeth from 120 individuals were sampled, creating 48 paired bone and tooth samples.

Table 5.1 Sample counts

Mass Grave (FC)	Battle Context	Total # skeletons (Viva et al., 2020)	# Bones	# Teeth	Paired bones and teeth
FC1+2	480	18	16	16	15
FC3	480	22	20	18	18
FC4	480	15	8	8	8
FC5	480	4	4	4	4
FC6	480	3	3	3	3
FC7	480	2	2	2	2
480 Total		**64**	**53**	**51**	**50**
FC8+9	409	69	31	12	12
409 Total		**69**	**31**	**12**	**12**
Civilians		**~10,000**	**72**	**120**	**48**

5.1.5 Baseline sampling

In order to identify possible locals and non-locals, it is necessary to establish a range of isotope values local to Himera. For the local $^{87}Sr/^{86}Sr$ baseline, I analyzed modern fauna, including Muridae (rats and mice) and Lacertidae (lizards – likely *Podarcis siculus*) spotted on the ground at and near the archaeological site of Himera, archaeological fauna discovered occasionally in the burial boxes during osteological analysis, modern permanent human teeth donated by local dentists' offices in nearby Campofelice di Roccella, and soils recovered from inside archaeological human bone cortices. At Agrigento, I analyzed modern land snails, faunal bones, and soil. The baseline for Syracuse was estimated based on the local geology of the Hyblean Plateau.

For diet isotope comparisons, nine animals from archaeological burial contexts were analyzed. All animal remains were recovered from the West necropolis as isolated bones including cow, dog, horse, pig, and sheep or goat. Cow, pig, and sheep or goat are especially useful as potential dietary components for the people because they were part of the diet.

To estimate the local, environmental baseline for Himera, I consider the average annual $\delta^{18}O$ value for precipitation of -5.4‰ from OIPC, and I calculated $\delta^{18}O$ measurements of (1) modern waters from taps and fountains from areas near Himera collected in 2017-2018 and (2) modern tooth enamel from a dentist's office in Campofelice di Roccella in 2018. OIPC, or the Online Isotope Precipitation Calculator, calculates the predicated oxygen and hydrogen isotopic signatures of precipitation based on latitude, longitude, and elevation according to equations outlined in Bowen and Wilkinson (2002), defined in Bowen and Revenaugh (2003) and Bowen et al., (2005). Oxygen isotope environmental baselines are estimated for Agrigento and Syracuse using OIPC estimated precipitation values (-5.8‰ for Agrigento and -5.3‰ for Syracuse), and measurements of local waters from taps and fountains collected in 2017-2018. Vials were rinsed at least three times in sample water before final collection. Sources included sink taps, rivers, public drinking fountains, and public water faucets.

5.2 Predictions and hypotheses

This dissertation will address the question: how were military bodies constructed in 480 and 409 BCE in Greek Sicily? To address this issue, I examine whether soldiers who died in battles lived characteristically different lives than civilians, or whether the difference between a soldier and a civilian was minimal until the time of battle. In one case, it would mean that warfare in the Greek Mediterranean involved ideas of prestige that differentiated between soldiers and non-soldiers from earlier ages. This differentiation would have manifested through training as children or enlistment early in adulthood (as suggested by van Wees 2004, and Hanson 2000) and/or recruitment from outside the local region. On the other hand, similar lives shared between civilians and soldiers will show that military forces were constructed based on

current need and expediency, regardless of prior training, and the use of more local forces. Two forms of evidence are used to address this question: cultural background, represented by diet; and geographic point of origin.

5.2.1 Prediction 1

Soldiers are more likely to be non-local to Himera than civilians, as evidenced by strontium, lead, and oxygen isotope ratios from their tooth enamel. This would indicate that armies could be made up of individuals from diverse geographic areas, representing different geopolitical backgrounds and reflecting recruitment practices utilized by Sicilian tyrants. Tyrants were known to hire bodyguards and move subsets of city populations to other cities for their own political gain, so it is likely that they would have amassed armies from further afield than Sicily.

5.2.2 Prediction 2

Soldiers from the Battle of 480 BCE are more likely to be non-local than soldiers from the Battle of 409 BCE, supporting historical accounts of Diodorus Siculus who describes a large allied force in the 480 BCE, with soldiers from all over Greece and Sicily, while the 409 BCE battle consisted of mostly Himerans with few, if any, forces from other areas. Herodotus and Diodorus Siculus mention allied forces from Agrigento and Syracuse coming to aid Himera in 480 BCE (Diod. 11.20-21; Hdt. 7.166) At the beginning of the battle in 409 BCE, there were some allies from Syracuse aiding Himera, however, when there was word that the Carthaginians were going to attack Syracuse, the allies refocused their attention on evacuating the city of women and children as much as possible and went to protect their own city (Diod. 13.61).

5.2.3 Prediction 3

Prediction 3(a) Soldiers will exhibit carbon and nitrogen isotope differences compared to civilians, indicative of different diets. Considering the confounding problem that people from different geographic points of origin may have different diets, and the likelihood that some individuals at Himera were non-locals, I also test Prediction 3(b) that among individuals determined to be locals on the basis of strontium, lead, and oxygen isotope analysis, local soldiers will show carbon and nitrogen isotope differences compared to local civilians, indicative of different diets within a community where local soldiers were provisioned differently than local civilians.

5.3 Methodologies and data analysis

This section will outline the particular methods employed in this dissertation, including steps taken to preserve samples for future research, collagen extraction, pretreatment of enamel, pretreatment of modern water samples, and data analysis, including descriptions of the methods used in QGIS to create isoscapes for interpreting isotopic values.

5.3.1 Data collection

Prior to destructive analysis of the teeth macroscopic observations of dental pathologies were conducted, dental metric and nonmetric traits were recorded as part of the NSF REU field seasons, and teeth were impressed in Coltene® President light/regular body polyvinyl siloxanes in order to make high-resolution epoxy replicas. These replicas are available to use for future study on non-metric and metric dental traits and external micro and macro-defects.

5.3.3 Method 1: Enamel pretreatment

For all analyses, enamel samples were mechanically cleaned and separated from the dentin using a Dremel ® tool. This removes the outer enamel surface and any external contaminants. Dentin is removed because it also contains a mineral component that may affect the isotopic composition. Samples were broken into ~1mm sized fragments in a steel mortar and pestle. Each sample was divided into a subsection reserved for $\delta^{18}O$ and a subsection reserved for $^{87}Sr/^{86}Sr$ and $^{20n}Pb/^{204}Pb$ analyses. Subsections were roughly equal in weight 0.020-0.050g.

Enamel samples reserved for $\delta^{18}O$ analysis were treated according to Garvie-Lok's (2004) protocol. Each sample was added to a 15mL centrifuge tube and then soaked in 5mL of 2-3% lab grade NaOCl for 24 hours to remove organic contaminants. Samples were then rinsed in 10-15mL of RO H_2O for a total of 5 rinses. After the last rinse, 0.1M Acetic acid was added to the centrifuge tubes to remove secondary carbonates and soaked for 4 hours. They were then rinsed 6 times in RO H_2O and frozen and freeze-dried.

At the University of Georgia Center for Applied Isotope Studies, pretreated enamel powder was digested in 100% phosphoric acid and measured on a Thermo Scientific Gas Bench II to be introduced to an IRMS. $\delta^{18}O$ are reported relative to the VPDB carbonate standard and are expressed in per mil (‰) values. Mean $\delta^{18}O$ of Fisher analytical standard is -14.9‰, with a standard deviation of 0.12‰.

5.3.4 Method 2: Sr/Pb pretreatment

Subsamples for $^{87}Sr/^{86}Sr$ and $^{20n}Pb/^{204}Pb$ were sent to the Center for Isotope Geoscience at the University of Florida and processed in a class 500 clean lab, equipped with class 10 laminar flow hoods. Tooth enamel samples were dissolved in 8N HNO_3 and then evaporated to

dryness in a laminar flow hood. Strontium and lead were sequentially separated by ion chromatography from single aliquots. The stems of 100ul columns were packed with Dowex© 1X-8 (100-200 mesh) resin rinsed with 2ml of 6N HCl (optima). Each enamel sample was dissolved in 100-200ul of 1N Seastar HBr and loaded onto the column resin, then washed three times with 1ml HBr. Lead was collected in a final wash of 1ml 20% HNO_3 (optima), and evaporated to dryness in a laminar flow hood.

During the lead elution step all of the wash cuts were collected for subsequent Sr separation, as the latter is not absorbed on the Dowex© resin. The wash was dried down on the hot plate and 500 µl 8N HNO_3 (otpima) was added to the dry residue and evaporated to dryness. The dried residues from the washes were dissolved in 3.5N HNO3 and loaded on to cation exchange columns packed with strontium-selective crown ether resin (Sr-spec, Eichrom Technologies, Inc.) to separate Sr from other ions following procedure by Pin and Bassin, (1992). Each 100 microl column stem was packed with Sr-spec resin, washed with 2ml 4xH_2O and equilibrated with 2ml 3.5N HNO3 (optima). Dissolved samples were loaded onto the resin columns and washed four times with 100 microl 3.5N HNO_3 (optima), then washed with 1ml 3.5N HNO_3. Strontium was collected in 1.5 ml 4xH2O and evaporated to dryness on a hot plate in a laminar flow hood.

$^{87}Sr/^{86}Sr$ and $^{20n}Pb/^{204}Pb$ were measured at the Department of Geological Sciences, University of Florida using a “Nu-Plasma” multiple-collector inductively-coupled-plasma mass spectrometer (MC-ICP-MS), using the time-resolved analysis method of Kamenov and colleagues (2008). For the Sr isotope analyses, on-peak zero were determined before each sample introduction in order to correct for isobaric interferences caused by impurities of Kr in the Ar carrier gas. $^{87}Sr/^{86}Sr$ was corrected for mass-bias using exponential law and

$^{86}Sr/^{88}Sr=0.1194$. ^{87}Sr was corrected for presence of Rb by monitoring the intensity of ^{85}Rb and subtracting the intensity of ^{87}Rb from the intensity of ^{87}Sr, using $^{87}Rb/^{85}Rb=0.386$ and mass-bias correction factor determined from $^{86}Sr/^{88}Sr$. Average value of the TRA-measured $^{87}Sr/^{86}Sr$ of NBS 987 is 0.710246 ($2\sigma = 0.000030$). Pb isotopic analyses were conducted using Tl normalization technique on fresh mixtures to prevent oxidation of thallium to Tl^{3+} (Kamenov et al., 2004). Analyses of NBS 981 conducted together with the sample analyses gave the following results: $^{206}Pb/^{204}Pb=16.937$ (+/-0.004 2σ), $^{207}Pb/^{204}Pb=15.490$ (+/-0.003 2σ), and $^{208}Pb/^{204}Pb=36.695$ (+/-0.009 2σ).

During the 2016 REU season, some (n=30) of the civilians were analyzed for $^{87}Sr/^{86}Sr$ at the Center for Applied Isotope Studies at UGA (Kazmi et al., 2017; Stamer et al., 2017). The sample pretreatment of those are as follows, using modified protocols from the Radiogenic Isotope Laboratory at MIT (Dudás 2016).

Tooth enamel samples were put into a metal-free quartz test tube and treated with 0.1M ammonium acetate, vortexed and ultrasonicated for 10 minutes. Samples were then centrifuged and decanted to remove liquid. These steps were repeated with deionized water to rinse the sample, then with 0.1M ultrapure acetic acid, and with a final rinse of deionized water before drying. Treated and dry samples were transferred into a clean Savillex beaker and dissolved overnight in 8N HNO_3.

The caps of the beakers were removed and samples were evaporated to dryness in a laminar flow hood. Ultrapure hydrogen peroxide was added and allowed to dry down to remove any remaining organic compounds. Then 8N HNO_3 was added and allowed to evaporate to dryness. Final samples were taken up into 0.250mL of 8N HNO_3 for separation during ion chromatography. Solutions are loaded onto cation exchange columns packed with strontium-

selective crown ether resin (Sr-spec, Eichrom Technologies, Inc.) to separate Sr from other ions following established procedures. Each column was washed twice with alternating 5mL of HNO_3 and 5mL of H_2O, and equilibrated with 4mL 8N HNO_3. 0.250ml of dissolved samples were loaded onto the resin columns and washed with 4mL 8N HNO_3. Strontium was collected in the last 1mL of H_2O.

$^{87}Sr/^{86}Sr$ were measured using a Nu-Plasma multiple-collector inductively-coupled-plasma mass spectrometer (MC-ICP-MS). Average value of the TRA-measured $^{87}Sr/^{86}Sr$ of NBS 987 is 0.710223 ($2\sigma = 0.000019$).

5.3.2 Method 3: Collagen extraction

Collagen from bone was extracted using a modified Longin (1971) method. Bone samples were mechanically cleaned using a Dremel ® tool to remove the outer layer of cortical bone and physical contaminants from the soil. Trabecular bone was also removed from the inner layer because the high surface area is susceptible to diagenesis in the burial environment (Kral et al., 2021). Samples were then ultrasonicated in vials of about 20 ml of RO water for 10 minutes and repeated until water was clear, until all the smaller adherent contaminants were removed. Samples were then dried either in a 60 degree C oven for 2 hours or overnight in the fume hood.

Collagen was extracted in batches of 10 samples using a modified version of methods from Ambrose (1990). Each sample was placed in a filter funnel with a small wad of glass wool attached to a sidearm flask below. The glass wool keeps the sample from sticking to the glass frit of the filter funnel and allows the solution in the filter funnel to access all sides of the bone sample. The filter funnel holds the sample while the attached sidearm flask below collects waste solutions. Because of the poor preservation of bone at Himera, I used 0.500g of sample for

"well" preserved bone and about 1.0g for poorly preserved samples. Whole bone pieces were demineralized, instead of small fragments as outlined in Ambrose (1990) to better preserve collagen fragments. Sample preservation was estimated by manually inspecting the density of the bone and observations of its strength during mechanical cleaning.

About 50ml of 0.2M HCl was added to each filter funnel to demineralize the bone, dissolving the inorganic portion. Acid solutions were replaced twice daily until the bone was soft. In many cases the HCl solution was diluted by half (50% RO H2O, 50% 0.2M HCl) because the bone samples were poorly preserved and disintegrating.

Once bone samples were soft, representing the insoluble collagen and other organic contaminants, samples were rinsed with 4 soaks of RO H2O until pH was neutral.

Samples are then soaked for 20 hours in 50mL of a dilute NaOH solution (50% 0.125M -OH and 50% RO H2O). This step removes any organic acid contaminants such as humic acid and fulvic acid which are contaminants present in the soil, but base-soluble (Ambrose and DeNiro, 1986). Samples are then rinsed 4 times with ≥1 hour soaks of RO H2O followed by a fifth soak in RO H2O overnight.

Filter funnels containing samples are transferred to clean sidearm flasks and 50mL of 0.001M HCl is added to each sample. The solution should have a pH of about 3 to allow samples to dissolve. Each apparatus is placed in a 92 degree oven and gelatinized for about 24 hours. The low pH and high temperature denatures the proteins in the collagen (Piez 1984). The pH was checked at least twice during the process and 1-2 drops of 0.2M HCl was added if solution was not at pH of 3. Once samples were dissolved, they were drained into the sidearm flasks below and condensed to about 5mL before transferring to vials.

Samples in vials were frozen and freeze-dried to remove remaining liquid, retaining only the final collagen. Purified collagen was weighed to calculate % collagen in each sample and then homogenized with an agate mortar and pestle. The % collagen is one indicator of how well preserved the bone sample is with well-preserved bones falling between 5-10% and poor preserved bones at 1-4%. The average % collagen for soldier samples was 3.6 ± 2.3% (range 1 to 10%).

5.3.5 Modern water

Modern water samples were analyzed using a Thermo Thermal Conversion Elemental Analyzer connected to a Thermo Delta V plus IRMS at the Center for Applied Isotope Studies at the University of Georgia. $\delta^{18}O$ values were reported relative to VSMOW. To compare to enamel $\delta^{18}O$ results, I had to convert water VSMOW values to enamel carbonate VPDB.

Oxygen isotope ratios were first converted to enamel carbonate (VSMOW) based on known water values:

$\delta^{18}O_{VSMOW}$ Drinking water = 1.590($\delta^{18}O_{VSMOW}$ carbonate) – 48.634 (Chenery et al., 2012)

These predicted enamel values were then converted to VPDB:

$\delta^{18}O_{VPDB} = 0.97001(\delta^{18}O_{VSMOW}) - 29.99$ (Coplen 1988)

5.3.6 Data analyses

Random sampling is difficult in bioarchaeological research because of preservation of remains. All samples of soldiers from the mass grave have been analyzed if there was

appropriate preservation. For these reasons, it is appropriate to consider the data here representative of the overall population and randomly sampled.

Data are analyzed using the statistical software platform R. Mann-Whitney U non-parametric tests are used for pair-wise comparisons. Non-parametric tests are appropriate for samples whose distributions deviate from normality and when sample sizes among groups differ. Differences between non-locals and local soldiers and civilians, and variation between the two battle samples, are compared using chi-square tests to explore variation between and among the groups.

5.3.6a Isoscape creation $\delta^{18}O$

Oxygen isoscapes were created in QGIS 3.10. Open-source raster files were downloaded from USGS and public domain shapefiles were downloaded from natural Earth. I loaded the GMTED 2010 (Global Multi-resolution Terrain Elevation Data) raster file for mean elevation from the USGS and the national Geospatial-Intelligence Agency (NGA) (Danielson and Gesch 2011). I also loaded a shapefile of country outlines (Made with Natural Earth). I clipped the elevation raster layer using these shape files to create separate elevation layers for Italy and the countries surrounding the Mediterranean. Using the vector menu research tools, I created "Random Points in Extent" for Sicily and countries surrounding the Mediterranean for separate interpolations. This created random points across the whole image (Sicily 750 pts, Mediterranean 5000 pts; 0.01 degrees minimum distance for Italy, 0.001 degrees minimum distance for the Mediterranean).

Once random points were created, I went into the Attribute table and using the Open Field Calculator added Longitude ($x function) and Latitude ($y function) values for each point.

Next, I used the Sampling Raster Values processing algorithm and selected the Random points created previously as the "Input Point Layer" and the selected the individual elevation rasters as the "Raster Layer to sample" in three separate steps. This sampled each elevation raster and added the altitude data to the random points attribute table. The random points attribute table was then downloaded as a CSV file where the latitude, longitude, and altitude values were input into equations to calculate predicted oxygen values for the individual points.

For the larger Mediterranean map and Sicily, Italy, I used the OIPC equation from https://wateriso.utah.edu/waterisotopes/index.html following Bowen and Wilkinson 2002:

$\delta^{18}O = -0.0051(|LAT|)^2 + 0.1805(|LAT|) - 0.002(ALT) - 5.247$

Oxygen isotope ratios were first converted to enamel carbonate (VSMOW) based on known water values and then converted to VPDB using equations listed above.

Once oxygen values were calculated, I input the CSV file as a new dataset into QGIS. I ran a IDW interpolation with a distance coefficient of 4 and 0.01 pixel size (0.001 for the Mediterranean). The subsequent interpolation output was the clipped to the relevant layer outline (Sicily, Italy and countries around the Mediterranean) and symbology was edited for a spectral gradient where dark blue represented more negative oxygen values and red represented less negative oxygen values.

5.3.6b Isoscape creation $^{87}Sr/^{86}Sr$

The $^{87}Sr/^{86}Sr$ isoscape was created in QGIS using a published model that predicts $^{87}Sr/^{86}Sr$ values in global bioavailable strontium (Bataille and Bowen 2012; Bataille 2020; Bataille 2021). This model uses a multivariate random forest regression framework, combining

biological, geological, and environmental covariates and bioavailable $^{87}Sr/^{86}Sr$ data, to predict the average $^{87}Sr/^{86}Sr$ at each pixel and associated uncertainty. Most of the bioavailable $^{87}Sr/^{86}Sr$ data used to calibrate the model are from areas without farming activities, so Bataille and colleagues (2020) assume fertilizers had little impact on the predicted $^{87}Sr/^{86}Sr$ variability and values would, therefore, be a good estimation of ancient bioavailable strontium. This model was published in a raster file and made publicly available (Bataille et al., 2021). Once the raster was input into QGIS the shapefile layers mentioned above were used to clip the layer down to Sicily, Italy and the countries surrounding the Mediterranean. The symbology was edited for a spectral gradient where dark blue represented higher $^{87}Sr/^{86}Sr$ values and red represented lower $^{87}Sr/^{86}Sr$ values.

CHAPTER 6:

RESULTS

6.1 Sample quality

From the 86 bones attempted, 69 bones from the soldiers yielded collagen material with acceptable carbon and nitrogen concentrations (%C, %N) and carbon-to-nitrogen ratios (C:N). The other 17 soldier bones failed to yield collagen with enough carbon or nitrogen for measurement, or failed to yield collagen with acceptable quality indicators. The C:N, %C, %N, and %Coll values of all samples are presented in Appendix A. Only samples with C:N ratios of 2.9-3.6 (n=69) are included in the following interpretations below, following DeNiro (1985).

This dissertation uses a subset of the data from the general populace at Himera published by Reitsema et al., (2020), using only individuals buried in the western necropolis (n=75). The western necropolis general populace samples' carbon content ranged from 3.1% to 39.9% (mean: 28.8 ± 7.0%) and nitrogen content ranged from 1.0% to 14.4% (mean: 10.3 ± 2.5%), excluding one individual with inappropriately high %C and %N (61.9% and 22.4% respectively), likely due to a weight recording error. The individual had an acceptable C:N ratio (3.2) so was still used for analysis. The percent of collagen in human bone (%Coll), indicating how much collagen was preserved, ranges from 1% to 11% (mean 4.3 ± 1.9%). The average C:N ratio of the civilian collagen samples was 3.3 ± 0.1 with a range of 3.0 to 3.6.

The soldier samples' (n=69) carbon content ranged from 9.3% to 39.1% (mean: 26.0 ± 5.6%) and nitrogen content ranged from 3.2% to 14.1% (mean: 9.1 ± 2.0%). The average C:N

ratio of the soldier samples was 3.3 ± 0.1 (3.2 to 3.6). The average % collagen for soldier samples was 3.6 ± 2.3% (range 1 to 10%).

6.2 Establishing a baseline for Himera

As described in the methods section, numerous types of samples were collected to calculate an expected isotopic range for Himera. This section presents the expected baselines. Fauna baselines are useful to 1) estimate the local range of isotopic values to be used to compare to human data ($\delta^{18}O$, $^{87}Sr/^{86}Sr$, $^{20n}Pb/^{204}Pb$) and 2) make interpretations about what the humans in the study were eating ($\delta^{13}C$ and $\delta^{15}N$).

6.2.1 Oxygen

To estimate the local, environmental baseline for Himera, I consider the average annual $\delta^{18}O$ value for precipitation of -5.4‰ from OIPC, and I report $\delta^{18}O$ measurements of (1) modern waters from taps and fountains from areas near Himera collected in 2017-2018, and (2) modern tooth enamel from a dentist's office in Campofelice di Roccella in 2018 (Table 6.1). Oxygen isotope environmental baselines are estimated for Agrigento and Syracuse using OIPC estimated precipitation values (-5.8‰ for Agrigento and -5.3‰ for Syracuse), and measurements of local waters from taps and fountains collected in 2017-2018 (Table 6.2). Additional values of predicted $\delta^{18}O$ values for other sites in Sicily is presented in Table 6.3.

Himera's $\delta^{18}O$ baseline is calculated using the mean ±1 standard deviation of 25 individuals from the general populace ($\delta^{18}O$ = -3.5±0.9‰) (Reinberger et al., 2021). Local water and predicted precipitation values from Himera, Agrigento, and Syracuse were converted to

predicted enamel values (VPDB) using previously established equations (Coplen 1988; Chenery et al., 2012). All $\delta^{18}O$ values are reported in VPDB in the following interpretations.

Table 6.1. Samples used to create Himera baseline.

ID	Sample Type – Source	$\delta^{18}O_{water}$ (vSMOW, ‰)	$\delta^{18}O_{carbonate}$ (vPDB, ‰)	$^{87}Sr/^{86}Sr$
CF-TEETH-1	Modern enamel		-4.3	0.70897
CF-TEETH-2	Modern enamel		-4.0	0.70970
CF-TEETH-3	Modern enamel		-4.4	0.70858
CF-TEETH-4	Modern enamel		-4.1	0.70908
H1-18	Modern water – Sink tap	-6.4	-4.2*	
H2-18	Modern water – Sink tap	-6.5	-4.3*	
H3-18	Modern water – River	-7.1	-4.6*	
H-Upper City	OIPC	-5.5	-3.7*	
H-Lower City	OIPC	-5.3	-3.6*	
H-W1993	Arch. Fauna – Dog			0.70878
H-W1114-P	Arch. Fauna – Pig			0.70896
HMFCAP	Arch. Fauna – Caprine			0.70863
H-W3704-D	Arch. Fauna – Dog			0.70875
H-W704-H	Arch. Fauna – Horse			0.70913+
H-W-3030-H	Arch. Fauna – Horse			0.70882+
H-F-L1	Modern Fauna			0.70846
H-F-R1	Modern Fauna			0.70871
H-F-R2	Modern Fauna			0.70841
H-F-R3	Modern Fauna			0.70839
H-F-M1	Modern Fauna			0.70866
H-Alta-N-SH	Snail shell			0.70858
H-Alta-T-SH	Snail shell			0.70864
HSH-1	Snail shell			0.70849
HSH-2	Snail shell			0.70853
HSH-3	Snail shell			0.70825
H-W234-S	Soil			0.70859
H-W699-S	Soil			0.70857

*$\delta^{18}O$ values were calculated from Coplen (1988) and Chenery et al. (2012) equations.

+Values from horses were not used to calculate the baseline but are included in figures.

Table 6.2. Agrigento (AG) and Syracuse (SY) Isotopic Baseline.

ID	Sample Type -- Source	$\delta^{18}O_{water}$ (vSMOW, ‰)	$\delta^{18}O_{carbonate}$ (vPDB, ‰)	$^{87}Sr/^{86}Sr$
AG1-18	Modern water – Sink tap	-6.5	-4.3*	
AG2-18	Modern water – Sink tap	-6.5	-4.3*	
AG3-18	Modern water – Sink tap	-6.6	-4.3*	
AG4-18	Modern water – Sink tap	-6.6	-4.4*	
AG5-18	Modern water – Spigot	-6.4	-4.3*	
AG1-17	Modern water – Sink tap	-7.4	-4.9*	
AG1-17	Modern water – Spigot	-6.7	-4.4*	
AG-Valley	OIPC	-5.4	-3.6*	
AG-City	OIPC	-5.8	-3.9*	
AG-CA	Modern fauna			0.70899
AG-F-P	Modern fauna			0.70892
AG-MU-SH1	Modern shell			0.70892
AG-MU-SH2	Modern shell			0.70897
AG-MU-SH3	Modern shell			0.70899
AG-MU-SH4	Modern shell			0.70900
AG-TE-SH	Modern shell			0.70891
SY1-18	Modern water – Sink tap	-5.1	-3.5*	
SY2-18	Modern water – Spigot	-5.1	-3.4*	
SY3-18	Modern water – Drinking fountain	-5.2	-3.5*	
SY4-18	Modern water – Sink tap	-5.0	-3.4*	
SY-Ortigia	OIPC	-5.3	-3.6*	

*$\delta^{18}O$ values were calculated from Coplen (1988) and Chenery et al. (2012) equations.

Table 6.3. Average $\delta^{18}O$ values for sites in Sicily from OIPC

Site Name	Site Culture	$\delta^{18}O_{water}$ (vSMOW, ‰)	$\delta^{18}O_{carbonate}$ (vPDB, ‰)
Himera	Greek	-5.4	-3.7*
Agrigento	Greek	-5.6	-3.8*
Syracuse	Greek	-5.3	-3.6*
Gela	Greek	-5.4	-3.6*
Zankle	Greek	-5.4	-3.6*
Selinunte	Greek	-5.3	-3.6*
Morgantina	Greek	-6.3	-4.1*
Motya	Phoenician	-5.3	-3.6*
Palermo (Panormus)	Phoenician	-5.4	-3.6*

*$\delta^{18}O$ values were calculated from Coplen (1988) and Chenery et al. (2012) equations.

6.2.3 Strontium

In order to identify possible locals and non-locals, it is necessary to establish a range of isotope values local to Himera. For the local $^{87}Sr/^{86}Sr$ baseline, we analyze modern fauna collected at or near the archaeological site of Himera (e.g. land snails), archaeological fauna discovered occasionally in the burial boxes during osteological analysis, modern permanent human teeth donated by local dentists' offices in nearby Campofelice di Roccella, and soils recovered from inside archaeological human bone cortices (Table 6.1). At Agrigento we analyze modern land snails, faunal bones, and soil (Table 6.2). The baseline for Syracuse was estimated based on the local geology of the Hyblean Plateau.

A local environmental strontium baseline is calculated using the mean value plus and minus one standard deviation of the mean of all archaeological fauna, modern land snails associated with the necropolis, and soil samples from the site. Values for the Himera baseline are in Table 6.1. The calculated local Himera range for $^{87}Sr/^{86}Sr$ is 0.70837 – 0.70900.

The strontium isotope baseline range for Agrigento is 0.70892 – 0.70900. The estimated range from local geology for Syracuse is 0.70800 – 0.70900, based on expected Sr isotopic compositions of Oligocene to Pleistocene carbonate rocks (Howarth 1997). Based on precipitation estimates from OIPC and collected water samples, the $\delta^{18}O$ baseline for Agrigento is -5.1‰ to -3.1‰ and Syracuse is -4.5‰ to -2.5‰. The expected baselines for Agrigento and Syracuse overlap significantly with Himera because of their similar underlying geology and proximity to the coast.

6.2.4 Lead

For the local Pb isotope baselines, I analyzed fauna found during archaeological excavations at Himera and soil samples from inside human skeletal remains. Soil samples contained within the bones were collected during the mechanical cleaning process of pretreatment. Values for the Pb baseline are in Table 6.4. The calculated local Himera range (using the mean ± 2 standard deviations) for $^{208}Pb/^{204}Pb$ is 38.842 – 38.919, for $^{207}Pb/^{204}Pb$ is 15.657 – 15.677, and for $^{206}Pb/^{204}Pb$ is 18.739 – 18.824.

