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DIPLOMA THESIS:

USE OF GIS IN ANALYZING ARCHAEOLOGICAL SITES: THE CASE STUDY OF MYCENAEAN CEPHALONIA, GREECE

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Abstract

This thesis aims to present a method to investigate the relationship between the funerary archaeological sites of Mycenaean Period (1.700/1.680 – 1.060/1.040 B.C.) in the island of Cephalonia and their geomorphological and environmental characteristics. Cephalonia, located in the Southwest part of Greece, yields a significant number of Mycenaean archaeological remains, providing the opportunity to spatially analyse the funerary archaeological sites from this area using Geographic Information System (GIS), a program that is becoming more widely employed and accepted in archaeological studies. In this thesis, GIS and spatial analysis were applied in order to investigate possible relations between the sites and a number of geological, morphological and environmental criteria. Some of the geomorphological characteristics of the study area are analysed and explained, such as Aspect, Elevation, Geology, Hydrographic Network and Slope. The combination of all available geological and environmental data with archaeological information can provide a better understanding of the past and innovating ways to reveal the unknown to us Mycenaean's world. The results of this investigation, which are presented below, include some important factors, for instance orientation, low terrain area, geological resources, hillshade, water and incline that could be associated with the preferred location of burial archaeological sites.

Keywords: Aspect, Elevation, Geology, GIS, Hillshade, Hydrographic Network, Mycenaean, Slope

Περίληψη

Σκοπός της παρούσας διπλωματικής είναι η παρουσίαση μιας μεθόδου για τη διερεύνηση της σχέσης μεταξύ των ταφικών αρχαιολογικών χώρων της Μυκηναϊκής Περιόδου (1.700 / 1.680 - 1.060 / 1.040 π.Χ.) στην Κεφαλονιά και των γεωμορφολογικών και περιβαλλοντικών χαρακτηριστικών τους. Η Κεφαλονιά, που βρίσκεται στο νοτιοδυτικό τμήμα της Ελλάδας, απέδωσε ένα σημαντικό αριθμό μυκηναϊκών αρχαιολογικών καταλοίπων, παρέχοντας την ευκαιρία να αναλυθούν χωροταξικά αρχαιολογικοί χώροι της περιοχής με τη χρήση Γεωγραφικών Συστημάτων Πληροφοριών (ΓΣΠ), προγράμματα που γίνονται όλο και πιο ευρέως διαδεδομένα και αποδεκτά στην αρχαιολογική έρευνα. Στα πλαίσια αυτής της διπλωματικής εφαρμόστηκε (ΓΣΠ) και χωρική ανάλυση για να διερευνηθούν οι πιθανές σχέσεις μεταξύ των αρχαιολογικών χώρων και μια σειρά γεωλογικών, μορφολογικών και περιβαλλοντικών κριτηρίων. Μερικά από τα γεωμορφολογικά χαρακτηριστικά της περιοχής μελέτης αναλύονται και εξηγούνται, όπως ο προσανατολισμός, το υψόμετρο, η γεωλογία, το υδρογραφικό δίκτυο η σκίαση και η κλίση του εδάφους. Ο συνδυασμός όλων των διαθέσιμων γεωλογικών και περιβαλλοντικών δεδομένων με τις αρχαιολογικές πληροφορίες μπορεί να προσφέρει καλύτερη κατανόηση του παρελθόντος και καινοτόμους τρόπους ανακάλυψης του άγνωστου κόσμου των Μυκηναίων. Τα αποτελέσματα αυτής της έρευνας που αναλύονται στη συνέχεια παρουσιάζουν μερικούς σημαντικούς παράγοντες, όπως για παράδειγμα τον προσανατολισμό, την χαμηλή έκταση του εδάφους, τους γεωλογικούς πόρους, το νερό, την σκίαση του εδάφους και την κλίση του εδάφους, που θα μπορούσαν να συσχετιστούν με την προτιμώμενη θέση των ταφικών αρχαιολογικών χώρων.

Λέξεις Κλειδιά: Γεωγραφικά Συστήματα Πληροφοριών (ΓΣΠ),Γεωλογία, Κλίση εδάφους, Μυκηναϊκή εποχή, Σκίαση του εδάφους, Προσανατολισμός **,** Υδρογραφικό δίκτυο, Υψόμετρο

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Chapter I

1.1. Introduction

Cephalonia is the largest of the Ionian Islands and is located in western Greece in a particularly interesting area, which yields a number of archaeological sites and remains. Archaeological excavations in Cephalonia have been carried out around the whole island with sites that belong to different eras and periods. The first archaeological sites excavated were in the nineteen century and research is still continuing till today providing new archaeological findings. This thesis serves to add to the knowledge of the island and to enhance previous research providing innovating ways to understand the past. The main research objective of this thesis was to analyse the relationship between the Mycenaean burial sites and their geomorphological characteristics using a GIS. The coordinates of the sites were collected and georeferenced into ArcGIS. Then, six different criteria were applied to extract results and examine any possible correlation between them. In order to interpret the results, it is important to present the historical and archaeological context of the island. *Index* (1.) shows the historical periods that are going to be discussed in this thesis.

In order to fully understand the history of the island, spatial analysis of the sites using a Geographic Information System was applied. A Geographic Information System (GIS) is a powerful tool used in various fields. The combination of GIS and archaeology has been proven to be an ideal combination for the archaeological studies (Wheatley and Gillings 2002). The spatial analysis of sites can give us information for the relationship between the remains and help us interpret the historical and cultural circumstances (Merkouri and Kouli 2012). The main research of this thesis is to analyse spatial patterns of the archaeological sites from Cephalonia using a Geographic Information System (GIS).

Stone Age	Chronology
Palaeolithic Era	
Lower or Old Stone Age	Till 200.000 BP
Middle Paleolithic	200.000-35.000 BP
Late or Upper Paleolithic	35.000-10.000 BP
Mesolithic Era	10.000-7.000/6.900 B.C.
Aceramic or Pre-Pottery	7.000/6.900-6.400 B.C.
Neolithic	
Early Neolithic	6.600-5.900/5.800 B.C.
Middle Neolithic	5.900/5.800-4.800 B.C.
Late Neolithic	4.800-3.300 B.C.
Bronze Age **Early Bronze Age (EBA)**	
EBA I	3.300-2.700/2.500 B.C.
EBA II	2.700/2.500-2.300 B.C.
EBA III	2.300-2.000 B.C.
Middle Bronze Age (MBA)	
MBA I	2.000-1850 B.C.
MBA II	1.850-1.775 B.C.
MBA III A	1.775-1.750 B.C.
MBA III B	1.750-1.700/1.680 B.C.
Late Bronze Age (LBA) or Mycenaean	
LBA I A	1.700/1.680-1.675/1.650 B.C.
LBA I B	1.675/1.650-1.625 B.C.
LBA II A	1.625 - 1520/1480 B.C.
LBA II B	1.520/1.480-1.435/1.405 B.C.
LBA III A1	1.435/1.405-1.390/1.370 B.C.
LBA III A2	1.390/1.370-1.360/1.325 B.C.
LBA III B	1.360/1.325-1.200/1.190 B.C.
Early LBA III C	1.200/1.190-1.150/1.140 B.C.
Middle LBA III C	1.150/1.140-1.100/1.090 B.C.
Late LBA III C	1.100/1.090-1.060/1.040 B.C.
Sub - Mycenaean (SM)	1.060/1.040-1.000 B.C.

Index 1. Archaeological Periods of Cephalonia.

1.2. Overview

The thesis is organized into six chapters. Part one consists of an introduction of the essay including information about the Geographic Information System (GIS) and some important information about this thesis. The second chapter is a literature review of the history of GIS and its use in archaeological research. Chapter three is outlines the GIS methodology, an overview of the study area, including its historical presentation and a more extensive presentation of each location under study. The next chapter presents the processes and factors applied as well as the presentation of the results. The next two chapters that follow are about the results of the analysis, its discussion and conclusions, providing a summary of the research carried out in this thesis. The benefits of using GIS in an archaeological research are highlighted and future directions of the use are discussed. Finally, the references and appendices are given.

1.3. Purpose

This thesis' main purpose is to investigate the relationship between burial archaeological sites and the geomorphological characteristics of the surrounding area. The research attempts to find a possible relation between the Mycenaean burial sites and the natural environment. GIS is a necessary tool in this process (Malaperdas and Zacharias 2018 .– Merkouri and Kouli 2011). One of the main assumptions in this research is that the site's location is influenced by geomorphological conditions. Affecting factors could be the hydrographic network, geology, elevation, aspect and hillshade.

Cephalonia Island is rich in archaeological sites but remains unexplored in relation to similar areas in Greece. This makes the island ideal for archaeological studies and the implementation of a geographic information system analysis. This thesis intends to offer an overview of GIS possibilities in archaeology and the possibilities of applying them for better understanding Cephalonia's history. Different factors influencing the location of Mycenaean sites could be the climate, soil type and proximity to natural and cultural resources, social and economic activities.

This thesis intends to present the need for investigating the relationship between the archaeological sites and their natural environment. In addition, it will show the importance for the investigation of archaeological sites and the creation of digital archaeological maps for the protection and preservation of the archaeological remains.

Chapter II

2.1. History of GIS

Geographic Information Systems (GIS) are computer – assisted systems for the capture, storage, retrieval, analysis and display of spatial data (Clarke 1986). GIS is a system that enables you to capture information, model and manipulate, retrieve and analyse spatial information and present geographically referenced data (Gumusay *et al* 2008). GIS was first designed during the 1960s for the need of Canada's federal government to handle spatial data. Its technology is rooted in Geography, which means that some portion of the data is spatial. More recently, computerized systems for managing spatial information have been developed and increased rapidly within a variety of fields. Many definitions and terms have been proposed for defining GIS use and possibilities, to illustrate the range of applications and emphasis. The term GIS was firstly used by Roger F. Tomlinson, the primary originator and visionary of the geographic information system (Chrisman 1999). But today's GIS has been enriched after decades of scientific development.

The first application of GIS concept was in 1832 when the French geographer Charles Picquet represented cholera outbreak across forty-eight (48) districts of the city of Paris (Jangra et 2013). His work 'Rapport sur la marche et les effets du choléra dans Paris et le département de la Seine' contained one of the earliest applications of spatial analysis in epidemiology. An early thematic map showed the 48 districts of Paris represented by color gradient according to the percentage of deaths from cholera per 1000 inhabitants (Jangra et 2013). In 1854 John Snow showed a cholera outbreak in Soho, London by marking points on a map which lead to identifying the sources of the disease, contaminated water pump. His study was one of the earliest uses of a geographic methodology in epidemiology. Hand drawn maps had been the traditional mean of record about the Earth information and visual representation. John Snow representation was not only depicting data in a map but also analysing clusters of geographically dependent data.

In the early 20th century a printing technique called Photozincography was introduced, which allowed users to separate layers on a map. The technique was particularity used for printing contours (Awotunde 2014) and although it was an intensive task, it provided the preliminary step towards the development of GIS.

The GIS technology evolved during the 1960s (Clarke 1986) when the first true operational GIS was developed by DR. Roger Tomlinson. It was presented in Ottawa in his paper "A Geographic Information System for Regional Planning" (Tomlinson 1962) by the Federal Department of Forestry and Rural Development and was called the Canada Geographic Information System (CGIS). In August 1963, it was organized the First Annual Conference on Urban Planning Information Systems and Programs by Edward Horwood.

In 1964 Howard T. Fisher formed the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design. During the late 1970s two public domain GIS Systems MOSS (Map Overlay and Statistical System) and Grass GIS (Geographic Resources Analysis Support System) emerged and by the early 1980s, dominant companies among the GIS software venders of GIS software appeared (Waters 2017). Intergraph and ESRI (Environmental Systems Research Institute) were among these first companies, which are now the leading experts in GIS software development, combining the first approach to separation of spatial data and attribute with a second of organizing attribute data into database structures.

In 1986 the first desktop GIS product was created for the DOS operating system (Jangra et 2013). It was named MIDAS (Mapping Display and Analysis System), which was renamed to MapInfo in 1990 when it was ported to the Microsoft Windows platform (Jangra et 2013). This was the beginning of the business and corporate GIS.

During the 1990s the development of GIS saw tremendous changes of the academic use and new educational initiatives characterized this period. By the end of 1990, GIS software products were used in many different kinds of academic and administrative departments (Water 2017). Nowadays, online repositories like ArcGIS can store massive amount of spatial data and the number of commercial GIS software products range fitting the needs and demands of the user. Open source GIS software is gradually entering different academic and educational departments. QGIS (Quantum Geographic Information System) is the most widely used open Source desktop GIS worldwide.

2.2. Previous Studies

Archaeology is specialized in the study of human and material remains and human society development, from the beginning of human appearance up to present day. The application of physical sciences for answering questions that arise during archaeological research was an innovation in the field of cultural heritage. As it is known, archaeology deals with an enormous amount of data, varying in scale, location and context. Researchers have long been aware of the importance of technology and its applications in the field of archaeology. The need for highly precise maps and ground – plans dates back in the 18th century, where some of the earliest excavations were recorded. GIS can refer to different practices and fields, it has many applications related to archaeology. Over the past few years, what is called GIS has emerged as a promising new approach for studying the past. GIS has a wide range of application using geospatial technologies and analytical techniques for archaeological research and investigation. The main technology is usually GIS software. As a research method for archaeology, GIS systems offer a range of tools to help visualize archaeological information in its natural context and examine them.

As more environmental data are becoming available archaeologists are presented with the possibility to compare the environmental and social development with detail. Over the last decades, the quality and volume of spatial data have increased with new techniques and equipment, available to the archaeology community.

In 1980s GIS was commonly used by North American archaeologists and in Cultural Resource Management. In 1990s (Katsanis and Tsipidis 2005), the growths of interest in GIS lead to the wide use of GIS among the research tools. A pioneer example of GIS work was during the Bokerley Dyke excavation in the Southeast of England by General Pitt – Rivers

(Wheatlet and Gillings 2002) where the artefacts and features of the excavation were displayed in 3 – dimensional models. In North United States and Canada the large geographic areas led to the adoption of locational modelling methods for their management (Wheatlet and Gillings 2002). In 1978 Chadwick J. explored thematic layers containing archaeological information with environmental variables in Helladic settlement in the Messenian region of southern Greece. The results were displayed with Digital Elevation Models (Wheatlet and Gillings 2002). Tomlinson 1987, writing in the first volume of what was to become a flagship journal of GIS (Waters 2017) and in 1992 an international conference on GIS was held in Santa Barbara in California.

The distribution of Chalcolithic settlements was examined using ArcGIS in the Southern Levant, Israel. The spatial distributions of the Terminal Classic Maya ceremonial cave site in Belize were analysed. Wheatley using a digital elevation model (DEM) examined the construction of long barrows on the Salisbury Plain and the Avebury region. Lithic tool scatters near Grand Junction, Colorado were examined using GIS system. The spatial distribution of charcoal and sediment starch over horizontal space at the Petzke's Cave rockshelter in South Wales was analysed and showed that the two examples had inverse criteria. Conductivity and magnetic susceptibility test of sediments were examined from New Zealand to determine their cultural alteration (Mills 2009). The Bonfire Shelter was analyzed with DEM models to support the environmental conditions of a bison kill site. The spatial analysis of archaeological artefacts have been analysed in a number of cases, such as the Bird's Nest Site where the huge amount of recovered archaeological remains could not analysed otherwise (Mills 2009).

