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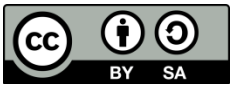



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INTERVIEW

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# Archaeometric Studies in The Aegean (30000-3000 BC and 800-200 BC): A review

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**Abstract.** *The present paper constitutes a review of the archaeometric (or archaeological sciences) studies focusing on the area of Aegean between 30000 and 3000 BC., alongside a focus on the area of Dodecanese islands (SE Aegean) for the period from 800 to 200 BC. This systematic work is part of a project (2012-2013) that aimed to create a database including metadata related to the diachronic habitation in Aegean. The current review is classified into nine broad categories, namely Chemical Analysis, Dating Techniques, Palaeoenvironment, aDNA Analysis, Archaeomagnetism, Isotopic Analysis, Restoration and Conservation and Geophysical studies. This interdisciplinary review serves as a useful guide to a significant academic discipline, that of archaeological sciences, which is progressively advanced in methods, techniques and major applications. Delving into the material culture offers valuable information to the deciphering of the human prehistoric and historic past.*

**Keywords:** dating, analytical, pottery, archaeomagnetic, conservation, geophysical, palaeoenvironment, chemical, aDNA, spectroscopy

## Introduction

Archaeological Science or Archaeometry is an interdisciplinary field that applies science and scientific tools and techniques on the study of archaeological materials and artefacts of cultural heritage (Liritzis *et al.* 2020). Therefore, archaeometry entails interdisciplinarity, since it combines many different disciplines, mainly Physical Sciences and Humanities effectively complementing each other.

The main objective of this review paper is the collection and presentation of the total of archaeometric studies which have been carried out at the area in the Aegean (Fig.1) in the period spanning 30000 to 3000 BC and especially the area of the Dodecanese islands during the period from 800 to 200 BC. This assemblage of archaeometric studies has been digitized and is available to the scientific community and the public through keyword and / or geographical areas of interest search engines.

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**Figure 1.** Map of Greece with the Aegean Islands (in yellow), the Dodecanese islands (red) and Kastelorizo (Megisti) (red arrow). The multi-insularity of Aegean archipelagos counts 1,200 to 6,000 islands, depending on the minimum size. The number of inhabited islands is variously cited as between 166 and 227. Roughly extends in latitude between 34° – 41°N and longitude 29° to 23°E. In this region, including the coasts of Anatolia (today Turkey) the cradle of most important civilization, and the cultural base of modern European, was flourished during the Anthropocene, and for several millennia, where modern Greek people are descending from Mycenaean and Minoan cultures.

The broad term "archaeometric studies" refers to dating techniques used in organic and inorganic materials, geophysical analyses, analysis- characterization- provenance of inorganic materials, mainly ceramics, metal and glass, study of dietary patterns in the past, preservation and restoration of cultural heritage monuments, DNA studies of ancient

preserved genetic materials , study and characterization of inorganic- organic pigments, and 3D reconstruction of monuments and/or objects of cultural heritage.

There exists a significant number of applications of archaeometric studies in Greece and especially in the Aegean region, covering a wide range of different time periods via multiple techniques. The Aegean area from prehistory to late antiquity was particularly important and great civilizations developed in its wider geographical boundaries (Treuil *et al.* 1996). Special role in the development of the Aegean over time played the existence of sea routes which facilitated the movement of people, materials, technologies and cultures throughout the continental and insular world (Stampolidis *et al.* 2015).

The aim of this project, i.e. the documentation of the archaeometric studies, was fulfilled through an Integrated Program for Island Research (IPIR) of the University of the Aegean Project[4] completed in 2013. On the premises of this program an open access website was constructed and is available both to the relevant researcher and the general public, rendering access to a vast amount of information organised in a detailed database regarding the history, archaeology and archaeometry of the Aegean area, including maps, images, tables, metadata, bibliography etc. (http://archipelago.aegean.gr/). Since then, until today our project has been enriched with further works. Proper use and management of the archaeometric data results to sustainability and economic development (cultural tourism) on a local, regional and national scale (Liritzis and Korka 2019).

**Method of research**

The compilation of the archaeometric studies involved thorough research using specific key words through the basic electronic data bases used in academia[5]. Furthermore, the bibliographic research was complemented with visits in libraries in various academic institutions, such as the American School of Classical Studies at Athens, the British School at Athens, the University of Athens, the University of Ioannina, the University of the Aegean and the University of Nottingham. The bibliographic lists of the relevant papers were further examined, in order to explore the citations of interest. After thorough research, 87 studies that refer to archaeometric studies in the area of Aegean Sea from 30000 to 3000 BC and in the area of Dodecanese islands from 800-200 BC were located. These studies can be divided into the 9 broad categories, according to the field of study (Table 1).

[4] 'The University of the Aegean, the prominent and driving factor for the economic and social growth of the wide Aegean area' of the Operational Program 'Education and Lifelong Learning'. https://www.researchgate.net/project/Integrated-Program-for-Island-Research-IPIR-of-the-Program-The-University-of-the-Aegean-the-prominent-and-driving-factor-for-the-economic-and-social-growth-of-the-wide-Aegean-area.

[5] such as www.scopus.com, www.researchgate.com, www.academia.edu.com, www.googlescholar.com and www.sciencedirect.com.

**Table 1.** The nine categories of the review study and respective publication numbers.

| Field of study | Number of studies |
|---|---|
| Chemical Analysis | 27 |
| Dating Techniques | 18 |
| Paleoenvironment | 15 |
| DNA Analysis | 7 |
| Archaeomagnetism | 25 |
| Isotopic Analysis | 5 |
| Restoration and Conservation | 6 |
| Geophysical studies - GIS | 4 |

**Results**

*i. Chemical Analysis*

Chemical analyses in inorganic materials are distinguished in four broad sub-categories depending on the analyzed material: ceramics-pottery, glass, obsidian and various materials (metals, steatite etc.). The relevant studies are focused on chemical characterization, the technology of the raw materials and provenance studies.

Pottery and ceramics are investigated with an array of different techniques, including spectroscopic, X-ray related techniques, optical and electronic microscopy and nuclear methods. In particular, Papageorgiou and Lirtizis (2007) investigated and compared Neolithic ceramics from Aegean and mainland Greece (Ftelia at Mykonos, Gyali and Pergoussa near Nissiros, Rhodes island, Sarakinos cave in Boeotia), Cyprus (two settlements) and Asia Minor (Ulucak near Smyrna) by means of X- ray Fluorescence spectroscopy and by application of multivariate statistical techniques. The paper by Quinn *et al.* (2010) explores Neolithic pottery from Youra island located in the North Aegean (in Sporades, close to Alonnessos island) with a combination of petrographic analysis and Neutron Activation Analysis. In addition, Liritzis *et al.* (1991) studied Neolithic pottery from Aghios Petros (North Aegean, Sporades) and the neighboring sites of Thessaly Dimini and Sesklo in an effort to explore the degree of contacts and influences among these sites through trace element analysis by Neutron Activation Analysis (iNAA) and Cluster Analysis. Furthermore, Hein *et al.* (2008) studied wine transport amphoras from Kos island (part of the Dodecanese complex) using Neutron Activation Analysis (NAA), Xray Diffraction and Petrographic analysis for chemical and mineralogical composition respectively. Moreover, they investigated the mechanical properties of amphoras and their mechanical performance with simulated computer models. Karatasios *et al.* (2013) examined ceramic microstructure, chemical and mineralogical composition of Hellenistic ceramic beehives from Agathonisi island (in the Dodecanese complex) using Scanning Electron Microscopy (SEM), Xray Diffraction and petrographic analysis providing a first insight into the

