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Mediterranean Archaeology and Archaeometry
Vol. 21, No 2, (2021), pp. 1-27
Open Access. Online & Print.

DOI: 10.5281/zenodo.4643747

AN UPDATED OVERVIEW OF ARCHAEOLOGICAL SCIENCES RESEARCH IN INSULAR GREEK AEGEAN ISLANDS

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Received: 02/01/2021
Accepted: 02/04/2021
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ABSTRACT

The current work presents an overview of applications of archaeological sciences which include the Aegean region between the commencement of last Glacial period (27-3,0000 BP) to Bronze Age, as well as a focus on the Dodecanese islands (SE Aegean) between 800 and 200 BC. The present study is an updated of earlier work made as part of a project aiming to develop a database with metadata about diachronic habitation in the Geek Aegean and coastal sites.

The updated current overview is allocated into 9 major subject categories, namely chronological methods, (geo)chemical analysis, palaeoenvironment, ancient DNA, archaeomagnetism, isotopic analysis, conservation and restoration studies, geophysical studies, archaeoastronomy). The interdisciplinary overview data serves as a convenient guide to an important academic discipline, that of archaeometry or archaeological sciences, which is steadily developed in methods and methodology, new techniques and major results in basic research and applications. Probing into the material culture the overview presents useful information concerning the human prehistoric and historic past in the SE Mediterranean area.

KEYWORDS: Chronology, analysis, ceramic, archaeomagnetic, conservation, geophysical, palaeoenvironment, (geo)chemical, DNA, spectroscopy, settlement, database

1. INTRODUCTION

Archaeology and Cultural Heritage has been benefited a great deal in deciphering past human development from the natural sciences. For over 70 years the application of natural sciences to archaeology and cultural heritage has been ever growing with multiple contributions to the past cultures. The novel techniques, applied to almost all material culture, and the interdisciplinarity, converged to solving many questions regarding the living and evolution of humans, the environment they lived, the environmental reconstruction, their knowledge about things and the intangible heritage. Archaeometry or archaeological sciences is reviewed regarding major categories of specialties. Characterization and provenancing, dating methods, cyber-archaeology, location of antiquities with geophysical methods, archaeoastronomy, bioarchaeology, geoarchaeology, conservation sciences, and major applications are discussed. Archaeometry is Science at the Service of Human History and Art. (Liritzis and Korka, 2019). As described in an earlier work: "*Archaeology, the sister of History, is completed in the targeted object that is studied through the synergy of the combined natural sciences and the new technologies. No longer as an information on the external peel of an onion-target, but as a continuous peeling in the search for solutions that concern the archaeologist, resulting in the implementation of thousands of applications and the discovery of new methods of problem solving. The knowledge of the roots of humans and the extraction of information from the material culture requires an interdisciplinary and multiscientific investigatory approach, which is realized by archaeometry*" (Liritzis et al., 2020).

Archaeological Science, also known as archaeometry, is an interdisciplinary field that studies archaeological materials and cultural heritage artifacts using science and scientific methods and techniques. As a result, archaeometry entails interdisciplinarity, as it brings together a variety of disciplines, primarily Physical Sciences and Humanities, which complement each other effectively.

The aim of this overview is the updated collection and presentation of archaeometric studies of earlier study (Liritzis & Oikonomou 2020), which have been carried out at the area in the Aegean (Fig.1) in the period spanning 30000 to to Bronze Age BC and especially the area of the Dodecanese islands during the period from 800 to 200 BC. Major part of 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.

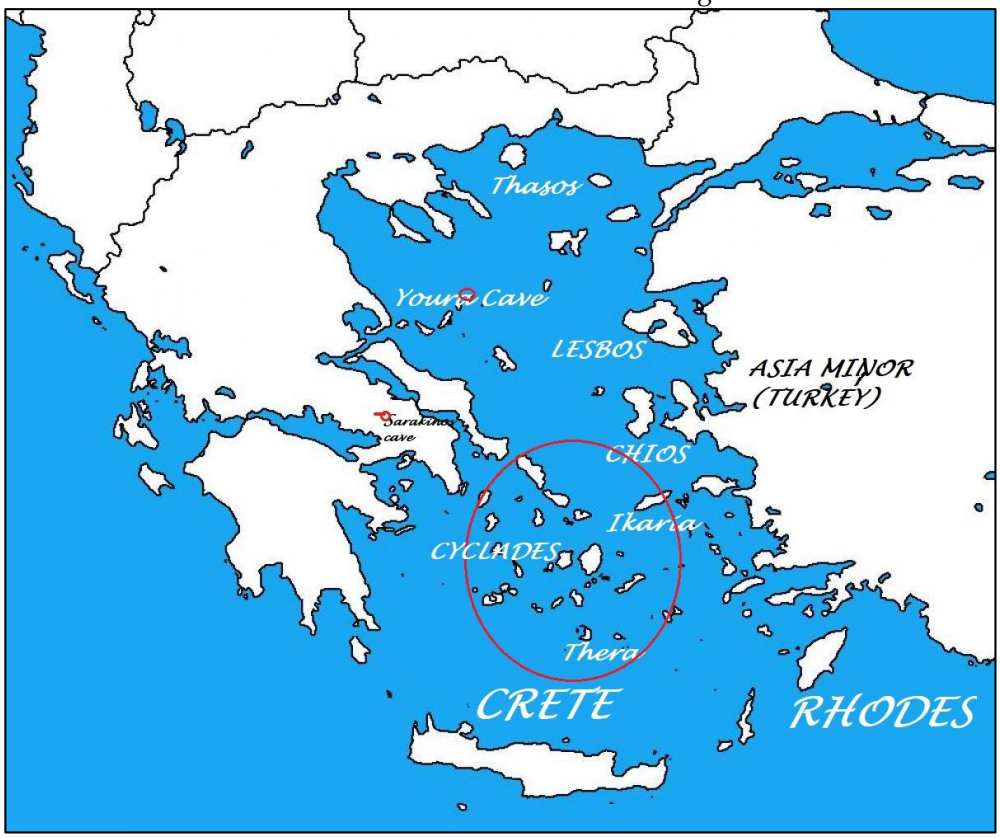


Figure 1. Map of Greece with the Aegean Islands. Depending on the size the multi-insularity of Aegean archipelagos counts around 1,200 to 6,000 islands. It covers the latitude between 34º – 41ºN and longitude 29º to 23ºE. In this region, including the coasts of Asia Minor (today Turkey) the cradle of most important cultures was flourished during the Anthropocene, for several millennia, where modern Greek people are descending from Mycenaean and Minoan cultures.

The wide term "archaeometric work" 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, as well as devices and intentional orientation of temples which serve the purpose of determining the time, festivities, rituals and for navigation.

In Greece, particularly in the Aegean region, archaeometric studies are used in a variety of ways to cover a wide range of time periods using a variety of methods.

From prehistory to late antiquity, the Aegean region was especially important, and great civilizations arose within its broader geographical limits. (Treuil *et al.* 1996; Renfrew and Bahn, 1991; Renfrew, 2011).

The existence of sea routes, which enabled the movement of people, materials, technologies, and cultures across the continental and insular world, played a special role in the development of the Aegean over time (Stampolidis *et al.* 2015; Laskaris et al., 2011).

The scope 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[1] completed in 2013 (Liritzis & Oikonomou 2021). 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 updated with further works and enriched with archaeoastronomy.

2. DATA COLLECTION- METHODOLOGY

The compilation of the archaeometric studies involved thorough research using specific key words through the basic electronic data bases used in academia[2]. Furthermore, the bibliographic research was complemented with visits in libraries in various academic institutions (e.g. 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).

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

Field of study	Number of studies
1.Chemical Analysis	31
2.Dating Techniques	22
3.Paleoenvironment	16
4.DNA Analysis	11
5.Archaeomagnetism	25
6.Isotopic Analysis	5
7.Restoration and Conservation	6
8.Geophysical studies - GIS	5
9.Archaeoastronomy	21

3. RESULTS AND DISCUSSION

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, Liritzis et al (2020), Xanthopoulou et al (2021) and Baziotis et al., (2020) explored mineralogical and microstructure analysis for characterization and provenance by pXRF, XRD, SEM, EPMA of ceramic artifacts from late Helladic Kastrouli settlement, Delphi, and in the same site aerial images by drone was made in search of surrounding landscape (Koh et al 2020; Liritzis 2021). Further SIMS analysis of Melian obsidian as well as

[1] '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.

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

from tools of Sarakinos Cave, Ikaria island, and Youra cave and Desfina (Delphi) for surface and interface investigations to improve dating (Laskaris & Liritzis 2020).

Archaeometrical analysis using XRF, Chromatography has been reported for the murex (po-pure in Liner B) in workshops, in pre-roman sites from the Aegean and central eastern Mediterranean (Kalaitzaki et al., 2017).

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 (13th c. BC to 1st 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 5th to 4th 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. Chronological Methods

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. Radiocarbon 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, Cyclop's cave (off the island of Alonissos in Sporades, See Fig.1) 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.

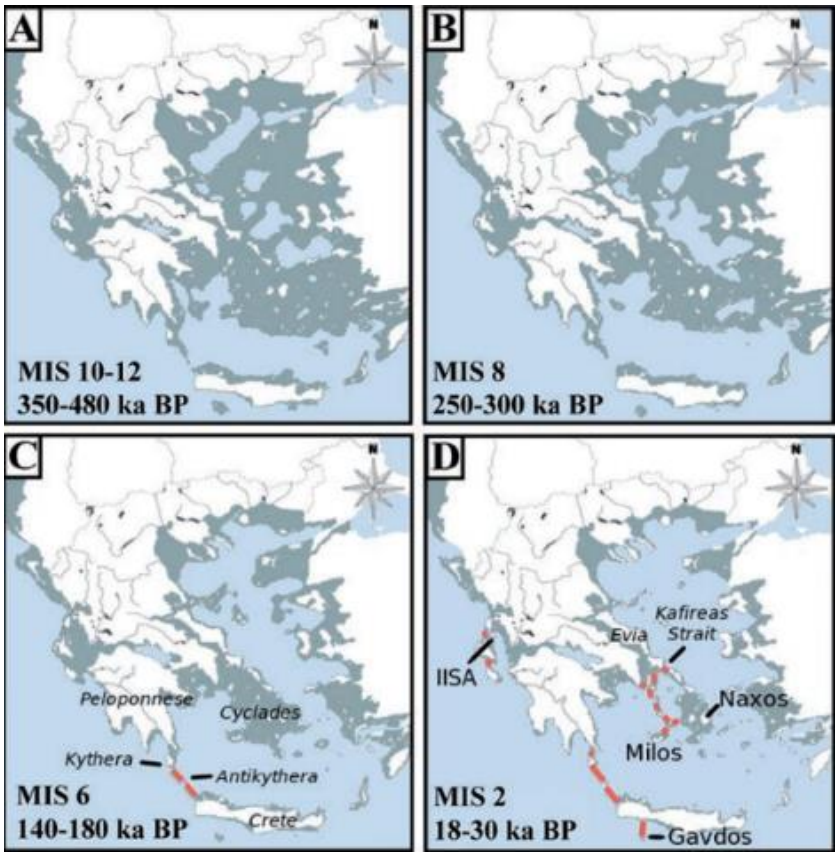


Figure 2. Reconstruction of sea level changes in the Aegean islands and surrounding mainland coasts. The gray parts imply joining with the mainland (from Papoulia 2016, Fig.4).

