INTRA-INSULAR MOBILITY AND ANCIENT HUMAN ADAPTATIONS TO RESTRICTED ENVIRONMENTS. CASE STUDY: STRONTIUM ISOTOPE ANALYSIS AND THE ARCHAEOLOGY OF LANZAROTE, CANARY ISLANDS

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ABSTRACT

INTRA-INSULAR MOBILITY AND ANCIENT HUMAN ADAPTATIONS TO RESTRICTED ENVIRONMENTS. CASE STUDY: THE USE OF STRONTIUM STABLE ISOTOPE ANALYSIS AND THE ARCHAEOLOGY OF LANZAROTE, CANARY ISLANDS.

Paloma Cuello del Pozo

Provenience of first Canary Islands populations is still a matter of dispute after a few centuries of enquiry. The amount of material culture exhibiting Classical Mediterranean craftsmanship alludes that the islands must have been populated earlier than previously thought. Several bioarchaeological techniques have shown the intricacies behind Canarian archaeology; methods such as the use of Carbon-14 dating have revealed dispersed chronologies throughout the archipelago. Mitochondrial DNA has shown substantial gene flow inherent in Canary islander, thus making it difficult to pinpoint ancestry through biomolecular studies. Trace element or stable isotope analyses have not yet been fully incorporated in the archaeological toolkit of the archipelago; specifically, the assay of stable isotopes of strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) as a measurement to understand population mobility has not been exploited. Archaeology throughout the world is aware of the fruitful results the technique has yielded regarding ancient human and animal mobility. This research project focuses on understanding the viability of documenting the bioavailable ratios of $^{87}\text{Sr}/^{86}\text{Sr}$ in Lanzarote Island to tackle questions regarding migration, and the peopling of the Canaries. Knowing the signatures of $^{87}\text{Sr}/^{86}\text{Sr}$ in Lanzarote Island today provides a picture of the type of values that can be potentially found in the organic remains of
pre-Hispanic insular communities. This study aims to demonstrate the possibility of adding an interdisciplinary method to the archaeological toolbox of the Canary Islands thus helping to augment the knowledge we have today about these extinct societies.
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CHAPTER 1: INTRODUCTION

Why Strontium and the Canary Islands

Like more than half of islanders today, I cannot take pride in Canary aboriginal genetic heritage; my family migrated into the region right after the Spanish Civil War (1936-39). Only a small portion of inhabitants today can claim more than three generations being born in the Canaries, and those who do, show as an assorted genetic make-up as the people of Europe today. Modern DNA analyses have revealed substantial biomolecular diversity among Canarians with genes from the Iberian Peninsula, North and sub-Saharan Africa, Northern Europe, and even the Americas. A tentative answer to such genetic diversity relies on the geographical enclave of the islands. El Puerto de La Luz in Gran Canaria Island is considered one of the busiest seaports in the world. La Luz is located at the crossroads of important North Atlantic sea-trading routes, connecting America and Canada to Africa and Europe. Its strategic geographical location has made this port one of the busiest seaports in the world, turning Las Palmas into a cosmopolitan city where different nationalities coexist and share their cultural diversities.

Such genetic admixture is not only reflected in modern populations, but also has been detected through ancient DNA (aDNA) analysis of pre-Hispanic aboriginal islanders. Results have suggested a great amount of genetic variation also inherent among archaeological societies. Furthermore, scientists have detected singular genetic subgroups, known as haplogroups that are endemic to the archipelago (Rosa Fregel et al.)
These evidences are scarce, and provide more questions than answers to the issue of human settlement of the Canaries. The successful application of aDNA analyses depends on sophisticated and strict protocols. The poor preservation of ancient bone in general is an added difficulty in the process of analysis due to a lack of DNA material in the archaeological sample. Results can be vague and difficult to interpret at times, but also very revealing when studying former human mobility.

History, as a field of knowledge, has brought information from primary sources revealing that the ancient Mediterranean world knew about the existence of these islands (García-Talavera 2006). Periplus and narratives of seafaring adventurers delivered by Roman scholars suggest that this archipelago must have been transited in routes travelling southward to the coasts of northwest Africa. This recurrent use of the islands as a layover during transoceanic journeys is a phenomenon that is still taking place in modern with sea-trade connections facilitated by prominent seaports such as La Luz. Moreover, since the islands became a Spanish colony, merchants and sailors from all over the world have transited the region leaving their cultural imprint across the archipelago. This activity of using the islands as layovers during sea-voyages seems to be consistent diachronically, which could suggest a clue to understanding the geopolitical role of the region throughout history. For that matter, archaeology has yet to agree upon a feasible human settlement model that forms the foundations of research about extinct aboriginal populations of the Canary Islands.

One technique that has not been exploited in this region is the use of strontium stable isotopes ($^{87}$Sr and $^{86}$Sr) as tracers of human migration. The intricacies of the
technique and its cost are perhaps main factors hindering the development of this method, however, results have revealed valuable information about provenance of ancient societies across the world. This research explores the viability of investigating $^{87}\text{Sr}/^{86}\text{Sr}$ in Lanzarote Island and thus elucidates on its probable application throughout the Canarian archaeological landscape. In an aim to explore additional methods, this study applies knowledge from interdisciplinary fields such as chemistry, geology and biochemistry to help answer questions regarding the peopling of the Canary Islands.

Stable Isotopes of Strontium and Archaeology

The study of $^{87}\text{Sr}/^{86}\text{Sr}$ from the archaeological organic and mineral record is a relatively new technique that serves to tackle former socio-economic questions related to human migratory trends. Chemical analyses of ancient bones have provided direct answers regarding migration, dietary patterns, hierarchical tendencies, kinship distinctions, foreign exchanges and trade. The outcomes of applying stable isotopic analyses on ancient samples are promising, but the limitations of the technique are also notable given the amount of interdisciplinary input archaeologists need to invest. As Sillen and colleagues (1989) have pointed out, those experts inherently qualified, namely geochemists or biochemists, may not be as interested in ancient human questions as archaeologists. As discussed further in Chapter 3, research from last few decades has shown that the collaboration of archaeologists with experts from the natural sciences helps bring an all-encompassing view to the problem at hand. Hence, modern
archaeology has been actively introducing techniques from a wide range of fields allowing the discipline to take advantage of a wide spectrum of scientific resources.

When applying this method the researcher must take into account the intricate metabolic processes that affect the reading of results from faunal and floral specimens. In addition, when working with ancient samples one must acknowledge the possible amount of degradation of the material. The geology of Earth has specific chemical isotopic values that are transmitted into living organisms through uptake of minerals from water and food. Animal and plants average-out a range of elemental values from their food source; neither do they absorb the same percentage of isotopes, nor do their metabolism eliminate them at the same rate. Furthermore, diagenetic or contamination of organic tissue is a prominent obstacle when using ancient buried samples (Schwarcz 1991). The field of geochemistry also presents intricate information about the geological distribution of $^{87}\text{Sr}/^{86}\text{Sr}$ signatures. The interdisciplinary emphasis in archaeology regarding the use of trace elements is gathered from the natural sciences. The fields of botany, zoology, geochemistry and biochemistry are fields of research where the archaeologists will want to attain an overarching understanding for the success of this multidisciplinary approach.

Spatio-Temporal Background

Archaeology in the Canary Islands has continually relied on the landscape and ancient narratives to develop the time frame when the region was discovered and settled. This research keeps in mind the background provided by experts and conceives the hypothetical chronological approach borrowed from Professor Pablo Atoche Peña and his
investigation team (Table 1). It is agreed that the islands were occupied prior to the turn of the millennia, information that has been provided by ancient narratives that allude to this region. Historians have paid especial attention to Pliny the Elder’s Natural History published around AD 77. Here the Roman historian describes the archipelago at the time of Imperial occupation by Roman-Mauritanian King Juba II. The strategic insular positioning, ca. 100 km away from North African shores and about 900 km from the South of the Iberian Peninsula, locates the islands at the center of seafaring routes sailing towards the occidental coasts of Africa or westward in the Atlantic Ocean.
Table 1: Table originally assembled by Professor Atoche Peña. It presents an up-to-date chronology of human habitation in the Canary Archipelago.

<table>
<thead>
<tr>
<th>Island</th>
<th>Archaeological Site</th>
<th>Chronology (centuries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Graciosa</td>
<td>El Descubrimiento</td>
<td>11 BC</td>
</tr>
<tr>
<td>Lanzarote/Tenerife</td>
<td>El Descubrimiento/Buenavista/Cueva (C.) de los Guanches</td>
<td>10 BC</td>
</tr>
<tr>
<td>Lanzarote/Tenerife</td>
<td>Buenavista/C. de los Guanches/C. de la Arena</td>
<td>6 BC</td>
</tr>
<tr>
<td>Lanzarote</td>
<td>Buenavista</td>
<td>4 BC</td>
</tr>
<tr>
<td>Tenerife/La Palma</td>
<td>C. de las Palomas/C. de las Estacas 1/C. de la Palmera</td>
<td>3 BC</td>
</tr>
<tr>
<td>Lanzarote/Tenerife</td>
<td>Buenavista/Risco de los Guanches</td>
<td>2 BC</td>
</tr>
<tr>
<td>Lanzarote/Tenerife</td>
<td>Buenavista/El Bebedero/C. de la Arena/C. de las Palomas</td>
<td>1 BC</td>
</tr>
<tr>
<td>Lanzarote/Tenerife/Gran Canaria</td>
<td>El Bebedero/C. de la Arena/C. de las Palomas/El Chorrillo/Los Caserones</td>
<td>AD 1</td>
</tr>
<tr>
<td>Lanzarote/El Hierro/Gran Canaria</td>
<td>Buenavista/El Bebedero/Caldereta de Tinache/C. de la Lajura/Los Caserones</td>
<td>AD 2</td>
</tr>
<tr>
<td>Lanzarote/Gran Canaria</td>
<td>El Bebedero/C. del Rey/Lomo Granados</td>
<td>AD 4</td>
</tr>
<tr>
<td>Lanzarote/La Palma</td>
<td>El Bebedero/C. de el Tendal</td>
<td>AD 5</td>
</tr>
<tr>
<td>Lanzarote/La Gomera</td>
<td>El Bebedero/La Fortaleza</td>
<td>AD 6</td>
</tr>
</tbody>
</table>
Most of the archaeological knowledge gathered from these islands has been paralleled to Castilian chronicles and European descriptions originating from contact with aboriginals during the beginnings of evangelization 14th century onward. Moreover, the Islamic tradition also presents references to these islands. Ibn Jaldún – a prominent historian, geographer, mathematician and scholar in general – has been an important source of narrative material alluding to the Canaries and the insular cultures (Serra Rafols 1949). Despite this literature, experts are not quite clear about the role these islands played during the Moors’ Empire.

Chronicles from the reign of Mallorca, current Catalonia, are some of the first and most detailed accounts regarding the beginnings of an evangelization attempt in the Canaries (Abreu y Galindo 1632; Alonso de Espinosa 1594; Marín de Cubas 1687; Torriani 1588). Through these primary sources, we know that in the beginnings of the 14th century the first activities towards the commercializing of human slaves started taking place (Tejera and Aznar 1999). The narrative of conquistadores has coincided at times with archaeological records regarding diet, economy, religious practices and socio-political distribution of pre-Hispanic aborigines. These populations were sheep-goat herders with a mixed diet based on arboreal fruits and roots, meat from goats, sheep and pigs, as well as heavily agricultural reliance on barley and wheat, in addition to lacteous products from those bovid species (Arco and Navarro 1987; Hutterer 1990; Fernández-Palacios et al 2008; Morales et al 2007). A trademark of Canarian societies was their
eschatological conceptions emphasizing the preservation of the dead, which they mummified. Many questions still arise from this practice that varies in methodology throughout the archipelago, but seems to coincide in the fact that only royalty was carefully preserved.

Organization of the Thesis

This research considers the viability of \(^{87}\text{Sr}/^{86}\text{Sr}\) analyses in the island of Lanzarote, Canary Islands. Being the first time the technique is applied for archaeological purposes, I have paid special attention to the fields of biochemistry and geochemistry, as these are the keys to understand the specific results this technique yields. In addition, I have reviewed the development of anthropology in the Canaries in an aim to recognize how such interdisciplinary technique can fit in this particular archaeological context. At last, I have conducted a preliminary study on the local bioavailability of strontium stable isotopes in the environment of Lanzarote. The purpose of this endeavor has been to create a tentative baseline presenting specific \(\text{Sr}\) ratios from this region to assess the viability of the test in the region as a whole. The preliminary guide presented here will serve as a reference for future research on population mobility through the application of \(^{87}\text{Sr}/^{86}\text{Sr}\) analyses on pre-Hispanic Canary aboriginal bone samples.

Therefore, Chapter 2 describes the geo-ecological processes that have contributed to the emergence of the Canarian archipelago. This background knowledge from the fields of ecology and geology are required at the moment of interpretation of isotopic data. Chapter 3 provides a chronological review of stable isotope analysis and its
incorporation as an anthropological subdivision. This section also explains the ways in which Sr becomes available in our biosphere, and how archaeology has learned to use it as a tool to answer ancient population mobility patterns. Moreover, Chapter 4 encompasses a brief review of anthropological research in the Canary Islands and the development of archaeology in this particular socio-political insular context, whereas we will see has been highly influenced by personal interests. Chapter 5 presents the theoretical standpoint of this research using the main framework of landscape archaeology and sub-theories namely island biogeography and resilience theory. At last, Chapter 6 illustrates the results obtained from the chemical analyses here performed with discussion and ideas for future contributions – a prelude to future research.
CHAPTER 2: THE PALEOCLIMATOLOGICAL AND GEOLOGICAL HISTORY OF THE CANARY ISLANDS

Introduction

Paleoclimatological knowledge of archaeological landscapes is an important part in the assessment process of ancient population dynamics as it helps contemporary researchers put an environmental context to their investigation. Knowing the resources at hand for those former communities allows archaeology to infer possible behavioral specificities that come with ecological adaptations. Therefore, I will describe the paleogeological and paleoenvironmental history of the Canary Islands as necessary background knowledge to understand the geological nature of the Canaries, specifically Lanzarote Island. The Canarian archipelago began to emerge from the sub-Atlantic plateau around 20 Ma, and its volcanic activity has not ceased until historical times providing a unique landscape for habitation. The islands’ geological history is also responsible for the uniqueness in its geochemical markers, information that will be assessed in this project through the study of stable isotopic research of Lanzarote’s bioavailable strontium. As a way to understand the formation processes behind the Macaronesian landscape, I will use the theory of island biogeography – also known as general dynamic model – in conjunction with contemporary investigations on the formation and species foundation of oceanic islands. The description of paleoecological
and geomorphological events will help understand the results obtained from the tentative baseline of atmospheric available strontium that will be presented in Chapter 5. The progressions that contribute to alkaline deposition in Lanzarote are important pieces of information to elucidate on the strontium levels obtained here, information that will ultimately serve as proxy for ancient population mobility. In essence, revealing the geochemistry of this insular region will provide a tentative idea for the biochemistry that could be found on ancient denizens of Lanzarote.

Geographic Location

The Canary archipelago occupies an area of 7,447 km² in the Macaronesian islands system, which is a cluster of islands neighboring the coasts of Northwest Africa and the West Iberian Peninsula. The Canaries are located about 100 km away from the southernmost shorelines of Morocco, Northwestern Africa. The archipelago is comprised of seven islands from east to west from Figure 1: La Palma, El Hierro, La Gomera, Tenerife, Gran Canaria, Fuerteventura and Lanzarote. A group of islets can be also found: Isla de Lobos, Aleganza, Montaña Clara, Roque del Oeste, Roque del Este, and La Graciosa, and are not inhabited aside from La Graciosa.
Origin of Canarian Archipelago and Its Ecology

Canary Islands’ biogeography

To understand the natural creation of this archipelago, Robert H. McArthur and Edward O. Wilson first outlined the theory of island biogeography in 1963, as a framework to explain the life cycle of oceanic islands (Whittaker et al. 2008). This paradigm is also known as the general dynamic model (GDM). From the birthing period at the time of emerging from the sea, islands grow up in altitude until volcanic activity ceases. Once the volcano is inactive gradual erosion takes over as a dominant process until it weathers back into the ocean or as a reduced atoll, see Figure 2 (Fernández-Palacios et al. 2011). However, not all oceanic islands are formed in the same strict
manner (Whittaker et al. 2007). For example, Tenerife Island seems to be a fusion of two or three islands with the oldest formation dating back to 11 Ma and its youngest 3.5 Ma (Carracedo 2006). This complexity has been attributed to hotspot archipelagos that are formed within island arcs, such as the Canary Islands (Whittaker 2008). Each island endures its own geological conditions that are specific to its life cycle (Carracedo and Tilling 2003; Whittaker et al. 2007; 2008). In this manner, younger islands would be ecologically colonized by species from adjacent older islands (Whittaker et al. 2008). This is reflected in the vegetation of the Canaries with thermophile species found throughout the archipelago, except in those older islands, i.e. Lanzarote and Fuerteventura, showing a highly eroded landscape.

Figure 2: General representation of the idealized progression of the life cycle of an oceanic island under the GDM premises Whittaker et al. (2008). Reproduced with permission by Michael Krabbe Borregaard.
Following the geological progression of GDM, once the oceanic island erodes below sea level, also defined as island submergence (Figure 2 above), it becomes a seamount resting below the water surface. This has been the case for several underwater summits in the Macaronesian island chain, where ecologists speculate that these summits acted as colonial sites of certain invertebrate species found on the Canaries today (Fernández-Palacios et al. 2011). Paleoecologists argue the role of these seamounts as refuges for paleoflora to survive the drastic climate changes from the warmer Pliocene to the colder Pleistocene epoch (Rodríguez-Sánchez 2008). Southern Europe and North Africa were areas that appeared as large islands with the Tethys Sea connecting the Atlantic and Indian Oceans (Fernández-Palacios et al. 2011). Monsoon rains and high temperatures kept a tropical landscape in today’s rather arid Mediterranean basin (Uriarte 2003). The climate temperature descent from Pliocene to Pleistocene (Rodríguez-Sánchez and Arroyo 2008; Rodríguez-Sánchez et al. 2009) prompted Tethyan tropical taxa to escape the continents and find refuge in the Macaronesian islands chain. At present, these paleoendemisms share the landscape of the Canaries with new species that once originated from colonizing events of closely related Mediterranean and North African species, also defined as neoendemisms (Kim et al. 2008). In essence, research affirms the Macaronesian flora is an assortment of neoendemics and paleoendemics reflecting the relictual nature of these islands’ unique vegetation (Aigoin et al. 2009; Fernández-Palacios et al. 2011; Vanderpoorten et al. 2007). Today the Macaronesian laurel forest contains around 40 Madeiran/Canarian paleoendemic species now extinguished in other
parts of the world (Hollerman 1981), such as *Persea, Ocotea, Apollonias, or Piconeas* (Vargas 2007).

Species such as the ones mentioned above would have survived the declination of temperatures during Pliocene-Pleistocene changes in the Macaronesian regions. A consequence of less drastic climatic changes in the islands (Fernández-Palacios et al. 2011) resulted in a Thetyan Tertiary landscape (Sunding 1979) filled with thermophilic forests and other subhumid species (Nogué et al. 2013), i.e. the Macaronesian ecological system (Verneau and Berthelot 1845). Given the Canaries proximity to the North African coast, this relictual landscape was later supplemented by more modern species such as the *Erica arborea*, already present in Madeira by ca. 2 Ma (Heer 1885). In the case of inter-island floristic variation, phylogenetic studies have shown a progression rule where older islands contain the same species that have later colonized younger island formations, in addition to *in situ* ramification and variegation (Whittaker and Fernández-Palacios 2007). Furthermore, the drastic altitude changes from island to island and their different ontogeny provide a case for the distinct ecozones comprising the Canarian archipelago (Fernández-Palacios et al. 2011).

These environmental factors seem to coincide with the premises under the single-island endemics’ concept (SIEs) (Emerson and Kolm 2005a; Whittaker et al. 2008), which justifies the high diversity rate and speciation through competitive mechanisms occurring in archipelagos such as the Canaries or Hawaii (Emerson and Kolm 2005a; 2005b). For example, the convergent evolution of several Lauraceae tree species in
Macaronesian islands, which is highly diversified compared to the Iberian *Laurus*, shows the genetic floral range that is consequential to extensive isolation periods represented in island environments (Rodríguez-Sánchez et al. 2009). The *Pistacia atlantica* and *P. lentiscus* (Figure 3) are also examples of single-island endemisms; they are no longer found in Madeira Islands but are currently prominent in the “Mediterranean-like thermophilus woodlands of the Canaries” (Fernández-Palacios et al. 2011:236).

![Figure 3: *P. atlantica*](https://www.atlasruraldegrancanaria.com)

Figure 3: *P. atlantica* know as the Almácigo, and used locally for its medicinal properties (Jáen 1996). Picture retrieved from: [www.atlasruraldegrancanaria.com](http://www.atlasruraldegrancanaria.com)

Faunal phylogenetic analyses also reveal a similar ‘stepping-stone’ process of island colonization as with vegetative species. Mitochondrial DNA studies from Canarian lizards (Figure 4) (González et al. 1997; Thorpe et al. 1994) infer dispersal events within the archipelago just as revealed in the Hawaiian island chain, where researchers have recognized a gradual species colonization process from oldest to youngest insular
formations (Juan et al. 2000). As easy as it might sound, there are complications to this island-founding model, since other factors influence the diversification and settlement of biota on insular landscape. Some of the phenomena responsible for the dynamism inherent in the ecological completion of oceanic archipelagos are namely, ‘back-colonization,’ recent colonization, within-island differentiation, adaptation, and extinction (Emerson 2002; Juan et al. 2000; Whittaker and Fernández-Palacios 2007; Whittaker et al. 2008).