Carmichael presented a predictive model of prehistoric site distribution located in an area of north – central Montana (Middleton 1998). A GIS was used to characterize the archaeological sites Ft. Hood U.S. A site prediction model was created to survey the area of Fort Drum, in New York. Hydrological data were used by Allen to create travel patterns in eastern Great Lakes Region. Parker in 1985 introduced a predictive modelling technique for studying archaeological sites distribution with an application in Sparta Research Area. Kvamme in 1985 presented an approach to detect environmental features that could have influenced the selection of settlements. Zubrow used GIS techniques to study the spread of European population in NewYork in 1990. Warren in 1990 described the predictive models for prehistoric sites, and Lopata and Shaw in 1992 studied predictive models for the location of shipwrecks in the Sea of Marmara. Dalla Bona in 1993 studied the visual possibility of prehistoric sites in Thunder bay, Ontario. Silbemagel studied the distribution of human occupation on a landscape to retrieve information about the different cultural aspects in 1997. Ozdemir seeked a relationship between rock types and settlements distribution in 2002. White in 2002 attempted to predict archaeological locations with statistical relationships of the sites and their natural environment (Middleton 1998).

In order to fully understand the study area, all sites must be studied, in conjunction with their cultural and chronological context. The spatial analysis of the sites examines the relation between the sites and their environment, in order to interpret the cultural and natural aspects. The spatial patterns of the sites were investigated using a GIS. Detailed spatial information were collected and entered into databases. Spatial analysis or spatial statistic includes any of the formal techniques which study entitles using their topological, geometric or geographic properties. Spatial analysis includes a variety of techniques, using different analytic approaches and applied in a variety of fields. It can be carried out on archaeological sites in many ways and can be used to describe and analyse distributions, and to examine patterns. The analysis focuses on the spatial structure to determine the intensity of patterns, in order to detect concentrations of artefacts, features and sites, as well as to describe, interpret and explain any spatial relation. The complexity and many aspects of spatial analysis can vary from simple map overlay to complex statistic models.

Hand drawn maps and artifacts plots were initially used for spatial analysis (Mills 2009). As a context was first conceived in the 1950s (Mills 2009) and in 1970s was adopted by archaeologists. The first archaeological study of spatial distribution was that of Binford's in Alaska. The earliest studies of spatial patterning were the Paleolithic studies in Europe during the 1960s, such as the Leroi – Gourhan at Pincevent to define the clusters of tools (Middleton 1998). In 1978 Wilmeth created extensive maps and profiles of the Anahim Lake site in an attempt to establish a link between the complexes. In 1984 Kraoll and Isaac examined the behaviours of hominids in Koobi For and Oldai Gorge East Africa by composing clusters and gaps of artefacts. In 1995 a visual approach was used to analyse a bison kill on the Columbia Plateau. In 1984, Whallon employed the nearest neighbour analysis for the study of spatial patterning at Abri Pataud in France (Middleton 1998).

Chapter III

3.1. Study Method

A total of sixten funerary archaeological sites dated on the Mycenean Period were processed in this study. This thesis is a combination of study analysis, bibliography and on site research. First, most of the archaeological sites were visited by the researcher and the physical location was recorded in a GPS system (Mobile Topographer 9.2.0 version for Mobile Android) in order to acquire the exact coordinates, latitude and longitude. It should be noted here that not all the archaeological sites presented in this thesis were visited. Some sites were unable to be visited or identified mostly because of their natural position (wild vegetation, not accessible locations). The exact location is problematic only for a couple of archaeological sites that contained more than one burial structures in near distances and other that could not be identified in situ because of lack of inforation or their natural position. These sites were identified via Google Earth Maps, the available bibliography, topographic maps and the Ongoing Catalogue of the Listed Archaeological Sites and Mounuments of Greece[1].

Secondly, the bibliographical data including books, articles, maps and other publications were studied. All this material was used for the creation of databases using the topographic attributes of the sites and processing the information. Following, the data were digitized using software packages such as ArcGIS 10, Microsoft Excel 2010 and Google Earth Pro for comparing results and getting histograms and graphs.

No distinction was made between the funerary sites considering their size or population. The applied citeria were the chronology and the nature of the sites, as a Mycenaen burial location. All Mycenean funerary sites identified were counted in the database and

[1] Ongoing Catalogue of the Listed Archaeological Sites and Monuments of Greece: http://listedmonuments.culture.gr/

considered as a single archaeological site. Each site is considered as a single area independently of the number or the types of tombs located in the same site. The archaeological sites are represented by a point on the map with x and y coordinates and georefered to the Greek Geodetic Reference System 1987.

In total sixeteen (16) Mycenaean archaeological funerary sites which are dated on the Late Bronze Period are going to be analyzed: Aghia Pelagia Svoronata, Diakata, Gefyri, Kardakata, Kokkolata- Menegata, Kontogenada, Lakithra, Litharia Poros, Mavrata, Mavrata - Chairata, Mazarakata, Metaxata, Oikopeda Myrsines, Parisata, Riza Alafonos, Sami – Vigla and Tzanata (*Index* 3.).

At the end of the Late Bronze Period, Cephalonia is flourishing. In total, more than thirty sites have been identified as Mycenaean remains, which is the richest archaeological period of the island. As previously mentioned, the sites are organized in alphabetical order and are dated from the Paleaolithic to Sub – Mycenean Period. As seen in *Fig*. (2) and Fig. (10), most of the sites are located at the South part of the island, in the area of Kranea.

The sites can be isolated tombs or part of cemeteries. Their positiong in the environment and their relation to other elements are essential for the analysis of the Mycenean tombs within the landscape. The elements were organized into a database, where thematic layers were processing using GIS technology in order to analyse their spatial distribution. Mycenaean tombs depending on their function and period of use can have many variations and characteristics, both external and internal. There are no any specific reference for the location of the tombs in the Greek mainland and the islands they could be placed in flat areas or hill tops.

All available data archaeological, geomorphological and topographical were collected from bibliography and on site research and used to create several GIS thematic layers, that would provide the appropriate information information for the determination of the criteria. All the data were implenmented into a GIS environment and data digization using Arc GIS software package was applied.

3.1. Study Area

The study area is located in the southwest part of Greece at latitude 38° 3' 25.9" N - 38° 28' 29.3" N and longitude 20° 20' 12.1" E - 20° 48' 58.3" E. The elevation varies from 0 to 1628 meters above sea level and the area consists of seven main districts of Argostoli, Eleios – Pronnoi, Erisos, Ithaca, Leivathos, Palliki, Pylaros, Sami and the Municipality of Omala. Argostoli District is the largest and covers an area of 151,6 km^2, also is the most populated area of the island with 12.589 based on the national population censuses of 2001[2], mostly in the main town of Argostoli. The climate on the island is generally mild, with rainy winters and hot summers. The rain amount is about 700 millimeters per year and an average amount of sunshine is at 7.8 hours per day.

[2] http://www.kefallonia.gov.gr/

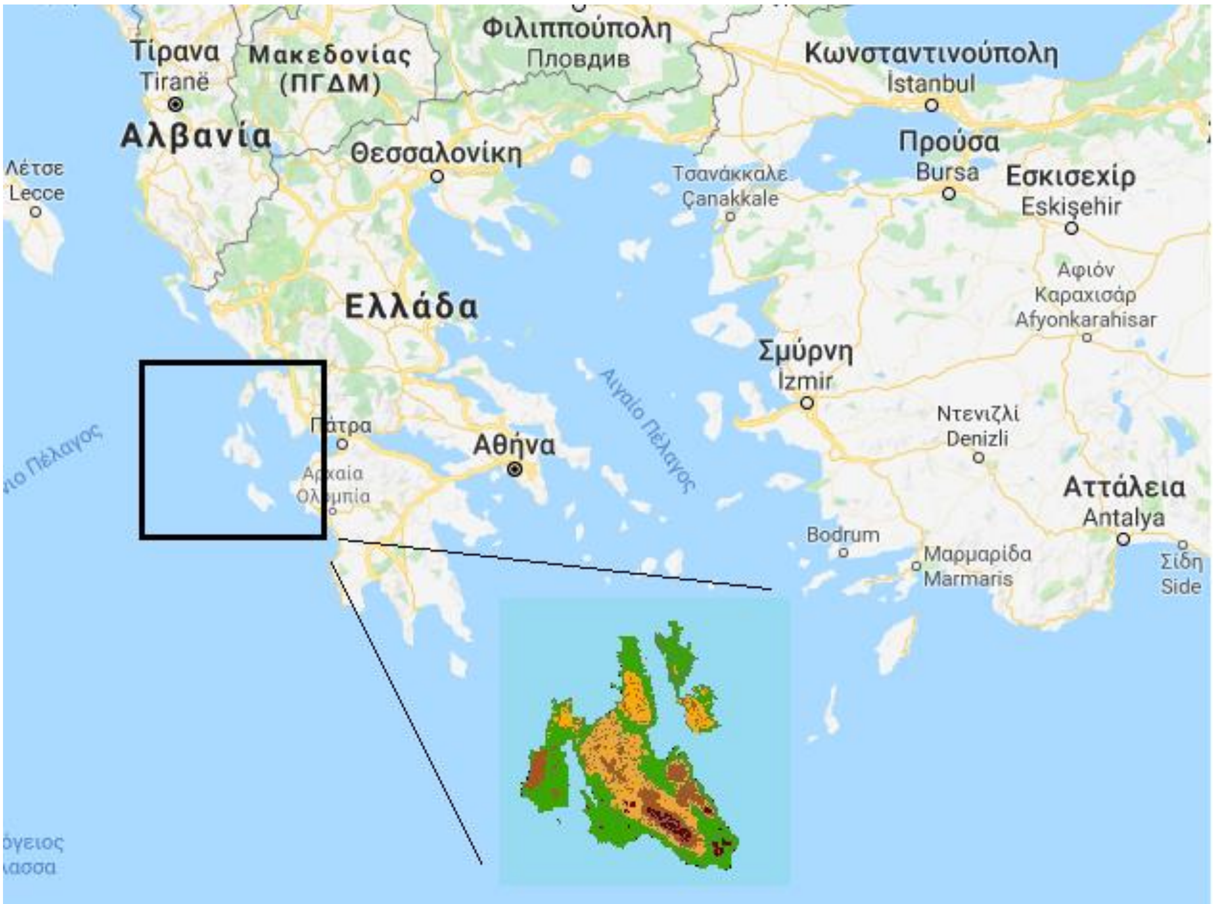

Figure **1. Map of Cephalonia**

Cephalonia or Kefallonia, also known as Kephallenia is the largest (781 km^2) (Karymbalis *et al* 2013) and the island with the highest point of the Ionian Islands. It is located opposite of the Corinthian Gulf, north of Zakynthos, west of Ithaca and south of Lefkada (Λοβέρδου Κωστή 1888). The highest mountain is Aenos, oriented in a NW-SE direction and is designated as a National Park area. The most important plains are the ones of Kranaia, Arakleio, Sami and of Paliki peninsula, also plenty of bays and capes are formed at the island's coast line. Cephalonia is characterized by intense seismicity with strong frequent earthquakes. During the 1953 earthquake, the island was mainly uplifted and huge destruction was caused, with only the north region remaining intact (Gaki-Papanastassiou *et al* 2011).

The Ionian Islands were initially connected to the mainland, but during the Tortonian Age, between 11 to 9 million years ago, they were partially or completely covered with sea water. In the Messinian age during the late Miocene, at about 5 million years ago, the Mediterranean Sea went into desiccation, sealing the Mediterranean off from the Atlantic and the Indian Ocean (Ευθυμιάτου - Κατσούνη 2012). During that period Cephalonia was separated from the mainland and at about 800.000 yr BP, Pleistocene epoch, the islands of Zakynthos, Cephalonia and Ithaca were connected with each other (Ferentinos *et al* 2012.- Θεοχάρης 1970). In the Latest Pleistocene, about 72.000 yr BP ago, the sea level was about 120m lower (Perissoratis and Conispoliatis 2003), meaning that the Ionian Islands were again connected to the mainland. About 18.000 yr BP, during Holocene period, the sea started rising rapidly. Rising sea levels just 9.000 yr BP gradually cut off the Ionian Islands from the mainland, that was due to ice melting and sea level changes that covered parts of Greece's. During that period the Ionian Islands obtained their present shape (Ευθυμιάτου – Κατσούνη 2012).

The archaeological evidences confirm that Cephalonia was inhabited since the Paleolithic period (Καββαδίας 1984.– Μόσχος 2007). The human presence dates back to the Stone Age, during the Middle and Lower Paleolithic period (100,000 - 44,000 years ago) (Μόσχος 2007) but the absence of archaeological data cannot determine the exact time. Human activity was constant on the island during all historic periods. However, the most important and significant one was during the Mycenaean era, as it has produced a wealth of archaeological sites and findings all around the island.

The island is historically referred as Taphos or Teleboas, Doulichion and Same and later as Tetrapolis from the four city-states (polis) that Cephalonia was divided into (Λοβέρδος Κωστή 1888). According to Greek mythology, Taphius son of Poseidon, colonized the island of Taphos and named its inhabitants Teleboas. Later, his son, Pterelaus, ruled the neighbouring Cephalonia, and his followers became known as Taphians or Teleboans. Based on another legend, the island was named after the mythic hero Cephalus who reached the island as a refugee from Athens and displaced the initial inhabitants, the Taphians or Teleboans (Μπαμπινιώτης 2012). According though to the Greek archaeologist S. Marinatos (Μαρινάτος 1962), the island got its name after Kefallines or Kefalanes, a tribe from western Greece, as it is known to us from the Linear B scripts of Pylos. Homeric poems also refer to Cephalonia by the names Doulichion, Samos or Same, name which is still maintained for a Cephalonian town. Even though Homer mentions that Odysseus is the leader of Kefallines people[3], the first historian ever to refer to the island by the name of Kefalinia[4] is Herodotus at about 450 B.C.

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[3] Homer Odyssey Οδύσσεια:υ210, ω355, ω378, and ω429. – Homer Iliad: Δ330
[4] Herodotus, The Histories: 9.28.5

The four city-states of Sami, Pronnoi, Pali and Krani were flourished during antiquity. Later, the island was occupied by the Romans and throughout the Middle Ages it became a part of the Byzantine Empire. It was also the centre of the Theme of Cephallenia together with all the other Ionian Islands (Μοσχόπουλος 1951). The Normans, the Venetians and Ottomans conquered the island. It was again under the Venetian rule until 1797 A.D when it was annexed into the France Republic. During the French occupation, resistance groups started to form and the people, influenced by the French Revolution rioted and overturned the feudal regime. The United States of the Ionian Islands was created under the amical protection of the United Kingdom. The British invested in the island's infrastructure, constructing ports, bridges and road networks, while they annulment the Constitution of Eptanisa, the Libro d' Oro[5], that was originally established by the French. The Ionian Islands united with the Kingdom of Greece on 21st May of 1864.

Cephalonia was occupied by the French forces at the World War I and by the Italians at the World War II, who aimed at the integration of the Ionian Islands to Italy. In 1943, the Germans occupied the island. Many resistance groups were developed and a strong resistance movement was formed. The German occupation was followed by the civil war with many conflicts and battles in the island.

3.2. Archaeological Sites

The transformation of natural landscape to a cultural one is a fundamental characteristic of the human nature (Scarre 2011). The Mycenaean monuments symbolize a connection between people and the land. Besides, of the practical reasons for their construction, they also had social, political and economic implications. There is a relation between the monuments and landscape, the natural and the cultural. Mycenaean monuments

[5] Libro d' Oro or the Golden Book was the formal directory of nobles in the Republic of Venice including the names of noble, wealth and titled families of the island.

are closely associated with social and cultural honouring of the dead (Scarre 2011). They can provide information for the ritual practices and beliefs. Several interpretations have been made to explain the placement of the tombs, and over the last decades a number of publications have proved that the location of tombs within an area is not incidental (Dederix 2014). The examination of the spatial arrangement of tombs can give us information not only about the monument itself but also about the surrounding area, the settlements and the different aspects of Mycenaean life. The burial structures are associated with the settlement, the community and the relation between them is fundamental.