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 4th 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*

The TL and/or OSL dating is applied on various inorganic materials such as ceramics, sediments, obsidian, burnt of sun exposed rocks, soils and special architectural remains i.e. an archaeometallurgical kiln, brick wall, stony fortified wall.

Liritzis et al., (2020) investigated the value of OSL in distinguishing ancient from more recent structures in the archaeological landscape of Andros Island, the geometric settlement of Zaggora. An interesting OSL surface luminescence dating and TL-OSL has also been successfully applied to the prehistoric settlement of Kastrouli, off Corinthian Gulf, near Delphi (Liritzis et al., 2018).

Zacharias et al. (2006) used TL dating to explore archaeometallurgical kiln remains from two prehistoric sites on the island of Seriphos (Cyclades, Greece), revealing the chronological time of the corresponding operations. Through its methodological approach, this study gave absolute ages for the kiln assemblages as well as highlighting potential sources of errors.

Using OSL dating, Vafiadou et al. (2007) studied geo-archaeologically significant rock samples and associated underlying surface (floor) soils from three regions: Greece, Sweden, and a contemporary surface stone-sample from a Danish site. Using a single-aliquot regenerative-dose (SAR) protocol and blue light and infrared stimulation, luminescence signals from quartz and feldspars were obtained.

Zacharias *et al.* (2009) explored the area of Istron in the Gulf of Mirabello in eastern Crete, trying to date the sediments using optical stimulated luminescence (OSL). Their method provided information on the area's landscape evolution. Other analytical methods used include field surveys, geophysical prospection, and archaeological excavations, as well as chemical and spectrometry analysis on selected deltaic deposits enlightened paleoenvironmental differentiations that prevailed at neighboring sites. Landscape evolution was primarily influenced by environmental changes in an area inhabited by humans since the Neolithic period, according to their research.

Polymeris et al. (2010) investigated the potential for dating obsidian samples using luminescence methods (Thermoluminescence-TL and Optically Stimulated Luminescence-OSL).

They came to the conclusion that the artificially irradiated samples show all promising luminescence characteristics and that the signal is not related to quartz but rather to other silicates.

At any rate, the NTL signal's lack of bleaching ability, as well as the NOSL's unusual shape, pose major difficulties in dating applications. Liritzis (2010) dated the building of the excavated coastal prehistoric village of Strofilas on Andros Island (Cyclades, Greece) in the Aegean. He used luminescence dating on two samples from the fortified wall with engraved ships, giving a date of 3520 (540) BC on average (Fig.3).

A volcanic eruption in Yiali have been dated by TL with an age ca.1400 BC (Liritzis et al., 1996).

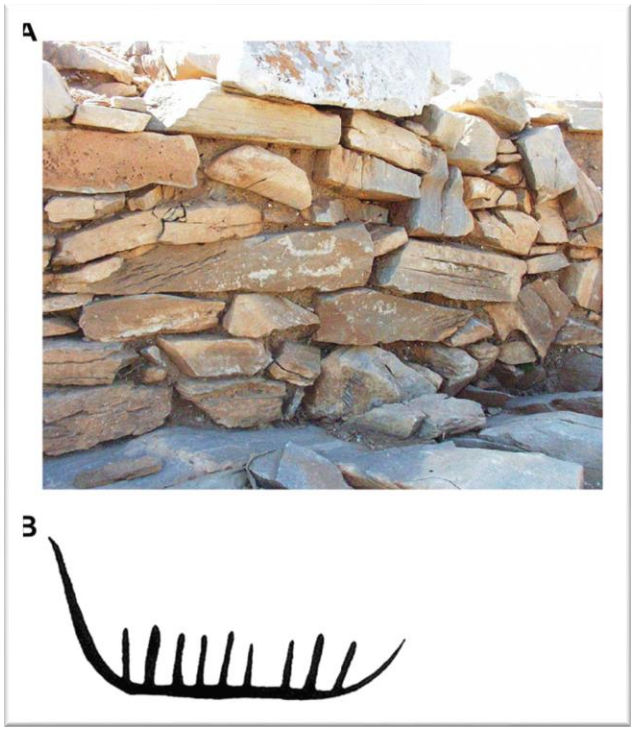


Figure 3. a) Engraved ships on the surfaces of the fortified wall, b) representation of such a ship by Televantou (2005) (In my first visit to the site I indicated the first engravings to the excavator, and later the excavator identified the engravings of many more ships, four of which form a convoy and is analogous to a miniature wall-painting from Thera) (Liritzis, 2010).

Athanassas and Zacharias (2010) published an OSL dating framework for raised marine sequences on Greece's south-west coast during the Upper Quaternary in the same year.

Paleontological studies and Geographic Information System (GIS) analysis of elevated marine landforms in South Greece have revealed a record of uplift and eustacy dating back to the Early Pleistocene (1.6 Ma). As a result, they used coarse-grained quartz

aliquots from emerged nearshore outcrops to test the suitability of the SAR methodology for recuperated-OSL (Re-OSL).

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

3. *Obsidian Hydration Dating*

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.

Further dating attempts have been made with Melian obsidian tools (Liritzis et al., 2004). Recently Laskaris and Liritzis (2021) investigated obsidian artifacts with TOF-SIMS.

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, geoarchaeological 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. Aegean sediments were measured for their radioactivity and a chronostratigraphic method was proposed based on drastic changes in radioactivity due to climatic effects (Liritzis et al., 1999).

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 geoarchaeological 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.

Theodorakopoulou *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. Ancient DNA analyses

A sparsely explored field is the genetic studies through ancient aDNA. Ancient DNA (aDNA) research has produced a breakthrough in ancient population mobilities and steadily brings new surprises Since the end of 90's most experienced aDNA researchers thought that the full genome sequencing of extinct species (e.g. the woolly mammoth and Neandertals) was not effectively possible (Sarkissian et al., 2015).

But despite the previously limited focus to mitochondrial DNA and a few nuclear markers, the whole genome sequences from the remote past can now be retrieved satisfactorily. The ability of next-generation sequencing platforms to target short and degraded DNA molecules, as well as their enormous sequence throughput, are key factors in this breakthrough. In terms of fossil material, experimental work load, and cost, the best available technology at the time was extremely demanding.

To produce a consensus sequence free of sequencing errors, each piece of target genomic DNA had to be amplified several times by PCR, then ideally PCR amplicons had to be propagated using bacterial vectors and a number of clones had to be sequenced (Hofreiter et al., 2001). Secondly, this whole procedure often needed to be replicated in another laboratory, before DNA sequences could be considered authentic (Cooper & Poinar, 2000).

In the Aegean and Greece aDNA studies has been produced in a limited capacity but is starting to emerge a picture which verifies the Neolithic and hunter-gatherers continuity in the region down to the Minoan and Mycenaean times to modern Greek society and in a early northwards mobility, but evidence of a mixture from the NE and eastern interactions is indicated.

Genetic studies focus on the investigation of Y-chromosome on Crete (Malaspina *et al.* 2001; Martinez *et al.* 2007; King *et al.* 2008) and also on the origin of Minoans and Myceneaens (Lazaridis *et al.* 2017). There is only two works referring to aDNA derived from amphora remains (Foley *et al.* 2012) and on a 2400-year-old shipwreck from Chios (Hansson & Foley 2008).

An initial 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 researchers created a network 1.2 in the Y-chromosomal phylogenetic tree, dated it in comparison to other lineages linked to the same movements by other researchers, looked at its diversity using tri- and tetra-nucleotide loci, and discussed the implications for reconstructing the spread of this group of chromosomes in the Mediterranean region.

According to their findings, a tripartite phylogeny within HG 9 (Rosser et al. 2000) is identified, with alleles T (Haplogroup Eu10) or G (Haplogroup Eu9) at M172 (Semino et al. 2000) defining the deepest branching, and network 1±2 defining the subsequent branching within Eu9.

The occurrence of HG 9 and network 1±2 in the surveyed region is not due to the spread of individuals from a single paternal population, but rather to a process punctuated by at least two stages, according to population distributions.

The data identified a large area of the Balkans, the Aegean, and Anatolia as the potential homeland with the most variation within network 1±2. Furthermore, the use of recently proposed tests based on the stepwise mutation model indicated that its spread was linked to a population expansion in the Turkish–Greek region, with a high rate of male gene flow.

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 what the 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, after collecting and reporting genome-wide data from nineteen ancient people in an effort to determine the origins of the Bronze Age Minoan and Mycenaean cultures (Lazaridis et al. 2017), a study led by Lazaridis and a large scientific group (Lazaridis et al. 2017) has yielded useful findings.

The data obtained by Minoan individuals from Crete, Mycenaeans from mainland Greece, and their eastern neighbors 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.

Recently screening of archaeological bone for palaeogenetic and palaeoproteomic studies from Aegean islands and elsewhere was made by Kontopoulos et al., (2020), and on bone diagenesis in a Mycenaean secondary burial at Kastrouli settlement, which presents criteria for screening initial bones for investigation of presence of collagen (Kontopoulos et al., 2019).

On a comparison basis, DNA analysis from 88 human skeletons from Neolithic and Bronze Age sites in Greece and Crete has shown that, although aDNA might be present in some Eastern Mediterranean skeletons from later centuries of the Bronze Age, it is not commonly found in material from this period and is likely to be absent from older material in Neolithic times (Chilvers et al., 2008).

Genome-wide patterns of identity-by-descent among the 24 analyzed individuals from the Mokrin necropolis in Serbia regarding ancestry, structure, and genetic diversity, was compared to Aegean samples. The Aegean/Mediterranean ancestry component dominates in these sample (pooled 55% ± 2.5%), while the hunter-gatherer component is relatively low (pooled 8% ± 1.2%), which is a valuable result regarding Neolithic to Bronze age migrations (Zegarac et al., 2020; Hofmanová, et al., 2016).

v. Archaeomagnetism

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

The goal was to create archaeomagnetic intensity (including inclination and declination) curves for the

past 8000 years in areas where there was available ceramic material and well-fired kilns/hearths. The majority of archaeomagnetic research takes place on the Greek mainland rather than on the Aegean islands.

Several scholars (Walton 1979, 1984; Xanthakis and Liritzis 1991; Tema and Kondopoulou 2011; De Marco et al. 2008; Spatharas et al., 2000) have reported data for mainland Greece, including some data from the southern Balkans. I. Liritzis and colleagues from Oxford made a breakthrough in intensity measurements on well-dated tiles (by inscription) from Byzantine monasteries in 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).

In particular, 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 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^{o}, Long = 26.10^{o}). (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).