Table 6.4. Himera Pb Isotope Baseline

ID	Sample Type – Source	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{206}Pb/^{204}Pb$
H-234-S1	Soil – burial W234	38.876	15.670	18.806
H-234-S2	Soil – burial W234	38.899	15.668	18.799
H-699-S1	Soil – burial W699	38.860	15.659	18.771
H-699-S2	Soil – burial W699	38.909	15.667	18.795
Carth-S1*	Soil – Carthage	38.685	15.661	18.574
Carth-S2*	Soil - Carthage	38.669	15.657	18.565
H-1993-D	Fauna - dog	38.864	15.674	18.761
H-1114-P	Fauna - pig	38.876	15.665	18.756
H-W704-H*	Fauna - horse	38.913	15.674	18.840
H-W3030-H*	Fauna - horse	38.889	15.667	18.791

* Values from horse samples and Carthage soil samples were not used for the calculation of Himera's baseline

6.2.5 Carbon and Nitrogen

Reitsema et al., 2020 reported data from nine animals found in the West Necropolis (Table 6.5). The $\delta^{13}C$ values ranged from -21.1‰ to -19.2‰ (mean = -20.1 ± 0.6‰) and $\delta^{15}N$ values were 6.9 to 12.0‰ (mean = 8.1 ± 1.8‰). C:N ratios of the faunal remains were 3.2-3.4 (mean = 3.3 ± 0.1).

Table 6.5: Fauna from Himera (from Reitsema et al., 2020)

ID	Type	$\delta^{13}C$	$\delta^{15}N$	%C	%N	C:N	%Coll
W303-BOS	Cow	-21.2	7.0	33.5%	12.0%	3.3	4.5%
W1993-D	Dog	-19.7	9.9	38.7%	13.9%	3.2	6.5%
W704-H	Horse	-20.2	8.5	24.0%	8.6%	3.3	1.7%
W3030-H	Horse	-19.7	7.6	37.9%	13.8%	3.2	4.5%
W813-H	Horse	-19.7	7.5	39.6%	14.4%	3.2	7.6%
W4434-H	Horse	-20.3	6.2	26.4%	9.2%	3.4	
W1509-SUS	Pig	-20.8	6.9	37.7%	13.4%	3.3	3.3%
W1114-SUS	Pig	-19.2	12.0	29.8%	10.9%	3.2	3.8%
W951-OV	Sheep	-19.8	7.2	34.1%	12.2%	3.3	3.7%

6.3 Isotope analysis of migration

The results of isotopes that reflect possible place of origin are presented here for soldiers from 480 BCE, 409 BCE, and civilians, starting with $\delta^{18}O$ values, then $^{87}Sr/^{86}Sr$, and followed by $^{20n}Pb/^{204}Pb$. Soldiers from the 480 BCE battle are associated with mass graves, fosse comuni (FC), 1-7. Soldiers from 409 BCE are associated with the mass graves, fosse comuni (FC), 8-9.

6.3.1 Oxygen

Mean $\delta^{18}O$ for all soldiers is -5.3 ± 1.1 ‰ and ranges from -7.3‰ to -3.4‰ (Figure 6.1). Mean $\delta^{18}O$ for soldiers from 480 BCE is -5.6 ± 1.0 ‰ and ranges from -7.3‰ to -3.4‰. Mean $\delta^{18}O$ for soldiers from 409 BCE is -4.1 ± 0.4 ‰ and ranges from -4.8‰ to -3.5‰. Mean $\delta^{18}O$ for citizens is -3.6 ± 1.0 ‰ and ranges from -6.2‰ to -1.0‰.

Soldiers from 480 BCE have significantly different values of $\delta^{18}O$ than soldiers from 409 BCE (Mann-Whitney: W=62, p-value < 0.001) and civilians (W=577, p-value < 0.001). Soldiers from 409 BCE do not have significantly different values of $\delta^{18}O$ than civilians (Mann-Whitney: W=422.5, p-value=0.049).

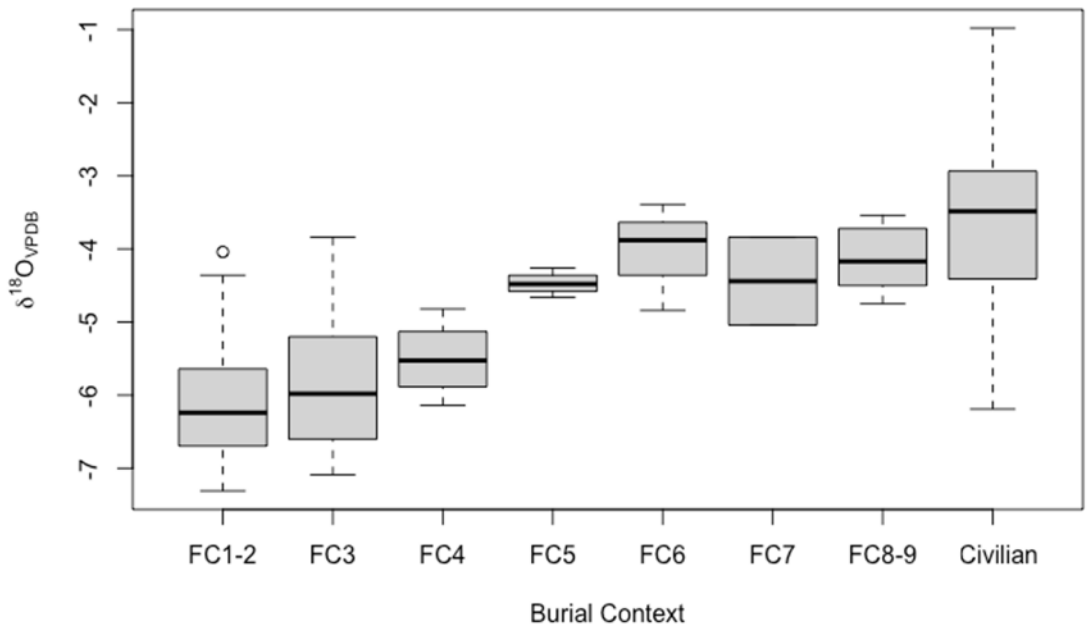

Figure 6.1. Boxplot of $\delta^{18}O$ values organized by burial context.

6.3.2 Strontium

Mean $^{87}Sr/^{86}Sr$ for all soldiers is 0.709196 ± 0.00056 and ranges from 0.708109 to 0.710711 (Figure 6.2). Mean $^{87}Sr/^{86}Sr$ for soldiers from 480 BCE is 0.709273 ± 0.00058 and ranges from 0.708109 to 0.710711. Mean $^{87}Sr/^{86}Sr$ for soldiers from 409 BCE is 0.708840 ± 0.00012 and ranges from 0.708672 to 0.709112. Mean $^{87}Sr/^{86}Sr$ for citizens is 0.708733 ± 0.00017 and ranges from 0.708458 to 0.709122.

Soldiers from 480 BCE have significantly different values of $^{87}Sr/^{86}Sr$ than soldiers from 409 BCE (Mann-Whitney: W=434, p-value=0.005) and civilians (Mann-Whitney: W=1375, p-value=1.1e-06). Soldiers from 409 BCE do not have significantly different $^{87}Sr/^{86}Sr$ values than civilians (W=270, p-value=0.017). The $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ values are presented in Figure 6.3.

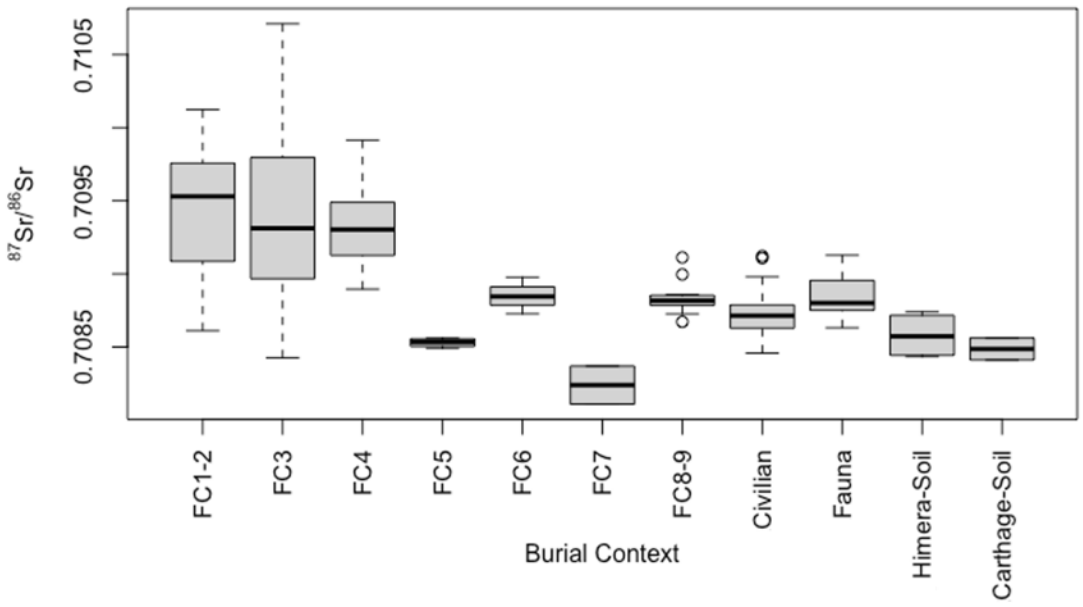

Figure 6.2. Boxplot of $^{87}Sr/^{86}Sr$ values organized by burial context. Includes data from soils from Himera and Carthage.

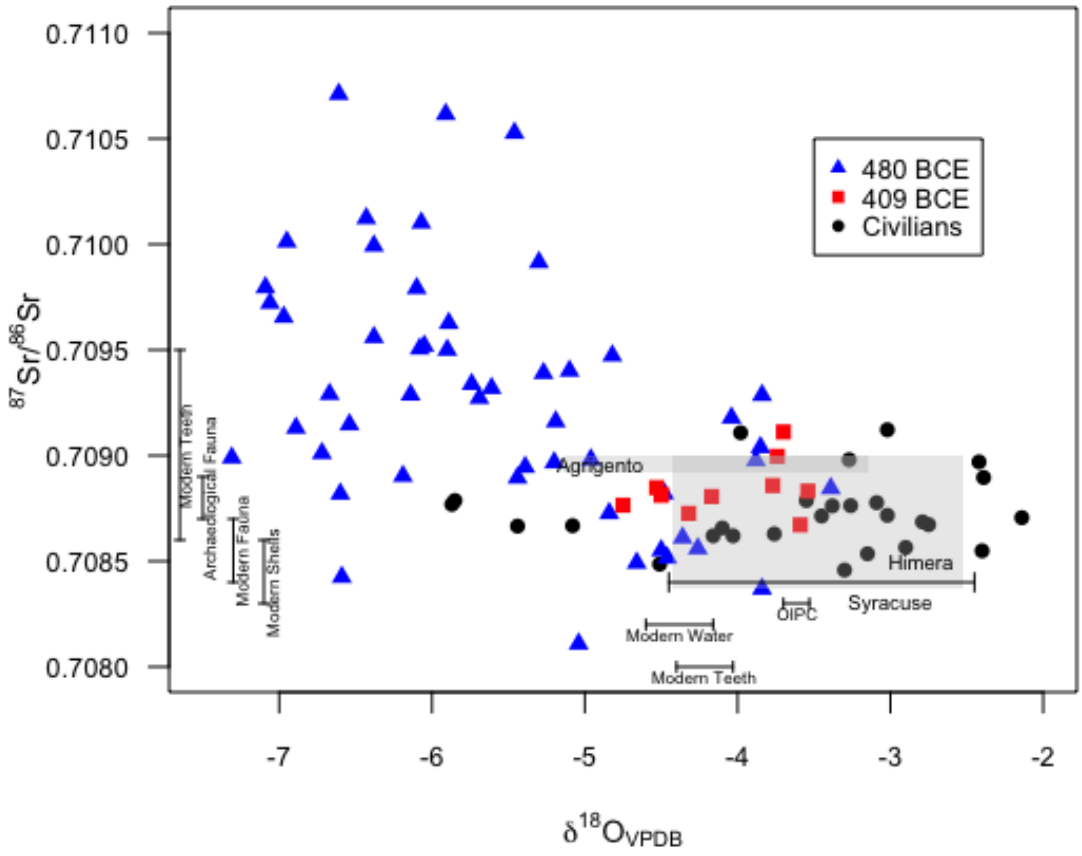

Figure 6.3. $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values for soldiers from 480 BCE and 409 BCE, and civilians. Gray shaded areas represented the measured values for Agrigento and Himera. The bar representing Syracuse's expected $\delta^{18}O$ values is placed close to the $^{87}Sr/^{86}Sr$ values that can be expected for Syracuse, based on its underlying geology (0.70800-0.70900). Bars at the base of the figure represent mean/stdev $\delta^{18}O$ values of measured modern water and modern enamel, and estimated precipitation at Himera. Bars on the left of the figure represent mean/stdev $^{87}Sr/^{86}Sr$ values of measured modern teeth and fauna, archaeological fauna, and shells at Himera (modified from Reinberger et al., 2021).

6.3.3 Lead

Mean $^{208}Pb/^{204}Pb$ for all soldiers is 38.85106 ± 0.0418 and ranges from 38.7453 to 38.9623 (Figure 6.4). Mean $^{208}Pb/^{204}Pb$ for soldiers from 480 BCE is 38.84903 ± 0.0455 and ranges from 38.7453 to 38.9623. Mean $^{208}Pb/^{204}Pb$ for soldiers from 409 BCE is 38.86028 ± 0.0148 and ranges from 38.8412 to 38.886. Mean $^{208}Pb/^{204}Pb$ for citizens is 38.82628 ± 0.0511 and ranges from 38.7553 to 38.8948 (Figure 6.5).

Mean $^{207}Pb/^{204}Pb$ for all soldiers is 15.66798 ± 0.0109 and ranges from 15.6495 to 15.7052 (Figure 6.6). Mean $^{207}Pb/^{204}Pb$ for soldiers from 480 BCE is 15.66753 ± 0.0119 and ranges from 15.6495 to 15.7052. Mean $^{207}Pb/^{204}Pb$ for soldiers from 409 BCE is 15.67006 ± 0.0030 and ranges from 15.6648 to 15.6757. Mean $^{207}Pb/^{204}Pb$ for citizens is 15.66684 ± 0.0131 and ranges from 15.6536 to 15.6839 (Figure 6.7).

Mean $^{206}Pb/^{204}Pb$ for all soldiers is 18.80495 ± 0.0758 and ranges from 18.6828 to 19.1004 (Figure 6.8). Mean $^{206}Pb/^{204}Pb$ for soldiers from 480 BCE is 18.80753 ± 0.0835 and ranges from 18.6828 to 19.1004. Mean $^{206}Pb/^{204}Pb$ for soldiers from 409 BCE is 18.79324 ± 0.0107 and ranges from 18.7786 to 18.8132. Mean $^{206}Pb/^{204}Pb$ for citizens is 18.77264 ± 0.0762 and ranges from 18.6791 to 18.8516.

Sample size for civilians with Pb values is only 5 individuals so statistical analyses will only be done between soldier groups. Soldiers from 480 BCE are not significantly different from soldiers from 409 BCE for all lead isotope ratios: $^{208}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, or $^{206}Pb/^{204}Pb$ (Mann-Whitney: respectively: W=238, p-value=0.4935; W=165, p-value=0.03995; W=266, p-value=0.8733).

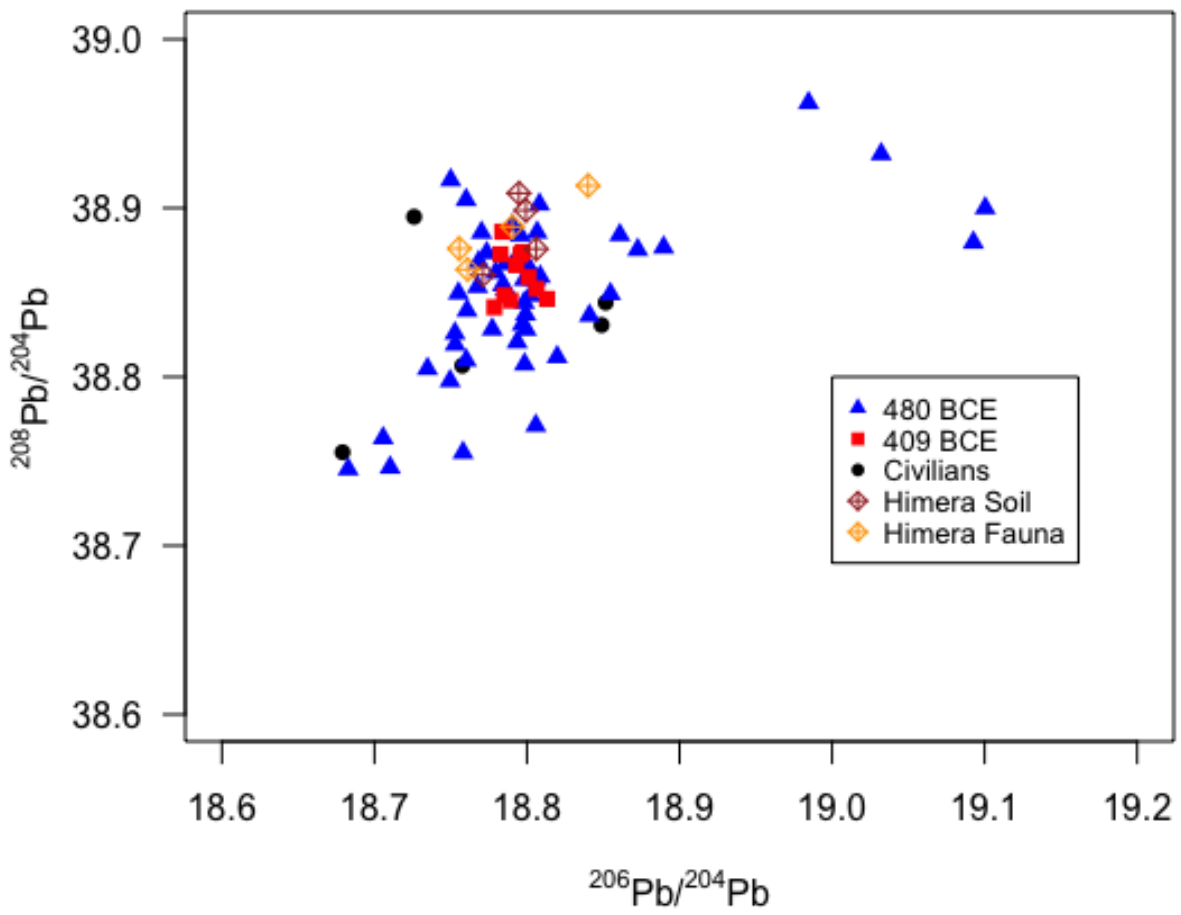

Figure 6.4. $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ values for soldiers and civilians. Soil and fauna from Himera are included.

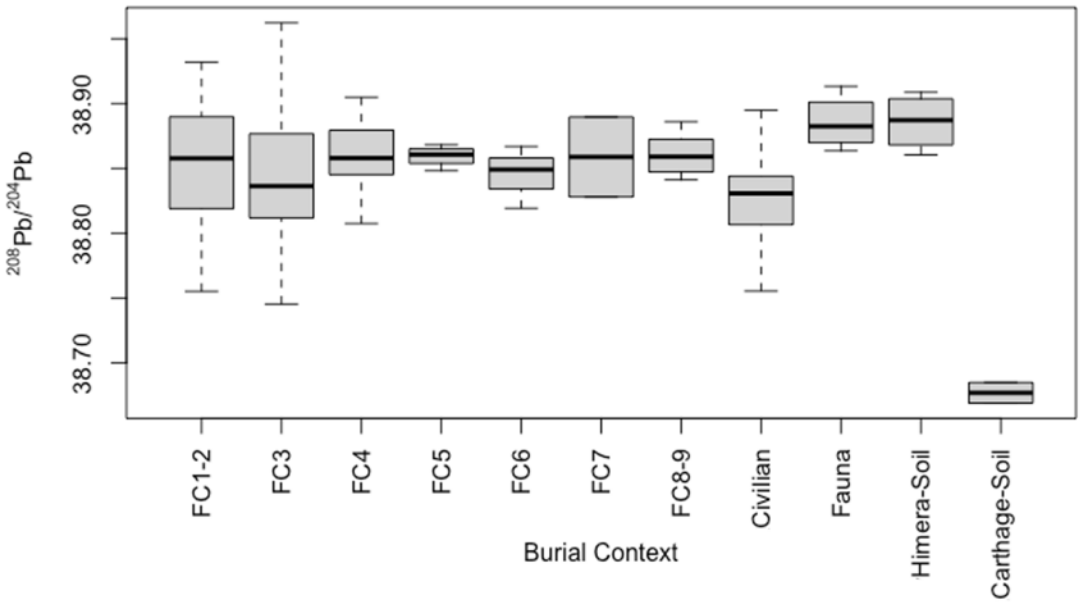

Figure 6.5. Boxplot of $^{208}Pb/^{204}Pb$ values organized by burial context. Includes data from soils from Himera and Carthage.

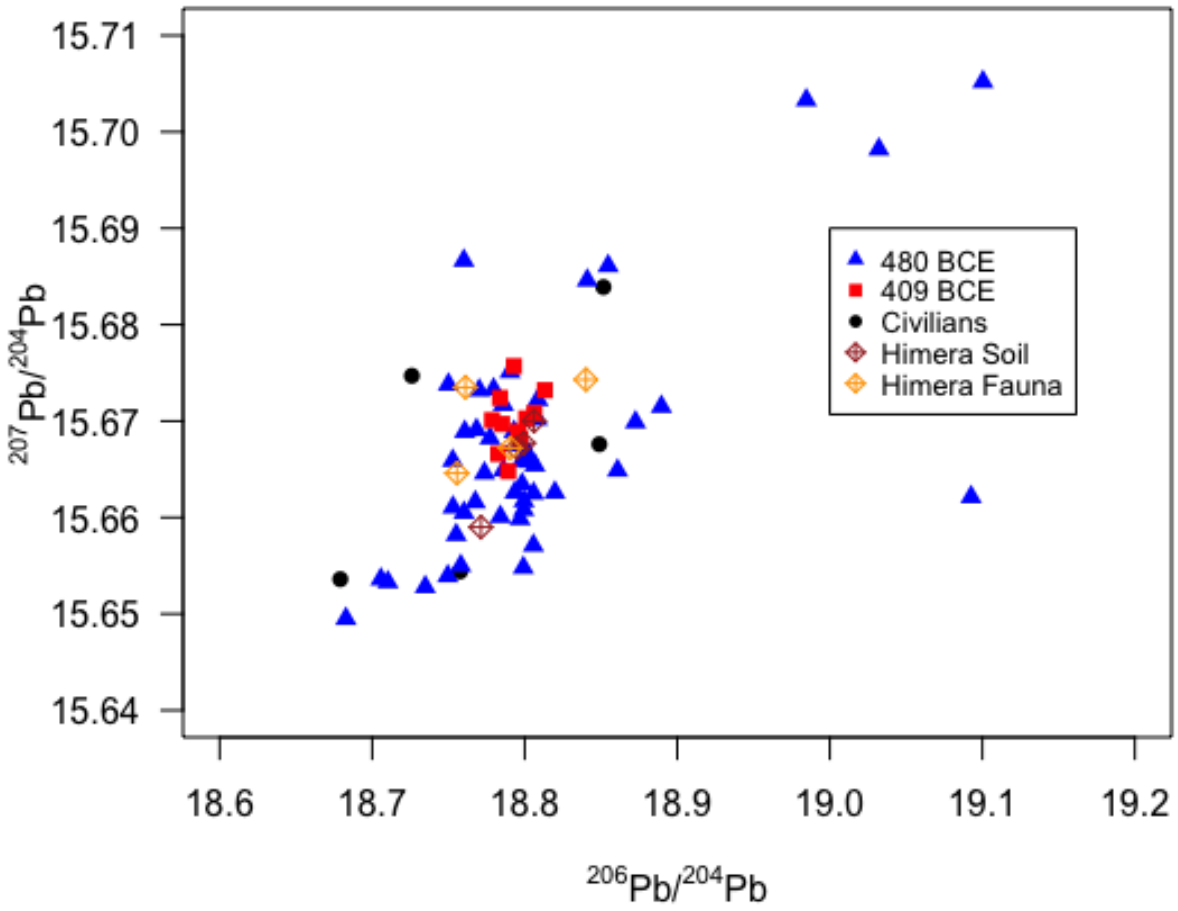

Figure 6.6. $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$ values for soldiers and civilians. Soil and fauna from Himera are included.

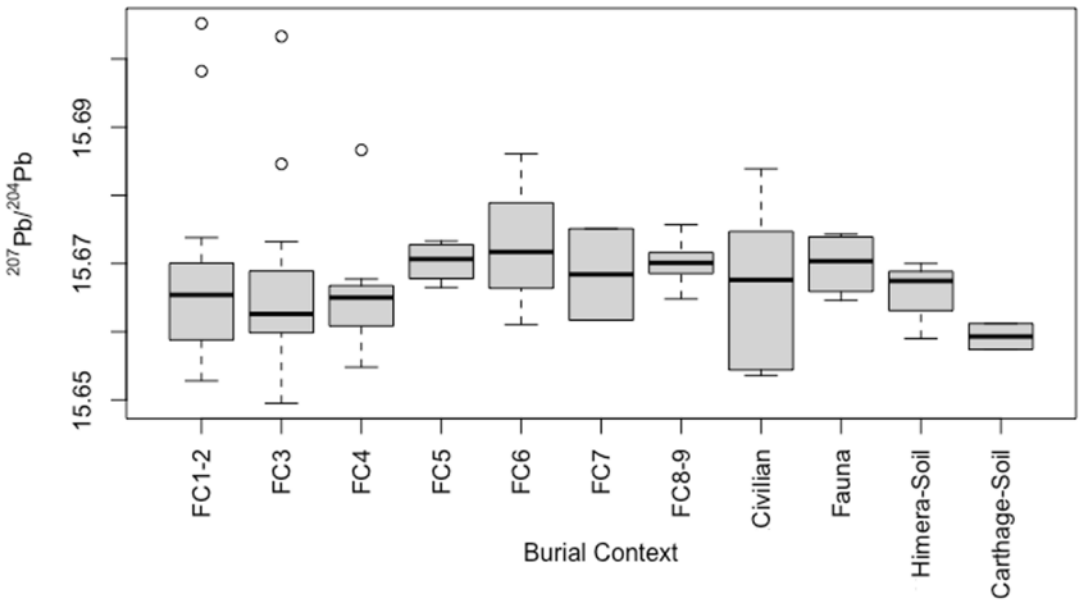

Figure 6.7. Boxplot of $^{207}Pb/^{204}Pb$ values organized by burial context. Includes data from soils from Himera and Carthage.

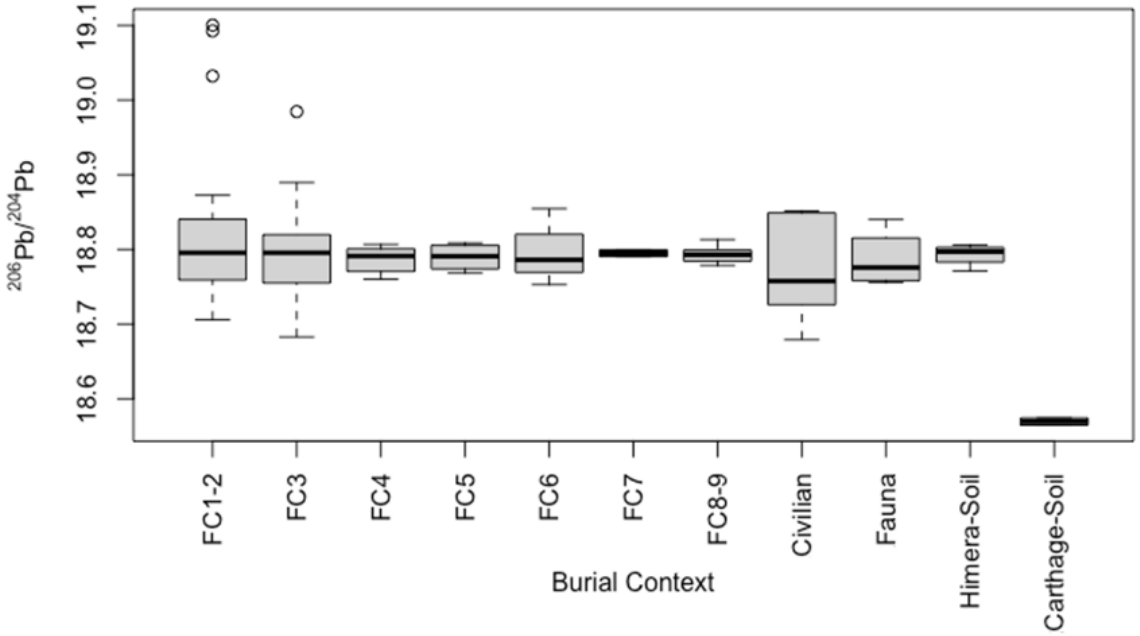

Figure 6.8. Boxplot of $^{206}Pb/^{204}Pb$ values organized by burial context. Includes data from soils from Himera and Carthage.

6.4 Stable isotope analysis of diet

This section will present the results from the soldiers from 480 BCE, 409 BCE, and civilians. Carbon will be presented first, followed by nitrogen.

6.4.1 Carbon

As discussed in Chapter 3, there are two tissues from which I measured carbon: collagen from bones which represent an aggregate of soldiers' consumption across a longer period of time and enamel which reflects $\delta^{13}C$ values consumed in childhood. Results are presented here, starting with collagen.

6.4.1a Collagen

Mean $\delta^{13}C$ in bone collagen ($\delta^{13}Ccoll$) for all soldiers is -18.5 ± 1.2‰ and ranges from -20.4 to -15.8 (Figure 6.9). Mean $\delta^{13}Ccoll$ for soldiers from 480 BCE is -17.8 ± 1.2 ‰ and ranges from -19.6 to -15.8. Mean $\delta^{13}Ccoll$ for soldiers from 409 BCE is -19.4 ± 0.4 ‰ and ranges from -20.4 to -18.7. Mean $\delta^{13}Ccoll$ for citizens is -19.4 ± 0.3 ‰ and ranges from -20.0 to -18.6 (Figure 6.10).

Soldiers from 480 BCE have significantly different values of $\delta^{13}Ccoll$ than soldiers from 409 BCE (Mann-Whitney: W=1070, p-value=6.8e-09). Soldiers from 480 BCE have significantly different values of $\delta^{13}Ccoll$ than civilians (Mann-Whitney: W=2608.5, p-value=6.4e-13). Soldiers from 409 BCE do not have significantly different $\delta^{13}Ccoll$ values than civilians (Mann-Whitney: W=1239, p-value=0.6).