The visibility and proximity of the tombs from a settlement should be taken into consideration. The proximity of a tomb to a settlement depended on a number of factors, which included topography and the surrounding landscape. Tombs' location in relation to the settlements is important, as in most of the cases in Cephalonia the corresponding settlement has not yet been found. Analysis of the patterns and spatial distribution with GIS could create a predictive model of settlements in the area.

The most important and well known historical period for the island is the Late Bronze Period, as a result of the high amount of burial structures and monuments, especially in the south, west and east part of the island. For this reason the Mycenean Period was chosen for the present research. The research was limited to the funerary monuments as they are the most frequently met on the island. Other Mycenaean sites, not analyzed in this thesis are a few settlements and surface findings.

In total, sixteen (16) funerary archaeological sites dated on Mycenaean or Late Bronze Age Period are presented. The sites (*Fig*. 2) are organized below in alphabetical order.

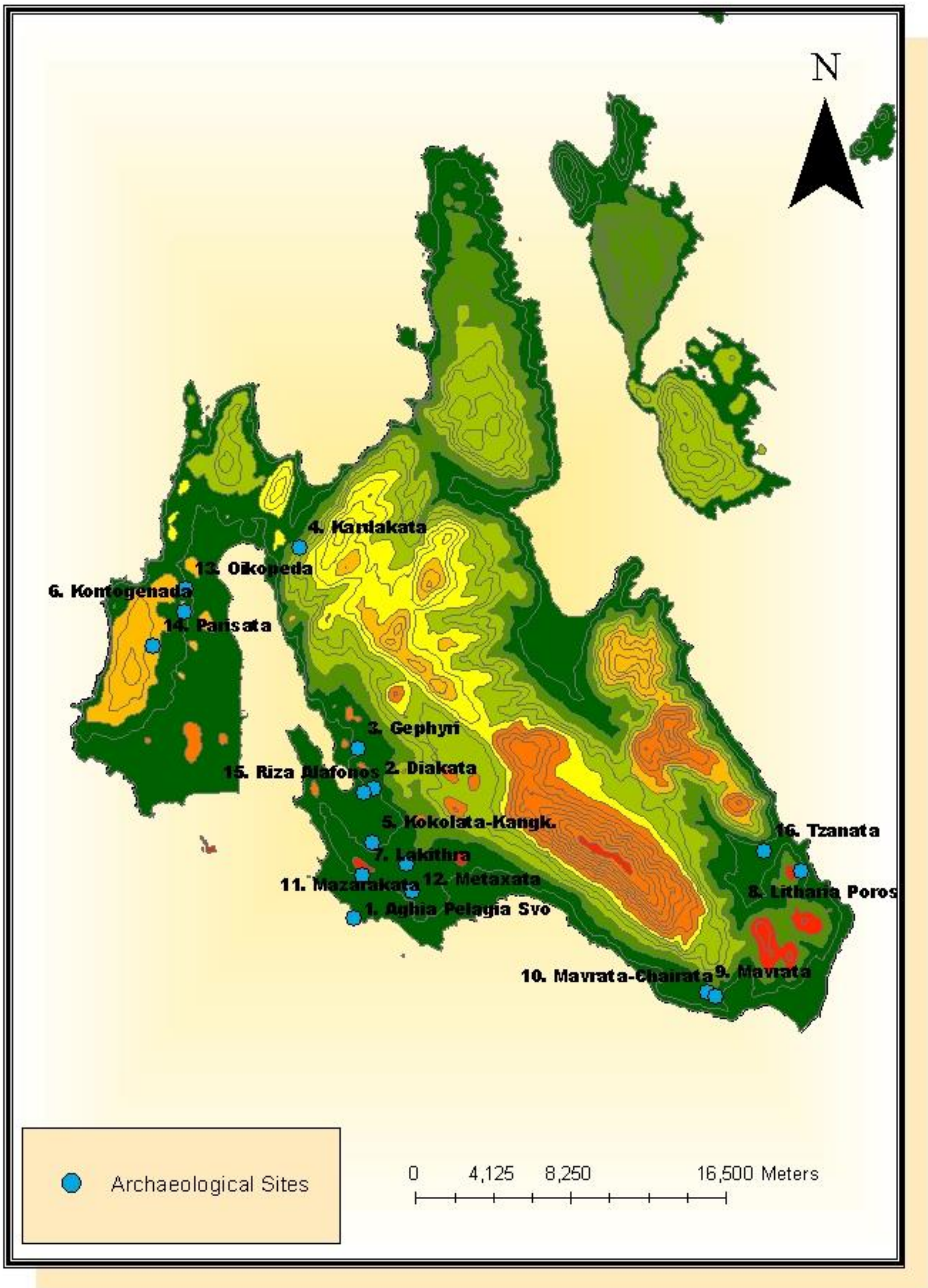


Figure 2. Archaeological Sites under study.

3.2.1. Aghia Pelaghia Svoronata

Excavations in the area in 1912 were fruitless concerning the discovery of Mycenaean monuments although a high number of trenches were dug covering the plain down to the sea (Κυπαρίσσης και Φιλαδελφεύς 1912). Iakovides S. later identified two or three chamber tombs, near the port of Aghia Pelagia (Souyoudzoglou – Haywood 1999). The tombs were dated in LBIII period.

3.2.2. Diaka or Diakata

Two chamber tombs lie at the north part of Diaka hill at the eastern edge of Alafona valley, at the west flank of Mt Ainos. Kyparisses in 1912 and 1914 (Kyparisses 1912) firstly excavated the tombs. The first chamber tomb (Tomb I) contained ten deep pits, five at each side of a footpath, and the second one (Tomb II) just two burial pits. Tomb I was almost square, its dimensions were 5.00 x 4.70 m., and Tomb II had elliptical plan and smaller dimensions of 2.65 x 2.10 m. (Souyoudzoglou – Haywood 1999). A high number of archaeological findings originate from the tombs of Diakata, which is mostly consisted of pottery. In total more than 100 vases were found in the tombs. Tomb I contained vases, three bronze dress pins, a bronze ring, a knife, a large fibula and twenty five biconical steatite conuli. Tomb II contained more than twenty vases, two type F swords, four knives, a cleaver and many jeweler like amber beads, beads of agate, one crystal bead and beads made from glass (Souyoudzoglou – Haywood 1999 and Κυπαρίσσης 1912). Pieces of gold and silver jewelry artifacts are dated to later than the Mycenaean period depositions. Both of the chamber tombs were used from LBIII C until the Roman Period as a locus of cult for honoring the Heroes. Unfortunately, many artefacts were lost during the catastrophic earthquake of 1953 (Souyoudzoglou – Haywood 1999).

3.2.3. Gefyri (Prokopata - Razata)

G. Pylarinos excavated in 1909 a chamber tomb in the area of Gephyri, between the villages of Prokopata and Razata below the main Argostoli to Sami road. The Tomb was briefly described by Kyparisses (Κυπαρίσσης 1919). It was a small tomb, without burial pits in the chamber. Skeletal remains were not mentioned but three vases datable to the LH III A2 and LH IIIB1 places were recovered, a piriform jar, a stirrup jar and a krater. The small finds included a razor and a simple bronze ring (Souyoudzoglou – Haywood 1999, Hope Hipson 1979 and Dickinson1979). The exact position of the tomb remains unknown (Μόσχος 2007).

3.2.4. Kardakata

Wardle (1972) is referred to the existence of a Mycenaean Tomb in the area of Kardakata. Unfortunately, no more information than a Mycenaean lekythos vase was found on the site. (Μόσχος 2007).

3.2.5. Kokkolata – Menegata

The Mycenaean cemetery of Kokkolata Kangelisses is the earliest cemetery found on the island. It is located across the modern settlement of Kokkolata, in the location Kangkelisses or Mavro Spelio. Kavvadias P. excavated a MBA and LBA cemetery in a low and rocky area in 1908 and 1909 (Καββαδίας 1912). Four different types of burial structures were recognized, slab cists, tholos tombs, rock – cut pits, and some cairn – like structures.

Six slab cists were listed and illustrated by P. Kavvadias (Καββαδίας 1912) and the findings were consisted of fifty two vases and a bronze knife, each of them possible had more than one burial pits. The slab cists are dated to the late MH period and may have been used until the early Mycenaean Period. Kalligas P. supported that above of the slab cists there was tumulus, opinion, which was contradicted from Korres G. (Μόσχος 2007).

An unknown number of pit graves were excavated few meters north – west from the cist graves. They were used for successive burials or as ossuaries. Based on the pottery and other gravegoods found in the cists, it is certain that they were used in LH IIIA-C period (Μόσχος 2007). Also eleven lentoid seals, a bead made from gold, and others made of agate, sardonyx and steatite were found. There were also three old hair spirals, a bronze knife and a needle, and several conuli of clay and steatite.

Two small tholos tombs built next to each other were also found in the area. The first one (Tholos A) had a diameter of 2.70m and the other one (Tholos B) a diameter of 2.90-3.10m, unfortunately only the foundation layer is preserved today. The tombs contained two and three burial pits, respectively. Tholos A was in use in LH IIIC and consisted of findings of vases, sealstones, beads, a hair spiral made of gold, fragments of bronze knives and needles and seven steatite buttons. Tholos B yielded eighteen vases, four steatite sealstones, steatite and clay conuli, one glass bead and three beads of emerald. In addition there were twenty five relief beads of glass paste.

A few meters south of tholos tombs, Kavvadias excavated three cairn like structures. Kavvadias identified them as graves, although there is no reference of human remains or gravegoods. Twelve vases are possible finds of these structures, which are datable to the pre LH IIIC period (Souyoudzoglou – Haywood 1999).

3.2.6. Kontogenada

Kontogenada site is located on a low hill in the Halikias valley at the southern edge of the Kontogenada settlement. The location is also known as Skiniotiko Vouni. Marinatos excavated the site and published three chamber tombs of tholoid type (named here A, B and C) (Μαρινάτος 1933) (*Fig.*14). Only Chamber Tomb A contained burial pits and a stone sarcophagus burial. A fourth Chamber Tomb was discovered in 1951 again by Marinatos, but its contraction was never completed. All the tombs were found looted and only Chamber

Tomb A contained remains of pottery datable in LH IIIC (Souyoudzoglou – Haywood 1999). Other gravegoods were a blue glass bead and the catch plate of a bronze fibula.

In 2010, two more tombs were discovered at the site of Skineas. The first one had been looted and only its short dromos yielded any finds. It is a chamber tomb, the upper part of which was built in the corbelling technique and contained four burial cuts through its floor. The dromos of the second chamber tomb, as well as the part nearest to the entrance of the chamber, had been looted. Among the remaining gravegoods of the tomb, a considerable quantity of pottery was collected and abundant skeletal remains. Similar to the first chamber tomb, it had a corbelled vault, but without any burial pits inside the chamber. The dromos is short, but carefully constructed, with a threshold at the entrance to the chamber (Sotiriou 2013 and Sotiriou 2012). The 35th Ephorate of Prehistoric and Classical Antiquities recently discovered another chamber tomb. The chamber was consisted of four burial pits, three of them were deep and narrow (Βικάτου 2017). Also in the same area, a number of rock cut pit graves were discovered.

3.2.7. Lakithra

Marinatos excavated four chamber tombs (*Fig*. 13) and a number of round pits at the southern face and on the cliffs of the hill, where the settlement of Lakkithra lies, in 1931 and 1932 (Μαρινάτος 1932 and Μαρινάτος 1933). Tombs A and B were found unviolated and both were of the cave dormitory type. Their dimensions where 5.00 x 5.00 x 1.80 m and consisted of ten burial pits, five of each side of a footpath. Each burial pit contained several burials inside. The majority of the tombs contained pottery datable in Early LBA IIIC period (Μόσχος 2007).

Tomb A contained 148 vases datable no earlier than LH IIIC indicating that the tombs where used until the latest phase of Mycenaean occupation of the island. Other burial findings were a bronze sword, a spearhead, five single edged knives, a razor and fragments of pins or wire, beads made of glass, steatite, sardonyx and crystal, three amber beads and a gold necklace. Tomb B contained thirty-two vases, an ovate javelin head and three or four knives, steatite conuli, a small sealstone and a pendant of whitish stone. None of the vases are dated earlier than LH III C (Souyoudzoglou – Haywood 1999).Tomb C, was of dimensions 1.40 x 1.75 m. and contained no pits inside the burial chamber. The tomb yielded human bones and offerings, twenty-four vases and three beads. Based on the pottery found,the tomb was constructed in LH IIIB and continued its use in LH IIIC. Tomb D was the largest one, with dimensions of 5.40 x 7.00 x 2.00 m. In total, eleven burial pits were found in the burial chamber and another burial pit across the dromos. One hundred twenty two vases, few bronze objects, knives and a needle, round headed rivets and nails, fragments of sheet metal, gold jewellery and gold leafs, glass reads, stone beads and a pendant of sardonyx were found in the tomb (Souyoudzoglou – Haywood 1999). Tomb D was the earliest, constructed in the Early LH IIIB and was used alongside tombs A and B until the latest stage of Mycenaean inhabitation on the island. The site was in use from LB III A2/B until the late LB IIIC.

3.2.8. Litharia Poros

A small burial structure of 2.80m. dimensions was identified at Litharia of Poros in 1991. The tomb was preserved to the course of stones and courseware, and wheel – tumed sherds and a whorf were collected from the site. Souyoudzoglou – Haywood identifies the tomb as a tholos tomb (Souyoudzoglou – Haywood 1999). Mosxos I. (2007) is referred to the existence of a tumulus or an open to the sky tomb (Μόσχος 2007) which dates the tomb to the LB III period. Sotiriou A. (2000) dates the burial structure to the ME period.

3.2.9. Mavrata

Marinatos excavated a tholos tomb in 1936 at the plain of Mavrata, at the south – eastern edge of the homonym modern settlement. The burial chamber contained three burial pits with several burials each of them. Two more burial pits were found near the stomion and under it. Seventy vases originate from this tomb. Based on the pottery the tomb dates in LH IIIB/C or early LH IIIC, with intensive use in the early part of LH IIIC (Souyoudzoglou –

Haywood 1999and Μόσχος 2007). The tomb's stomion had a length of 3m, but no dromos is recognized. Nowadays, the tomb's preserved diameter is 4.00 meters.

3.2.10. Mavrata – Chairata

Near the tholos tomb of Mavrata, at Chairata, Marinatos excavated a cave or rock cavity, which contained human bones, coarseware pottery and four reconstructed amphorae. Marinatos identified the site as an ossuary. Based on the findings, the tomb dates to the LH III period (Souyoudzoglou – Haywood 1999 and Μόσχος 2007).

3.2.11. Mazarakata

The first archaeological research and study of Mycenaean Period in Cephalonia started in Mazarakata, when the Swiss Colonel Charles Philippe de Bosset ordered the opening of a new road in the area of Livathos in 1810. Colonel de Bosset donated the contents of the tombs to the Museum of Neuchatel in Switzerland where they remain until today. P. Kavvadias re – discovered and excavated the site in 1899, 1908, 1909 and 1913 (Καββαδίας 1913). Mazarakata is the latest chronologically Mycenaean cemetery on the island.

Kavvadias excavated 16 chamber tombs that contained 83 burials (Καββαδίας 1913). Marinatos discovered and excavated another chamber tomb in 1951. Marinatos (Μαρινάτος 1951) described findings such as, plaques and glass beads, two beads of cornelian, flywheels and small sized vases. The seventeenth chamber tomb was excavated and then, covered up. No plan or dimensions were published, it had a dromos longer than 1.50m and the chamber contained no burial pits.