The most recent SV curve data (Tema and Kondopoulou, 2011) were derived from all data collected within a 700-kilometer radius centered on Thessaloniki (40.60^{o}N, 23.00^{o}E). A continuous SV curve for intensity was calculated using the sliding moving window method, while directional SV curves were calculated using the bivariate extension of the Fisher statistics.

These geomagnetic data curves are well constrained and have clearly demonstrated the dominant features of geomagnetic field variation in this area over the last eight millennia, which is comparable to previous attempts (Xanthakis and Liritzis, 1991).

The SCHA.DIF.3K and SCHA.DIF.8K regional geomagnetic field models, as well as the CALS7K.2 and ARCH3K.1 global geomagnetic field models, show good agreement for the last 3000 years, but there are some differences for older times.

The Balkan SV curves identify several rapid changes in the geomagnetic field, which have already been identified by Liritzis (1989), Aitken et al. (1989), and Liritzis and Kovacheva (1992), and can be used as archaeomagnetic dating reference curves in the Balkan Peninsula. Despite the fact that they have enriched the previous archaeointensity curve, their reliability is slightly increased and of the same order of uncertainty. (Thomas 1981; Liritzis 1989; Kovacheva 2003; Kovacheva *et al.* 2009).

Xanthakis and Liritzis (1991) used robust statistical methods of smoothed data comparison to compare archaeomagnetic intensity curves for the Greek region, including some Aegean sites, with limnomagnetic curves.

The intensity and directional data were also subjected to spectral analysis in order to identify any periodic variations (Liritzis 1985a, 1985b; Xanthakis and Liritzis 1989, 1991). Of interest is the correlation between aurorae and archaeomagnetism and comparison with China and Italy in the 1st millennium BC (Liritzis et al., 2017).

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. Conservation and Restoration

What happens to an archaeological site after an archaeologist has done their work? Can the site (or parts of it) be returned to what we think it once looked like (based on evidence)? Should the site be conserved and left alone, or should it be protected by conservation? Even the most lavish ancient sites will appear to be piles of unorganized stone if they are not restored. Before making an archaeological restoration, three essential issues must be examined: 1. What specific point in a site or monument's history will be the subject of the restoration? 2. How will future changes in the interpretation and knowledge about a site or monument be accommodated by restorations? 3. Lastly and most importantly, restorations must be non-destructive and reversible.

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). But in other Aegean islands conservation science has been made and restoration has been assisted by the results. (Moropoulou et al., 1998).

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.

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.

Building materials of the walls at the Ialyssos Acropolis (Sarantapichos) and the Acropolis of Erimokastro in Rhodes island has been investigated by Labropoulos et al. (2010) 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 biodecay present on the two types of stones, grey compact limestone and off-white limestone that revealed 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 Infrared Thermography were used to characterize the building material and its decay products to further assess the conservation treatments.

Bakolas *et al.* (2013) have worked on 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. In their results, there is extensive bio- decay present on grey compact limestone, as well as cracking, delamination and detachment of original material.

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 has been performed by Delegou et al. (2013), which was used in order to accomplish the mapping of building materials, decay patterns and conservation interventions of both investigated sites. They focused on 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. In addition, 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.
A significant work has been made in the famous monastery of St. John the Theologian in Patmos, which dates back to the 11th century, which today is 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 around 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

During the time periods studied here, only a few geophysical studies focused on the Aegean and the

Dodecanese. One of them refers to the use of electric resistivity, resistance, and magnetic measurements to investigate buried archaeological relics on the island of Mytilene (Papamarinopoulos et al. 1985). In addition, there is a research project on palaeoenvironmental reconstruction on Crete island by the application of GIS (Siart et al. 2010) and an investigation of ancient Mediterranean seafaring (Leidwanger 2013), and on Bronze age buildings (Constantinidis, 2007).

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.

A research conducted with remote sensing and GIS analyses, geophysical prospection (refraction seismics, earth resistivity tomography) at the most promising archive locations has been reported by 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. Moreover, 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. In 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. Also, XRD-spectra of clay minerals and quartz-grain morphology indicated a significant aeolian dust contribution to soil formation and pedosediments. Glass shards and substantially heterogeneous heavy mineral compositions point to supra-regional origin and external volcanogenic deposits (Minoan eruption of Santorini, ca.3,600 years BP). 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.

Sarris et al. (2007) from the Institute of Mediterranean Studies in Crete developed a series of GIS applications. The Aegean Minoan 3D GIS Project began in 2007 with the goal of creating a three-dimensional (3D) full-color map of Minoan archaeological sites in the Aegean Sea region using Google Earth.

It is intended to serve as a comprehensive geographical reference for all (http://www.etana.org/node/10848). Minoan sites are also using a GIS technique to create a cultural landscape model of Minoan peak sanctuaries (Soetens et al. 2002).

The project of Leidwanger (2013) focused 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.

ix. Archaeoastronomy or astronomy in culture

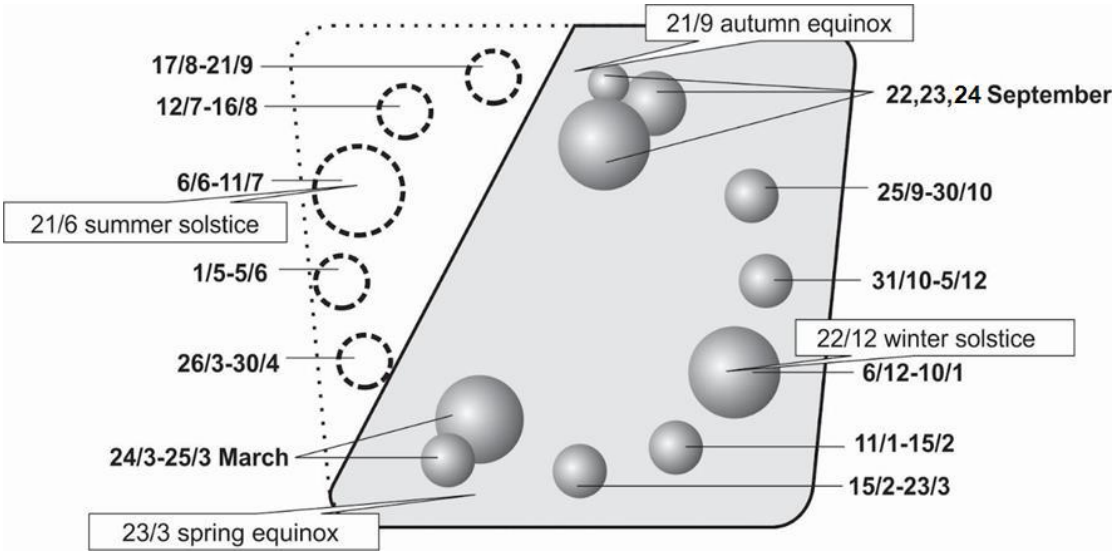
The origins of ancient calendars have been a hot topic of debate around the World. (Parker 1950; Richards 1999; Steele 2007; Stern 2012; Castro 2015; Hannah 2015).

Since prehistoric times, human observation, wonder, and curiosity have been inextricably linked to the skyscape and periodic phenomena of celestial bodies.

The astronomical knowledge in the Aegean and mainland with respect to hitherto thought origin to ancient cultures along the Middle East - Near East and South Eastern Mediterranean axis, has been reassessed confirming a 3rd millennium BC Aegean knowledge of Minoan culture, and transmitted to later Aegean cultures (Tsikritsis et al., 2015; Liritzis et al., 2017; Liritzis & Castro 2013; Liritzis & Vassiliou 2003, 2006).

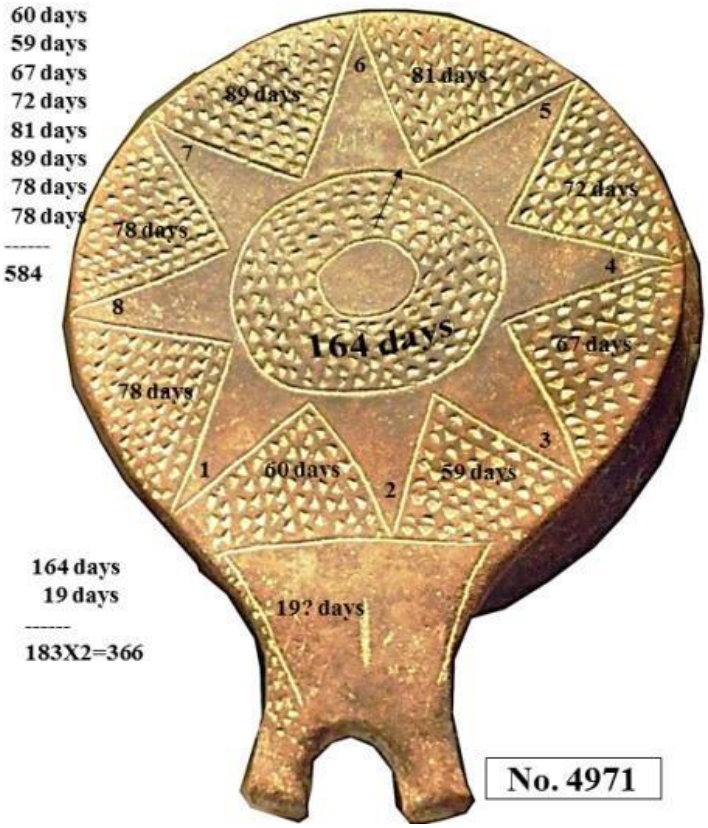
It has been shown that Minoans had developed a calendar system (Henriksson & Blomberg 2011). The kernos (a ceramic ring or stone tray in which several cups for holding offerings are carved, Fig.4) and ceramic frying pans bearing geometrical designs and spots, in Cyclades and Crete (Fig.5, Tsikritsis et al., 2015), have been shown that they were calendars, i.e. systems for managing the time, whereby the beginning, the length and the division of time are fixed, and days as well as longer divisions of time are arranged in a definite order (Pliakos, 2021).