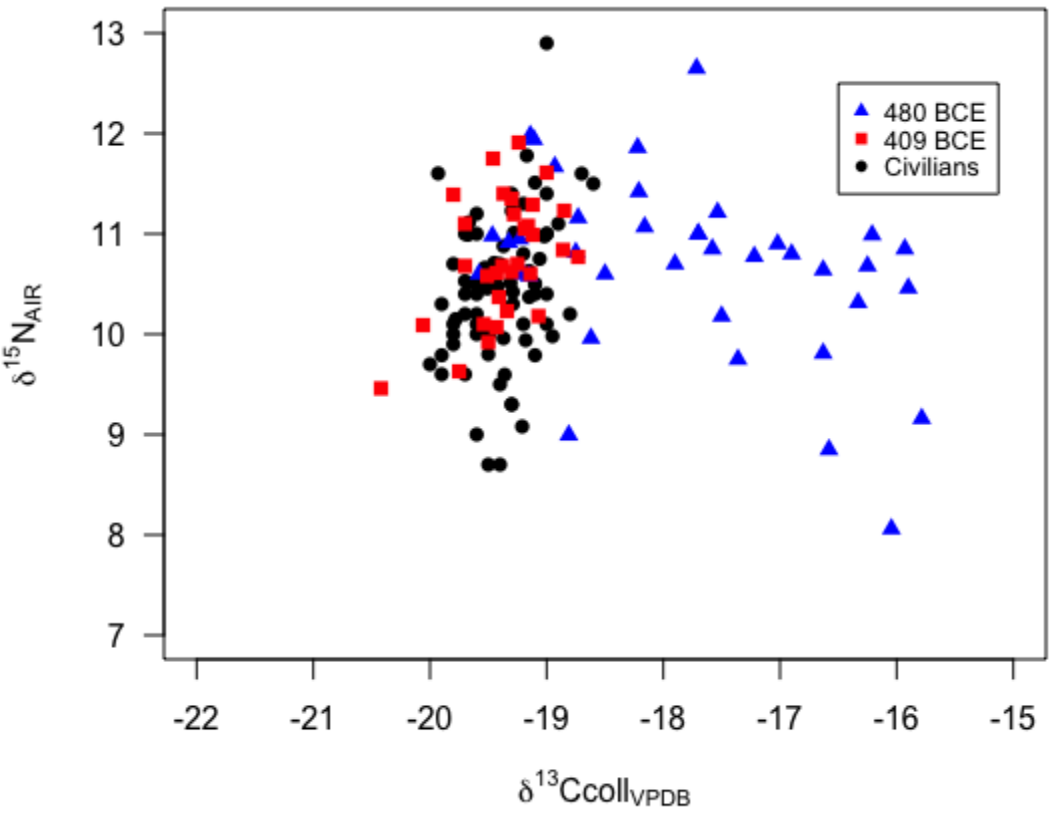

Figure 6.9. $\delta^{15}N$ and $\delta^{13}C$ data for soldiers from 480 BCE and 409 BCE, and civilians.

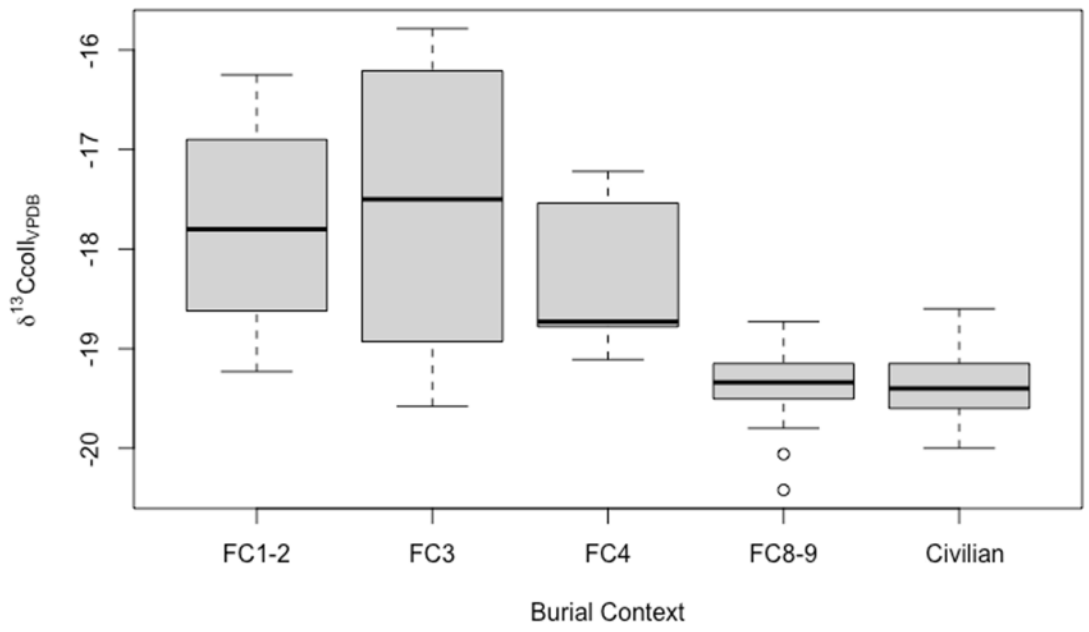

Figure 6.10. Boxplot of δ^{13}Ccoll values grouped by civilians and *fosse comuni* (FC). FC1 and FC2 considered the same grave after excavation and so have been grouped. Similarly, FC8 and FC9 are considered the same grave after excavation and are grouped here. Poor preservation in FC5, FC6, and FC7, did not yield satisfactory collagen for δ13C or δ15N analysis.

6.4.1b Enamel

Mean δ^{13}C in tooth enamel mineral (δ^{13}Cap) for all soldiers is -10.1 ± 2.3‰ and ranges from -13.0 to -5.1 (Figure 6.11). Mean δ^{13}Cap for soldiers from 480 BCE is -9.6 ± 2.3 ‰ and ranges from -13.0 to -5.1 Mean δ^{13}Cap for soldiers from 409 BCE is -12.2 ± 0.3 ‰ and ranges from -12.7 to -11.7. Mean δ^{13}Cap for citizens is -12.4 ± 0.7 ‰ and ranges from -13.8 to -10.6 (Figure 6.12).

Soldiers from 480 BCE have significantly different values of δ^{13}Cap than soldiers from 409 BCE (Mann-Whitney: W=444, p-value=0.003) and civilians (Mann-Whitney: W=5023.5, p-

value=5.3e-12). Soldiers from 409 BCE do not have significantly different δ^{13}Cap values than civilians (Mann-Whitney: W=780.5, p-value=0.27).

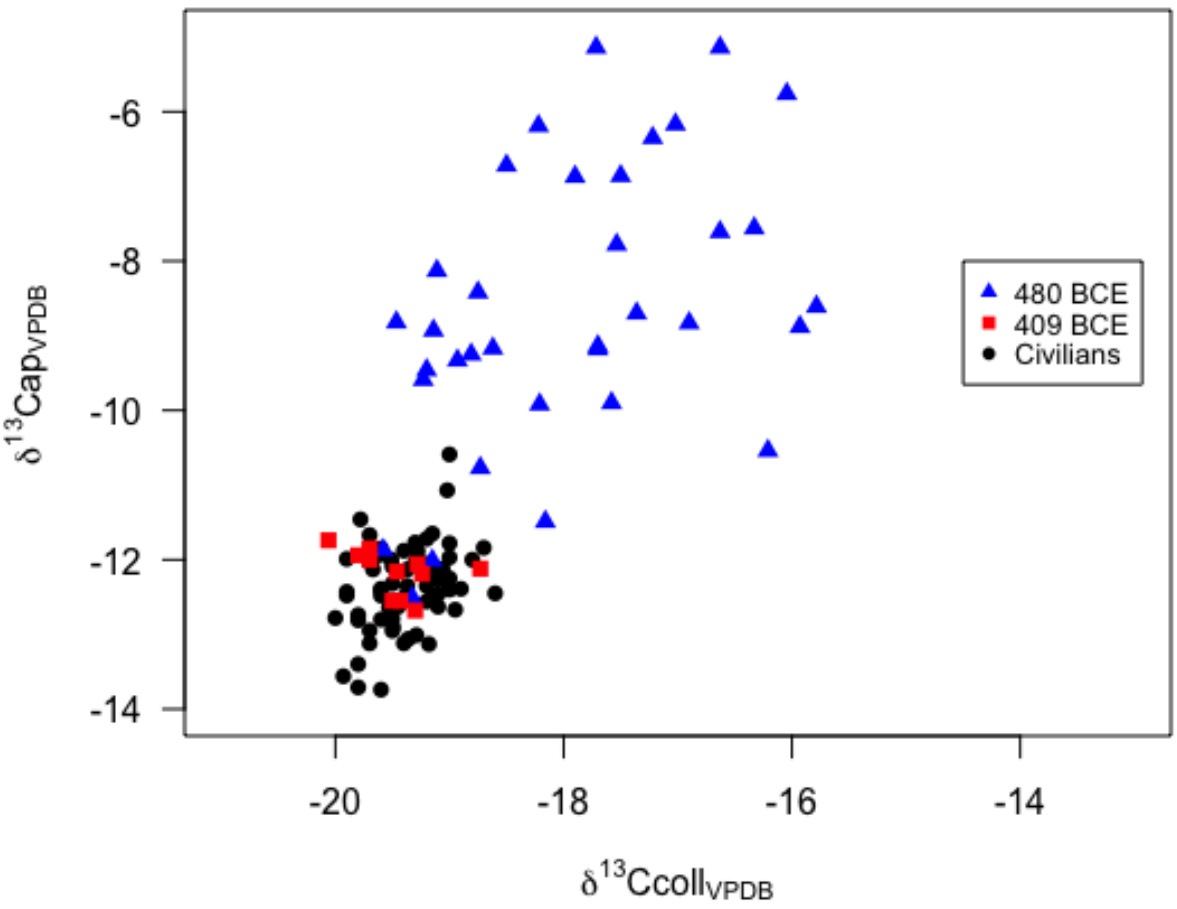

Figure 6.11. δ^{13}Cap and δ^{13}Ccoll for soldiers and civilians.

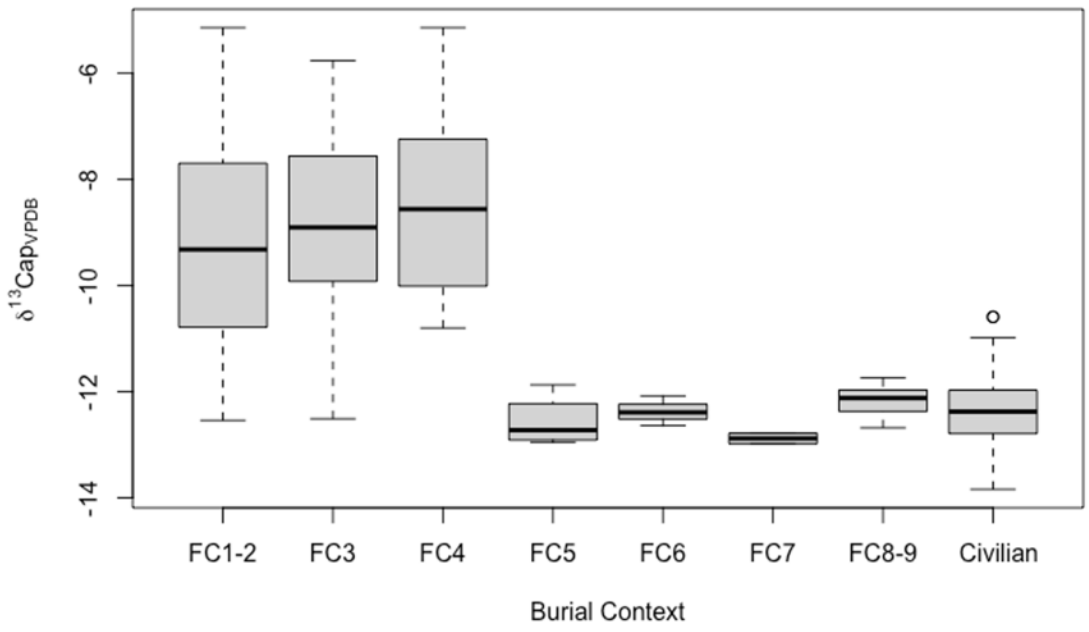

Figure 6.12. Boxplot of δ^{13}Cap values organized by burial context.

6.4.2 Nitrogen

Mean δ^{15}N for all soldiers is 10.7 ± 0.8 ‰ and ranges from 8.0 to 12.7 (Figure 6.13). Mean δ δ^{15}N for soldiers from 480 BCE is 10.7 ± 0.9 ‰ and ranges from 8.0 to 12.7. Mean δ^{15}N for soldiers from 409 BCE is 10.8 ± 0.6 ‰ and ranges from 9.5 to 11.9. Mean δ^{15}N for citizens is 10.4 ± 0.7 ‰ and ranges from 8.7 to 12.9.

Soldiers do not have significantly different δ^{15}N values between the early and the late battle (Mann-Whitney: W=574.5, p-value=0.87). Soldiers from 480 BCE have significantly different values from civilians (Mann-Whitney: W=1772.5, p-value=0.035). Soldiers from 409 BCE have significantly different values from civilians (Mann-Whitney: W=1490.5, p-value=0.023).

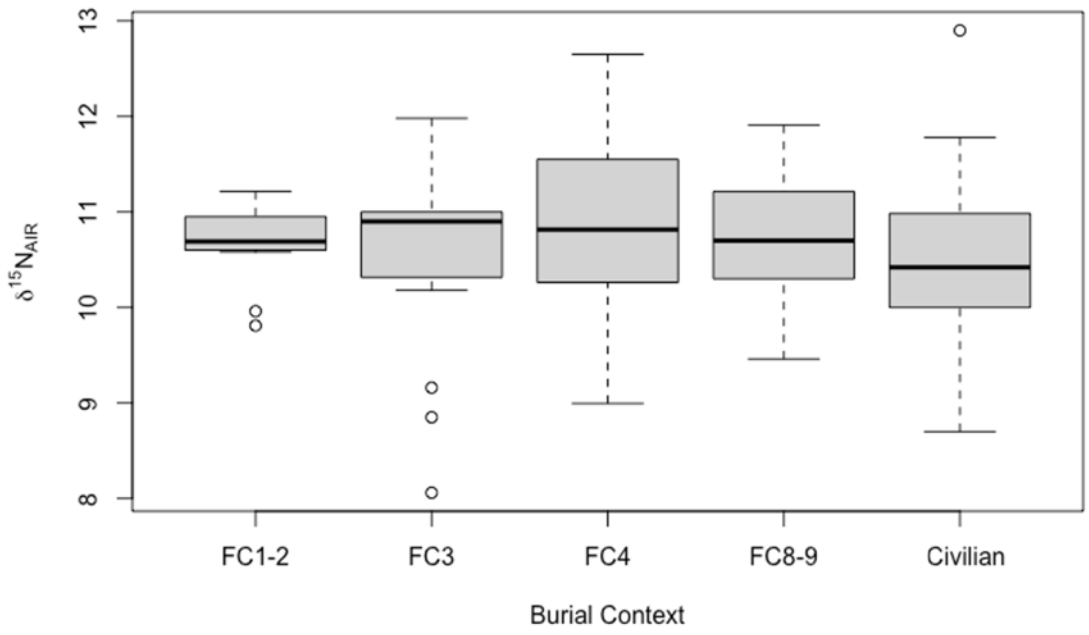

Figure 6.13. Boxplot of $\delta^{15}N$ values based on burial context.

6.5 Relationship of childhood diet and place of origin: PCA

I ran a Principal Component Analysis to explore childhood bulk diet in $\delta^{13}Cap$ and isotopes for geographic origin ($^{87}Sr/^{86}Sr$ and $\delta^{18}O$). This allowed for the inclusion of soldiers from FC5-7 which did not yield well-preserved collagen for $\delta^{13}C$ and $\delta^{15}N$ analysis. I first removed rows and columns that had no data, resulting in n=87 observations with three variables: $\delta^{13}Cap$, $\delta^{18}O$, and $^{87}Sr/^{86}Sr$. The PCA found the first two principal components explained about 76.6% of the variance. The first principal component (PC) explained 74.1% of the variance, while the second principal explained 17%. Only the first PC explained more variance than their proportional amount if all axes explained an equal amount of variance (33%). The third PC only explained 8.9% of variance and so were not considered for the analysis.

The first principal component was estimated to be from $\delta^{18}O$ and $\delta^{13}C$ from apatite and separates the sample clearly into two groups (Figure 6.14). The cutoff for important loadings was

calculated by expected loadings if all variables were contributing equally to each principal component (0.58). Using this cutoff, we can see that the first principal component has a slight positive loading for δ^{13}Cap and a slight negative loading for δ^{18}O. This first principal component distinguishes between soldiers in the earlier battle from the later battle. The second principal component was most likely $^{87}Sr/^{86}Sr$ (Table 6.6). The large loading indicates there is a strong, positive effect on the second principal component by $^{87}Sr/^{86}Sr$. Points are plotted to depict a clearer relationship between FC1-4, FC5-7, FC8-9, and civilians in Figure 6.15.

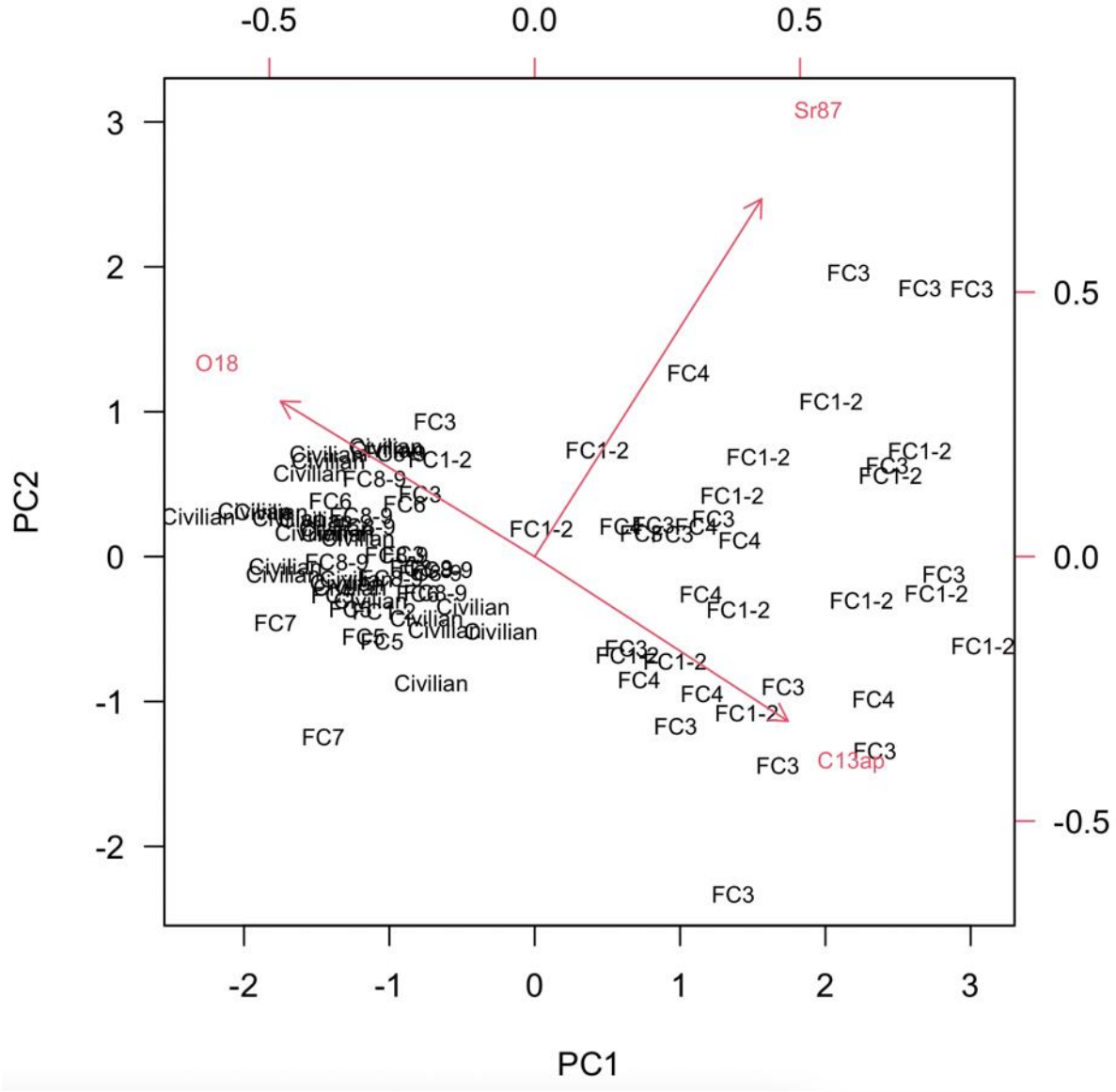

Figure 6.14. PCA Biplot showing relationship between the three variables and the two main principal components.

Table 6.6. PCA Loadings

	PC1	PC2	PC3
$^{87}Sr/^{86}Sr$	0.535	0.845	-0.014
$\delta^{18}O$	-0.598	0.367	-0.712
$\delta^{13}Cap$	0.597	-0.389	-0.702

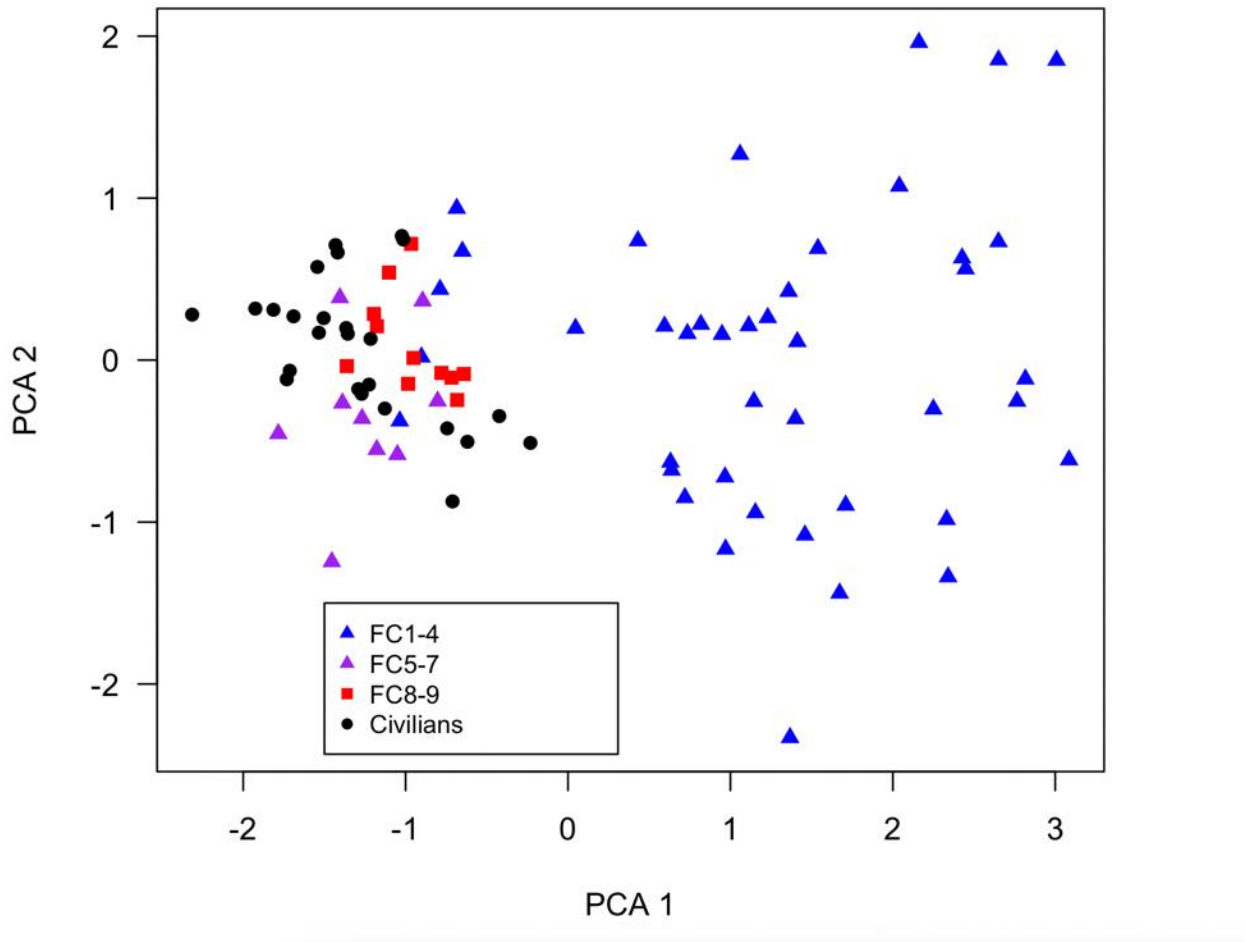

Figure 6.15. PCA biplot with graves FC1-4, FC5-7, and FC8-9 divided, and civilians.

6.6 Conclusion

Overall, sample quality was satisfactory according to accepted values for well-preserved collagen, with the exception of bone samples from FC5-7 which were too poorly preserved to yield high-quality collagen indicators and $\delta^{13}C$ and $\delta^{15}N$ values. Using datasets presented here and from the larger BMCP, I was able to establish environmental context and baseline values when appropriate. The main findings indicate that one group of soldiers (480 BCE) seem very different than the other group from 409 BCE and the civilians in geographic origin and diet. More analysis and interpretations will be presented in Chapter 7 with further discussion.

CHAPTER 7

DISCUSSION

7.1 Introduction

In the discussion, I will further interpret the results presented above, with consideration given to relationships between the different isotopic systems, including how place of origin affects dietary variation. Additionally, I will consider how historical texts and other work on the Greek warfare informs our data interpretations. Through embodiment, this study considers how the isotopic values presented her provide inside into the effects of power and politics on soldiers' bodies in the framework of the body politic. The predictions related to geographic place of origin can corroborate historical sources and illuminate how far soldiers were being recruited to join military forces in Sicily. Predictions related to diet provide insight into provisioning and how soldiers exploited their environments while maintaining connections to their homeland and cultural backgrounds. Both aspects of these predictions help construct the lives of soldiers.

7.2 Exploring the presence of non-locals in the Battles of Himera

Predictions 1 and 2 addressed the presence of non-locals in the Battles of Himera. Prediction 1 stated that soldiers are more likely to be non-local to Himera than civilians, as evidenced by strontium, lead, and oxygen isotope ratios from their tooth enamel. This hypothesis was partially supported. There was a higher proportion of non-locals in the soldiers from the battle of 480 BCE than non-locals buried with the general populace. The soldiers from 409 BCE,

however, had a lower proportion of non-locals than the civilians. This would indicate that armies are made up of individuals from diverse geographic areas, representing different geopolitical backgrounds and reflecting recruitment practices utilized by Sicilian tyrants. Tyrants were known to hire bodyguards and move subsets of city populations to other cities for their own political gain, so it is likely that they would have amassed armies from further afield than Sicily (Griffin 2005). Chi-square tests showed that soldiers were more likely to be non-local than civilians for both $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ ($X^2 = 22.999$, $p < 0.001$; $X^2 = 23.997$, $p < 0.001$, respectively) (Table 7.1).

Understanding the geographic origin of soldiers can provide novel information to supplement historical documents. Prediction 2 stated that soldiers from the Battle of 480 BCE are more likely to be non-local than soldiers from the Battle of 409 BCE, supporting historical accounts of Diodorus Siculus who describes a large allied force in the 480 BCE, with soldiers from all over Greece and Sicily, while the 409 BCE battle consisted of mostly Himerans with few, if any, forces from other areas. Herodotus and Diodorus Siculus mention allied forces from Agrigento and Syracuse coming to aid Himera in 480 BCE. At the beginning of the battle in 409 BCE, there were some allies from Syracuse aiding Himera, however, when there was word that the Carthaginians were going to attack Syracuse, the allies evacuated Himera and returned to protect their own city. Results from this study support the historical account, that soldiers from the earlier battle were not from the local area.

7.2.1 Non-locals in the general populace

The civilian burials studied in this dissertation are representative of what the general populace would have looked like at the time of both battles and not a snapshot when there was

more or less migration. The general populace buried in the western necropolis represents a sample of those who lived in Himera during the colony's occupation. There are some periods of an influx of population to Himera, including Theron's repopulation of the city of Dorian colonists from Greece in 476 BCE and the return of some of the original population, previously removed by Hieron I when he was a tyrant at Syracuse (476 to 467/466 BCE), from Syracuse and other cities in 461 BCE, but in general, there is no evidence of more migration before 480 BCE than 409 BCE. Futher evidence of consistent cultural practices is seen in burial customs during this time period. One common burial style in the western necropolis, *a cappuccina*, are made of large tiles, often recycled roof tiles, that are angled in a tented form over the body (Vassallo and Valentino 2012). These *cappuccina* burials represent a 5th century burial custom and so would be roughly contemporaneous with the battles (Alarcia et al., 2017; Kyle et al., 2018) and do not have more variability than any other burial practice. The general populace of Himera studied here do not show varied isotopic results similar to the soldiers of 480 BCE, which suggests that any population movements that was occurring as part of migration to the colony was not as large geographically as the recruitment of soldiers to fight in the first Battle of Himera.

7.2.2 Variation among non-locals between the different groups of soldiers (480 BCE vs 409 BCE)

Prediction 2 stated that soldiers from the Battle of 480 BCE are more likely to be non-local than soldiers from the Battle of 409 BCE, supporting historical accounts of Diodorus Siculus. Results supported this hypothesis, with 84% non-local soldiers in 480 BCE and 36% non-local soldiers in 409 BCE according to $\delta^{18}O$, and 67% non-local soldiers in 480 BCE and

9% non-local soldiers in 409 BCE according to $^{87}Sr/^{86}Sr$. Soldiers from 480 BCE were more likely to be non-local than soldiers from 409 BCE for both $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ ($X^2 = 12.20$, $p < 0.001$; $X^2 = 11.34$, $p < 0.001$, respectively) (Table 7.1).

According to Viva et al., (2020), the archaeological and osteological evidence suggests that soldiers buried in FC1-4 were younger and had more evidence of dragging, while soldiers buried in FC5-7 were older and seem to have been treated with much more care. In Figure 7.1, I compare the $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values for four groups: soldiers buried in FC1-4 (480 BCE), soldiers in FC5-7 (480 BCE), soldiers in FC8-9 (409 BCE), and civilians. Unfortunately, due to preservation issues, quality collagen was not able to be extracted from any of the burials in FC5-7 so $\delta^{13}C$ and $\delta^{15}N$ isotope values were not used or were below limit of detection, so it is not possible to compare diets of soldiers buried in FC5-7 versus FC1-4.

According to $^{87}Sr/^{86}Sr$ values, 22% of soldiers buried in FC5-7 are non-local, compared to 9% buried in FC8-9 and 6% of civilians. $^{87}Sr/^{86}Sr$ values indicate 76% of soldiers buried in FC1-4 are considered non-local. Using $\delta^{18}O$ values, 90% of soldiers in FC1-4 are non-local, 56% are non-local in FC5-7, 36% non-local in FC8-9, and 38% of civilians. Soldiers buried in FC1-4 were significantly more likely to be non-local than soldiers buried in FC5-7 according to both $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ values ($X^2 = 9.71$, $p = 0.002$; $X^2 = 6.83$, $p = 0.0089$, respectively) (Table 7.1). Alternatively, soldiers buried in FC5-7 were not significantly more likely to be non-local than soldiers from 409 BCE or civilians ($^{87}Sr/^{86}Sr$: $X^2 = 0.67$, $p = 0.41$; $X^2 = 2.14$, $p = 0.14$, respectively; $\delta^{18}O$: $X^2 = 0.74$, $p = 0.39$; $X^2 = 1.15$, $p = 0.28$, respectively).