All the tombs were preceded by a dromos (*Fig*. 11), occasionally quite long. The ground plan of the chamber was elliptical, rectangular or trapezoidal. The chambers varied in size from exceptionally small (Z = 1.60 x 1.35) to very large (XI) 5.50 x 6.50m. All but Chamber tomb (Z) had a number of burial pits dug in the chamber floor (*Fig*. 12). The chamber tombs were constructed in a row, each one parallel to another and facing to the same direction. All tombs had a long dromos that varied in length with longest the (N) which reached ten meters. The length of the dromos was probably depended on the hardness of the natural rock (Μόσχος 2007). A number of vases originate from the tombs, datable from LB IIIA2 to LB IIIC (Souyoudzoglou – Haywood 1999). Except from the high amount of pottery, other archaeological findings were two bronzes spearheads of northern and leaf shape type and a bronze knife, a violin bow fibula and two pins. Gold artefacts were also discovered, gold ornament, fragments of gold leaf and relief, and also glass beads, paste and rosettes.

A tholos tomb of 3.60 m. dimension was discovered in 1881. It was excavated by Kavvadias in 1908 without any gravegoods inside. Nowadays, the tholos is not preserved.

3.2.12. Metaxata

, six chamber tombs were excavated (*Fig*.15) near the modern settlement of Metaxata, south west at the location of Chalikera. The first three chamber tombs were discovered and excavated by Marinatos Sp. in 1933, 1960 and 1973, and another two by Kalligas, in 1973. All the tombs except tomb C were violated in antiquity. Tombs A, D, E, and F were of the cave dormitory type with rectangular chamber, whereas tombs B and C were of the tholoid type and had circular chambers. Tombs A, D, E and F had eight to ten burial pits inside the burial chamber, symmetrical constructed in the floor of the burial chamber. Tomb A contained fifty-one vases, all of LH IIIC, two spearheads, a gold bead, glass findings and a few steatite conuli.

The archaeological findings contained in total 304 vases. Some findings were five lentoid seals of steatite with animal representations, steatite seals, buttons, plaques made of glass and a number of beads made of amber, two spearheads of the northern type, knives and bronze jewellery (Μόσχος 2007). The Metaxata cemetery was first used in LBA III A2 – B1 and its use lasted until the final stage of the local LH IIIC (Souyoudzoglou – Haywood 1999).

3.2.13. Oikopeda Myrsines

Sp. Marinatos investigated a tomb near the village of Kontogenada, between the ridges of Kedros and Sgourou Voulgarina in 1921. The site was excavated later, in 1930. Fourteen vases were discovered, datable from LBA II – III A 1 to LBA IIIB. Among the archaeological findings were also found seven knives, one flat axe or chisel, one parallel sided chisel, one bronze pin, two leaf shaped spearheads and many fragments of pottery, jewellery made of gold, crystal, sardonx and glass. Also, clay and steatite conuli and a flat pendant of soft stone were found. Marinatos originally presumed it was a circular construction with a stone dais, 2 – 2.50 m in diameter. Sotirou A. based on new excavations on the site supported that is a burial structure of the MBA period that was used as an ossuary during the Mycenaean Period. The archaeological findings date the site from MBA to the LBA IIIC (Μόσχος 2007 and Σωτηρίου 2000).

3.2.14. Parisata

Marinatos discovered two chamber tombs south – east of the settlement of Parisata in 1951. Tomb A is a tholos – shaped tomb with four burial pits in its burial chamber. It was looted and contained only a juglet, a gold button or head of rivet and fragments of one or more stone sarcophagi (Souyoudzoglou – Haywood 1999). Few meters away, lies Tomb B with a roughly shaped stomion and a large slab nearby is almost certainly the original door. The 35th Ephorate of Prehistoric and Classical Antiquities excavated another chamber tomb. The tomb had a long dromos and circular chamber floor (Βικάτου 2017).

3.2.15. Riza Alafonos

The site Riza is located at the south of Krani, North West of Alafona Plain. P. Kavvadias excavated an unknown number of oval shaped pits surrounded by stones in 1909 (Kavvadias 1912). The tombs where found looted and no archaeological finds were recorded. Near the pits, Kavvadias explored a Mycenaean tholos tomb. The only artefacts found where a spearhead, two fragmentary vases and one silver needle. Other findings that possibly originate from this site and are listed in The Argostoli Museum Catalue are bronze fragments form a knife, beads of glass and haematite, and eleven buttons (Mosxos 2007). The tombs are dated in the LB III (Souyoudzoglou – Haywood 1999).

3.2.16. Tzanata

L. Kolonas excavated a tholos tomb at a locality called Borzi near the modern settlement of Tzanata, in 1992. It is the largest and well-preserved tholos tomb in the Ionian Islands. It has a diameter of 6.80 meters and its stomion height is 1.83 meters. The tholos was built of local sandstone and poros stones. Its wall is preserved up to the height of 3.95 meters. The main grave was a built cist constructed at a depth of 2.20 meters from the chamber floor and two smaller built cist graves were constructed at a higher level. At a later stage, three deep pits were dug through the floor. Even though the tholos was looted, a gold ornament and sealstones of crystal and steatite were found. The tholos is dated to the 14th century, but it is supported by Kolonas that it was constructed on top of a previous tholos, the stones of which were re used for the construction of the new one. The ossuary is a rectangular structure of irregular stones with an entrance and threshold. Its floor was laid with pebbles and contained human bones, possibly from seventy-two individuals. The findings included pottery, clay figurines, sealstones, bronze tools and golds beads (Souyoudzoglou – Haywood 1999 and Μόσχος 2007).

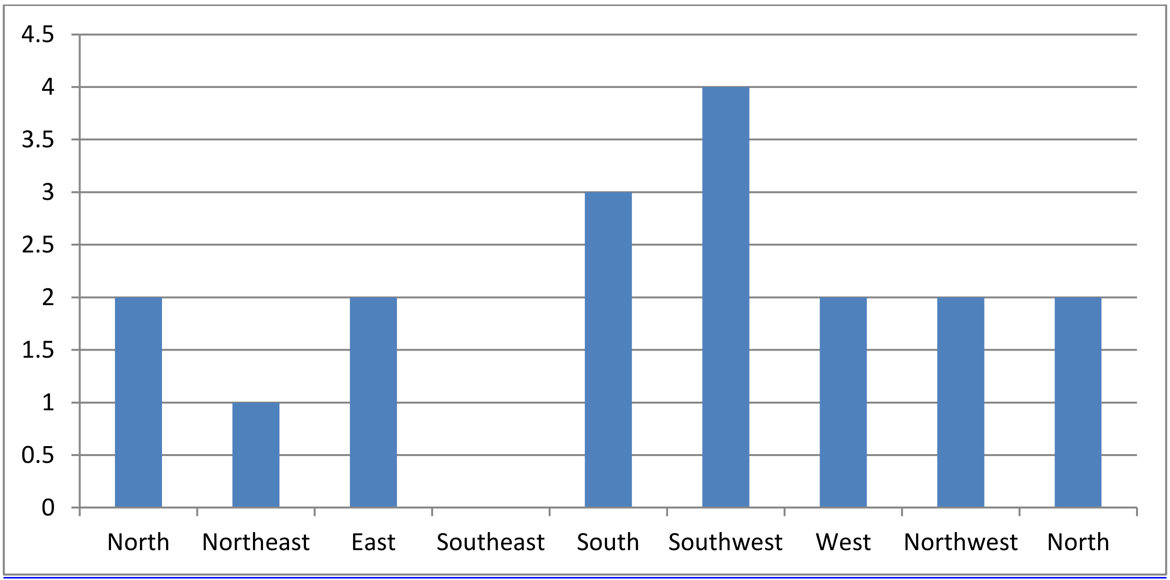
Chapter IV

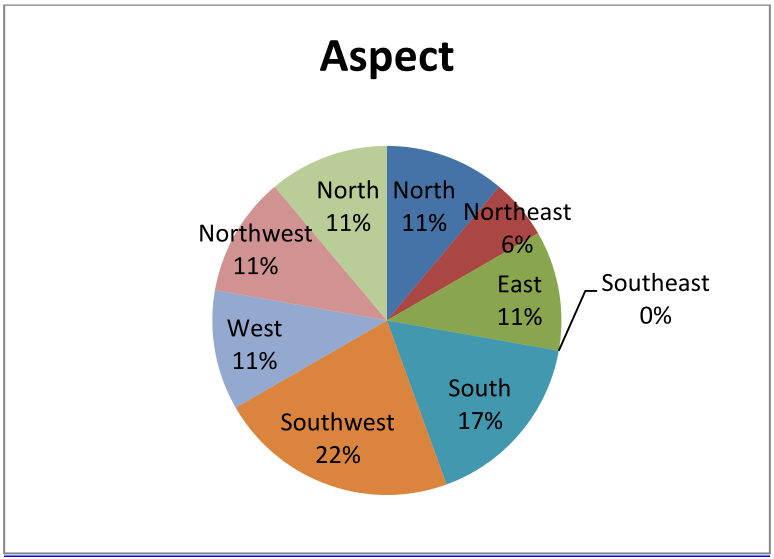
3.1. Results

As mentioned in previous chapters the main objective of this thesis is to identify any relation between the archaeological sites and their geomorphological charasteristics. Each archaeological site was identified and digitized into the ArcGIS software in order to carry out the spatial analysis. In order to fully understand the relationship between sites and spatial characteristics, six maps were created representing each one of the criteria applied. This chapter starts with the examination of aspect and gradually presents the other five criteria applied during this study.

3.2. Aspect

Aspect estimates the maximum slope direction of each cell. The output value is the compass direction expressed from 0 to 360 degrees, where 0=north, 45=northeast and 90=east. If the estimate slope is zero, there is no slope direction and a value of -1 is returned for aspect (Verbyla 2002). Aspect calculates the direction a slope faces and is expressed by a cardinal direction such as NNW or ESE (Williams 2007). This analysis can help identify and calculate the solar illumination for each location in the island. The Aspect tool of ArcGIS was applied to a digital elevation model of the island in order to extract a grayscale image, which was edited to different colours representing the aspect values.



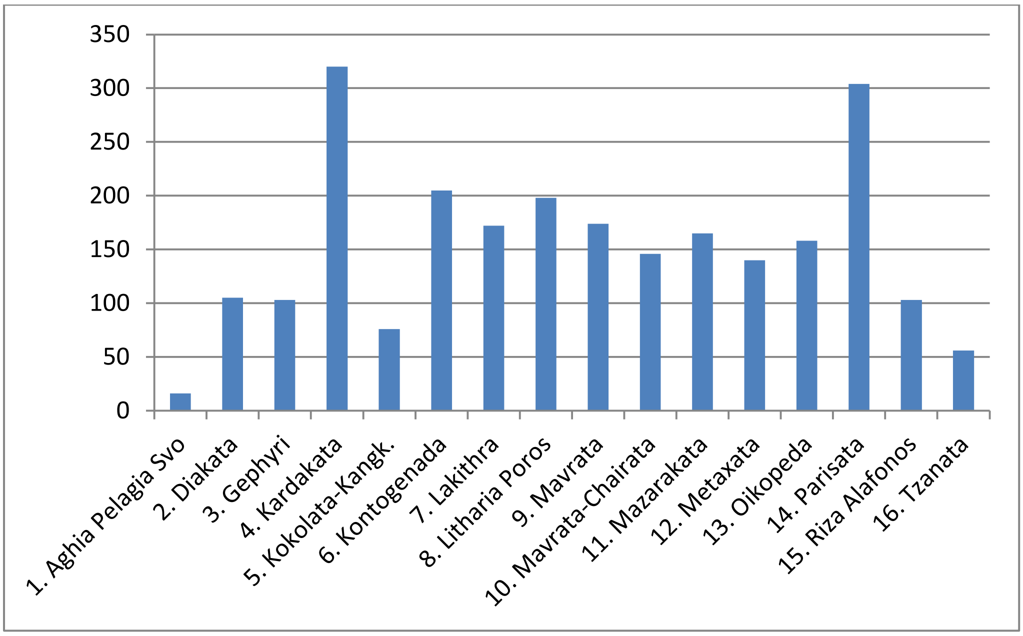


Graph 1. Aspect of archaeological sites

Based on the results (*Graph* 1. and Fig. 3.), 22 % and 17 % of the sites are located Southwest and South, respectively. The same percentage (11%) of sites are located East, South and West, North and Northwest. It should be noted here that none of the sites are oriented to the Southeast and only one site (Kontogenada) is orientated northeast.

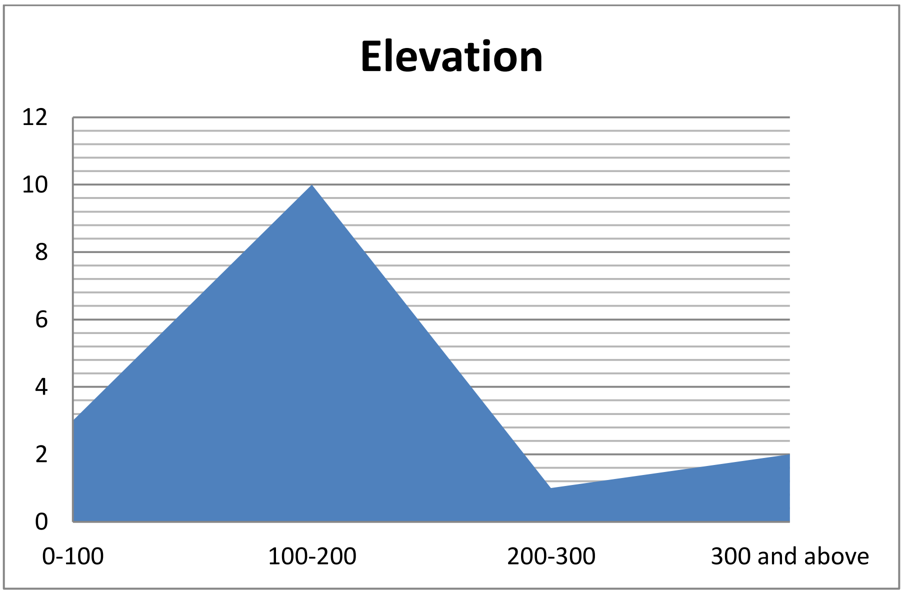
3.2. Elevation

Elevation of a site is its height above or below a fixed reference point. In GIS, a digital elevation models are commonly used to represent the surface of an area and its elevation is typically measured and expressed as height above mean sea level (Davis 1994). The ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) GLOBAL DEM (Digital Elevation Model) V2 (Version) topographic database of the Earth Observing System Data and Information System (EOSDIS) part of NASA's Earth Science Data Systems (ESDS) Program were used for the elevation map. The ASTER GLOBAL GDEM V2 is a dataset released by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA). ASTER GDEM V2 data are available free of charge to users worldwide from the Land Processes Distributed Active Archive Center (LP DAAC). The data was downloaded into a GeoTIFF file, then visualized and georeferenced into the ArcGIS.



Graph 2. Elevation of the archaeological sites

Based on the results, the elevation of Cephalonia can be divided into four categories. Areas with low elevation (0 – 265 m.), areas with elevation of 265 – 470 m., areas with altitude of 470 – 701m. and areas with 701 to 1.628m of elevation. The fist category can be described as lowland areas with small or no hills. The second category represents hills near mountainous areas. The third category is semi mountainous areas and the last category, areas with elevation more than 701 can be characterized as mountainous environments (Malaperdas and Zacharias 2017). Elevation of the study sites ranges from 16m to 304 m in the island. The lowest elevations are dominant around the southern part of the island. The highest elevations, on the other hand, can be observed at the west and east parts.