ceramic technology of Aegean beekeeping and honey production. On top of that, a data base of analytical results of analyses of diachronic pottery covering a wide range of areas in Greek region including a series of Aegean islands was published by Hein and Kilikoglou in 2012 (Hein and Kilikoglou 2012). Hein *et al.* (2004) sampled 17 clayey raw materials from seven different locations in Central and Eastern Crete, an area rich in archaeological pottery and, thus, very popular for ceramics provenance studies. All samples were characterised using chemical and mineralogical analysis, as well as petrography. Using this approach, it was possible to distinguish seven deposits, although some deposits presented compositional relations. Furthermore, the samples were compared to Neogene clay deposits in the same area, showing that the variability among the examined red clayey deposits was clearly higher and exceeded by far the intra-deposit variability.

Glass studies have been focused on the Dodecanese islands covering the historical period from 800 to 200 BC and combining various analytical techniques such as Scanning Electron Microscopy (SEM), Electron Probe MicroAnalysis (EPMA), Xray Fluorescence (XRF), Raman spectroscopy and Fiber Optics Microscopy.

In particular, Brill (1976, 1999) laid the scientific foundations for the analysis of Mycenaean, Hellenistic and Roman glass from the Hellenic region. In particular, Brill in his work of life in the 3-volume publication of *Chemical Analyses of Early Glass* (Brill 1999; Brill and Stapleton 2012) included analyses of glass belonging to the Hellenistic glass workshop in Rhodes island. The techniques he applied combined Flame Photometry, Optical Emission Spectroscopy, Atomic Absorption, Inductively Coupled Plasma Spectroscopy and occasionally X-ray fluorescence and Electron Microprobe in special glasses, when the sample size was extremely small, in order to reconstruct the production technology (to identify raw materials and define melting conditions).

The study by Rehren *et al.* (2005) focuses on the study of Hellenistic glass excavated in Rhodes island. Based on the analytical results obtained by an Electron microprobe analyser (EPMA), an attempt was made to assess whether or not primary glassmaking did occur on the island of Rhodes. The studies of Oikonomou *et al.* (2008, 2012, 2014, 2018) investigate glass beads excavated in Rhodes island dating to the archaic period (640-600 BC), in an effort to identify the technology and raw materials and give answers regarding the provenance of the primary glass. These studies used Raman spectroscopy, mostly SEM-EDS and XRF analysis, while there is one paper investigating the trace element fingerprint of the beads using the LA-ICPMS method. Triantafyllidis *et al.* (2012) have investigated an assemblage of a special category of glass, the so-called core formed vessels dating from Late Bronze Age to late Hellenistic period ($13^{th}$ c. BC to $1^{st}$ c. AD) from Rhodes island by means of SEM-EDS. This study revealed special technological characteristics highlighting the importance of Rhodes as a glassmaking center in Eastern Mediterranean. In addition, Beltsios *et al.* (2012) compared the glass beads from two different archaeological sites, Thebes and Rhodes, in order to identify differences in glass

technology and production using data derived from SEM/EDX and XRF analysis. Furthermore, a non-destructive approach was carried out on glass from the Dodecanese islands dating to 5$^{th}$ to 4$^{th}$ c. BC by Cheilakou *et al.* (2013). The combination of Fiber Optics Microscopy and Scanning Electron Microscopy gave interesting results regarding the manufacturing technique.

Similar to glass studies, various techniques, such as X-ray Fluorescence Spectroscopy, Scanning Electron Microscopy, Neutron Activation Analysis and Inductively Coupled Plasma Mass Spectrometry have been applied on obsidian artefacts to answer mainly provenance questions. Obsidian is an ideal material for the investigation of prehistoric social interaction, trade and exchange networks among ancient civilizations. Artefacts made from obsidian usually can be linked to their geological source with a high degree of reliability using such analytical techniques. Obsidian studies have been mainly focused on Aegean and in particular covering the Aegean sources of Melos, Antiparos and Gyali. In particular, Perlès *et al.* (2011) investigated obsidian blades from Coşkuntepe in Northwestern Turkey which were compared with three samples from the Cycladic island of Melos using both X-Ray Fluorescence and Laser-Ablation High Resolution Inductively- Coupled Plasma Mass Spectrometry confirming that certain coastal villages in the Turkish coast occasionally acted as nodes of exchange for Aegean seafarers in the late 7th millennium BC. Furthermore, Acquafredda *et al.* (1999) investigated non-destructively obsidian from 6 main Mediterranean sources including samples from Gyali and Melos islands in the Aegean using SEM-EDS instrumentation. According to this paper, it is possible to discriminate the six sources by using major elements analysis, such as $SiO_2$, $Al_2O_3$, CaO, $Na_2O$ and $K_2O$. Similarly, in a recent paper Milić (Milić 2014) examined obsidian from central Anatolia, the Aegean and the Carpathians and managed to successfully discriminate the provenance of such artefacts using portable XRF underscoring its usefulness, since it can offer non-destructive on-site analyses in contexts in which sampling of artefacts is often difficult if not impossible.

A different approach in obsidian studies was adopted by Kilikoglou *et al.* (1997) who compared the INAA and ICPES methods for their discriminative power in obsidian source characterisation. According to this study, both techniques worked successfully, however, INAA proved to be more efficient, as it offers interregional discrimination (discrimination of neighbouring sources). In the same line, De Francesco *et al.* (2008) examined obsidian samples from Mediterranean including samples from Melos and Gyali using XRF analysis and in particular they compared two different methods i.e. a non-destructive analytical method using wavelength-dispersive X-ray fluorescence (WDXRF) and the classical XRF method on powders (crushing, powdering and pelletizing). According to their results, the non-destructive approach is an extremely valid method for the attribution of the provenance of the archaeological obsidian from Neolithic sites. Finally, Frahm *et al.* (2014) tested two portable XRF instruments, in an attempt to distinguish the four Aegean obsidian sources: Melos (Nychia and Dhemenegaki), Antiparos and Gyali. Although in both cases the sources were distinguished

successfully, the newer model between the two offered superior precision for most elements and shorter measuring times.