Table 7.1 Chi-square (X^2) tests of local vs. non-local for each group

Test	Isotope system	n	X^2_1	*p* value
Soldiers (480 and 409 BCE) vs Civilians	$^{87}Sr/^{86}Sr$	95	22.999	< 0.001
	$\delta^{18}O$	182	23.997	< 0.001
480 BCE vs 409 BCE soldiers	$^{87}Sr/^{86}Sr$	62	12.20	< 0.001
	$\delta^{18}O$	62	11.34	< 0.001
480 BCE soldiers vs Civilians	$^{87}Sr/^{86}Sr$	84	30.05	< 0.001
	$\delta^{18}O$	171	31.40	< 0.001
409 BCE soldiers vs Civilians	$^{87}Sr/^{86}Sr$	44	0.12	0.73
	$\delta^{18}O$	131	0.006	0.94
FC1-4 vs FC5-7	$^{87}Sr/^{86}Sr$	51	9.71	0.002
	$\delta^{18}O$	51	6.83	0.0089
FC1-4 vs 409 BCE soldiers	$^{87}Sr/^{86}Sr$	53	16.70	< 0.001
	$\delta^{18}O$	53	15.52	< 0.001
FC5-7 vs 409 BCE soldiers	$^{87}Sr/^{86}Sr$	20	0.67	0.41
	$\delta^{18}O$	20	0.74	0.39
FC1-4 vs Civilians	$^{87}Sr/^{86}Sr$	75	36.67	< 0.001
	$\delta^{18}O$	162	34.95	< 0.001
FC5-7 vs Civilians	$^{87}Sr/^{86}Sr$	42	2.14	0.14
	$\delta^{18}O$	129	1.15	0.28

It is clear the majority of non-local soldiers were buried in FC1-4, strongly supporting Viva et al.'s argument that the soldiers in FC5-7 may have been buried by friends or family because they were local. The burials in FC5 and 6 were accompanied by grave goods, there was less evidence of dragging, and the individuals tended to be older (Viva et al., 2020).

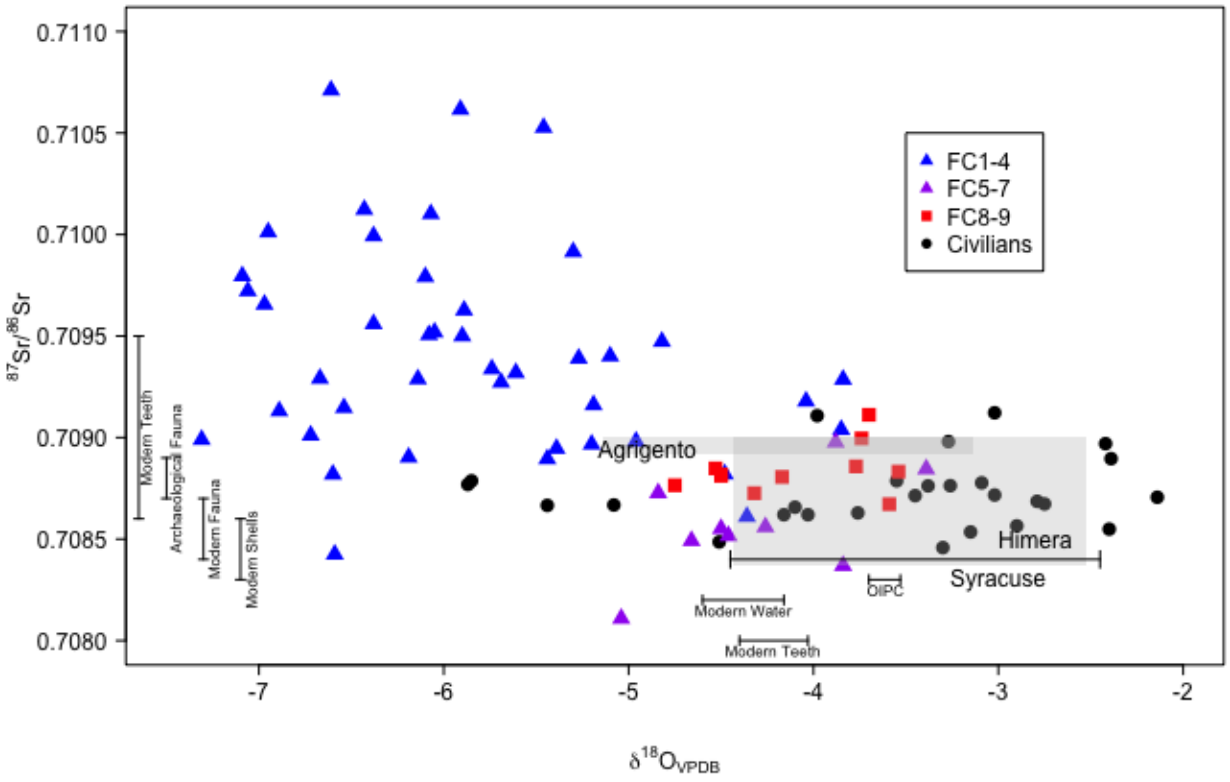

Figure 7.1. Modified Figure 6.3 with separation between FC1-4 and FC5-7.

7.2.3 Issue of mercenaries

The presence of non-locals in the first battle in 480 BCE strongly suggests the use of mercenaries. It is well established at this point that Greek mercenary soldiers were used in foreign armies (Hdt 8.26.52, 7.165; Thuc.I.60; Griffin 2005). Herodotus himself is clear about the presence of mercenaries in the Carthaginian army that attacked Himera (Hdt. 7.165). However, there is limited physical evidence of mercenaries outside of the Greek world being employed by Greek armies. Mercenaries in Greek Sicily likely started out as bodyguards for tyrants. Literary sources suggest Hippocrates of Gela hired indigenous Sicels for his army (Polyaen 5:6). Gelon hired Greek mercenaries from Arcadia after succeeding Hippocrates as tyrant of Gela in the 5th century BCE (Graells 2014; Trundle 1996; Trundle 2004). As time went

on and Greek tyrants such as Gelon began to seek more and more land, the use of bodyguards and fighters unrelated to the general populace would have increased to further their military and their colonial exploits on the island. While Gelon is not explicitly said to have hired foreign mercenaries for his army in 480 BCE, by 466 BCE the tyranny in Syracuse is abolished and Diodorus mentions that Gelon enfranchised 7,000 of 10,000 foreign mercenaries (*xenosmisthophoros*), allowing them to remain in the city as citizens, despite the displeasure it roused among the rest of the citizenship (Diod. 11.72). As discussed in chapter 2, Sicilian tyrants were known for pushing the boundaries when it came to military practices, the hiring and later paying for mercenary support being one example.

While historical sources do point to aid and alliances with Syracuse and Agrigento, the isotopic baselines expected for those regions of Sicily are almost indistinguishable from Himera's local baseline. Therefore, it is significant that the isotopic values of some of the soldiers are much higher in $^{87}Sr/^{86}Sr$ and lower in $\delta^{18}O$, very different than the regions from where aid was known to have come, suggesting these non-local soldiers may not have only come from Sicily, but much further afield.

7.2.4 Origins of the mercenaries

The large range in isotopic values not common in Sicily clearly shows that soldiers came from areas outside of the island to participate in the first Battle of Himera. We now must consider from where these mercenaries were coming. Greeks were known to fight in foreign armies as mercenaries, so it is possible Greeks originally from the mainland could have fought in the Battles of Himera. However, mainland Greece was entrenched in the Persian Wars during the first battle, with some historians reporting the battle inf 480 BCE occurred on the same day as

the Battle of Salamis. Generals from Athens even contacted Gelon, urging him to send troops to aid the Greek force against the Persians (Hdt 7.145, 7.158). It seems that if there were mainland Greek mercenaries looking for battle, they would not have had to look further than their own homeland. Sicily was an advantageous location with far more resources than mainland Greece, so it's possible the soldiers would have chosen to travel further from home for the increased economic gain. Payment in coinage for mercenaries was only thought to be common after the first Battle of Himera so money would not have enticed potential mercenaries in 480 BCE, though some mercenaries were paid with land and citizenship (Diod 11.72).

It is reported that there were Iberians fighting as mercenaries in the Carthaginian army (Hdt 7.165). It is possible that soldiers from further west of Sicily, far more removed from the Persian Wars, could have also joined the Greek side. There were several Greek colonies in Iberia (Dietler and López-Ruiz 2009) so these soldiers could themselves have been Greek while fighting against their Iberian neighbors.

Regardless of their origins and motivations, isotopic evidence suggests people from distant regions joined the fight at Himera. If they were all of Greek origin, it is significant that Greeks from all over the Mediterranean would have joined together at the same time in two great military pursuits against foreign powers – the Battle of Himera and the Persian War. The greater-good of Greek influence and power was being attacked from both sides and defended by people who may have had common beliefs, language, and culture.

Military power creates different avenues for people to become engaged, such as through identity, shared cultural values, and economic gain. If the soldiers were not all of Greek origin, it is impactful that this battle drew in a diverse group of people, locals and non-locals, to fight for a common cause. While the prospect of economic gain is a huge motivator, it is still critical to

evaluate how peoples' pursuit of economic gain can lead them to engage in risky, violent behavior.

7.3 Exploring the lifestyle of soldiers from the Battles of Himera: Dietary variation among different soldier groups and civilians

Prediction 3 stated that soldiers will exhibit carbon and nitrogen isotope differences compared to civilians, indicative of different diets. Considering the confounding problem that people from different geographic points of origin may have different diets, and the likelihood that some individuals at Himera were non-locals, I also tested Prediction 3(a) that among individuals determined to be locals on the basis of strontium, lead, and oxygen isotope analysis, local soldiers will show carbon and nitrogen isotope differences compared to local civilians, indicative of different diets within a community where local soldiers were provisioned differently than local civilians.

7.3.1 Comparing soldiers' diet to civilians and between different battle contexts

The soldiers from the later Battle of Himera (409 BCE) have similar diets to the local civilians. The soldiers from the first Battle of Himera (480 BCE) have a large range of diets that are characterized by higher (less-negative) $\delta^{13}C$ values. The higher $\delta^{13}C$ values could be the result of cultural backgrounds that had a larger C_4 component or a higher marine content in the diet.

There are no differences in $\delta^{15}N$ values between groups of soldiers and civilians suggests that there was no group with significantly more access to animal protein. It also indicates that the soldiers with higher $\delta^{13}C$ values were not likely to have been consuming larger fish from the

Mediterranean, which would have been high in both $\delta^{13}C$ and $\delta^{15}N$ but could indicate the consumption of lower trophic position fish, such as sardines and anchovies, which have been shown to have high $\delta^{13}C$ but low $\delta^{15}N$ (Bachiller et al., 2020).

The variation in dietary isotopes found among the soldiers and between the soldiers of 480 BCE and civilians indicates that these signatures represent the consumption of different foodstuffs. This suggest that the majority of the soldiers from 480 BCE had culturally-different diets than the diets of Himera. The dietary isotopes from the general populace of Himera are not greatly different from other Greek contexts (Table 3.2), which hints that the disparate isotopic values from 480 BCE could indicate culturally non-Greek populations. This finding strongly suggests the presence of foreign mercenaries at the first Battle of Himera.

7.3.2 Multivariate analyses of diet at Himera

As mentioned previously, $\delta^{13}C$ from collagen ($\delta^{13}Ccoll$) should reflect the values of a person's dietary protein, while $\delta^{13}C$ from apatite ($\delta^{13}Cap$) reflects the overall diet or the values in their dietary energy source. It is important to utilize models that combine different dietary isotopes to explore contributions of different foods. The first model used here will be the Kellner and Schoeninger (2007) model which provides more details on the isotopic values of whole diet and protein by considering both $\delta^{13}C$ from apatite and collagen. The second model combines $\delta^{15}N$ with the other two to attempt to distinguish between protein from C_4 sources and marine protein (Froehle et al., 2012). When using $\delta^{13}C$ to look at protein sources, note this is from the protein from the plants as well as protein from animals who consumed those plants. The use of both models is especially important for an ancient Greek warfare context because historical texts and recent isotopic work are conflicting on whether individuals at Greek colony sites would have

consumed significant amounts of fish, even when it would have been a readily provisioned source of food for soldiers, especially those who may have traveled by sea.

Figure 7.2 presents the bivariate carbon model lines from Kellner and Schoeninger (2007), according to δ δ^{13}Ccoll and δ^{13}Cap. All soldiers and civilians are aligned with the C_3 protein line, indicating the majority of their protein was coming from C_3 plants or animals consuming C_3 plants. Some soldiers, especially from 480 BCE have increased C_4 energy contributions, suggesting they had consumed more C_4 plants than civilians or soldiers from 409 BCE.

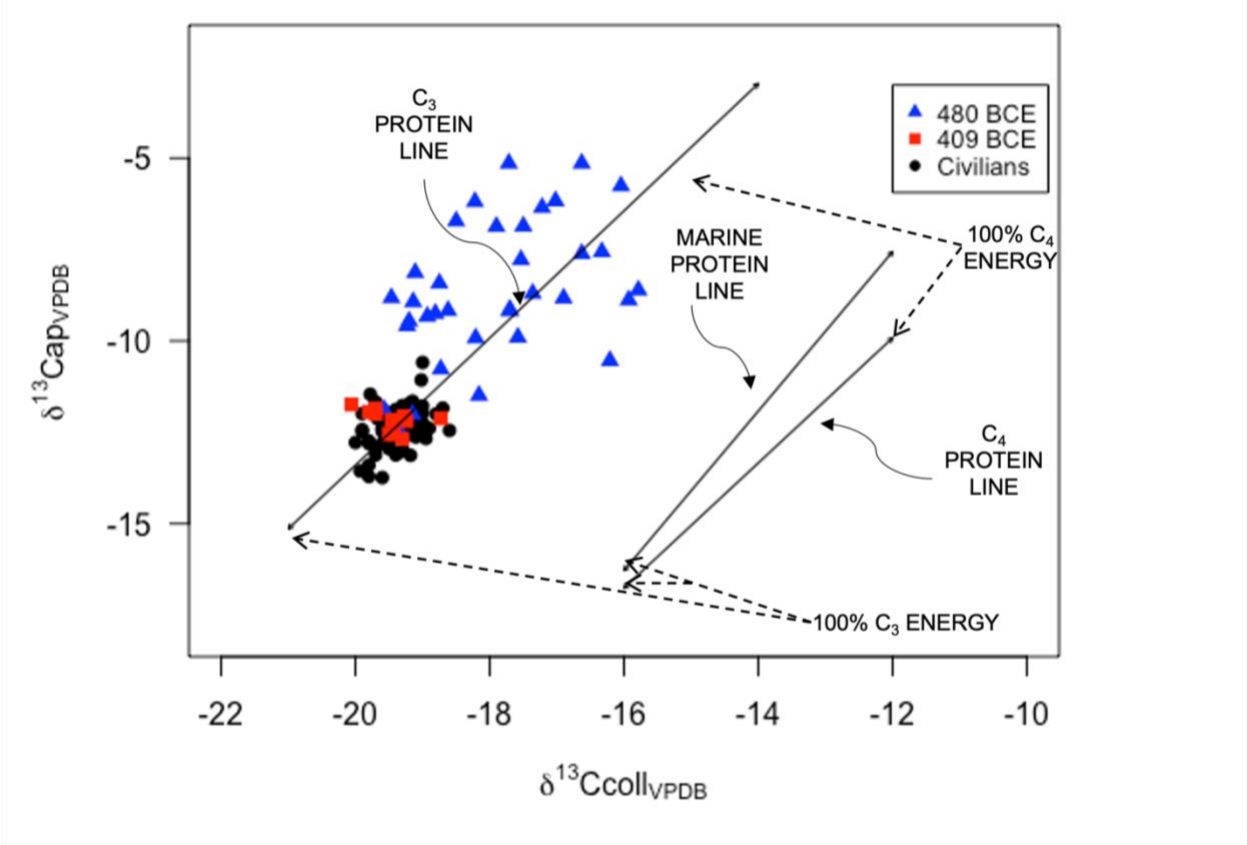

Figure 7.2. δ^{13}Ccoll vs δ^{13}Cap plot with the bivariate carbon model lines from Kellner and Schoeninger (2007).

I then plotted the data from Himera with the archaeological sample discriminant function scores from Froehle and colleagues (2012) (Figure 7.3). Figure 7.4 presents a three-dimensional plot of all dietary isotopes, δ^{13}Ccoll, δ^{13}Cap, and δ^{15}N. The majority of the civilians and soldiers from the 409 BCE battle plot within values indicative of a high C_3 diet with a majority of C_3 protein. Soldiers from 480 BCE have similarly high C_3 diet and protein, with some (n = 6) suggesting a majority C_4 overall diet but maintaining the majority protein from C_3 sources. Using Froehle and colleagues (2012), there is no evidence that the soldiers nor the civilians were consuming fish or had a large C_4 protein component. However, this model is limited in its ability to distinguish between lower trophic positioned fish, such as anchovies and sardines. These types of fish have lower δ^{15}N and δ^{13}C values that would not map on with the types of marine fish used to create the model (Richards et al., 2020). The current model indicates that while some soldiers from 480 BCE were consuming C_4 plants (seen in overall C_4 diet), it is less likely they were consuming animals who were fed C_4 plants (common grazing fodder such as grasses). It is possible that the soldiers from 480 BCE came from regions that consumed more C_4 plants, instead of the C_3 plants most common in Sicily at the time. Higher contributions of C_4 in the diet is uncommon in Classical Greek Sicily because wheat (a C_3 plant) was one of the largest crops and highest export for the island.

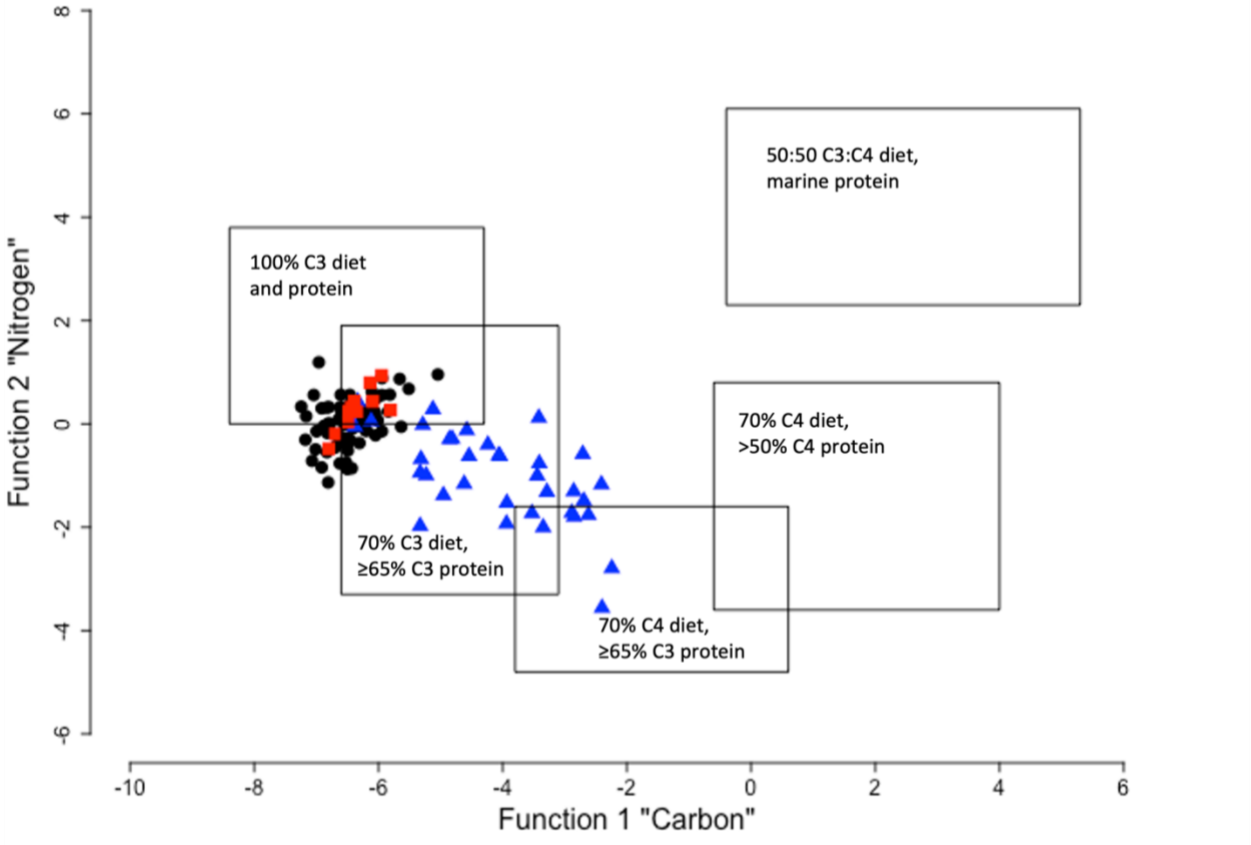

Figure 7.3. Data plotted with archaeological sample discriminant function scores from Froehle and colleagues (2012). Isotopic data were converted using the Carbon (1) and Nitrogen (2) functions calculated (Froehle et al., 2012).

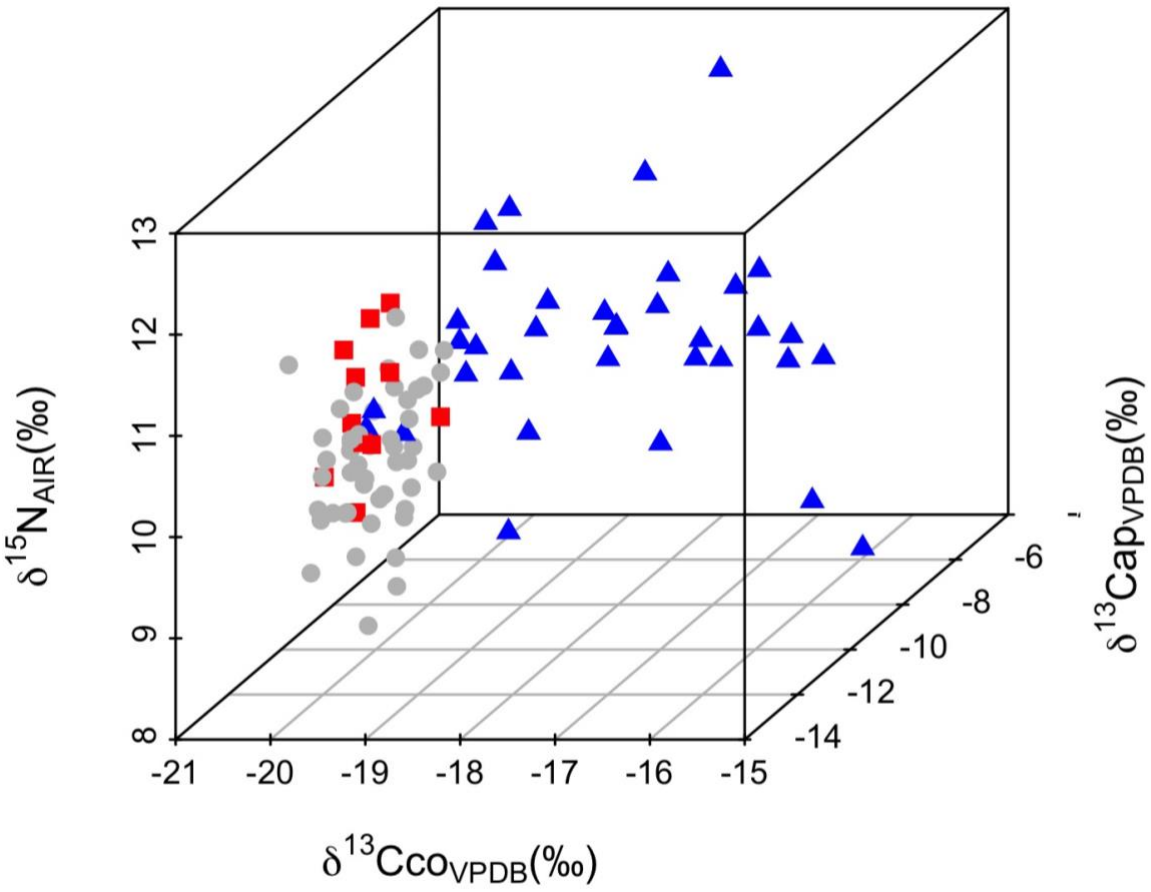

Figure 7.4. Three-variable plot of dietary isotopes, δ^{13}Ccoll δ^{13}Cap and δ^{15}N. This figure is comparing soldiers from the 480 BCE battle (blue triangles), soldiers from the 409 BCE battle (red squares) and civilians (gray circles).

7.3.3 Dietary variation among locals

For Prediction 3(b), I evaluated the δ^{13}Ccoll and δ^{15}N of individuals considered local based on $^{87}Sr/^{86}Sr$ values (Figure 7.5). The civilians and soldiers from 409 BCE who are local have similar diets that are not significantly different for both δ^{13}C and δ^{15}N (Mann-Whitney: W=23.5, p-value=0.51; W=40, p-value=0.31; respectively). Even among the several individuals from 480 BCE who are local, there are significant differences in δ^{13}C values for both the 409

BCE soldiers and the civilians (Mann-Whitney: W=6, p-value=0.002; W=48, p-value=0.012; respectively). Local soldiers with higher $\delta^{13}C$ values indicate that soldiers, especially from the first battle of 480 BCE, may have had different diets, regardless of place of origin. This provides some evidence for the possibility of distinguishing a soldier class from the civilians. This finding partially supports Prediction 3(b) which said local soldiers will show carbon and nitrogen isotope differences compared to local civilians. While most local soldiers and local civilians had similar diets, there are a few outliers which suggest some soldiers were considered part of society separate from civilians and provided or provisioned different foods.

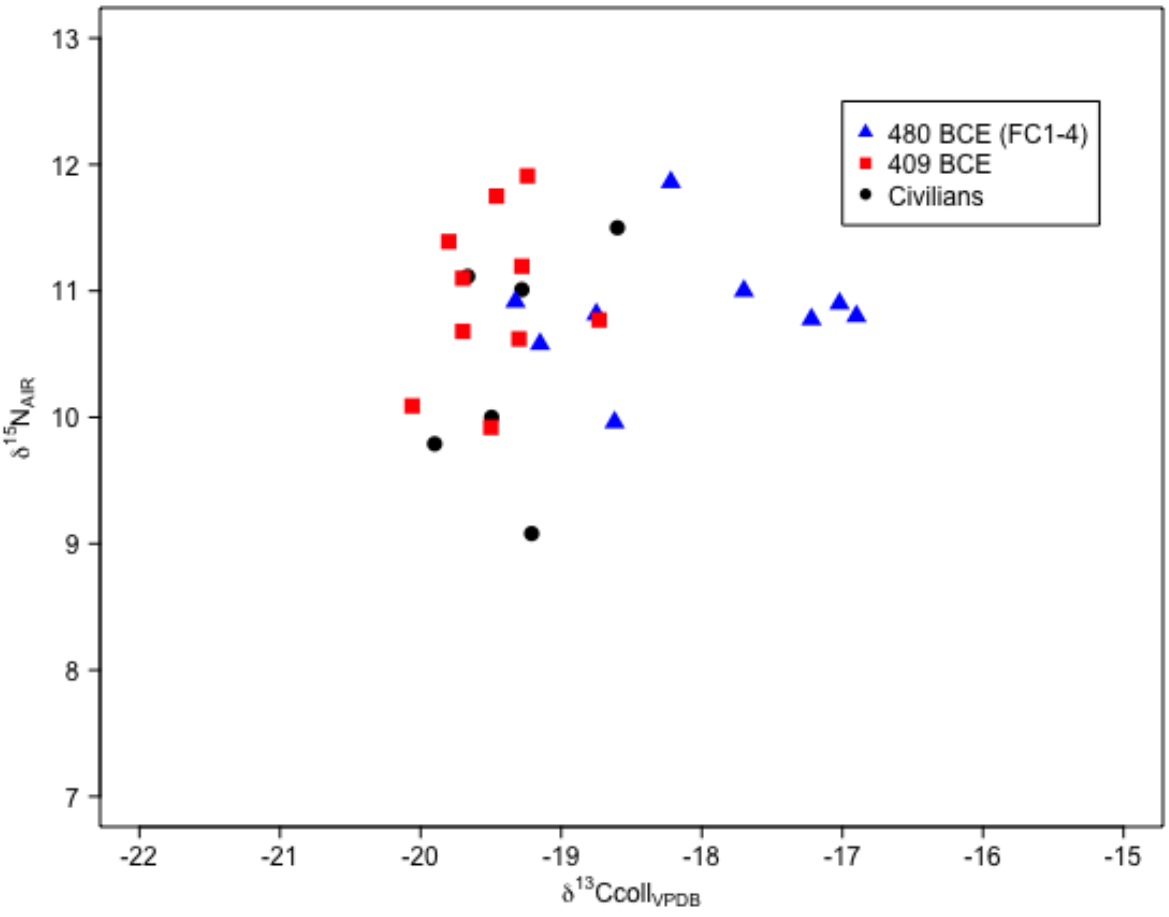

Figure 7.5. $\delta^{13}C$ and $\delta^{15}N$ values of individuals with $^{87}Sr/^{86}Sr$ signatures that suggest local origins.

7.4 The role of mercenaries in Sicilian society: Body politic and the craft specialization of mercenary soldiers

The relationship between military advancements and changes in political structures has been extensively studied in ancient Greece. Pitsoulis (2011), in particular, connects the adoption of majority rule and democratic institutions to the increase of political participation of citizens as they were recruited into military participation. These elements were increasingly integrated as a way to resolve conflicts between new members of the citizen population and the old, elite classes. The rise of hoplite warfare is deeply entangled with the rise of the early *polis* through the "hoplite orthodoxy" (Kagan and Viggiano 2013). This orthodoxy explains that there was a change in fighting style because of innovations in the shield construction. The new phalanx structure depended on cohesion of the group to keep all members of the phalanx covered by the shields. To keep fighting efficient, it was necessary to increase the number of hoplite soldiers, and thus the number of citizens eligible to fight had to grow (Kagan and Viggiano 2013). In this case, there is a direct relationship between the development of the city-state, its class structures and state institutions, and military service.