Figure 4: *Gallotia galloti*. Canarian lizard. Photo by Angelika and Siegfreid Troidl. Retrieved from: http://www.herp.it/indexjs.htm?SpeciesPages/GalloGallo.htm

Modern Ecological Characteristics

The environmental ecology of the Canarian archipelago has been described as a mixture of semi-desert, evergreen forest and alpine desert (Nascimento et al. 2009; Zobel
et al. 2011) covering a surface land of 7,447 km² (Nascimento et al. 2009) with 18,000 floral species and of those ca. 3,800 species and 113 genera are endemics (Izquierdo et al. 2004). The vegetation today seen in the islands are the Canarian pine woodland, the Canarian palm and willow communities, and the thermophilus and moteverde (ever-green) forests (Nogué et al. 2013; Zobel et al. 2011). In the ever-green forest, the two Pistacia species abovementioned are found as shrubs resilient to extreme weather conditions such as drought and low temperature. This differentiation is due to the drastic altitude changes in a single island, which provide microclimate conditions thus environmental uniqueness within each region. The central and highest islands are characterized by their volcanic and steep landscapes –Tenerife Island has the 3rd tallest volcano (El Teide) on Earth with an elevation of 3,718 m above sea level (asl). In these mountainous areas, cloudbanks are typical above 1,000 m on the upwind declinations. These clouds are a consequence of the upper hot dry air and the lower humid trade winds (Juan et al. 2000). As an effect of these climatic interactions, the mixture of ever-green forest, semi-desert and alpine desert can be finely divided into five different ecozones (Figure 5): (1) arid subtropical scrub growing up to 250 m; (2) semi-arid and subtropicalscrubs, and woods covering from 250 m to 650 m of altitude; (3) humid laurel forest in the cloudbank areas from 650 to 1000 m; (4) humid to dry temperate pine forest from 1000-2000 m; and (5) dry subalpine scrub 2000 m upwards (Juan et al. 2000).
The Macaronesian endemic *monteverde* forest is characterized by a mixture of laurel forest and Morella woody heath (Nogué et al. 2013), with temperatures ranging from 13-16°C that retain the humid conditions necessary for the ecosystem. Those Lauraceae species once originating from Tertiary European landscapes (ca. 5.3 Ma) include *Laurus novocanariensis*, *Ilex canariensis*, and *Picconia excelsa* (Axelrod 1975; Nascimento et al. 2008; Santos-Guerra 1999). The Canarian coniferous forest ranges in temperatures from 10-15°C and is represented by species such as *Phoenix canariensis* and *Juniperus turbinata* (Nascimento et al. 2008). High altitude summit scrub vegetation endures temperatures between 5-10°C, achieving 0°C in highest elevations. Currently, only 12.5% of this Tertiary relictual flora survives in the Canaries, mainly in the island of La Gomera in the National Park of El Garajonay (Fernández-Palacios et al. 2008; Nogué et al. 2013); which can be seen in Figures 6 and 7 below.
Figure 6: El Garajonay National Park with el Teide volcano on Tenerife Island rising in the forefront. Image retrieved from: www.taringa.net.
The Environmental and Geological Past of the Canaries

Geological history of Lanzarote

As mentioned earlier, Macaronesian archipelagos are volcanic islands that emerge from the ocean through episodes of eruption. Just like the Hawaiian Islands, the Canaries are a hotspot volcanic chain, growing as the African plate moves over a rising plume of magma. Bathymetric studies of submarine Macaronesian seamounts show the existence of submarine summits dating back to 60 Ma (Fernández-Palacios et al. 2011). The set of islands closest to Africa emerged around 20 Ma in contrast to the younger westernmost groups of islands such as La Palma, El Hierro and La Gomera dating back to 2 Ma (Juan
et al. 2000). The Canary Islands’ chain resulted from hotspot magmatic eruptions consequence of the African plate moving eastward from the Mid-Atlantic Ridge towards the center of the Atlantic Ocean (Carracedo 1999; Carracedo et al. 2002). Not all seven main islands have evolved similarly; easternmost locations (Tenerife, Gran Canaria, Fuerteventura and Lanzarote) have a geology characteristic of intense volcanic activity followed by long-lasting dormant phases (Carracedo 1999). The most dramatic example is that of Lanzarote Island with volcanic activity taking place as late as the 18th century of current times (Figure 9). In addition, the ontogeny of these four islands resembles Hawaii, where both archipelagos contain ancient insular formations highly eroded with contrasting landscapes to the younger and westernmost eruptions (Carracedo 1999). This is the case for La Palma, El Hierro and La Gomera, which had later eruptions and therefore retaining their geomorphological volcanic layer. The landscapes are highly differentiated as shown in Figures 8 and 9, where the oldest islands are of lesser altitude and have suffered much more erosion than the younger and higher summits.
Figure 8: El Hierro Island (1.12 Ma). Retrieved from: www.spain.info

Figure 9: Lanzarote (15.5 MA). National Park of Timanfaya, resulting landscape of volcanic eruption from 1730. Retrieved from: http://www.hellocanaryislands.com/nature-areas/lanzarote/timanfaya-national-park/. 
Paleoclimatological progression

The amount of marine and terrestrial deposits found on the shores of these islands has been useful in revealing the paleoclimatological history of the islands. Fuerteventura Island and Lanzarote’s formations of Los Ajaches and Famara once emerged from intense volcanic activity during the Miocene, 23.03-5.33 Ma (Grandstein et al. 2004). In addition, Upper Pliocene marine deposits found in Gran Canaria, Fuerteventura and Lanzarote contain fauna typical of tropical warm waters. Among these faunal remains is *Nerita emiliana*, a mollusk found within lava flows from the Western coast of Lanzarote (Meco et al. 2007, 2015). *N. emiliana* is representative of European and Moroccan Miocene and Pliocene epochs; the specie’s presence (Meco et al. 2005) throughout the islands has served as proxy for hot and littoral environments during Upper Pliocene in the Canaries (Meco et al. 2015). During the Miocene older islands were higher and bigger than today, progressively suffering strong erosional phenomena such as mega landslides (Acosta et al. 2005; Stillman 1999).

Geological deposits containing *N. emiliana* demonstrate the warmer temperatures of the region at the beginning of the Pliocene epoch, which followed a transition into a more arid climate interrupted by long-lasting rainy periods (Fernández-Palacios et al. 2011; Meco et al. 2006). Faunal deposits of egg-pods from the Lower Pliocene have been attributed to *Dociostaurus maroccanos*, a type of locust, found in the easternmost islands and indicating climatic seasonality (Meco et al. 2010, 2011). The end of a cold period
enhancing seasonal changes allowed these locust species to colonize early insular landscapes (Meco et al. 2015). Prior to the Pleistocene there are indicators of a detriment of temperatures, which are the littoral bioclastic dunes indicating a drop on sea level of at least 30 m (ca. 4.2- 3.0 Ma). These deposits have resulted in sand dunes due to their high content of carbonate skeletal fragments, which have been shaped by trade winds driven by the Cold Canary Current. The latter has been identified as an atmospheric phenomenon derived from the icing of poles, which produced a dramatic drop in sea level thus allowing the dunes to establish (Meco et al. 2015).

The Pleistocene (1.8- 0.0117 Ma) was characterized by abovementioned Cold Canarian Current, which signified the end of the tropical littoral Miocene and Pliocene (Meco et al. 2003; Rognon and Coudé-Gaussen 1996). This climate deterioration transitioned into glacial-interglacial epochs and continued throughout the Quaternary (2.58 -0 Ma). The Canarian Current, still present today, is associated with the forthcoming of strong trade winds contributing to the carbonate skeletal deposits, or dune formations, characteristic of the geochemical composition of these islands (Fernández-Palacios et al. 2011; Meco et al. 2003; Rognon and Coudé-Gaussen 1996). Also, ecologists contemplate the Canarian Cold Current phenomenon as a trigger of the climatic changes from tropical to a Mediterranean-humid and cold environment (Fernández-Palacios et al. 2011; Meco et al. 2006). Furthermore, the last interglacial period (125 ka) allowed tropical water temperatures to surround the islands again, but for a shorter period (Meco et al. 2002; Montesinos et al. 2014; Muhs et al. 2014). On a
different note, paleosol deposits in Lanzarote and Fuerteventura exemplified the combination of arid and humid episodes that must have aided the soil formation of the islands (Ortiz et al. 2006). Sahara desert trade winds, during alternate periods, seem to have played an important role in the stabilization of dunes and supplementing aeolian deposits in the parent material of the islands, mostly in the easternmost locations (Fernández-Palacios et al. 2011; Ortiz et al. 2006). The last prominent humid episode took place during early Holocene (8 ka) (Meco et al. 2006, 2011).

Climate changes from wetter (6,000-4,000 BC) to drier environments (3,000-2,000 BC) during the Holocene contributed to the aridification of the Sahara desert. Pollen and fossilized plant material studies have shown that the Morocco region retained its humid conditions for a longer time (Cheddadi et al. 1998). Tree taxa originating from this wetter environment period of North Africa, such as the *Quercus* and the *Carpinus*, have been found in the Canaries since around 3,000 BC (Nascimento et al. 2008). A timeframe that coincides with mid-Holocene changes taking place on the nearby continent, and perhaps suggesting the dispersal of new seeds into the Macaronesian island system.

Geomorphology and Chemistry of Lanzarote’s Terrain

During the low-sea level bearings of the Pleistocene, Lanzarote was part of a bigger island connected with Fuerteventura. Geologists have named this larger island *El Mahan*, which occupied a land area of 5,000 km², more than half of the land than the
entire archipelago covers today (7,447 km²). El Mahan did not fraction until Upper Holocene (Whittaker et al. 2008) retaining its earliest formations from the Miocene of Los Ajaches and Famara (Carracedo and Baldiola 1993). Los Ajaches are basaltic formations in the southernmost part of the island occurring ca. 15.5 Ma (Carracedo et al. 2002). It is hypothesized Los Ajaches emerged in a continuous yet relatively short episode of volcanic activity (Carracedo et al. 2002; Muhs et al. 2010). To the contrary the Famara ridges, located northward, took three geological stages to form its stratigraphy (Coello et al. 1992; Fúster and Carracedo 1979; McDougall 1979; Muhs et al. 2010; Tarling 1983). The formation of these volcanic edifices spanned from late Miocene, 10.2-8.3 Ma (Coello et al. 1992) to Upper Pliocene 3.8 Ma when Famara’s building stages come to an end (Figure 10) (Carracedo and Baldiola 1993). The Upper Pliocene is a period of volcanic inactivity and general erosion for proto-Lanzarote. This period of weathering continued for about 2.5 million years until the transition into the early Pleistocene when a new period of volcanic activity begins characterized by fissure vents and small eruptions near extinct volcanic vents (Carracedo and Baldiola 1993). The last eruption recorded in the island dates back to historical times, as shown in the landscape of Figure 9, with the eruption of the Timanfaya volcano.
Specific geochemical measurements are found in the island as a result of the volcanic activity and inactivity of the territory. Parent material from Lanzarote is produced after magmatic events from a mixture of feldespathic minerals and phenocrystals such as peridote or olivine, and alkaline basalts (Carracedo 1993). Most of Lanzarote’s parent material is composed of basalt as a result of volcanic activity.
Moreover, a pedological study from the La Corona volcano revealed thin deposits of clay-like material inter-mixed with lava flows (Muhs et al. 2010). The clay and silt deposits also contain mica, quartz, kaolinite and hematite, mineralogy commonly found in African soils; furthermore the size of the particles studied in La Corona have revealed the possibility of long-range transport from remote African areas (Muhs et al. 2010). The intrusion of kaolinite appears to be rare for experts who recognize two possible events. Birkeland (1999) has proposed the possibility of the alteration of plagioclase, which Muhs and colleagues (2010) claim unlikely due to the young basaltic nature of Lanzarote, thus not providing enough time for this phenomenon to occur. Researchers argue the possibility of low precipitation levels during late glacial periods thus allowing foreign aeolian transport of kaolinite coming from the Sahel region (Hooghiemstra et al. 1992; Muhs et al. 2010). The Sahel is a desertic strip located between the Sahara desert and Sudanian savanna; it represents a prominent dust source during drought periods (Muhs et al. 2010).

Discussion

The island of Lanzarote is mainly composed of basaltic material originated from intense volcanism and depositional stratigraphy of minerals from neighboring African continent. The youthfulness in geological times of this archipelago shares geochemical characteristics with other volcanic islands such as, Hawaii, Iceland or the Pacific archipelagos. Similarities that will later serve as comparative assessment to understand
how strontium is delivered into Lanzarote’s atmosphere and eventually reflected on archaeological deposits. The high content of basalt and carbonate skeletal material (calcareous dunes) in Lanzarote should be indicative of specific measurements regarding the bioavailable Sr levels of the island. In addition, the calcareous dunes present across the island should resemble Sr levels from the ocean water given the dunes’ salinity. At last, the aeolian deposits of kaolite, mica and quartz could contribute to the rise of Sr measurements bringing these levels closer to the geochemistry of the Sahelian and Sahara deserts.

The following chapter will present how strontium is incorporated into the biochemistry of organisms such as animals, vegetation, gastropods and mineral material. It will review the geo-ecological phenomena that allow the release of Sr into the local environment, consequently making it available for human diet and its incorporation into the bone mineral structure. Additionally, chapter 3 presents a chronological review of the stable isotope studies and their increasing popularity in the field of archaeology. This type of background knowledge will also present the intricacies behind the application of the technique as a way to understand its viability in environments such as the Tethyan relictual landscape of the Canaries.
CHAPTER 3: SR TESTING AS A MEAN TO UNDERSTAND ANCIENT
POPULATION MOBILITY IN THE CANARY ISLANDS: A COMPARATIVE
ANALYSIS, LANZAROTE ISLAND

Introduction

This chapter presents a brief chronological review of what has been done in the
field of geoarchaeology with stable isotopes, particularly in Sr studies (Figure 11).
Applying Sr testing in tandem with other isotopic research and traditional archaeological
techniques will help create a more complete image in order to create an all-encompassing
image of the past. In the following pages I aim to provide an understanding of what Sr is
and why this alkaline element has become a great tool in archaeological research. In
addition, I provide a brief overview of how stable isotopes of strontium are measured in
the landscapes of islands and continental landmasses. This project emphasizes the use of
stable isotope testing in insular environments since the location of the research is the
Canary Islands. Given that research of this kind has not been done on the Canaries, it is
important to consider how experts interpret trace elements in the skeletal material from
oceanic islands around the world. Sr has been analyzed in the island of El Hierro
(Velasco et al. 1997b), however, with an emphasis in diet and dismissing strontium’s
ability to trace mobility patterns. Moreover, there has been a critique on the
inconclusiveness behind palaeodiet studies from the region due to their lack of an all-
inclusive biochemical research of trace elements on archaeological skeletons (González Antón and Arco 2007). Therefore, and aiming to cover these issues, this chapter will bring about how experts have dealt with the problems that come with this type of analysis in island environments.

Figure 11: Bone is one type of organic material where isotopic testing is usually performed. These are popular elements and their isotopes that are analyzed when applying stable isotopic research on the archaeological human/animal record. Image reproduced with permission by Dr. Thomas Tütken (Tütken and Vennemann 2011).
Literature Review

What is an isotope?

Questions on palaeo-dietary habits, provenience and palaeo-climate alteration can now be answered through an understanding of the organic and geological chemistry of the ancient records. Modern atomic theory tells us all matter is made of atoms, and that each atom has a number of protons, neutrons, and electrons making up the atomic composition of an element. Each element is identified by the number of protons (p+), whereas the number of electrons (e-) and neutrons (n0) vary. It is this variation in n0 that adds substantial mass to the atom. The element of Sr has 38 p+ and can have up to 89 neutrons, which determines the different versions of an atom called isotopes. The number of p+ and n0 added together gives the isotope its name, for example an isotope with 38 p+ and 48 n0 is referenced as Sr 86.

The atomic mass of each element is determined in the periodic table by averaging the relative abundance of most common found isotope in nature; 12C is nearly 100 times more abundant in the atmosphere than 13C (Malainey 2011). This differentiation between ‘lighter’ (less n0) and ‘heavier’ (more n0) isotopes is useful for delineating baselines for paleoecological studies. Lighter isotopes (12C, 16O and 14N) are more abundant on colder and wetter environments than their heavier counterparts (13C, 18O, 15N), which reflect warmer and drier periods. The reason for such phenomena lies on the atomic weight of the isotope and the kinetic equilibrium effect. This means that stable isotopes of less
atomic mass are easily transported into the atmosphere until condensation and precipitation deposit them back into the surface. Isotopes of heavier mass stay on the surface of the Earth less affected by evaporation or melting.

Atoms can have stable (non-radioactive) and non-stable (radioactive) isotopic versions. Non-radioactive isotopes can be used to source nonorganic material such as rocks and metals, as well as organic archaeological deposits. Stable isotopes do not decay maintaining their number of p+ over time such as carbon 12 ($^{12}$C) and $^{13}$C. To the contrary non-stable isotopes undergo fractionation, or radioactive decay (β decay), a process that involves the gaining or loosing n⁰ and p+ to form stable isotopes of a different or same element. For example, $^{14}$C will turn into nitrogen ($^{14}$N) through a steady rate β decay, or change in number of protons, from the time the organism dies.

Researchers have been able to calculate the amount of time passed between each fractionation thus allowing $^{14}$C analyses to become the most powerful dating tool for archaeological deposits.

Sr isotopes have been studied in the discipline of geochemistry mainly to understand geo-chronological data on Earth (Ericson 1985). This is due to the alkaline nature of the element along with rubidium, which both contribute substantially to the mineralogy of this planet. Alkaloids originate from the bulk of the Earth, unlike gaseous elements present on our atmosphere. Isotope ratios of strontium generally remain stable throughout their pathways into the biosphere from the source rocks where they originate (Graustein 1989). Stable isotopes released into the biosphere majorly from rock
weathering and river flow, in addition, atmospheric phenomena such as wind, rain or sea spray also contribute to the delivery of strontium into the terrain. The latter is a strong influence delivering major quantities of marine Sr into coastal areas (Bentley 2006).

Strontium has two electrons in its outer valence shell, which allows Sr to have two electrons less and a positive charge of +2 (Sr⁺²), the same phenomena occurs for Ca (Ca⁺²). This allows Sr to readily substitute for Ca in minerals, including those in human bone, namely apatite (Bentley 2006; Malainey 2011). Strontium has four naturally occurring isotopes: ⁸⁴Sr, ⁸⁶Sr, ⁸⁷Sr and ⁸⁸Sr (Faure 1986). The latter is the more profuse isotope followed ⁸⁷Sr and ⁸⁶Sr, at last ⁸⁴Sr is less common. Unlike the rest, ⁸⁷Sr develops from radioactive decay of ⁸⁷Rb, which has a half-life of ca. 4.7 x 10¹⁰ years and comprises 7 % of total Sr (Fauer and Powel 1972; Price et al. 2002). Hence, the chemical composition and geological variability of a rock will depend partly on age and its initial concentration of ⁸⁷Rb (Ericson 1985; Price et al. 2000). Bioavailable strontium in the biosphere is represented as the ratio of ⁸⁷Sr and ⁸⁶Sr (⁸⁷Sr/⁸⁶Sr) (Faure 1989; Malainey 2011).

Pioneering work

Some of the first studies on strontium analysis focused on dietary patterns of ancient hominid remains. Knowledge of this element originated after the signing of the nuclear test-ban treaty in 1963 when radioactive research on ⁹⁰Sr became possible (Sillen and Kavanagh 1982). The earliest literature considering strontium isotopic testing as a means to answer behavioral questions on human evolution included studies by Toots and
Voorhies (1965), and Parker and Toots (1970). The latter confirmed the correlation between Sr levels on bone composition and trophic levels moving from plants to herbivores to carnivores (Boaz and Hampel 1978). Odum’s publications in 1957 were the first studies on the comparison between Sr levels from plants and the animals that eat them.

Along this line of investigation, other isotope studies started to become influential in the field of archaeology. Concretely, Vogel and van der Merwe (1977) pioneered the applicability of C and N isotope extraction from humans’ osteological remains from archaeological deposits uncovered in New York State. The primary interest, in concordance with past strontium research on paleontological human remains was food procurement and variations in dietary patterns. Such emphasis on diet was understood to provide insights on the political and social structures of ancient populations (de Niro 1987; Hastorf 1985). Stable isotope research has revealed overarching information such as the introduction of maize and millet into palaeodiets, resources procurement of ancient coastal populations, mobility patterns, economic strategies and trade networks. Also, trace element research – or archaeometry – as given specific information evincing the relevance of salmon in the diet of Upper Paleolithic sites in Southern France (Hayden et al. 1987), and the origin of sacrificial victims from a Late and Terminal Classic Maya site in Belize (Somerville 2010). During the last decades, as the application of quantitative methods has grown in the field of anthropology, we are seeing stable isotope research being done in a myriad of geographical locations. Namely from seashores in North
America’s North and Southwest coasts (Ezzo et al. 1997), to mountainous landscape as in the case of pre-Hispanic Andean societies (Knudson et al. 2004), Mesoamerican Lowlands (Somerville et al. 2013), and insular regions such as Iceland (e.g. Price and Gestsdóttir 2006), and New Zealand (Leach et al. 2001). Furthermore, the contributions of Pate and colleagues (2000) along the coastline regions of Southern Australia have greatly contributed to studies on archaeological bone chemistry. At last, dessert African zones such as Egypt and the more tropical Southern area of the continent have also been assessed (Macko et al. 1999).

During the 1980’s there was a shift in the applicability of strontium from a dietary perspective towards a long-held interest on population migration (Ericson 1985; Sealy 1989). The geochemical composition of each world region varies including their Sr composition. This Master’s research focuses on how such variation is reflected in the Canary Islands and the information this methodology could provide regarding ancient aboriginal population mobility into the archipelago.

Strontium in the Earth and Skeleton

Geochemistry: $^{87}\text{Sr} / ^{86}\text{Sr}$

Since the atomic mass differences between $^{87}\text{Sr}$ and $^{86}\text{Sr}$ are minimal, fractionation does not greatly affect these isotopes thus reflecting the radiogenic composition of the habitat throughout millennia (Graustein 1989; Price et al. 2000). Superannuated rock material (>100 Ma) generally will show high $^{87}\text{Sr} / ^{86}\text{Sr}$ ratios, above
In the case of young rock formations (<1-10 Ma) \(^{87}\text{Sr}/^{86}\text{Sr}\) values are expected to be about 0.702-0.704 (Bentley 2006). Oceanic islands composed mainly of basaltic material are expected to show values between 0.703-0.707 (Dickin 1995). Phanerozoic (541-0 mya) marine limestone and dolomite rock formations contain ratios within 0.707-0.709 averaging out the Sr signature from ocean water (Bentley 2006), which remains constant at approximately 0.7092 (Veizer 1989). The continental crust of our earth has values ranging between 0.702-0.750.