The last category of inorganic materials includes metals, steatite, volcanic tephras and inorganic pigments. In particular, Pelton *et al.* (2014) investigated ancient metallurgical slags from the island of Kea, located in central Aegean Cyclades, by thermodynamic simulations with a view to understand the ancient metallurgical processes. According to their results, these slag samples resulted possibly from copper processing activities. Jones *et al.* (2007) investigated steatite from Crete island using ICP-MS in tandem with INAA, attempting to identify its chemical composition and its origin. With the application of this technique Jones *et al.* managed to partially differentiate four sources of steatite in central Crete. Galloway and Liritzis (1992) applied Gamma spectrometry using a hyper-pure Ge detector on volcanic tephras from Aegean and, in particular, from the islands of Santorini, Yiali, Nisyros, Kos and Rhodes, in order to identify volcanic eruptions and to correlate with the Santorini eruption of about 1650 BC. Katsaros *et al.* (2009) using a combination of techniques, such as SEM-EDS, XRD and Raman spectroscopy managed to characterise a wellknown pigment named *melian earth* and suggest that the site of Kontaros in Melos island could be the place of extraction of *melian earth*.

Finally, Secondary Ion Mass Spectrometry (ToF-SIMS) and Quad-SIMS have been applied for both the evaluation of the surface topography, as well as the detection of remaining organic compounds via various amino acids, that may have been trapped in the surfaces, in Ikaria and Youra in Sporades (Laskaris and Liritzis 2020).

*ii. Dating techniques*

In the field of dating the archaeometric studies focus on the early period (30000-3000 BC.) and are divided in 3 sub-categories depending on the technique which was applied: 1. Carbon 14 dating 2. TL-OSL dating and 3. Obsidian hydration.

*1. Carbon 14 dating*

Facorellis *et al.* (1982) investigated marine and terrestrial materials from the deserted island of Youra and more specifically from the Cyclope cave. The aim of this research was twofold: a) to date charcoal-seashell pairs, in order to determine the marine reservoir effect in this region, based on samples spanning from the end of the 8th millennium to the beginning of the 7th millennium BC and b) to date the stratigraphy of the site, by using the calculated δR value, in conjunction with the marine calibration curve. According to their results, Cyclope cave (in Alonissos island) is one of the oldest human settlements found on an Aegean island even though Pleistocene occupation has been traced elsewhere (Carter *et al.* 2019). In fact, hominins were present in the region by 200 ka ago, accessing the chert quarry during a glacial low stand when exposed land connected Anatolia to continental Southeast Europe, by seafaring, or through some combination of the two (Fig. 2). Throughout the remainder of the Pleistocene, this region was occupied and/or traversed at least sporadically, including by early *H. sapiens* ~40 to 30 ka ago (who may have arrived by boat), and later by indisputably seafaring

Mesolithic hunter-gatherers of the Early Holocene (Papoulia 2016). Fig.2 shows insular- sea interaction, due to sea level changes and subsistence in the Aegean Sea, during the past 400 Ka. The alternated glacial and interglacial periods formed land routes for transition and migration, yet sailing was practiced facilitating trade and general transitions.

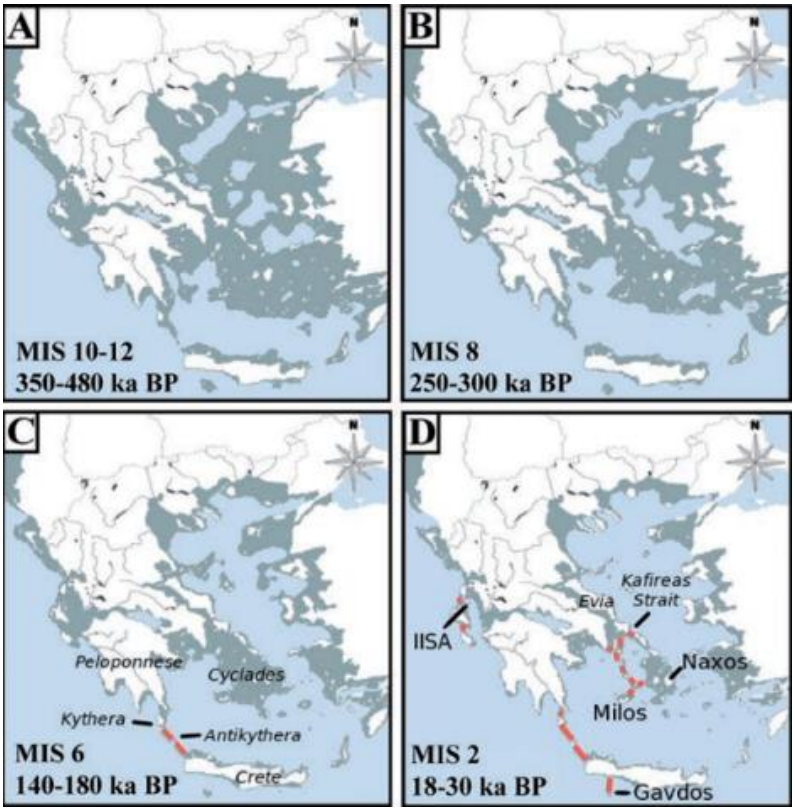


**Figure 2.** Sea level changes in the Aegean archipelagos referred to islands and coastal areas. Shaded parts imply joining with the mainland (from Papoulia 2016, Fig.4).

Ammerman *et al.* (2008) applied a combined method using high quality cores and AMS dating, in an attempt to trace (or identify) the beginning of the Neolithic period in northern Aegean and in particular in Thrace, constituting up to that time a missing piece in the jigsaw puzzle of the arrival of agriculture in Europe. In addition, the method applied traced the edge of the marine transgression dating to later times (ca. 2900 years ago), which implies that various sites/settlements located near the coastline in early Neolithic times most likely have been lost in the sea.

Furthermore, Mavridis and Tankosić (2009) examined pottery from Ayia Triadha cave in Euboea, in order to explore early maritime connections in the Aegean during the Late Neolithic I and II and the Early Bronze Age. Even though they examined pottery with an archaeological approach, they also provided archaeometrical data i.e. dating of a trench using charcoal performed by Dr Y. Maniatis.

Two years later, the paper by Maniatis and Papadopoulos (2011) gives new insights about the transitional period known as the Final Neolithic-Early Bronze Age in Greece which falls within the 4$^{th}$ millennium BC. In particular, the paper presents archaeological evidence and radiocarbon dates from Aghios Ioannis site on Thassos, the northernmost Aegean island. The 14C dates obtained fall towards the end of the 4th millennium, suggesting presence of human activity during this period, a find of particular environmental and cultural significance.

Finally, Strasser *et al.* (2011), showed that Palaeolithic artefacts in the Plakias region in southwestern Crete are associated with geological contexts that can be dated to the late Middle or early Late Pleistocene. Since Crete has been separated from the mainland throughout the Pleistocene, the presence of Pleistocene age artefacts there suggests that early hominins were able to cross open water.

*2. TL-OSL dating*

TL-OSL dating is applied on various inorganic materials such as obsidian, rocks, soils and special architectural remains i.e. an archaemetallurgical kiln.