With a different economic lens, it has been recognized that with state formation comes a reorganization of class structures and state institutions which has created conditions where craft production and social property relations are restructured, creating craft specialization (Patterson 2005). Furthermore, in these new conditions, part of the traditional craft production and work are subsumed by the state. I argue that the same phenomenon was happening in the 5th century BCE, especially in Sicily, and later in the 4th century for mainland Greece, for the restructuring of Greek warfare with the introduction and more formal use of mercenaries in armies. The formation of city-states as a result of colonization, particularly in Sicily, began with the

relationship between the mother city and its colony, and then developed according to the political and social conquests of the tyrants (Griffin 2005). In terms of occupational specialization within a larger economy, mercenaries are similar to merchants and artisans, except instead of objects and materials, they are specializing in military skill and, in a way, commodifying their bodies.

To understand the role that mercenaries play in the larger economy, it is necessary to look at the development of economic systems as a result of colonization. The biggest issue in the study of colonization has traditionally been the potential causes. In the 5th century, parts of the Mediterranean, especially Greece, were dealing with class conflict and overpopulation. Some emphasize overpopulation and land hunger, which are seen as relating to each other or separated based on the inability of the land to feed all the people in climatic crisis, and not just about absolute population size, while others stress commercial motives and political explanations (Osborne, 1997). Pomeroy and colleagues (1999) emphasize the wealth inequality in mainland Greece that contributed to emigration and colonization. The widening economic inequality produced tensions between the few rich who owned most of the land and the many poor who wanted land (Pomeroy et al., 1999). There were two major causes of the expansion: the search for sources of metal and the hope of acquiring land required to live the life of a citizen in the new *poleis* (Pomeroy et al., 1999). The increase in people in mainland Greece created pressure on resources, which encouraged agricultural innovation and competition between groups of people (Osborne, 2009).

Mercenary service was one method for individuals to achieve economic gain and combat the overpopulation in regions where they were from as mercenaries were often quite mobile. Military service during this time was treated as an honorable way to increase social reputation, which was heavily emphasized by the works of Homer. However, Classical Greek society

criticized mercenaries as paid soldiers, referring to them with derogatory terms such as "wage earner" *misthophoros,* separating them from social classes who saw wages as deprecatory. Additionally, the shifting allegiances of mercenaries offended ideals of citizenship and loyalty (Tagliamonte 1994) and a disdain for mercenaries is evident in the writings of Herodotus and other Classical period authors (Hdt. 8.26.1) (Lavelle 1986). Greek society separated military service in the service of one's home from military service to get ahead, but it was still a common, and sometimes necessary, option. This is especially true in the 4th century when warfare became more frequent and the economic situation worsened in Greece (Whitehead 1991), increasing the number of mercenaries as more citizens were hired to escape poverty (Griffin 2005). With changing economic conditions in parts of the Mediterranean, military service became an advantageous avenue for prosperity, regardless of the risks involved, both physical and social.

Mercenary soldiers participated in a form of craft production where they specialized their own bodies as part of a craft of violence and technique on the battlefield. "Since artisans and producers are members of communities that exert varying degrees of control over the means of production and their conditions of work, the states and their associated classes strive to protect and reproduce those institutions that provide them with the labor power and knowledge of the direct producers" (Brenner 1986: 48-49). The body politic allows us to consider mercenary military prowess and their bodies as a form of "means of production," connecting mercenary bodies to the economic benefit of individuals and the state. Furthermore, prior to the late 5th century when mercenaries were starting to receive payment of coin and money, individual soldiers were paid for their service in land and citizenship rights, a privilege normally only available to male, Greek landowners.

In the same way that craft production begins with the individual and can become subsumed by the state as specialization increases, as mercenaries began to specialize more, it became advantageous for the government to harness these skills and hire more mercenaries for their own gain (Patterson 2005; Griffin 2005). Instead of monetary gain seen with craft specialization, mercenaries provided a mechanism for tyrants to achieve more political power. Increased political power is evidenced by more control over more cities and land, often increasing the available resources and economic power at the tyrant's disposal. This process began with tyrants hiring mercenaries as bodyguards and would lead to the eventual hiring of entire armies of mercenaries by a centralized government, even without the lead of a tyrant. As the ruler acquires more mercenaries, they gain control over a higher cut of people willing to engage in violence for economic gain.

Considering this process from a bottom-up approach, it was also advantageous for mercenaries to become part of these larger groups. Mercenary soldiers on their own were not able to gather and hold onto the same amount of capital as a they were when they operated as a collective under someone with existing resources and capital. This allowed mercenaries to operate in a unit alongside citizen soldiers who were fighting for the more "traditional" motivations of protecting their home. Again, a mercenary soldier can specialize and be an expert in their practice of violence, but are only so powerful as a single individual. Citizen soldiers continued to be a part of the military structure until the 4th century BCE and were present at the Battles of Himera. However, these citizen soldiers likely played other roles in society and were often at odds with the tyrants because of forced migrations and political strife (Lomas 2006). In this way, the specialized craft of the military bodies shapes the body politic of the military unit and society.

Brenner (1986) argues that modern economic growth requires the break-up of precapitalist property relations (producers' possession and exploiters' surplus extraction) by economic extraction. Brenner further maintains that this break-up is the unintended consequence of relations of reproduction of individual actors and the conflicts between classes. These transformations are more common in precapitalist societies where the direct producers possess the means of production as individuals and the state and upper classes extract goods and labor directly from the individual production rather than from the community as a whole. The increase of mercenaries, extracted individually by the tyrants of Sicily, allowed for the economic growth of the region to the benefit of both tyrants and mercenaries, as well as the whole community in times of military success. Examples of this economic growth can be seen in the creation of coinage for the payment of mercenaries, first seen in Sicily. The production of large amount of currency to pay troops first appeared under Gelon in 479 BCE (Harris 2020).

Harris (2020) recognized this process directly in Sicily: highlighting the transition between rulers recruiting a large number of mercenaries to fight for them and balancing the movement of mercenaries around the island with methods to integrate soldiers into new social, economic, and political environments. Harris argues that the tyrants' hegemony became long-lasting because of the integration of non-Greek soldiers into armies and subsequently granting them full citizenship rights, something that is seen in the troops at Himera (2020). In Scheper-Hughes and Lock's (1987) description of the body politic, they emphasize how societies regularly reproduce and socialize the kind of bodies they need. With this in mind, the Sicilian tyrants found ways to incorporate foreign mercenaries into their armies and communities, first with bodyguards and then through larger scale use in their armies. The pressures from the society

influenced by tyrants alongside fundamental Greek values of bravery and strength, created an environment where men could apply their bodies for economic and social gain.

The military force in 480 BCE Battle of Himera was characterized by a group of men likely from different backgrounds based on where they were from and what they grew up eating. The political powers of Himera likely encouraged a more flexible, collective body politic on the community to allow differences in identity to come together. Body politic would have been based on the tyrants' need for soldiers who became specialized in their military craft. Traditional separations, such as being from different places, would not have been as important because of the need for a strong, fighting unit. Malkin has discussed how with greater distance, Greeks began to recognize their sameness, creating similar cultural practices that linked colonies to their mother city (2003). In the first Battle of Himera, the people were potentially not even Greek, but may have recognized their sameness in other ways, such as a bonding over shared economic pursuits with violent actions. These specialized bodies, from disparate regions of the Mediterranean, were joined together by a body politic that allowed for connection based on engaging in violence for economic gain. As discussed earlier, mercenaries likely recognized the power they had as a collective unit. They were able to acquire more economic capital, either through land or money, when fighting under someone with existing resources and social and political capital.

Body politic is the way political and social forces shape the bodies of society, often it can mean a forceful shaping of bodies to look the same if that's what the political forces think is necessary (Scheper-Hughes and Lock 1987), therefore it is interesting that people of many different backgrounds were able to fight and die together. The body politic has been a way for societies to exclude members based on not fitting into their model (see examples in Scheper-

Hughes and Lock 1987), but the body politic also been a useful lens to observe how in Greek Sicily, under the rule of tyrants, soldiers came together in the pursuit of economic gain to fight alongside potential strangers.

The 5th century BCE after the first Battle of Himera was characterized by political instability and military exploits for Syracuse and little mention of Agrigento in the historical record. Following the death of Gelon in 478 BCE, Hieron I becomes the tyrant of Syracuse until his death in 466 BCE. The only mention of Agrigento is the death of Theron in 472 BCE, though the first Battle of Himera ended in an agreement for Syracusan control over Agrigento, so it's likely Hieron I was considered the ruler for both cities at this time. Following Hieron I's death, riots in Syracuse lead to an oligarchic government in the mid-5th century. There is a period of peace following a peace proposal by Syracuse in 424 BCE in which a number of Greek cities came together in the Congress of Gela. Just prior to the later battle of Himera in 409 BCE, Syracuse is becoming politically powerful and cause for concern by the mainland Greeks and the Carthaginians, who both respond to calls for aid from Segesta. Athens attacks first in 415 BCE as part of their Sicilian Expedition but subsequently is defeated by Syracuse in 413 BCE. Shortly after, the Carthaginians invade Sicily and sack Selinunte, Himera, Agrigento, Gela, and Camarina from 409 to 406 BCE.

The army in 409 BCE all had more similar values so represent a group of men who likely interacted before the war, maybe even grew up together (had the same place of origin and similar diets). While not entirely clear what the political situation of Himera, there is no mention of one strong general or leader of the Himeran army so was likely an oligarchic regime, similar to Syracusan politics at the time. The army in 409 BCE would have been a mix of all available citizens, with the possibility of some mercenaries. The generally younger group of soldiers (Viva

et al., 2020) may not have been as trained or as organized but did likely have similar backgrounds.

7.5 The role of mercenaries in Mediterraneanization

Migration through trade and colonization is considered the primary mechanism for Greek culture to have spread across the Mediterranean (i.e. Hellenization), likely because it is the most visible, though is vaguely documented by ancient historians and sometimes replaced with grand foundation stories and focus on stability (Harris 2020; Moatti 2006). While Sicily's population was possibly considered unstable in ancient times, the mixed populations and mobility characterizing Sicily also allowed for the transfer of people, goods, and ideas which created a supra-*polis* system and unified regions (Harris 2020). Additionally, these connections built networks of reciprocity. Mercenaries, in many ways, especially in Sicily's geographically advantageous position, created a connection between the western and eastern parts of the Mediterranean.

There has been much research on the connectivity of Sicily, often evidenced by objects found at archaeological sites. An important issue in anthropology is whether those objects are directly connected to people from those diverse regions or if they were simply brought in through trade. The skeletal remains of mercenaries provide a direct line of evidence of a mobile population and isotopic analysis allows us to understand how far reaching was the connectivity of Greek Sicily.

Morris (2003) coined the term Mediterraneanization to bring focus to the process of the Mediterranean Sea becoming interconnected, as opposed to the static form, with discreet moments where people were less connected or more connected (Mediterraneanism).

Mercenaries, by using their bodies as specialized craft, contributed to this process of connection in micro- and macro-migrations. Travelling as individuals, or possibly small units, would make them not as detected in the material and historical record, the methods usually used to study those periods of more or less interconnectedness. Putting the focus on mercenaries, allows us to consider the many ways that the Mediterranean was connected and shows how an individual participates in the process of connection.

Another part of Mediterraneanization is the development of Greek identity. The social migration from mercenary to citizen impacts ideas of citizenship and identity within the *poleis* in Sicily, providing a pathway for "barbarians" or outsiders to the *poleis* to gain access to the rights of citizens (Trundle 1996; Trundle 2004; Tagliamonte 1994, Lomas 2006, Harris 2020; Sekunda 2013). The hoplite soldier was a symbol for other social changes in the ancient Greek world, such as the rise of the middle class (Bintliff 2012) in the Classical period. Malkin (2003) explains that as Greeks in new colonies began copying each other in cultural, religious, and artistic practices, they created new models in the political community that were further spread to new communities while also reflecting on the older, mainland communities, creating what we now understand as ancient Greek culture. It is possible that the use of mercenary soldiers created a similar phenomenon: changing the body politic of future armies and subsequent rules of citizenship. What it meant to be a Greek citizen seems to have left out the idea of foreigners, but modern scholarship is challenging this idea, pointing to the edges of the Greek world, the colonies, where new avenues were found to incorporate traditionally non-Greek communities into Greek society and culture.

Greek colonial life in the Classical period was based on equality among the elite citizens. This equality was defined in terms of equal landownership and citizenship, where citizens were

expected to be active participants in political, cultural, and military activities of the urban center. These colonies were communities of urban farmers, given equal sized plots of land but living within walled cities. However, there were many other groups that colonies were dependent on for their economic function. These other people with various biological, cultural and ethnic identities, were present in the physical spaces, but not necessarily the political spaces because they were not considered part of the colonial communities based on Greekness, citizenship and equality (Zuchtriegel 2017). Traditionally, everyone who were not male citizens and landowners, such as women, non-Greek, artisans, servants and slaves, children, and rural communities, were excluded from political life and not considered equal.

Citizenship meant having a role in political life and was often reserved for wealthier men with Greek heritage. It was rare for foreigners to have a way into this highly esteemed position because, traditionally, one had to be Greek. Zuchtriegel (2017) argues that colonies were subject to more cultural hybridization that overtime challenged the ideologies of the traditional colony and complicated subsequent dichotomies between citizen and noncitizen, Greek and barbarian, urban and rural, etc. Zuchtriegel (2017) makes a link between subalternity and hybridity in these communities: as more cultural hybridization occurs, the lines between the different groups become blurred and spaces are created for subaltern identities such as non-Greeks and artisans to exert their power. Additionally, participation in warfare often provided opportunities for citizens to become more politically powerful, as well as affording an avenue for outsiders to become citizens through landownership.

CHAPTER 8:

CONCLUDING COMMENTS

8.1 Introduction

Human skeletons from the Battles of Himera offered an unprecedented opportunity to evaluate historical accounts of the Battles recorded by Diodorus Siculus and Herodotus, and to evaluate the composition of Greek armies in the Classical period. Stable isotope ratios from mass graves associated with the Battles of Himera support ancient historians' accounts of a Greek alliance that saved Himera in 480 BCE and promoted Gelon, the tyrant of Syracuse, to a celebrated ruler in Sicily. The soldiers aiding Himera in 480 BCE likely included foreign mercenaries, which could have included those already in Syracuse hired by Gelon. The first Battle of Himera in 480 BCE is one of the first major military campaigns in Greek warfare to include the widespread use of mercenaries. The wide range of isotopic values of soldiers from 480 BCE points to a key role played by foreign mercenaries in the Greek victory, expanding on the information ancient authors elect to emphasize. The isotopic data also supports ancient authors' claims that Himera was unaided in 409 BCE, leading to its demise.

This dissertation has provided an important example of how warfare, through mercenaries, was another mechanism of connectivity in the ancient Mediterranean, moving beyond typical studies of trade and colonization. This study has also revealed more about the composition of armies and cross-checked historical records. Additionally, this research combines the disciplines of Classics through ancient literature, anthropology, bioarchaeology, and isotopic

analysis in an interdisciplinary way to illuminate the connections between the soldiers, military practices, and the larger Mediterranean from a variety of perspectives. At the end of this chapter, I will explore limitations of the current study and ideas for future directions.

8.2 Connectedness in the ancient Mediterranean

The movement of people across the Mediterranean through colonization has been a widely studied and recorded series of events in history. Previous research focused on the unidirectional exchange of culture and practices from Greek populations (Dunbabin 1948), but more recently has moved to a focus on the local responses of various communities to the colonial movement of people (Hodos 2006; Morris 1999). However, the overwhelming emphasis on colonization and these larger, more visible migration events has clouded the study of smaller movements of people. Horden and Purcell (2000) noted that the low-level, smaller scale movements leave behind less evidence and so are harder to document and study.

People were constantly moving across the Mediterranean, creating connections with and knowledge about the distant shores and their peoples (Horden and Purcell, 2000; Osborne, 2009). This dissertation provides an important case study of one such type of movement that was happening constantly, and not just as part of colonial events or migration for the purpose of settling in a new area. The economic pursuit of mercenary soldiers provided the impetus for the large-in-geographic-scale movement of a determined few. Additionally, while historical evidence focuses on warfare, looking at the mercenaries as individuals coming together for a common cause allows us to consider mechanisms of cooperation and alliances between these specialists in war.

Using isotope analysis has allowed me to consider these soldiers as individuals, buried alongside soldiers with disparate backgrounds. Considering the many ways that human lives intersect with others and understanding those interpersonal relationships is at the forefront of anthropology. Human interaction is a central focus in anthropology and bioarchaeology. In this dissertation, I have shown evidence that mercenaries played an important role in the connectedness in the past and that the movement of people across the Mediterranean happened in many ways.

8.3 Composition of armies: case study from the Battles of Himera, Sicily, Italy

This dissertation incorporated an innovative theoretical framework to build on past research of how ancient military forces were constructed and mobilized. An anthropological perspective on warfare connects human behavior in the past with wider global conditions in which individuals were interacting (Martin and Harrod 2015; Walker 2001). This dissertation used battle mortuary data within the framework of the body politic to situate our understanding of how institutions can shape the goals and actions of diverse communities, ultimately bringing them together, even in situations of conflict.

This dissertation has increased our understanding of the Himera assemblages, providing isotopic insight on where these soldiers came from and what their diet was like. In addition, I have bolstered the historical narrative of human conflict in this time period, elucidating the high prevalence of non-local soldiers in Greek armies in Sicily.

8.4 Cross-checking historical records

Greek historians were some of the earliest to write down their people's stories and histories. Most written records of similar antiquity have been lost through time, ensuring a permanent, leading role for the ancient sources that remain as sources of knowledge of the past (James 2013). Because they cannot be replaced, and because they are not only works of art but unique sources of otherwise inaccessible historical details, critically evaluating literary sources for their fidelity using other available evidence is useful and warranted. The present study supports the fidelity of ancient records of the Battles of Himera in documenting the divergent outcomes of battles aided by others versus fought alone. However, the ethnocentric accounts of ancient authors downplay the true heterogeneous nature of the Greek colonies and armies, discounting the use of mercenaries, likely to align the victory at Himera with other prominent Greek victories across the Mediterranean (e.g. Salamis). Foreign mercenaries played an important role in the military prowess of some Greek armies as early as 480 BCE, and reflect the diversity of ancient communities in the western Mediterranean (Griffin 2005). Not only does the discovery of foreign mercenary forces clarify the history of the first Battle of Himera, it also transforms our understanding of who lived and had power and privilege in Sicily during the Classical period.

By comparing the isotopic ratios of soldiers to those from other regions, I conclude the soldiers had diverse geographic origins ranging through the Mediterranean and likely beyond. This contrasts previous interpretations based on historical documents of the soldiers as Greek or even more narrowly, Himeran. The discovery of foreign soldiers, likely mercenaries, presented here is uniquely possible through the interdisciplinary emphasis this study takes on individuals using archaeological chemistry, by describing the geographic histories of individual men,

plugged into the much broader context of ancient historians' accounts. Hiring foreign mercenaries has broader significance related to community formation in the Classical period and suggests that warfare was a key source of culture contact and human mobility, in addition to colonial developments and trade.

The use of ancient written histories was imperative for contextualizing the isotopic data presented here. The limited available studies on military practices using methods from archaeology or bioarchaeology meant the historical sources were often the best source of information. In this dissertation, I have challenged the particulars of ancient historians' writing, but also acknowledge the combination of these ancient texts and more recent scholarly analysis of them, were an integral part of the interdisciplinary approach, combining traditional sources of information from the humanities with innovative theories from bioanthropology research and methods from biogeochemistry and bioarchaeology.

8.5 Broader implications for bridging anthropology, bioarchaeology, Classics, and isotope analysis

In this dissertation, I have built on research in multiple disciplines, including anthropology, bioarchaeology, history, and classics. The results of this study provide a narrative of major events in classical history and provide insight into the social construction of peoples' lives and society's ability to affect daily activities and long-term actions. Bioarchaeology has given key insight into the impacts of warfare across the globe (Eerkens et al., 2016; Holder et al., 2017; Sparacello et al., 2015). Lived experiences encompassed by violence can become embodied into skeletal and dental tissue, reflecting cultural, political, economic, and biological changes in a person's life, as well as individual practices. Skeletal remains can be used to

understand the lived experiences of soldiers and others embroiled in violent warfare. Much bioarchaeological research, however, continues to homogenize soldiers' experiences, looking at armies as singular units and not made up of individual actors, so forgets to address the variations in lived experiences of individuals (Martin and Harrod 2015). The isotopic analysis of the soldiers from the Battles of Himera is an important first step in uncovering the individual identities.

8.6 Limitations and future directions

This dissertation has increased the amount of available isotopic data in the Mediterranean and especially for Sicily. There is growing interest in completing isotopic analysis at archaeological sites in this region as it is a focal point in many studies of Greek and Phoenician colonization. One limitation of this dissertation is the limited amount of baseline data used for comparison of presented isotopic values. This was in part due to gaining access to suitable comparative fauna, both archaeological and modern. Future directions with this research would be to create a more robust database of baseline information, including fauna, soil, and water for use in future isotopic studies. A similar undertaking was completed by Nafplioti (2011) in the Aegean region and Tafuri and colleagues (2016) in Southeastern Italy on $^{87}Sr/^{86}Sr$. A similar study focused on Sicily and more of southern Italy would be useful to a large number of scholars, those focused on the region in particular, such as researchers on colonization in Magna Graecia, and those needing a comparison for their own regions of study. Particular focus will be on lead data to improve 1) lead baselines in the Mediterranean and 2) my interpretations specific to the preliminary lead data presented her.

Another future direction is to develop quantitative geographic assignments. A similar undertaking was done by Bataille and colleagues (2021) to assess the origin of local animals and humans from Brittany, France. They used a novel sulfur isoscape and existing strontium and oxygen isoscapes of Western Europe, and applied a triple isotopes continuous-surface probabilistic geographic assignment. A continuous-surface probabilistic assignment framework determines the probability of origin of individuals by comparing the isotopic composition of the individual isotopes with that of the corresponding isoscape (Bataille et al., 2021). Bataille and colleagues (2021) created a new $\delta^{34}S$ (sulfur) isoscape and I plan to create a Pb isoscape that can be used in tandem with $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ isoscapes. A future direction will be to use this analysis to find potential, more specific, origins of the soldiers.

The difference in context suggests the identities of soldiers buried in FC1-4 and those in FC5-7 differed by place of origin, with FC1-4 representing almost entirely non-local, while FC5-7 are local and were likely buried by friends or family. I would like to explore the soldiers buried in FC5-7 and do further comparisons between them and the soldiers buried in FC1-4. The archaeological evidence suggests differences in burial treatment for soldiers in FC5-7 and isotopically there were differences between the two groups with soldiers from FC5-7 being more local. However, poor preservation in bone collagen did not allow for $\delta^{13}C$ and $\delta^{15}N$ analysis on any of the soldiers from FC5-7. To further advance a better understanding of the identities of the soldiers and how coming from disparate cultural backgrounds would have affected the psychological willingness to fight for a foreign cause, I would like to attempt collagen extraction on the dentine, which can often be better preserved than bone collagen. Understanding the diets of the potentially elite soldiers in FC5-7 is important to know to look for patterns other aspects of

daily life, not just geographic origins, such as in how certain ranks of soldiers were treated and provisioned.

Future research would explore potential lines of cultural memory between the battles. Diodorus Siculus is very clear that in the 409 BCE battle the grandson of the Carthaginian general who was killed in the 480 BCE battle sought to destroy Himera to avenge his grandfather. While the Temple of Victory in the lower city of Himera and the Temple of Athena in Syracuse would have remained permanent symbols of the Greek's victory over the Carthaginians, there is no mention in the historical sources that soldiers in the later battle were related to those who fought in 480 BCE. It is certainly likely that the grandsons and great-grandsons, or grand-nephews, of those soldiers were part of the effort in 409 BCE, but currently there is no clear evidence. Interestingly, while the mercenaries in 480 BCE would have been more likely to have the non-local isotopic signatures, their grandchildren, if they were born and raised in Sicily, would now be considered local by the isotopic analysis. Further aDNA and biodistance analysis would need to be done to make clear links between individual soldiers and to look for potential family groups. Additionally, as part of the research into cultural memory, I will also explore how the idea of cultural memory has been discussed in historical texts. To do this, I will investigate different accounts of battles in the Classical period, in addition to other historical events described in ancient texts and evaluate when each account was written and by whom.

Future work that addresses the previously discussed limitations and further questions of interest within the theoretical framework, methods, and results of this dissertation will provide more insight into the construction of military units and the movement of people in the Mediterranean during the Classical period in Sicily. The study presented here provides an

appropriate theoretical and methodological framework to address how the lived experiences of soldiers elucidate the recruitment practices and the role of the military in connecting the broader Mediterranean.

REFERENCES CITED

Adamesteanu D. 1958. Scavi e scoperte nella provincia di Caltanisetta dal 1951 al 1957. Notizie degli Scavi di antichità. 12:290-307.

Adcock FE. 1957. The Greek and Macedonian Art of War. University of California Press.

Agarwal SC, Glencross BA. 2011. Building a Social Bioarchaeology. In: Agarwal SC, Glencross BA, editors. Social Bioarchaeology. New York, NY: Wiley-Blackwell. p 1–11.

Alarcia VC, Reitsema LJ, Kyle B, Vassallo S. 2017. Intermarriage and hybridity at an ancient Greek colony: Oxygen stable isotope analysis at Himera in Sicily. Am J Phys Anthropol, 162, 95.

Allegro N. 2000. Imera. In: Greco E, editor. La Città Greca Antica: Instituzioni, Società e Forme Urbane. Rome: Donzelli Editore. p 269–301.

Ambrose SH. 1990. Preparation and characterization of bone and tooth collagen for isotopic analysis. J Archaeol Sci 17:431–451.

Ambrose SH, DeNiro MJ. 1986. The isotopic ecology of East African mammals. Oecologia 69:395-406.

Ambrose SH, Norr L. 1993. Experimental Evidence for the Relationship of the Carbon Isotope Ratios of Whole Diet and Dietary Protein to Those of Bone Collagen and Carbonate. In: Prehistoric Human Bone. Berlin. p 1–37.

Antonaccio CM. 2005. Excavating colonization. In Hurst H, Owen S, eds. Ancient colonizations: analogy, similarity and difference. London: Duckworth. pp 97-113.

Armelagos GJ. 1990. Health and disease in prehistoric populations in transition. In: Swedlund AC, Armelagos GJ, editors. Disease in Populations in Transition: Anthropological and Epidemiological Perspectives. New York: Bergin and Garvey. p 127-144.

Asheri D, Lloyd A, Corcella A. 2008. A Commentary on Herodotus. Books I-IV. Oxford: Oxford University Press.

Bachiller E, Albo-Puigserver M, Giménez J, Pennino MG, Marí-Mena N, Esteban A, Lloret-Lloret E, Jadaud A, Carro B, Bellido JM, Coll M. 2020. A trophic latitudinal gradient revealed in anchovy and sardine from the Western Mediterranean Sea using a multi-proxy approach. Sci Rep 10:1–18. Available from: https://doi.org/10.1038/s41598-020-74602-y

Balco W. 2012. Tri-Nodal Social Entanglements in Iron Age Sicily: Material and Social Transformation. F Notes A J Coll Anthropol 3:24–35.

Bardunias P, Ray F. 2016. Hoplites at War: A Comprehensive Analysis of Heavy Infantry Combat in the Greek World, 750-100 BCE. Jefferson, NC: McFarland & Company, Inc.

Bataille CP, Bowen GJ. 2012. Mapping $^{87}Sr/^{86}Sr$ variations in bedrock and water for large scale provenance studies. Chem Geol 304–305:39–52. http://dx.doi.org/10.1016/j.chemgeo.2012.01.028

Bataille CP, Crowley BE, Wooller MJ, Bowen GJ. 2020. Advances in global bioavailable strontium isoscapes. Palaeogeogr Palaeoclimatol Palaeoecol 555:1–18.

Bataille CP, Jaouen K, Milano S, Trost M, Steinbrenner S, Crubézy É, Colleter R. 2021. Triple sulfur-oxygen-strontium isotopes probabilistic geographic assignment of archaeological remains using a novel sulfur isoscape of western Europe. PLoS One 16:1–21.

Beard B, Johnson C. 2000. Strontium isotope composition of skeletal material can determine the birth place and geographic mobility of humans and animals. J Forensic Sci 45:1049–1061.

Belvedere O. 2001. Il territorio di Himera e il problema della chora coloniale in Sicilia. In: Stazio A, editor. Problemi della chora coloniale dall'Occidente al Mar Nero: Atti del quarantottesimo convegno di studi sulla Magna Grecia, Taranto, 29 settembre–3 ottobre 2000. Taranto. p 707–755.

Bentley RA. 2006. Strontium isotopes from the earth to the archaeological skeleton: A review. J Archaeol Method Theory 13:135–187.

Bintliff J. 2012. The Complete Archaeology of Greece: From Hunter-Gatherers to the 20th Century AD. Chichester: Wiley-Blackwell.

Bogaard A, Heaton THE, Poulton P, Merbach I. 2007. The impact of manuring on nitrogen isotope ratios in cereals: archaeological implications for reconstruction of diet and crop management practices. J Archaeol Sci 34:335–343.

Boschian G. 1988. Note geoarcheologiche sul territorio di Himera. In: Himera 3: prospezione archeological nel territorio. Rome: L'erma di Bretschneider. p 49–62.

Bourbou C, Fuller BT, Garvie-Lok SJ, Richards MP. 2011. Reconstructing the diets of Greek Byzantine populations (6th-15th centuries AD) using carbon and nitrogen stable isotope ratios. Am J Phys Anthropol 146:569–581. http://dx.doi.org/10.1002/ajpa.21601

Bowen GJ, Revenaugh J. 2003. Interpolating the isotopic composition of modern meteoric precipitation. Water Resour Res 39:1299.

Bowen GJ, Wilkinson B. 2002. Spatial distribution of $\delta^{18}O$ in meteoric precipitation. Geology 30(4): 315-318. doi: https://doi.org/10.1130/0091-7613(2002)030<0315:SDOOIM>2.0.CO;2

Braudel F. 2001. The Mediterranean in the Ancient World. Translated by Reynolds S. London: Penguin Books Ltd.

Brenner R. 1986. The social basis of economic development. In: Roemer J, editor. Analytical Marxism. Cambridge: Cambridge University Press. p 23-53

Brettell R, Montgomery J, Evans J. 2012. Brewing and stewing: The effect of culturally mediated behaviour on the oxygen isotope composition of ingested fluids and the implications for human provenance studies. J Anal. At. Spectrom 27:778–785.

Catalano R. 2004. Geology of Sicily: An introduction. Bocconea 17:33–46.

Cernenko EV. 1983.The Scythians. In: Windrow M, editor. Men-at-Arms series Vol. 137. London: Osprey Publishing Ltd. p 1310–1310.

Chandezon C. 2015. Animals, meat, and alimentary by-products: Patterns of production and consumption. In: Wilkins J, Nadeau R, editors. A Companion to Food in the Ancient World. Chichester: Wiley Blackwell. p 135–146.

