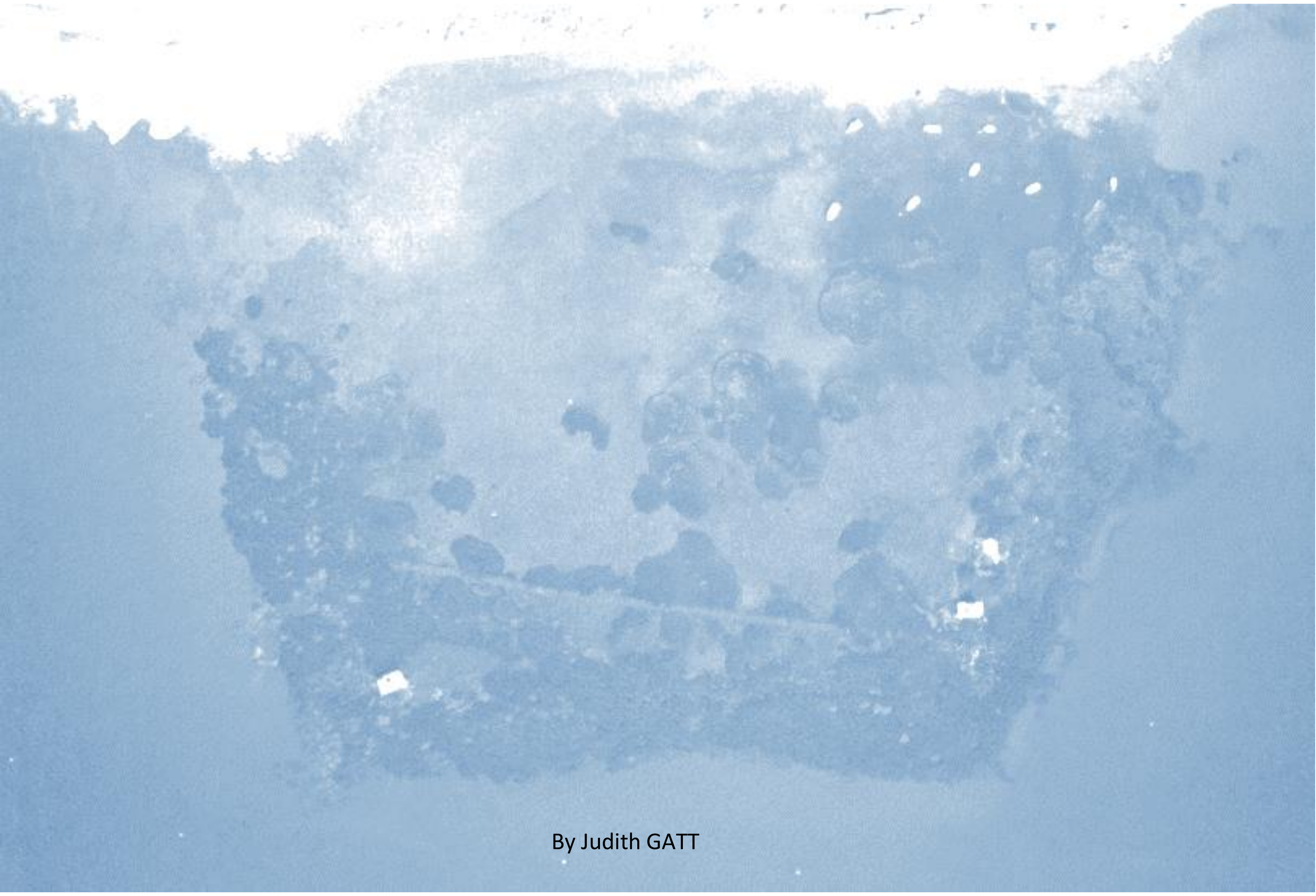
PASSIVE IMITATORS OR INNOVATORS ?

REVISITING THE CLASSICAL AND HELLENISTIC HARBOUR CONSTRUCTION TECHNIQUES OF THE ISLAND OF CYPRUS THROUGH A COMPARATIVE ANALYSIS WITH HARBOURWORKS IN THE AEGEAN AND THE EASTERN MEDITERRANEAN.



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A dissertation submitted by
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I need the sea because it teaches me

Neruda 2003

Early January 2021 I discovered Pablo Neruda's poems. His words were mesmerizing, especially his collection of poems titled *On the Blue shore of Silence*. The line that marked me most was « I need the sea because it teaches me » form the Poem titled *The Sea*. Indeed, I need the sea. It teaches me how man is such a little being in front of its nature, and how despite our efforts to conquer it, it will always prevail. While exploring the ancient harbouworks of Cyprus, a new horizon of knowledge opened. I simply managed to get a glimpse of it through these two years. I have still a long way to go. Learning though was not a lonely journey. I have been blessed with inspiring, enthusiastic and supportive captains and sailors who guided me with patience through the unknown routes of the sea. Words are not enough to express my gratitude to my dear friends, colleges, and professors from France and Cyprus.

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Finally, to the person I dedicate this research, Giorgos Filippou. Thank you for believing in me, supporting me and being such a wonderful person from the moment I decided to apply for MoMArch. You made me a stronger person. This is for you with a sincere appreciation.

ABSTRACT

This dissertation explores the harbour construction techniques of the Classical and Hellenistic period that are identified in the harbourworks on the island of Cyprus. Previous research on the harbours of Cyprus (Theodoulou 2006 ; Leonard 2005 ; Raban 1995 ; Marangou 1997 ; Empereur et al. 2018) has already concentrated a rich corpus of information on the ancient harbour structures of the island. Despite these considerable efforts, these harbourworks have been constantly examined under the shadow of the Phoenician and Greek tradition (Raban 1995 ; Marangou 1997 ; Theodoulou 2006), lacking a systematic and comparative study that takes equally into account the Classical and Hellenistic harbourworks of the Eastern Mediterranean and the Aegean. A general analysis of the Classical and Hellenistic harbour construction techniques will benefit an objective understanding of the harbourworks of the island away from the spectrum of the Phoenician and Greek influence. As a result, the character of the island's ancient harbourworks will be highlighted without however underestimating the contribution of the Greek and Phoenician tradition in the Classical and Hellenistic harbourworks.

NOTE TO READER

- This dissertation is subdivided into four main sections. The Five Chapters which constitute the main chapters in which the discussion unfolds, the two catalogues which is divided in two. I-XII Catalogue entries for Cyprus and XIII-XXIX catalogue entries for harbours of the Aegean and the Eastern Mediterranean. This is followed by the Appendix in which the excel database of the harbour construction techniques , the Glossary, the proposed harbour construction documentation worksheet as also a series of Chapters with complimentary information on the island's history and RSl change is found. The last section is the Bibliography ad the list of Figures, Maps and Tables.
- For the figures, maps and Tables each chapter follows a unique numbering based on the number of the Chapter (Figure –Number of Chapter-Number of image/plan/table). However, in some cases a reference to the images/plans and maps of the catalogues found in the second section of the dissertation is made. The reference is made by placing first the number of the catalogue entry number (i.e. Amathus-III) followed by the number of the Figure. Each entry in the catalogue has its own unique numbering.
- The Catalogue for the harbour of Cyprus includes a detailed description of the harbour sites followed by indicative bibliography, and figures. Similarly for the harbours of the Eastern mediterranean and the Aegean follows however, the description of the site and harbourworks are made in less.
- The catalogues and the Prelimenary Database for the harbour construction techniques (Appendix A) are linked through the latin numbering of the catalogue entries. This facilitates the reader who consults the table to refer to a detailed description of the harbourworks and the indicative bibliography concerning the harbour.
- The Glossay for the harbours under study (Appendix B) aims in creating a bridge between the terminology used in the different publications and the uniform terminology used in the framework of this study.
- Where an asterix accompanies a term please refer to the Glossary for the definition.

INTRODUCTION

The Classical and Hellenistic harbours* that lay along the coast of Cyprus (**Map 0.1**) remind us that the sea was and still is a challenging space, not destined to be altered by man. Constructing functional and lasting harbourworks in the open sea required not only the technological know-how, the sources to supply the needed building material and human labour, but also a detailed understanding of the surrounding physical environment. Breakwaters*, moles*, quays* and jetties* are the main elements for the formation of functioning harbour basins that would ensure a safe arrival and departure to and from the island. Today these harbouworks are either silted, submerged and covered by sea life, buried under modern harbourworks or simply invisible since they didn't survive the test of time. The harbours have, since the beginning of Cypriot maritime archaeology, attracted the attention of researchers (amongst many : Taylor du plat 1980 ; Nicolaou 1966 ; Raban 1995 ; Leonard 2005 ; Theodoulou 2006).

These preceding studies, though, have been systematically conducted under the shadow of the Greek and Phoenician tradition. These two terms mainly address the early harbourworks of the Late Bronze Age and Archaic period identified in the Aegean and the Levantine Coast (Raban 1995 ; Frost 1995 ; Shaw 1978 ; Baika 2009) however, for the case of Cyprus, the use of the aforementioned terms in the bibliography continues also when referring to Classical and Hellenistic harbourworks (Raban 1995 ; Marangou 1997 ; Theodoulou 2006). This approach led to a focus on the provenance of the harbour construction techniques identified on the island and the contribution of these two traditions to the island's harbourworks. This discussion though leads to a question which for the time being has been marginalized. Were the ancient harbour builders of the island indeed passively applying the Phoenician and Greek tradition to construct the needed harbourworks ? Or once the aspect of a direct influence from these traditions is put aside to a local character, an innovation that reflects an adaptation of these traditions to the local environment is reviled ?

This question generated the need to define the reality of the harbourworks of the Classical and Hellenistic period to rightly contextualize the harbour structures* of the island without though forgetting the contribution of the Greek and Phoenician tradition. The replacement of these two terms with the term Classical and Hellenistic harbour construction techniques contributed significantly to an objective approach to the harbour construction techniques of the island of Cyprus. Distanced from the above-mentioned discussion, it is possible to move beyond and explore new grounds that testify the local touch of the harbour structures. Therefore, to accomplish the above, a comparative study between the harbourworks of Cyprus and those of the Eastern Mediterranean and Aegean was undertaken. Several limitations (that will be stated in detail in Chapter 1) rendered this study difficult however, through the case study of Amathus outer harbour basin moles and breakwater a concrete comparative analysis with strong arguments was constructed to revile (on a preliminary level) the character of the harbourworks of Cyprus.

This dissertation is divided into five main chapters. The first chapter introduces the reader to the former research around the ancient harbours of Cyprus, the main research issues as well as the methodology applied. The second chapter aims to contextualize the harbourworks of Cyprus, the Eastern Mediterranean and the Aegean in the wider historical, and geomorphological context. This leads up to the third chapter, which presents the harbour construction techniques of Cyprus in comparison with those of the surrounding region. In this chapter, the harbour construction techniques of the Classical and Hellenistic harbours will be presented and the terms Greek and Phoenician tradition will be discussed. The fourth chapter presents the case study of Amathus whose harbourworks of the outer basin are compared with those of the surrounding region. Finally, the fifth chapter aims to present a series of preliminary conclusions and to examine future perspectives of this research.

Map 0.1 : Location of the ancient harbours of Cyprus included in this study (J. Gatt 2021, after www.bingmaps.com).

Chapter 1 : THE HARBOURS OF CYPRUS

Cyprum insulam portuosam...

Ammianus Marcellinus (14.8.14)

1.1 STATE OF THE ART

Numerous travellers in the past such as Richard Pococke (1738) in his book *Description of the East and Other Lands*, David George Hogarth (1889) in his book *Devia Cypria* and Athanasios Sakellarios (1890) in his book *Ta kypriaka,* gave vivid descriptions of the remaining ancient harbour structures of the island. The archaeological remains of the ancient harbours that were visible to the eyes of the travelers of the 16th-19th century occupied an important part of the description of the island's archaeology. Hogarth's reference to Carpasia's harbour is a representative example of the ample information one can retrieve from these amateur descriptions "*The most remarkable of its features are the harbour and the tombs.... Its pair of artificial moles are the most considerable works of the kind in Cyprus. That on the eastern side can be followed for 370 feet from its starting place to the shore: it is made for its most part of large squared blocks, formerly riveted to each other by clamps of metal the marks of which only remain*" (Hogarth 1889: 90).

The first step towards an archaeological study of the ancient harbours of the island was a compiled work titled *Αρχαίοι λιμένες εν Κύπρω* (Ancient harbours of Cyprus) published by Kyriakos Nicolaou in 1966 in which nineteen ancient harbours were identified (Nicolaou 1966: 7-11). The first harbour to be investigated was that of ancient Carpasia by Joan du Plat Taylor in the 1930s (Taylor du Plat 1980; 1981). This was followed by the investigation of the Nea Paphos harbour in the 1950s, when a training mission titled "Operation Aphrodite" of the British Army took place in the ancient harbour basin and a rough report of the findings was handed over to the Department of Antiquities. However, in the 1960s Witold Daszewski, visited Nea Paphos harbour and conducted the first ever archaeological and historical study of an ancient Cypriot harbour (Dasweski 1987: 171-175 ; Leonard 2008: 131).

The survey of Elisha Linder and Avner Raban is also of great importance as they documented the majority of surviving harbour structures along the coasts of Cyprus before the Turkish invasion in 1974 (Raban 1995: 139-190). Nicholas Flemming's survey in Salamis in 1973 was the first in Cypriot harbour archaeology to combine the application of geology and archaeology (Flemming 1974 ; 1987). In 1972, an underwater survey was conducted by the Swedish along the coastline of Cape Kiti, aiming in locating the anchorage of Hala Sultan Tekke (Åström 1986 ; Engvig and Åström 1975 ; Demesticha 2018 : 64).

After the events of 1974, important harbour excavations and surveys began by foreign expeditions on the island. The excavation of Kition's shipsheds* since 1976 (Yon 2000 ; Yon & Sourisseau 2010) and the geoarchaelogical study of the harbour of Kition as well as that of Hala Sultan Tekke anchorage pointed out the significant coastal progradation in the area (Devillers et al. 2014 ; Gifford 1978). Cathy Giangrande's (Giangrande et al. 1987: 185-197) survey between 1983-1984 along the west coast of Cyprus identified a series of potential anchorages. The survey and excavation of the outer harbour basin of Amathus conducted by the French School of Athens under the direction of Jean Yves Empereur in the 1980s revealed the exceptionally preserved Hellenistic harbour (Empereur 2018a-b). Between 1993-1996, the Tsaroukkas, Myceneans and Trade project investigated a Late Bronze Age anchorage near Maroni-Tsaroukas which revieled a unique ceramic deposit that reflected the international trade of the period (Manning et al. 2002). In 1996, PAHEP (Paphos ancient harbour exploration project) conducted a geoarchaeological study of the harbour basin of Nea Paphos (Hohlfelder et al. 1998: 141-157). All the above-mentioned led in 1993, to the International Symposium *Cyprus and the Sea*, organized by the Univeristy of Cyprus and the Ports Authoriteis, were through the presented papers of Honor Frost, Avner Raban, Margarite Yon, and Jean-Yves Empreur the archaeological interest of the ancient harbours of the island was highlighted.

All the above-mentioned studies and projects indicated the potential of the harbour archaeology on the island and instigated the beginning of a series of research projects and publications on the subject. Anna Marangkou's book *Τα λιμάνια της Κύπρου* (The harbours of Cyprus) published in 1997 presented the harbours of Cyprus (namely Kyrenia, Salamis, Amathus, Nea Paphos, Marion, Lapithos and Carpasia) in relation to photographic material of the 19th century taken by the company Coode and Partners which repaired and reinforced the harbours of Cyprus at that time. Important studies such as the P.h.D. thesis of John Leonard titled *Roman Cyprus Harbours Hinterlands and "hidden powers"* documented the ancient harbours and anchorages by surveying the south coast of Cyprus (Leonard 2005). Theotokis Theodoulou (2006) P.h.D thesis focused on the Classical and Hellenistic harbours of the north and south coast of Cyprus. A recent and important publication for Cypriot harbour archaeology is the publication of Amathus Hellenistic harbour by Jean–Yves Empereur were the results of the excavation seasons are presented as well as the potential for future research on the site (Emprereur et al. 2018 a-b). Finally, a series of Master dissertations tackled problematics concerning the anchorages and the harbours of the island such as Zinonas Socratous (2018) unpublished dissertation titled *Cypriot ports during the Classical and Hellenistic periods: the case of Kourion,* Lefki's Papacosta (2017) published report on *The Late Roman anchorage of Cape Petounda, Cyprus,* Duncan Howitt Marshall's survey on the west coast of Cyprus attempted to identify the location of Palaepaphos harbour (Howitt 2012) while Leidwagner surveyed the south central coast of the island (specifically Episkopi Bay and Akrotiri) to identify Late Roman anchorages (Leidwagner 2004; 2005a-b).

Currently, several harbour projects are ongoing such as the site of the Dreamer's Bay by the University of Southampton and the University of Leicester which aims in contextualizing this harbour structure within the wider landscape of Akrotiri's peninsula (Blue et al. 2018 ; Blue et al. 2019 ; James et al. 2021). Also, Maniki's anchorage on the southwest coast of Cyprus is under study by a multi-disciplinary research program under the direction of the New York University (Connelly 2018). The study of the Nea Paphos harbour under the direction of the Jagiellonian University identified through geophysical survey the possible location of a second harbour basin (Miszk and Wladyka 2016). Finally, the excavation and study of the silted interior harbour basin of Amathus has been ongoing since 2014 by the French school of Athens (Thely et al. 2016; Thely et al. 2020 a-c).

Interestingly, the ancient harbours and anchorages of Cyprus were the main area of focus in the first years of Maritime Archaeology in Cyprus (Demesticha 2018 : 64). For the past fifty years this field of research has been developing gradually thanks to the contribution of numerous research projects, and supporting foundations (i.e. THETHIS foundation and Honor Frost Foundation) however, the potential for further research in this area is vast / there is still potential for further research in this area

1.2 RESEARCH ISSUES AND OBJECTIVES

The coastline of Cyprus had been endowed with harbours and anchorages since antiquity. These were the only portals of contact and exchange with the surrounding region as they concentrated and distributed goods, ideas and connected communities (Gordon 2018). For this reason, their study is essential for the analysis of any subject of Cypriot archaeology or history. Despite their importance, several aspects of these coastal sites remain to be explored such as the charachteristics of the harbour construction techniques* identified on the Classical and Hellenistic harbourworks* of Cyprus. This is a subject that offers an insight to the technological know-how of the local maritime communities and contributes to a variety of other research areas of harbour archaeology such as the funcionality of the harbour structures, the dating of the construction phases, and the study of the different parameters that impacted the form and orientation of the harbourworks.

The harbour structures that are preserved on the island are mainly breakwaters and moles (with few examples of quays) that date mainly between the Classical and Hellenistic period. The PhD thesis of Theodoulou (2006) was the first research to contribute to this subject. However, a systematic study and detailed documentation of the harbourworks has been conducted only in the cases of Amathus and Dreamer's Bay. Despite the gaps in the architectural and constructional documentaiton of the ancient harbourworks of the island, these archaeological remains have been included in a discussion concerning the provenance of the harbour construction techniques identified on the island.

Raban (1995) attempted to differentiate the *Greek from the Phoenician tradition* wjich are identified in the harbour structures of Cyprus. For instance, concerning Salamis he stated that the «spiled rampart or breakwater was not used in Phoenician harbours » and that this may represent an era where the «focus of maritime activity was aimed more towards the Greek harbours of southern Anatolia and the Aegean». On the other hand, in Lapithos he identified « Phoenician harbour construction techniques » without giving any further description. Amathus, having some characteristics in common with the Phoenician harbours is described as « a transitional type in the introduction of the Hellenistic *kleistos limen* in the Near East » (Raban 1995 : 159-169). This attempt to attribute a « sphere of influence » to the harbour structures indicates that both traditions were present on the island, although the Aegean world seems to have been favoured as the major source of influence.

Marangou (1997 : 69) argued that the presence of the Greek tradition in the ancient harbours was a result of the intense contacts of the Cypriot polities with the Greek world, even though at the same time that the Levantine influence on the harbour structures is acknowledged (Marangou 1997 : 69). These arguments reflect the debate that has for long concerned the ancient history of the island. The local identity in relation to the Phoenician and Greek presence on the island (Iacovou 2007) has managed to infiltrate into the study of the ancient harbourworks.

Finally, Theodoulou (2006 : 95, 257), elaborated on this subject by questioning the attribution of the Phoenician technique to the so-called first phase of the construction of Lapithos breakwater (Raban 1995 : 165) or the use of natural foundations for the building of harbour structures as an exclusive Phoenician invention. He also raisedthe issue wether the use of certain techniques might reflect a direct influence of the Aegean world on the harbour structures (Theodoulou 2006 : 262-263). He concludes though, despite frequently referring to the *Greek and Phoenician tradition*, that Cyprus seems to have been equally influenced by both worlds.

Regardless, the interest of this discussion the majority of the arguments lack substantial and direct archaeological evidence that can only stem from a detailed archaeological documentation. The possibility of a local character in the harbour construction techniques has not been adressed yet. A projection of the two prevailing traditions (Phoenician and Greek) has been reflected continuously on these structures, favouring mainly the Aegean world as the main sphere of influence. Nor did a collective and systematic study of the ancient Cypriot harbour construction techniques in comparison with those of the surrounding region been undertaken, to rightly adress this subject. Cyprus as an island underwent numerous and continious influences from the Aegean and the Levant on different levels (art, cult, language, technology) but it always managed to give a Cypriot character to the foreign influences (Papantoniou 2013).

In this respect, one wonders, how can the comparison of the Cypriot harbour construction techniques with those of the surrounding area contribute to a new understanding of the characteristics of the islands harbourworks? Can this contribute in identifying a "local", "Cypriot" character in the harbour construction methods? On a second level though, what do the terms *Phoenician* and *Greek tradition* represent in the Classical and Hellenistic harbourworks of Cyprus? For now these terms seem to be used as a reflection of the innovation of a civilization and its application in the harbourworks of Cyprus(Raban 1995). The questioning of the use of these two terms would perhaps contribute to establishing a more correct use of the term not only in the context of Cyprus but also in the surrounding region.

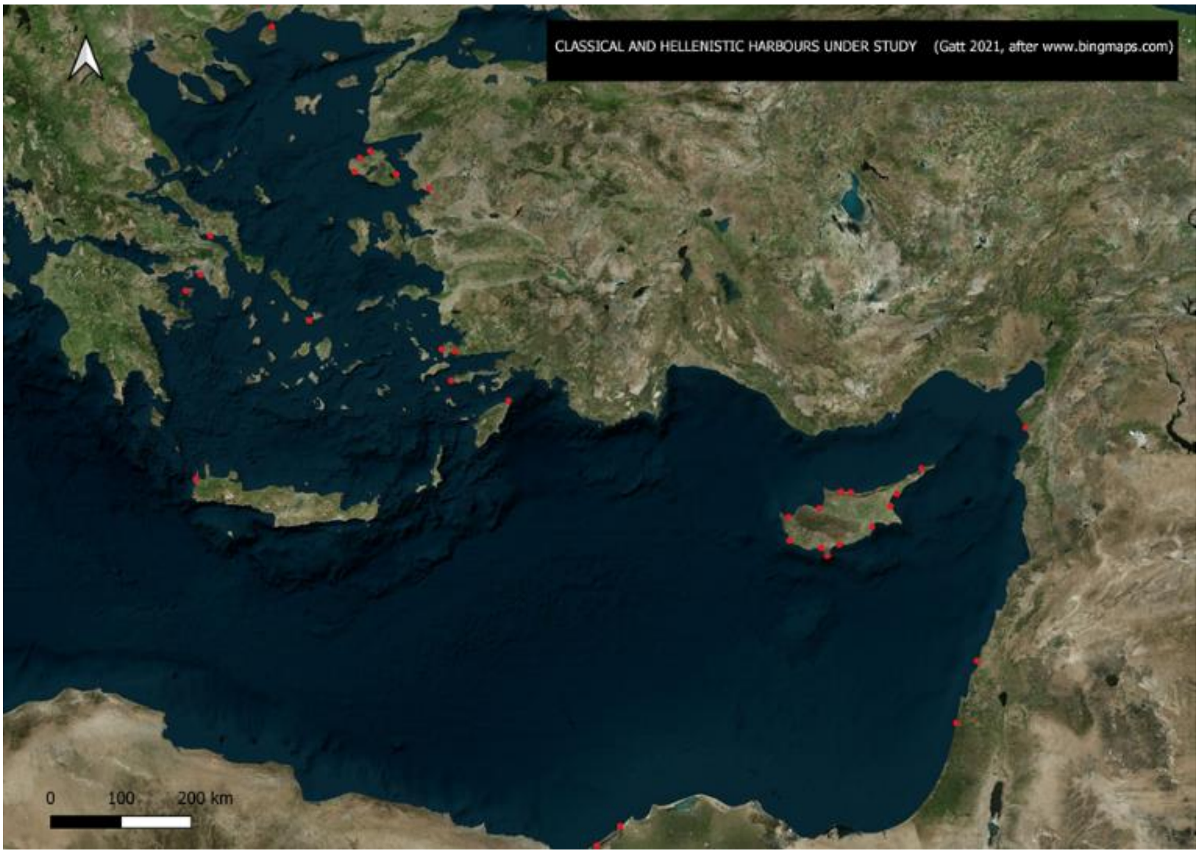
This comparative study though, underlined the fact that the study of harbour construction techniques has been mainly focusing on the harbour construction techniques of the Roman period (Brandon et al. 2014). Only one unpublished master dissertation by Mazarakis-Ainian (1992) titled *Les Structures Portuaires en Grece Antique* focused on the harbour construction techniques of the Classical period, although limited to the geographical region of the Aegean. No collective and comparative study of the Classical and Hellenistic harbour construction techniques identified in the Aegean and the Levant in comparison with those of Cyprus has been to the author's knowledge attempted for the time being. Only in cases of publications of harbour sites, an attempt to compare the harbourworks with other known harbour sites, a comparative study is undertaken (i.e. Piraeus- Loven & Sapountzis 2019 ; Amathus- Empereur et al. 2018a ; Caesaria Maritima-Hohlfelder 1996). This gap creates the opportunity to initiate a comparative and inclusive study on the harbour construction techniques of the Classical and Hellenistic period in the Eastern Mediterranean and the Aegean, on a prelimenary level.

Therefore, by studying the construction techniques of a series of Classical and Hellenistic harbourworks located in the Aegean and Eastern Mediterranean would contribute to a better understanding of the harbour construction techniques that developed in the Classical and Hellenistic period in Cyprus as also in the surrounding region. Most importantly though, this would contribute to the question that this research aims to investigate in the first place. Do the Classical and Hellenistic harbourworks of Cyprus reflect a local charachter or do they simply follow the trends that circulated in the Aegean and the Levant?

1.3 METHODOLOGY APPLIED AND LIMITATIONS OF THE RESEARCH

Studying the harbour construction techniques of the Classical and Hellenistic period is a challenging task which includes a variety of approaches as also limitations. To explore the Classical and Hellenistic harbour construction techniques, an excel database (**see Appendix A**) which accumulated information on the building material, the masonry, the nature of the foundation level* and the identified joints of the harbourworks of Cyprus, the Eastern Mediterranean and the Aegean was created. Only harbour structures were taken into account (such as moles, quays, breakwaters and jetties) and not harbour facilities (such as shipsheds). In total, 29 harbours, that preserve harbourworks were included, twelve harbours from Cyprus and other seventeen from the Aegean and the Eastern Mediterranean. The seventeen harbours were chosen based on two main parameters. The first and most important is the preservation of harbour structures dating to the Classical and Hellensitic times (although the dating for some still remains in question) and the access to published material concerning the harbourworks. (**Map 1.1**).

In the first place, the concentration of this data enabled the study of each individual harbourwork from its foundation level up to its upper structure* (when possible). Secondly, by inserting the excel database in a QGIS enviroment, the comparative study was facilitated through the visualization of the collected data. To rightly adress the harbour construction techniques of the Classiacl and Hellenistic harbourworks a series of dictionaries (Ginouvès & Roland 1985 ; Orlandos 2004), articles (Sharon 1987), and manuals (CIRIA. Et al. 2007) were consulted. Parallel to that, a prelimenary glossary (**Appendix B**)[1] regarding harbour terminology was compiled based on prexisting glossaries and definitions proposed by various



researchers. For this the glossary of NAVIS (https://www2.rgzm.de/Navis2/Home/FramesE.cfm and HARE SPP1630) and HAFEN PROJECT terminology (http://haefen.i3mainz.hs-mainz.de/resources/vendor/HARE_Terminology%20for%20Harbour%20Data%20entry.pdf) were consulted. In addtion to that, since publications of the harbourworks under study vary in the use of harbour terminology, a table was created to attribute a consistent terminology in the framework of this study (**see Appendix B**).

Map 1.1 : Location of Classical and Hellenistic harbours included in this study (J.Gatt 2021 after www.bingmaps.com).

Concerning the harbourworks of Cyprus a detailed catalogue was also created based on the work of Theodoulou (2006) (**Map 0.1**). It aimed in collecting all the published data, ranging from the history of the site and research to the description of the harbour structures and RSL change estimations attested on the site. For the harbours of the Aegean and the Levant under study a catalogue was also formed however, in a rather simplified version (due to the lack of time) which concentrated mainly on the historical context, the general description of the harbour and its harbourworks and the collection of an indicative bibliography. These catalogues allowed to place the harbourworks in their wider historical, archaeological and environmental (the latest only for Cyprus) context which is essential to their interpretation.

[1] This was compiled in collaboration with Mauro Frontini Miguel

To showcase, the charachter of the harbour construction techniques of Cyprus and also the contribution of this architectural study of the harbourworks to the wider understanding of the ancient harbour sites, a case-study from the island, was selected. Amathus submerged outer basin (**Fig. 1.1**), located on the south central coast of Cyprus due to its excellent preservation enabled such a study. Excavated in the early 80s and recently published by Jean-Yves Empereur (Empereur et al. 2018 a-b), this harbour site has opened a broad debate on the interpretation of the site in terms of its construction, function and abandonment (cf. Aupert 2020). Therefore, Amathus thanks to the excellent preservation of its harbour structures consists an opportunity to proceed to a more detailed study of the charateristics of the harbour structures and their construction technique.

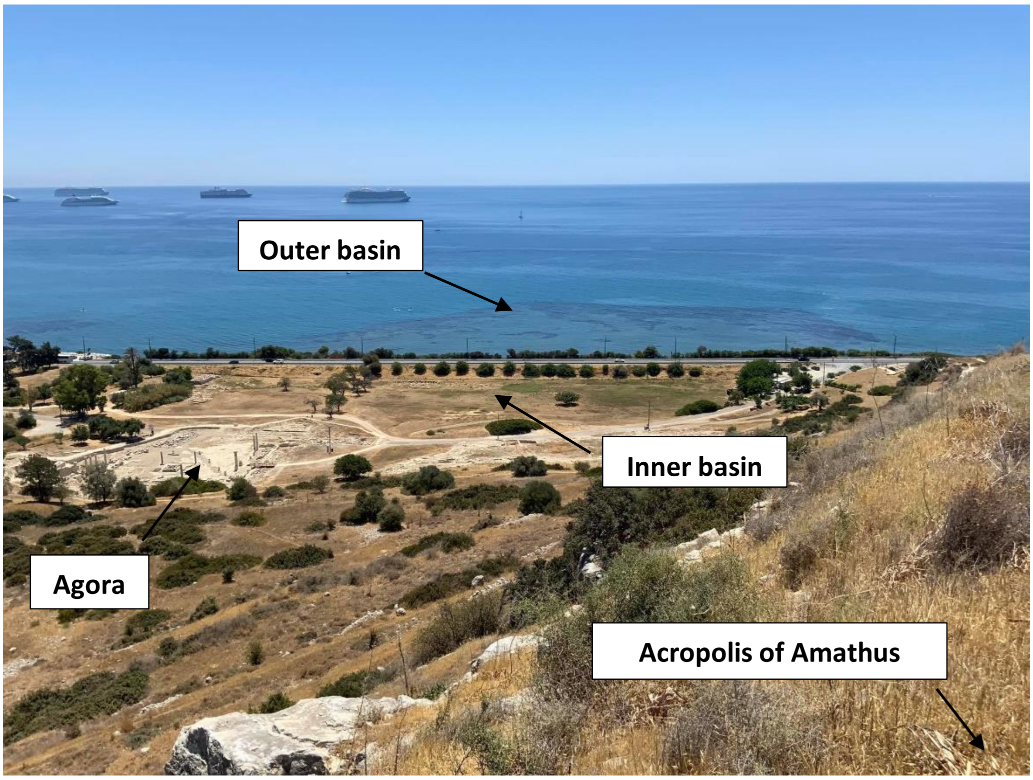


Figure 1.1 : The harbour city of Amathus. View of the outer basin from the acropolis (Photo taken by A. Gatt 2021).

The study of the harbour structures of Amathus was possible firstly through the visual prospection of the site (in summer of 2020) which was conducted by MARELab of the University of Cyprus (under the direction of Dr. Stella Demsticha and Dr. Anna Demetriou) in the framework of the ongoing ANDIKAT project (https://www.ucy.ac.cy/marelab/en/research/andikat-project) that aims in promoting the submerged archaeological site to the public. This prospection consisted mainly of familiarizing with the site, conducting preliminary observations and documenting the site through video and photography. An orthophoto of Amathus also was generously provided by Dr. Dimitrios Skarlatos and Dr. Panagiotis Agrafiotis that contributed to a more detailed study of the harbour site. This orthophoto was produced after the SfM-MVS (Structure from Motion – Multiview Stereo) processing of UAV (Unmanned Aerial Vehicle) imagery to obtain a visual documentation of the terrestrial and underwater site as well as document the eelevation (terrestrial and underwater) of the site. Concerning the extraction of the bathymetry from the submerged harbour the issue of water refraction which affects depth estimation by leading to erroneus depths was taken into account. This was tackled through the creation of an algorithm that exploits structure from motion (SfM) and machine learning tools (such as DepthLearn (Agrafiotis et al., 2019a, 2019b) to correct the refraction effect and create high resolution and accurate bathymetric maps and then establish an image correction methodology (Skarlatos & Savvidou 2015 ; Skarlatos & Agrafiotis 2018; Agrafiotis et al. 2020).A GIS database was also created aiming in concentrating and organizing all the published data and plans of the outer and inner harbour of Amathus that would facilitate future research on the site (**Fig.1.2**).

Figure 1.2 : Screenshot of the QGIS database created for the harbour site of Amathus (J.Gatt 2021).

It must be however underlined that this study has a series of limitations that must be addressed. First, published data on the harbour construction techniques accompanied by explanatory plans and photos are not always present in the publications of ancient harbours. A lack of systematic use of harbour terminology rendered the collection and interpretation of information difficult and many times uncertain for the case of Cyprus and the surrounding region. In addition to that, a great amount of bibliography regarding the harbours located in today's Turkey were difficult to access and read.[2] For this reason, no harbour from the South coast of Turkey was included in this comparative study. It was also complicating to differentiate between harbour construction techniques of the Classical-Hellenistic from those of the Roman period. This led to the incorporation of harbour sites whose chronology remains uncertain (i.e Seleucia Pieria, Taposiris Magna, Alexandria). Furthermore, no in situ prospection had been conducted to better understand the harbour structures except that of Amathus.

Concerning the harbour structures of Cyprus the majority are either poorly documented, unexcavated and/or covered by modern harbour structures, as in the rest of the Aegean and the Eastern mediterranean. During the English occupation, important harbourworks were conducted on the island's ancient harbours as also in the 1960s (i.e. Kyrenia and

[2] For this I had the generous assistance of Eylul Demirtas who kindly suggested bibliography and helped with the translation of the Turkish articles concerning the harbours of Myndos, Nea Cnidus and Halicarnassus.

Ammochostos) (Marangou 1997 ; Panayiotou 2013 : 95-97). Thankfully, photos taken by the British company Coode and Partners (1878- 1960), which are today kept in the archives of the Ports Authorities of Cyprus, offer an interesting insight on the changes that ancient harbours underwent (Marangou 2012: 11, 27). It must be also admitted that this study was mainly concentrated on the south coast of Cyprus since all archaeological research on the north coast of Cyprus has been halted since the events of 1974. Aerial photos (from the Department of Land and Surveys) and preliminary work conducted on behalf of the Department of Antiquities (see Theodoulou 2006: 104) and numerous research projects (Raban 1995 ; Leonard 2005 ; Theodoulou 2006) have safeguarded information on harbour structures that are today inacessible due to coastal development (i.e. Marion, Nea Paphos) or the current political situation on the island (i.e Salamis, Soloi, Lapithos, Kyrenia).

Chapter 2 : THE HARBOUR CONSTRUCTION TECHNIQUES OF THE CLASSICAL AND HELLENISTIC PERIOD IN CONTEXT

Everything must be recaptured and relocated in the general framework of history, so that despite the difficulties, the fundamental paradoxes and contradictions, we may respect the unity of history which is also the unity of life.

Braudel 1980 : 16

The water-line is in constant state of flux : almost everywhere along the Eastern Mediterranean seaboard the waterfront is not the same as in the past, and i twill change again in the future

Raban 1995 :139

This chapter consists of three subchapters. The first includes a presentation of the sources consulted for the study of ancient harbourworks as also an overview of the development of the harbour construction techniques from the Bronze Age to the Roman Period. Two complimentary sub-chapters follow, aiming in setting the historical context of the Classical and Hellenistic period and placing the harbourworks in their geomorphological and geological context. Since the subject of study of this dissertation are the harbour construction techniques of the Classical and Hellenistic harbourworks, it is considered essential to refer to the general historical framework and the prexisting traditions of harbour construction techniques as also the natural enviroment which undoutabley impacted the form and scale of the harbourworks.

2.1 THE STUDY OF HARBOUR CONSTRUCTION TECHNIQUES. A GENERAL OVERVIEW

The study of the ancient harbour construction techniques demands the consultation of a variety of sources such as ancient literature, ichonography and archaeological remains. Starting from ancient literature, technical works that describe the construction of harbours poorly survive although their existence is known through the survival of titles of works such as *Limenopoika* by Philon and the work of Timosthenes of Rhodes titled *Harbours* (both dating to the 3rd century BC). The only surviving document that provides us with a detailed description of the construction of a harbour structure (breakwater) in antiquity is that of Vitruvius *De Architetura* (Blackman 2008 : 643-645 ; Blackman 1982: 79 ; Baika 2009: 436). Other historical sources give indirect information on harbour structure construction such as the *Letters* of Pliny the younger (VI 31). *«… A broad barge brings up a number of immense stones, which are thrown into the water, one on top of the other, and these are kept in position by their own weight, and gradually become built up into a sort of breakwater. The ridge of stones already overtops the surface, and when the waves strike upon it, it breaks them into spray and throws them to a great height. That causes a loud-resounding roar, and the sea all round is white with foam…».*

The above description refers to the construction of the Centumcellae harbour, a rare and vivid testimony of the construction of harbourworks in the Roman period (Yorke & Davidson 1985 : 157-164 ; Brandon et al. 2014 : 31).

These rare references can also be accompanied by visual testimonies of harbour structures such as the wall painting harbour scene from the villa of Stabiae (**Fig.2.1**) dating to the 1st century AD (Blackman 1982: 80). Other rare depictions are the fresco in Kenamon's tomb in Thebes dating to the 14th century BC and a tomb painting from Amarna showing a quay with bollards dating to the late second millennium BC (**Fig. 2.2**). Harbour works dating to the Classical and Hellenistic period do not survive in ancient iconography except through Roman iconography of Greek harbours. For instance, a coin (**Fig. 2.3**) of Antoninus Pius portrays the harbour of Cenchreae, with a statue located in the middle of the basin (Blackman 1982: 80-81). Nonetheless, no iconographic source seems to contribute to our knowledge of the Classical and Hellenistic construction techniques of the harbourworks. As the literary and iconographic sources concerning the Classical and Hellenistic period remain scarce, the archaeological remains are the only source left to consult. Although the archaeological remains come with limitations (**see Chapter 1.3**) it remains a promising and reliable source of information.

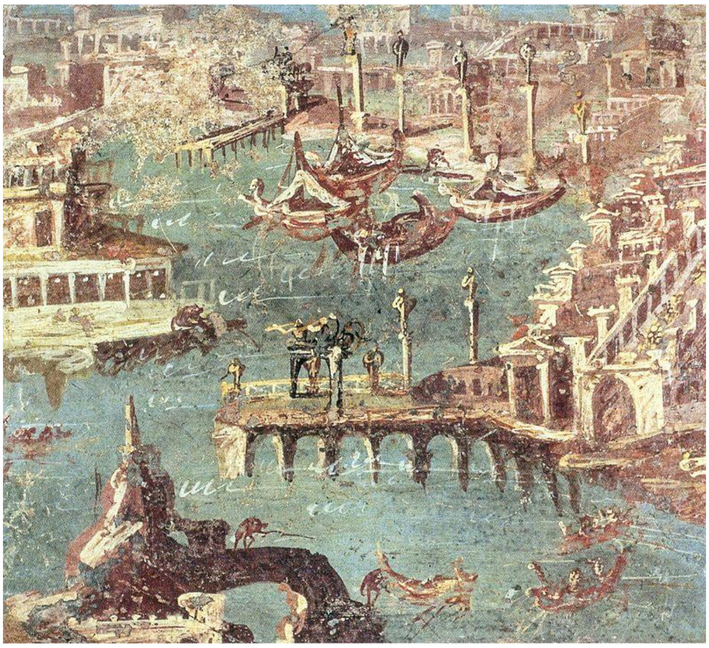


Figure 2.1 : Wall painting harbour scene from the villa of Stabiae dating to the 1st century AD (Retrived from https://en.wikipedia.org/wiki/Stabiae#/media/File:Wall_painting_from_Stabiae,_1st_century.jpg Last accessed 31st May 2021).

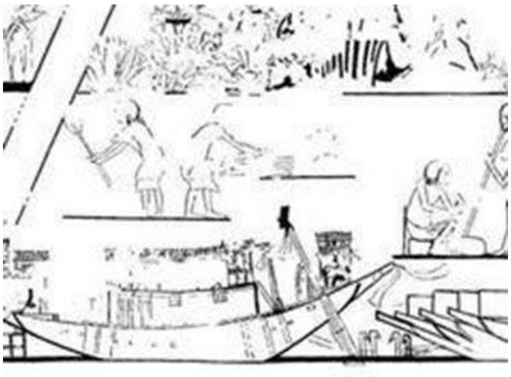


Figure 2.2 : Funerary picture with moored ships found in Amarna (c. 1365 BC) (Retrived from https://www.pinterest.se/lenawennberg/egypt-city-amarnaakhetaten/ Last accessed 9th June 2020).

Figure 2.3 : Coin of Antoninus Pius, portraying the harbour of Cenchreae (Blackman 1982 : 81 figure 1, G).

Despite, the variety of archaeological remains our knowledge on the harbour construction techniques of the Classical and Hellenstic period is limited. Generally, what had existed prior to Roman harbour technology is labelled with the term *Phoenician* and *Greek tradition*. The Phoenicians are considered to be the first in the Mediterranean to build freestanding ashlar built, rock-cut* harbour works along the Levantine coast (Raban 1995: 143 ; Frost 1995: 6 ; Baika 2009: 436). Quays and jetties at sites like Sidon, Arwad, Tyre Athlit, and Akko, were built with ashlar blocks* (Blackman1982: 92 ; Raban 1995: 158) or by carving already existing reefs to create a stable foundation. On the other hand, the Greeks developed the so-called *Greek tradition* of harbour construction in the Aegean which is represented mainly by the use of rubble* for the construction of breakwaters on which structures (walls, towers, quays) were built with ashlar blocks joined either with clamps or dry-construction (Baika 2009: 436-437 ; Blackman 1982: 185). Such an example is the breakwater of Samos built by the tyrant Polycrates (in the 6th BC) or Delos breakwater that has been dated to the late 8th century BC (this dating is far from certain) (Baika 2009: 431). These two terms, represent the first harbourworks identified in the Aegean and the Levantine coast in the Bronze Age and the Archaic period (Shaw 1972 ; Blackman 1982).

In the existing bibliography, these two traditions are followed by a technological revolution, the introduction of the hydraulic cement (*pozzulana*) in the construction of Roman harbour structures. This allowed the construction of larger scale structures, less dependent on the natural forms (i.e. reefs, natural closed bays) (Blackman 1982: 185). The use of wooden cofferdams built on land or sea, filled with hydraulic cement was the major technological feat of the Roman harbour technology. This subject has been systematically studied by the ROMACONS project whose results are published in the book *Building for Eternity: The History and Technology of Roman Concrete Engineering in the Sea* (Brandon et al. 2014). There with great detail the Roman building techniques of the harbourworks have been analysed in their archaeological, historical and geological context (see Brandon et al. 2014). Although this large scale project has initiated a systematic study of the harbour structures of the Roman period, the Classical and Hellenistic harbourworks remain still little addressed as a distinct period in the development harbour construction techniques.

Due to the major focus that research has invested in Roman harbourworks, harbour construction techniques of the Classical and Hellenistic period have been described in a rather simplified manner. Many articles and books on the history of ancient harbourworks of the Classical and Hellenistic period (Shaw 1972 ; Blackman 1987 ; Blackman 2008 ; Coulon & Golvin 2020) focus mainly on the typology and the basic characteristics of the Greek and Phoenician harbours than the actual construction techniques.

Leaving aside the above fact, it is important to question why it is important to study the harbour construction techniques of Classical and Hellenistic period? From a macroscopic view it seems that harbour technology develops in a linear process. On a microscopic level though it is evident that this is far from the truth. Harbour construction techniques that date to the pre-roman times continue to be used on different levels for the construction of Roman harbouworks (i.e. Lechaion, Eretria, Halicarnassus) (Brandon et al. 2014 : 79). The harbour of Leptis-Magna (Bartoccini 1958), the Claudian harbour basin of Portus (Testaguzza 1970), and the harbour of Centumcellae (as described by Pliny the younger VI, 31) are considered as Roman harbours or harbours that underwent considerable works in the Roman period, that reflect the use of harbour construction techniques attested in the Classical and Hellenistic harbourworks (Blackman 2008: 645).

Let us though not forget the aim of this study. The exploration of the charachter of the harbour construction techniques of the island of Cyprus in the Classical and Hellenistic period, is the driving force of this research. By carefully studying the harbour construction techniques identified in the harbourworks of the Classical and Hellenistic period we will be able to rightly adress and intepret the technological know-how of the island's ancient harbour builders.

2.2 THE CLASSICAL AND HELLENISTIC HARBOURWORKS IN THE HISTORICAL FRAMEWORK

Since this dissertation focuses mainly on the Classical and Hellenistic harbour structures of Cyprus, the Eastern Mediterranean and the Aegean it is important to set the historical framework in which they were built. Harbourworks cannot be studied solely as functional structures that serve the need for mooring ships, and loading and unloading goods. They consist the meeting points of civilizations, and symbols of political, maritime and economic power (Karmon 1985: 3). Also, although the Classical and Hellenistic harbour construction techniques are examined under the same umbrella (since its difficult to distinguish differences between construction techniques of the Classical and Hellenistic period), it must be clarified that historically the Classical and Hellenistic period are two distinct phases of history that represent different socio-political contexts.

The Classical period, aside the feats of architecture, literature, and politics was a time when *polis* and empires clashed. Democracies were established and expanded into mini-empires (Athenian “empire”) while poleis competed for prevalence. It is challenging to narrate in a few paragraphs the numerous events that ancient historians recall through their texts however, an outline of the events will be briefly presented down below.

The Greco-Persian wars, which were a result of the expansion of the Persian Empire to the west since the Archaic period, culminated with a series of historical battles on land and sea in the Classical Period. These wars between the Greeks and Persians (492 BC to 449 BC) led to two decisive battles, that of Plateia and Mycale in 479 BC which marked the end of the Persian expansion in the Aegean. As a result of these long-term wars the *polis* of Athens prevailed, a fact that led to the formation of the Delian League in 478 BC, a military alliance of the Greek poleis that aimed in providing military support to its allies. However, this alliance led to a conflict of interest between Athens and Sparta that resulted in the Peloponnesian wars (431-404 BC). This 30-year period of wars rendered Sparta the prevailing power after the battle of Aegospotami (405 BC), while the Persians had once more an opportunity to interfere in the Aegean. A third milestone in the history of the 5th-4th century BC was the expansion of Macedonian power in Greece. After the failing attempts of Athens and Thebes to rise in prominence, Philip II of Macedon submitted the Greek *poleis* under his power. His ambitions in expanding his power beyond the Aegean were made a reality by his son Alexander the Great who in 334 BC marched towards the heart of Asia Minor bringing to an end the Persian empire (Bengtson 1991 : 155-241 ; Boardman et al. 1987 :124-156).

During these times harbours such as those of Piraeus, Thasos, Aigina and Lesbos flourished. The investment of the polies in the naval fleets led to the construction of harbours (such as Thasos and Aegina) that could ensure the storage and protection of the cities navy. This led subsequently to the formation of rivalries. In Thasos, in 464 BC the city revolted against Athens and underwent a two year siege which ended with Thasos surrendering its trirems to Athens and the city walls being destroyed (Shipley et al. 2006: 874). The fortification of harbours was also gradually initiated in the Classical peirod and a distinct function was attributed to each basin starting with the harbour of Piraeus (Baika 2009 : 434-435). This investment in harbourworks that could equally protect the city and its ships from man and sea culminated in the Hellenistic period.

The Hellenistic period begins with the death of Alexander the Great (323 BC) and the division of his empire into kingdoms. It is characterized by the “fragmentation and the formation of the Hellenistic kingdoms” (Heckel 2002: 91). The so-called politics of distrust laid by Alexander the Great did not allow the whole empire to be ruled by one individual, a fact that led to a series of wars, the so-called Diadochi wars. From the first division of the kingdoms, several changes took place leaving in the end only three main powers controlling Alexander’s empire: the Ptolemaic kingdom in Egypt, the Seleucid kingdom in Persia and Anatolia, and the Antigonides in Macedonia (Heckel 2002: 91-92 ; Hammond 1959: 642-645). During this period an important increase in the ability to construct artificial harbours is attested (Blackman 1982: 93). The “ever-changing arena of the Hellenistic world, where political boundaries and alliances shifted with bewildering frequency” (Hohlfelder 1995:194) was the driving force for the construction of harbours. Here below a detailed narration of the happenings of the Diadochi wars will follow.

