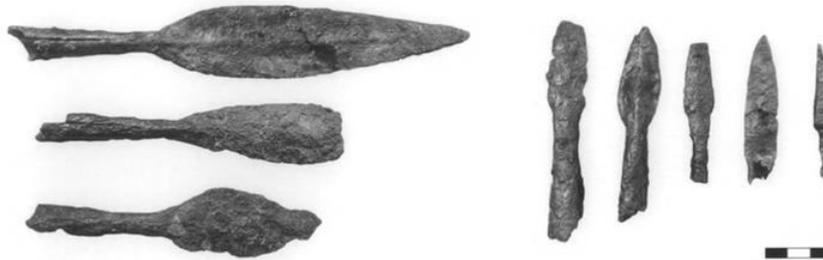


**Master of Science in
«Cultural Heritage Materials and Technologies»**

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DIPLOMA THESIS:

Study of Offensive Armament through Analytical Methods



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My personal involvement with the offensive armament and its research through analytical methods arose after my military service as an officer cadet and the encouragement of my supervisor, Professor Nikolaos Zacharias, whom I would like to warmly thank for his cooperation. The reasons above motivated me to study the subject in depth and realize the importance it has nowadays, but also its historical and cultural connection with Messenia. Also, my studies in the University of Peloponnese and my stay in the city of Kalamata were also factors that allowed me to engage with the local history.

The research that was carried out for this dissertation was based not only on bibliography, but also on on-site study of archaeological objects with the permission of the local Ephorate of Antiquities. Ten samples have been selected from ten artifacts coming from the region of Ano Melpeia; they have also been recorded, studied in the literature and investigated using analytical methods in order to collect more information about their manufacturing technology and their state of preservation. The study was performed macroscopically and microscopically accompanied with a considerable number of images.

For this effort I would also like to thank for the guidance and the genuine interest, the excavator of Ano Melpeia Dr. Xenia Arapogianni for giving me her permission to study the ancient artifacts and Dr. Charilaos Tselios for his valuable contribution. Also, I would like to thank the Ephorate of Antiquities of Messenia for all their actions concerning my research, the staff in the laboratory for their inestimable assistance, the instructors and professors of the postgraduate program for their valuable help during my studies, the modern metal maker Dimitrios Katsikis for his tremendous assistance but also my colleagues, co-students and friends for their support and assistance all these years. Lastly, I would like to thank my parents Konstantinos and Zoe, thanks to those and their support and effort I am close to the end of another cycle, and I am ready to open a new one in my life.

To my parents, Konstantinos & Zoe

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Introduction

A part of the cultural richness of Messenia is identified through the region's ancient remnants, as a piece of the Greek world connected with myths, stories and achievements of great persons and events, drawing the world's eyes even today upon this majestic land. During the last decades several new historical sites, settlements and other monuments or objects have been found confirming the ancient authors about the importance of the region and reinforcing the scientific dialogue to support the research efforts in Messenia and her northern part, Andania.

In 2010, at the north of the modern village of Ano Melpaia, on a hilltop the ruins of an ancient building have been found and thus systematic excavations took place. Among the remnants of this building and other findings, what has also been discovered was a large number of an ancient and significant ensemble of weapons made of iron. The aim of this thesis is to highlight the cultural value of these weapons, studying at the same time the conditions and corrosion products through SEM/EDS accompanied with optical microscopy and underlining the importance of the area through the following investigation.

However, before the examination of the iron-made material some historical facts should be illustrated, so the reader has the chance to form a more comprehensive image of the material's identity. Starting from the Dark Ages through Hellenistic and Roman era, the first section refers to the people and the events that shaped local history and are admired until nowadays, presenting at the same time the important role of Messenians in the history of the ancient world. The history of ancient Andania will be placed in the same context, where several aspects of its history will be highlighted.

Next, the study will focus on Ano Melpaia, where the ancient temple has been found along with the iron-made ensemble. The location and the description of the surrounding area will be included in this section up to the point of presentation of the excavation process. Apart from these, the archaeological artifacts will also be mentioned, emphasizing at the same time at the temple itself and its characteristics.

Certainly, a reference to the military equipment of the ancient Greeks could not be missing in this research. The spear, the sword, the bow, the javelin and the slingshot are some of the main offensive weapons which will be examined and a historical approach will be made regarding their role in the war and life of the Greek hoplite along with his appearance during the first dark centuries.

The study concludes with the process of the ancient bloomery, the steel production and the chemical analysis of the offensive military equipment. The aim of this research is the characterization and chemical composition in macroscopic and microscopic level of the offensive weapons found in Ano Melpeia, in order to understand the conditions, the corrosion products and the material and nature of the war objects coming from the examined area.

I. The Inhabitation in Messenia During Antiquity

Dark Ages

The southwestern Peloponnese has always been a prosperous region for several reasons, fertile lands, territorial advantages, great strategic position and connection with various trade routes. The large amount of Mycenaean artifacts and significant *tholos* tombs make the region of Messenia one of the most interesting places today.. During the late Bronze Age, the most known Mycenaean centers were Pylos in the western part, Leuktron (re-u-ko-to-ro in the Linear B tablets) around Pamisos valley, valley of Soulima from north to south and Nichoria in the gulf of Messenia. Around 1200 BC for reasons not yet known, the old kingdoms of Messenia collapsed. According to the literary, two generations after the end of the Trojan campaign, a huge migration wave driven by the Dorians moved to the south, invading and opening a new chapter in the Aegean area.

Nonetheless, Pausanias' work mentions that the old Messenians did not abandon their land but they were forced to accept the new order and adapt a new way of life accompanied by the new regime of Kresphontes¹ (Fig. 3). Thus, Messenia was divided into five sub-regions: 1) The Stenyklaros plain, 2) Pylos, 3) Rhion, 4) Mesola and 5) Hyameitis².

Although the aforementioned events are generally accepted, the reliability of Homer's work arises, since he is one of the main sources regarding this era. For a long time various theorists were trying to understand whether Homer's narratives correspond to his time or if his works were based on oral tradition which described events of the past. Eventually, it seems that the civilization in Homer's epic cycle is in line with the new findings of the long-term excavations which brought to light the famous heroes and citadels of the Late Bronze Age, like Agamemnon's Mycenae, Priam's Troy and Nestor's Pylos.

The archaeological material which has been excavated from the Mycenaean citadels and other sites reassured the researchers about the content of Homer's poems which was associated with a civilization that precedes the Dark Ages (boar's tusk helmets, spears, swords, war chariots, and other stuff). Nevertheless, Homer's depiction of small kingdoms which used to conduct incursions and continuous wars with each

¹ Pausanias 4.3.5-7

² Rapp & Aschenbrenner 1978: 92

other in a turbulent environment is in contrast with the linear B findings which indicate a very strict and structured social and political system. Moreover, in the Homeric society heroes are usually cremated after their death instead of the common burial practice, since it was not before 1050 B.C. when cremation replaced the luxurious bury. This fact, along with the *tholos* tombs indicate that Homer combined real facts of his era with oral tradition which was formed based on people's memories. According to the scholars the described culture is connected with the Mycenaean period or the first decades of the Dark Ages. Apart from these, it is clearer today that the unstable political system of the autonomous kingdoms is probably referred in the poet's era.

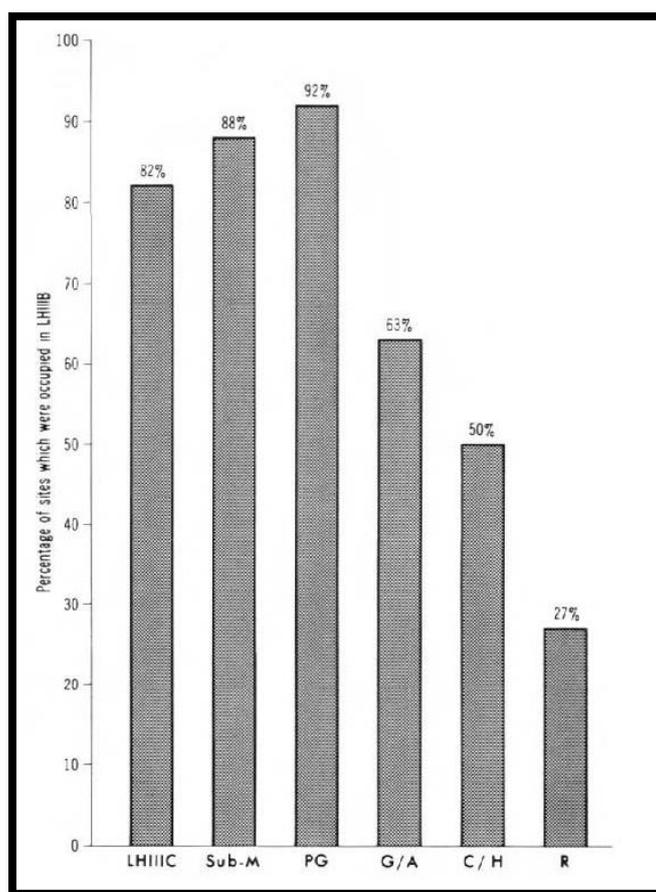


Figure 1 Frequency of previous occupied settlements in Messenia in later ages

About settlement distribution in Messenia, it looks that most of the communities were quite isolated from each other and placed on old Mycenaean sites (Fig. 1), the same pattern also found in the Five Rivers area (Fig. 2). Starting from the 10th until 8th century B.C., the influence of Mycenaean past seems that have affected quite enough the life of Geometric Messenia concerning the settlement distribution pattern where some sites were placed on hilltops instead on flatten terrains. The only exception here is

Mavromati, (the site of later Ithome / Messene), where geometric pottery has been found indicating a ninth century settlement³.

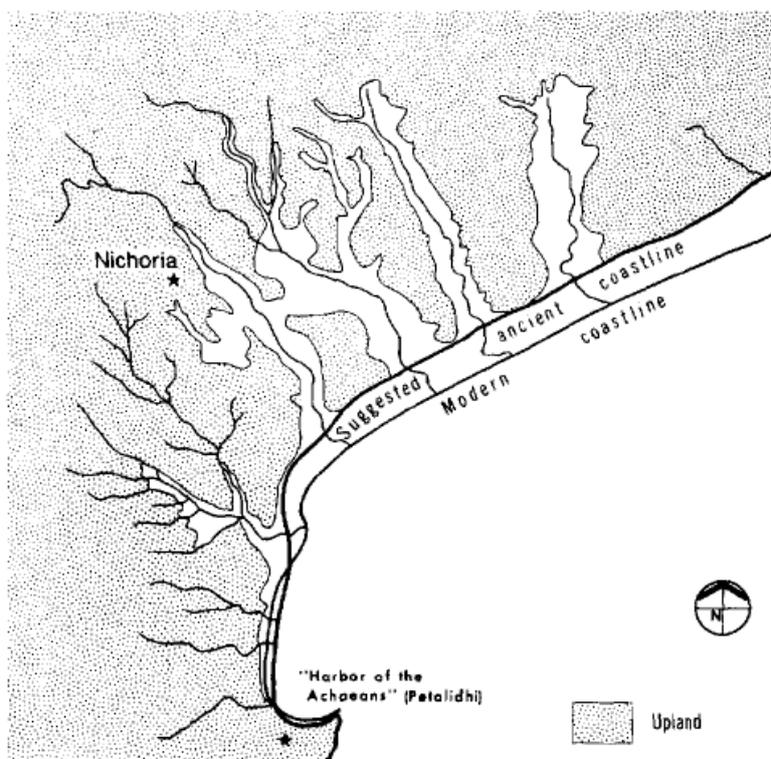


Figure 2 The Five Rivers area.

So it seems that in most cases, geometric settlements built on older ones. Moreover, regarding the case of Nichoria, researchers faced up with a random building orientation indicating lack of settlement planning with insufficient data number of dwellings and therefore any effort to fully understand the inner – settlement plan would lead with complex conclusions. The only exception here is the road system where have been found that was the same during the Late Bronze Age⁴.

In contrast of what was happening in the rest of Greek peninsula during the 8th century, in Messenia seems to be a period of little or no progress. The lack of pottery samples, the plain decoration or pottery with some Lakonian influences indicates signs of stagnation and lack of investigation⁵. Nonetheless, Messenia during 8th century has

³ Luraghi 2008: 112

⁴ Rapp & Aschenbrenner 1978: 93

⁵ Luraghi 2008: 113

significant cultural customs, mainly related with rituals evidenced through artifacts in a number of sites and sanctuaries, indicating an attachment with the Bronze Age past⁶.

