University of Alberta

Residential Mobility in the Rural Greek Past: A Strontium Isotope Investigation

by

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Abstract

Excavations conducted at the ancient city of Stymphalos and the monastery of Zaraka in the valley of Stymphalos, Greece, yielded a number of human graves. Neither group of burials was contemporaneous with the structures in which they were interred and they are believed to represent small farming populations dating to the Late Roman/Early Byzantine (4-6th c. AD) and Late Medieval periods (14-15th c. AD). A dietary reconstruction conducted by Pennycock (2008) found that most individuals had similar $\delta^{13}C$ and $\delta^{15}N$ values, but a few had values that indicate dietary differences. Pennycook suggested that perhaps these differences were the result of residential mobility.

For this thesis, tooth enamel was analyzed for strontium isotopes to investigate mobility. The $^{87}Sr/^{86}Sr$ values show substantial movement by some human inhabitants of the valley, and may also be indicative of animal transport. These results suggest that rural peasants may have been more mobile than previously expected.

Acknowledgments

First, I wish to give thanks to my supervisor Dr. Sandra Garvie-Lok, for without her knowledge and dedication this thesis would not have been possible. Her support and expertise were invaluable to my thesis and her enthusiasm for the field of stable isotope analysis is what first drew me to this field of study. Thank you Sandra, I will never forget all that you have done for me.

This thesis would also not have been possible without the aid of the original excavators, Dr. Hector Williams and Dr. Sheila Campbell, as well as the LZ Ephorate of Prehistoric and Classical Antiquities and the 25th Ephorate of Byzantine Antiquities, for giving me the access to the archaeological material. I would like to thank Dr. Rob Creaser for his knowledge and expertise on isotope analysis, and for his generous donation of lab time and resources to this project. I would like to thank the Department of Anthropology at the University of Alberta for giving me the opportunity to apply myself to post-graduate studies. I also wish to show my appreciation to the Government of the Province of Alberta for its support through the Queen Elizabeth II scholarship fund, which provided me with much needed financial resources.

Finally I would like to thank my mom and dad for their ongoing support. It has been a long road and one that I would never have travelled without their continual encouragement.

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Chapter 1: Introduction

The goal of this thesis is to further our understanding of the Early Byzantine and Medieval inhabitants of the valley of Stymphalos, Greece, by conducting strontium isotope analysis on human and faunal tooth enamel in an attempt to assess individual mobility and identify patterns of migration.

Archaeological investigations at the sites of ancient Stymphalos and the Cistercian monastery of Zaraka, by teams led by Dr. Hector Williams and Dr. Sheila Campbell respectively, uncovered several human burials dating to the Late Roman/Early Byzantine and Medieval periods. These graves are not contemporaneous with the habitation phase of either site, and are thought to be representative of rural farming communities who used the abandoned sites as cemeteries. Osteological examination of the remains from both sites was performed by Dr. Sandra Garvie-Lok. Subsequent research on the burial populations was conducted by Robert Stark (2008), who assessed the prevalence of scurvy (vitamin C deficiency) among the juvenile individuals using radiology, and Carlie Pennycook (2008), who use stable carbon and nitrogen isotope analysis of bone collagen in order to reconstructing the diet and weaning practices of these inhabitants.

Pennycook's (2008) analysis found that while many of the individuals grouped together and likely consumed a similar diet, a few individuals displayed results indicating different dietary staples. Pennycook (2008) hypothesised that these individuals may have been migrants to the valley of Stymphalos and that the observed differences in diet may be partly related to regional/cultural differences in diet.

This thesis will address this question using strontium isotope analysis, which is an established technique for analyzing mobility within an archaeological framework. The chemistry of strontium isotopes and their interaction within a biological setting are well understood. Since its first use for this purpose by Jonathon Ericson in 1985, the technique has been applied in a wide variety of archaeological contexts and continues to be refined (Bentley, 2006; Budd et al., 2004; Evans et al., 2006; Ezzo and Price, 2002; Montgomery et al, 2000; Nafplioti, 2008; Price et al., 1994a; 1994b; Schweissing and Grupe, 2003; Slovak et al., 2008; Wright, 2005).

For the rural inhabitants of the valley of Stymphalos, strontium isotope analysis may allow us not only to test Pennycook's hypothesis, but also to gain a much better understanding of mobility among rural Greek peasants. Since no habitation site contemporaneous with either the Early Byzantine burials at ancient Stymphalos or the Medieval burials at the monastery of Zaraka has been located to date, it is possible that at least some of these individuals did not reside in the valley permanently and only travelled there on a seasonal or annual basis.

Although there were many reasons for rural inhabitants to move, a review of the literature suggests that peasants were integral not only to the financial stability of the Byzantine Empire but also to the health of its armies and populace, and that great lengths were taken to ensure that they remained on their land and did not stop cultivation. Therefore the main questions to be answered by this thesis are as follows. Based on strontium isotope analysis, how mobile were those interred in the valley of Stymphalos? Is there evidence for seasonal migration between the valley and the coast? Is there evidence for migration into the valley from more distant lands, and if so, what could have caused these people to move? Do the results of the strontium isotope analysis suggest that Early Byzantine and Medieval peasants or rural inhabitants were effectively tied to the land, or that they were much more mobile than we assume them to be?

Chapter 2 of this thesis will present the historical and cultural background required to establish a contextual basis for the present analysis. It begins with a brief history of the Byzantine Empire, encompassing its entire history from beginnings to collapse, but focusing on the two periods in question. Then a brief overview of the cultural, social, and legal aspects that governed Byzantine society will be presented. While this section discusses the general social environment of Greece, it focuses on the rural inhabitants of the countryside, since these individuals are the focus of study. Throughout this chapter, an emphasis is placed on identifying possible origins of migrants and why they moved.

Chapter 3 discusses the theoretical background of strontium isotope analysis and how it is employed within an archaeological framework. There is a brief general discussion of the stable isotopes used by archaeologists to study past peoples, as well as a short review of the carbon and nitrogen techniques used by Pennycook (2008) to study Stymphalos diets. Then there will be an general overview of strontium isotopes, how strontium comes to be present within organisms, and how strontium isotopes are employed by archaeologists. Following this, previous archaeological research using strontium isotopes is reviewed and the current analysis is introduced.

Chapter 4 describes the archaeological sites, archaeological materials and analytical methods related to this thesis. A description of the valley of Stymphalos is followed by a discussion concerning the underlying geology of the region and what range of strontium isotope ratios should be expected in local bedrocks. Then there is a brief discussion regarding the known history of ancient Stymphalos and the monastery of Zaraka, as well as their subsequent excavation. After this, the human and faunal osteological material are discussed in terms of their archaeological context and the methods employed to determine their strontium isotope ratios.

Chapter 5 reports the results of the strontium isotope analysis. It discusses the possibility of sample contamination and sample integrity. The local strontium isotopic range for the valley of Stymphalos based on the results of this analysis is established, and the human and faunal values are briefly compared with it and with the results of previous strontium isotope analyses conducted in Greece.

Chapter 6 interprets the results of the strontium isotope analysis in depth, placing them within the larger archaeological framework. There is a discussion concerning the mobility of livestock and both local and non-local humans at both sites and time periods. The strontium isotope results are then compared to Pennycook's (2008) stable nitrogen and carbon isotope results. This chapter assesses the validity of Pennycook's hypothesis and discusses the other questions posed above, concluding with a discussion of rural mobility in the Greek past in the light of the findings of this study.

Chapter 7 summarizes the results and conclusions of this analysis and suggests topics for future research that would further our understanding of the Stymphalos results and of the mobility of past populations in Greece in general.

Chapter 2: The History and Culture of Late Antique and Medieval Greece

2.1- Introduction

This chapter will provide the cultural-historical background necessary to place the isotopic investigation presented in this thesis into a contextual framework. It is extremely important that isotopic analyses of past populations be well rooted and understood within the cultural-temporal context in which they are conducted. Strontium isotope values recovered from human tissues would provide little insight into the past if that past were not already somewhat known to us by other means, such as archaeological evidence or historical sources. Greece has been subjected to extensive archaeological investigations, and the periods in question are generally well documented by historical records including treatises, personal communications, trade records, and legal documents. Unfortunately, though, there is very little evidence on the specific focus of this thesis, the rural inhabitants of Early and Late Byzantine Greece. So, although archaeological records and historical documents are useful in constructing a contextual framework, isotopic studies can provide valuable insights into daily life.

The first section of this chapter contains a brief historical review of the Byzantine Empire. With approximately a thousand years separating the human remains buried in the ruins of ancient Stymphalos from those recovered from the Cistercian monastery of Zaraka it is necessary to briefly cover the entirety of Byzantine history. However, focus is placed on the time periods to which the recovered human remains are dated, namely the 4th-6th and 15th centuries AD. This review also highlights Greece's place within the larger Byzantine Empire, as well as major events that could have stimulated human mobility in the region of study. To write this brief review of Byzantine history, I relied heavily on the work of modern historians including Ostrogorsky (1969) and Gregory (2005).

The second section of this chapter provides the reader with the cultural background required to fully contextualize the isotope data presented later. It starts by describing Byzantine social structure as it was in the Late Antique/Early Byzantine period and moves on to discuss the rural inhabitants of Byzantine Greece and the role of rural agriculturalists within wider Byzantine society. Although there has been very little archaeological research focused on the lives of rural Byzantines, historical writing provides some information on this topic. Two important historical sources (both of which were consulted in translation) are the *Farmer's Law* and the *Geoponika*. The *Farmer's Law*, written in the late 7th – early 8th century, provides a list of laws aimed at regulating disputes between rural villagers and provides some insight into daily life in Byzantine villages (Mango, 1980; Ostrogorsky, 1969; Rautman, 2006). The *Geoponika*, which contains 20 books dedicated to agricultural topics, was compiled in the 10th century (Ostrogorsky, 1969; Rautman, 2006). The *Geoponika* contains a wealth of information concerning medieval farming techniques and those who employed them. These two sources, along with other writings such as land records, tax legislation and religious chronicles, allow current scholars a brief glimpse into the lives of Byzantine peasants.

Rural diet is also an important topic, since strontium is incorporated into the skeleton via the ingestion of calcium and dietary items vary in calcium content. There is much information concerning diet available from historical and archaeological sources, and Pennycook (2008) has also reconstructed the diet of the inhabitants of the Valley of Stymphalos based on archaeological, historical and isotopic evidence. Finally, this section will discuss possible reasons for human mobility around the Valley of Stymphalos.

2.2 - Historical Background

The beginning of the Byzantine Empire can be dated to 306-324 AD, when Constantine emerged as a political leader, became emperor and re-founded the city of Constantinople (Angold, 2001; Grant, 1998; Gregory, 2005; Mango, 1980; Ostrogorsky, 1969). At this time, however, the old Roman Empire was still intact, and would remain so until the fall of its western half in 476, so the Early Byzantine Period is also commonly referred to as the Late Roman or Late Antique Period (Mitchell, 2007; Ostrogorsky, 1969). As part of the Eastern Roman Empire, Greece remained under imperial control after 476. Except for a relatively short period in the 13th and 14th centuries when it was under the control of Crusaders from Western Europe, it remained part of the Byzantine Empire for over a thousand years until that Empire fell to the Ottomans in 1453. Following this, Greece remained an Ottoman possession until its independence in the 19th century (Clogg, 1992). The following historical review will begin with the early division of the Roman Empire in 284 AD, and end with the fall of Greece to the Ottoman Empire in the 16th century.

2.2.1 - Dividing the Empire

In AD 284, when Diocletian (284-305) was proclaimed emperor, the Roman Empire was in a state of near collapse (Gregory, 2005; Mitchell, 2007). The murder of Severus Alexander in AD 235 at the hand of his rebellious troops ended a period of dynastic rule and began what is commonly referred to as the 3rd century crisis (Gregory, 2005:21). During the 50 years between Severus Alexander and Diocletian, control shifted rapidly between soldier emperors, most of whom were not trained to rule an Empire and died violent deaths at the hands of their adversaries (Gregory, 2005; Mitchell, 2007). Civil war was rampant and the political instability of this period caused an economic crisis that severely devalued the Roman currency (Treadgold, 1997; Gregory, 2005). The Empire became vulnerable to its enemies as its borders buckled. Essentially this period "witnessed the near collapse of the whole Roman way of life" (Gregory, 2005:21).

Diocletian introduced reforms that brought a brief period of stability to the Roman world (Gregory, 2005; Mitchell, 2007; Treadgold, 1997). Recognizing that the Empire was too much for one man to successfully administer, Diocletian divided it into eastern and western halves and created a tetrarchy (Grant, 1998; Gregory, 2005; Mitchell, 2007). He named himself *augustus* of the east and Maximian, an old friend, as *augustus* of the west, and each had a lesser emperor, or *caesar*, to assist him (Gregory, 2005:34; Treadgold, 1997:14). This system of rule took much of the pressure away from any one man and essentially eliminated usurpation, as *caesares* would replace their *augusti*, and in turn select their own *caesares* (Gregory, 2005). Although the Empire had been viewed in terms of East and West for some time, Diocletian’s reforms formalized the political division of the Empire into two halves, ruled by two separate administrations (Figure 2.1).

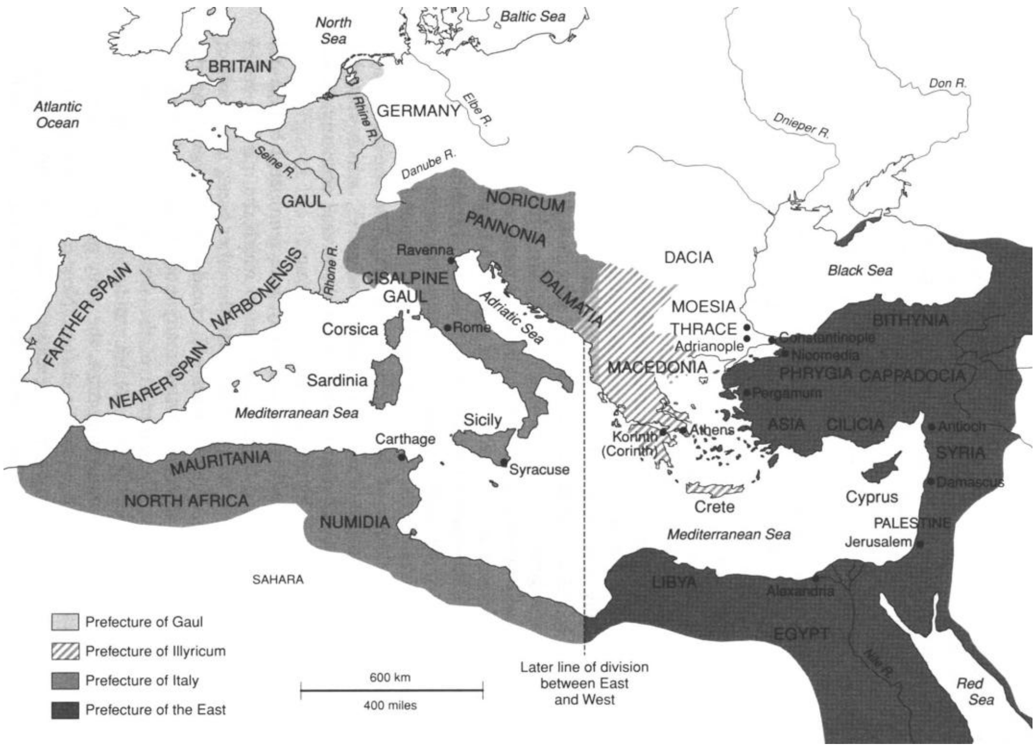


Figure. 2.1 - The Roman Empire during the reign of Diocletian (284-305) (Gregory, 2005: map 0.2).

2.2.2 - The Early Byzantine Period (AD 306-717)

Constantine (311-337) became *caesar* in 308. However, Diocletian’s tetrarchy began to deteriorate by 311 AD and after yet another civil war, Constantine became the sole Emperor of an undivided empire in 324 (Gregory, 2005; Mitchell, 2007; Thorndike, 1917). Constantine continued many of the reforms enacted by Diocletian, yet he is better known for being the first fully

Christian emperor and for his relocation of the Roman capital to the Anatolian Greek city of Byzantium (Gregory, 2005). Byzantium was chosen by the Emperor because of its strategic location and defensibility (Gregory, 2005; Mitchell, 2007; Ostrogorsky, 1969; Thorndike, 1917). Many scholars recognize either the beginning of the reign of Constantine or the re-founding of Byzantium as Constantinople as the formal beginning of the Byzantine Empire, although the Western portion of the Empire was not lost for another 150 years (Angold, 2001; Grant, 1998; Gregory, 2005; Mango, 1980; Ostrogorsky, 1969).

After the devastating defeat of the Romans by Gothic armies at the Battle of Adrianople in 378, Emperor Theodosios made concessions to the Goths which included becoming allies, accepting Gothic migration into Roman territory, allowing allied Gothic soldiers to be commanded by their own officers, and a general “barbarization” of the Roman army (Gregory, 2005:82-83). The relationship with the Goths established by Theodosios quickly deteriorated and shortly after his death, the Goths under Alaric invaded Greece (Cheetham, 1991; Mitchell, 2007; Thorndike, 1917). Even though the walls of Thebes held, and concessions saved Athens, much of Greece was ransacked by Alaric’s Goths (Cheetham, 1981).

In 401 Alaric invaded Italy, and was able to sack a virtually defenceless Rome in 410 (Grant, 1998; Gregory, 2005; Thorndike, 1917). After a period of great instability in the Western Empire, the Goths eventually took control of Italy in 476 (Cameron, 1993; Gregory, 2005; Mitchell, 2007; Treadgold, 1997). Shortly thereafter Gaiseric, the Vandal king, took Africa from Roman control.

Attempts made by the Romans to reclaim their territory were expensive, but largely unsuccessful (Mitchell, 2007). The next several decades were generally wrought with instability, constant warfare, and political manoeuvring as powerful groups fought for the remainder of the territory, yet essentially the Western Roman Empire was no more (Figure 2.2).

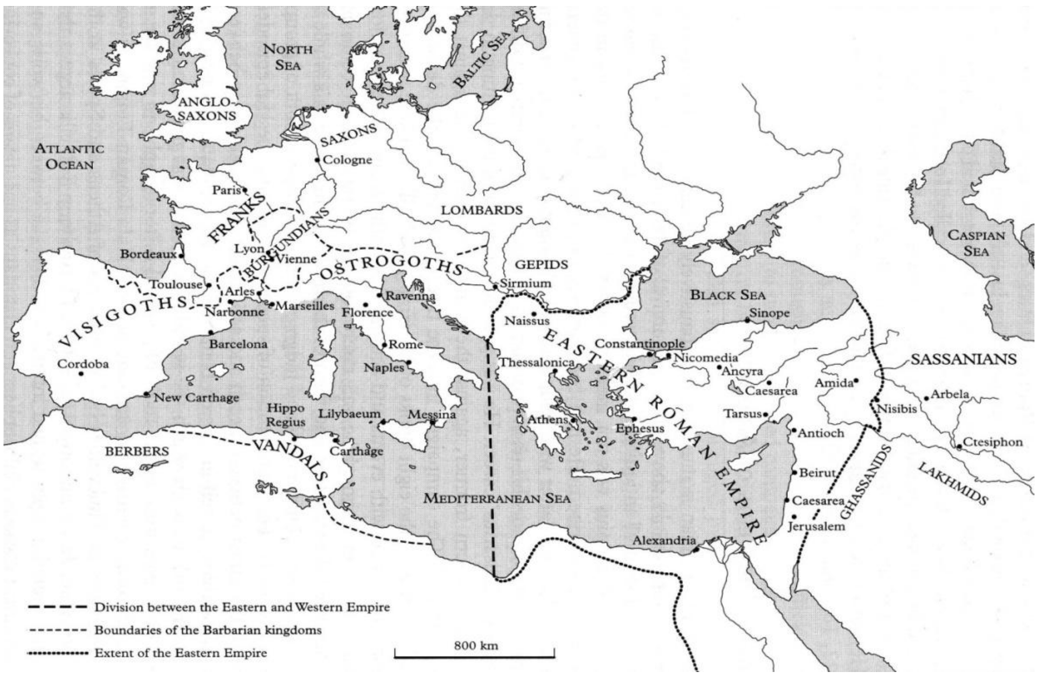


Figure 2.2 - The Eastern Roman Empire and barbarian kingdoms in 525 (Mitchell, 2007: map 4.1).

Compared to the West, the Eastern Empire had a better political, economic and military situation. Although it had its share of external pressures, it was farther removed from immediate threat and benefited from better defenses (both natural and constructed), stronger emperors with clear successions that limited political infighting, and a stronger financial situation (its treasury remained intact and production and trade remained strong) (Grant, 1998; Treadgold, 1997). These and other factors led to its surviving approximately 1000 years longer than the West.

For several decades after the fall of the Western Roman Empire, the Byzantine Empire was relatively prosperous. The Byzantines were able to stabilize their western positions in Greece, Dacia and Thrace, while two separate Gothic groups fought for control of Italy and the Vandals enjoyed their new territory in North Africa (Mitchell, 2007). War with Persia periodically threatened the Empire's eastern front until Emperor Justinian (527-565) was able to establish a mutually beneficial peace (Cameron, 1993; Mitchell, 2007:134). In 530, confusion following a political usurpation among the Vandals provided Justinian an opening to invade North Africa (Cameron, 1993; Mitchell, 2007; Ostrogorsky, 1969; Treadgold, 1997). With North Africa occupied after a successful campaign, Justinian proceeded to invade Italy in 535, while the Goths were still recovering from the aftermath of King Theoderic's death in 526 (Mitchell, 2007). Although the Byzantines had taken Africa with a quick easy victory, the reclamation of Italy became an extremely expensive war of attrition, lasting 20 years (Cameron, 1993; Gregory, 2005; Ostrogorsky, 1969).

At first, the campaign went well and by 540 the Byzantines had pushed the Goths all the way from Sicily to northern Italy (Mitchell, 2007; Ostrogorsky, 1969). To this point, Justinian's attempt to re-conquer the Western Roman Empire had been very successful, but it had cost the strength of the eastern borders (Mitchell, 2005; Treadgold, 1997). The Persians renewed their attacks and the Byzantines took expensive losses, though they were able to repel the invaders for the most part and started to rebuild their sacked cities (Ostrogorsky, 1969). Justinian also began reinforcing Italy, while refortifying the Balkans in an attempt to prevent Slav and Bulgar raids, which had been penetrating deep into Greece as early as 530 (Cheetham, 1981). In the fall of 541 it seemed that the Byzantines would be able to hold onto what they had ambitiously taken in the past 10 years. However, a plague struck Egypt in October and spread throughout the Mediterranean by the spring of 542 (Mitchell, 2007:373; Treadgold, 1997:196).

The Justinian Plague severely disrupted the socio-economic fabric of the Empire and essentially destroyed its ability to defend itself (Cameron, 1993; Gregory, 2005). In Constantinople alone, over 230,000 people perished (Mitchell, 2007:373; Treadgold, 1997:196). Heavily populated areas such as cities and army camps were the worst affected (Mitchell, 2007:373; Treadgold, 1997:196). Seizing the opportunity the Goths again invaded Italy in force, recapturing most of their lost territory (Gregory, 2005; Treadgold, 1997). Justinian himself contracted the plague, causing political chaos among his generals (Treadgold, 1997:197). The Moors in Africa then began making war on the Empire, and the Slavs increased their incursions into the Balkans (Cheetham, 1981; Treadgold, 1997).

Although there would be outbreaks for decades after, the plague began to subside in 544 (Mitchell, 2007) and in 545 Justinian was able to establish a lasting peace with Persia, allowing the resources of the recovering Empire to be directed at securing Africa and retaking Italy (Treadgold, 1997). By 554 Justinian was able to raise a large enough army to capture and hold Italy, secure Africa and begin campaigning to reclaim Spain in the Roman name (Treadgold, 1997). Due to a re-emergence of the plague the Spanish campaign never came to fruition, but under the veteran general Belisarius, the Byzantines were able to defeat a massive Slav invasion into Greece in 559 that reached as far as the pass at Thermopylae (Cheetham, 1981). Justinian died in 565, not long after the war in Italy was won. Although his reign almost restored the old Roman Empire (Figure 2.3), many scholars believe his ambitious conquests cost far more than they were worth and laid the groundwork for the "Dark Ages" that were to come (Gregory, 2005:140-146; Ostrogorsky, 1969:78; Treadgold, 1997:218).

Figure. 2.3 - The extent of the Empire under Justinian ca.565 (Mitchell, 2007:149: map 4.3).

Shortly after Justinian's death, the Empire began to lose territory. In 581 an allied invasion force of Slavs and Avars entered the Balkans and penetrated as far as the Peloponnese (Cheetham, 1981). It was possibly due to this action that Nemea, a settlement in the valley adjacent to Stymphalos, was abandoned (Miller et al., 2001). This invasion turned into a mass migration and settlement of the Balkans by the Slavs that would continue for centuries (Cheetham, 1981). By 581, Greece was so depopulated from 50 years of war and plague that the "Slav immigrants took possession of a magnificent but half-deserted country" (Cheetham, 1981:18). The Lombards gradually took control of Italy during the late 6th century, North Africa was also lost, and although the Byzantines were triumphant over Persia in the early 7th century, the Arab invasions began shortly thereafter (Gregory, 2005; Treadgold, 1997). The Arab conquest of Egypt denied the Empire its major source of grain and by the early 8th century the Empire controlled little territory and Constantinople itself was under threat (Gregory, 2005; Teall, 1959).

2.2.3 - The Middle and Late Byzantine Periods

Sieges of the Byzantine capital bracket the Middle Byzantine Period (717-1204). In 717, not long after Leo III (717-741) seized the throne, Arab forces attacked Constantinople (Gregory, 2005). However, Leo III was able to defeat the siege, reclaim much of Asia Minor and introduce reforms that would strengthen the Empire in the coming years (Gregory, 2005:185). Despite almost constant warfare on the eastern front, the Empire gradually grew in size and strength. The reign of Basil II (976-1025) may represent the apogee of Byzantine power (Gregory, 2005). Under Basil the Empire flourished economically, and once again controlled borders not held since the reign of Justinian (Angold, 1997). However, like Justinian's, Basil's Empire did not survive for long after his death (Angold, 1997; Gregory, 2005). In the two centuries following the death of Basil, the Byzantine Empire went from being the richest and most powerful state in Europe to being its "sick man" (Angold, 1997:316; Lock, 1995:3).

The relationship between the Byzantines and the Latin powers in the west gradually worsened throughout the 11^{th} and 12^{th} centuries and the schism between the Greek Orthodox and Catholic churches grew (Angold, 1997; Gregory, 2005; Lock, 1995). Despite being a Christian state, the Orthodox Byzantine Empire was hesitant to allow massive crusading armies into its territory or commit large amounts of resources to the Crusades, and this caused distrust among western Catholics. The Byzantines failed to assist the western armies during the siege of Antioch during the First Crusade (1096-99), and actually interfered with the Third Crusade (1188-89), which in part led to its failure (Angold, 1997; Harris, 2003). Although Byzantium was not their original target, the Frankish leaders of the Fourth Crusade were promised financial support if they aided a usurper trying to gain the Byzantine throne (Harris, 2003; Lock, 1995; Phillips, 2004). They fulfilled their role. However, the Latins were once again denied the support they were promised, at which point they decided to take it by force and unleashed the combined force of the crusading armies on the Byzantine capital (Angold, 1997; Harris, 2003). The irreconcilable differences between the Orthodox and Catholic churches, as well as the Byzantines' actions towards the Latins in the 12th century, had removed any moral issues that the crusaders may have had concerning the killing of Christians while on a Crusade (Angold, 1997; Gregory, 2005; Harris, 2003). Constantinople was sacked by the Latin armies on April 9th, 1204 and the Byzantine Empire was divided up among them (Figure 2.4) (Angold, 1997; Gregory 2005; Harris, 2003; Lock, 1995).

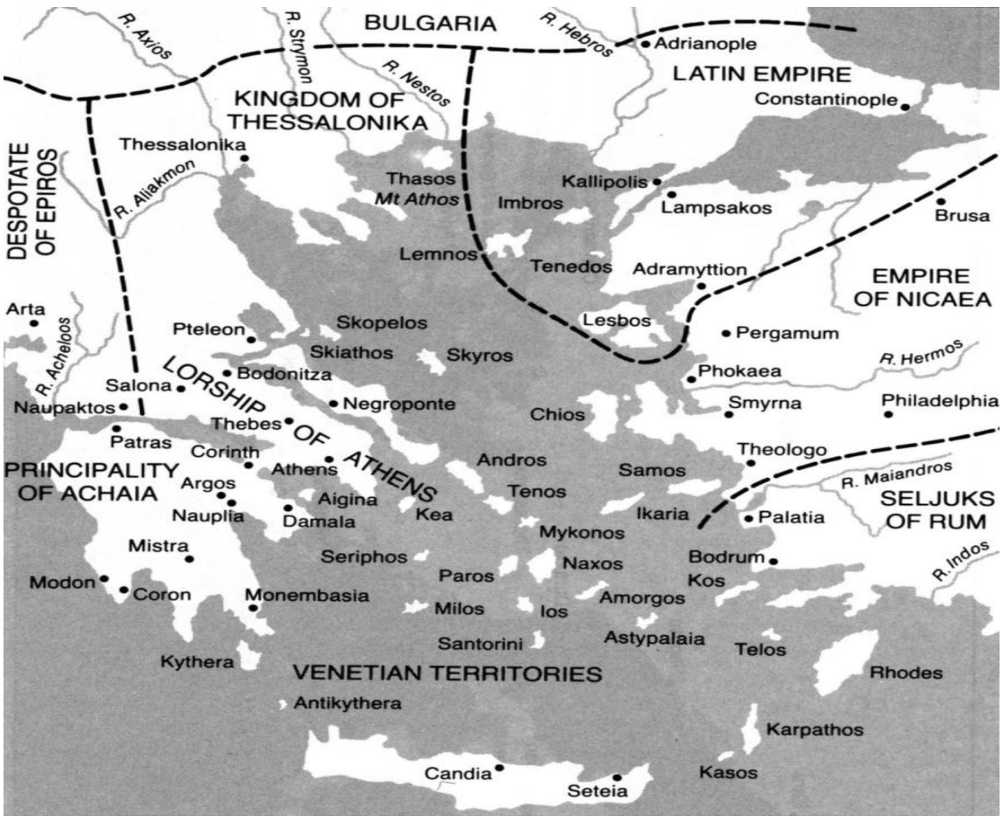


Figure 2.4 - The Byzantine Empire showing Latin Divisions after the Fourth Crusade, 1214 (Lock, 1995: map 2).