The period of the Diadochi Wars starts in 323 BC and ends with the Battle of Ipsus in 301 BC. This corresponds to a period of around 20 years during which the empire of Alexander was gradually divided between his generals-successors, although in reality this had continued till 276 BC (victory of Antigonos Gonatas over the Galatians after which he was crowned king of Thessaly and Macedonia). The main personalities of this period were the generals of Alexander; Perdiccas, Meleager, Ptolemy, Lysimachus, Seleucus, Eumenes, Cassander, Antigonus and Antipater (**Table 2.1**). This period can be divided into two parts. The first part between 323-320 BC when Perdiccas was trying to take under his control the empire of Alexander. While the second phase, between 320-301 BC, includes the growing power of Antigonus and his death in the battle of Ipsus (301 BC).

	NAMES	DESCRIPTION
1	ANTIGONUS MONOFTHALMUS	General of Alexander the Great, Founder of the Antigonides dynasty, prominent figure of the Diadochi Wars
2	DEMETRIUS POLIORKITES	Son of Antigonus Monofthalmus, Assisted his father during the Diadochi wars
3	ANTIGONUS GONATAS	Son of Demetrius Poliorcetes, established the Antigonides dynasty in Macedon
4	PTOLEMY I SOTER	Historian and companion of Alexander the Great, Pharoh of Egypt
5	CASSANDER	Son of Antipater, king of Macedon between 305-297 BC
6	SELEUCUS	General of Alexander the Great, Established the Seleucid empire
7	POLYPERCHON	General of Alexander the Great, regent and commander of the Empire after Antipater's death
8	ANTIPATER	General of Alexander the Great, commander of the Empire
9	PERDICCAS	General of Alexander the Great, Supreme Commander of the Empire, regent of Philip III
10	EUMENES	Alexander the Great secretary, satrap of Cappadocia and Paphlagonia
11	PYRRHUS	King of Epirus

Table 2.1 : Main personalities of the Diadochi Wars found in the text (J.Gatt 2020).

Alexander's death created a conflict regarding who would be the successor of his empire. Both his sons Alexander II who was supported by Perdiccas and Philip III who was supported by

Meleager were announced as kings. However, they were both of very young age and were used for the interest of the prevailing powers. In the end Perdiccas became supreme commander of Alexander's army, Antipater regent of Alexander's empire, Ptolemy took over Egypt, Antigonus took over the entire West Anatolia, Lysimachus Thrace, while Eumenes Paphlagonia and Cappadocia. Perdiccas ambition drove him soon to expand his power. A coalition consisting of Antipater, Antigonus, Ptolemy, Lysimachus and Craterus against Perdiccas led in 320 BC to a war against him which ended with his death. After this event, the Triparadisus treaty (321 BC) took place and the empire of Alexander was formally divided between Alexander's generals while, Antipater became the protector of the generals.

After this event, Antigonus ambition became an imminent danger to the others. Till 316 BC he was in war with Eumenes to conquer the rest of Anatolia. However, when Polyperchonta was announced as successor of Antipater (as he had died a year after Triparadisus treaty), Antigonus created a coalition with Cassander (Antipater's son), Lysimachus, Ptolemy and Eumenes which led Cassander to gain control of Athens and then of Macedonia. Nevertheless, Antigonus continued his war against Eumenes which resulted in 315 BC in the execution of Eumenes by Antigonus. He also managed to drive out Seleucus from Anatolia. As a result Lysimachus, Ptolemy and Seleucus turned against him. He continued to conquer South Syria, Caria and became an ally with Polyperchon leading him to a war against Cassander in 314 BC. Antigonus announced the freedom of the Greek cities, demanded the repositioning of Alexander's son to the throne and also established the League of the Islanders (314/3 BC). Not much is known of what this league meant, although it was most probably an alliance of Antigonus with the Islands of the Aegean (in some cases Ptolemy is considered to be the founder of the League of the islanders. Antigonus eye was now on Greece. He instigated a rebellion in Peloponnesus and fought Lysimachus in Thrace (313-312 BC). Meanwhile, Demetrius, Antigonus son had lost his war against Ptolemy in the battle of Gaza (312 BC). This allowed Seleucus to regain his land. A peace treaty in 311 BC between Antigonus and Ptolemy, Cassander and Lysimachus resulted in the redivision of Alexander's Empire. Antigonus had Anatolia, Ptolemy Egypt, Cassander Macedonia and Lysimachus was granted the title of SuAlexander'spreme Commander of the Empire, while Thrace and the Greeks obtained their autonomy. This treaty recognized the coexistence of four different powers namely, Antigonus, Ptolemy, Cassander and Lysimachus, although it did not last for long.

Antigonus and Seleucus were soon again at war after the treaty. Ptolemy on the other hand conquered Cyprus (316 BC) and became an ally with Rhodes while Cassander and Polyperchon became allies and took control of the Greek cities, therefore, the Greeks asked for Ptolemy's and Antigonus support. Ptolemy invaded Greece (308 BC) but ended up in a treaty with Cassander. Demetrius arrived in Athens in 307 BC and restored democracy in Athens. In 306 BC Antigonus sent his son to Cyprus where he took control of the island. This victory led to the use of the title of basilies first by Antigonus and Demetrius, which was then adopted by the rest. Demetrius tried for one year to siege Rhodes (305 BC) however, it ended with a treaty according to which the Rhodians would be his allies, except if in war with Ptolemy. In 304-33 BC Demetrius occupied the Corinthian gulf and in 302 BC he announced the re-establishment of the Hellenic League or League of Corinth (formed by Philip II, which united the Greek cities after the battle of Chaeronea in 338 BC to unify the forces against the Persians) while he kept on fighting against Cassander. Soon, a crucial battle in Ipsus took place. Seleucus, Cassander and Lysimachus on the one side, and Antigonus and Demetrius Poliorkites on the other. This led to Antigonus death and Demetrius escape to Greece. As a result, Lysimachus took under his control most of Anatolia and Ptolemy the Levantine coast. This battle is considered to mark the end of the Diadochi wars however, in reality it took more years for the end of the conflict between the successors (Fig.25). Demetrius following his loss in Ipsus established shortly his power between 301-286 BC in Macedonia. However, the threat of Phyruss (king of Epirus) and the expansion of Ptolemy in the Aegean brought him in a vulnerable situation. Lysimachus and Pyrrhus drew him out of Macedonia and Seleucus captured him, leading to his death in prison in 285 BC. Lysimachus took over Macedonia and Seleucus expanded to Asia, this led to the absence of a prominent power in Anatolia as a result the Galatians settled in Greece and Anatolia in 279 BC. However, the son of Demetrius, Antigonus Gonatas, was able to keep under his control Corinth, Demetrias and Chalkis and in 276 BC he won over the Galatians in the battle of Lysimacheia (277 BC) and established his power in Macedonia and Thessaly. This led to the establishment of Ptolemy in Egypt, the Antigonides in Macedonia and the Seleucides in Syria, and Mesopotamia (Walbank 1999: 59-78). However, the wars between the Diadochi never ended as the Syrian Wars (274-168 BC) soon followed.

During this time a series of harbours were established such as Caesaria maritima, Elaia, Alexandria (although this dates back to the Classical period), and Taposiris Magna while pre-existing harbours continued to be reinforced (such as Rhodes), so to serve the interests of the Diadochi and the newly formed kingdoms (i.e. kingdom of Pergamon). A distinct function of each harbour basin is established, meaning that commercial and military harbours were separated. Commercial harbours with well-protected harbour basins, equipped with infrastructure such as wide quays, warehouses and mooring stones*, and Naval harbours with ship sheds, dockyards, forts, slipways, shipyards and storage facilities became a reality. This resulted also into the creation of a new harbour type, the so called *kleistos limen* (**see Appendix A**) a harbour protected by the city walls extending along the breakwaters-moles which ended in towers on either side of the entrance. Before, the Diadochi Wars, such types of harbours were never before needed to this scale. The protection of the harbours was reinforced also through laws. For instance, in Hellenistic Rhodes arson or entrance in the naval harbour was a crime and strictly punished (Blackman 1982: 79-80, 189, 194 ; Baika 2009: 432-433, 435, 438 ; Baika 2013: 187 ; Raban 1995: 163). Warfare altered the scale of needs of society. The provisions for the army, and its transportation became even more demanding. This led evidently to a new level of harbour works in harbours strategically located.

Equally Cyprus, located in the middle of these events underwent significant socio-political changes. From the Classical Cypriot Polities that were established on the island since the Archaic period and guarded their autonomy through Assyrian and Persian rule to the arrival of the Diadochi on the island and the gradual abolition of the Cypriot polities after 294 BC harbourworks were built and abandoned (for more information on the island’s history see **Appendix C**).

2.3 THE GEOMORPHOLOGY OF THE ANCIENT HARBOURS OF CYPRUS AND THE RELATIVE SEA LEVEL CHANGE.

Including in this study the parameter of geomorphology and RSL is imperative to gain an overall understanding of the dynamics that impacted the construction of the harbourworks and their current state of preservation. In the framework of this study, a classification of the harbours of Cyprus under study will take place so as to reflect on the natural spaces in which the harbourworks were placed. This will hopefully contribute to our understanding of the impact the environment had on their scale and charateristics. This typology is based on that proposed by Mauro (2019) and is divided into 6 general sub-categories: Lagoons and Estuaries, Promontories/headlands, River mouths, Natural closed Basins, Open Bays, and “Mixed” environment (**Fig. 2.4 ; Fig. 2.5 ; Table 2.3**).

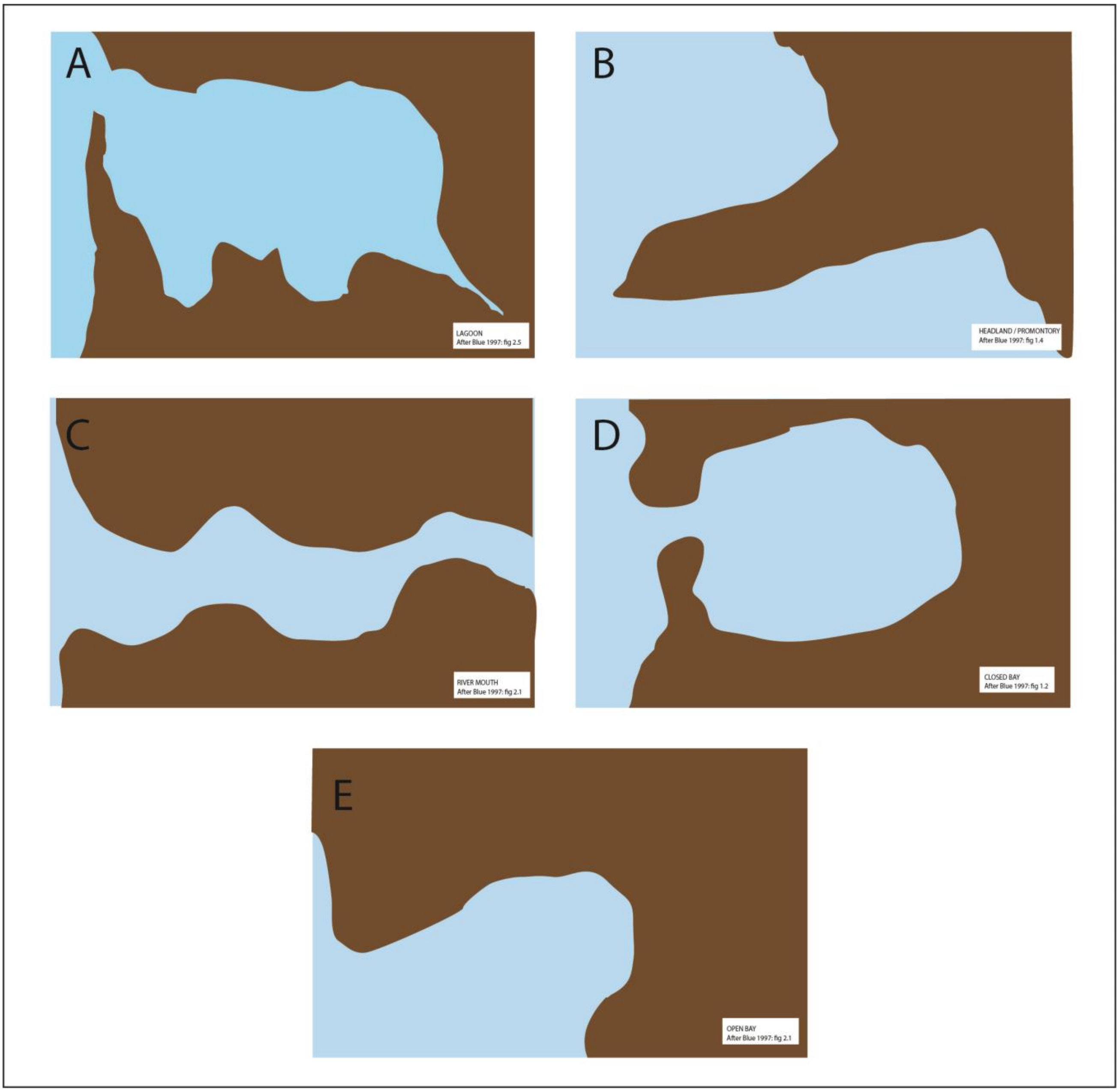


Figure 2.4 : Schematic representation of the five categories of geomorphology of harbours (J. Gatt 2021, after Blue 1997).

Harbours located in Lagoons

Lagoons are naturally enclosed coastal spaces which are gradually formed by sandspits while estuaries are natural semi-enclosed basins which are connected to the sea (Mauro 2019: 39). A series of harbours can be included in this category such as Hala Sultan tekke Bronze Age anchorage*, as also Paphos, Soloi, and Salamina (although with a question mark since no palaeoenvironmental studies have been conducted).

The Hala Sultan tekke Bonze Age coastal settlement based on the series of geoarchaeological studies conducted (Gifford 1978 ; Devillers et al. 2014:73-80) was located on the borders of an estuary which gradualy formed into a lagoon rendering the access to the site difficult and therefore the site was abandoned. Paphos harbour is inserted in this category with a question mark since no geoarchaeological study has been conducted. One of the proposed locations of the Paphos (Palaepaphos) harbour is in the area called today Loures, however this remains only a hypothesis (Iacovou 2014c: 165). Nevertheless, according to Archimandriti Kyprianou (1788, 18) in the 18th century AD refers to a lagoon in the area which was accessed by ships. Soloi and Salamina are too included with great scepticism since no geoarcheological study has been conducted. Sakellarios (1890, 131-132) reference however on Soloi indicates that in later periods the area was known as a lagoon accessible to ships with low draught and were eal was fished. On the other hand, according to Raban the North harbour of Salamis was located in a lagoonal environment (Raban 1995: 163). This however, according to the survey of Flemming was disapproved since probably the so-called North harbour was part of the city, now submerged. Therefore, the existence of a lagoon or not in Salamis remains to be proved. Nevertheless, the study of the Gialias river basin plain indicated the possibility of the existence of a lagoon in Bronze Age Enkomi which due to the coastal progradation was separated from the sea and therefore the installation of a coastal settlement (Salamis) was prompted (Devillers 2015: 156-157).

These lagoons although today are in the forms of salt lakes or silted valleys they reflect the impact of the ancient rivers of Cyprus and the difficulty of preserving a harbour in areas with high sediment input. Tremithos river for Hala Sultan Tekke, Diarizos and Cha Potami river for Paphos, Kampous and Xeros river for Soloi while Pedaios river for Salamis all had drastically altered the ancient coastline as also impacted the function and lifespan of the harbour basins of these coastal settlements.

Harbours located in Promontories/headlands

A promontory is a rocky formation (i.e. cliff) which stretches towards the sea creating on both or one of its sides favourable conditions for safe anchorage (Mauro 2019: 26). Two harbours are included in this category, Nea Paphos and probably also Kourion. Nea Paphos harbour, which is till today in use, is located on the east side of a headland. Probably according to

Stadiasmos (297) Paphos had three basins. Multiple theories on the location of the basins have been expressed (see catalogue) however, the recent studies conducted by the Jagiellonian University identified through Lidar survey a depression to the west side of the promontory which could perhaps be interpreted as the second harbour (Miszk and Wladyka 2016: 12-16). Kourion's harbour location on the other hand remains open to discussion. The only element that has been used for the localization of the ancient harbour basin was the so-called submerged breakwater identified by Leonard during the Cyprus Coastal Survey project (Leonard 2005 : 561-565). Further to the west the bay of Tripiti which is protected from the prevailing west winds by another headland preserves the remains of a rock-cut channel that connected the bay with the settlement and sanctuary. Although no harbour structures survive, it has been assumed that this bay was used as either a sacred harbour for the sanctuary of Apollo Ylatis or as a naval station of Kourion (Leonard 2005: 556 ; Leidwagner 2004 : 19-20 ; Socratous 2018 : 51).

Harbours located in river mouths

River mouths, are located in the interface between the open sea and the riverine environment. These liminal spaces offer a calm environment for ships to anchor (Mauro 2019: 37-38). In this category the harbour of Salamis and Marion can be inserted, all though with a question mark, since no geoarchaeological study has taken place.

The Classical harbour of Marion is thought to have been located at today's camping site of Polis Chrysochous were once the river Chrysous flowed into the sea. However, the drawing of an English engineer in the 20th century refers to the area as a marshy lagoon which was later on drained. Therefore, it remains unclear to which category the Classical harbour of Marion should be attributed too (Theodoulou 2006: 112-116). Salamis harbours as also the predecessors of Salamis, Enkomi and Kalopsidha were all impacted by the high sediment input of river Pedieos (as seen above). The existence though of a third basin proposed by Raban (Raban 1995 : 163-164) and Theodoulou indicate the possibility for a basin right at the river mouth of Pedeios river. Theodoulou based on aerial photos of 1963 and satellite imagery supported the documentation of T. Graves dating to 1849 who had placed on the map two structures (breakwater-moles?) one to the North and one to the South closing the river mouth of Pedieos (Xatzipaschalis & Iacovou 1989: fig. 75 ; Theodoulou 2006: 181). However, this remains to be archaeologically verified.

Harbours located in natural closed basins

Natural closed basins are bays that are protected by sand spits, islands or rocky formations that lessen the impact of waves in the basin (Mauro 2019: 33-37). For instance, Kition's harbour basin were the shipsheds have been located although frequently presented as a cothon according to the latest geoarchaeological research it was a natural bay. In effect, two naturally enclosed basins were formed by sand spits one south were the shipsheds were located and one north and both were connected between them, with the North basin being directly connected to the sea (Morhange et al. 2003: 253-272).

Harbours located in open bays

The majority of the island's harbours are included in this category since open bays is what characterizes the island's coastline. Open bays have the lowest degree of protection and therefore for this reason we attest here the majority of the harbourworks. Amathus, Marion's Hellenistic harbour, Akrotiri Elaia-Knidos, Akrotiri-Dreamers bay Lapithos, Carpasia, and Kyrenia are all inserted in this category. Kyrenia on its relatively straight coastline had had two basins, probably one to the east and one to the west. The east basin however does not seem to had been protected with harbouworks (Theodoulou 2006: 188-196). Amathus interior basin (now silted) was probably an open bay which gradually silted probably due to the existance of man-made strucutures or natural formations (i.e. sanspits) that delimited the extent of the basin as also construction of the outer Hellenistic basin (Thely et al. 2016). Marion's Hellenistic harbour was located too in an open bay and therefore required the construction of a breakwater (Theodoulou 2006: 103-112). A similar case is attested also in Akrotiri Elaia-Knidos (Bouzek 1988: 71-75), Lapithos and Carpasia (Theodoulou 2006: 197-202, 222-229).

Harbours located in a "Mixed" environment

Some harbour sites presented above have been mentioned in several categories since they possess several harbour basins or the interpretation of their environment remains open for discussion. These cases are Salamis and Marion. According to Linder and Raban's survey as also that of Theodoulou, Salamis had probably more than one basin which each probably possessed a different geomorphology. However, this always remains in the spectrum of theory since no geoarchaeological research has been conducted. Marion had also probably two harbour basins, perhaps functioning during two distinct periods (although this remains to be verified). According to the current bibliography the Hellenistic harbour was located under's today Marina of Latsi while the second perhaps Classical basin in the river mouth of river Chrysous or in a lagoonal environment.

	LAGOON	PROMONTORIES	RIVER MOUTHS	NATURAL CLOSED BASINS	OPEN BAYS
Geoarchaeolo-gicaly verified	Hala Sultan Tekke	Nea Paphos	-	Kition Maniki Ourania	Carpasia Amathus, Marions Hellenistic harbour, Elaia-Knidos, Lapithos, Dreamer's Bay

To be studied	Salamis Paphos Marion Soloi	Kourion	Salamis Marion	-	-

Table 2.3 : Geomorphology of the harbours of Cyprus based on Mauro 2019 classification(J.Gatt 2021)

A- Kition (Mckenzie 2013: fig. B.9.18) B- Kourion (Leonard 2008) C- Nea Paphos (www.bingmaps.com) D- Marion (Theodoulou 2006 : fig.25) E- Salamis (Google Earth Pro) F- Carpasia (Google Earth Pro) G- Marion (Theodouou 2006: fig.8) H- Kyrenia (Google Earth Pro) I- Elaia/Knidos (Theodoulou 2006: fig.188) J- Akrotiri-Dreamer's Bay (Google Earth Pro) K- Amathus (Google Earth Pro) L- Lapithos (Google Earth Pro).

Figure : Plans and Aerial photos of the harbour sites of Cyprus (J.Gatt 2021).

It is evident from the table above that a series of harbours remain unknown in terms of their geomorphology which indicates the potential future orientation of Cypriot harbour archaeology. On the other hand this classification points out to an interesting fact that the coastline of Cyprus was not rich in naturally protected basins. This led to the exploitation mainly of open bays which however demanded the investment of large scale harbourworks. Parallel to that, 5 of the ancient landing sites were most probably located in low energy-low lying coasts which led to a dramatic change in the coastline and thus to the siltation of the harbour basin. Since siltation seems to have affected the majority of the sites even those located in open bays as major active rivers were located in the vicinity leaves us with the question if dredging activity existed on the island since that was the main way to affront this issue. Taking the example of Enkomi and Hala Sultan Tekke it seems that these coastal settlements were abandoned once their landing sites weren't accessible any longer, leading to the establishment of new settlements near the coast which persisted persevered from the Archaic up to the Roman times. Therefore, this may indicate the possibility that with the establishment of the Cypriot-polities major maintenance projects such as dredging assured the continuous function of the harbour basin. The evidence of dredging though in the archaeological context remains for now invisible while the existence of channels in the harbourworks has been attested in Amathus which perhaps had a role in the circulation of water in the basin to avoid sedimentation. However, this remains to be verified (**see Catalogue entry III**).

Chapter 3 : THE CLASSICAL AND HELLENISTIC HARBOUR CONSTRUCTION TECHNIQUES OF CYPRUS, THE AEGEAN AND THE EASTERN MEDITERRANEAN.

Un front de mer et un plan d'eau ne font pas un port

Les annales de la recherche urbaine, 55-56, 1992 : 182

This chapter focuses on the harbour construction techniques identified in Cyprus, the Eastern Mediterranean and the Aegean. This will contribute in identifying the harbour construction techniques of the Classical and Hellenistic harbourworks and will facilitate the comparative study that will follow in the subsequent chapter. Parallel to that, it will be also possible to readress the terms *Phoenician and Greek tradition* in the harbourworks of Classical and Hellenistic Cyprus.

3.1 THE CLASSICAL AND HELLENISTIC HARBOUR STRUCTURES OF CYPRUS AND THEIR CONSTRUCTION TECHNIQUES

A presentation of the harbour structures will be undertaken starting from the foundation level up to the upper structure and moving on to the joints* and machinery used in their construction (**Map 0.1**) In some harbours (i.e. Elaia/Knidos, Soloi) a detailed description of the harbourworks is not possible since the research conducted is limited. In addition, many harbouworks have been described by several researchers who have proposed different interpretations of the harbourworks and therefore, the presentation of the harbour structures in this chapter is a result of an interpretation based on the different descriptions. When possible, a hypothetical reconstruction (not to scale) based on the descriptions given by the publications accompanies the text to visualize the given information. In this discussion harbouwroks whose datation remains unclear (ie. Carpasia & Dreamer's bay) are also included. This would encourage a discussion on their dating. Finally, a continious reference to the catalogue of the harbours of Cyprus is made in the text to offer the reader with supplementary information and images for a general overview.

Starting from the harbourworks of **Amathus** which are located in the outer harbour basin three harbour structures are preserved. A west and east mole and a south breakwater-mole. The east and west mole extend vertically from the shore with a north-south direction (145, 130 meters long respectivley and 11 meters wide), and the south breakwater-mole extends east to west with a length of 180 meters and a width of 18 meters (Empereur & Verlinden 1987b: 9 ; Theodoulou 2006: 150 ; Aupert 2000: 96) (III- Fig.3).

In the publication, the west mole remains unclear if the foundation of pebbles and gravel (c. 0.20 cm thick) attested in Sondage 8 (III-Fig. 4) on a level of mud was man-made or natural (Empereur et al.2018a : 33-35). This mole was made of two parallel walls of single rows* of headers (ashlar piers in rubble walls with headers/stretchers). Only three courses* are preserved. In between the walls a filling of gravel was placed. The filling is an alteration of a layer of small gravel, a layer of larger gravel and a final layer of small gravel (Empereur et al.2018a : 33-38, 57) (III-Fig. 6).

The construction of the south breakwater-mole according to Aupert (2000 : 96) is particular. It must be studied in four distinct sections : the mole, the breakwater, the filling and the entrance area. No foundation level has been attested. A single row of ashlar blocks (headers) consisted of the mole according to Sondage A. This mole was 180 m long and preserves up to 6 courses of headers. The headers in sondage A attests a quincunx pattern which was perhaps the result of a miscalculation in the positioning of the blocks. Nevertheless, not enough sections along the mole have been excavated to verify this theory (Empereur et al. 2018a : 38). The breakwater attests a concentration of large boulders mainly on its west corner (Empereur et al. 2018a : 37). Between the breakwater and the mole a concentration of gravel (unworked stones) was placed. The width of this debris between the mole and the breakwater are not systematic since it ranges from approximately 5-20 m. The eastern extremity of the south mole which consists the entrance areaof the outer harbour basin is also particular in terms of its construction as an alteration of courses of stretchers and headers is observed. In this area, up to seven courses were preserved (III-Fig. 7).

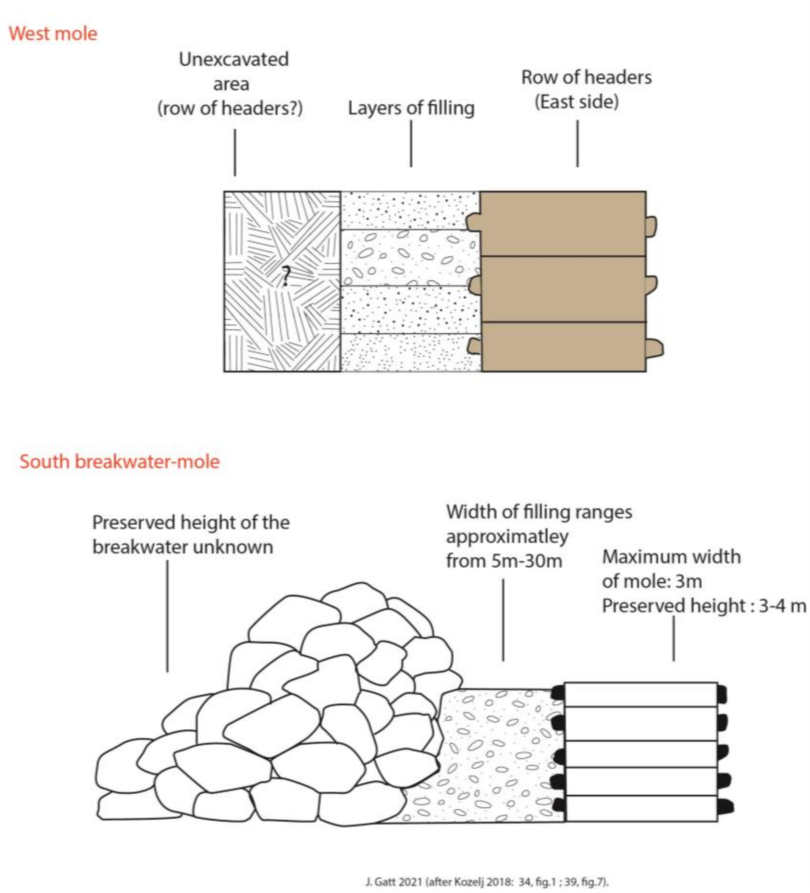


Figure 3.1 : Hypothetical reconstruction of the breakwater-mole based on the observations of Empereur et al. 2018a (Not to scale) (J. Gatt, after Kozejl 2018 : 34, fig.1 ; 39, fig.7).

The southern extremity of the eastern mole which also consists part of the entrance is preserved up to 8 courses of headers (sondage 14). It had similar dimensions with the west mole. Interestingly in sondage 2 a higher presence of gravel in between the headers was observed (Empereur et al. 2018a : 45-53). The northern part of the east mole (sondage 15, 16, 17, 18) preserves only 2-3 courses of headers that formed a single row. According to aerial photos taken between 1984-1986 though two walls of headers seem to have existed as in the west mole. However, no observations were made concerning the filling between the two walls nor the foundation level **(III-Fig.8)** (Empereur et al. 2018a : 57).

The dimensions of the blocks range from an average of 1-3 meters in length, 0.50-0.75 meters in width and 0.25-0.55 meters in thickness (Empereur et al. 2018a : 83). No different phases of construction were identified on the harbour structures, indicating perhaps a single phase of construction. It is though interesting to identify especially along the south mole and the east mole areas where the mole seems to miss its systematic consistency of blocks (Empereur et al. 2018a : 161-162). Specifically, in Sondage 2 and 12 of the east mole the headers were surrounded by gravel, while in sondage 1, the use of unworked stones in the lower courses is identified in the extremity of the south mole. In Amathus two clamps were found in the basin, one of which is 40x20cm and is 10 cm thick and around 54 kg (**III-Fig. 9**). Also traces of clamps were identified along the south mole however, the majority of the structures seems to have been a result of dry-construction (Empereur et al. 2018a: 79) (**for more information see Catalogue entry III**).

In **Dreamer's Bay** the mole was 135 m long (**Fig. 3.2**) [3]. To the north it had a width of 4.75 m which widened towards the south to 8.5-9 m. Up to four courses have been preserved (**I-Fig. 4**). The average size of the blocks ranges to 0.9/1.1/1.3 (length) x 0.4 (width) x 0.3 (height). Two different construction methods have been identified that may represent two phases of construction. From the North towards the south for 80 m the use of headers in the outer part of the mole and the use of stretchers in the centre is observed (**I-Fig. 5).** This part of the structure was placed on a natural foundation of solid marl. After these 80 m towards the south the structure continued to have on the outer sides headers however in its interior irregular blocks and fragments of blocks were used. This part of the structure was located directly on the sandy seabed (Blue et al. 2019 ; 2018). Haggerty identified also the presence of 2 shafts (spondiloi) in the construction of the harbour structure (Leonard & Demesticha 2003 : 192-194). No evidence of binding material has been identified and therefore a dry construction seems to have been implemented (**for more information see Catalogue entry I**).

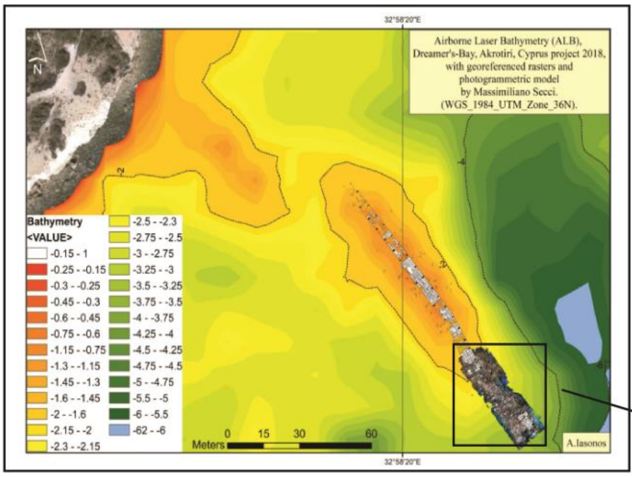
In **Nea Paphos** harbour the dimensions for the harbouworks vary between researchers (**Fig. 3.3**). The west breakwater-mole (?) is estimated to have been between 170-280 meters (Nicolaou 1966 : 578 ; Leonard & Hohlfelder 1993 : 374 ; Hohlfelder 1995 : 197 ; Theodoulou 2006 : 132). It is difficult to understand its actual length, due to the modern breakwater-mole built on top of it. The width is thought to have been approximately 5-15 meters (Dasweski 1987 : 174). The blocks used ranged around 2.5 m (length) X1m (width) x 0.8 m (height). The blocks lie dispersed today on the seabed or can be traced still in situ to the north of the Nea paphos Castle (**X-Fig.4**). A concentration of rubble (spur), consisting of a mixture of boulders and amorphous blocks stones was identified on the west breakwater-mole's (?) angel extending for a length of 50-70 m below current sea level between 0-3 m (Daszewski 1987 : 174 ; Leonard & Hohlfelder 1993 : 374). The boulders dimensions vary from 1.80- 2.70 m (length) X1.60-2.70 m (width) X0.85-1.15 m (height) while the amorphous stones average size vary from 0.32-0.45 m (length) X 0.20-0.22 m (width) X0.16-0.21 m (height) (Leonard & Hohlfelder 1993 : 3). The east breakwater-mole (?) is estimated to have been between 350-500 meters long and 5-10 meters wide (Nicolaou (1966, 578 ; Daszewski 1987 : 174 ; Leonard & Hohlfelder 1993 : 375-376). According to Hohlfelder though, the width extends to 20-25meters (Hohlfelder 1995 : 197). In the east breakwater-mole (?) (**Fig.3.4**), the blocks found were around 0.5 meters high and 2 m long. On the outer side of the breakwater-mole (?) boulders were identified (Theodoulou 2006: 138). Two columns along the east breakwater-mole (?) were identified indicating probable elements belonging to the upper structure. According to Dasweski (Daszewski 1987: 174) smaller blocks were used for the leeward side of the structure and larger blocks for the seaward. He also supported that this structure had vertical facades and was narrower than the west breakwater-mole (?) since the impact of the waves was less. Nevertheless, none of these descriptions were supported by the PAHEP project (Leonard & Hohlfelder 1993: 378). Parallel to the eastern breakwater-mole (?), 30 meters south of it a second breakwater of 199 meters long and a width of 5 meters at a depth of 4-4.4 meters built with boulders was identified. The boulder's dimensions range around

[3] Although the dating of the mole of Dreamer's Bay remains to be determined. It has been included in the discusssion since according to the prelimenary reports of the Dreamer's Bay project it may also date to the Hellenistic period (Blue et al. 2018 ; Blue et al. 2019).

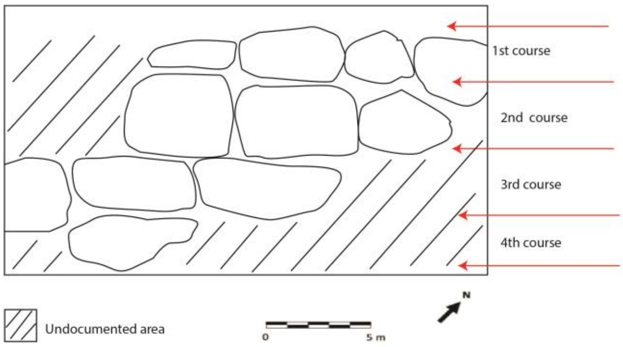
1.80-2.70 m (length) X0.90-1.40 m (width) X0.70-1.00 m (height) (Hohfelder 1992: 256 ; Leonard & Hohlfelder 1993 : 375 ; Hohlfelder 1995 : 204-205) (**for more information see Catalogue entry X**).

Concerning **Marion's** breakwater-mole (?) it extended from the coast towards the North-East[4] for around 50m. The structure was built most probably partially on a rubble foundation. A section of the ancient harbour structures that was cut in the framework of the modern harbourworks, observed by Theodoulou allows a better understanding of the constuction technique of the rubble foundation. A layer of amorphous stones covered by a layer of boulders seem to have existed (**Fig. 3.5**). Based on the plan of the ancient harbour structures of the Department of Antiquities (**IX-Fig.5**) made prior to the construction of the modern harbourworks in 1960 it seems that an alteration of rows of headers and strechers* consisted the construction of the mole (**Fig. 3.5**). A column too (similar to that of Nea Paphos and Dreamer's Bay) was retrived during a dregging operation which may indicate the type of elements that may have decorated the upper structure (Theodoulou 2006 : 103-109). On the corner of the stucture probably the remains of the breakwater were identified by Raban and Theodoulou. The dimensions of the ancient blocks documented range around 2-2.50 (lenght) x1.00-0.80 (width) x 0.70-0.80 (height) m (Raban 1995 : 165 ; Nicolaou 1966 : 97). According to Raban traces of dovetail clamps were attested on the blocks however no such trace was found by Theodoulou (**for more information see Catalogue entry IX**).

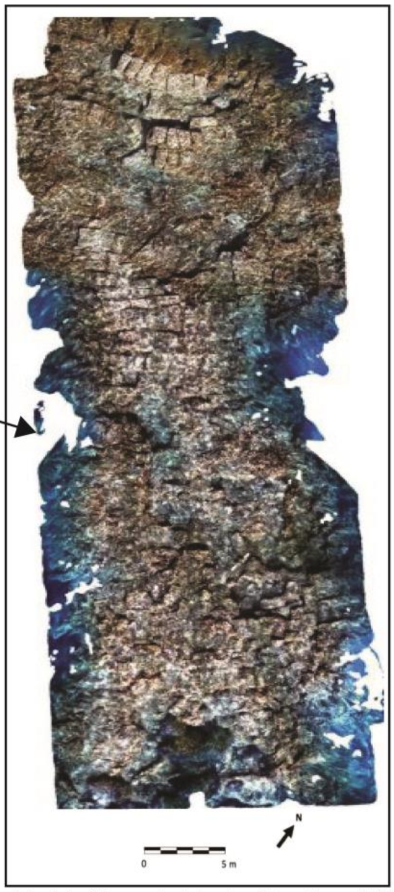
[4] The above descritption of the orientation of the harbourworks is based on Theodoulou's latest observations (Theodoulou 2006 : 107-108). Raban and Linder considered the existance of two moles (one with a South North direction and a second with a East West Direction (Raban 1995 : 164-165).



The breakwater as recorded during the 2018 season and Haggerty 1990 (Blue et al 2018 : fig.14 by A. Iasonos and M. Secci)



Drawing after orthophoto of the reconstructed portion of the eastern side of the breakwater (J. Gatt 2021 After Blue et al. 2018, fig 18, (Photogrammetry survey and processing: M. Secci)



Orthophoto of the reconstructed portion of the southern end of the mole (Blue et al. 2018: fig.7 (Photogrammetry survey and processing: M. Secci)).

Figure 3.2 : Dreamer's bay south extremity of mole in Plan and Facade (Blue et al. 2018 ; 2019).

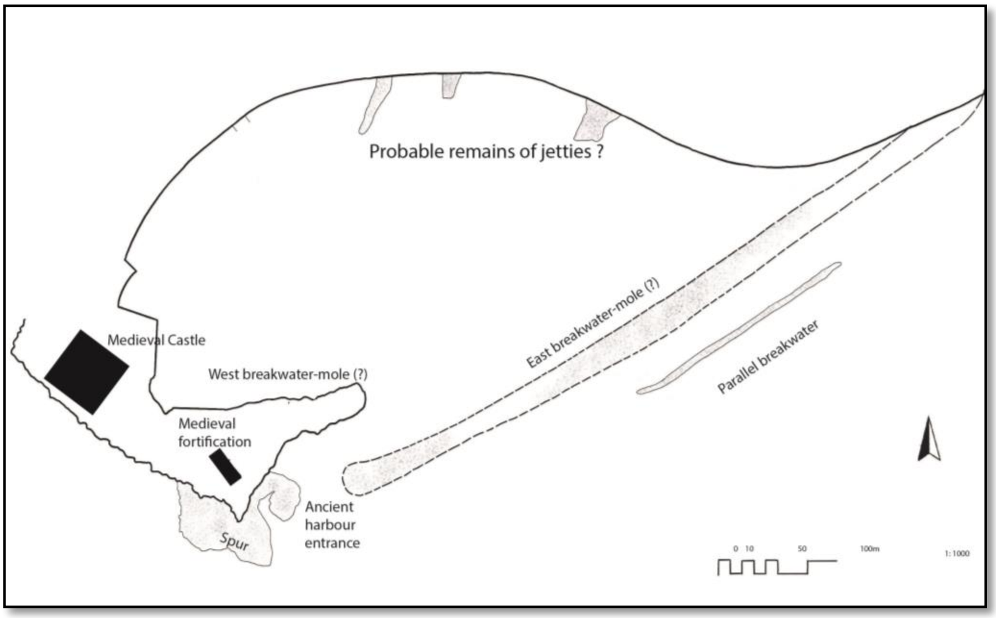


Figure 3.3 : Plan of the ancient remains of the harbour (J. & A. Gatt 2021, after Hohlfelder 1995 : fig. 3).

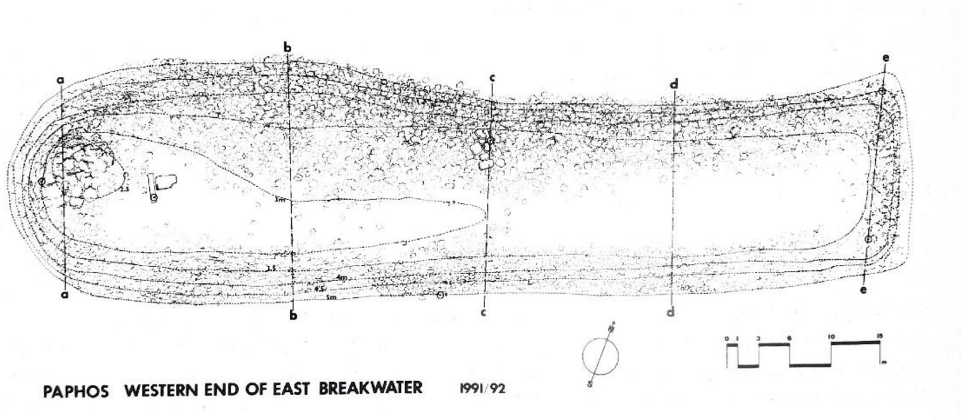
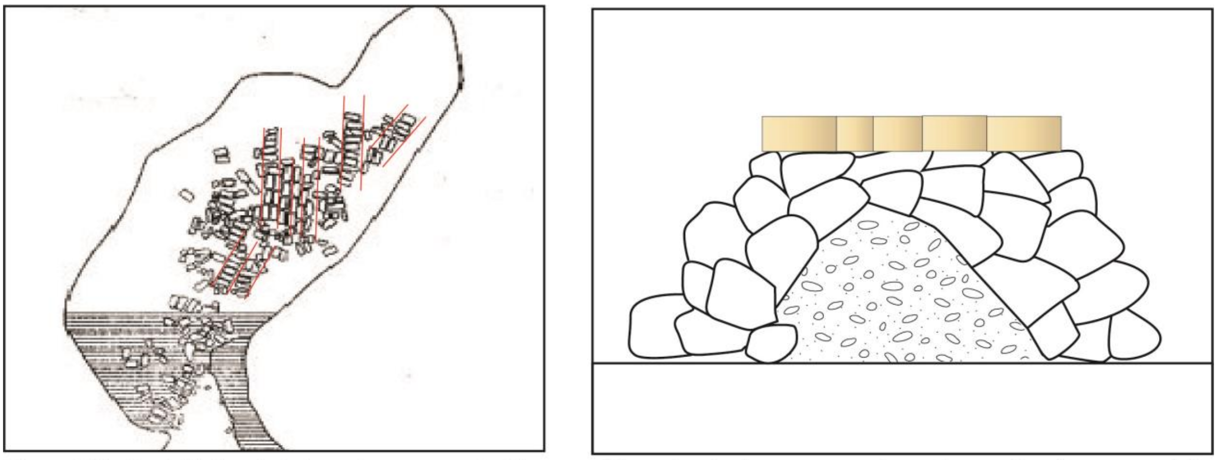


Figure 3.4 : Plan of western end of east breakwater-mole (?) (Hohlfelder 1995 : fig. 4).

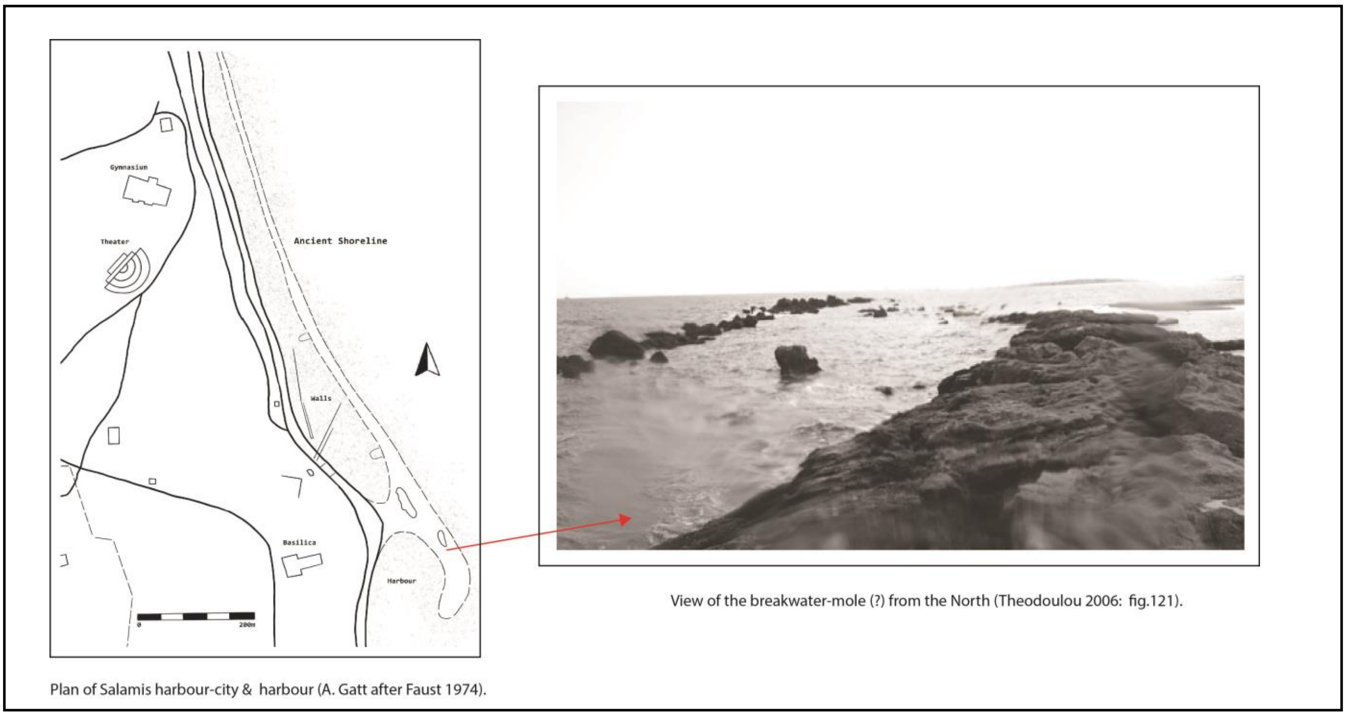


Plan of Marion's Hellenistic breakwater-mole (?) remains. In red rows of blocks identified. (edited by J. Gatt 2021 after plan made in 1960 by the Department of Antiquities.

Hypothetical reconstruction of a section (not to scale) based on Theodoulou's observations (2006: 103-109) and the plan of the Department of antiquities (1960). (J. Gatt 2021).

Figure 3.5 : Plan of Marion's hellenistic breakwater-mole (?) by Department of Antiquites (1960) and hypotethical section of the breakwater-mole based on Theodoulou's observations (J.Gatt 2021, after Theodoulou 2006 : 103-109).

Salamis, preserves a man-made breakwater-mole in the south harbour which is estimated to have been 250 meters long (**Fig.3.6**). During Theodoulou's fieldwork, a preliminary study of the structure was conducted. Most probably as a foundation level a reef was used on the north extremity and to the south a rubble foundation. The breakwater was built of large boulders positioned in a tilting direction to lower the dynamics of the waves on the seaward side, while the mole (on the leeward side) had a vertical profile made out of ashlar blocks whose gaps were filled with small stones (Theodoulou 2006: 175-184 ; Raban 1995: 163-164 ; Flemming 1974: 166-167). No joints have been attested which indicates probably a dry construction* (**for more information see Catalogue entry XI**).



Plan of Salamis harbour-city & harbour (A. Gatt after Faust 1974).

View of the breakwater-mole (?) from the North (Theodoulou 2006: fig.121).

Figure 3.6 : Salamis breakwater-mole (?) location (J. Gatt 2021).

Carpasia's preserves a quay (?) and a mole **(Fig.3.7)**. The quay (?) is located at the north-east side of the natural basin on the north side of the south promontory and has an approximate length of 100 m and a width of 3 m. It was built with ashlar blocks of an average dimension of 1 m (length) X0.5 m (width) X0.5 m (height) which were connected with metal clamps. On the southwest side of the bay the remains of a mole 120 meters long are preserved, built partially on a rocky formation that stretched from the islet towards the land. The ashlar blocks are connected again with clamps. Based on the photos taken by Theodoulou of the southwest mole and north-east quay(?) it seems that both stretchers and headers were used for the construction. Stretchers were used on the outer face while headers in the interior (Theodolou 2006: 222-229). Nevertheless, this pattern is only identified through photos taken by Theotokis Theodoulou **(for more information see Catalogue entry IV).**

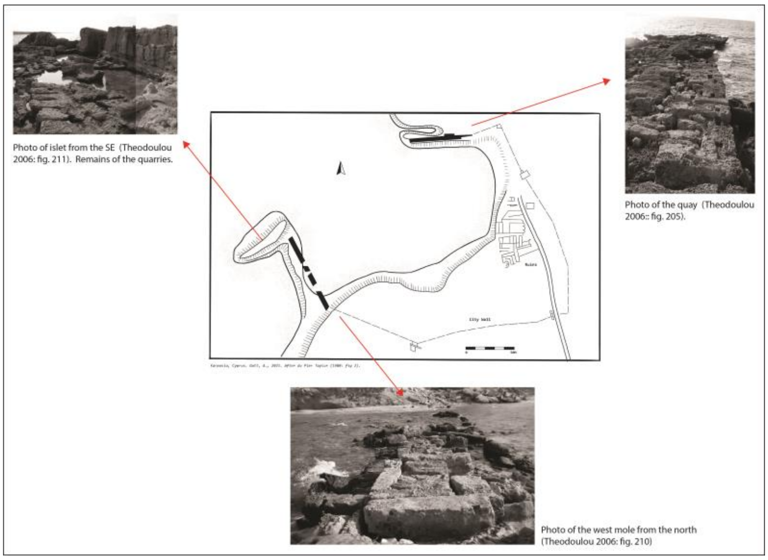


Photo of islet from the SE (Theodoulou 2006: fig. 211). Remains of the quarries.