Chenery CA, Pashley V, Lamb AL, Sloane HJ, Evans JA. 2012. The oxygen isotope relationship between the phosphate and structural carbonate fractions of human bioapatite. Rapid Commun Mass Spectrom 26:309–319.

Chisholm BS, Nelson DE, Schwarcz HP. 1982. Stable-carbon isotope ratios as a measure of marine versus terrestrial protein in ancient diets. Science 216:1131–1132.

Colleter R, Bataille CP, Dabernat H, Pichot D, Hamon P, Duchesne S, Labaune-Jean F, Jean S, Le Cloirec G, Milano S, Trost M, Steinbrenner S, Marchal M, Guilbeau-Frugier C, Telmon N, Crubézy É, Jaouen K. 2021. The last battle of Anne of Brittany: Solving mass grave through an interdisciplinary approach (paleopathology, biological anthropology, history, multiple isotopes and radiocarbon dating). PLoS One 16(5): e0248086. https://doi.org/10.1371/journal.pone.0248086

Collin-Bouffier S. 1987. L'alimentation en eau de la colonie grecque de Syracuse: Réflexions sur la cité et sur son territoire. Mélanges de l'école française de Rome. 99(2):661–691.

Collin-Bouffier S. 2009. La gestion de l'eau en Sicile grecque: etat de la question. Pallas Rev d'etudes Antiq Press Univ du Mirail 79:65–79.

Collins MJ, Nielsen-Marsh CM, Hiller J, Smith CI, Roberts JP, Prigodich R V., Wess TJ, Csapò J, Millard AR, Turner-Walker G. 2002. The survival of organic matter in bone: A review. Archaeometry 44:383–394.

Continto A. 1988. Geologia e geomorfologia della bassa valle dell'Imera settentrionale. In: Himera 3: prospezione archeological nel territorio. Rome: L'erma di Bretschneider. p 25–48.

Coplen TB. 1988. Normalization of oxygen and hydrogen isotope data. Chem Geol Isot Geosci Sect 72:293–297.

Crouch DP. 2003. Geology and Settlement: Greco-Roman Patterns. Oxford: Oxford University Press.

Cvetkoska A, Levkov Z, Reed JM, Wagner B. 2014. Late Glacial to Holocene climate change and human impact in the Mediterranean: The last ca. 17ka diatom record of Lake Prespa (Macedonia/Albania/Greece). Palaeogeogr Palaeoclimatol Palaeoecol 406:22–32.

Dalby, A., 1996. Siren feasts: A history of food and gastronomy in Greece. London: Routledge.

Danielson JJ, Gesch DB. 2011. Global multi-resolution terrain elevation data 2010 (GMTED2010). Available from: http://pubs.er.usgs.gov/publication/ofr20111073

Dansgaard W. 1964. Stable isotopes in precipitation. Tellus 16(4):436–468.

Daux V, Lécuyer C, Adam F, Martineau F, Vimeux F. 2005. Oxygen isotope composition of human teeth and the record of climate changes in France (Lorraine) during the last 1700 years. Clim Change 70:445–464.

De Angelis F. 2002. Trade and agriculture at Megara Hyblaia. Oxford J Archaeol 21:299–310.

De Angelis F. 2006. Going against the grain in Sicilian Greek economics. Greece Rome 53:29–47.

De Angelis F. 2016. Archaic and Classical Greek Sicily. Oxford University Press.

DeNiro MJ. 1985. Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction. Nature 317:806–809.

DeNiro MJ, Epstein S. 1978. Influence of diet on the distribution of carbon isotopes in animals. Geochim Cosmochim Acta 42:495–506.

DeNiro MJ, Epstein S. 1981. Influence of diet on the distribution of nitrogen isotopes in animals. Geochim Cosmochim Acta 45:341–351.

Dickin AP. 2005. Radiogenic isotope geology. Cambridge: Cambridge University Press.

Dietler M. 2007. Culinary encounters: food, identity, and colonialism. In: Twiss KC, editor. The Archaeology of Food and Identity. Carbondale: Center for Archaeological Investigations, Southern Illinois University Carbondale. p 218–242.

Dietler M. 1998. Consumption, agency, and cultural entanglement. In: Cusick J, editor. Studies in culture contact: Interaction, culture change, and archaeology. Carbondale: Center for Archaeological Investigations, Southern Illinois University Carbondale. p 288–315.

Dietler M, López-Ruiz C. 2009. Colonial encounters in Ancient Iberia. Chicago: University of Chicago Press. Pp 339.

Dudás FÖ, LeBlanc SA, Carter SW, Bowring SA. 2016. Pb and Sr concentrations and isotopic compositions in prehistoric North American teeth: A methodological study. Chemical Geology 429:21-32.

Dunbabin TJ. 1948. The Western Greeks. The History of Sicily and South Italy from the Foundation of the Greek Colonies to 480 B.C. Oxford: Clarendon Press.

Eerkens JW, Carlson T, Malhi RS, Blake J, Bartelink EJ, Barfod GH, Estes A, Garibay R, Glessner J, Greenwald AM, Lentz K, Li H, Marshall CK. 2016. Isotopic and genetic analyses of a mass grave in central California: Implications for precontact hunter-gatherer warfare. Am J Phys Anthropol 159:116–125.

Emery MV, Stark RJ, Murchie TJ, Elford S, Schwarcz HP, Prowse TL. 2018. Mapping the origins of Imperial Roman workers (1st-4th century CE) at Vagnari, Southern Italy, using $^{87}Sr/^{86}Sr$ and $\delta^{18}O$ variability. Am J Phys Anth 166(4):837-850.

Epstein SR. 1992. An Island for Itself: Economic Development and Social Change in Late Medieval Sicily. Cambridge.

Erdkamp P. 2015. Supplying cities. In: Wilkins J, Nadeau R, editors. A companion to food in the ancient World. Chichester: Wiley Blackwell. p 183–192.

Ericson JE. 1985. Strontium isotope characterization in the study of prehistoric human ecology. J Hum Evol 14:503–514.

Ezzo JA. 1994. Putting the “chemistry” back into archaeological bone chemistry analysis: Modeling potential paleodietary indicators. J Anthropol Archaeol 13:1.

Faure G, Mensing TM. 2004. Isotopes: principles and applications. New York: John Wiley & Sons.

Faure G, Powell JL. 1972. Strontium isotope geology. Berlin: Springer-Verlag. Pp 188

Froehle AW, Kellner CM, Schoeninger MJ. 2012. Multivariate caron and nitrogen stable isotope model for the reconstruction of prehistoric human diet. Am J Phys Anth 147:352-369.

Fry B. 2006. Stable isotope ecology. New York, NY: Springer Science+Business Media B.V.

Garnsey P. 1999. Food and society in Classical Antiquity. Cambridge: Cambridge University Press.

Garvie-Lok SJ, Varney TL, Katzenberg MA. 2004. Preparation of bone carbonate for stable isotope analysis: The effects of treatment time and acid concentration. J Archaeol Sci 31:763–776.

Goodman AH. 2010. The biological consequences of inequality in antiquity. In: Leatherman TL, Goodman AH, editors. Building a New Biocultural Synthesis: Political-Economic Perspectives on Human Biology. Ann Arbor: University of Michigan Press. p 147–169.

Goodman AH, Leatherman TL. 1998. Traversing the chasm between biology and culture: An introduction. In Leatherman TL, Goodman AH, eds. Building a new biocultural synthesis: Political-economic perspectives on human biology. Ann Arbor: University of Michigan Press. pp 3-41.

Gosden C. 2004. Archaeology and colonialism: Cultural contact from 5000 BC to the present. Cambridge: Cambridge University Press.

Graells I. Fabregat R. 2014. Mistophoroi ex Iberias: Una aproximación al mercenariado hispano a partir de las evidencias arqueológicas (s. VI - IV a.C.). Italy: Osanna Edizioni.

Green P. 2010. Diodorus Siculus, The Persian Wars to the Fall of Athens. Austin: University of Texas Press.

Gregoricka LA, Sheridan SG. 2017. Continuity or conquest? A multi-isotope approach to investigating identity in the Early Iron Age of the Southern Levant. Am J Phys Anth 162:73-89.

Gremillion KJ. 2011. Ancestral appetites: Food in prehistory. Cambridge: Cambridge University Press. pp 198.

Griffin MJ. 2005. The tyrannies in the Greek cities of Sicily: 505-466 BC. PhD Dissertation, University of Leeds.

Gustafson G, Koch G. 1974. Age estimation up to 16 years of age based on dental development. Odontol Revy 25(3);297-306

Håkansson S. 1976. University of Lund Radiocarbon Dates VII. Radiocarbon 16:307–330.

Hale JR. 2013. Not patriots, not farmers, not amateurs: Greek soldiers of fortune and the origins of hoplite warfare. In: G. V, D. K, editors. Men of Bronze: Hoplite Warfare in Ancient Greece. Princeton: Princeton University Press. p 176–193.

Hanson VD. 2000. The Western way of war: Infantry battle in Classical Greece. Berkeley: University of California Press. pp 271.

Hare PE, Fogel ML, Stafford TW, Mitchell AD, Hoering TC. 1991. The isotopic composition of carbon and nitrogen in individual amino acids isolated from modern and fossil proteins. J Archaeol Sci 18:277–292.

Harris J. 2020. The power of movement: mercenary mobility and empire building in Sicily during the Classical Period. In: Jonasch M, editor. The Fight for Greek Sicily: Society, Politics, and Landscape. Oxford: Oxbow Books. p 130–153.

Haynes V. 1968. Radiocarbon: Analysis of inorganic carbon of fossil bone and enamel. Science 161(3842):687–688.

Heaton THE, Vogel JC, Von La Chevallerie G, Collett G. 1986. Climatic influence on the isotopic composition of bone nitrogen. Nature 322:822–823.

Hedges REM, Lee-Thorp JA, Tuross NC. 1995. Is tooth enamel carbonate a suitable material for radiocarbon dating? Radiocarbon 37:285–290.

Hedges REM, Clement JG, Thomas CDL, O'Connell TC. 2007. Collagen turnover in the adult femoral mid-shaft: Modeled from anthropogenic radiocarbon tracer measurements. Am J Phys Anthropol 133:808–816.

Henneberg RJ, Henneberg M. 2003. The diet of the Metapontine population as reconstructed from the physical remains. In: Living Off the Chora: Diet and Nutrition at Metaponto. Institute. Austin: Prieto A. and Carter J. C. p 29–36.

Hitch S. 2015. Sacrifice. In: Wilkins J, Nadeau R, editors. A Companion to Food in the Ancient World. Chichester: Wiley Blackwell. p 337–347.

Hodos T. 2006. Local responses to colonization in the Iron Age Mediterranean. London: Routledge.

Holder S, Dupras TL, Jankauskas R, Williams L, Schultz J. 2017. Reconstructing diet in Napoleon's Grand Army using stable carbon and nitrogen isotope analysis. Am J Phys Anthropol 163:53–63.

Horden P, Purcell N. 2000. The corrupting sea: A study of Mediterranean history. Oxford: Blackwell. Pp 761.

Hornblower S. 2008. Greek identity in the Archaic and Classical Periods. In: Zacharia K, editor. Hellenisms. Ann Arbor: University of Michigan Press. p 37–58.

Howarth RJ, McArthur JM. 1997. Statistics for strontium isotope stratigraphy: A robust LOWESS fit to the marine Sr-isotope curve for 0 to 206 Ma, with look-up table for derivation of numeric age. J Geol 105:441–456.

Huelga-Suarez G, Diez-Fernández S, Moldovan M, Pardiñas AF, López B, Ignacio García Alonso J. 2016. The quest for the soldier's rest: Combining anthropological and archaeochemical approaches to study social and occupational diversity in the medieval graveyard of San Andrés de arroyo (Palencia, Spain). Anthropol Sci 124:169–184.

Hunt P. 2001. Slaves, warfare, and ideology in the Greek Historians. Cambridge: Cambridge University Press.

James S. 2013. The archaeology of war. In Campbell B and Tritle LA, eds. The Oxford Handbook of Warfare in the Classical World. Oxford: Oxford University Press p 91-127.

Kagan D, Viggiano G. 2013. The hoplite debate. In: Viggiano G, and Kagan D, editors. Men of bronze: Hoplite warfare in ancient Greece. Princeton: Princeton University Press. pp 1-56.

Kamenov GD. 2008. High-precision Pb isotopic measurements of teeth and environmental samples from Sofia (Bulgaria): Insights for regional lead sources and possible pathways to the human body. Environ Geol 55:669–680.

Kamenov GD, Mueller P, and Perfit M. 2004. Optimization of mixed Pb-Tl solutions for high precision isotope analyses by MC-ICP-MS, J. Anal. At. Spectrom. 19:1262-1267.

Kamenov GD, Perfit, MR, Mueller PA, Jonasson IR. 2008. Controls on magmatism in an island arc environment: study of lavas and sub-arc xenoliths from the Tabar-Lihir-Tanga-Feni island chain, Papua New Guinea. Contrib. Mineral. Petrol. 155:635-656.

Katzenberg MA. 2008. Stable Isotope Analysis: A Tool for Studying Past Diet, Demography, and Life History. In: Katzenberg MA, Saunders SR, editors. Biological Anthropology of the Human Skeleton. Hoboken: John Wiley & Sons. p 413–442.

Kazmi AC., Reitsema LJ, Reinberger KL, Kyle B, Vassallo S. 2017. Cultural hybridity and Greek colonization of Sicily: A case study of Himera utilizing strontium isotope analysis. Am J Phys Anthropol 162:240–240.

Keenleyside A, Schwarcz HP, Panayotova K. 2011. Oxygen isotopic evidence of residence and migration in a Greek colonial population on the Black Sea. J Archaeol Sci 38:2658–2666.

Keenleyside A, Schwarcz H, Panayotova K. 2006. Stable isotopic evidence of diet in a Greek colonial population from the Black Sea. J Archaeol Sci 33:1205–1215.

Keenleyside A, Schwarcz H, Stirling L, Ben Lazreg N. 2009. Stable isotopic evidence for diet in a Roman and Late Roman population from Leptiminus, Tunisia. J Archaeol Sci 36:51–63.

Kellner CM, Schoeninger MJ. 2007. A simple carbon isotope model for reconstructing prehistoric human diet. Am J Phys Anthropol 133:1112–1127.

Knudson KJ, Tung TA. 2011. Investigating regional mobility in the southern hinterland of the Wari empire: Biogeochemistry at the site of Beringa, Peru. Am J Phys Anthropol 145:299–310.

Knusel C, Smith MJ. 2014. Introduction: The bioarchaeology of conflict. In: Knusel C, Smith MJ, editors. The Routledge Handbook of the Bioarchaeology of Human Conflict. London: Routledge. p 3–24.

Koch PL, Tuross N, Fogel ML. 1997. The effects of sample treatment and diagenesis on the isotopic integrity of carbonate in biogenic hydroxylapatite. J Archaeol Sci 24:417–429.

Kontopoulos I, Sampson A. 2015. Prehistoric diet on the island of Euboea, Greece: An isotopic investigation. Mediterr Archaeol Archaeom 15:97–111.

Kral AG, Ziegler A, Tütken T, Geisler T. 2021. Experimental aqueous alteration of cortical bone microarchitecture analyzed by quantitative micro-computed tomography. Front Earth Sci 9:609496. doi: 10.3389/feart.2021.609496

Krieger N, Smith GD. 2004. "Bodies count," and body counts: Social epidemiology and embodying inequality. Epidemiol Rev 26:92–103.

Kron G. 2015. Agriculture. In: Wilkins, John, Nadeau, Robin (Eds.), A Companion to Food in the Ancient World. Wiley Blackwell, Chichester, pp. 174–196.

Krueger HW. 1991. Exchange of carbon with biological apatite. J Archaeol Sci 18:355–361.

Krueger HW, Sullivan CH. 1984. Models for Carbon Isotope Fractionation Between Diet and Bone. In: Turnland JR, Johnson PE, editors. Stable Isotopes in Nutrition. Washington, D.C.: American Chemical Society. p 205–220.

Kyle B, Reitsema LJ, Tyler J, Fabbri PF, Vassallo S. 2018. Examining the osteological paradox: Skeletal stress in mass graves versus civilians at the Greek colony of Himera (Sicily). Am J Phys Anthropol 167:161–172.

Lagia A. 2015. Diet and the polis: An isotopic study of diet in Athens and Laurion during the Classical, Hellenistic and Imperial Roman Periods. In: Papathanasiou A, Richards MP, Fox SC, editors. Archaeodiet in the Greek world: dietary reconstruction from stable isotope analysis. Princeton: The American School of Classical Studies at Athens. p 119–145.

Larsen CS. 2015. Bioarchaeology: Interpreting behavior from the human skeleton. Cambridge: Cambrdige University Press.

Lavelle BM. 1986. Herodotus on Argive misthotoi. Liverpool Class Mon 11:150.

Lee-Thorp JA, van der Merwe NJ. 1991. Aspects of the chemistry of modern and fossil biological apatites. J Archaeol Sci 18:343–354.

Lee JWI. 2007. A Greek army on the march: Soldiers and survival in Xenophon's Anabasis. Cambridge: Cambridge University Press.

Lee JWI. 2008. Warfare in the Classical Age. In: Kinzi KH, editor. A Companion to the Classical Greek World. John Wiley & Sons. p 480–508.

Lee JWI. 2013. The Classical Greek experience. In: Campbell B, Tritle LA, editors. The Oxford Handbook of Warfare in the Classical World. Oxford. p 142–161.

Leppard TP, Esposito C, Esposito M. 2020. The bioarchaeology of migration in the ancient Mediterranean: Meta-analysis of radiogenic ($^{87}Sr/^{86}Sr$) isotope ratios. J Mediterr Archaeol 33:211–241.

Livingstone FB. Anthropological implications of sickle cell gene distribution in West Africa. American Anthropologist 60(3): 533-562.

Lomas K. 2006. Tyrants and the polis: migration, identity and urban development in Sicily. In: Lewis S, editor. Ancient Tyranny. Edinburgh: Edinburgh University Press. p 94–116.

Longin R. 1971. New method of collagen extraction for radiocarbon dating. Nature 230:241-242.

Longinelli A. 1984. Oxygen isotopes in mammal bone phosphate: A new tool for paleohydrological and paleoclimatological research? Geochim Cosmochim Acta 48:385–390.

Lonoce N, Palma M, Viva S, Valentino M, Vassallo S, Fabbri PF. 2018. The Western (Buonfornello) necropolis (7th to 5th BC) of the Greek colony of Himera (Sicily, Italy): Site-specific discriminant functions for sex determination in the common burials resulting from the battle of Himera (ca. 480 BC). Int J Osteoarchaeol 28:766–774.

Lukacs JR. 1991. Localized enamel hypoplasia of human deciduous canine teeth: Prevalence and pattern of expression in rural Pakistan. Human Biology 63(4):513-522.

Luraghi N. 1994. Tirannidi arcaiche in Sicilia e Magna Grecia: Da Panezio di Leontini alla caduta dei Dinomenidi. Firenze: L.S. Olschki.

Luz B, Kolodny Y, Horowitz M. 1984. Fractionation of oxygen isotopes between mammalian bone-phosphate and environmental drinking water. Geochim Cosmochim Acta 48:1689–1693.

Lyons C, Bennett M, Marconi C. 2013. Sicily: Art and invention between Greece and Rome. Los Angeles: Getty Publications.

Malainey ME. 2011. A Consumer's Guide to Archaeological Science: Analytical Techniques. New York: Springer Science+Business Media B.V.

Malkin I. 2003. Networks and the Emergence of Greek Identity. Mediterr Hist Rev 18:56–74.

Malkin I. 2011. A Small Greek World: Networks in the Ancient Mediterranean. Oxford: Oxford University Press.

Mannino MA, Catalano G, Talamo S, Mannino G, Di Salvo R, Schimmenti V, Lalueza-Fox C, Messina A, Petruso D, Caramelli D, Richards MP, Sineo L. 2012. Origin and diet of the prehistoric hunter-gatherers on the Mediterranean island of Favignana (Egadi Islands, Sicily). PLoS One 7:1–12.

Mannino MA, Thomas KD, Leng MJ, Di Salvo R, Richards MP. 2011. Stuck to the shore? Investigating prehistoric hunter-gatherer subsistence, mobility and territoriality in a Mediterranean coastal landscape through isotope analyses on marine mollusc shell carbonates and human bone collagen. Quat Int 244:88–104.

Martin DL, Harrod RP, Pérez VR. 2013. Bioarchaeology: An integrated approach to working with human remains.

Martin DL, Harrod RP. 2015. Bioarchaeological contributions to the study of violence. Am J Phys Anthropol 156:116–145.

McKechnie P. 1989. Outsiders in the Greek Cities in the Fourth Century BC (Routledge Revivals). London: Routledge. New York: Springer. Pp 276.

Mercuri AM, Allevato E, Arobba D, Mazzanti MB, Bosi G, Caramiello R, Castiglioni E, Carra ML, Celant A, Costantini L, Di Pasquale G, Fiorentino G, Florenzano A, Guido M, Marchesini M, Lippi MM, Marvelli S, Miola A, Montanari C, Nisbet R, Peña-Chocarro L, Perego R, Ravazzi C, Rottoli M, Sadori L, Ucchesu M, Rinaldi R. 2006. Pollen and macroremains from Holocene archaeological sites: A dataset for the understanding of the bio-cultural diversity of the Italian landscape. Rev Palaeobot Palynol 218:250–266.

Minagawa M, Wada E. 1984. Stepwise enrichment of 15N along food chains: Further evidence and the relation between δ15N and animal age. Geochim Cosmochim Acta 48:1135–1140.

Mitchell PD, Millard AR. 2009. Migration to the medieval Middle East with the crusades. Am J Phys Anthropol 140:518–525.

Moatti C. 2006. Translation, migration, and communication in the Roman empire: Three aspects of movement in history. Classical Antiquity 25(1):109-140.

Morris I. 1991. Burial and Ancient Society: The Rise of the Greek City-State. Cambridge: Cambridge University Press.

Morris I. 2003. Meditrraneanization. Mediterr Hist Rev 18:30–55.

Morris I, Jackman T, Garnard B, Blake E, Tusa S, Agozzino P, Hnatiuk T, Mahood G, Meskell L, Schon R, Stika HP. 2004. Stanford University excavations on the Acropolis of Monte Polizzo, Sicily, IV: Preliminary report on the 2003 season. Mem Am Acad Rome 49:197–279.

Nafplioti A. 2008. "Mycenaean" political domination of Knossos following the Late Minoan IB destructions on Crete: negative evidence from strontium isotope ratio analysis ($^{87}Sr/^{86}Sr$). J Archaeol Sci 35:2307–2317.

Nafplioti A. 2011. Tracing population mobility in the Aegean using isotope geochemistry: A first map of local biologically available $^{87}Sr/^{86}Sr$ signatures. J Archaeol Sci 38:1560–1570.

O'Connell TC, Kneale CJ, Tasevska N, Kuhnle GGC. 2012. The diet-body offset in human nitrogen isotopic values: A controlled dietary study. Am J Phys Anthropol 149:426–434.

Osborne R. 1997. Early Greek colonization? The nature of Greek settlement in the West. In: Fisher N, van Wees H, editors. Archaic Greece: New approaches and new evidence. London: Duckworth with The Classical Press of Wales. p 251–269.

Osborne R. 2009. Greece in the Making, 1200-479 BC. London: Routledge.

Panter-Brick C. 2010. Conflict, violence, and health: Setting a new interdisciplinary agenda. Soc Sci Med 70:1–6.

Papathanasiou A, Richards MP. 2015. Summary: Patterns in the Carbon and Nitrogen Isotope Data through Time. In: Papathanasiou A, Richards MP, Fox SC, editors. Archaeodiet in the Greek World: Dietary Reconstruction from Stable Isotope Analysis, OWLS volume 2. Princeton: The American School of Classical Studies at Athens. p 195–203.

Patterson TC. 2005. Craft specialization, the reorganization of production relations and state formation. J Soc Archaeol 5:307–337.

Pestle WJ, Crowley BE, Weirauch MT. 2014. Quantifying inter-laboratory variability in stable isotope analysis of ancient skeletal remains. PLoS ONE 9(7): e102844. https://doi.org/10.1371/journal.pone.0102844

Piez KA. 1984. Molecular and aggregate structures of the collagens. In Piez KA, Reddi AH, editors. Extracellular matrix biochemistry. New York: Elsevier. p 1-39.

Pin, C., and Bassin, C., 1992, Evaluation of a Sr-specific extraction chromatographic method for isotopic analyses in geological materials. Analytica Chimica Acta, 269, p.249-255.

Pitsoulis A. 2011. The egalitariuan battlefield: Reflections on the origins of majority rule in archaic Greece. European Journal of Political Economy 27:87-103

Pomeroy SB, Donlan W, Roberts JT BSM. 1999. Ancient Greece: A political, social, and cultural history. Oxford: Oxford University Press.

Price TD, Burton JH, Bentley RA. 2002. The characterization of biologically available strontium isotope ratios for the study of prehistoric migration. Archaeometry 44:117–135.

Price TD. 2014. An introduction to the isotopic studies of ancient human remains. J North Atl 7:71–87.

Price TD, Manzanilla L, Middleton WD. 2000. Immigration and the ancient city of Teotihuacan in Mexico: A study using strontium isotope ratios in human bone and teeth. J Archaeol Sci 27:903–913.

Pritchett KW. 1985. The Greek State at War, Part IV. Berkeley: University of California Press.

Prowse TL, Schwarcz HP, Saunders S, Macchiarelli R, Bondioli L. 2004. Isotopic paleodiet studies of skeletons from the Imperial Roman-age cemetery of Isola Sacra, Rome, Italy. J Archaeol Sci 31:259-272

Prowse TL, von Hannius TE, Barta JL. 2010. Stable isotope and mtDNA evidence for geographic origins at the site of Vagnari (2nd-4th centuries AD), Italy. Am J Phys Anthropol Supplement:215.

Rawlings L. 2013. War and warfare in Ancient Greece. In Campbell B, Tritle LA, eds. The Oxford handbook of warfare in the Classical world. Pp 3-28.

Reinberger KL, Reitsema LJ, Kyle B, Vassallo S, Kamenov G, Krigbaum J. 2021. Isotopic evidence for geographic heterogeneity in Ancient Greek military forces. PLoS One 16(5): e0248803.

Reitsema LJ, Kozłowski T. 2013. Diet and society in Poland before the state: Stable isotope evidence from a Wielbark population (2nd c. AD). Anthropol Rev 76:1–22.

Reitsema LJ, Kyle B, Vassallo S. 2020. Food traditions and colonial interactions in the ancient Mediterranean: Stable isotope evidence from the Greek Sicilian colony Himera. J Anthropol Archaeol 57.

Richards TM, Sutton TT, Wells RJD. 2020. Trophic structure and sources of variation influencing the stable isotope signatures of Meso- and Bathypelagic micronekton fishes. Frontiers in Marine Science 7:507992. Doi: 10.3389/fmars.2020/507992.

Rogers G, Hawkesworth CJ. 1989. A geochemical traverse across the North Chilean Andes: evidence for crust generation from the mantle wedge. Earth Planet Sci Lett 91:271–285.

Roseberry W. 1998. Political economy and social fields. In: Leatherman TL, Goodman AH, editors. Building a new biocultural synthesis: Political-economic perspectives on human biology. Ann Arbor: University of Michigan Press. p 75–91.

Sadori, L., Ortu, E., Peyron, O., Zanchetta, G., Vanniere, B., Desmet, M., Magny, M., 2013. The Postglacial record of environmental history from Lago di Pergusa, Sicily. Clim. Past 9, 1969–1984.

Samuelsen JR, Potra A. 2020. Biologically available Pb: A method for ancient human sourcing using Pb isotopes from prehistoric animal tooth enamel. J Archaeol Sci 115:1–23.

Sapouna-Sakellaraki E, Coulton J, Metzger I., Sarpaki A, Wall-Crowther S. 2002. The Fort at Phylla, Vrachos: Excavations and researches at a late Archaic fort in Central Euboea. London: British School of Athens.

Sarpaki A. 1992. The paleoethnobotanical approach: The Mediterranean triad or is it a quartet? In: Well B, editor. Agriculture in Ancient Greece: Proceedings of the Seventh International Symposium at the Swedish Institute at Athens, 16-17 May 1990. Stockholm. p 61–76.

Scheper-Hughes N, Lock MM. 1987. The mindful body: A prolegomenon to future work in medical anthropology. Med Anthropol Q 1:6–41.

Schoeller DA. 1999. Isotope fractionation: Why aren't we what we eat? J Archaeol Sci 26:667–673.

Schoeninger MJ. 1995. Stable isotope studies in human evolution. Evol Anthropol Issues, News, Rev 4:83–98.

Schoeninger MJ. 2011. Diet reconstruction and ecology using stable isotope ratios. In: Larsen CS, editor. A companion to biological anthropology. Chichester: Wiley-Blackwell. p 445–464.

Schoeninger MJ, DeNiro MJ. 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. Geochim Cosmochim Acta 48:625–639.

Schwarcz HP. 2000. Some biochemical aspects of carbon isotope paleodiet studies. In: Ambrose SH, Katzenberg MA, editors. Biogeochemical approaches to paleodietary analysis. New York, NY: Kluer Academic Publishers. p 189–210.

Schwarcz HP, Nahal H. 2021. Theoretical and observed C/N ratios in human bone collagen. J Archaeol Sci 131:1–7.

Sealy JC, van der Merwe NJ, Sillen A, Kruger FJ, Krueger HW. 1991. $^{87}Sr/^{86}Sr$ as a dietary indicator in modern and archaeological bone. J Archaeol Sci 18:399–416.

Sekunda N V. 2013. War and society in Greece. In: Campbell B, Tritle LA, editors. The Oxford handbook of warfare in the Classical world. Oxford: Oxford University Press. p 198–215.

Sekunda N V. 2000. Greek hoplite 480-323 BC. London: Osprey Publishing Ltd.

Serrati J. 2000. Sicily from pre-Greek times to the fourth century. In: Sicily from Aeneas to Augustus: New approaches in archaeology and history. p 9–14.

Smith DG. 2003. How the west was one: The formation of Greek cultural identity in Italy and Sicily. PhD Dissertation, Stanford University.

Snoeck C, Staff RA, Brock F. 2016. A reassessment of the routine pretreatment protocol for radiocarbon dating cremated bones. Radiocarbon 58:1–8.

Sofaer JR. 2006. The body as material culture: A theoretical osteoarchaeology. Cambridge: Cambrdige University Press.

Sparacello VS, D'Ercole V, Coppa A. 2015. A bioarchaeological approach to the reconstruction of changes in military organization among Iron Age Samnites (Vestini) From Abruzzo, Central Italy. Am J Phys Anthropol 156:305–316.