Also, burial sites like in Nichoria or Pera Kalamitsi most of them evidenced through burial pithos vessels, are depicting armed dead warriors, showing the militarization of a Messenian elite could be connected with a group of people who have been in a continuous pressure from internal conflicts or external threats. So, even it seems that from the dawn of 8th century the region of Messenia appeared to be quite isolated, gradually started to have more interactions with its neighbors and maybe conflicts, most of them coming from Lakonia. From the other hand though, coming to the late 8th century, when local pottery features influenced by other Greek regions they were more prominent, Messenia looks to have a very slow or non-existent development not only to this but also in the appearance of new major settlements⁷.



Figure 3 Messenia after Kresphontes' division

⁶ Luraghi 2008: 114

⁷ v. sup: 116

Archaic and Hellenistic period

The years that followed the Dark Ages, a new settlement pattern was born in Messenia. The people who were living in sites which have been occupied since Late Helladic started gradually to be abandoned. Previous research has been shown a substantial drop regarding the number of inhabited sites in Messenia. In detail, sites dated since LH period decreased from 90% during the Dark Ages to 63% in Late Geometric/Archaic Age and then to 50% in Classical/Hellenistic era, until the number of these continuous inhabited settlements dropped by 27% during the Roman times⁸. Fortunately, due to Pausanias' "*Description of Greece*" work, we managed to have one of the most comprehensive history mentions about Messenia during the archaic period and Spartan conquest of the region. Pausanias' whose events in the narrative took part probably around the second quarter of the eighth century BC, helping us to extract many conclusions regarding the period he is writing about. Although when he started to work on his book he was far away from his time, we are able to connect the historic pieces between him and previous authors⁹. One of the most precious evidence of the Spartan conquest in Messenia is the Tyrtaeus in his *elegies*.

Thus, while the distribution of settlements in Messenia during geometric era was looking similar with those during the Bronze Age, this started to be changed in the archaic period and later; meaning that the population relocation and the development of new settlements¹⁰ to a new direction started from the western coast and its plains towards the gulf of Messenia and the "Five Rivers" area (Nedon, Pamisos, Epis, Aris, Belikas). The number of inhabited sites there during the archaic period looks to have been increased. Moreover, in a broad area under archaeological investigation have been found a larger number of settlements than burial sites (Fig. 4), indicating the abandonment of older places towards a coastal orientation¹¹. Based on geometric settlements which 63% of them shown archaeological data of earlier periods, archaic settlements presented only 36% similar habitation traces. In addition, the construction of new temples completes this hypothesis.¹²

⁸ Rapp & Aschenbrenner 1978: 95

⁹ Luraghi 2008: 68

¹⁰ v. sup: 117

¹¹ Rapp & Aschenbrenner 1978: 95

¹² Alcock et al. 2005: 159

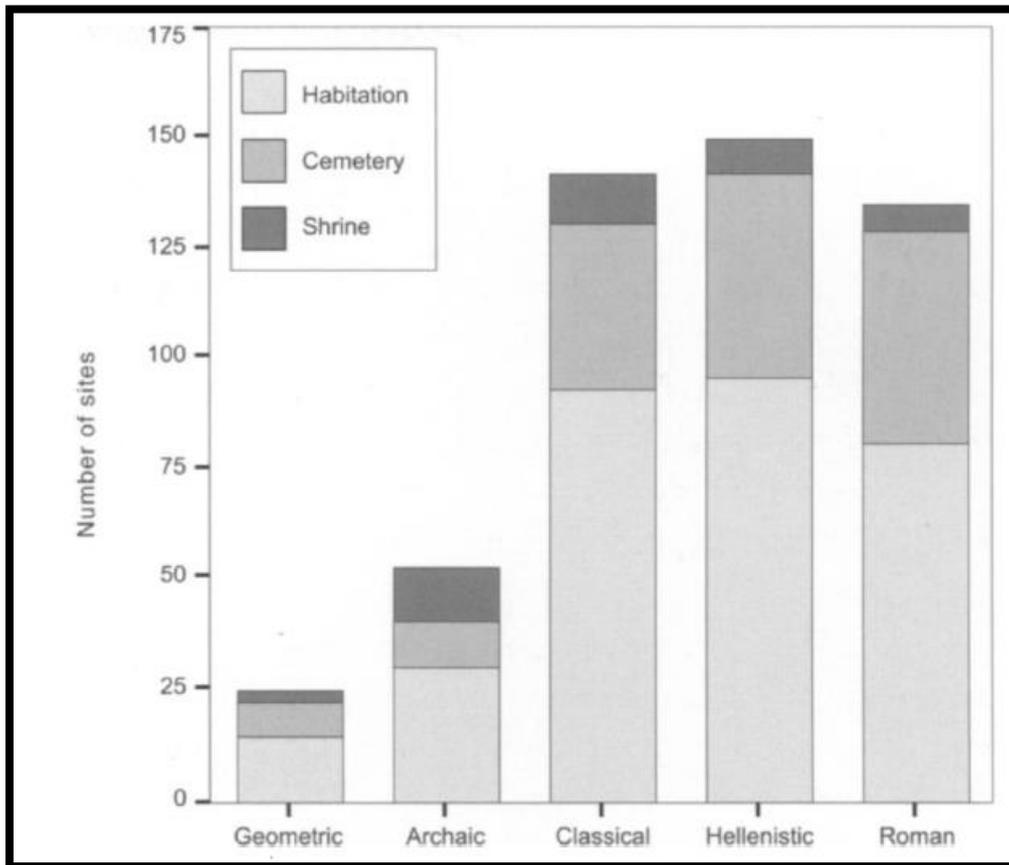


Figure 4 Site numbers through ages by UMME (habitation, cemetery, shrine). Geometric - Roman

Additionally, we must underline here that Messenia was not consisted only by helots but also by *Perioikoi* communities who founded new settlements. In detail, towns like Pherai (Kalamata), Kardamyle, Thouria, Aithaia, Asine (Koroni), Methone, Kyparissia and Aulon were built by Laconian newcomers after the end of the Archaic period. The fact that *Perioikoi* also were contributing to the Spartan economy, gave them the advantage to live close to each other developing craftsmen's skills and boost their area of expertise increasing and expanding at the same time the Sparta's income¹³.

¹³ Rapp & Aschenbrenner 1978: 96

Therefore, the trade in the inland and the ports along with the well-established rout trades in the land and the sea had as a result to bring together steadily more settlers. That's probably also the reason why after the liberation of Messenia, the settlements of *Perioikoi* were still flourishing since they were in constant alignment with the Spartan metropolis. Thus, in the following years (around 365 BC), the Messinians have been forced in some way to found new cities such as Korone and Kolonides, trying to control the areas around Methone and Asine which were still under Spartan rule¹⁴.

Furthermore, in the late fifth through fourth century BC the use of some old centers like Nichoria started to change acquiring a more ritual role rather than a residential one. A layer of ash and pottery dated to the 5th century referred to Nichoria's burial monuments – like *tholos* tomb – seems to be used as a cult center, but since the difficulty to distinguish the archaeological remains between Classical and Hellenistic period, it brings up often enough some questions about the previous habitation role of Hellenistic sites¹⁵. About the settlement distribution pattern in Messenia, didn't change much keeping the tendency though to develop people's activities and establish new settlements towards the coast¹⁶ (Fig. 5).

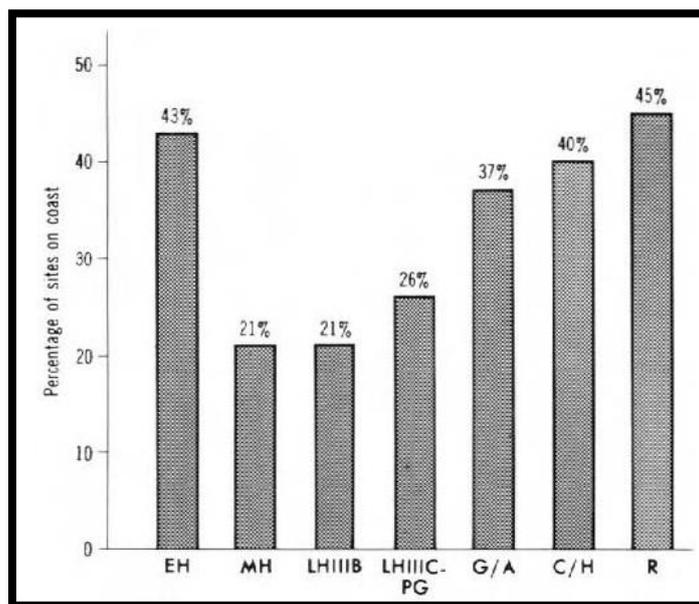


Figure 5 Frequency of coastal settlements in messenia divided by archaeological periods

¹⁴ Rapp & Aschenbrenner 1978: 96

¹⁵ v. sup: 117

¹⁶ Alcock et al. 2005: 179

Roman Messenia

The war operations between Philip V of Macedon and Rome during the 2nd century BC had as an aftereffect the influence of Rome on Messenia, asking the Messenians in 191 BC to join the Achaian League as an ally. Although Messenians stood by the side of Rome, their troops remained at home as defensive force against any aggressive operations. By the end of war, Messenia kept her independence but until today it is unclear whether they used to have political domination in all lands of the region. After the war conflicts, Messenia have been included under *de facto* Roman control and protection. Therefore, local officials using Messene as their headquarters, started to exert control over the population, collecting taxes, filling the Roman coffers and proceeding into financial contributions (*octobolos eisphora*)¹⁷.

During the Caesar's Civil War, fortunately Messenia did not suffer as much as other Greek areas, but in the war between Augustus and Mark Antony, Agrippa launched attacked in Methone because Messenia took the side of Antony and Cleopatra with a cost to lose some territories in favor of Sparta. After the victory of Augustus, Messenia have been included as part of the province of Achaia maintaining though each polis – like Messene - its administrative privileges as political autonomy and ritual freedom¹⁸. In the time of imperial ages, being Athenian, Spartan or Messenian didn't have the same meaning as they used to be in the past since *patris* (=homeland) constituted just a feature of a sophisticated identity based now on a unified notion of Hellenic values, shared cultural practices and genealogy. Alongside, the Roman authority took advantage of Greek elite who was stabilizing the new regime in Greece and finding at the same time a new recruit area for its own imperial elite¹⁹.

Apart from these, seems that some areas of Messenia prospered during Roman times. In the inscriptions of Andanian Mysteries were referring large amounts of money in the region. This is verified, with an overall decrease of Roman sites in Messenia as a whole, but in the area of Five Rivers (Andania) during the same period the numbers of Roman settlements have been increased²⁰. On this matter, the land fertility had an important role indicating more relocations to Andania. Varro's²¹ and Cato's²² assistance on this subject lead modern researchers to comprehend more about the region, especially

¹⁷ Alcock et al. 2005: 175

¹⁸ v. sup

¹⁹ v. sup

²⁰ Rapp & Aschenbrenner 1978: 98

²¹ Varro: 15

²² Cato: 1

on the Five Rivers area, finding in their project commentaries about Roman villas which were functioning as local markets and the nearby towns of Korone and Strefi as entrepôts and seaports. Based on these, according the Roman provincial administrative system, Korone could probably be a significant town including also other smaller settlements, showing many strategic features in the area since it is placed near crucial land and sea routes with a natural harbor and a trade center, noting also great water supplies and having at the same time access in four springs at least²³. In the following centuries, the contribution of *Pax Romana* led Messenia to a significant development on many levels, although these prosperous times and economic growth would be greatly disturbed mainly from the 4th to 7th century. Later, during the 6th century A.D. barbarian incursions, plagues and other natural disasters - that considered as God's wrath – put a pause on the region's life stability. Towards the Late Roman Period until the fall of Roman West (5th century A.D.) it seems the whole Greek peninsula affected by many factors leading to a general decay. Before the end of antiquity, the emergence of Christian bishoprics in the area brought a new era, dedicated mainly to Christianity and around religion issues.