Photo of the quay (Theodoulou 2006:: fig. 205).

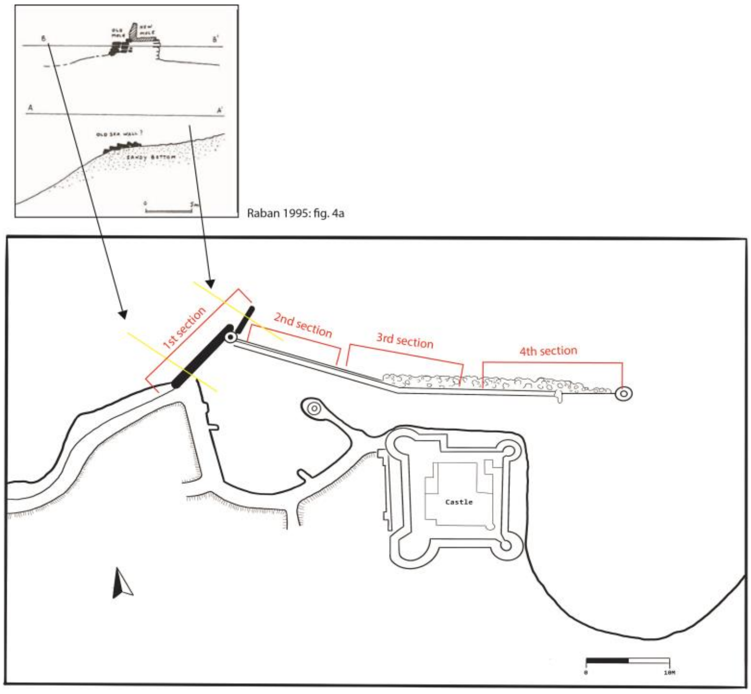
Photo of the west mole from the north (Theodoulou 2006: fig. 210)

Figure 3. 7 : Location of harbourworks of Carpasia (Taylor du Plat 1980 : fig.2 ; Theodoulou 2006 : fig. 205, 210, 211).

Lapithos preserves two moles. The north mole was 155 meters long with a width of 10 meters while the south mole was 40 meters long (**VIII-Fig 3**). A foundation of rubble of a width of 50 m was used that narrowed up to 30 m on its upper area. The south mole had a width of 3.6 meters that was built with ashlar blocks (Raban 1995: 165; Nicolaou 1966: 98 ; Nicolaou and Flinder 1976: 135 ; Theodoulou 2006: 198-202). Raban and Linder identified two building phases in the north mole. The first one is described as a careful construction with ashlar blocks related to the so-called Phoenician technique, while the second phase was dated to the Roman period and is attested through scattered ashlar blocks 1.5 (length) X1.5 (width) X1.5 (height) m. Mortar was also identified on the south mole. No arguments to support the distinction of these two construction phases have been presented (Raban 1995: 165 ; Theodoulou 2006: 200) (**for more information see Catalogue entry VIII**).

Kyrenia's east harbour preserves the remains of a breakwater-mole (?). The breakwater-mole (?) started from the coast (west of the medieval castle) with a direction to the north and then extended towards the east creating an angel. The breakwater-mole (?) was divided into four sections according to Raban (first section 80 meters long with a SN direction, second section 130 meters long with a WE direction, third section 170 meters long with a WE direction, and the fourth section 120 meters long with WE direction) (**Fig. 3.8**). This sectorization of the breakwater is based on the fact that probably the ancient harbour structure was built on a reef which did not follow a linear and continuous direction. Understanding the construction of the harbourworks of Kyrenia is a complicating task since the harbour of Kyrenia underwent significant additions in the 19th-20th century. Raban and Linder had identified ancient remains, at the first section of the breakwater-mole (?) on the seaward side of the current breakwater-mole consisting of a series of ashlar blocks of an average dimension of 0.6(length x 1(width) x 2.3 (height) m that dated according to Raban to the Roman or Medieval period. In the second section, a so-called "flat platform" made out of headers of dimensions 0.6 (length) x0.5 (width) x2m (height) built on top of beachrock. Its lenght is estimated to have been around 40 meters and its width 12-15 m. This is thought to have been the mole that extended along the ancient breakwater. On the third part of the north breakwater-mole (?), an ancient « sea wall » probably referring to the breakwater was documented by Raban without explaining its consistency. No reference to the binding material was made (Raban 1995: 166 ; Theodoulou 2006: 185-196) **(for more information see Catalogue entry VII).**

Soloi's visible remains of the ancient harbour structures consist solely of the west and east mole that formed the entrance of the harbour. The east mole's length is estimated to be not more than 110 meters, while the west mole extends towards the sea for more than 80 meters long (**XII-Fig. 3**). They were built with ashlar blocks whose average dimensions consist of 0.6 (length) X 0.6 (width)X2(height) m (Nicolaou 1966: 98 ; Raban 1995: 165; Theodoulou 2006: 206-210). No further information has been published on the foundation, and joints of the moles of Soloi's harbour (**for more information see Catalogue entry XII**).



Raban 1995: fig. 4a

A. Gatt, after Raban 1995: fig. 4b

Figure 3.8: Representation of the breakwater-mole (?) of Kyrenia (plan & section) based on Raban (1995: 167).

Concerning, **Kourion**, the only survivng harbour structure is a breakwater (?) (**VI-Fig.2**) around 80 meters long with a north-south orientation divided into two parts by a 3 m wide channel (considered to be created by the sea). The first part is around 68 meters long with a 12 meters width, while the second part had a length of 30 meters with the same width as the first part (Leonard 1995: 238 ; Leonard 2005: 562-565). The construction of the breakwater (?) is described by Leonard (2005 : 562) as built of « squared and amorphous stones » which probably indicate two construction phases (**for more information see Catalogue entry VI**).

Till nowadays no rock-cut harbourworks have been attested on the island. Solely, two examples of rock cut installations (**Fig**. **3.9**) (on the beach) found in Maniki and Ourania remain uninterpreted however these in any case are not included in the category of harbour structures but of harbour facilities (perhaps). Maniki preserves according to Hadjisavvas a rock-cut ramp facility which he interpreted it as a shipshed (Hadjisavvas 1995, 95). However, no in detail documentation of the rock cut installations has been conducted to support this theory yet. In Ourania, unidentified carvings similar to those of Maniki were found with a width of 0.6-0.7m and a depth of 0.10-0.15 m. These carvings are parallel to the shore and have a distance between each other of 1m. The published measurements of theses rock-cut carvings do not allow their interpretation as shipshed installations (Theodoulou 2006: 215-216, 220-222).

Figure 3.9 : Rock-cut « installations » in Maniki (above) and Ourania (below) (Hadjisavvas 1995 : fig.10 ; Theodoulou 2006 : fig.194).

No ancient harbour sites of the Classical and Hellenistic period in Cyprus preserve wooden harbour structures (i.e. wooden jetties) however this does not mean that no such structures existed. In antiquity, Cyprus had ample of wood according to ancient sources (Strab. Geo. XIV.6.5 ; Hauben 1987 : 217-222) and therefore its rational to consider the possibility of existence of such structures. For instance, wooden structures dating to more recent periods are attested in photos taken in the 19th century (especially those of the Coode and Partners company). A jetty (most probably wooden) was referred to in the description of Pietro Casola dating to the 15th century AD in the harbour of Limassol (Marangou 1997 : 229). Today the remains of a 19-20th century wooden jetty remain visible in the modern marina of Limassol. A similar example of a wooden jetty is also referred to in the harbour of Larnaka by travellers of the 19th century (**Fig. 3.10**) (Panayiotou 2013 : 95).

Having completed the brief presentation of the harbour structures of the island of Cyprus (**for more information on the ancient harbours of Cyprus see Catalogue entry I-XII**) one wonders how were these structures built. What kind of machinery had been used ? The only reference ever made to the machinery that may have constructed the ancient harbours of the island was made in the framework of the recent publication of Amathus (Empereur et al. 2018a: 87-91). Kozelj proposed for the construction of Amathus harbour a machinery used for the lifting and positioning of the blocks. According to his estimations the machinery must have been as wide as the mole and consisted of a jib (crane) which functioned by the block and tackle system (which consisted of two or more pulleys connected with ropes that were used to lift heavy objects) and advanced on the mole with rollers (**III-Fig. 10**). The machinery was based on the idea of counterweights which means when a block was carried by the jib another block on its rear was set so as not to leave the machinery fall forwards with the weight of the block that was being lifted. This hypothesis is based on existing ancient literature that describes such kinds of machinery (i.e. barulkos in the writings of Hero of Alexandria 1st century AD) (Papadopoulos 2007: 4, 6, 12). Regardless the interest of this proposition this machinery has left no imprint and therefore many questions remain unanswered.

Figure 3.10 : Construction of wooden jetty at the harbour of Larnaka in the early 20th century (Marangou 1997 : 219). Photo taken by Coode & Partners.

Did the jib function in water ? Where there more than one jibs working simultaneously ? What was the direction of the jib ? How were the boulders of the breakwater placed ? The only evidence that we have of the existence of a lifting machinery (**Fig. 4.23 ; Table 4.2**) are the lifting mortises as also the areas where a miscalculation in the placement of the blocks is attested through the so-called quinxem pattern (i.e. Sondage A) (**III-Fig7**). Regarding the latest it is an interesting fact that may indicate the orientation of the jib. How did this miscalculation happen to take place ? Perhaps two jibs were working on the mole with opposite directions and once these reached a meeting point, the quinxem pattern was formed ? To assure that this is the case, a more detailed survey should be conducted along the south mole (Empereur et al. 2018a : 43, fig.12). Unfortunately, for the rest of the harbours no traces of machinery has been found.

3.2 A PARALLEL STUDY OF THE HARBOUR CONSTRUCTION TECHNIQUES OF CYPRUS, THE AEGEAN AND THE LEVANT.

Having presented the harbour structures of the island of Cyprus it is possible now to proceed to a collective study of the harbour construction techniques identified in Cyprus, the Eastern Mediterranean and the Aegean (**Map 3.1**). This parallel study aims in brining foward the harbour construction techniques of the Classical and Hellenistic harbourworks which will enable the identification of the existence or not of a local character in the harbour works of the island and second to understand on which grounds the *Greek and Phoenician tradition* can be addressed for the harbourworks of the Classical and Hellenistic period.

Map 3.1 : Location of harbours under study in the Aegean and the Eastern Mediterranean (J. Gatt 2021, after www.bingmaps.com).

To study the harbour construction techniques each harbourwork was divided into two levels. The foundation level and the upper structure. Sub-categories for both sections were created to describe in detail the different techniques identified in the structure (**Table 3.1**). Therefore, the foundation level was divided into four sub-categories: natural, man-made, mixed and absence of foundation level while the upper structure was also divided into three general categories: ashlar, rock-cut and rubble construction. These three were subsequently divided into sub-groups. For the rubble two general categories (**Table 3.3**) were formed mound and composite rubble construction (CIRIA et al. 311) while for the ashlar construction a more detailed classification was possible based on the point of view of study of the structure lateral side of the structure (masonry) and section (**Table 3.4**). Unfortunately due to lack of a detailed study of the rock-cut structures no sub-groups were formed for this sub category.

RUBBLE	ROCK-CUT	ASHLAR	MIXED
UPPER STRUCTURE			
NATURAL	MAN-MADE	MIXED	ABSENCE
FOUNDATION			

Table 3.1 : The sub-division of the two levels (foundation and upper structures) of the harbour structures (J.Gatt 2021).

3.2.1 The foundation level

The foundation level consists an integral part of the structure which supports the upper structure (i.e. breakwater, mole, quay). Its main purpose is to provide a solid and stable foundation. There are four main categories of harbour structure foundation levels that have been identified in the area under study (**Table 3.2**). A) Man-made foundation (i.e. rubble, gravel) B) Natural Foundation (i.e. reefs), C) Absence of a solid foundation (muddy sandy foundation) and D) Mixed foundation type (man-made and natural).

Man-made foundation

Beginning with the harbour structures with man-made foundation the use of rubble which consists either of large boulders with gravel or a mixture of materials combining boulders and pottery sherds seems to be the common trend. Since the study of the lower part of the structure is always challenging due to visibility and preservation issues, the descriptions given are rather general.

Elaia's west breakwater-mole (**XVIII-Fig. 2**) consisted of a foundation of « stone debris, broken bricks and ceramics ». The foundation had a width of nearly 8 m and a height of more than 2 m (Seeliger et al. 2013: 72). Myndos (breakwater-mole and quay), Halicarnassus (breakwater) and Cnidus (breakwater-mole) harbour stuctures had all a similar foundation of rubble. In

Cnidus the rubble was placed at a depth of 30 m on a sandy seabed (**XIX-Fig.2**). It was around 50 m wide at its bottom and narrowed upwards to 20 m (Blackman 1982: 196, 198 ; Büyüközer 2012: 44,46-47). The rubble foundation of Myndos Asar island quay was around 12 m high (Dumankaya et al. 2016: 26). Lesbos harbours of Mytelene (**XXIV-Fig.2**), Mythimna, Antissa and Eressos also used rubble as a foundation level when natural formations weren't available. However, no detailed description of the foundation's height, has been published (Theodoulou 2011 : 93-102 ; Theodoulou & Kourtzellis 2019 : 88-152). Piraeus (M-FM1) Mounichia's mole revealed that the rubble foundation consisted of irregularly shaped stones on a compact clayish sediment mixed with pebbles (Loven & Nielsen 2011: 236-237 ; Loven & Nielsen 2019 : 172). Delos' quays were also built on a foundation of rubble as also the south extremity of the north breakwater seems to have had a layer of gravel 80-50 cm which was then followed by the upper structure consisting of granite blocks (Duchene et al. 2001: 67-68 ; Mazarakis 1992: 16-17). Thasos commercial harbour mole had a 1 m high foundation level consisting of boulders (of 2-5 kg) of schist and marble mixed with ceramics (Empereur et al. 1993 : 647-648 ; Kozelj & Kozelj 2000: 33-34). Aigina's moles of the naval harbour were also laid on a foundation of amorphous stones of 1 m height (Mourtzas & Kolaiti 2013: 419).

In Cyprus several harbour structures were built entirely or partially on a rubble foundation. Salamis east breakwater-mole (Theodoulou 2006: 180 ; Raban 1995: 164), Lapithos moles (approximately a foundation of 50 meters wide) (Theodoulou 2006: 200), Carpasia's southwest mole was most probably partially built on a rubble foundation (Theodolou 2006: 226) while Nea Paphos breakwater-moles (?) may have also been built on a foundation of rubble, although this remains difficult to support archaeologically since the ancient west breakwater-mole (?) is buried under the modern breakwater-mole (Theodoulou 2006 : 139). Marion's breakwater-mole (?) too seems to have had a man-made foundation to compromise for the areas where the reef didn't reach. Interestingly, for the case of Marion, according to recent cut in the ancient structure, it seems that the foundation of rubble had two layers an inner layer consisting of amorphous stones followed by a layer of boulders (Theodoulou 2006 : 103-109).

Natural foundation

The use of natural foundation such as beachrock and reefs was also attested, sometimes accompanied by an artificial foundation (i.e rubble. In Caesarea Maritima, the Hellenistic quay was built on a rocky formation (Raban 1981: 293). Thasos archaic west mole of the naval harbour was built on a foundation of beachrock (Empereur & Simossi 1988: 736-742). Lesbos, moles of Antissa and Mythimna were both partially resting on reefs (Theodoulou 2011: 97-98) while the Evnostos harbour breakwater-mole (?) at Alexandria was also located on a reef (Belov 2019 : 8-9) as also Delos quay in some areas (Duchene et al. 2001: 53 ; Mazarakis 1992: 14-15).

Concerning Cyprus, the use of natural formations as a foundation level was also identified. In Carpasia's southwest mole's south extent a reef was used as a foundation level (Theodoulou 2006 : 226), Marion's Hellenistic breakwater-mole (?) partially rested on a reef (Raban 1995 : 165), Kyrenia's breakwater may have also been partially built on a rocky foundation according to the observations of Raban and Linder (Raban 1995: 166 ; Theodoulou

2006: 185-196) as also Salamis east breakwater seems to have been based partially on a reef (Theodoulou 2006: 175-184). Dreamer's Bay breakwater north extremity was built on a solid sea-bed of marl (Blue et al. 2019).

Mixed foundation

The following sites though seem to use both a natural and a man-made foundation Delos, Mythimna and Antissa in Lesbos, Marion, Carpasia and Salamis as also Thasos. Interestingly, this combination of types of foundation levels has been attested for the time being only on islands.

Absence of foundation

The last category consists of an absence of a foundation level. These seem to be the harbour structures of Alexandria (this remains unclear in the publication of Fabre & Goddio 2010), Dreamer's bay south extremity of the breakwater (Blue et al. 2019) and Amathus harbourworks (Empereur et al. 2018a : 33-61) were directly built on a non solid foundation. Specifically, Amathus sondages indicate a natural sandy foundation, although it remains unclear if the foundation of pebbles and gravel (c. 0.20 cm high) on a level of mud attested only on the west mole can be considered as a solid man-made foundation level (Empereur et al. 2018a : 33-38, 57). Dreamer's Bay breakwater to the south attests no solid foundation (Blue et al. 2019). Only at the jetty of Mytelene's euripus since the structure was placed on a sandy foundation wooden poles along the structure were placed as a probable preventive measure for the process of liquefaction (Theodoulou & Kourtzellis 2019: 102-106, 116-118). Blackman (1978: 196-197) enlists also in this category of breakwaters with no solid foundation, among others the breakwater of Cnidus. Cnidus breakwater-mole was constructed at a depth of 30 m and therefore a breakwater-mound was built on which the upper structure was then laid. Due to the significant depth this breakwater-mound can be considered as a foundation level. Regarding Cyprus, Amathus and Dreamer's bay harbourworks were located at a shallow depth in comparison with that of Cnidus and therefore the lack of foundation cannot be considered due to practical issues but perhaps due to a rush in building the structure.

Despite this effort to describe the different types of foundation level many of the harbours under study did not possess published information on the foundation level since many remain unexcavated or documented on a preliminary level These harbours are Seleucia Pieria, Taposiris Magna, Rhodes, Eretria, Aigina, Thasos naval harbour mole's, Cantharos moles, Kourion and Tyr.

This classification indicates that the ancient builders acknowledged the importance of the construction of a solid foundation prior to the construction of the upper structure. It has underlined the fact that our knowledge on the foundation level of the harbour structures remains limited. What sizes and kind of stones were used for the construction of the man-made foundation level. Was there a stratigraphy in the rubble foundations as attested today in modern harbour engineering ? These questions remain to be answered, hopefully through future documentation.

MAN MADE FOUNDATION	NATURAL FOUNDATION	MIXED (MAN-MADE AND NATURAL)	ABSENCE OF FOUNDATION
Salamis	Dreamer’s Bay	Salamis	Dreamer’s bay
Lapithos	Marion	Carpasia	Amathus
Carpasia	Carpasia	Marion	Alexandria
Nea Paphos (?)	Kyrenia	Thasos	
Marion	Salamis	Delos	
Elaia	Thasos	Antissa	
Myndos	Delos	Mythimna	
Halicarnassus	Antissa		
Cnidus	Eressos		
Mytelene	Caesaria		
Mythimna			
Antissa			
Eressos			
Piraeus-Munichia			
Delos			
Thasos			
Aigina			

Table 3.2 : Classification of harbourworks based on their foundation level (J. Gatt 2021).

3.2.2 The Upper structure

Rubble construction

Rubble structures* can be divided into two categories, horizontal composite and mound breakwaters. Mound breakwaters are till today the most commonly used form of breakwater. They have a trapezoidal shape in cross-section that facilitates the breaking of the waves. Horizontal Composite breakwaters are breakwaters that are placed on the sea-ward side, usually of a mole, in a tilting position (CIRIA et al. 2007: 793-802) Eretria (**XXXVIII-Fig.2**), Kourion, Lapithos, Aigina's north and south breakwater and Delos represent the mound breakwater while Amathus and perhaps also Mythimna (breakwater-mole (?), Nea Paphos, Marion, and Salamis represent the composite breakwater. A question that remains to be answered is. Was there a stratigraphy of the breakwater as today in modern engineering (CIRIA et al. 2007 : 780,789)? We may sometimes consider that these breakwaters were the result of simply dumping blocks in the water. However, to create a functional rubble structure greater care must have been taken. For instance Delos breakwater was built first with a layer of gravel 80-50 cm (as a foundation level) followed by granite blocks (Duchene 2001: 67-68, 92-93).

RUBBLE CONSTRUCTION	
HORIZONTAL COMPOSITE CONSTRUCTION	MOUND CONSTRUCTION

Table 3.3 : The subdivision of the rubble construction (J.Gatt 2021).

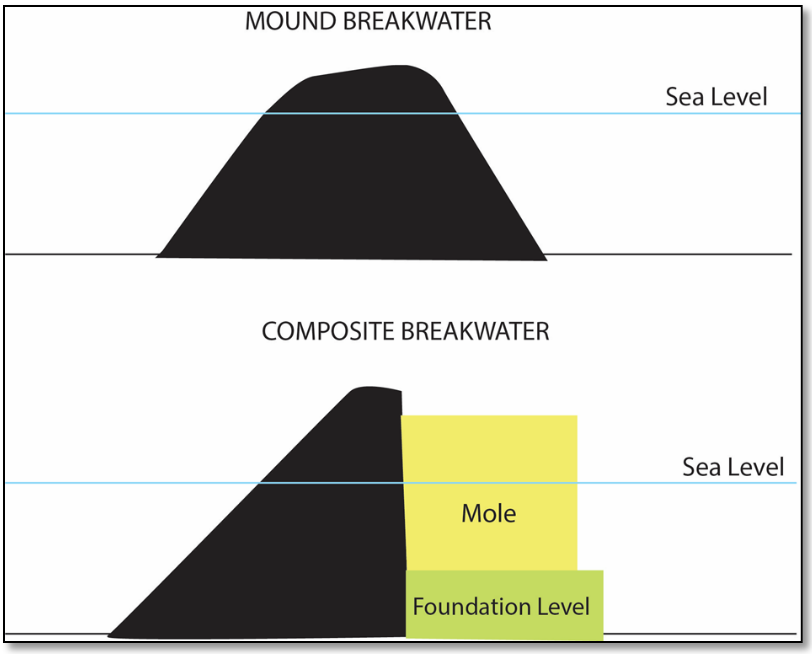


Figure 3.11 : Demonstration of the difference between a mound and composite breakwater (J. Gatt 2021, after CIRIA 2007 :781).

Such structures are identified solely in the Aegean and Cyprus. Although no such structures seem to have ever existed along the Levantine coast, in the Western Mediterranean this practice was attested in the Punic world (i.e. Sabaratha) (**Fig. 3.12**) (Carayon 2008: 382). As Carayon's PhD thesis concluded, most basins (85%) on the Levantine coast were located in naturally protected bays (i.e. river-mouths, pocket bays, and headlands) which did not demand any large scale artificial structures (Carayon 2008: 682-689).

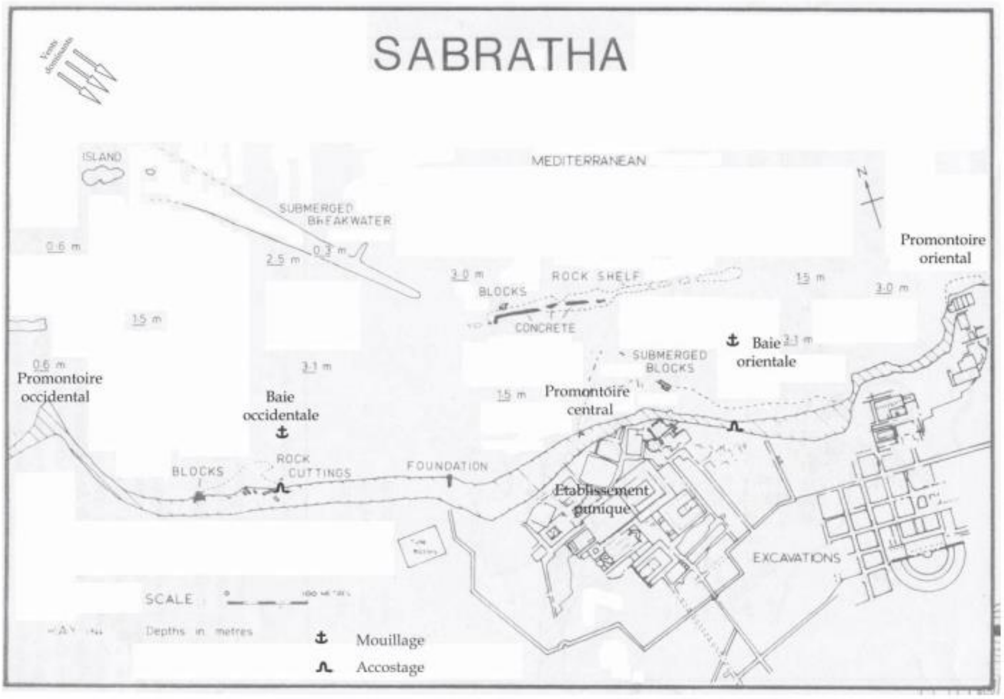


Figure 3.12 : Plan of Sabratha's submerged structures (Carayon 2008 : 1078, Fig. 59.02 ; Yorke 1986).

Rock-cut harbourworks

Rock-cut harbour structures have been identified in Alexandria's Mega's Limen. In the so-called fourth harbour basin in the area of the «Yacht club centre and the Ball trap sector » a rock-cut structure whose location and nature hasn't been specified was located (Goddio and Fabre 2010 : 59-62). In Cnidus, the quays found in the commercial harbour were also rock-cut (Büyüközer 2019: 220) (**XIX-Fig.3**). This technique was mainly identified along the rocky Levantine coast (i.e. Arwad, Zire and Batroun) (Carayon 2008 : 275, 277, 278, 659).

Ashlar Construcion

The ashlar construction has been divided into two categories as stated above to understand in the integrality the upper structure (**Fig.3.4**).

ASHLAR CONSTRUCTION	
A. LATERAL VIEW OF THE UPPER STRUCTURE (MASONRY)	B. SECTION OF THE UPPER STRUCTURE
I. PSEUDO-ISODOMIC MASONRY	I. ASHLAR PIERS IN RUBBLE WALLS WITH HEADERS/STRETCHERS

II. ISODOMIC MASONRY	
III. POLYGONAL MASONRY	II. HEADERS WITH A CORE OF STRETCHERS OR VICE VERSA
IV. IRREGULAR ASHLAR MASONRY	III. SINGLE OR MULTIPLE ROWS OF HEADERS/STRETCHERS
V. MASONRY WITH STACKED JOINTS	

Table 3.4 : The ashlar construction subdivision in two categories (Masonry and Composition) (J.Gatt 2021).

Latteral side of the upper structure (Masonry).

The masonry of the structure refers to the patterns identified in the façade of the structure. A variety of masonry techniques have been identified (**Fig.3.13**).

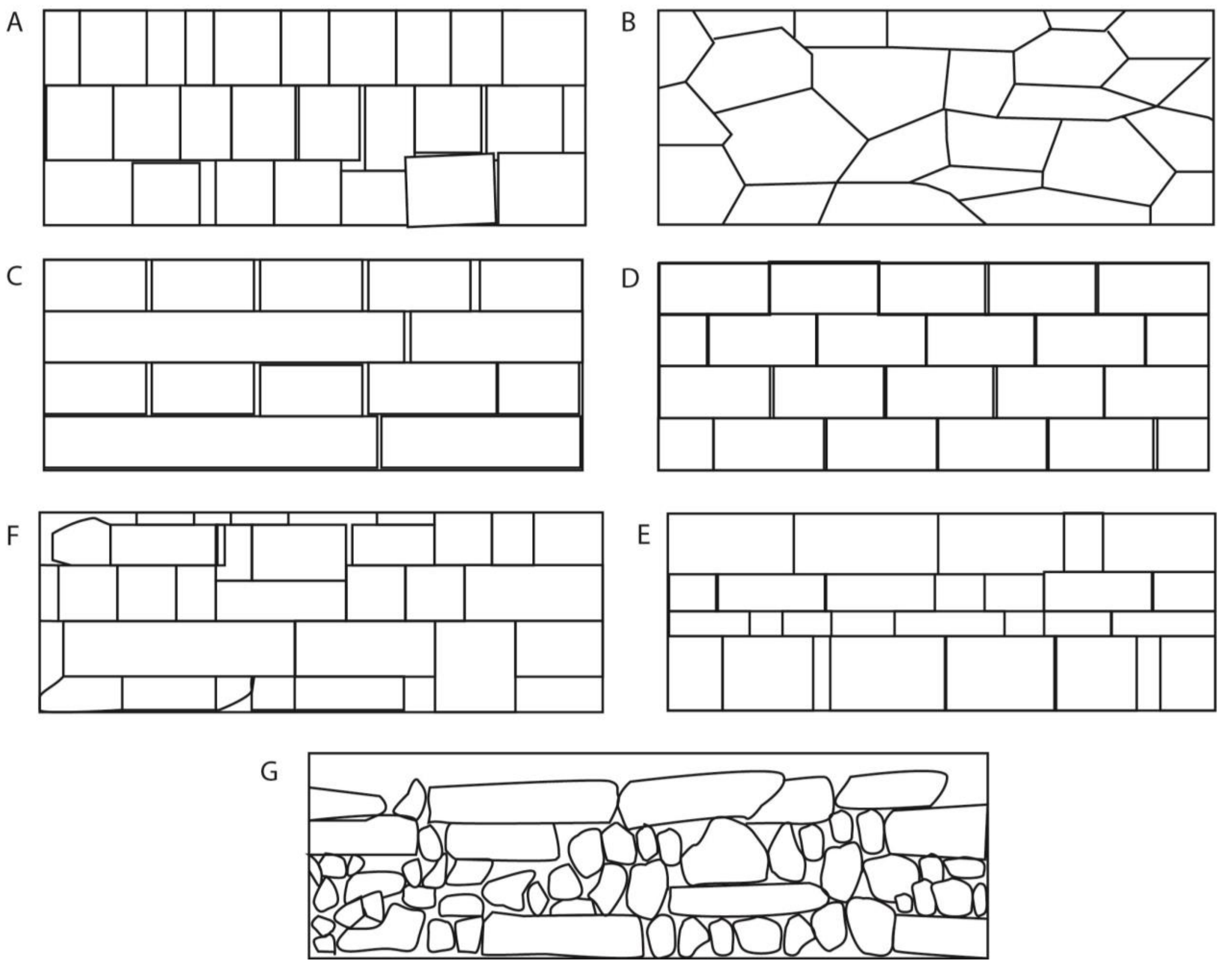


Figure 3.13 : Types of masonry applied in the upper structure (J. Gatt 2021).

I. **Polygonal masonry** (**Fig.3.13 B**) consists of the use of stones that have more than four sides (Ginouves & Martin 1985: 97). This masonry has been identified in the upper structure of the breakwater in Delos (**XXIII-Fig.3**), Antissa and Eressos (**XXIV-Fig. 5,6**). Once again this unique characteristic seems to be attested solely on islands, although the polygonal masonry has been identified in fortifications of the Aegean (islands and mainland) (McNicol 1997). Delos polygonal masonry in the north breakwater is identified on the south extent of the structure (Duchene 2001: 67-68, 92-93) while Lesbos polygonal masonry in Antissa and Eressos may have been probably part of the fortification walls that extended on the rubble foundation, although this remains unclear (Theodoulou and Kourtzellis 2011: 129-148). For this construction no joint or material was used.

II. **Pseudo-isodomic masonry** (**Fig.3.13 D**) is characterized by courses of irregular height built with alternating stones of irregular dimensions while **isodomic masonry** (**Fig.3.13 E**) is characterized by courses of equal height built with stones of equal dimensions (Ginouves & Martin 1985: 98-99). Mytelene's and Mythimna's moles were constructed with isodomic masonry (**XXIII-Fig. 2 & 4**) while Myndos (**XXI-Fig. 2**) and Cnidus seem to apply pseudo-isodomic masonry (Dumankaya et al. 2016: 14-21 ; Büyüközer 2012: 44,46-47). The pseudo-isodomic masonry identified in Nea Cnidus resulted into the formation of a trapezoidal profile of the structure otherwise known as a *crepidoma* (Robertson 1929 : 90). With this masonry the use of clamps has been attested at all structures (except the east mole of Mytelene's north harbour).

III. **Irregular ashlar masonry** (**Fig.3.13 F**) consist of courses of blocks that are irregular and alternate the joints along each course in an inconsistent manner (Ginouves & Martin 1985: 99). This was attested in Thasos naval harbour east mole (**XXVI-Fig. 5**), and Seleucia's Pieria south mole (**XVII-Fig. 2**). In Taposiris Magna's mole (**XIII-Fig. 3**) the courses preserve an irregular pattern. Every course of stretcher is followed by a course of headers which is followed by a course of alternating blocks of stretchers and headers (Boussac 2009: 131). For this masonry, in Thasos clamps have been identified, mortar in Taposiris Magna and in Seleucia Pieria, dry construction.

IV. **Headers staggered between courses** (**Fig.3.13 A**) is the technique that seems to be identified on the only documented harbour structures of the island of Cyprus. This masonry includes rows of headers (relatively equal in size) whose vertical joints are staggered each time by half a header (Sharon 1987: 24). This has been attested in Dreamer's bay mole (**I-Fig.4**) and Amathus mole's (**III-Fig. 7**). For the rest of the harbours of Cyprus their masonry hasn't been documented, and therefore we have no information on the subject. Concerning the binding material no evidence has been found on Dreamer's bay mole while concerning Amathus along the south mole evidence of clamps was identified although not documented in detail. Myndos, Caesaria Maritima and Delos quay probably can also be included in this category however since no published plans and sections have been published it remains difficult to consider.

V. A masonry consisting of **an alteration of courses of stretchers and headers** (**Fig.3.13 C**) was solely identified on the entrance area of the artificial harbour of Amathus. The joints used remains unclear. In the entrance a clamp was found therefore perhaps it may have belonged to this part of the structure.

VI. **Masonry with stacked joints** (**Fig.3.13 G**) has been solely identified in Thasos archaic mole (**XXVI-Fig.4**). This masonry consists of irregularly placed blocks and stones of different sizes and shapes and no courses are identified (Ginouves & Martin 1985: 97). Clamps were identified too with this masonry.

The section of the upper structure.

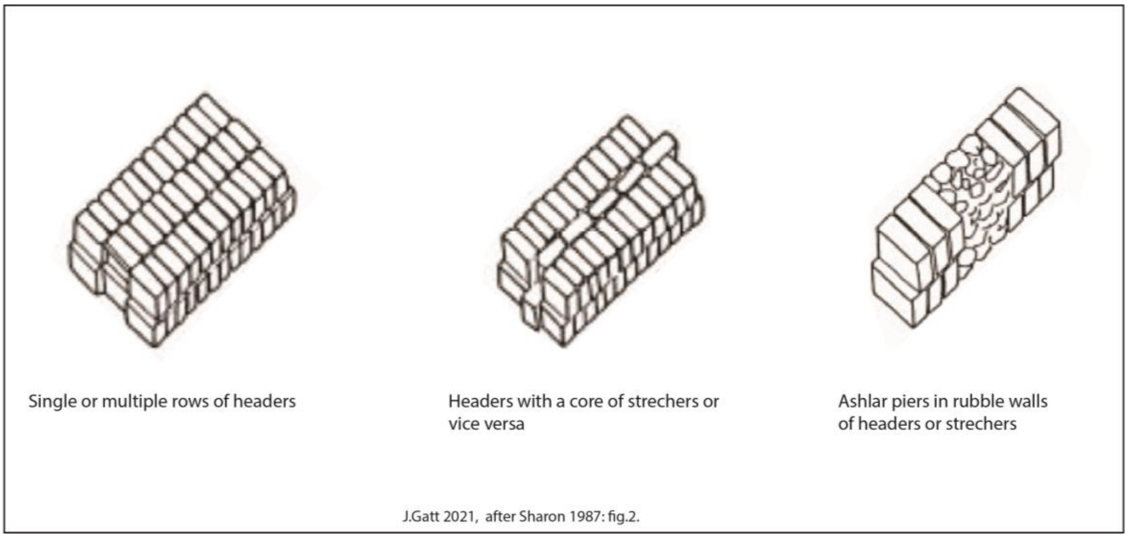


Figure 3.14 : The construction of the upper structure in section (J. Gatt 2021, after Sharon 1987 : fig. 2).

I. **Ashlar piers in rubble walls with headers or strechers** are identified in Thasos (**XXVI-Fig. 5**), Aigina, Evnostos harbour, Amathus, Taposiris Magna (**XIII-Fig. 3**), Mytilene, Mythimna, and Tyre (?) (**XV-Fig. 2**). All seem to be included in this category however with slight differences in between. Thasos commercial mole (Kozelj & Kozelj 2000: 33-34) consisted of two rows of blocks with a distance in between of around 18 m, however the nature of the filling remains unknown. Evnostos breakwater consisted of two walls (40-60 m apart) which in between were filled with gravel. Their distance almost corresponds to the width of a football ground pitch (Belov 2019 : 8-9). Aigina's north breakwater eastern section was also constructed with two parallel walls (Moutzas & Kolaiti, 2013: 414) however the filling between both structures and the distance in between has not been determined. Taposiris Magna mole was built by two parallel walls. In between it seems that a compact filling of earth seems to have been placed. The width of the jetty was around 6 m wide. Mytelene and Mythima seem to attest the same practice too. In Mytelene two parallel walls filled in between with debris and amorphous stones. Similar was attested in Mythimna (Theodoulou & Kourtzellis 2019: 88-100 ; Theodoulou 2011 : 95-97; Koldeway 1890: 3-16). Tyre's jetty remains in question since the U shape formation of walls I-III seem to correspond to this category however since a holistic understanding of the structures has not been undertaken we must with caution add the northeast mole (?) of the Sidonian harbour of Tyre to this category (El amouri et al. 2005 : 115-126). Amathus east and west mole also belong to this category. Single rows of headers were used to build the two walls however, interestingly Amathus seems to have preserved a stratigraphy of the filling. An alteration of a layer of small gravel, a layer of larger gravel and a final layer of small gravel was attested (Empereur et al. 2018a: 33-37).

II. **Headers with a core of strechers or vice versa** are identified in Carpasia (**IV-Fig. 4**), Rhodes (**XXII-Fig. 2**), Seleucia Pieria (**XVII-Fig. 2**) and Dreamer's bay (**I-Fig.5**). It seems that instead of the gravel fill, the heart of the structure consisted of strechers. From photos taken by Theodoulou of Carpasias quay above-mentioned mole it seems that strechers were placed in the exterior and headers in the interior. However, this must be confirmed on the field. Dreamer's bay mole (in the publication it is described as a breakwater but based on the terminology used in the framework of this study it is considered to be a mole) consisted on the outer sides of headers and inner part of strechers. Seleucia Pieria's south breakwater is made on the lower courses of, headers on the outer sides while in the centre of the structure, smaller blocks were used. "After a few courses" smaller blocks (headers) are used on both sides and in the middle larger blocks (strechers) (Parmi 2014: 193). Finally Rhodes, jetty (?) in the north-west harbour (now silted) (Konstantinopoulos 1986: 209) was contstructed with strechers on the outer sides and in the interior of the structure headers were placed. Here the majority attests a dry construction although in Carpasia clamps have been attested.

III. **Single or multiple rows of headers/strechers** are attested in Myndos Asar's island quay (**XXI-Fig.3**) (Dumankaya et al. 2016: 26), Caesaria's Hellenistic quay (**XVI-Fig. 2**) and Amathus south mole (**III**-**Fig.7**). These structures can be easily compared with the quays of Tyre, Athlit and Akko (**Fig. 3.15**) (Raban 1995: 154 ; Raban et al. 2009: 19). This masonry has been attested solely on quays and moles that are built along the shoreline or in well protected spaces. Amathus single row of headers was protected by the breakwater on its south side while, Myndos and Caesaria's quay were built along the coast. Here also solely dry construction has been attested although along the south mole of Amathus according to Empereur traces of clamps were identified however it remains unclear to which extent they are present.

Figure 3.15 : Rows of headers in Atliht mole (Raban 1995 ; Carayon 2008 : 1012, 31.04).

Rubble and Ashlar construction techniques

A **combination of techniques** on the same structures have been also attested in the cases of Delos and Aigina's breakwater. Aigina's north breakwater has been separated into three construction methods that correspond to three different sections. The eastern extremity consists of the ashlar piers in rubble walls with headers or strechers. The central area of the breakwater consists of simply rubble and the western end of the breakwater consists also of rubble of rounded stones (Mourtzas & Kolaiti, 2013: 414 ; Knoblauch, 1972: 63-72). Delos, north breakwater attests different construction methods (**Fig. 3.16**). To the north the area in front of the Maison au flanc de la Colline was constructed with ashlar blocks (headers). While to the south, two other methods of construction are identified that of rubble and thirdly polygonal masonry (Baika 2009: 431; Duchene 2001: 67-68, 92-93 ; Ardailon 1896: 430-431). The question here is: Do these different construction methods represent different phases of the structure's construction or do they reflect the prevailing dynamics that affect these large scale structures? Perhaps the use of rubble for the construction of a mound breakwater in certain sections may indicate higher wear or hydrodynamic impact (Knoublauch 1972 : 63-72 ; Frontini 2020: 45).

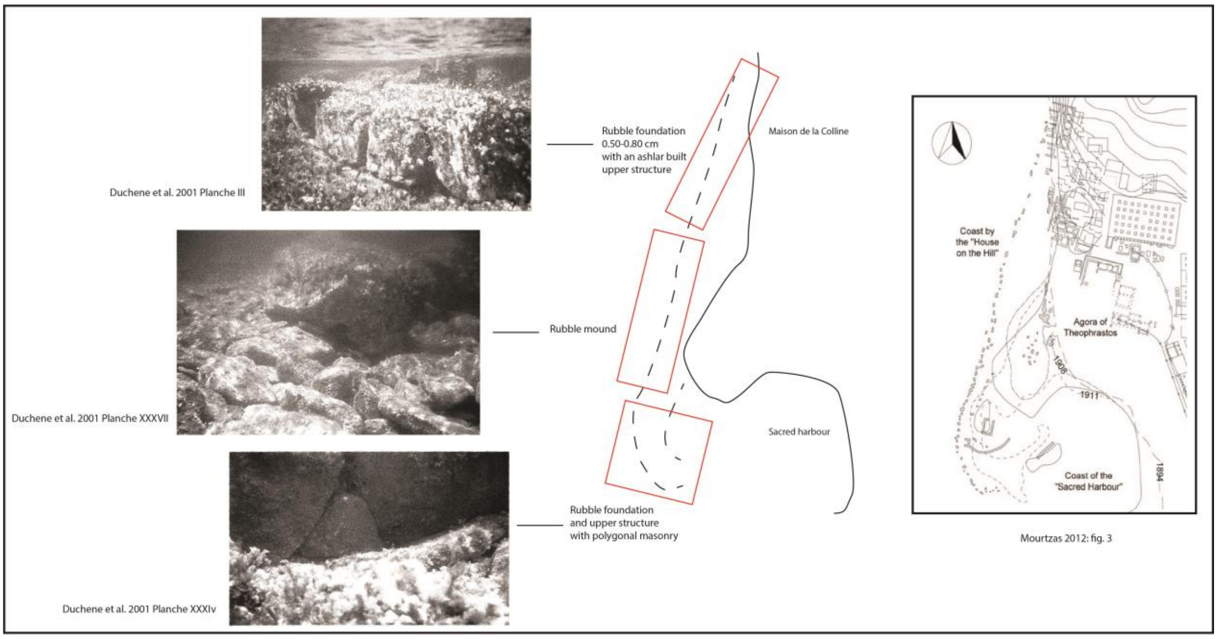


Figure 3.16 : Location of different construction along the Breakwater of Delos (J. Gatt 2021 ; after Duchene et al. 2001 ; Mourtzas 2012).

3.3 THE PHOENICIAN AND GREEK TRADITION, AND THE CYPRIOT HARBOURWORKS IN THE CLASSICAL AND HELLENISTIC PERIOD.

The exploration of this subject started with the characterization of the harbour structures of the island of Cyprus as a product of the *Greek and Phoenician tradition* (Raban 1995). Exploring the Classical and Hellenistic harbourworks identified in the Eastern Mediterranean and the Aegean contributed significantly in setting the right framework in which the harbourworks of Cyprus are adressed.

The Phoenician and Greek tradition define the first techniques applied in the early harbourworks of the Bronze Age and Archaic Period. The *Phoenician tradition* is carachterized by the rock-cut structures (seawalls and basins) and free standing ashlar built harbourworks placed on either rocky sea bottom or a layer of foundation (i.e. Tel Dor, Tabat el-Hammam), while the Greek tradition is affiliated with the use of rubble as a foundation level for the ashlar upper structure as also for the consrtuction of breakwaters (i.e. Delos and Samos archaic breakwaters) (Raban 1995 ; Blackman 1982 ; Coulon & Golvin 2020 : 21-23 ; Baika 2009 : 430-431). Out of the inconviniences of the coastline each geographical region mastered a certain technique which subsequently generated a tradition (Frost 1995: 6), the Greek and Phoenician.

Indeed some techniques continue to be more popular in the Levantine coast and Aegean respectivley also through later periods. Rock-cut structures prevail in the Levantine coast as few are the examples of rock-cut structures in the Aegean in the Classical and Hellenistic period (i.e. Cnidu's quays). Rubble mounds for the construction of breakwaters are very common in the Aegean while no such structure has been identified during this time in the

Levantine Coast. However, based on other « distinctive charateristics » when it comes to attributing a certain technique to one of the two traditions (as in the case of Cyprus) it becomes complicated to draw a line and identify sphere's of influence. For example, the use of natural (reefs) and artificial foundation (rubble) have been both attested in the Aegean (among many Delos, Lesbos, Cyprus) (see Catalogue entries) and the Levantine coast (i.e Akko, Tabbat el Hamam and Atliht) (**Fig. 3.17**) (Carayon 2008 : 649). In addition, although according to Raban the use of clamps is « typical of Classical Greek architecture » the presence of clamps is also attested in the harbours of the Levantine coast since the Archaic period (Persian period) **(Table 3.5).** Equally, the same construction techniques of the upper structure (from a lateral and section point of view) have been also widely implemented in the Aegean and the Eastern Mediterranean world.

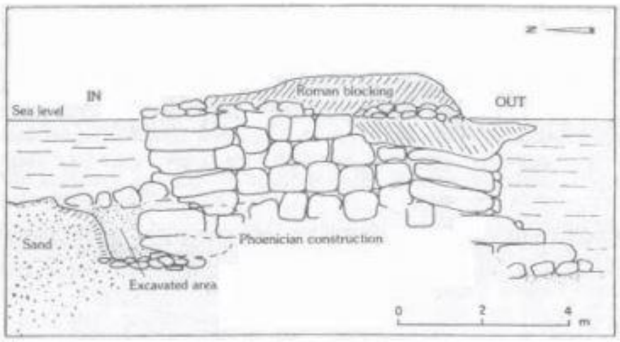


Figure 3.17 : Section of the mole of Akko indicating a foundation of pebbles (Raban 1993 ; Carayon 2008 : 1004 ,27.06).

LOCATION	STRUCTURE	DATE	BIBLIOGRAPHICAL REFERENCE
SARPETA	Jetty	Unknown	PRITCHARD, 1971 ; Carayon 2008 : 291-292
SIDON (Allenby road - chantier Bey 039)	Quay	Persian- Hellenistic	ELAYI et SAYEGH, 2000 Carayon 2007 : 270-272, 661
SIDON	East-mole	Byzantine ?	Carayon 2007 : 272 ; POIDEBARD et LAUFFRAY, 1951
ZIRE	South and North jetty	Persian-Hellenistic	Carayon 2008 : 281-285, 653 ; Renan, 1864 ; Poidebard & Lauffray 1951

CAESARIA MARITIMA	« wall » (?) south of hellenistic quay	Pre Roman times – Hellenistic	Raban 1989: 144-145

Table 3.5 : Example of clamps identified on harbour structures on the Levantine coast (J.Gatt 2021).

In an interesting article on the ashlar construction techniques identified at the terrestrial site of Tel Dor (from the Bronze Age to the Hellenistic period) the different potential technological influences were analysed (Sharon 1987). The author attempted to classify the different categories of ashlar masonry and then proceeded in comparing the techniques with those from the neighbouring civilizations (i.e. Greek, Persian). This led to the identification of common patterns in the Levantine Coast and the Aegean and rendered difficult its attribution to one of the two civilizations. As Sharon (1987 : 24-36) correctly stated « The fact that a single technique is found both in the local and the Greek building traditions does not seem to imply a connection between the two, since there is no way to explain such selective imitation ».

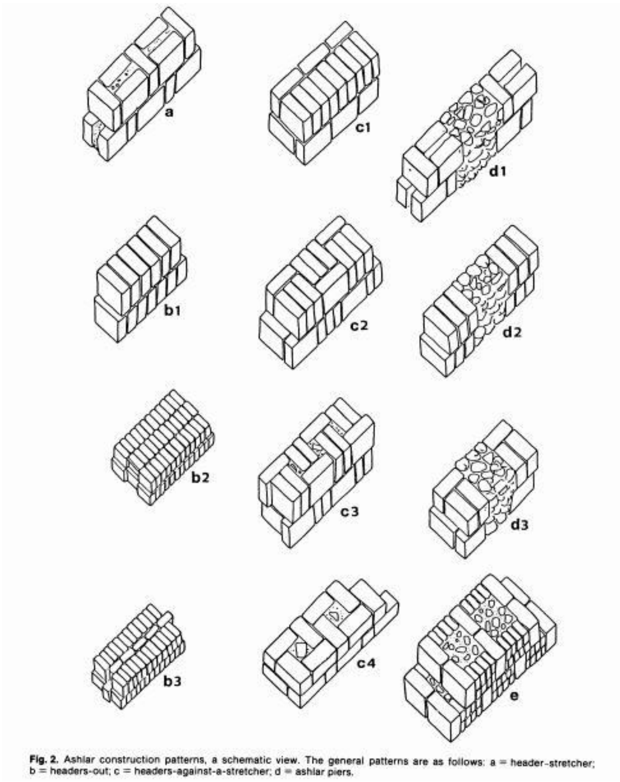


Figure 3.18 : The different ashlar construction patterns identified in Tel-dor (Sharon 1987 : 25, fig.2).