Stamer JR, Reinberger KL, Kyle B, Fabbri PF, Vassallo S, Reitsema LJ. 2017. Assembling a winning army: Strontium isotope analysis of local and non-local Soldiers from the ancient Greek Battles of Himera (480 BCE, 409 BCE). Am J Phys Anth 162:368-368.

Stallo J. 2007. Isotopic study of migration: Differentiating locals and non-locals in tumulus burials from Apollonia, Albania. MA Thesis, University of Cincinnati.

Steele KW, Daniel RM. 1978. Fractionation of nitrogen isotopes by animals: A further complication to the use of variations in the natural abundance of 15N for tracer studies. J Agric Sci 90:7–9.

Stika HP, Heiss AG, Zach B. 2008. Plant remains from the early iron age in western Sicily: Differences in subsistence strategies of Greek and Elymian sites. Veg Hist Archaeobot 17:139–148.

Szpak P. 2014. Complexities of nitrogen isotope biogeochemistry in plant-soil systems: Implications for the study of ancient agricultural and animal management practices. Front Plant Sci 5:288.

Tafuri MA, Fullagar PD, O'Connell TC, Belcastro MG, Iacumin P, Conati Barbaro C, Sanseverino R, Robb J. 2016. Life and death in Neolithic southeastern Italy: The strontium isotopic evidence. Int J Osteoarchaeol 26:1045–1057.

Tafuri MA, Craig OE, Canci A. 2009. Stable isotope evidence for the consumption of millet and other plants in bronze age Italy. Am J Phys Anthropol 139:146–153.

Tagliamonte G. 1994. I Figli di Marte: Mobilità, mercenari e mercenariato italici in Magna Grecia e Sicila. Rome: Giorgio Bretschneider.

Tanasi D, Tykot RH, Vianello A, Hassam S. 2018. Stable isotope analysis of the dietary habits of a Greek community in Archaic Syracuse (Sicily): a pilot study. Sci Technol Archaeol Res 3:466–477.

Tieszen LL, Fagre T. 1993. Effect of diet quality and composition on the isotopic composition of respiratory CO_2, bone collagen, bioapatite, and soft tissues. In: Lambert JB, Grupe G, editors. Prehistoric human bone. Berlin: Springer-Verlag. p 121–155.

Tinner W, van Leeuwen JFN, Colombaroli D, Vescovi E, van der Knaap WO, Henne PD, Pasta S, D'Angelo S, La Mantia T. 2009. Holocene environmental and climatic changes at Gorgo Basso, a coastal lake in southern Sicily, Italy. Quat Sci Rev 28:1498–1510.

Traina G. 1992. Sale e saline nel Mediterraneo antico. Parola del passato 47(5):363–378.

Tricca A, Stille P, Steinmann M, Kiefel B, Samuel J, Eikenberg J. 1999. Rare earth elements and Sr and Nd isotopic compositions of dissolved and suspended loads from small river systems in the Vosges mountains (France), the river Rhine and groundwater. Chem Geol 160:139–158.

Trundle M. 2004. Greek mercenaries: From the late Archaic period to Alexander. London: Routledge.

Trundle M. 1996. The Classical Greek mercenary and his relationship to the polis. PhD dissertation. Hamilton, Ontario: McMaster University.

Tung TA. 2007. Trauma and violence in the Wari empire of the Peruvian Andes: Warfare, raids, and ritual fights. Am J Phys Anth 133:941-956.

Tung TA. 2012. Violence against women: Differential treatment of local and foreign females in the heartland of the Wari Empire, Peru. In: Martin DL, Harrod RP, Perez VR, editors. The Bioarchaeology of Violence. University Press of Florida. p 180–198.

Turner BL, Kamenov GD, Kingston JD, Armelagos GJ. 2009. Insights into immigration and social class at Machu Picchu, Peru based on oxygen, strontium, and lead isotopic analysis. J Archaeol Sci 36:317–332.

Turner BL, Zuckerman MK, Garofalo EM, Wilson A, Kamenov GD, Hunt DR, Amgalantugs T, Frohlich B. 2012. Diet and death in times of war: Isotopic and osteological analysis of mummified human remains from southern Mongolia. J Archaeol Sci 39:3125–3140.

Valenzuelana-Lamas S, Orengo HA, Bosch D, Pellegrini M, Halstead P, Nieto-Espinet A, Trentacoste A, Jiménez-Manchón S, López-Reyes D, Jornet-Niella R. 2018. Shipping amphorae and shipping sheep? Livestock mobility in the north-east Iberian peninsula during

the Iron Age based on strontium isotopic analyses of sheep and goat tooth enamel. PLoS One 13:1–14.

van der Merwe NJ, Vogel JC. 1978. ^{13}C Content of human collagen as a measure of prehistoric diet in woodland North America. Nature 276:815–816.

van Dommelen P. 1997. Colonial constructs: Colonialism and archaeology in the Mediterranean. World Archaeology. 28(3): 305-323.

van Dommelen P. 2012. Colonialism and migration in the ancient Mediterranean. Annu Rev Anthropol 41:393–409.

van Hook LR. 1932. On the Lacademonian burials in the Keramicon. Am J Archaeol 36:290–292.

van Klinken GJ. 1999. Bone collagen quality indicators for palaeodietary and radiocarbon measurements. J Archaeol Sci 26:687–695.

van Klinken GJ, Richards MP, Hedges BEM. 2000. An overview of causes for stable isotopic variations in past European human populations: Environmental, ecophysiological, and cultural effects. In: Ambrose SH, and Katzenberg AM, editors. Biogeochemical approaches to paleodietary analysis. New York: Kluwer Academic/Plenum Publishing. p 39-63.

van Wees H. 2004. Greek warfare: Myths and realities. London: Duckworth.

Vassallo S. 2010. Le battaglie di Himera alla luce degli scavi nella necropoli occidentale e alle fortificazioni i luoghi, i protagonisti. Sicil Antiq 7.

Vassallo S. 2014. Indigeni ad Himera? Il ruolo dei Sicani nelle vicende della colonia. In: Greco G, Ferrara B, editors. Segni di Appartenenza e Identità di Comunità nel Mondo Indigeno. Napoli: Naus Editoria. p 355–368.

Vassallo S. 2005. Himera città greca. Guida alla storia e ai monumenti. Sicilia: Soprintendenza ai Beni Culturali E Ambientali Servizio Beni Archeologici Palermo.

Vassallo S. 2012. La colonia dorico-calcidese di Himera. Dai dati storici di Tucidide e di Diodoro Siculo all'archeologia. Sicilia Antica, Caltanissetta:1–14.

Vassallo S. 2015. Le sepolture dei cittadini Imersi vittime della strage del 409 a.C. In: Nizzo V, editor. Archeologia E Antropolgia Della Morte. Bari: Edipuglia.

Vassallo S. 2019. Gestione e uso dell'acqua ad Himera. In: Bouffier S, Belvedere O, Vassallo S, editors. Gérer l'eau en Méditerranee au premier millénaire avant J.-C. p 185–192.

Vassallo S, Valentino M. 2012. Scavi nella necropoli occidentale di Himera, il paesaggio e le tipologie funerarie. In: Ampolo C, editor. Sicilia occidentale: Studi, rassegne, ricerche. Pisa: Scuola Normale Superiore Pisa. p 49–58.

Vaughn P. 1991. The identification and retrieval of the hoplite battle-dead. In: Hanson VD, editor. Hoplites: The Classical Greek battle experience. London: Routledge. Pp 38-62.

Veale SL. 2019. Fallen soldiers and the gods: Religious considerations in the retrieval and burial of the war dead in Classical Greece. The Pomegranate 21:5–25.

Veizer J. 1989. Strontium isotopes in seawater through time. Annu Rev earth Planet Sci Vol 17 1:141–167.

Viva S, Lonoce N, Vincenti G, Cameriere R, Valentino M, Vassallo S, Fabbri PF. 2020. The mass burials from the western necropolis of the Greek colony of Himera (Sicily) related to the battles of 480 and 409 BCE. Int J Osteoarchaeol 30:307–317.

Vogel JC, van der Merwe NJ. 1977. Isotopic evidence for early maize cultivation in New York state. American Antiquity 42(2):238-242.

Walker PL. 2001. A bioarchaeological perspective on the history of violence. Annu Rev Anthropol 30:573–596.

Weiner S, Traub W. 1992. Bone structure: From Ångstroms to microns. The FASEB (Federation of American Societies for Experimental Biology) Journal 6(3):879-885.

Whitehead, D. 1991. Who equipped mercenary troops in Classical Greece?. Historia 40:105-113.

Wilson RJA. 2001. Aqueducts and water supply in Greek and Roman Sicily: the present status quaestionis. In: Jansen GCM, editor. Cura Aquarum in Sicilia: Proceedings of the Tenth International Congress on the History of Water Management and Hydraulic Engineering in the Mediterranean Region. Leiden: Stichting Babesch.

Wood R, Duval M, Mai Huong NT, Tuan NA, Bacon AM, Demeter F, Duringer P, Oxenham M, Piper P. 2016. The effect of grain size on carbonate contaminant removal from tooth enamel: Towards an improved pretreatment for radiocarbon dating. Quat Geochronol 36:174–187.

Wright LE, Schwarcz HP. 1996. Infrared and isotopic evidence for diagenesis of bone apatite at Dos Pilas, Guatemala: Palaeodietary implications. J Archaeol Sci 23:933–944.

Wright LE, Schwarcz HP. 1998. Stable carbon and oxygen isotopes in human tooth enamel: Identifying breastfeeding and weaning in prehistory. Am J Phys Anthropol 106:1–18.

Zacharia K. 2008. Hellenisms, Herodotus' four markers of Greek identity. In: Zacharia K, editor. Hellenisms. Ann Arbor: University of Michigan Press. p 21–36.

Zazzo A, Saliège JF. 2011. Radiocarbon dating of biological apatites: A review. Palaeogeogr Palaeoclimatol Palaeoecol 310:52–61.

Zuchtriegel G. 2017. Colonization and subalternity in Classical Greece. New York, NY: Cambrdige University Press.

Zuckerman MK, Armelagos GJ. 2011. The origins of biocultural dimensions in bioarchaeology. In: Agarwal SC, Glencross BA, editors. Social bioarchaeology. New York, NY: Wiley-Blackwell. p 13–43.

APPENDIX A:

DEMOGRAPHY TABLE

Table A.1 Demography Table. Summary Age: SA (subadult, 0-18), YA (young adult, 18-35), MA (mid-aged adult, 35-50), OA (older adult, 50+), A (adult, 18+), Sex: F (female), M (male), UID (unidentifiable), S (subadult, unable to estimate sex)

Sample ID	Burial	Summary Age	Sex
W0213	Cappuccina	YA	F
W0234	Inhumation	MA	M
W0237	Cappuccina	YA	M
W0303	Inhumation	YA	F
W0306	Inhumation	YA	F
W0338	Cappuccina	MA	M
W0340	Cappuccina	YA	M
W0341	Cappuccina	YA	M
W0421	Cappuccina	OA	F
W0835	Inhumation	MA	M
W0843	Cappuccina	MA	M
W0908	Cappuccina	YA	M
W0916	Cappuccina	SA	S
W1046	Cappuccina	SA	S
W1078	Cappuccina	MA	F
W1133	Cappuccina	YA	F
W1138	Cappuccina	YA	M
W1153	Cappuccina	MA	M
W1377	Cappuccina	YA	M
W1411	Cappuccina	MA	M
W1480	Inhumation	MA	M
W1528	Cappuccina	YA	UID
W1562	Cappuccina	YA	F
W1624	Cappuccina	MA	F
W1631	Inhumation	MA	M
W1636	Inhumation	YA	M

W1656	Inhumation	YA	F
W1685	Cappuccina	YA	UID
W1708	Cappuccina	YA	F
W1726	Cappuccina	MA	F
W1746	Cappuccina	YA	UID
W1788	Inhumation	YA	M
W1829	Cappuccina	YA	F
W1838	Inhumation	MA	M
W1877	Cappuccina	MA	F
W1896	Inhumation	YA	F
W1901	Cappuccina	MA	F
W1902	Inhumation	YA	M
W2065	Cappuccina	YA	F
W2066	Cappuccina	OA	M
W2073	Inhumation	YA	UID
W2219	Inhumation	YA	M
W2301	Cappuccina	YA	M
W2309	Inhumation	YA	F
W2407	Inhumation	YA	F
W2463	Inhumation	YA	M
W2468	Inhumation	YA	F
W2472	Inhumation	YA	M
W2485	Cappuccina	MA	F
W2499	Inhumation	YA	F
W2504	Cappuccina	YA	M
W2510	Inhumation	SA	S
W2538	Cappuccina	MA	F
W2574	Inhumation	YA	F
W2660	Cappuccina	MA	M
W2715	Inhumation	YA	UID
W2717	Cappuccina	OA	M
W2792	Inhumation	YA	M
W2816	Cappuccina	YA	UID
W2830	Cappuccina	MA	M
W2831	Inhumation	YA	M
W2851	Cappuccina	A	UID
W2865	Cappuccina	MA	F
W2873	Cappuccina	MA	UID
W2881	Inhumation	YA	UID

W2907	Inhumation	YA	F
W2923	Inhumation	YA	UID
W2924	Inhumation	YA	UID
W2926	Cappuccina	YA	UID
W2992	Cappuccina	YA	M
W3182	Inhumation	OA	UID
W3242	Cappuccina	SA	S
W3275	Cappuccina	YA	F
W3378	Cappuccina	MA	F
W3452	Inhumation	A	UID
W3523	Cappuccina	YA	M
W3556	Cappuccina	OA	M
W3606	Inhumation	MA	M
W3612	Inhumation	SA	S
W3616	Inhumation	SA	S
W3636	Inhumation	MA	F
W3637	Inhumation	SA	F
W3699	Inhumation	MA	F
W3700	Inhumation	SA	S
W3702	Inhumation	OA	M
W3725	Inhumation	MA	UID
W3834	Inhumation	YA	M
W3855	Cappuccina	OA	M
W3888	Inhumation	YA	F
W3959	Cappuccina	YA	F
W3967	Cappuccina	YA	F
W4235	Inhumation	YA	M
W4242	Inhumation	MA	M
W4294	Inhumation	YA	M
W4324	Cappuccina	YA	M
W4412	Cappuccina	YA	F
W4433	Inhumation	YA	F
W4434	Cappuccina	YA	M
W4460	Cappuccina	YA	F
W4532	Cappuccina	OA	M
W4613	Inhumation	OA	UID
W4781	Inhumation	MA	M
W4829	Cappuccina	MA	F
W4940	Inhumation	YA	F

W4941	Inhumation	MA	UID
W4945	Inhumation	MA	M
W4981	Cappuccina	YA	M
W4982	Inhumation	SA	S
W4984	Inhumation	MA	UID
W4986	Inhumation	YA	UID
W4990	Inhumation	YA	M
W4991	Inhumation	SA	S
W5189	Cappuccina	YA	F
W5209	Cappuccina	YA	M
W5794	Inhumation	SA	S
W6022	Inhumation	OA	M
W6048	Inhumation	MA	M
W6049	Inhumation	A	M
W6052	Inhumation	YA	F
W6057	Inhumation	OA	UID
W6081	Inhumation	MA	UID
W6083	Inhumation	MA	F
W6111	Inhumation	YA	M
W6112	Inhumation	SA	S
W6268	Cappuccina	YA	M
W6269	Cappuccina	YA	UID
W6289	Cappuccina	YA	F
W6376	Cappuccina	YA	F
W6537	Cappuccina	MA	M
W6613	Cappuccina	YA	F
W6677	Cappuccina	MA	M
W482	FC1	MA	M
W403	FC1	YA	M
W336	FC1	YA	M
W276	FC1	YA	M
W396	FC1	YA	M
W423	FC1	MA	M
W461	FC2	YA	M
W737	FC2	YA	M
W428	FC2	YA	M
W577	FC2	YA	M
W503	FC2	A	M
W462	FC2	MA	M

W463	FC2	YA	M
W576	FC2	YA	M
W464	FC2	YA	M
W494	FC2	YA	M
W429	FC2	YA	M
W706	FC3	MA	UID
W696	FC3	MA	UID
W701	FC3	YA	UID
W815	FC3	UID	UID
W705	FC3	MA	M
W703	FC3	YA	M
W702	FC3	YA	M
W650	FC3	YA	M
W808	FC3	YA	M
W813	FC3	YA	M
W814	FC3	YA	M
W704	FC3	YA	M
W807	FC3	MA	M
W653	FC3	YA	M
W809	FC3	YA	M
W811	FC3	YA	M
W699	FC3	YA	M
W810	FC3	YA	M
W812	FC3	MA	M
W698	FC3	A	UID
W1781	FC4	YA	M
W1773	FC4	MA	M
W1779	FC4	YA	M
W1783	FC4	YA	M
W1770	FC4	YA	M
W1777	FC4	YA	M
W1771	FC4	YA	M
W1774	FC4	YA	M
W2588	FC5	MA	M
W2587	FC5	YA	M
W2589	FC5	YA	M
W2590	FC5	YA	M
W2738	FC6	YA	M
W2737	FC6	YA	M

W2739	FC6	YA	M
W2825	FC7	YA	M
W2764	FC7	YA	M
W4376	FC8	YA	M
W4378	FC8	MA	M
W4380	FC8	YA	M
W4375	FC8	A	UID
W4382	FC8	A	UID
W4342	FC8	A	UID
W4341	FC8	A	UID
W4383	FC8	A	UID
W4384	FC8	A	UID
W4689	FC9	MA	UID
W4684	FC9	YA	UID
W4687	FC9	YA	UID
W4688	FC9	A	UID
W4671	FC9	YA	M
W4680	FC9	YA	M
W4651	FC9	YA	M
W4674	FC9	MA	M
W4666	FC9	A	M
W4670	FC9	YA	M
W4682	FC9	A	UID
W4677	FC9	A	UID
W4683	FC9	A	UID
W4653	FC9	A	UID
W4685	FC9	A	UID
W4681	FC9	A	UID
W4654	FC9	A	UID
W4652	FC9	A	UID
W4686	FC9	A	UID
W4655	FC9	A	UID
W4675	FC9	A	UID
W4702	FC9	A	F

APPENDIX B:

ORIGIN ISOTOPES DATA

Table B.1. Study Table of Origin Isotopes – $^{20n}Pb/^{204}Pb$, $^{87}Sr/^{86}Sr$, $\delta^{18}O$.

Sample ID	Burial	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{206}Pb/^{204}Pb$	$^{87}Sr/^{86}Sr$	$\delta^{18}O$
W0213	Cappuccina	-	-	-	-	-4.5
W0234	Inhumation	38.807	15.654	18.758	0.70878	-
W0237	Cappuccina	-	-	-	-	-3.5
W0303	Inhumation	-	-	-	0.70876	-3.3
W0306	Inhumation	-	-	-	-	-3.1
W0338	Cappuccina	-	-	-	-	-4.3
W0340	Cappuccina	-	-	-	-	-3.3
W0341	Cappuccina	-	-	-	-	-4.5
W0421	Cappuccina	-	-	-	-	-4.0
W0835	Inhumation	-	-	-	-	-6.2
W0843	Cappuccina	-	-	-	-	-2.0
W0908	Cappuccina	-	-	-	-	-2.5
W0916	Cappuccina	-	-	-	-	-4.7
W1046	Cappuccina	-	-	-	-	-3.2
W1078	Cappuccina	-	-	-	-	-
W1133	Cappuccina	-	-	-	-	-3.5
W1138	Cappuccina	-	-	-	-	-3.6
W1153	Cappuccina	-	-	-	-	-5.3
W1377	Cappuccina	-	-	-	-	-3.7
W1411	Cappuccina	-	-	-	-	-2.9
W1480	Inhumation	-	-	-	0.70890	-2.4
W1528	Cappuccina	-	-	-	0.70879	-
W1562	Cappuccina	-	-	-	-	-3.4
W1624	Cappuccina	-	-	-	-	-4.1
W1631	Inhumation	-	-	-	-	-5.0
W1636	Inhumation	-	-	-	-	-2.0
W1656	Inhumation	-	-	-	0.70897	-2.4
W1685	Cappuccina	-	-	-	-	-3.9
W1708	Cappuccina	-	-	-	-	-4.5

W1726	Cappuccina	-	-	-	-	-3.3
W1746	Cappuccina	-	-	-	-	-3.4
W1788	Inhumation	-	-	-	0.70871	-2.1
W1829	Cappuccina	-	-	-	-	-2.5
W1838	Inhumation	-	-	-	0.70854	-3.2
W1877	Cappuccina	-	-	-	-	-2.0
W1896	Inhumation	38.755	15.654	18.679	0.70879	-5.9
W1901	Cappuccina	-	-	-	0.70867	-5.1
W1902	Inhumation	-	-	-	-	-2.7
W2065	Cappuccina	-	-	-	-	-4.3
W2066	Cappuccina	-	-	-	-	-3.7
W2073	Inhumation	-	-	-	-	-4.8
W2219	Inhumation	-	-	-	-	-
W2301	Cappuccina	-	-	-	0.70863	-3.8
W2309	Inhumation	-	-	-	-	-5.5
W2407	Inhumation	-	-	-	-	-3.8
W2463	Inhumation	-	-	-	0.70869	-2.8
W2468	Inhumation	-	-	-	0.70876	-3.4
W2472	Inhumation	-	-	-	0.70867	-2.8
W2485	Cappuccina	-	-	-	0.70862	-4.2
W2499	Inhumation	-	-	-	0.70872	-3.0
W2504	Cappuccina	-	-	-	-	-3.2
W2510	Inhumation	38.844	15.684	18.852	0.70848	-
W2538	Cappuccina	-	-	-	-	-4.7
W2574	Inhumation	-	-	-	0.70855	-2.4
W2660	Cappuccina	-	-	-	-	-2.9
W2715	Inhumation	-	-	-	-	-3.2
W2717	Cappuccina	-	-	-	-	-4.1
W2792	Inhumation	38.831	15.668	18.849	0.70867	-
W2816	Cappuccina	-	-	-	-	-3.7
W2830	Cappuccina	-	-	-	-	-5.0
W2831	Inhumation	-	-	-	0.70846	-3.3
W2851	Cappuccina	-	-	-	-	-3.0
W2865	Cappuccina	-	-	-	-	-3.0
W2873	Cappuccina	-	-	-	-	-4.2
W2881	Inhumation	-	-	-	-	-5.0
W2907	Inhumation	-	-	-	-	-2.6
W2923	Inhumation	-	-	-	-	-2.5
W2924	Inhumation	-	-	-	-	-3.9

W2926	Cappuccina	-	-	-	-	-4.8
W2992	Cappuccina	-	-	-	-	-2.7
W3182	Inhumation	-	-	-	0.70898	-3.3
W3242	Cappuccina	-	-	-	-	-1.8
W3275	Cappuccina	-	-	-	-	-2.3
W3378	Cappuccina	-	-	-	-	-4.4
W3452	Inhumation	-	-	-	-	-4.4
W3523	Cappuccina	-	-	-	-	-4.5
W3556	Cappuccina	-	-	-	-	-5.0
W3606	Inhumation	-	-	-	-	-3.5
W3612	Inhumation	-	-	-	0.70879	-3.6
W3616	Inhumation	-	-	-	-	-
W3636	Inhumation	-	-	-	-	-3.0
W3637	Inhumation	-	-	-	-	-2.9
W3699	Inhumation	-	-	-	-	-4.4
W3700	Inhumation	-	-	-	-	-3.9
W3702	Inhumation	-	-	-	0.70871	-3.5
W3725	Inhumation	-	-	-	-	-2.0
W3834	Inhumation	-	-	-	-	-2.6
W3855	Cappuccina	-	-	-	0.70890	-
W3888	Inhumation	38.895	15.675	18.726	0.70890	-
W3959	Cappuccina	-	-	-	-	-4.6
W3967	Cappuccina	-	-	-	-	-3.1
W4235	Inhumation	-	-	-	-	-1.0
W4242	Inhumation	-	-	-	-	-4.1
W4294	Inhumation	-	-	-	-	-3.4
W4324	Cappuccina	-	-	-	0.70911	-4.0
W4412	Cappuccina	-	-	-	-	-2.7
W4433	Inhumation	-	-	-	-	-3.5
W4434	Cappuccina	-	-	-	-	-3.2
W4460	Cappuccina	-	-	-	-	-3.2
W4532	Cappuccina	-	-	-	-	-5.7
W4613	Inhumation	-	-	-	-	-4.5
W4781	Inhumation	-	-	-	-	-4.7
W4829	Cappuccina	-	-	-	-	-4.6
W4940	Inhumation	-	-	-	-	-3.6
W4941	Inhumation	-	-	-	-	-4.5
W4945	Inhumation	-	-	-	-	-2.8
W4981	Cappuccina	-	-	-	0.70866	-4.1

W4982	Inhumation	-	-	-	-	-4.8
W4984	Inhumation	-	-	-	-	-2.9
W4986	Inhumation	-	-	-	-	-4.2
W4990	Inhumation	-	-	-	-	-2.8
W4991	Inhumation	-	-	-	-	-2.3
W5189	Cappuccina	-	-	-	-	-4.3
W5209	Cappuccina	-	-	-	0.70857	-2.9
W5794	Inhumation	-	-	-	0.70877	-5.9
W6022	Inhumation	-	-	-	0.70912	-3.0
W6048	Inhumation	-	-	-	-	-4.7
W6049	Inhumation	-	-	-	0.70867	-5.4
W6052	Inhumation	-	-	-	-	-4.7
W6057	Inhumation	-	-	-	-	-
W6081	Inhumation	-	-	-	-	-
W6083	Inhumation	-	-	-	0.70849	-4.5
W6111	Inhumation	-	-	-	0.70862	-4.0
W6112	Inhumation	-	-	-	0.70878	-3.1
W6268	Cappuccina	-	-	-	-	-3.7
W6269	Cappuccina	-	-	-	-	-3.3
W6289	Cappuccina	-	-	-	-	-3.3
W6376	Cappuccina	-	-	-	-	-3.0
W6537	Cappuccina	-	-	-	-	-3.4
W6613	Cappuccina	-	-	-	-	-1.9
W6677	Cappuccina	-	-	-	-	-2.6
W482	FC1	38.900	15.705	19.100	0.70972	-7.1
W403	FC1	38.932	15.698	19.032	0.70999	-6.4
W336	FC1	38.852	15.665	18.786	0.71010	-6.1
W276	FC1	38.875	15.670	18.873	0.70966	-7.0
W396	FC1	38.880	15.662	19.093	0.71012	-6.4
W423	FC1	-	-	-	-	-
W461	FC2	38.858	15.657	18.806	0.70929	-6.7
W737	FC2	38.902	15.670	18.808	0.70950	-5.9
W428	FC2	38.805	15.653	18.735	0.70963	-5.9
W577	FC2	38.828	15.668	18.777	0.70956	-6.4
W503	FC2	38.870	15.669	18.793	0.70979	-6.1
W462	FC2	38.844	15.664	18.798	0.70895	-5.4
W463	FC2	38.858	15.666	18.798	0.70861	-4.4
W576	FC2	38.755	15.655	18.758	0.70916	-5.2
W464	FC2	38.917	15.674	18.750	0.70901	-6.7

W494	FC2	38.810	15.661	18.760	0.70918	-4.0
W429	FC2	38.764	15.654	18.706	0.70899	-7.3
W706	FC3	38.886	15.673	18.770	0.70904	-3.9
W696	FC3	38.746	15.653	18.710	0.70934	-5.7
W701	FC3	38.839	15.669	18.761	0.70843	-6.6
W815	FC3	-	-	-	-	-
W705	FC3	38.826	15.666	18.753	0.70882	-4.5
W703	FC3	38.831	15.660	18.797	0.70890	-6.2
W702	FC3	38.745	15.650	18.683	0.70913	-6.9
W650	FC3	38.877	15.672	18.890	0.71001	-7.0
W808	FC3	38.771	15.663	18.806	0.70952	-6.1
W813	FC3	-	-	-	-	-
W814	FC3	-	-	-	0.71053	-5.5
W704	FC3	38.962	15.703	18.985	0.71071	-6.6
W807	FC3	38.868	15.661	18.799	0.70940	-5.1
W653	FC3	38.798	15.654	18.750	0.70915	-6.5
W809	FC3	38.836	15.685	18.841	0.71062	-5.9
W811	FC3	38.884	15.665	18.861	0.70980	-7.1
W699	FC3	38.821	15.663	18.794	0.70882	-6.6
W810	FC3	38.884	15.668	18.796	0.70939	-5.3
W812	FC3	38.812	15.663	18.820	0.70929	-3.8
W698	FC3	38.850	15.658	18.755	0.70897	-5.2
W1781	FC4	38.873	15.665	18.774	0.70951	-6.1
W1773	FC4	38.905	15.687	18.760	0.70929	-6.1
W1779	FC4	38.861	15.666	18.803	0.70927	-5.7
W1783	FC4	38.853	15.662	18.768	0.70947	-4.8
W1770	FC4	38.807	15.668	18.798	0.70890	-5.4
W1777	FC4	38.886	15.665	18.807	0.70932	-5.6
W1771	FC4	38.854	15.660	18.784	0.70898	-5.0
W1774	FC4	38.837	15.655	18.799	0.70992	-5.3
W2588	FC5	38.868	15.669	18.768	0.70849	-4.7
W2587	FC5	38.859	15.672	18.809	0.70852	-4.5
W2589	FC5	38.862	15.673	18.780	0.70855	-4.5
W2590	FC5	38.848	15.667	18.802	0.70856	-4.3
W2738	FC6	38.867	15.672	18.786	0.70885	-3.4
W2737	FC6	38.819	15.661	18.753	0.70873	-4.8
W2739	FC6	38.849	15.686	18.855	0.70898	-3.9
W2825	FC7	38.828	15.662	18.800	0.70811	-5.0
W2764	FC7	38.890	15.675	18.790	0.70837	-3.8

W4376	FC8	38.848	15.670	18.785	0.70886	-3.8
W4378	FC8	38.841	15.670	18.779	0.70882	-4.5
W4380	FC8	38.859	15.670	18.801	0.70867	-3.6
W4375	FC8	-	-	-	-	-
W4382	FC8	-	-	-	-	-
W4342	FC8	-	-	-	-	-
W4341	FC8	-	-	-	-	-
W4383	FC8	-	-	-	-	-
W4384	FC8	-	-	-	-	-
W4689	FC9	38.872	15.669	18.796	0.70881	-4.2
W4684	FC9	38.846	15.673	18.813	0.70900	-3.7
W4687	FC9	38.866	15.676	18.793	0.70911	-3.7
W4688	FC9	-	-	-	-	-
W4671	FC9	-	-	-	-	-
W4680	FC9	38.852	15.671	18.806	0.70883	-3.5
W4651	FC9	38.886	15.672	18.784	0.70881	-4.5
W4674	FC9	38.874	15.668	18.797	0.70885	-4.5
W4666	FC9	38.845	15.665	18.789	0.70877	-4.8
W4670	FC9	38.873	15.667	18.783	0.70873	-4.3
W4682	FC9	-	-	-	-	-
W4677	FC9	-	-	-	-	-
W4683	FC9	-	-	-	-	-
W4653	FC9	-	-	-	-	-
W4685	FC9	-	-	-	-	-
W4681	FC9	-	-	-	-	-
W4654	FC9	-	-	-	-	-
W4652	FC9	-	-	-	-	-
W4686	FC9	-	-	-	-	-
W4655	FC9	-	-	-	-	-
W4675	FC9	-	-	-	-	-
W4702	FC9	-	-	-	-	-