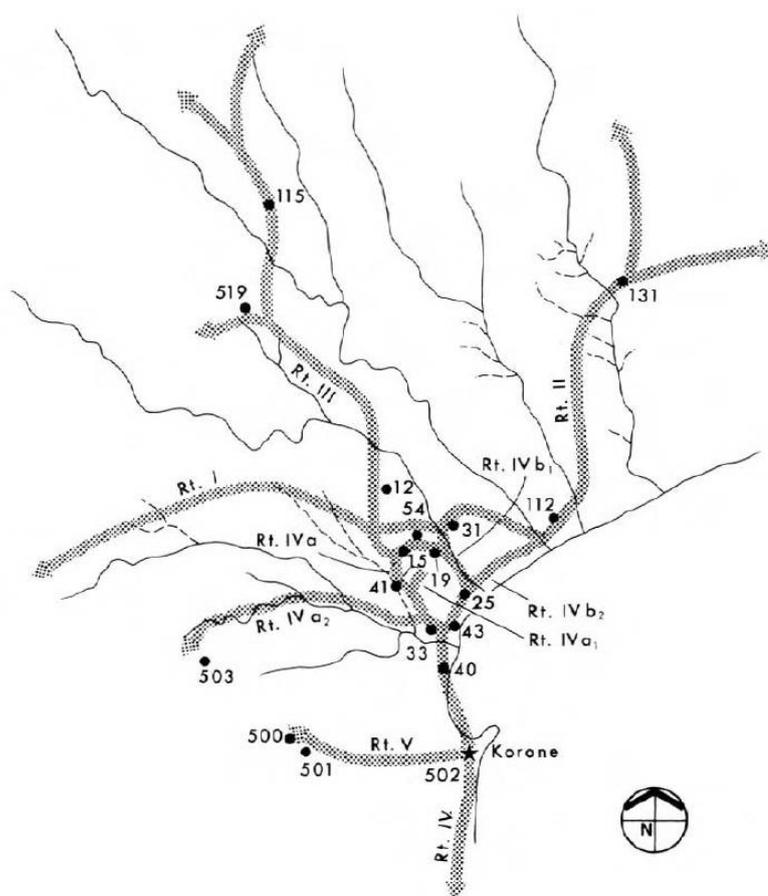


Figure 6 The Roman routes in the Five Rivers area

²³ Rapp & Aschenbrenner 1978: 99

The History of Andania

Ancient Andania was the first capital city of Messenia. The name means the one that is beautiful and attractive in sight. During antiquity, in Stenyklaros plain the city was located in the upper valley of Messenia, hence the whole region took this name, as Stephanus of Byzantium also mention²⁴. The first king was *Perieres*, a man who relocated from central Greece (Thessalia) at the time of early 3rd millennium BC. *Polykaon* the son of *Lelegas* of Sparta and husband of *Messene* was the city's founder. In Pausanias' work *Kaukon* was mentioned as the man who introduced the worship of the Great Gods, a ritual originated from Eleusina. It was also the military operation center of Messenians during the Messenian wars against Spartans who invaded in order to conquer and subjugate *Aristomenes*, the leader of Messenian forces and his men. The city was destroyed in 500 – 489 BC by Spartans and the people who were living there have been killed or expelled from their country²⁵. Nonetheless, after 338 BC and the battle of Chaironeia the city have rebuilt by Phillip's II order. It was not before the Hellenistic period when the city started to show development signs again. The historical events that led researchers in such conclusions were the following:

- i. The successful defensive actions against a Spartan assault in 217 BC
- ii. It was a common meeting place between Achaean League (in which Messenians also joined) and Romans in 191 BC in order to solve political issues
- iii. A renewed sense of common cult and social affairs listed also in the ritual layout of Andania in 91 BC by hierophant Mnasistratos
- iv. Pausanias' comments in his writes, where he mentions the city as a cult center²⁶

According to Strabo it seems that Andania until the 1st century BC was a small town²⁷ and was destroyed a little before or around 2nd century AD, since Pausanias when he was visited the area saw the city's ruins.

²⁴ Stephanus *Ethnika*: 94. Ἀνδανία, πόλις Μεσσηνίας, ὁμώνυμος τῇ χώρᾳ. οὕτω γὰρ καὶ ἡ Μεσσηνία Ἀνδανία ἐκαλεῖτο, ἦν οἰκῆσαι φασὶ τινὰς τῶν Κρεσφόντου καὶ οὕτως καλέσαι διὰ τὸ μὴ ἀνδάνειν αὐτοῖς. [94] τὸ ἔθνικόν Ἀνδανιεύς, ὡς Φίλων ἐν τῇ περὶ πόλεων. ἐκ ταύτης Ἀριστομένης ἐγένετο, ἐπιφανέστατος στρατηγός. τοῦτον οἱ Λακεδαιμόνιοι πολλάκις αὐτοὺς νικήσαντα θαυμάσαντες, ὡς μόλις ἐκράτησαν ἐν τοῖς Μεσσηνιακοῖς, ἀνατεμόντες ἐσκόπων εἰ παρὰ τοὺς λοιποὺς ἐστὶ τι, καὶ εὖρον σπλάγγνον ἐξηλλαγμένον καὶ τὴν καρδίαν δασεῖαν, ὡς Ἡρόδοτος καὶ Πλούταρχος καὶ Ῥιανός. τὸ θηλυκὸν Ἀνδανιάς. λέγεται δὲ καὶ Ἀνδάνιος, ὡς Ῥιανός.

²⁵ Vertsetis: diavolitsi.gr

²⁶ v. sup 2007: 29

²⁷ Strabo 3.60 (οὐκ εὖ πάλιν ὁ Σκῆψιος Ἀρκαδικὴν τινα λέγων, ἦν νῦν Ἀνδανίαν καλοῦσιν)

The question though remains, where is it located? The great German historian Curtius, in 19th century mentions that during an excavation in 1840 found a cyclopean wall. He said that the city was northeast of Stenyklaros plain, below the “Hellinikon” hill²⁸. From the other hand though, the Swedish archaeologist Mattias Natan Valmin, conducting a survey in 1930, argues that Andania was located northwest of Stenyklaros plain, between Konstantinoi, Polichne and Kalliroe villages.²⁹. A new research may answer these questions.

II. The Ancient Temple of Ano Melpeia

During 1995, in a well elevated position, where the temple of Apollo is visible towards the north, after preliminary surveys were conducted 7 kilometers north of the modern village of Ano Melpeia, researchers found the remains of an archaic temple under a demolished Christian chapel. Ancient building material was also found, consisted by the building’s superstructure, entablature’s parts along with metopes, triglyphs and others sections made by local limestone³⁰.

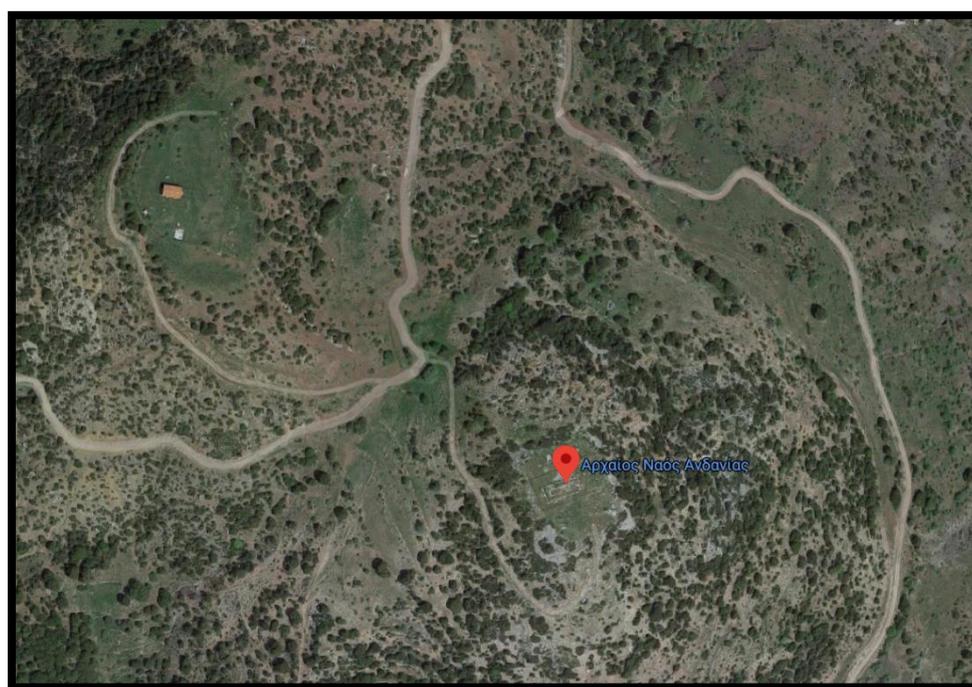


Figure 7 Satellite top view of temple's area

²⁸ Curtius 1867: 296

²⁹ Valmin 1930: 97 - 98

³⁰ Hatzi-Spiliopoulou 2000: 186

The Excavation Chronicle

The modern village of Ano Melpēia where near the temple have been found nearby is located in the region of Andania (northern Messenia), before the Arcadian borders. In the same area (Krempeṇi site) have been also found habitation traces from MH and LH periods along with scattered building material dated back to the Classic and Hellenistic times. It is a place with a continuous habitation evidenced also by a nearby medieval castle known as "Castle of Krempeṇi" where in its foundations are exist ancient fortification ruins. About the hill where the temple have been found, it is placed north of the village of Ano Melpēia and across another hill which hosts the chapel of Prophet Elias.

The temple's site and hill is called "Petroula" where in 2010 conducted surveys shown the existence of ancient ruins. During antiquity, the hilltop had been shaped into a flatten terrain, accessible from the western side; while in northwest was a retaining wall to hold the soil. The initial researches started when the region's inhabitants decided to demolish the aforementioned chapel and found re-used ancient building material³¹. In the preliminary works that followed, identified the foundations of an ancient building 5, 50 m. in length along with the following parts:

³¹ Arapogianni 2010: 249

TEMPLE'S REMAINS³²			
	Section Numbers	Type	Notes
1	27	Triglyph sections with attached metopes	
2	81	Cornice sections	
3	10	Orthostate sections	
4	3	Marble revetments	
5	5	Massive limestone stonewares	Probably from the temple's foundation
6	10	Ribbed colonnade sections	Probably bases for votive offerings

Table 1 The remaining building parts

The absence of column drums and capitals or their fragments caused many question marks. Nonetheless, the excavation works proceeded with the removal of the architectural remains and vegetation and gradually finding the temple's foundations, all the remnants exposed for study.

The temple's direction is East to West and the most distinguishable part today is the western one and a line of stones where the effthintiria used to be. The wall's width ranges from 0.60 to 0.90 m. Moreover, in a distance of 2.40 m. from the western wall another transverse wall did its appearance during the excavation process, as well a similar 5.60 m long wall has been found in the eastern part of the temple.

³² There were also a large number of unidentified building objects coming from the temple's masonry

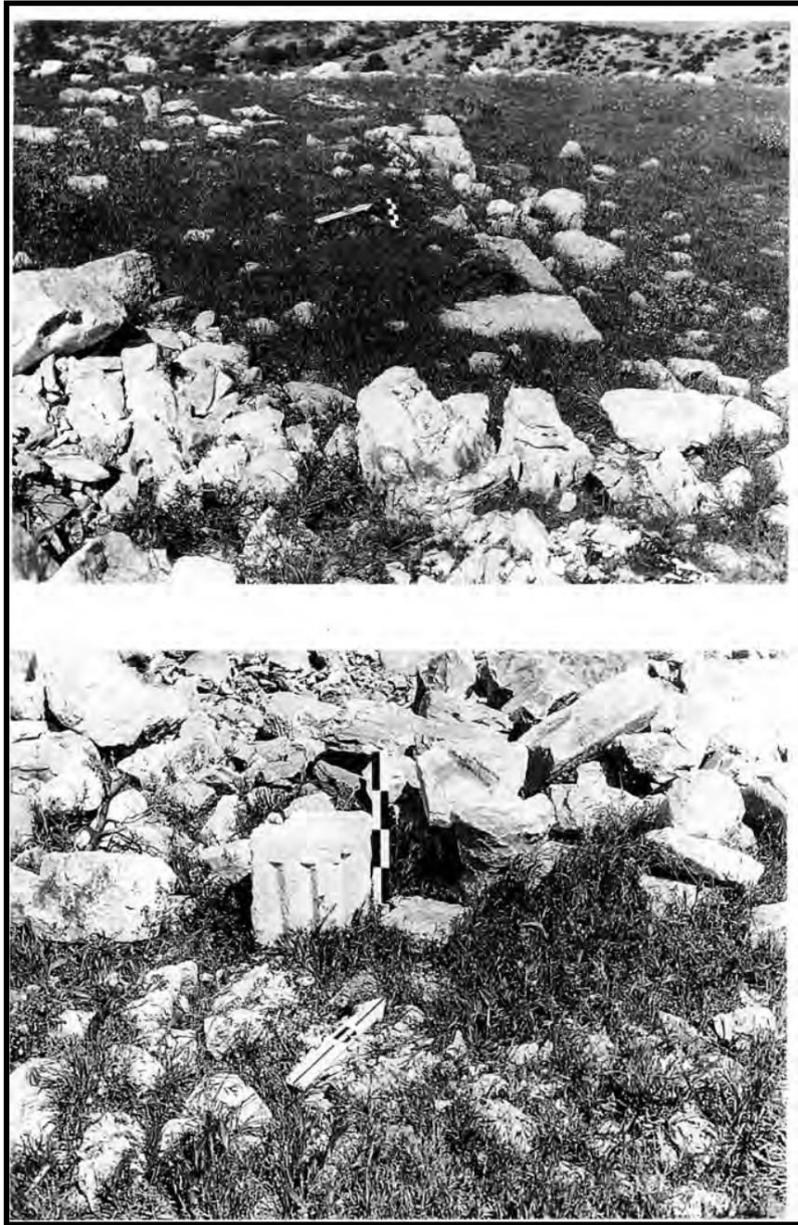


Figure 8 Temple's foundation looking from south and scattered part buildings

Wall Dimensions					
	South (T1)	North (T2)	West (T3)	Transverse Wall / West (T4)	Transverse Wall / East (T5)
Length	9.60	22.70	11.70	3.30	5.60
Width	0.60 – 0.90	0.60 – 0.90	0.60 – 0.90	0.73	0.70

Table 2 Temple's wall dimensions

They have been also found are some very significant and impressive artifacts around the temple. In detail, in the T1 section have been revealed a cylinder shaft with lion - shaped edge (M7550) whilst in T2 the researchers found a number of pottery shreds coming from mikylla vessels. Various bronze plates have been discovered, along with four bronze bracelets with a snake – shaped edge (M7545a-b & M7546a-b), an olive leaf (M7547) and an hemispherical vessel with fine engraving decoration on its surface (M7548).