Graph 3. Elevation

Based on Graph 3 and Graph 4, 88% percent of the sites are located in low altitude areas, most on them on small hills, such as Tzanata, Kontogenada and Aghia Pelaghia. Only two of the sites, Parisata and Kardakata are located on areas with altitude more than 265m, on hills. The majority of the sites are located in small revelations area, representing only the first two elevation categories. The maximum observed elevation is 320 meters in the area of Kardakata and the minimum elevation is 16 meters in the port of Aghia Pelaghia.

3.3. Geology

Based on the geological map of the Hellenic Military Geographical Service (HMGS) and the online information from the Greek Institute of Geology and Mineral Exploration (IGME), seven different geological types were recognized in the island (*Fig*. 5). Two topographic maps of the HMGS covering the island were georeferenced and digitized with ArcGIS.

The island of Cephalonia is dominated by the external zones of the Hellenide, the Prepulian (or Paxos), Ionian and Gavrono zones (Karakitsios and Rigakis 2007). The bedrock consists of two main bedrock units the east dipping belonging to the Pre Apulian (Paxos) and the Ioniat unit (Karymbalis *et al* 2013*).* The Lower Cretaceous are the oldest on the surface and can be found at the southwestern to the northwestern part of the island (*Phitos* et al 2015). The Upper Cretaceous consists mostly of limestones and the Palaeocene are found in Pylaros area, north and south of Fiskardo (*Phitos* et al 2015). The Eocene – Oligocene layers expand mostly in Paliki and Thinia. Miocene layers expand in western Paliki, Thinia, Pylaros and Sami. The Holocene consists of alluvium and scree deposits (Karymbalis *et al* 2013) .

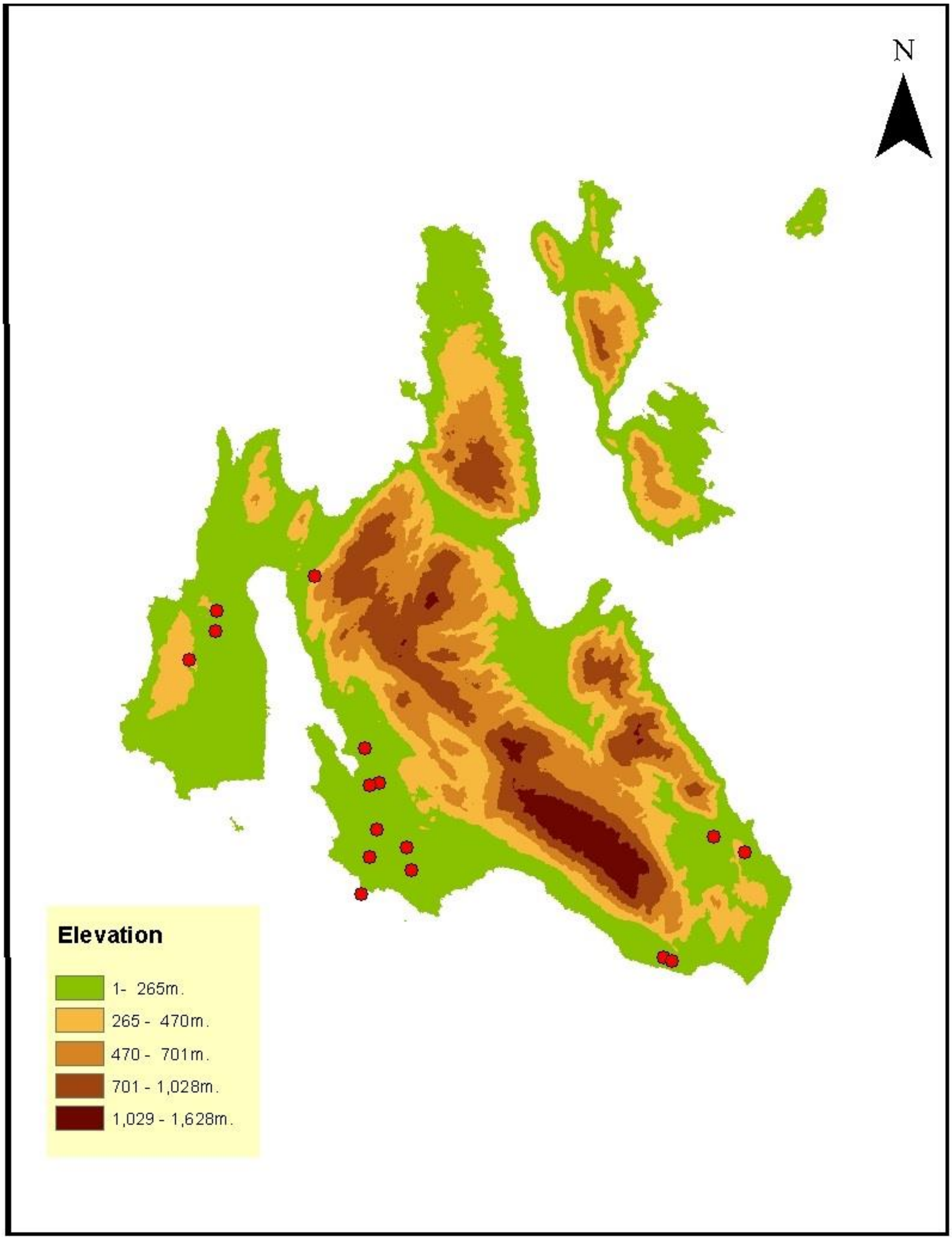
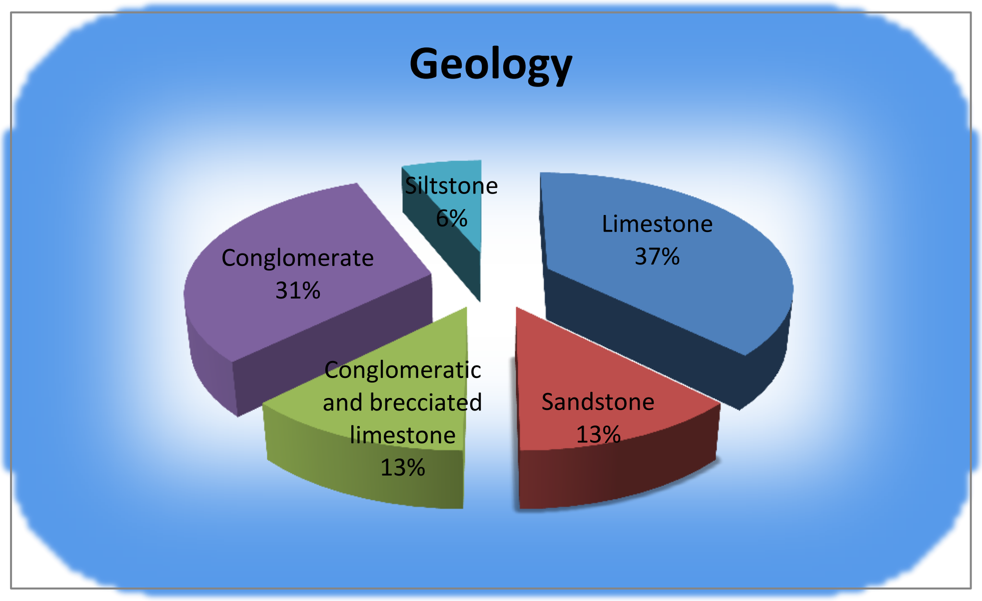


Figure 3. Elevation of Cephalonia

Five categories were recognized in the areas where the archaeological sites under study are located. As *Graph* (4.) shows the majority of the sites (37%) are located to areas with Limestone and 31% of the sites in conglomerate terains. The rest of the sites are located on Sandstone (13%), Conglomeratic brecciated limestone (13%) and only 6% on Siltstone areas.



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Graph 4. Geology

3.4. Hillshade

Hillshading is a technique used to visualize terrain as shaded relief, illuminating it with a hypothetical light source. The illumination value for each raster cell is determined by its orientation to the light source, which is based on slope and aspect. Hillshade can provide information on which site is visible or hidden from a specific view, the real position of the sun at a particular date and time of a year. This application makes it possible to simulate different ranges of view, time and periods and in that way, multiple measures of visibility can be obtained. In archaeology, sites are highly depended on vegetation and terrain of a historical landscape. The sun's location is a primary factor for the creation of a hill shade map for any location. In *Map*.(6) the azimuth was set to 315 degrees (NW) which is the default angular direction of the sun. The default altitude of the illumination source above the horizon (0 to 90 degrees) was set to 45 degrees.

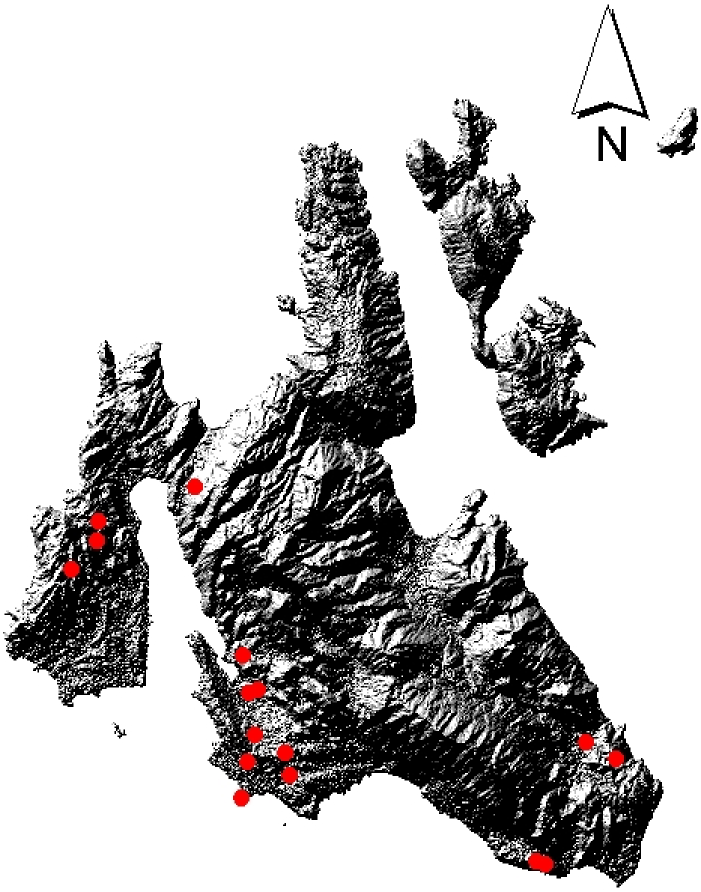


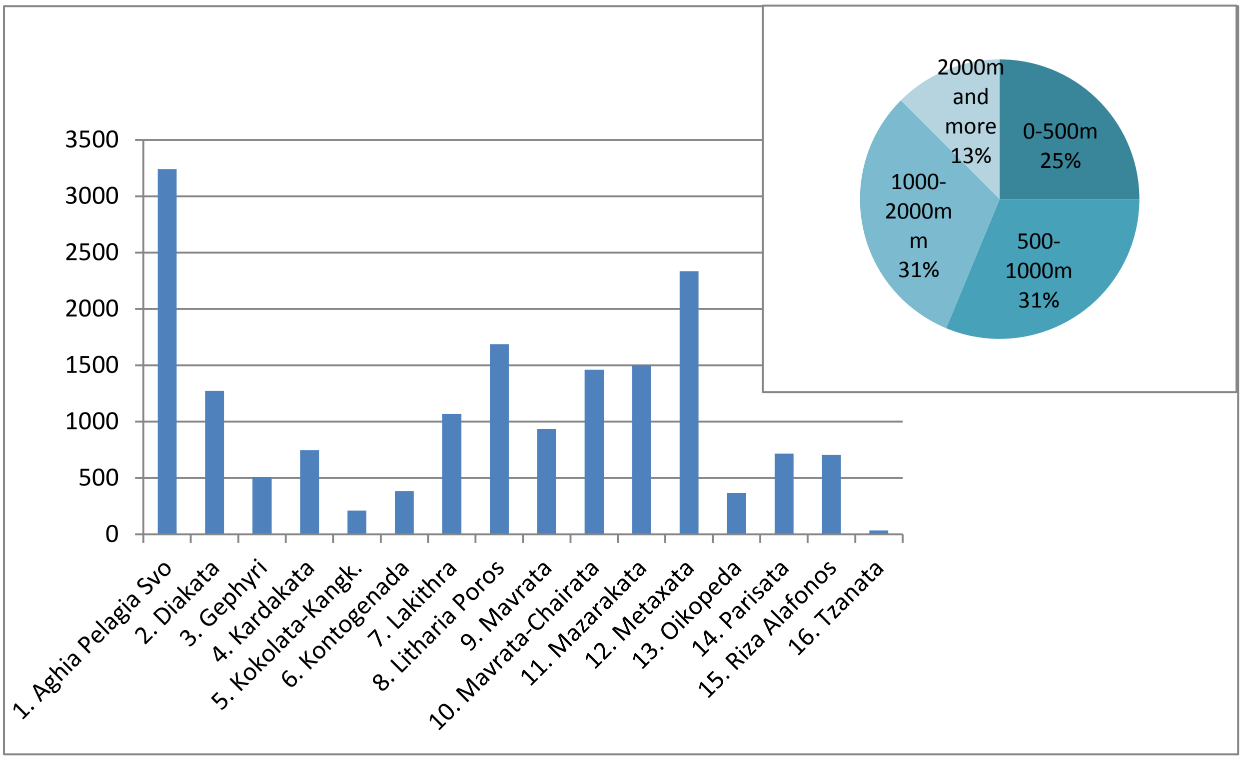
Figure 4. Hillshade Map of Cephalonia and Distribution of Sites

Based on the results, the majority of sites are located in positions that could profit by the sunlight.

3.5. Hydrographic Network

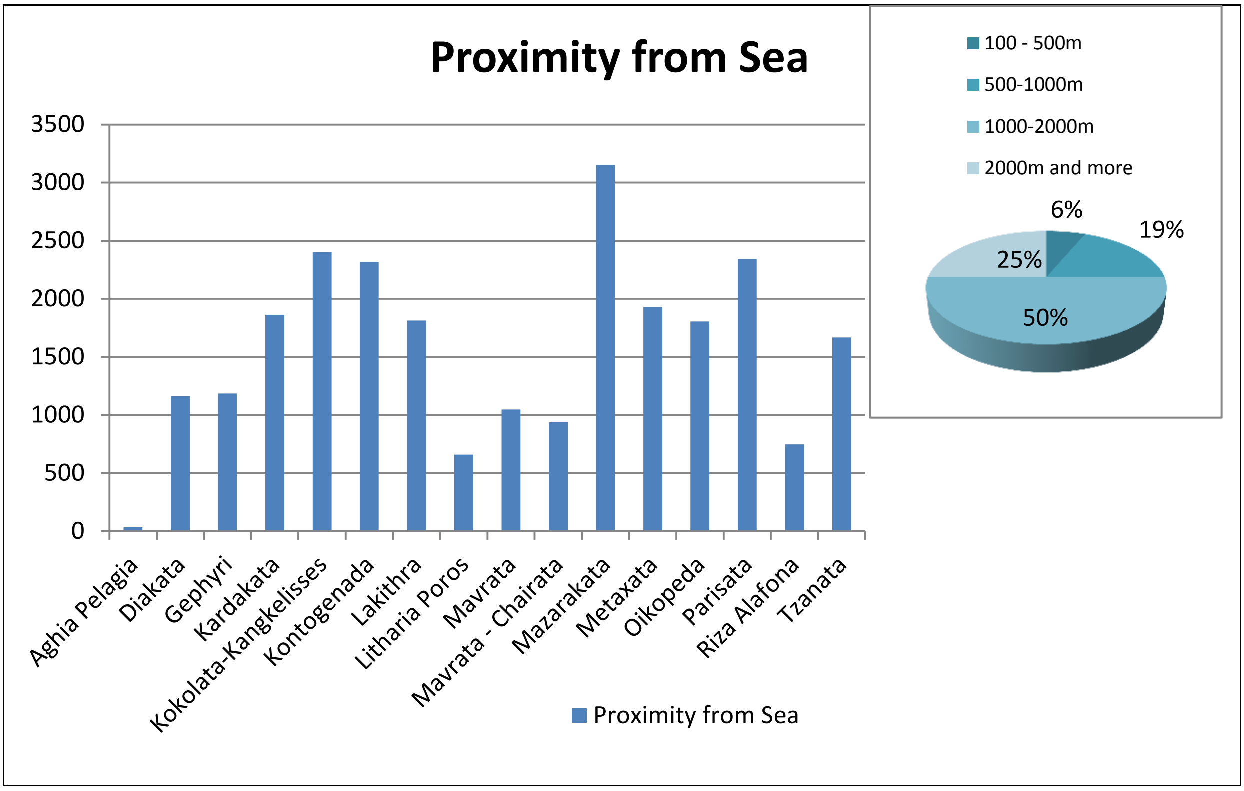
GIS emerged as an important tool for hydrographic modelling during the 1990s (Merkouri and Kouli 2011). GIS description of hydrography and related data is spatially intensive and changes little in time (Maidment 2002). Hydrography is the study, description, surveying and mapping of the physical features of oceas, seas, coastal area, lakes and rivers, as well as the prediction on their change over time (International Hydrographic Organization).