The transmission of Sr into the human skeleton follows a pathway inherent in the food and water ingestion processes to end up absorbed by hydroxyapatite \([\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]\), the most prominent skeletal mineral (Montgomery 2010). Sr\(^{+2}\) is a non-nutritious trace element and a benign substitution for Ca\(^{+2}\) in mammalian hard tissue (Montgomery 2010), these ions are transported across cell membranes thus regulating the passage of certain substances into the organic system (Storey and Leigh 2004). This mechanism of membrane permeability dictates the average of Sr/Ca uptake into the living organism. Thus, the individual incorporates strontium from natural resources into the skeleton, a significant process in bioarchaeological studies since it has been proven to reflect the isotopic values of the environment where food and water is being procured (Montgomery 2010; Price et al. 1986). Hence, the transmission of geochemical signatures follows a life cycle originated in the bulk of the earth as the source where all mineral material comes from. Bedrock contains the local mineralogy that gets released into the surface through natural phenomena. Vegetation uptakes Sr and other trace elements,
which in turn get transferred into animals and prehistoric denizens through the trophic chain. At last, the drinking of water is also another source of Sr and other elements such as C, oxygen (O) and sulfur (S).

**Continental Sr**

Part of the process of understanding the strontium levels that exist in Lanzarote Island includes investigation of the $^{87}$Sr/$^{86}$Sr signatures of the landmasses that surround the archipelago. In this case Northwest Africa and South Spain are the closest territories where human populations could have departed to reach the Canaries. In this section Spain’s strontium levels as well as Moroccan geochemistry will be briefly assess. Strontium signatures in each area are influenced by the age and type of rock as a function of radiogenic decay from $^{87}$Rb to $^{87}$Sr (Faure 1986). Therefore, continental landmasses that are very old (>100 Ma) will have high original Rb/Sr ratios and therefore high $^{87}$Sr/$^{86}$Sr ratios. To the contrary, younger geologic formations such as late-Cenozoic volcanic areas will most likely yield ratios lower than 0.706, simply because not enough time has passed for a portion $^{87}$Rb atoms to convert into $^{87}$Sr (Rogers and Hawkesworth 1989). Spain and North-West Africa are older landscapes than the archipelago, and thus are expected to have higher strontium levels than those from the islands. If ultimately I want to understand human population mobility into the Canaries, it is important to have a clear picture of the type of $^{87}$Sr/$^{86}$Sr levels that should be present in these possible places of origin.
South Iberian Peninsula and its radiogenicity

As discussed in previous sections, an understanding of the heterogeneity of geological compositions throughout a landscape is necessary to effectively investigate strontium stable isotope ratios in archaeological human remains. Migrants from distinct geological regions will have a strontium imprint in the skeletal composition different from the local bioavailable geochemistry. Given the proximity of the Canarian archipelago, a possible population origin for insular inhabitants could be the Southern tip of Spain, where ancient empires such as Phoenicians, Punics and Romans were established. Famous Roman geographer Pomponius Mela described the settlement of Phoenician Cádiz or *Gadir* sometime after the Trojan War (Wagner 2008). Given the sophistication of Phoenician helmsmanship and the access of *Gadir* to Atlantic sea-routes it is important to keep in mind this location and understand the geological variability that existed in this region.

The Iberian Meseta has a geological antiquity dating back to the Precambrian period (4600-541 Ma) (Julivert et al. 1980). The area of interest contains Palaeozoic (541-252 Ma) and crystalline rocks characterized by a series of lithological build-ups termed Variscian and Caledonian orogens (Voerkelius et al. 2010; Waterman et al. 2014). Compared to the geology of the oceanic Canaries, the Iberian Peninsula is geologically older than the islands, and therefore has a higher radiogenic rate (Voerkelius et al. 2010). In their analysis of natural mineral waters throughout Europe, Voerkelius and colleagues (2010) they found Spain to have the highest $^{87}\text{Sr}/^{86}\text{Sr}$ of samples obtained (0.7777). This
increased in radiogenic signatures from the basalt derived geology of islands to the mineralogy of Palaeozoic and crystalline rocks natural of South Spain, presents a spike contrast that will be valuable to consider throughout this study.

**North-west African loesses**

The coastline of Morocco is only about 60 km away from Lanzarote Island, the closest point to the African continent. Aeolian dust deposits form the Sahara and Sahelian desert, as we have seen in chapter 2, are a major atmospheric factor influencing the landscape of Lanzarote and the Canary Islands in general. There are data for strontium levels on Moroccan and Tunisian loesses. The geologic origin of Africa goes back to the Pan-African Shield (600 Ma), a moment when supercontinents Gondwana and Panotia were being formed. This provides information on potential strontium stable isotopic ratios from samples of this region. In the case of Moroccan aerosols, Grousset and colleagues (1992) used samples from Late Holocene deposits over a Precambrian plateau. The $^{87}\text{Sr}/^{86}\text{Sr}$ obtained in the region measured 0.7231. For Tunisian aerosols, the same study by Grousset et al. (1992) recorded $^{87}\text{Sr}/^{86}\text{Sr}$ levels of about 0.7142. The latter where deposits from the Late Glacial period dating between 20,000 and 10,000 BC (Grousset et al. 1992).

Knowing the radiogenic levels of these areas is important to understanding the possible foreign $^{87}\text{Sr}/^{86}\text{Sr}$ signatures that could be reflected in the archaeological human. The geological heterogeneity surrounding the Canaries is advantageous since levels portray a marked variation between regions.
This section is a comparative analysis of how strontium is reflected in the archaeological record of insular landscapes and the issues researchers encounter when dealing with the method in such a particular environment. I have chosen four different studies focusing on the viability of applying Sr as a trace element to illustrate population mobility into, and colonization of, islands. Hawaii, Iceland, the Caribbean archipelagos and the Efate Islands demonstrate the possibilities archaeometric research could yield if applied properly on the Canary Islands.

The archipelagic regions mentioned above all coincide in their relatively recent geological history (<35 Ma) and their oceanic origin from submarine volcanic activity. Therefore, the geochemical composition of bedrock in these areas follows similar processes in their creation since they are highly influenced by the surrounding chemistry of ocean water and aeolian dust deposition from continental landmasses. For the Hawaiian Islands, Chadwick and colleagues (1999, 2008) have identified three major sources of strontium delivery onto parent material: basalt lava, Asian dust deposition and rainfall. The latter two are atmospheric sources of strontium that tend to increase the radiogenicity of the area, with mineral debris such as mica and quartz as well as sea spray providing a range from lowest values of 0.703-0.704 up to 0.722-0.723 (Chadwick et al. 2009). In the case of Iceland, which is part of the Tertiary Volcanic Provinces from the North Atlantic Ocean (Larsen et al. 1999), strontium signatures range from 0.703-0.704
These measures correspond to the geochemistry of the basaltic nature of the region. A predominance of alkaline basalt that is comparable to that of the parent material forming Lanzarote Island in the Canaries.

In the case of the Caribbean islands, their geologic activity ranges from Jurassic to Quaternary formations from volcanic activity, thus their epithet: *Volcanic Caribbees* (Laffoon et al. 2012:2374). Their geologic composition is mainly igneous material of basaltic-andesites rocks, in addition to limestone and pyroclastic deposits as well as metamorphic lithologies and marine limestone. A substantial amount of carbonate deposits can be found in the Caribbean region (Laffoon et al. 2012), just as we encounter in the lithology of the Canaries. The latter is reflected in sand dunes composed of carbonate skeletal fragments, or shell debris, from Quaternary periods (Meco et al. 2011).

The similarity in geochemistry of these archipelagic regions can be shown through their radiogenic Sr signatures, with Volcanic Caribbees ranging from 0.704 to 0.711 (Laffoon et al. 2012). Lanzarote’s geology parallels these relatively younger Jurassic formations of the Caribbean. It is interesting to note the emphasis that authors such as Laffoon and colleagues, and Price and Gestsdóttir have made about the ideal situation these insular regions presuppose for the application of radiogenic methods to understand ancient transhumance. Following this logic, and based on geologic similarities, it would not be imprudent to assume the Canary Islands are a propitious setting for strontium stable isotopic research to aid in the search of the peopling of the region.
The last regional comparison is the Efate Island group between the edge of the
Australia-India Plate and the Pacific Plate. Also known as the Vanuatu Islands, the Efate
are considered geologically young with basaltic rock types such as tholeiitic lavas and
volcanic breccias from explosive activities (Bentley et al. 2007; Raos and Crawford
2004). Basalts, as mentioned earlier, provide \(^{87}\text{Sr}/^{86}\text{Sr}\) signatures between ca. 0.703 – ca.
0.7045; in high contrast to formed reef limestone material that resembles marine values,
0.7092 (Bentley et al. 2007). Again, we see similar geologic connections with the Canary
region, which also rises above metamorphic basalt and limestone deposits as their major
geochemical components in addition to the influence of seawater.

In two of the four examples used in this section, Sr signaling has been successful
in tracing migration onto islands, in addition to providing data on dietary patterns.
Bentley and colleagues (2007) discovered four outliers in their sample from the Vanuatu
Islands. Their research investigated \(^{87}\text{Sr}/^{86}\text{Sr}\), oxygen 18 (\(^{18}\text{O}\)), the relationship between
barium and Sr (Ba/Sr), and \(^{14}\text{C}\) as trace elements to aid in the decipherment of
biochemical levels of ancient individuals. In the case of Price and Gestsdóttir’s analysis
on Iceland, the researchers found between 9 and 13 possible migrants from a sample of
90 human individuals.

**Sr in the biosphere**

As abovementioned, natural phenomena alters the local bedrock through
geological and atmospheric processes. In this manner, \(^{87}\text{Sr}/^{86}\text{Sr}\) becomes part of the local
landscape providing specific signatures to the region of study. For example, the Faroe
Islands, a volcanic archipelago located in the North Atlantic Ocean, have a basaltic geology originated during Tertiary eruptions expecting to yield low $^{87}\text{Sr}/^{86}\text{Sr}$ values in between 0.702-0.703. However, analyses on soil leachates and ovid (goat) hair provide ratios ca. 0.708, indicating the influence of marine strontium through sea spray deposition (Frei and Price 2012; Frei et al. 2009). In modern times the influence of pesticide needs to be accounted when analyzing Sr. In the area of Maryland, agricultural pesticides have contributed to increase the local ratios of bioavailable Sr from 0.708 to 0.715 (Böhlke and Horan 2000). This addition poses a difficulty in areas where pesticide strontium values have not been fully researched, such as in Europe (Frei and Price 2012).

In any case, regional geologic material is the highest supplier of $^{87}\text{Sr}$ and $^{86}\text{Sr}$ into the local environment (Bentley 2006). In the Hawaiian region of Manua Loa, plants from an area where there is moderate annual rainfall provide ratios of ca. 0.704 in concordance with the volcanic soil where they grow, rather than rainfall values (0.7092) (Vitousek et al. 1999).

**Sr in the vegetation**

Strontium uptake by plants follows a similar pathway to that of Ca since both are atomically similar. The amount of Sr/Ca absorbed by foliage differs between taxa implying a correlation between length of roots and amount of Sr absorbed (Maurer et al. 2012). The $^{87}\text{Sr}/^{86}\text{Sr}$ in vegetation derives from bedrock weathering as well as atmospheric deposition; in this manner, bioavailable levels are incorporated into the plant or tree (Pozswa et al. 2004). The metabolizing of trace elements depends on the root
system of the plant and its strategy to distribute the nutrient (Maurer et al. 2012; Rediske and Selders 1953), varying among plant species (Pozswa et al. 2004). An early study conducted by Rediske and Selders (1953) showed the variations in Sr discrimination that took place for Red Kidney bush bean (*Phaseolus vulgaris* L.), Rutgers tomatoes (*Lycopersicum escolentum*), White Russian wheat (*Triticum vulgare*), Belsford Beardles Barley (*Hordeum vulgare*), and Russian thistle (*Salsola pestifer*) (Rediske and Selders 1953:594). Among other things, researchers discovered a correlation between soil pH acidity and Sr distribution throughout the plants’ metabolism – as the acidity increased in their controlled experiment (pH 7– 4), the accumulation of Sr concentration on the root decreased. Also, the amount of Sr on leaves increased as soil acidity decreased. Furthermore, this early research was able to show the different rates of Sr accumulation that takes place from plant to plant.

Understanding the variation of $^{87}\text{Sr}/^{86}\text{Sr}$ throughout species of vegetation depends on the physiology or Sr-cycling of the plant, as well as its anatomy or root system (Poszwa et al. 2004). Scientists have discovered a marked difference between the $^{87}\text{Sr}/^{86}\text{Sr}$ levels in ground plants versus tree leaves. The former has lower levels, owing to the overall lower $^{87}\text{Sr}/^{86}\text{Sr}$ ratios found in surface soils compared to deeper strata reached by tree roots (Maurer et al. 2012). Research has shown leaves have higher strontium content than other sections of the plant (Burton and Wright 1995; Knudson et al. 2009). In addition, exchangeable Sr is also influenced by differences in soils chemistry (Drouet et al. 2007; Maurer et al. 2012; Pozswa et al. 2004). Among other natural phenomena
mentioned above, the weathering of parent material will dictate the $^{87}\text{Sr}/^{86}\text{Sr}$ levels on soil that become bioavailable to later be metabolized by organisms (Drouet et al. 2007).

Various studies, including this one, have used vegetation as proxy of available $^{87}\text{Sr}/^{86}\text{Sr}$ in the landscape. Knowing the factors that influence the more or less radiogenic levels found in materials from the Canaries aids in interpreting the results.

**Sr in the prehistoric human skeleton**

Just as plants have their metabolic mechanism to incorporate and/or discriminate trace elements, so do humans and the rest of animal species. As seen previously, there is variability of radiogenic signatures between geological regions of the world, and these differences on $^{87}\text{Sr}/^{86}\text{Sr}$ levels can help archaeologists trace migration patterns of ancient communities. The atomic similarity between Sr and Ca allows these two alkaline elements to follow a similar absorption process into the hydroxapatite composition of living mammals; research has shown that >99% of both elements are found in the bone rather than other body tissue (Dahl et al. 2001). It is generally recognized the deposition of Sr occurs through the generation of new bone and long-term exchange processes of old bone (Reeve et al. 1983). The latter is a slower process since large amounts of Sr get eliminated in comparison to atoms of Ca, in theory one atom of Ca out of ten can be substituted by Sr (Boivin et al. 1996). Mammals absorb Sr, Ba and Ca from the gastrointestinal track with a preference to incorporate calcium over strontium and barium (Dahl et al. 2001); scientists call this process *biopurification* (Bentley 2006; Burton et al. 1999; Elias et al. 1982). Mammalian metabolism allows 10-40% of ingested Sr to be
deposited on skeletal tissue, against the 40-80% absorption of Ca (Burton et al. 1999; Comar et al. 1957; Lengeman et al. 1963). The relative intake of Ba/Ca and Sr/Ca levels is influenced by diet and trophic level (Burton et al. 1999). At last, the kidneys are in charge of discriminating $^{87}\text{Sr}/^{86}\text{Sr}$ atoms by their excretion through urine (Comar et al. 1956; Dahl et al. 2001; Mazzuoli et al. 1958).

The progression of the food chain, or trophic level, account for the diminution of Sr/Ca and Ba/Ca from the original source into the second, third and fourth consumers. Therefore, the ratio of Sr/Ca in plants is 20% of the total Sr/Ca amount in the soil, Sr/Ca in herbivores is 20% of that in plants, and Sr/Ca in the bones of carnivores is 20% of the herbivores they ingest (Bentley 2006; Burton and Wright 1995). Hence, the discrimination of strontium increases with trophic level; the ratios of Sr/Ca will vary depending on who is ingesting what. Such variance also applies to the biopurification of stable isotopes of $^{87}\text{Sr}/^{86}\text{Sr}$, which are reduced severely as one analyzes specimens higher up in the food chain (Bentley 2006). As herbivores eat local plant species, their uptake of $^{87}\text{Sr}/^{86}\text{Sr}$ is not fully transmitted into the carnivores eating local herbivores. Hence, we see a substantial lowering of $^{87}\text{Sr}/^{86}\text{Sr}$ levels from individuals having a more carnivorous diet rather than those with agricultural or herbivorous preferences.

Marine source diets are a key influence in the process of bioaveraging strontium values by the human body. The $^{87}\text{Sr}/^{86}\text{Sr}$ signature of seawater is set (0.7092) and the concentration of Sr/Ca on oceans is higher than freshwater environments (Pate 1994). Research has shown that the ingestion of 6 g of salt per day will increase the ratios of
\(^{87}\text{Sr}^{86}\text{Sr}\) in an individual (Cucina et al. 2015; Wright et al. 2005a). Therefore, populations relying strongly on marine foods will have values really close to that of seawater regardless the coastal location (Bentley et al. 2007). In order to resolve the haziness of dietary intakes in archipelagic landscapes where marine diets might be a given, Bentley and colleagues (2007) analyze barium in conjunction with strontium. They report that the Vanuatu islands of the Western Pacific, marine diets contribute to low ratios of Ba/Sr in tooth enamel compared to higher ratios provided by more terrestrial-based and carnivorous diets. Other ways to reflect differences between seawater-based protein intake and land resource procurement is by measuring the variance in ratios of stable carbon isotope ratios between atmospheric carbon dioxide (CO\(_2\)) and marine bicarbonate (HCO\(_3\)). Chisholm and colleagues (1983) showed populations whose diet was ocean sourced had \(^{13}\text{C}\) values on bone collagen near -12 per mil compared to those obtaining food from land resources with -21.5 per mil (Hobson and Collier 1984). Following the use of this trace element, Hobson and Collier (1984) were able to show that certain coastal populations based 85\% of their diet on terrestrial proteins versus the expected ratio of C\(_3\) from seawater proteins.

\(^{87}\text{Sr}^{86}\text{Sr}\) results will vary depending on the bone material being sampled. Bones have a slow turnover rate during which they remodel their hydroxapatite structure by incorporating new trace elements into their tissue. This process results in full turnover on 10-20 years (Price et al. 2000). Tooth enamel is also used for strontium analysis; in fact, determining mobility of an individual through \(^{87}\text{Sr}^{86}\text{Sr}\) values requires the use of both
teeth and bone material (Bentley 2006). Dental enamel is an acellular and avascular tissue undergoing no change after its formation during gestation and early childhood (Montgomery 2010). Therefore, radiogenic signatures from enamel of the permanent first molar will reflect the geological location where the person resided during childhood (Hillson 1996; Price et al. 2000; Price and Gestsdóttir 2006). In contrast, the regenerative rate of bone material provides isotopic ratios corresponding to where that person resided in the 10-20 years prior to death (Bentley 2006; Price and Gestsdóttir 2006). Four results could be produced when comparing tooth enamel and bone: 1) if tooth and bone strontium signatures are similar, then the individual did not move from his/her childhood location; 2) if enamel Sr levels are different from the bioavailable local Sr, then the individual moved from the place of origin into the geological zone at death; 3) if tooth enamel ratios coincide with the local signatures but bone ratios are different, possibly the individual moved somewhere and returned at the time of death or 4) if enamel is different, the individual was born outside and came to the area at the time of death. The last two cases are less common (Price and Gestsdóttir 2006). At last, additional material used for the extraction of \(^{87}\text{Sr} / {^{86}\text{Sr}}\) values in animals, including humans, is hair, which contains hydrophobic proteins making the alteration of its organic composition difficult (Macko et al. 1999).
Stable isotope analyses can add quantitative data to questions regarding human and animal ecology. Also, it can reveal behavioral traits regarding territoriality, food sharing and exchange, residence patterns, warfare, and kinship relationships (Ericson 1985; Knudson et al. 2009; Price et al. 2000). The applicability of the method on the archaeological record is wide; however, its limitations on accuracy can be just as wide. One concern when studying strontium is diagenesis or contamination of the sample due to the porous and soft nature of bone composition, which allows the absorption of exogenous strontium and other minerals from the soil where deposits are buried (Ambrose and Krigbaum 2003; Bentley 2006; Macko et al. 1999). For this matter, teeth enamel is preferred as sample material due to their non-porous and hard composition, hence making them less susceptible to diagenetic processes. Furthermore, when sampling bone, researchers recommend the use of lamellae or cortical bone, which is the hard tissue of the bone versus the spongy or trabecular bone (Leach et al. 2001). Hal Krueger (1965) was the first to come up with a depollutant method for the apatite phase of the bone eliminating the carbonate contamination with a weak acetic acid solution (Ambrose and Krigbaum 2003; Krueger 1965). As a standard procedure, the technique has been applied to the samples of this research, which is explained in a further section. With the improvement of pre-treatment methods, and the refinement in identifying exogenous material, the field of bioarchaeology is now able to obtain isotopic data from samples up
to 50 million years old (Bryant et al. 1996; Cerling et al. 1997; Spoonheimer and Lee-Thorp 1999b).

Additional factors to account when measuring bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are the geological variations that may influence results. The greater the regional geochemical differences, the better the potential contrast reflected on the archaeological sample (Hodell et al. 2004). Signatures similar to one another cannot provide viable information since neither local nor foreign individuals can be distinguished due to the chemical homogeneity of the terrain where archaeological remains are found. Another important factor is the ability to define catchment areas; knowing the extension of the dwelling area where populations resided can pose difficulties when working in continental landmasses (Ericson 1985). In essence, $^{87}\text{Sr}/^{86}\text{Sr}$ will point out where the individual is not from. For example, archaeometric research on 4,600-year-old burials from the Corded Ware Culture belonging to the Central Europe Neolithic revealed the patrilocal tendencies of this community (Haak et al. 2008). Males and infants contained local radiometric signatures in comparison to females, who denoted foreign $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. In this case, researchers were not able to pinpoint the origin of the women due to a lack of a radiogenic map; however, they were able to reveal the potential exogenous social practices of this group (Haak et al. 2008). Note the abovementioned research was done in tandem with aDNA analyses on the same individuals tested for $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, a detail that brings us to the next important caveat when performing Sr analyses on human
remains – the need to perform radiogenic testing along with complementary bioarchaeological methods.