More specifically, Zacharias *et al.* (2006) have investigated archaeometallurgical kiln remains from two prehistoric sites on the island of Seriphos (Cyclades, Greece) using TL dating, thus, providing information on the chronological period of the corresponding activities. This study provided absolute ages for the kiln assemblages, as well as highlighting sources of potential errors through its methodological approach.

Vafiadou *et al.* (2007), using OSL dating, investigated rock samples and associated underlying surface (floor) soils of geo- archaeological significance from three regions, Greece, Sweden and a modern surface stone-sample from a Danish site. Following a single-aliquot regenerative-dose (SAR) protocol and luminescence signals from quartz and feldspars using blue light and IR stimulation respectively, the obtained geo- archaeological ages were in good agreement with independent age estimates.

The area of Istron, Gulf of Mirabello in eastern Crete, was investigated by Zacharias *et al.* (2009), attempting to date the sediments using optical stimulated luminescence (OSL). Their approach provided information on the landscape evolution of the area. Using also various other analytical techniques, such as field-survey, geophysical prospection, and archaeological excavations, chemical and spectrometric studies on selected deltaic deposits enlightened paleoenvironmental differentiations that prevailed at neighboring sites. According to their

study, landscape evolution was influenced mainly by environmental changes at an area occupied by the man since Neolithic onwards.

Polymeris *et al.* (2010) applied luminescence techniques (Thermoluminescence-TL and Optically Stimulated Luminescence-OSL) on obsidian samples to investigate its potential for dating purposes. They concluded that the artificially irradiated samples indicate all promising luminescence features and the signal does not relate to quartz, but in fact to other silicates. However, the lack of bleaching ability for NTL signal, along with a peculiar shape of NOSL, provide major difficulties in dating applications.

Liritzis (2010) investigated the excavated coastal prehistoric settlement of Strofilas on Andros Island (Cyclades, Greece) in the Aegean providing dates for its construction. In particular, he applied luminescence dating on two samples from the fortified wall bearing engraved ships yielding an average date of 3520 (±540) BC.

In the same year, Athanassas and Zacharias (2010) published an OSL dating framework for raised marine sequences in the South-West coast of Greece during Upper Quaternary. The paleontological investigations and Geographic Information System (GIS) analysis on various elevated marine landforms have proved that a record of uplift and eustacy exists in South Greece since the Early Pleistocene (~1.6 Ma). Therefore, in their paper they tested the suitability of the SAR methodology for recuperated-OSL (Re-OSL) on coarse-grained quartz aliquots from emerged nearshore outcrops.

Kanavou *et al* (2014) using OSL dating with a modified SAR protocol calculated the ages for the Upper Pumice samples from Nissyros island with average values of 15.3 ± 8.6 ka BP and 40.3 ± 23.1 ka BP respectively, and for a paleosol ages varied from 29.6 ± 10.2 ka BP to 39.0 ± 15.1 ka BP respectively; all corresponding to successive volcanic eruption phases.

*3. Obsidian Hydration*

In this field of dating Liritzis *et al.* (2004) proposed a new approach in dating ancient obsidian artifacts. This approach is based on the modeling of water diffusion profiles and multiple archaeological test cases of known age were used to evaluate the method. The method is based on the $H_2O$ concentration versus depth profiles which are modeled, so as to produce diffusion ages. Secondary Ion Mass Spectrometry was used to date fourteen obsidian specimens of well-known age and have been compared with radiocarbon ages producing an excellent convergence validating the new approach.

Furthermore, Liritzis *et al.* (2008) tested a new method, SIMS-SS dating, by investigating the limitations derived from the surface roughness of obsidian by incorporating in the study Atomic Force Microscopy (AFM) images. According to this study, anomalies on the obsidian surface, such as presence of wells, cracks, pits, crystals and/or crests can induce uncertain errors in the dating procedure.

Likewise, Liritzis (2010) investigated the excavated coastal prehistoric settlement of Strofilas on Andros Island (Cyclades, Greece) in the Aegean In particular, he applied SIMS-SS method on two blades for obsidian hydration, suggesting that the main settlement occurred during the Final Neolithic period.

Moreover, Laskaris *et al.* (2011) provided new results of absolute dating with new obsidian hydration dates by employing the novel SIMS-SS method. This contribution shed new light on the Late Pleistocene/Early Holocene exploitation of obsidian sources on the island of Melos in the Cyclades reporting dates of c. 13th millennium until the end of 10th millennium B.P. which are concordant with the excavation data. Archaeological evidence regarding the presence of obsidian in levels that antedate the food production stage suggests that it could have been the result of usage or intrusion of small obsidian artifacts from overlying Neolithic layers.

*iii. Paleoenvironment*

A significant volume of work has been done in the broad field of paleoenvironment. There are many works related to the coastline of specific areas, geo- archaeological investigations of archaeological sites and study of the archaeobotanical remains.

An early investigation of coastlines of Greece and especially the Aegean was performed by Tjeerd and Shackleton (1982). According to the results of this study, many islands, among which Euboea and the northern Sporadhes, were connected with the mainland, while most of the Cyclades were joined together in a semi-peninsula. The post-glacial rise of sea level took place between 15000-9000 y. B.P. restored the coastal geography to almost its present configuration. As it can be assumed, this change affects significantly the archaeological environment. For example, the island of Melos, a known source of obsidian for toolmaking since at least 10000 B.P., may have been discovered considerably earlier, when access to the island was largely over land.

The paper by Perissoratis and Conispoliatis (2003) investigates the tentative coastline configuration in three major periods, namely 21500 cal y B.P., 11500 cal y B.P. and 8000 cal y BP. Based on the results, many islands were connected with each other and with the mainland during the first period, while in the second period most of the gulfs were overflowed by the advancing sea and only a few islands remained connected with the mainland. Finally, at 8000 cal yr BP onwards, the sea intruded the lowlands and the gulfs. Subsequently many human settlements and old cities that were maritime during Hellenistic or older times are now a few to tens of km inland.

Megaloudi (2006) provided in a monograph a synthesis of information on Greek food plants recovered mainly through archaeobotanical studies. This study provided a diachronic overview of the use of vegetal species in the Eastern Aegean region in the period spanning the millennia between the Early Neolithic (ca. 7000 BC) and Classical times (4th century BC). The

data obtained from this study shed light on several aspects of ancient food and diet, including the geographical and chronological distribution of cereals and legumes, the beginnings of arboriculture in Greece, and the use and symbolic meaning of plants in ancient times.

Pavlopoulos *et al.* (2007) was the first geoaracheological investigation of Istron area, in northeastern Crete, Gulf of Mirabello in recent years. The importance of the area is evident by indications of human installations from the Neolithic to the Roman period, proving the continuous human activity in this area. A variety of methods Was implemented, such as geomorphological mapping of the coastal area, excavation of six trenches, pollen and microfaunal (benthic foraminifera and ostracodes) analyses, AMS and Conventional radiocarbon dating. Sea level rise along with sea-land interactions to the landscape evolution and the transgression of sea in 5000BP have been verified. Furthermore, several implications for the use of land and human impact civilization have been revealed.