The resulting map (*Fig*.7) was geo-referenced to the Greek Geodetic Reference System 1987 so that all the infromation could be tied to the same projection system. In the map, the blue lines describe water features of the surface. The island's shoreline was also digitized making it possible to calculate the distance of the archaeological sites from the sea. Any relationship between the archaeological sites and the rivers was recognized with the assistance of ArcGIS. A spatial join was used to connect a layer of representing the rivers and streams of Cephalonia with single points, the archaeological sites. The distance between all the sites was calculated with the shortest seperation between them, that is, where the two features (sites and rivers) are closest to each other. Distance showed below, refers to the smallest seperation between these two features. Proximity tool was used to discover proximity relationships between the sites and water resources. The same join was used to calculate the distance of each arhcaeological sites from the shoreline.



Graph 5. Proximity to Water

The illustration of the results (*Fig*. 7) was presented using buffer lines and points, that create area features at specified distance around the input features. As shown in *Graph* (5), 25 % of the sites are located in a short distance from fresh water, 0 – 500 meters away. Archaeological sites located 500-1000m and 1000-2000m away from water have a percentage of 31% each. Lastly, only 13% of the sites are located to a distance more that 2000 meters away from water. The same model was created for calculating the proximity of sites from the sea. As shown in *Graph* (6), most of the sites (50%) are located 1000-2000 meters away from the sea, 25% more than 2000 meters away from the sea, 19 % between 500 – 1000 meters and only 6% of the sites are located near the sea. None of the sites are located more than 3.153 meters away from the sea. An average distance of the sites is 1073m from rivers and 1566m from sea's shoreline.



Graph 6. Proximity to Sea

3.6. Slope

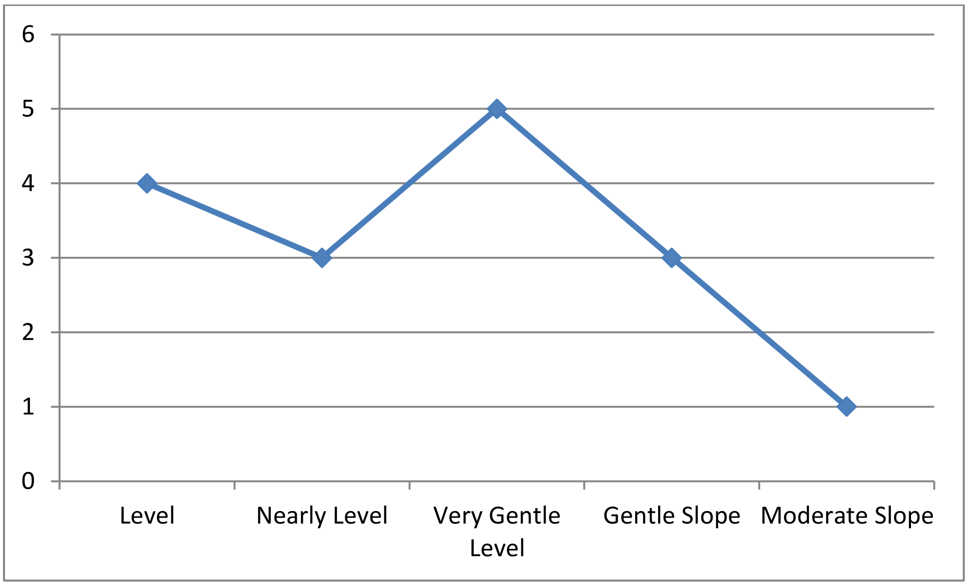
Slope is a measure of steepness or the degree of maximum incline of spatial change across a surface (Williams 2007). In GIS, slope computation tools estimate the rate of change between each cell and its neighbours. Slope gradient can be expressed in several ways, but the most three commonly used notations are ratio, percent and angle. In this thesis, the results are presented as a slope percentage (also called percent rise). A flat surface is represented as 0 percent and as the surface becomes vertical, the slope percent increases. Slope can be categorized into seven (7) different classes (Index 2, Chabala et al., 2013).

Slope classes	Range of slope (percentage)
1	0-1
2	1-3
3	3-5
4	5-8
5	8-12
6	12-30
7	>30

Index 2. Slope Categories

For the needs of this thesis the slopes ranges where descripted as: Level (0-1%) where the terrain is flat. Nearly Level (1-3%)where the terrain is characterized by little incline, Very Gentle Slope (3-5%) with a very slightly inclined terrain, Gentle Slope (5-8%) slightly inclined terrain, Moderate Slope (8-12%) with moderate incline of the terrain, Strong Slope (12-30%) where the terrain has a strong incline, Extreme Slope (>30) with extremely inclined of the area.

As *Fig* (8) shows most of the archaeological sites are located in areas with a low percent of slope steepness. The results (*Graph* 7) present that majority of the archaeological sites are located in an area with very gentle level (3-5%) of slope and flat areas (0-1%). Only one site (Kardakata) is located on a terrain with Moderate Slope and the rest of the sites are located on Nearly Level (1-3%) or Gentle Slope(3-8%). None of the archaeological sites under study are located to an area with Strong Slope or Extreme Slope. The slope results indicate that the gentle slopes are dominated in the south part of the island, where most of the archaeological sites under study are located.



Graph 7. Slope

Chapter V

4.1. Discussion of Results

This study was carried out in the island of Cephalonia to investigate the relationship between Mycenaean burial sites and their geomorphological characteristics. As reviewed in Chapter IV, a number of different criteria were applied in order to create graphs and maps representing them. In this chapter, an attempt to further examine the practical and cultural reasons and conditions for the location of the archaeological sites is made.

4.2. Aspect

The results show (*Graph* 1.) that the majority of the funerary sites are oriented to the Southwest and South, possible to profit from the sunlight (Malaperdas and Zacharias 2018). In general, terrains with southern orientation provide protection from northern winds and ensure more sunshine conditions and temperature. The distribution of the sites is limited to the South and South West, lying protected from the northern winds and the winter weather conditions, due the geomorphological conditions of the island and the mountain, standing as a natural barrier. This element is visible even to the distribution of modern settlements of the island (*Map*.9).

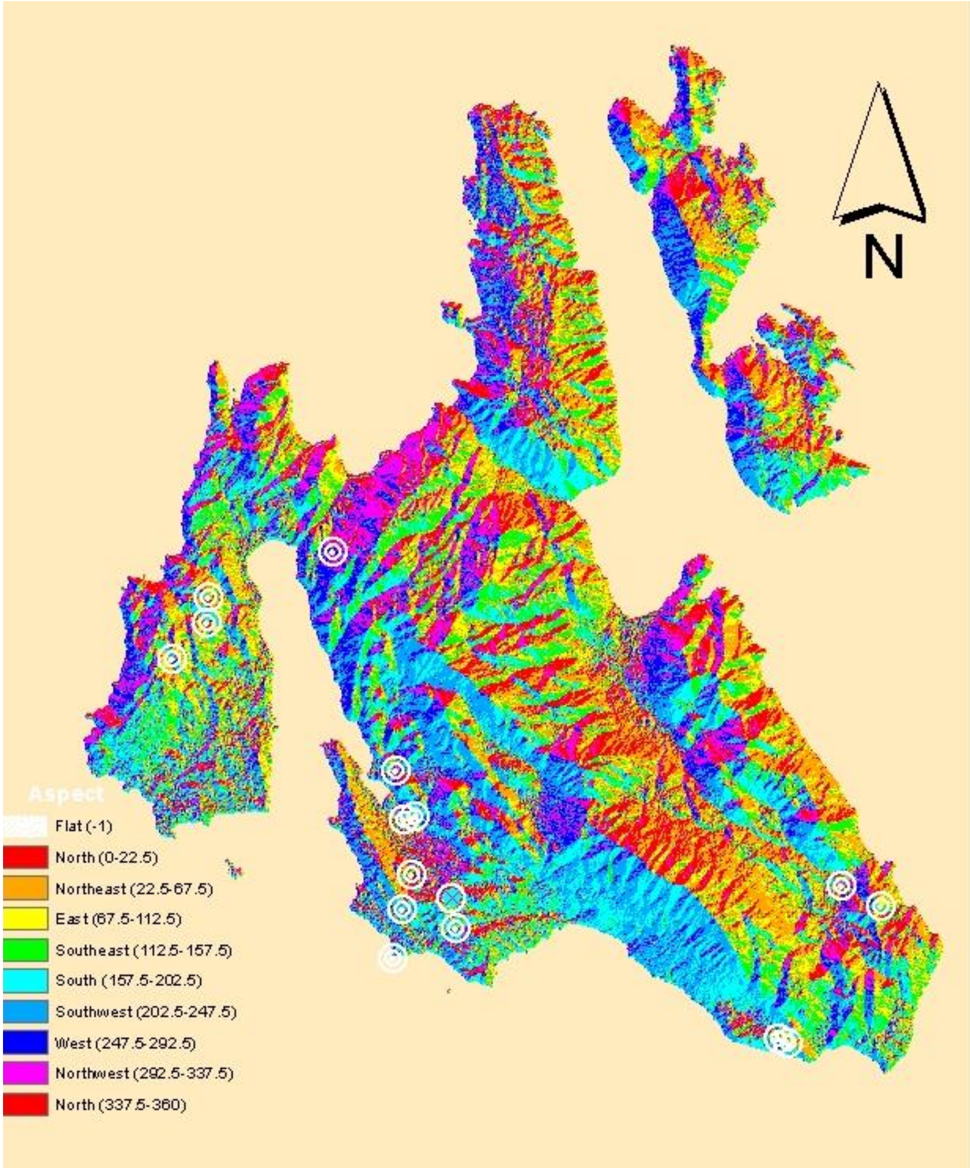


Figure 5. Aspect of Cephalonia

4.3. Elevation

The first category of elevation level, with altitude from 0 to 250 meters represents the 88 % of the arhcaeological sites. Access to the site could be a factor affecting the location and altitude of a site. Easy access for the ceremony of the funerary rituals (Mee and Cavanagh 1990) and from road or paths could also be an element that affected the primary location of the tombs.

4.4. Geology

Limestone represents the 70% of the total area of the island (Fig 5.), making it easily accessible from inhabitations areas. Limestone can be used as building material for the construction of tombs, walls and houses, and for sculpture. Chamber tombs are commonly dug into limestones and sandstones terrains. Also, limestone works as a soil conditioner, improving the soil's physical qualities and structure.

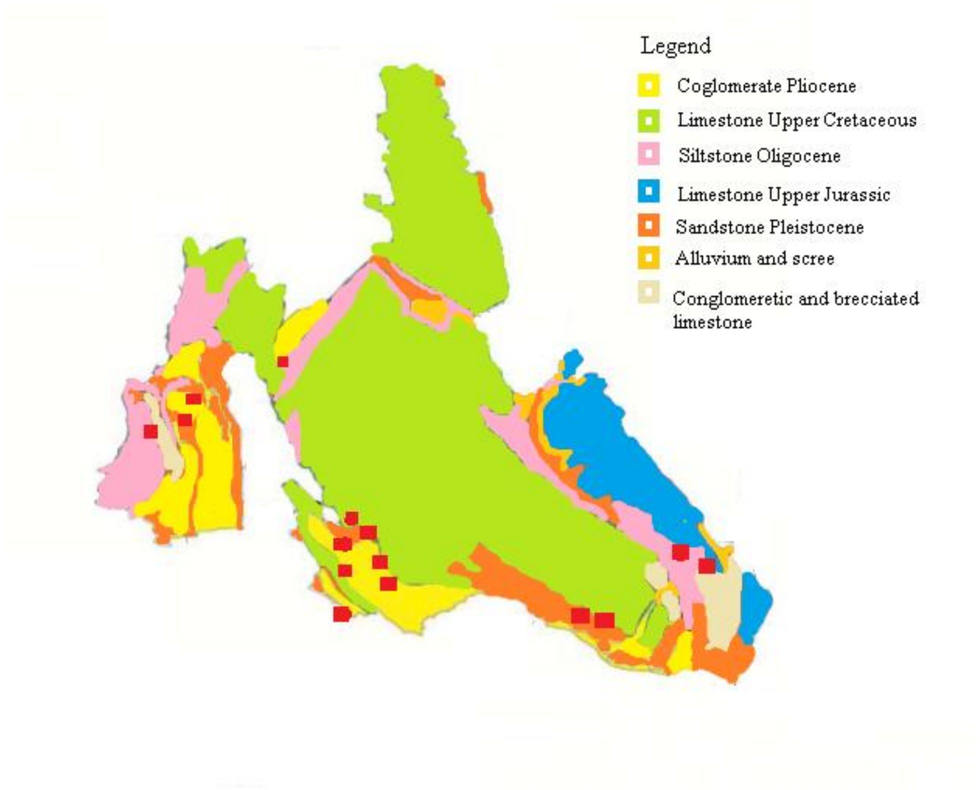


Figure 6. Geological Map of Cephalonia and Distribution of Archaeological Sites

4.5. Hillshade

Previous researches have supported the importance of monumental tombs and their relation with their natural and cultural environment. Several interpretations have been made to explain the placement of tombs, which is ranging from social to natural reasons. But, the visibility of tombs varies depending on the topography and the natural environment. Tholos tombs for instance were primarily visible from a short distance but there are some examples that the achieved long distance visibility. In addition, cosmological and mythological landscape was an element that affected the location of tombs and its relation with the past. For instance, the Mesara tombs are aligned to the dawn at specific times of the year (Goodison 2004), the summer and winter solstice. Another characteristic example is Vapheio tholos tomb that was aligned to the axis of mountain Profitis Ilias and summer sunlight. A more extensive archaeological research in Cephalonia is necessary to interpret the meaning of visibility and sunlight of the Mycenaean tombs in the area.

4.6. Hydrographic Network

This chapter examines the influence of water in the construction and the location of Mycenean burial sites. Even today water is fundamental to human life, population growth and economic developoment is hightly connected to the existance of water. The importance of water for the creation of settlements and the rise of past civilizations have long noted from the archaeologists. Water management and water research have been undertaken by scientists all around the ancientworld in order to gain a greater understanding of the past. Environment in general, had a major role in the origins of socities and creation of cities and the availability of water has been considered an essential part of civilization througout all the historical periods. Hydrographic Network in GIS can be an important tool for understanding how the landscape can influence societies and impact their evolution. Relationships betweeen features and single factors, such as rivers, sea or lakes, can been revealed with the assistance of GIS. Also GIS is applicable for studying spatial relantioship between water features and burial elements. Hydrography involves a number of applied sciences and can define the nature of the environment throught which water move and in this case it can define the relation of funerary archaeological sites to their natural environment. The proximity of a funerary site from natural resourches could reflect cultural and social representations of the Mycenean's life. Proximity is depended on a number of factors, which included topography and surrounding landscape. It should be noted here that the relationship of archaeological settlements with the natural envrionemnt has pratrical aspects as the distance from water matters the most (Merkouri and Kouli 2011), but in the case of burial sites such aspects need to be investigated further.