The analysis of stable isotopes is influenced by many variables due to the complex chemical processes naturally occurring within living organisms. Plants do not conform to the same metabolic processes as animals, which also have species-specific developmental stages. In order to understand the information provided by stable isotopic signatures, the archaeologist must be knowledgeable on the field of biochemistry – additionally, if using Sr, overall knowledge on geochemistry is a must. Yet, an ample background on in these areas does not ensure conclusive information; archaeometry is a complex field of analysis. Iacumin et al. (1996) conducted C and N isotope analyses of the Nile Valley using ancient human skeletal remains, which provided inconclusive results due to the lack of a marked difference between a shift in carbon and nitrogen ratios, a sign of environmental variation. For Scheeres and colleagues (2013) investigating Celtic migratory patterns and contact with Etruscan inhabitants of Monte Bibele, strontium signatures did not yield a clear answer to questions on kinship relationships and transhumance. The relatively narrow range provided by Sr isotope levels of human tooth enamel in this sample group could be explained by various reasons. Researchers argued how communities could be using similar agricultural resources. Moreover, lack of Sr variation could be ascribed to the homogeneous geological nature of the terrain where these individuals resided thus masking clues on food procurement from outside sources or mobility patterns.
The viability of strontium in the archaeological sphere does not only rely on the type of landscape where it is being applied, but also on the understanding of the different food sources consumed by ancient individuals. Not every foodstuff provides the same amount of Sr ratios (Hodell et al. 2004). Meat eaters have lower amounts of Sr than plant eaters (Price 1989). The opposite can also occur where food types have exceeding concentrations of Sr, therefore masking the variability from other feeding sources that might be representative of a group’s diet (Ericson 1985). For example, populations heavily relying on a marine based diet will provide skewed values towards the ocean’s \(^{87}\text{Sr} / {^{86}\text{Sr}}\) measurements (0.7092) and so hiding the bioavailable values of the geological location where the individual under research once resided. This has been shown in previous examples where island archaeology has applied stable isotope analysis keeping in mind the component of the ocean and the chemical influence of its presence. By resorting to additional isotopic measurements such as the extraction of barium or nitrogen, the research can potentially distinguish dietary markers. Finally, in order to acquire meaningful answers from application of this technique, archaeologists agree that it must be done in conjunction with additional testing. Other biochemical studies include dental morphology, palaeopathology, mtDNA research, investigation of a wide range of stable isotopes, proper theoretical approaches, and traditional archaeological methods.
Synthesis

The study of ancient human mobility through the use of stable isotopes of strontium 86 and 87 is not a monothematic task. The archaeologist is not only responsible for understanding the intricacies behind the metabolic processes that contribute to the distribution of trace elements throughout the human body, but also must understand the geochemistry of the landscape where the research is being performed. In addition, and as part of investigating the local $^{87}\text{Sr}/^{86}\text{Sr}$ bioavailable levels, the researcher must also gain insight on a variety of multidisciplinary subfields such as plant physiology, geochronology, and paleoecology. In essence, the archaeologist needs to learn about biological processes that make up the sample of choice. When measuring stable isotopic ratios, there is a myriad of choices in the range of materials that can be used for this purpose. The amount of depth that is applied to the research will obviously aid the result interpretation process, but as literature has been showing, this depth must also be accompanied by an all-encompassing focus on trace elements. When performing stable isotope analyses, it is important to look at a series of complementary elements that can help fill in the gaps.
CHAPTER 4: THE DEVELOPMENT OF ARCHAEOLOGY IN THE CANARY ISLANDS: YESTERDAY AND TODAY

Introduction

The peopling of the Canaries has been a subject of dispute among past and contemporary scholars. Anthropological investigation becomes a recognized field of knowledge during the 19th and 20th century Europe. The governing theoretical approaches were based on raciology and evolutionism and were developed mainly by French and German schools of anthropology. This is a time when European colonization of the world was taking place and the idea of Eurocentrism began to emerge; a perspective that bases the western world as a superior cultural manifestation over any foreign community. Therefore, scientific investigations were usually driven by the curiosity of European scholars to examine otherness and to proof the assumed western Roman-Catholic superiority. Upon European contact, pre-Hispanic Canary aboriginals were also victims of Eurocentrism, which classified these populations as illiterate Cromagnoids and barbaric troglodytes. As time passed, the increasing discovery of rock engravings began to provide clues about the peopling of the islands.

Archaeological research suffered a crisis during the dictatorial regime imposed after the Spanish civil war. Political interests influenced heavily on identity questions of former Canary inhabitants, this gave a reason to proof Aryan superiority and sovereignty
of Iberian cultures using history as a justification. Therefore, investigations were biased and archaeological records were manipulated to fit the socio-political agenda of those in power. The discipline continued to develop under the supervision of different institutional bodies until modern times, when archaeology as a scientific field of research has become more prominent. Yet, theoretical disagreements explaining human settlement models into the archipelago are still marking the development of Canarian archaeology. In any case, advancements in science and the inclusion of multidisciplinary collaborations have allowed the field to diverge in alternate lines of investigation, thus providing new sources of information.

This chapter will review the different stages of archaeological research in the region and the diverse paradigms that have developed over the centuries. Perusing over ancient narratives is a must when carrying out research in the Canaries. This region has been inspirational for the literature of antiquity, which experienced an information gap from the early turn of the millennia until the beginnings of imperial enterprises in the 13th century. Modern archaeology has relied heavily upon these primary sources, which often times pose more questions than clarifications; discordance between the archaeological record and former literature can be common. However, the purpose of this research thesis is not to critique this type of consultation but rather to provide a review of the main literary works that experts from this region tend to resort. In addition to pointing out the most prominent hypotheses that these narratives have suggested.
Ancient Narratives

The idealized conception of the Canary Islands, also known as the Fortunate Islands, has carried on since Augustan times, when writer Plutarch (AD 75) first mentioned this region in *The Life of Sertorius* (García–Talavera 2006). Sertorius, a Roman militant (124-72 BC) who fleeing from the Roman Empire encountered two fishermen from Gades – today’s city of Cádiz in southern Spain – and described two paradisiacal islands off the coast of North Africa. The seamen assumed these islands were the Homeric Elysian Fields due to their beauty and nonchalant living of their inhabitants (Blázquez 1977). Plutarch’s mentioning of the *Fortunatae Insulae* was amongst the first ancient accounts insinuating the existence of the Canary Islands. Interestingly, there were additional descriptions by Pomponius Mela in his narrative *de Chorographia* (AD 43) mentioning the existence of Atlantic islands off the southern coast of the Roman Mauritania. Most detailed accounts of the *Hespérides* and *Afortunadas* came from *Historia Naturalis* (AD 77) by Pliny the Elder. The latter provided perhaps much of the information describing a group of islands off the coast of Northwestern Africa (García-Talavera 2006; Santana and Arcos 2007). Pliny’s accounts were a compilation of stories by Estacio Seboso and the Mauritanian King Juba II who was said to have explored, and exploited the islands in order to extract the high-priced imperial purple dye. This claim has been discussed by Santana and Arcos (2007), who have claimed that the main purpose of the African king was to set the principal meridian for the *Orbis Terrarum*, a
map initiated by Julius Caesar (44 BC) and concluded by Marco Vipsania Agripa (AD 12) under Augustus rule (Dilke 1985). See Figure 12 below for a visual of Agripa’s map.

![Agripa's Map](image)

Figure 12: Reconstruction of Agripa’s *Imago Mundi* by Raisz (1938) with the *Fortunatae Insulae* in the right corner of the picture. Scholars believe the real representation of the *Orbis Terrarum* was most likely rectangular for its placement on a column in the Porticus Vipsani.

However, the earliest and most dubious account was that of an Atlantic voyage captained by Hannon, a Phoenician admiral who travelled along the Northwestern African coasts down to Cape Bojador in search for gold (Atoche Peña et al. 1997;
Blázquez 1977; López-Pardo 1990). The Periplus of Hannon (ca. 460 BC) reached our current literature through the allegories of Mela and Pliny the Elder. This information has been repeatedly analyzed by historians such as Jérôme Carcopino and the eminent admiral Juan José Jáuregui, who claimed the impossibility of navigating along the North African coasts without berthing in the Canary Islands (Blázquez 1977; Gonzalbes Cravioto 2009). Hence, archaeology in this region cannot ignore ancient Classic literature and its hidden clues, as the field has been able to unearth material that relates to such accounts by analyzing Classic narratives. Excavated deposits and chronologies correspond to the context of Classical Mediterranean societies who once exploited the rich natural resources geographically available to those dominating the seas.

The Beginnings of Archaeology in the Canary Islands

Late 18th to early 19th century

The interest of historians was only a continuation of a long-held curiosity on the mythological origin of the aboriginal inhabitants of the islands. Historian José de Viera y Clavijo considered ideas about the origin of the ancient Canary islander as a possible descendant of a superior race, such as Atlanteans or the last survivors of Noah’s flood (Viera y Clavijo 1777). These stories not only fed the imagination of early scholars, but also hindered their research. Early science was heavily influenced by religious ideologies, which in turn would not permit science to inquire about identity, at a moment when the remnants of ancient Canary Island cultural traditions were still accessible. By the late
1800’s scientific investigations began to consider the importance of Canarian islanders in their role as inheritors of a soon-to-be-lost ancient tradition.

The first studies came from the natural sciences of botany, zoology, geology and biogeography, with Charles Darwin’s *Voyage of the Beagle* II one of the most renowned fieldworks in the area. In 1845, the islands officially became part of the Macaronesian region, a term of Greek etymology with *makaroi* meaning fortunate and *nesoi* islands. Philip Barker-Webb, an English botanist, introduced this ecological classification in the *L’Histoire Naturelle des Iles Canaries* with his co-author Sabine Berthelot (Morales-Matos 2001). This narrative was the leading scientific recompilation of the time and still serves as a reference today. Berthelot’s contribution to ethnography and physical anthropology was the beginning of an empirical research aiming to understand the origins of Canary aborigines (Navarro-Mederos 1997; Pellicer 1968-69). His last narrative, *Antiquités Cannariennes* (1879) has been considered the first archaeology book of the region (Navarro-Mederos 1997). During the 19th century European scientific interest directed its attention to the archipelago. The findings of mummified ancient Canarians sparked the interest of physical anthropologists, as well as curious collectors, who began to look at the islands as an anthropological area of research. During this time, scientific societies were created in order to store and study archaeological material in Tenerife Island with *El Gabinete Científico* in 1877, *El Museo Canario* in Gran Canaria in 1880, and *La Sociedad Cosmológica* of La Palma Island in the year of 1881 (Farrújia 2005b, 2010; Navarro-Mederos 1997). These institutions emphasized an antiquarianism that was
typical of early archaeology, a field that began as a hobby with doctors, pharmacists and contemporary intellectuals eagerly storing archaeological remains in their private collections (Farrújía 2010).

Another important driving force for the development of archaeology in the Canaries was the influence of Canarian scholarship in France. Local scholars were studying in French universities, events that served as bridges between prominent authors such as Boucher de Pèrthes with the dissemination of their scientific literature across the archipelago (Farrújía 2010). A notable local author was Juan Bethencourt Alfonso, from Tenerife, who contributed to local ethnographic knowledge through his book *Historia del Pueblo Guanche* (Trapero 1994a). In addition, historian Buenaventura Bonnet Reverón and journalist Leoncio Rodríguez highlighted the importance of Canary history and her landscape in a time of decadence and regional conflict (Yanes-Mesa 2007).

The study of populations outside the European mainland promulgated ethnocentric paradigms such as diffusionism and evolutionism – outlooks that conceived native populations as relics of a remote human past. The idealization of the exotic was a common theme throughout Imperial Europe. In this sense, studies on the Canarian past adopted the same attitude embraced by the British enterprise in Australia and Tasmania, where aboriginality was synonym of “otherness” (Cove 1995:25). This concept translated to a natural inferiority providing the European thought with a justification to subordinate indigenous populations throughout the world (Cove 1995; Tejera and Aznar 1992). This outdated mentality has endured in the field of archaeology under the name of cultural
evolutionism. The later became a widely use expression that was first coined by Herbert Spencer in the 19th century, who wrongly adopted the biological evolutionism of Darwin to explain cultural conundrums (Johnson 1999).

Furthermore, evolutionism was a trend that went hand in hand with the idea of the noble savage, which originated in the early 17th century from French narratives of New World expeditions. Ellingson (2001) has argued explorer Lescarbot first brought up the term in 1609 as a critique to European modern life. John Dryden translated this expression into English in 1672 in his heroic play *The Conquest of Granada*, signifying this idealization of the man in peace with nature (Hames 2007). However, this romantic definition of the indigenous life style was not reflected by the actions of conquerors violently taking away this ‘natural state’ of living from indigenous societies. Evangelizers justified the savagery of their occupation as an instrument of ‘good’ Christianity attempting to save infidels from their lack of faith in the Catholic God (Cioranescu 1959-69; Cove 1995; Tejera and Aznar 1992).

19th to 20th century

During the 19th century, while native communities overseas were still in the process of evangelization, Canary traditional knowledge had turned into a mythological past. In essence, this society had entered “modernity” at an early stage of European Colonization (Estévez 2011:148). Modern islanders of the 1800’s were the result of a society that had lived through European occupation, being sold into slavery, and mixing of its native populations. In the case of the Canary Islands, conquering was exercised
through genocide, with only few aborigines surviving violent European invasions (Abreu y Galindo 1632; Alonso de Espinosa 1594; Marín de Cubas 1687; Torriani 1588; Verrier and Boutier 1491). The remnants were sold in slave markets throughout Europe (Cortés 2009; Fregel et al. 2009; Tejera and Aznar 1992). Lastly, those who were able to stay in the archipelago, mostly women, intermixed with Europeans and slaves from sub-Saharan Africa, who were brought in the islands as workforce for the sugar mills (Cortés 2009; Fregel et al. 2009; Wölfel 1930). Europe in the 19th century was exploring the world and making contact with the rest of native communities that did not get conquered by the early colonialism of the 15th and 16th centuries. Hence, Eurocentrism was still in vigor leading colonial enterprises, and also influencing scientific inquiry. The subject of ancient inhabitants of the islands was viewed from that superior perspective held by European scholars over their subject of study, in this case the lost heritage of Canarian aborigines.

A pioneer in archaeological research was French anthropologist René Verneau (Figure 13), who led the first official scientific study on the anthropology of the islands (Pellicer 1968-69). His mind frame was built on the so-called European ethnocentrism that deemed pre-Hispanic island populations to be frozen in a Neolithic time, populations that he ascribed a Cro-Magnon origin. His co-authored research with Berthelot, on the engraved inscriptions that appeared throughout the islands in caves and stonewalls were the clues scientists utilized to develop the first chronology on the archipelago, see Figure 14 of a petroglyph from the island of La Palma. Berthelot argued for an early prehistoric
epoch characterized by the engravings of *Cueva de Belmaco* in La Palma Island, and those in El Hierro. This phase followed a protohistoric era represented by megalithic constructions (Berthelot 1980 [1879]; Farrújía 2010). Verneau argued for two main colonizing events, lead first by a Semitic population and second by a Numidian (modern day Algeria-Tunisia) intromission responsible for the inscriptions of the Ravine of Balos in Gran Canaria Island (Farrújía et al. 2010; Verneau 1996 [1886]). Both Berthelot and Verneau discredited the thought of indigenous populations living during Spanish conquest to be the authors of such enigmatic inscriptions due to their presupposed illiteracy (Farrújía et al. 2010). In any case, French studies were able to recognize the influence of North African tribal populations through the engraved Lybico-Berber alphabet, a recognition that was used as foundation for later research to expand on the heritage of ancient islanders (Farrújía 2005a).
Figure 13: René Verneau manipulating Canarian aboriginal crania at *El Museo Canario*.

Photo retrieved from the archives of *El Museo Canario* and presented with permission by the *Museo Canario*. 
The etymology of the term – *berber* – denotes the despotic assignation that Romans once gave to the tribes residing in modern Algeria, Tunisia and Morocco, regions of North Africa that were generally designated in the ancient world as Lybia. *Berbers* referred to ‘barbarian’ populations and/or anyone beyond the Greco-Latin sphere. Today these non-Arab populations avoid such terminology by calling themselves *Amazigh*, an expression that has been traced back to the epoch of Ramses III (13th century BC) (Chafik 2005; Farrúa 2010). In any case, this racist model based on a Neolithic
presence of island barbarians governed the perspective of Canarian anthropology at the time. Among supporters of such hypotheses was Gregorio Chil y Naranjo, director of Museo Canario (Farrujía 2010), who shared the opinion that former islanders denoted cromagnoid physical attributes (Navarro-Mederos 1997). The archaeological methodology of Chil y Naranjo highly differed from that of Víctor Grau-Bassas y Mas, a curator of the museum who showed more interest about the context of discoveries rather than the objects (Navarro-Mederos 1997).

The 19th century archaeology of race was in opposition with the creationist and anti-Darwinist ideas of Manuel de Ossuna and van Den Heede, two historians whose work transitioned into the 20th century carrying on ideas on the Semitic, Cananaean, and even Celtic and Iberian heritages of pre-Hispanic Canarians (Farrujía et al. 2010; Jiménez and Navarro-Mederos 2001). Authors such as Ossuna and Bethencourt-Alfonso linked the Ravine of Balos engravings (Figure 15) with Celtic influences. Their dismissal of Africanity went beyond dismissal by erroneously ascribing an Iberian identity and language to all islanders (Farrujía et al. 2010). Bethencourt and Ossuna were interested on promulgating unity through a unique cultural character all over the islands. Furthermore, this hypothesis was applied to political ideologies supporting unanimity in a time of opposition and internal conflict that ended up with the political division of the Canaries into two provinces; ideology that marked the beginning of archaeological research as a tool for political interests. The partition of the archipelago was highly celebrated by the separatist politics of León y Castillo, leader of the Gran Canaria Liberal
Party (Farrujía et al. 2010; Guimerá 1979). In 1927, the islands were divided into two provinces with Santa Cruz de Tenerife representing the occidental section (accounting the islands of La Palma, La Gomera, El Hierro and Tenerife) and Gran Canaria as capital of the oriental set of islands (with Lanzarote, Fuerteventura and Gran Canaria).
Figure 15: *Barranco de Balos*, Gran Canaria. Copied representations from the Ravine of Balos. Name of authors from top to bottom: Hernández Bautista (1989); Jiménez Sánchez (1962); Guzmán (1984); Delgado (1964); Beltrán Martínez (1962); Hernández Bautista
By the end of the 19th century, cultural evolutionism fell in popularity due to a transition led by the Industrial Revolution and the uprising of the middle class into political arenas (Farrújia 2010). European thought experienced a gradual change from evolutionist theories of racial typologies towards a diffusionist model, where similarities among distant cultures of the world were recognized and ascribed to contact and cultural exchange. Lewis Binford criticized this descriptive framework by terming it ‘an aquatic view of culture’ (Binford 1964); this analogy pictured prehistory as a water pool where the ripples from an object dropped in the water where cultural influences washed over anything in their way (Binford 1964; Johnson 1999). Historians ascribed the same phenomenon for the development of culture in the Canary Islands, which paradoxically was a suitable parallel since the islands would have been influenced by innovations from greater cultural forms just like waves arriving ashore. In the early 20th century, migration hypotheses began to flourish as a mean to explain cultural change throughout the islands (Daniel 1979; Farrújia 2010; Johnson 1999). During this time, archaeology began to experience a lapse of activity, remaining somewhat dormant until the 1940’s when a new methodological outlook took over excavations in the Canaries (Arco et al. 1992; Farrújia and Arco 2004; Navarro-Mederos 1997). This new perspective was born under the dictatorship of Francisco Franco and the consequent Spanish Civil War, which allowed
Canarian archaeology to develop a close relationship with the nationalistic politics of the time.

Spain, *Franquist* Politics and Canarian Archaeology

‘Provincial Stations of Archaeological Excavations’

Scholars have considered Franco’s Spain of the twentieth century (1939-1975) a time and space of crisis for Canarian archaeology. The fascist rule of the dictator permeated not only social spheres but also scientific arenas. The field of anthropology as a highly humanistic science was certainly affected in its practices because it became a tool to promulgate the Aryan race, and Castilian superiority over folkloric manifestations.

The field of archaeology was highly influenced by dictatorial politics, which can be seen in the records created by the ‘Provincial Stations of Archaeological Excavations,’ or central administrative organisms controlling directly archaeological practices over the archipelago (Farrújía y Arco 2004). Two administrations were located in each insular province, Tenerife and Gran Canaria, where only the appointed administration was allowed in the development of anthropological activities; needless to say, chosen officials were those supporting right-wing fascist ideologies (*falangistas* or *franquistas*). The General Commissioner was Julio Martínez Santa-Olalla, who was also in charge of the *Comisaría* of Gran Canaria along with Sebastián Jiménez Sánchez and José Pérez de Barradas. Jiménez-Sánchez was an extremist *falangista* with no archaeological background who commissioned Dr. Ilse Schwidetsky the classification of pre-Hispanic
Canarian skeletal remains based on craniometrical comparisons (Eddy 1992, 1994a, 1994b). Sánchez took charge for 25 years and had an amicable relationship with pro-Nazi propagandist Dominick Wölfel (Eddy 1995). This close relationship with the Nazi school saturated anthropological studies in the archipelago, mainly through Schwidetsky’s theoretical approach that came to be defined as the “racist school of Canarian archaeology” (Arco and Navarro 1987; Eddy 1995:444; Tejera and Gonzáleiz 1987, 1992). In the island of Tenerife, Dacio V. Darias Padrón exercised the role of provincial commissioner, renouncing a few years later due to his opposition to the bureaucratic emphasis of the institution (Farrujía and Arco 2004). Darias Padrón was substituted by *franquista* Juan Álvarez Delgado, who in turn was replaced by Luis Diego Cuscoy (Díaz 1994; Díaz and Ramírez 2001; Farrujía and Arco 2004; Ramírez 2002). The development of this nationalization of Canarian archaeology left behind the French archaeological methodology that was once promoted by the studies of Verneau and Berthelot. However, the ethnic emphasis of racial archaeology remained constant in the anthropological study of ancient Canary Islanders.