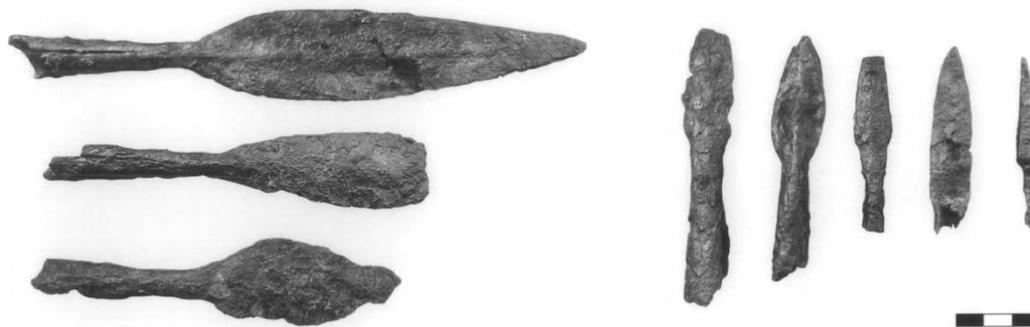


Figure 9 Spearheads and a savrotir from section 2 (T2)

In addition to the above, a significant number of iron offensive weapons have been revealed (15 of them were intact) during the excavations.³³ Most of them were identified as spearheads and daggers from section 2 (T2)³⁴.

³³ Maybe as votive offerings to the temple's deity

³⁴ Arapogianni 2010: 257



Figure 10 The pottery shred with the characteristic votive word

Also, a lot of accessories of iron utensils and nails have been brought to light. However, it seems that the most significant object was an ancient votive vessel's shred of 5th century BC with a graffito engraved with the word: ANEΘEKE(N) on the inner side, near the rim.

So, it seems that the excavation process and the later studies in “Petroula” site have established some initial assumptions that an archaic temple devoted to an unknown deity³⁵ during the 6th – 5th century BC, but due to newer information from the excavator of the ancient sanctuary, it is also possible the temple based on its location and its offerings, mainly iron weapons³⁶, was dedicated to the god Apollo, protector of warriors³⁷. Therefore, the need to continue the research project seems to be the only way to shed more light about the identity of the worshipped deity and investigate how the temple is connecting with the area³⁸.

³⁵ On this subject, a work by Koursoumis states that probably - and based on primary sources - the temple belongs to the goddess Artemis

³⁶ A common practice to the Greeks during antiquity after victories over enemies

³⁷ Arapogianni 2017: 8

³⁸ v. sup. 2010: 258

III. Weapons and their Use

The Dawn of the Greek Hoplite

The Dark Ages are better perceived after the invention of the alphabet, which gave a continuous sense of improvement regarding the communication between people and the development of the Greek culture. There was also the revival of art, including pottery - very important to study various aspects of antiquity - as long as well the rise of hoplite and the development of offensive and defensive war equipment, which affected by a new sense of war tactics on the battlefield and depicted in the Greek art.

From an archaeological point of view, this kind of revolution is very prominent also in the gradually preference of veterans to devote their war equipment – and other daily objects – in burial sites, but also as votive offerings to sanctuaries for divine protection and gratitude (Delphi, Olympia, etc.). These arms and armors dedicated to the gods are more just than war tools; they constitute a part of a sequence of the western way of war find its origins in Greece.³⁹ Thus, during the late 8th century BC, in Greece where the fight for the foot soldier on the battlefield was a simple skirmish style with continuous advances and retreatings eventually turned to a decisive hand to hand combat in tighter formations. From the other hand, horsemen they used to dismounting in order to throw the spear but gradually left the horses and joined the infantry. Therefore, the foot soldier considered that it is better to be protected and equipped with improved body armor, a round shield accompanied with a helmet and a thrusting spear⁴⁰.

Spear

In Greece, Geometric period spearheads were a common burial artifact among other finds. It seems that iron spearheads replaced the bronze ones even before the Dark Ages, approximately in 11th century BC. The only exception here coming from Olympia when after 8th century BC (or later) researchers found bronze spearheads. Iron even though it was hard as material to be processed with and quite expensive, was more effective than bronze and faster to its productive process. Bronze used to be better known than iron – maybe because the latter was aesthetically not so pleasant – mainly in Sicily, South Italy and Crete. Regarding mainland Greece, it seems that bronze reintroduced during 6th century BC, this might be explained by the rapid expansion of hoplite institution.

³⁹ Snodgrass 1967: 48.

⁴⁰ Hanson 1989: 45.

When it comes to combat, initially, before the enemy contact – and the sword comes out from its holster – the spears were used also as javelins in 9th and 8th century and their heads which have been found in graves, most of the times were in pairs (since warriors were carrying more than one) ranging from 30 to 50 cm long. Eventually, during the 7th century the spear becomes the main weapon replacing the sword except the case when the spear was broken or the battle was hand to hand⁴¹. On this matter, another example comes from the “MacMillan” aryballos (640 BC) depicting a group of early hoplites carrying again a pair of spears using probably the first as javelin and the second one as a thrusting weapon. Thus, the hoplite institution started to use the throwing spear less and less and around 520 BC abandoned the second spear. The main reason for this was the need of movement and free space in the hoplite, when a second throwing spear gradually started to be irreconcilable with the phalanx formation and thus hoplites were depending more and more on thrusting hits.

Sword

The Naue II type sword did its first appearance during the 13th century in Aegean and it was the main weapon until the late Archaic period. Its length was varied from 50cm – 70cm with half – moon pommels and proved to be as one of the most characteristic and effective swords during the Geometric period. Usually, early hoplites were using the sword after the throwing spears for a hand to hand combat. This type of fight though will be abandoned until late Archaic period.⁴² Therefore, the sword until the last decades of the Iron Age – depicted in various contemporary ancient vases – was long and used as a secondary weapon, in case the spear was broken, lost or the situation was demanding closer contact. The only difference in contrast with the classical period was the shorter blade, since a large sword would be unnecessary in such fight conditions. The necessity of a sword is shown also in the ancient literature. Characteristically, in *Tyrtaios*’ work we are able to notice this.

Let him fight toe to toe and shield against shield hard driven, crest against crest and helmet on helmet, chest against chest; let him close hard and fight it out with his opposite foeman, holding tight to the hilt of his sword, or to his long spear.

(Tyrtaios 11.31–34)

⁴¹ Everson 2013: 99

⁴² v. sup: 101



Figure 11 The Dipylon Krater. The "ekphora" scene showing the body's transportation followed by armed figures. The warriors here are carrying two spears in order to be used also as throwing weapons. Around 750 BC. National Archaeological Museum.

For these reasons, with the dawn of the phalanx institution, the sword usage gradually decreased mostly after 700 BC when became shorter and sharper at its pointy end with few artistic examples but some single-edged, straight slashing sword can be visited today in Olympia, dated back to the 8th century when this type had appeared and used later⁴³. It is related with known sword types which can be found in Macedonia, Thrace and Thessaly⁴⁴. From this type evolved also the *machaira* or *kopis* swords, introduced in the ancient armies. They have curved shape with a very sharp inner side, perfectly balanced for the cavalry but they have been used also by the infantry. A variety of opinions stood up on this matter, mostly about the origin of *machaira*. Connolly argues that is coming from Etruria⁴⁵, Sekunda from Near East⁴⁶ and Snodgrass indicate Thrace. Regardless, it seems that neither the straight sword nor *machaira* was the primary weapon for the infantry, unless the spear could not be a choice anymore. But both sword types had a crucial role in the ancient battlefield.

⁴³ Sekunda 2002: 16, 29.

⁴⁴ Snodgrass 1965a: 100.

⁴⁵ Connolly 1998: 63.

⁴⁶ Sekunda 2000: 16.



Figure 12 The Macmillan aryballos. A fight scene between hoplites. 640 BC. British Museum

Bow

The capabilities of offensive weapons in the ancient Greek infantry were beyond spears and swords; such as bows and javelins. Archery required a special skill that not everyone possessed and needed a range of training time. From a young age, many Greeks had the opportunity to learn the art of archery, not only for military training but also for hunting. But before proceed to the description of the weapon and its use it would be useful to mention that the archers along with javelinmen and slingers were forming the institution of *psiloi*; it was a skirmisher corps which usually coming from social strata that did not have the necessary financial resources for their defensive protection. Thus, their numbers were channeling either to the light infantry as *psiloi* or as ship rowers (*eretai*).

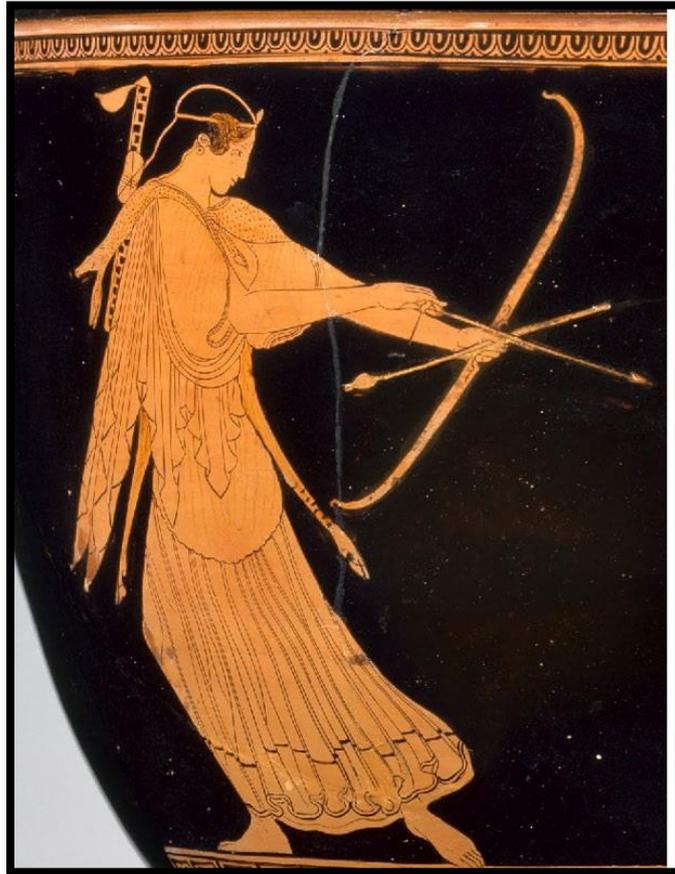


Figure 13 Artemis drawing her bow. Goddess wears a deer - skin shawl, a head-band and a quiver. Krater depicting the death of Actaeon. ca. 470 BC.

Compared to the weapons we have mentioned so far, the bow was not the first choice of the Greeks but of the lower classes as mentioned above. Nevertheless, its use seems to have been quite widespread inside and outside the Greek world, with its presence being more evident among the Scythians who significantly influenced the Greeks in its use and construction. The importance of this weapon is seen not only through the material remains but also from art⁴⁷. Representations of vases depicting Artemis and Hercules with a bow indicate its primary role in some cases, especially among the Cretans who were quite famous for their skill on this and the fame they had as mercenaries.