Since their main concern was maritime trade, the Venetians laid claim to the majority of the Greek islands, while the rest of Byzantine territory west of Constantinople was arbitrarily split into three sections: the Kingdom of

Thessalonike, the Duchy of Athens, and the Principality of Achaia (also referred to as Morea) (Cheetham, 1981; Gregory 2005; Harris, 2003; Lock, 1995; Ostrogorsky, 1969; Phillips, 2004; Treadgold, 1997). The whole of the Peloponnese, and with it the valley of Stymphalos, was included in the Principality of Achaia. For the most part, the Greek population was no worse off under Frankish occupation then they had been under the declining Byzantine state (Cheetham, 1981; Gregory, 2005; Lock, 1995). Both the Greek language and religion were preserved in most areas, and in some of the longer occupied territories, such as the Principality of Achaia, a blending of Byzantine and western traditions can be observed (Gregory, 2005; Lock, 1995). Throughout the next half century, the Westerners' situation in the Levant quickly deteriorated. The remnants of the Byzantine Empire in the east recovered, and by 1261 they were once again in possession of Constantinople (Gregory, 2005). However, the Byzantines were never again able to recover their position of power.

The Ottoman Empire had grown in strength substantially while the wars in the west were fought (Lock, 1995). In 1453, with the use of gunpowder and heavy cannons, the Ottomans reduced Constantinople's walls, captured the city and renamed it Istanbul (Treadgold, 1997:799-800). The Ottoman Turks then proceeded to conquer the remaining Byzantine and Latin territories in Greece (Cheetham, 1981; Gregory 2005; Harris, 2003; Lock, 1995; Ostrogorsky, 1969; Phillips, 2004; Treadgold, 1997). Even though the Latins were able to hold the castles at Nauplia and Monemvasia until 1540, the Ottomans were in effective control of the entirety of mainland Greece by 1458 (Lock, 1995). Although the fall of Constantinople to the Turks signalled the end of the Byzantine Empire, most scholars would agree that many Byzantine cultural traditions are still visible to this day in Greece and other Balkan regions, as well as Turkey, Italy and Russia (Gregory, 2005; Herrin, 2007; Lock, 1995; Ostrogorsky, 1969; Treadgold, 1997).

2.3 - Cultural Background

2.3.1 – Cultural Introduction to the 'Byzantines'

The term 'Byzantine', taken from the name of the city Byzantium, would not have been used by the people to whom it refers (Gregory, 2005; Ostrogorsky, 1969; Rautman, 2006). This term has been used by scholars since the 17th century when discussing the Empire that emerged after the collapse of the Roman West (Rautman, 2006). However, the Byzantines thought of themselves as Romans (*Rhomaioi* in Greek), members of a civilization which, by the time of Constantine, was already rooted in over a thousand years of tradition (Gregory, 2005; Ostrogorsky, 1969; Rautman, 2006). Hence, as Ostrogorsky (1969:28) explains:

> Byzantine history is indeed only a new phase of Roman history, just as the Byzantine state is only a continuation of the old *imperium romanum*. The last three centuries of Roman, or the first three centuries of Byzantine, history cover a characteristic age of transition and bridge a gulf between the Roman Empire and the medieval Byzantine Empire. It was during this period that the old Roman life gradually gave way to the new Byzantine elements.

As the early centuries of the Byzantine Empire were essentially an extension of the old Roman Empire, Roman customs were still very much a part of daily life. However, the loss of the western territories shifted the physical center of the

Empire eastward, increasing the influence of Greek culture and creating a new administrative system (Ostrogorsky, 1969; Rautman, 2006). Roman thought still provided the basis of Byzantine governance and engineering, but the Greek language eventually replaced Latin as the language of administration and Hellenistic culture altered the old Roman customs (Herrin, 2007; Ostrogorsky, 1969).

While very influential, the Greek and Roman cultures were obviously not the only ones represented in the Byzantine Empire. Like the Roman Empire, the Byzantine Empire continued to be a cultural melting pot, uniting many diverse ethnic groups under a common banner (Mango, 1980; Rautman, 2006). People from many regions were drawn to the Empire for various reasons. The Romans had a long history of bolstering their own forces with armies recruited from the provinces, and this practice was continued by the Byzantines (Gregory, 2005; Treadgold, 1997). Moreover, the Byzantines controlled a major route connecting Europe and Asia, which brought people from throughout the known world into their territory. Although more than seventy languages were spoken in Constantinople, the provincial countryside would have been much more linguistically homogeneous (Mango, 1980). Indigenous languages would have been used on a daily basis, yet Greek had been spoken in the heart of the Byzantine Empire for centuries and was a strong cultural unifier among its diverse populace (Herrin, 2007; Ostrogorsky, 1969; Rautman, 2006).

The Byzantine Empire was predominantly a Christian State and like language, religion bound its people together. The blending of Roman and Greek traditions within a Christian ideological framework was fundamental in forming what we now refer to as Byzantium (Herrin, 2007; Ostrogorsky, 1969; Treadgold, 1997). Diocletian attempted to eradicate Christianity with the "Great Persecution" starting in 302 AD (Gregory, 2005; Herrin, 2007). However, shortly after Diocletian's reign ended, Emperor Constantine himself converted, and Christianity quickly became one of the dominant religions in the western world (Gregory, 2005; Mitchell, 2007; Treadgold,1997). Despite its fundamental Christianity, religious tolerance was practiced within the Empire. Although Constantine banned some rites, pagan practices continued, especially in the countryside where the influence of churches was diminished by distance (Cameron, 1993; Treadgold, 1997). The Roman Empire had a long tradition of tolerance of Judaism, and this continued into the Byzantine era (Mango, 1980; Rautman, 2006; Treadgold, 1997). Later on, Muslim worshippers were similarly tolerated by the Byzantine Empire despite the threat that Islamic forces posed to its eastern borders (Angold, 2001; Herrin, 2007).

The religious tolerance of the Byzantines was one of the many factors which led to a division between the Roman Catholic and Greek Orthodox churches. In the early centuries of Christianity the most prominent bishops of Rome, Constantinople, Alexandria, Antioch and Jerusalem formed a pentarchy that dictated religious dogma and led the Christian world together (Herrin, 2007). Throughout the Early and Middle Byzantine Periods, the relationship between the Pope in Rome and Patriarch in Constantinople deteriorated and differences in beliefs and teachings arose between the Latin and Greek churches (Gregory, 2005; Herrin, 2007; Ostrogorsky, 1969; Treadgold, 1997). This led to schism between the Greek and Latin churches, as each thought that its own version of the Christian doctrine was more accurate (Gregory, 2005). These differences eventually culminated in the sack of Constantinople by Catholic armies during the Fourth Crusade.

2.3.2 - Byzantine Social Structure

In the Early Period, the social structure and political organization of the Byzantine Empire were essentially Roman. By the Middle Period, Hellenistic and Christian influences had begun to alter Byzantine administrative and political systems, yet the social organization remained relatively the same (Ostrogorsky, 1969). As with many highly stratified state level societies, there were three general socio-economic classes: upper, middle, and lower (Rautman, 2006). Although movement was somewhat limited, social boundaries were not impermeable, and people's ethnic or economic backgrounds did not strictly limit their social advancement (Rautman, 2006). However, wealth was generally measured by excess resources and the vast majority of the Empire's inhabitants would have had great difficulty accumulating any (Patlagean, 1997).

Wealth, and thus power, in Byzantium was controlled by a small number of aristocratic landowners, whose members occupied positions as military leaders, high standing bureaucrats and government officials (Gregory, 2005; Rautman, 2006). The Byzantine emperor, of course, sat at the apex of the social hierarchy. Although this title was usually in the possession of wealthy dynastic families, military commanders were likely candidates for the position and it was not unheard of for a peasant or civil servant to work his way up to the top (Ostrogorsky, 1969; Treadgold, 1997). Although major landowners such as senators and other government officials, who were tax exempt, could accumulate vast personal fortunes, the state's wealth was at the emperors' disposal (McCormick, 1997). The Byzantine emperor was considered the highest military commander, but rarely led troops into battle (Gregory, 2005; Ostrogorsky, 1969). According to McCormick (1997:239), "unlike any other European ruler before the thirteenth century, Byzantine emperors commanded a professional army and a highly organized bureaucracy expert at extracting wealth from the layers of the population least able to afford it, thanks to an elaborate tax system". The emperors' word was law, and thus they were considered to be above normal state legislation (McCormick, 1997). However, the emperor was also thought to be appointed by God, and therefore was expected to follow Christian teachings (McCormick, 1997; Rautman, 2006).

With time the power of the church grew, and so did its influence (Ostrogorsky, 1969; Treadgold, 1997). The Byzantine Emperor and the Patriarch of Constantinople shared a special relationship. Usually, the patriarch was chosen by the emperor from a list of bishops put forward by the church. However, it was within the emperor's power to reject the candidates if none of them suited his political goals (Herrin, 2007; von Falkenhausen, 1997). The clergy were not allowed to hold bureaucratic or military titles, but the hierarchal structure of the Church and the administrative power given to bishops by Justinianic legislation made the patriarch an extremely powerful political position (von Falkenhausen, 1997). Local bishops could acquire great wealth through their churches and were thus considered among the elite (von Falkenhausen, 1997). Although their primary role was that of teachers and protectors of Christian orthodoxy, bishops were responsible for the spiritual and physical welfare of the Christian followers within their territory (von Falkenhausen, 1997). They were also expected to manage their districts' finances, churches and priests, while acting as mediators between the state and its populace (von Falkenhausen, 1997). Bishops were only permitted to live in cities and had to rely on lower ranking priests to manage the towns and countryside (von Falkenhausen, 1997).

Gregory (2005:7) states that "there was nothing like a middle class in the Roman Empire and the vast majority of individuals were poor farmers, either engaged in subsistence agriculture or tenant farmers who worked the fields of large landowners". However, both Mango (1980:41) and Rautman (2006:21) discuss the "middle class" within a Byzantine context, and I feel that the term is a useful indicator of individuals or families that were neither rich nor poor. Generally, middle class households would have had enough income to provide for basic needs and afford certain luxuries. As today, the middle class would have been quite broad and income would vary greatly between families and professions. Occupations such as priests, smaller landowners, bureaucrats, soldiers, merchants, and prosperous tradesmen could all be expected to generate surplus income (Mango, 1980; Rautman, 2006). To be fair, I think Gregory's (2005) comment concerning the lack of a Byzantine middle class was made to place emphasis on the disparate number of people belonging to the other two socio-economic categories: a very small amount of upper class elites living in luxury, compared to the large percentage of the population that lived in poverty.

To be sure, the vast majority of Byzantines would have had trouble earning enough money to procure basic necessities, let alone afford luxuries or advance their families' position. Lower class does not necessarily imply poverty-stricken and some lower class families would have been able to afford a comfortable, if not luxurious existence. However, many individuals would have indeed been completely destitute and unable to provide for themselves. Patlagean (1997:15) describes two situations recognized by the Byzantines: "the *penēs* had an activity, but his efforts were not enough to provide him with a satisfactory and secure living; the *ptōchos* was reduced to passive impoverishment and depended on others for everything". Most *penēs*, earned money by means of unskilled positions, and contributed much of the manual labour required for building projects and rural agricultural production (Patlagean, 1997). The *ptōchos*, such as the elderly, orphaned children, and the mentally or physically disabled were unable to work and had to rely on charity (Patlagean, 1997). Providing for the truly needy or *deomenos* was an important function of the Christian church (Mango, 1980; Patlagean, 1997; Rautman, 2006; von Falkenhausen, 1997). The Christian teachings concerning philanthropy and the protection of the poor allowed the churches to redistribute money provided by the more financially stable members of society to those who could not provide for themselves (Cameron, 1993; Patlagean, 1997).

Like their predecessors, the Byzantines used institutionalized slavery as a means of fulfilling some of their labour requirements. Slaves could not own property or testify, and lethal punishment was permitted (Rautman, 2006). The number of slaves within any given period was based largely on the military success of the Empire, as most new slaves were acquired through warfare (Kazhdan, 1997; Rautman, 2006). As a result of Christian teachings and military failure, the number of slaves present in the Empire declined over time (Gregory, 2005; Rautman, 2006). In earlier times, large farms worked by slaves contributed a large portion of Roman agricultural produce. However, some authors caution against assuming that this was the case during Byzantine times and suggest that slaves would have been scarce on the rural landscape (Gregory, 2005; Mango, 1980). Although large and small farms would have undoubtedly utilized slave labour, the vast majority of agricultural production came from the free tenant farmer (Cameron, 1993; Gregory, 2005; Mango, 1980; Ostrogorsky, 1969).

2.3.3 - Byzantine Peasants

Rural farmers, or peasants (*geōrgikē* in Greek), would have undoubtedly constituted the bulk of the Byzantine population (Kazhdan, 1997; Rautman, 2006). Equality was not characteristic of the Byzantine peasantry, and some would have definitely been better off than others. Kazhdan (1997:43) lists several words used to designate peasants based on their ownership: *oikodespotai* (house owners); *kalybiotai* (hut owners); *kapnikarioi* (hearth owners); *zeugaratoi* (owner of a pair of oxen); *aktēmōes* (have-nots). Although some peasants led comfortable lives, the majority, especially those who did not own their own land, likely lived in poverty. The dependent farmers (*paroikoi* in Greek or *coloni* in Latin) were considered to be little more than slaves to their landlords and it was entirely possible for someone to be considered "*servus et colonus* [or] both a slave and a *colonus*" (Cameron, 1993:86; Charanis, 1951; Mango, 1980). During planting and harvesting the number of rural inhabitants would have undoubtedly increased due to movement of seasonal labourers from the larger centers.

Even though they were technically free, Byzantine peasants were effectively tied to the land (Cameron, 1993; Charanis, 1944; 1951; Gregory, 2005; Ostrogorsky, 1969; Rautman, 2006). Unlike true slaves, peasants were free to move, yet they were expected to meet their financial obligations to the state's tax collectors, money lenders and landlords. In order to keep as much land as possible under cultivation, Diocletian, Constantine, Theodosius II, and Justinian all passed laws that restricted the social mobility of peasants (Cameron, 1993; Ostrogorsky, 1969). Imperial decrees made professions hereditary for farmers and tradesmen (Cameron, 1993; Charanis, 1944; Mango, 1980; Ostrogorsky, 1969). Furthermore, the *paroikos* could not marry whomever he wished and could not voluntarily join the army (Mango, 1980). Land ownership was also hereditary in nature, and was usually passed to close relatives (Charanis, 1944; 1951; Rautman, 2006). The continual cultivation of a plot by a farmer for 30 years made it his legal possession (Charanis, 1951). Peasants could not be evicted from their land, and many were free to move provided they did not reside on the same plot over 30 years (Charanis, 1944; 1951; 1961; Setton, 1953; Ostrogorsky, 1969). However, these peasants were expected to meet their financial obligations before moving, and land left fallow for 30 years was considered abandoned (Charanis, 1951; Setton, 1953). Indeed, imperial legislation, social norms and financial obligations made it very difficult for the majority of peasants to create enough surplus wealth to advance their position.

Taxes were the main source of income for the Empire, and "peasants were considered the main taxpayers who supported the state and its military machine" (Kazhdan, 1997). The goal of typical peasants was to produce enough to meet their families' needs as well as pay state taxes and rent (Rautman, 2006). They were also obligated to provide labour for building projects, as well as donate supplies and conscripts to the military when required (Kazhdan, 1997). All land, cultivated or not, was assessed by the state and taxed according to its estimated value (Charanis, 1944; Rautman, 2006). In addition, all peasants, whether they owned their land or were dependents of a larger landholder, were required to pay a head tax (Charanis, 1944; Ostrogorsky, 1969). If unable to afford taxes, those who owned land could use it as collateral to borrow from money lenders or they might choose to sell their land and become *paroikoi* (Kazhdan, 1997). Those unable to pay taxes could be flogged or worse, and according to ancient sources tax collectors were particularly corrupt and disliked (Kazhdan, 1997). However, dependent farmers also had to pay rent and landlords, like the state's tax collectors, were known to sometimes ruthlessly extort their tenants (Cameron, 1993; Charanis, 1944; Kazhdan, 1997). Peasants would sometimes flee the harsh living conditions imposed on them by their lords or tax collectors and a large number of peasants were always on the move (Charanis, 1944; Kazhdan, 1997). Peasants who were required to pay taxes were referred to as *dēmosiarioi* (Kazhdan, 1997). Those who moved to avoid taxes were called *eleutheroi* (meaning "free from taxes" or "unknown to the treasury") and if caught they could be flogged and returned to their former lands in chains (Kazhdan, 1997:67).

To make matters worse, a life of farming in the countryside was very difficult and peasants might lose their livelihood in a variety of ways. Civil wars and invasions were common throughout the history of the Empire, and in all likelihood would have caused significant disruption in the lives of the peasants in the area of hostilities (Kazhdan, 1997; Rautman, 2006). Hostile raids could also bring great instability to an area, as could piracy, riots, revolts, and minor conflicts between wealthy families (Kazhdan, 1997). Moreover, farming is a dangerous occupation and accidental injuries and deaths would have been commonplace (Kazhdan, 1997; Rautman, 2006). In the countryside away from medical practitioners, illness and infection could easily lead to death or leave a person debilitated and unable to work (Kazhdan, 1997; Rautman, 2006). If unable to work, a peasant's productivity would suffer and debt would quickly accumulate. Environmental conditions, extreme weather or natural disasters, such as strong winds, early frosts, hail, floods, drought, earthquakes, landslides, wildfires, or insect and vermin infestation, could financially ruin the small farmer and result in the loss of his land or even starvation (Kazhdan, 1997; Rautman, 2006).

Basically, the small proprietor was crushed between the large aristocratic landholders and the state's bureaucracy. The selling of property by small landholders unable to meet their financial obligations allowed certain families to accumulate massive estates worked by *paroikoi* and slaves (Kazhdan, 1997; Rautman, 2006). Many emperors tried somewhat unsuccessfully to limit the power of wealthy aristocratic families by preventing the accumulation of vast tracts of land and protecting the small proprietor (Gregory, 2005; Ostrogorsky, 1969). Although the number and economic importance of large estates fluctuated over time, they persisted throughout the duration of the Empire (Gregory, 2005; Ostrogorsky, 1969). Over time, the Church became a substantial landowner (Ostrogorsky, 1969). Christian principles influenced many people from all classes to donate to the Church, and some wealthy individuals donated whole estates along with those who worked them (Cameron, 1993; Ostrogorsky, 1969). Because of this, the Church also became the owner of large numbers of slaves (Cameron, 1993). The tax exempt status of the Church further supported its economic advancement (Ostrogorsky, 1969). Moreover, like all wealthy landowners, the Church was in the position to purchase land from small landholders to increase its holdings.

2.3.4 - Rural Settlements

Recent archaeological surveys conducted in Greece have significantly improved our understanding of how rural settlement patterns have changed over time (Alcock, 1993; Athanassopoulos, 1993). Survey data from Greece suggests that there was a significant decline in the number of small sites (< 0.3 ha), usually assumed to represent small farmsteads or shelters, and a general increase in site size from the Late Hellenistic to the beginning of the Late Roman period (Alcock, 1993; Athanassopoulos, 1993). During the Late Roman/Early Byzantine period the number of small sites increased until the virtual abandonment of the countryside during the Greek "Dark Ages" starting in the 7th century (Alcock, 1993; Athanassopoulos, 1993). The number of rural sites once again increased from the 9th century onward, as the Empire recovered and moved towards a largely feudal agricultural system dominated by large estates (Athanassopoulos, 1993). Although the Valley of Stymphalos has never been the subject of an intensive archaeological survey, the neighbouring Valley of Nemea has been. Data from the Valley of Nemea suggests that the area was densely populated and extensively farmed during the Late Roman period, and followed a similar pattern to the rest of Greece throughout the Medieval period (Alcock, 1993; Athanassopoulos, 1993). Even though survey evidence is lacking, the findings from the Nemea survey suggest that the neighbouring valley of Stymphalos would have also had a substantial population density and that many of the individuals uncovered during excavations were likely local inhabitants.

Alcock (1993:55) states that "the rural landscape in a pre-industrial society is formed above all by the conditions governing the division and exploitation of the land". There are several different ideas concerning the fluctuations of site distribution and size in Greece through time. Population density may explain the distribution and size of rural settlements, and most authors believe that this is at least partly responsible for the changes observed in surface surveys (Alcock, 1993; Athanassopoulos, 1993). An increase in population would bring more people to the countryside, thus increasing the number of small sites while decreasing the size of individual landholdings. Changing agricultural practices have also been proposed as a factor affecting the size and distribution of small sites (Alcock, 1993; Athanassopoulos, 1993; Halstead, 1987). Halstead (1987) suggests that two types of agricultural strategies operated in the Mediterranean: the "traditional" and the "alternative". The "traditional" strategy in Greece involved extensive land use and agricultural practices typically involved non-fertilized cereal production rotated with bare fallowing. The farmers would generally live among others separate from their fields in nucleated settlements. Halstead's (1987) "alternative" strategy involved a much more labour intensive regime of cereal/pulse rotations combined with animal husbandry and the use of manure as fertilizer. This strategy would have required farmers to be located closer to their land and lead to an increase in small dispersed sites. Halstead (1987) states and Alcock (1993) agrees that these two strategies were not mutually exclusive and both would have been used simultaneously depending on the situation and goals of individual families. It has also been suggested that an increase in small sites may reflect the replacement of large estates which utilized "traditional" agricultural systems with small proprietors practicing "alternative" intensive farming methods, or perhaps a dispersed settlement pattern is related to the availability of markets and agricultural methods geared to surplus production (see Athanassopoulos, 1993:89-93). However, Alcock (1993) stresses that the limitations of intensive survey must be realized and archaeologists should refrain from making intricate interpretations concerning ancient settlement patterns without conclusive evidence.

Although more recent research has avoided interpreting the exact nature of Byzantine archaeological sites, Foss (1995:216) lists a variety of rural settlement types classified by Georges Tchalenko (1905-1987) during his extensive archaeological research into the Syrian countryside during the Late Antique: "there were primitive settlements; peasant villages; villas; groups of aristocratic residences; villages developed from a single estate; villages of small farmers; small market towns; outlying industrial and commercial centers; and imperial estates – in other words, a great variety of settlements". The majority of peasants lived in villages referred to as *komai* during the Late Antique, or *choria* in later sources (Kazhdan, 1997; Rautman, 2006). The *agridion*, or hamlet, was located closer to the fields away from the village and was usually inhabited by slaves, hired labourers, or villagers during harvest (Kazhdan, 1997). Villages could vary in size, as well as layout, yet they were rarely fortified (Rautman, 2006). A *chōrion* might be centrally oriented with peasants' houses placed close together (*kathedra*) or it could have several foci with relatively spaced out dwellings (*kathedrai*) (Kazhdan, 1997). According to Rautman (2006:161), "like in western Europe, village domains were arranged in three concentric zones". The land closest to the village was used for gardening and the collection and processing of dairy and agricultural products, since these activities required daily attention. Fields, vineyards and orchards required less attention and were generally further away. Beyond the fields, pastures and forests belonging to the village were utilized for gathering food, wood, and grazing.

The land surrounding a village was both individually and communally owned. Forests, pastures, lakes and streams were available for all to use, but fields, orchards, vineyards and gardens were independently owned (Kazhdan, 1997). The rights of villagers and the legal ownership of land were both highly developed and regulated (Kazhdan, 1997; Rautman, 2006). For instance, when selling land it had to be first offered to potential buyers within the community before it could be sold to an outsider (Kazhdan, 1997). One also had to ensure that the buyer would continue to respect the rights that other villagers had to the land, such as the right to gather nuts and fire wood (Kazhdan, 1997). Although families were independently responsible for their own taxes, the state assessed land and collected taxes at the village level and individual deficits had to be made up by the rest of the community (Ostrogorsky, 1969; Rautman, 2006). Whereas the village formed the primary fiscal unit within the State, the nuclear family formed the primary unit within the village (Rautman, 2006).

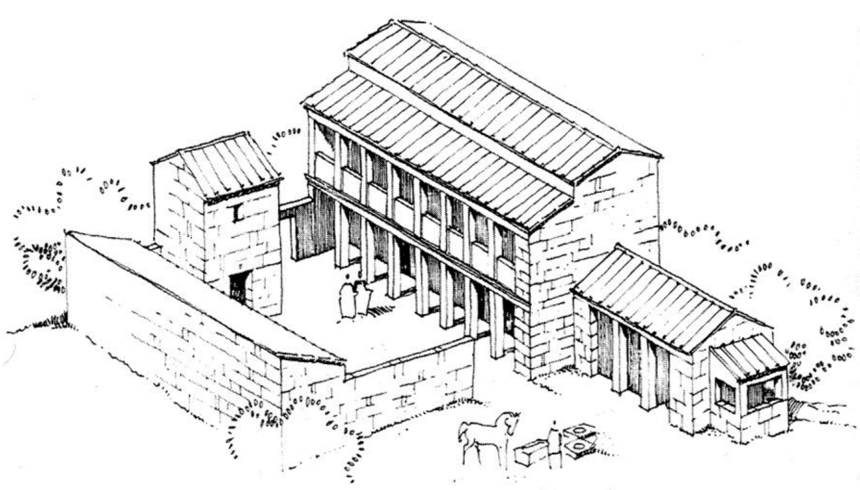


Figure 2.5 - Reconstruction of a 5th century farmhouse with olive press (Rautman, 2006:168).

Dwellings in villages could vary greatly depending on the prosperity and requirements of their owners and ranged from large mansions to small temporary shelters (Kazhdan, 1997; Rautman, 2006). Due to their poor archaeological preservation little is known concerning rural Byzantine houses, but typically they had two to four rooms, thatched roofs, and were usually constructed using locally available materials, such as mud brick, stone, or timber (Charanis, 1962; Kazhdan, 1997; Rautman, 2006). Mud brick was still sometimes used as a building material in and around the Valley of Stymphalos in modern times. Sleeping and living areas were generally kept separate if possible, and foodstuffs were usually stored in a separate room within *pithoi* and other ceramic vessels (Rautman, 2006). Walled courtyards were commonly attached to houses and served as a place to conduct activities and keep livestock, grapevines and small gardens (Rautman, 2006). Water was collected from natural bodies, but cisterns and wells were also common (Rautman, 2006). Lean-tos were sometimes built onto an existing wall and used as storage or shelter for animals (Kazhdan, 1997). For the most part, rural houses would have been poorly furnished and dimly lit by small glassless windows and oil lamps (Kazhdan, 1997; Rautman, 2006).

There was little change in the daily lives of rural Greek agriculturalists throughout the duration of the Byzantine Empire. Much of what we know about peasants of the Late Roman/Early Byzantine period comes to us from either earlier Roman or later medieval sources. To be sure, large scale socio-political events such as the Slavic, Frankish or Ottoman invasions could have dramatically altered the lives of individual populations. However, the actual living conditions and activities in the countryside changed very little over time. Neither the Latin nor Ottoman occupiers of Greece felt the need to drastically change the Byzantine agricultural system, which was very similar to the hereditary serfdom of the West (Angold, 1997; Charanis, 1951; Lock, 1995; Ostrogorsky, 1969). During both the Frankish and Ottoman occupations the conquered population of Greece was allowed to continue practicing the Christian Orthodox religion, and although they were extracted by new lords, the taxes and obligations expected of peasants essentially remained the same. By the Frankish period there is little mention of small proprietors and it is thought that virtually all peasants were considered *paroikoi* (Angold, 1997). In many instances, new Frankish lords would likely have been a welcome relief from cruel landlords and extortionist taxmen. Throughout the thousand year duration of the Byzantine Empire the typical peasant would have lived a hard life of servitude that remained unchanged by the centuries. Although it was possible for peasants to advance the position of their families, the daily life of the average small farmer during the Ottoman period had changed very little from what is known from Roman times.

<u>2.3.5 - Agricultural Production and Diet</u>

Roman agricultural practices persisted in Byzantium for a long time before they were gradually replaced by medieval innovations (Kazhdan, 1997; Rautman, 2006). The “scratch” plow (sole ard or *gyes*) was the main implement used for plowing. Although its prolonged use has been suggested as the reason for “Byzantium’s slow agricultural development,” it was well suited to the thin rocky soils of Greece and was used well into the Ottoman period (Rautman, 2006:178). The sole ard was relatively inexpensive and easy to build and repair. However, because it had no wheels and was harnessed to the neck of the animal (not the shoulders) it had to be light and could not cut as deep as the heavier plows used in the west (Rautman, 2006). Since the sole ard only scratched the soil it did not cause the loss of deeper moisture which was crucial in arid environments (Kazhdan, 1997; Rautman, 2006). Yet it also did not turn the earth and this had to be done manually with hand tools such as hoes or mattocks, and sometimes a field would require to be worked two or three times before sowing (Kazhdan, 1997; Rautman, 2006). This piece of equipment, and the ability to power it, was so essential to agricultural production in Byzantium that the amount of oxen a family owned was a large determinant of how much land they could realistically cultivate (Charanis, 1951). As Charanis (1951:139) explains:

> The *paroikoi* with property were those, of course, to whom land allotments had been given. The size of these allotments depended largely upon the ability of the holder to cultivate his share, and this ability was determined largely by the number of oxen at his disposal. Thus, the landholding of a *paroikos* who possessed two pairs of oxen was considerably greater than that of another who possessed only one ox. The *paroikoi* with land were, thus, classified according to the size of their holdings and they were usually referred to as *duozeugaratoi*, holders of land of a size which could be managed with two pairs of oxen, *zeugaratoi*… one pair of oxen, and *boidatoi*… one ox.