This remark although expressed in the framework of a different study, indicates an important parameter to consider. That of an inert innovation that is generated under different circumstances simultaniously. Therefore not everything that corresponds to the charateristics of the Greek or Phoenician tradition can be traced back or direclty linked to the later. The Classical and Hellenistic harbourworks of Cyprus have been mainly studied (see Chapter 1.2) under the shadow of the Greek and Phoenician tradition influence Although the impact of these traditions on the harbourworks of the island cannot be ignored, their contribution should be the driving force to explore how the local harbour builders applied these traditions and modified them according to their needs and capacities.This approach would undoutabley contribute to a productive discussion. For this reaso, in the following chapter such an attempt will be undertaken.

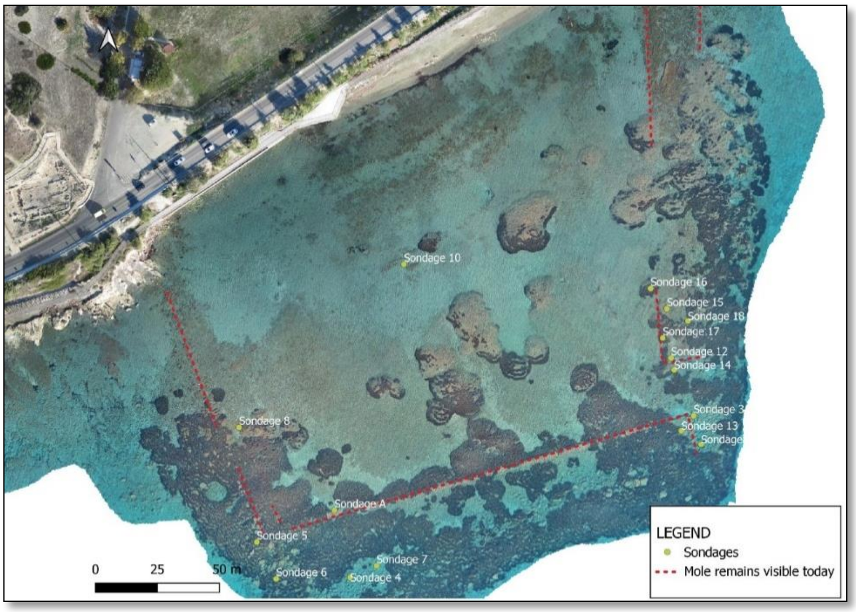
Chapter 4: THE CYPRIOT HARBOUR CONSTRUCTION TECHNIQUES THROUGH THE CASE-STUDY OF AMATHUS.

Un belissimo porto delquale anchora si vede vestigio di esso…

Lusigniano 1573 : 9

In the context of the Classical and Hellenistic period, where do the harbour construction techniques of Cyprus stand ? Are they a reflection of a passive implimantation of the Greek and Phoenician tradition or an evidence of a society that experimented with the established techniques ?

Since most of the harbours of Cyprus remain unexcavated, the information on the subject is fragmentary. However, Amathus outer harbour basin consists, a concrete case-study which will offer strong arguments on the subject. Amathus harbour-city has the best preserved example of an ancient artificial harbour basin. Between 1984 and 1986 the submerged harbour was excavated for the first time by the French school of Athens, leading to its recent publication (Empereur et al. 2018 a-b). Empereur acknowledged in the last chapter of the first volume of the publication, that the submerged harbour of Amathus had a «strange history» and that several aspects remain to be investigated since harbour archaeology in the 80s was a field of research in the making (Empereur et al. 2018a : 161-164). Thanks to the multiple questions that have unfolded with the recent publication (see Aupert 2021) and its well preserved harbour structures, this site consists an excellent case study that would offer the opportunity to study the harbour construction techniques in the framework of several research questions such as the configuration and function of Amathus harbour, and the question of its abandonment in the Hellenistic period. Therefore, the following sub-chapters will investigate different issues surrounding the harbour basin with a special focus on the harbourworks and their construction techniques in comparison with those of the surrounding area.



Map 4.1 : Location of Sondages conducted in the 1980's in the outer basin (J. Gatt, after Empereur et al. 2018a : Plan2 and Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.

4.1 AMATHUS HARBOUR CONFIGURATION AND FUNCTIONALITY

When observing the plan of Amathus harbour in the publication of Empereur (**Fig. 4.1**)[5] an intriguing question arises. Did two harbour basins exist or simply one ? What was the harbour's function/role and what kind of ship's could access it ? In other words, what was the configuration and function of the harbour basin of Amathus ? This question is an important one as it can have an impact on the interpretation of the function of the harbour and its internal organization. However, it is difficult to answer this question since the landscape has been altered by the modern works. Pseudokylax who dates to the 4th century BC refers to the harbour of Amathus (Pseud. 77.103) as desserted (…*Ἀμαθοῦς, (αὐτόχθονές εἰσιν). αὗται πάσαι λιμένας ἔχουσαι ἐρήμους*). It remains unclear whether he saw two or one harbour basins since he first refers to a series of harbours that have deserted basins and then states in the end «*all these have deserted harbours*».

Therefore, since ancient sources do not offer any clarification on the subject, the question remains open. Any geophysical prospection in the area to identify the harbour structure or the natural formation that could have divided the two basins is not the answer to this question since this area has been covered by a modern road and heavily disturbed by the touristic promenade bridge that runs along the current coastline.

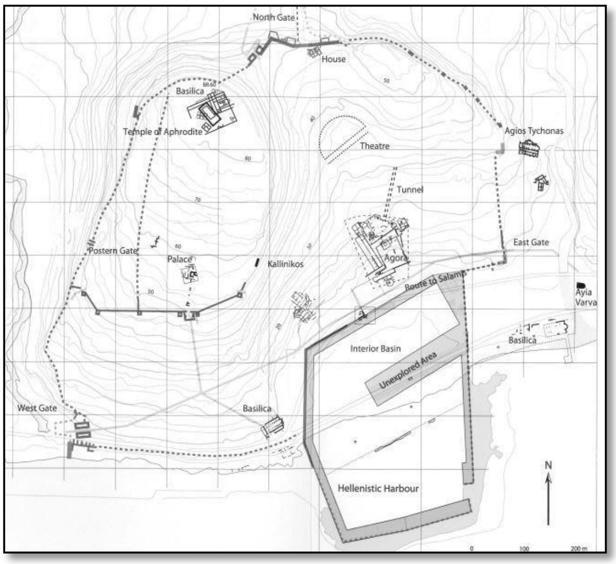


Figure 4.1 : Plan of Amathus harbour-city. Unexplored area between the silted inner basin and the outer basin (Empereur et al. 2018a : plan 1).

[5] For a Plan of the site with all the submerged finds identified see Catalogue Entry III, Fig.III.4.

Recurring to other evidence that may indicate the existence of two separate basins is the only option. The geoarchaeological study of the inner basin in 2014 by Antoine Chabrol proposes an answer to this question. According to the coaring stratigraphy it seems that, there were three main phases (**Fig. 4.2**) in the so-called inner basin. The first phase (Unit A) corresponds to a sandy paleocoastline that existed prior or parallel to the occupation of the site. The second phase (Unit B) corresponds to a clayish layer rich in organic material and marine organisms interpreted as a « decantation deposit sediment » which represents a closed low energy environment and the final phase (Unit C) is represented by clayish-sandy sediments that are related to the abandonment phase of the inner basin and led to its final and definite filling with sediments.

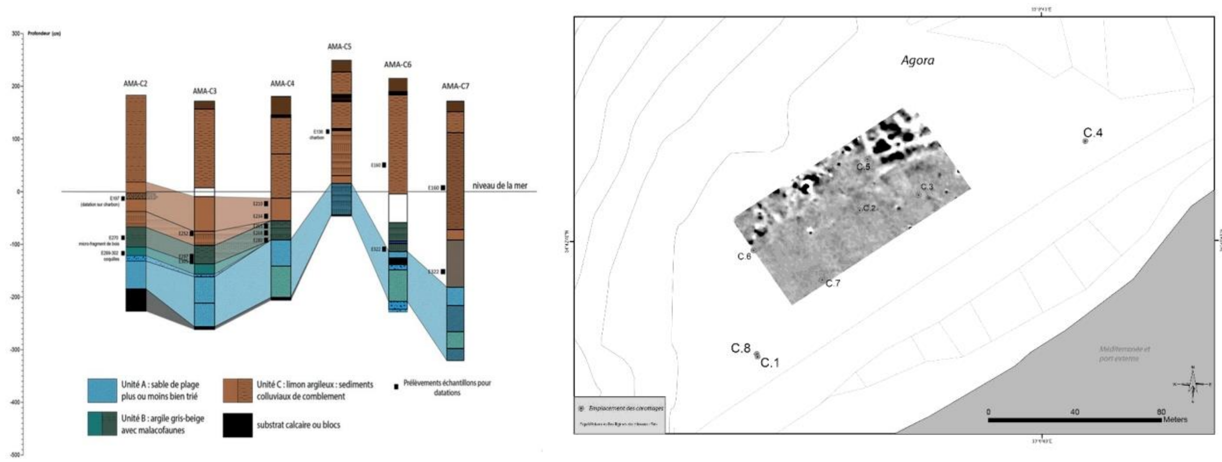
Unit B pointed out that the siltation that led to the abandonment of the interior basin was driven by three probable factors : A) The existence of sand dunes which created a naturally enclosed lagoonal environment that favoured the siltation of the basin, B) the construction of the outer artificial basin that led to a gradual siltation of the so-called inner basin and finally C) a result of the decantation process which gradually led to the deposition of sediments in the protected basin (Thely et al. 2016). Unfortunately none of these phases have been dated yet.

The proposed interpretations on the siltation of the inner basin lead to the assumption that probably a natural or man-made structure separated the two basins which consequently favoured its siltation. From the section of the harbour basin of Amathus (generated by the QGIS terrain tool) an obstacle upon which today the road passes seems to separate the basins. However, its nature (man-made or natural) remains unknown for now (**Fig**. **4.3**). Finally, an observation of the orthophoto of Amathus indicates a probable « path » that extends from the NW corner of the outer basin orientated towards the harbour entrance located on the SE corner. This may indicate an access channel* to the inner basin[6] (**Fig. 4.4**). This observation agrees with the proposed entrance of the inner harbour in the plan of Empereur. Also, the location of the beachrock and wells located on the north-east side of the harbour leave this sandy area (NW corner) (**Fig. 4.9**) clear from any archaeological or geological features. From the current bathymetry no depression or channel can be identified. Therefore, till now this

[6] This observation was first made by Mauro Frontini Miguel who when seeing for the first time the orthophoto of Amathus made this comment.

remains a speculation. Perhaps a marine geophysical prospection with a sub-bottom profiler accompanied with vibra-coaring, could verify or reject this observation.

Figure 4.2 : Sections of the cores of the inner basin of Amathus (left- Thely et al. 2016 : fig.10) Plan of the location of the cores in the inner basin (right- Thely et al. 2016 : fig.9).



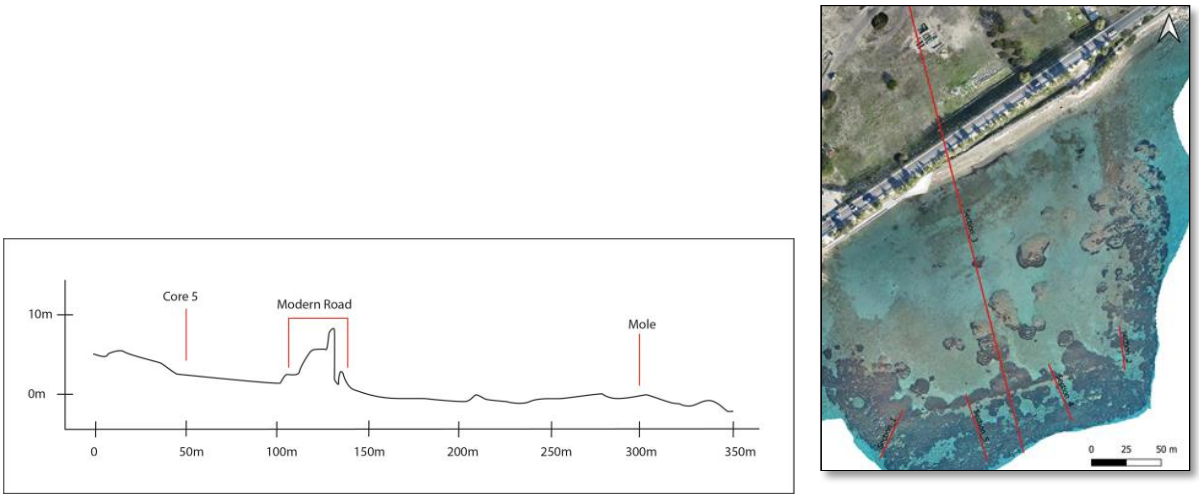


Figure 4.3 : Section (4) of the harbour of Amathus (measurements in meters) (J. Gatt, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

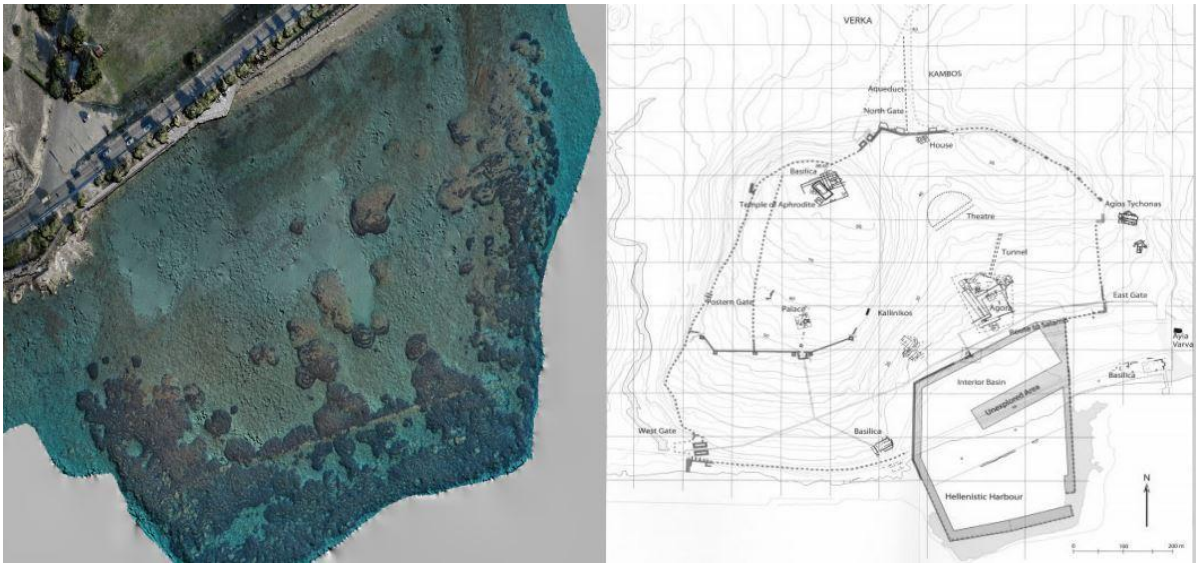


Figure 4.4 : The area where the depression is identified (highlighted) (after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.) in comparison with the proposed plan of Amathus site (Left- ; Right- Emperuer et al 2018a : Plan 1).

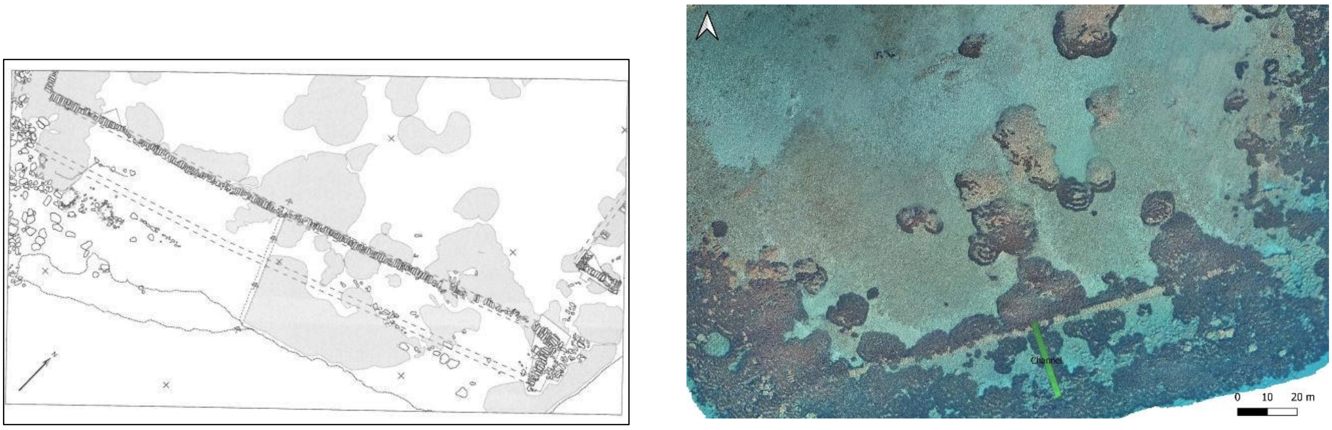


Figure 4.5 : Location of the channel (Empereur et al 2018 : 61, Fig. 30a-b) and today's probable location of the now silted channe (Georeferenced based on Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

Another element that may be considered as an indicator for two separate basins is the existence of a channel on the south breakwater-mole that was identified during the survey of the French school of Athens (**Fig.4.5**). This « covered » channel is described as 36.86 m long located roughly 92 m from the east extremity and 80 m from the west extremity of the south mole. However, the width and depth of this channel are not mentioned (Empereur et al. 2018a : 45). The approximate location was established by georeferencing the plan of Empereur with the orthophoto of Amathus. Having visited this area in the framework of the

ANDIKAT project it seems that the channel is now silted and covered by the posedonia. Perhaps the gradual siltation of the inner basin (if we consider that two distinct basins existed) led to the creation of a channel that would enhance water circulation in the basin and subsequently lower the impact of sedimentation in the outer basin.

Although according to the excavator this channel had a role in the circulation of sediments in the basin, at the same time he doubts the efficiency of the feature « as it was too high to play the efficient flushing role » (Empereur et al. 2018a : 162). Empereur compares it with the channel identified on the mole of Taposiris Magna (**XII. Fig.3**) however since no details are given on the dimensions and form of the channel the comparison remains weak. On the other hand, Aupert compares the channel with that of Sussa and Thapsus breakwater channels. On the contrary, these channels were used to break the force of the waves (Cintas 1976 : 234-235 ; Aupert 2020 : 210). Since the role of the channel remains in question, it is difficult to sustain that the channel is an element of evidence for two separate basins. The 180 m south breakwater-mole may have possessed also multiple channels that have yet to be located. In addition, the mole seems to be located opposite of the hypothetical entrance and perpendicular to the mole. It would be interesting to place this mole in relation to the waves and currents of the area so as to understand the real role this structure had in the outer basin. Only further research along the mole may indicate the character of this channel.[7]

In terms of size, the artificial outer basin of Amathus is around 3 hectares (based on QGIS measurements), while the interior basin is around 1.6 hectares (based on QGIS measurements). This indicates that both basins were sufficiently spacious to function as individual spaces since other harbour basins of antiquity possessed a similar size. In comparison, with other harbours of the same period (**Table 4.1**) the outer basin of Amathus is of a rather small size. Alexandria's basins of Megas Limen is in total 600 hectares and is subdivided in smaller basins that range from 7-16 hectares (Fabre &Goddio 2010 : 55-59). Taposiris Magna's basin is estimated around 8 hectares (Boussac 2007 : 453), Elaia's closed harbour* covers a surface of 4.8 hectares (Seeliger et al. 2018: 1; Seeliger et al. 2013: 70-73) while Kantharos is estimated to cover an area of around 50 hectares (Belov 2013: 20). Nevertheless, both harbours can be considered to be equally spacious to harbour ships.

In relation now to the sizes of the ancient harbour basins of Cyprus only estimations can be presented. Carpasia's basin is also estimated to be around 3 hectares (based on QGIS measurements), Nea Paphos basin today is around 10 hectares (based on QGIS measurments) although in antiquity the basin seemed to cover a wider area as the coastline was further in land (Leonard et al. 1998: 146). Therefore, Amathus external basin seem to be not one of the largest basins on the island. However, once a more detailed estimation of the water area of other Cypriot ancient harbour baisns takes place (example Salamis, Kourion, Kition, Nea Paphos) the size of Amathus could be properly compared. It is interesting that despite the large scale harbourworks the harbour basin of Amathus remains for now of no exceptional

[7] This is an idea expressed by Mauro Frontini Miguel to test the functionality of the channel based on the sea climate of the region.

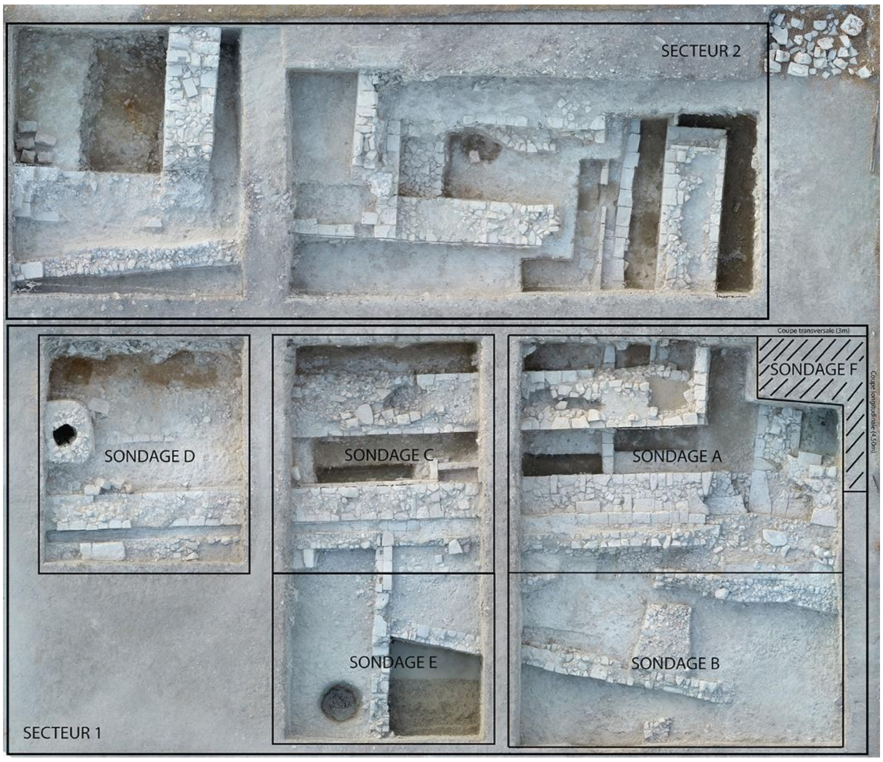
size and is even comparable with harbour basins of other coastal settlements of the island (i.e. Carpasia).

	HARBOUR	WATER AREA (ha)
1	Piraeus – Kantharos	50
	Alexandria Megas Limen	226
2	Alexandria-Harbour 1	7
3	Alexandria-Harbour 2	15
4	Alexandria-Harbour 3	16
5	Elaia- Closed harbour	4.8
6	Nea Cnidus - Commercial harbour	13
7	Aigina – Military harbour	1.4
8	Taposiris Magna	8
9	Seleucia Pieria- Outer harbour	3
10	Amathus- Outer basin	3
	Caesarea Maritima –Outer basin	20

Table 4.1 : Water area of Classical and Hellenistic harbour basins (J. Gatt 2021 ; after Belov 2014 : 20 fig. 14 ; Wilson et al. 2012 : 381, Table 20.11).

Moving on to the second question, the function of the harbour basin is also an open subject for discussion. The harbour is considered to have been built by Antigonus son, Demetrios Poliorketes. The construction of this basin in the framework of the Diadochi wars leads to the interpretation of the basin as a naval station (Theodoulou 2006: 230-231, 236, 239 ; Empereur & Verllinden 1987 : 759 ; Empereur et al. 2018a :115-116) however, this is not a strong argument since no literary or archaeological evidence confirms this theory. Where are the shipsheds or other elements that can point out to its function as a naval station? No shipsheds, or mooring stones have been identified in either of the basins. According to the latest publication the naval station was located in the inner basin (Empereur et al. 2018a : 115-116). A recent excavation, more specifically, in Sondage F – Secteur 01 located south of the Agora has identified a structure (consisting of two walls UC1005 & UC1012 and not excavated to their full extent) which has been interpreted on a prelimenary level as a hauling-ramp ? (cale sèche). This interpretation is sustained by the construction of wall UC1005[8]. Gaps between the blocks have been identified as features to support the ship when in repair (Empereur et al. 2018b : 218 ; Thely et al. 2020c) (**Fig. 4.6**). Although this is a very interesting find, further research is needed to properly interpret this structure as a hauling-ramp (?). The dimensions of the hauling ramp (?) as also the access of the ships to the dry dock remain to be defined through further excavation (Thely et al. 2020c).

[8] The dating of these two structures remains to be established, however based on the current evidence may date to the earliest phase of the use of this area (Archaic-Classical) (Thely et al. 2020c).



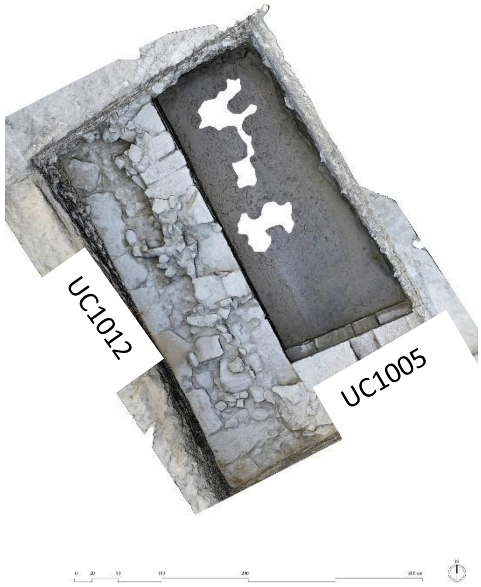
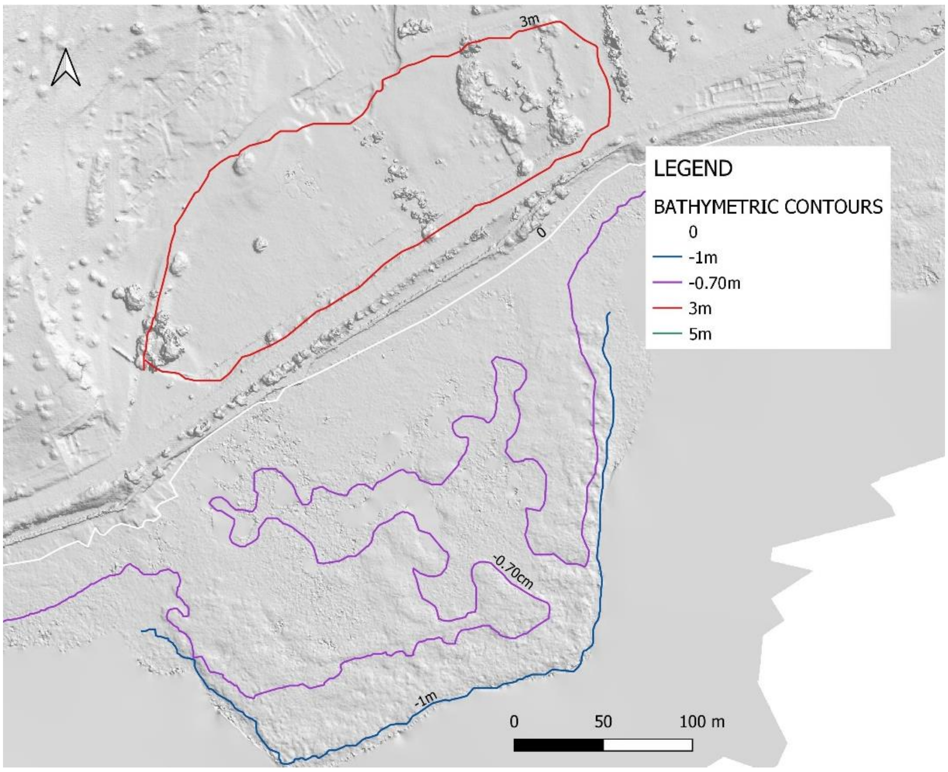


Figure 4.6 : Warehouse located in the inner basin to the north (left). The so-called hauling ramps (?) located in Sondage F (Thely et al. 2020c : fig. 1,6).

From a hypothetical point of view though, could a naval ship enter the harbour of Amathus ? The size of a trireme is estimated to be 35-37 m long and 5 to 6 m wide while its draught is estimated to have been around 1.1 m (unloaded) as the floating hypothesis of the Olympia's trireme indicates (Blackman 1968: 184-185, Murray 2012: 13 ; Morrison 1996, 345; Morrison et al. 2000, 156). The question now is, was there enough space and depth for triremes to enter and navigate the outer and inner basin? Concerning the interior basin, the cores (**Fig. 4.2 ; Fig. 4.7**) indicate that during the second phase (UNIT B) according to core AMA C-7, the seabed was approximately -2 meters below the current sea-level, while when approaching the warehouse and the agora the seabed was approximately -1 to 0.60 m (based on cores AMA C-2/3/4/6) below current sea level (Thely et al. 2020b). Although the sea level at the time when the interior basin was accessible remains undetermined it seems that based on the current sea level this basin was at least partially accessible to triremes.

Figure 4.7 : Location of cores based on an approximate georeferencment (based on Thely et al. 2016 : fig.9 ; Cannavo 2021 ; after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

Regarding the outer basin according to the bathymetry of Amathus outer basin provided by Dr. Dimitrios Skarlatos and Dr. Panagiotis Agrafiotis the current seabed of Amathus outer basin is around -1 m below current sea level (**Plan 4.2**). Sondage A along the breakwater-mole indicated a layer of sediment of approximatley 2m that covered the mole from its lowest course to its upper preserved course. In addition, the section (exported from the Qgis terrain model) indicates a probable inclination of the seabed (**Fig. 4.3 ; Fig.4.8**) which however remains to be verified through coaring the outer basin. This inclination would perhaps also justify the fact that in Sondage 8 only three courses were documented leading to the assumtion that this area of the basin was shallower (Empereur et al. 2018 33). These elements however do not allow any further elaboration on the subject since the ancient seabed location in relation to the ancient relative sea level (for the inner and outer basin) hasn't been estimated yet.



Map 4.2 : Bathymetric lines based on (J.Gatt 2021, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

Amathus outer and inner harbour basins must not be seen from the point of view of a naval station[9]. It was first the harbour of the Cypriot Polity of Amathus. This was a harbour that catered above all the city's commercial needs. From the excavations of Amathus city a series of finds attest the trade with the surrounding region since the Cypro-geometric period (Thely et al.2020c). The excavation of 2014 in the inner basin warehouse (built by the end of the Hellenistic period and beginning of the Imperial times (1st century BC), uncovered a significant number of Papmphylian amphoras which date to the second quarter of the 2nd century BC (Thely et al. 2016). In addition, the outer harbour basin pottery (interpreted as a filling that prompte dits abandonment) found during the excavation of the outer basin although the majority is related to local production (i.e. basket handle amphoras, so-called persian bowls) a series of imported glazed Attic and Ionian pottery were found also (Empereur et al. 2018b : 14, 40-44, 67-70). A warehouse (south of the agora and west of the potential hauling ramp ?) has been uncovered during the 2014 excavation in the inner basin in secteur 01 & 02. This warehouse was constructed (Thely et al. 2020c).

[9] For the time being both harbour basins are considered to have had a commercial function and a possible naval role.

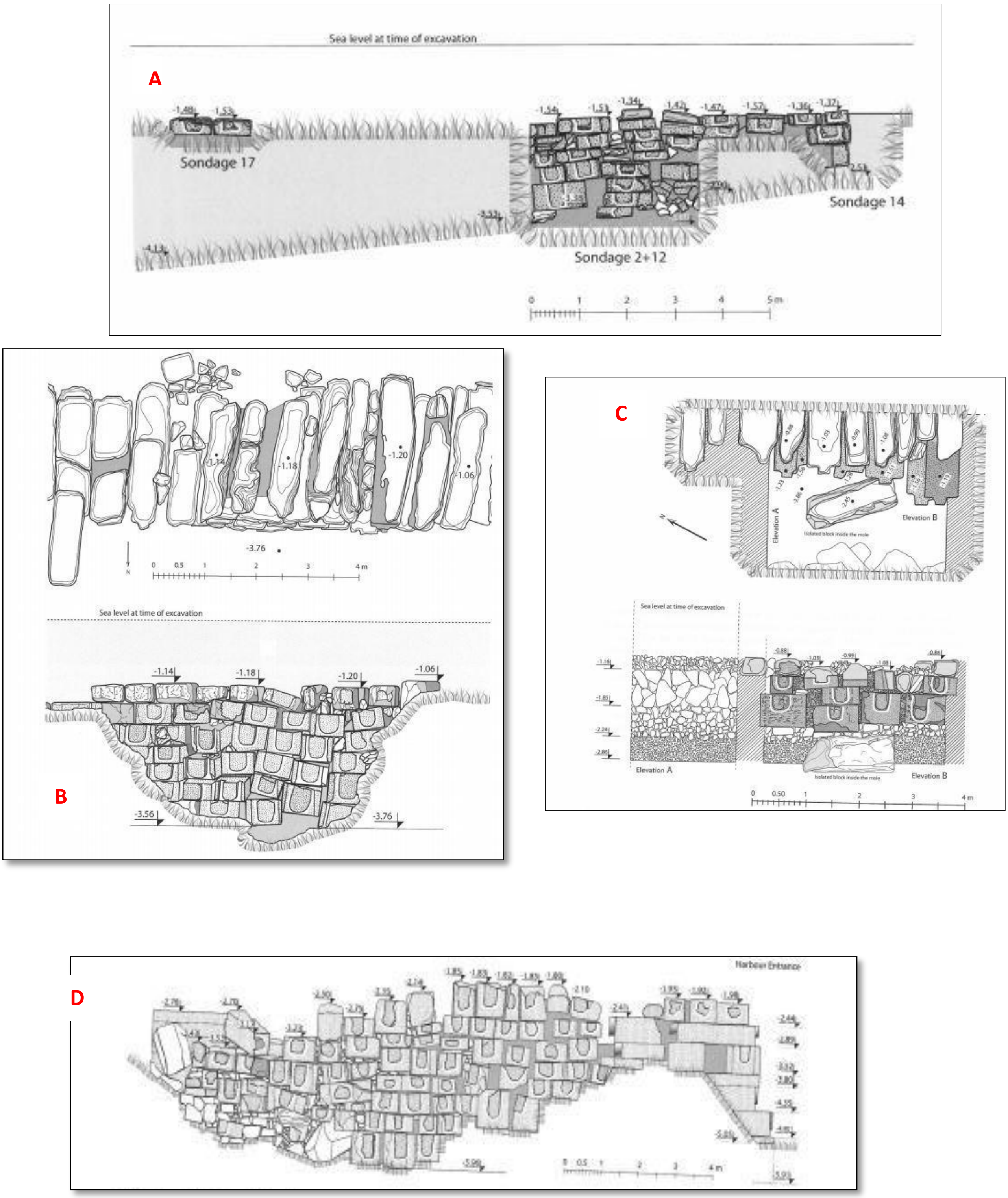


Figure 4.8 : **A**-Sondage 2,12,14,17. (Empereur et al. 2018a : 59 fig. 28b) **B**-Sondage A.(Empereur et al. 2018a : 42 fig. 11) **C**-Sondage 8. (Empereur et al. 2018a : 34, fig. 1) **D**-Sondage 1,3,13 (Empereur et al. 2018a : 46, fig. 16).

However, did the moles serve as areas for loading and unloading goods. Aupert's remark that the south mole's function was not related to this activity as it was destined to retain the wall that was planned to be built along the breakwater-mole leads us to rethink the organization of the activities in the harbour basin (Aupert 2020 : 202). However, if one takes into account the published section of the south mole (**III-Fig. 7 ; Fig. 3.1**), the distance between the mole and breakwater is separated by a filling of gravel which varies in distance along the south mole (from 5 m to 30 m - measurements deriving from Qgis) Couldn't this space be used for the building of the maritime fortifications leaving space for the loading and unloading of goods along the south mole ? However, since along the south mole a channel that may have had a flushing role would that disturb the mooring of the ships along the south mole ? Since the channel' role remains in question further elaboration on the subject cannot be proposed.

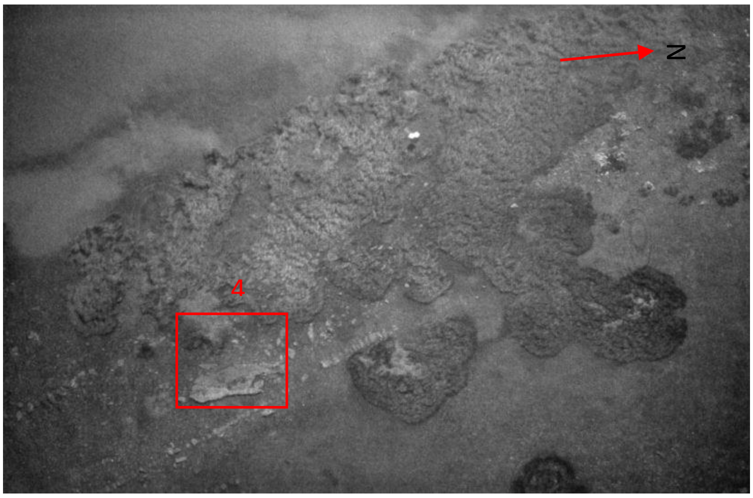
On the other hand while the west and east mole are considered by Aupert as structures that could facilitate such activities, both are poorly preserved (especially their northern extremities) to estimate the functional height of these structures (**Fig. 4.8**). In Sondage 8 located on the south extremity of the west mole the lowest course of headers is located -2.24 m below present sea level while the upper part at -0.86 m below current sea level. In sondage A, on the west side of the south mole the lowest course is identified at -3.76 m while the upper course is located -1.06 m below current sea level. In the harbour's entrance south side in the sections of sondages 1,3,13 the lowest course was identified at -5,96 m depth while the upper course at -1.60 m. Finally, the south extreme of the east mole (entrance area), located in the sondages 17,12,2,14 the lowest course was identified at a depth of -4,84 m while the upper course is -1.34 m. These measurements indicate that in Sondage 8 (west mole) the structure survives up to 1.38 m, in Sondage A the structure survives up to 2.7 m, in sondages 1,3,13 it survives up to 4.16 m (Sondage A,1,3,13 are located along the south mole) and in sondage 17,2,12,14 (east mole) it survives up to 2.46 m height (after Empereur et al. 2018a : 33-61).

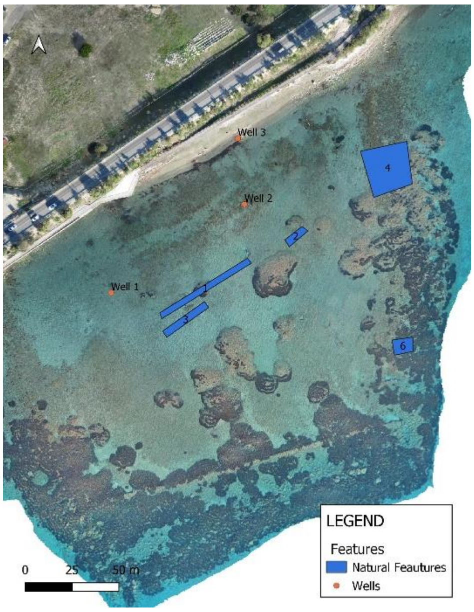
	SONDAGES	PRESERVED HEIGHT
1.	Sondage 8	c.1.38m
2.	Sondage A	c.2.7m
3.	Sondage 1,3,13	c.4.16m
4.	Sondage 17,12,2,14	c.2.46

Table 4.2 : Preserved height of the west east and south mole (J, Gatt 2021, after Empereur et al. 2018a : 33-61). (For location of Sondages see Plan 4.1)

Concerning the draft of the commercial ships and the ancient seabed. Aupert mentioned the possibility for commercial ships to enter the outer basin and moor on the moles however the ships used in his argument date to later periods (Cavalière - 1st century BC and Dramont E - 5th century AD). Kyrenia's ship, dating to the Hellenistic period which sunked on the North coast of the island, had an estimated draft (when loaded) of 1,47 m. This could be a representative boat that circulated in the island's harbours in the Classical and Hellenistic period (Nantet 2016 : 226, table 47). Therefore, in terms of the estimated depth of the inner basin (**Fig. 4.2**) (approximately -2 m below current sea level according to AMA C-7) commercial ships were most likely able to navigate at least in some areas of the basin. However, for the outer basin based on the available data it is early to discuss the accesibiltiy of the ships in the basin. Once a geoarchaeological study is conducted this interesting discussion could conitnue.

The most interesting question though is, which areas of the harbour basins were accessible during which times ? The beachrock lying parallel to the south mole (**Fig. 4.9**) as also the Late Roman wells indicate that at a certain period of time a part of the basin (approximately half of the basin, 1.5 hectares) surface was not accessible. How did these changes affect the function of the basin ? Only a geoarchaeological study can propose answers to these questions.





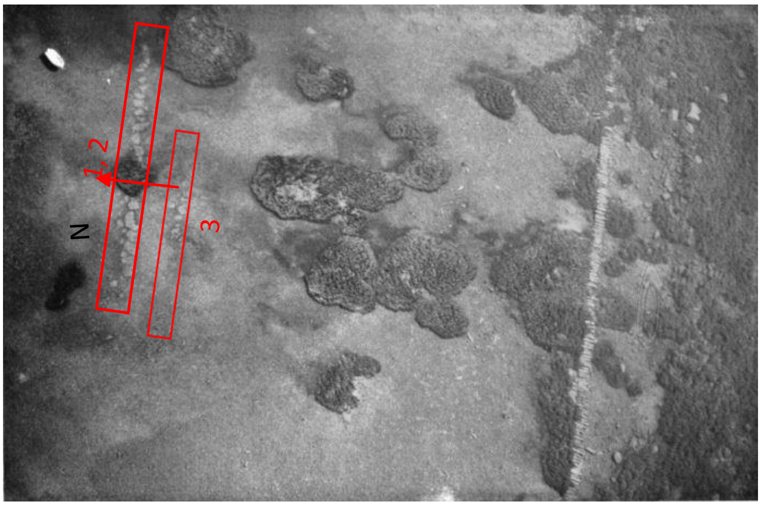


Figure 4.9 : Aerial photos with the location of beachrock (Empereur et al. 2018: 128, Fig.1a-b left) Identified locations of beachrock and wells in the outer harbour basin of Amathus (right) (J.Gatt 2021 after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

The final question which this sub-chapter addresses concerns the configuration of the harbour. Amathus has been in several occasions addressed as a closed harbour (Raban 1995 : 161 ; Theodoulou 2006 : 150). The prevailing definition of a closed harbour consists of a basin included in the fortification of the city (**see Appendix B**). For the case of Amathus there is no clear evidence that fortifications extended to the harbour structures. The fact that the harbour construction was perhaps never completed leaves the possibility to assume what the initial plan was. The existence of towers was identified by Empereur. In Sondage 12, as Empereur describes « dozens of small carefully worked parallelepiped blocks, some with clamps and lever holes, which belonged to a construction…. Certain of them displayed a curved face suggesting that they belonged to a building with an upper cylindrical storey ». However, the question remains were exactly in Sondage 12 this tower was located since the width of the row of headers in this area is less than 2 m (measurements qgis) and the total width of the east mole remains unclear. Based on this insufficient evidence Aupert disagrees with the existence of towers (Aupert 2020 : 202-203 ; Empereur et al. 2018a : 49-53). However, a pile of blocks seem to be concentrated on the east of sondage 12 perhaps insinuating the existence of a fallen tower (**Fig. 4.10**). On the opposite side, in the area of sondage 1,3,13 (**Fig. 4.10**) a pile of blocks whose nature remains undetermined may indicate also a fallen tower. This pattern of concentration of blocks in the area of the entrance has been identified also in Nea paphos and interpreted as evidence of towers (Leonard & Hohlfelder 1993 : 365, 367). Especially when comparing the positioning of the ashlar blocks (alteration of strechers and headers) of the area of sondage 1,3,13 with the platform of Tower 4 of Phalassarna (**XXV-Fig.1**) which consisted of an alteration[10] between strechers and headers a similar pattern is identified indicating perhaps indirectly to the existence of a tower in this area (Hadjidaki 1988 : 464). In addition, in terms of space the east extremity of the south mole ends in a corner creating an area of 4x4m (measurements in Qgis) (**Fig. 4.10**) enough to build a tower.

Regarding the maritime fortifications, no evident walls seem to extend on the moles and breakwater-mole. Aupert though refers to two coastal walls that are directed towards the east and west mole (**Fig. 4.11, 4.12, 4.13)** (Aupert 2020 : 200-202). The indirect evidence that supports the existence of maritime fortifications and entrance towers, as also the narrow entrance can at least support the idea that Amathus was probably planned to be a closed harbour included in the fortification system of the city. Raban stated that Amathus is the «the transitional type of the *kleistos Limen* to the Near East» (Raban 1995 : 161). The term *kleistos limen* is identified in texts of ancient navigation referring to harbours located in the Aegean. No ancient writer though has attributed this characteristic to this harbour. Amathus doesn't seem to indicate any striking difference in terms of its configuration with the *kleistoi limenes* of the Aegean, however, it probably consists the first planned to be closed harbour of the Eastern Mediterranean probably prior to that of Caesarea Maritima (Raban et al. 2009 : 27-32, 37-38).

[10] No photo of this tower was found in any publication that shows the alteration between strechers and headers

Figure 4.10 : Probable location of the remains of the fallen tower in yellow. In red area were measurments were taken (4x4m) (J. Gatt 2021, after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

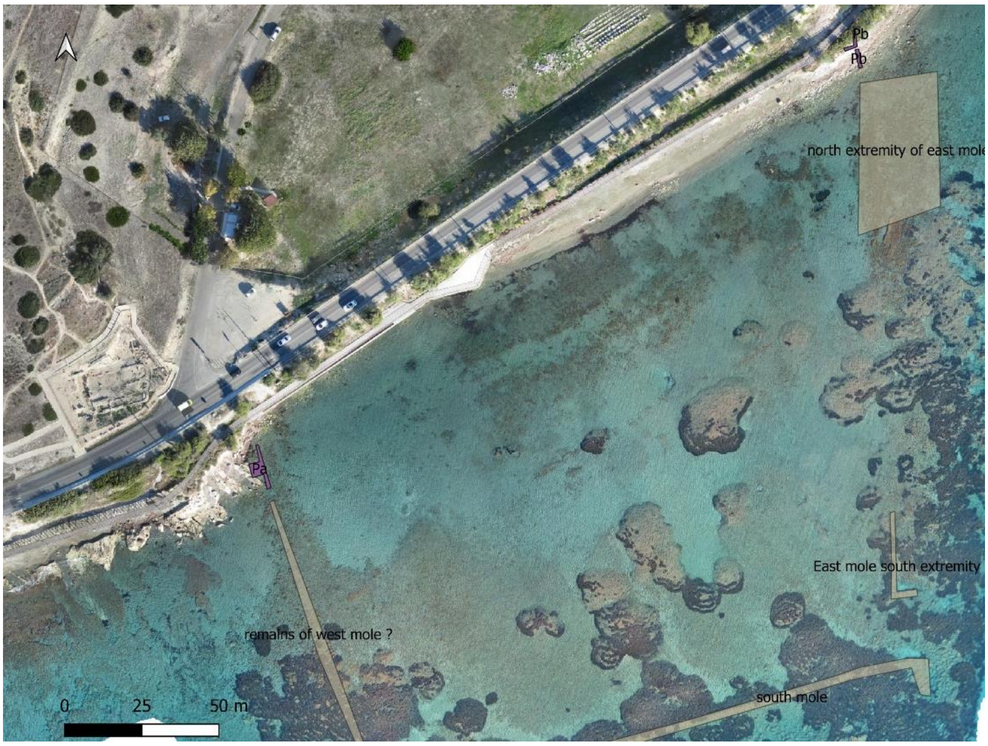


Figure 4.11 : Location of coastal walls (Pa & Pb) in relation to the remains of the East and west mole based on Aupert 2021 : fig.2 , after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

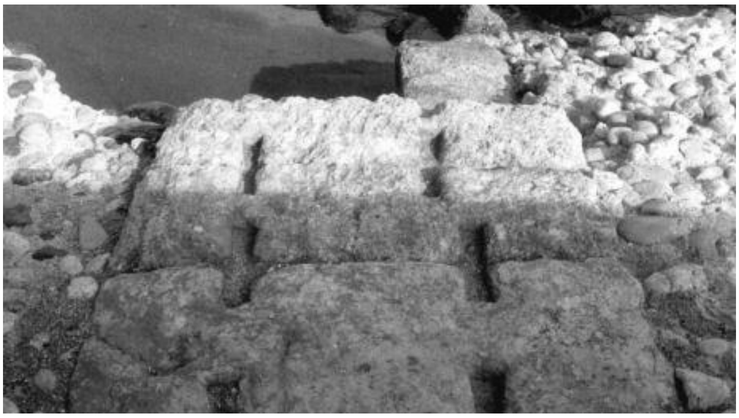


Figure 4.12 : Blocks on the beach north on the west mole (Empereur et al. 2018 : 82, fig.43)

Figure 4.13 : Wall Pa (left) and Wall Pb (right) (Aupert 2020 : 207 fig4-5)

4.2 THE HARBOUR CONSTRUCTION TECHNIQUES OF AMATHUS. A COMPARATIVE STUDY.

The general description of the harbour structures of Amathus outer basin and their construction techniques were already presented in Chapter 3 (3.1) and therefore will not be repeated. This sub chapter aims in comparing the harbour construction techniques of Amathus harbourworks with those identified in the Eastern Mediterranean and the Aegean. This would contribute to the discussion of the character of the harbour construction techniques of the island of Cyprus in the Classical and Hellenistic period. Parallel to that, it will be possible to expand the discussion towards the subject of an uncompleted and roughly built harbour along with the dating of the harbourworks.