APPENDIX C:

DIETARY ISOTOPES DATA

Table C.1. Study Table of Dietary Isotopes – δ^{13}Ccoll, δ^{13}Cap, δ^{15}N, and collagen quality indicators (%C, %N, C:N, % Collagen)

Sample ID	Burial	δ^{13}Cap	δ^{13}Ccoll	δ^{15}N	%C	%N	C:N	% Collagen
W0213	Cappuccina	-12.4	-19.6	10.5	28.7	10.2	3.3	2.9
W0234	Inhumation	-	-19.7	11.1	24.935	8.83	3.3	5.6
W0237	Cappuccina	-11.7	-	-	-	-	-	-
W0303	Inhumation	-12.5	-19.6	11.2	35.5	12.7	3.3	10.8
W0306	Inhumation	-11.5	-19.8	10.2	20.42	7.35	3.2	4.1
W0338	Cappuccina	-12.0	-	-	-	-	-	2.1
W0340	Cappuccina	-12.3	-	-	-	-	-	-
W0341	Cappuccina	-11.7	-	-	-	-	-	-
W0421	Cappuccina	-12.6	-19.2	10.1	30.8	11.1	3.2	2.7
W0835	Inhumation	-12.5	-	-	-	-	-	-
W0843	Cappuccina	-12.2	-19.2	11.8	35.05	12.4	3.3	5.7
W0908	Cappuccina	-12.0	-18.8	10.2	38.3	13.8	3.2	8.6
W0916	Cappuccina	-12.6	-19.5	10.7	22.81	8.4	3.2	3.8
W1046	Cappuccina	-12.7	-19.0	10.0	31.36	11.71	3.1	3.8
W1078	Cappuccina	-	-19.3	10.5	18.38	6.62	3.2	2.7
W1133	Cappuccina	-12.4	-18.9	11.1	34.2	12.2	3.3	7.9
W1138	Cappuccina	-12.4	-19.0	10.4	15.3	5.7	3.2	1.9
W1153	Cappuccina	-12.5	-19.1	10.4	31	11.1	3.2	4.8
W1377	Cappuccina	-12.9	-	-	-	-	-	-
W1411	Cappuccina	-13.1	-19.7	10.4	31.9	11.3	3.3	7.9
W1480	Inhumation	-11.7	-	-	-	-	-	-
W1528	Cappuccina	-	-	-	-	-	-	-
W1562	Cappuccina	-12.4	-19.9	9.6	38.9	14.1	3.2	3
W1624	Cappuccina	-11.7	-	-	-	-	-	-
W1631	Inhumation	-12.2	-	-	-	-	-	-
W1636	Inhumation	-12.4	-19.2	11.3	36.2	12.8	3.3	1.5
W1656	Inhumation	-11.6	-	-	-	-	-	4.3
W1685	Cappuccina	-13.1	-19.2	9.9	27.17	10.4	3	3.7

W1708	Cappuccina	-12.0	-19.3	11.2	25.64	9.5	3.2	8.1
W1726	Cappuccina	-13.5	-	-	-	-	-	1.9
W1746	Cappuccina	-13.1	-19.4	9.6	24.51	9.4	3.1	3.1
W1788	Inhumation	-11.5	-	-	-	-	-	5.5
W1829	Cappuccina	-12.1	-19.5	8.7	30.6	11.0	3.2	5.5
W1838	Inhumation	-12.3	-19.1	10.5	28.5	9.8	3.4	6.2
W1877	Cappuccina	-13.0	-	-	-	-	-	-
W1896	Inhumation	-12.9	-19.5	10.0	24.215	8.5	3.3	3.9
W1901	Cappuccina	-11.9	-19.3	11.0	34.92	13.1	3.1	4.5
W1902	Inhumation	-11.7	-19.2	10.8	61.9	22.4	3.2	2.4
W2065	Cappuccina	-12.8	-19.6	11.0	31.5	11.4	3.2	3.8
W2066	Cappuccina	-12.6	-	-	-	-	-	2.1
W2073	Inhumation	-12.1	-19.3	9.3	20.1	6.9	3.4	2.6
W2219	Inhumation	-	-19.1	11.5	27.84	9.7	3.4	5.4
W2301	Cappuccina	-12.0	-	-	-	-	-	-
W2309	Inhumation	-12.8	-20.0	9.7	33.5	11.7	3.3	4.1
W2407	Inhumation	-12.9	-	-	-	-	-	1.2
W2463	Inhumation		-	-	-	-	-	-
W2468	Inhumation	-12.1	-	-	-	-	-	-
W2472	Inhumation	-12.8	-	-	-	-	-	-
W2485	Cappuccina	-12.1	-19.2	9.1	29.77	10.95	3.2	4.1
W2499	Inhumation	-12.6	-	-	-	-	-	0.28
W2504	Cappuccina	-12.0	-	-	-	-	-	2.2
W2510	Inhumation	-	-	-	-	-	-	3.1
W2538	Cappuccina	-12.2	-	-	-	-	-	1.9
W2574	Inhumation	-13.2	-	-	-	-	-	-
W2660	Cappuccina	-11.0	-	-	-	-	-	0.96
W2715	Inhumation	-12.4	-19.6	9.0	29.9	10.2	3.4	6
W2717	Cappuccina	-13.5	-	-	-	-	-	1.6
W2792	Inhumation	-	-	-	-	-	-	1.9
W2816	Cappuccina	-12.4	-19.4	10.9	33.3	12.5	3.1	nd
W2830	Cappuccina	-12.6	-	-	-	-	-	2
W2831	Inhumation		-	-	-	-	-	0.28
W2851	Cappuccina	-12.0	-19.0	11.4	32.4	11.5	3.3	nd
W2865	Cappuccina	-12.0	-19.7	11.0	26.8	9.9	3.2	5.2
W2873	Cappuccina	-12.0	-19.7	11.0	26.75	9.9	3.2	4
W2881	Inhumation	-10.6	-19.0	12.9	28.1	9.6	3.4	3.8
W2907	Inhumation	-12.2	-19.1	9.8	28.48	10.32	3.2	4.8
W2923	Inhumation	-13.7	-19.8	10.1	32.3	11.3	3.3	2.7

W2924	Inhumation	-11.9	-19.6	10.2	26.5	9.5	3.2	3
W2926	Cappuccina	-13.0	-19.7	10.5	34.04	12.6	3.1	5.8
W2992	Cappuccina	-12.3	-19.0	10.1	36.3	13.1	3.2	3.6
W3182	Inhumation	-13.1	-	-	-	-	-	-
W3242	Cappuccina	-11.1	-19.0	11.0	10.49	4.0	3.0	nd
W3275	Cappuccina	-12.5	-19.9	10.3	38.2	13.6	3.3	2.4
W3378	Cappuccina	-12.7	-	-	-	-	-	-
W3452	Inhumation	-12.0	-19.5	10.5	36.76	13.315	3.2	9.7
W3523	Cappuccina	-12.7	-19.8	10.7	27.6	9.9	3.3	3.7
W3556	Cappuccina	-13.5	-	-	-	-	-	-
W3606	Inhumation	-13.0	-19.3	10.3	33.99	12.31	3.2	6.3
W3612	Inhumation	-12.0	-19.9	9.8	31.54	11.41	3.2	5.3
W3616	Inhumation	-	-19.4	10.5	33.8	12.32	3.2	3.4
W3636	Inhumation	-13.7	-19.6	10.4	29.1	9.9	3.4	4.1
W3637	Inhumation	-11.8	-18.7	11.6	31.4	11.1	3.3	2.3
W3699	Inhumation	-12.3	-19.5	9.8	22	7.6	3.4	3.9
W3700	Inhumation	-12.6	-19.1	10.5	27.9	9.7	3.4	5.4
W3702	Inhumation	-12.7	-	-	-	-	-	-
W3725	Inhumation	-12.5	-19.4	9.5	27.9	9.5	3.4	3.9
W3834	Inhumation	-11.6	-	-	-	-	-	-
W3855	Cappuccina	-	-	-	-	-	-	1.7
W3888	Inhumation	-	-	-	-	-	4.2	1.6
W3959	Cappuccina	-13.8	-	-	-	-	6.8	1.6
W3967	Cappuccina	-13.4	-19.8	10.0	25.6	8.8	3.4	0.7
W4235	Inhumation	-12.6	-	-	-	-	5.5	0.6
W4242	Inhumation	-11.9	-19.4	10.7	19.3	7.1	3.2	nd
W4294	Inhumation	-12.4	-19.0	11.0	29.6	10.9	3.2	2.4
W4324	Cappuccina	-13.2	-	-	-	-	-	-
W4412	Cappuccina	-12.0	-19.7	10.2	35.1	12.7	3.2	4
W4433	Inhumation	-13.6	-19.9	11.6	37.42	14.0	3.1	2.7
W4434	Cappuccina	-11.8	-	-	-	-	-	0.68
W4460	Cappuccina	-11.8	-19.3	9.3	33.3	12	3.2	3.5
W4532	Cappuccina	-11.8	-19.0	11.0	39	14	3.2	5.7
W4613	Inhumation	-12.8	-19.5	10.6	25.9	8.9	3.4	4.8
W4781	Inhumation	-11.7	-19.2	10.4	28.69	10.46	3.2	4.4
W4829	Cappuccina	-12.6	-	-	-	-	-	0.77
W4940	Inhumation	-12.5	-19.2	10.6	38.64	14.37	3.1	6.7
W4941	Inhumation	-12.1	-19.1	10.8	31.41	11.29	3.2	4
W4945	Inhumation	-12.1	-19.7	10.5	16.46	5.83	3.3	2.2

W4981	Cappuccina	-12.5	-18.6	11.5	14.9	5.1	3.4	4.7
W4982	Inhumation	-13.1	-19.4	8.7	39.9	14.3	3.3	2.9
W4984	Inhumation	-12.1	-19.4	10.0	26.89	9.68	3.2	3.6
W4986	Inhumation	-11.9	-19.6	10.1	29.74	10.87	3.2	3.9
W4990	Inhumation	-12.6	-19.5	10.7	32.97	11.69	3.3	5
W4991	Inhumation	-11.9	-19.3	10.4	28.06	10.39	3.2	2.8
W5189	Cappuccina	-13.0	-19.5	10.0	27.3	9.7	3.3	4
W5209	Cappuccina	-11.9	-	-	-	-	-	0.36
W5794	Inhumation	-12.2	-	-	-	-	3.5	2.5
W6022	Inhumation	-11.7	-19.7	9.6	20.6	7.1	3.4	5
W6048	Inhumation	-13.3	-	-	-	-	-	1.5
W6049	Inhumation	-12.9	-	-	-	-	-	4.3
W6052	Inhumation	-11.2	-	-	-	-	-	0.6
W6057	Inhumation	-	-19.6	10.0	25.3	8.8	3.4	3.4
W6081	Inhumation	-	-19.3	11.4	34.9	12.6	3.2	4
W6083	Inhumation	-10.6	-	-	-	-	-	4.3
W6111	Inhumation	-12.4	-	-	-	-	-	2.4
W6112	Inhumation	-11.7	-	-	-	-	-	-
W6268	Cappuccina	-13.0	-	-	-	-	3.6	2.1
W6269	Cappuccina	-11.1	-	-	-	-	-	1.4
W6289	Cappuccina	-11.1	-	-	-	-	-	-
W6376	Cappuccina	-12.4	-	-	-	-	-	0.65
W6537	Cappuccina	-12.8	-19.8	9.9	17.7	6.5	3.2	2.1
W6613	Cappuccina	-13.7	-	-	-	-	-	-
W6677	Cappuccina	-12.6	-	-	-	-	-	1.3
W482	FC1	-6.7	-18.5	10.6	24.4	8.2	3.5	7.1
W403	FC1	-7.8	-17.5	11.2	31.98	11.28	3.3	9.4
W336	FC1	-9.2	-17.7	11.0	26.5	9.2	3.4	3.8
W276	FC1	-5.1	-16.6	9.8	22.74	7.96	3.3	3.9
W396	FC1	-7.6	-16.6	10.6	26.22	9.09	3.4	4.7
W423	FC1	-	-16.3	10.7	28.41	10.1	3.3	nd
W461	FC2	-9.5	-19.2	10.6	27.3	9.5	3.4	8.1
W737	FC2	-12.5	-	-	-	-	-	2.1
W428	FC2	-9.6	-19.2	11.0	30.47	10.9	3.3	4.2
W577	FC2	-6.9	-17.9	10.7	36.1	12.3	3.4	5.4
W503	FC2	-9.9	-17.6	10.9	32.325	11.41	3.3	nd
W462	FC2	-8.8	-16.9	10.8	28.5	10.1	3.3	2.2
W463	FC2	-12.0	-19.2	10.6	23.98	8.34	3.4	3.8
W576	FC2	-11.5	-18.2	11.1	31.92	11.43	3.3	6.5

W464	FC2	-10.1	-	-	-	-	-	1.7
W494	FC2	-12.2	-	-	-	-	-	2.9
W429	FC2	-9.2	-18.6	10.0	23.57	8.26	3.3	3
W706	FC3	-11.9	-19.6	10.6	22.95	8.25	3.3	2.5
W696	FC3	-10.5	-16.2	11.0	25.85	9.31	3.2	3.2
W701	FC3	-6.2	-17.0	10.9	27.38	9.61	3.3	5.5
W815	FC3	-	-15.9	10.5	27.31	9.3	3.4	5
W705	FC3	-12.5	-19.3	10.9	22.295	7.915	3.3	3.3
W703	FC3	-6.2	-18.2	11.9	16.66	5.97	3.3	1.1
W702	FC3	-5.8	-16.0	8.1	9.3	3.23	3.4	3.5
W650	FC3	-8.9	-15.9	10.9	23.81	8	3.5	2.5
W808	FC3	-9.9	-18.2	11.4	29.94	10.72	3.3	3.9
W813	FC3	-	-16.6	8.9	25.74	8.96	3.4	4.3
W814	FC3	-9.3	-18.9	11.7	27.06	9.33	3.4	4.5
W704	FC3	-8.8	-19.5	11.0	26.515	9.705	3.2	6.8
W807	FC3	-8.9	-19.1	12.0	21.89	7.94	3.2	3.8
W653	FC3	-7.6	-16.3	10.3	17.16	6.175	3.2	0.37
W809	FC3	-8.6	-15.8	9.2	30.72	10.885	3.3	nd
W811	FC3	-6.9	-17.5	10.2	23.48	7.98	3.4	7.1
W699	FC3	-9.1	-17.7	11.0	17.6	6	3.4	4.1
W810	FC3	-9.7	-	-	-	-	4.4	-
W812	FC3	-12.4	-	-	-	-	5.2	1.7
W698	FC3	-8.6	-	-	-	-	-	1.1
W1781	FC4	-9.3	-18.8	9.0	10.13	3.515	3.4	3.7
W1773	FC4	-5.1	-17.7	12.7	31.115	11.045	3.3	3.4
W1779	FC4	-8.7	-17.4	9.8	30	10.37	3.4	3.1
W1783	FC4	-8.1	-19.1	11.9	25.1	9.17	3.2	5.9
W1770	FC4	-8.4	-18.8	10.8	31.905	11.365	3.3	3.9
W1777	FC4	-10.8	-18.7	11.2	24.525	8.625	3.3	3.3
W1771	FC4	-6.4	-17.2	10.8	30.1	10.635	3.3	4.1
W1774	FC4	-10.8	-	-	-	-	4.1	2
W2588	FC5	-12.6	-	-	-	-	-	0.98
W2587	FC5	-11.9	-	-	-	-	-	1.1
W2589	FC5	-12.9	-	-	-	-	-	1.4
W2590	FC5	-13.0	-	-	-	-	4.7	0.87
W2738	FC6	-12.6	-	-	-	-	-	1.1
W2737	FC6	-12.4	-	-	-	-	-	1.4
W2739	FC6	-12.1	-	-	-	-	-	1.2
W2825	FC7	-12.8	-	-	-	-	-	1.9

W2764	FC7	-13.0	-	-	-	-	3.5	2.2
W4376	FC8	-12.6	-19.5	9.9	19.31	6.89	3.3	2
W4378	FC8	-11.9	-19.7	11.1	37.7	13.5	3.3	5.6
W4380	FC8	-12.2	-19.5	11.8	39.11	14.14	3.2	8.5
W4375	FC8	-	-19.4	10.2	30.12	10.67	3.3	4.8
W4382	FC8	-	-19.0	11.6	23	7.96	3.4	5.1
W4342	FC8	-	-19.5	10.1	33.71	12.15	3.2	12.4
W4341	FC8	-	-19.5	10.6	28.08	9.72	3.4	2.9
W4383	FC8	-	-18.9	11.2	25.99	9.11	3.3	4.3
W4384	FC8	-	-19.2	11.1	31.27	11.08	3.3	6
W4689	FC9	-12.1	-18.7	10.8	23.18	8.02	3.4	3.8
W4684	FC9	-12.7	-19.3	10.6	25.43	8.68	3.4	4.9
W4687	FC9	-12.6	-19.4	10.6	27.06	9.26	3.4	3.5
W4688	FC9	-	-19.3	10.7	25.99	9.05	3.4	4.8
W4671	FC9	-	-20.4	9.5	29.11	10.07	3.4	3.5
W4680	FC9	-12.0	-19.7	10.7	25.26	8.92	3.3	2.2
W4651	FC9	-12.1	-19.3	11.2	33.875	12.095	3.3	5.5
W4674	FC9	-11.7	-20.1	10.1	22.14	7.77	3.3	2.6
W4666	FC9	-11.9	-19.8	11.4	28.08	9.9	3.3	9.7
W4670	FC9	-12.2	-19.2	11.9	33.14	11.77	3.3	4.3
W4682	FC9	-	-19.4	10.1	21.42	7.53	3.3	2.8
W4677	FC9	-	-19.8	9.6	24.32	8.55	3.3	4
W4683	FC9	-	-19.1	11.3	28.22	9.88	3.3	3.5
W4653	FC9	-	-19.1	10.6	17.1	5.56	3.6	2.5
W4685	FC9	-	-19.3	11.4	21.47	7.29	3.4	1.9
W4681	FC9	-	-19.4	11.4	26.17	9.1	3.4	3.4
W4654	FC9	-	-18.9	10.8	26.18	8.84	3.5	2.4
W4652	FC9	-	-19.2	11.1	27.41	9.64	3.3	5.9
W4686	FC9	-	-19.1	11.0	19.19	6.43	3.5	3.3
W4655	FC9	-	-19.1	10.2	27.53	9.79	3.3	2.8
W4675	FC9	-	-19.4	10.4	21.24	7.26	3.4	1.9
W4702	FC9	-	-19.4	10.7	19.31	7.14	3.2	nd

APPENDIX D:

MAP DRAWINGS OF MASS GRAVES

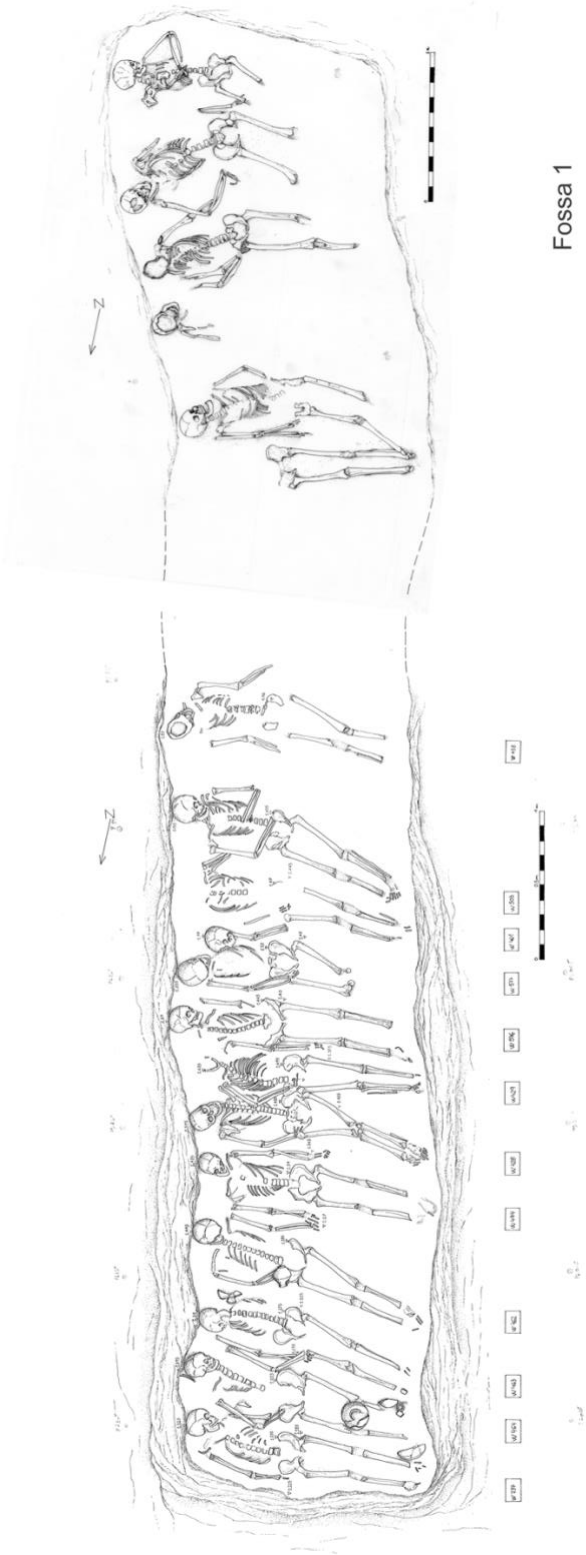

Figure D.1. Map drawing of FC 1+2

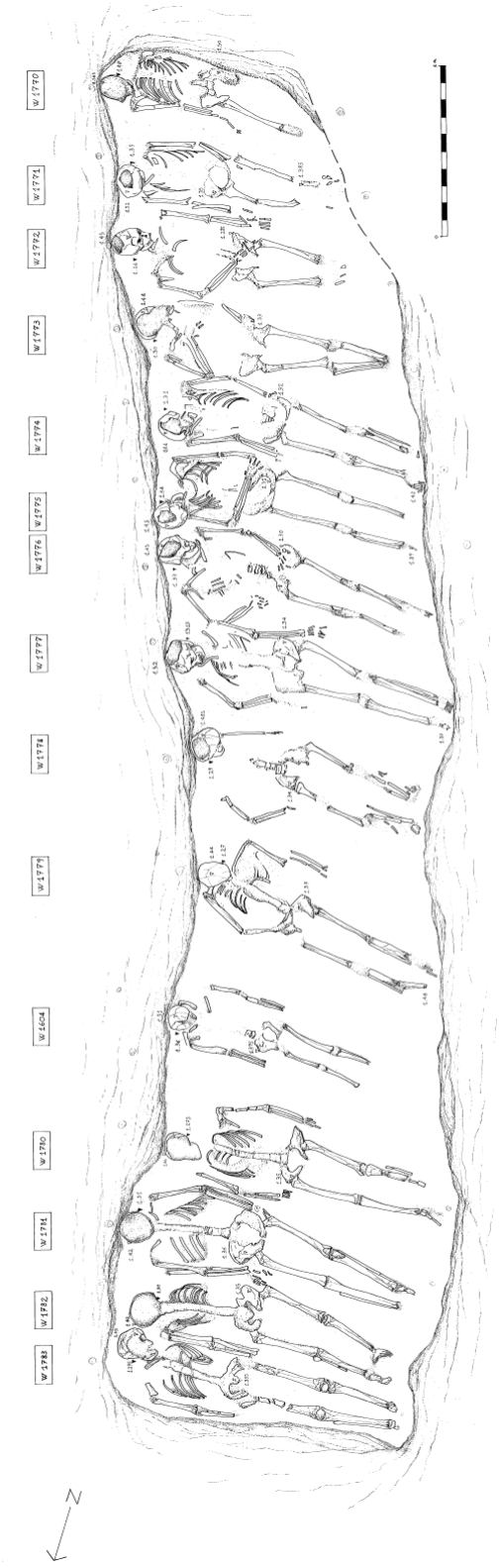

Figure D.2. Map drawing of FC4

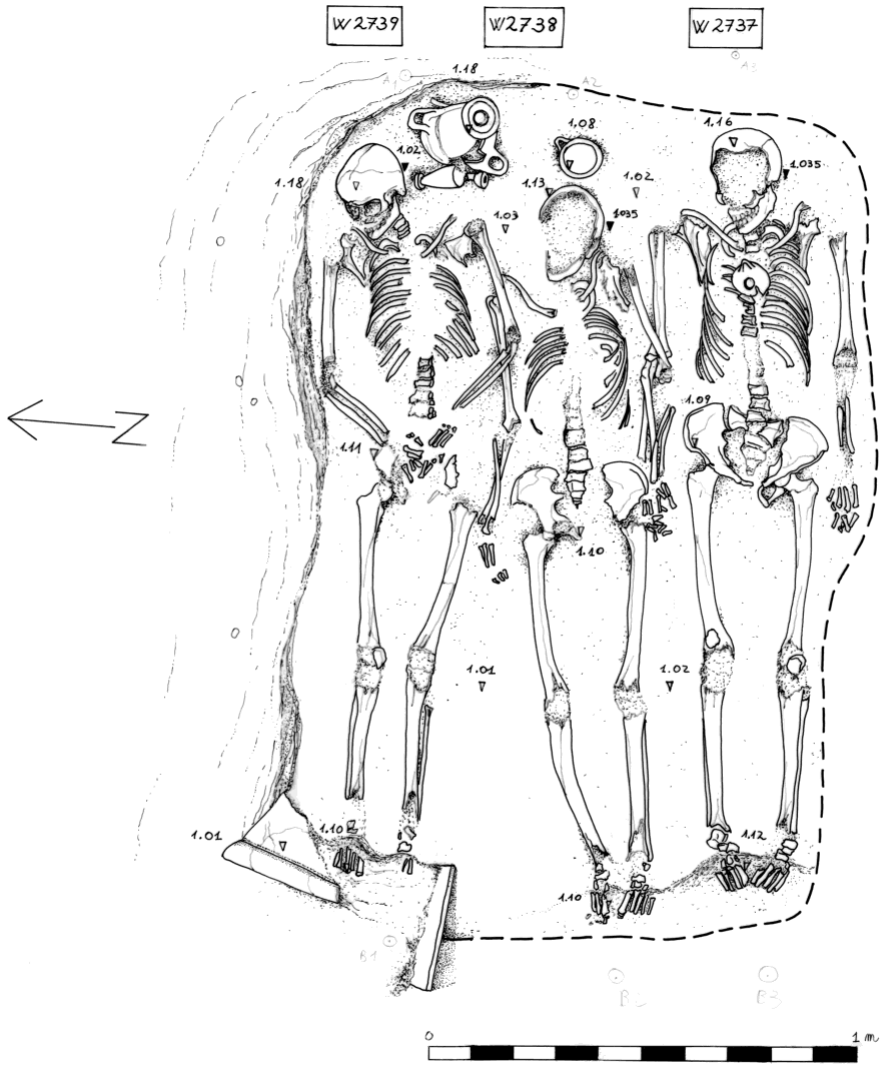

Figure D.3. Map drawing of FC6

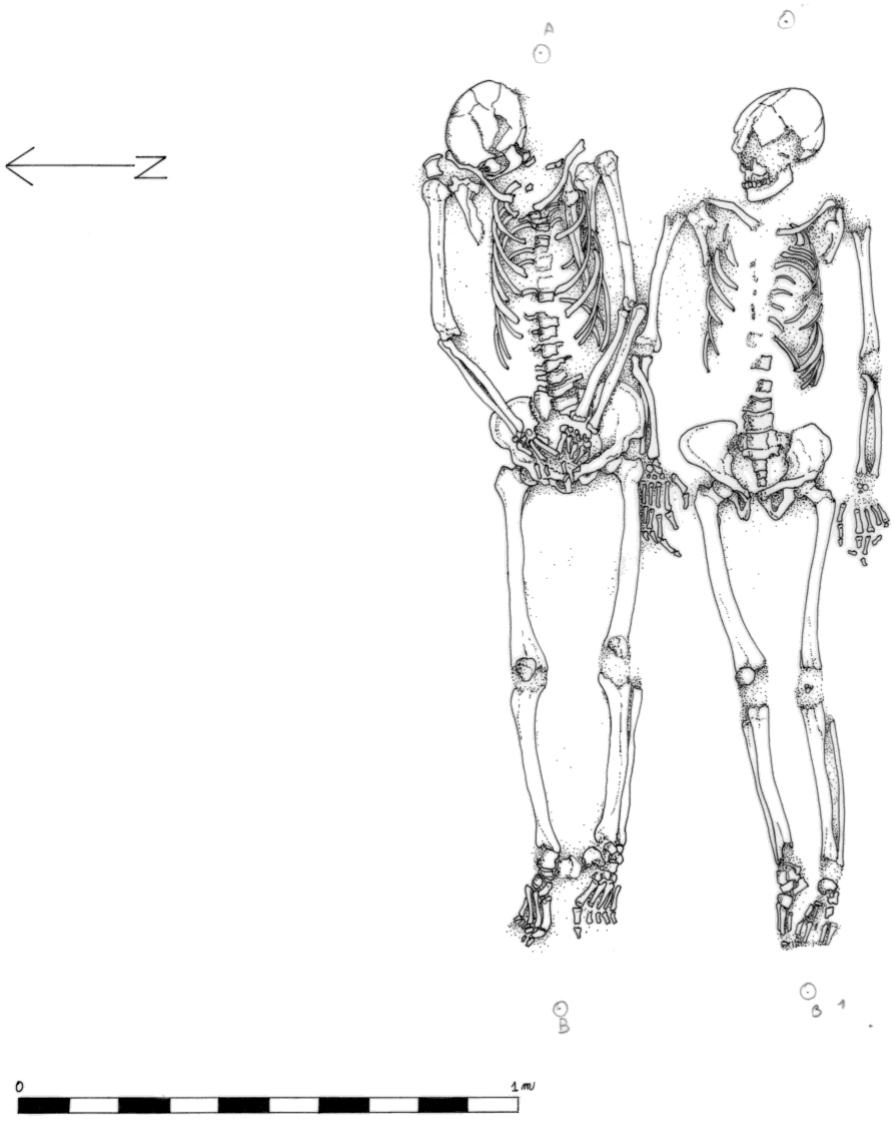

Figure D.4. Map drawing of FC7