Once the soil was turned and planted, weeding and harvesting was done manually with mattocks (*makele*), forked spades (*lisgarion*), and sickles (*drepanon*) (Kazhdan, 1997; Rautman, 2006).

Figure. 2.6 - A man plowing with a sole ard (Rautman, 2006:179).

Once harvested, ox drawn carts and wagons were used to transport produce back to villages or farmsteads for processing and then to markets for sale. These carts and wagons had changed little from Roman times and could not carry heavy loads since they too used a harness that attached to the neck of the animal limiting its efficiency (Rautman, 2006). Transporting produce to markets would have been difficult for peasants due to poor roads, topographical challenges and environmental conditions (Rautman, 2006). If topographical challenges or the quality of roads were not conducive to use of carts, pack animals such as donkeys or mules were likely employed. However, many rural families may have had no other choice but to carry their produce to markets themselves. Distance and difficulty of travel would have likely been an important factor contributing to a family's decision to live in a village closer to markets or on an isolated farmstead closer to their fields.

The mainstay of the Byzantine diet, as it had been in the Mediterranean for thousands of years, was cereals and therefore, a substantial portion of the Empire's agricultural production was dedicated to their cultivation (Braun, 1995; Kazhdan, 1997; Megaloudi, 2006; Rautman, 2006). Cereals were consumed daily, by virtually every person in the Empire, in the form of bread and porridges that varied based on the type of grain and the degree of its processing (Dar, 1995). Light coloured bread was preferred over the darker breads eaten by the poor (Dalby, 1996; Dar, 1995). Wheat was considered to be superior to other grains because it made the best bread (Adamson, 2004; Braun, 1995; Rautman, 2006). Unlike wheat, most cereals do not contain gluten forming proteins and will not produce a well leavened loaf when used alone. According to Braun (1995:25), "barley bread, prepared with yeast and baked, is poor stuff". Although wheat was preferred and fetched a higher price, barley was grown more than wheat in Greece and much of the Balkans, where thin soils and environmental conditions were not always suited to wheat (Braun, 1995; Garvie-Lok, 2001; Kazhdan, 1997; Megaloudi, 2006). Barley is hardier, needs less water, and has a shorter growing season than wheat (Kazhdan, 1997; Rautman, 2006). The replacement of wheat rations with barley was a popular collective military punishment and some people claimed barley to be unsuitable for human consumption (Braun, 1995). However, it was likely the dietary staple for much of the Byzantine population, especially in the areas where it was heavily cultivated.

Several grains aside from wheat and barley were also cultivated. Oats and millet were generally considered only to be suitable as fodder for animals, even though they were sometimes utilized as dietary staples by the poor (Adamson, 2004; Megaloudi, 2006). Rice and rye were also known to the Romans, but neither seems to have been cultivated extensively in the Byzantine Empire until later in its history (Garvie-Lok, 2001; Kazhdan, 1997; Megaloudi, 2006; Rautman, 2006). Maize became an important crop in Greece once it was introduced from the Americas during the Ottoman period. Like barley, maize grows well in thin rocky soil and the Balkans were one of the first areas in Europe to adopt its cultivation, likely in the early 16th century (Andrews, 1993; Garvie-Lok, 2001). The consumption of millet and maize, since they are C4 plants, can be distinguished from use of the other grains eaten in Greece using stable carbon isotope analysis. Pennycook's (2008) isotopic dietary reconstruction of diet in the Late Roman and Medieval valley of Stymphalos does not suggest that they consumed much, if any, millet or maize.

Along with cereals, grapes and olives both constituted a large part of the Byzantine diet. Both grapes and olives are well suited to the Mediterranean environment and were common crops in southern Greece. Olive oil was not only heavily consumed as a dietary staple, but was also used for hygiene and cosmetics, while also being the main source of indoor lighting (Rautman, 2006:46; Dar, 1995:331). Olives were also an important cash crop and cured olives and olive oil could be easily transported to distant markets where they fetched a high price. Foss (1995) suggests that surpluses due to an increase in olive cultivation by small peasant proprietors may have contributed to the break-up of large estates witnessed in the Late Roman period. Grapes could also be eaten whole or processed into an easily stored and expensive commodity. They too grow well in the Mediterranean climate, and the Valleys of Nemea and Stymphalos are still important olive and grape producing areas to this day. Although raw grapes would have comprised a large part of the seasonal diet in areas in which they were cultivated, large portions of the harvest would have been dedicated to wine production. In medieval Greece everyone drank wine and it was considered a basic caloric staple similar to olive oil (Dalby, 1996; Garvie-Lok, 2001). Like olive presses, grape presses could be either communally or individually owned and were extremely important for the making of wine (Rautman, 2006). As with olive oil, the making of wine is a tedious, labour intensive process and significant time was likely devoted to it each season.

Besides cereals, olives and grapes, a wide variety of vegetables, fruits, nuts and herbs were grown and consumed. Gardens, orchards and woodlands would have all been important sources of food for the typical Byzantine peasant (Kazhdan, 1997; Rautman, 2006). Pulses, or legumes, were an important source of protein especially for poorer individuals who could not afford to eat meat on a regular basis (Garnsey, 1999). Peas, grass peas, broad beans, chickpeas, lentils, and vetches are all known to have been grown in Byzantine gardens (Megaloudi, 2006; Rautman, 2006). Pulses were an important dietary component, yet they were also important in some agricultural regimes since pulses are nitrogen fixing plants and they can replace much of the nitrogen that cereals remove from the soil. Because pulses fix nitrogen, the consumption of large amounts of pulses is observable in stable nitrogen isotope values. However, Pennycook's (2008) dietary reconstruction does not suggest that the individuals recovered from the Valley of Stymphalos ate a significant amount of legumes. Other vegetables grown by the Byzantines include carrots, okra, wild lettuce, capers, celery, garlic, cucumber, cabbage, onion, leeks, radish, beets, turnip, parsnip, eggplant, artichokes, melons, pumpkins and gourds (Megaloudi, 2006; Rautman, 2006). Orchards provided various fruits such as apples, pears, peaches, figs, plums, cherries, apricots and quince, as well as many different nuts such as chestnuts, pistachios, walnuts, hazelnuts, acorns and almonds (Megaloudi, 2006; Rautman, 2006). A wide range of herbs used to flavour foods and for medicinal purposes were also known to have been cultivated by Byzantine farmers (Rautman, 2006).

Although the typical Byzantine peasant would have consumed very little meat, various animal products would have been eaten on a regular basis. Young or suckling animals were preferred for meat, but older individuals were also consumed once they had outlived their usefulness (Lafuente, 2007; Wilkins, 1995). Sheep and goats were kept primarily for milk, which was used to make a wide variety of cheeses, but of course, sheep were also kept for their wool (Faas, 2003; Lafuente, 2007; Rautman, 2006). Similarly, cattle were seldom eaten for they are expensive to keep and were more valuable as beasts of burden (Adamson, 2004; Faas, 2003; Rautman, 2006). The milk of cows was not nearly as highly regarded as that of sheep and goats (Garvie-Lok, 2001). Pigs were the only large mammal that was used primarily for meat and pork was likely the most common meat consumed by the average peasant family (Faas, 2003). Pigs are easily kept, reproduce in large litters and require little extra labour to feed as they will scavenge for food and readily eat human leftovers and waste (Adamson, 2004; Rautman, 2006). Many different types of birds and fowl were kept for their meat and eggs, which were a highly regarded food (Adamson, 2004; Faas, 2003; Kazhdan, 2006; Rautman, 2006). When available, meat procured from wild sources was likely a welcome addition to the peasant diet (Rautman, 2006). It is also known that the Byzantines ate a wide variety of fish and aquatic foods depending on their regional availability (Adamson, 2004; Pennycook, 2008; Purcell, 1995; Rautman, 2006). Although the remains of some fish (marine: tuna and gilt head sea bream; freshwater: chub) were recovered from archaeological excavations in the valley of Stymphalos, Pennycook's (2008) isotopic investigation found that aquatic resources did not significantly contribute to the diet of the individuals analyzed. The valley's lake would have provided some fresh fish, but it is highly unlikely that marine fish would have made it to the Valley without being preserved in some fashion.

Diet is an important consideration when examining the mobility of a population using strontium isotope analysis. As detailed in the following chapter, strontium enters the body along with calcium. Therefore it is not the entire diet that contributes to an individual's strontium values, but only those foods that are high in calcium. Dairy products would have been regularly consumed by rural peasants and would likely be responsible for a large portion of their dietary calcium and strontium. Green vegetables are also very high in calcium and would have also been an important source of strontium. Since they do not travel well, it is likely that the majority of vegetables consumed in the Valley would have been locally grown. Although some dairy products can survive being transported, and herds of livestock may be moved over large distances, it is still likely that the much of the dairy consumed by the Valley's inhabitants would have been locally procured and thus reflect local strontium values.

2.3.6 - The Mobility of Rural Inhabitants

Even though Byzantine peasants were effectively tied to the land by socio-economic institutions such as taxes, occupational inheritance, and other factors that limited their mobility, were they as stationary as we tend to assume? There are many reasons for which rural inhabitants would move, or have been forced to move and during both the periods in question, long systems for long distance travel (e.g. roads, water craft, transportation routes) were well established. In times of instability, such as Justinian's conquests in Italy or the migration of Slavic peoples from the north, thousands would have migrated. Obviously, slaves from re-conquered territories would have had little choice in where they eventually resided, while others may have chosen a certain locality for a variety of social or individualistic reasons. Similarly, a large amount of people moved to and from the country on a seasonal basis for farming purposes and an individual's choice to move may have depended on a variety of personal factors such as marriage, the preference to live in a larger area, or choosing to work at a different profession. The inherent difficulties that accompany being a pre-modern rural inhabitant, namely the plight of the peasant, likely caused people to migrate for a variety of reasons. By conducting strontium isotope analysis I hope to shed light on the question of rural mobility in Byzantine Greece. Are rural inhabitants as sedentary as we assume them to be? Can we observe mobility in the human remains recovered from the valley of Stymphalos? And if so, how far had these individuals may have travelled to eventually be laid to rest in the remains of ancient Stymphalos or the monastery of Zaraka?

Chapter 3: Theoretical Background for Strontium Isotope Analysis

3.1 - Introduction

Thirty years ago, researchers first recognized the wealth of information that stable isotope analysis could add to archaeological investigations (Vogel, 1977). Since then, much time and effort has been spent on refining analytical techniques as well as developing new ways in which isotopes may be used. To date, the utility of several different elements have been explored and each of them may provide researchers with valuable information concerning past societies.

Atoms of each element contain a characteristic number of protons, which give that element its distinctive properties. The number of protons in an element distinguishes it from every other element and gives the element its atomic number. The nucleus of the atom also contains neutrons, which have no charge but do have mass. While the number of protons present never varies between the atoms of a given element, the number of neutrons can vary. Atoms that have the same atomic number but a different number of neutrons are called isotopes. Isotopes are symbolically represented by the element name followed by a hyphen and the total number of protons and neutrons (e.g. carbon-12, carbon-13), or they may be represented with the periodic table's elemental abbreviation with the number of protons and neutrons as a prefix written in superscript (e.g. ^{13}C, ^{12}C). The number of neutrons that can be present in an atom of a given element is not infinite, as not all proportions of neutrons to protons are stable. Atoms of stable isotopes do not undergo spontaneous decay. Unstable (radioactive) isotopes decay through the release of a subatomic particle, causing the transformation of atoms of the unstable isotope (parent) into a different element (daughter) which may be radioactive or stable. An example of this process is the emission of an electron from radioactive ^{14}C producing stable ^{14}N, the reaction that makes radiocarbon dating possible. A stable isotope created through decay of a radioactive one is sometimes referred to as radiogenic (created by radiation).

Stable isotope ratios are measured using an isotope ratio mass spectrometer, which is a device that is able to distinguish between ions based on their mass (Ehleringer and Rundel, 1986). Essentially, samples are ionized and passed through a magnetic field. Here their charge causes them to be diffracted, with the degree of diffraction depending on their mass. This produces streams of ions of the same mass following different paths. A series of collectors traps the ions and determines the relative quantity at each position, which allows the isotopic composition of the sample to be determined (Ehleringer and Rundel, 1989).

Variable atomic mass between isotopes also causes some isotopes to be discriminated against, a process known as fractionation (Ehleringer and Rundel, 1989). Enzymatic discrimination occurs in biochemical processes, when an isotope with a certain mass is more readily used than another. Similarly, geochemical processes can also cause fractionation. For example, fractionation occurs in hydrogen and oxygen during changes in state, as the heavier ^{18}O has a tendency to stay in liquid form and the lighter ^{17}O in a gaseous one. This observation has provided the foundation for a wide range of research into stable oxygen isotopes (e.g. paleoclimate data from ice cores), and fractionation provides the framework for many of the techniques employed by archaeologist utilizing a wide variety of elements.

3.2 - Stable Isotope Analysis in Archaeology

3.2.1 - Carbon

Although ^{14}C was used from the early 1950's for the purposes of chronometric dating (Currie, 2004), the carbon isotopes ^{13}C and ^{12}C became the first stable isotopes to be used by archaeologists in the 1970's (Vogel, 1977). Stable carbon isotopes are mainly used to gain information about the dietary activities of past people. The ratio of $^{13}C/^{12}C$ in a sample, expressed in per mil departure from a standard as $\delta^{13}C$, can allow researchers to distinguish whether dietary staples were based on C4 plants, such as corn or millet, or C3 plants, which include most other grains, fruits and vegetables (Harrison and Katzenberg, 2003). However, $\delta^{13}C$ values may also be used to provide evidence for freshwater (Bocherens et al., 2007; Katzenberg et al., 2009) and marine resource use (Harrison and Katzenberg, 2003; Polet and Katzenberg, 2003). They may also provide evidence of trophic level (Bocherens and Drucker, 2003; Hedges and Reynard, 2007) as well as the introduction of weaning foods into the juvenile diet (Dupras et al., 2001; Dupras and Tocheri, 2007; Fuller et al., 2006a; Fuller et al., 2006b; Richards, 2002; Schurr and Powell, 2005; Williams et al., 2005). Most current investigations interested in reconstructing the dietary habits of past populations use a combined analysis of stable carbon and nitrogen isotopes.

3.2.2 - Nitrogen

Like stable carbon isotopes, the stable nitrogen isotopes ^{15}N and ^{14}N can be utilized to gain information concerning the dietary habits of past individuals and populations. $^{15}N/^{14}N$ ratios, expressed as $\delta^{15}N$, can provide archaeologists with an indication of an organism's place within the food chain because $\delta^{15}N$ values rise with each trophic level (Bocherens and Drucker, 2003; Hedges and Reynard, 2007). Herbivores have low $\delta^{15}N$ values relative to carnivores. With regards to humans, by comparing the $\delta^{15}N$ values of human remains to those of archaeological fauna, it is possible for researchers to estimate what portion of their diet came from plant or animal sources (Bocherens et al., 2006). In some cases, it is possible for archaeologists to suggest what specific animal represented the main meat staple for a population (Bocherens et al., 2006). Because aquatic ecosystems tend to have elevated $\delta^{15}N$ values, $\delta^{15}N$ analysis also provides researchers with insights concerning marine (Polet and Katzenberg, 2003; Richards et al., 2006) or freshwater resource use (Bocherens et al., 2007; Katzenberg et al., 2009). Finally, because a lactating woman's milk $\delta^{15}N$ is similar to that of her tissues, a breast-feeding infant has tissue $\delta^{15}N$ above that of its mother. Based on this effect, many researchers have used $\delta^{15}N$ values to determine the duration of breastfeeding and age of weaning in archaeological populations (Dupras et al., 2001; Dupras and Tocheri, 2007; Fuller et al., 2006a; Fuller et al., 2006b; Richards, 2002; Schurr and Powell, 2005; Williams et al., 2005).

3.2.3- Oxygen

Although stable oxygen isotopes are also incorporated into the human body by ingestion of a nutritional requirement, mainly water, archaeologists do not use them to gain information about past diet, as is the case with carbon and nitrogen. Instead, the stable oxygen isotope ratio $\delta^{18}O$ (expressing the proportion of ^{18}O to ^{16}O) is generally used to gain knowledge concerning past environments. $\delta^{18}O$ values can be recovered from a variety of materials and can provide information concerning environmental conditions such as rainfall and temperature (Hedges et al., 2004; Rick et al., 2006; Schoeninger et al., 2003; Surge and Walker, 2005). Moreover, since different bodies of water in different regions also show differences in $\delta^{18}O$, many scholars have used these values to investigate mobility or resource catchment areas of archaeological humans (Budd et al., 2004; Evans et al., 2006; Prowse et al., 2007). Because the $\delta^{18}O$ value of the water ingested by an organism during the formation of skeletal tissues is recorded in the tissue, researchers may compare tissue values to those considered local in order to determine individual mobility between different regions.

3.3 - Strontium Isotope Analysis

Just as stable oxygen isotopes may be used to investigate mobility and catchment areas, strontium isotopes can aid archaeologists with similar interests. Although the method was already being used to study movement among other animals (Bentley, 2006), Ericson (1985) was the first scholar to apply strontium isotope analysis to an archaeological context. Ericson's (1985) study not only proposed the method and began to test it, but also explored issues related to mobility among the Chumash peoples of prehistoric California. Since this initial archaeological use, many scholars have used strontium isotopes to investigate past human mobility (e.g. Bentley et al., 2003; Budd et al., 2004; Evans et al., 2006; Ezzo and Price, 2002; Montgomery et al, 2000; Nafplioti, 2008; Price et al., 1994a; 1994b; Schweissing and Grupe, 2003; Slovak et al., 2008; Wright, 2005). Bentley (2006) provides an excellent overview of strontium isotopes and how they may be utilized to investigate mobility within an archaeological setting. This article is relied upon heavily in the following discussion.

3.3.1 - Strontium Isotopes in Minerals

Strontium (atomic number 38) is an element which only exists naturally in compounds with other elements in the form of minerals (Bentley, 2006). Strontium has an ionic radius (1.32 Å) which is very similar to calcium (1.13 Å), and this allows for it to substitute for calcium in many minerals, such as calcite, dolomite, gypsum and apatite (Bentley, 2006). Strontium has four stable isotopes, occurring naturally in the following abundances: ^{84}Sr (~0.56%); ^{86}Sr (~9.87%); ^{87}Sr (~7.04%); ^{88}Sr (~82.53%) (Bentley, 2006). ^{84}Sr, ^{86}Sr and ^{88}Sr are products of primordial synthesis, while ^{87}Sr is a radiogenic isotope created from the β-decay of rubidium-87 (Bentley, 2006). Rubidium (atomic number 37) has an ionic radius (1.52Å) similar to that of potassium, allowing it to substitute in potassium-containing minerals (Bentley, 2006).

It is the ratio of two of strontium's isotopes, $^{87}Sr/^{86}Sr$, which holds the interest of geologists and archaeologists alike. At the time of their formation, rocks generally contain ^{86}Sr, ^{87}Sr, and ^{87}Rb. Because ^{86}Sr is stable and non-radiogenic, its abundance remains relatively constant and can be used to determine the amount of ^{87}Sr that was present in the rock at the time of its formation (Bentley, 2006). Since ^{87}Rb decays (half-life $4.88x10^{10}$ years) to produce ^{87}Sr, the $^{87}Sr/^{86}Sr$ ratio of a given rock at the time of its testing will be directly related to its original $^{87}Sr/^{86}Sr$ ratio, the $^{87}Rb/^{86}Sr$ or Rb/Sr ratio, and the time elapsed since the rock's initial crystallization (Bentley, 2006). This relationship has been exploited extensively by scholars to date geological formations and rock that contain rubidium (Evans, 1991; Faure, 2000)

The original Rb/Sr ratios of rocks vary greatly with their composition and age, with the result that $^{87}Sr/^{86}Sr$ ratios also vary. To quote Bentley (2006), "rocks that are very old (>100 mya) with high original Rb/Sr have $^{87}Sr/^{86}Sr$ ratios generally above 0.710, and rocks formed recently (<1-10 mya) with low Rb/Sr ratios have low $^{87}Sr/^{86}Sr$ ratios generally less than 0.704". This effect creates large regional variation in bedrock $^{87}Sr/^{86}Sr$ depending on composition and time of formation. Oceanic sedimentary rocks, such as the limestones that form the majority of bedrock in the Peloponnese, have $^{87}Sr/^{86}Sr$ ratios that reflect that of the world's seawater during the period of their formation (Burke et al., 1982). The $^{87}Sr/^{86}Sr$ value of seawater represents an average of the earth's continental crust, which is deposited in the ocean via erosion and has fluctuated between ~0.707 and ~7.709 over the last 500 million years (Bentley, 2006; Burke et al., 1982). The highly variable $^{87}Sr/^{86}Sr$ of bedrock is very important for archaeologists, since this strontium is incorporated into the food chain and eventually human tissue.

3.3.2 - Strontium in the Environment

Strontium becomes incorporated into the soil and groundwater via the weathering of rocks (Bentley, 2006). Because strontium is able to substitute for calcium, it moves from the soil and water into plants and animals. However, because calcium is taken up more readily than strontium, the Sr/Ca ratio of organisms will decrease the higher they are in the food chain (Bentley, 2006). This process is known as biopurification and has allowed researchers to use Sr/Ca values to comment on the trophic level of humans within past environments (Ezzo, 1994; Mays, 2003). Biopurification causes Sr/Ca to decrease by a factor of about five with each step up the food chain. Thus in a given region herbivore Sr/Ca will be about 20% that of plants and carnivore Sr/Ca will be about 20% that of herbivores. This strontium content must be distinguished from $^{87}Sr/^{86}Sr$ ratio. Although the amount of strontium decreases up the food chain, the $^{87}Sr/^{86}Sr$ ratio of that strontium does not. The regional $^{87}Sr/^{86}Sr$ ratio of bedrock is incorporated unchanged into plants and animals because strontium has a relatively large atomic mass, with the result that the isotopes ^{87}Sr and ^{86}Sr do not differ enough in relative weight for either to be significantly selected over the other (Price et al., 1994; Bentley, 2006).

Within any given geological region, there are likely several different sources for strontium, and therefore there may be many different $^{87}Sr/^{86}Sr$ values being incorporated into the food chain. Although much of the biologically available strontium will derive from the local bedrock, any erosive force can potentially remove bedrock from one geological area and transfer it to another. Water can move strontium from highland areas to the lowlands (Bentley, 2006). Wind can transfer strontium great distances creating soils with non-local $^{87}Sr/^{86}Sr$ values (Price et al., 2002). Wind also transfers strontium from the oceans to the land in the form of sea spray (Bentley, 2006). Currently the $^{87}Sr/^{86}Sr$ ratio of the world's oceans is 0.7092 and thus, coastal areas will have an $^{87}Sr/^{86}Sr$ ratio that reflects the contribution of strontium from the ocean (Bentley, 2006). Because of such factors, the $^{87}Sr/^{86}Sr$ values of an locale's plants and animals will rarely be identical to that of the underlying bedrock.

Although $^{87}Sr/^{86}Sr$ ratios do not change as they pass into the food chain, there is the possibility for variance among the organisms of a given region due to multiple sources of strontium with different $^{87}Sr/^{86}Sr$ (Bentley, 2006). Because plants receive strontium directly from the soil and groundwater in their immediate vicinity, they are likely to exhibit the most variation within any given region (Bentley, 2006). Herbivores in the region may eat any of these plants, incorporating strontium from all of them into their tissues. The $^{87}Sr/^{86}Sr$ value of an herbivore that takes in strontium from a variety of sources will be a weighted average of these $^{87}Sr/^{86}Sr$ values (Bentley, 2006). Similarly, a carnivore consuming many different herbivores will also show a single $^{87}Sr/^{86}Sr$ value that is a weighted average of dietary strontium derived from all of them. In this way the variance between organisms' $^{87}Sr/^{86}Sr$ ratios decreases as their trophic position gets higher, with plants showing considerably higher variation and carnivores showing the least (Bentley, 2006). This is good news for archaeologists, since humans are usually situated in high trophic positions and variation among individuals inhabiting the same area should be less than that seen in plants or herbivores.

To summarize, the basic premise of strontium isotope analysis is as follows. $^{87}Sr/^{86}Sr$ ratios of bedrock move via weathering into groundwater and soils (Faure and Powell, 1972). These $^{87}Sr/^{86}Sr$ ratios then move into plants, and although there may be some variation depending on strontium source, these ratios are averaged as herbivores consume many different plants (Bentley, 2006). Higher trophic level organisms then eat the herbivores, which again averages the $^{87}Sr/^{86}Sr$ ratios consumed by herbivores (Bentley, 2006). The resulting $^{87}Sr/^{86}Sr$ ratios of these organisms reflects a weighted average of biologically available strontium in their catchment area (Bentley, 2006). Although there will be some $^{87}Sr/^{86}Sr$ variation among organisms at higher trophic levels, it is relatively slight when compared to the variation in natural sources of Sr between areas. Therefore it becomes possible for researchers to distinguish organisms that derived their strontium from local biologically available sources and those that received it from elsewhere (Ericson, 1985; Price et al., 1994a; Montgomery et al., 2000; Bentley et al., 2002; Budd et al., 2003; Bentley, 2006). If archaeologists excavating a cemetery are interested in examining mobility in the past, this may allow differentiation between individuals who originated from this catchment area and those who moved into the area from elsewhere.

3.3.3 - Strontium in the Skeleton

As mentioned above, strontium is able to substitute for calcium in some minerals, including the mineral component of bone and teeth. The matrix of bone is comprised of an organic portion and an inorganic portion. The organic portion is comprised mostly of collagen (Ottani et al., 2002). These collagen fibers are permeated and surrounded by crystals of hydroxyapatite, a calcium phosphate based mineral with the chemical formula $Ca_{10}(PO_4)_6(OH)_2$, which forms a crystal lattice (Posner, 1969). Strontium (along with some other elements such as lead and barium) is able to penetrate this lattice substituting directly for calcium (Bentley, 2006). Therefore, biologically available strontium becomes incorporated into the mineral portion of the skeleton through the consumption of foods that contain calcium (Bentley, 2006). This strontium then stays in the body by substituting again for calcium in the mineral portion of bone during its formation (Bentley, 2006). Since the collagen portion of bone does not contain calcium, it also does not contain strontium, and is not pertinent to this study.

There are several different types of mineralized tissues in the mammalian body. Bone matrix is comprised of approximately 70% organic material, comprised mainly of collagen, and about 30% inorganic material, comprised mainly of hydroxyapatite (Sillen, 1989). Because of its high organic content, bone is the softest mineralized tissue. Three further mineralized tissues are present in teeth. The core of the crown and roots of teeth is formed from dentine. Dentine is comprised of approximately 20% organic material and 75% inorganic material (Williams and Elliot, 1989). Cementum is found at the junction between the root and crown of a tooth and functions as an attachment point for the periodontal ligament (Hillson, 1996:198). Fresh cementum has a similar composition to bone, but does not turn-over or remodel (Hillson, 1996:198). The hardest mineralized tissue in the body, enamel, forms the outer portion of the crown. Enamel is extremely hard because it is almost entirely mineral and the hydroxyapatite crystals in enamel are much longer and more tightly packed than either dentine or bone (Hillson, 1996). Enamel is approximately 97% hydroxyapatite, and involves very little organic material (~1%) (Williams and Elliot, 1989).

Strontium is incorporated into mineralized tissue during its development and remodeling. During bone deposition the osteoblasts secrete osteoid, which is comprised mainly of collagen (Scheuer and Black, 2004). Hydroxyapatite then invades the osteoid causing it to mineralize (Scheuer and Black, 2004). At this point in development strontium is incorporated into the bone. However, bone is a living tissue and therefore it has the ability to remodel throughout life. When this occurs, osteoclasts remove bone tissue and osteoblasts lay down new bone matrix which will also include strontium (Scheuer and Black, 2004:44). Thus, strontium is incorporated into bone throughout the entire life of an organism. The complete remodeling of a bone is called turnover, and this happens at different rates for different bones. Ribs for example may be completely re-modeled in a few years; however, denser bone such as the femoral cortex may take substantially longer to be completely re-modeled (Price et al., 1994a). Researchers must be aware of bone turnover, as bone $^{87}Sr/^{86}Sr$ represents an average $^{87}Sr/^{86}Sr$ of all strontium consumed during their turnover period. Rib apatite samples then, will provide $^{87}Sr/^{86}Sr$ values averaged from the last few years of an individual's life, whereas a femoral sample will give a $^{87}Sr/^{86}Sr$ value from the past few decades.

Teeth begin to form early in life. The deciduous teeth begin to form in utero around the 16^{th} fetal week (Hillson, 1996; Scheuer and Black, 2004; Baker et al., 2005). Most of the permanent teeth begin to form by the fourth year, with the exception of the third molars, which begin to form around ten years of age (Hillson 1996; Scheuer and Black, 2004; Baker et al., 2005). Strontium is incorporated into dental tissue during its formation, but unlike bone, dentine will only remodel slightly throughout life and enamel does not remodel at all (Hillson, 1996). As teeth wear down due to use, secondary dentine may be secreted by odontoblasts (dentine producing cells) in order to prevent the pulp cavity of the tooth from being exposed to the oral cavity (Hillson, 1996). Once enamel is formed, however, the ameloblasts (enamel producing cells) die off, so that the fully formed crowns of teeth do not contain any living cells capable of remodeling it (Hillson, 1996). Although strontium may potentially be incorporated into dentine after its initial formation, enamel only contains $^{87}Sr/^{86}Sr$ values from the period of life during its formation. Thus, tooth enamel provides a snapshot of $^{87}Sr/^{86}Sr$ values during its development, which may allow researchers to determine whether individuals were raised within the local environment in which they were recovered archaeologically, or whether they moved into the region after the period of dental formation.