The paper by Theodorakopoulou *et al.* (2009) examined the application of several geoarchaeological methods to provide useful information regarding the paleoenvironment of Istron-Kalo Chorio, Gulf of Mirabello, in eastern Crete. In particular, the combination of detailed field-survey, geophysical prospection, archaeological excavations, along with geomorphologic observations, analyses and dating on deposited sediments, gave evidence of the paleogeographical evolution of the area and its impact on prehistoric, classical and Roman establishments. The study suggests that landscape evolution of the area was influenced both by environmental changes and human presence during the Holocene.

Pavlopoulos *et al.* (2010) investigated the Palamari Bay, located on the northeastern coast of Skyros Island (Sporades Islands, Aegean Sea), attempting to reconstruct its palaeoenvironment and landscape evolution, since at the northern edge of the bay a fortified prehistoric settlement is found, dating between 2800 and 1700 BC (Early Bronze Age II-Middle Bronze Age I). Thus, three main sedimentary units were recognized: the lowermost sedimentary unit A, deposited between before 7500 and 3500 cal B.P., the overlying unit B (ca. 3500–800 cal B.P.) and the uppermost sedimentary unit C which corresponds to a backshore environment dominated by aeolian activity modified by fluvial processes. Furthermore, a strong human presence since the Neolithic was identified by evidence of cultivating and grazing activities in the vicinity of the lagoon.

The review paper of Colonese *et al.* (2011) investigate the exploitation of marine molluscs from sites dating from Lower to early Upper Paleolithic in Mediterranean, including the Aegean Sea. In particular, they investigate the consumption of molluscs by humans, however, the scale of mollusk exploitation is still unclear, due to biases produced in the coastal archaeological record especially by Late Glacial and post-Glacial sea level rise. In addition, the consumption of shellfish, and of other small animals (aquatic and continental), probably contributed to the success of the flexible and opportunistic subsistence strategies adopted by Mediterranean hunter–gatherers for much of prehistory.

Aidona and Liritzis (2012) investigated marine sediments from the Aegean, in order to identify their magnetic susceptibility and its correlation with the alpha- and beta-particle radioactivity. The sediments were obtained using cores covering the Holocene period. In addition, closely spaced data have been sampled from all cores. By applying a new statistical elaboration of the final time series, they showed that there is a significant correlation between the magnetic susceptibility and the radioactivity data.

Tourloukis and Karkanas (2012) investigate the gap in early human geography of the Mediterranean, due to the scarce Pleistocene record. In this paper through a synthetic study they provide the Lower Palaeolithic record of Greece., In essence, using a geo- archaeological approach they identified that this gap is due to the high-magnitude site loss and not a real absence of hominins. In such dynamic landscapes, the geomorphic processes can significantly bias archaeological patterns. Another outcome of their study was that in the early Pleistocene, the Aegean was important bio-geographical land-bridge and new routes can be envisaged for hominin dispersals within Eurasia and between Africa-Eurasia.

Theodorokapoulou *et al.* (2012) aim to reveal the depositional environment of Istron and its sedimentological response to Holocene climatic events. By applying a multi-disciplinary geoarchaeological approach they gathered information on the depositional environment and the palaeoenvironmental evolution of the area during the Holocene. In particular, using sediment cores and analytical studies, such as OSL dating and XRF analysis, they provided evidence for landscape evolution of the coastal area.

Livarda and Kotzamani (2013) published a synthetic work on the archaeobotany of Crete from Neolithic to Bronze age Crete. This paper explores various aspects, such as agricultural practices and resource management and mobilisation, so as to give new insights into the social dynamics of Neolithic and Bronze Age Crete. Data was obtained from six sites, namely Kephala Petras, Pryniatikos Pyrgos, Aghia Fotia, Knossos Little Palace North, Sissi and Zominthos and allowed an in-depth study of a total of 80 archaeobotanical records. Furthermore, the dataset was analysed according to its temporal, spatial and contextual distribution across the island providing a contextualised picture of their availability and use, and identifying lacunae and interpretational potential.

Mourtzas and Kolaiti (2013) based on geomorphological and archaeological indications identified three distinct sea levels on the coast of Aegina island which were also dated. According to their results, there is sea level stability for at least 2100 years, from Middle Bronze Age to Roman times. Furthermore, with the aid of the paleogeographical reconstruction of the coast, they found that the ancient harbour installations could potentially stretch up to 1600 m of coastline.

Drinia *et al.* (2014) investigated the north Evoikos gulf in central Aegean Sea by studying six gravity cores taken from different physiographic settings of the Gulf, aiming to identify their benthic foraminiferal content. In this way, they were able to reconstruct the local

and regional palaeoenvironmental changes having taken place in the Gulf. In particular, they managed to recognize two main palaeoenvironmental settings, the first dominated by Biofacies Ia and Ib, while in the second setting, the species typical of shelf environment (C. laevigata–H. balthica) giving way to opportunistic species (B. spathulata) and species that are more resistant to bottom water changes (*B. marginata*).

The study of Stiros *et al.* (2014) focuses on an enigmatic coastal uplift and subsidence along the coasts of Rhodes island through the investigation of a Hellenistic harbor in Rhodes. In particular, the paper investigates the remains of a ship shed which was built around 250-225 BC. and some decades later it was repaved, after a major earthquake. According to the results, the only reasonable explanation for the ramp reconstruction was to counteract a 1 m seismic subsidence, which took place at around 220 BC. or earlier.

*iv. aDNA analyses*

Another poorly explored field is the genetic studies through ancient aDNA. These studies focus on the investigation of Y-chromosome on Crete (Malaspina *et al.* 2001; Martinez *et al.* 2007; King *et al.* 2008) and on the origin of Minoans and Myceneaens (Lazaridis *et al.* 2017). There is only a single work referring to aDNA derived from amphora remains (Foley *et al.* 2012).

The first approach in aDNA analysis has been performed by Malaspina *et al.* (2001) who focused on a microsatellite-defined Y-chromosomal lineage (network 1±2) whose geographic distribution and antiquity appear to be compatible with the Neolithic spread of farmers. The research team set a network 1.2 in the Y-chromosomal phylogenetic tree, dated it with respect to other lineages associated with the same movements by other authors, examined its diversity by means of tri- and tetra-nucleotide loci and discussed the implications in reconstructing the spread of this group of chromosomes in the Mediterranean area. According to their results, a tripartite phylogeny within HG 9 (Rosser *et al.* 2000) is defined, with the deepest branching defined by alleles T (Haplogroup Eu10) or G (Haplogroup Eu9) at M172 (Semino *et al.* 2000), and a subsequent branching within Eu9 defined by network 1±2. Population distributions of HG 9 and network 1±2 show that their occurrence in the surveyed area is not due to the spread of people from a single parental population but, rather, to a process punctuated by at least two phases. The analysed data identified the wide area of the Balkans, Aegean and Anatolia as the possible homeland harbouring the largest variation within network 1±2. In addition, the use of recently proposed tests based on the stepwise mutation model suggested that its spread was associated to a population expansion, with a high rate of male gene flow in the Turkish–Greek area.