(A)

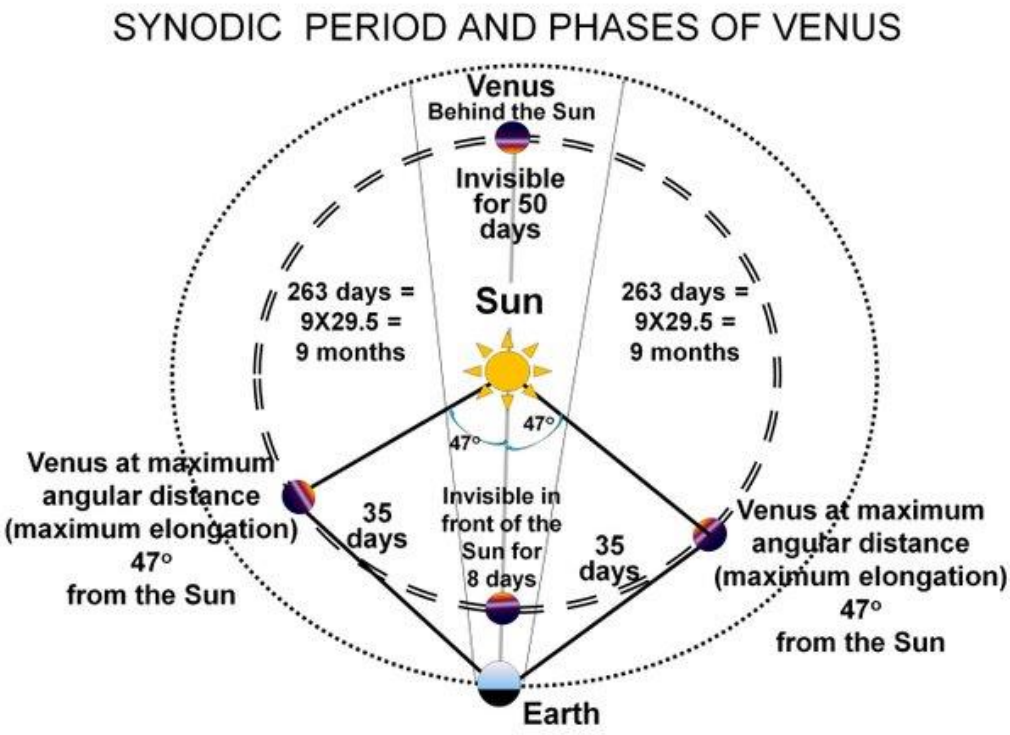


(B)

Figure 4. A). The offering table or Kernos in the Palace of Malia, Crete, Greece of Middle Minoan period (© Bernard Gagnon licensed under the Creative Commons Attribution-Share Alike 4.0 International), B) Part of original Kernos found by Evans (1930) of Middle Minoan II. The gray part is the found piece and white is the complementary part by Evans too. The circles are cups, some partially superimposed. The dashed cups were added by Evans on a symmetrical pattern with respect to the original gray pattern. The numbers are our own. The 23/3 and 21/9 points to the expected location (Pliakos 2021, Fig.3) [NB: Middle Minoan ~2200-ca.1600 B.C.]



(A)



(B)

Figure 5.A. Frying Pan no. 4971 from Chalandriani, Syros. National Archaeological Museum of Athens. Notice the pubic symbol near the handle, the eight rayed star that is the eight year period planet Venus takes to return to the same distance from the Sun, which is equal to 99 lunar months or tow Olympiad periods, one of 49 months and the next of 50 months, B) Venus conjunctions and periodicities. Notice the 9 month period which very naturally makes humans to associate this planet with women, the goddess of fertility and love, Aphrodite or Venus (Tsikritsis et al., 2015).

In the past there were made measurements for the orientation, analysis and interpretation of some ancient monuments and movable structures, such as Temples, tombs, pyramidals, metal objects, amongst other from Crete, Delos, and mainland (Papathanassiou & Hoskin, 1994, Papathanassiou & Hoskin 1996, Liritzis 1998; Henriksson and Blomberg 1996, Blomberg & Henriksson 1996).

The Minoans seems to have practiced astronomical orientation and making of calendars developing a solar, lunisolar and lunar calendar system (e.g. peak sacred sanctuaries in Petsofas, Traostalos in Crete). As Marinatos eminent Greek archaeologist had noted the East-West alignment of the Minoan palaces was of paramount importance. Bright stars, synodic months, planetary processional periods and solar stands have been recorded.

The Troyan war and the return of Odyssey to Ithaca via the Aegean and SE Mediterranean Sea and islands also has been decoded based on solar eclipses (Henriksson 2012; Papamarinopoulos et al., 2014, 2016).

This astronomical knowledge weas transmitted to later generations in Mycenaean culture and later the 1st millennium BC which culminated in the 1st c. BC sophisticated bronze device found in a wreckage in the Antikythera island. This device now split into 82 fragments, only a third of the original survives, including 30 corroded bronze gearwheels. Microfocus X-ray Computed Tomography (X-ray CT) in 2005 decoded the structure of the rear of the machine but the front remained largely unresolved. X-ray CT also revealed inscriptions describing the motions of the Sun, Moon and all five planets known in antiquity and how they were displayed at the front as an ancient Greek Cosmos. Inscriptions specifying complex planetary periods forced new thinking on the mechanization of this Cosmos, but no previous reconstruction has come close to matching the data. Recent discoveries lead to a new model, satisfying and explaining the evidence. Solving this complex 3D puzzle reveals a creation of genius—combining cycles from Babylonian astronomy, mathematics from Plato's Academy and ancient Greek astronomical theories (Freeth et al., 2021).

Many ancient Greek Temples were orientated towards stars, constellations and solar positions to indicate the timing of certain events for sites in the Aegean islands and some coastal sites (Liritzis 2001; Liritzis & Vassiliou 2002, 2003, 2006; Liritzis & Coucouzelis 2007; Liritzis and Artelaris 2010; Liritzis and Castro 2013; Castro et al., 2015; Liritzis et al., 2017).

5. CONCLUSIONS

We were able to find and collect the majority of archaeometrical investigations that relate to the islandic region of the Aegean from 30000-3000 BC and the Dodecanese islands from 800-200 BC thanks to this intensive and systematic study. The majority of the information received is available on the http://archipelago.aegean.gr website (which has been updated since 2013 and from the 2020 work) and includes a more extensive database.

Given the importance of the area in the archaeological record, more research is expected after the current work is completed. However, there has been a steady increase in the number and quality of archaeometric studies in the last ten years, even more the last two years, owing to the establishment of Archaeological Science/Archaeometry in the field of Archaeology.

Many archaeometrical studies exist, but they are focused on later periods, such as the Late Bronze and Iron Age or/and the Roman-Byzantine period, and therefore do not fall within the scope of this research.

ACKNOWLEDGEMENTS

The initiative of the project was mainly supported by the Integrated Program for Island Research (IPIR) of the University Project: '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', which was co-funded by the European Union (European Social Fund) and National Resources. Since 2013 the work is extended as part of Sino-Hellenic Academic Project (www.huaxiahellas.com) for which IL is thankful for support from Key Research Institute of Yellow River Civilization and Sustainable Development & Collaborative Innovation Center on Yellow River Civilization of Henan Province, Lab. of Yellow River Cultural Heritage, Henan University, Kaifeng, China. Dr Maria Kaparou and Prof. Yiannis Karapanagiotis are greatly acknowledged for proofreading this paper.

REFERENCES

Acquafredda, P., Andriani, T., Lorenzoni, S., Zanettin, E., 1999. Chemical characterization of obsidians from different Mediterranean sources by non-destructive SEM-EDS analytical method, *Journal of Archaeological Science*, Vol. 26, Issue 3, pp. 315-325.

Aidona, E., Liritzis, I., 2012. Magnetic susceptibility and radioactivity changes of aegean and ionian sea sediments during last glacial/interglacial: Climatic and chronological markers, *Journal of Coastal Research*, Vol. 28, Issue 2, pp. 342-353.

Aitken, M.J., Allsop, A.L., Bussell, G.D., Liritzis, Y. and Winter, M.B., 1989. Geomagnetic intensity measurements using bricks from Greek churches of first and second millenia AD, *Archaeometry*, 31, 1, pp. 77-87.

Aksu, A.E., Yaşar, D., Mudie, P.J., Gillespie, H., 1995. Late glacial-Holocene paleoclimatic and paleoceanographic evolution of the Aegean Sea: micropaleontological and stable isotopic evidence, *Marine Micropaleontology*, Vol. 25, Issue 1, pp. 1-28.

Ammerman, A.J., Efstratiou, N., Ntinou, M., Pavlopoulos, K., Gabrielli, R., Thomas, K.D., Mannino, M.A., 2008. Finding the early Neolithic in Aegean Thrace: the use of cores, *Antiquity*, Vol. 82, Issue 3, pp. 139-150.

Athanassas, C. and Zacharias, N., 2010. Recuperated-OSL dating of quartz from Aegean (South Greece) raised Pleistocene marine sediments: current results, *Quaternary Geochronology*, Vol. 5, Issue 1, pp. 65-75.

Baziotis, I, Xydous, S, Manimanaki, S, Liritzis, I (2020) An integrated method for ceramic characterization: A case study from the newly excavated Kastrouli site (Late Helladic). *Journal of Cultural Heritage* 42, pp. 274–279

Blomberg, M. and Henriksson, G. (1996) 'Minos Enneoros'. Archaeoastronomical light on the priestly role of the king in Crete. In: Religion and Power in the ancient Greek world. Proceedings of the Uppsala symposium 1993 (= BOREAS. Uppsala Studies in Ancient Mediterranean and Near Eastern Civilizations, 24) P. Hellström and A. Alroth (eds.), Uppsala University, Uppsala, pp. 27-39.

Bajnóczi, B., Schöll-Barna, G., Kalicz, N., Siklósi, Z., Hourmouziadis, G.H., Ifantidis, F., Kyparissi-Apostolika, A., Pappa, M., Veropoulidou, R., Ziota, Ch., 2013. Tracing the source of Late Neolithic Spondylus shell ornaments by stable isotope geochemistry and cathodoluminescence microscopy, *Journal of Archaeological Science*, Vol. 40, Issue 2, pp. 874-882.

Bakolas, A., Delegou, E.T., Ksynopoulou, E., Tsilimantou, E., Labropoulos, K.C., Oikonomopoulou, E., Sayas, J., Moropoulou, A., 2013. An integrated diagnostic study of the building materials of the walls at the Ialyssos Acropolis (Sarantapichos), Rhodes, *Scienza e Beni Culturali XXIX*, Publ. Arcadia Ricerche Editore Padova, pp. 341-351.

Beltsios, K.G., Oikonomou, A., Zacharias, N., Triantafyllidis, P., 2012. Characterization and Provenance of Archaeological Glass Artifacts from Mainland and Aegean Greece, in Liritzis, I. and Stevenson, C.M., (eds), *Obsidian and Ancient Manufactured Glasses*, University of New Mexico Press Albuquerque.

Brill, R.H. and Stapleton, C.P., 2012. *Chemical Analyses of Early Glasses, Volume 3, the Years 2000-2011, Reports, and Essays*, Corning Museum of Glass, Corning NY.

Brill, R.H., 1976. Scientific studies of the panel materials, in: Ibrahim, L. and Scranton, R., (eds.), *Kenchrai, Eastern Port of Corinth: Results of Investigations by the University of Chicago and Indiana University for the American School of Classical Studies at Athens*, Vol. 2, The Panels of Optus Sectile in Glass, Leiden, pp. 225-255.

Brill, R.H., 1999. *Chemical analyses of early glasses. Volume 2: the tables*, Corning Museum of Glass, Corning NY.