Stone writings were still of much interest, therefore, the two province Commissioners, Cuscoy and Barradas, embarked on a mission to ascribe a meaning to the engravings—an endeavor that turned into the quest for scientific excuses promoting the imperialist agenda of dictator Franco. The spiral rock carvings of La Palma became related to those in Celtic Galicia, North Spain (Farrujía et al. 2010). In addition, officials correlated epigraphs and petroglyphs with a type of North African rock art, which they
termed the Iberian-Sahara culture (Farrújía et al. 2010). This terminology, gave the Canary Islands a direct link to the greater Iberian culture, by default related to the Aryan races of Britain, Ireland, Scotland and Galicia. Franquist archaeological practices ascribed an Aryan heritage to pre-Hispanic aborigines (Farrújía 2007). The lack of radiocarbon dating at this time also provoked the miss-classification of ceramic sherds by Delgado and Barradas who constructed chronologies based in little or almost no field research (Farrújía 2007). Cuscoy also tackled the questions behind rock engravings but dismissed cultural material evidences (Farrújía et al. 2010). Each commissioner had their own political agenda and by doing so they hindered collaboration between the two provincial administrations (Arco 1998). In fact, Jiménez-Sánchez requested Martínez Santa-Olalla to create a separate journal under the name of Revista de las Canarias Orientales to cover the archaeological endeavors of Gran Canaria – including the islands of Lanzarote and Fuerteventura – (Farrújía and Arco 2004). Hence, the strong social division that existed between Gran Canaria and Tenerife marked the development of archaeological research in the archipelago during the 20th century. This separation not only kept contemporary insular communities in opposition, but also provoked the creation of a fractioned vision that kept each cultural island in complete isolation from the rest of the archipelago.

Evolutionism had lost popularity during the decades of Comisarías, opening the doors to the theoretical paradigm of diffusionism, a perspective that served to support the national unity and firm religiosity behind the ideologies of the dictator (Díaz-Andreu
1997; Hernando 2001; Farrújía and Arco 2004; Pasamar 1991). This framework has also been termed as cultural-historicism by main supporters Hugo Obermaier and Luís Pericot. Spanish theories have used this paradigm to explain the development of prehistory in the Iberian Peninsula as a closed network of cultural affinities where different groups once shared a common identity (Farrújía and Arco 2002; Pasamar 1991; Pasamar and Peiró 1991). For these authors, the plausible explanation for cultural change was the taking over and domination of established groups by foreign societies. The *franquista* mentality did not envision the possibility of coevalness between distinct cultures; therefore, cultural-historicism was used as a paradigm to answer archaeological questions (Farrújía and Arco 2002, 2004; Lull and Micó 1997).

Regardless of the common political interest, *franquistas* also experienced clashes between theoretical stands. Barradas, Tenerife commissioner, highly supported the cultural-historicism framework, which explained the peopling of the islands by the aggrandized Iberian-Sahara societies of North Africa and the Iberian Peninsula (Farrújía and Arco 2004). On the other hand, Jiménez-Sánchez promoted a two-fold settlement of the archipelago: the *Guanche* people as conquerors of Tenerife and the occidental islands, and the *Canarios* as those once taking over the Gran Canaria province (Farrújía and Arco 2004; Jiménez-Sánchez 1949). The latter was highly supportive of the diversionist mentality that kept Tenerife and Gran Canaria in archaeological, and also political, conflict (Farrújía 2002). Moreover, there is a contradictory aspect in Jiménez-Sánchez’ narrative since he distinguished two populations inhabiting the two provinces, however,
he agreed both societies came from a unique race of North African heritage (Farrújia and Arco 2002; Jiménez-Sánchez 1949). Hence, the racial discourse was still latent in Canarian archaeology of the 20th century. This theoretical scope dangerously percolated into public arenas and provided the foundations of a sociopolitical dialogue motivating extremists to violently promote the independency of the Canary Islands.

**Self-determination and Guanchismo**

Provoked by this interest on raciology, Canarian nationalism began to mature during the late 1960’s using the imagery of **Guanches**. This nomenclature has been misused widely to define the aborigines of the Canaries; today, it is still applied by some scholars wrongly, as we know **Guanches** only resided in the island of Tenerife. The growth of the ideology of **guanchismo** (Mercer 1980) was used by pro-independence supporters claiming the “African-ness” (Eddy 1995:444) of contemporary Canary populations. These arguments were taken as scientific fact by the separatist group MPAIAC (Movimiento Para la Autodeterminación e Independencia del Archipiélago Canario) (Eddy 1995; Gari-Hayek 1992), translated as: Movement for the Self-Determination and Independency of the Canarian Archipelago. The anti-imperialist faction (independentistas) first launched by Antonio Cubillo in 1964 was based in Algeria and resorted to terrorist attacks on Spanish grounds as means to redeem the lost identity of Canarian locals. Figures 16 and 17 below show the symbolisms used by MPAIAC.
Figure 16: F.A.G. translates as Guanche Army Strong. This picture shows the violent emphasis behind this self-determination movement lead by Canarian independentistas (image retrieved from http://oceanorojo.blogspot.com).

Figure 17: MPAIAC propaganda (image retrieved from https://xaviercasals.wordpress.com).
Cubillo’s self-determination movement permeated the archaeological arena in the years to come. Once again, the field of archaeology became a propagandistic tool for a political party to support an ideology, in this case the uniqueness of Canariety or *guanchismo*. In 1992 Rafael Muñoz, professor from the University of La Laguna in Tenerife publicized the discovery of the Zanata Stone, a pisciform shaped rock with the engraving ‘ZeNaTa,’ a word related to the name of a tribe in North Africa (Figure 18). Some experts rapidly adopted this archaeological piece as the trademark of cultural identity for pre-Hispanic islanders (Eddy 1995; Hernández et al. 2004-2005). The intromission of this stone into the archaeological discourse took place at a sensitive political moment since *independentistas* were reaffirming the auto-determination of the Canaries. Not only that, the unearthing of the artifact was controversial due to a lack of background regarding the discovery (Eddy 1995, 1993a, 1993b; Hernández et al. 2004-2005). The local newspaper *La Gaceta de Canarias* published information that accused González Antón of falsifying the stone (Eddy 1995). A local junk dealer that collaborated with the scholar had one receipt showing a large amount of money paid for the ‘assistance in archaeological work,’ which the public interpreted as if González Antón had bought the object from this source (Eddy 1995). In addition, authors such as H. Nowak, Lionel Galand and colleagues refuted the linguistic interpretation of the engravings – although, their arguments were ignored by regional media, which had a strong influence in the spread of *independentista* ideology (Eddy 1995; Nowak 1994). Weeks after the object had been published, a group of academics disputed the finding,
and in 1994 González Antón, director of the *Museo Arqueológico de Tenerife*, was accused of falsifying the artifact (Eddy 1995). Committee members from the opposition board of the *Museo* ordered an inquiry, but with the support of academic and political colleagues he was able to retain his position as director of the *Museo* and Heritage Inspector for Tenerife (Eddy 1995). Today, the Zanata Stone, attributed to its fish-like shape, as seen in Figure 18 below, is considered one veritable archaeological proof of a correlation between deep-sea fishing practices and the life-style of ancient insular populations (González Antón and Arco 2007).

Figure 18: *Piedra Zanata* or Zanata Stone. Its fish-like shape has given a reason for some scholars to attribute the special connection of ancient Canary aborigines with fishing practices. Image reproduced with permission by [www.museosdetenerife.org](http://www.museosdetenerife.org).
Development of the discipline and current trends

After Franco’s death in 1975, the Spanish Constitution was redrafted to fit the new democratic government. The decentralization of administrative agencies also changed the way in which archaeology was applied on the archipelago. The investigation of the Canaries whirled from being under the responsibility of the central administration of Spain’s Historical Patrimony (*Patrimonio Histórico*), to university regards and finally to its total control by local governments (*Comunidades Autónomas*) (Navarro-Mederos 1997, 2002). The change in administration shifted the focus behind archaeological activities to emphasize exertions of ‘rescue’ or ‘urgency,’ defined as ‘*Arqueología de Gestión*’ or administrative archaeology (Ballart and Terreseras 2001; Gámez-Mendoza 2004; Querol 2010). Currently, the managerial emphasis that has been ascribed to modern archaeological investigations comes from the use of the discipline as a safeguard to rescue historical patrimony from destructive developmental construction (Gámez-Mendoza 2004).

In terms of theoretical approaches, after the 1970’s anthropology detaches from leading German neo-positivism, thus racial archaeology. Even though it can still be seen in the thought process of some academics, the racist school became a thing of the past. The inclusion of archaeology as a scholastic discipline allowed local archaeological research to gain the scientific weight bestowed in other parts of the world. There was a
recognized intensive period of archaeological investigation during the 1980’s and the first half of the 1990’s with the two universities of Tenerife and Gran Canaria as motors of archaeological activity (Navarro-Mederos 1997). Some of the most popular frameworks used in the last two decades are those of cultural ecology (Atoche Peña et al. 1995; Atoche Peña and Rodríguez 1988; Atoche and Paz 1996; Criado and Atoche Peña 2003; Galván et al. 1991; Martín 1993; Navarro and Martín 1985-87), historical materialism (Navarro-Mederos 1997), processual archaeology (Martín 1985-1986) and ethnohistorical approaches devised from the ‘American anthropological school’ (Hernández et al. 2004-2005; Jiménez 1990, 1999; Tejera et al. 1987).

In essence, the study of the peopling of the Canaries has oscillated between two main postulations. On one side, a trend has supported the fortuitous arrival of individuals through shipwreck, or the wash away of boats by ocean-currents without the possibility of returning to their homeland. Another viewpoint supports the contrasting argument for a rather planned occupation. Those populations reaching the insular coasts would have been transported by ancient societies with a sophisticated knowledge on helmsmanship (Gonzalbes Cravioto 2009). This last assumption implies, among other assessments, that Canarian aboriginal societies descended from Mediterranean Classical nations marauding the deep seas in antiquity –the main cultures alluded in this context are Phoenicians, Punics and Romans. Two marked trends have been developed under the second argument: those hypothesizing an early Phoeno-Punic contact (i.e. Arco et al. 2000b; Atoche Peña et al. 1999a; Balbín et al. 2000; Farrújía et al. 2010; González Antón and

Canarian ancient history is still a matter of heated debate and the cause of division among academics. The archaeological record in this region is many times difficult to correlate with the rest of the findings in the islands. The lack of strict methodological approaches during a major part of the 20th century dictatorial Spain and the preceding popularity of antiquarianism in the region are some of the factors affecting the lack of cohesiveness between archaeological material findings from the Canaries. Since the mid 1990’s, there has been a notable decline on archaeological prospection coming from university grounds. Historical patrimony has fallen under the competence of regional governments (cabildos), which use institutions to control archaeological activities – institutions such as museums, where their own staff is habitually employed in historical activities. Many of the recent archaeological deposits that are found on museums are coming from the salvage intervention of cultural resource management (CRM) firms, which urgently exhume former human remains in sediment packages to later be stored in institutional repositories (Gámez-Mendoza 2004). Occasionally, excavations are reduced to the will of cabildos, which have shown a tendency to apply archaeology as a tool in order to move forward with the construction of roads and buildings throughout the islands. In addition, the aim of national and local governments to accommodate the insular landscape to the tourism industry has deconstructed numerous ancient deposits
laid along the coastlines. A lack of interest by governmental institutions, and therefore funds, has made archaeology an intricate and controversial field of research in the Canaries, becoming even harder to inquire about historical archaeology, since most research focuses on prehistory (Gámez-Mendoza 2004). However, there is hope for academic archaeology in this region thanks to various lines of investigation coming from University of La Laguna in Tenerife Island, the Archaeological Museum of Tenerife, and University of Las Palmas of Gran Canaria. As science advances, archaeological endeavors increasingly incorporate the knowledge of hard sciences, such as chemistry or ecology, in order to supplement the voids left by contemporary personal interpretations of ancient records.

Natural Science and Archaeology: My Contributions to the Field

C14 began to be incorporated in the methodology of archaeology; however, it had problematic beginnings due to its subjectivity to contaminants and lack of understanding. Further, the inclusion of paleomagnetism and thermoluminescence from interdisciplinary geological experts in vulcanology was able to bring about the revelation of chronological data (Navarro-Mederos 1997). Thermoluminescence techniques have yielded some of the earliest chronologies in the archipelago with a ceramic sherd from La Graciosa dating back to 3099 ± 278 BP/ 1096 BC and 2953 ± 227 BP/ 950 BC (García-Talavera 2003; González Antón and Arco 2007). The oldest dates provided by C14 are found in Tenerife at La Cueva de los Guanches 4599: 2770 ± 160 BP/ 820 BC (Arco et al. 1997, 2000a,
2007; González et al. 1995), as well as from the site of Buenavista in Lanzarote Island (Atoche Peña 2011). The oldest chronologies for each island can be seen in Table 2.
Table 2: Most ancient chronologies for the Canarian archipelago (González Antón and Arco 2007:36).

<table>
<thead>
<tr>
<th>Islands and Sites</th>
<th>Laboratory Measurements</th>
<th>Max. Calibration</th>
<th>Min. Calibration</th>
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<tr>
<td>La Graciosa</td>
<td>TLM</td>
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<tr>
<td>El Descubrimiento</td>
<td>-Mad-3292-3099±278 BP/1096BC</td>
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<td></td>
<td>-Mad-3334 2953±227 BP/950 BC</td>
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<tr>
<td>Tenerife</td>
<td>C¹⁴</td>
<td>1391 BC</td>
<td>698 BC</td>
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<tr>
<td>Los Guanches</td>
<td>GAK-14599/CNZ-SED</td>
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<td></td>
<td>2770±160 BP/820 BC</td>
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<tr>
<td>La Palma</td>
<td>C¹⁴</td>
<td>403 BC</td>
<td>AD 36</td>
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<td>La Palmera</td>
<td>GrN-13753/M</td>
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<td></td>
<td>2190±90 BP/240 BC</td>
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<tr>
<td>Lanzarote</td>
<td>C¹⁴</td>
<td>362 BC</td>
<td>AD 265</td>
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<tr>
<td>El Bebedero</td>
<td>GrN-19194/1980±140 BP/30 BC</td>
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<tr>
<td>Gran Canaria</td>
<td>C¹⁴</td>
<td>209 BC</td>
<td>AD 437</td>
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<td>Los Caserones</td>
<td>GAK-8064/M</td>
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<td>1890±150 BP/AD 60</td>
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<tr>
<td>El Hierro</td>
<td>C¹⁴</td>
<td>AD 132</td>
<td>AD 237</td>
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<td>La Lajura</td>
<td>1830±? BP/AD 120</td>
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<tr>
<td>Fuerteventura</td>
<td>C¹⁴</td>
<td>AD 210</td>
<td>AD 420</td>
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<td>CSIC-556/C</td>
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<td>La Gomera</td>
<td>C¹⁴</td>
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This Master’s thesis focuses on information coming from the fields of geochemistry and biochemistry to understand human population mobility into the Canary Islands. The use of stable isotopic analysis is a fairly new approach in archaeological methodology and even more of a novelty for the Canarias. The lack of economic resources is perhaps one of the main limitations of this technique, as well as the requirement of a deep understanding of chemistry. In my opinion, Canarian archaeology is in need of interdisciplinary collaboration coming from the hard sciences as a means to provide quantitative data that can supplement the qualitative knowledge obtained from material -culture found up-to-date. 

Synthesis

This chapter has presented a diachronic development of archaeology in the Canary Islands, which evolved from early evolutionary theories and a misguided emphasis on the mythological past of pre-Hispanic aboriginals, through diffusionist models of cultural expansion, and up to the Canarian racist school motivated by Nazi Germany and Fascist Spain. During a period of time, political ideologies have been present in archaeological studies regarding the identity of first settlers. The Zanata stone was a clear example of the amount of controversy this subject has provoked within the scientific community, in addition to the use of the topic to justify certain social movements (i.e. MPAIAC). In order to walk away from errors of the past, this research on the use of geochemistry contemplates the peopling problem and suggests a
quantitative approach that has served to understand ancient population mobility into oceanic islands from other parts of the world. Stable isotope analyses focused on ratios of $^{87}\text{Sr}/^{86}\text{Sr}$ obtained from faunal and floral records, as well as human bone and/or teeth, have proven the viability of this technique in archaeology and it is a promising tool for this particular location.
CHAPTER 5: THEORETICAL APPROACH: LOOKING AT THE NATURE OF ANCIENT SETTLEMENTS

Introduction

As narrated in the previous chapter, ancient and modern scholars have been trying to decipher how communities with little or no knowledge of seafaring succeeded in settling of the Atlantic insular region of the *Fortunatae Insulae*. Being aware of the factors that came into play when the first settlers began to take control of natural insular resources will certainly help on developing a strong hypothetical identity for those first occupants of the islands. Landscape archaeology and eco-culture frameworks are potential paradigms to approach the ‘problem’ of the peopling of the Canary Islands since the environment is still present and it can be studied through the aid of natural sciences. Therefore, adopting a pragmatic view where ecological and biological factors are taken into account to understand the archaeological record across the landscape seems propitious. The ecological sensitivity of these islands was presented in Chapter 2 with geological processes as important molders of life within the rigid geophysical limits of the region. In a similar fashion, environmental pressures must have posed adaptive barriers that would have modified the living behaviors of inaugural human populations.

Canary archaeology recognizes that those first settlers must have been distinct from those communities that Europeans encountered during evangelization (14th century).
First populations already had a rooted cultural system in the regions they departed from; their arrival to the archipelago forced them to change their subsistence methods as a way to survive in the new environment. As material culture and provisions had to be selected for the voyage and new establishment, adaptations to the insular terrain must have also forced them to select the cultural traits best suiting their new needs (P. Atoche Peña, personal communication lecture, March 2015). There is a consensus that first islanders were not comparable to the guanches, canarios or bimbaches (names to define the different populations of Tenerife, Gran Canaria and La Palma respectively) found at the time of Castilian conquest. This research will refer to the first denizens as pre-aboriginals, because at the time of first human arrivals Canary aboriginality did not exist as the established socio-cultural identity that Europeans encountered.

These islands have hosted a myriad of migrant cultures coming from all corners of the globe due to their strategic position as a geographically mandatory stop in any trip west or south of the Atlantic Ocean. Christopher Columbus stopped in Gran Canaria before reaching the Americas; it is one of many historical instances exemplifying the need for berthing in the Canaries prior to trans-Atlantic voyages (Rosa 2010). Another factor bringing many ethnicities into the region was the economic phenomenon of slave markets in Europe, which was prominent during colonialism. Explorations to the African coasts were a major resource for the acquisition of slaves. The Canaries where utilized as a layover for returning merchants to Europe as well as a sugar cane production hotspot (Cortés 1964; Tejera and Aznar 1992). For these matters, today the richness of
multiculturalism is reflected on modern islanders whose DNA provides high polymorphic rates with genetic imprints from sub-Saharan populations, European, North African, and even American heritage (Flores et al. 2001). Surprisingly, genetic diversity seemed to be present also among pre-Hispanic islanders. Ancient DNA (aDNA) studies have revealed multifarious genetic groups existing within former Canary populations, to whom it is ascribed a mutation of African origin that has yet to be found on the continent—concretely, the ubiquitous subgroup U6b1 (Arnay-de-la-Rosa 2009; Fregel et al. 2009; Maca-Meyer et al. 2004). Moreover, aDNA studies from La Palma have provided additional genetic subgroups that cannot be found on other islands and vice versa (Fregel et al. 2009). As one can imagine, the migratory situation is complex and arises much speculation, and contradiction, when archaeological deposits are unearthed or colonial-historical accounts are revised.

Questions that arise when thinking about the peopling of the Canaries

Given the amount of genetic diversity provided by aDNA studies on pre-colonial islanders, could we compare the recurrent pattern of today’s migratory activity to former times’ population mobility models? The particular geographic location of this archipelago allows seafarers to prepare for long distance journeys or to rest after such; thus, were ancient seamen also taking advantage of the strategic position of the islands by using them for berthing and provisioning locations? If so, is it possible that these seafarers brought along foreign populations that ended up settling in the region just like in modern times? Therefore, could various human groups have once shared the same region and
perhaps also the same island? If so, how did they reconcile their cultural differences and modes of subsistence? Was there inter-insular contact? If so, how did it manifest and to what extent? At last, how can archaeology tackle some of these questions? The enquiry is vast since the topics of these questions vary from population dynamics, to knowledge of seafaring in antiquity, and to biomolecular analyses among other interests. Hence, archaeology in the Canaries is an ever-growing scientific field becoming more intricate as research evolves.

My theoretical preference

Settlement archaeology is a type of paradigm within the discipline of archaeology capable of tackling former mobility questions that have created great controversy among experts and modern inhabitants of the islands. The following sections of this chapter suggest the potentials of a theoretical background that best encompasses the particularity of Canarian archaeological conundrums. Landscape archaeology and its theoretical ramifications provide an eclectic methodology that originates from the hard sciences, and reaches the social sciences, uniting both spectrums in one pragmatic approach. This research defends the idea that landscape archaeology opens the door to interdisciplinary methodologies indispensible for the understanding of complex ancient social phenomena.
Review of early work

Landscape archaeology can be rooted back to the 18th century with the work of Thomas R. Malthus on his *Essay on Population* (1798), where he found a correlation between ecological depletion and competition for survival between populations (Panakhyo and McGrath 2009). In his view communities were doomed to exhaust their resources thus provoking an inevitable stress and anxiety to strive at all costs. In the long run this inherent unease would turn into events of war, famine and illness, effects of this automated depletion; conflict in itself would serve as a regulatory mechanism against population growth (Seymour-Smith 1986). Within this reductionist approach, the ideas of Darwin began to take form to later become a reality in *The Origin of Species* (1859) (Panakhyo and McGrath 2009), which gave rise to the concept of evolutionism –later to be overused in all academic realms. During the early 19th century the field of humanities began to increasingly address the influence of environment and socio-cultural development. Among other early anthropologists, Julian Steward (1902-1972) came up with the term ‘cultural ecology’ in his study on the Shoshone of the Great Basin, a hunter and gatherer community heavily reliant on the pinon nut tree, and where he demonstrated a relationship between resource-base and population density (Panakhyo and McGrath 2009; Steward 1938). Steward often used comparative approaches in his anthropological studies of cultural ecology, in which he developed a three step methodology: (1) point out
environmental resources at reach and the technological approaches humans are utilizing to excerpt and handle those resources; (2) list the communal configuration behind such economic activities; and (3) understand how agency and the mechanisms for subsistence affect culture (Barfield 1997; Panakhyo and McGrath 2009). Under the theoretical umbrella of landscape archaeology, a contrasting paradigm emerges from Leslie A. White (1900-1975) and his focus on materialism (Barfield 1997). He defended that the evolution of a culture cycled with the amount of energy human groups spent on resource exploitation, the more energy exhausted on taking advantage of natural resources, the more culturally evolved the society (Barfield 1997; White 1959). The technological aspect was another important ingredient as tool making determined the thought process of human groups (Barfield 1997; Panakhyo and McGrath 2009).