⁴⁷ Snodgrass 1967: 83.

Javelin

Like the case of archers, javelin throwers usually were coming from lower social strata. In general, the javelin was considering to be a very critical weapon, especially at the beginning of the battle; its throw was disorganizing the opponent lines before the hand to hand combat. The javelinmen were the most famous skirmishers among the light infantry.

Since they did not have the financial means to procure heavy individual military equipment they were equipped and characterized by a small shield called *pelti* (πέλιτη), hence their name, *peltastai* (πελτασταί). *Pelti* was widely used from the region of Scythia to Thrace where it was more widespread. During the tyranny of Peisistratos this shield type was introduced also in Attica. Its construction usually was coming from organic materials such as wicker wood and animal skin, without a metal rim and navel⁴⁸.

Sling

Like in the rest military classes, in the skirmisher corps, the slingers also were coming from lower social strata. The use of slingshot did not require special skills, while its construction and materials were easily accessible. Slingshot missiles were usually simple stones / pebbles or even molded lead projectiles⁴⁹ engraved with various expressions of insults, addressed towards the enemy. Slingers were not in need of a long period of training or skills, so it was a unit which could be recruited quickly, easily and was often sent first against the enemy with purpose to disorganize his defense.

⁴⁸ Snodgrass 1967: 79

⁴⁹ v. sup: 84

IV. Characterization and Analysis of the Metallic Samples

Ancient Bloomery

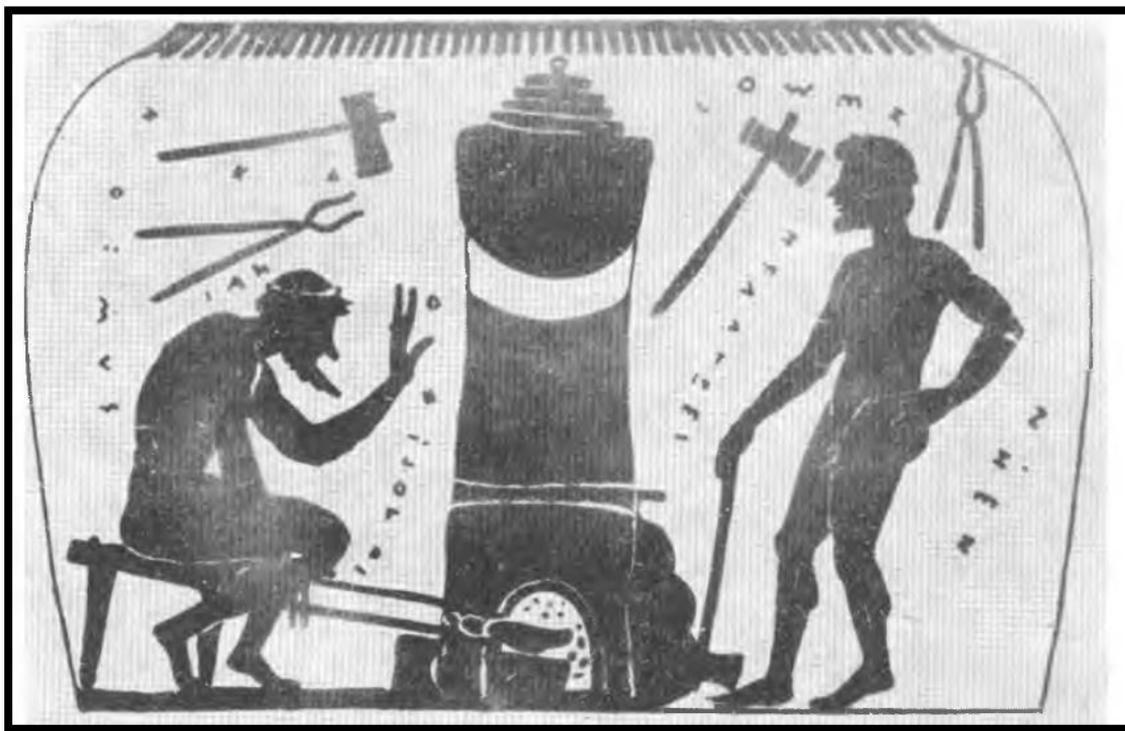


Figure 14 Representation of Smelting Furnace in Ancient Workshop

In antiquity, iron was producing in furnaces through the reduction process, where the temperatures were not rising over 1200°C , which means the iron was not fluid - since its liquid form starting from 1536°C - but was in a spongy form. In this process, the furnace was filling with iron ores, fluxes⁵⁰ and charcoal. Also, the ancient metallurgists in order to get the metal they had to separate it first from the gangue⁵¹ and then proceed with the “bloom iron” (or sponge iron)⁵² through hammering and annealing, until the product was enough homogenous and eventually take its shape. The reduction was taking place in smelting furnaces made by shale with the inner layer covered by clay material and a nozzle in the lower part. The process was starting with preheating the furnace, stuffing it with charcoal and woods up to the top and blowing through the blower’s nozzle, the temperature was rising until the iron minerals were mixed along with the charcoal. Thus, after 6 – 10 hours putting the raw material in the furnace and

⁵⁰ It is a substance that is used to remove soil contaminants. Limestone was commonly used for iron production

⁵¹ The unusable and uninteresting mineral in an ore deposit

⁵² Direct Reduced Iron (DRI) or sponge iron. The process from the reduction of the iron ore to metallic iron.

when the iron minerals have been transformed into bloom iron, they were extracting the metal through the hammering and annealing process which has been mentioned above⁵³.

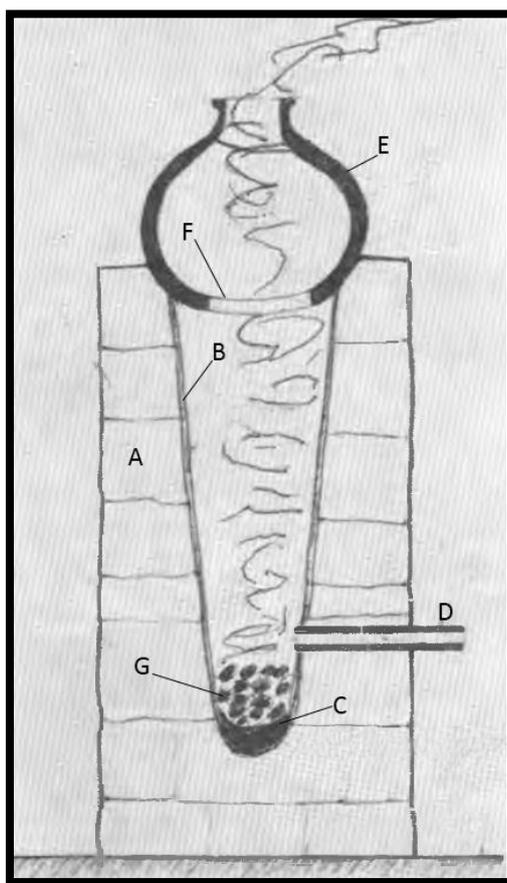


Figure 15 A Work in Progress Smelting Furnace

On the figure above: A. Shale walls B. Clay coating C. The Furnace's bottom, where the iron bloom is formed D. Nozzle blower E. Ceramic vase F. Perforated bottom G. Iron Bloom.

The Steel Production

The produced iron bloom by nature is a soft and flexible product and its value was upgraded when this – accidentally - converted to steel by carbonation. Steel has the characteristic of hardness, strength and elasticity when it contains from 0.2% to about 0.5% C, while it is superior to iron. Although, because the carbonation it cannot be achieved in great thickness but with diffusion, the steel production was being done in iron layers, putting these in ceramic vessels stuffed with charcoal powder. This process was needed another furnace (the same which have being used also for ceramics) in a temperature around 800 – 900 °C.

⁵³ Κ. Κονοφάγος & Γ. Παπαδημητρίου 1981: 158

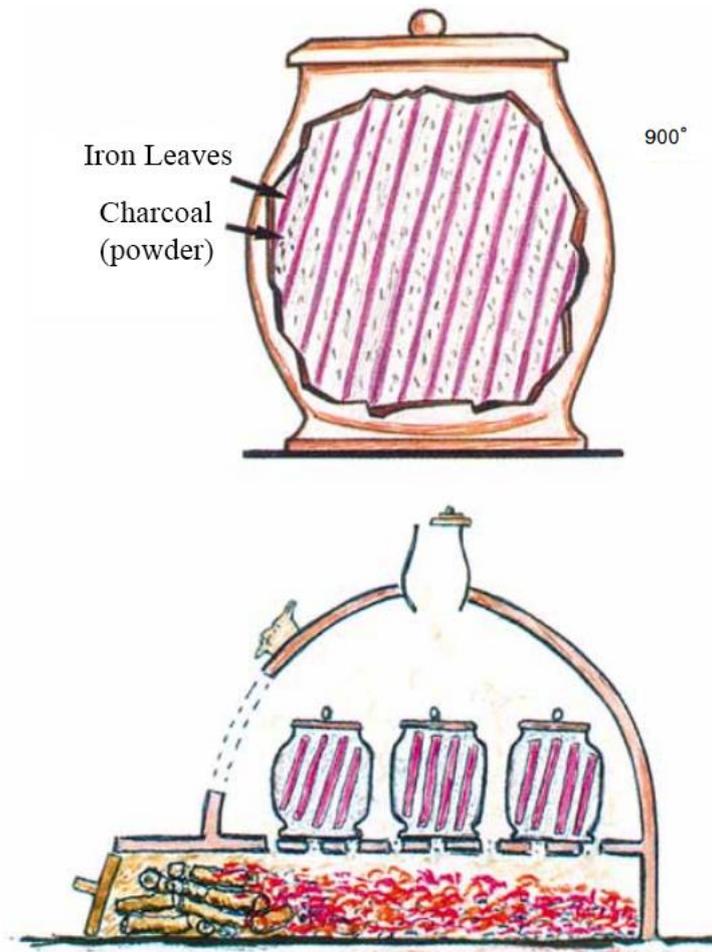


Figure 16 Iron Leaves in Ceramic Vessels

The next stage was the welding; this could be carried out by welding multiple layers of steel or iron and steel alternately by forging and in temperatures around 1200 °C – 1300 °C. Subsequently and after autogenous hot welding (mainly on blades, swords and other weapons), the hot iron was being putted instantly in water by the ancient artisan in order to increase the metal's hardness⁵⁴. On this point, although the current examined metallic ensemble is made by steel, it was not possible to be investigated for its amount in carbon due to insufficient analytical methods.

Experimental Procedure

The aim on this point is to present the archaeometric results of ancient offensive armament from the Archaic Temple in Ano Melpeia of Messenia. The study which has been conducted in the Laboratory of Archaeometry of the University of Peloponnese was intended to analyze the chemical properties of iron weapons. These are depending

⁵⁴ Tsaimu 2015: 54

on a number of factors, like the reaction in different temperatures, the iron ore composition, the amount of carbon in the metal and the forging process. Therefore, the aforementioned variables along with the initial alloy elements have a front line importance regarding the material's properties. On this study, the most common elements affecting the microstructure were Mg, Al, Si, P, S, Cl, Ar, K, Ca, Fe and Cu. Some of these elements which have been found in the examined material possibly are coming from the initial iron ores and subsequently into the alloy.

Also, to facilitate the discussion, it must be underlined that due to the lack of specific analytical instruments the detection of carbon was not possible. Regarding the chemical distribution in the iron specimens, it should be noted that the homogenization of trace elements was low, probably because iron have not been melted properly and distributed smoothly or have been mixed by various soil depositions on specific sample areas.

In connection with this, all ancient objects have been photographed in advance and for the macroscopic observation it has been employed a "Leica Zoom 2000" Optical Microscope. For further research an "I-Scope USB 2.0" LED Microscope accompanied by a "I-Scope Viewer Ver. 2.0." software has been used. The investigation closes with a "SEM type JEOL – JSM 6510 LV / Coupled with Oxford Instruments and Energy Dispersive Spectro Meteor (EDS)". No sample preparation was carried out prior to the analysis.