Martinez *et al.* (2007) investigated the geographic stratification of the contemporary Cretan Y-chromosome gene pool, which was assessed by high-resolution haplotyping aspiring to investigate the potential imprints of past colonization episodes and the population substructure. In addition, this study includes samples from the isolated interior of the Lasithi Plateau, a mountain plain located in eastern Crete. Comparisons of Y-haplogroup frequencies

among three Cretan populations, as well as with published data from additional Mediterranean locations revealed significant differences in the frequency distributions of Y-chromosome haplogroups within the island. The most outstanding differences were observed in haplogroups J2 and R1, with the predominance of haplogroup R lineages in the Lasithi Plateau and of haplogroup J lineages in the more accessible regions of the island. Y-STR-based analyses demonstrated the close affinity that R1a1 chromosomes from the Lasithi Plateau shared with those from the Balkans, but not with those from lowland eastern Crete. In contrast, Cretan R1b microsatellite-defined haplotypes displayed more resemblance to those from Northeast Italy than to those from Turkey and the Balkans.

Furthermore, King *et al.* (2008) tried to investigate farmers in Crete and mainland Greece and their debated origin from Anatolia and whatthe role of maritime colonization was. To achieve this, they collected 171 samples from areas near three known early Neolithic settlements in Greece together with 193 samples from Crete. They performed an analysis of Y-chromosome haplogroups and determined that the samples from the Greek Neolithic sites showed strong affinity to Balkan data, while Crete shows affinity with central/Mediterranean Anatolia.

Foley *et al.* (2012) have tested the remnant aDNA inside empty amphoras excavated in Classical/Hellinistic greek shipwrecks which were archived at the Ministry of Culture and Tourism, Ephorate of Underwater Antiquities in Athens, Greece. They showed that ancient DNA can be isolated and analysed from inside the empty jars from either small amounts of physical scrapings or material captured with non-destructive swabs. Collected DNA samples reveal various combinations of olive, grape, Lamiaceae herbs (mint, rosemary, thyme, oregano, sage), juniper, and terebinth/mastic (genus Pistacia). General DNA targeting analyses also revealed the presence of pine (Pinus), and aDNA from *Fabaceae* (Legume family); *Zingiberaceae* (Ginger family); and *Juglandaceae* (Walnut family). The results of this paper demonstrated that amphoras were much more than wine containers. DNA analysis showed that these transport jars contained a wide range of goods, bringing into question long-standing assumptions about amphora use in ancient Greece. Ancient DNA investigations open new research avenues, and will allow accurate reconstruction of ancient diet, medicinal compounds, value-added products, goods brought to market, and food preservation methods.

Finally, a work led by Lazaridis and a large scientific group (Lazaridis *et al.* 2017) has produced valuable results after gathering and reporting genome-wide data from nineteen ancient individuals in an effort to identify the origins of the Bronze Age Minoan and Mycenaean cultures. The data obtained by Minoan individuals from Crete, Mycenaeans from mainland Greece, and their eastern neighbours from southwestern Anatolia. This extensive study showed that Minoans and Mycenaeans had at least three quarters of their ancestry from the Neolithic farmers of western Anatolia and the Aegean showing that they were genetically similar. The remainder are coming from ancient populations, such as the Caucasus and Iran.

Furthermore, the Mycenaeans derived additional ancestry from an ultimate source related to the hunter-gatherers of eastern Europe and Siberia, which was the main difference between Minoans. The results of this study showed and supported the idea of continuity and that the populations of the Aegean were not isolated before and after the time of its earliest civilizations.

*v. Archaeomagnetism*

In Greece, systematic archaeomagnetic investigations for recording the secular variation (SV) started at the late 1970s (Walton 1979; Liritzis and Thomas 1980; Thomas 1981; Aitken *et al.* 1989; Downey and Tarling 1984; Papamarinopoulos 1987; Tarling and Downey 1989).

The aim has been to construct the archaeomagnetic intensity (including inclination and declination) curves of the past 8000 years, where available ceramic material and well fired kilns/hearths could be found. Most archaeomagnetic work is on Greek mainland, rather than in the Aegean islands. However, in the Aegean area earlier works focus on the Minoan Crete, as well as other islands of the Aegean, such as Santorini, Chios and Paros. In particular, these works refer to the intensity and directional data (Tarling *et al.* 1989; Liritzis and Thomas 1980; Walton 1990; Liritzis and Thomas 1980; Liritzis 1985a, 1985b; Downey and Tarling 1984; Downey and Liritzis 2013; De Marco *et al.* 2008; Nachasova *et al*. 2007, 2008) studying ceramics imported from the Greek islands of Kos, Lesbos, Thasos, Chios and Rhodes and from Asia Minor (Heracleia and Sinop), found at the archaeological sites of Nymphaion and Panticapaeum at the Crimean Peninsula, using as geographic coordinates the Chios Island (Lat = 38.60°, Long = 26.10°).

In Mainland Greece including some data of the southern Balkans have been reported by: Walton 1979, 1984; Xanthakis and Liritzis 1991; Tema and Kondopoulou 2011; De Marco *et al.* 2008; Spatharas *et al..*, 2000). A step forward in intensity measurements was made in Oxford laboratory by I. Liritzis and colleagues from Oxford on well dated tiles (by inscription) from Byzantine monasteries from Greece (Aitken *et al.* 1989) and revealing rapid variations of the archaeomagnetic intensity field peaked around 1300 AD (Liritzis 1989; Aitken *et al.* 1989; Liritzis and Kovacheva 1992; Kovacheva *et al.* 1999).

The most recent SV curve (Tema and Kondopoulou, 2011) data were based on all data within a 700 km circle centred at Thessaloniki (40.60°N, 23.00°E). The sliding moving window technique, was used to calculate a continuous SV curve for intensity while the directional SV curves were calculated using the bivariate extension of the Fisher statistics. These curves are well constrained and clearly show the main features of the geomagnetic field variation in this region during the last eight millennia, comparable to earlier attempt (Xanthakis and Liritzis, 1991). Comparisons with the predictions of the SCHA.DIF.3K and SCHA.DIF.8K regional and the CALS7K.2 and ARCH3K.1 global geomagnetic field models show a good agreement for the last 3000 years, however some differences were noticed for older times. The Balkan SV curves identify several rapid changes of the geomagnetic field, already pinpointed by Liritzis (1989),

Aitken *et al.* (1989) and Liritzis and Kovacheva (1992), which can be used as reference curves for archaeomagnetic dating in the Balkan Peninsula. However, although enriched the earlier archaeointensity curve, their reliability is marginally improved and of the same order of uncertainties with those of earlier data (Thomas 1981; Liritzis 1989; Kovacheva 2003; Kovacheva *et al.* 2009).

A comparison of archaeomagnetic intensity curve for the Greek area including some Aegean sites with limnomagnetic curves has been made by Xanthakis and Liritzis (1991) applying robust statistical techniques of comparison of smoothed data.