Castro Martin B., (2015) A historical review of the Egyptian calendars: the development of time measurement in ancient Egypt from Nabta Playa to the Ptolemies. *SCIENTIFIC CULTURE*, Vol. 1, No 3, pp. 15-27. DOI: 10.5281/zenodo.18446

Castro Belen, Liritzis, I, and Nyquist A. (2015) Oracular Functioning And Architecture of Five Ancient Apollo Temples Through Archaeastronomy: Novel Approach And Interpretation Nexus Network Journal, Architecture & Mathematics, 18(2), 373-395 (DOI:10.1007/s00004-015-0276-2)

Carter, T., Contreras, D.A., Holcomb, J., Mihailović, D.D., Karkanas, P., Guérin, G., Taffin, N., Athanasoulis, D., Lahaye, Ch., 2019. Earliest occupation of the Central Aegean (Naxos), Greece: Implications for hominin and Homo sapiens' behavior and dispersals, *Science Advances*, Vol. 5, no. 10, DOI: 10.1126/sciadv.aax0997.

Cheilakou, E., Liarokapi, N., Koui, M., 2012. Non destructive characterization by FOM and ESEM-EDX of ancient glass objects from the Aegean with an approach of the manufacturing technique, *Materials and Structures*, Vol. 45, Issue 1-2, pp 235-250.

Constantinidis, D (2007) Digitising Aegean bronze age buildings: building typologies from digital plans. In: Georgopoulos, A (ed.) Proceedings of XXI International CIPA Symposium, 01-06 October, Athens, Greece.

Colonese, A.C., Mannino, M.A., Bar-Yosef Mayer, D.E., Fa, D.A., Finlayson, J.C., Lubell, D., Stiner, M.C., 2011. Marine mollusc exploitation in Mediterranean prehistory: An overview, *Quaternary International*, Vol. 239, Issues 1-2, pp. 86-103.

Cooper, A and Poinar H.N. (2000) Ancient DNA: do it right or not at all. *Science* 289, 1139 (10.1126/science.289.5482.1139b).

Chilvers, E.R, Bouwman, A.S,, Brown K.A,, Arnott, R.G, Prag, A.J.N.W, , Brown, T.A. (2008) Ancient DNA in human bones from Neolithic and Bronze Age sites in Greece and Crete. Journal of Archaeological Science 35(10), pp. 2707-2714. DOI: 10.1016/j.jas.2008.04.019

De Francesco, A.M., Crisci, G.M., Bocci, M., 2008. Non-destructive analytic method using XRF for determination of provenance of archaeological obsidians from the Mediterranean area: A comparison with traditional XRF methods, *Archaeometry*, Vol. 50, Issue 2, pp. 337-350.

De Marco, E., Spatharas, V., G´omez-Paccard, M., Chauvin, A., & Kondopoulou, D., 2008. New archaeointensity results from archaeological sites and variation of the geomagnetic field intensity for the last 7 millennia in Greece, *Phys. Chem. Earth,* 33, 578–595.

Delegou, E.T., Labropoulos, K.C., Ksinopoulou, E., Tsilimantou, E., Oikonomopoulou, E., Sayas, J., Bakolas, A., Moropoulou, A., 2012. Diagnostic strategies for planning of conservation interventions at the Acropolis of Erimokastro, Rhodes, *Scienza e Beni Culturali XXVIII*, Publ. Arcadia Ricerche Editore Padova, pp. 393-403.

Delegou, E.T., Tsilimantou, E., Oikonomopoulou, E., Kiousi, A., Sayas, J., Moropoulou, A., 2010. Strategic planning of materials and conservation interventions for the damage rehabilitation of the Sarantapicho acropolis and the Erimokastro acropolis in Rhodes, *Proceedings of MONUBASIN 2010*, Greece.

Delegou, E.T., Tsilimantou, E., Oikonomopoulou, E., Sayas, J., Ioannidis, C., Moropoulou, A., 2013. Mapping of building Materials and Conservation Interventions using GIS: The case of Sarantapicho Acropolis and Erimokastro Acropolis in Rhodes, *International Journal of Heritage in the Digital Era*, Vol. 2, number 4, pp. 631-653.

Downey, W and Liritzis, I., 2013. Archaeomagnetic intensity of ceramic sherds from two Rhodian Byzantine churches: a preliminary initiative, *Mediterranean Archaeology and Archaeometry*, Vol. 13, No 2, pp. 221-229.

Downey, W.S. and Tarling, D.H., 1984. Archaeomagnetic dating of Santorini volcanic eruptions and fired destruction levels of Late Minoan civilization, *Nature*, 309, 519-523.

Drinia, H., Antonarakou, A., Anastasakis, G., 2014. Late Quaternary micropalaeontological record of a semi-enclosed marine basin, North Evoikos, central Aegean Sea, *Quaternary International*, Vol. 345, pp. 18-31.

Evans, A. (1930) The Palace of Minos, Vol. III, 390-1, fig. 261 and 393-394.

Facorellis, Y., Maniatis, Y., Kromer, B., 1982. Apparent 14C ages of marine mollusk shells from a Greek Island: Calculation of the marine reservoir effect in the Aegean Sea, *Radiocarbon*, Vol. 40, Issue 2, pp. 963-973.

Foley, P. Brendan, Hansson, C. Maria, Kourkoumelis, P. Dimitris, Theodoulou, A. Theotokis, 2012. Aspects of ancient Greek trade re-evaluated with amphora DNA evidence, *Journal of Archaeological Science*, Vol. 39, Issue 2, pp. 389-398.

Frahm, E., Doonan, R., Kilikoglou, V., 2014. "Handheld portable X-ray fluorescence of Aegean obsidians", *Archaeometry*, Vol. 56, Issue 2, pp. 228-260.

Freeth, T., Higgon, D., Dacanalis, A. et al. A Model of the Cosmos in the ancient Greek Antikythera Mechanism. *Sci Rep* 11, 5821 (2021). https://doi.org/10.1038/s41598-021-84310-w

Galloway, R.B., Liritzis, I., 1992. Provenance of Aegean volcanic tephras by high resolution gamma-ray spectrometry, *Nuclear Geophysics*, Vol. 6, Issue 3, pp. 405-411.

Hansson, M and Foley, B (2008) Ancient DNA fragments inside Classical Greek amphoras reveal cargo of 2400-year-old shipwreck. *Journal of Archaeological Science* 35(5), pp. 1169-1176. DOI: 10.1016/j.jas.2007.08.009

Hein, A. and Kilikoglou, V., 2012. ceraDat-prototype of a web-based relational database for archaeological ceramics, A*rchaeometry*, Vol. 54, Issue 2, pp. 230-243.

Hein, A., Day, P.M., Cau Ontiveros, M.A., Kilikoglou, V., 2004. Red clays from Central and Eastern Crete: geochemical and mineralogical properties in view of provenance studies on ancient ceramics, *Applied Clay Science*, Vol. 24, Issues 3-4, pp. 245-255.

Hannah R. (2015) The roles of observational astronomy in ancient Greece, *SCIENTIFIC CULTURE*, Vol. 1, No 2, pp. 47-56

Henriksson & Blomberg (2011) The evidence from Knossos on the Minoan calendar; *Mediterranean Archaeology & Archaeometry*,Vol. 11, No 1, pp. 59-68.

Henriksson, G. and Blomberg, M. (1996) Evidence for Minoan astronomical observations from the peak sanctuaries on Petsophas and Traostalos. *Opuscula Atheniensia* vol. 21, 99-114

Henriksson, G (2012) The trojan war dated by two solar eclipses. *Mediterranean Archaeology and Archaeometry,* Vol. 12, No 1, pp. 63-76

Hein, A., Georgopoulou, V., Nodarou, E., Kilikoglou, V., 2008. Koan amphorae from Halasarna - investigations in a Hellenistic amphora production centre, *Journal of Archaeological Science*, Vol. 35, Issue 4, pp. 1049-1061.

Hofmanová, Z et al., (2016) Early farmers from across Europe directly descended from Neolithic Aegeans. Proc. Natl. Acad. Sci. U. S. A. 113, 6886–6891.

Hofreiter M, Jaenicke V, Serre D, von Haeseler A, Pääbo S. (2001) DNA sequences from multiple amplifications reveal artifacts induced by cytosine deamination in ancient DNA. *Nucleic Acids Res*. 29, 4793–4799. (DOI:10.1093/nar/29.23.4793).

Jones, R.E., Kilikoglou, V., Olive, V., Bassiakos, Y., Ellam, R., Bray, I.S.J., Sanderson, D.C.W., 2007. A new protocol for the chemical characterisation of steatite - two case studies in Europe: the Shetland Islands and Crete, *Journal of Archaeological Science*, Vol. 34, Issue 4, pp. 626-641.

Kalaitzaki, A, Vafiadou, A, Frony, A., Reese, D.S., Drivaliari, A, Liritzis, I (2017) PO-PU-RE: workshops, use and αrchaeometric analysis in pre-roman central eastern Mediterranean. *Mediterranean Archaeology and Archaeometry*, Vol. 17, No.1, pp. 103-130

Kanavou, B.K et al., 2014. OSL dating of volcanic formations at Nisyros island-Greece. Abstract Book, 4th ARCH_RNT Archaeological Research and New Technologies, University of Peloponnese, Lab. Of Archaeometry, kalamata, Greece.

Karydis, C, Oikonomou, A & Konstanta, A. 2019. The unpublished Coptic textiles of the monastery of St. John the theologian: preliminary results of previous alterations and scientific analysis. *Mediterranean Archaeology and Archaeometry,* Vol. 19, No 1, pp. 133-142.

Karatasios, I., Hein, A., Müller, N.S., Triantafyllides, P., Kilikoglou, V., 2013. Technological insights into the ancient ceramic beehive production of Agathonisi island, Greece, *Applied Clay Science*, Vol. 82, Issue 1, pp. 37-43.

Katsaros, T., Liritzis, Ioannis, Laskaris, N., 2009. Is white pigment on appeles' palette A TiO_2-rich kaolin? new analytical results on the case of Melian-earth, *Mediterranean Archaeology and Archaeometry*, Vol. 9, Issue 1, pp. 29-35.

Kilikoglou, V., Bassiakos, Y., Doonan, R., Stratis, J., 1997. NAA and ICP analysis of obsidian from Central Europe and the Aegean: Source characterisation and provenance determination, *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 216, Issue 1, pp. 87-93.

King, R.J., Özcan, S.S., Carter, T., Kalfoğlu, E., Atasoy, S., Triantaphyllidis, C., Kouvatsi, A., Lin, A.A., Chow, C-E.T., Zhivotovsky, L.A., Michalodimitrakis, M., Underhill, P.A., 2008. Differential Y-chromosome Anatolian Influences on the Greek and Cretan Neolithic, *Annals of Human Genetics*, Vol. 72, Issue 2, pp. 205-214.

Kovacheva, M., Boyadziev, Y., Kostadinova-Avramova, M., Jordanova, N., andDonadini, F., 2009. Updated archaeomagnetic data set of the past 8 millennia from the Sofia laboratory, Bulgaria, *Geochem. Geophys. Geosyst.*, 10, Q05002, doi:10.1029/2008GC002347.