Starting with the harbour construction techniques, each harbourwork will be presented individually. The south breakwater (composite breakwater) (**III-Fig.4**) is of special interest. According to modern harbour engineering there is usually a stratigraphy, a series of layers in the building of a breakwater (CIRIA et al. 2007 : 780,789). Was this also applied in Amathus ? As it was evident from Chapter 3 the majority of breakwaters built with rubble are not documented in detail, nor in the case of Amathus, therefore this remains to be investigated. The second point is what material indeed belongs to the breakwater and what to the south mole? Although at first a retracing of the blocks was attempted (through the available orthophoto), to proceed to a discussion concerning the size and orientation of the blocks, this was quickly abandoned since the orthophoto not clear in some areas and therefore the contours of the blocks were rather difficult to discern with precision. Nevertheless, studying sections of the breakwater generated by the QGIS terrain tool gave an insight on the morphology of the structure (**Fig. 4.14, Fig. 4.3**). It is interesting to note that in the east and west section (section 4 and 5 respectively) the breakwater seems to rise after the concentration of gravel and then gradually takes a tilting direction while in the southwest corner (section 1) the breakwater has a gradual tilting position from the very beginning. Was this a structural difference made on purpose ? In the southwest corner the density of boulders is higher while along the rest of the breakwater the boulders are dispersed and mixed with amorphous stones (**Fig. 4.15**). In addition, the concentration of gravel between the south mole and breakwater ranges between 5-20 m. In the southwest corner, the area which theoretically is the one which is mostly impacted by the prevailing winds has the narrowest concentration of gravel. Although these sections may have been affected by the presence of posedonia which is spread along the breakwater, these first results should instigate our interest for further studying this structure.

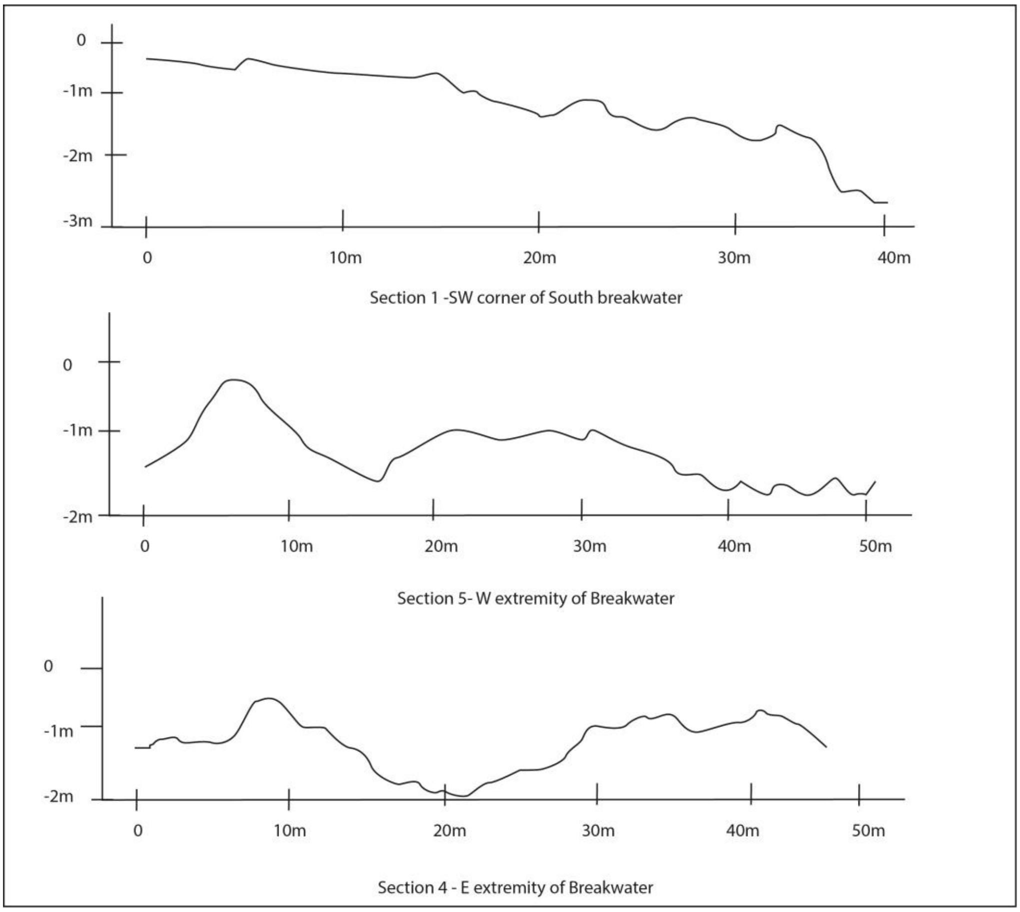


Figure 4. 14 : Sections of the breakwater's profile (in order from up to down Section 4,5,1) (J.Gatt 2021, after . after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.) For location of sections see Fig. 4.3).

Regarding the south mole, although it was mainly built with a headers staggered between courses masonry. From a bird eye view the mole resembles the first Phoenician ashlar harbourworks (i.e Atliht, Tabbat el-hammam, Caesarea Maritima) this was also a pattern identified in Myndos and Delos quay (**see catalogue entry for bibliography XXI, XXIII**). From the facade of the structure, in Sondage A (east extremity of south mole) an irregular placement of the blocks (described by Empereur as a quincunx pattern) (**Fig. 4.16**) probably as a result of miscalculation and orientation of the jib on the wall was identified. This is an interesting indicator that once an overall documentation of the south mole is undertaken a reconstruction of the process of the building of this structure can be obtained. Moreover, the alteration of headers and strechers attested in the harbour entrance (**Fig. 4-D**) (east extremity of south mole) is also identified in the harbour basin of Phalassarna, more specifically in the base of tower 4 (as already mentioned in the previous sub-chapter. An alteration in strechers and headers was also observed in the in the entrance bridge of Taposiris Magna's harbour (**Fig. 4.17**) This masonry was identified in all three cases in areas of control and surveillance which is rational since this is one of the strongest masonry based on dry construction but however more time consuming (Mahajan 2020).

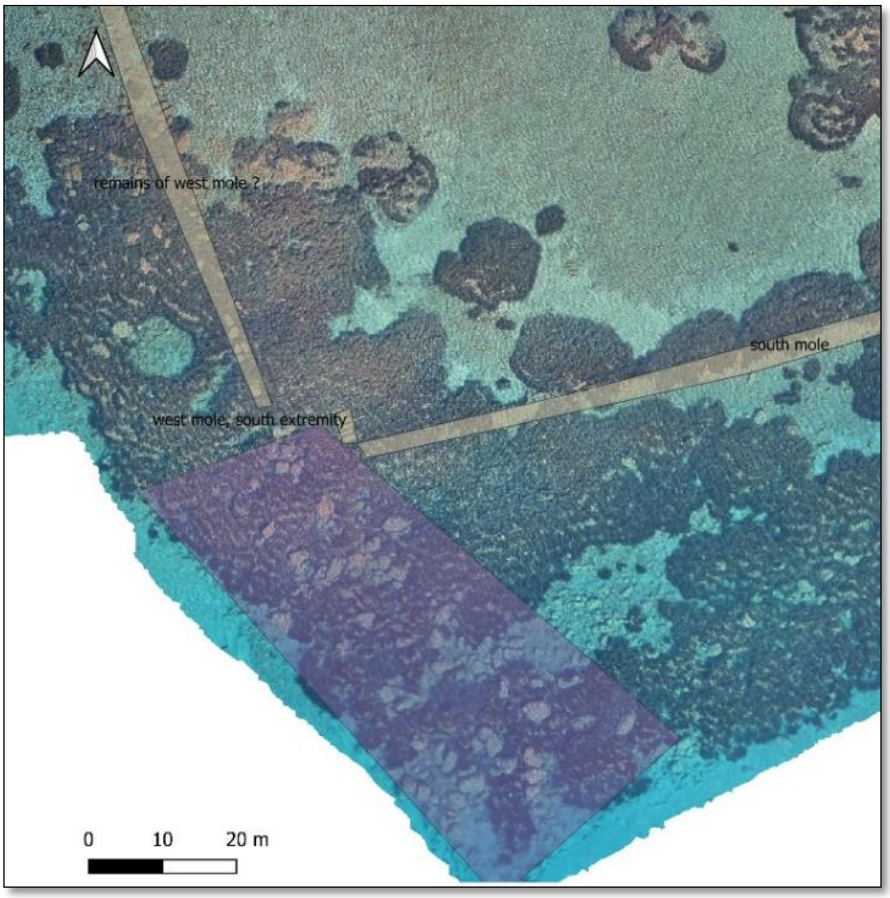


Figure 4.15 : Area with the largest concentration of boulders (in purple) located at the south west corner of outer basin (J.Gatt 2021 after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

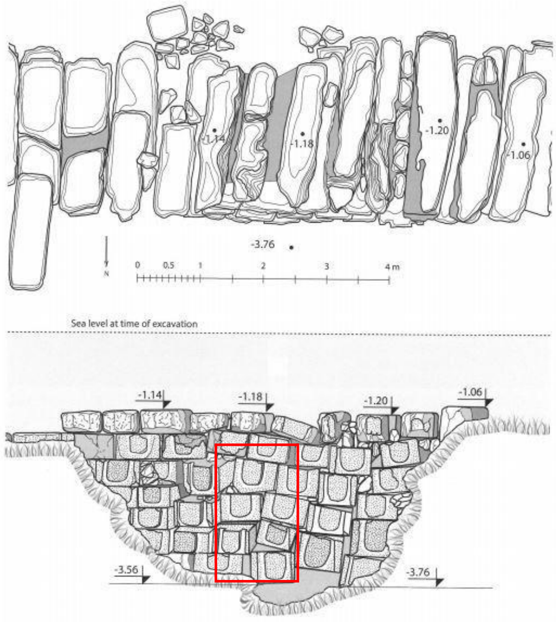


Figure 4.16 : Sondage A plan and lateral side. Quincunx pattern in a red frame (Empereur et al. 2018a : 43, fig.11).

Figure 4.17 : Photo of the entrance bridge of Taposiris Magna basin (Boussac 2009 : 130, fig.6).

Regarding the south breakwater-mole as an entity, this remains an exeptional structure. The filling of gravel between the mole and the breakwater hasn't been observed in any of the harbours included in this study (**III-Fig. 7 ; Fig. 3.1)**. This filling consists a logical addition to the structure which also explains the excellent preservation of the south mole till today. The filling difusses the energy that passes trhough the breakwater and therefore protecting the stability of the mole (CIRIA et al. 2007 : 120). The only parallel to this construction is Caesaria Maritima's western mole that dates however to the Roman Period. According to a schematic rendering of the structure between the blocks of hydrolic cement and the so called quay rubble was used to support both sides of the cement blocks (**Fig. 4.18**). Although this may not be an exact replica of Amathus south breakwater-mole section it inhibits a similar practical mentality.

Regarding the east and west moles their northern extremities have been represented through dotted lines in the published maps. In these areas no surveys took place. Do these dots represent preserved archaeological remains or are they hypothetical ? Based on a comparison of the published plans (**Fig. 4.19**) and the orthophoto of Amathus it seems that the dotted lines reflect mostly a hypothetical reconstruction. For instance, the west mole according to Emperuer has in the begining an east to west direction and then turns south to meet the south breakwater-mole. However, from the orthophoto and the published aerial photo this north section of the west mole is placed in the quarries areas were evidence of such a structure doesn't seem to survive. However, from the current orthophoto (**Fig. 4.20**) probable remains of the northern extremity have been identified. In other words, the connection of the moles with the land is not clear and demands further investigation. In addition, although both moles are described as *Ashlar piers in rubble walls with headers* the remains of the two parallel walls especially in the west mole (sondage 8) are not clear since no aerial photo or plan of the site indicates its existance with certainty.

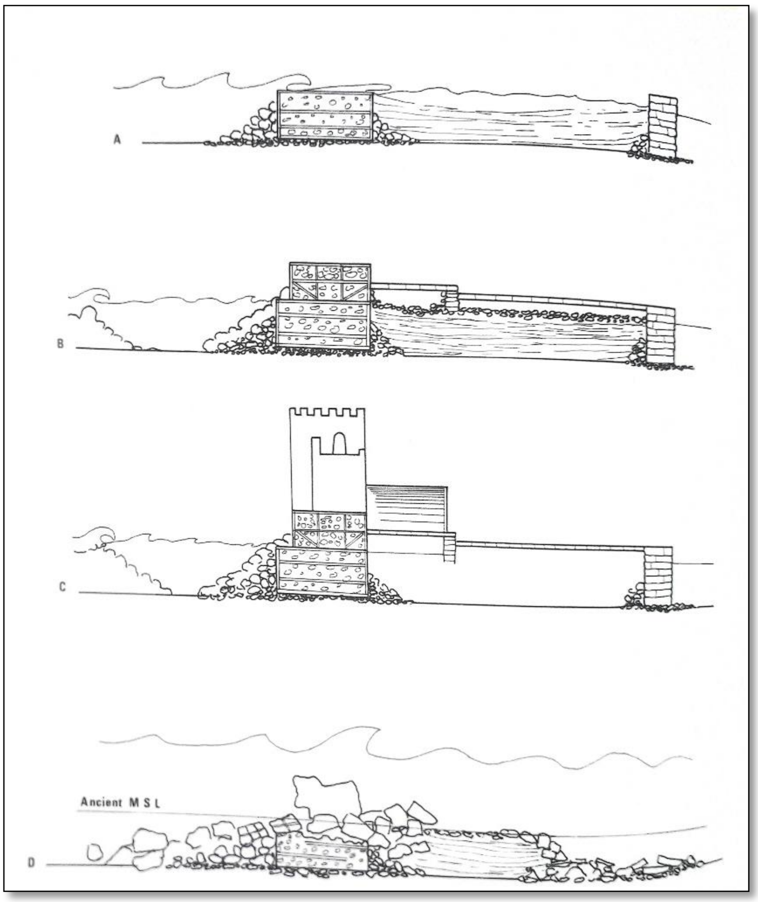


Figure 4.18 : Schematic representation of the section of the west mole of Roman Caesaria Maritima (Raban et al. 2009 : 96, fig.5.35).

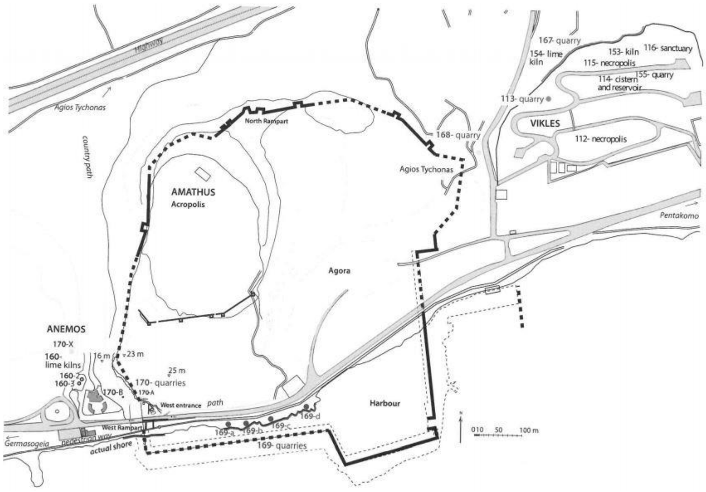


Figure 4.19 : Plan of Amathus harbour showing the extension of the west mole towards the west (Empereur et al 2018 : 96,Fig. 1).

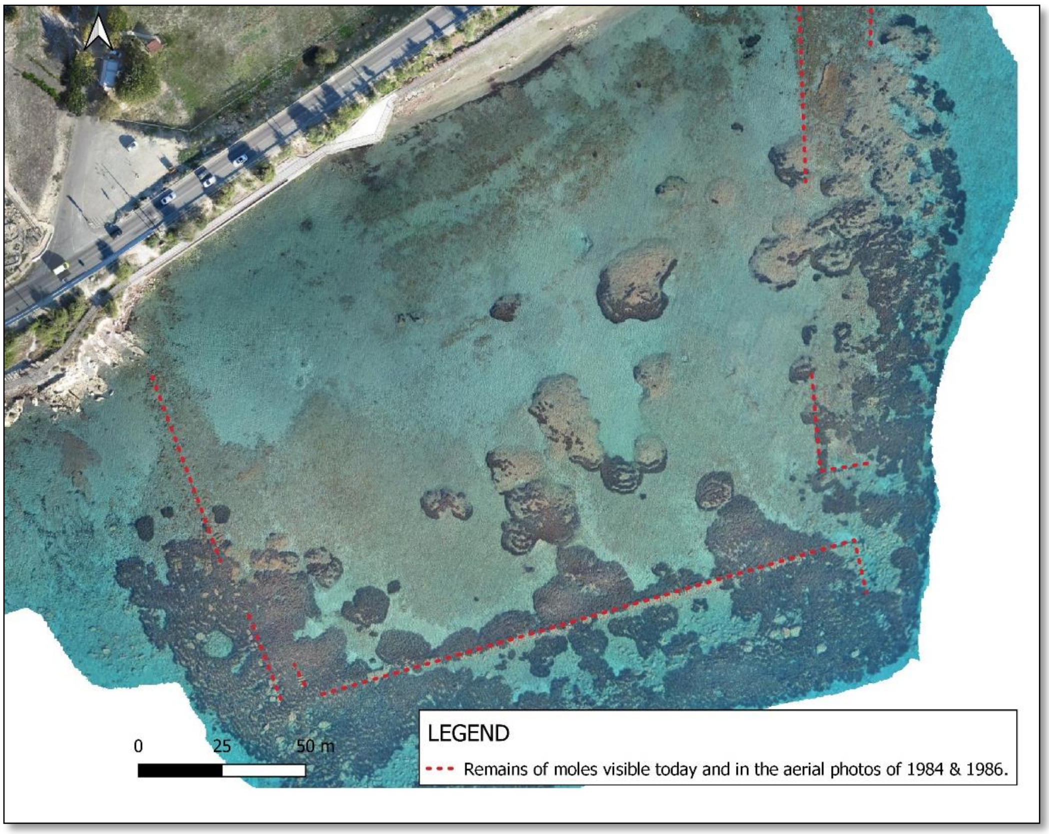


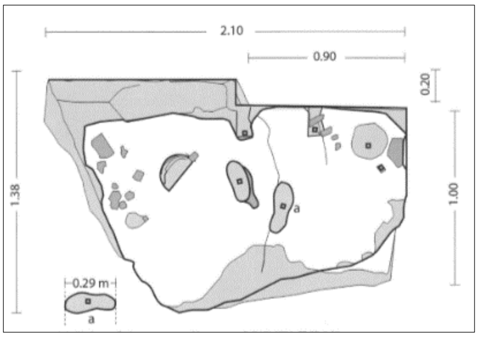
Figure 4.20 : Location of remains of the ancient moles based on the aerial photos of 1984 & 1986 (J. Gatt 2021, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

Figure 4.21 : Left- Location of west quarry in relation to the west mole (J. Gatt 2021, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)). Right- Wind rose of Limassol indicating how many hours per year the wind blows from the indicated direction (Available https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/limassol_cyprus_146384 Retrived from 16th June 2021.

Nevertheless, based on the given desciription the technique of ashlar piers in rubble walls with headers is identified in the architecture along the Levantine coast (Sharon 1987 : 24-36) and harbours in the Aegean such as Thasos and Mytilene (**see Catalogue entry XXVI, XXIV**). An interesting observation is the width of the west mole which is described as less thick in the publication since it is less exposed to the prevailing winds (Empereur et al. 2018a :33). However, based on today's climate recordings the prevailing winds have a West and South West direction. Why would they build a narrow west mole in the area that was most vulnerable ? Perhaps an answer to this question would be the location of the now submerged quarries that once extended towards the sea and may have played a role in protecting the narrow west mole (**Fig.4.21**) by diverting the waves and currents to the south west corner were the greatest concentration of boulders is attested.[11]

The presence of of a possible statue in the entrance of Amathus outer harbour, corresponds also to a similar staute base found in the military harbour of Thasos (in the area of the Phare rouge) (**Fig. 4.22**) (Empereur & Simossi 1994 : 407-415 ; Empereur et al. 2018a : 49-55).

[11] This idea was formulated with the help of Mauro Frontini Miguel



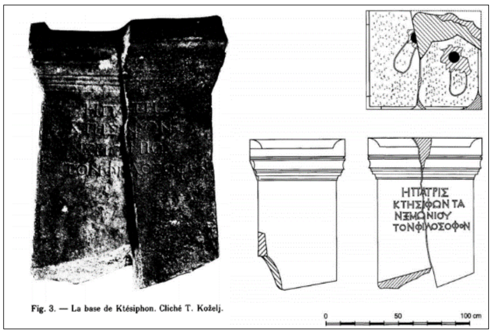
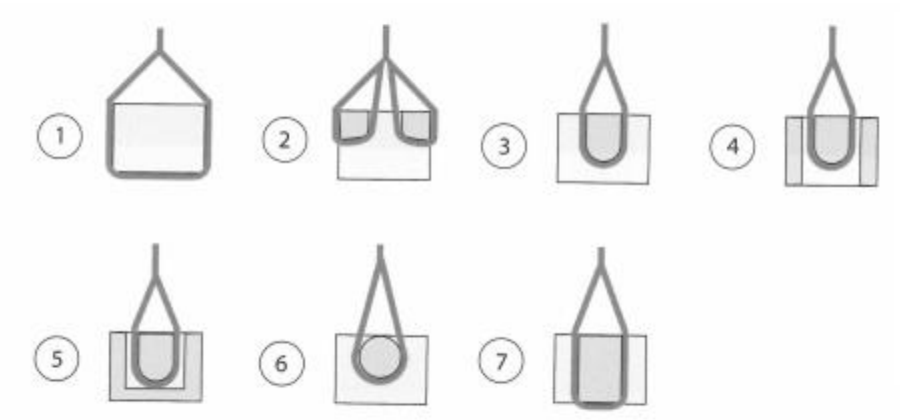


Figure 4.22 : Right : Base of statue with inscription found at Phare rouge in the entrance of the Naval Harbour of Thasos (Empereur et al. 2018a : 410 fig.3-4). Left : Base of a statue found at the entrance of the harbour of Amathus (Empereur et al. 2018 a : 55. Fig.24c).



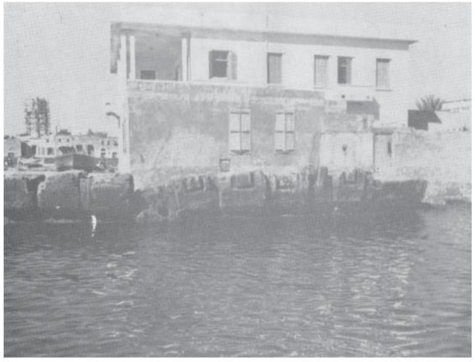


Figure 4.23 : Left - The types of lifting mortaises identified in Amathus (Empereur et al. 2018a : 62, fig.31). Right- Photo of the lifting mortaises in Arwad (Frost 1966 ; Carayon 2008 : 908, fig. 01.20

Finally, the lifting mortises are a relatively rare find since usually they are removed once the lifting and positioning of the block is completed. Not many documented parallels to compare with exist. An interesting comparison would be with the lifting mortises of the blocks preserved in Arwad on the south-east side of the island which belong to the U shape type (Type 5 according to Amathus typology) and are dated to the Hellenistic period. This type of lifting mortise was one of the least used in the harbour basin of Amathus (**Fig. 4.23**).

Amathus outer harbour basin is one of the best examples one can use to represent the « innovative » charachter of the harbourworks of the island. The south breakwater-mole is located in the open sea and is only linked to the land indirectly through the west mole. This led the harbour’s engineers to implement well known techniques (whose first examples are identified in the Early harbourworks of the Aegean and the Eastern Mediterranean) and develop so as to withstand the sea.

Moving on to the dating of the external basin, Empereur dates it to the end of the 4th century BC, as a harbour built by Antigonus. This dating was supported by the ceramics and coins found during the excavation. However, as Demesticha pointed out, the coins and ceramics used to justify this dating indicate a wider chronological spectrum that ranges from the Classical to the Roman times (Demesticha 2021 : 6). Regardless, the problematic use of the archaeological material, the Hellenistic period cannot be excluded from this discussion as other elements may justify this dating.

Taking a closer look to sondage 1,3, 13 and A traces of a hasty and rough construction is observed (Empereur & Verlinden 1987 : 8,15). This is perhaps a fact which reflects the antagonism and uncertainty generated by the Diadochi wars (Raban 1995 : 161). In addition, despite the accessible depth the harbour was built in, it seems that there was no time to prepare a proper foundation level (a fact also attested in the south extremity of Dreamer's bay breakwater which could also be dated to the Hellenistic period according to the prelimenary reports (Blue et al. 2018 ; 2019)). This hypothesis, of a rough construction is also encouraged by an interesting observation deriving from the detailed documentation of the lifting mortises (**Table 4.2**) (Empereur et al. 2018a : 62-66). There is no homogeneity in the types of lifting mortises used for each structure (except in the west mole-sondage 8). The area which posses the greatest variety in lifting mortises is the southern extremity of the east mole (sondage 14) and the east extremity of south mole (sondage 1) which is also one of the less well-built areas as gravel, headers and unworked stones were used (**Fig. 4.8 ,Fig. 2.24**). When correlating these elements : lack of a solid foundation, hasty construction (in certain areas) and different types of lifting mortises a rush in the construction of this basin is attested. No phases of construction have been identified by the excavators however, what about the channel that was described as placed to too high to play the efficient flushing role (Empereur et al. 2018a : 162). Could it be considered as a second phase in which an attempt to protect the harbour from siltation led to the creation of a channel ? This however is rather a speculation. Only when a detailed study of the channel is conducted and perhaps the location of other channels is identified we could proceed to such a hypothesis.

South mole		
Sondage A	Type 1(1) , Type2(1), Type3(30), Type4(6) 7 non identified	
Sondage 1	Type1(7), Type2(2), Type 3(44), Type 4(19), Type 6(11), Type 7(2). 2 broken	
Sondage 3	Type 1(10), Type 3(28), Type 4(2), Type5(2)	
West mole		
Sondage 8	Type 3(10) 7 broken-non identified	
East mole		
Sondage 2	9 non identified, type 3(13) ; type4(8)	
Sondage 12 eastern face	Type2(3), type3(27), type4(2) one non identified	
Sondage 12 southern face	Type1(2), type2(1), Type3(15), Type6(1) one non identified	

Sondage 14	5 non identified, type1(5), type2(1), type 3(17), type4(4), type5(1), type6(2)	

Table 4.2 : Types of Lifting Mortaises identified in each sondage (After Empereur et al. 2018a : 63).

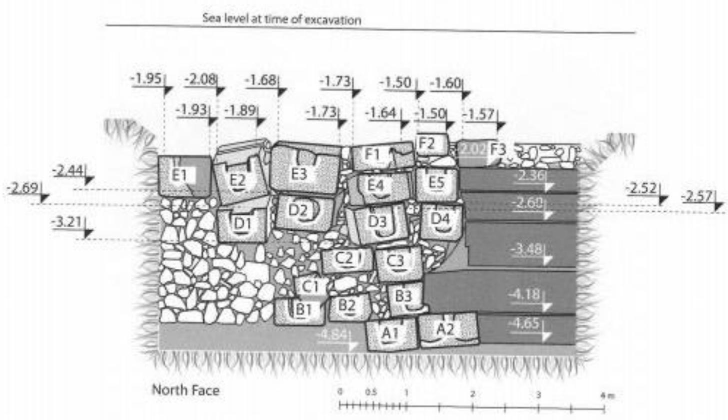


Figure 4.24 : Sondage 12 lateral face (Empereur et al. 2018a : 48, fig.18).

The final point regarding this subchapter, concerns the question if indeed these harbour constructions were completed and to what level do these structures survive ? Traces of clamps may be considered as indicators of the preservation of the upper course of the structure (Papakonstantinou 2019 : 1045). In Amathus traces were identified only in the entrance of the harbour and on the south mole (the exact location is not specified) (**Fig. 4.25**). However along the east and west mole no such traces have been reported. Perhaps a detailed photogrammetry of the harbourworks would allow the identification of more traces of clamps along the east and west mole.

However, the state in which we see Amathus today does it represent in reality the Hellenistic harbour as it was abandoned ? The use of the Zefyros database of Sylvia Ioannou Foundation led to the discovery of a very interesting reference regarding the ancient harbour of Amathus (**Fig. 4.26**). Lusigniano Steffano a member of the clergy of the Dominican order in Cyprus wrote in his book titled *Chorograffia, Et Breve Historia Universale Dell'Isola de Cipro principiando al tempo di Noè per in sino al 1572. per il R. P. Lettore Fr. Steffano Lusignano di Cipro dell'Ordine de Predicatori. In Bologna, Per Alessandro Benaccio. 1573. Conlicentiade' Superiori.* He refers to ancient Amathus (Limiso Vechia) as having had a beautiful port, of which some remains remain visible (aveva un belissimo porto delquale anchora si vede vestigio di esso) (Lusigniano 1573 : 9). This interesting reference is the only one to the authors' knowledge that refers to this harbour in this way. What did Lusigniano Steffano see in the 16th century AD ? Were there any visible harbourworks? Other travellers such as Franz von Loher refer to the harbour of Amathus « as a natural basin formed by rocks which extend some to the sea »[12] (Loher 1878 : 344 ; Empereur et al. 2018a : 161).

[12] This reference was translated with the help of Professor Rena Papadaki of the University of Cyprus who kindly confirmed the translation of the text from Italian to Greek. I would like to thank her for her time and generous help.

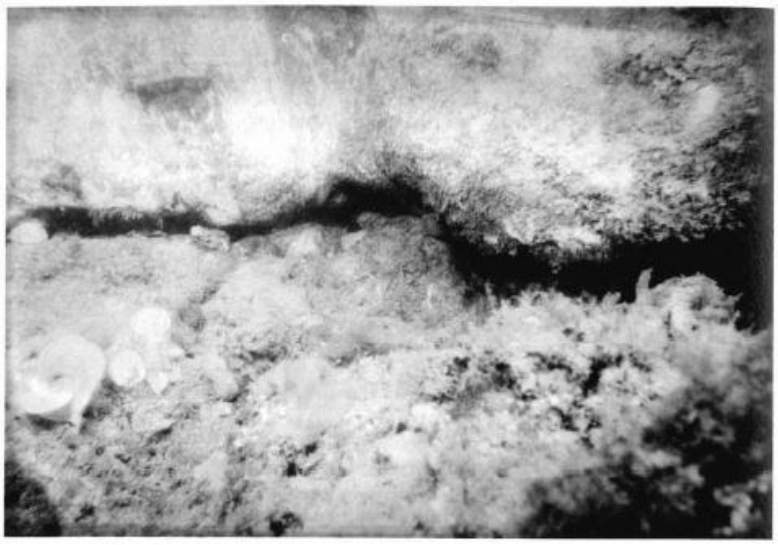
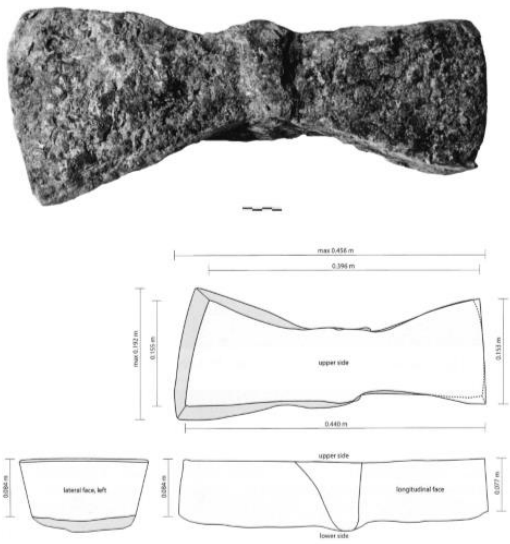


Figure 4.25 : Traces of clamps in the harbour structures of Amathus. Left: Trace of a dovetail clamp on an ashlar slab of the



south mole. (Empereur et al.2018a : 82, fig. 42). Right: Lead dove-tail clamp identified in sondage 2 (Empereur et al.2018a : 81, fig. 41a-b).

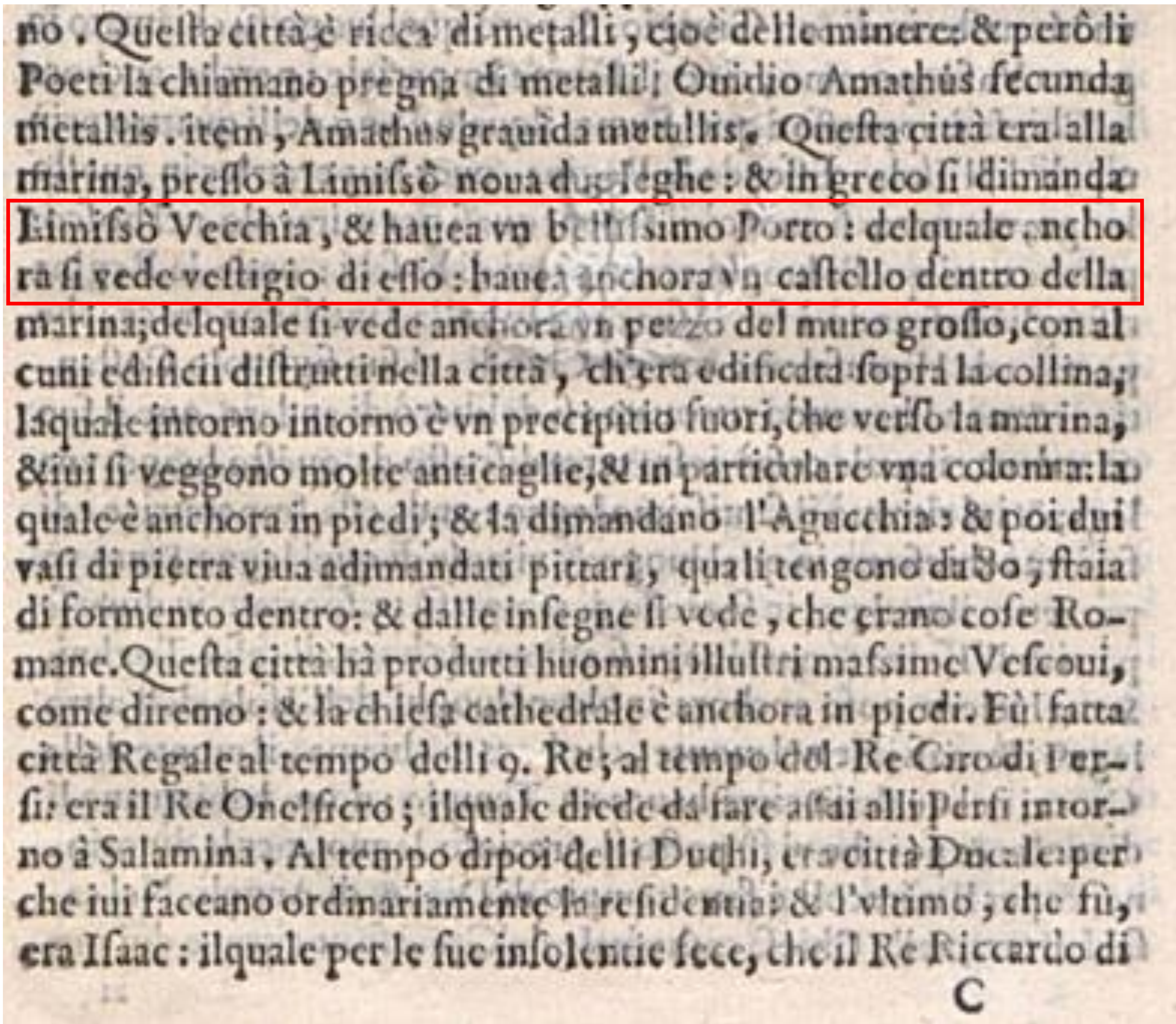

no. Questa città è ricca di metalli, cioè delle minere: & però li
Poeti la chiamano pregna di metalli: Ouidio Amathûs fecunda
metallis. item, Amathus grauida metallis. Questa città era alla
marina, presso à Limisso noua due leghe: & in greco si dimanda
Limisso Vecchia, & hauea vn bellissimo Porto: delquale ancho
ra si vede vestigio di esso: haueua anchora vn castello dentro della
marina; delquale si vede anchora vn pezzo del muro grosso, con al
cuni edificii distrutti nella città, ch'era edificata sopra la collina;
laquale intorno intorno è vn precipitio fuori, che verso la marina;
& iui si veggono molte anticaglie, & in particulare vna colonna: la
quale è anchora in piedi; & la dimandano l'Agucchia: & poi dui
vasi di pietra viua adimandati pittari, quali tengono da 80; staia
di formento dentro: & dalle insegne si vede, che erano cose Ro-
mane. Questa città hà produtti huomini illustri masime Vescoui,
come diremo: & la chiesa cathedrale è anchora in piedi. Fù fatta
città Regale al tempo delli 9. Re; al tempo del Re Ciro di Per-
si: era il Re Onelsicro; ilquale diede da fare assai alli Persi intor-
no à Salamina. Al tempo dipoi delli Duchi, era città Ducale: per
che iui faceano ordinariamente la residentia: & l'vltimo, che fù,
era Isaac: ilquale per le sue insolentie fece, che il Re Riccardo di
C

Figure 4.26 : A screenshot of the book's page were the reference to Amathus is made (Retrived from : https://inspiral.org/en/zefyros/bookpages/?fidf_book=9&fidf_bookpage=29 Last accessed 11th June 2021).

These different descriptions indicate perhaps a change in the landscape of the harbour. Perhaps what we see today is not as the harbour was left after its abandonment. This idea is encouraged by the *Legend of Amathus* as Aupert defines it (Aupert 2000 :36-37). According to local tradition, ancient blocks from Amathus were used for the construction of the Suez Channel. This is a tradition, that circulates among the locals as Emperuer writes[13]. Although, some disagree with this fact since it was not practical to use these kinds of stones as they were damaged by erosion and sea vegetation (Aupert 2000 :36-37), Empereur in his publication refers to the *Archives National du monde du travail* in Roubaix, France as source that may in the future give some insight on the subject (Empereur et al. 2018a : 79).

Fortunatley, these were researched by Elizabeth Hoak-Doering (2012) and in a series of her articles she explores this local legend. Although these archives didn't state any clear evidence on the matter, she extended her research towards other sources. For instance, the painting of

[13] This local tradition was confirmed by a personal discussion the author had with Mimis Sofokleous, head of the Limassol Historical Archives in the summer of 2020.

Luigi Mayer titled *Roadstead in the Island of Cyprus, Showing the Ramparts of Amathunta and the Town of Limassol* (1792) (**Fig.4.27**) testifies clearly the use of Amathus ancient remains as two people are seen transporting blocks from the ancient seawall into a boat. Also, Cesnola's book titled *Cyprus, its ancient cities tombs and temples* refers to the quarrying on the acropolis of Amathus which altered heavily and menaced the integrity of the archaeological site. However, Cesnola doesn't make any reference to the harbour (Cesnola 1877 : 252 ; Hoak-Doering 2017 : 170-171). Another reference was made by the French geographer Elisee Reclus in the 9th volume of *La Nouvelle Géographie universelle* (1884) «The remains of the ancient city and its tombs are rapidly disappearing, the rock of the acropolis is being used as a quarry for the buildings and the quays of Port Said : it is from Cyprus that the engineers of the canal import some of the stones ». This quarrying actvity of ancient blocks in Amathus continued also in the British occupation. A letter in 1888 written by the Receiver General to the Chief Secretary reports the removal of stones from ancient Amathus (Emperuer et al. 2018a : 79 ; Aupert 1978 : 967 ; Hoak-Doering 2012 : 211-212). There are multiple other similar references which have been collected in a series of articles by Hoak-Doering (2012 ; 2017) that refer to the exportation of ancient stones from the island including in the list Amathus. Although this fact is usually overshadowed by the debate whether these stones were used for the construction of the Suez channel or not, what interest us is the undeniable fact that Amathus site was a quarrying source. The question that remains to be answered is : What we see now is it the result of a harbour battered by the sea and man or a harbour that remains to be completed ?

Figure 4.27 : Roadstead in the Island of Cyprus, Showing the Ramparts of Amathunta and the Town of Limassol (1792) by Luigi Mayer (Hoak-Doering 2012 : 211, fig.3)

4.3 THE ABANDONMENT OF THE HARBOUR OF AMATHUS

The final thematic this chapter discusses the subject of abandonment of the harbour of Amathus in the Hellenistic Period. According to Empereur the harbour basin of Amathus was destroyed with the reconquest of Cyprus by Ptolemy in 294 BC. This statement is supported by evidence deriving from the terrestrial site as also the submerged harbour. Layers of destruction were identified in the so-called palace on the acropolis of Amathus and were dated through coins to the Antigonides therefore, it is interpreted as the destruction layer related to the reconquest of Ptolemy (Marchetti 1978 : 948-949 ; Emperuer et al. 2018a : 114). On the other hand, the destruction of the basin is identified by Empereur through the filling of the harbour with pottery which rendered it inaccessible (Empereur et al. 2018a : 114-115).

Theodoulou's (2006) was the first to point out to an abandonment of harbours in Hellenistic Cyprus. He argued that four harbour sites were built by the end of the 4th and the beginning of the 3rd century BC (during the Diadochi Wars) by the successors of Alexander the Great to fortify the island with naval stations : the outer basin of Amathus, Nea Paphos, Carpasia and Marion's. They are thought to have been probably built by Antigonus Monofthalmus or Ptolemy I Soter but never completed and seem to have been (except Nea Paphos) abandoned at an early stage (Theodoulou 2006: 230-231, 236, 239). The arguments used to justify this abandonment are the following : For Carpasia and Marion the harbour is considered to have remained insufficiently protected by the prevailing winds, while Amathus seems to have been destroyed. The dating of these structures to this period is based on the harbour typology (they are all considered by Theodoulou to belong to the *Kleistos limen* type), the use of clamps, and their similarities in their construction (Theodoulou 2006 : 230-250). Combining the recent publication of Amathus and the theory of Theodoulou (Empereur et al. 2018 : 17, 162) it seems that a major rupture in the development of the island's harbour is attested. As Leonard (2005) indicates, there are no major ex nihilo harbourworks that we know of (except those of Nea Paphos and perhaps Dreamer's bay which remains a potential hellenisitc or roman harbourwork (Blue et al. 2018 ; 2019) that date solely to the Roman or Byzantine times (this though could be also due to our difficulty in understanding the construction phases of the structures). Therefore, it seems that a rupture in the harbour's development is attested.

This pattern is also attested on the island's fortifications, since there is little evidence of fortification works during Ptolemy's control over the island (after 294 BC) (Balandier 2002). This halt in harbour development can be partially explained through the change in the socio-political organization of the island after the reconquest of the island by Ptolemy in 294BC. The different centres of power on the island, that could each sustain and support large scale works (fortifications and harbourworks) lost gradually their autonomy (Iacovou 2014c: 163; Satraki 2012: 223-224 ; Papantoniou 2013: 178-181) and this subsequently may have led to the abandonment of large scale projects such as construction of harbourworks.

What do we define though as an abandonment in the context of a harbour ? The term abandonment in reality refers to the disuse of the basin due to lack of accessibility and protection for the ships. This state of abandonment could be generated by a series of factors (man-made and natural). The above-mentioned theories though seem to attribute this abandonment mainly to the socio-political context of the time (the Diadochi wars and the abolition of the Cypriot polities). However, a harbour is never abandoned solely by man, its abandoned also by the sea[14] and for this reason research must move beyond the socio-political context. As Emperuer acknowledged other elements should be taken into account such as unforeseen silting, seismic activities and, **liquefaction** (Empereur et al. 2018a : 161-162).

[14] I would like to thank Michel l'Hour, Director of the DRASSM who pointed out this thought-provoking fact during the presentation of my Master 2 dissertation on the 15th of January 2021, which led me to use more carefully and consciously the term of abandonment.

Therefore, a series of man-made and natural processes will be discussed in the content of this sub-chapter.

A. Filling of basin with pottery :

The filling of the basin with Hellenistic pottery was interpreted by Emperuer as a sign of destruction since no other evidence of violent destruction was identified during the survey along the harbour structures. However, this filling of the basin with pottery can be interpreted differently as also questioned. First, harbour basins were in antiquity considered as dumping areas (Marriner et al. 2005 : 1324). Amathus is well known for its local production. Throwing wasters was maybe one of the practices of the workshops of Amathus. On the other hand, maybe the published material may also represent pottery that was being loaded on ships to be imported and accidentally ended on the seabed. Nevertheless, to verify any of the above theory a reassessment of the pottery and a study of its spatial distribution which in the publication remains unclear would clarify the nature of this pottery (Demesticha 2021 :3).

Nonetheless, the pottery collected in the external basin during the survey indicates (as stated above) points towards a wider chronological period that predates and post dates the Hellenistic period (Demesticha 2021 : 6). This is a fact that also corresponds to the pottery excavated in the internal basin (Thely et al. 2016 ; Thely et al. 2020 a-c). In addition, regardless of the events of 294 BC the city continues to flourish in the Roman and Byzantine times. Several buildings were built in the Hellenistic, Roman and Byzantine times such as the temple on the top of the acropolis, the nymphaeum reservoir, and the Byzantine churches (Aupert 2000 :34-37). Therefore, it is difficult to support the idea that in the early Hellenistic period this harbour was abandoned simply by the filling of the basin with pottery from the local workshops.

B. Unforeseen silting

Unforeseen silting is also an issue to consider. The inner basin and the channel of the south mole as discussed above probably indicate the consideration of this problem. Garyllis and Germasoyeia rivers to the west and Maroni and Pendaskoinos to the east of Amathus must have contributed to the siltation of Amathus harbours (**Figure 4.28**) as the predominant longshore drift of the island is from west to east on the southern coast (Nir 2010). As described above the interior basin was silted leading in the 3rd century AD to the abandonment of the warehouse, while the harbour structures of the external basin as mentioned above were covered by a layer of sediment up to 2 m in sondage A (**Fig. 4.8)** (Thely et al. 2016 ; Thely et al. 2020c). Nevertheless, only coaring and a sedimentological study could shed light on the sedimentation rate of the basin.

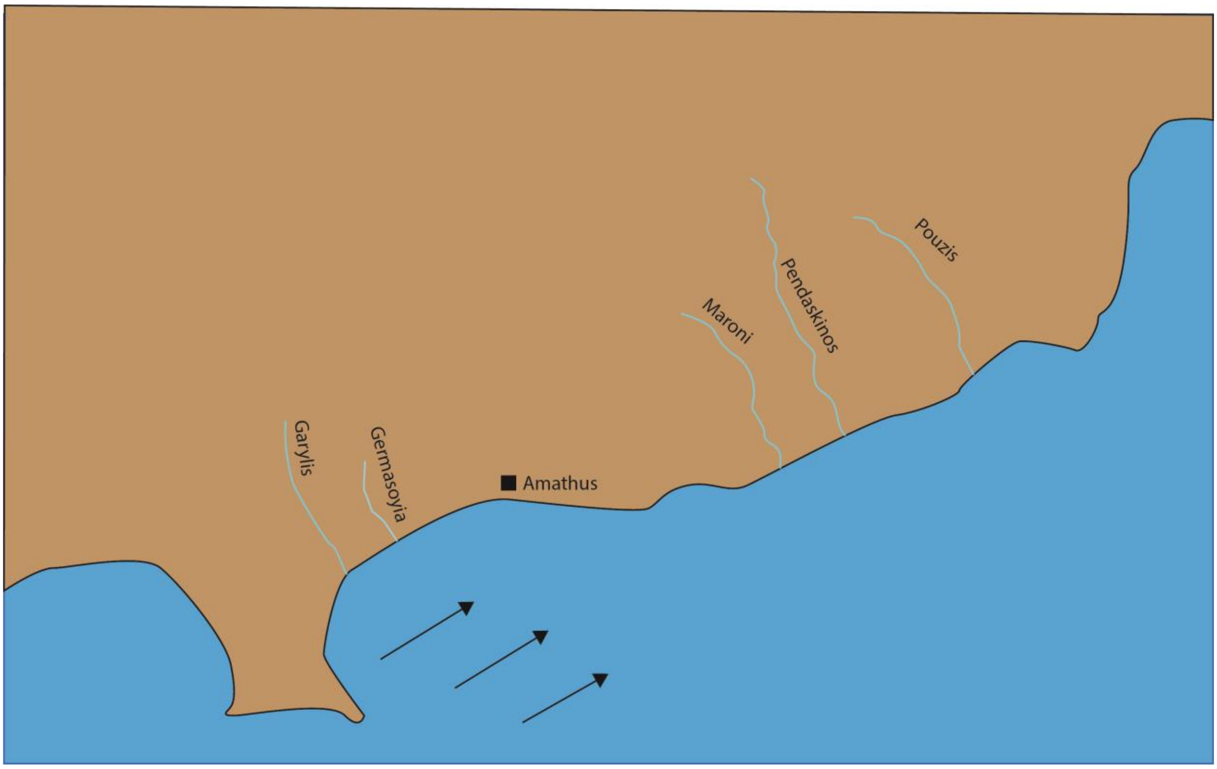


Figure 4.28 : Rivers located nearby Amathus harbour-city and the main direction of the privailing winds and currents in the area (J. Gatt 2021, after Aupert 2000 : 8, fig.1).

C. Tectonic movements :

Tectonic movements, had afflicted the island since antiquity. Various earthquakes are attested mainly through ancient sources and archaeological remains (**Table 4.3**). These references to earthquakes although they may not make clear reference to Amathus it is rational to assume that as Kourion (the neighbouring Cypriot polity to the west) was destroyed (especially by the in the 4th century AD) (Jensen 1985), so was Amathus probably affected. Although, no clear archaeological evidence sustains the destruction of the city by an earthquake the different reconstruction phases in the Imperial period (i.e. temple, nymphaeum etc.) and the abandonment of the agora in the Byzantine times may be related to an earthquake (Prête 2001 : 59-62).

Parallel to that, active fault zones are located on the coast of Limassol which produced earthquakes of significant magnitude in the past and present (Constantinou and Panayides 2012: 255). (**Fig.4.29 ; Fig. 4.30**) leading the south coast the most prone to seismic activity.

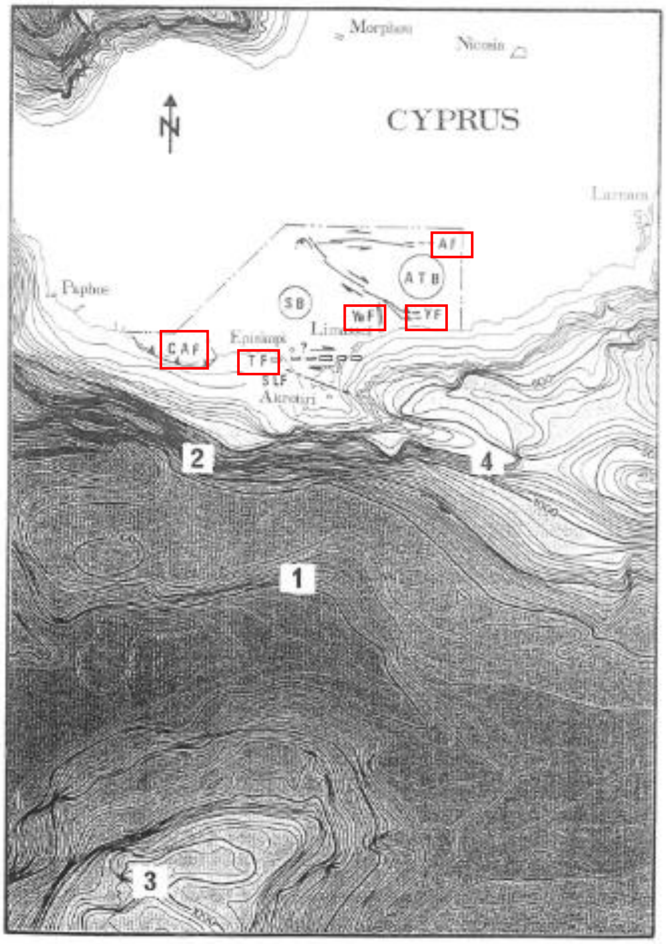


Figure 4.29 : Location of the major Fault zones (AF-Arkapas Fault, YF-Yerasa Fault, YeF-Yermasogeia Fault, TF-Trachoni Fault, CAF- Cape Aspro Fault) in the vicinity of Amathus (Soulas 1999 : fig.1).