3.4 - Issues with Strontium Isotope Analysis

Although strontium isotope analysis has become a popular method for determining individual mobility within past populations, it is not without problems. There are two major issues related to the study of mobility via strontium isotope analysis. The first is a question of taphonomy. How can we be certain that a $^{87}Sr/^{86}Sr$ value observed in archaeological skeletal material actually represents a biogenic signal rather than a diagenetic one? Do the $^{87}Sr/^{86}Sr$ values received from archaeological skeletal samples reflect the strontium present in the diet of the individual, or could they be the result of post-mortem contamination of strontium from the burial environment? The second problem concerns the differentiation between local and non-local individuals. How do we define the local $^{87}Sr/^{86}Sr$ signal? In other words, how do we determine who is 'local' and who is not?

3.4.1 - Diagenesis

The term diagenesis refers to the post-mortem chemical alteration of skeletal remains due to their interaction with the burial environment (Price et al., 1992). Components of skeletal tissues may react with the burial matrix, resulting in alteration of the original chemical composition of an individual's bones and teeth (Price et al., 1992). Strontium from the burial environment (i.e. soil and groundwater) may substitute for the biogenic calcium and strontium ions in the skeletal tissues. Minerals from the burial environment may also simply penetrate the surface of skeletal remains through pores and cracks, thus contaminating these tissues with non-biogenic strontium (Price et al., 1992). Both of these forms of contamination could potentially remove the original $^{87}Sr/^{86}Sr$ signal of the archaeological skeletal samples under analysis.

3.4.2 - Contaminants

There are two sources of strontium that could possibly contaminate archaeological skeletal material and obscure the biogenic $^{87}Sr/^{86}Sr$ signal. Naturally occurring geological strontium can potentially add to, or entirely replace, the biogenic strontium of an archaeological skeleton (Bentley, 2006). Similarly, strontium from modern anthropogenic sources, such as fertilizers and pollution, may also contaminate the biogenic $^{87}Sr/^{86}Sr$ signature of an individual (Bentley et al., 2004; Bentley, 2006). These two sources of strontium contamination and possible solutions to problem of diagenesis will be discussed in the remainder of this section.

Anthropogenic strontium in the groundwater and soil can potentially replace biogenic strontium in archaeological human tissues, resulting in loss of their original $^{87}Sr/^{86}Sr$ value. Because the $^{87}Sr/^{86}Sr$ value of anthropogenic strontium is likely to differ from that of local groundwater and soil, this may cause a deviation in tissue $^{87}Sr/^{86}Sr$ away from the local signal. This would lead to an overrepresentation of non-local individuals at a site.

Several researchers have reported cases where agricultural activities have introduced strontium from non-local sources and altered biologically available local $^{87}Sr/^{86}Sr$ values (Böhlke and Horan, 2000; Négrel et al., 2001; Bentley, 2006). Anthropogenic strontium may also enter the environment in the form of pollution from industrial activities (Bentley et al., 2004; Bentley, 2006). Seepage then adds strontium from anthropogenic sources into waterways such as rivers, creeks and streams, resulting in the contamination of local water sources with anthropogenic strontium from far off places. All of these problems have the potential to alter archaeological tissue $^{87}Sr/^{86}Sr$ and create a non-local bias, in which individuals of local origin falsely appear to be non-local.

Researchers must also be aware of how local strontium contamination may bias our interpretation of $^{87}Sr/^{86}Sr$ values. Just as anthropogenic strontium can cause an increase in the apparent number amount of non-local individuals at a site, sample contamination by strontium from local bedrock, soils and groundwater may mask the actual $^{87}Sr/^{86}Sr$ variability observed in a population. By shifting their tissue $^{87}Sr/^{86}Sr$ values into the range typical of local strontium, this may misrepresent non-local individuals as local (Bentley et al., 2003; Bentley et al., 2004). The usual objective of strontium isotope mobility research is to identify non-local individuals. Hence, the post-mortem contamination of skeletal remains with local strontium has the potential to greatly hamper our successful interpretation of past mobility.

3.4.3 - Assessing and Removing Contamination

Due to its potential to interfere with strontium isotope analysis, researchers have devised several strategies to cope with contamination. One such strategy is to test samples for diagenesis prior to analyzing their $^{87}Sr/^{86}Sr$ values.

As the chemical formula of hydroxyapatite is $Ca_{10}(PO_4)_6(OH)_2$ it contains approximately 40.3% Ca and 18.4% P (Hancock, 1987), and thus uncontaminated bone should have a Ca/P mass ratio of approximately 2.1 (Hancock, 1987). This elemental relationship offers a potential way to assess whether hydroxyapatite has been diagenetically altered by testing its Ca/P ratio (Hancock, 1987). Any samples that strongly deviate from a Ca/P ratio of 2.1 are assumed to be contaminated and unusable. Similarly, many trace elements such as aluminum and magnesium are also present in relatively constant quantities in living bone, and their presence can also be used to assess diagenesis in archaeological samples (Hancock, 1987).

Although it is important that researchers be able to test samples for possible contamination, subsequent research has found that these tests alone are not an adequate indicator of diagenesis and further steps much be taken to remove contaminates prior to testing (Price, 1992). Fortunately, methods for removing contaminants from archaeological skeletal tissues have also been devised. One method is to mechanically abrade the surface of bone and enamel, in order to remove the layers of tissue that may have been permanently altered by chemical reaction with the burial environment (Price et al., 1992). It has also been found that pre-treating samples with a dilute acid solution can removes secondary chemicals that may be contaminating the pores and cracks of skeletal tissues (Price et al., 1992). The secondary chemicals adhering to skeletal tissues are typically much more soluble than apatite, and therefore the diagenetic Sr may be removed. Ca/P ratios and trace element concentrations can be measured after mechanical and chemical pre-treatments, to determine whether the diagenetically altered material has been removed. These two techniques for removing contamination have become a standard practice during the preparation of samples for strontium isotope analysis (Budd et al., 2000; Ezzo and Price, 2002; Bentley et al., 2003; Bentley et al., 2007)

3.4.4 - The Differential Diagenesis of Enamel and Bone

In order to reduce the effects of diagenesis, many researchers choose to sample enamel instead of bone, as enamel is much less prone to post-mortem contamination (Hillson, 1996; Budd et al., 2000; Trickett et al., 2003). Compared to bone, the hydroxyapatite crystals of enamel are much longer and densely packed, which causes them to be much more resilient to chemical alteration (Hillson, 1996; Budd et al., 2000; Trickett et al., 2003). Furthermore, the surface of enamel is much less porous than bone, making it less likely to be penetrated by secondary chemicals (Budd et al., 2000). For these reasons, many researchers in recent years have focused on the analyses of enamel, rather than bone (Ezzo and Price, 2002; Price et al., 2002; Bentley et al., 2004; Montgomery et al., 2005; Bentley, 2006; Price et al., 2006; Bentley et al., 2007; Nafplioti, 2008).

Because bone remodels throughout life, whereas enamel does not, the $^{87}Sr/^{86}Sr$ value of bone and enamel will represent different periods during an individual's life. Tooth enamel will only contain strontium that was ingested during its formation, and therefore its $^{87}Sr/^{86}Sr$ ratio will be related to a period sometime during childhood or adolescence. On the other hand, a bone will contain strontium ingested during the entire time it has taken that bone to turn over. Thus, bone $^{87}Sr/^{86}Sr$ values will represent the biologically available strontium consumed over the last approximately 5-35 years of life depending on the bone sampled. Although enamel may be a better reservoir for biogenic strontium than bone, there are many interesting research questions about adult movement that it cannot answer. Yet if a bone has been negatively affected by diagenesis it may not provide researchers with a biogenic strontium signal, which is a more serious problem. Therefore given current techniques bone samples are not as useful as enamel when assessing past mobility.

3.4.5 - Defining the Local $^{87}Sr/^{86}Sr$ Signature

Since it is not uncommon for human populations to procure resources from a large territory with variable $^{87}Sr/^{86}Sr$ values, it is important that the researcher interested in studying mobility be able to define what is considered the local $^{87}Sr/^{86}Sr$ signature. Ericson (1985:508) recognized this problem early in the development of this technique, stating that "there is no 'magic circle' of containment that can be drawn around any group without a high degree of uncertainty". Defining an isotopic catchment area is not merely a matter of interest for researchers utilizing strontium isotope analysis. Defining the local $^{87}Sr/^{86}Sr$ signature is vital to our being able to identify individuals whose $^{87}Sr/^{86}Sr$ values deviate from what is expected locally. To determine whether or not individuals were local to an area, it is imperative that we understand what local means in terms of $^{87}Sr/^{86}Sr$ values.

Ericson (1985) suggested three different methods for determining the local $^{87}Sr/^{86}Sr$ signature. The first method, which Ericson (1985:508) refers to as "direct empirical study", averages the $^{87}Sr/^{86}Sr$ values of human bone samples from a population and this average value becomes the local signature. Individual $^{87}Sr/^{86}Sr$ values are then compared to the average. Individuals close to the average are considered local, whereas those whose $^{87}Sr/^{86}Sr$ values substantially deviate from the average are considered non-local. Many researchers have used this method to determine local $^{87}Sr/^{86}Sr$ signatures (Price et al., 1994a; Price et al., 1994b; Grupe et al., 1997; Bentley et al., 2002). Such researchers generally assume that any individuals within two standard deviations of the population $^{87}Sr/^{86}Sr$ mean are local, whereas individuals whose $^{87}Sr/^{86}Sr$ values fall outside this range are considered non-local. However, this method is not always feasible, since it requires that enough samples be analyzed as to make the average statistically sound (Ericson 1985). If ten individuals were analyzed and four of them were actually non-local to the area, the average $^{87}Sr/^{86}Sr$ value of all ten would definitely not reflect the actual local $^{87}Sr/^{86}Sr$ signature. It is possible that diagenetic strontium in the samples could alter the actual variation in human $^{87}Sr/^{86}Sr$ values, causing either a local or non-local bias as described above (Bentley et al., 2003; Bentley et al., 2004). This problem has been addressed by some authors who insist that human enamel, not bone, be used in order to avoid bias (Price et al., 2002; Bentley et al., 2004; Bentley, 2006). Even given this caution, this method for determining the local $^{87}Sr/^{86}Sr$ signature is still based upon a "subjective partitioning of the data rather than an objective representation of rigid isotopic 'boundaries', which may misrepresent the actual division between local and non-local" (Bentley et al., 2004:366). It is also very problematic since it assumes that all human groups will exhibit the same pattern of isotopic variation (with 'locals' falling into a ±2 sd range around the mean) regardless of differences in subsistence strategy and the size of the actual ecological ranges exploited.

The second method proposed by Ericson (1985) involves grid sampling plants and animals from the proposed catchment area. The $^{87}Sr/^{86}Sr$ values measured on the collected material are then used to create a range typical of the local resources that might have been consumed. The main problem with this approach is that modern plant and animal $^{87}Sr/^{86}Sr$ values may not be entirely representative of the $^{87}Sr/^{86}Sr$ values of the past environment under investigation. Local domestic animals may have been fed non-local foods, altering their $^{87}Sr/^{86}Sr$ values (Knudson et al., 2004; 2005). Even if the local animals are known to have consumed only local food (Knudson et al., 2004; 2005), the $^{87}Sr/^{86}Sr$ ratios of this food could still have been altered by the introduction of anthropogenic strontium. Using modern wild animal and plant samples to determine the local $^{87}Sr/^{86}Sr$ signature is susceptible to similar problems, because the environment they represent may have a much different $^{87}Sr/^{86}Sr$ signature than it did in the past (Bentley et al., 2004). Plants and animals can incorporate strontium from chemical fertilizers into their tissues, which causes their $^{87}Sr/^{86}Sr$ values to deviate from what is naturally available (Bentley, 2006). Modern chemical fertilizers may be added directly to the soil and enter the groundwater of an area during agricultural activities. Natural fertilizers such as manure, can also contaminate the local $^{87}Sr/^{86}Sr$ signature, as they may be produced by non-local animals may be transported into a region from elsewhere, or local animals may consume feed grown in non-local environments (Knudson et al., 2004; 2005).

If the previous methods for determining the local $^{87}Sr/^{86}Sr$ signal are unavailable, Ericson (1985) proposes that researchers may use $^{87}Sr/^{86}Sr$ values taken directly from the parental bedrock. Although this is in fact the method that Ericson (1985) employed to determine the local signature for his pilot study, it may be the most problematic of the three. Geological mapping of the $^{87}Sr/^{86}Sr$ values present in rocks provide a good starting point, and may allow the researcher to estimate the local signature based on underlying bedrocks. However, this method seems to only be applied by itself if the area in question is characterized by regionally distinct isotopic boundaries that enable researchers to confidently attribute an individual's dietary strontium to these distinct regions (Blum et al., 2000). The $^{87}Sr/^{86}Sr$ value of the parental bedrock may not be identical to the $^{87}Sr/^{86}Sr$ values observed in the local dietary items consumed by the past human populations under investigation (Price et al., 2002). Similarly, soil sampling has proven to be a poor method for determining the local $^{87}Sr/^{86}Sr$ signature (Price et al., 2002). Soils may contain strontium from any number of geological sources, and therefore they may not reflect the $^{87}Sr/^{86}Sr$ ratio of the local bedrock (Price et al., 2002). Since plants also receive strontium from water, soil sampling is not always a good method for determining the $^{87}Sr/^{86}Sr$ ratio introduced into the food chain by primary producers (Price et al., 2002). The direct measurement of $^{87}Sr/^{86}Sr$ in bedrock or soil does not account for strontium that may have come into the region from other sources, and it may create an unrealistic view of the past, as catchment areas take the shape of geological formations. It is important that researchers be aware of how much local variation is potentially present in a given region and what would (and would not) be realistic local $^{87}Sr/^{86}Sr$ signals given the local geology, and geological maps are useful in this respect. However, they should not be the only source of information when determining the local $^{87}Sr/^{86}Sr$ signature.

A final method for determining the local $^{87}Sr/^{86}Sr$ signature is to sample archaeological faunal remains (Price et al., 2000; Bentley et al., 2004). Bentley and colleagues (2004) suggest analyzing various different animals to determine how much intra-taxon $^{87}Sr/^{86}Sr$ variation can be seen. They suggest that the taxon with the least amount of variation be taken as representative of the local $^{87}Sr/^{86}Sr$ signature, to which human $^{87}Sr/^{86}Sr$ values can then be compared. In their pilot study, Bentley et al. (2004) found that pigs had the least amount of variation of all the animals analyzed. Bentley and colleagues (2004) suggest that animals such as dogs and pigs be used since they are unlikely to have ranged very far, and likely ate much of the same food as humans. Since, like human remains, animal remains may also be diagenetically altered by groundwater, Bentley and colleagues (2004) stress that in order to reduce bias, tooth enamel should be analyzed rather than bone and that proper pre-treatment of all samples should occur. Some researchers suggest that contamination of the faunal remains with local strontium is not very detrimental since this will not alter their local $^{87}Sr/^{86}Sr$

signal (Grupe et al., 1997; Price et al., 2000; Bentley et al., 2004), which is what they are used to assess in the first place. However, it is important to note that because diagenesis may reduce the natural $^{87}Sr/^{86}Sr$ variation seen in faunal remains, creating a falsely invariable local signal, it remains an important factor to consider. Because the animals represented by archaeological faunal remains would not have had access to modern anthropogenic strontium from fertilizers or pollution, their $^{87}Sr/^{86}Sr$ ratio should be an accurate reflection of natural biologically available strontium (Bentley et al., 2004). Also, because herbivores and carnivores have $^{87}Sr/^{86}Sr$ values averaged from all their food sources, measuring archaeological faunal remains should produce a better idea of the overall value range typical for foods in the region (Bentley, 2006). Finally, using archaeological fauna to determine the local $^{87}Sr/^{86}Sr$ range does not require prior assumptions about the distribution of human $^{87}Sr/^{86}Sr$ values to be made. Overall, this method for determining the local $^{87}Sr/^{86}Sr$ signature seems to have the least amount of problems associated with it.

3.5 - Previous Applications of Strontium Isotopes

As mentioned earlier, Ericson (1985) was the first scholar to apply strontium isotope analysis in an archaeological context. He suggested that analyzing the $^{87}Sr/^{86}Sr$ values of human bone could potentially provide answers to archaeological questions that were previously only investigated through indirect means, gaining direct evidence for human ecology and territoriality, food sharing and exchange, migration and warfare, marital residence and animal ecology related to human use and domestication. Ericson's pilot study of human remains from Chumash individuals from California coast suggested that inland villagers moved to the Coast during spring and summer to harvest fish, a scenario that was supported by both stable carbon and nitrogen isotopes and ethnographic data. Although Ericson (1985:512) admitted that this method is not without its limitations, he insisted that "the strontium isotope characterization technique following further development will offer numerous possibilities for investigating various aspects of prehistoric lifeways." He further stated (1985:512) that even "at this preliminary stage, the strontium isotope technique appears to offer an exciting new source of information for the study of prehistory." Since this initial study, strontium isotope analysis has become a well known and widely used method for investigating archaeological questions.

Strontium isotope analysis can be used to provenance archaeological materials such as gypsum, marble and glass (Gale et al., 1998; Brilli et al., 2005; Henderson et al., 2005). The $^{87}Sr/^{86}Sr$ values of animals that are important to humans, such as horses (Bendry et al., 2009), fallow deer (Sykes et al., 2006), and cattle (Evans et al., 2007) have also been analyzed. Recently, Benson and colleagues (2008; 2009) proposed a method for the sourcing of prehistoric maize using strontium isotope analysis, which will likely promote much work related to determining the $^{87}Sr/^{86}Sr$ values of non-meat foodstuffs.

The majority of studies involving $^{87}Sr/^{86}Sr$ analysis have focused on human remains. Although most of these focus on recent archaeological contexts, a few have studied our pre-modern hominid ancestors (e.g. Horn et al. 1994; Sillen et al. 1995, 1998). In one analysis with relevance to this thesis, Richards and colleagues (2008) used laser ablation mass spectrometry to sample multiple enamel incremental growth structures on a single third molar of a Neanderthal found at Lakonis, Greece. This study was the first time laser ablation was conducted on a fossil hominin, and the authors suggest it provides the first concrete evidence that Neanderthals ranged more than 20 km (Richards et al., 2008). Although this study was criticised by Nowell and Horstwood (2008), Richards and colleges insist that their results were accurate and that laser ablation mass spectrometry is likely the best method for analyzing sensitive palaeoanthropological material for strontium isotopes (Richards et al., 2009).

The American Southwest, Mesoamerica, Central Europe and Britain have been the focus of numerous $^{87}Sr/^{86}Sr$ studies in archaeological contexts. Although several other areas have also been investigated using strontium isotopes (midwestern U.S. and Florida, South Africa, Egypt, Southeast Asia, South Pacific islands, Siberia, Bavaria, Austria, Hungary and Greece), they have not received nearly as much attention.

Aside from Ericson's (1985) initial pilot study, work in the American Southwest (e.g. Price et al., 1994b; Ezzo et al., 1997; Ezzo and Price, 2002) has focused on using $^{87}Sr/^{86}Sr$ values to gain information about the inhabitants of Grasshopper Pueblo in Arizona. For example, Ezzo and Price (2002) used strontium isotope analysis to investigate how migration to Grasshopper Pueblo may have changed over time, to determine the geographic origins of non-locals, and to comment on ethnic diversity and social organization at the pueblo. In recent years, other areas of the United States including Florida (Quinn et al., 2008) and the American Midwest (Hedman et al., 2009) have also been investigated using strontium isotopes.

Strontium isotope research in Mesoamerica has investigated a wide variety of geographical areas and time periods. These include ancient Teotihuacan (Price et al., 2000), colonial Campeche, Mexico (Price et al., 2006), and the Mayan city of Tikal, Guatemala (Wright, 2005). Such investigations have been aided by a comprehensive list of environmental $^{87}Sr/^{86}Sr$ values compiled by Hodell et al. (2004) for the Mayan region. In Andean South America, many authors have investigated the movement of people using $^{87}Sr/^{86}Sr$ values during the Middle Horizon (500-1000 AD) (e.g. Knudson et al., 2004, 2005; Knudson and Price, 2007; Slovak et al., 2008; Tung and Knudson, 2009). For instance, Turner et al. (2009) employed strontium, oxygen and lead isotopes to explore immigration and social class at the Incan ceremonial center of Machu Picchu, Peru. The results suggest that the skeletal sample represents a rather diverse group of individuals from various regions of the central Andes, possibly representing a class of elevated retainers based on contextual evidence.

Archaeological investigations in Africa utilizing strontium isotopes are rather limited. Early work conducted by Sealy et al. (1991; 1995) in South Africa focused on assessing the value of $^{87}Sr/^{86}Sr$ for paleodietary reconstruction, tracing past movements and reconstructing life histories, as well as identifying possible problems with diagenesis. A later study conducted in South Africa by Balasse et al. (2002) analyzed the enamel of sheep (as a proxy for humans) to investigate the mobility of prehistoric herders. Work in northern Africa includes an exploration of mobility and kinship in southwestern Libya (Tafuri and colleagues, 2006) and a study of migration in the Nile Valley that suggests colonial agents in Tombos (ancient Nubia) included both local and non-local individuals (Buzon et al., 2007).

As in Africa, archaeological investigations employing strontium isotopes in Asia are rather limited. The Baikal Archaeology Project has employed $^{87}Sr/^{86}Sr$ ratios to gain a better understanding of mobility and foraging ranges of prehistoric hunter-gatherers inhabiting the area around Lake Baikal, Siberia (e.g. Weber et al., 2002; Haverkort et al., 2008; Fraser-Shapiro, 2012). Other work done in the continent includes an investigation of mobility and intermarriage during the transition to agriculture in prehistoric Thailand (Bentley and colleagues, 2005) as well as a number of studies of Pacific island populations (e.g. Bentley et al., 2007).

Much of the strontium isotope work done in Europe has been in central Europe, which has been the focus of several strontium isotope investigations, many of which studied the Neolithic Bell Beaker and Linearbandkeramik cultures (e.g. Price et al., 1994a; 1998; 2004; Grupe et al., 1997; 1999; Horn and Müller-Sohnius, 1999; Price et al., 2001; Bentley et al., 2002; 2003; 2004; Bentley and Knipper, 2005; Bickle and Hofmann, 2007). Other strontium isotope work in Central Europe has focused on the Late Roman period (Schweissing and Grupe, 2003; Prohaska et al., 2002). There has also been a considerable amount of strontium isotope analysis conducted in Britain, including $^{87}Sr/^{86}Sr$ analyses of

Neolithic remains (Budd et al., 2001; 2003; 2004; Montgomery et al., 2000), an analysis of three Bronze Age individuals from a single grave near Stonehenge revealing that all shared a similar pattern of mobility during their childhood (Evans et al., 2006a), several studies of Romano-British populations (Budd et al., 2004; Montgomery et al., 2005; Evans et al., 2006b), and Montgomery and colleagues' (2003) attempt to identify Norwegian Vikings at Cnip, Isle of Lewis, Scotland (600-1000 AD) using $^{87}Sr/^{86}Sr$ values.

In Greece, the region of focus for my investigation, only a few previous $^{87}Sr/^{86}Sr$ analyses have been conducted using recent human remains. The first was conducted by Lê (2006) on teeth from a 13th century AD cemetery in Corinth. This study was aimed at discerning whether individuals interred in the cemetery of a hospice were local to the Corinth area or perhaps represented the remains of Frankish crusaders from Central/West Europe (Lê, 2006). Although Lê was successful in identifying two individuals who did not originate from the Corinth area, their $^{87}Sr/^{86}Sr$ values could not be matched with any previously published values for Europe and could represent a number of European regions, including areas elsewhere in Greece. Coupled with an earlier oxygen isotope analysis that suggested that individuals buried at the hospice grew up in a climate similar to that of Greece, these findings led Lê (2006) to suggest that although people buried at the hospice may have been of Frankish decent, they would likely have been born in Greece.

A $^{87}Sr/^{86}Sr$ analysis in Greece was conducted by Nafplioti (2008) on remains recovered from cemeteries in the vicinity of the palace of Knossos, Crete, dating to Late Minoan IB (ca. 1480 BC). Cultural artifacts, writing systems and burial practices during this period suggest that Crete was politically dominated by mainland Mycenaean inhabitants (Nafplioti, 2008). However, contrary to this assumption the $^{87}Sr/^{86}Sr$ values of all the individuals sampled indicate that they were local to the island. Based on these results, Nafplioti (2008) suggests that although the island was undoubtedly under Mycenaean influence, the island was not necessarily inhabited by Mycenaean colonizers.

Another very recent study carried out by Nafplioti (2011) has contributed greatly to the field of strontium isotope analysis in Greece. Nafplioti (2011) analyzed the $^{87}Sr/^{86}Sr$ ratios of archaeological faunal remains and modern snail shells in order to construct the first biologically available strontium isotope map of Greece. Her results are of use for this study, as well as many others, and create a substantial base on which future strontium isotope studies in the region can build.

3.6 - The Present Strontium Isotope Analysis

The present strontium isotope analysis will investigate residential mobility in the valley of Stymphalos, Greece. The valley is located in the north-eastern mountains of the area of Greece known as the Peloponnese (Williams 1996). As reviewed in detail in the following chapter, archaeological excavations in the valley uncovered human remains representing a rural agricultural community dating to the Late Roman period (Williams 1998; 2002). The excavations conducted by Williams were intended to investigate the ancient fortified city of

Stymphalos, which is thought to have been in use as early as the 5th century BC (Williams 1983; 1998). Although the city was largely abandoned by the middle of the 1st century AD, an early Christian farming community continued to inhabit the area and used various parts of the city as cemeteries, some of which were uncovered in the course of Williams' excavations (Williams 2002). Nearby, Campbell (1997) uncovered medieval remains while excavating the Cistercian monastery of Zaraka. This monastery was built much later than the city of Stymphalos, during the Fourth Crusade (Campbell, 1997). After it was abandoned in the 14th century AD, the valley's inhabitants used it as a cemetery, leaving remains that were recovered in the course of excavation of the building (Campbell 1997).

Pennycook (2008) carried out a previous analysis of the Stymphalos remains using stable carbon and nitrogen isotopes as dietary indicators. Her results raised several questions regarding the past inhabitants of the valley. Pennycook (2008) found that most of the Late Roman individuals analyzed displayed similar stable carbon and nitrogen isotopic ratios consistent with a diet made up of local foodstuffs (Pennycook 2008). This would lead us to believe that this population was comprised of local individuals who had consumed similar diets during their life. However, one Late Roman individual has values suggesting a very different diet and may perhaps represent a migrant to the area (Pennycook 2008). In contrast, the values of the later medieval individuals recovered from Zaraka are quite variable and differ from the "local" carbon and nitrogen values seen in the Late Roman remains (Pennycook 2008). This may be evidence for a change in the local diet over time or for migration into the area. I will conduct strontium isotope analysis of tooth enamel from burials from both periods to test the hypothesis that some of these individuals were immigrants to the region. Differentiating between these two possibilities will shed light on mobility and diet in the valley and thus more broadly on life in Greece during the Late Roman and medieval periods.

Chapter 4: Site Context, Materials and Methods

4.1 - Introduction

In this chapter I will describe the archaeological sites from which the skeletal remains used in this investigation were recovered, as well as the methods employed to sample the remains, prepare the samples for analysis and measure their $^{87}Sr/^{86}Sr$ ratios. Skeletal remains were discovered during the excavation of two temporally distinct sites within the valley of Stymphalos. In the first section of this chapter, each site will be discussed in turn following a brief description of the topography and geology of the valley itself. For this, the writings of historical authors (both ancient and more recent in the case of Stymphalos) and modern archaeological findings will be reviewed. The skeletal remains uncovered during their excavation will also be discussed. Although a detailed skeletal survey is beyond the scope of this thesis, a brief description of the remains is provided. Naturally, I will rely heavily on the works of Dr. Hector Williams, who supervised the most recent modern excavations in the valley, Dr. Sheila Campbell, who was responsible for excavating the Cistercian monastery and Dr. Sandra Garvie-Lok, who studied the human remains. Following this I explain the methods used to document the teeth prior to sampling and how enamel samples were extracted. Next, the techniques employed by Dr. Robert Creaser's laboratory to process enamel samples, test them for possible contamination and analyze their $^{87}Sr/^{86}Sr$ ratios will be described. This information will give the reader both a contextual and methodological background in which to better understand the results of this isotopic investigation.

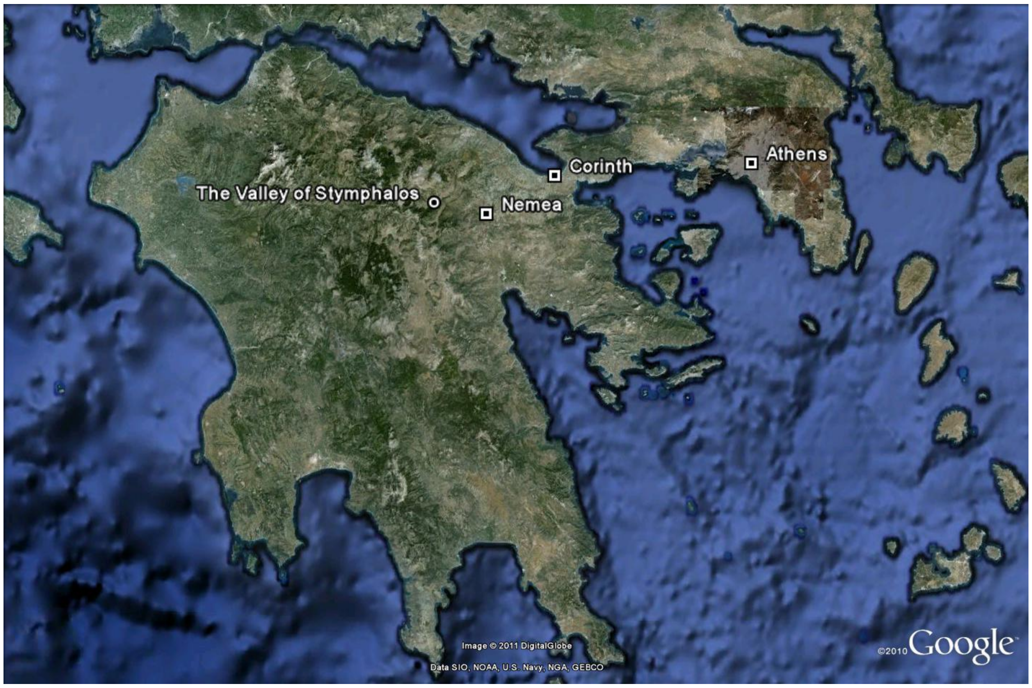


Figure 4.1 - Satellite imagery of the Peloponnese, Greece, showing the relationship between the valley of Stymphalos and the modern communities of Nemea, Corinth and Athens (Google Earth, 2010).