Kontopoulos, I Kirsty Penkman; Victoria Elizabeth Mullin; Laura Winkelbach; Martina Unterländer; Amelie Scheu; Susanne Kreutzer; Henkrik B Hansen; Ashot Margaryan; Matthew D Teasdale; Birgit Gehlen; Martin Street; Niels Lynnerup; Ioannis Liritzis; Adamantios Sampson; Christina Papageorgopoulou; Morten E Allentoft; Joachim Burger; Daniel G Bradley; Matthew James Collins, (2020) Screening archaeological bone for palaeogenetic and palaeoproteomic studies. PLOS ONE (https://doi.org/10.1371/journal.pone.0235146 June 25, 2020.

Kontopoulos, I, Kirsty Penkman, Ioannis Liritzis, Matthew J. Collins (2019) Bone diagenesis in a Mycenaean secondary burial (Kastrouli, Greece) Archaeological and Anthropological Sciences (published online, https://doi.org/10.1007/s12520-019-00853-0).

Kovacheva, M., Spatharas,V., Liritzis, I., 1999. New archaeointensity results from the Greek materials, *Archaeometry*, 42, 2, pp. 415-429.

Koh.A.J., Birney.K.J, Roy.I,M, Liritzis.I (2020) The Mycenaean citadel and environs of Desfina-Kastrouli: a transdisciplinary approach to southern Phokis Mediterranean Archaeology and Archaeometry. Vol. 20, No 3, (2020), pp. 47-73. DOI: 10.5281/zenodo.3930420.

Labropoulos, C.K., Katsiotis, N., Xinopoulou, E. Delegou, E.T., Bakolas, A., Moropoulou, A., 2010. Diagnostic study at the acropolis of sarantapicho and the acropolis of erimokastro Rhodes, *Proceedings of MONUBASIN 2010*, Greece.

Laskaris, N., Sampson, A., Mavridis, F., Liritzis, I., (2011) Late Pleistocene/Early Holocene seafaring in the Aegean: new obsidian hydration dates with the SIMS-SS method, *Journal of Archaeological Science*, Vol. 38, Issue 9, pp. 2475-2479.

Lazaridis, I., Mittnik, A., Patterson, N., Mallick, S., Rohland, N., Pfrengle, S., Furtwängler, A., Peltzer, A., Posth, C., Vasilakis, A., McGeorge, P.J.P., Konsolaki-Yannopoulou, E., Korres, G., Martlew, H., Michalodimitrakis, M., Özsait, M., Özsait, N., Papathanasiou, A., Richards, M., Roodenberg, S.A., Tzedakis, Y., Arnott, R., Fernandes, D.M., Hughey, J.R., Lotakis, D.M., Navas, P.A., Maniatis, Y., Stamatoyannopoulos, J.A., Stewardson, K., Stockhammer, P., Pinhasi, R., Reich, D., Krause, J., Stamatoyannopoulos, G., (2017) Genetic origins of the Minoans and Mycenaeans, *Nature*, 10; 548 (7666), pp. 214-218. doi: 10.1038/nature23310.

Leidwanger, J., 2013. Modeling distance with time in ancient Mediterranean seafaring: a GIS application for the interpretation of maritime connectivity, *Journal of Archaeological Science*, 40, pp. 3302-3308.

Laskaris, N and Liritzis, I (2020) Surface and interface investigation of archaeological obsidian artefacts with TOF-SIMS: case study. *SCIENTIFIC CULTURE*, Vol. 6, No. 3, pp. 85-99.

Liritzis, I and Oikonomou, A (2020) Archaeometric Studies in The Aegean (30000-3000 BC and 800-200 BC): A review. Studia Antiqua et Archaeologica, *Studia Antiqua et Archaeologica* 27(1), pp. 1-32.

Liritzis.I, Diakostamatiou.M, Stevenson.C.M, Novak.S.W and Abdelrehim.I (2004) The dating of hydrated obsidian surfaces by SIMS-SS. *J. Radioanal. Nucl. Chemistry,* vol.261, no.1, 51-60.

Liritzis.I (2001) Archaeoastronomical orientation errors: the case of the two Hellenic pyramidals. J. Radioanalytical & Nuclear Chemistry, vol.247, No 3, 723-725

Liritzis.I and Vassiliou.H (2002) Astronomical orientations of ancient temples at Rhodes and Attica with a tentative interpretation. Mediterranean Archaeology & Archaeometry, vol.2, No 1, 69-79.

Liritzis.I and Vassiliou.H (2003) Archaeoastronomical orientation of seven significant ancient Hellenic temples. Archaeoastronomy International, vol.17, 94-100.

Liritzis.I and Vassiliou.H (2006) Does sunrise day correlate with eastern orientation of Byzantine Churches during significant solar dates and Saint's day name? A preliminary study. Byzantinische Zeitscrift (K.G.Saur Munchen, Leipzig) 99, 2, 523-534

Liritzis, I and Coucouzeli, A (2007) Ancient Greek Heliocentric Views Hidden from Prevailing Beliefs? Studies in History and Philosophy of Science, 11(1), 39-49.

Liritzis I., Michael C. and Galloway R.B. A (1996) A significant Aegean volcanic eruption during the second millennium B.C. revealed by thermoluminescence dating. *Geoarchaeology Internat.,* 11, 4, 361-371.

Liritzis, I and Artelaris, G (2010) Astronomical orientations of Dragon Houses (Palli Laka, Kapsala, Oche) and Armena Gate (Euboea, Greece). Mediterranean Archaeology & Archaeometry, Special Issue, (D.Keller, Guest editor.), Vol.10, No.3, 41-52

Liritzis, I and Castro, B (2013) Delphi and Cosmovision: Apollo's absence at the land of the hyperboreans and the time for consulting the oracle. Journal of Astronomical History and Heritage, 16(2), 184-206.

Liritzis Ioannis, Panou Evangelia, Changhong Miao, Fengxian Xu, Cai Shuhui (2017) Aurorae and archaeomagnetism from the 1st millennium BC. China, Greece and Italy: a brief overview and critical assessment. *Mediterranean Archaeology and Archaeometry,* Vol. 17, No 3, pp. 273-300.

Liritzis., I (2010) Strofilas (Andros Island, Greece): New evidence of Cycladic Final Neolithic dated by novel luminescence and Obsidian Hydration methods. *Journal of Archaeological Science* 37, pp. 1367- 1377

Liritzis Y. & Thomas R.C., (1980). Palaeointensity and thermoluminescence measurements on Cretan Kilns from 1300 to 2000 BC, *Nature*, 283, 54–55.

Liritzis Y., 1989. Greek archaeomagnetic intensities; Some aspects of reliability and geophysical implications, *Earth, Moon and Planets*, 47, pp. 1-13.

Liritzis, I., 2010. Strofilas (Andros Island, Greece): new evidence for the cycladic final neolithic period through novel dating methods using luminescence and obsidian hydration, *Journal of Archaeological Science*, Vol. 37, Issue 6, pp. 1367-1377.

Liritzis, I., Diakostamatiou, M., Stevenson, C.M., Novak, S.W., Abdelrehim, I., (2004) Dating of hydrated obsidian surfaces by SIMS-SS, *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 261, Issue 1, pp. 51-60.

Liritzis, I., Lagios, E., and Kosmatos, D. 1995. Detailed radon isotope measurements in Nissyros and Susaki geothermal fields, Greece, *Comptes Rendus de l'Academie des Sciences Serie 2*, Sciences de la Terre et des Planetes, 321(6), pp. 473-480.

Liritzis, I., Laskaris, N., Bonini, M., 2008. Nano- and micro-scale resolution in ancient obsidian artefact surfaces: The impact of AFM on the obsidian hydration dating by SIMS-SS, *Physica Status Solidi (C) Current Topics in Solid State Physics*, Vol. 5, Issue 12, pp. 3704-3707.

Liritzis, I., Laskaris, N., Vafiadou, A., Karapanagiotis, I., Volonakis, P., Papageorgopoulou, C., Bratitsi, M., 2020, Archaeometry: an overview, *Scientific Culture*, Vol. 6, No. 1, pp. 49-98, DOI: 10.5281/zenodo.3625220.

Liritzis, Y. and Kovachena, M., 1992. Evidence for sharp changes in the archaeomagnetic intensity variation during the last 2000 years, *Physics of the Earth and Planetary Interiors* 70, pp. 85-89.

Liritzis, Y., 1985a. Archaeomagnetism, Santorini volcanic eruption and destruction levels on Crete, *Nature*, 313, pp. 74-76.

Liritzis, Y., 1985b. Maximum entropy and power spectrum analyses of geomagnetic data: emphasis on the 200-year period, *J. Earth, Moon and Planets*, 34, pp. 235-249.

Liritzis, Y., Orphanidis-Georgiadis, L., Efstratiou, N., 1991. Neolithic Thessaly and the Sporades. Remarks on cultural contacts between Sesklo, Dimini and Aghios Petros based on trace element analysis and archaeological evidence, *Oxford Journal of Archaeology*, Vol. 10, Issue 3, pp. 307-313.

Livarda, A. and Kotzamani, G., 2013. The archaeobotany of Neolithic and Bronze age Crete: synthesis and prospects, *Annual of the British School at Athens*, Vol. 108, pp. 1-29.

Liritzis, I & Korka, E (2019) Archaeometry's Role in Cultural Heritage Sustainability and Development. *SUSTAINABILITY*, 11, 1972.

Liritzis, I and Oikonomou, A (2021) Archaeometric Studies in The Aegean (30000-3000 BC and 800-200 BC): A review. *Studia Antiqua et Archaeologica* 27(1), pp. 1-32.

Liritzis I., Galloway. R.B., Lykousis V., Chronis G. and Anagnostou G. (1999). Towards a new chronostratigraphic method based on the marine sediment radioactivity variation. *Journal of Coastal Research*, 15, 4, 958-965.

Liritzis, I. and Castro, B. (2013) Delphi and Cosmovision: Apollo's absence at the land of the hyperboreans and the time for consulting the oracle. *Journal of Astronomical History and Heritage*, 16(2), 184-206.

Liritzis, I. and Vassiliou, H. (2003) Archaeoastronomical orientation of seven significant ancient Hellenic temples. *Archaeoastronomy International*, vol.17, 94-100.

Liritzis.I (2001) Archaeoastronomical orientation errors: the case of the two Hellenic pyramidals. J. Radioanalytical & Nuclear Chemistry, vol.247, No 3, 723-725.

Liritzis, I. and Vassiliou, H. (2006) Were Greek temples oriented towards aurora? *Astronomy & Geophysics*, vol.47, 2, 1.14-1.18.

Liritzis I. (1998) Bronze Age Greek Pyramids and Orion's belt. Griffith Observer, vol.63, n.10, 10-21

Liritzis.I and Vassiliou.H (2002) Astronomical orientations of ancient temples at Rhodes and Attica with a tentative interpretation. *Mediterranean Archaeology & Archaeometry,* vol.2, No 1, 69-79.

Liritzis, I and Coucouzeli, A (2007) Ancient Greek Heliocentric Views Hidden from Prevailing Beliefs? *Studies in History and Philosophy of Science*, 11(1), 39-49.