For the studied material, they have been selected ten weapon objects excavated during the summer of 2010 from Ano Melpeia, identifying most of them as spearheads or spear parts with the rest belonging probably to daggers or sword segments, and in a time period ranging from 6th to 4th century BC based on the archaeological context. The conservation status of the objects was deemed to be very low due to the long term oxidation. They have been obtained from each ancient object at least two or three samples almost naturally detached from the ancient material, in order to conduct an initial macroscopic observation and subsequently analyze their elemental composition. All objects and samples were put into conservation by the Ephorate of Antiquities of Messenia under the following methods and solutions:

- Cleaning: Dental drill, Fiberglass eraser
- Solutions: Acetone (C_3H_6O), Ethanol (C_2H_5OH)

- Welding: Araldite (C₃H₆O)
- Protection: Microcrystalline wax, Paraloid B72 8%

The study will be focused on four samples with the following given codenames linked to their initial objects: i) M7583 – Sample A, ii) M7835 – Sample F, iii) M7581 – Sample G, and iv) M7834 – Sample J.

Macroscopic and Microscopic Observations

In the following images are presented the ancient iron weapons from Ano Melpaia, in northern Messenia. The ancient artifacts will be short described and their specimens will be discussed based on their macroscopically observations. The photos were taken in the conservation laboratory of the Archaeological Museum of Messenia (Kalamata). It is a remarkable archeological ensemble which highlights the significant culture of ancient Andania and Messenia.

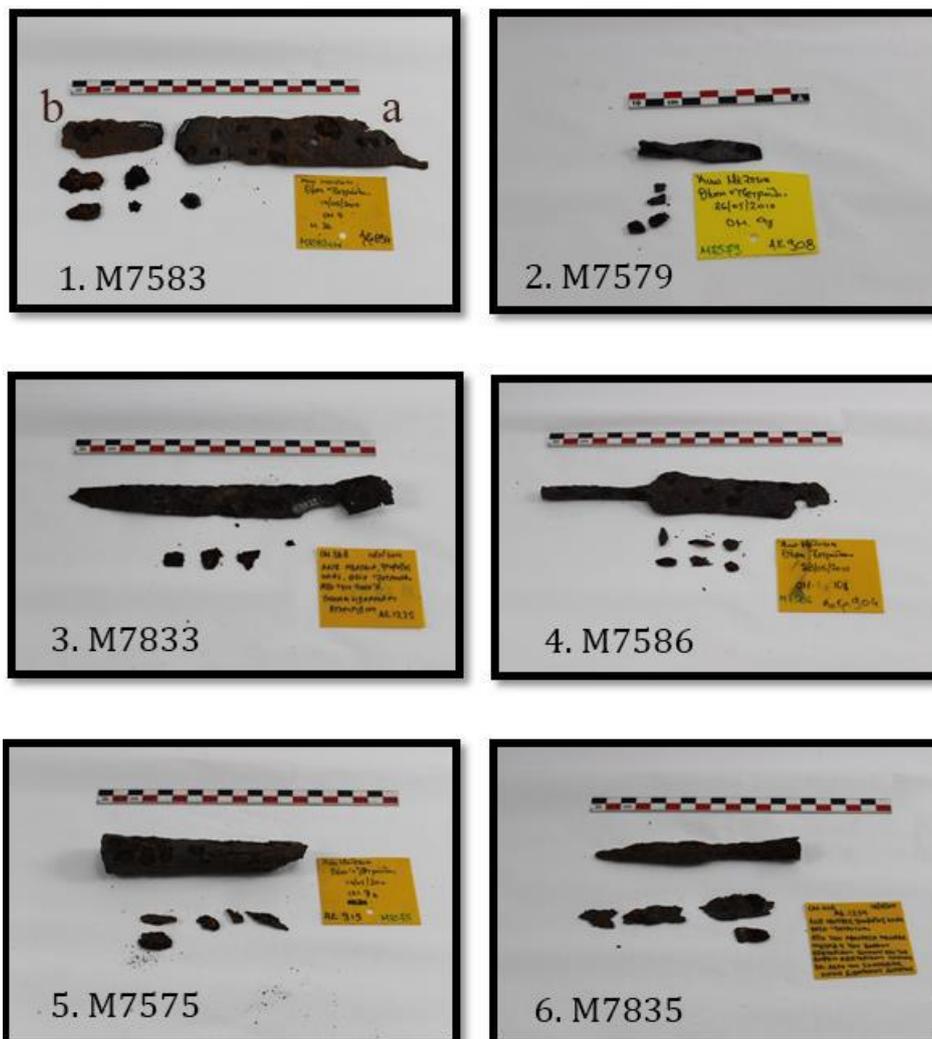


Figure 17 The ancient ensemble of offensive armament from Ano Melpaia

- 1) **M7583:** a) Part of iron object (probably sword handle). It is flattened and corroded with a missing part. In the center the handle has two holes with the second one covered by corrosion material. b) Iron object, part of the previous one (a). Both of its ends are missing. A lot of pieces are missing cause of the corrosion. Dimensions: Length: 0.169 / Distance between the holes: 0.601 / Hole Diameter: 0.004.
- 2) **M7579:** Iron spearhead (or arrowhead). A part of its edge is missing. The spear's (or arrow's) blade is narrow, leaf-shaped and flat. From the lower part are missing many pieces. Dimensions: Length: 0.169 / Distance between the holes: 0.601 / Hole Diameter: 0.004.
- 3) **M7833:** The iron knife here have corroded surface with its initial shape almost preserved. The handle is missing, probably made by a different material (a type of wood). On the point where the handle starts a small nail exists assuming was the join between the blade and the handle. Next to it, there is a hole for a second nail. Dimensions: Length: 0.205 / Width: 0.002 / Blade width: 0.025 – 0.015 / Handle width: 0.023.
- 4) **M7586:** Iron attachment or dagger. The conservation state looks well based on its shape, although the pointy part it is missing. It consists by a compact stem (where the handle – made by organic material – was placed possibly) which ends up to a flattened body (or blade) with a hole close to the edge. Dimensions: Length: 0.205 / Width: 0.008 / Blade width: 0.033 / Thickness: 0.006.
- 5) **M7575:** Part of iron *avlos* (the lower segment of a spearhead, where the wooden part is attached) with a missing piece. During the conservation some parts welded together. Throughout its length small cracks are visible. Dimensions: Length: 0.130 / Width: 0.027 / Reed diameter: 0.026.
- 6) **M7835:** A well preserved flame-shaped iron spearhead with a small piece only missing from the *avlos* and a worn edge on its pointy spot. : Saved length: 0.13 / Reed diameter: 0.016 / Width: 0.002.

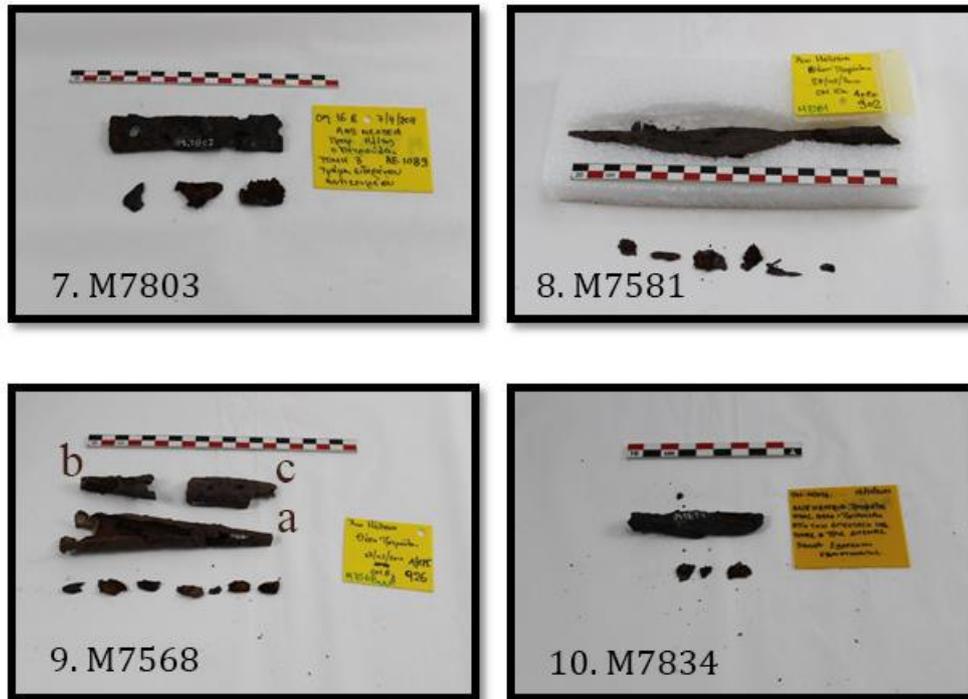


Figure 18 The rest of the ancient ensemble from Ano Melpia

7) **M7803:** Part of iron flattened object with corroded surface. One edge has a hole while on the other is only the half. Dimensions: Length: 0.094 / Width: 0.021 / Thickness: 0.002 – 0.003/ Hole diameter: 0.006.

8) **M7581:** A whole iron leaf-shaped spearhead with its *avlos*. The corroded blade has a long crack in the middle. Dimensions: Length: 0.215 / Length of the reed: 0.072 / Length of the blade: 0.143 / Blade diameter: 0.015.

9) **M7568:** Iron parts of ancient *sauroters*. Object (a) is a quite well preserved *sauroter* with welded pieces in contrast with *sauroters* (b) and (c) which only small fragments found. They have cracks at their bodies. Dimensions: (a) Length: 0,114 / Width: 0.031 / Thickness: 0.02 / (b) Length: 0.056 / Width: 0,020 / Thickness: 0.002 (c) Length: 0.66 / Width: 0.030 / Thickness: 0.04.

10) **M7834:** Part of iron corroded spear. Only the *avlos* is partially preserved. Dimensions: Maximum preserved length: 0.025 – 0.015 / Reed width: 0.023 / Thickness: 0.002.

Proceeding to the microscopic analysis of the samples, below in the left column is the inner side whilst in the right column is the conserved surface. The samples were observed at x10 and x 50 magnification in a LED USB Microscope. Here are shown at x10.