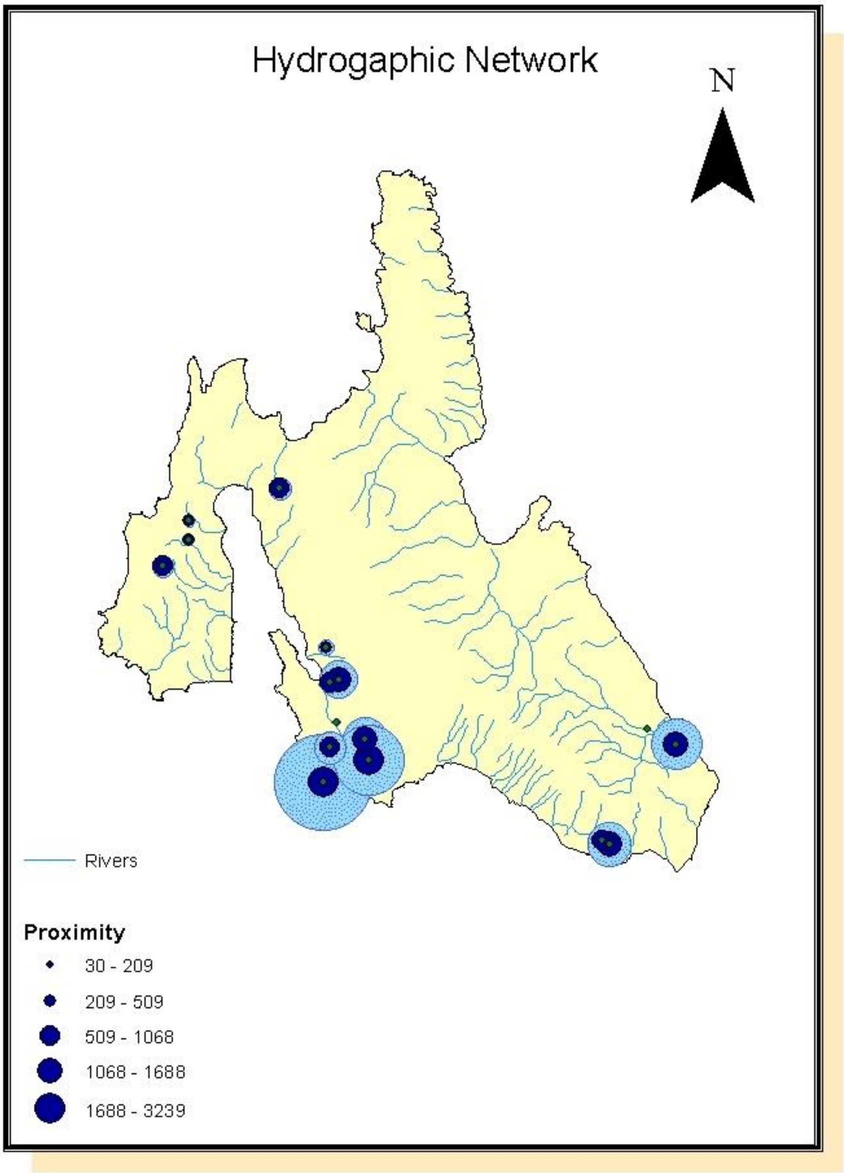


Figure 7. Hydrographic Network and Archaeological Sites

4.7. Slope

Most of the archaeological sites under study are located in areas with a low percent of slope steepness. The location and steepness of a site could be affected by the accessibility from the settlement, the path or the ritual processes needed to take place in the area. Mycenaean's possibly preferred easily approachable sites for the needs of the cultural and daily aspects of life. Although, the historical landscape could be vary than today it is obvious that Mycenaean burial sites are easily accessible for possible practical or ritual reasons.

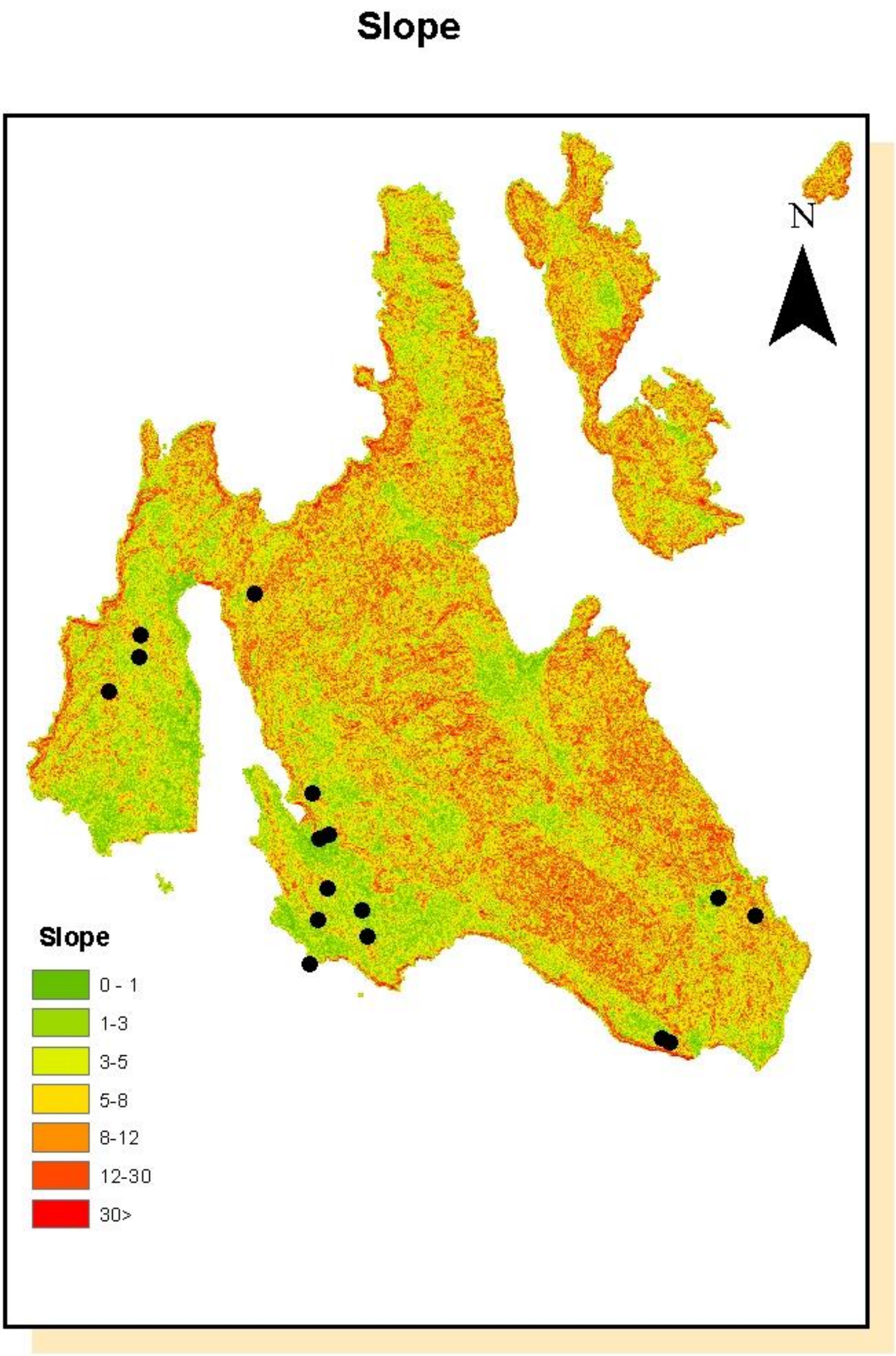


Figure 8. Slope of Cephalonia

Chapter VI

5. Conclusions

In this thesis, a geospatial analysis was applied in order to examine the relation of Mycenaean funerary sites of Cephalonia with a number of single factors (*Index* 4.). The GIS program was essential in preparing and analysing the data, as it has the capabilities and applicable tools to create maps for the presentation and interpretation of the results. Based on the results presented, the use of GIS was beneficial in the present thesis and has proven that it can be used to capture information, model and manipulate, retrieve and analyze spatial information and present geographically referenced data of previously collected data from archaeological sites.

The study was conducted in sixteen (16) burial sites that were identified, a deliberate signal of presence in the landscape. All the sites are funerary remains, tombs or cemeteries dated on the Mycenaean Period (1.700/1.680 – 1.060/1.040 B.C.), which considered to be one of the most important eras of the island. The funerary remains were chosen for this research as there are the most frequently found in the island, in comparison to settlements or surface remains. The first archaeological research of the Mycenaean Period in Cephalonia was is Mazarakata in 1810 and new findings are discovered as the archaeological research continuous. The archaeological sites in Cephalonia are still under research, therefore the analysis performed, was limited, however, valuable information was obtained. GIS can help identify spatial and visual relations between the tombs, settlements, topography and natural resources in comparison to the cultural factors of the Mycenaean people and the function of the burial structures, practices and their social meanings.

The majority of sites were located to a small distance from water, 1000 to 2000 meters and not far away from the sea, an average of 1566 meters from sea's shoreline. Water resources are essential and can be significance analytical tools for the historical reconstruction and identification of new archaeological sites. Regarding elevation, an 88% percent of the archaeological sites are located on small elevation terrain or on small hills, but no of them to mountainous areas, providing easy accessibility. These results indicate that, people preferred to construct their burial sites at low terrain and small elevation areas. The highest concentration of archaeological sites is observed in the fertile region of Kranaia and Leivathos. Most of the sites, are located in areas with low percent of slope steepness. Steepness and elevation could affect a site location regarding the easy access from a path or a settlement and their visibility.

Limestone ground covers more than 70% (Phitos *et al* 2015) of the island, which affected the geomorphological formation of its total area. Thus, justifing the results showing that 37% of the sites are located on limestone terrains. Limestone can be used as a building material, for the settlements and the tombs, can work as a soil conditioner and also, is a suitable terrain to be dug for the creation of chamber tombs.

Hillshade can provide useful information regarding the visibility and the cosmological or theological meanings of the tombs. The majority of the sites are oriented South and Southwest, profiting from the sunlight and protected from the north winds and extreme environmental conditions.

An important element that could affect the location of a funerary site is the visibility and accessibility of the tomb from the settlement that could have both practical and symbolic role. Nevertheless, in Cephalonia in contrast to the numerous tombs and cemeteries, the information about settlement remains is fragmentary. Tombs are difficult to be identified as natural forces alter the archaeological environment. Each funerary tomb could vary depending on the period built and time of use. For the Mycenaean's the landscape has various meanings and can interpreted with many ways, that could have a connection between people and land, and has mythological and cosmological symbolism. Mycenaean tombs represent a valuable source for identifying the social and cultural aspects of past. It is important to study and analyse them in order to take information and conclusions about the different perspectives of the Mycenaean landscape. The selection of the location or the area that the tombs were constructed, represent aspects of the Mycenaean life, social, cultural and economic.

Absolute determination of the main reasons for the location occurrence is almost impossible with the existing information, as it is believed that many elements can affect selection of a site, some of these factors are presented above. The location of a tomb is a complex matter and the criteria could vary depending on natural and cultural factors. The results should be interpreted within their social context, such as results based on cultural aspects of a particular group or society.

The location of settlements, to which the tombs or cemeteries belonged, is an element influencing the site location. Because tombs occur in regions with dense settlement remains, it is important to identify the tombs corresponding settlement. The corresponding settlements were probably located in environments unsuitable for the living, such as hills, providing separation between the two of them (Merkouri and Kouli 2008).

Previous research and analysis of the existing archaeological, environmental and geomorphological information can be proven an efficient tool for the prediction and identification of archaeological sites. Predictive models can be generated to locate archaeological remains, based on a sample of that region or on aspects concerning observed patterns, features and human behaviour. The distribution of environmental and natural features of a region can be used as basis for the prediction of archaeological remains. Aspects such as water resources, geology and visibility in combination to cultural criteria can be used for the creation of these models. Common environmental criteria in predictive models are geological information, hydrographic network elevation, slope, orientation and vegetation. Other parameters such as proximity to settlements, road or paths are important. These criteria can vary even for the same archaeological site, as they may be related to a specific time, period or specific culture. It is common the tombs to be re used during many historical phases. In Cephalonia, most of the tombs were used during different phases, from the Early Bronze Age till the Roman time. A predictive model can contribute to archaeological research, indicate area with high probability of archaeological site's occurrence, reduce the cost of excavations and expand our knowledge about the occurrence of archaeological remains.

An archaeological survey in the area that will focus on the occurrence of burial sites would contribute a lot to the understanding of archaeological burial sites, the environment and the settlements. However, it is difficult to determine in what degree the environmental and natural conditions, such as water, slope, aspect and hillshade influenced the construction and the location of the Mycenaean funerary sites.

The highest concentrations of archaeological sites are located in the fertile region of Kranaia and Leivathos, with eight studied sites. At the north part of the island, which is barren and mountainous, is observed absence of archaeological sites. Based on the natural division of the island, the geomorphologic research and the maps presented, we could assume that different Mycenaean centres existed on the island. However, our knowledge and understanding of the Mycenaean civilization in the island is incomplete. The economy, society and hierarchy of the people are still partially unknown.

During the last phases of the LBA period, the Mycenaean civilization shows signs of decline. The fall of the Mycenaean world resulted to a dramatic population decrease in the mainland of Greece (Θεοχάρης 1971). In addition, while these regions witnessed the collapse of the Mycenaean economy and society, Cephalonia appears to be more densely populated. This event could have occurred from the immigration of the Mycenaean people from the large and important centres of the mainland. Cephalonia could be part of this immigration from the centre to the edges of the Mycenaean world. The study and analysis of these burial sites could provide us with new information regarding the habitation in the island, but also about the transitions that occurred to the Mycenaean world during this phase.

In conclusion, this thesis offers an overview of the Mycenaean funerary sites located in the island and factors that could play an important role in the construction and location of these sites. Finally, I hope that though this thesis I have succeeded in generating an interest in the use of GIS for the archaeological analysis. I would hope this thesis to be the motive for a more extensive archaeological investigation in the area, for the identification of all the Mycenaean archaeological sites, but also the discovery of new cemeteries and settlements around the island, that can improve our knowledge and understanding of the Mycenaean world.

Technology has progressed rapidly and GIS have gradually become accessible to archaeologists and to all the users, expanding our knowledge and providing innovating ways of handling archaeological data. In this thesis, only a few examples of the GIS analysis in which geographic information systems can assist research were provided. Additional research into the processing of the archaeological data in conjunction with a GIS is necessary for the extraction of new information about Mycenaean Cephalonia. In conclusion, the goal of the present thesis was to demonstrate that the analysis of complex archaeological sites would benefit from the implementation of a Geographical Information Systems.

All the questions arise in this thesis could be only answered with future archaeological research, excavations and analysis of the existed information with the help of computer technologies. GIS is a powerful tool that can help the researches to design, analyze and interpret the geographic information for better understanding of the archaeological data, in this case the topographical aspects of the Mycenaean's in the island, and also the natural and cultural connection in-between the sites, their settlements and the environment.