4.2 - The Valley of Stymphalos

4.2.1 – Description of the Valley

Located in the northeastern Greek Peloponnese, a region known as Arcadia in ancient times and Corinthia in the present, lies the valley of Stymphalos (Williams, 1983; Williams et al., 1998). The valley is approximately 10 kilometres long, situated approximately 600 metres above sea level with the Kyllene Mountains on the north and the Apelauron on the south (Williams, 1983). The only permanent lake in the area, Lake Stymphalos, occupies most of the eastern end of the valley and is fed by Mt. Apelauron, Mt. Kyllene and Mt. Ziria, as well as several springs whose waters were once routed to Corinth via a Hadrianic aqueduct (Higgins and Higgins, 1996; Lolos, 1997). Water from the lake and springs is drained by a sink hole which eventually re-emerges as springs in the Argolid area (Higgins and Higgins, 1996). The lake is occupied by several species of fresh water fish, many different amphibians and reptiles, and was traditionally believed to be the stage of Herakles' triumph over the Stymphalian birds, likely because it is one of the most important waterfowl habitats in southeast Europe and southwest Asia (Apollodorus, 1921:2.5.6; Bourne, 1982; Lucretius, 1931:5.29; Strabo, 1917:8.6.8; Williams, 1983).

Figure 4.2 - Satellite imagery of the valley of Stymphalos, displaying the modern village of Stymfalia, the site of ancient Stymphalos and the monastery of Zaraka, as well as the surrounding terrain (Google Earth, 2010).

Hot dry drought stricken summers in southern Greece cause the lake to recede while winter rains result in seasonal flooding, which has encumbered excavation teams and displaced archaeological materials (Bourne, 1982;

Williams, 1983; Williams and Price, 1995). Summer recession of the lake allowed farmers throughout history to take advantage of rich alluvial soils, which were very important since Greece has very little arable land due to its extremely mountainous terrain (Bourne, 1982; Higgins and Higgins, 1996; Pepelasis and Thompson, 1960). However, intense deforestation resulting in siltation has caused the lake to expand in recent years (Bourn, 1982). This, along with the use of modern fertilizers, has caused the lake to become choked with reeds. Ancient efforts to decrease the amount of marshy land in the valley consisted of cutting a canal from the springs to the sink-hole and constructing a tunnel which drained some of the springs elsewhere (Higgins and Higgins, 1996). In the fifth century the tunnel became clogged causing flooding, yet it was repaired in the 19th century and is still functioning (Higgins and Higgins, 1996). Today, almost all the available land within the valley is agricultural and tended by the residents of four modern villages: Lafka, Karteri, Kionia, and Stymfalia.

4.2.2 - The Geology of the Valley

In chapter 3, the importance of characterizing local bedrock due to its contribution to an organism's strontium isotope ratio was discussed. Determining whether or not an individual was local to an area depends on variation of bedrock strontium isotope values. Like much of Greece, most of the underlying bedrock in the Peloponnese is limestone. Yet the geological makeup of the region containing the valley of Stymphalos is somewhat unique compared to the rest of the country. Along the Gulf of Corinth there is a narrow coastal plain of alluvial deposits

(Bornovas, 1983; Higgins and Higgins, 1996). Uplifted lacustrine sediments, such as sand, conglomerates, clays, and peat, as well as marine deposits comprised of sand, marls and clays dating from the Plio-Pleistocene extend from the coastal plain approximately 20 km to surround the valley of Nemea and create the northeast edge of the valley of Stymphalos (Bornovas, 1983; Higgins and Higgins, 1996). South of the band of lacustrine sediments, the hills become comprised mostly of a pelagic limestone dating to the Upper Cretaceous period (Bornovas, 1983).

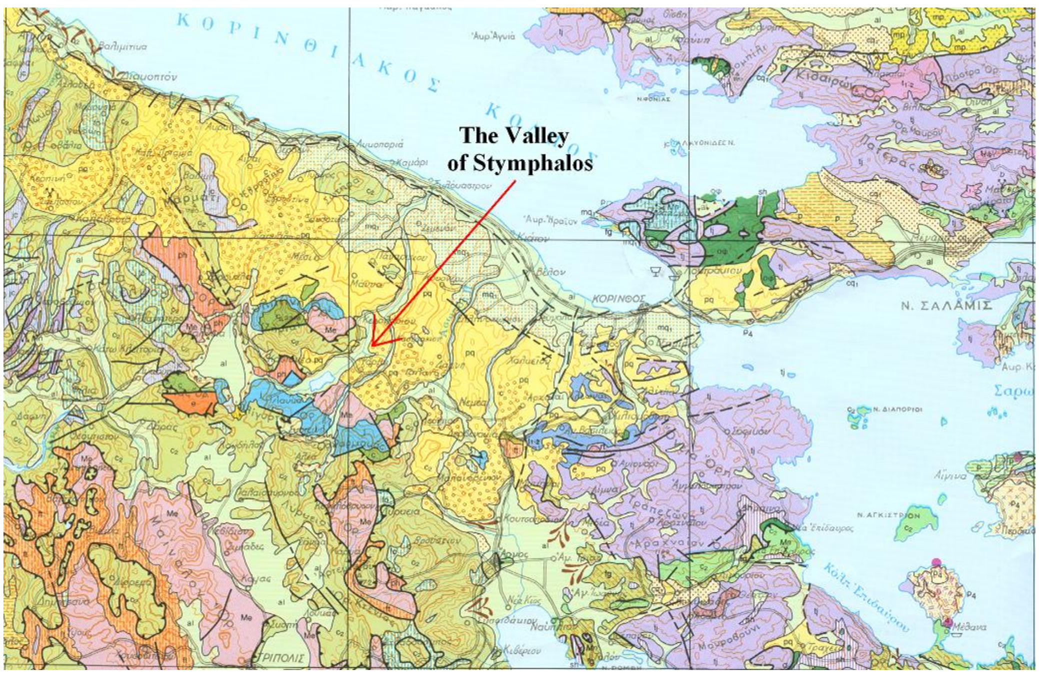


Figure 4.3 - Section of a geological map displaying the bedrock formations of the northeastern Peloponnese (Bornovas, 1983).

However, the valley of Stymphalos is bordered not only by this common pelagic limestone, but also by limestones dating to the Jurassic, Mesozoic to Eocene, and Permotriassic periods that are not found elsewhere in the region (Bornovas, 1983). These limestones, the pelagic limestone from the Cretaceous, and the lacustrine deposits all combine to create the valley of Stymphalos' alluvial floor. Because the valley's geology is unusual, the local $^{87}Sr/^{86}Sr$ ratios of its inhabitants are likely distinguishable from those living in the surrounding areas.

4.2.3 - Previous Strontium Results

Although the problems with directly estimating $^{87}Sr/^{86}Sr$ values of organisms in an area from bedrock values have been reviewed above, the bedrocks do provide a rough idea of value ranges to expect and are useful to review here. The $^{87}Sr/^{86}Sr$ ratios of marine sedimentary deposits such as limestone are directly related to the $^{87}Sr/^{86}Sr$ ratio of seawater (which is constant across all the oceans) at the time of their formation (Bentley, 2006; Burke et al., 1982). The research of Burke and colleagues (1982), which estimated seawater $^{87}Sr/^{86}Sr$ ratios through time, can be used to predict the $^{87}Sr/^{86}Sr$ ratio of marine limestones. Seawater $^{87}Sr/^{86}Sr$ values were much lower in the Jurassic (~0.7068-0.7070), Cretaceous (~0.072-0.7075) and Eocene (~0.7077) compared to those in the Plio-Pleistocene, which range anywhere from ~0.7080 to the value of Holocene (modern) oceans (~0.7092) (Burke et al., 1982). Because the valley of Stymphalos contains older limestones than elsewhere in the region, the $^{87}Sr/^{86}Sr$ ratios of its inhabitants should be lower than those of people living in surrounding areas such as Nemea, which has mostly Plio-Pleistocene deposits, or the coast, which should fall closer to the Holocene $^{87}Sr/^{86}Sr$ ratio due to the effect of ocean spray. Dia and colleagues (1997) found that fossil coral samples taken from uplifted deposits along the Gulf of Corinth had $^{87}Sr/^{86}Sr$ ratios of approximately 0.7090-0.7091, which agrees with the local $^{87}Sr/^{86}Sr$ value for Corinth determined by Lê (2006). Nafplioti's (2011) analysis of archaeological faunal remains from Corinth provided a slightly lower mean $^{87}Sr/^{86}Sr$ value (0.7086); however, this was still higher than her reported values for the Argolid region of the eastern Peloponnese (0.7080-0.7084).

It is unlikely that local inhabitants of the valley of Stymphalos would have $^{87}Sr/^{86}Sr$ ratios higher than 0.7095 since the whole area is comprised of various limestones, whose $^{87}Sr/^{86}Sr$ ratios, according to Burke et al. (1982), rarely exceed 0.7095. None of the limestone and marbles from Euboea analyzed by Tremba et al. (1975) displayed $^{87}Sr/^{86}Sr$ values over 0.7092. Individuals exceeding this value would have likely travelled from areas with higher local $^{87}Sr/^{86}Sr$ values. $^{87}Sr/^{86}Sr$ values above 0.710 are usually found in rocks that are very old (> 100 million years) and have a high initial Rb/Sr ratio (Bentley, 2006). These generally include rocks of the continental crust, such as older granites whose $^{87}Sr/^{86}Sr$ ratios are generally between 0.710 and 0.740 (Bentley, 2006).

Although granite outcrops are virtually nonexistent in the Peloponnese and southern Greece, they do occur in some of the Cycladic Islands (Bornovas, 1983; Higgins and Higgins, 1996). Nafplioti's (2011) survey of biologically available strontium around the Aegean only reports values higher than 0.7095 for two islands, Naxos and Chios, and one sample from Euboea which was above 0.7100. Some northern parts of the country around Thessaloniki and the borders of Albania and Bulgaria also have granite outcrops which could lead to $^{87}Sr/^{86}Sr$

values above 0.7100 (Bornovas, 1983; Higgins and Higgins, 1996). Juteau and colleagues' (1986) survey of circum-Mediterranean granites generally shows $^{87}Sr/^{86}Sr$ ratios above 0.7100. Italian granites display a $^{87}Sr/^{86}Sr$ range of 0.7114-0.7166, whereas in northern Africa, granite $^{87}Sr/^{86}Sr$ values reach as high as 0.8141. Juteau et al. (1986) also found that the $^{87}Sr/^{86}Sr$ ratio of one sample taken near Athens was 0.7102, yet further testing is needed to determine whether this granite, which lies far beneath the soil surface, would actually contribute to the local biologically available $^{87}Sr/^{86}Sr$ signature of the area.

Other geochemical analyses conducted in and around Greece can further our understanding of regional $^{87}Sr/^{86}Sr$ values. Anders and colleagues' (2006) geochemical investigations on basement rocks taken from the Pelagonian Zone in northern Greece displayed that some do have a relatively high $^{87}Sr/^{86}Sr$ ratio (0.7105). However, the same study also found rocks with extremely low $^{87}Sr/^{86}Sr$ ratios (<0.7000) (Anders et al., 2006). Other studies concerned with volcanic rocks from northern Greece have shown $^{87}Sr/^{86}Sr$ ratios ranging from 0.7081 to 0.7098; while values over most of this range could be confused with sedimentary rock values, the highest values in the range exceed those expected for sedimentary rocks (Eleftheriadis et al., 2003; Pe, 1975). Geochemical studies conducted on rocks from the Greek islands have provided $^{87}Sr/^{86}Sr$ ratios for Santorini (0.7046-0.7051), Serifos (0.7092-0.7119), Tinos (0.7037-0.7121), Naxos (0.7108-0.7116), Mykonos/Delos (0.7055-0.7122), Ikaria (0.7129-0.7195), Samos (0.7060-0.7071), and Kos (0.7063-0.7073) (Altherr et al., 1988; Barton et al., 1983; Briqueu and Lancelot, 1984; Broecker and Franz, 1998). Although biologically available strontium in some of these areas could well have $^{87}Sr/^{86}Sr$ ratios greater than 0.710, it is important to remember that the $^{87}Sr/^{86}Sr$ values of individual rocks only allow us to speculate as to what the biologically available $^{87}Sr/^{86}Sr$ of an area may be and thorough testing is needed to accurately determine the local $^{87}Sr/^{86}Sr$ signature.

4.3 - Ancient Stymphalos (Lat. 37º51’30" N, Long. 22º27’26" E)

4.3.1 - Description of Ancient Stymphalos

The ancient city of Stymphalos is located on the northern shore of the lake, approximately 1 km southeast of the modern village of Kionia and 2 km south of Stymfalia. Although the orthogonally planned ancient city is about 1 km in length with walls enclosing a triangular shaped area of roughly 640 000 m^2, some lower areas along the lake are now under water (Williams, 1983; Williams et al., 2002). Towers and gatehouses intersperse the walls which lead up to the acropolis located about 30 m above the lake on the western end of the city on a spur of Mt. Kyllene (Williams, 1983). Streets and avenues 6 m wide create long narrow blocks 30 m wide and 100 m long on a north-south orientation (Williams et al., 2002). So far, archaeological excavations have identified a plethora of buildings including large city gates, artillery bastions, a theater, a fountain house, a palaestra, a sanctuary, a few temples, a Roman villa, and several houses (Williams, 1983, 1984, 1985, 1996, 2000, 2005; Williams and Price, 1995; Williams and Schaus, 2001; Williams et al., 1997, 1998, 2002).

4.3.2 - Historical References regarding Stymphalos

Aside from being the home of the Stymphalides, the multitude of troublesome birds that required no less than Herakles to drive away, relatively little is written about Stymphalos in ancient times (Apollodorus, 1921:2.5.6; Bourne, 1982; Lucretius, 1931:5.29; Strabo, 1917:8.6.8; Williams, 1983; Williams et al., 1998). The two earliest mentions of Stymphalos come from Homer's *Iliad* (1990:2. 696-708), likely composed sometime between the late 8th and early 7th century BC, and from the *Olympic Odes* of Pindar (Pindar, 1961: *Olympian Odes* 6), written in the 5th century BC. Homer briefly mentions Stymphalos when discussing the gathering of Agamemnon's mighty host. "Those who held Arcadia under Cyllene's peak… men who held Stymphalus" joined with others from the area to fill "sixty ships in all, and aboard each vessel crowded full Arcadian companies skilled in war" (Homer, 1990: 2.696-704). However, they do not seem to have been skilled in sea travel since Agamemnon had to give them "well benched ships" because the "works of the sea meant nothing to those landsmen" (Homer, 1990: 2.705-707). Pindar's mention of Stymphalos is also brief. He simply writes that Hagesias, the Olympic winner of the mule chariot race in 472 BC, originated from Stymphalos (Pindar, 1961: *Olympian Odes* 6; Williams et al., 1998). However brief they may be, these writings suggest that the valley may have been occupied as early as the 8th century BC and had produced an Olympic victor by the 5th century.

Several other literary accounts detailing warfare in the area also make reference to Stymphalos. Xenophon (1918a: 4.4.9-15, 6.5.49-52, 7.3.1) mentions that Aeneas, general of the Arcadians, was from Stymphalos, and that the Athenian general Iphicrates attacked the region in the 4^{th} century BC (Williams et al., 2002). According to Diodorus, the city was suddenly captured during a night assault by Apollonides, a commander under Cassander, in 315 BC (Williams, 2002). Polybius (1922:4.68.2-7) discusses troops moving through the area of Stymphalos in 219 BC and suggests that the area was controlled by the inhabitants of Stymphalos. Similarly, Livy (1961:33-14-10) writes of Nicostratus' plans to amass an army at Apelauron near Stymphalos in the early 2^{nd} century BC. By the first century BC Strabo (63 BC- 24 AD) writes that Stymphalos was mostly deserted, an abandonment that likely occurred during the Roman general Mummius' campaigns against the Achaean League, which led to the defeat of Corinth in 146 BC (Catling, 1982; Strabo, 1917: 8.8.2; Williams, 1996; Williams and Price, 1995).

Perhaps the most comprehensive ancient detailing of Stymphalos is provided by the Roman author Pausanias (ca. 2^{nd} century AD) during his travels in Greece. Pausanias states that Stymphalos was an Arcadian city located in the northeast Peloponnese, which at the time of his visit was largely abandoned (Pausanias, 1918: 8.22; Williams and Schaus, 2001; Williams et al., 2002). Pausanias writes that the nearby river and city were named after the city's founder Stymphalus, son of Elatus, son of Arcas, son of Callisto, and still had a functioning temple to Artemis and aqueduct (Pausanias, 1918: 8.22; Williams et al., 2002). Unfortunately Pausanias does not provide any details concerning the inhabitants of the valley, although he does mention that the city was likely founded on the remains of an earlier site, which reinforces the possible Bronze Age occupation of the valley suggested by Homer and/or the Archaic Period inhabitants whose Olympian is mentioned by Pindar.

After Pausanias, little mention of Stymphalos is made until travel books became popular in the early 19th century. Travellers to the area such as Gell (1817), Pouqueville (1822), and Leake (1830) make mention of the valley but are generally unimpressed with its collection of ancient ruins. In 1910 the German Archaeological Institute briefly explored the site of ancient Stymphalos, yet these efforts provided little valuable information concerning the remains (Williams and Schaus, 2001).

4.3.3 - Archaeological Investigations

It was not until later in the 20th century that the first comprehensive archaeological excavations took place at Stymphalos. Excavations directed by Anastasios Orlandos, under the Archaeological Society of Athens, explored the site from 1924 till 1930 (Orlandos, 1924, 1925, 1926, 1927, 1928, 1929, 1930; Williams, 1983; Williams and Schaus, 2001). Orlandos' expeditions, carried out a few weeks at a time over a period of unusually dry years, focused mainly on the southern area of the city next to the lake shore (Williams, 1983). Although Orlandos did conduct work in what is later referred to as the Sanctuary of Athena and discovered the Phlious Gate, much of his research was unfortunately lost and unavailable to modern scholars (Orlandos, 1925, 1926; Williams, 1983, 1985; Williams and Price, 1995; Williams and Schaus, 2001; Williams et al., 1996).

After 1930, scholarly interest concerning the ancient city decreased substantially until a project directed by Dr. Hector Williams from the University of British Columbia (UBC) on behalf of the Canadian Archaeological Institute at Athens (CAIA) renewed excavations in the valley. From 1982 until 2005, archaeological teams under Dr. Williams conducted large scale excavations and surveys at ancient Stymphalos, which included the extensive utilization of ground penetrating radar (Williams, 1985, 2005; Williams et al., 1997, 2002).

Modern research by archaeological teams revealed much information concerning the ancient city and its inhabitants. Although occasional artefacts dating to earlier periods suggest that the valley was occupied during the Late Archaic period, earlier settlements have yet to be discovered (Williams et al., 2002). Numismatic and ceramic studies suggest that the city was founded ca. 375-350 BC (Williams et al., 2002). Ceramic analyses have shown that while most fine wares were imported coarse wares and transport vessels were mostly locally produced, suggesting the city was rather independent of its larger neighbours (Williams et al., 1997). Debris layers containing projectile points suggest that the city experienced some hostile activity in the late 3rd and early 2nd centuries BC and was partially destroyed in the mid 2nd century BC, possibly by the same Roman forces responsible for the destruction of Corinth during the Achaean War (Williams et al., 2002). After this the city of Stymphalos seems to have been mainly abandoned, although it is likely that some occupation persisted in the valley (Williams et al., 2002). The city seems to have seen limited resettlement in the late 1st century BC, which coincides with the resettlement of

Corinth (Williams et al., 2002). It is likely that a Roman *colonia* was established at the site of ancient Stymphalos as excavations revealed a possible Roman villa constructed on top and out of earlier remains and coins, pottery and lamps that also attest to occupation into the 6th century AD (Williams, 2002). A large number of Late Roman/Early Byzantine (4th to 6th centuries AD) graves uncovered in the remains of much earlier structures indicate the presence of small communities nearby (presumably farmers); their abundance suggests that the valley may have seen a population increase during this time (Williams et al., 2002). Although as of yet no Late Roman/Early Byzantine habitation site has been found in the valley (Williams et al., 2002), it is possible that further excavation may reveal that these people not only also reused parts of the ancient city to bury their dead, but also to house their living members.

4.3.4 - Human Burials at Stymphalos

During archaeological explorations at ancient Stymphalos several graves dating to the 4th to 6th century AD and containing the skeletal remains of a minimum number of 40 individuals were uncovered. Williams and colleagues (2002) suggest that the abandoned buildings of the ancient city made a natural burial site since its remains were easily recognisable and the land would have been unsuitable for agricultural activities. The graves are typically orientated on an east-west axis (head pointing west) and individuals were interred in extended supine position with their arms at their side or crossed across their chests (Garvie-Lok, 2009; Williams et al., 2002). This burial position, and the fact that very few grave artefacts were found, suggests that these individuals were likely the followers of Christ, since these graves display characteristics common to Christian burials of the period (Williams et al., 2002).

Even though the burials display many commonalities, there are some differences based mainly on the elaboration of their construction and the number of individuals found within them. The graves were commonly found between walls and foundations, lined and capped with stones and tiles recovered from the ruins (Garvie-Lok, 2009; Williams et al., 1998). While some smaller graves consist of only a shallow pit covered by Laconian roof tiles, others are much larger and completely lined with stacked tiles and plaster (Williams et al., 2002). Although many graves contained only one individual, several comingled graves containing multiple individuals were discovered. It has been suggested that some of these comingled graves may represent family tombs that would have been reopened from time to time (Garvie-Lok, 2009). In such cases, the skeleton of the previous occupant was uncovered and moved aside to make room for the new corpse (Garvie-Lok, 2009). This resulted in a cumulative deposit of skeletal remains, with missing skeletal elements and poor preservation in all but the last individual interred (Garvie-Lok, 2009).

Excavations uncovered human remains from various areas in the ancient city. Two graves were found amongst the ruins of “The Sanctuary” (Stym II), or acropolis temple (Williams et al., 1998). The first was a multiple burial containing the comingled remains of three middle aged adults (one male and two females), an adolescent and an infant, as well as the articulated remains of another juvenile, possibly a female based on evidence suggesting that the individual was wearing bronze earrings (Garvie-Lok, 2009; Williams et al., 1998). The second grave contained the remains of an infant of neonatal age which may have been stillborn or died shortly after birth (Garvie-Lok, 2009). Explorations of the "Monastiraki" site (Stym III) located away from the city proper at the northern end of modern Stymfalia uncovered a number of graves along with scatterings of human bone. Three bronze coins found in close proximity to the graves suggest that they date to the 5th to 6th century AD (Williams et al., 1998). These graves contained the remains of an adult male and four juveniles (Garvie-Lok, pers. comm.). Excavation of the large artillery tower (Stym IV) located at the southwestern corner of the city also revealed a late antique necropolis containing at least ten burials of varied elaboration. These contained the remains of at least six adults (three males and three females) and three children (Garvie-Lok, pers. comm.). Also present was a tomb containing the remains of a dog, which may suggest a ritual nature to human/canine interactions among these people (Williams et al., 2002). Another artillery tower (Stym V) located on the western end of the city also contained a number of graves. Again these varied in elaboration and the number of individuals within them; they included individual tombs as well as larger commingled deposits and contain the remains of at least seven adults (three male, one female and three of unknown sex, a neonate and a child (Williams et al., 2002; Garvie-Lok, pers. comm.). Finally human burials were also found during the excavation of the eastern (Stym IX) acropolis terrace (Williams et al., 2002). These produced the remains of an adult woman, a child and an adolescent. Three more canine burials, two of Roman date and one possibly dating to the Late Classical or Early Hellenistic, were also found at Stym IX, which lends further evidence to the ritual use of dog remains at the site (Williams et al., 2002).

4.4 - The Monastery of Zaraka (Lat. 37º52’01" N, Long. 22º27’29" E)

4.4.1 - History of the Monastery

Zaraka is the best preserved of the twelve monasteries established in Greece by the Cistercian order between 1204 and 1276 AD, after the area was conquered by Latin armies during the Fourth Crusade (Brown 1958; Campbell, 1997; Panagopoulos, 1979). Located next to the main road at the edge of modern Kionia approximately 1.5 km west of Stymfalia, the monastery was named after the valley of Zaraka (also known as Saracez, Saracaz, Sarakez, Zaracca, or Zaraca), the name for the valley of Stymphalos used by the Latins (Brown, 1958; Gell, 1817; Panagopoulos, 1979; Pouqueville, 1822). The Cistercians were not only supporters of the Second, Third and Fourth Crusades, but at some points were also active participants. This, as well as the fact that the order had some influence over the papacy due to the aid given by them during previous holy wars, made them the favoured monastic order of many Crusaders (Brown, 1958; Efthymiou, 1999; Lock, 1995).

The monastery of Zaraka seems to have been established at the request of the Prince of Achaia, Geoffrey I Villehardouin, who received title to the land during the division of the Byzantine Empire after the successful capture of

Constantinople in 1204 (Brown, 1958; Campbell, 1997; Lock, 1995; Panagopoulos, 1979; Salzer, 1999). Through church channels, in 1210 Villehardouin requested that Pope Innocent III send monks of the Cistercian Order to Greece, where he would finance the construction of a monastery (Brown, 1958; Campbell, 1997; Panagopoulos, 1979; Salzer, 1999). Although originally Villehardouin stated he would build the house in Patras, it seems that nothing became of this, since there is no evidence of this monastery and in 1225, Villehardouin once again requested that monks be sent in order to spread Catholicism in Achaia (Brown, 1958; Campbell, 1997; Lock, 1995; Panagopoulos, 1979; Salzer, 1999). Whether or not the monastery of Zaraka was the direct result of this request (as there are other Cistercian monasteries in the region) and which abbey was the motherhouse to Zaraka (Hautecombe or Morimond) are debatable (Brown, 1958; Campbell, 1997; Panagopoulos, 1979; Salzer, 1999). Nevertheless, the monastery of Zaraka was founded ca. 1225 and seems to have been well occupied by 1236 (Brown, 1958).

There are only seven existing medieval documents that reference the monastery of Zaraka (Salzer, 1999). Three letters from Pope Gregory IX in 1236-37 mention Zaraka, one of which asks that Master Peter, the abbot of Zaraka, aid in collecting and distributing money for the war effort (Campbell, 1997; Salzer, 1999). The four remaining documents are all letters issued from the Chapter General of the Cistercians. One letter from 1241 orders the monks at Zaraka to hunt down fugitive monks in Greece, tell them to return to their houses, and excommunicate them if they did not comply (Brown, 1958; Campbell, 1997).

One letter, written in 1257, reprimands the abbot of Zaraka for not attending the meetings of the Chapter General for several consecutive years, while another from 1260 asks the abbots of Zaraka and St. Angelus to investigate an accusation made by a Lord Aymo de Molay against the abbot of Daphni (Brown, 1958; Campbell, 1997; Salzer, 1999). The last known communication regarding the monastery of Zaraka was another letter written in 1260, which instructed the abbots of Daphni and Rufinianai to inspect the location in which the abbot of Zaraka requested to move the monastery and determine if it was suitable (Campbell, 1997; Salzer, 1999). It is unknown whether this move took place, but around this time Frankish control of Greece started to falter and the monastery of Zaraka seems to have been abandoned shortly thereafter. Although most of the chapter houses in Greece had closed by ca. 1276, the monasteries of Daphni and Crete persisted until the 15th century (Campbell, 1997).

4.4.2 - Archaeological Investigation

Like ancient Stymphalos, the monastery of Zaraka was not archaeologically investigated until Anastasios Orlandos began working in the valley in the 1920's (Orlandos, 1926; Panagopoulos, 1979; Williams and Schaus, 2001). Excavations were also conducted by E. Stikas in the 1960's, and although none of his work was ever published, these early explorations did result in a clear plan of the site (Panagopoulos, 1979). In the 1980's, archaeological teams directed by Dr. Williams used aerial photography and geophysical investigations to document the site, yet formal excavations were not conducted (Williams, 1984;

Williams, 1985; Williams, 1996; Williams and Price, 1995). Excavations of the Cistercian monastery of Zaraka commenced in 1993 under the direction of Dr. Sheila Campbell as part of the UBC/CAIA project, but on behalf of the Pontifical Institute of Medieval Studies (Campbell, 1997). These investigations, which lasted until 1997, provided a great deal of information concerning the architecture and inhabitants of the monastery. Although they were not able to firmly establish the date it was founded, a coin of St. Martin of Tours suggests it is ca. 1225 (Campbell, 1997).

The site consists of a church, a gate tower and house and a tomb speculated to have contained the founding abbot, all enclosed within a fortification wall (Campbell, 1997). Much of the building materials used in the site's construction were pillaged from the ancient city of Stymphalos (Campbell, 1997). The church measures approximately 34 m by 16 m and was constructed on a southwest/northwest orientation with thick masonry wall filled with rubble (Campbell, 1997). Although the church is definitely of western design and decor, showing great similarities with other Cistercian churches in Europe, building techniques attest to the use of local craftsmen (Campbell, 1997). Excavations uncovered a living quarters and bell tower attached to the church, and large piece of bronze thought to be a monastery bell was also found (Campbell, 1997). Campbell states that the presence of a church bell suggests that "the area of land under cultivation by the monks was quite extensive...since the use of a bell tower in a Cistercian monastery was restricted to locations where the monks might have difficulty hearing the call to services". This is supported by the discovery of an irrigation system consisting of trenches that carried water from a nearby spring (Campbell, 1997). A large amount of ash may also suggest that the monks inhabiting the monastery were smiths, a trade known to have been practiced by the Cistercians (Campbell, 1997). Excavations were unable to determine the exact date in which the monastery was abandoned (Campbell, 1997). However the recovery of later artefacts including Venetian coins dating to the 14th century suggests that the site was periodically inhabited from time to time (Campbell, 1997).