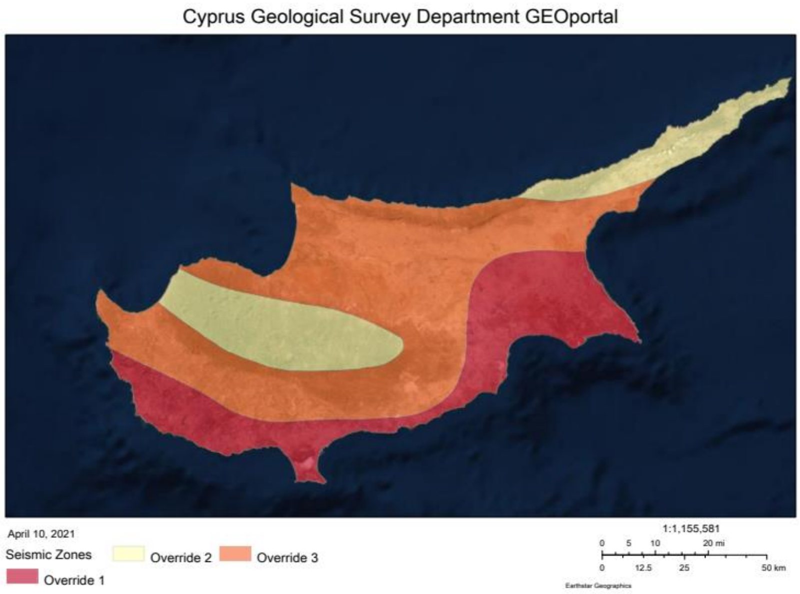


Figure 4.30: Cyprus seismic zones according to Cyprus geological Department Survey Geoportal (retrieved from

https://www.arcgis.com/apps/View/index.html?appid=e6f54157fe8640cc853df09bf2e75dd7 10th April 2021)

LOCATION	DATE	AUTHOR	DESCRIPTION
Paphos	17 BC	Dio Cass. 54.23.7 ; Eus. Hieron. Chron. 166c	Dio Cassius (3rd AD) mentions the rebuilding of Paphos by Augustus after the earthquake Chronicon of Eusebius refers to the fact that large parts of the towns on the island were destroyed.
Cyprus	77AD	Eus. Hieron. Chron. 188 ; OrosHist. 7.9.11	Eusebius refers to three towns that were destroyed by the earthquake. Same information is documented by Orosius
Salamis	293-306 AD	Mal. 313	Malalas refers to the fact that an earthquake led the city to plunge in the sea. The emperor Constantius Chlorus invested in rebuilding the city.
Salamis	332 AD	Theoph. 29	The chronography of Theophanes refers to the destruction of the city by an earthquake.

Salamis	342 AD	Theoph. 37	The chronography of Theophanes refers to the destruction of the city by an earthquake.
Paphos	370 AD	Liban. Gr. 2.52 ; Greg. Nyes. PG 45,108 ; Hieron. V. Hilar. 30.2	Libanius refers to an earthquake that generated the compassion of the people of Antioch

Table 4.3 : Earthquakes that took place affected the island of Cyprus according to ancient sources (J.Gatt 2021, after Catalogue of ancient earthquakes in the Mediterranean area up to the 10th century).

These tectonical movements are evident from various indicators on the site of Amathus. The Late Roman wells which are today submerged (Well 1, 2) in the outer harbour basin(Fig.) were dated through pottery to the 5th-7th century AD and according to Empereur these wells possessed sweet water that was used for the tannery's activity located in the Agora (Empereur et al. 2018a : 141, 148). The well's construction dates to the 4th-5th century AD (Aupert 2020 :198-199 ; Empereur et al. 2018a : 148 ; Empereur et al. 2018b : 215). Also, the quarries located west of the basin are currently submerged -1 m below the current sea level. The dating of these quarries is extremely difficult. In addition, in the area of Sondage 10, south of well 1 and 2, and 100 m north of the south mole a line of beachrock **(Fig.4.31)**, parallel to the south mole was identified in the 1980s. It is currently 1-1.5 m below sea level. Further south of this line another line of beachrock was also identified. The two lines of beachrock indicate a gradual change in the sea level which took place at different time periods. The beachrock formations extend towards the east mole in the area of Sondage 18 located at a depth of -0.80 m The only indicator that was used to date the beachrock in Sondage 18 was a Late Roman 1 amphora handle that was dated to the 4th century AD (Emperuer et al. 2018a : 125-126).

Geoarchaeology at the time of the excavation of Amathus was a discipline in its infancy as Empereur correctly states therefore the study of the beachrock was yet not possible. Today with the OSL (Optically-Stimulated Luminescence) dating technique in relation to coaring and the archaeological indicators (wells) the series of events which led to the RSL change will be correctly defined.

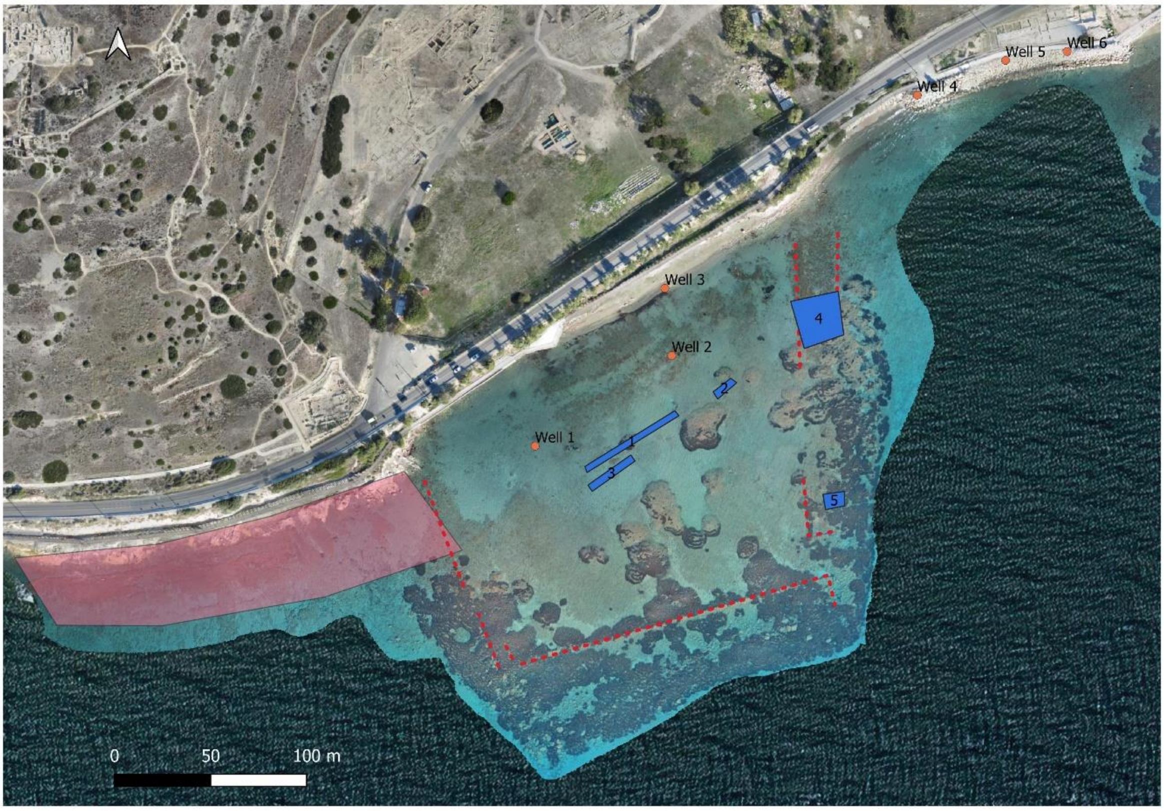


Figure 4. 31 : Location of submerged and coastal wells, quarries and beachrock (J. Gatt 2021, based on Empereur et al. 2018a, after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

D. Subsidence

The southeast Mediterranean basin is prone to the process of liquefaction as attested in the harbour of Alexandria (Goddio and Fabre 2010: 54-55). The lack of a proper foundation level in the harbour structures of Amathus in relation to seismic activity probably led to the gradual subsidence. This is also attested in other harbour structures of the Eastern Mediterranean such as in Cnidus, Alexandria, Myndos, as also Dreamer's bay breakwater south extremity. The process of liquefaction remains till today a major concern in harbour construction and in several cases harbour structures are affected by this process after seismic activity (Kardoğan & Bhattacharya 2018 ; CIRIA et al. 2007 : 815, 852).

Based on the above presented factors, we can either consider that Ptolemy had conducted a successful Damnation memoriae which literally erased this monumental harbour from the face of history or introduce other factors that in accordance with the archaeological remains (i.e. the continuation of the sites existence, warehouse, pottery) prolong the dating of the harbour up to the 3rd-4th century AD. Although the harbour structure itself does not preserve direct evidence of use till the 4th century AD, it is perhaps our lack of ability to differentiate phases of construction, as also the rather selective study of specific areas of the structure that cut the long story of this basin short.

During the Late Roman period other harbour cities experienced similar events due to coastal progradation and sea level change. In Elaia, six submerged walls probably associated with salt works (4^{th}-6^{th} century AD based on OSL and radio carbon dating) located 1 km south of the closed basin are today located -1.7 m below present sea level (Seeliger et al. 2013: 138-155). Miletus harbours too were heavily afflicted by the intensification of siltation due to human presence and the river's sediment input (Brückner et al. 2006 : 76-77). In addition, Ephesus harbour in the Late Byzantine period was also cut off from the sea due to the coastal progradation (Delile et al. 2015 :210 ; Kraft et al. 2011 : 36). Concerning Amathus, if we consider that the wells were built in the 4th century AD, their construction can be related to the seismic activity attested on the south coast at that time (which is archaeologically recorded also in Kourion).

The question that also needs to be answered is not only how and why this harbour did not remain functional, but where was the Roman and Byzantine harbour ? Amathus profited from public works financed by Roman emperor's and in the Byzantine period a series of churches were built. Can we consider that Amathus at some point had seized to be a harbour-city ? As the recent publication considers the harbour as abandoned in the early Hellenistic period, where was the harbour of the later periods ? Aupert, considers that probably Amathus used the harbour of Limassol (which harbour exactly remains unspecified) and transported goods via land (Aupert 2020 :218).

Perhaps the two points that we should take into account to answer the question is what we define as a harbour and second how did the coastline evolve in this time to better define the possible location and nature of the Roman and Byzantine Harbour. The southeast basilica which is currently located on the shoreline was heavily affected by erosion, the architectural elements on the east side of the outer harbour, the possible structure in sondage 19 (**Fig. 4.32**) (Aupert 2000 : 12-13) as also the above-mentioned submerged quarries, wells and beachrock point out to a change in the coastline. Only a geoarchaeological study of the external harbour basin can indicate the true phase of abandonment.

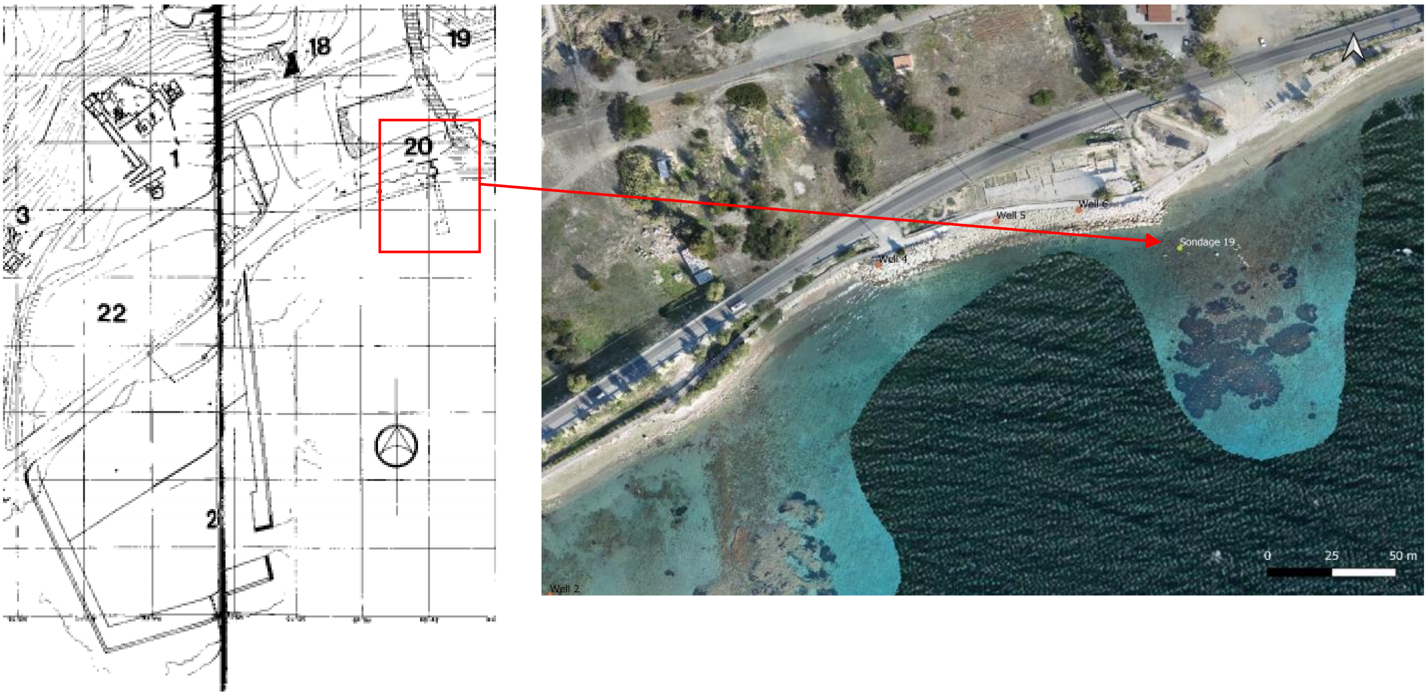


Figure 4.32 : Location of Sondage 19 (J. Gatt 2021, based on Empereur et al. 2018a : Plan 2 ; Aupert 2000 : 12-13, after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

Chapter 5 : PRELIMINARY CONCLUSIONS AND FUTURE PERSPECTIVES

The end is just the begining

Bethany Hamilton

5.1 PRELIMENARY CONCLUSIONS

A simple reflection inspired by the work of previous researchers led to a question that challenges the established concept of the character of the harbourworks of Cyprus. Were the Cypriot ancient builders masters of immitation who incorporated passivley harbour construction techniques deriving from the Greek and Phoenician tradition? Or were they pathfinders, innovators that experimented and enhanced their harbourworks according to their surrounding enviroment? In other words, in the Classical and Hellenistic harbour structures of Cyprus is a local character identified rather than simply the Greek and Phoenician tradition ? Few are the arguments that can be presented for the time being as space for systematic and meticulous documentation and research remains to be conducted on the harbourworks of Cyprus.

Nevertheless, through the collective analyses of the Cypriot harbourworks certain interesting patterns were revieled. Breakwaters are solely attested in the major harbour-cities (more specifically Amathus, Kourion (?), Kyrenia (?), Marion, Nea Paphos and Salamis) indicating that the construction of such structures was probably only feasible by a well organized authority. In addition, two breakwaters, those of Amathus and Nea Paphos (spur) seem to have applied an « economizing and practical technique » by reinforcing mainly the corners that were the most vulnerable to the prevailing winds, with large concentrations of blocks or boulders (**Fig.4.15, Fig.3.3**) and did not seem (based on the current documentation) to equally place the same consistency of boulders along the breakwater. On the other hand, Dreamer's bay and Carpasia's moles seem to attest a similar ashlar construction (Headers with a core of strechers). Their datation remains open for discussion but perhaps their parallel study would contribute in establishing a date for their construction. Finally, the harbourworks of Amathus and Dreamer's bay (the south extremity of the mole) do not seem to attest a solid foundation. In relation to the signs of a rough construction identified in both harbour structures (see Chapter 3.1) these could be characterized as built perhaps under pressure of time. Could this by any chance be linked with the rivarly between the Diadochi for the island and their plan to fortify the island with naval stations ? (Theodoulou 2006 : 231).

Concerning the harbour construction techniques, this study based its arguments on the harbourworks of Amathus, for reasons stated previously. The comparative study reflected the fact that Cyprus followed equally the harbour construction techniques identified in the Eastern Mediterranean and the Aegean however, this was not an obstacle for innovation. The south breakwater-mole of Amathus represents the capability of the ancient builders to improve the durability of the harbourworks and adapt to the demands posed by the enviroment (in the case of Amathus an open bay, highly affected by the west and south west winds). This underlines the fact that although the *Phoenician and Greek tradition*, are the forefathers of harbour technology, retracing their presence in the Cypriot harbourworks overshadows the uniqness of these harbourworks. By placing the harbourworks in the famework of the Classical and Hellenistic world a more objective understanding can be obtained, that reflects how these traditions had evovled in later periods on a local level.

5.2 PROSPECTS FOR THE FUTURE

This dissertation opened a door to a rather ambitious attempt to readress the harbour construction techniques identified in the harbourworks of the island. In the time limits of this dissertation only a small fraction of the potential of this subject was explored. Many aspects remain to be examined, space remains for ideas to mature, as also exploring different approaches from other fields of research could contribute to an indepth understanding of the ancient harbourworks.

To be able though to continue the research, meticulous documentation of the harbourworks of Cyprus, the Aegean and the Levant is needed. This would undoutabley contribute in inserting other harbours to this comparative study. In addition as previously stateted, there is a lack of systematic documentation of harbour structures through plans, sections, photos and detailed descriptions and measurements. For this reason, a filling form was created, aiming in facilitating the archaeologist excavating or studying on the field a harbour structure, with the information that is required to document sufficiently the structure[15] (**see Appendix B**). Only a systematic documentation would allow deeper questions to be asked on the construction. This form was used on a trial level during the excavation of quay E in the Anse des Laurons, Marseille during the MoMArch fieldschool (May-June 2021). This trial underlined the need for a rather more flexible form that could easily adapt to the charachteristics of every harbour structure. Perhaps in the future, the formation of an online database (i.e. in filemaker pro) would facilitate a more systematic, flexible and organized entrance of the data.

This subject though should be under the spectrum of a multidisciplinary approach that would benefit from and contribute to other research subjects. The harbourworks of Amathus consist an excellent opportunity in pursuing a research towards this direction.

Through the QGIS database that was created in the framework of this study potential areas to explore were identified. A detailed documentation of the harbourworks remains to be completed through underwater photogrametry as also a closer aerial photogrammetric coverage of the site. Fortunatley, the above will be conducted in the framework of the ANDIKAT project for Amathus. This would generate a detailed, georeferenced plan of the remained structures, that would facilitate future research such as the study of the blocks dimensions and orientation and the identification of traces of tools and clamps. A study of the spatial distribution of the location of the pottery retrived from the external harbour basin would be intersting so as to understand further the nature of the pottery of the site (Demesticha 2021). Areas also that have not been surveyed such as Sondage 19, or the north area of the east mole (see map below) remain to be investigated (**Fig.5.1**). Furthermore, a detailed documentation of the remains of the submerged quarry (although this could be conducted with great difficulty since the quarries have been eroded) would benefit in establishing the relation of the quarry with the west mole. Moreover, coaring the external

[15] This form was created in collaboration with Mauro Frontini Miguel.

basin would be the least destructive method and at the same time the most contributing for a deeper understanding of the harbour basin's bathymetry and site formation processes. A proposition for the location of coaring of the external basin of Amathus is presented, however remains open for discussion. Core 9 and 7 in combination with a sub-bottom profiler would uncover perhaps the stratigraphy in the area and contribute perhaps in identifying in the area the possible location of the channel that linked the inner to the outer basin. Core 6 and 1 would offer complimentary data to possible beachrock analysis that may be conducted in the area. Core 2 would indicate perhaps the role of the west mole and its contribution in creating a safe basin protected from the prevailing west winds. Core 4 and 5 are more likley « experimental cores » that are taken along the south breakwater-mole. Perhaps through coaring a better understanding of the possible liquefaction process that led possibly to the submergance of the structure may be detected. Core 3 would also define the enviroment of the entrance while core 8 would contribute in identifying the nature of these « mounds » that are located in the middle of the basin.Parallel to that in Figure 5.2 areas in red lines are signaled as they remain to be explored.

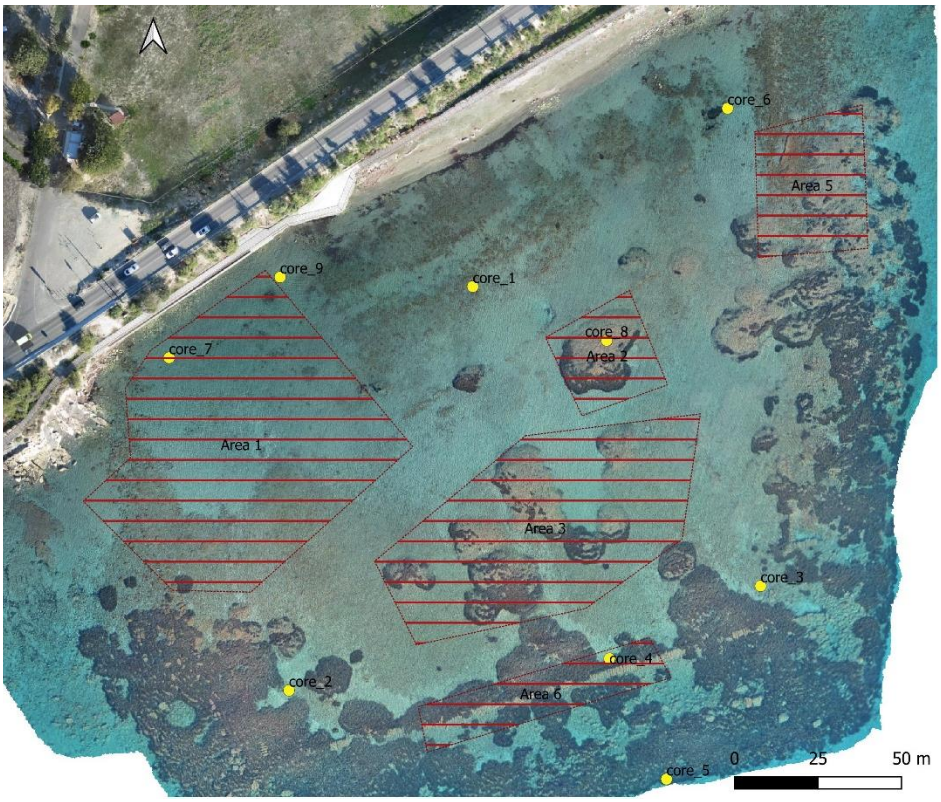


Figure 5.1 : Areas that remain to be investigated and proposed coaring to be conducted in the outer basin (J. Gatt 2021, after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

More specifically, concerning the harbourworks, four other approaches on the site of Amathus (and maybe also other sites) would be interesting to apply. A petrographic and geochemical analyses of the blocks of the harbour to identify their proveneance, a comparative study of the harbourworks construction techniques with those of the island's ancient fortifications to define the common charateristics and differences, the use of harbour structures as potential relative sea level change indicators and finally a study of the ancient harbourworks from a modern engineering point of view would contribute to an indepth undesrtanding of the harbouwroks not only from a constructional aspect, but also logistic and functional point of view.

I. THE STUDY OF THE BUILDING MATERIAL. RETRACING THE SUPPLY CHAIN.

Quarries are attested in the vicinity of almost all harbour cities and settlments that preserve evidence of harbour structures (**Table 5.1**). Their vicinity to the harbours may reflect the practical organization of the supply chain of the harbour building material. According to the recent publication of Amathus, the quarries in the surroundings of the harbour may have been the source for the construction material (Empereur et al. 2018a : 95-110). However, in the case of Dreamer's bay mole, the analysis of samples from blocks indicated that the quarries in the vicinity were not the source of supply (Blue et al 2019). This opens the question if this was also the case for Amathus.

In Amathus five quarries have been identified in the harbours vicinity (imagae). Although nothing can indicate for sure that they had supplied the ashlar blocks for the construction of the outer basin a detailed documentation of the dimensions of each excavated block led to a comparison with the quarry negatives. This indicated the possibility that these neighboring quarries supplied the material for the construction of the harbourworks (Empereur et al 2018:95-110). Nevertheless, a petrographic and geochemical analysis of the ashlar-blocks of the moles would offer a strong argument to either support or reject the above hypothesis.

	HARBOUR SITE	VICINTY OF QUARRIES	PROVENANCE OF STONES FROM QUARRIES IN THE VICINITY
1.	KITION	?	?
2.	AMATHUS	Yes	Probably
3.	DREAMER'S BAY	Yes	No
4.	KOURION	Yes	Unknown
5.	NEA PAPHOS	Yes	Unknown
6.	MARION	?	Unknown
7.	SOLOI	Yes	Unknown
8.	CARPASIA	Yes	Unknown
9.	LAPITHOS	Yes	Unknown
10.	KYRENIA	?	?
11.	SALAMIS	?	?
12.	CAPE ELAIA-KNIDOS	Yes	Unknown

Table 5.1 : Vicinity of quarries to ancient harbours and their use as a supply source for the building material (J. Gatt 2021).

II. FORTIFICATIONS

Another interesting study that needs to be conducted is how the local architecture had influenced the construction techniques of the harbourworks. A startpoint would be the island's fortifications which have been studied in detail in the PhD thesis by Balandier (1999) titled *Fortifications et défense des territoires à Chypre de l'époque archäique aux invasions arabes (VIIIe AV. N. E. - VIIE de N. E.)*. As fortifications provide protection from attacks and define the extents of a settlement, so do harbourworks. Therefore, both are surrounded by a similar philosophy. The first remains of fortifications date to the Late Bronze Age such as in Maa-Paleokastro and Enkomi (not taking into account the Neolithic walls of Khirokitia and Tenta). By the end of the Cypro Geometric III period the walls of Salamis, Kition and Idalion were built. However, most fortification walls were built in the Archaic period, meaning that most of the Cypriot-polities started to be gradually fortified by this time (i.e. Amathus, Marion and Soloi). Two phases of construction were identified, one in the 8th century BC and the second on the 6th century BC. These fortifications continued to be used with phases of restoration and reshaping in the 5th-4h century BC. In the Hellenistic period, the defensive system of the island changes. New settlments are established such as Leukolla, Arsinoe, Palaiokastro while most Cypriot-polities had undertaken the restoration and rebuilding of their walls. Parrallel to that, the building of towers which were part of a defensive system located in the Kormakiti peninsula dates also to this period. However, with the reconquest of Cyprus by Ptolemy in 294 BC a disinterest in investment in fortification works is attested, but not for long. By the end of the 3rd century BC Cyprus was the only area of control for the Lagids outside Egypt and thus, between 221 and 116 BC numerous fortification works and repairs took place on the island (Nea Paphos, Kormakiti Peninsula towers etc.), probably supervised by Ptolemy VIII Evergetes II Physcon (143-116) (Balandier 2002).

The main practises identified on the island's fortification construction according to Balandier's research is the use of a natural foundation which eventually in some cases was modified or enhanced with additional material (mainly stone or mudbrick). The upper structure (wall) was built based on different techniques. Either solely of mud brick, or a wall of mud brick covered by masonry. Also a caisson system, of 2 parallel walls divided into sections and filled with gravel or walls consisting of multiple rows was identified. The masonry applied ranges from cyclopean masonry to irregular ashlar masonry (Balandier 1999 : 537-557). No substantial parallel study between Cypriot harbourworks and fortifications (for the time being) can be conducted in the framework of Cyprus since the masonry of the upper structure of the harbourworks has been little documented.

In the Aegean though it is interesting to note that similarities in the masonry between harbour structures and fortifications are identified on a regular basis. For instance in Myndos and Cnidus were pseudo-isiodomic masonry in the harbour structure (mole) was attested an isodomic masonry on the northeast tower of Myndus and a pseudo-isodomic masonry in wall TT 31-32 was also identified (McNicoll 1997 : 25, 56).

III. HARBOURWORKS AS RSL CHANGE INDICATORS

The study of relative sea level change in Cyprus has been till know based mainly on biological and geological indicators (**see Appendix E**) which were in some cases supported by archaeological indicators, most famously the fish tanks of Lapithos. However, the harbour structures of the ancient harbours of the island haven't been systematically included in the discussion as reliable archaeological indicators. According to Marriner & Mohrange harbour installations (such as quays, breakwaters, slipways, etc) in relation to geological and biological proxies can produce detailed sea-level curves (Mohrange & Marriner 2015 : 148).

Since this study focused on the ancient harbour structures, an attempt to collect all the potential harbourworks that could in the future contribute to the study of RSL change was undertaken. In the table below a series of archaeological indicators deriving from the studied harbour sites are presented. From a first glance these indicators present a rather rich source of information. However, when moving on to a more practical use of this data a problem is identified. Once a graphic chart was attempted with this data, so to create a sea level curve based solely on the archaeological indicators (taking into account the estimation of the change in the sea level and the chronology proposed), this was not possible. This is due to the fact that the majority of the estimations are either not dated or simply the change of the sea level in antiquity has not been calculated yet. Therefore, by encouraging a detailed documentation (were possible) of the harbourworks (i.e. preserved height, datation of construction phases, identification of biological indicators on the harbour structures) an additional proxy can be in the future included in the study of RSL change.

SITE NAME	RSL CHANGE ESTIMATION	ARCHAEOLOGICAL RSL INDICATOR	DATING/METHOD	AUTHOR
KITION	+2m from Bronze Age period sea level)	Core CVI and excavated marine layer dating to the Bronze Age (13th BC)	Ceramics/ marine sediments dated by C14.	Morhange et al. 2000 : 223
	Second phase of shipshed construction raised (4th BC). A rise in sea level ?	Shipsheds	Ceramics/stratigraphy	Mckenzie 2013 : 349-361 ; Yon & Sourisseau 2010 : 65
	Marine sediments date to Roman times (865+-75BP) slightly above sea level.	Marine sediments from Bamboula's harbour	Marine sediments C14	Mohrange et al 2000 : 225 ; Yon 1991

NEA PAPHOS	2-4 m below present sea-level +0.5-1m uplift west side of Promontory +1.5m uplift Around 4m below present sea level Date unknown	East breakwater surviving height : unknown East basin Kato Paphos (not specified) 'Additional' breakwater	Manual measurement Coaring, sediment deposit Molluscan fauna analysis Manual measurement	Hohlfelder 1995 : 201 Leonard et al. 1998: 154-155 Giangrande et al. 1987 : 187 Hohlfelder 1995 : 205
AYIOS YEORGIOS	+0.45cm uplift Date unknown	Roman fish tanks	Manual measurement from fishtank inlet (sluice gate)	Giangrande et al. 1987 : 189
AMATHUS	Well 1 : 0.66m-0.84m upper part of w1ell, 2.03m lower part of well Well 2 : 1.06-1.15m upper part, 3.36m lower part of well	Wells : Well 1,2	Manual measurement, pottery LR	Empereur et al. 2018 : 133-137 Hermary 1973 : 177

	Late Roman 5-7th century AD			Leonard 2005 : 507
AMATHUS	West : 1m below present sea level East : 1.06-1.20m below present sea level South : 1.95m below present sea level Date unknown	Breakwater-moles West : 2m surviving height (estimated functional height unknown) East : 2.70m surviving height (estimated functional height unknown) North : 4.16 survivng plan height (estimated functional height unknown)	Manually. Height from excavated sections. Measurements taken from published plans	Empereur et al. 2018 : 34-35, 42-43, 46-47
AMATHUS	-0.80 Late Roman	Beach-rock	Manual measurement, dating from LR amphora	Empereur et al. 2018 : 57
SALAMIS	1.80-2m below sea level, two submerged roads and structure ashlar foundation 4th AD	Lagoonal basin (north basin)	Manual measurement, no dating	Flemming 1974 : 167 See figure 3 pg 167
KOURION	1-3m below current sea level Date unknown	Breakwater-mole (preserved height : unknown)	Manual measurement	Leonard 2005: 561, 563-564
DREAMER'S BAY	1-5m below current sea level Date unknown	Breakwater-mole (preserved height 1.55m	Manual measurement	Blue et al. 2018 ; Blue et al. 2019

Table 5.2 : Ancient harbourworks that can consist possible RSL change indicators (J. Gatt 2021).

IV. APPLYING MODERN ENGINEERING IN THE UNDERSTANDING OF ANCIENT HARBOURWORKS AND THEIR IMPACT ON THE COASTLINE.

Ancient harbourworks tend to be studied as archaeological features mainly from an architectural point of view. Their functionality and interaction with the martime climate remains little adressed (Noli & Franco, 2009; Noli, 2015; Cerezo et al., 2020). By applying modern harbour engineering analysis in the context of ancient harbours a clearer understanding of the function of the structure can be obtained. Parallel to that, an opportunity to decipher the dynamics (i.e. winds, currents, waves) that shape the harbourworks as also the impact that their construction has on the coastline and the operability of the harbour may be possible. This approach of course requires the assitance of harbour engineers that would conduct analyses based on the available archaeological data.

For example, it would be interesting to evaluate the enviroment in the outer basin and the level of protection that harbourworks offered from the open sea. Another aspect to examine is the impact the construction of the outer harbour had on the coastline of Amathus. It is already evident today that the area to the south of the east basilica has been heavily eroded and therefore a modern seawall was built to moderate the impact of erosion. This process of erosion, in this specific area may have been generated by the construction of the south breakwater-mole which diverted the orientation of the prevailing current (western direction) (**Fig. 5.2**).

Figure 5.2 : Eroded south side of basilica now protected by a modern seawall (J.Gatt 2021, after after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: Cyorus Univ. of Technology, Photogrammetric Vision Lab.)

CATALOGUE OF THE HARBOURS OF CYPRUS WITH SURVIVNG HARBOUR STRUCTURES

GUIDELINES

LOCATION	Description of the geographical location of the harbour-city.
HISTORY AND TOPOGRAPHY OF THE HARBOUR-CITY	Brief presentation of the site's history based on the archaeological remains followed by the topographical relation of the harbour with the settlement.
ANCIENT WRITERS AND TRAVELLERS	Reference to sources (non-archaeological) that describe the harbour in antiquity and later times.
TYPOLOGY, FUNCTION, CONFIGURATION OF THE HARBOUR	Description of role of harbour based on archaeological evidence, the shape (i.e. trapezoidal) and type of the basin (i.e. closed, inner or outer basin) .
PREVIOUS RESEARCH	Brief summary of the research conducted on the harbours.
HARBOUR STRUCTURES	General description (i.e. dimensions) of harbourworks. When (?) it means that the nature of the structure remains unclear.
HARBOUR CONSTRUCTION METHODS	Description of the construction techniques and materials used for the building of the harbourworks.
MARITIME FORTIFICATION	Reference to the existance of fortifications extending on or towards the harbourworks.
RELATED INSTALLATIONS	Harbour installations i.e. shipsheds, warehouses. Complimentary structures for the function of the harbour.
RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY	Indicators and measuements/datation of the change in the sea level and other factors that altered the coastline.

GEOHAZARDS AND OTHER ISSUES	Dangers (human and natural) that are endangering the integrity of the harbour.
OTHER FINDS	Descritption of finds (anchors, architectural elements etc.) found in the vicinity of the harbour.
CHRONOLOGY	Datation of the harbour based on arguments.
SOURCES	Bibliography
FIGURES	Plans, sections, photos and aerial photos.

I. AKROTIRI-DREAMER'S BAY

LOCATION

Akrotiri or otherwise called Dreamer's bay is located in an open bay on the South of the promontory located on the south central coast of Cyprus. The remains of the mole are situated between Cape Zevgari and Cape Gata in the boundaries of today's Limassol RAF base (**Fig. 1**).

HISTORY AND TOPOGRAPHY

Habitiation in the peninsula of Akrotiri dates back to 12.000 years ago when the first human presence is identified on the island at Akrotiri-Aetokremnos located on the west side of the promontory. Habitation extends up to the Byzantine period in the area. Along the south coast of the promontory a series of warehouses (dating to the Roman and late Roman period), quarries and necropolis (Hellenistic-Roman) survive. These coastal installations and the mole seem to have been connected with a series of settlements located further inland such as Pano Katalymata, Kato Katalymata and Katalymata ton Plakoton (James et al. 2021). The harbour of Akrotiri-Dreamer's Bay has been located to the south of the peninsula to the west of the coastal quarries (**Fig. 2**).

TYPOLOGY FUNCTION CONFIGURATION

The harbour of Akrotiri must have had several functionalities. It may have had a role in the maritime transport of the blocks from the coastal quarries as also as a station for ships in long distance trade. It may have also played a role for the distribution of goods in the area (James et al. 2020). The configuration of the basin of Akrotiri's harbour remains unknown since the connection and function of the mole with the coast remains unclear.

ANCIENT WRITERS AND TRAVELLERS

Strabo (Geog. XIV.6.3), Ptolemy (V.13.1-7) and Pliny (Nat. Hist. V.129-131) refer to Dreamer's Bay as Cape Kourias. Stadiasmos (303) also refers probably to Cape Kourias through the name *Karaïa*, He locates the site at a promontory and having a harbour and a small *hormos* (Ἀπὸ δὲ τοῦ Κουριακοῦ ἐπὶ

Καργαίας στάδιοι μ' ἀκρωτηριόν ἐστιν ἔχον λιμένα, ὕφορμον…). Kitchner also in his map (1885) names the ancient settlement today known as Katalymata ton Plakoton as Kurias (Theodoulou 2006 : 217 ; James et al. 2021).

PREVIOUS RESEARCH

A harbour structure and a settlement with a necropolis dated to the 5-6th century AD was documented by Heywood in the 20th century (Heywood 1982). Between 1984 and 1989 Haggerty (1990), an amateur archaeologist was the first to clean and document the ancient mole (**Fig.3**). In 1999 and 2003 the area was surveyed by Leonard and Demesticha (Leonard & Demesticha 2003). In 2003 the Episkopi Bay survey took place were Late roman and byzantine pottery was found with other nine stone anchors (Leidwagner 2004 ; 2005). The mole is currently under study by Southampton University and Leichester university since 2018, and hopefully more information on this structure will be reviled (Blue et al. 2018 ; Blue et al. 2019 ; Theodoulou 2006 : 216-217)

HARBOUR STRUCTURES

Mole

A mole with a north-west to southeast direction is located 40 meters away from the current shoreline. The total length is about 135 meters and to the north it had a width of 4.75m which widened towards the south to 8.5-9m.

HARBOUR CONSTRUCTION METHODS

Mole

Dreamer's Bay mole was built to the north on a natural solid marl foundation while to the south directly on the sandy seabed. Up to five courses have been preserved (**Fig. 4**). The average size of the blocks used in the construction ranges to 0.9/1.1/1.3 in length, 0.4 in width and 0.3 in height. Two construction phases have been identified. From the North towards the south for 80m the use of headers in the exterior side of the mole and the use of strechers in the center is observed. This technique is called headers with a core of strechers (Sharon 1987: 25). After these 80m, towards the south, the structure continued to have on the outer sides headers however in its interior irregular blocks were used (Blue et al 2019 ; 2018) (**Fig. 5**). Haggerty identified also the presence of 2 shafts (spondiloi) in the construction of the harbour structure (Leonard & Demesticha 2003 : 192-194 ; Theodoulou 2006: 216-218).

MARITIME FORTIFICATION

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RELATED INSTALLATIONS

Bollards* carved in the rocky coast have been identified during the coastal survey conducted by the Leicester university in the east coast of Akrotiri. One of the interpretations of these rock-cut features is their use as mooring stones (**Fig. 6**) (James et al. 2017).

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

Akrotiri Promontory was once a rocky island that was gradually connected to the shores of the island of Cyprus through a tombolo forming at the same time in the heart of the promontory a lagoon, today a salt lake. This theory was first expressed by Leonard and Demesticha based on Strabo's description of Kourias, as chersonisidos (χερσονησώδης) which means a promontory island (Leonard &

Demesticha 2003 : 191). Geological study of the formation of Akrotiri's peninsula was conducted by Salmon and Polidorou (for more information see Salmon et al 2015 ; 2016 ; 2018 ; Polidorou 2019 a-b).

Coaring was also conducted in 2018 on the east and west side of the mole which hopefully will reveal the enviroment on both sides of the harbour structure and will contribute in understanding its functionality (Blue et al. 2018 : 18-26). Dreamer's bay is located in an active tectonic area. The preserved structure is -1m beneath current sea-level. An ongoing study of the beachrocks in the area would perhaps yield information on the RSL change identified on the site.

GEOHAZARDS AND OTHER FACTORS

Coastal erosion seems to have altered the coastline and therefore the connection between the mole and the coast is not well understood (Blue et al. 2018: 35) yet.

OTHER FINDS

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CHRONOLOGY

The date of this structure hasn't been concluded but it is estimated to date to the Hellenistic period. A publication of the results of the survey and the cores taken around the mole will perhaps propose a more reliable date (James et al. 2019: 7 ; Blue et al. 2018 ; Blue et al. 2019 ; Theodoulou 2006: 216-218).

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FIGURES

Figure 1 : Location of Akrotiri-Dreamer's bay site (J.Gatt 2021).

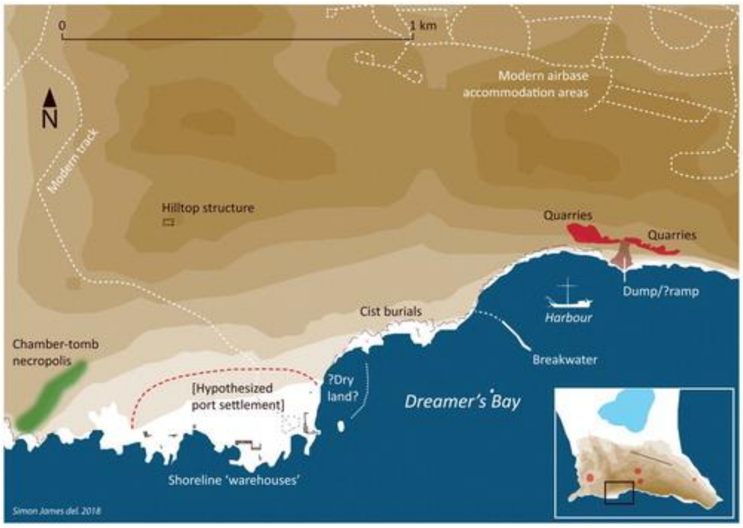

Fig. 2 : Plan of the coastal site of Dreamer's bay (James et al. 2021, fig. 3).

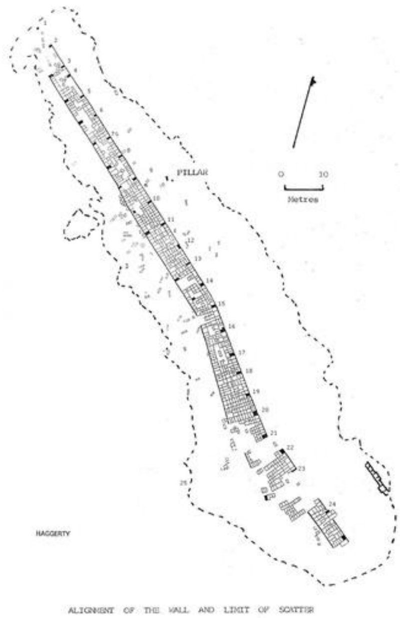

Fig. 3 : Plan of Dreamer's bay breakwater by Haggerty produced in 1990 (James et al. 2021 : fig. 8).

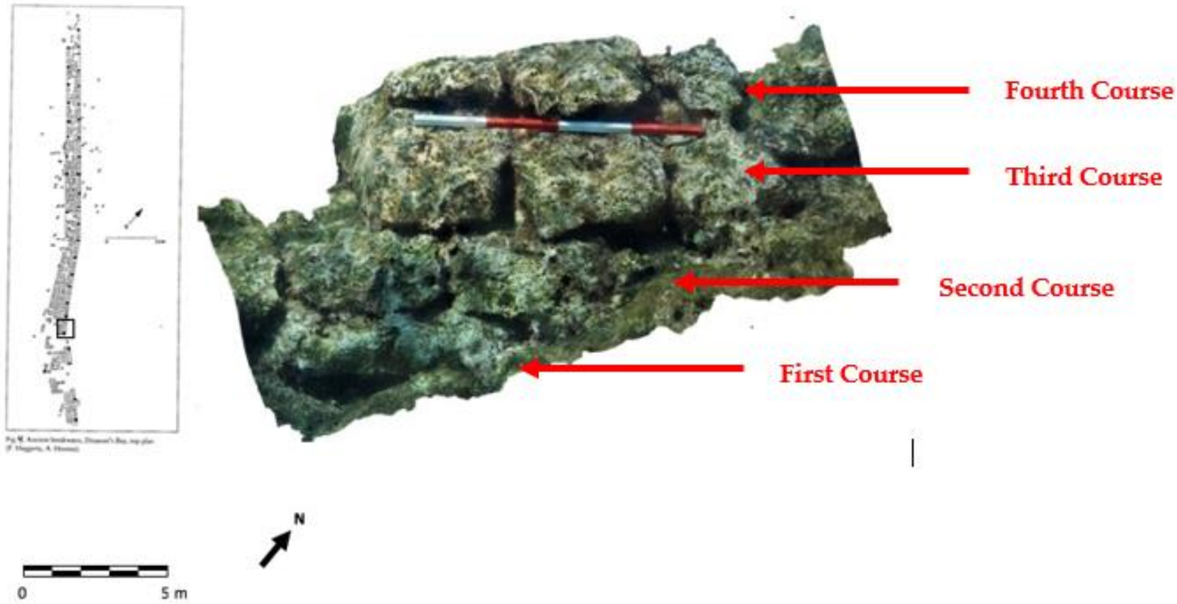

Fig. 4: Orthophoto of the reconstructed portion of the eastern side of the breakwater (Photogrammetry survey and processing: M. Secci) (Blue et al. 2019 : Fig. 7).

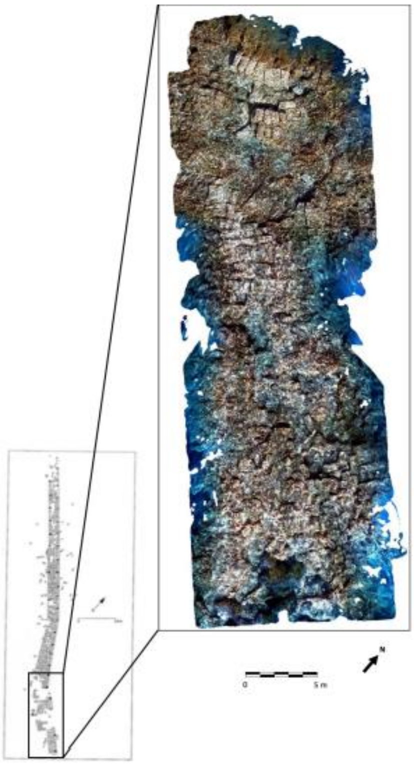

Fig. 5 : Orthophoto of the southern end of the breakwater (Photogrammetry survey and processing by M. Secci) (Blue et al. 2018 : fig.7).

Fig. 6 : Photo of the coastal rock-cut « bollard » (James et al. 2017 : fig. 3).

II. AKROTIRI (CAPE) ELAIA/ KNIDOS

LOCATION

It is located at the south coast of the Carpasia Penisula, on a cape on the east coast of the island (**Fig. 1**).

HISTORY AND TOPOGRAPHY OF THE HARBOUR CITY

Habitation in the area is attested from the Bronze Age till medieval times based on pottery distribution. A walled acropolis dating to the archaic and classical period as also a necropolis and the remains of an enclosed building dating to the Classical or Hellenistic period were documented. Quarries in the area have been also identified (Bouzek 1988: 73-75). The harbour is located to the south of the settlement. The exact configuration of the harbour basin remains unknown (Theodoulou 2007: 218-219) (**Fig. 2**).

TYPOLOGY, FUNCTION, AND CONFIGURATION

Since no study has been conducted on the harbour site of Elaia Knidos no information on the typology, function and configuration is available.

ANCIENT WRITERS AND TRAVELLERS

Cape Elaia was mentioned by Ptolemy (V.14.1-17) and Ovid in Metamorphosis (Metam. 10.530-531) however no references to the harbour were made. Ovid reference though : «…non alto repetit Paphon aequore cinctam, piscosamque Cnidon gravidamque Amathunta metallis» refers to the fishing activity in the area and Hogarth (1889: 65) documentation of the mortuary stele found on the site on which it was written «Συμμάχο ἐστὶ τὸ σᾶμα τριηράχο Κνιδίου» meaning that a local was a captain of a trirem by Knidos, indicate the relation of the locals with the sea (Theodoulou 2006 : 219).

PREVIOUS RESEARCH

The area was known to the Deparment of Antiquities for its terrestrial finds such as tombs. In 1972 a preliminary survey was conducted in the area by Bouzek, whose results were published in RDAC. An archaeological Czechoslovak-Cypriot excavation was about to be conducted but due to the Turkish invasion in 1974 it was not possible (Theodoulou 2006: 218).

HARBOUR STRUCTURES

Bouzek documented the existence of a curved breakwater-mole (?) that extended from the peninsula of Cape Elaia with a south-west direction. This was confirmed through an aerial photo taken in 1963 which was studied by Theodoulou. Theodoulou identified from the aerial photo a possible second breakwater-mole (?) located north-west of the later (Theodoulou 2006: 217) (**Fig. 3**).

HARBOUR CONSTRUCTION METHODS

No observations on the construction methods have been made. No measurments of the harbour structure or underwater photos were taken (Bouzek 1988: 73).

MARITIME FORTIFICATION

-

RELATED INSTALLATIONS

-

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

Bouzek refers to the fact that the breakwater mole is -1m below current sea level indicating a change in the sea-level (Bouzek 1988: 73).