5.2. Useful Software and Links

- ArcGIS Online by Esri - https://www.arcgis.com
- Aster Global DEM - https://asterweb.jpl.nasa.gov
- Google Earth - https://www.google.com/intl/el/earth/
- GRASS GIS - https://grass.osgeo.org/
- Hellenic Military Geographical Service - http://web.gys.gr
- National Cadastre and Mapping Agency - http://www.ktimatologio.gr/Pages/Default.aspx
- QGIS Quantum GIS - https://qgis.org
- USGS - https://www.usgs.gov/

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Appendices

Number	Name	Chronology	Suggested Bibliography
1	Aghia Pelagia Svoronata	LBA III	Kyparisses and Filadelfeus 1912, Mosxos 2007, Souyoudzoglou – Haywood 1999
2	Diakata	LBA IIIC, Sub-Mycenaean	Kyparisses and Filadelfeus 1912, Marinatos 1933, Mosxos 2007, Souyoudzoglou – Haywood 1999
3	Gefyri	LBA III A2-B1	Kavvadias 1913, Mosxos 2007, Souyoudzoglou – Haywood 1999
4	Kardakata	LBA III	Mosxos 2007
5	Kokkolata Kangkelisses	MBA IIIA-B (-LBA IA), LBA IIIA2-C	Kavvadias 1912, Kyparisses and Filadelfeus 1912, Mosxos 2007, Souyoudzoglou – Haywood 1999
6	Kontogenada	Paleolithic, LBA IIIC	Hope Simpson and

			Dickinson 1979, Marinatos 1933, 1951,Mosxos 2007, Souyoudzoglou – Haywood 1999,
7	Lakithra	LBA III A2/B-LBA IIIC	Marinatos 1932,1933 Kyparisses and Filadelfeus 1912, Mosxos 2007, Souyoudzoglou – Haywood 1999
8	Litharia Poros	MBA or LBA III	Mosxos 2007 and Souyoudzoglou – Haywood 1999
9	Mavrata	LBA III B-C	Mosxos 2007, Souyoudzoglou – Haywood 1999, Randsborg 2002
10	Mavrata-Chairata	LBA III	Mosxos 2007, Souyoudzoglou – Haywood 1999, Randsborg 2002
11	Mazarakata	LBA IIIA2-LBA IIIC	Kavvadias 1912, Marinatos 1951Mosxos 2007, Souyoudzoglou – Haywood 1999
12	Metaxata	LBA IIIA2 - LBA IIIC, Sub-Mycenaean	Marinatos 1933,1951, Mosxos 2007, Souyoudzoglou – Haywood 1999

13	Oikopeda Myrsines	MBA, LBA IIB-III A1, LBA IIIC	Marinatos 1931,1932, Mosxos 2007, Mosxos 2007, Souyoudzoglou – Haywood 1999
14	Parisata	LBA IIIC	Mosxos 2007, Souyoudzoglou – Haywood 1999
15	Riza Alafonos	EBA, MBA, LBA III	Kyparisses and Filadelfeus 1912, Marinatos 1932, Mosxos 2007, Souyoudzoglou – Haywood 1999
16	Tzanata	LBA II B/ IIIA- Late LBA III C, Sub-Mycenaean	Mosxos 2007 Souyoudzoglou – Haywood 1999

Index 3. Distribution of the Mycenaean Archaeological Sites

Number	Name	Aspect	Elevation	Geology	Water in m.	Sea in m.
1	Aghia Pelagia Svoronata	SW	16	Coglomerate Pleocene	3239	35
2	Diakata	SW	105	Limestone Upper Cretaceous	1271	1164
3	Gefyri	N	103	Limestone Upper Cretaceous	509	1186
4	Kardakata	W	320	Limestone Upper Cretaceous	746	1863
5	Kokkolata-	E	76	Coglomerate	209	2403

	Kangkelisses			Pleocene		
6	Kontogenada	NE	205	Conglomeratic and brecciated limestone	384	2317
7	Lakithra	W	172	Coglomerate Pleocene	1068	1812
8	Litharia Poros	E	198	Limestone Upper Jurassic	1688	659
9	Mavrata	S	174	Sandstone Pleistocene	933	1047
10	Mavrata-Chairata	NW	146	Sandstone Pleistocene	1459	938
11	Mazarakata	SW	165	Coglomerate Pleocene	1499	3153
12	Metaxata	N	140	Coglomerate Pleocene	2335	1928
13	Oikopeda Myrsines	NW	158	Siltstone Oligocene	367	1805
14	Parisata	SW	304	Conglomeratic and brecciated limestone	715	2342
15	Riza Alafonos	S	103	Limestone Upper Cretaceous	705	747
16	Tzanata	S	56	Limestone Upper Jurassic	35	1666

Index 4. Analysis Index where Aspect, Elevation, Geology and Proximity to Hydrographic Network is given

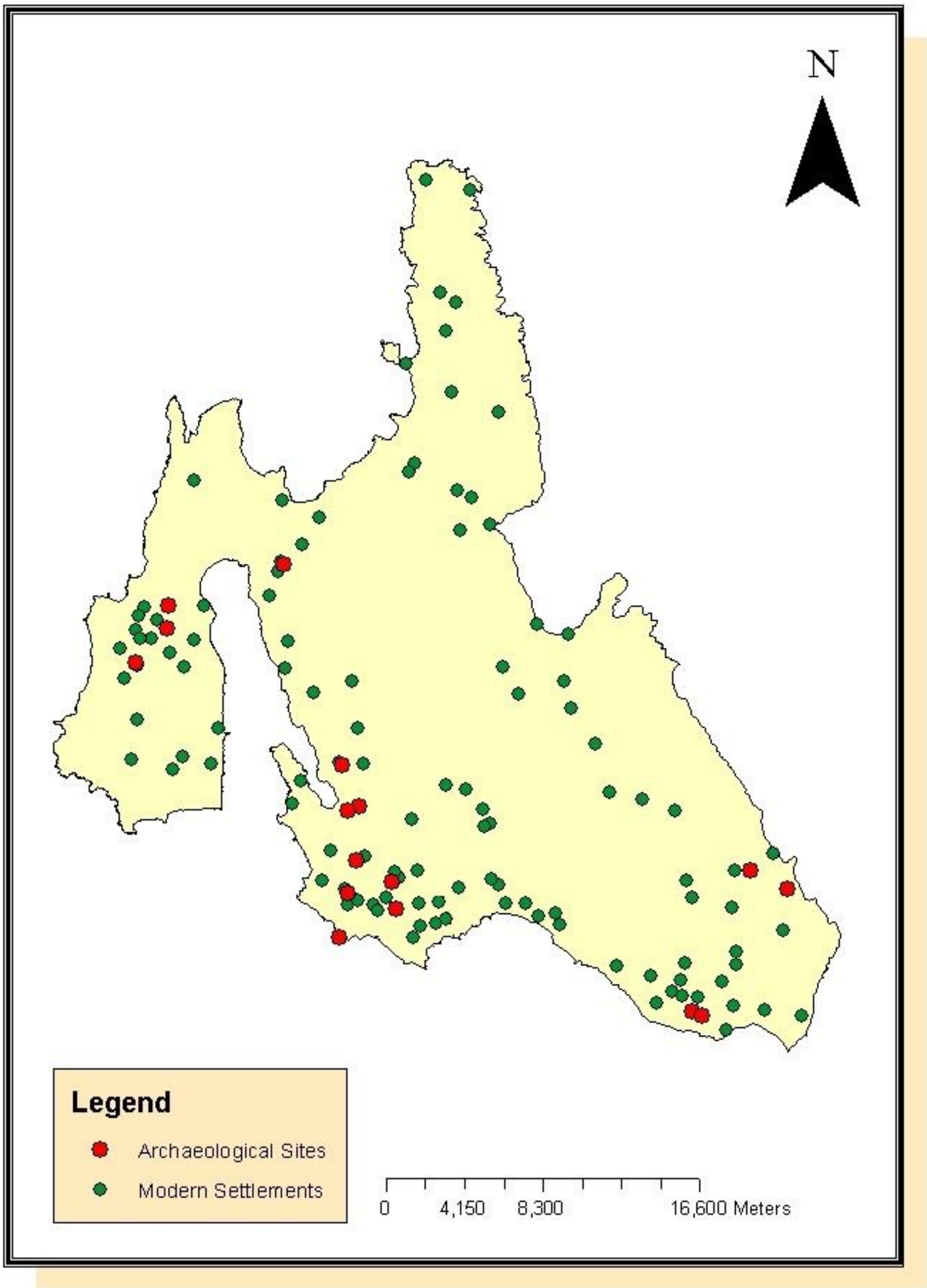

Figure 9. Distribution of Archaeological Sites and Modern Settlements of the island.

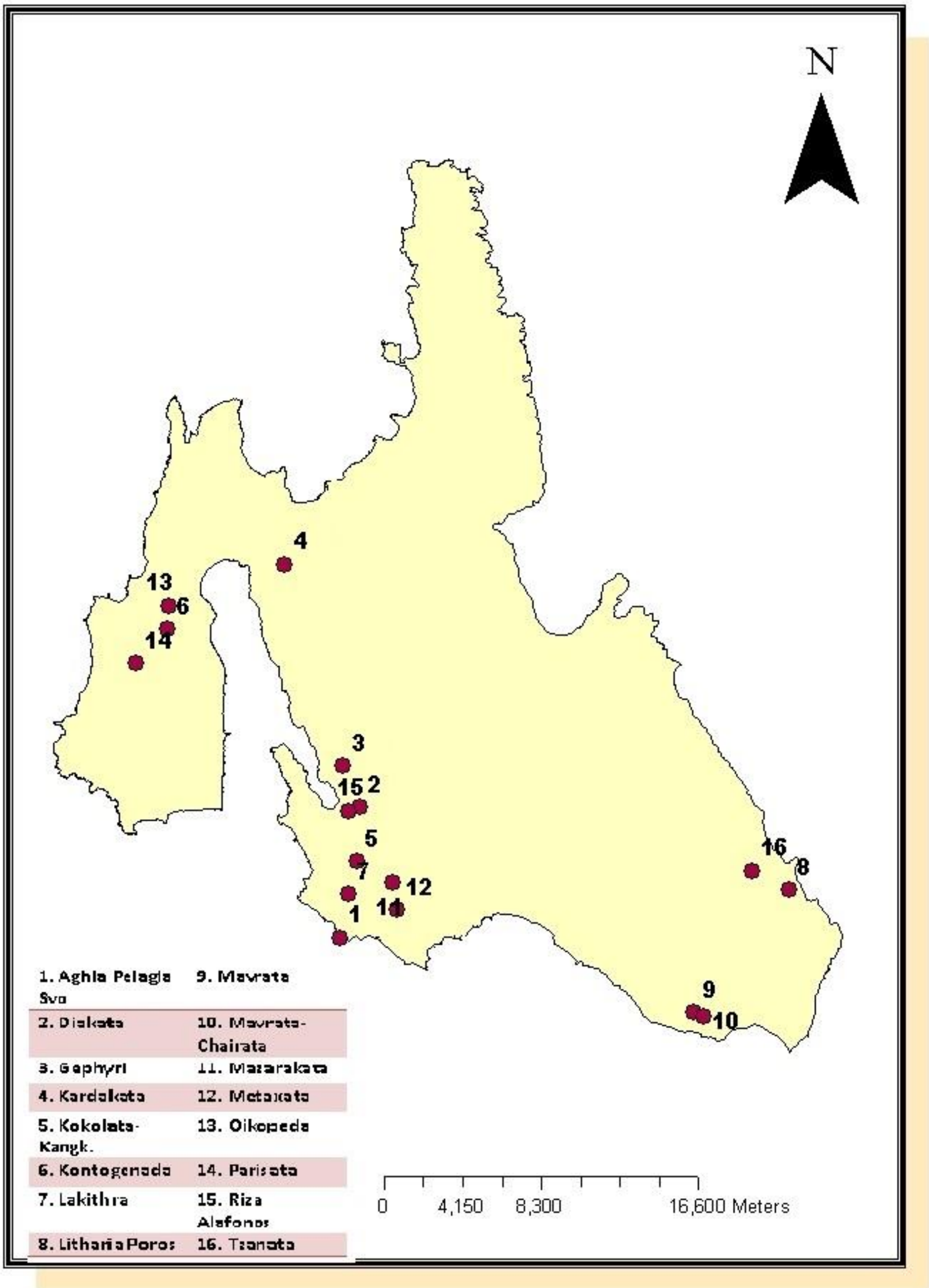

Figure 10. Distribution of Archaeological Sites

Figure 11. Chamber tomb A, Mazarakata

Figure 12. Chamber Tomb A Mazarakata, Interior

Figure 13. Lakithra Tombs

Figure 14. Kontogenada Tombs (Source: Marinatos 1933)

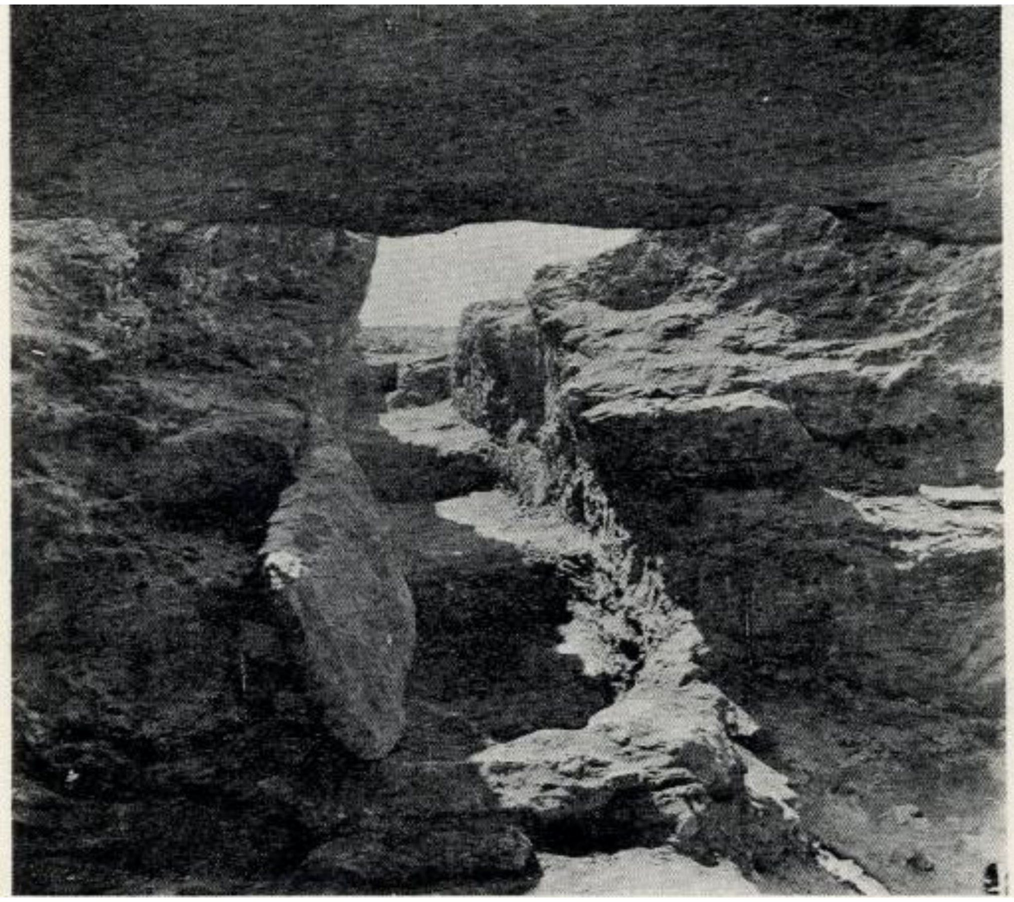

Figure 15. Metaxata Tombs (Source: Marinatos 1933)