4.4.3 - Human Burials at Zaraka

Nine individuals were uncovered during excavations at the monastery of Zaraka, and were examined by Dr. Garvie-Lok (Campbell, 1997; Garvie-Lok, n.d.). The burials did not comprise an organised cemetery, but were rather scattered about the ruins of the monastery. Two individuals, an adult female (96-1) and a adolescent (96-2), were uncovered within a single grave, but all the other graves were single burials. 96-1 was interred first and after the soft tissue had decomposed her bones were removed and the corpse of 96-2 was placed in the grave. The skeletal remains of 96-1 were then placed back into the grave in an disarticulated manner and the tomb was closed. Of the remaining single burials, two older adult males (96-3 and 96-5) were discovered near the south wall of the church. 96-5 was noted to have two congenital anomalies of the spine as well as severe osteoarthritis of the spine and shoulders. The remains of two infants (96-4 and 96-6) were buried near 96-5. The remains of an child (97-1) and two infants

(97-2 and 97-3) were also found in the narthex of the church. Tiny glass beads were recovered along with the remains of both 97-2 and 97-3.

The age/sex distribution of these skeletons and the scattered nature of the burials suggest that the remains uncovered at Zaraka do not belong to members of the monastic community (Campbell, 1997). If these burials represent the mortuary treatment of monks, it is highly unlikely that they would have been placed in such a random fashion (Campbell, 1997). It is also unlikely that any women or children would have been buried at the monastery while it was still in use (Campbell, 1997). Campbell (1997) suggests that the burials likely contain individuals that died while travelling through the region after the monastery was abandoned. However grave re-use also suggests that some individuals or families may have been more rooted to the area (Garvie-Lok, n.d.). Similar to the ancient city, the monastery would have provided an ideal burial location, as it is an easily recognisable landmark, which would have allowed the graves to be revisited.

4.5 - Materials

Human and animal teeth uncovered during the excavations in the valley of Stymphalos were collected from a storage facility in Stymfalia in 2008 and transported to Canada by Dr. Garvie-Lok under a permit granted by Greece's LZ Ephorate of Prehistoric and Classical Antiquities and the 25th Ephorate of Byzantine Antiquities. Due to its ability to withstand the contaminating effects of diagenesis enamel rather than bone was chosen for this study. In most cases, human teeth were removed from mandibles and maxillae in order to ensure they represented the correct individual. In a few instances only loose teeth were available. When this was the case for comingled remains, matching size and wear were used to differentiate individual dentitions. In all, Dr. Garvie-Lok collected 62 human teeth from 38 individuals (32 from ancient Stymphalos and six from the monastery of Zaraka), as well as five teeth belonging to pigs (genus *Sus*) and another five belonging to sheep or goat (genus *Ovis* or *Capra* respectively).

Table 4.1 - Human enamel samples from ancient Stymphalos and the monastery of Zaraka analyzed for $^{87}Sr/^{86}Sr$ ratios. "Sample" column denotes lab processing numbers; "Individual" column displays field identification numbers.

Sample	Individual	Age	Sex	Tooth Sampled
STE5	Stym II-99-2	Neonate	?	Upper right first deciduous incisor
STE7	Stym III-96-1	Adult	M	Lower left first premolar
STE14	Stym III-97-2-2	6-8 y	?	Upper right first molar
STE19	Stym IV-97-2	5-9 y	?	Upper right first molar
STE21	Stym IV-97-3	30-39 y	M	Lower right first molar
STE23	Stym IV-97-5	10-12 y	?	Upper right first molar
STE25	Stym IV-99-1	40-44 y	M	Upper right first molar
STE27	Stym IV-99-2	35-50 y	F	Lower left first molar
STE28	Stym IV-00-1-1	45-49 y	M	Upper right second molar
STE39	Stym V-99-6-1	Adult	?	Lower left first molar
STE43	Stym V-00-1-1	Young Adult	?	Lower left first molar
STE48	Stym V-05-1	18-24 y	M	Lower right first molar
STE50	Stym IX-00-2-1	8-10 y	?	Lower right first molar
STE53	Stym IX-00-4	45-60 y	F	Lower right first premolar
STE54	Stym II-97-1-1	1.5-2.5 y	F	Upper left deciduous canine
ZAE2	Zar 96-2	12-15 y	?	Lower right first molar
ZAE4	Zar 96-3	45-49 y	M	Upper right first molar
ZAE5	Zar 97-1	3-4 y	?	Upper left first deciduous incisor
ZAE6	Zar 97-2	6-9 m	?	Upper right first deciduous incisor
ZAE7	Zar 97-3	12-24 m	?	Upper right first deciduous incisor

Table 4.2 - Faunal samples from ancient Stymphalos analyzed for $^{87}Sr/^{86}Sr$ ratios. "Provenience" displays locality and year of excavation. Individual tooth types were determined using the zooarchaeological reference collection located in the Department of Anthropology at the University of Alberta.

Sample	Provenience	Taxon	Tooth Sampled	Date
STEF1	Stym II 99	Ovis/Capra	Lower second molar	ca. 2nd c. BC
STEF2	Stym II 99	Sus	Lower canine	ca. 2nd c. BC
STEF3	Stym II 99	Ovis/Capra	Lower second molar	ca. 2nd c. BC
STEF4	Stym II 99	Ovis/Capra	Upper second molar	ca. 2nd c. BC
STEF5	Stym II 99	Sus	Lower first molar	ca. 2nd c. BC
STEF6	Stym I 96	Ovis/Capra	Upper second molar	ca. 1st c. BC
STEF7	Stym I 96	Sus	Upper forth premolar	ca. 1st c. BC

4.5.1 - Human Samples

Typically, enamel from the permanent first molar (M1) was analyzed. Assuming that dental development and eruption times during the Late Roman/Early Byzantine period are similar to those currently expected, the enamel of this tooth should contain strontium isotopes ingested by an individual roughly between birth and 2.5 years of age. However, due to the age-at-death and skeletal preservation of some individuals, this tooth was not always available. If it was available the first permanent premolar (PM1) was chosen. However this too was not always possible, usually because of the very young age-at-death of some individuals. In these cases deciduous teeth were usually all that was available, and the best preserved and most fully formed tooth was chosen. For the purposes of this study, individuals are considered local if their enamel $^{87}Sr/^{86}Sr$ ratios suggest that they spent the first few years of life, while the enamel of the analyzed tooth was forming, living in the valley of Stymphalos. Individuals with enamel $^{87}Sr/^{86}Sr$ ratios suggesting they spent the first years of their lives residing elsewhere are considered ‘non-local.’ The exact age when these individuals moved and eventually came to be buried in the valley cannot be determined by this project’s research design. Further analysis using multiple samples from a single individual (enamel samples taken from a variety of teeth with different development times and samples from bones with varying turnover rates) may be able to narrow down the age when an individual actual migrated from one area to another. However, a project like this is not only far beyond the scope of this thesis, but it would also be extremely expensive to pursue and very destructive to the remains of analyzed individuals.

Although enamel was sampled from all 62 human teeth, the research budget for this study permitted analysis of only a single tooth from 20 human individuals (15 from ancient Stymphalos and 5 from the monastery of Zaraka). A preliminary analysis of 10 individuals (5 from Stymphalos and 5 from Zaraka) was conducted to determine the quality of the samples, whether or not they displayed variation in $^{87}Sr/^{86}Sr$ ratios, and to test the idea that individuals with outlying $\delta^{15}N$ and $\delta^{13}C$ values would also show unusual $^{87}Sr/^{86}Sr$ ratios. Therefore, preliminary samples included individuals that displayed isotopic dietary differences. The preliminary analysis was followed by a second round of tests that attempted to create a statistically acceptable sample set that not only contained a mixture of juveniles and adults, men and women, but also analyzed individuals from all the different areas in that valley where graves were discovered.

4.5.2 - Faunal Samples

In total, 7 out of 10 faunal enamel samples (3 *Sus sp.* and 4 *Ovis/Capra sp.*) were analyzed for $^{87}Sr/^{86}Sr$. Two of these samples (STEF 6 and STEF 7) originated from a section of the lower domestic quarter (Stym I), in an area containing Early Roman material dating to the approximately the 1st century BC based on recovered coins and pottery (Williams et al., 1997; Williams et al., 2002). The remainder of the animal teeth were recovered from the acropolis sanctuary (Stym II), from trenches dating to the Hellenistic period, or approximately 2nd century BC (Williams et al., 2002). It is thought that the pig teeth represent the domesticated species *Sus scrofa domesticus,* but it is possible that may be representative of wild boar (*Sus scrofa*) as they are found in the region and hard to distinguish skeletally from their domestic relatives. Faunal remains were analyzed with the hope that they would provide a local $^{87}Sr/^{86}Sr$ signature from which the human values can be compared. As discussed in chapter 3, it has been suggested that using faunal remains to determine a local $^{87}Sr/^{86}Sr$ signature may provide better results than simply using the human $^{87}Sr/^{86}Sr$ average. However, this method assumes that the animals did not range vary far and were raised and consumed locally, and it likely that there was in fact a considerable amount of livestock trade during the time period in question. It will be interesting to see whether the pig and sheep/goat teeth analyzed for this study confirm a local $^{87}Sr/^{86}Sr$ signature, or if they themselves were perhaps non-local to the valley.

4.6 - Methods

4.6.1 - Choice of Analytical Method

Currently three methods are used for $^{87}Sr/^{86}Sr$ analysis. The first, thermal ionization mass spectrometry (TIMS), is the oldest method. It requires samples to be dissolved in acid and then loaded onto a metal filament, which is then heated to produce ions that pass to the mass spectrometer for analysis (Horstwood et al., 2008). The TIMS method is time- and labour-intensive and requires a relatively large sample weight. The second method, solution-mode multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS), also requires samples to be dissolved in acid. However, the sample solution is then aspirated into a plasma torch, producing the ion stream to be analysed. Like TIMS, MC-ICP-MS destroys the sample, yet it requires far less sample and analysis time is considerably shorter, making the method less labour-intensive (Buzon et al., 2007; Simonetti et al., 2008). The third method is basically a variation of solution mode MC-ICP-MS. Instead of dissolving the sample, LA-MC-ICP-MS uses laser ablation to remove a small portion of its surface; these particles then pass into the plasma torch where they are ionized (Copeland et al., 2008; Horstwood et al., 2008). Compared to solution-mode MC-ICP-MS, this method requires even smaller samples and reduces sample preparation time (Copeland et al., 2008; Horstwood et al., 2008; Richards et al., 2008). It also has the advantage of leaving the sample largely intact because LA-MC-ICP-MS allows a small amount of material to be ablated from the sample in *situ*. This also means that pinpoint samples can be taken from multiple incremental growth features within a single tooth, potentially allowing researchers to study mobility within a relatively short period of an individual's life (Copeland et al., 2008; Haverkort et al., 2008; Horstwood et al., 2008; Richards et al., 2008). This approach was recently used by Richards and colleagues (2008) to investigate the mobility of a single Neanderthal individual uncovered at the site of Lakonis, Greece. Richards and colleagues (2008) suggest that $^{87}Sr/^{86}Sr$ values of the tooth and associated fauna indicate that Neanderthals periodically migrated distances of at least 20 km. They advocate LA-MC-ICP-MS as the quickest, most affordable and least destructive method for analyzing sensitive archaeological material (Richards et al., 2008; Richards et al., 2009). However, other researchers suggest that although LA-MC-ICP-MS is quick and affordable, molecular interference produced by laser ablation reduces its accuracy when compared to solution mode MC-ICP-MS and TIMS (Horstwood et al., 2008; Nowell and Horstwood, 2009; Simonetti et al., 2008). Furthermore, the mathematical correction for the molecular interference is quite time-consuming and in order to fully sample incremental growth structures a tooth must be thin sectioned, which is also time consuming and partially destroys it. For all of these reasons, these authors suggest that LA-MC-ICP-MS is not as advantageous as it may appear (Horstwood et al., 2008; Nowell and Horstwood, 2009; Simonetti et al., 2008). The future of LA-ICP-MS must be closely observed, since if it becomes refined and accepted, it could revolutionize archaeological strontium isotope research. However, the debate over its accuracy led to the selection of the more accepted solution mode MC-ICP-MS as the method for the current study at Stymphalos.

4.6.2 - Identification and Documentation

Prior to sampling, tooth type identifications made in the field by Dr. Garvie-Lok were double-checked by this author using guidelines provided by Bass (2005) and White and Folkens (2005). Species and tooth type identifications of the animal teeth were conducted in the field by Dr. Garvie-Lok and confirmed by this author using the Department of Anthropology's Zooarchaeological collection located at the University of Alberta.

All 72 teeth were then thoroughly documented to minimize the loss of information caused by destructive sampling. Measurements were taken of the crown length, the crown width and the total length using calibers. Then, macro photographs were taken of the buccal, lingual, mesial, distal and occlusal surfaces of each tooth using a digital camera.

4.6.2 - Sampling Procedure

Enamel sampling of all 72 teeth was conducted in the Department of Anthropology's stable isotope pre-preparation lab at the University of Alberta under the supervision of Dr. Garvie-Lok. Sampling was carried out by this author and Ms. Cynthia Kwok. In order to remove any surface enamel that may have been contaminated by the burial environment each tooth was first abraded using a grindstone attachment fitted to a Dremel tool. To avoid cross contamination, in between uses all tools were cleaned, rinsed and then sonicated for five minutes in purified water. Enamel samples were removed from the crown using a diamond disk saw and then any remaining dentine was removed with a grindstone attached to the same Dremel tool. A few juvenile teeth were too small and delicate to be abraded and sampled properly, and in such cases the entire crown was used. However, only one of these teeth (STE5, from a neonate) was actually analyzed for strontium isotopes. An attempt was made to obtain sample weights of at least 40 milligrams. Four samples (STE5, STE25, STE39, ZAE6 l) utilized in this study were slightly lighter (~30 mg), but this amount of enamel proved sufficient for analysis. After each tooth was sampled a photograph recording the sampling damage was taken. The enamel samples were labelled and stored in the lab, while the remainder of the teeth were taken to the University of Calgary (Alberta, Canada) by Ms. Kwok, who is analyzing the dentine as part of a PhD dissertation on dietary reconstruction.

4.6.3 - Enamel Processing

Enamel sample selected for testing were prepared in the Class 100 cleanroom in the Radiogenic Isotope Facility, Department of Earth and Atmospheric Sciences, University of Alberta. Samples were prepared and analyzed by Dr. Robert Creaser following the methods outlined in Buzon et al. (2007). First, the samples were sonicated for 15 minutes in Millipore water (MQ), and then in 5% acetic acid for another 15 minutes. Samples were then leached overnight in 5% acetic acid. The acid was removed and the samples were rinsed with MQ and transferred into vials. An Rb-Sr spike was added to the samples and then they were digested in a microwave oven in 4ml 16N HNO_3 and 1ml ~10 N HCl. Samples were then dried overnight on a hot plate set at 80°C.

The samples were then dissolved in 3ml of 0.75N HCl and placed in 10 cm ion exchange columns containing 1.42 ml of 200-400 mesh AG50W-X8 resin. 5 ml samples of 2.5N HCl were collected into Teflon vials, a drop of H_3PO_4 was added to each and then samples were once again left to dry overnight on a hotplate (80°C). Prior to analysis, Sr bearing aliquots were diluted in a 2% HNO_3 solution.

4.6.4 - Analytical Methods

Samples were introduced into the mass spectrometer by aspirating them into the ICP torch using a desolvating nebulising system (DSN-100 from Nu Instruments Inc.). However, before a sample was introduced, a 30 second measurement of a gas blank was taken, and this was used to correct for isobaric interferences. A NuPlasma MC-ICP-MS instrument in static, multicollection mode using five Faraday collectors for 400 seconds (or 40 scans of 10 second integrations) was used to obtain strontium isotope values. After each sample a 'wash-out' period of 5 minutes was preformed. A 100 ppb solution of NIST SRM 987 strontium isotope standard was used throughout the analysis to ensure accuracy and reproducibility.

Chapter 5: Results

5.1 - Introduction

The results of the strontium isotope analysis will be discussed in this chapter. After a brief description of the results using tables and graphs, there will a discussion concerning sample quality and diagenesis. Next, the local signal must be determined, so that non-local individuals may be identified. This will be done using the $^{87}Sr/^{86}Sr$ values from both the faunal remains and the human values. Once the local signal has been established, 'non-locals' will be identified and a brief discussion concerning their possible origins will be discussed briefly. However, the bulk of the discussion concerning the interpretation of the strontium data, their implications concerning mobility, and their relation to previous studies in the region will be presented in chapter 6.

5.2 – $^{87}Sr/^{86}Sr$ Values

The results of the strontium isotope analysis of the enamel samples from ancient Stymphalos and the monastery of Zaraka are provided in Table 5.1 and 5.2. The results are displayed graphically in Figure 5.1.

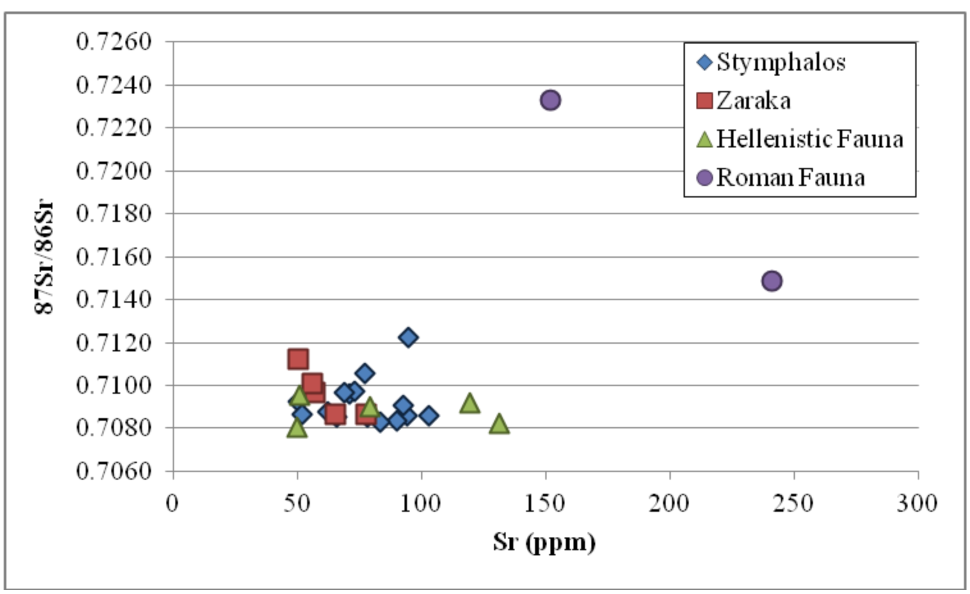
Table 5.1 - Results for the strontium isotope analysis of faunal enamel samples.

Sample	Sr (ppm)	$^{87}Sr/^{86}Sr$	2sd
STEF1	51	0.709574	0.000044
STEF2	131	0.708219	0.000024
STEF3	79	0.709017	0.000030
STEF4	50	0.708046	0.000019
STEF5	119	0.709190	0.000016
STEF6	241	0.714900	0.000030
STEF7	152	0.723330	0.000030

Table 5.2 - Results for strontium isotope analysis of human enamel samples from ancient Stymphalos and Zaraka.

Sample	Sr (ppm)	$^{87}Sr/^{86}Sr$	2sd
STE5	95	0.712240	0.000030
STE7	50	0.709234	0.000026
STE14	66	0.708561	0.000034
STE19	94	0.708570	0.000023
STE21	77	0.710544	0.000027
STE23	103	0.708610	0.000020
STE25	52	0.708663	0.000028
STE27	93	0.709075	0.000024
STE28	71	0.709610	0.000030
STE39	62	0.708777	0.000034
STE43	78	0.708530	0.000020
STE48	90	0.708371	0.000020
STE50	73	0.709762	0.000021
STE53	83	0.708310	0.000030
STE54	69	0.709679	0.000028
ZAE2	78	0.708670	0.000020
ZAE4	65	0.708640	0.000030
ZAE5	57	0.709670	0.000030
ZAE6	50	0.711220	0.000030
ZAE7	56	0.710070	0.000020

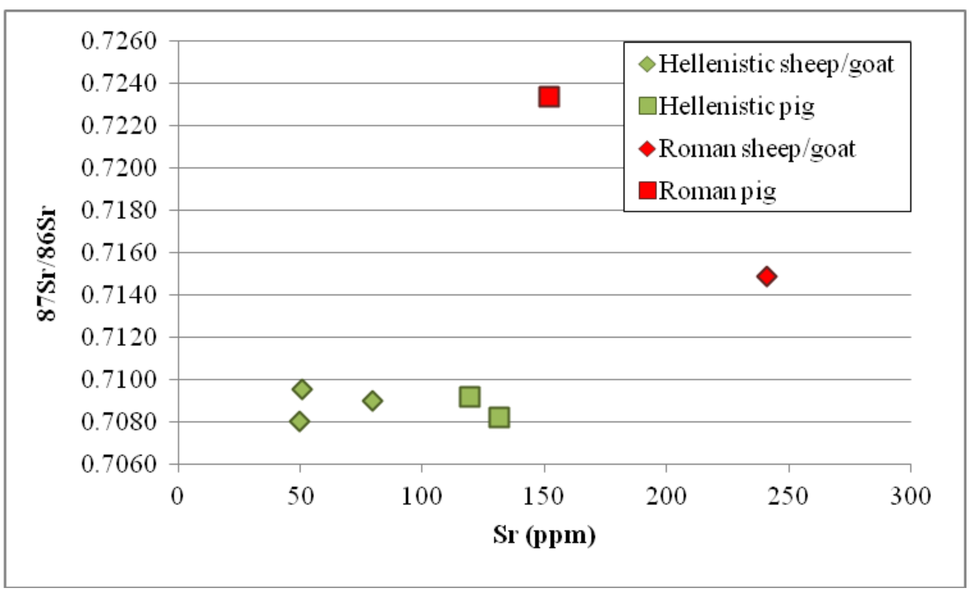
Figure 5.1 - Scatter plot displaying the results of strontium isotope analysis of human and faunal enamel samples.



5.2.1 - Faunal $^{87}Sr/^{86}Sr$ Values

Faunal enamel samples vary widely in $^{87}Sr/^{86}Sr$. Although none of the teeth recovered from the Hellenistic ritual deposit (Stym II 99) have $^{87}Sr/^{86}Sr$ ratios higher than 0.7100, two are at the upper end of the range predicted for the valley based on previous research (STEF3 at 0.7090 and STEF5 at 0.7092) and one sample (STEF1 at 0.7096) exceeds it. The $^{87}Sr/^{86}Sr$ ratios of the two samples taken from the Roman midden (Stym I 96) are well above that value (STEF6 at 0.7149 and STEF7 at 0.7233). While there do not appear to be any patterns in the $^{87}Sr/^{86}Sr$ values related to taxon (sheep/goat versus pig) among the Hellenistic fauna, there is substantial $^{87}Sr/^{86}Sr$ variation between the two samples buried in the Roman midden (Figure 5.2). The implications of this discrepancy will be discussed below.

Figure 5.2 - Strontium analysis results for faunal remains by location and taxon.



5.2.2 - Human $^{87}Sr/^{86}Sr$ Values

Individual $^{87}Sr/^{86}Sr$ values range from 0.7083 to 0.7122 and generally fall into four major groupings. Eight samples from Stymphalos (STE14, STE19, STE23, STE25, STE39, STE43, STE48 and STE53) and two from Zaraka (ZAE2 and ZAE4) create the lowest group, having $^{87}Sr/^{86}Sr$ values ranging from 0.7083 to 0.7087. The second lowest group is comprised of two individuals from Stymphalos with slightly higher $^{87}Sr/^{86}Sr$ ratios (STE27 at 0.7090 and STE7 at 0.7092). Four individuals (STE28, STE50, STE54 and ZAE5) group tightly together between 0.7096 and 0.7097. The last group (STE5, STE21, ZAE6 and ZAE7) is comprised of four individuals with highly variable $^{87}Sr/^{86}Sr$ ratios above 0.7100.

5.3 - Sample Quality and Diagenesis

5.3.1 - Precautions

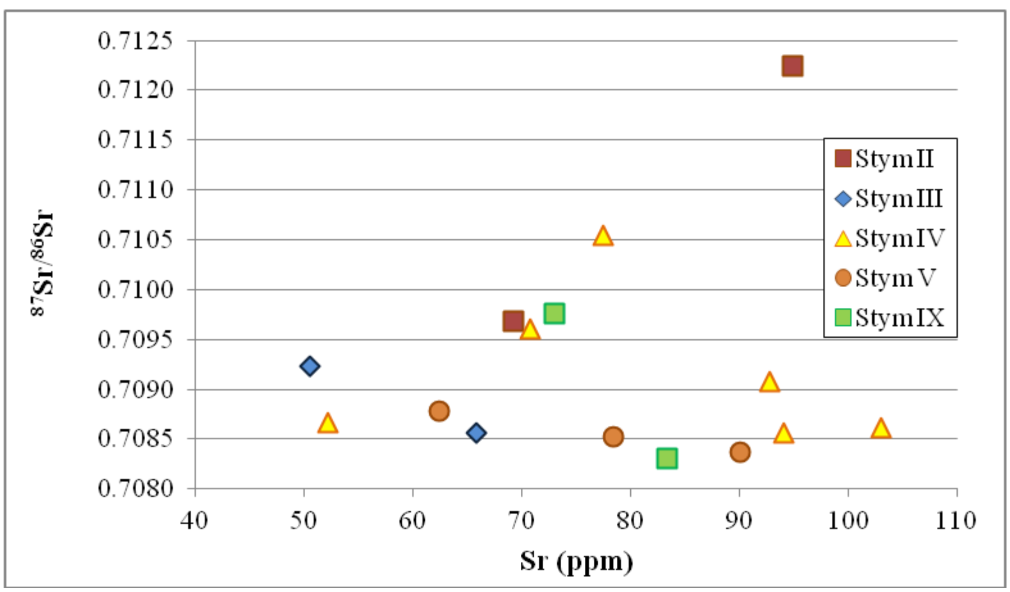
The choice to use tooth enamel instead of bone was one of the first steps taken to ensure good sample integrity. As mentioned in chapter 3, many researchers use tooth enamel for strontium isotope studies since it is much less permeable than bone and is therefore more resistant to post-mortem contamination (Bentley, 2006; Bentley et al., 2004; Bentley et al., 2007; Ezzo and Price, 2002; Montgomery et al., 2005; Nafplioti, 2008; Price et al., 2006). Although it is possible for contaminants to adhere to the outside of enamel, or even permeate into pores and cracks, this contamination can usually be removed by abrading the outside of the tooth before enamel samples are removed, as was done for all the teeth in this study. As a further measure to remove contaminants, all enamel samples were sonicated in Millipore water and then soaked in 5% acetic acid. These procedures are standard practices for removing contaminants before enamel Sr isotope analysis and are generally considered sufficient to deal with enamel contamination (Budd et al., 2000; Ezzo and Price, 2002; Bentley et al., 2003; Bentley et al., 2007).

5.3.2 - Sr Content of Enamel Samples

The overall strontium content of enamel samples in ppm (parts per million) has been employed by several scholars as a measure of diagenesis (Budd et al., 2000; Evans et al., 2006; Montgomery et al., 2000; Montgomery et al., 2003). Samples between 50 and 300 ppm (Underwood, 1977) and even up to 500 ppm (Bentley, 2006) are considered to be within the normal human range. Samples that are above this range are considered to be too degraded or contaminated by soil Sr for reliable analysis (Montgomery et al., 2000; Montgomery et al., 2003; Bentley 2006). Sr content of the Stymphalos and Zaraka human and faunal samples are displayed in Table 5.1. None of the samples have Sr values outside the normal range for humans, which suggests that the samples are indeed well-preserved enough for analysis.

Although it is seldom incorporated into studies, overall Sr content can further be used to aid in the identification of local individuals. As mentioned in chapter 3, strontium is incorporated into the skeleton through the consumption of calcium. Therefore, individuals at the same trophic level who consume calcium from the same sources should have a similar Sr content. This method was used by Montgomery and colleges (2003) to argue that even though two individuals at a site had similar $^{87}Sr/^{86}Sr$ ratios, they were probably not from the same locale based on the fact that they differed in Sr content. As we can see in Figure 5.1, there is no observable correlation between $^{87}Sr/^{86}Sr$ ratio and Sr content in this study. Nor is there any correlation between sample $^{87}Sr/^{86}Sr$ values and Sr content related to the burial localities within ancient Stymphalos (Figure 5.3). In this study it seems that Sr content will be of little use in the identification of non-local individuals.

Figure 5.3 - $^{87}Sr/^{86}Sr$ and Sr content by burial area at ancient Stymphalos.



5.3.3 - Possible Contamination of STE5

One tooth taken from a neonate (STE5) was unerupted and its enamel was not fully mineralized. This made it very fragile, and because it was impossible to abrade the enamel surface or separate it from the underlying dentine, both enamel and dentine were sampled. Thus, although the tooth was sonicated in Millipore water and soaked in 5% acetic acid, STE5 did not receive the same pre-analysis treatment as the rest of the samples and has a somewhat different composition. Like bone, dentine is more porous than enamel, and incompletely mineralized enamel is more porous than normal mature enamel (Hillson, 1996; Williams and Elliot, 1989). This raises concern for potential contamination issues with STE5, but because this neonate produced the most extreme collagen δ^{13}C value in the Stymphalos remains (Pennycook 2008) it was considered important to try running the sample.