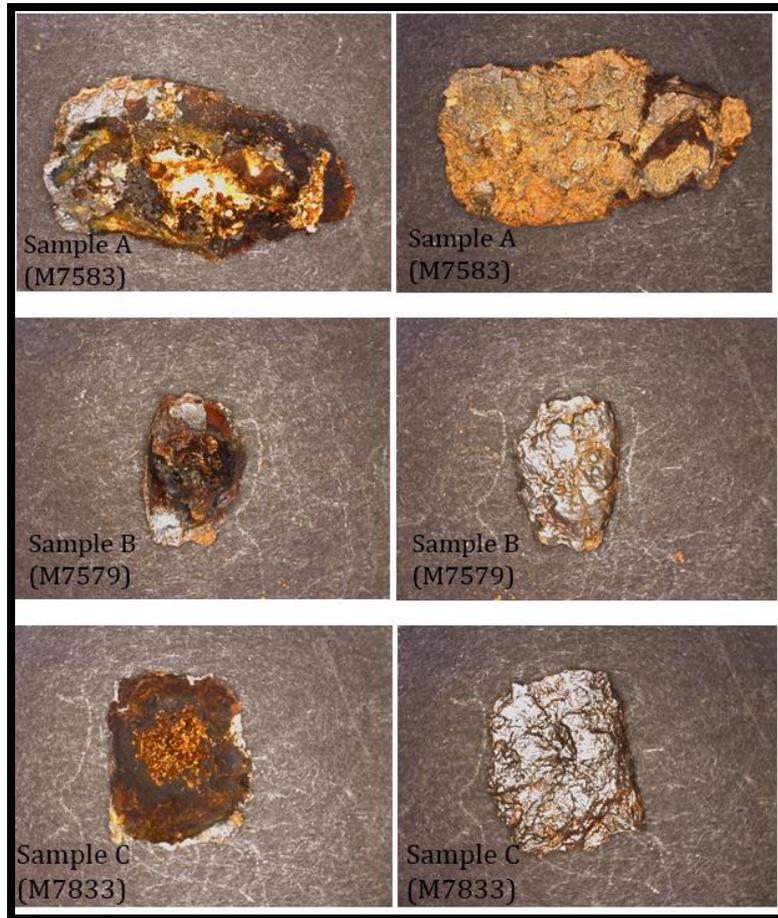


Figure 19 Samples A – C. LED Microscope Sample Images

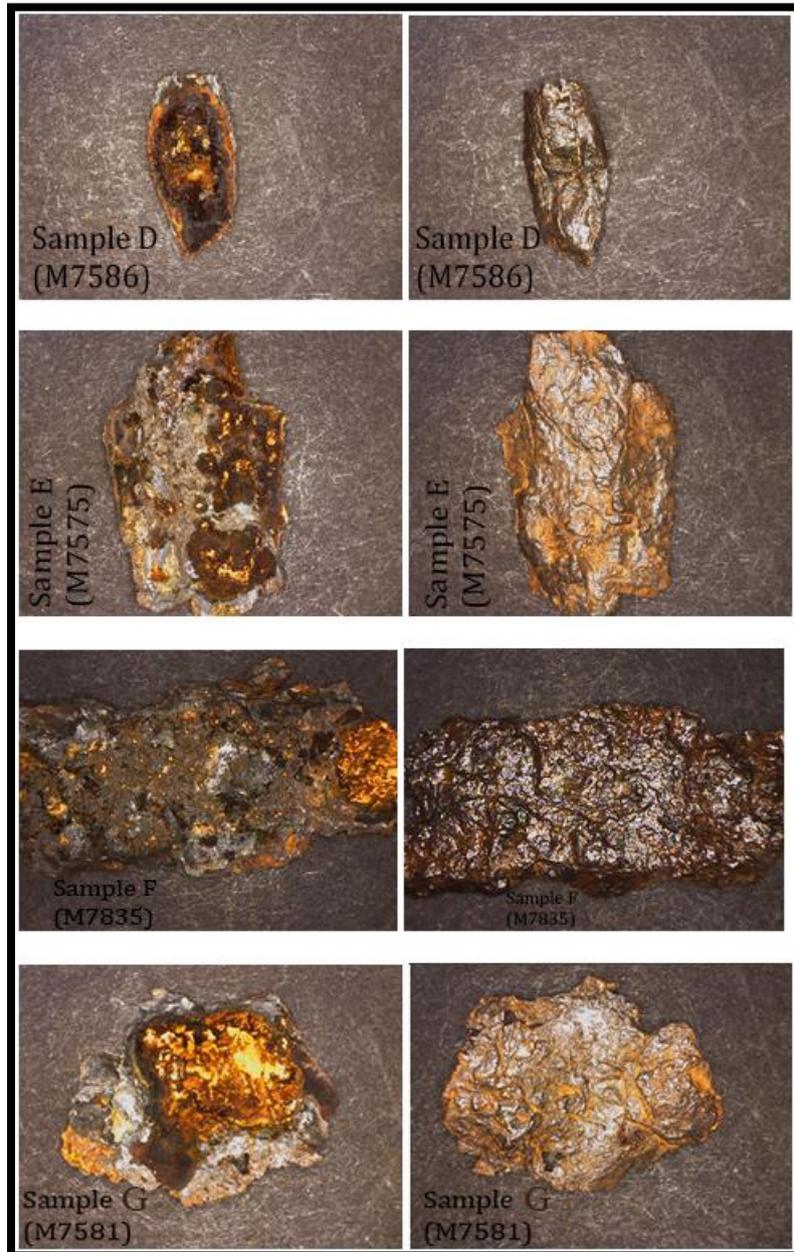


Figure 20 Samples D - G. LED Microscope Sample Images

O.M. Notes / Inner side: Most of the samples have irregular shape with rough surface and detachment trends on some specimens. Also, most sample areas have corrosion on their center forming orange-colored crystals (probably Akaganeite / Fe_3O_4 (OH,Cl)) which have shown on various spots while the rest of their surface is covered by dark grey or black surface. Furthermore, on some edges the metallic nature is exposed. External Side: Most of the conserved surfaces have unshaped edges with a slippery, rough and dark grey surface. All samples are corroded with crack lines and on some of them have been noticed steep and un-shaped cavities.

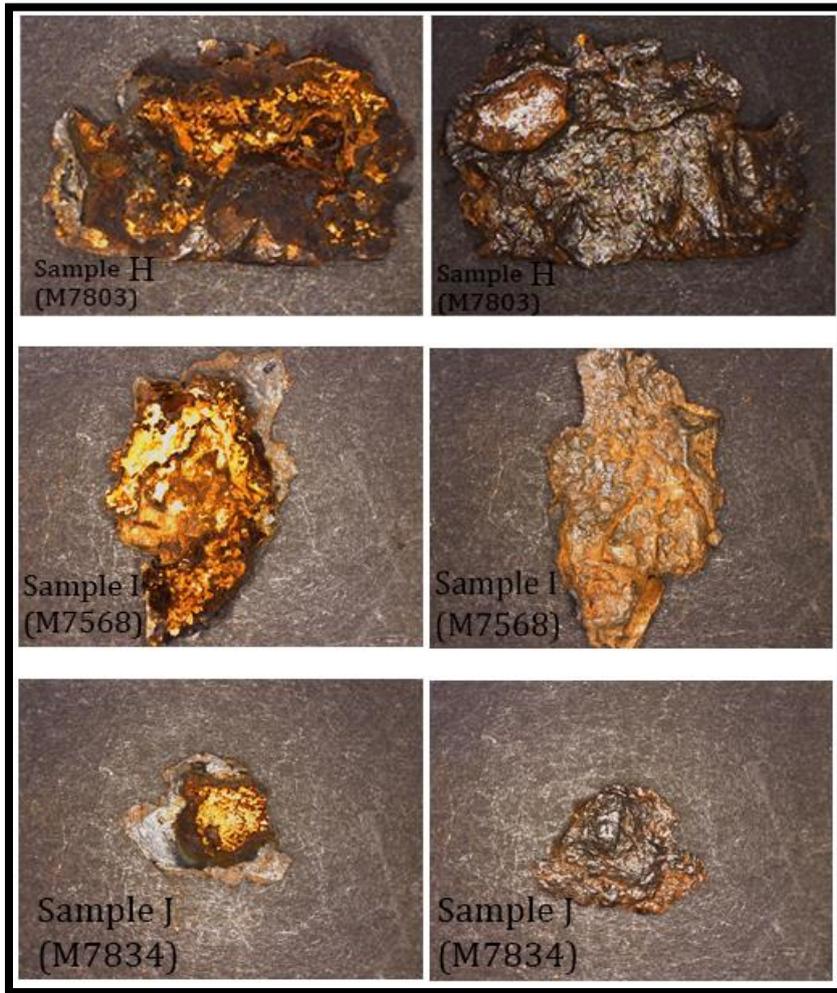


Figure 21 Samples H - J. LED Microscope Sample Images

SEM/EDS Analysis

As mentioned before, four samples have been selected (i. M7583 – Sample A, ii. M7835 – Sample F, iii. M7581 – Sample G, and iv. M7834 – Sample J) for the chemical analysis through Energy Dispersive Spectroscopy (EDS), fulfilling the necessary preconditions as characteristic iron specimens from the ancient armament ensemble.

	Sample A (M7583)	Sample F (M7835)	Sample G (M7581)	Sample J (M7834)
Al	0.00	0.73	0.73	0.00
Si	0.00	0.40	4.26	1.38
Cl	2.70	1.59	4.14	3.58
Ca	0.00	11.35	0.86	0.29
Fe	97.30	86.66	90.02	94.75

Table 3 Elemental Composition of the Investigated Iron Specimens Expressed in wt%.

For the aforementioned samples, the SEM/EDS analysis has shown an iron average amount of $92.18 \pm 4.76\%$. Other elements with high concentrations are the Si and Cl. Silicon here is a product probably coming from the iron ore like P, S, Cu, As, N and Mn. In other case, it could indicate that the iron bloom was in quite low temperatures since needs 1250^0 C more or less to eliminate the remnant slags from the desirable iron product. This is not possible to be achieved during the process of ancient bloomery or smithing, forming slag inclusions. From the other hand, the soil depositions rich in Si could be also a possibility.

Also, what has been observed regarding the corrosion mechanism it seems to be confirmed, that it has a uniform pattern throughout the archeological objects. So, in all samples, Cl (chlorine) is the most prominent element after Fe corresponding to a percentage of $3.00 \pm 1.11\%$. The high presence of Cl, is a result of rapid corrosion in the iron, maybe due to the number of chlorides in the alloy and the soil when this had covered the ancient artifacts. This reinforced by the shown orange crystals of akaganeite ($\text{Fe}_3\text{O}(\text{OH},\text{Cl})$) on the samples, indicating an aggressive type of corrosion. This can be seen also in the images below.

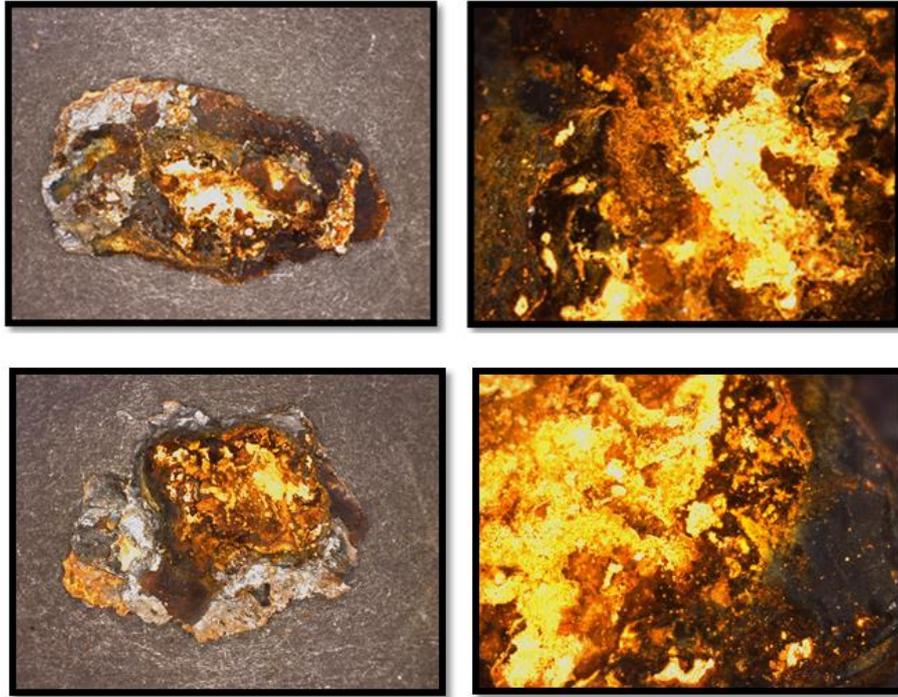


Figure 22 Samples A (M7583) and G. LED images. The inner side of an iron sample. What is most distinct here is the high corrosion degree (CI). Some areas have shown their metallic nature.

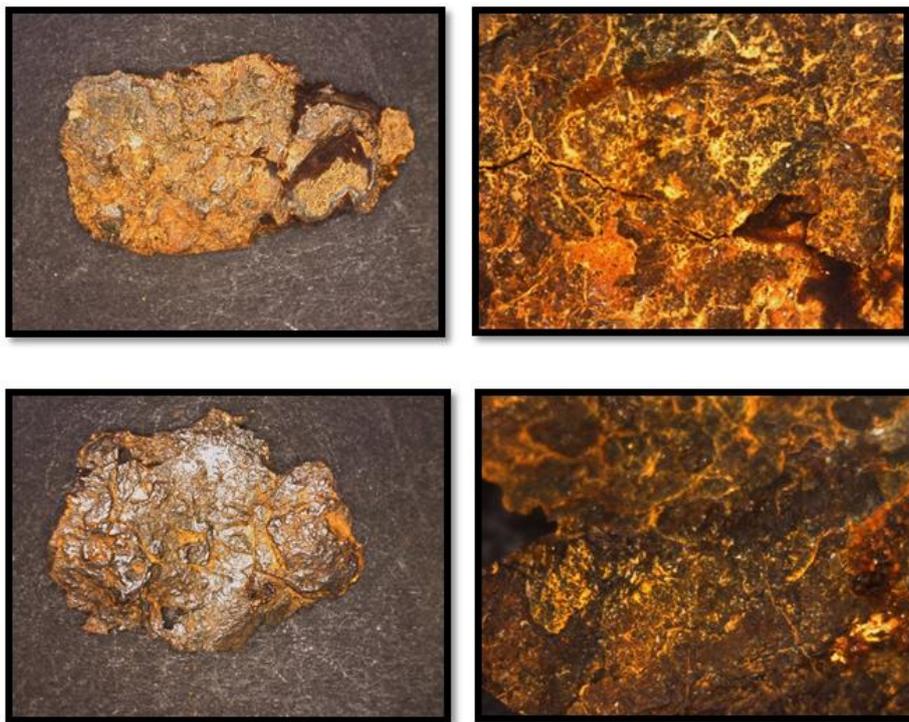


Figure 23 Samples A (M7583) and G. LED images. Conserved surfaces. These pictures reveal the conservation efforts, although as time went on and without suitable and stable conditions the iron weapons started to show corrosion signs once more.