Liritzis, I and Artelaris, G (2010) Astronomical orientations of Dragon Houses (Palli Laka, Kapsala, Oche) and Armena Gate (Euboea, Greece). *Mediterranean Archaeology & Archaeometry,* Special Issue, (D.Keller, Guest editor.), Vol.10, No.3, 41-52.

Liritzis, I., Bousoulegka E., Nyquist A., Castro B., Fahad Mutlaq A., Drivaliari A. (2017) New evidence from archaeoastronomy on Apollo oracles and Apollo-Asclepius related cult. *Journal of Cultural Heritage* 26, 129–143. http://dx.doi.org/10.1016/j.culher.2017.02.011

Liritzis, I, Miller, M.C, Alappat, L (2020) The value of OSL in distinguishing ancient from more recent structures in an archaeological landscape. *SCIENTIFIC CULTURE*, Vol. 6, No. 2, pp. 23-34. DOI: 10.5281/zenodo.3724844.

Liritzis, I, Xanthopoulou, V,Palamara, E, Papageorgiou, I, Iliopoulos, I, Zacharias, N, Vafiadou, A, Karydas A.G (2020) Characterization and provenance of ceramic artifacts and local clays from late Mycenaean Kastrouli (Greece) by means of P-XRF screening and statistical analysis. *Journal of Cultural Heritage*. 46, pp. 61–81.

Laskaris.N and Liritzis. I (2020) Surface and interface investigation of archaeological obsidian artefacts with TOF-SIMS: case study. *SCIENTIFIC CULTURE*, Vol. 6, No. 3, pp. 85-99 DOI: 10.5281/zenodo.3742358

Liritzis, I (2021) Kastrouli fortified settlement (desfina, phokis, Greece): a chronicle of research. *SCIENTIFIC CULTURE*, Vol. 7, No. 2, pp. 17-32. DOI: 10.5281/zenodo.4465472

Liritzis,I, Polymeris, G.S, Vafiadou, A, Sideris, A, Levy, T.E. (2018) Luminescence dating of stone wall, tomb and ceramics of Kastrouli (Phokis, Greece) Late Helladic settlement: case study. Journal of Cultural Heritage. Vol. 35, pp.76-85

Malaspina P., Tsopanomichalou M., Duman T., Stefan M., Silvestri A., Rinaldi B., Garcia O., Giparaki M., Plata E., Kozlov A.I., Barbujani G., Vernesi C., Papola F., Ciavarella G., Kovatchev D., Kerimova M.G., Anagnou N., Gavrila L., Veneziano L., Akar N., Loutradis A., Michalodimitrakis E.N., Terrenato L., Novelletto A., 2001. A multistep process for the dispersal of a Y chromosomal lineage in the Mediterranean area, *Annals of Human Genetics*, Vol. 65, Issue 4, pp. 339-349.

Moropoulou et al., (1998) Historic mortar technologies in Crete and guidelines for compatible restoration mortars, In Biscontin G et al eds), Technical Chamber of Greece, PACT 55, pp. 55-73.

Maniatis, Y., Papadopoulos, S., 2011. 14C dating of a final Neolithic-Early Bronze Age transition period settlement at Aghios Ioannis on Thassos (North Aegean), *Radiocarbon*, Vol. 53, Nr 1, pp. 21-37.

Martinez, L., Underhill, P.A., Zhivotovsky, L.A., Gayden, T., Moschonas, N.K., Chow, C-E.T., Conti, S., Mamolini, E., Cavalli-Sforza, L.L., Herrera, R.J., 2007 Paleolithic Y-haplogroup heritage predominates in a Cretan highland plateau, *European Journal of Human Genetics*, 15(4), pp. 485-493.

Mavridis, F., Tankosić, Ž., 2009. The Ayia Triadha cave, southern Euboea: Finds and implications of the earliest human habitation in the area (A preliminary report), *Mediterranean Archaeology and Archaeometry*, Vol. 9, No. 2, pp. 47-59.

Megaloudi, F., 2006. *Plants and Diet in Greece from Neolithic to Classic Periods: The Archaeobotanical Remains*, Volume 1516 of BAR international series, British archaeological reports, Archaeopress.

Milić, M., 2014. PXRF characterisation of obsidian from central Anatolia, the Aegean and central Europe, *Journal of Archaeological Science*, Vol. 41, pp. 285-296.

Moropoulou, A., Bakolas, A., Bisbikou, K., 2000. Investigation of the technology of historic mortars, *Journal of Cultural Heritage*, Vol. 1, Issue 1, pp. 45-58.

Mourtzas, N.D. and Kolaiti, E., 2013. Historical coastal evolution of the ancient harbor of Aegina in relation to the Upper Holocene relative sea level changes in the Saronic Gulf, Greece, *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 392, pp. 411-425.

Nachasova, I.E., Burakov, K.S., and Il'ina, T.A., 2007. Geomagnetic field intensity in the Eastern Mediterranean region in the second half of the 1st millennium BC and the beginning of our Era, *Phys. Solid Earth*, 43(12), pp. 1024-1030.

Nachasova, I.E., Burakov, K.S., and Il'ina, T.A., 2008. Variations in the geomagnetic field strenght in the 5th-3rd centuries BC in the Eastern Mediterranean (according to Narrowly Dated ceramics), *Geomagn. Aeronomy*, 48(3), pp. 408-414.

Nafplioti, A., 2011. Tracing population mobility in the Aegean using isotope geochemistry: a first map of local biologically available $^{87}Sr/^{86}Sr$ signatures, *Journal of Archaeological Science*, vol. 38, 7, pp. 1560-1570.

Oikonomou A., Beltsios K., Zacharias N. and Triantafyllidis P., 2014. Technological and provenance study of archaic glassy materials from Rhodes island using XRF and SEM/EDX analysis, *Proceedings of the 39th International Symposium on Archaeometry*, 28 May - 1 June 2012, Leuven, Belgium, pp. 245-250.

Oikonomou A., Beltsios K., Zacharias N., Aravantinos V. and Triantafyllidis P., 2012. Glasses from Aegean and Mainland Greece of historical times, in: Zacharias N., Georgakopoulou M., Polykreti K., Fakorellis G. and Vakoulis Th., (eds), *Proceedings of the 5th Symposium of HAS*, University of Peloponnese Press, pp. 507-527 (in Greek).

Oikonomou, A., and Triantafyllidis, P., 2018. An archaeometric study of Archaic glass from Rhodes, Greece: Technological and provenance issues, *Journal of Archaeological Science: Reports*, Vol. 22, pp. 493-505.

Oikonomou, A., Triantafyllidis, P., Beltsios, K., Zacharias, N., Karakassides, M., 2008. Raman structural study of ancient glass artefacts from the island of Rhodes, *Journal of Non-Crystalline Solids*, 354, pp. 768-772.

Papageorgiou, I., Liritzis, I., 2007. Multivariate mixture of normals with unknown number of components: an application to cluster neolithic ceramics from Aegean and Asia Minor using portable XRF, *Archaeometry*, Vol. 49, Issue 4, pp. 795-813.

Papamarinopoulos, S.P., 1987. Geomagnetic intensity measurements from Byzantine vases in the period between 3000 and 1650 AD, *J. Geomagn. Geoelectr.*, 39, pp. 261-270.

Papamarinopoulos, St.P., Tsokas, G.N., Williams, H., 1985. Magnetic and electric measurements on the island of Lesbos and the detection of buried ancient relics, *Geoexploration*, Vol. 23, Issue 4, pp. 483-490.

Papoulia, C., 2016. Late Pleistocene to Early Holocene Sea-Crossings in the Aegean: Direct, Indirect and Controversial Evidence, in: Ghilardi, M., (ed), *Géoarchéologie des îles de Méditerranée - Geoarchaeology of the Mediterranean Islands*, CNRS ÉDITIONS, 33-46. DOI: 10.4000/books.editionscnrs.28488.

Papamarinopoulos,S, Preka-Papadema, P, Gazeas, K, Nastos, P, and Kiriakopoulos, K.G (2016) Extreme physical phenomena during the trojan war. *Mediterranean Archaeology and Archaeometry,* Vol. 16, No. 3, pp. 135-155. 10.5281/zenodo.160963

Papamarinopoulos, S, Preka-Papadema, P, Mitropetros, P, Antonopoulos, P, Mitropetrou, E, Saranditis G. (2014) A new astronomical dating of the trojan war's end. *Mediterranean Archaeology and Archaeometry*, Vol. 14, No. 1, pp. 93-102.

Papathanassiou M, Hoskin M. (1994) Orientations of the Greek Temples on CORFU. *Journal for the History of Astronomy,* 25(2), pp. 111-114. doi:10.1177/002182869402500204.

Papathanassiou M, Hoskin M. (1996) The Late-Minoan Cemetery at Armenoi: A Reappraisal. *Journal for the History of Astronomy*, 27(1), pp. 53-59. doi:10.1177/002182869602700104

Pavlopoulos, K., Theodorakopoulou, K., Bassiakos, Y., Hayden, B., Tsourou, T., Triantaphyllou, M., Kouli, K., Vandarakis, D., 2007. Paleoenvironmental evolution of Istron (N.E Crete), during the last 6000 years: depositional environment, climate and sea level changes, *Geodinamica Acta*, vol. 20, Issue 4, pp. 219-229.

Pavlopoulos, K., Triantaphyllou. M., Karkanas, P., Kouli, K., Syrides, G., Vouvalidis, K., Palyvos, N, Tsourou, Th., 2010. Paleoenvironmental evolution and prehistoric human environment, in the embayment of Palamari (Skyros Island, Greece) during Middle-Late Holocene, *Quaternary International*, Vol. 216, Issues 1-2, pp. 41-53

Pelton, A., Stamatakis, M.G., Kelepertzis, E., Panagou, T., 2014. The Origin and Archaeometallurgy of a Mixed Sulphide Ore for Copper Production on the Island of Kea, Aegean Sea, Greece, *Archaeometry*, DOI:10.1111/arcm.12080, Article first published online: 16 FEB 2014

Perissoratis, C. and Conispoliatis, N., 2003. The impacts of sea-level changes during latest Pleistocene and Holocene times on the morphology of the Ionian and Aegean seas (SE Alpine Europe), *Marine Geology*, Vol. 196, Issues 3-4, pp. 145-156.

Perlès, C., Takaoğlu, T., Gratuze, B., 2011. Melian obsidian in NW Turkey: Evidence for early Neolithic trade, *Journal of Field Archaeology*, Vol. 36, Issue 1, pp. 42-49.

Pliakos, A (2021) Are there 12 or 10 the minoan solar 'months'? a reassessment. *Mediterranean Archaeology and Archaeometry,* Vol. 21, No 1, pp. 227-236.

Polymeris, G.S., Gogou, D., Afouxenidis, D., Rapti, S., Tsirliganis, N.C., Kitis, G., 2010. Preliminary TL and OSL investigations of obsidian samples, *Mediterranean Archaeology and Archaeometry*, Vol. 10, Issue Spec. Issue 4, pp. 83-91.

Parker, A. (1950) The Calendars of Ancient Egypt, Studies in Ancient Oriental Civilization, 26. Chicago: University of Chicago Press.