Given the potential preservation issues it is interesting that STE5 has the highest ^{87}Sr/^{86}Sr ratio at 0.7122. It is possible that this tooth was contaminated by strontium from anthropogenic sources such as modern fertilizers and pollutants. However, STE5 was interred among rock-cut foundations on the site's acropolis, where no agriculture is possible and no agricultural runoff could reach. As well, STE5's Sr content is well within the limits for fully formed mature enamel. Finally, as discussed further below the infant's unusual collagen δ^{13}C value had already suggested that the ^{87}Sr/^{86}Sr ratio might prove to be unusual. Give these factors it was decided to retain the sample and proceed cautiously under the working assumption that it was not contaminated.

5.3.4 - Previous Work Concerning Sample Integrity

During her stable isotope analysis investigating the diet of the individuals recovered from ancient Stymphalos and the monastery of Zaraka, Pennycook (2008) ran several tests to ensure that her samples were of sufficient quality. Even though that analysis used bone collagen rather than enamel samples, the results are important to this study. If the bone samples are not diagenetically altered it is likely that the less permeable enamel is also well-preserved.

Pennycook (2008) used the combination of four methods to determine whether collagen samples were of good enough quality to ensure accurate results. The first, collagen yield, is the final dry weight of extracted collagen as a proportion of the initial weight of the bone sample. Poor collagen yields suggest that the bone is too degraded to provide a usable sample. The second method was an examination of the texture and appearance of the collagen model left after demineralizing whole pieces of bone in dilute HCl. Well preserved samples usually produce a firm, intact model. Pennycook also measured the collagen's atomic C/N ratio and its C and N content. Both of these tests compare the amount of C and N present in the prepared sample to the amounts present in fresh human bone collagen. Sufficient degeneration of collagen will cause the loss of C or N and an atypical atomic C/N ratio, which indicates that the sample is compromised (Pennycook 2008).

Pennycook (2008) rejected two samples from her study due to poor preservation. Of the two samples, only one (STE43) was from an individual used in the current isotope analysis. This individual was considered for rejection from this study. However, the enamel Sr content of STE43 is within normal range and the sample has an average $^{87}Sr/^{86}Sr$ ratio. Although the bone of this individual may have suffered from poor preservation, it seems that the more diagenetically resistant enamel is of sufficient quality to be retained in the study.

5.4 - Determination of the Local $^{87}Sr/^{86}Sr$ Signal

Chapter 3 mentioned several methods for determining the local $^{87}Sr/^{86}Sr$ signature. Two of these techniques will be used and their results will be compared. The first uses the archaeological faunal enamel samples, while the second employs the human enamel samples themselves. Both of these methods use two standard deviations (2sd) from the mean $^{87}Sr/^{86}Sr$ values to create a local range, which can then be used to discriminate local individuals.

5.4.1 – Faunal Values

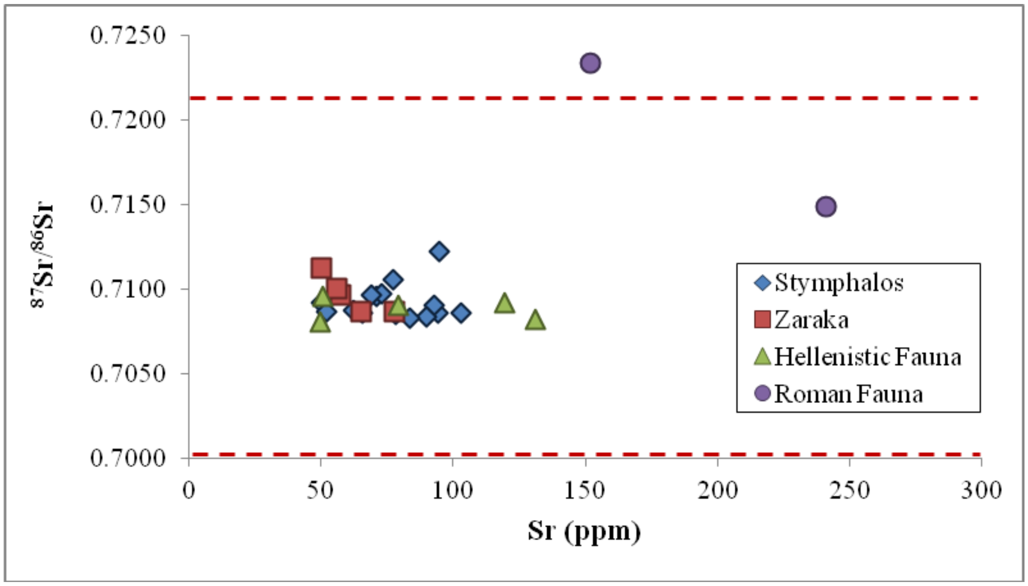
For this study, seven faunal teeth were analysed for $^{87}Sr/^{86}Sr$ ratios. Two of the teeth (STEF6, a pig, and STEF7, a sheep/goat) were recovered from a Roman era midden, while the others (three sheep/goat and two pig) are from a Hellenistic ritual context. The results of the strontium isotope analysis are provided in Table 5.2. Given the geology of the region, three of the samples have $^{87}Sr/^{86}Sr$ values higher than predicted for the valley. One of the Hellenistic samples (STEF1) has a $^{87}Sr/^{86}Sr$ slightly higher than modern seawater (0.7092) and two samples from the Roman era midden display $^{87}Sr/^{86}Sr$ values well above what is expected for the valley of Stymphalos. The two Roman midden values are very high, corresponding to older igneous rocks rather than the sedimentary rocks of the area (Bentley, 2006). They are also substantially higher than the values found for the Hellenistic fauna.

There are two possible explanations for the elevated $^{87}Sr/^{86}Sr$ values for the Roman fauna. The first is that these two teeth may have been contaminated by an artificial source of strontium. These two teeth originate from an area of ancient Stymphalos (Stym I) close to the shore of the lake, which is prone to seasonal flooding (Williams et al., 2002). Modern fertilizers and pollutants likely add non-local strontium to the lake and repeated submersion of these teeth could possibly lead to contamination. The $^{87}Sr/^{86}Sr$ values of fertilizers can vary greatly (0.708-0.835) and in their area of study, Böhlke and Horan (2000) found that fertilizers had raised the $^{87}Sr/^{86}Sr$ ratios of oxic ground waters to 0.713-0.715. However, neither of these teeth were observed to be poorly preserved, and both have Sr contents well within the normal range. Also, if these two teeth were both contaminated by water from the same source their $^{87}Sr/^{86}Sr$ ratios should be similar, which they are not. Furthermore, the outside of both teeth were abraded prior to sampling and they were chemically treated to remove contaminants. The impermeability of enamel, the mechanical and chemical removal of contaminants, the samples' observed good preservation, their Sr content, and their disparate $^{87}Sr/^{86}Sr$ ratios all suggest that contamination is an unlikely explanation for the two values.

The second explanation for the high $^{87}Sr/^{86}Sr$ values observed in these two faunal teeth is that perhaps these animals were imported into the region, and thus they themselves were non-local. These two teeth were recovered from a context dating to the period of Roman occupation of Greece in the 1st century BC

(Williams et al., 2002). It is possible that Roman settlers, or perhaps a military force garrisoned in the area, brought livestock with them from their place of origin. This possible explanation for the elevated $^{87}Sr/^{86}Sr$ ratios of the Roman era fauna will be further discussed in chapter 6.

Figure 5.4 - Local range for the valley of Stymphalos determined using both Hellenistic and Roman faunal $^{87}Sr/^{86}Sr$ values.



To determine the local signature, the mean and standard deviation (sd) of the faunal $^{87}Sr/^{86}Sr$ values must be calculated. Then the standard deviation must be multiplied by two and used to calculate a ± 2sd range around the mean to serve as the upper and lower local $^{87}Sr/^{86}Sr$ limits. Using all the faunal values (including the two from Stym I) generates a $^{87}Sr/^{86}Sr$ mean of 0.71175, sd of 0.005612, and a local range of 0.70053 to 0.72298 (Figure 5.4). This local $^{87}Sr/^{86}Sr$ range does not identify any non-local human individuals. However, the upper end of this range is implausibly high because of the inclusion of the two

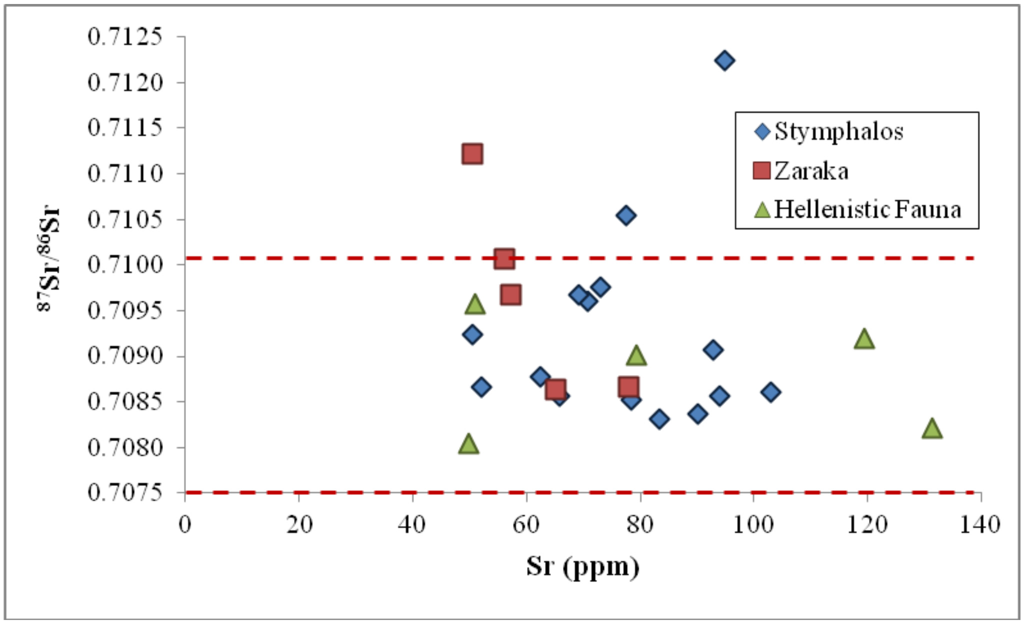
Roman era samples. As discussed above, these samples are likely non-local based on their elevated values. It only stands to reason that they should be omitted from the calculations.

When only the Hellenistic fauna are used to determine the local $^{87}Sr/^{86}Sr$ range, a very different picture emerges (Figure 5.5). The mean for the Hellenistic fauna is 0.70881 and the sd is 0.000653, which gives a 2sd range of 0.7075 to 0.71012. Although omitting the two Roman era samples provides a much smaller range, and offers a more well-defined view of the human $^{87}Sr/^{86}Sr$ variation, it is still higher than the valley's geology predicts; this point is discussed further below. Bentley (2004) states that pigs are the best choice for determining local $^{87}Sr/^{86}Sr$ ranges since they are usually not herded like sheep or goats and often eat human refuse. Even though the one Hellenistic animal with a higher than predicted $^{87}Sr/^{86}Sr$ value is from a sheep or goat, if we use only the $^{87}Sr/^{86}Sr$ values from the pigs the 2sd range (0.70733 to 0.71001) is still very similar to the range for all the Hellenistic fauna. Furthermore, milk products from sheep and goats would have been an important source of dietary calcium, and thus strontium. Therefore, the local $^{87}Sr/^{86}Sr$ signature provided by all of the Hellenistic fauna will be used to identify non-local residents in the valley of Stymphalos' burial population.

5.4.2 – Human Values

Human enamel samples have been used by many authors to determine the local $^{87}Sr/^{86}Sr$ range (Bentley et al., 2002; Ericson, 1985; Grupe et al., 1997; Price et al., 1994a; Price et al., 1994b). Yet for the purposes of this study, the local range provided by the human samples is only used to check the reliability of the range received from the faunal samples.

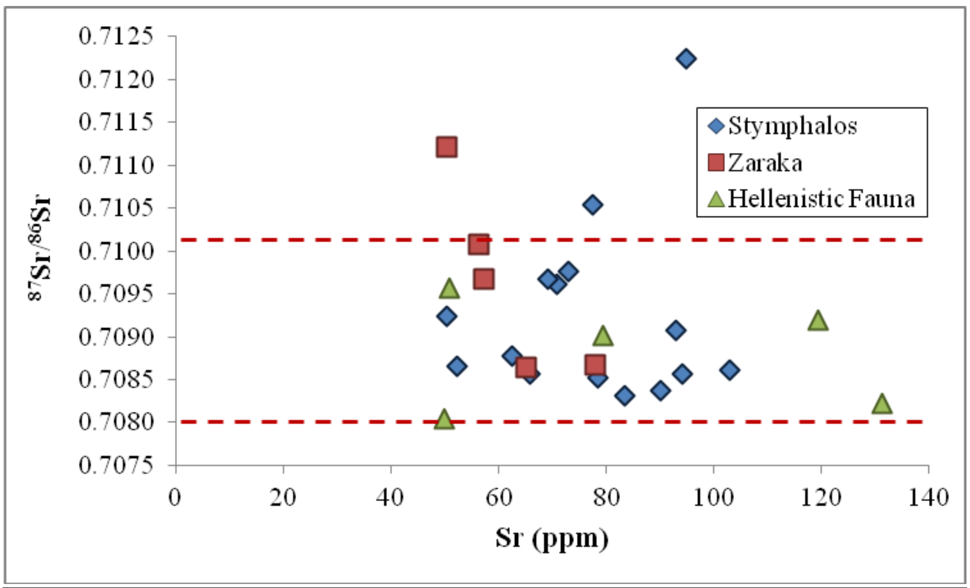
Figure 5.5 - Local range for the valley of Stymphalos determined using only the Hellenistic fauna.



The human samples from ancient Stymphalos have a mean of 0.70924 and a 2sd range of 0.70714 to 0.71133, while the Zaraka samples have a mean of 0.70965 and a 2sd range of 0.7075 to 0.7118. The lower and upper limits of the Zaraka range are slightly elevated compared to Stymphalos. Combining the samples from Stymphalos and Zaraka provides a $^{87}Sr/^{86}Sr$ mean of 0.70934 and a range of 0.70726 to 0.71142, which lies between the ranges received from the Stymphalos and Zaraka samples as expected. The total human range is broader than the range determined using the Hellenistic fauna (0.70881 to 0.71012).

However, if the individuals deemed non-local by the Hellenistic fauna (STE5, STE21 and ZAE6) are omitted from the calculations, the human samples provide a mean of 0.70899 and a $^{87}Sr/^{86}Sr$ range of 0.70786 to 0.71011 (Figure 5.6). This is very similar to the 2sd range of the Hellenistic fauna, and does not identify any more non-local individuals. Therefore, it seems that even though it is quite broad, the local $^{87}Sr/^{86}Sr$ range determined using the Hellenistic faunal is reliable.

Figure 5.6 - Local range determined using human $^{87}Sr/^{86}Sr$ values. Outliers identified by Hellenistic fauna have been omitted from this local range calculation.



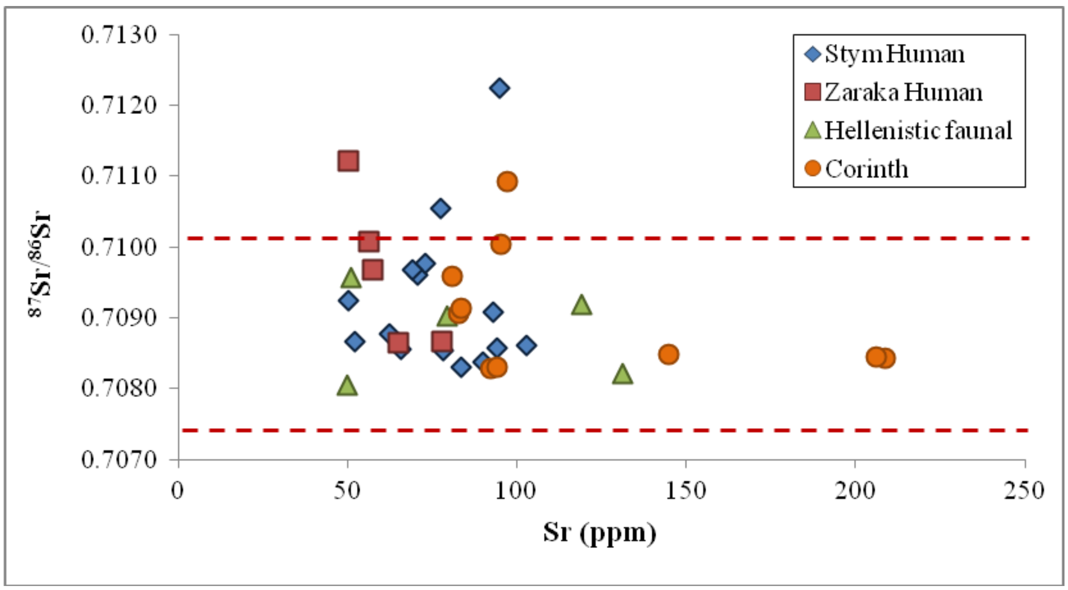
5.4.3 - Comparison to Literature Values

The local range determined for the valley of Stymphalos in this study is unexpectedly elevated compared to what was predicted based on geological formations and previous research. The underlying bedrock, comprised mostly of limestones of various geological ages, suggests that the valley should have a local range of approximately 0.7068 to 0.7092. The range determined using the Hellenistic fauna is much higher than this estimated range. It is also elevated in comparison to the range of 0.7080 to 0.7084 reported by Nafplioti (2011) for the Peloponnese, although those values do overlap the lower end of the range reported in this study. Therefore it seems that not only is the lower component of the predicted range absent from the enamel samples, but there also seems to be a source of higher $^{87}Sr/^{86}Sr$.

There are several explanations for why the 'local' range is elevated compared to what is geologically expected, and why many individuals considered 'local' have $^{87}Sr/^{86}Sr$ values at or well above the upper end of the predicted range. Both seawater and some of the limestones in the valley should have a $^{87}Sr/^{86}Sr$ ratio of 0.7092, and this may account for the large number of samples in the upper end of the local range. However, several of the enamel samples are well above this value and thus must be receiving even higher $^{87}Sr/^{86}Sr$ ratio strontium from another source. It is possible that Nafplioti's survey, which did not intensively sample the Peloponnese, has missed some higher local $^{87}Sr/^{86}Sr$ values in the peninsula. Using laser ablation, Richards and colleagues (2008) reported values above 0.7092 for sections of a Neanderthal tooth, as well as deer and rhino samples, from the Lakonis region of the southern Peloponnese. Because $^{87}Sr/^{86}Sr$ values are based on bedrock geology these values should also be applicable to recent times, and the high values of the deer and rhino in particular suggest high $^{87}Sr/^{86}Sr$ values local to the Peloponnese. However, these results have been criticised based on the study's use of laser ablation. Also, although this opens the possibility that there is bedrock in the Lakonis region with an elevated $^{87}Sr/^{86}Sr$ ratio, that area is still about 100 km from the valley of Stymphalos.

The local $^{87}Sr/^{86}Sr$ range for this study is similar to the range Lê (2006) calculated for Frankish Corinth, and the outliers in both studies are in the same direction (Figure 5.7). The individuals determined to be local at Corinth exhibit a similar $^{87}Sr/^{86}Sr$ range (0.7083 to 0.7091) to many of the individuals in this study.

Figure 5.7 - A comparison of the results received from the valley of Stymphalos with those obtained by Lê (2008) for Corinth. The local range determined using Hellenistic fauna from ancient Stymphalos is displayed.



However, due to high variation in the $^{87}Sr/^{86}Sr$ values of the Hellenistic fauna from Stymphalos, only one outlier from Corinth would be considered non-local in the present study (whereas Lê identified two non-locals).

The Hellenistic faunal results from Stymphalos may indicate that there is a wider range in $^{87}Sr/^{86}Sr$ than expected in the Peloponnese and much overlap between regions. However, it could also mean that the local range established for the valley of Stymphalos is too wide to effectively identify all non-local human individuals because of unanticipated mobility in the animal population. Two of the five Hellenistic faunal samples had values at the high end of the predicted range and one is higher than modern seawater. While these three Hellenistic samples were not as elevated as their Roman era counterparts, there is still the possibility that at least one represents a non-local animal, since it is quite difficult to identify a potential source of $^{87}Sr/^{86}Sr$ higher than 0.7092 in the region surrounding the valley of Stymphalos.

5.5 - Conclusion

The results of the current strontium isotope analysis are quite interesting. Three human and two faunal samples are well above the upper $^{87}Sr/^{86}Sr$ limit established using the Hellenistic fauna and seem definitively non-local. As well, five human individuals and one Hellenistic faunal sample have values higher than what was predicted for the valley. While this may be indicative of a source of elevated $^{87}Sr/^{86}Sr$ somewhere in the region, it is difficult to plausibly identify a potential source given that the geology of the Peloponnese is based largely on marine sedimentary rocks, which rarely show $^{87}Sr/^{86}Sr$ values above 0.7092. It is also possible that the 2sd range of the Hellenistic fauna is too broad to effectively identify all non-local human individuals because some of the fauna themselves are non-local. This raises concerns regarding the use of archeological remains of domestic fauna to determine a local $^{87}Sr/^{86}Sr$ signature when studying a society able to transport livestock over long distances, since the animals themselves may have been non-local. There are also four humans and two Hellenistic faunal samples that have values at the very upper end of the geologically predicted range. Although these samples are within the local range determined using Hellenistic fauna, their $^{87}Sr/^{86}Sr$ values coincide with that of modern oceans and may indicate substantial movement between the valley and its neighbouring coastal regions. These results suggest that the Late Roman and medieval rural inhabitants of the valley of Stymphalos, as well as the livestock of its Roman-era occupants, may have been quite mobile indeed. Where these non-local individuals may have been from, and why they may have been in the valley at the time of their deaths, are questions that will be discussed in the next chapter.

Chapter 6: Discussion

6.1 – Introduction

This chapter focuses on the interpretation of the results of the strontium isotope analysis and discusses them in relation to previous research. Since it is possible that these results have identified non-local fauna, the movement of livestock is addressed prior to a discussion concerning local versus non-local humans. The results for the human samples will be discussed within their corresponding temporal framework. The skeletal remains uncovered from ancient Stymphalos and the monastery of Zaraka are separated by approximately one thousand years, and although the reasons why people migrated may not have changed, the world in which they moved certainly had. A discussion concerning the interpretation of patterns of residence and possible reasons for long distance migration will follow. Did people inhabiting the valley of Stymphalos live there permanently or did they only migrate there to conduct seasonal activities - or were both situations true for different people? From how far away did people move before they were laid to rest in the remains of an ancient city or medieval monastery, and what are some possible reasons why such a journey would be undertaken?

6.2 – The Mobility of Livestock

The $^{87}Sr/^{86}Sr$ values of four of the five Hellenistic faunal samples suggest that these animals were local. These four samples fall within the expected local $^{87}Sr/^{86}Sr$ range, agreeing with the geologically predicted signature for the valley of Stymphalos. There is some variation among them (0.7081- 0.7092), which was expected, since the slopes surrounding the valley are comprised of various limestones with different ages. However, the $^{87}Sr/^{86}Sr$ value of STEF1, at 0.7096, is slightly higher than what was predicted for any bedrocks in the region. Although it is possible that there is an undetected local source of elevated $^{87}Sr/^{86}Sr$, it is more likely that this animal was non-local. The inhabitants of ancient Stymphalos were undoubtedly capable of moving livestock over large distances and this animal could have been transported for a variety of purposes. It may have come a substantial distance or, given the possible existence of local $^{87}Sr/^{86}Sr$ values in this range in Lakonis (Richards et al. 2008), perhaps from as little as a hundred kilometers away.

The geology of the valley, as well as that of the Peloponnese in general, makes it difficult to ascertain the foraging range or mobility of the local animals. As mentioned in chapter 4, there is a large band of Plio-Pleistocene deposits running along the coast from Corinth to approximately 50 km to the northwest from the valley of Stymphalos. This limestone, which has the same $^{87}Sr/^{86}Sr$ ratio as modern seawater, makes up the northern slope of the valley and a portion of its eastern slope. While STEF2 and STEF4 have $^{87}Sr/^{86}Sr$ ratios well below 0.7092, suggesting that they likely pastured on the south or western slopes of the valley, STEF3 and STEF5 fall around 0.709, suggesting that they obtained their $^{87}Sr/^{86}Sr$ ratios from the northern or eastern slope. However, STEF3 and STEF5 may have also acquired $^{87}Sr/^{86}Sr$ values of ~0.709 from the coast, being herded or transported to the valley later. As discussed more thoroughly below, the inability to distinguish between a coastal $^{87}Sr/^{86}Sr$ signature and the signature of the northern and eastern slopes of the valley presents a challenge for this study.

Though it is possible that the two faunal samples from the Roman era midden (STEF6 and STEF7) with elevated $^{87}Sr/^{86}Sr$ ratios were contaminated it is unlikely, and therefore it is necessary to briefly discuss the longer-distance transport of livestock. Like all the faunal remains, these two animals are not contemporaneous with the human burials at ancient Stymphalos. These samples came from a Roman midden dating to not long after Mummius' occupation of the area (Catling, 1982; Strabo, 1917: 8.8.2; Williams, 1996; Williams and Price, 1995). Therefore it seems entirely possible that the elevated $^{87}Sr/^{86}Sr$ values of these samples reflects the animals' being transported to the valley from quite some distance away. Chapter 4 identified several areas that were part of the Roman empire at the time and that could produce $^{87}Sr/^{86}Sr$ ratios higher than 0.7100. These include some of the Cycladic islands, northern Greece and the Balkans, Italy and northern Africa.

It is difficult to say precisely where these animals may have originated but, based on the Roman cultural association, Italy seems a likely candidate. Roman armies on the march required vast amounts of food and materials (Southern, 2007:217-225). What they did not bring with them had to be purchased, scrounged or plundered from local sources (Southern, 2007:217-225). Butchers, animal slaughters, hunters and veterinarians were vital to the Roman war effort and were exempt from "onerous duties" (Shelton, 1988:300) The Romans would not only introduce non-local animals to conquered territories, but they would also deplete the local livestock. Therefore it seems reasonable to assume that once local stocks were depleted, Roman colonial settlers would bring more livestock with them to occupied areas. A large amount of goods would be transported and traded between Italy and the new Roman province. The Romans even introduced fallow deer (*Dama dama*) to Britain during their occupation (Sykes et al., 2006) and they commonly shipped livestock by sea. The trade and transportation of sheep, goats and pigs by Roman settlers moving into a depopulated area is a probable explanation for the non-local animals discovered at ancient Stymphalos.

Although the $^{87}Sr/^{86}Sr$ ratio of STEF6 (0.7149) corresponds to what has been reported for some Italian granites (0.7114-0.7166) (Juteau et al., 1986), STEF7 has an even higher $^{87}Sr/^{86}Sr$ ratio (0.72333). Based on this limited research, $^{87}Sr/^{86}Sr$ values this high are not found in either Greek or Italian granites. It is possible that this animal may have originated in northern Africa where granites with $^{87}Sr/^{86}Sr$ values as high as 0.8100 are reported (Juteau et al., 1986). A more extensive Mediterranean strontium isotopic survey could aid in determining the origin of this animal.

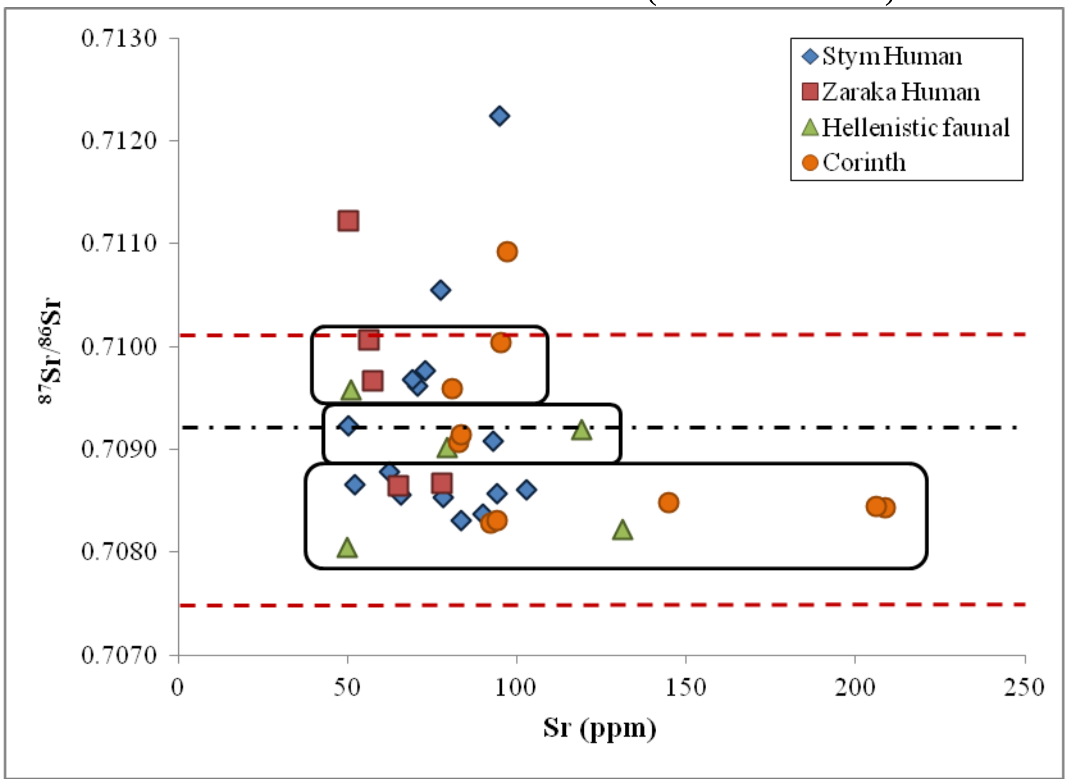
6.3 – Ancient Stymphalos

Most of the individuals sampled from Stymphalos fell within the geologically predicted $^{87}Sr/^{86}Sr$ range of ~0.7068 to 0.7092. All but two were deemed to be local based on the 2sd range of the Hellenistic faunal values, although three of these show values around 0.7096, above the range predicted for the valley based on its geology. At ancient Stymphalos there is no observable pattern of $^{87}Sr/^{86}Sr$ ratio by burial location. Therefore it stands to reason that place of origin had no effect on the choice of burial location. The lower end of the geologically predicted range is not observed in any of the samples analyzed. This may reflect the fact that Jurassic limestone is only a small portion of the valley's bedrock; it may not contribute greatly to the overall $^{87}Sr/^{86}Sr$ signature of the valley.