Spectral analysis of these intensity and directional data have been applied also aiming to define any periodic variation (Liritzis 1985a, 1985b; Xanthakis and Liritzis 1989, 1991).

*vi. Isotopic analysis*

Isotopic analysis is a well-established methodological tool for detecting dietary and migrating patterns in archaeological population. Furthermore, it is widely used to detect geological features of the paleoenvironment. No or little attention is paid to the area of Aegean Sea in the period from 30000-3000 BC and especially the area of the Dodecanese during the period from 800-200 BC.

One of the earliest studies of isotopic measurements were carried out by Liritzis *et al.* (1995). In this early study the differences in the radon isotope measurements in Nissyros Caldera and the Susaki geothermal field showed that are depended on the lithology and geothermal activity of the two regions. Furthermore, the distribution of radon and thoron in these areas was correlated as expected with the complicated geology of these two geothermal fields.

Aksu *et al.* (1995) investigated paleoclimatic and paleoceanographic changes from late glacial to Holocene periods in Aegean Sea using an array of different indicators, such as records of calcareous and organic-walled marine microfossils, pollen and terrestrial spores and oxygen isotope data in cores from the Aegean Sea basins. According to the results of this study, the late Glacial-Holocene transition in the region was associated with a large warming of surface water of around 5°-10°C from ~14,000 to ~9600 yr B.P. In addition, transfer function results indicate corresponding 1.0 to 1.5‰ salinity reductions for this tim (ca. 6400–9600 yr B.P.) throughout the Aegean Sea. Pollen, dinoflagellate and isotopic data show that the early Holocene excess fresh water originated from rapid melting of the northern European and Siberian ice sheets, supplied primarily from the Black Sea by the opening of Bosphorus and Dardanelles Channels, during the post glacial sea-level rise, and supplemented by major rivers entering the Aegean Sea.

Nafplioti (2011) presents a map of biologically available $^{87}Sr/^{86}Sr$ signatures for the Aegean in an effort to investigate past population movement and residential mobility. The $^{87}Sr/^{86}Sr$ values recovered mainly from archaeological animal dental enamel and modern snail shells from sites largely distributed in the southern part of Aegean. Local biologically available

$^{87}Sr/^{86}Sr$ signatures show clear geographical patterning among mainland sites of the Pindos and Parnassos zones and the islands of south-eastern Aegean crossed by the Sub-Pelagonian zone, and sites in the central Cyclades and the north-eastern Aegean islands falling into the Attic-Cycladic metamorphic belt and the Vardar zone, respectively. In addition, the biologically available $^{87}Sr/^{86}Sr$ values from sites on central Euboea, south-eastern Attica, the western Cyclades, and on Crete were found to be relatively high, but still lower than those recorded for the central Cyclades and the north-eastern Aegean.

Vika and Theodoropoulou (2012) measured for the first time isotopes from fish bones in a rather wide chronological period from the Mesolithic to the Classical times. The main aim of this work is to identify whether the absence of fish data is a matter of dietary preferences in the past or just a methodological approach issue. According to their results, regional trends are stronger that temporal ones in fish isotope values. The range of values overlaps with terrestrial resources, making it difficult or impossible to reject fish consumption based on isotope data alone. Frequent consumption of fish will not be directly evident isotopically.

Bajnóczi *et al.* (2013) performed stable isotope analysis in a big assemblage of Spondylus objects, mainly ornaments and beads, from sites in Hungary, neolithic Greece, modern shells from the Aegean and the Andriatic, as well as fossil Spondylus and Ostrea shells from the Carpathian Basin. The identification of the source of Spondylus objects is essential for the interpretation of Late Neolithic exchange systems and the social role of shell ornaments. The use of oxygen and strontium isotopes was essential to find similarities and differences between the diferrent groups of shells. Even though the focus of this paper is on Hungarian Neolithic objects, it yields values for Aegean Neolithic artefacts which can be further used in future research.

*vii. Restoration and conservation*

Restoration and conservation of Cultural Heritage is a well-established field, with a history of more than150 years. In this field, there are only few studies regarding the conservation and restoration of monuments during the early period (30000-3000 BC) and historical times (800-200 BC) in the area of interest. These studies are focused mainly on Rhodes island and refer to investigation of building materials and conservation strategies of various sites on the island such as Sarantapicho and Erimokastro acropolis (Bakolas *et al.* 2013; Delegou *et al.* 2010; 2012; 2013) as well as the investigation of historic mortars (Moropoulou *et al.* 2000).

Moropoulou *et al.* (2000) performed mortar sampling on historical constructions, masonry and architectural surfaces of Rhodes island. They have investigated the different mortar technologies aiming to answer questions regarding their finality, i.e. whether their differences arise mainly from the various historical periods of construction or from the purposes they had to serve, imparting to the mortars the properties required by their function in the structure. Various techniques, such as mineralogical, chemical, physical and mechanical

investigations have been performed on characteristic samples with gradation. Hence, parameters determining the diversification of the resulting mortar/matrix types concern the raw materials employed as binding materials and the production processing.

Delegou *et al.* (2010) applied GIS modelling and analysis operations to accomplish strategic planning of materials and conservation interventions, for the damage rehabilitation of the Sarantapicho Acropolis and Erimokastro Acropolis in Rhodes, Greece. In this study, GIS thematic maps were developed presenting characteristic parts of the walls of the two Acropoles. Using orthophotos as the GIS base-map, various materials/decay data collected after the application of non-destructive testing, evaluation techniques in- situ and analytical techniques in lab after sampling, comprised the attribute data sets which describe the characteristics of the spatial entities. All this information resulted in the development of building materials and decay thematic maps. In addition, they compiled databases containing the physicochemical characteristics and linked with the internal database file of the corresponding GIS materials/decay mapping project of the Acropoles walls. Finally, using geo-processing analysis the conservation intervention thematic map was produced, where data from both materials and decay themes were incorporated into the new output theme, contributing to the strategic planning of materials and conservation interventions, for the damage rehabilitation of the Sarantapicho Acropolis and Erimokastro Acropolis. It was concluded that GIS modeling and analysis operations of the developed materials/decay/conservation interventions thematic maps along with the corresponding relational databases, can contribute decisively to the monuments monitoring, as well as to the management and control of building materials life cycle.

Labropoulos *et al.* (2010) investigated the building materials of the walls at the Ialyssos Acropolis (Sarantapichos) and the Acropolis of Erimokastro in Rhodes island using various analytical techniques such as ultrasonics, ground penetrating radar, infra-red thermography and fibre optics microscopy which were supported by a range of characterization techniques which included polarized Optical Microscopy, X-ray diffraction, Scanning Electron Microscopy, Mercury Porosimetry, conductivity measurements and mechanical testing. This multi analytical approach was carried out to characterize the structural materials and the decay products of the walls. According to the results, there is extensive bio-decay present on the two types of stones, grey compact limestone and off-white limestonethat results in cracking, delamination and detachment of original material.