Paradigm shift in anthropological archaeology

The linearity of early cultural ecology began to change by the 1960’s and 1970’s in tandem with what has been called “New Archaeology” (Johnson 1999:12-34). This birthing “trend” was to be characterized by an emphasis on empirical archaeological methodology. More than a trend, David Clarke defined New Archaeology as a change of attitude where the rhapsodizing of the past through artifacts and romanticized ideas of lost cultures turned into a scientific enquiry about real people and their life stories (Johnson 1999). This new archaeological thought promulgated the creation of hypotheses and the testing of such, just like in the experimental hard sciences; the emphasis on scientism on the field was coined with its own title and methodology: positivism and the
hypothetico-deductive-nomological (HDN) model (Johnson 1999). In this sense, cultural evolution was still in the background, yet cultural ecology and environmental determinism seemed to become static; their lack of a hypothesis-testing system was not able to explain the intricacies behind former cultural processes (Panakhyo and McGrath 2009). As the natural sciences advanced, interdisciplinary interests began to provide scientific tools that could be used in the theory-formulation process coming from the social aspect of the enquiry. Multidisciplinary collaboration allowed this focus on environment to provide a perspective based on empirical judgments regarding the origin of human ethnic diversity. Such paradigm shift came along with the globalizing context of the last decades and the technological developments after the Second World War, which motivated anthropologists to look at cultures in an ecumenical manner using all the resources scientific technology allowed (Johnson 1999; Panakhyo and McGrath 2009). In this sense, globalization had helped put a mirror on the scholars’ mind by showing the crude reality of the colonialist phenomenon as the reflection of an intrusion of the western mind into the indigenous world. The objectivism of science began to sink in the anthropological enquiry by accepting the influences of Occidentalism on conquered lands causing the destruction of native cultures. As a result, researchers began to accept the idea that ancient societies could not have stayed untouched throughout millennia, but were rather influenced by their surroundings just as much as modern times (Johnson 1999).
At last, postwar military progress on nuclear research, geographic devices and other biological interests allowed the natural sciences to provide the scientific techniques HDN was eager to utilize. Some of these advances came from discoveries on paleoethnobotany, carbon 14 dating, stable isotope testing, and dendrochronology among other scientific fields (Johnson 1999). Within this admixture of interdisciplinary technological inputs and the realization of the colonizing west, the subfield of paleoecology as an archaeological framework with its own methodology was crafted (Kottak 1999). In essence, landscape perspectives consider the relationship between culture-nature in order to study former economical and socio-cultural spheres of a lost society, thus archaeology can study the intangible humanity of the past. Some of the methods that have helped, and continue to aid archeologists understand this reciprocity between humans and nature come from the fields of ethnohistory, ethnobotany, climate studies, faunal analyses and ethnography (Walker 2012).

Certainly, this project focuses on paleoecology in order to perceive how environmental processes of the past can aid in understanding the results that modern science is providing for archaeologists. In the case of isotopic research, it is crucial to understand how biochemical processes occur in the biosphere, and how these in turn reflect in the organic archaeological deposits. Hence, the interaction of islanders with their environment needs to be understood, and landscape archaeology as a theoretical perspective seems to fit such need.
Landscape Archaeology and Its Trends

Four subcategories

The theoretical framework of landscape archaeology has many representations in the archaeological narrative because, as some scholars have proposed, the meaning we give to landscape is culturally based (Layton and Ucko 1999). In spite of its subjectivity, this paradigm adopts similarities from anthropogeography and physiogeography; the essential question regarding the relationship between humans and ecosystems sprout from the growing body of knowledge within the natural sciences (Jahnkhun 1977). Erz and Lindstadter (2009) are able to discern four different approaches to landscape: empirical, pragmatic, emic view, and the postmodern turn (Lenssen-Erz and Lindstadter 2009). The empirical views within landscape archaeology follow along Johnson’s New Archaeology of the 1960’s and 1970’s (Hodder and Orton 1976; Vita-Finzi 1978). The aim is quantitative and culturally materialistic since it puts nature in a secondary place where the environment is just a source for humans to exploit it (Lenssen-Erz and Lindstadter 2009). In contrast, the pragmatic view accepts archaeology as an inseparable phenomenon from the landscape; for example, in order to interpret rupestre art the observer needs to also look at the environment where it takes place. Pragmatism in landscape archaeology argues the stability of large-scale properties on the geology and topography of an area. This approach personifies nature by using landmarks as witnesses of past events (Bradley 1994; Bradley et al. 1994; Lenssen-Erz and Lindstadter 2009;
Swartz and Hurlbutt 1994). Furthermore, the postmodern approach as defined by Erz and Lindstadter provides a “highly theoretical and abstract background” (Lenssen-Erz and Lindstadter 2009:161). For example, the perceiver of the landscape today can potentially comprehend a Mesolithic landscape only if he or she focuses deeply in the environment (Tilley 1994). To ‘focus deeply’ implies the arbitrariness of the postmodern approach when applied to archaeological research because the relative deepness in perceptions makes this interpretation highly biased. At last, the emic view – also known as the phenomenological approach – opens the dialogue to non-western perspectives about landscape by allowing indigenous knowledge to be a part of the research. This is a culture-centered approach as it allows populations under scrutiny to give their own perception of their surroundings (Basso 1984; Lenssen-Erz and Lindstadter 2009; Littlejohn 1963; Ouzman 2002). The emic approach provides archaeology with a more humanistic outlook by deviating its attention from material culture and focusing on a natural landscape that is in itself loaded with traditional knowledge.

Humanism and landscape archaeology

In order to further develop the phenomenological approach and this idea of humanism in archaeology, this research looks at Tim Ingold’s perception of landscape and introduces his concept: taskcape. He considers archaeologists and how they can conceive the environment as “pregnant with the past” (Ingold 1993:153). In his view the terrain is full of clues left by the activities of former populations who invested their efforts and time to thrive in that environment. Ingold compares the relationship between
archaeologists and the environment with that of a former inhabitant, and even a cartographer, because all of them are painting a picture of the natural world in constant movement (Ingold 1990, 1993). Movement is another important aspect for this author who claims that without the motion of the foot a print cannot exist; therefore both the print and the motion of that ancient dweller are all a part of something called the temporality of landscape, also known as taskcape (Ingold 1993:159). Taskcape is defined as a vivid picture, where a series of activities are held together and maintained by the movement of the people exercising those activities and the social interactions originating from this motion.

Humans are interacting with each other and creating a temporality. Ingold plays with the relativity of time and differentiates “social time” from that of “historical time” (Ingold 1986b, 1993:156). The former is uncountable and full of variability and the latter is quantitative and homogenous as it is quantified by days and years (Ingold 1990; Soroking and Merton 1938). Taskcape falls under the umbrella of social time as it is created through the interactions of agents as they move through the terrain. In this sense, time becomes relative to the emotional effects that originate from the social movement that creates the landscape. Ingold makes the clear distinction between visual and auditory as being the senses by which landscape and taskcape can be experienced accordingly (Ingold 1993). Therefore, if taskcape is noise, how does the archaeologists unearth taskcape if it represents no materiality?
Ingold’s perception of this social movement – noise – and how archaeology deals with the landscape is complex but highly sophisticated. The author is able to point out a phenomenon that is universal and eternal; this is ‘society’ in itself. *Homo sapiens* in their evolutionary history have constantly interacted with the surrounding environment through our bodily senses, a type of movement we continue to exercise. This constant interaction makes taskcape the imprint that allows landscape to be eternal and therefore archaeologically researchable. For example, if certain topography has remained the same for millennia, the researcher can easily argue that the terrain is reflecting the same picture to all ancient and modern dwellers that have interacted with this landscape. For Ingold, this constant natural imagery represents a “baseline of permanence” (Ingold 1993:165). Former and contemporary habitants share this topographic permanence; although they might internalize it differently. Another type of permanence is that of biological life cycles that are universal to all living beings, senescence is itself a constant motion, such as nature and its geological changes. For Ingold, nature and human are interrelated and no separation exists since both agents interact and create the landscape that is being studied through archaeology. This interexchange goes in contrast to a generally established division between culture and nature, which defines human actions as sovereign over the land where activities simply take place and thus create a cultural landscape (Lenssen-Erz and Lindstadter 2009; Sauer 1963; Schade 2000).

Indigenous cultures do not conceive this dichotomy between the natural environment and humanity (Dowson 2007; Heyd 2002). The differentiation seen between
traditional cultures and westerners, regarding the conception of ecosystems and the role 
of humans, departs from this notion of separation from nature inherent in occidental life 
styles (Lenssen-Erz and Lindstadter 2009). Such division when studying the past has also 
influenced archaeology as a science of the West. The increasing collaboration of native 
cultures with research has opened the door for some academics to recognize the emic 
approach, or what Ingold calls the phenomenology of landscape. Yet the author 
recognizes that a separation exists between mind and nature, which is evidenced by the 
material creations of buildings and other man-made structures. In Ingold’s example, a 
church is a marker of time, also called a chronotope, reflected in the landscape, which has 
in turn been created by the taskcape of builders and their society (Bakhtin 1984). It is a 
chronotope because historical time has been used to determine the exact date the building 
was completed; this chronology will help the future researcher get an understanding of 
the temporal context when the church was built. At last, the archaeologist’s duty is to 
study the possible interactions that must have taken place for the completion of the 
church. Ingold defines archaeology as the science that studies the “temporality of the 
landscape” (Ingold 1993:172).

As phenomenology has shown, the emic view of landscape archaeology can help 
academics to elucidate on economic subsistence methods, social interactivity, cultural 
manifestations, spatial distribution and settlement management (Lenssen-Erz and 
Lindstadter 2009; Schade 2000). The humanistic approach provides a space where 
indigenous perceptions are accepted in cultural definitions of ecology. Thus using a
combination of perspectives able to tackle questions regarding settlement, economy, society, and ecology in archaeology. The emic view provides a versatile framework capable of developing a coherent picture of the past (Lenssen-Erz and Lindstadter 2009; Lüning 1997).

Taskcape and landscape in the Canaries

Ingold, in agreeance with cultural anthropologists Keith H. Basso or Dennis E. Cosgrove, sees landscape as something that is not material nor utilitarian but rather humanistic. Just like the Western Apache, whose stories about their surrounding terrain provide a way to engage the listener with specific landscape features and their meaning, archaeology as a science has the potentials to reveal the humanistic side behind those decaying imprints in our landscape today. This is done through digging into the taskcape of ancient populations (Basso 1984; Cosgrove 1989). The emic view allows the breaking away from materialist notions and the hoarding tendencies of a type of archaeology that only shows interest for objects. How does the emic view apply to this research and its territory of interest? In one hand, it would be difficult to adopt this view when studying a site located underneath a modern urban center because no natural landscape is preserved as witness of ancient dwellings. The terrain has been drastically modified becoming saturated with chronotopes that represent the fast movement of contemporary dwellers whose taskcape is based on increasing manmade forms. On the other hand, this emic view of landscape archaeology seems certainly suitable in areas where topography has not been altered considerably. Here, humanistic and naturalistic perspectives can be
combined to comprehend the information that the environment reveals. Since it has not been modified by artificial structures, nature is allowed to speak for itself as it once did for ancient inhabitants.

Going back to this idea on the difficulty of applying this humanistic approach to places where natural landmarks no longer exist, the following case exemplifies the limits of the emic view. Modern cities and their buildings have dramatically changed the landscape once inhabited by former dwellers, thus forcing archaeology to focus its investigation on material deposits. Ancient cities such as Cádiz (South Spain), once hosted multiple urban centers for Phoenician (Wagner 2007), Punic (Deamos 1997; Fear 1990; van Dommelen and Gómez Bellard 2008), and Roman populations (Deamos 1997; Sillières 1997). Their stratigraphic superposition under the pavements of the modern city of Cádiz are a perfect example of how cultural historicism and a focus on materiality are inevitable in this landscape. The archaeology of cities like Cádiz is a type of systematic exercise where material culture must be salvaged from developmental prospection. Here, deposits are removed and analyzed in complete detachment from its original context, which will soon disappear underneath new buildings. Generally, archaeological objects are rapidly removed, mapped and taken into a facility to be studied under an arbitrary classificatory system. In many cases, these artifacts are simply stored in boxes until some scholar, usually someone who was not present in the archaeological activity, decides to examine them by imposing his/her inherent typological biases.
In contrast, the emic view becomes an appropriate perspective in territories where the topography is still characterized by natural landmarks such as mountains, coastlines and other monumental geographic features. Looking at the orography of the Canarian archipelago, where the shape of coastlines has generally maintained its form throughout the settlement history of the islands and where volcanoes and gorges have stood tall since the islands’ discovery, natural landmarks have witnessed the development of insular societies. Tall summits, such as Roque Bentayga (Gran Canaria) (Figure 19) or El Teide volcano (Tenerife), are examples of these landmarks or baselines of permanence. Such natural wonders have imposed their magnificence acclaimed by tourists, locals and former natives. Rock writing and archaeological remains in El Bentayga (Figure 20) suggest the religious importance this location held for aboriginal Gran Canarian populations. In addition, chronicles of conquistadores have made allusion to El Teide (Figure 21) as a landmark beholding superstitious beliefs for Tenerife indigenes. Hence, how could Ingold’s humanistic archaeology be applied to the phenomenology of these locations? How is the terrain of this region providing us with a baseline of permanence that could help with deciphering the identities of those who settled the islands?
Figure 19: El Roque (summit) Bentayga, 1,404 m asl, Gran Canaria Island. Photo by author.
Figure 20: Rock incisions forming a series of channels that seem to end on a pentagon-like carved shape. El Bentayga. Archaeologists, based on accounts of conquistadores, hypothesize these engravings are related to a religious activity where offerings in the form of milk were poured into the carved canals. The destruction of the floor impedes the clear assessment of these symbols. Photo by author.
Another baseline of permanence characteristic of the Canaries is the shape of coastlines and the relative proximity between islands. These geographical features are enough to make them visible to their inhabitants during clear atmospheric conditions as seen in Figure 22. This natural imagery stands impressive on the horizon provoking a feeling of curiosity on viewers, an emotion that could be coined as timeless; current-day observers that are highly aware of who and what is showing the skyline are still vulnerable to this intriguing natural landscape. The clear visibility between each
formation alludes that ancient inhabitants also saw neighboring islands, evidence that could be translated into Ingold’s words as a baseline of permanence.

Figure 22: *El Archipiélago Chinijo* (the small archipelago) showing the group of islets of Alegranza, Montaña Clara, Roque del Este, Roque del Oeste and the inhabited La Graciosa Islet.

**Connected isolation**

Eriksen (1993), in his study of the Mauritius Island of Madagascar, promotes a less isolated concept when thinking about islands than what literature has tended to portray. To explain how islands are interrelated, the author argues for an “updated
version of diffusionism” (Eriksen 1993:137), where insular regions are seen dependent on trade networks and communication with neighboring lands, therefore never completely isolated. Bronislaw Malinowski (1922) and Marcel Mauss’ (1925) fieldwork on the Western Pacific revealed the complexity behind systems of exchange between indigenous islanders. Trade routes connected the Melanesian archipelago through legal responsibilities between tribes that were fulfilled by specific economic exchanges, allowing for the continuation of amicable relationships between islanders for generations. Similarly Mauritians have always been connected with mainland despite their distance from Indian and African continents. In general, Eriksen makes a case for the susceptibility of islands to human migratory movements. Islanders have a tendency to look for bigger lands, i.e. Trinidadians migrating as far as New York and Toronto, or Grenadians from small Grenada striving to arrive to the larger Trinidad and Tobago (Eriksen 1993). In the case of Mauritians, they too migrate to mainland. A peculiarity of this region is the bio-cultural barriers that exist within the island; inhabitants accept their cultural disparities and live in equanimity without intermixing their Creoles, Hindis and Muslims heritages (Eriksen 1993). Therefore, Eriksen argues that isolation is a product of human agency and not so much of environmental imposition.

Going along with Eriksen’s perception of island interconnectivity, we could also apply a similar hypothetical distribution manifesting in former Canary aboriginal trade-work systems, or at least acknowledge that a type of communication must have occurred. Given that ancient Canarians would be able to see other islands, and as Eriksen presents,
these populations too would have had the curiosity to expand. In fact, *Le Canarien* (1419) confirms contact between inhabitants of Lanzarote and Fuerteventura who, to the judgment of European explorers, did not seem to share a common dialect. These two formations are only about 14 km away from each other, La Gomera and Tenerife are separated by only 38 km. Therefore, following this logic of proximity and inherent curiosity by islanders to reach out, it could be argued that former inhabitants might have had contact between territories. How would this have affected the culture of each island? Were they violent encounters? Or on the other hand, and like the Kula of Malinowski, were these cordial economic systems of exchange? The baseline of permanence is telling us ancient aborigines were completely aware of foreign proximal lands. Evidence of such postulation is scant, and Castilian chronicles briefly mentions these questions.

Island Biogeography and Human Populations

**How can archaeology think about early denizens of the Canaries?**

Pre-aboriginal populations, upon arrival to the islands, witnessed the true Tertiary Tethyan relictual vegetation described in Chapter 2. Given the sensitivity of insular ecosystems, early human populations must have impacted the landscape changing it in ways that made the terrain suitable for their subsistence methods. But, which strategies did pre-aboriginals use to adapt to the new environment and its limitations? How flexible were these groups in order to succeed when presented with the new challenges of island life? And how did these strategies become the foundations for a series of unique
indigenous cultures that would later represent the aborigines of the Canary Islands? The scientific community today has yet to agree on a solid theory that explains when the discovery and appropriation of the archipelago took place, the identity of first settlers, and the diachronic social processes that molded the cultures of the archipelago by the time of Castilian conquest. Only in the most recent decades archaeology has begun to reveal valuable information about this question (Morales-Matos 2001).

In this section, we will review resilience theory as another theoretical approach that sprouts from the ecological perspective. Concretely, it focuses on cultural ecology in order to understand the history of land-use and the consequences behind social and exploitation practices in the long run. Moreover, resilience theory examines the ability of a community to resist ecological and cultural changes. This recent perspective emerges from the urgency of understanding how natural degradation can be previewed and avoided as much as possible through the study of culture. Anthropologists and ecologists have united their sciences to discover that short-term productivity methods have provoked natural and social damage only appreciated through long-term perspectives.

Resilience Theory and Its Premises

Resilience theory is the capacity of a society to be flexible in order to thrive in new environments or when faced with transformations (Holling 1973; Levin 1999; Rappaport 1968). This theoretical approach uses the ‘deep time’ view, or long-term effects of human actions, as means to anticipate the future impacts of subsistence
practices (Redman 2005). The foundation of resilience relies on the assumption that
transformation and stability are interrelated. Four premises are accepted when applying
this framework: 1) change is periodic; 2) the terms ‘large’ and ‘small’ to define scale are
relative to spatial and temporal attributes within the ecosystem or society; 3) destabilizing
forces trigger diversity, opportunity and means to test resilience; 4) at last, strict social
rules facilitate the inability to adapt to the smallest disturbance (Redman 2005; Redman
and Kinzig 2003). Users of this perspective recognize a purpose behind every change and
opportunity resulting from new phenomena that alters the routines of organisms
(Carpenter and Gunderson 2001).

Within this narrative, terms such as ‘vulnerability’ and ‘robustness’ have been
used to define the capability of a population to thrive (Redman 2005). To stay away from
evolutionary inputs, some researchers classify this constant flow of variation as the
adaptive cycle, and it is represented as an eight-like graphic (Figure 23) (Holling 1973;
2001; Holling and Gunderson 2002). Researchers consider environmental changes as
natural means to test the level of resiliency within populations, and most importantly
elucidate on the origin of the conflict (Redman 2005). The success of this
interdisciplinary effort between archaeologists and ecologists has birthed the subtheory of
Conservation Ecology, also known as “Human Ecosystems: Towards the Integration of
Anthropology and Ecosystem Sciences” (Able and Stepp 2003; Redman 2005:72). One
main question asked by resilience theory: how flexible is a social system when
conflicitive agents appear? The aim of archaeology when using this paradigm is to discover the source of change and the adaptive strategies populations have resorted to.

Figure 23: “Eight figure” representing the adaptive cycle governed by the periodicity of transformation (Holling and Gunderson 2002; Redman 2005).

Archaeology has taken apart the misconception that claims indigenous populations are in complete balance with nature; humans have been altering their environment for millennia (Krech 2000; Leveau et al. 1999; Redman 2005). Therefore, resilience theorists divide all human adaptive cycles into four stages of movement: 1) exploitation, 2) conservation, 3) release and 4) reorganization. Exploitation takes place in the r-phase of Figure 23 and is represented by the colonization and rapid alteration of an invaded ecosystem. Conservation is the following K-phase of Figure 23, a period characterized by the accumulation of exploited goods and energy. Release, or phase Ω, is the moment when external agents provoke the liberation of the accumulated material; the
fragile nature of massive storage is sensitive to alteration by any outside force. At last, the reorganization phase comprehends the reutilization of certain aspects from old systems in order to take advantage of opportunities opened by transformations. These stages are applied in the larger societal scope, however, individuality is taken into account as a type of force that could aid the thriving process or to the contrary, disturb the system. In social language, this agency is termed as “revolt” and it takes place when small-scale nuances outburst into large-scale crises (Redman 2005:73). This interaction between smaller entities over bigger institutions is called “panarchy” and it has considerable effects (Gunderson and Holling 2002; Redman 2005). The theory argues that the new structure will either resemble the preceding system or be completely renovated to suit the needs of the new cultural or ecological environment (Holling 2001; Holling and Gunderson 2002; Redman 2005; Redman and Kinzig 2003).