6.3.1 - Local Individuals

The individuals deemed to be local to the valley based on the Hellenistic fauna have a wide range of $^{87}Sr/^{86}Sr$ values (0.70831 to 0.70976) and seem to form three distinct groups. The first group is well within the geologically predicted range, while the second is at its extreme upper end. The third is consisted of individuals with $^{87}Sr/^{86}Sr$ values higher than expected based on local geology. Further study of local $^{87}Sr/^{86}Sr$ signatures in the northern Peloponnese might identify the three individuals with $^{87}Sr/^{86}Sr$ values around 0.7096 as actually being non-local. Given the incomplete nature of local geological surveys, it is theoretically possible that there is bedrock with an elevated $^{87}Sr/^{86}Sr$ of ~ 0.7096 somewhere in the area, although it is difficult to propose one in the immediate vicinity of the valley. $^{87}Sr/^{86}Sr$ ratios above 0.7100 have been reported for the Athens region and the southern Peloponnese (Juteau et al., 1986; Richards et al., 2008). Given that it would likely take at least a week to travel that far using traditional methods, these potential locations are not really 'local' and would instead indicate mobility over moderate distances.

Figure 6.1 - Scatter plot displaying the result of $^{87}Sr/^{86}Sr$ for the valley of Stymphalos and Corinth (Lê, 2006). Note the three groups of 'local' individuals and their relation to the value of modern seawater (hatch and dot line).



The first two groups of local individuals have $^{87}Sr/^{86}Sr$ values within the range predicted for the valley. However, within this range both the valley of Stymphalos and Corinth (Lê, 2006) seem to have two distinct groups of local individuals (Figure 6.1). The first group of individuals have $^{87}Sr/^{86}Sr$ values around 0.7085, which is what was predicted for the inland Peloponnese. The second group has a more coastal-looking signature around 0.7092. It is possible that even though both of these groups are considered 'local' to their own site based on human and faunal 2sd ranges, both groups may include people who migrated. The group with values around 0.7092 may consist of people from the coast, representing truly 'local' people at Corinth and people who had moved inland at Stymphalos. The group with lower $^{87}Sr/^{86}Sr$ values may consist of inland people, representing truly 'local' people at Stymphalos and people who moved to the coast and were then buried at Corinth. As mentioned above, portions of the northern and eastern slopes also have $^{87}Sr/^{86}Sr$ values similar to that of modern seawater. While it is possible that the Hellenistic fauna with $^{87}Sr/^{86}Sr$ ratios around 0.7092 may have been herded and grazing solely in these parts of valley, it seems unlikely that the human individuals would have received strontium from only one small area. Rautman (2006) suggests that rural Byzantine inhabitants would have utilized a large catchment area around villages to procure food. However, it is conceivable that if the majority of a person's dietary calcium came from food grown or raised on only one area of the valley, people from the various areas of the valley may have their own 'local' $^{87}Sr/^{86}Sr$ signature. Samples with a 'coastal' signature may represent individuals residing on bedrock with values around 0.7092, whereas the group with the values considered 'in-land' resided in portions of the valley with lower $^{87}Sr/^{86}Sr$ ratios. As mentioned in chapter 3, organisms at higher trophic levels have $^{87}Sr/^{86}Sr$ ratios averaged from all their ingested biogenic strontium. For individuals to display a 'hyperlocal' signal, they would have to spend the time in which their enamel was forming eating food procured from only one small area. If this was the case, we would expect the majority of 'local' individuals to have $^{87}Sr/^{86}Sr$ ratios closer to 0.7092, since ancient Stymphalos itself, is on the northern side of the valley. However, the majority of human individuals have $^{87}Sr/^{86}Sr$ values that are closer to the middle of the valley's geological range (~0.7068 - 0.7092), which suggests that they a utilized a larger catchment area.

It is more probably the case that short distance travel was quite regular during the Late Roman period. Although sampling teeth only provides biogenic $^{87}Sr/^{86}Sr$ values for that tooth's enamel formation period, short distance movement after this age may have been common. Individuals moving to and from the coast after this period of growth would have likely been buried close to where they died. So far, a habitation site contemporaneous with the remains uncovered at Stymphalos has not been located. Therefore, it is feasible that many of the local individuals were actually not permanent residents of the valley. The samples with $^{87}Sr/^{86}Sr$ values around 0.7085 do not seem to have a coastal component and likely represent individuals that spent the majority of their enamel formation period in the valley. This suggests that there were at least some permanent residents and the most likely explanation for the large $^{87}Sr/^{86}Sr$ range of the local individuals is that a mixture of both seasonal migrants and year round residents, who likely herded and planted winter crops, are present in the burial population. As with the Hellenistic fauna, the origin of seasonal migrants would be difficult to discern given the geological composition of the Peloponnese. Conducting an extensive archaeological survey of the valley to locate possible rural habitation sites, as well as further strontium isotope analyses of material from the Peloponnese, may help clarify the question of permanent residence.

6.3.2 - Non-local Individuals

Two individuals from ancient Stymphalos were identified as definitely non-local (STE5 at 0.71224 and STE21 at 0.71054). Sample STE21 was taken from a middle aged male and has a $^{87}Sr/^{86}Sr$ ratio only slightly outside the faunal 2sd range. For sample STE5, an entire upper right first deciduous incisor of a neonate was analyzed and its $^{87}Sr/^{86}Sr$ was the highest of all the human values. The reasons why this sample is unlikely to be contaminated and more likely to reflect an actual human signature were outlined in chapter 5. Since STE5 came from a neonate, its $^{87}Sr/^{86}Sr$ value would actually reflect the mother's place of habitation while the foetus was developing. Thus, by analyzing the tooth of a neonate we actually receive a true adult $^{87}Sr/^{86}Sr$ ratio reflecting the strontium biologically available to the mother during foetal tooth development, which is a relatively short period of time (2-3 months). This suggests that the mother of the analyzed neonate travelled for quite some distance at a late stage of pregnancy to arrive at the valley. This journey was likely strenuous for both the mother and the child.

Although these non-local individuals may have travelled from as far away as northern Africa, Italy, or northern Greece, as shown in chapter 4 $^{87}Sr/^{86}Sr$ values similar to this have also been observed in the Athens area, Euboea, and several of the Cycladic islands (Anders et al., 2006; Altherr et al., 1988; Barton et al., 1983; Briqueu and Lancelot, 1984; Broecker and Franz, 1998; Juteau, 1986; Nafplioti, 2011). Unless there are currently unknown bedrocks with a $^{87}Sr/^{86}Sr$ ratios around 0.7112 and 0.7122 somewhere in the Peloponnese, both of these individuals must have travelled over one hundred kilometres to reach the valley of Stymphalos. This distance could be covered quickly on horseback. On foot, at a quick pace with a light load, this distance could easily be covered in under a week. Yet given the topography and terrain of the Peloponnese and Greece in general, this distance would likely take a good deal longer, especially if the migrants brought along trade goods and other burdens. It is important to remember that we only know a specific period of travel for the neonate's mother. STE21 could have moved at any time between his early childhood and age at death (30-39 years). In fact, this individual may have moved a great distance many times throughout his life. A sampling of multiple teeth and bones from a single individual may reveal multiple relocation events. Provided the method is refined and universally accepted, laser ablation as a sample induction method could lower analysis costs, decrease preparation times, and make multisampling of this sort much more feasible.

6.4 - The Monastery of Zaraka

Of the five individuals analyzed from the monastery of Zaraka, one is considered non-local (ZAE6 at 0.71122), one is slightly below the upper 2sd boundary (ZAE7 at 0.71007), one has an elevated local $^{87}Sr/^{86}Sr$ value (ZAE5 at 0.70967), and two have values similar to the predicted local signature (ZAE4 at 0.70864 and ZAE2 at 0.70867). Four out of the five individuals analyzed are juvenile (ZAE 4 being the only adult), and three are younger than five years of age (ZAE5, ZAE6 and ZAE7).

6.4.1 – Local Individuals

The local individuals from the monastery of Zaraka exhibit a pattern in $^{87}Sr/^{86}Sr$ values similar to ancient Stymphalos and Corinth (Figure 6.1). Two of the individuals have $^{87}Sr/^{86}Sr$ values slightly above 0.7085. Two others have elevated $^{87}Sr/^{86}Sr$ ratios higher than 0.7092. Although they may have been seasonal migrants, their $^{87}Sr/^{86}Sr$ is higher than what is expected for coastal dwellers. Like the elevated local individuals in the Stymphalos population, these individuals could possibly be non-local, if further testing does not identify a source of elevated $^{87}Sr/^{86}Sr$ in relatively close proximity to the valley. ZAE7 may represent an individual from further away as its $^{87}Sr/^{86}Sr$ ratio is just below the upper 2sd boundary and is higher than 0.7100. A value above 0.7100 suggests residence within close proximity of older granites, which do not occur in the northern Peloponnese.

6.4.2 - Non-local Individuals

The $^{87}Sr/^{86}Sr$ ratio of ZAE6 lies between those of the outliers in the Stymphalos population and above any of the values observed at Corinth (Lê, 2006). This individual may have came from any of the places suggested above in the discussion of the Stymphalos outliers. During the Medieval and Ottoman periods, technological advancements in transportation would have made moving such long distances somewhat easier. Although land travel did not improve significantly over the millennium spanning the fall of the Western Roman Empire and the fall of the Byzantines, there were major advances in sea travel. Greece and its islands have always been vital for sea transport within the Mediterranean, but this position was increased substantially by both the Venetians and the Ottomans. Because Greece during the 15th century would have been much more accessible by sea than it would have been in the 5th century, similar-appearing 'non-local' signatures in the two periods might not have the same implications in terms of origin or difficulty of travel.

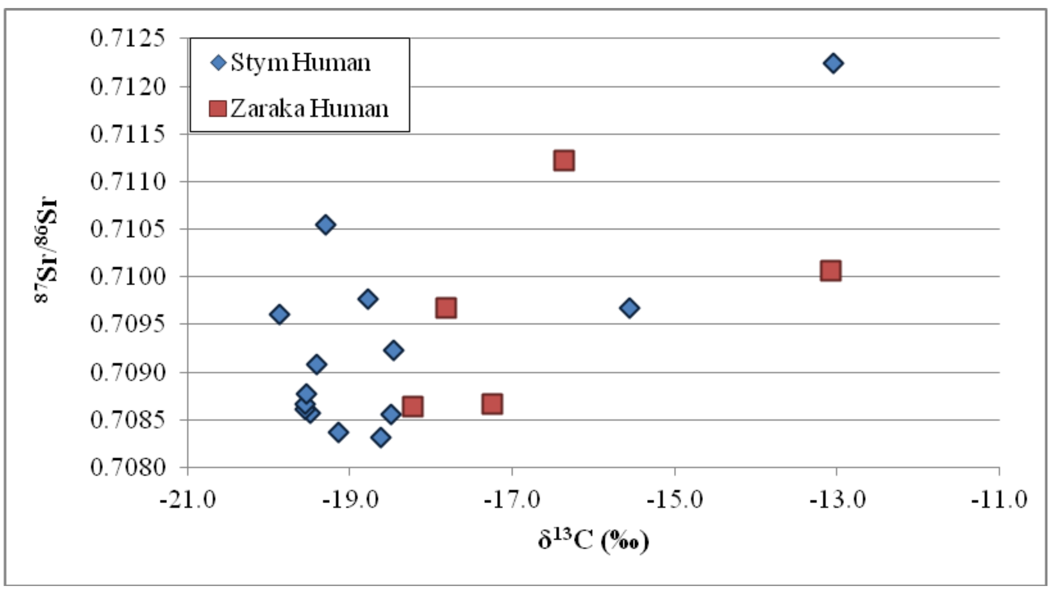
6.5 - Comparing $^{87}Sr/^{86}Sr$ to $\delta^{13}C$

Table 6.1 - Enamel $^{87}Sr/^{86}Sr$ compared to bone collagen $\delta^{15}N$ and $\delta^{13}C$ results from Pennycook, 2008.

Sample #	$^{87}Sr/^{86}Sr$	$\delta^{13}C$	$\delta^{15}N$
STE5	0.7122	-13.0	9.7
STE7	0.7092	-18.5	9.3
STE14	0.7086	-18.5	8.4
STE19	0.7086	-19.5	8.4
STE21	0.7105	-19.3	9.3
STE23	0.7086	-19.6	7.3
STE25	0.7087	-19.6	8.8
STE27	0.7091	-19.4	9.2
STE28	0.7096	-19.9	8.9
STE39	0.7088	-19.5	8.2
STE43	0.7085	collagen rejected	
STE48	0.7084	-19.1	9.3
STE50	0.7098	-18.8	8.9
STE53	0.7083	-18.6	9.0
STE54	0.7097	-15.6	12.5
ZAE2	0.7087	-17.3	10.8
ZAE4	0.7086	-18.2	8.5
ZAE5	0.7097	-17.8	10.8
ZAE6	0.7112	-16.4	11.2
ZAE7	0.7101	-13.1	12.3

The results of this Sr isotope analysis support Pennycook's (2008) hypothesis that some individuals buried at ancient Stymphalos and the monastery of Zaraka were migrants into the valley. Moreover, there is a clear tendency toward elevated $^{87}Sr/^{86}Sr$ in individuals with higher $\delta^{13}C$ values (Table 6.1 and Figure 6.2). This suggests that the unusual $\delta^{13}C$ variation at the sites reflects, at least in part, mobility rather than food choice. In contrast, figure 6.3 displays the relationship between $^{87}Sr/^{86}Sr$ and $\delta^{15}N$, showing no observable correlation. Neither of the definitively non-local individuals have abnormal $\delta^{15}N$ values compared to the rest of the group.

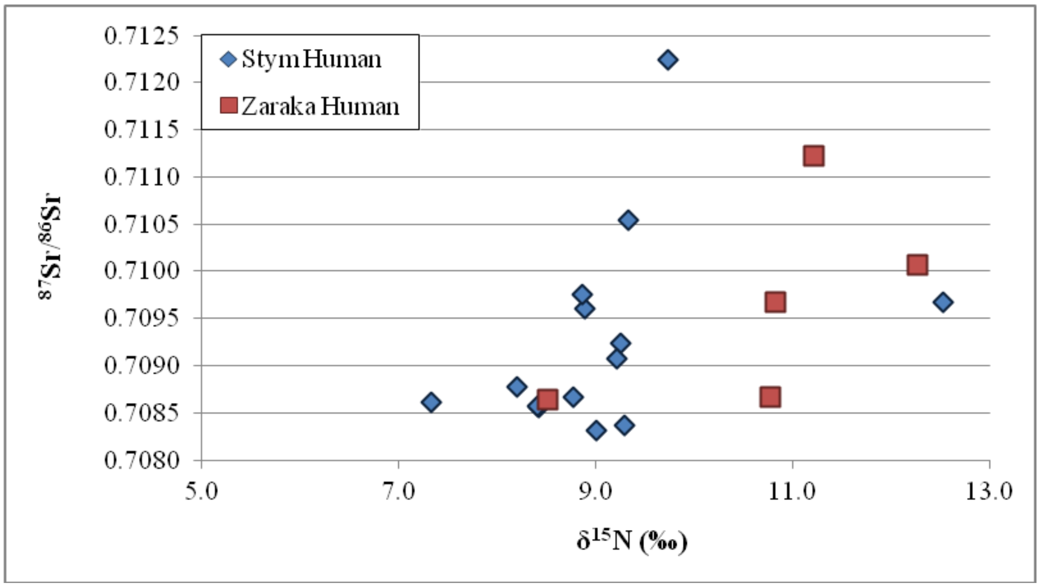
Figure 6.2 - Correlation between enamel $^{87}Sr/^{86}Sr$ and collagen $\delta^{13}C$ values.



It is interesting that the individuals (STE5 and ZAE6) with the highest $\delta^{13}C$ values are both infants. It is possible that nursing could be partially responsible for the elevated $\delta^{13}C$ of these infants, since nursing children have $\delta^{13}C$

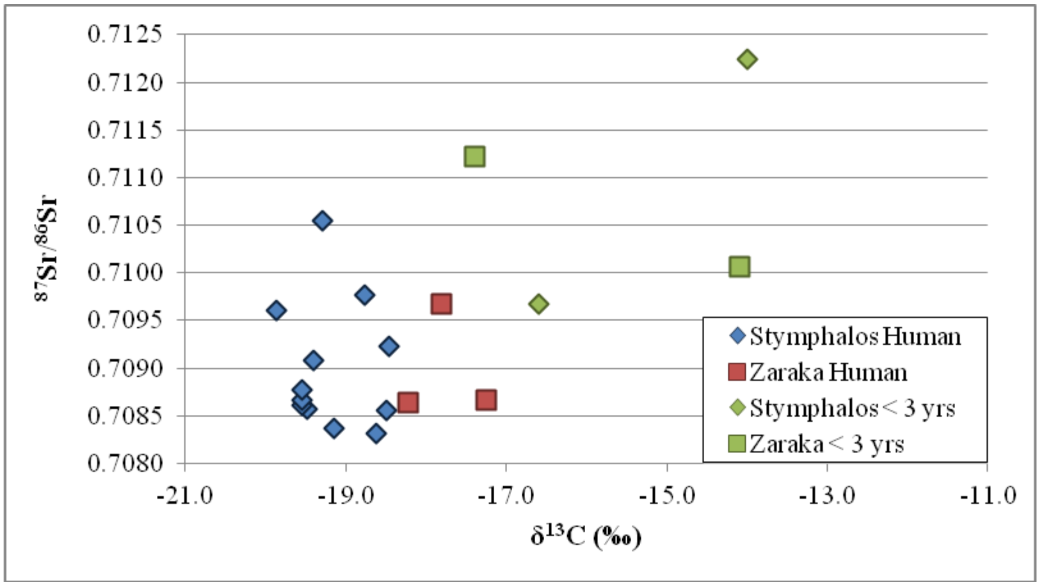
values elevated by ~1‰ compared to their mothers (Pennycook, 2008). However, this can only account for a minor portion of their total $\delta^{13}C$ elevation. The lack of a correlation between $^{87}Sr/^{86}Sr$ and $\delta^{15}N$ (Figure 6.3) suggests that there is no relationship between nursing and $^{87}Sr/^{86}Sr$ value.

Figure 6.3 - Correlation between enamel $^{87}Sr/^{86}Sr$ and collagen $\delta^{15}N$ values.



This can also be confirmed by eliminating possible breastfeeding $\delta^{13}C$ signatures from the youngest individuals (STE5, STE54, ZAE6 and ZAE7) by shifting them -1‰ to account for $\delta^{13}C$ enrichment. Although this causes some change in the relationship between $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ (Figure 6.4), an overall relationship is still clear and the two individuals with the highest $^{87}Sr/^{86}Sr$ ratios still have clear $\delta^{13}C$ enrichment relative to other individuals. This indicates that Pennycook (2008) was correct in suggesting that the observed variation in $\delta^{13}C$ was likely the result of mobility and regional differences in diet.

Figure 6.4 - Human enamel $^{87}Sr/^{86}Sr$ and collagen $\delta^{13}C$ values. Individuals < 3 years of age were shifted -1 ‰ to remove possible enrichment due to nursing.



<u>6.6 - Models for the Mobility of Rural Inhabitants</u>

<u>6.6.1 - Long Distance Travel</u>

People may have moved or migrated over long distances to reside in the valley of Stymphalos for a variety of reasons. As we have seen, the large scale movement or displacement of individuals was not uncommon throughout the duration of the Byzantine Empire. The constant warfare witnessed during the periods in question would have undoubtedly caused a disruption in rural life that would have, in turn, increased mobility in the affected areas. Invasions or large scale migrations, such as those of the Slavs during the Late Roman period or Western and Ottoman settlers in later centuries, would also have brought many non-local individuals to the countryside (Cheetham, 1981, Gregory, 2005). In the instance of a mass migration, one would expect to see several individuals with non-local $^{87}Sr/^{86}Sr$ ratios, whereas this study identified only three with definite non-local values. If the local range established using the Hellenistic fauna is too broad, and the group of individuals with $^{87}Sr/^{86}Sr$ ratios around 0.7096 are also non-local, then it is possible that a larger group did migrate into the region. However, even if this slightly elevated group is indeed non-local, there is still a large amount of variation among the non-local individuals, and it is improbable that all eight individuals would have migrated from the same area.

Long-distance migrations were not always voluntary. Forced migration was a tactic commonly employed by the Byzantine Empire to increase the amount of cultivated land in depopulated areas, and free-tenant farmers, might be relocated to meet agricultural labour requirements (Ostrogorsky, 1969). As reviewed in Chapter 2, slavery was institutionalized and provides another mechanism for involuntary long distance movement. Justinian's reclamation of the Western Roman Empire would have introduced many slaves from Italy and Africa into more stable Byzantine territories. Large farms owned by the church or aristocratic families were worked by both slaves and free tenant farmers, and although there was a decline in the use of slaves over time in Greece (Gregory, 2005; Kazhdan, 1997), the practice was still common by the era of the Zaraka burials. There would have undoubtedly been slaves in the region during both periods in question and they may be represented by the non-local individuals interred in the valley of Stymphalos.

Besides slavery and mass migration, non-locals may have ended up in the valley of Stymphalos for a variety of other reasons. Military veterans were usually given land as payment or a sailor from the islands may decide to try his hand at farming and move his family with him. Also, while travellers may not have been a common site on the rural landscape, recreational and business activities may have drawn people to the lake. This makes it possible that some non-local individuals observed in this study were not even residents of the valley, and were simply passing through when struck by an unfortunate circumstance. While Sr isotope analysis may aid in identifying long distance migrants in a burial population, what brought them to the region and where they were specifically from is much harder to discern.

6.6.2 - ‘Local’ Movement

The considerable amount of ‘local’ variation in $^{87}Sr/^{86}Sr$ values is quite interesting and suggests that a great deal of short distance movement occurred around the valley. The presence of three distinct groups of local individuals, one with values above the geologically predicted range, one with coastal-appearing $^{87}Sr/^{86}Sr$ signatures and the last with lower $^{87}Sr/^{86}Sr$ values more expected of a inland population, is a trend also observed in Corinth (Lê, 2006). Agricultural production requires a substantial amount of labour investment, and large amounts of labourers would have moved into the countryside during planting and harvest seasons. Differential farming strategies could possibly explain the diversity in $^{87}Sr/^{86}Sr$ between the three groups. The group with the lower inland $^{87}Sr/^{86}Sr$ signature may represent farmers living closer to the land and employing “alternative” intensive farming practices, such as pulse rotation or planting winter crops (Alcock, 1993; Halstead, 1987). The group with a coastal $^{87}Sr/^{86}Sr$

signature may be more representative of seasonal labourers or farmers practicing "traditional" methods and living near the sea during the rainy months (Alcock, 1993; Halstead, 1987). The group with higher than expected $^{87}Sr/^{86}Sr$ ratios may still represent seasonal migrants and indicate that people were moving to the valley from more distant locales. Both seasonal labourers and "traditional" farmers would have probably been buried in the valley if they died there, since they were likely poor and transportation of their remains may not have been feasible.

It is important to consider the vast number of reasons for which individuals may have decided to move short distances away from the locale of their early childhood. Peasants may have had to move to escape their current situations or simply because they had better opportunities in a different region. Agricultural produce also had to be transported to markets and the distance and difficulty of travel would likely have been a factor when deciding which agricultural strategy to employ and where to live. Also, as much as we would like to view all rural locations, and the farmers in them, as homogenous, there was likely to be a large disparity between them, with some inhabitants having the means to produce a large surplus and transport it to market, while others could barely feed themselves. Gatherings, such as markets and festivals, would have provide social contact and would have been a catalyst promoting movement.

Marriage is a particular cultural mechanism that may bring individuals from nearby areas into the valley. Roman society was very patriarchal and if individuals were moving because of marriage it is likely that we would see a disproportionate number of non-local women, moving to live with their husbands' families. Although this analysis did not identify a disproportionate number of non-local women, it did identify non-local children below the normal age of weaning, who are themselves a isotopic proxy for their mothers.

6.7 - Conclusion

Although I have given a few reasons for people to be moving into the valley of Stymphalos, my list is by no means exhaustive. We can use strontium isotopes to determine whether or not there were non-local people in the Valley, or perhaps movement between the valley of Stymphalos and the coast, but the reasons for this movement may be impossible to ascertain. Furthermore, we can only use strontium isotopes to speculate on where someone may have originated. While some individuals may have $^{87}Sr/^{86}Sr$ ratios that deem them to be non-local, it is impossible to determine exactly where they are from. Nonetheless, the results of this strontium isotope analysis indicate that peasants were much more mobile than a literature review would suggest and maybe were not as tied to the land as their emperors would have liked.

Chapter 7: Conclusion and Future Considerations

7.1 - Summary and Future Considerations

The results of this strontium isotope analysis indicate that people in the rural Greek countryside during the Early Byzantine and Medieval periods did sporadically move long distances. Three human individuals and two animals were identified as definitively non-local, and their $^{87}Sr/^{86}Sr$ ratios suggest that they may have travelled from as far as north Africa, Italy, the Balkans, or perhaps one of the Greek islands, where there is igneous bedrock capable of producing these high values. Future strontium isotope studies in the Mediterranean will continue to build on the work of previous research such as Nafplioti's (2011) survey of Greece, and may allow for a more accurate assessment of the origin of these individuals.

The non-local faunal samples that were recovered from a Roman midden and date to the period directly following the Romans' initial occupation of Greece. It is quite possible that these animals were transported into the region by the Roman invaders or the subsequent settlers, and Italy seems to be a likely place of origin. It may be interesting to analyze more animals in the areas from different contexts to determine if any patterns of animal transport may be discerned.

The non-local human individuals would have had to travel quite a long distance by land or sea to get to the valley of Stymphalos. For the non-local adult male (STE21), this distance may have been covered gradually throughout his life. However, since the non-local infants serve as proxies for their mothers in terms of

$^{87}Sr/^{86}Sr$ ratios, we can conclude that the mothers of STE5 and ZAE6 must have migrated into the valley shortly before the death of their young children. Although improvements in seafaring may have made long distance travel easier during the Medieval period, perhaps the rigors of travel in pre-modern times was too difficult for these young children.

While many of the humans have $^{87}Sr/^{86}Sr$ values within the 2 sd range established for the valley using the Hellenistic fauna, there is a substantial amount of variation among both these individuals and the Hellenistic fauna used to establish the 'local' $^{87}Sr/^{86}Sr$ signature. My results suggest that there was a substantial amount of movement between the valley of Stymphalos and the neighbouring coastal regions, but because strontium isotope analysis uses tooth enamel, only a small period of an individual's life is recorded and seasonal movement is difficult to ascertain. Many local individuals have $^{87}Sr/^{86}Sr$ ratios that are indicative of inland residence, while others have values consistent with modern seawater. Movement between inland agricultural areas and the coast likely occurred frequently for some people, and never for others. However, since a habitation site has never been discovered for the individuals buried in ancient Stymphalos or the monastery of Zaraka, the question of actual permanent residence in the valley is yet to be answered. Perhaps an extensive archaeological survey of the valley may reveal a Early Byzantine or Medieval habitation site. However, it is possible that the small agricultural community did not leave many traces and their habitation sites may never be found, or if found may provide little evidence for this specific question.

Seasonal migration could be examined in the future using laser ablation mass spectrometry. It is difficult to directly measure seasonal migration of past peoples by analyzing incremental growth structures in enamel, because these structures are not chemically well-defined in human enamel (Haverkort et al., 2008). However, they are quite clear in faunal enamel and by using herd animals as proxies, laser ablation may be utilized to look for seasonal variability of $^{87}Sr/^{86}Sr$ ratios suggesting seasonal movement in the animals and thus, perhaps, in the people that herded them. Although faunal remains would not provide direct evidence for human mobility, domesticated animals are usually not be left to wander on their own, and if they are found to migrate seasonally, it is likely that their owners did as well. It will be interesting to observe the progression of laser ablation mass spectrometry in archaeology, as its many benefits may revolutionize the field of strontium isotope analysis, as long as its limitations are overcome.

A few 'local' individuals and one Hellenistic animal have $^{87}Sr/^{86}Sr$ slightly above what was predicted for the valley of Stymphalos based on local geology and previous strontium isotope studies. It is possible that there is a currently unknown source of elevated $^{87}Sr/^{86}Sr$ in the immediate vicinity of the valley. However, it is more likely that these individuals are indeed non-local, as elevated $^{87}Sr/^{86}Sr$ ratios have been reported for the southern Peloponnese and the east of Athens. Future analyzes in the region could clarify this question and should not only focus on the sampling of humans, but also an extensive regional testing of archaeological faunal enamel and modern snails from non-agricultural areas.

Although the Peloponnese is comprised mostly of limestone, further research may reveal that it is not as isotopically homogenous as it appears.

7.2 - Final Remarks

Rural inhabitants have played an integral role throughout history by supporting the economic and nutritional needs of the larger population. Even though large numbers of historical documents survive from both the Early Byzantine and Medieval periods of Greece, very little is written concerning this marginalized group. Similarly, there has been little archaeological research concerning agriculturalists, or rural inhabitants in general, and only recently have these groups begun to received more attention in the literature. This thesis has attempted to provide a better understanding of the mobility of rural inhabitants in the valley of Stymphalos using modern chemical techniques. Although little can be concluded regarding the actual place of origin or the particular reasons why rural inhabitants may have decided to relocate, the results of this analysis suggest that there was a substantial amount of movement into and around the valley. Although there is a tendency throughout history to consider people living in the countryside as a homogeneous group attached to the land where they scratch out their existence, in reality rural inhabitants were likely much more heterogeneous in many respects than they appear to be.

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