Televantou, C.A., (2005) Andros. In: Vlachopoulos, A.G. (Ed.), Archaeology of the Aegean Islands. Melissa Press, Athens, pp. 214–219 (in Greek).

Quinn, P., Day, P.M., Kilikoglou, V., Faber, E., Katsarou-Tzeveleki, S., Sampson, A., 2010. Keeping an eye on your pots: the provenance of Neolithic ceramics from the Cave of the Cyclops, Youra, Greece, *Journal of Archaeological Science*, Vol. 37, Issue 5, pp. 1042-1052.

Rehren, Th., Spenser, L., Triantafyllidis, P., 2005. The primary production of glass at Hellenistic Rhodes, in: *Annales du 16e Congrès de l' association Internationale pour l' Histoire du verre. 2005*, International Association for the History of Glass, Nottingham, pp. 39-43.

Renfrew C.A, and Bahn, P (1991) Archaeology: Theories, Methods, and Practice. London, Thames & Hudson.

Renfrew, C. A (2011) The Emergence of Civilisation: The Cyclades and the Aegean in the Third Millennium BC. Oxford; Philadelphia: Oxbow Books.

Richards E.G. (1999) Mapping Time: The Calendar and its History, Oxford University Press

Rosser, Z.H., Zerjal, T., Hurles, M.E., Adojaan, M., Alavantic, D., Amorim, A., Amos, W., Armenteros, M., Arroyo, E., Barbujani, G., Beckman, G., Beckman, L., Bertranpetit, J., Bosch, E., Bradley, D.G., Brede, G., Cooper, G., Côrte-Real, H.B., de Knijff, P., Decorte, R., Dubrova, Y.E., Evgrafov, O., Gilissen, A., Glisic, S., Gölge, M., Hill, E.W., Jeziorowska, A., Kalaydjieva, L., Kayser, M., Kivisild, T., Kravchenko, S.A., Krumina, A., Kucinskas, V., Lavinha, J., Livshits, L.A., Malaspina, P., Maria, S., McElreavey, K., Meitinger, T.A., Mikelsaar, A.V., Mitchell, R.J., Nafa, K., Nicholson, J., Nørby, S., Pandya, A., Parik,

J., Patsalis, P.C., Pereira, L., Peterlin, B., Pielberg, G., Prata, M.J., Previderé, C., Roewer, L., Rootsi, S., Rubinsztein, D.C., Saillard, J., Santos, F.R., Stefanescu, G., Sykes, B.C., Tolun, A., Villems, R., Tyler-Smith, C., Jobling, M.A., 2000. Y-chromosomal diversity in Europe is clinal and influenced primarily by geography, rather than by language, *American Journal of Human Genetics*, 67(6), pp. 1526-1543.

Sarkissian C Der, et al., (2015) Ancient genomics. *Philos Trans R Soc Lond B Biol Sci.*; 370(1660): 20130387. doi: 10.1098/rstb.2013.0387

Semino, O, Passarino, G., Oefner, P.J., Lin, A.A., Arbuzova, S., Beckman, L.E., De Benedictis, G., Francalacci, P., Kouvatsi, A., Limborska, S., Marcikiae, M., Mika, A., Mika, B., Primorac, D., Santachiara-Benerecetti, A.S., Cavalli-Sforza, L.L., Underhill, P.A., 2000. The Genetic Legacy of Paleolithic Homo Sapiens Sapiens in Extant Europeans: A Y Chromosome Perspective, *Nature*, 290(5494), pp.1155-1159.

Siart, C., Hecht, S., Holzhauer, I., Altherr, R., Meyer, H. P., Schukraft, G., Eitel, B., Bubenzer, O., Panagiotopoulos, D., 2010. Karst depressions as geoarchaeological archives: The palaeoenvironmental reconstruction of Zominthos (Central Crete), based on geophysical prospection, sedimentological investigations and GIS, *Quaternary International*, Vol. 216, Issues 1-2, pp. 75-92.

Soetens, S., A. Sarris, S. Topouzi and A. Tripolitsiotis 2002. GIS Modeling of the Minoan Peak Sanctuaries of East Crete, in: Burenhult, G. and J. Arvidsson (eds.), *Archaeological Informatics: Pushing The Envelope. CAA2001. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 29th Conference*, Gotland, April 2001 (BAR International Series 1016). Archaeopress, Oxford, pp. 129-138.

Spatharas, V., Kondopoulou, D., Liritzis, I., and Tsokas, G., 2000. Archaeointensity results from two ceramic kilns from N. Greece, *J. Balkan Geophys. Soc.*, vol.3, N0.4, 67-72.

Steele J.M.(ed.) (2007) Calendars and Years: Astronomy and Time in the Ancient Near East, Oxbow Books.

Stern, S. (2012) Calendars in antiquity, empires, states and societies. Oxford University Press, Oxford

Stampolidis, N.C., Çiğdem, M., Kopanias, C., 2015. Nostoi. Indigenous Culture, Migration and Integration in the Aegean Islands and Western Anatolia during the Late Bronze and Early Iron Age, *Koç University Press* 58, Archaeology.

Stiros, C. Stathis, Blackman, J. David, 2014. Seismic coastal uplift and subsidence in Rhodes Island, Aegean Arc: Evidence from an uplifted ancient harbor, *Tectonophysics*, Vol. 611, pp. 114-120.

Strasser, T.F., Runnels, C., Wegmann, K., Panagopoulou, E., Mccoy, F., Digregorio, C., Karkanas, P., Thompson, N., 2011. Dating Palaeolithic sites in southwestern Crete, Greece, *Journal of Quaternary Science*, Vol. 26, Issue 5, pp. 553-560.

Tarling, D.H. and Downey, W.S., 1989. Archaeomagnetic results from Late Minoan destruction levels on Crete and the 'Minoan' Tephra on Thera, in: Hardy, D.A. and Renfrew, A.C., (eds), *Thera and the Aegean World III, Vol. 3, Chronology, Proc. Third Int. Congress,* Santorini, pp. 105–109, The Thera Foundation, London.

Tema, E. and Kondopoulou, D., 2011. Secular variation of the Earth's magnetic field in the Balkan region during the last eight millennia based on archaeomagnetic data, *Geophys. J. Int.*, 186, pp. 603-614 doi: 10.1111/j.1365-246X.2011.05088.x.

Theodorakopoulou, K., Pavlopoulos, K., Athanassas, C., Zacharias, N., Bassiakos, Y., 2012. Sedimentological response to Holocene climate events in the Istron area, Gulf of Mirabello, NE Crete, *Quaternary International*, Vol. 266, pp. 62-73.

Theodorakopoulou, K., Pavlopoulos, K., Triantaphyllou, M., Kouli, K., Tsourou, Th., Bassiakos, Y., Zacharias, N., Hayden, B., 2009. Geoarchaeological studies in the coastal area of Istron-Kalo Chorio (gulf of Mirabello- Eastern Crete): landscape evolution and paleoenvironmental reconstruction, *Zeitschrift für Geomorphologie*, Supplementary Issues Vol. 53, Supplementary Issue 1, pp. 55-70.

Thomas, R.C., 1981. *Archaeomagnetism of Greek pottery and Cretan kilns*. PhD thesis, University of Edinburgh.

Tjeerd H. van Andel and Judith C. Shackleton, 1982. Late Paleolithic and Mesolithic Coastlines of Greece and the Aegean, *Journal of Field Archaeology*, 9:4, pp. 445-454.

Tourloukis, V. and Karkanas, P., 2012. The Middle Pleistocene archaeological record of Greece and the role of the Aegean in hominin dispersals: new data and interpretations, *Quaternary Science Reviews*, Vol. 43, pp. 1-15.

Treuil, R., Darcque, P., Poursat J.-Cl., Touchais, G., 1996. *Les civilisations égéennes du Néolithique et de l'Age du Bronze (Οι Πολιτισμοί του Αιγαίου)*, Kardamitsas, Athens. Paris.

Triantafyllidis, P., Karatasios, I., Andreopoulou-Magkou, E., 2012. Study of core-formed glass vessels from Rhodes, in: Zacharias, N., Georgakopoulou, M., Polikreti, K., Fakorellis, G., Vakoulis, Th. (eds.), *Proceedings of the 5th Symposium of HSA*, University of Peloponnese Publications, pp. 529-544 (in Greek).

Tsikritsis, M, Moussas, X and Tsikritsis, D (2015) Astronomical and mathematical knowledge and calendars during the early helladic era in aegean "frying pan" vessels. *Mediterranean Archaeology and Archaeometry*, Vol. 15, No.1 (2015) pp. 135-149.

Vafiadou, A., Murray, A.S., Liritzis, I., 2007. Optically stimulated luminescence (OSL) dating investigations of rock and underlying soil from three case studies, *Journal of Archaeological Science*, Vol. 34, Issue 10, pp. 1659-1669.

Vika, E. and Theodoropoulou, T. 2012. Re-investigating fish consumption in Greek antiquity: results from $\delta^{13}C$ and $\delta^{15}N$ analysis from fish bone collagen, *Journal of Archaeological Science*, Vol. 39, Issue 5, pp. 1618-1627.

Walton, D., 1979. The geomagnetic intensity in Athens between 2000 B.CA. D 200, *Nature*, 277, pp. 643-644.

Walton, D., 1984. Re-evaluation of Greek archaeomagnitudes, *Nature*, 310, pp. 740-743.

Walton, D., 1990. Changes in the intensity of the geomagnetic field, *Geophys. Res. Lett.*, 17(12), pp. 2085-2088

Xanthakis, J. and Liritzis, I., 1991. Geomagnetic variation as inferred from archaeomagnetism in Greece and palaeomagnetism in British lake sediments since 7000 BC, *Academy of Athens Publications*, vol.53, Athens.

Xanthakis, J. and Liritzis, Y., 1989. Spectral analysis of archaeomagnetic inclinations for the last 2000 years, *Earth, Moon and Planets*, 45, pp. 139-151.

Xanthopoulou, V, Iliopoulos, Liritzis, I (2021) Mineralogical and microstructure analysis for characterization and provenance of ceramic artifacts from late Helladic Kastrouli settlement, Delphi (central Greece). *Goesciences* (in press).

Zacharias, N., Bassiakos, Y., Hayden, B., Theodorakopoulou, K., Michael, C.T., 2009. Luminescence dating of deltaic deposits from eastern Crete, Greece: Geoarchaeological implications, *Geomorphology*, Vol. 109, Issue 1-2, pp. 46-53.

Zacharias, N., Michael, C.T., Georgakopoulou, M., Kilikoglou, V., Bassiakos, Y., 2006. Quartz TL dating on selected layers from archaeometallurgical kiln fragments: A proposed procedure to overcome age dispersion, *Geochronometria*, Vol. 25, pp. 29-35.

Žegarac, A et al., (2020) ,Kinship, acquired and inherited status, and population structure at the Early Bronze Age Mokrin necropolis in northern Serbia. bioRxiv preprint doi: https://doi.org/10.1101/2020.05.18.101337; this version posted May 19, 2020.