The eight-like graphic is constructed in a way that provides stages of time for the community to recover from the perturbation. These stages of recovery are helpful to measure the level of flexibility or resilience within a population, because each stage provides a spatial and temporal opportunity to build up memory. For resilience theorists, the success of a society relies on the communal ability to memorize and accept that certain processes are inevitable. The capacity to thrive shows a resilience that allows populations to adapt to changes and persist over generations (Redman and Kinzig 2003). This social memory is the accumulation of experience that a society has gathered after many altering events. Additionally, the use of a shared knowledge that has been built
over a network of alliances and exchanges contributes to this database. Ceremonies, trade systems, and political alliances are some of the strategies societies have used in order to be flexible (Rappaport 1968; Redman and Kinzig 2003).

**Nature and humans from a resilient perspective**

Natural landscapes, alike humans, have their own temporal cycle ruled by their time of birth, their age of reproduction and their capacities to face disturbances ultimately to either survive or/and perish (Redman and Kinzig 2003). These disturbances in organisms have spatial connotations defined by the spread of the phenomena or the topography where they take place. In addition to ecological changes, humans act upon the landscape modifying its spatial aspects in a way that might aid them in the adapting process (Carpenter and Gunderson 2001; Schefferer et al. 2001). In a reciprocal manner, nature molds the spread and adaptation of communities to specific dimensional circumstances (Berkes and Folke 1998; Diamond 1997). Hence, resiliency theory argues one way for archaeological research to be successful in revealing information about ancient societies is if the discipline accepts nature as a direct agent of the culture being studied (Michener et al. 2001; Redman and Kinzig 2003). This paradigm fits right under the umbrella of landscape archaeology and its emphasis on nature and its effects on human enterprises. In addition, it provides hypotheses that are testable from the natural sciences, making a theoretical approach practical for this geographical location highly marked by, what Ingold has defined as ‘taskcape’.
Resilience theorists agree with premises of evolutionary theory in the sense that uncommon species are more susceptible to change than prolific ones. Transformation of the landscape could either extinguish them, or to the contrary aid in their colonization and expansion. In archaeology small- vs. large-scale societies are also susceptible to similar outcomes, the distribution of social scales provide for transitional zones where “entrepreneurial activities” (Redman and Kinzig 2003:9) might flourish causing the economic and even ecological transformation of large-scale societies (Barth 1967; Boone et al. 1997). Resilience theory acknowledges small-scale societies are more capable of retaining memory than the bigger systems more vulnerable to revolts, or ‘lumps’ (Redman and Kinzig 2003).

How resilient were Canary aborigines?

In general, ancient human settlement into pristine environments is characterized by the discovery of the territory with its full potentials and total accessibility for founders to adapt in the new terrain. In the case of human establishment of insular landscapes, the settlement possesses marked physical boundaries that cannot be ignored. The carrying capacity of islands restrains the adjustment techniques that settling communities need to employ thus dictating the level of success behind their adaptive strategies. Archaeology recognizes that Canarian societies were mostly herders and had a mixed diet consisting of agricultural plants, ocean products, meat, milk, cheese and possibly arboreal fruits and roots (Morales-Matos 2001; Stewart 2001). Known animal and plant species that were introduced by outsiders were goat, sheep and pig, as well as two or more dog breeds.
(Arco and Navarro 1987; Hutterer 1990; Fernández-Palacios et al. 2008). These ancient settlers also brought in a few plant species such as lentils, barley, wheat, fava beans, peas, fig trees and most likely date palm (Morales et al. 2007; Fernández-Palacios et al. 2008). Moreover, a demographic estimation was done using the accounts of European chronicles and it was speculated that by the year AD 1400 between 81,755 and 117,300 aboriginal islanders inhabited the Canaries (Macías-Hernández 1999).

Given the specific floral and animal species endemic of the Tethyan relictual biota, the introduction of these new taxa must have left noticeable imprints in the landscape of the Canaries. Some clues have been obtained from palynological analyses of a region in Tenerife where a lake existed in antiquity. Through this emphasis on ecology, archaeologists were able to discover the disappearance of the Quercus and the Carpinus tree, non-Macaronesian native species, becoming extinct by the time of European contact (Nascimento et al. 2009). Human practices influenced the early desertification of the Canaries by altering the land for grazing, acquiring fuel and wood, and developing agriculture (Criado 2002; Nascimento et al. 2009). The effects of agricultural practices on the insular landscape have been studied intensively in the island of Lanzarote, revealing herding intensification processes as the most possible factors for soil degradation in the island (Atoche Peña 2003).

Therefore, we see the effects of resource procurement on the sensitive insular ecosystem of the archipelago. These clues are only revealed through the incorporation of natural sciences into the archaeological toolbox. Fields such as paleoecology, botany and
pedology are great sources of knowledge for the archaeology; these multidisciplinary fields of research can point to the intricate subsistence strategies that ancient populations once used to adapt to the island landscape. The Canaries as an insular geographical location are sensitive ecosystems reactant to external pressures such as foreign species introduction or human activity. Interdisciplinary collaborations are proving a success of in adopting landscape archaeological paradigms into the research of ancient peopling of the Canaries.

Resilient theory provides a framework that allows archaeology to think about first settlers of the Canary Islands in a very approachable manner. Given the recent advances of the discipline, we can use this theoretical scope to talk about pre-aboriginal adaptation to insular landscapes, as well as social organization. The fact that human communities had survived and became culturally established by the time of European contact, give the field of archaeology a reason to argue that indigenous Canarian populations were resilient to environmental boundaries. Such postulation would require a deeper analysis by using this theoretical approach. In doing so, one would need to identify the phases and strategies early Canarian societies underwent and reflect on the ways they correspond with the four stages introduced by the eight-like graph presented in Figure 23. Some of the questions that arise when using resilience theory as a model to talk about former Canary islanders are the following: what was the temporal span in which first denizens of the Canary Islands prevailed the most? Or were they going through periods of conservation and release phase interchangeably? Given the delicacy of insular
environments, how destructive was the exploitation period(s) in the region? How did the accumulation stage manifest in these societies? Could we use colonialism as an example of the reorganization stage?

Societies spend variable time in each of the stages mentioned above (Redman 1999, 2005). Thinkers argue that contemporary globalizing societies are at the point of accumulation because our systems are centered on amassing as much material goods as possible without the release and reorganization of structures. This lack of flexibility drives the fragmentation of major political systems right at their peak stage, archaeological investigation shows how ancient prominent societies have rapidly switched from the K phase to Ω right in the crest of the accumulation step (Redman 2005). For example some researchers have pointed to the cause of the disintegration of the Ur III dynasty based on soil-nutrients depletion due to agricultural processes ultimately directing the central authority to collapse (Adams 1978; Redman 1992). In the case of the Canaries as an insular landscape, sensitive island ecosystems have a predominant tendency to show the scars of human impacts on their terrain. These circumstances enable archaeologists to look at the environment through the lenses of ecological research and reveal valuable information about ancient aboriginal living. In essence, theoretical scopes based on landscape, such as resilience theory or the emic view, can help create a discourse from all the quantitative data presented by the natural sciences.
An interesting line of evidence comes from the field of biomolecular analyses in the archaeological organic record. Studies on Y-chromosomes and mitochondrial DNA (mtDNA) have helped answers questions regarding ancient migration or evolutionary trends of living organisms. mtDNA is found outside the nucleus of the cell and is only inherited from the mother lineage and during the fertilization process the tail of the sperm containing its share of male mtDNA is left behind (Groleau 2003). Particular characteristics of mtDNA are its high mutation rate and its lack of recombination of alleles in the process of creating new cells, or meiosis (Nesheva et al. 2014). Random mutations provide the polymorphisms in mtDNA that are responsible for the apparition of haplotypes and haplogroups (Gluckman et al. 2009). The latter, when related, share markers of identity that tend to be geographically distinct (Nesheva et al. 2014). The earliest haplogroups are found in Africa (Estes 2013).

In the Canary Islands, the extraction of mtDNA from archaeological aboriginal remains has provided additional information inferring a possible contact between the islands of La Palma and Tenerife. Rosa Fregel et al. (2009) analyzed 38 individuals from AD 600-1200. Of these, 30 samples were replicated providing the following interesting results. In one hand, haplogroups T1a, W and X with mutations only found in La Palma had not been recorded in Tenerife. On the other hand, subgroups U61a/a2/a3 were not found in the former but appeared in the latter (Fregel et al. 2009). From these
investigations, it seems as if the amount of biomolecular diversity among pre-Hispanic islanders was as varied as modern mixed local inhabitants. Biomolecular research in this region has perhaps generated more questions than answers; in any case, it is an instrument that reveals clues about the genetic admixture that seemed to be present in pre-Hispanic times, data that should not be ignored.

Another way of investigating this question of connectivity between islands relies on archaeological traditional methods such as data analysis. Looking for answers in the material culture, such as ceramics or settlement structures, can also be another technique to tackle questions regarding inter-island communication. Mortuary archaeology is another technique that could point out similarities and/or differences in burial practices among island populations. This methodological approach looks at several components in the assessment of funerary systems such as: the presence of symbolic objects buried with the individual, the positioning of the deceased body in relation to cardinal points, and/or the structures that are being used to bury the bodies; these are some of the characteristics archaeologists use comparative analysis. Regionally, the field of anthropology recognizes the emphasis throughout all islands on mummification practices, but no conclusive answers have been given about possible cultural affinities.

Discussion

In his book about research design, John W. Creswell (2003) identifies four schools of thought that can be used to explain how facts become knowledge: post-
positivism, pragmatism, constructivism, and participatory (Creswell 2003). While crafting the methodology to approach population mobility into the Canary Islands, it seems as if one effective approach comes from an eclectic posture or pragmatic viewpoint. The intricacies of ancient population settlement are as problematic as modern migration, becoming even more convoluted when taking into account cultural relativism and spatio-temporal factors. The peopling of the Canary Islands represents, in miniature, the history of humanity; groups of people migrating to new lands and in this process of mobility, creating singular cultural expressions.

Finally, pragmatism is a view that is in tandem with pluralist ideologies. This approach avoids binaries and dualist terms that tend to classify ancient societies within the ethnocentric concepts of early anthropological inquiry; cultural relativism is only recognized after the New Archaeology scope enters the scientific field. Success of this perspective relies on accepting the gray areas and using methodology as a malleable unit that adapts to the ambiguities of specific research. One of the strategies used by pragmatic researchers is that of triangulating, which means to seek union between the results obtained from both qualitative and quantitative methods. Triangulating is one of the approaches adopted in this thesis as it uses knowledge from geochemical analyses to investigate anthropological questions such as ancient human migration into the Canary Islands. In summary, the creation of a tentative baseline for the local bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ in Lanzarote shows the viability of using stable isotopes of strontium for archaeological purposes in this region. The following chapter presents the preliminary
results from radiogenic testing of stable isotopes of strontium in Lanzarote. In addition to discussing results, data will be compared with analyses that have previously been done on other islands with similar geological attributes to the Canaries.
CHAPTER 6: LABORATORY METHODS AND SAMPLES

Sample Collection

One of the main goals of this project, aside from gaining a clear understanding of the archaeological situation of the Canary Island, was to develop a tentative $^{87}\text{Sr}/^{86}\text{Sr}$ bioavailable baseline for the island of Lanzarote. The purpose of this preliminary guideline was to investigate the viability of using the isotopic ratio of $^{87}\text{Sr}/^{86}\text{Sr}$ as means of understanding ancient human population mobility patterns onto the islands. Due to a paucity of archaeological human specimens in Lanzarote, and their poor preservation state, this project avoided using ancient aboriginal remains as sample material. Additionally, given this is the first time isotopes of Sr are being assessed for archaeological purposes in this area, it was required to begin by investigating the bioavailable strontium through vegetation and other materials at reach –through analysis of modern rodent tooth enamel, gastropod shells, and calcium carbonate rock (caliche). I was also able to include four ancient ovicaprid teeth provided by Professor Pablo Atoche Peña and his investigation team from Universidad de Las Palmas de Gran Canaria (ULPGC). The word ‘ovicaprid’ is applied to zooarchaeological remains of goats and/or sheep. These bovid species are indistinguishable when found in their skeletal state, hence the non-specific terminology. Castilian chronicles and archaeological records inform us that aboriginal Canarians were goat and sheepherders. For this matter, the prolific faunal
material has allowed this research to include zooarchaeological samples in order to test the viability of isotope signatures as a method to ascribe locality of pre-Hispanic insular populations. See Table 4 for a list of sample material utilized in this study, and see Figure 24 for a map showing the different geologic zones composing the island of Lanzarote.

Figure 24: Geologic map reproduced with permission by Dr. Daniel Muhs.
Researchers often use water, soil, rocks, plants, faunal and human remains (modern or ancient), gastropod’ shells, or a combination of these to reveal the average terrestrial strontium biologically available (Evans et al. 2009; Frei and Frei 2011; Lafoon et al. 2012; Voerkelius et al. 2010). Dental enamel of small, low-mobility mammals is a viable proxy for bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$. Animals, such as rodents, average out $(\text{bioaverage})$ the local variation of strontium isotopes from the region (Lafoon et al. 2012; Price et al. 2002). Therefore, faunal material provides a mean measurement of the strontium ratios that are potentially bioaveraged by Lanzarote’s biosphere.

**Vegetation**

Vegetation samples were chosen, among other materials, as a means to map $^{87}\text{Sr}/^{86}\text{Sr}$ variations throughout the island of Lanzarote. Vegetation was selected taking into account the different geological formations that constitute the island (Figure 24). The collected specimens were typically woody evergreen shrubs (Asteraceae, Chenopodiaceae, Solanaceae, Cactaceae), vegetative plants (Cistaceae, Asteraceae), and deciduous tree leaves (Ficus carica).

**Gastropod’ shells and caliche**

Land snails have been used for mapping the bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ of other places around the world (Evans et al. 2009). Lafoon and colleagues (2012) suggested these specimens might not be as appropriate as tooth enamel given the small catchment regions of the species and the unknown susceptibility to contamination of the material. However, their abundance in archaeological and modern sites around the island makes these
specimens a good choice for analysis, and also presents an opportunity to learn more about their applicability in understanding bioavailable Sr. One piece of *caliche* was chosen for this project to preliminary test the assumption that Sr in snails is representative of the composition of Sr in *caliche*; thus both specimen materials serve as markers of Sr stable isotopic variability in the island. Both snail shell and *caliche* are composed of calcium carbonate (CaCO₃). Strontium substitutes for calcium in calcium carbonate, therefore there should be measurable Sr in both.

**Ovicaprid teeth**

Ovicaprid teeth were analyzed as a pilot study to elucidate the $^{87}$Sr/$^{86}$Sr reflected in zooarchaeological material that was in direct contact with the local populations of the past. Samples were procured by Professor Atoche Peña excavated from a site called Buenavista (Teguise) in the central part of Lanzarote Island (Figure 25). The chronological range of this archaeological settlement falls between the 10th century BC and 3rd century AD, which sets the findings in a Phoeno-Punic temporal context (Atoche Peña 2011). The site connects with the sandy soils of El Jable plains. Its topographic position locates Buenavista in a strategic water catchment position, which allows rainwater to be deposited and naturally stored (Atoche Peña et al. 2007, 2011). Soils in this area are rich in organic material and potentially suitable for agricultural purposes (Atoche Peña 1993). The stratigraphy of this site is shown in Table 3, with layers I, I-1, II-1 corresponding to this project’s samples.
Table 3: General chronological results from Buenavista site and their C\textsuperscript{14} calibrations from original table in Atoche Peña 2011. Pilot samples 3 and 4 belong to strata II-1 and II-2, and PC-1pt and 2pt belong to strata I-1 and I-2. The stratigraphic layer corresponding to PC-4pt is not represented in this table.

<table>
<thead>
<tr>
<th>Site and Stratigraphy</th>
<th>Years</th>
<th>Calibration</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buenavista 06 B6/II-1</td>
<td>40</td>
<td>400 to 350 BC cal.</td>
<td>Organic Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 to 210 BC cal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>380 BC</td>
<td></td>
</tr>
<tr>
<td>Buenavista 07 E4/II-1</td>
<td>40</td>
<td>370 to 150 BC cal.</td>
<td>Organic Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140 to 110 BC cal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>330 BC cal.</td>
<td></td>
</tr>
<tr>
<td>Buenavista 07 F4/II-3Base</td>
<td>50</td>
<td>780 to 400 BC cal.</td>
<td>Organic Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>530 BC cal.</td>
<td></td>
</tr>
<tr>
<td>Buenavista 08 B10/ I-1</td>
<td>40</td>
<td>130 to AD 350 cal.</td>
<td>Ovicaprid Bones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD 240 cal.</td>
<td></td>
</tr>
<tr>
<td>Buenavista 08 D9/I-1</td>
<td>40</td>
<td>160 BC to AD 60 cal.</td>
<td>Organic Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 BC cal.</td>
<td></td>
</tr>
<tr>
<td>Buenavista 08 D9/II-3 wall</td>
<td>40</td>
<td>1050 to 890 BC cal.</td>
<td>Carbon</td>
</tr>
<tr>
<td>foundations</td>
<td></td>
<td>870 to 850 BC cal.</td>
<td></td>
</tr>
<tr>
<td>Buenavista 08 H2/I-2 base</td>
<td>40</td>
<td>360 to 290 BC cal.</td>
<td>Organic Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>240 to 50 BC cal.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>180 BC cal.</td>
<td></td>
</tr>
</tbody>
</table>
Figure 25: Localization of Buenavista in Lanzarote Island. Map reproduced with permission by Professor Atoche Peña.
Figure 26: Ovicaprid tooth used in this project.

Rodent teeth

This project used a modern rabbit crania and a lower mandible that were found at surface level soil from which teeth were extracted and processed for obtaining of strontium isotopic signatures. It is not possible to know if these were different rabbits or the same specimen due to the samples’ proximity when found.

Laboratory Methods
The tree leaves and plant material were rinsed with demineralized water and left to dry at room temperature. Once desiccated, leaves were crushed in crucibles, weighed, and placed inside a Thermolyne Dubuque III muffle furnace at 500-600°C for 12-14 hours. The ashing process was done at the Plant Physiology Laboratory in the College for Natural Resources and Sciences Core Research Facility (CNRS) at Humboldt State University (HSU) under the direction of Dr. Casey Lu and Dr. David S. Baston. Samples were weighed again after ashing and placed into scintillation vials for additional preparation and processing at the Isotope Geochemistry Laboratory at the University of North Carolina (UNC), Chapel Hill, under Professor Drew Coleman’s direction. Eric Bolling, laboratory technician at the Geology Department at UNC, collaborated in the preparation of samples and the loading of samples into the VG (Micromass) Sector 54 thermal ionization mass spectrometer (TIMS) for isotope analysis.

The preparation of the remaining samples went as follows. Snail shells were cleaned with ultrapure water using a scaler to clean off the adhered dirt. Cleaned shells were powdered with an agate mortar and pestle and placed into scintillation vials. About 0.5 g of caliche rock was also crushed manually with an agate mortar and pestle and placed into a vial. Each ovicaprid teeth was sonicated inside a glass beaker half-filled with MilliQ H₂O. After, samples were mechanically cleaned and abraded with a carbide burr drill using a cone-shape diamond tip in order to extract the enamel, careful to not include dentine and pulp, since these would have contaminated the sample. Powdered enamel, ca. 1 mg, was placed into vials ready for the weak acetic solution wash before
loading into the TIMS. The preparation steps needed to condition the samples for the obtaining of $^{87}\text{Sr}/^{86}\text{Sr}$ from the TIMS were all the same for vegetation, faunal remains and caliche.

Next, teeth, shells and caliche were dissolved in $\sim 550 \, \mu\text{L}$ 3.5 Molar (M) nitric acid (HNO$_3$). About 0.8 g of ashed plants were dissolved on $\sim 700 \, \mu\text{L}$ to ensure complete dissolution of material. All samples were left in acid for ca. 24 hours. Isolation of Sr was accomplished using 50-100 $\mu\text{m}$ Sr-Spec$^{\text{TM}}$ resin. Teflon columns that would hold the resin were rinsed in preparation for filling with resin. After, ultrapure water was added to the stem and reservoir of the column, they were loaded with the resin from a dropper bottle (filling column to just below base of reservoir). Each column was placed over waste beakers where all unnecessary elements from the sample were discarded while trapping the Sr on the resin. While resin was settling in the columns, dissolved samples were transferred to centrifuge tubes and centrifuged at a rate of 9,000 rpm for 9 minutes.

After columns were settled with Sr-Spec$^{\text{TM}}$, the resin was washed by filling the reservoir with 21 drops of MilliQ H$_2$O twice to ensure any previous Sr was flushed into the waste-beaker. Prior to loading the samples, the resin was preconditioned with a first set of 2 drops of 3.5 M of HNO$_3$ and a second set of 13 drops (a total of $\sim 450 \, \mu\text{L}$). Once the resin was ready to receive the sample diluted in nitric acid and centrifuged, 500 $\mu\text{L}$ of sample solution was pipetted from the centrifuge tube onto columns and allowed to drain through completely into the waste-beaker ($\sim 30$ minutes). 30$\mu\text{L}$ of 3.5 M HNO$_3$ were
added three times and allowed to flow completely through waste to fully set the sample onto the resin. Four times ~360 µL (12 drops) 3.5 M HNO₃ were added and each was allowed to flow completely into the waste-beaker before the next was added. These bulk rinses allow all elements, except Sr to be removed to waste. The waste-beaker was discarded and replaced by a clean beaker where the final sample was flushed via eluting the column with ~ 450 µL ultrapure H₂O two times (~ 20 minutes each). Finally, one drop of phosphoric acid (H₃PO₄) was added to each beaker and the Sr was evaporated to near dryness on a hotplate at 130°. The samples were loaded onto a single Re filament with a TaF₅-emitter solution in preparation for testing. Analyses were done with a 3V 88Sr ion beam (10¹¹ ohm resistors) in triple dynamic analysis mode using five faraday detectors. All data are reduced using a multi-dynamic reduction method normalized to 86Sr/88Sr = 0.1194 assuming exponential mass fractionation and are referenced to Sr standard NBS 987 with ⁸⁷Sr/⁸⁶Sr of 0.710250 (Personal Communication, Drew Coleman and Ryan Mills, March 2016).