GEOHAZARDS AND OTHER FACTORS

The breakwater-mole (?) identified by Bouzek has been covered by modern harbour installations which consist an obstacle for future study of the submerged breakwater-mole (?). In addition it seems that the harbour basin was silted (Bouzek 1988: 71-75; Theodoulou 2006: 218-220).

FINDS

-

CHRONOLOGY

Intense habitation in the area dating to the classical period is the the only argument used to the date this harbour structure to the Classical period (Theodoulou 2007: 219).

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FIGURES

Fig. 1: Location of Elaia-Knidos coastal site (J.Gatt 2021).

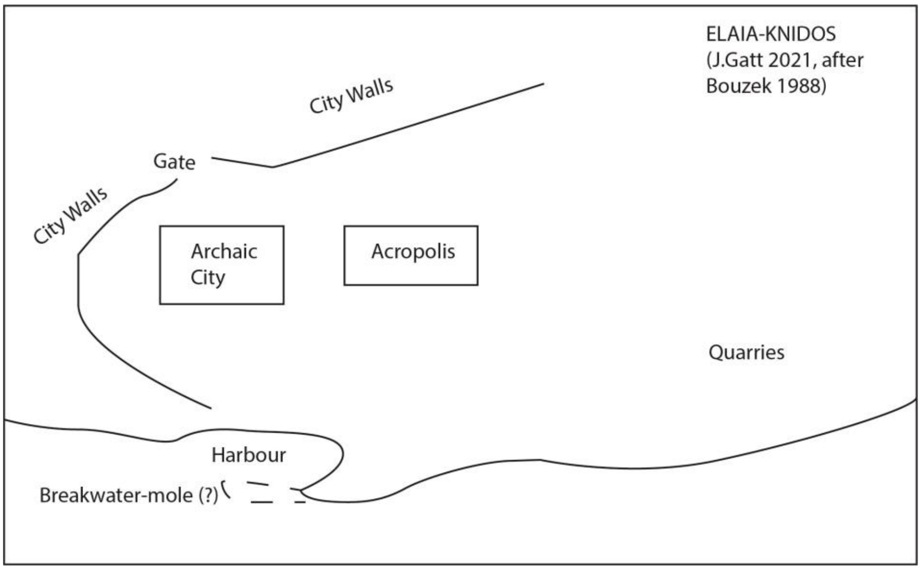

Figure 2 : Plan of Elaia-Knidos harbour and surrounding area (after Bouzek 1988: fig.2).

Figure 3 : Aerial photo of 1963 documenting the submerged ancient breakwater (Theodoulou 2006: 188).

III. AMATHUS

LOCATION

Amathus habour-city is located 10 km east of the center of Limassol city, between the Cypriot-Polities of Kourion and Kition and the rivers of Garylis and Germasoyeias to the west and of Maroni and Pendaskoinos to the east (Empereur 1995: 131 ; Satraki 2012: 158) (**Fig. 1**).

HISTORY AND TOPOGRAPHY

The surrounding area of Amathus attests the earliest habitation on the island through the Neolithic settlements of Shillourokambos and Klimonas (9000-8000 BC). Two important Late Bronze Age sites in the surrounding region are Kalavasos and Maroni which are around 15-20 km north of Amathus and were abandoned in the end of the Late Bronze Age. By the end of the 11th century BC, a well on the acropolis (the hill) filled with ceramics from the Cyprogeometric period is attested. Tombs of the Cyprogeometric period located north east and west of the hill indicate human presence in the area, although no settlement has been identified. The first monumental structure in the area was the so-called palace that dates back to the 9th-8th century BC and underwent several phases of construction in the Archaic and Classical period. The palace was destroyed in the 3rd century BC. On the top of the hill, a sanctuary dating back to the 8th century served the cult of a goddess. In the 1st century AD the first monumental temple was built and was one of the most prominent temples on the island with that of Palaepaphos. In the Archaic period the first fortification of the settlement took place including the acropolis and the surrounding area. The fortification underwent several phases and was abandoned in the 7th century AD (Satraki 2012: 158-159 ; Iacovou 2007: 28-31; Cannavo 2015 ; Hermary 2015 ; Aupert 2015).

Amathus was one of the Cypriot polities and this is proven by the minted coins of Amathus dating to the 5th century BC (Iacovou 2007: 28-31).However, Amathus name in the list of the Cypriot polities, on the stele of Esarchadon, has not been recognized (see discussion Satraki 2012: 234-235). In the 5th century BC phases of destruction both in the sanctuary and the palace have been attested and linked to the siege of Amathus by Onisilos during the Ionian revolt as Amathus denied to participate (Aupert 2000: 27).

In the Hellenistic period the harbour-city was affected by the Diadochi wars. In Diodorus detailed account Amathus is not referred to but based on the publication of the outer basin of Amathus the artificial basin was constructed during this period. Some, attribute the construction of the artificial/external harbour basin to Ptolemy I (Bekker-Nielsen 2000: 202) while Empereur's latest publication (2018) considers that with the arrival of the Antigonides on the island (301-294 BC) Amathus became a naval base. With the reconquest of the island by Ptolemy I, the city was destroyed in order to underline the end of the Antigonide's reign (Aupert 2000: 32). A phase of destruction in both the harbour basin (filling of harbour basin with pottery) and palace in the end of the 4th century BC have been linked to this event (Empereur 1995: 131-136 ; Satraki 2012: 248 ; Empereur et al 2018a : 114-115). Following the reconquest of the island by Ptolemy I the settlement was concentrated in the lower city and Ptolemaic cults were included in the sanctuary (Aupert 2000: 33). In the Roman period, emperors invested in the public works such as the Nymphaeum reservoir during Hadrien's regin. In the 4th century AD the first known bishop of Amathus is recorded and the Byzantine city is mainly attested through its churches. The city was abandoned by the 7th AD due to the Arab raids.

The settlement was spread on the slopes of the hill especially on the south and east slope. The city was surrounded by the necropolis in the north, east and west and the fortification walls (which included the acropolis and the lower city). In, addition to the south west and north east, quarries have been identified (Empereur et al. 2018: 96-110) while to the south the two harbour basins (inner and outer) were located. The inner silted basin is located south of the Agora, a common pattern in the topography of harbours (Baika 2013: 188-191). The acces from the city towards the harbour and vice versa and the configuration of the inner basin remain unclear. It also remains to be determined the connection of the artificial basin with the inner basin and the city's fortification. The area that connected the inner with the outer basin is currently covered by a main road and a touristic pathway while the fortification of the city may have extended on the jetties and moles. No clear evidence on these harbour structures has been identified (Aupert 2020: 200-202) (**Fig. 2**).

ANCIENT WRITERS AND TRAVELLERS

Pseudo-Scylax refers to Amathus as having a harbour by using the term ἐρήμους (erimous) meaning desserted (Pseu.77.103). Other ancient writers refer to the city of Amathus such as Strabo, Stadiasmos, and Pliny, but with no reference to its harbour. It is surprising that ancient literature remains silent in the presence of such a monumental outer harbour.

PREVIOUS AND CURRENT RESEARCH

The outer artificial harbour of Amathus (**Fig. 3**) was surveyed by the French school of Athens in the 1980's (**Fig.4**). Between 1984 and 1986 three underwater excavation campaigns took place. A series of reports and articles were published since the beginning of the survey however the final publication of the harbour was published in 2018 (Empereur et al. 2018 a-b). Concerning the inner basin, in 1978 a geophysical prospection took place by Aupert (1979) followed by a geoarchaeological study conducted by Antoine Chabrol in 2014 (**Fig. 5**) (Thely et al. 2016).

Regarding the terrestrial site of Amathus the first excavation of the French school of Athens in Amathus began in 1975 although previous excavations by amateurs, archaeologists and the Department of Antiquities of Cyprus took place from the 19th century mainly focusing on the necropolis (Aupert 2000: 15) (for the survey's and excavations concerning the terrestrial area see BCH 1976-2019).

Currently, the excavations of the French school of Athens in Amathus are ongoing in the inner basin (Thely et al. 2016 ; Thely et al. 2020a-c). A GIS database project directed by Anna Cannavo aims in the topographic study of the settlement (Cannavo 2016). Parallel to that Amathus external basin will be the first underwater archaeological park of Cyprus in the famework of ANDIKAT project (Marelab 2020).

TYPOLOGY, CONFIGURATION AND FUNCTION

The inner basin a natural open bay with no known till now harbour structures was bordered to the north by the Agora, the warehouse (dating from the archaic-classical period) and a possible hauling ramp ?. The outer artificial harbour of Amathus preserves the best known till now harbour structures on the south coast of Cyprus. It consists of three man-made harbour structures, two moles (east and west) and a breakwater-mole which forms an enclosed trapezoidal basin. The east and west mole extend vertically from the shore with a north-south direction (145, 130 meters long respectivley and 11 meters wide), and the south breakwater-mole extends east to west with a length of 180 meters and a width of 18 meters. The entrance to the harbour was located in the south-east corner and had a width of 20m (Empereur & Verlinden 1987b: 9 ; Theodoulou 2006: 150 ; Aupert 2000: 96).

In the middle of the south breakwater-mole according to Empereur a channel, 37 meters long similar to that, of Taposiris Magna (Boussac 2007: 460) was located. He interprets it as a flushing channel (Empereur et al. 2018a: 45). Aupert, however compares it with Sussa and Thapsus breakwater channels which were used so as to break the force of the waves (Cintas 1976 : 234-235 ; Aupert 2020 : 210).

Probably, the harbour's entrance was flanked by towers. According to Empereur the presence of towers is attested in Sondage 12 were a series of small blocks (different from those of the mole), some with traces of clamps and curved faces indicate a tower with a circular form. On the contrary Aupert is not satisfied by the evidence (Aupert 2020 : 202-203) and questions the existance of these structures. In addition, in the harbour entrance a stone with traces of a statue was found similar to that found in Thasos (Empereur & Simossi 1994 : 407-415 ; Empereur et al. 2018a : 49-55).

Raban considers that Amathus «as the transitional type of the *Kleistos Limen* to the Near East » (Raban 1995 : 161). According to Empereur and Theodoulou the outer basin was constructed to cater the needs of the Antigonides for a naval station (Empereur et al 2018a : 115-119). Nevertheless, it remains undeniable that this harbour was above all the commercial harbour of Amathus, the gateaway to acess and exchange goods (Thely et al. 2020c).

HARBOUR STRUCTURES AND CONSTRUCTION METHODS

WEST MOLE

The west mole (**Fig. 6**) according to sondage 8 was built by two parallel walls of headers. Only three courses are preserved. In between the walls a filling of gravel (limestone offcuts and debris) was added. The filling consists of an alteration of small gravel, larger gravel and a final layer of smaller gravel. It remains unclear if this structure was built on a man-made or natural foundation of pebbles and gravel (c. 0.20cm thick) (Empereur et al.2018a : 33-37).

SOUTH BREAKWATER-MOLE

The south breakwater-mole (**Fig. 7**) is particular. Ashlar blocks (headers) are present only on the leeward side of the breakwater-mole according to Sondage A. This mole was 180m long consisted of 6 courses of headers. The headers seem to be placed in a quincunx pattern. The eastern extremity of the south mole which consists the entrance of the harbour is particular. An alteration of strechers and headers in Sondage 1,3,13 was attested. No foundation level along the mole has been identified.The breakwater located on the seaward side of the mole was built with a concentration of large boulders (rubble) mainly on its west corner. Between the mole and the breakwater a concentration of gravel consting of minimum sized unworked stones was placed (Empereur et al. 2018a : 37-38, 45-48).

EAST MOLE

The southern extremity of the eastern mole (**Fig. 8**) consists part of the entrance. The extremity of the east mole (Sondage 2) attests a presence of gravel between the blocks (Empereur et al 2018a : 45-53).The northern part of the east mole (sondage 15,16,17,18) is poorly preserved. According to aerial photos taken between 1984-1986 two parallel rows of strechers existed, therefore a similar construction was applied with that of the west mole (Empereur et al. 2018a : 57). No foundation level has been identified.

CONSTRUCTION MATERIAL AND MACHINERY

Ashlar blocks used for the construction of the harbour had an average of 1-3 meters length, 0.50-0.75 meters width and 0.25-0.55 meters thickness. These blocks weighed from a third of a ton up to more than 4 tons. Around 5000 ashlar blocks are estimated to have been used (for more information see Empereur et al. 2018a: 62-92).

Mainly the harbourworks were of drystone construction meaning no joining element or material was used. The upper courses of ashlar blocks seem to have been connected with iron clamps. Iron clamps and their traces were found in the entrance of the outer harbour basin, on the south mole (**Fig. 9**) as also to the North of the west mole on the beach were a series of blocks retain traces of clamps. A clamp was also found prior to the beginning of the survey in the outer basin and is found today in the Limassol museum (Raban 1995: 161 ; Empereur et. al. 2018a: 79).

Empereur (Empereur et al. 2018a: 87) discusses the possible machinery used for the lifting and positioning of the blocks. According to their estimation, the machinery must have been as wide as the mole and consisted of a jib (crane) which functioned by the block and tackle system (**Fig. 10**) (which consisted of two or more pulleys connected with ropes that were used to lift the ahlar blocks). Lifting mortaises attested on the majority of the ashlar blocks indicate this process (for more information on the lifting mortaises see Empereur et al 2018a: 62-78). This hypothesis is based on existing ancient literature that describes such kinds of machinery (barulkos) such as Hero of Alexandria (Papadopoulos 2007: 4,6,12).

MARITIME FORTIFICATION

Amathus preserves a series of terrestrial fortifications that surround the acropolis and lower city (for more information on the terrestrial fortifications see Aupert & Leriche 1994). However, since the interface has been heavily eroded and disturbed by the modern infrastrucutre (road and pathway) the maritime fortifications are little preserved. The west rampart (**Fig. 11**) is the only standing fortification on the coastline while two walls (Pa and Pb) seem to extend on the east and west mole (**Fig. 12**) (Aupert 2020: 200-202). Nevertheless no evidence on the harbour structures indicates the construction of maritime fortifications on top of the jetties and breakwater moles.

RELATED INSTALLATIONS

UNIDENTIFIED STRUCTURES

To the east of the artificial basin and to the south of the southeast basilica in sondage 19 a possible submerged feature (depicted in some of the Plans of Amathus) seems to exist (i.e. Empereur et al. 2018a: 96, fig.1). Empereur did not describe the findings of the sondage.

WAREHOUSE

In the north side of the inner basin an excavation uncovered a series of walls (**Fig. 13**) which date from the classical and maybe even the archaic period up to the 3rd century AD. The location of this structure between the agora and the interior basin as also the pottery define this structure as a warehouse (Thely et al. 2016 ; Thely et al. 2020c).

CALE-SECHE-HAULING RAMPS ?

In the inner basin according to Empereur the possible location of a hauling-ramp (?) located east of the warehouse was expressed. In 2017 two walls (**Fig. 13**) (UC1005 & UC1012) were identified in Sondage F. These structures were interpreted as a hauling-ramp which dates prior to the Roman period probably to the Archaic-Classical times (Empereur et al. 2018a: 116 b: 218 ; Thely et al. 2020c).

RELATIVE SEA LEVEL CHANGE AND GEOARCAHEOLOGY. THE ABANDONMENT OF THE HARBOURS OF AMATHUS.

The inner basin is currently silted while the outer basin is submerged. The inner basin underwent geophysical prospection (Aupert 1979 ; Parhas & Spahos 1979) and coaring

(**Fig. 5**) (Thely et al. 2016) as also an excavation that uncovered a series of archaeological and geoarcheological data (Thely et al. 2016 ; Thely et al. 2020c). The inner basin underwent a gradual siltation. According to the cores three phases were identified. The first phase (Unit A) corresponds to a sandy paleocaostline that existed prior or parallel to the occupation of the site. The second phase (Unit B) corresponds to a clayish layer rich in organic material and marine organisims interpreted as a « decantation deposit sediment » which represent a closed low energy enviroment. The final phase (Unit C) is represented by clayish-sandy sediments that are related to the abandonment phase of the inner basin and led to its final and definite filling of the basin with sediments (Thely et al. 2016).

Regarding the outer harbour basin a series of submerged wells in the outer basin, submerged beachrock and quarries as also the submerged moles and breakwater-mole indicate a change in the coastline (**Fig. 4**). The two submerged wells (1,2) were filled with pottery dating to the 5th-7th century AD and according to Empereur these wells possessed sweet water that was used for the tannery's activity located in the Agora in the Byzantine period (Empereur et al. 2018a : 141, 148). The pottery of the wells does not date their construction but rather gives a terminus ante quem, however according to Emperuer the wells were constructed in the the 4th century AD (Aupert 2020 :198-199 ; Empereur et al. 2018a : 148). Well 1 upper part is currenlty -0.66m to -0.84m below sea-level while its lower part is -2.03m below current sea-level. Well 2 upper part is currently -1.06 to -1.15m while its lower part is -3.36m below current sea-level (Empereur et al. 2018a : 133-136). Concerning the quarries, they are currently -1m below present sea level. The datation of the use of these quarries is difficult to determine (Emperuer et al. 2018a : 93-101).

The beachrock has been identified in the area of Sondage 10, south of well 1 and 2, and 100m north of the south mole. It is crrently 1-1.5m below sea level. Further south of this line another line of beachrock was also identified. The two lines of beachrock indicate a gradual change in the sea level which took place at different time periods. The beachrock formation extends towards the east mole in the area of Sondage 12. The beachrock formation was identified on ashlar blocks at a depth of -0.80m below current sea-level. The only indicator that was used to date the beachrock in Sondage 12 was pottery, a Late Roman 1 amphora handle that was dated to the 4th century AD (Emperuer et al. 2018a : 125-126). The beachrock located to the north of the east mole is considered a recent formation. These two elements (beachrock and wells) indicate that at a certain period of time almost half of the harbour basin was land and became inacessible to ships (Empereur et al. 2018a : 125-126).

Finally, the harbour structures although non seem to be preserved to their functional height they must be also taken into account as possible indicators of the RSL change (once future documentation takes place). According to Sondage 8 on the west mole the lowest course of headers is located -2.24m below present sea level while the upper part at -0.86m below current sea level. In sondage A on the west side of the south mole the lowest course is identified at -3.76m while the upper course is located -1.06m below current sea level. In the harbour entrance (south side) in the sections of sondages 1, 3, 13 the lowest course was identified at -5,96m depth while the upper course at -1.60 m. Finally, the south extreme of the east mole (entrance area), in sondages 17,12,2,14 the lowest course was identified at a depth of -4,84m while the upper course at -1.34m. In Sondage A the structure survives to 2.7m, in Sondage 8 the structure survives up to 1.38m, in sondage 1, 3, 13 it survives up to 4.16m and in sondage 17, 2, 12, 14 up to 2.46 m height. Therefore, although today the bathymetry is around approximatley -1m in the harbour basin, from the sondages it is evident that the seabeb of the ancient basin was located deeper (Empereur et al. 2018a : 31-61).

Relative sea-level change must have had a significant role in the abandonment of the harbour basin in the Hellenistic period. The south coast of Cyprus has been afflicted by earthquakes since Late antiquity and therefore undoutabley tectonic movments must have been the primodial factor for the submergance of the basin. However, other factors such as the filling of the harbour basin with pottery (in the framework of Ptolemy's reconquest of the island in 294 BC), the process of liquefication (due to the absence of solid foundation), the problem of siltation due to the vicinity of the harbour to active rivers (Garylis, Germasoyeia, Maroni and Pendasxoinos) and the main direction of the long shore drift (west to east) must have led to the siltation of the basin (Empereur et al. 2018 : 162).

GEOHAZARDS AND OTHER ELEMENTS TO CONSIDER

Erosion is one of the major threats the coastline underwent the past years. For instance, the quarries on the coastline have been heavily deformed from the wave activity as also the southeast basilica has been partially eroded. The coastal erosion was prevented with the construction of a seawall along the coastline.

In addition, the touristic development in the area with the creation of a bridged passage-way along the coast has unfortunately covered most of the late roman wells and has made almost impossible the study of the connection of the outer with the inner harbour basin.

OTHER FINDS

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DATATION OF THE HARBOUR BASIN

Based on the coins, the ceramic evidence and the characteristics of the harbour structures, the outer harbour basin has been proposed to have been built by the end of the 4th century BC and the beginning of the 3rd century BC and thus being a project of most likely one of the Diadochi (Empereur et al. 2018a). Since no phases of construction or repair have been identified on the harbour structures of the submerged basin it seems that the harbour construction was never completed and that the harbour has a very short life. This is enhanced by the only reference to the harbour of Amathus in the ancient sources by Pseudo-Scylax who dates in the 4th century BC. The interior basin can be dated back to the Archaic period although no clear harbour structures can be attributed to this period with certainty yet. The final siltation and filling of the basin however seem to be dated to the 3rd century AD.

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FIGURES

Figure 1 : Location of the site of Amathus (J.Gatt 2021).

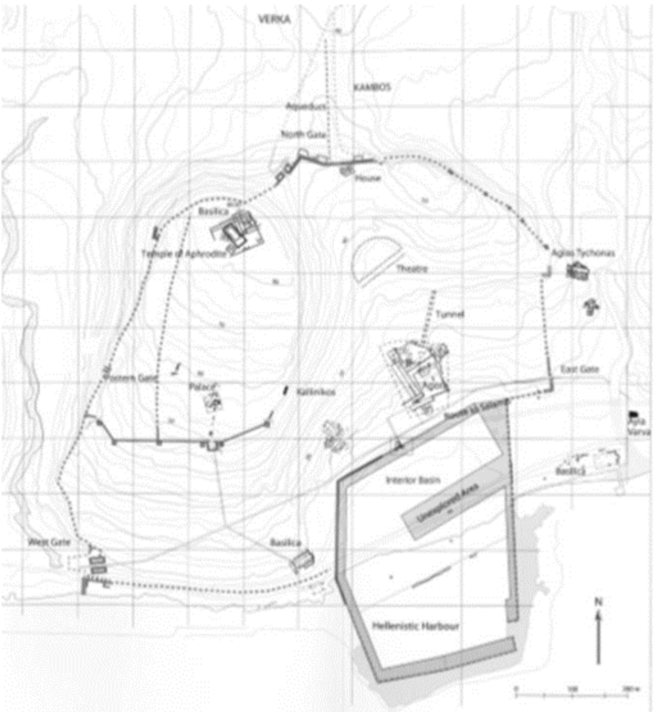


Fig. 2: Plan of Amathus coastal settlement and outer and inner harbour basin (Empereur et al. 2018 : 171).

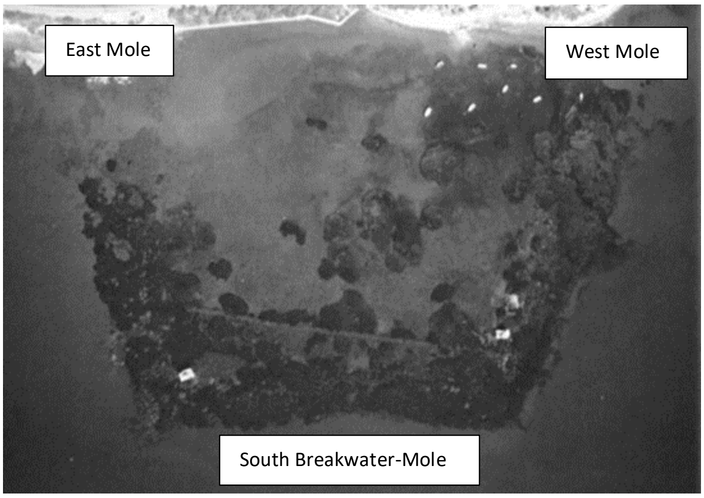


Figure 3: Aerial photo of the outer harbour basin of Amathus (Empereur et al. 2018: 10, fig.1).

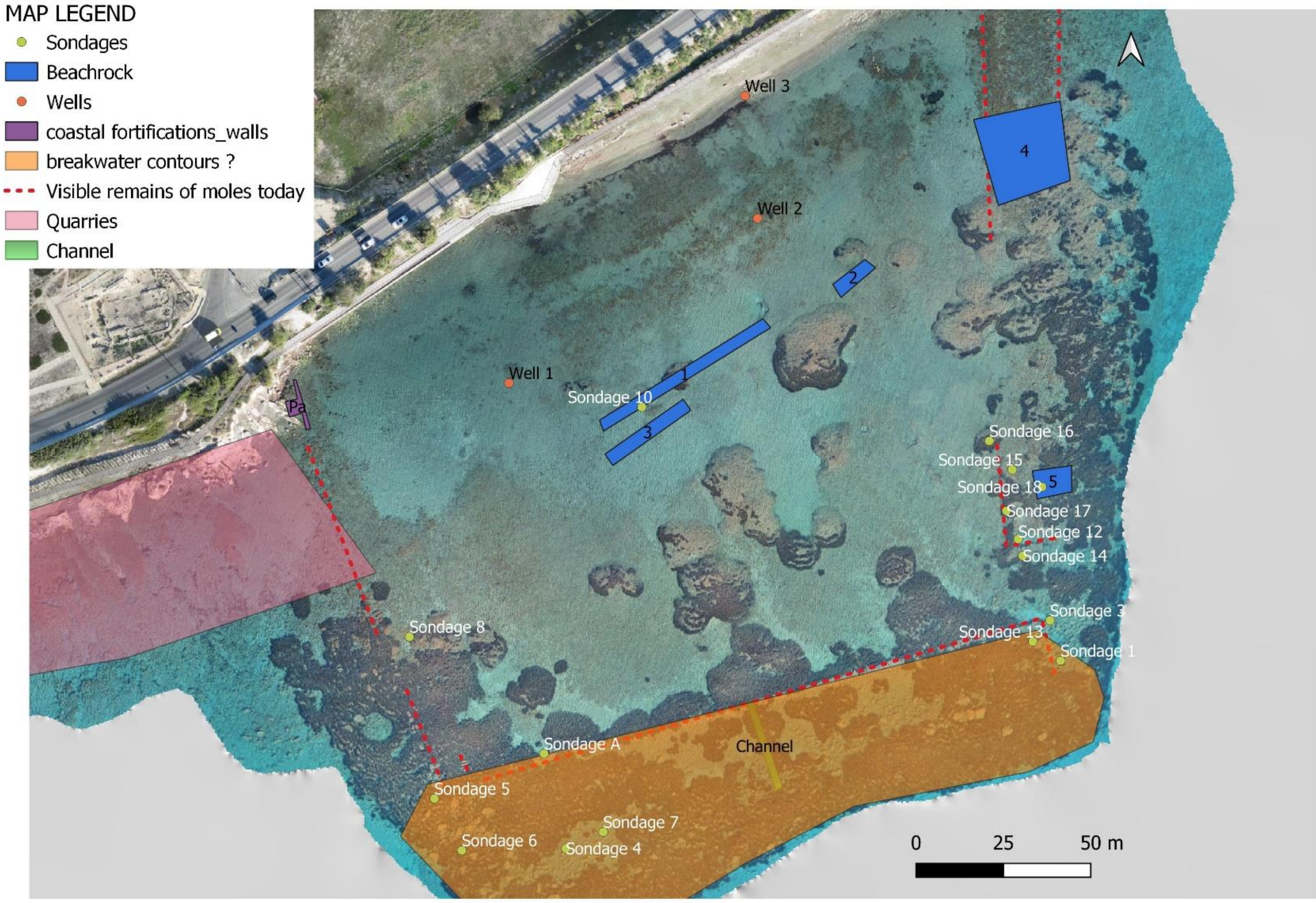
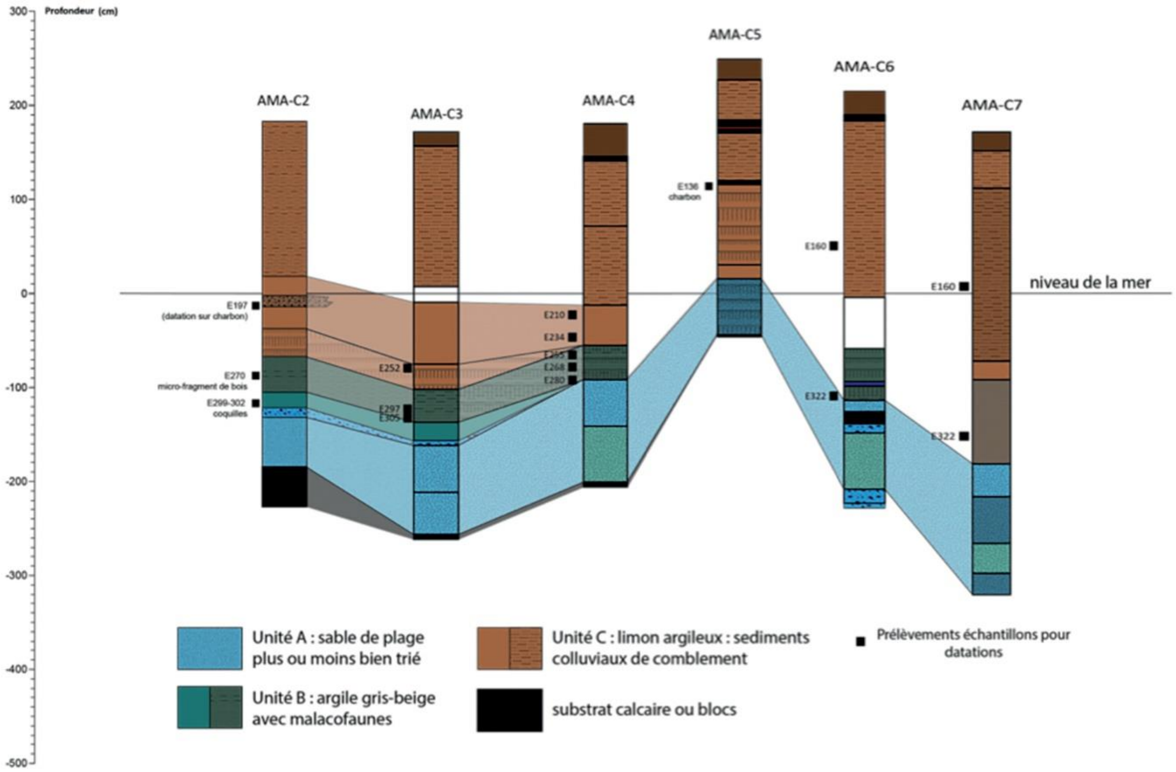


Figure 4 : General plan of Amathus (J.Gatt 2021, after Amathus orthophoto (Courtesy P. Agrafiotis & D. Skarlatos) and Empereure et al 2018a).



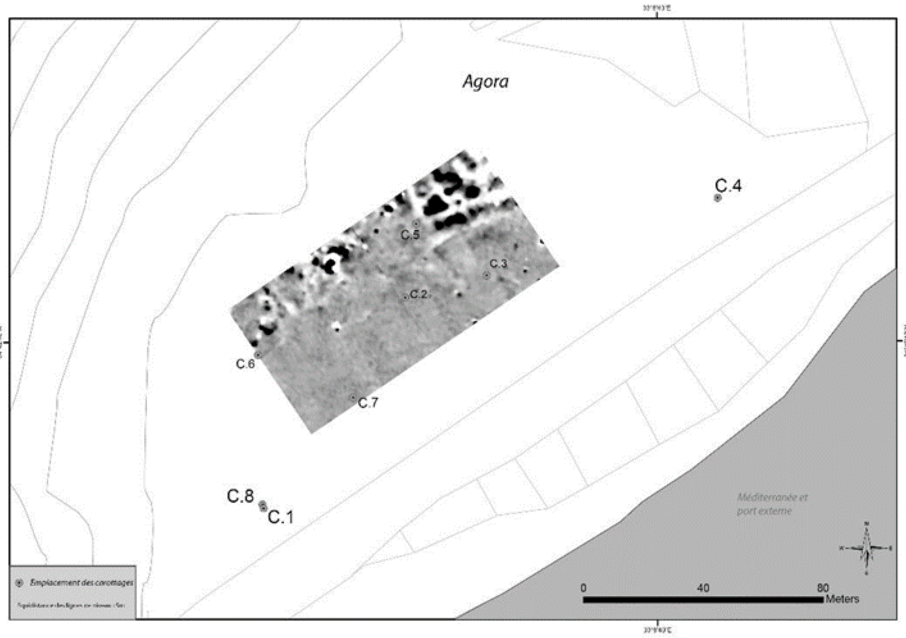


Figure 5 : Sections of the cores of the Interior basin of Amathus (above- Thely et al. 2016 : fig.10) Plan of the location of the cores in the interior basin and result of geophysical prospection conducted by Aupert in 1978 (below- Thely et al. 2016 : fig.9).

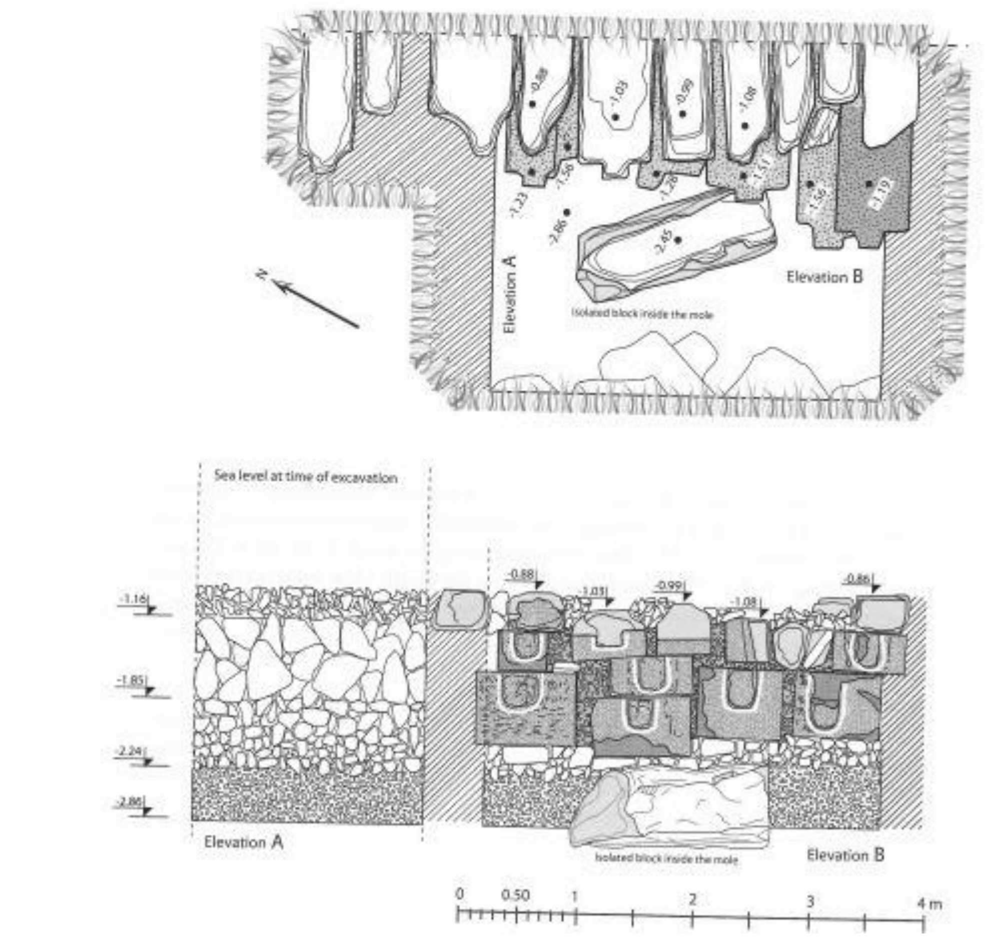
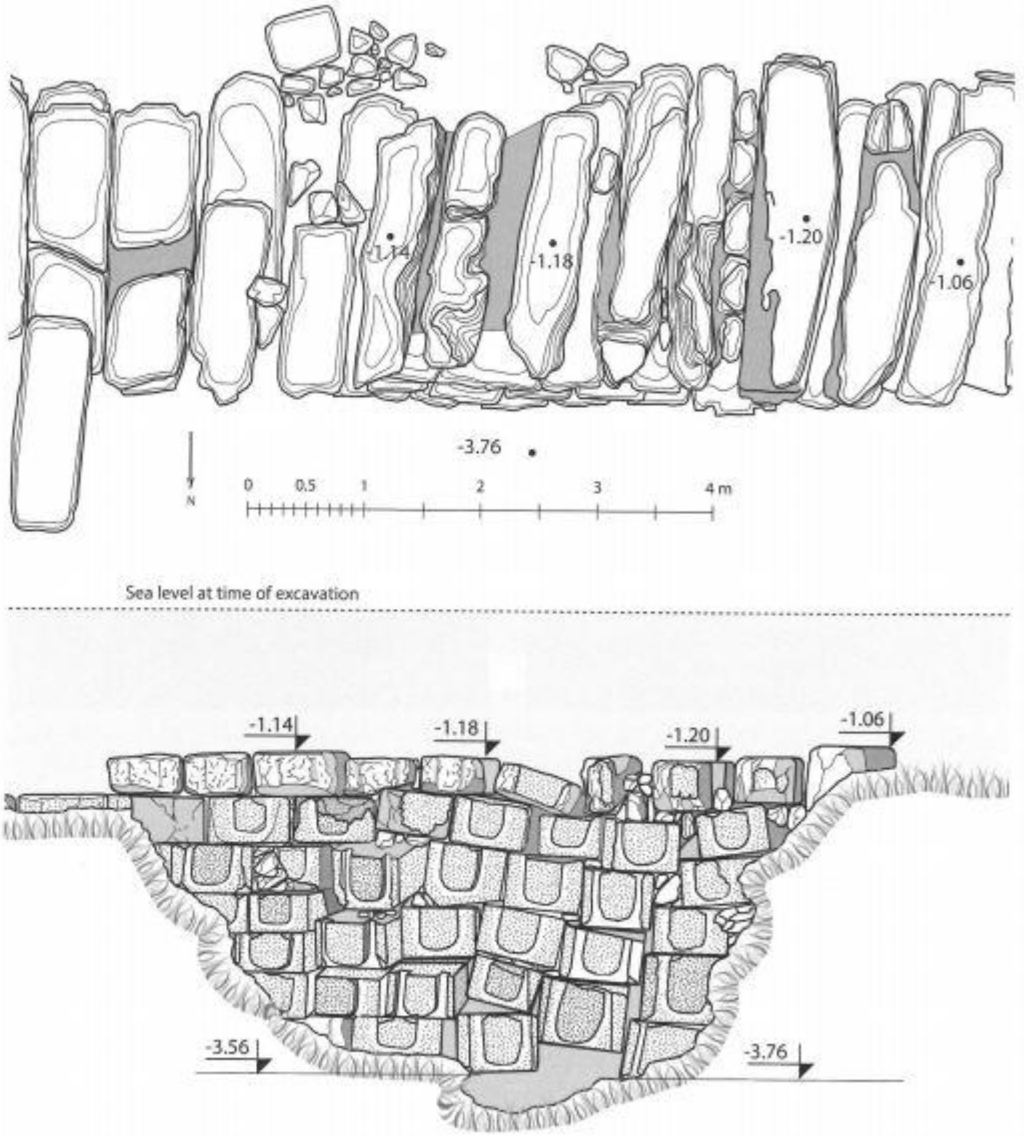
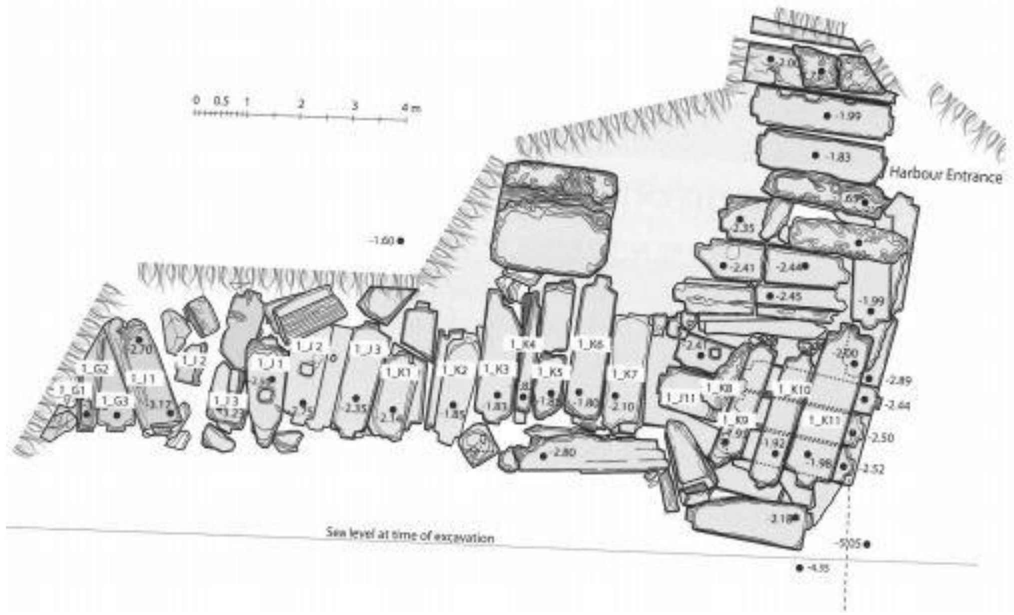


Figure 6 : Plan and section of west mole (Emperuer et al. 2018a: 34,fig.1).


-1.14
-1.18
-1.20
-1.06
-3.76
N
0 0.5 1 2 3 4 m
Sea level at time of excavation
-1.14
-1.18
-1.20
-1.06
-3.56
-3.76


0 0.5 1 2 3 4 m
-1.99
-1.83
Harbour Entrance
-1.60
-2.41
-2.45
-1.99
1_G2
1_G1
1_G3
1_I1
1_I2
1_I3
1_J1
1_J2
1_J3
1_K1
1_K2
1_K3
1_K4
1_K5
1_K6
1_K7
1_K8
1_K9
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1_J11
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-2.44
-2.50
-2.52
-2.80
Sea level at time of excavation

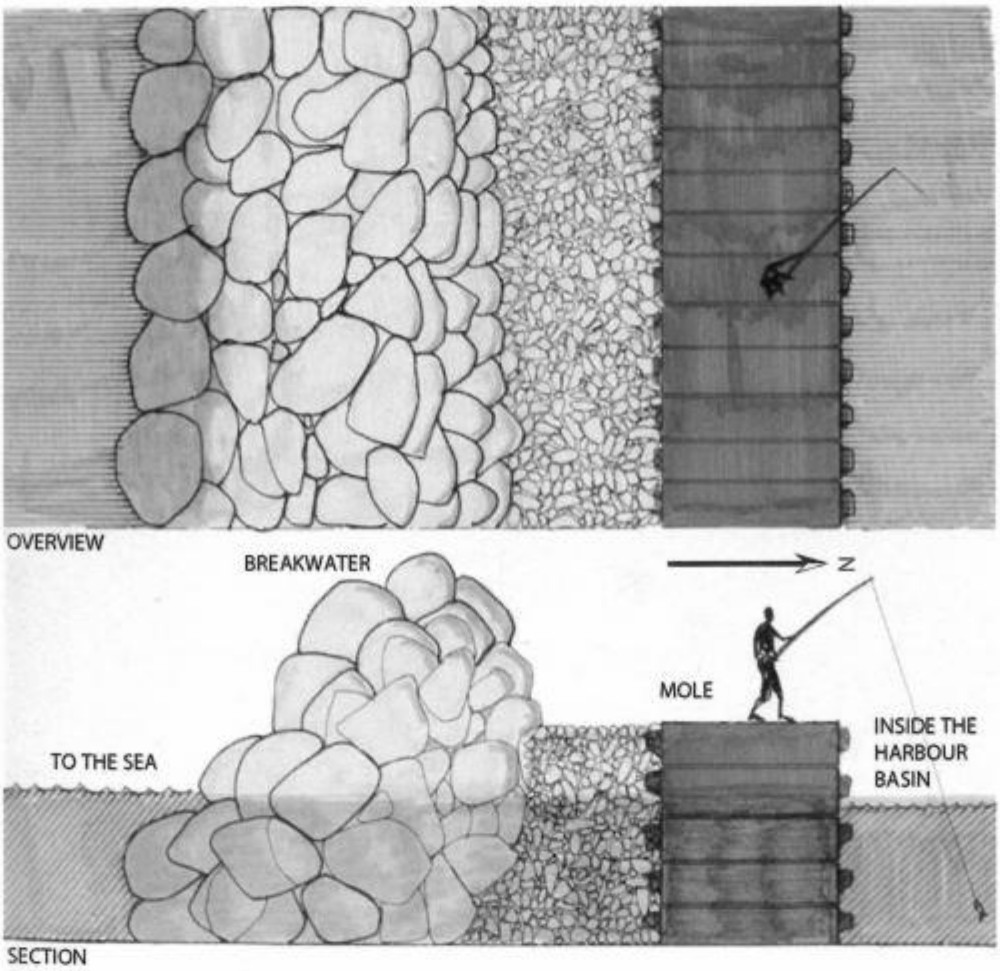

Figure 7 : Up- Plan and section of south mole in sondage A (Emperuer et al. 2018: 42, fig.11) Center-Plan of eastern extremity of south mole (sondage 1,3,13) (Emperuer et al. 2018: 46,fig.16). Down- Plan and section of the reconstructed south breakwater-mole (Empereur et al. 2018: 39, fig.7).

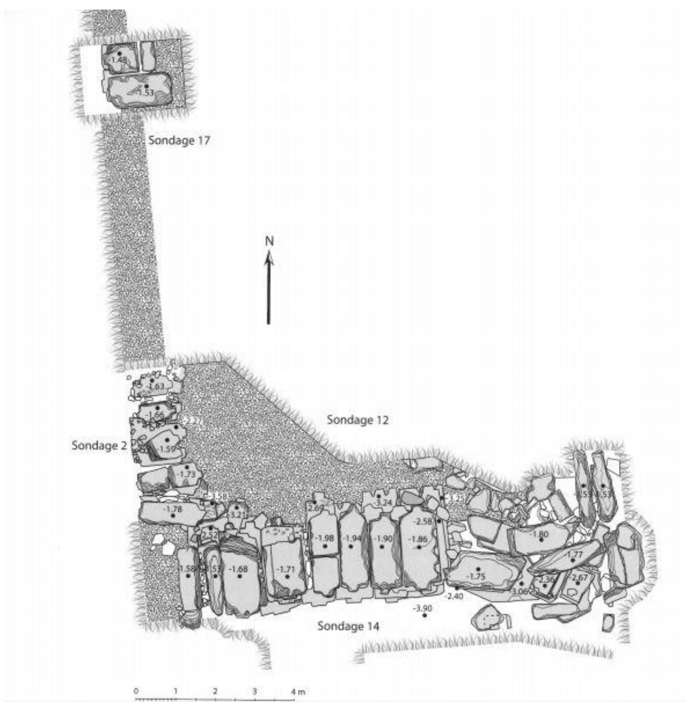

Figure 8 : Plan of East mole, entrance area Sondage 2,12,14,17 (Emperuer et al. 2018: 58,fig.28a).

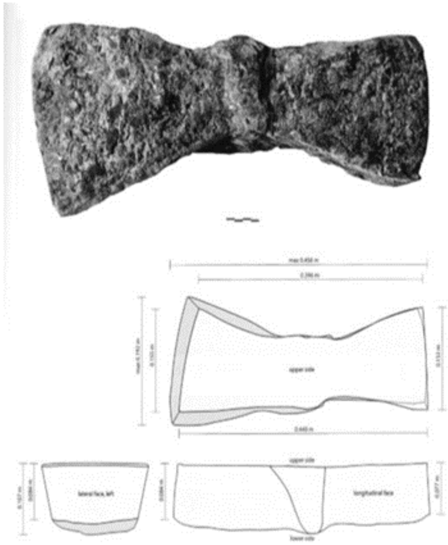

Figure 9 : Iron clamp found during the survey of Amathus basin (Empereur et al. 2018: 81, 41a-b).

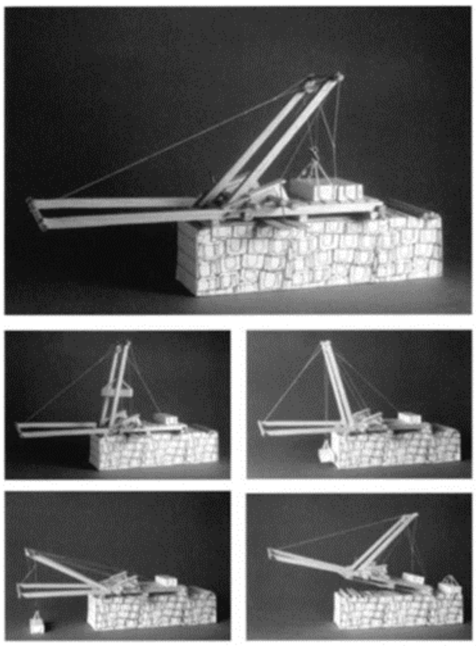

Figure 10: A hypothetical reconstruction by Kozelj of the machinery used to build the breakwater-mole (Empereur et al. 2018 : 91, fig. 51a-e).

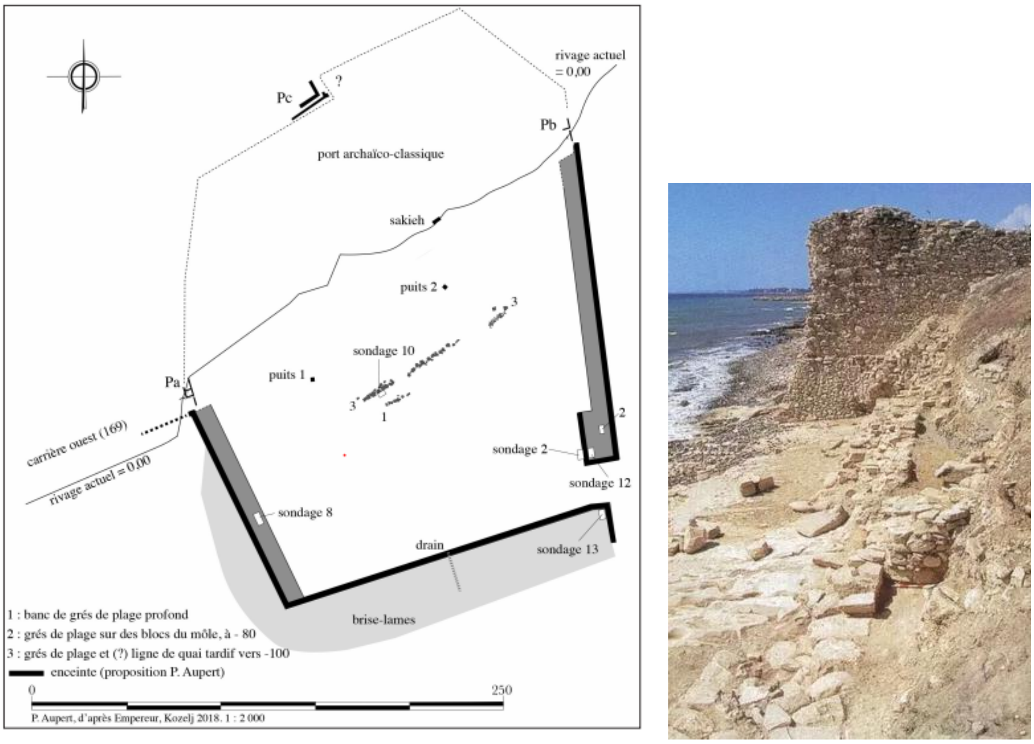

Fig. 11: Left- Location of walls Pa and Pb (Aupert 2020: 201, fig.2). Right- Remains of the sea-wall north-west of the outer basin dating to the Early Hellenistic period (http://kyprioscharacter.eie.gr/en/scientific-texts/details/archaeology/fortifications-and-defense-in-cyprus-from-archaic- to-hellenistic-period Last accessed 9th June 2020).