In Delegou *et al.* (2012) a combination of diagnostic strategies involving the application of in-situ non-destructive testing and in-lab techniques, GIS modelling and analysis operations were used to plan materials and conservation strategies at the walls of Erimokastro Acropolis Rhodes. In particular, Polarized Optical Microscopy Mercury Porosimetry, Scanning Electron Microscopy, determination of total soluble salt content, Fibre-optic Microscopy, Ultrasonics

and Infra-red Thermography were used to characterize the building material and its decay products to further assess the conservation treatments.

Bakolas *et al.* (2013) investigated the building materials of the walls at the Ialyssos Acropolis (Sarantapichos), in Rhodes island applying a wide range of in- situ analytical techniques, such as Ultrasonics, Infra-red Thermography, Fibre optics Microscopy and ground penetrating radar combined with in lab instrumentation such as Polarized Optical Microscopy, X-ray diffraction, Scanning Electron Microscopy and Mercury Porosimetry. According to the results, there is extensive bio- decay present on grey compact limestone, as well as cracking, delamination and detachment of original material.

Delegou *et al.* (2013) used the geometric documentation of characteristic parts of the walls of the Sarantapicho Acropolis and Erimokastro Acropolis in Rhodes, Greece, together with GIS modeling and analysis operations in order to accomplish the mapping of building materials, decay patterns and conservation interventions of both investigated sites. In particular, they have applied a similar approach, as in their 2010 study, using ortho-rectified images as base-maps and the building materials and decay data, comprised the spatial and attribute data sets. By collecting various data from the building materials and the techniques applied they managed to develop thematic maps of building materials and decay. Moreover, using geoprocessing analysis the thematic map of conservation interventions was produced incorporating attribute data from both building materials and decay themes. This multidisciplinary approach provides the basis for the compatibility assessment of conservation interventions (whenever applied) and for monitoring of the preservation state of building materials, contributing decisively to the sustainable protection of both investigated sites.

The monastery of St. John the Theologian in Patmos, which dates back to the 11th century, is today a major spiritual and artistic entity in the Mediterranean archaeological, ecclesiastical and cultural history and it is included in the UNESCO World Heritage list. The 84 valuable Coptic archaeological textiles, in the monastery, dated between the 4th and 7th centuries A.D., were recently analysed for conservation and preservation purposes with the application of scientific techniques to identify the fibres structure and the dyes used, via μFTIR (fourier transform infrared), SEM, optical microscopy (OM), Surface Enchased Raman Spectroscopy (SERS) and SEM methods (Karydis *et al*., 2019). The provided information concerns the decoration, weaving patterns, condition (stains, tears) and past conservation treatments on the textiles which are all recorded. Moreover, through the application of three different analytical techniques (μFTIR, μRaman and SERS) it was identified the dyes used on these textiles, in particular, madder, indigo, granule (kermes) and weld which are common for this type of textiles. Finally, through the application of SERS technique it was managed to avoid the fluorescence phenomenon and enhance the Raman spectra so as to make the particular peaks more visible and more identifiable.

viii. *Geophysical studies - GIS*

There are only few geophysical studies focused on the Aegean and the Dodecanese during the time periods examined herein. One of these refers to the investigation of buried archaeological relics on the island of Mytilene using electric resistivity and resistance and magnetic measurements (Papamarinopoulos *et al.* 1985). Furthermore, there is a study regarding a palaeoenvironmental reconstruction on Crete island by the application of GIS (Siart *et al.* 2010) and an investigation of ancient Mediterranean seafaring (Leidwanger 2013).

In particular, Papamarinopoulos *et al.* (1985) investigated a gridded archaeological site in Lesvos island by performing total geomagnetic field intensity measurements with a portable magnetometer. According to their results the measurement analysis reveals linear features which corresponded to ancient buried relics. In addition, they applied resistivity soundings on the same area allowing estimates of the thickness of the soil with respect to bedrock and revealed artificially made voids.

Siart *et al.* (2010) in their multidisciplinary study applied an approach in order to evaluate the potential of colluvial fillings for reconstructing the geoarchaeological landscape in mount Ida, central Crete. They have conducted remote sensing and GIS analyses, geophysical prospection (refraction seismics, earth resistivity tomography) at the most promising archive locations. In addition, they performed selective percussion drilling within the sinkholes which provided vibra-cores for further analysis such as mineralogical and sedimentological investigations (grain size distribution, heavy- and light minerals, X-ray diffraction, thin sections) as well as AMS 14C dates. According to their results the dolines are partially filled by loose material and, thus, offer valuable information about the environmental history. The diversified sediment constitution indicates several geomorphodynamic oscillations and a polygenetic nature of the colluvial fills. XRD-spectra of clay minerals and quartz-grain morphology both indicate a significant aeolian dust contribution to soil formation and pedo-sediments. Glass shards and substantially heterogeneous heavy mineral compositions point to supra-regional origin and external volcanogenic deposits (Minoan eruption of Santorini, 3.6 ka). Regarding the hitherto discussed distribution of Z2 tephra in the Mediterranean, the spatial fallout must be revised as great amounts have also been deposited in the high mountains of Crete. Moreover, the redeposition of the sedimentary fills proves to be comparatively young since most materials were accumulated within the dolines post-eruptively. Huge and previously unknown subsurface archaeological remains strongly suggest that year-around settlement in the mid-Holocene might have been possible under better climatic conditions.

The work of Leidwanger (2013) focuses on the use of Geographic Information Systems (GIS) to integrate environment and technology as analytical tools for exploring the complexity of seaborne connectivity. Their methodology involved the sailing days as practical units of distance and an Archaic Greek shipwreck off Turkey was used as a case study, in an effort to demonstrate how a more nuanced spatial approach can inform the human geography and socioeconomic structures of ancient maritime interaction.

A series of GIS applications has been made by Sarris *et al.* from the Institute of Mediterranean Studies, Crete in Crete. The Aegean Minoan 3D GIS Project was initiated in 2007 to produce a three-dimensional (3D) full-color mapping of the archaeological sites of the Minoans in the Aegean Sea area using Google Earth. It is intended to be a definitive geographical reference available to everyone (http://www.etana.org/node/10848). Also Minoan sites building a cultural landscape model of Minoan peak sanctuaries through a GIS approach (Soetens *et al.* 2002).

**Conclusions**

Through this intensive and systematic study, we were able to locate and gather the majority of archaeometrical investigations which refer to the islandic area of the Aegean from 30000-3000 BC and the Dodecanese islands from 800-200BC. The data obtained are mostly available on the http://archipelago.aegean.gr website (here updated since 2013) which comprises an extensive database including metadata files.

Upon completion of the present work, more studies would be expected given the importance of the region in the archaeological record. However, there has been a trend especially the last ten years suggesting a stable increase in the archaeometric studies in numbers and quality and this is due to the establishment of Archaeological Science/Archaeometry in the field of Archaeology.

It is noteworthy that a lot of archaeometrical studies do exist, but they are focused in later periods, e.g. Late Bronze Age or/and Roman-Byzantine period, so do not fall in the scope of this study.

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