Results

One way to determine the range of local Sr available in the terrain is to use the mean of the sample plus and minus two standard deviations (Knudson et al. 2009; Price et al. 2002). The range of strontium isotope ratios from this baseline study is situated between 0.7053 ± 0.0008 and 0.7090 ± 0.0007 (Figure 27 and 28). The lowest ratio was obtained from a vegetation sample growing on Upper Miocene volcanic formations (PC-
2 at a ratio of $0.7053 \pm 0.0008)$. The highest signature comes from sample PC-8, also vegetation, collected on Lower Pleistocene rocks ($0.7090 \pm 0.0007$).

Figure 27: This graph represents the results from stable isotopic analysis of $^{87}\text{Sr}/^{86}\text{Sr}$ in the island of Lanzarote. Data is arranged by geologic zone value. Each grouping goes as
follow from right to left: Miocene, Mid-Pleistocene, Low Pleistocene, Mio-Pliocene and Historic eruptions.

Figure 28: This chart groups the data by sample types. Vegetation represents up to 16 in the horizontal axis, snail shells are between 17-20, rabbit tooth 21-22, caliche 23, ovicaprid teeth 24-27.

Key additions to the sample size of this project were the zooarchaeological teeth from ovicaprids, once herded by ancient populations of Lanzarote. Professor Atoche-Peña and his investigation team dated (Table 3) these specimens from Buenavista, in the following way:
• PC-1pt 0.7082 ± 0.0007 located in a layer dated ca. AD 240
• PC-2pt 0.7083 ± 0.0007 situated around ca. 40 BC
• PC-3pt 0.7077 ± 0.0007 in stratigraphy ca. 380 BC
• PC-4pt 0.7089 ± 0.0007 with no data published in this sample’s stratigraphic location.

There is a slight variation between PC-3pt, zooarchaeological samples, showing the lowest ratio among the four teeth of the ovicaprids, which together provide a similar average. None of the values from these four ovicaprids from Buenavista match the composition of the terrestrial snail-shell (PC-30) also acquired in Buenavista. PC-30 is the second highest ratio measured in this sample group. See Table 4 for results.

Table 4: This table represents the project’s sample size. The different geologic locations of the island of Lanzarote are the following: Miocene (M), Mid-Pleistocene (MP) Historic eruptions (H), Late Pleistocene (LP) and Mio-Pliocene (MPL) epochs. The last four samples are separated to make a distinction between the results obtained from modern data and archaeological results.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Material</th>
<th>Location and Geology</th>
<th>87Sr/86Sr</th>
<th>% Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC-1</td>
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<td>Ajaches M</td>
<td>0.70772</td>
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<td>PC-2</td>
<td>Vegetation</td>
<td>Ajaches M</td>
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<td>PC-5</td>
<td>Snail Shell</td>
<td>Ajaches M</td>
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<td>0.0008</td>
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<tr>
<td>PC-7</td>
<td>Caliche</td>
<td>Ajaches M</td>
<td>0.708421</td>
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<td>PC-8</td>
<td>Vegetation</td>
<td>Montaña Roja MP</td>
<td>0.709075</td>
<td>0.0007</td>
</tr>
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<td>PC</td>
<td>Object Type</td>
<td>Site</td>
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<td>-----</td>
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</tr>
<tr>
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<td>MP</td>
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</tr>
<tr>
<td>PC-28</td>
<td>Vegetation</td>
<td>Tahiche</td>
<td>H</td>
<td>0.706498</td>
</tr>
<tr>
<td>PC-29</td>
<td>Vegetation</td>
<td>Tahiche</td>
<td>H</td>
<td>0.708197</td>
</tr>
<tr>
<td>PC-30</td>
<td>Snail Shell</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.709068</td>
</tr>
<tr>
<td>PC-31</td>
<td>Vegetation</td>
<td>Guenia</td>
<td>LP</td>
<td>0.707458</td>
</tr>
<tr>
<td>PC-33</td>
<td>Vegetation</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.708640</td>
</tr>
<tr>
<td>PC-34</td>
<td>Vegetation</td>
<td>Bebedero</td>
<td>MP</td>
<td>0.707319</td>
</tr>
<tr>
<td>PC-1pt</td>
<td>Goat-sheep tooth</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.708243</td>
</tr>
<tr>
<td>PC-2pt</td>
<td>Goat-sheep tooth</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.708361</td>
</tr>
<tr>
<td>PC-3pt</td>
<td>Goat-sheep tooth</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.707789</td>
</tr>
<tr>
<td>PC-4pt</td>
<td>Goat-sheep tooth</td>
<td>Buenavista</td>
<td>MP</td>
<td>0.708944</td>
</tr>
</tbody>
</table>
Lastly, during the preparing of leaves this research also calculated the percent loss after combustion of air-dried material. The greatest change in mass can be seen in sample PC-18 with 95.5% being lost after ashing 2.63 g of the crushed plant leaves. The least percentage loss can be seen in sample PC-8 at 71.2% reduction from a 5.9 g pre-ashed and crushed specimen. Refer to Table 5 for these values.
Table 5: 15 samples of vegetation and their amount in grams. The weight of how much of the plant was lost in the process of ashing as well as the percentage ratios of this amount of plant material loss.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Pre-ash (g)</th>
<th>Post-ash (g)</th>
<th>Ratio</th>
<th>% Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.13</td>
<td>0.63</td>
<td>4.13/0.63 = 6.556</td>
<td>84.7</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0.44</td>
<td>6.181</td>
<td>85.3</td>
</tr>
<tr>
<td>8</td>
<td>5.9</td>
<td>1.7</td>
<td>3.471</td>
<td>71.2</td>
</tr>
<tr>
<td>16</td>
<td>1.67</td>
<td>0.35</td>
<td>4.771</td>
<td>79</td>
</tr>
<tr>
<td>17</td>
<td>1.22</td>
<td>0.35</td>
<td>3.486</td>
<td>71.3</td>
</tr>
<tr>
<td>18</td>
<td>2.63</td>
<td>0.17</td>
<td>13.882</td>
<td>93.5</td>
</tr>
<tr>
<td>19</td>
<td>1.3</td>
<td>0.27</td>
<td>4.815</td>
<td>79.2</td>
</tr>
<tr>
<td>20</td>
<td>1.49</td>
<td>0.15</td>
<td>9.983</td>
<td>89.9</td>
</tr>
<tr>
<td>21</td>
<td>3.5</td>
<td>0.8</td>
<td>4.375</td>
<td>77</td>
</tr>
<tr>
<td>22</td>
<td>11.36</td>
<td>1.77</td>
<td>6.418</td>
<td>84.4</td>
</tr>
<tr>
<td>25</td>
<td>12</td>
<td>1.71</td>
<td>7.018</td>
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<tr>
<td>26</td>
<td>2.35</td>
<td>0.34</td>
<td>6.912</td>
<td>85.5</td>
</tr>
<tr>
<td>28</td>
<td>2.34</td>
<td>0.38</td>
<td>6.158</td>
<td>83.8</td>
</tr>
<tr>
<td>29</td>
<td>9.25</td>
<td>1.41</td>
<td>6.56</td>
<td>84.8</td>
</tr>
<tr>
<td>31</td>
<td>3.25</td>
<td>0.44</td>
<td>7.386</td>
<td>86.5</td>
</tr>
</tbody>
</table>
Discussion

There are myriad of factors that can influence the bioavailable ratios of strontium stable isotopes in this local environment. One of such is the fact that values obtained from vegetation are susceptible to the physiological variability that exists within plant species and how each incorporates isotopes of Sr into its tissues. As presented in chapter 3, root system types and the plant’s ability to distribute nutrients will influence the levels of strontium obtained from the analysis (Maurer et al. 2012; Rediske and Selders 1953). A second factor can be the weathering of the bedrock or parent material in addition to the atmospheric deposition of allochthonous strontium onto the biosphere (Pozswa et al. 2004). Sillen et al. (1998) showed there is a considerable amount of variability within the landscape through measuring the radiogenicity of local water, soil composition, rock and plants. Furthermore, strontium analyses from Hawaii presented the significant influence of rainwater in delivering strontium to the vegetation, affecting just as much as the weathering of bedrock (Chadwick et al. 1999). At last, this research recognizes that oceanic $^{87}\text{Sr}/^{86}\text{Sr}$ values (0.7092) can be a major influence on the ratios of strontium isotopes in plants and animals from Lanzarote.

The results here presented serve as a tentative baseline of bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ for the island. The lowest values come from vegetation samples PC-2 (0.7053 ± 0.0008) and PC-22 (0.7058 ± 0.0007), obtained from areas that belong to the geologic epochs of Miocene and Pleistocene. The highest values come from leave sample PC-8 (0.70907 ±
0.0007) and PC-30 a snail shell (0.70906 ± 0.0009), along with the ovicaprid teeth, PC-4pt (0.7089 ± 0.0007). Statistically, these two vegetation samples, PC-8 and 2 are significantly different, which means that concentration of strontium values from each specimen is distinctive. This could be related to the fact that each vegetation sample comes from different species; previous research has revealed that length of roots and individual metabolic processes of each plant type influence the incorporation of Sr into their tissue.

Other factor that contributes to the bioavailable strontium of Lanzarote Island is the weathering of bedrock. Volcanic formations such as the Canary Islands, the Caribbean archipelago, Hawaiian Islands or Iceland contain high levels of basaltic material in their geology and therefore low Rb/Sr ratios, which translates into having a diminished mount of $^{87}\text{Sr}/^{86}\text{Sr}$ levels in the parent material (Price et al. 2002). Such ratios are influenced by the youthfulness of late volcanic formations, which create a basalt-derived geology in places such as oceanic islands. Basalt usually shows ratios between 0.703 and 0.704 (Dickin 1997; Price and Gestsdóttir 2006; Price et al. 2002; Taylor et al. 1998). These low values corresponding to the geology of Lanzarote are reflected by vegetation samples PC-2, 22, and samples 23 and 24 (modern rodent teeth) with the lowest values analyzed in this study; their strontium levels of 0.705 are seemingly close to those expected from a volcanic island. However, they do not match the values of strontium in Canarian basalt that Grousset and colleagues (1992) obtained from the island of Fuerteventura (0.7031), nor do they coincide with strontium measurements from
Canary loesses (0.7122) from Figure 29. This is not surprising since research has demonstrated that bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ values are not representative of the bedrock’s geochemistry (Price et al. 2002).

![Graph showing strontium isotopic levels from different sources.](image)

Figure 29: This graph represents the range of radiogenicity in the areas surrounding the Canarian archipelago; note the marked difference for number 6 with the highest measurements of all. Strontium isotopic levels from Saharan aerosol (1); Moroccan loess (2); Fuerteventura loess (3); Tunisian dust (4); Canarian basalt (5); and Iberian Meseta (6). Data obtained from Grousset et al. 1992 and Voerkelius et al. 2010.

For this particular region, the influence of rainwater as source of Sr can be possibly ruled out. The mean annual precipitation is below 150 mm and generally torrential (Tejedor et al. 2011), which implies that not much of Lanzarote’s strontium is
being delivered by rain. As consequence of this aridity, local fresh water sources are not present in the island’s modern landscape. Aside from rainwater and local fresh water, other possible factors that can be delivering allochthonous Sr into the terrain are: aeolian deposition of African dust (Figure 29 above) and sea spray. Given the proximity to the Saharan and Sahelian deserts, aeolian deposits need to be taking into account when understanding the bioavailable strontium of Lanzarote’s landscape. As previously mentioned, the island is mainly composed of basalts originated from intense volcanic periods, as well as containing calcareous dunes and admixture from aeolian deposits from the neighboring African continent. Muhs and colleagues (2010) detected a layer of clay-like deposits in La Corona volcano, north of Lanzarote, where minerals such as mica, quartz, kaolinite, and hematite were studied. This mineralogy is typical of the Sahelian and Saharan deserts (Figure 29), which suggest its deposition through aeolian delivery (Muhs et al. 2010). Given the evidence obtained from the research of Grousset and colleagues (1992), where North African soils show strontium isotopic measurements between 0.7142 and 0.7231, and knowing that Muhs and colleagues identified allochthonous mineral material mixed with Lanzarote’s soils, this research was expecting to obtain bioavailable strontium values between 0.703, 0.7142 and 0.7231. The last two ranges are representative of North African loesses (Figure 30), which are the type of soil material that was detected in La Corona volcano (Muhs et al. 2010). Interestingly, none of the specimens in this project have yielded ratios as high as those of North African origin. Even the three samples obtained from a zone relatively close to La Corona with
the same Late Pleistocene geology did not show as high of ratios as those expected from
the strontium of Northwest Africa. These samples are PC-22 (fig tree leave), and 23-24 (rodent teeth), and their respective values are $0.70580 \pm 0.0007$, $0.70583 \pm 0.0010$ and $0.70589 \pm 0.0010$, which virtually represent the same ratios. This could suggest that these specimens are bioaveraging more the Sr delivered by parent material and sea spray than aeolian North African dust deposits.

Figure 30: The Canary Islands and the Saharan coasts. This picture clearly shows the significant influence of desert winds on the easternmost islands of Lanzarote and Fuerteventura (image retrieved from http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=12665).
Sea spray is another important contributing factor into the geochemistry of Lanzarote is oceanic strontium, which has universal values of 0.7092. Coastal and island settings are highly susceptible to marine-derived strontium into terrestrial ecosystems (Lafoon et al. 2012; Price and Gestsdóttir 2006; Vitousek et al. 1999). For example, previous research on the Vanuatu Islands has shown that strontium signatures of reef limestone material resemble marine radiogenic ratios (Bentley et al. 2007). Similarly, for the Canary region, limestone is one of the main geochemical components of the region and so the influence of seawater strontium on the landscape of these islands is a given. In fact, the tentative range provided here does not surpass 0.7090, which is an indicator of the possible tendency of plants and faunal specimens to be bioaveraging the strontium deposited by sea spray.

Other factors that could be contributing to results obtained by this research are those related to anthropogenic activities, for example previous research has shown the influence of pesticides in the atmosphere and the possibility of causing alterations to the biochemistry of local organisms (Böhlke and Horan 2000; Frei and Price 2012). Note that the samples PC-22, 23, and 24 were obtained from Máguez, an agricultural area, hence there is a possibility for the presence of man-made chemicals affecting faunal and floral strontium uptake. This influential factor is difficult to discern with the sample size of this project; in addition, there is not a substantial amount of research done on the influence of pesticides in Europe (Frei and Price 2012). This research used the teeth from specimens
23 and 24 in order to avoid contamination; however, given that rabbit skeletons were found at surface levels, the possibility of diagenesis, or post-mortem strontium, is taken into account. Apart from these factors, the similar ratios among PC-22, 23 and 24, could suggest the locality of the rabbit(s)’ life. The crania and lower mandible were found nearby a fig tree that was also sampled in Máguez (PC-22). Could these be reflecting the bioavailable Sr ratios of that specific terrain located in the northern part of the island?

The results from ovicaprid dental material do not provide significant variation even though each sample belongs to different chronological epochs. This observation seems reasonable due to the fact that measurements of the geochemistry of bedrock should remain the same over millennia unless dramatic geological events occur (Bentley 2006). Therefore, the mineralogy of Lanzarote should stay constant despite the ecological changes from wetter to drier periods, as well as changes in soil productivity. Hence, the fact that PC-1pt (0.7082 ± 0.0007), 2pt (0.7083 ± 0.0007) and 4pt (0.7089 ± 0.0007) have similar ratios suggests a possible consistent signature for the Buenavista site. However, PC-3pt (0.7077 ± 0.0007) shows a significantly different measurement from the other three. This variation could be due to metabolic influences from the animal’s ability to bioaverage Sr. Another factor could be the diet of the animal and if it was grazing in an area different from the other bovidae. Additionally, these four samples do have a similar ratio to the other specimens also obtained in Buenavista, PC-33 (vegetation) and 30 (snail shell. Again, this similarity of signatures within a site where samples are collected can also be recognized in 22-24. Given the almost identical signatures of these three samples
from Máguez, all collected within 5 m radius, and the similar ratios found in samples from Buenavista – also collected within a radius of 5-6 m – it could be tentatively inferred a possible relationship between short range and signature. Anyhow, in order to make an educated statement a greater sample size is required.

Conclusion and Further Research

This sample range does not have an isotopic composition directly linked to the geologic zone where each sample was obtained (Figure 24). Specimens collected from Mid-Pleistocene zones have inconsistent ratios ranging from 0.7068 ± 0.0007 (PC-19) up to 0.7090 ± 0.0007 (PC-8). Samples from Los Ajaches, mountains eroded during the Miocene, also have significant Sr isotopic variability. Within this limited geographic range $^{87}\text{Sr}/^{86}\text{Sr}$ ratios fall between 0.7053 ± 0.0008 (PC-2) and 0.7084 ± 0.0008 (PC-7, caliche). The snail shell analyzed from the same area has somewhat lower ratio of 0.7079 ± 0.0008 (PC-5). Furthermore, in order to understand trophic level and uptake of Sr, this sample size does not contain enough specimens to make educated statements about the relationship between taxonomy and how the bioaveraging of strontium is reflected.

Previous research has shown Sr/Ca in herbivores is 20% of that in plants (Bentley 2006; Burton and Wright 1995), thus having more abundance of Sr/Ca ratios in their organism than carnivores. From literature it could be inferred that vegetation should have higher quantities of strontium for being in direct contact with the terrain where Sr deposits. Furthermore, bovid teeth or samples PC-1-4pt, belonging to secondary consumers, should
have a higher content of Sr in their system that those possibly found in tertiary consumers, or humans.

In the case of Lanzarote, having a value range of 0.7053 to 0.7090 shows the relative amount of geochemical variability that exists within the region, which can be the product of a combination of the aforementioned atmospheric phenomena and metabolic processes. Investigations have shown bioavailable ratios are not always representative of the local parent material due to the multiple components that constitute the local environment (Price et al. 2002). The variability of local $^{87}\text{Sr}/^{86}\text{Sr}$ signatures in Lanzarote does not allow research to use strontium isotopes to identify intra-insular mobility within the territory. This means that archaeologists could not use this technique to talk about humans or animal populations moving from north to south of the island. To the contrary, mobility of communities from continental landmasses into the archipelago is a more reasonable approach when applying this technique. We know that the northern part of the African continent contains strontium ratios higher in radiogenicity than those of Lanzarote and Fuerteventura (Grousset et al. 1992). Moreover, Voerkelius et al. (2010) identified strontium bioavailable ratios for the south of Spain being as high as 0.7777. Such parameters are differentiated from what this study has obtained in Lanzarote, a discrepancy allowing us to compare the high radiogenic levels of continental landmasses against the low measurements of this island.

The amount of variation between Lanzarote and its continental neighboring regions has promising connotations for the study of ancient human migrations into the
islands. It can be tentatively assumed that populations born either in the Iberian Meseta or North Africa and moved into the island could potentially show differentiated strontium averages in their teeth and bone. The strontium isotopes that seem to be available for plants and animals of Lanzarote do not reflect the mineralogy of North African loesses, which is convenient for this type of study because it provides the marked distinction between what is biologically available in one location versus the other. If this research had obtained Sr isotopic levels reflecting Tunisian and Moroccan dust ratios in its samples, then Lanzarote’s homogenous geochemistry would not allow distinguishing between African originality and Canarian provenance. In addition, the extremely high bioavailable Sr levels of south Spain, another possible origin for migratory communities, serve as a great contrasting limit for this study. For example, an individual that spent his/her childhood in Spain, and later migrated and deceased in Lanzarote would be able to show this mobility through the different ratios on both enamel and bone isotopic levels. The teeth should reflect strontium isotopic ratios similar to the high radiogenicity of the Iberian Meseta against bone $^\text{87}\text{Sr}/^\text{86}\text{Sr}$ ratios, which should correspond to Lanzarote’s lesser signatures. This last hypothesis can only be tested if more vegetation and zooarchaeological samples are analyzed from Lanzarote as well as archaeological human samples.

The sample size used for this research shows a clear bias for MP locations with an almost total lack of specimens from H, LP or MPL zones (refer to Table 4). Therefore, future investigations need to include a higher range of materials from all geologic periods
of Lanzarote Island, as well as collecting soil matter and local fresh water if present. Additionally, if former human remains are going to be assessed, sampling collection methods need to focus on agricultural products consumed by the ancients such as wheat and barley, along with arboreal fruits, and other vegetation. A focus also needs to be directed to trace element analyses of ancient bovid species in an aim to understanding \(^{87}\text{Sr}/^{86}\text{Sr}\) uptake by these animals from Lanzarote.

In essence, the radiogenic difference between the geochemistry of continents and island formations makes studies on \(^{87}\text{Sr}/^{86}\text{Sr}\) levels viable for archaeological research on human population mobility. This research has shown the possibility of studying bioavailable Sr stable isotopes in Lanzarote Island as a mean to understand former migratory trends to the region. The preliminary baseline here presented, along with information provided by previous investigations on oceanic islands, gives us the foundation to believe in the viability of using Sr as a trace element to understand migration patterns into this region. In order to accept or reject this hypothesis, additional and extensive sampling needs to be done to adequately map \(^{87}\text{Sr}/^{86}\text{Sr}\) variability in Lanzarote. Further research would also include the rest of the archipelago and would especially focus on zooarchaeological samples that were in close contact with ancient human communities of the Canaries. Moreover, better assessment of plant material would need to be done as a way to understand the possible factors that are influencing the delivery of Sr ratios into the biosphere. At last, future research would select plant species that were once utilized by those former groups as a way to understand the amount of Sr
retained by such species relative to the percentage of the element that gets incorporated into the human organism.

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