Morphology and Corrosion Patterns

When it comes to the SEM/EDS analysis, has been proved as the most crucial tool to conduct the surface and structure investigation of the aforementioned samples. On the first two pictures below, the voids and cracks on the uppermost part of the specimens are very prominent. Each iron sample through SEM was looking to have the same tendency, being peeled in layers along with a rough and almost broken texture. But the most noticeable feature was the high oxidation degree. So, it is inferred based on the SEM mapping that the high corrosion degree and the rough surface prevented the proper examination of the morphology of rust products, since it was difficult to stabilize the magnification without display blurred images. Regarding the chemical composition, as have been mentioned before, the large number of concentration beside Fe is the Cl, indicating the presence of chlorides which is the main reason of high corrosion degree causing cracks, voids along with crystal and flake-like formations on the samples.

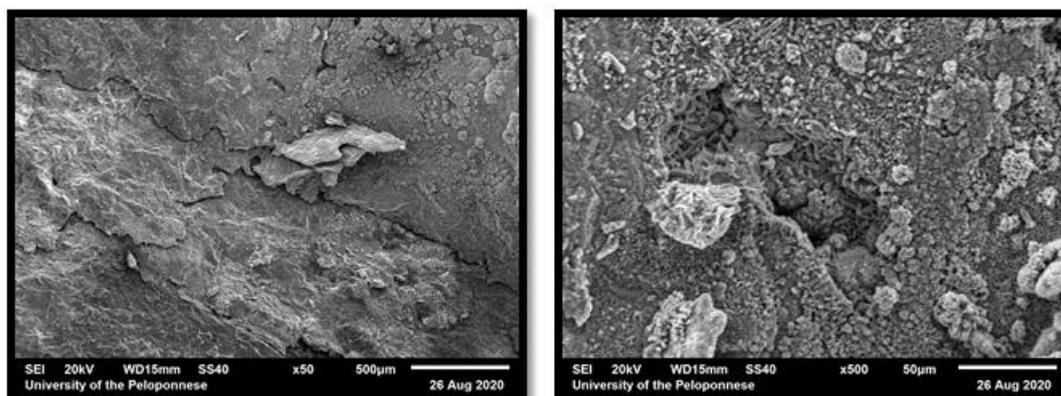


Figure 24 (a & b) Iron sample at x50 on the left and x500 magnification on the right. SEM micrograph of akaganeite morphology on rusted weathering iron. On the second image, akaganeite crystals can be seen in the cavity.

Figures 24 & 25 are reflecting these set of symptoms in ferrous iron (FeCl_2) showing also the typical morphology of corrosion products after many years of exposition in quite unstable conditions. The cigar shaped forms in the Fig. 24b, from sample G, have identified as akaganeite ($\beta\text{-FeOOH}$) crystals whilst in Fig. 25b (sample G) the cotton-like structure are most possibly goethite ($\alpha\text{-FeOOH}$) formations.

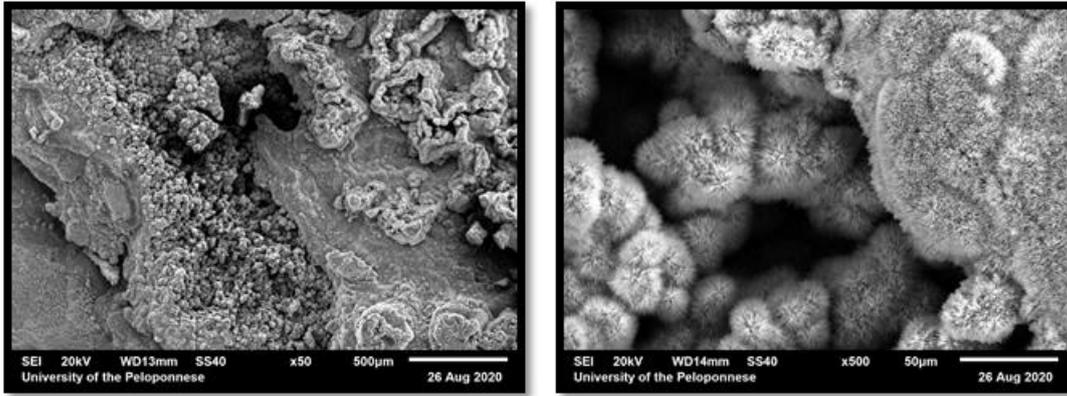


Figure 25 (a & b) Iron sample at x50 on the left and x500 on the right. SEM micrograph of goethite morphology on rusted weathering iron.

Therefore, this case verifying that rusting is a heterogeneous process and the results above are coming with a sequent of phases. This means that the morphological structures which have been mentioned are related with a reaction chain going through different phases, related with the time exposure. Thus, in the first stage of rusting appears lepidocrocite (γ -FeOOH) which under the presence of ion chlorides forms flaked rust and therefore crystals of goethite and akaganeite.

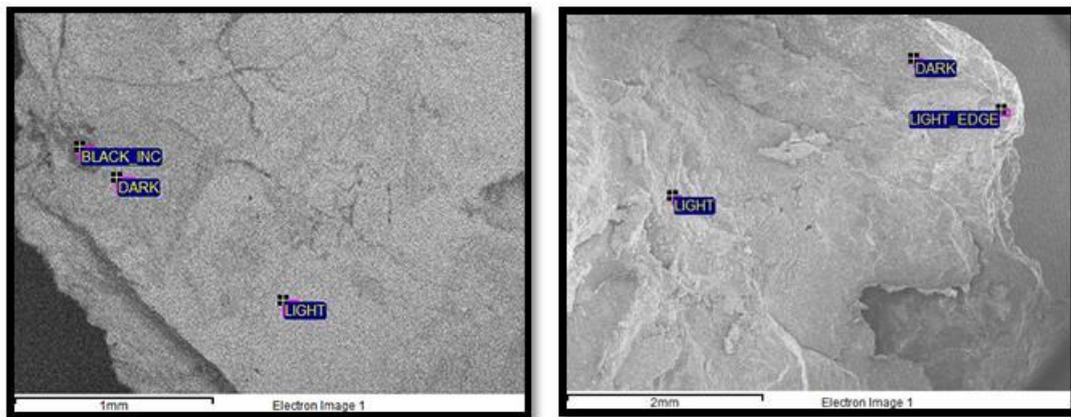


Figure 26 Iron samples on Backscatter mode. On the left (Sample F) the dark distinct area is rich in Ca the second one (Sample G) has high amounts of Si on its dark area.

In addition, analyzing in backscatter mode the samples (F & G here), it looks that some of them based on their dark or light hues had more than one elements raising the interest. For instance, in sample F, the light area looks to be enriched with Ca (LIGHT) while in sample G, a black spot (DARK) has high amounts of Si.

Discussion

The Macroscopic observation as a standard process in the study of ancient objects provided the necessary understanding of the material and constituted the guide for the subsequent microscopic analysis. The self-evident signs of corrosion, the fragile nature, and the need to comprehend and examine the iron weapons with an overhaul way, led the investigation in more analytical methods.

The SEM / EDS analysis turned out to be very helpful in order to understand the material's nature along with the alloy elements, any soil depositions, slag inclusions, verify the corrosion type and analyzing samples' chemical composition. Also, an additional factor to understand better the study would be the analysis of sediment samples in order to correlate the elements in the ferrous samples and those of the sediment where they have been found.

Furthermore, the lack of specific methods to detect the amount of carbon in steel confined the investigation. Another factor it was the preventive conservation, which was not efficient enough regarding this ancient ensemble. So, the acquired iron objects were high oxidized and therefore starting the study they had to be treated very gently.

Nonetheless, thanks to SEM the study was possible to proceed regarding the definition of iron (Fe) concentration in the specimens and the conservation status. Overall, it would be interesting and worth mentioning to say that the conduction of further research concerning the presence of offensive armament in the area, assists not only the cause or the function of these weapons but also the projection of the local history, through which more stories about the Messenian past could be drawn.

Bibliography

- Anthony M. Snodgrass (1965a). *Early Greek Armour and Weapons*. Edinburgh : University Press.
- Anthony M. Snodgrass (1967). *Arms and Armours of the Greeks*. New York: Cornell University Press.
- Athanasios V. Vertsetis (2007). *Το Διαβολίτσι και τα γεγονότα της γύρω περιοχής ανά τους αιώνες*. Αθήνα: Vasilis Konstantakopoulos.
- Athanasios V. Vertsetis *Αρχαία Ανδανία*. Retrieved September 04, 2020, from Ev Διαβολιτσίω: www.diavolitsi.gr
- C. Conophagos and G. Papadimitriou (1981). Η Τεχνική της Παραγωγής Σιδήρου και Χάλυβος από τους Αρχαίους Έλληνες στην Αττική κατά την Κλασική Περίοδο. *Πρακτικά της Ακαδημίας Αθηνών*, 56.
- D. Katsikis *Ancient Greek Armors*. Retrieved September 28, 2020, from Hellenic Armors – Ancient Greek and Medieval Byzantine Armors: www.hellenicarmors.gr
- Ernst Curtius (2011). *The History of Greece*. Cambridge: Cambridge, University Press.
- George Rapp, Jr., S. E. Aschenbrenner (1978). *Excavations at Nichoria in Southwest Greece* (Vols. I Site, Environs, and Techniques). Ontario: The University of Minnesota Press.
- Georgia Hatzi-Spiliopoulou (2000). *Αρχαιολογικό Δελτίο*. Athens: Fund of Archaeological Proceeds.
- İ. M. Kusoglu (2015). *Microstructural formations during the production of Early Byzantine iron nails from Hadrianoupolis in Paphlagonia (north-central Turkey)*. Izmir.
- Konstantina Tsaimu (2015). *Λόγος και Εικόνα – Η Αρχαία Μεταλλευτική και Μεταλλουργία*. Αθήνα: Stamouli Press.
- Marcus Porcius Cato. *De Agri Cultura*.
- Marcus Terentius Varro. *De Re Rustica*.
- Mattias Natan Valmin (1930). *Études topographiques sur la Messenie ancienne*. Lund: Chez C.W. Lindström.

- Miguel A. Ferrer Eres, Francisco M. Valle-Algarra, Jose V. Gimeno Adelantado, Juan Peris-Vicente, Mari´a D. Soriano Pinol, Rufino Mateo-Castro (2008). *Archaeometric study on polymetallic remains from the archaeological dig in Lixus (Larache, Morocco) by scanning electron microscopy and metallographic techniques*. Springer.
- Nicholas Sekunda (2000). *Greek Hoplite 480 - 323 BC*. Oxford: Osprey Publishing.
- Nicholas Sekunda (2002). *Marathon 490 BC - The first Persian invasion of Greece*. East Sussex: Osprey Publishing.
- Nino Luraghi (2008). *THE ANCIENT MESSENIANS Constructions of Ethnicity and Memory*. New York: Cambridge University Press.
- P. Dhaiveegan, N. Elangovan, T. Nishimura, N. Rajendran (2016). *Weathering Steel in Industrial-Marine-Urban Environment: Field Study*. National Institute for Materials Science, Tsukuba, Japan.
- Pausanias. *Μεσσηνιακά*.
- Peter Conolly (1998). *Greece and Rome at War*. Mechanicsburg: Greenhill Books.
- Stephanus of Byzantium (1849). *Ethnicorum*. Berolini: Impensis G. Reimeri.
- Strabo. *Geographica*.
- Socrates S. Koursoumis (2012). Μεσσηνία, Ἐν Δέραις καλουμέναις τῆς σφετέρας: Αναζητώντας μια αρχαία θέση και ένα ιερό στην βόρεια Μεσσηνία. *Tekmeria*, 11, 16.
- Susan E. Alcock, Andrea M. Berlin, Ann B. Harrison, Sebastian Heath, Nigel Spencer, and David L. Stone (2005). Pylos Regional Archaeological Project, Part VII: Historical Messenia, Geometric through Late Roman. *Hesperia: The Journal of the American School of Classical Studies at Athens*, 74, 147 - 209.
- Tim Everson (2013). *Warfare in Ancient Greece*. Stroud, Gloucestershire: The History Press.
- Victor Davies Hanson (1989). *The Western Way of War*. New York: Alfred A. Knopf.
- Xeni Arapogianni (2010). The Excavation in Ano Melpaia. In *Archaeologike Ephemeris* (p. 274). Athens: The Archaeological Society At Athens.

Xeni Arapogianni (2017). A Mountain Sanctuary in Ano Melpia. In *Sanctuaries and Cults of Messene from the pre-Classical to the Byzantine Period* (p. 8). Athens: Society of Messenian Archaeological Studies.