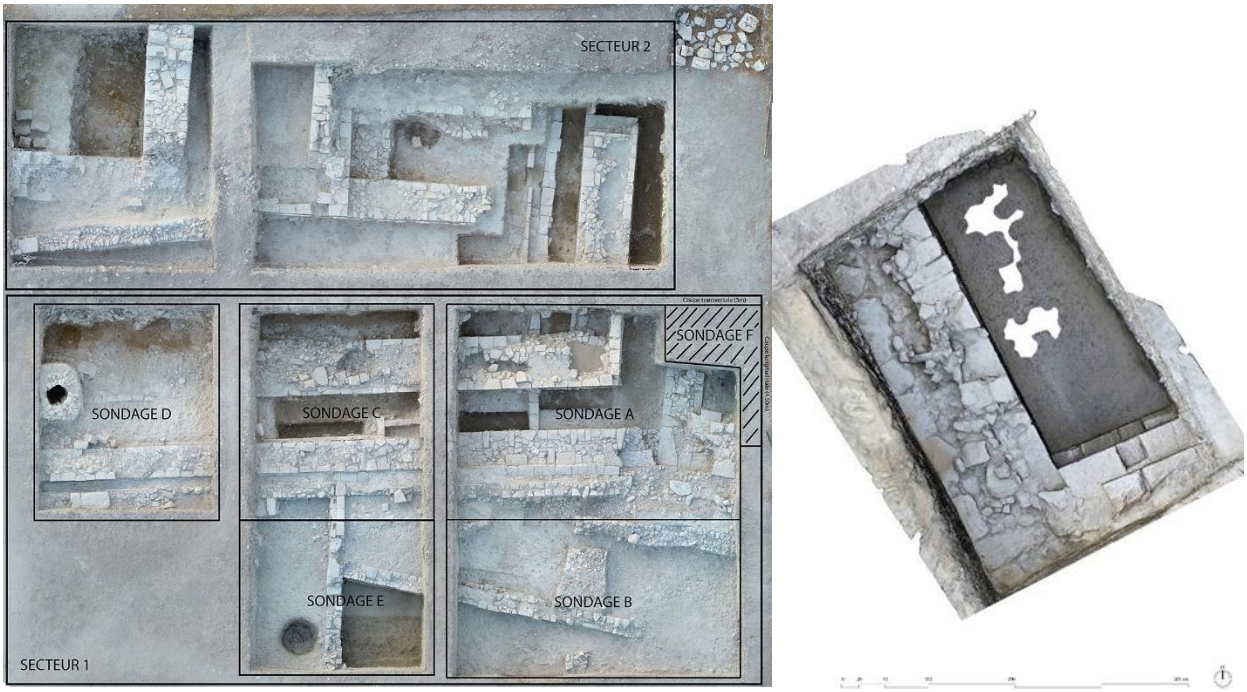

Figure 13 : Photo of the excavated warehouse located in the interior harbour basin of Amathus (left), Orthophoto of the so-called cale seche (hauling ramp ?) (Thely et al. 2020c : fig. 1,6).

IV. CARPASIA

LOCATION

Carpasia is located 3km north of Rizokarpaso village on the north coast of Cyprus (**Fig. 1**).

HISTORY AND TOPOGRAPHY

The first references to Carpasia according to Hill (1940 : 131) was in the 4th century BC concerning an inhabitant of Carpasia that when in Rhodes led the army of Konona to revolt. Pseudo-scylax (77.103) refers to the harbour of the settlement as also Diodoros Sikeliotis (XX.47.1) reference on the arrival of Demetrius Poliorkites in Cyprus (Theodoulou 2006 : 222-223). The remains of a settlement surrounding a medieval church of Saint Philon that dates back to the Hellenistic period was excavated in the 30's (Taylor 1980 ; 1981). The settlement was surrounded by walls that seem to extend towards the harbour located to the north of the settlement (**Fig.2**).

ANCIENT WRITERS AND TRAVELLERS

Pseudo-Scylax (77.103) referred to the harbour as desserted (ερημος λιμέν). Strabo (XIV.6.8) refers also to the existence of the harbour (εἶτα Καρπασία πόλις λιμένα ἔχουσα). Stadiasmos (297-317) refers also to Carpasia as having a harbour for small boats. Pococke (1745: 218), an 18th-century traveller, refers to the remains of the ancient city walls and the harbour to the north. Hogarth (1889 : 90), gives a more detailed description of the harbour and the construction of the harbouworks «… its pair of artificial moles are the most considerable works of the kind in Cyprus. That on the eastern side can be followed for 370 feet from its starting-place on the shore: it is made for the most part of large squared blocks, formerly riveted to each other by clamps of metal, the marks of which only remain, thus … but near the outer end, it has been patched in later times with fragments of columns, marble, and basalt, clamped together and to the neighboring blocks, while other drums may be seen through the clear water lower down. The uniform width of the mole is eight feet and its height above the present water-level about four. It projects from the shore in a north-westerly direction towards the point of the other mole which runs due north; the latter cannot be followed far, but its massive abutment on the shore is probably a fair sample of its character ». Similar is the description of Sakkelarios (1890 : 159) which refers to the remains of a quay (?) made of ashlar blocks connected with iron clamps.

TOPOGRAPHY, FUNCTION, CONFIGURATION

The harbour basin according to Stadiasmos (297-317) was accesible to small boats. The role of the harbour remains unclear. . The entrance of the harbour (formed by the quay (?) and mole) is located north-west with a width of 120 meters.

PREVIOUS RESEARCH

Travellers in the 18th-19th century gave detailed descriptions of the harbour structures of Carpasia (Pococke 1745 ; Hogarth 1889 ; Sakkelarios 1890). Plat Taylor (1980 ; 1981) conducted an excavation in 1935 and 1937-1938 were the medieval church, the settlement, the city wall and the necropolis was excavated. She also documented briefly the harbour structure remains of the harbour basin. Theodoulou was the first to photograph the harbour structures of Carpasia (Theodoulou 2006 : 222-229).

HARBOUR STRUCTURES

QUAY (?)

Documentation of the harbour remains can be found in J. du Plat Taylor report of the department of antiquities. She documented a quay (?) at the north-east side of the natural basin (**Fig. 3**) on the north side of the south promontory built with blocks of an average dimension 1X0.5X0.5m which were connected with metallic clamps. Its length is estimated to 78 meters and its width to 2.5 meters. According to Nicolaou (1966 : 10) the lenght was 100m and the width 3m. The different measurments are due to the lack of indetail documentation of the structures. Two phases seem to be attested on this structure as the upper part attests the use of mortar (Theodoulou 2006 : 224-229).

MOLE

On the southwest side remains of a mole (**Fig.4**) 120 meters long are preserved that streched from the islet towards the land. The mole connected the land with an islet (**Fig.5**) on which on its south side remains of fish tanks (?) can be identified as also remains of a quarry (Theodoulou 2006 : 224-229).

HARBOUR CONSTRUCTION METHODS

The harbour structures followed the original configuration of the bay. For the SW mole the north side of it was built partially on a rocky formation while the rest probably on a foundation of rubble. For both the quay (?) and mole it seems that the blocks were placed on the following pattern : headers were placed in the outer sides of the structures and strechers in the interior (headers with a core of strechers). Metal clamps were used for the connection of the stones as also mortar (attested at the quay (?), probably represents a repair phase of the structure (Theodoulou 2006 : 224-229).

MARITIME FORTIFICATION

Pococke (1745: 218) refers to the extension of the settlements fortifications towards the sea. No clear evidence though has been reported by Theodoulou (2006 : 229) on the subject.

RELATED INSTALLATIONS

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MOORING STONES

A mooring stone was identified and photographed (not in situ) by Theodoulou (2006 : 227) (**Fig. 5**).

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

The north coast according to Flemming did not undergo any significant change in the sea level (Flemming 1987 :415). The fact that the ancient quay (?) and mole remain till today visible above the surface of the sea proof the stability in this region.

GEOHAZARDS AND OTHER FACTORS

This site has been poorly documented. The gradual urbanisation of the area is endangering the saftey of the site.

OTHER FINDS

Fish tanks found east of the city and on the islet date according to Plat Taylor to the roman times. A stone weight/anchor or an olive oil pressure stone as part of the building material was also found built in the south west mole (Theodoulou 2006 : 227).

CHRONOLOGY

According to Theodoulou, the use of clamps, the mooring stones which are similar to that of Phalassarna (that date to the 4th century BC) and the fact that probably the basin's harbour structures were not completed as the basin was not protected sufficiently from the northern winds led Theodoulou to date the harbourworks to the Hellensitic period. A similar datation was given by Lehmann (1923 : 257) too. However, J. du Taylor (1980 : 228) dates the harbour to the Roman times.

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Inserts in databases	-
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FIGURES

Figure 1 : Location of the harbour of Carpasia (J.Gatt 2021).

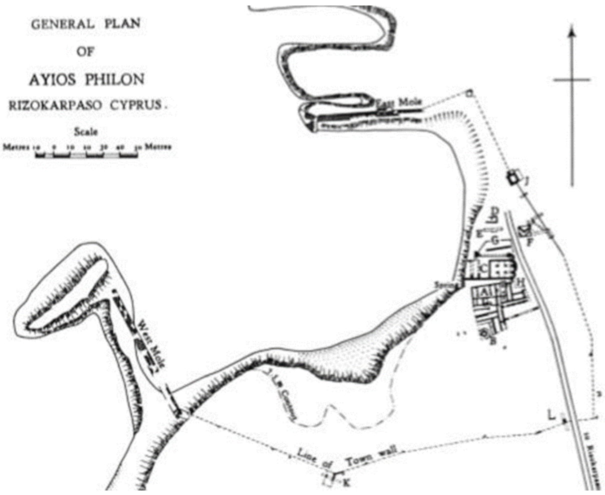

Figure 2 : Plan of Carpasia harbour made by Taylor (1980, fig.2).

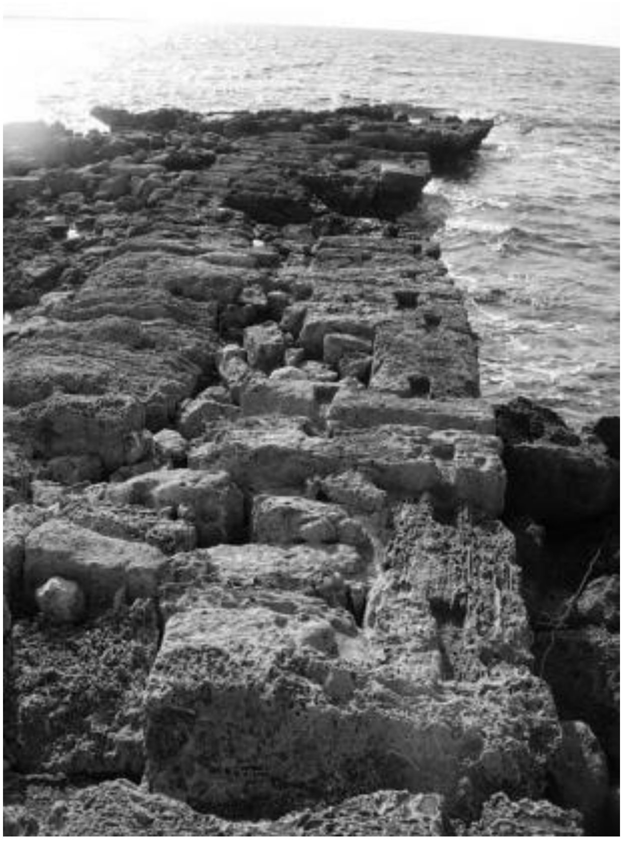

Figure 3 : Photo of the East quay (Theodoulou 2006 : fig 205).

Figure 4 : Photo from the north extremity of the west mole (Theodoulou 2006 : fig.210).

Figure 5 : Photo of the islet in the north extremity of the west mole with the quarry and so called fishtanks (Theodoulou 2006 : 211).

V. KITION

LOCATION

The harbour of Kition is located on the south east coast of Cyprus. It is located under the modern city of Larnaka. The remians of Kition's harbour are located around 400m away from the coastline.

HISTORY AND TOPOGRAPHY

In the Bronze Age, the coastal site of Hala Sultan Tekke flourished. More specifically, the settlement was located on the perimeter of a lagoon connected to the sea through a natural channel. This naturally protected basin favoured the establishment of an anchorage that would facilitate the import and export of goods. No harbourworks have been identified in the site of Hala Sultan Teke. By the end of the Late Bronze Age this site was deserted an the area of Kition was occupied (**Fig. 1**). The abandonemnt of this settlement is linked with the activity of the Tremithos river which enhanced the process of siltation (Gifford 1985: 45-47 ; Mohrange et al. 2000 ; Devillers et al. 2014).

In this newly established settlement of Kition-Bamboula/Kathari (**Fig.1**) a natural bay was used as a harbour. This has been proven through geoarchaeological studies (Morhange et al.1999: 133-49; Morhange et al. 2000: 205-230). An open bay directly connected through a channel to the sea and a naturally closed bay connected to the open bay where the shipsheds are located. In the Cyprogeometric period Kition is the only site that testifies its existence as a settlement not only through tombs but also through a temple and workshops (related to the production of metal objects). A rebuilding of the monumental temple of Kathari by the end of the 9th century BC as also a temple was built in Bamboula. This coastal settlement has been linked with the Phoenician world. Although the nature of their arrival remains under discussion (as merchants who established their presence in the harbour city or as a Phoenician colony) their presence cannot be denied (for more information on the subject see Satraki 2012: 153-155, 170-173).

Prior to the 5th century BC the character of this settlement remains unclear since its not attested in any of the Assyrian inscriptions enlisiting the Cypriot Polities (i.e. Essarchadon style). From the 5-4th century BC, there is clear evidence of the existence of a Cypriot-polity through the local minted coins. The kings had Phoenician names and a number of great works were realized in the 4th century BC including the rebuilding of the temple, and the building of the ship sheds in Bamboula. The kingdoms of Tamassos and Idalion were also integrated under the control of the city during this time. The harbour of Kition continued to function up to the Roman period as the imported pottery indicates (Nicolaou 1976: 73-83; Yon 1995: 120-121; Satraki 2012: 258-268 ; Mckenzie 2013).

TYPOLOGY, CONFIGURATION, FUNCTION

Many travellers from the 16th to the early 20th century refer to the location of the harbour of Ancient Kition. Among many, Denis Possot in 1533 described the harbour as ruined, Florio Bustron described as a closed harbour, Ascanio Savorgnano in 1562 refered to a channel that connected the harbour with the sea. A plan by Pococke dating to 1738, documents the existence of a basin (a marshy area) connected to the sea through a channel (Nicolaou 1976 : 73-80). An aerial photo of 1963 shows the channel that connected the now silted basin with the sea (Yon 1995:122; Theodoulou 2006: 159-162). This was verified through the geoarchaeological study of two interconnected basins one of which wass directly connected to the sea. Both basins attested through the geoarachaeological study document the existance of two natural bays **(Fig.2).** In the closed bay, the presence of shipsheds indicates a military charachter. Strabon (XIV.6.3) describes the existance of a kleistos limen in Kition however no refernce to the shipsheds are made. Parallel to that, the presence of a variety of imported pottery underlines the commercial role of this harbour. Amphora stamps and ancient texts (such as Demosthenes and Lysias) refer to the city as a trade center as also ancient inscriptions found in different sites such as Demetrias, Rhodes, Piraeus (Yon 1995: 120-121; Satraki 2012: 258-268).

PREVIOUS RESEARCH

During the filling and the drying of the basin in the 19th century Ohnefalsch-Richter documented the finds in his book *Kypros, the Bibel, and Homer*. The French Mission began excavations in Kition's temples in 1976 which led then to the discovery of the shipsheds in 1987. Geoarcheological studies to define the paleocostline and paleoenviroment of the site were also conducted on the site (Mohrange et al. 2000 ; Mohrange et al. 1999).

HARBOUR STRUCTURES

The only harbour structure that remains visible today is a quay located to west of the shipsheds although no detailed description has been published (Yon & Sourisseau ; Yon 2000 ; Yon 1995). However, other structures were documented in the 19th and 20th century before the urbanization of the area. Indications of probable harbour structures had been attested by L.P. di Cesnola, J. Myres and K. Nicolaou in the area of Saint Joseph monastery. Cesnola (Cesnola 1911: 49) refers to remains of city walls to the east of the monastery as also to the fact that the monastery was built on a mole. Myres also located a wall and a large concentration of ashlar blocks to the east of the monastery. Nicolaou considers that this wall documented by Myre was a quay (Nicolaou 1976: 59 , 81-82).

HARBOUR CONSTRUCTION METHODS

It is not possible to identify any harbour construction techniques since no information on the subject has been published.

MARITIME FORTIFICATION

A wall south of the shipsheds that seperates the harbour facilities from the settlement as also a wall to the west of the shipsheds with a north to south direction have been excavated. This wall consists part of the city's fortification's that date back to the Late Bronze Age (Mckenzie 2013: 352 ; Nicolaou 1976: 52-65).

RELATED INSTALLATIONS

Concerning the ship sheds (**Fig.3**), these are located in Kition-Bamboula (Fig.2). Six ship sheds have been identified with a north-south direction. The shipshed complex dimension is 40x40m. Each shipshed is 38 m of lenght and 6m wide. Their first phase of construction is dated to the 5-4th century BC. Their use continued to the Roman period. In total three phases of construction have been identified. The first phase is dated to the 5th century BC, second phase is dated to the early 4th century and phase three dates to the end of the 4th century BC (dating based on pottery). The existence of these ship sheds indicates that the technological knowledge for the construction of such facilities existed on this island (Yon 1995 ; Yon 2000 ; Theodoulou 2006: 163-166 ; Sourisseau & Yon 2010).

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

A rise in sea level can be attested in the 2nd phase of the shipsheds. They were built up to 3m high to the south (Callot 1997 : 73, fig. 2b). In addition, a tectonic uplift was attested through coaring. A sediment layer dating to the Bronze Age (13th century BC) in proximity of Core CVI which is identical to the base layer of core CVI, located 40cm higher than the present sea-level and 2meters higher than the estimated sea level of the Bronze Age (based on Pirazzoli 1999 estimations) (Mohrange et al. 2000 : 223). Parallel to that, marine sediments dating to the Roman period (865 +/- 75 years BP, on marine shells) were identified slightly above present sea level in the harbor of Bamboula (Pageorgiou1991 : 815-816) .The geoarchaeological study of the site indicates a coastal progradation (**Fig.4**) which led firstly to the gradual abandonment of the harbour in the Roman times as also the location of today's site 400m inland. This evidence points towards a tectonic uplift which has been already identified along the coastline (Flemming 1974 ; Dalongeville et al. 2000).

GEOHAZARDS AND OTHER FACTORS

The intense urbanization of the site has led to the loss of many data however the geoarcheogeological study of the site has proposed a reconstruction of the paleoenviroment and paleocoastline. The harbour basin of Kition and the channel were filled with sediment from the bamboula hill in the 19th century by the British authorities which led to the heavy alteration of the landscape of ancient Kition in an attempt to drain the marshy area.

OTHER FINDS

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CHRONOLOGY

The shipsheds first phase dates to the 5th century BC, the second phase which coincides with a phase of destruction and rebuilding dating to the beginning of 4th century, while phase three dates to the end of the 4th century and continues to be used up to the Roman times. Nevertheless the harbour of Kition must have been in use also prior to the construction of shipsheds since the Late Bronze Age (Mckenzie 2013: 356-357 ; Yon 2000 ; Yon & Sourisseau 2010).

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FIGURE

Figure 1: Location of Hala Sultan Tekke site (1-Dromolaxia-Vyzakia ; 2-Dromolaxia-Trypes ; 3-Artemis Paralia ; 4-Kition Bamboula ; 5-Kition-Chrysopolitissa ; 6-Kition-Kathari (Devillers et al. 2015: 74 ; Fig.1).

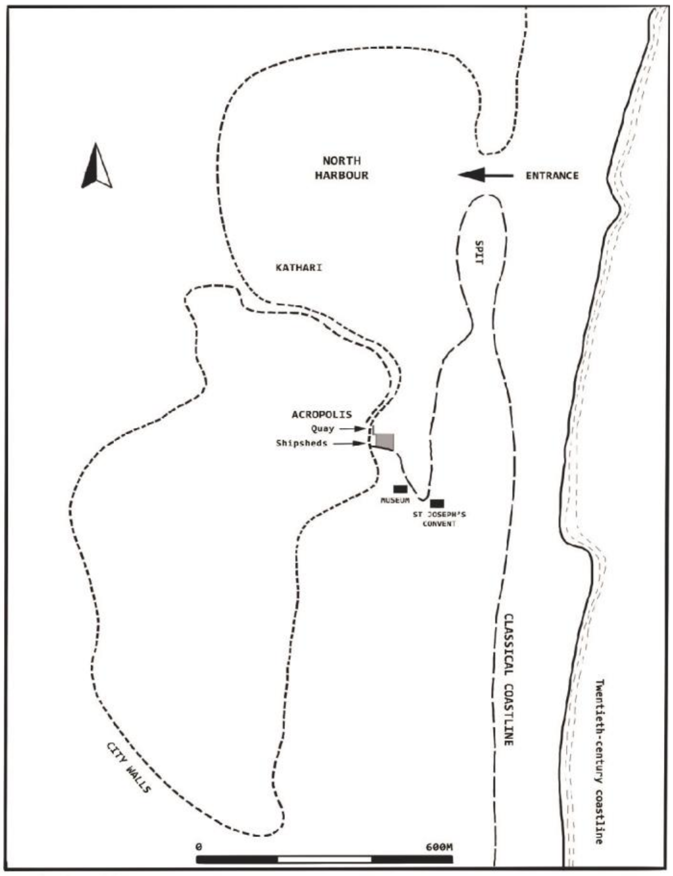

Figure 2 : Plan of Kition harbour basins (A.Gatt, after Mckenzie 2013: B.9.18)

Figure 3: The shipsheds of Kition. View from NE. Photo taken by Theodoulou (Theodoulou 2006: 68, fig.105).

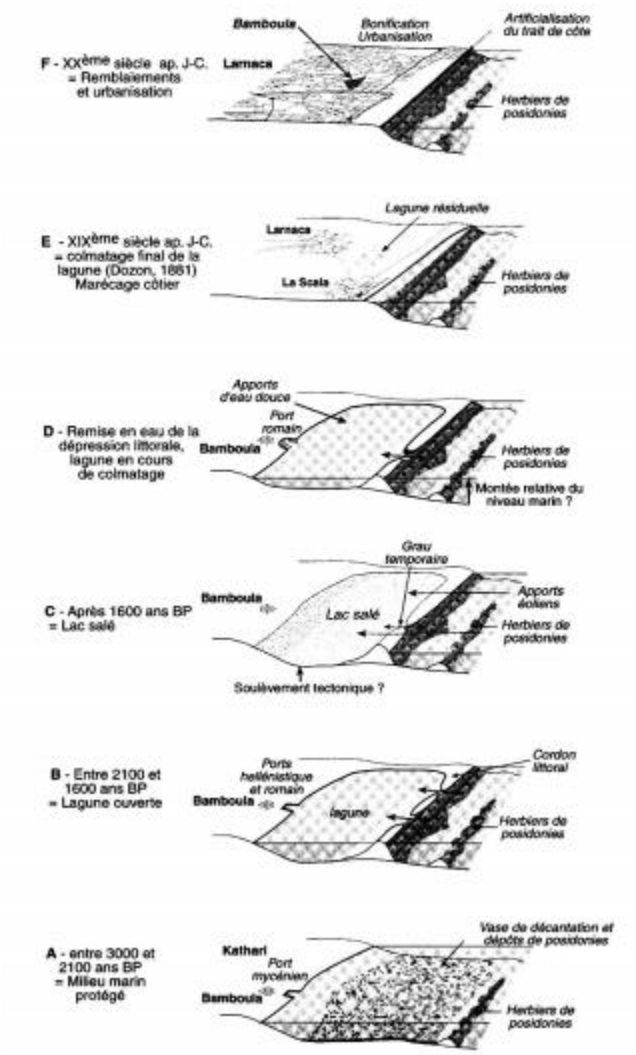

Figure 4: Reconstruction of the coastal progradation based on the Geoarchaeological study (Morhange et al. 1999: 176, fig.7).

VI. KOURION

LOCATION

Kourion is located on the southwest coast of Cyprus, west of Kouris river αnd Akrotiri Peninsula. More specifically it is located on an elevated plateau which ended to the south in limestone cliffs, overlooking the sea. To the south of Kourion a sandy bay, called Ayios Ermoyenis and to it's southwest the bay of Trypiti are located (**Fig.1**).

HISTORY AND TOPOGRAPHY

Evidence of habitation in the surrounding area of Kourion dates back to the Middle Bronze Age in the site of Episkopi-Pampoula which was abandoned by the end of the Late Bronze Age. In the Cypro-Geometric period the necropolis of Kaloriziki and Ayios Ermoyenis, were established and continued to be used in Late antinquity. In the archaic period, the Temple of Apollon Ylatis located to the west, 2 km of Kourion's acropolis was established. The remains of the first phase of the Cypriot polity of Kourion are not preserved however, through epigraphic evidence found in the temple it is evident that the Cypriot polity of Kourion was established in the 7th century BC. In addition, the existence of tombs and the reference to Kuri (Kourion) on the Esarchadon Prism, indicates once more the existence of the Iron Age kingdom. The remains in today's touristic archaeological site of Kourion date mainly to the Classical, Hellenistic, Roman and Byzantine period. The area was inhabited without interaption till the 4th century AD when a strong earthquake destroyed the settlement. A series of remains such as the acropolis (known also as Palaiokastro), Agora, theater, churches and roman baths that overlook the sea while further to the west (around 2km) the stadium and the temple of Apollo Ylatis are located attest the continious habitation. However, in the 4th century AD an earthquake destroyed the settlement and it never seems to have recovered from the natural disaster and with the Arab raids of the 7th century AD the settlement moved further inland to the location of today's Episkopi village. The harbour was most probably located to the south of the city (Satraki 2012: 157- 158, 177, 225-234, 258,261 ; Leonard 2005 : 552-556 ; Sokratous 2018 : 47-49).

TYPOLOGY, FUNCTION, AND CONFIGURATION

The only evidence for a harbour is through the submerged structure interpreted as a breakwater located on Ayios Ermoyenis bay. The connection of the harbour with the city located on top of the cliff is still not clear, although rock-cut steps at the base of the cliff seem to have existed (personal communication of Leonard with Haggerty) (Leonard 1995 : 238). To the west of Ayios Ermoyenis bay, a second Trypiti bay is located. There a rock-cut channel was carved on the west cliff, although no harbour structures have survived. This basin has been interpreted as a sacred harbour as also a naval station. The configuration and location of the harbour basins remains unclear. However, for a harbour to function in one of these bays further man-made protection was imperative to protect the basins from the southwest and west prevailing winds. The study of the harbour basin may need to be sought on land due to the coastal progradation driven by Kouris river. The location remains to be defined (Leonard 2005: 556 ; Leidwagner 2004 : 19-20 ; Sokratous 2018 : 51).

ANCIENT WRITERS AND TRAVELLERS

According to Strabo Kourion had a *hormos* (ορμός) (Strab. XIV.6.3). He is the only ancient writer that makes a clear reference to the existance of a harbour perhaps a fact that indicates its disuse in later times (Leonard 2005: 556-557).

PREVIOUS RESEARCH

Research on the harbour-city of Kourion were initiated in the 30's focusing on the terrestrial site (for more information on the terrestrial research see Leonard 2005 :558-560 ; Zinonas 2018 : 43-47). The only research that has been conducted on the harbour of Kourion (Ayios Ermoyenis and Trypiti Bay) was that of John Leonard during the CCS (Cyprus Coastal Survey) project. This was followed by a short survey in Trypiti bay and the so-called breakwater by Leidwagner in 2003, although the conditions did not allow any further documentation (Leidwagner 2004: 18-19). Recently, a Master dissertation of Zinonas Sokratous focused on the potential location of the Naval station of Kourion in Trypiti bay (Zinonas 2018).

HARBOUR STRUCTURES

BREAKWATER

The only known surviving harbour structure identified as a breakwater was first identified by Nicolaou (1976 : 467-468). This submerged structure is estimated to be around 80 meters long with a north-west direction and is divided into two parts (**Fig. 2**). The first part is around 68 meters long with a width that reaches 12 m, while the second part has a length of 30 meters with the same width as the first part. It has been also estimated that the breakwater-mole extremities remain buried under the seabed. Between these two sections a narrow channel of 3 meters created by the sea (according to Leonard) was located. Leonard mentioned buried structures on both extremities and sides (east and west) (Leonard 1995: 238 ; Leonard 2005: 562-565).

The description of the structure by Leidwagner corresponded to that of Leonard, although the width of Leidwagner is estimated to 4-5 meters. The difference in the width may be due to the continuing siltation. Leidwagner, had also identified that this structure is parallel to the prevailing wind's direction which renders its function as a breakwater problematic. A survey to the west and east took also place to identify other structures however nothing was found (Leidwagner 2004 :18-19).

The structure's maximum depth was measured by Leonard in the channel between both sections. It was estimated around -3.65 m below current sea-level. On the leeward extremity the lowest course of the breakwater reaches -0.95 m and the seaward extremity reaches -2.82 m below current sea level (Leonard 2005 :561).

HARBOUR CONSTRUCTION METHODS

The construction of the so-called breakwater according to Leonard consists of squared and amorphous stones which probably indicate two construction phases. The smaller amorphous stones were probably used in a later phase for repairs. No detailed description of the placement of the blocks is given (Leonard 2005 : 562). Leidwagner's description is similar, « rubble, irregularly sized ashlar blocks and boulders » consisted the material for the construction of the breakwater (Leidwagner 2004: 18).

MARITIME FORTIFICATION

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RELATED INSTALLATIONS

ROCK-CUT CHANNEL

An interesting structure is the rock-cut channel located on the west cliff of Tripiti bay (**Fig. 3**). It is a channel around 40 meters long (although it doesn't survive to its total length) whose date remains undetermined. This structure contributed to the interpretation of the function of Trypiti bay.

In ancient sources Kourion has been referred to as having a fleet. For instance, according to Arrian (Arr. II.22.2) king Pasikratis of Kourion sent 50 ships during the siege of Tyre to assist Alexander the Great. However, no archaeological evidence can support the existence of a fleet. An unpublished master dissertation from the University of Cyprus written by Zinonas Socratous supports the hypothesis that in Trypiti Bay, the military harbour of Kourion's kingdom may have existed. This theory is based on the vicinity of this site to the temple of Apollo (as a probable protector of the naval base), the natural protection of the bay and also the role of the rock-cut channel which allowed a more controlled and protected access to the harbour (Socratous 2018: 56-60). Leonard on the other hand, interprets the bay as a secondary harbour, anchorage when Ayios Ermoyenis bay was not accessible and a sacred harbour of the Temple of Apollon Ylatis. These theories require further investigation since this structure ws used also during the Byzantine times as a hermitage (Socratous 2018: 51-60 ; Leonard 2005: 563, 568 ; Leidwagner 2004 : 20).

BASILICA

An excavation conducted Northwest of the breakwater on Ayios Ermoyenis bay uncovered a three aisled basilica dating to the early sixth century B.C. The location of churches near harbours is a common pattern. This find enhances the hypothesis that a harbour basin is located in the area since the vicinity of sacred spaces with harbours is a common pattern (Christou 1997 : 371 ; Leidwagner 2004 : 19) (**Fig.4**).

OTHER STRUCTURES

A silted wall built on a sandy foundation, built of squared blocks may indicate a possible warehouse which followed the same alignment of the breakwater (Leonard 2005 :564).

OTHER FINDS

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RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGICAL STUDIES

The submerged breakwater as also the basilica discovered on the bay indicate a change in the sea level as also a coastal progradation. The breakwater is currently from -1 to -3 m below current sea level while the basilica was completely covered with sediments. Four cores taken perpendicular to the coastline, east of the basilica were used to define the paleo coastline. This study proved that the coast was 25 meters inland. The cores which were consisted only of sand (Leonard 2005: 561, 563-564). It must be also taken into account the fact that Kourion was highly impacted by earthquakes which had probably also affected the functionality and preservation of harbour structures (Jensen 1985).

GEOHAZARDS AND OTHER FACTORS

Trypiti bay underwent sand-quarrying which led to the heavy erosion of the coastline in the 1980s (Zinonas 2018 : 52-53 Leonard 2005 : 566).

The so-called breakwater is highly damaged and disturbed by the waves. Nevertheless, a cleaning of the structure from the Posidonia may reveal better preserved areas (Leonard 2005 :562).

CHRONOLOGY OF HARBOUR

It is impossible to date the breakwater and its two possible phases of construction since no complete study has been conducted on the site. The lack of reference to the harbour by Stadiasmos may indicate the abandonment of the site due to the series of earthquakes that afflicted Kourion (especially that of 365 AD) (Leonard 2005 : 562). Leidwagner identified at the base of the structure encrusted undiagnostic pottery sherds which do not contribute to the datation of the structure (Leidwagner 2004 : 18). Nonetheless, we can assume that the harbour structure dates to the Classical and Hellenistic period as the majority of the island's harbour-cities invested during this time in harbourworks.

SOURCES

References in ancient literature	Strab. XIV.6.3 Arr. II.22.2
Inserts in databases	https://www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Kourion
Other references	Christou, D. (1997). Appendix. Some Brief Thoughts on the Ancient Harbor of Kourion, στο R.L. Swiny – H. Hohlfelder – H. Wylde Swiny (επιμ.), Res Maritimae – Cyprus and the Eastern 65 Mediterranean from Prehistory to Late Antiquity, Proceedings of the 2nd International Symposium "Cities on the Sea", Nicosia, 18-22 October 1994, (CAARI Monograph Series 1), Atlanta, pp. 371. Jensen, R.C. (1985). *The Kourion Earthquake some possible litterary evidence*. RDAC, pp. 307-311. Leidwanger J. (2004). Episkopi Bay Survey, Cyprus, 2003, *INA Quarterly* 31.2, pp. 17-27. Leonard, R.J. (1995). Evidence for Roman Ports, Harbours and anchorages in Cyprus. In: Karageorghis, V. and Michaelides, D. (eds), *Cyprus and the Sea*. Nicosia: University of Cyprus. pp.228- 246. Leonard, R.J. (1997). Harbor terminology in Roman Periploi in R. Swiny, et al., (eds.), *Res Maritimae–Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity, Proceedings of the 2nd International Symposium "Cities on the Sea", Nicosia 18-22 Oct. 1994*, CAARI Monograph Series 1:Scholars Press, Atlanta, pp.163-200 Leonard, R.J. (2005). *Roman Cyprus: Harbors, hin terlands and "hidden powers"*. Unpublished PhD thesis of University of New York Nicolaou, K. (1976b). Appendix for Cypriot sites . In R. Stillwell (Ed.), *The Princeton Encyclopedia of Classical Sites*, Princeton University Press, Princeton. Satraki, A. (2012). Κύπριοι βασιλείς από τον Κόσμασο μέχρι το Νικοκρέοντα. Αθήνα: Πανεπιστήμιο Αθηνών Socratus, Z. (2018). *Κυπριακοί Ναύσταθμοι κατά την Κλασική και την Ελληνιστική Περίοδο: Η Περίπτωση του Κουρίου.* Unpublished Master dissertation of the University of Cyprus. Theodoulou, T. (2006). *Ναυτική Δραστηριότητα στην Κλασική Κύπρο. Το λιμενικό δίκτυο στα τέλη του 4ου αι. π.Χ.* Unpublished PhD thesis of the University of Cyprus.

FIGURES

Figure 1 : Map of the location of Kourion and its main sites (J.Gatt 2021, after Sokratous 2018 : 102, fig.52).

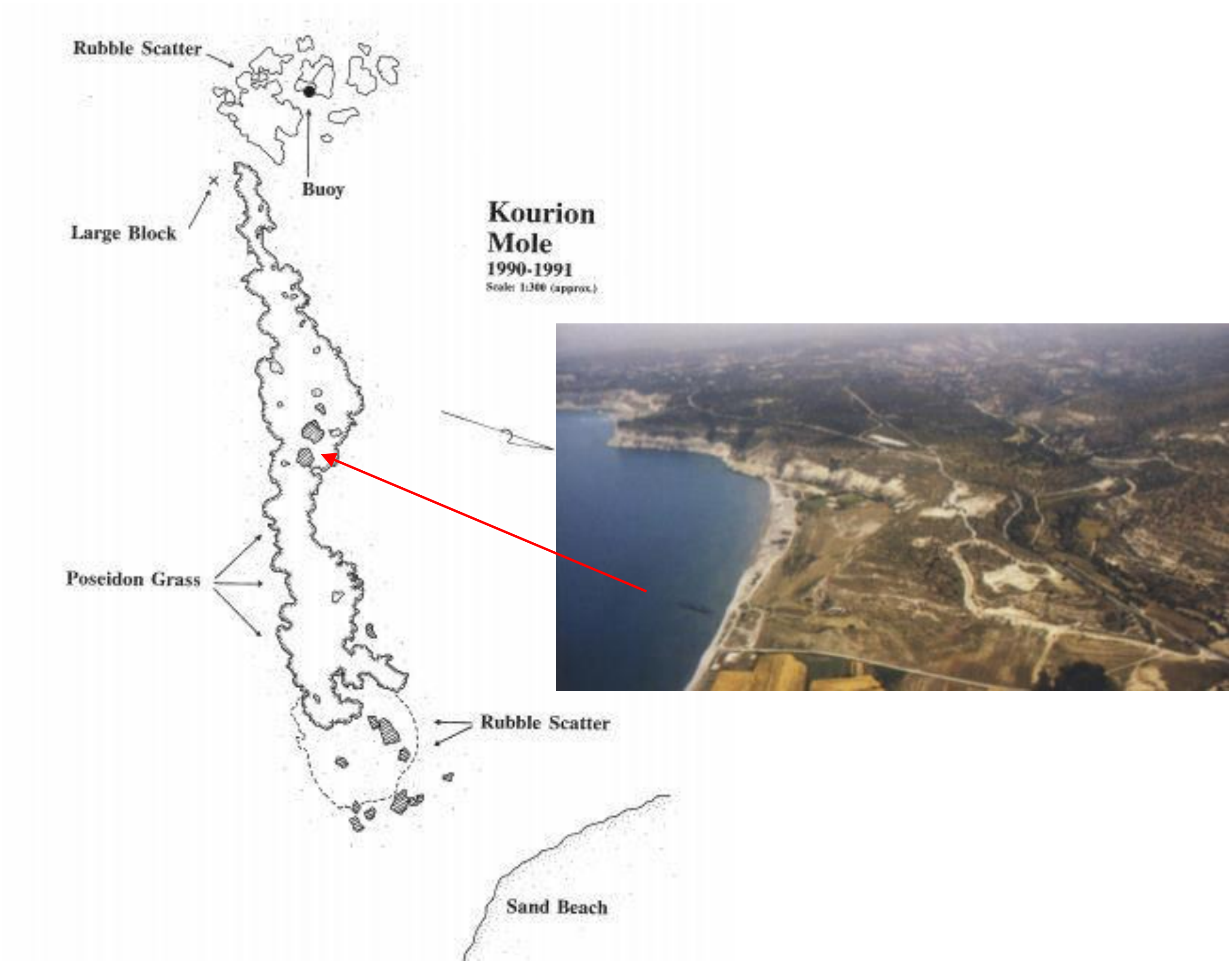

Figure 2 : Plan of the so called-breakwater of Kourion and its location in Ayios Ermoyenis bay (Leonard 1997: 180, fig.11)

Figure 3 : The bay of Tripiti and the rock-cut channel. Photos taken by Socratous (Socratous 2018: 104, fig 57 ; 107, fig.62).

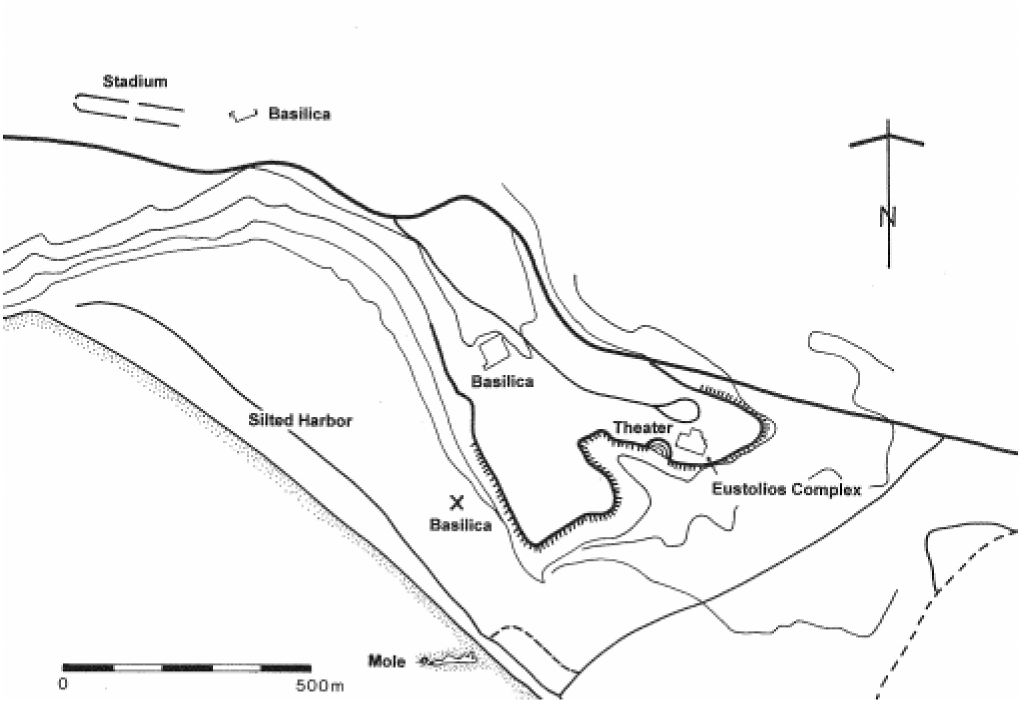

Figure 4 : The location of the silted basilica in relation to the mole (Leonard 1997:179,

VII. KYRENIA

LOCATION

Kyrenia is located on the North coast of Cyprus, in the occupied area. It is located on the north of mountain Pentadaktylos and west of Lapithos (**Fig. 1**).

HISTORY AND TOPOGRAPHY

The history of ancient Kyrenia is still today little known as no systematic excavation/research has been conducted to uncover the past of this ancient site. Tombs are the main indicators of human presence. The earliest, date to the Cyprogeometric period and continue to the Classical period. A rescue excavation in the 1960's uncovered also a temple dating from the Archaic up to the Hellenistic period. Ancient inscriptions refer to the existence of a gymnasium and an aqueduct dating to the Roman times. An important excavation was conducted also not far from the harbour of Kyrenia, that of the Kyrenia shipwreck. This shipwreck, allows us to understand the sizes of the ships in the Hellenistic period entering the harbour of Kyrenia. The role or position of Kyrenia in the general hierarchy of the ancient Cypriot polities is still not clear. It would be interesting to find an answer to this question so as to understand the driving force that planned and financed the construction of this harbour (Theodoulou 2006: 185; Satraki 2012: 269-270).

Two harbour basins existed, one west of today's medieval castle of Kyrenia (which consists of two breakwater-mole (?)). The entrance to the west harbour was probably in the north-east side. The second basin is an open bay on the east side of the medieval castle (**Fig. 2**). The connection with the settlement is not understood as no remains of the settlement have been uncovered. Today the harbour structures are covered by modern harbour structures.

TYPOLOGY, FUNCTION, CONFIGURATION

A hypothesis could be that one basin was the military harbour and the other the commercial harbour and they were simultaneously in use for different purposes however archaeologicaly this cannot be supported. It is also considered according to Raban that the west harbour was a *kleistos limen*. There is no sufficient archaeological evidence to sustain that though (Raban 1995:166; Theodoulou 2006: 188-196; Nicolaou 1966: 98).

ANCIENT WRITERS AND TRAVELLERS

According to Stadiasomos he refers to the harbour of Kyrenia as ifirmos (ὕφορμον) (Stad. 313) while Pseudo-Scylax refers to it as limenas erimous (λιμένας ἐρήμους) (Pseud. 77.103) meaning desserted harbour. The only evidence of how the harbour really looked like before any kind of alterations that took place in the 19^{th} century comes from two paintings of Ellis in 1878 and Graves in 1849. In Graves painting (**Fig. 3**) the remains of the breakwater-mole (?) is visible however it seems to be not a continuous structure. In Ellis painting, an east breakwater is visible on which its extremity a tower/lighthouse is visible. Most probably the depicted harbour structures represent the ancient Roman, Medieval harbour structure remains (Theodoulou 2006 : 193-196, fig.136-138).

PREVIOUS RESEARCH

The only study conducted on the harbour of Kyrenia was that by Linder and Raban in 1971 (Raban 1995: 166) (**Fig.4**). Theodoulou in the framework of his PhD thesis photographed some of the harbour structure remains that were visible by the end of the 2000s (Theodoulou 2006 : fig.146-156).

HARBOUR STRUCTURES

BREAKWATER-MOLE (?)

The east harbour has remains of two breakwaters. The west breakwater started from the coast (west of the medieval castle) with a direction to the north and then extends towards the east, while the east breakwater-mole had a north-west direction. The west breakwater-mole is divided into four parts (first 80 meters long (SN direction, second 130 meters WE direction, third 170 meters WE direction, and the fourth 120 meters long WE direction). The identification of four parts is not clearly described by Raban. This breakwater-mole underwent significant additions in the 19th and 20th century, a fact that disturbs the study of the ancient harbour structure. It is thought that todays breakwater-mole of Kyrenia lays on the ancient remains of the breakwater-mole (?).

Raban and Linder documented in the first part of the west breakwater-mole (80m) in the seaward side, ashlar blocks of dimensions of 0.6x1x2.3 m that dated more or less to the roman/medieval period and probably belonged to the ancient breakwater and are today at the foundation of the modern breakwater-mole. Under the second part, a so-called "flat platform" made out of squared ashlar blocks of dimensions 0.6x0.5x2m, which continues for 40 meters has a width of 12-15m. It is thought to have been the mole along the ancient breakwater and is founded on a rocky foundation. Nevertheless, the depth in which this structure is located is problematic as no change (3meters below sea level) in sea level has been detected in the area. Above the structure Hellenistic and Classical pottery was found. Also on the third part of the north breakwater, an ancient sea wall is visible. The west and east breakwater-mole that are visible today have been built above the ancient breakwater-moles and therefore, their direction is considered to have been the same (Raban 1995: 166 ; Theodoulou 2006: 185-196). No documentation of the east-breakwater-mole (?) has been published.

MOORING STONES

Mooring stones have been found in secondary use in a building located in the harbour area (Theodoulou 2007: 195).

LIGHTHOUSE

Sakellarios (1890:146) refers to the existence of two lighthouses at the entrance of the harbour of Kyrenia. He labels them as ancient and does not specify the period. No archaeological remains have ever been found.

CONSTRUCTION METHODS

It is extremely difficult to define the harbour construction methods as the given descriptions are insufficient. Ashlar blocks were used. No evidence of mortar or clamps has been attested.

MARITIME FORTIFICATION

There is only indirect indication of fortification which however must be taken with skepticism. Perhaps the existence of towers or lighthouse at the harbours entrance (visible in the depictions of Elis and referenced by Sakellarions) may be considered as an indicator of an ancient fortification running along the breakwater-moles (?) (Theodoulou 2006 : 195).

RELATED INSTALLATIONS

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RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

According to Flemming the North coast of Cyprus is considered to be stable. However, as Raban and Linder and Theodoulou indicated the flat platform in section two section was found below -4m. This indicator underlines the fact that perhaps Flemming's results are in need to be corrected in relation with archaeological indicators (Theodoulou 2006 : 193).

GEOHAZARDS AND OTHER FACTORS

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OTHER FINDS

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CHRONOLOGY

The chronology of this harbour basin is difficult to conclude with certainty but is generally considered to date around the Classical period. A hypothesis by Theodoulou is that the east basin was first used, and after its abandonement the west harbour basin was built in the 4th century BC (Theodoulou 2006: 185-196).

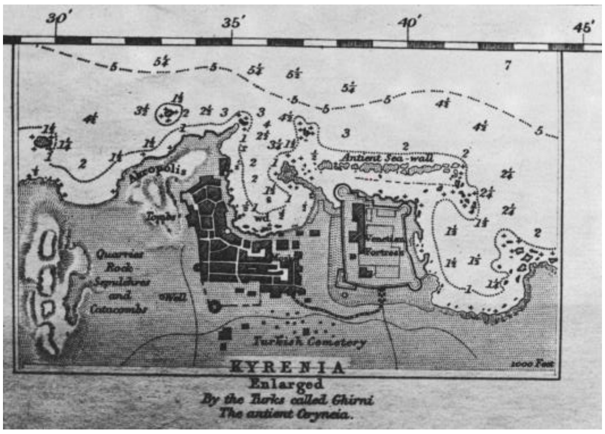
SOURCES

References in ancient literature	Pseud.77.103 Stad. 313
Inserts in databases	-
Indicative Bibliography	Marangkou, A. (1997). *Τα λιμάνια της Κύπρου.* Λευκωσία: Πολιτιστικό ίδρυμα τραπέζης Κύπρου. Nicolaou, K. (1966). Αρχαιοι λιμένες εν Κύπρω, *Δελτίον Τμιματος πολιτιστικης Αναπτύξεωσ Υπουργείου Παιδείασ.* pp.95-99. Raban, A. (1995). The heritage of Ancient Harbour Engineering in Cyprus and the Levant. In: Karageorghis, V. and Michaelides, D. (eds.), *Cyprus and the Sea*. Nicosia: University of Cyprus. pp. 139-190. Sakellarios, A. (1890). *Τα Κυπριακά : Ήτοι Γεωγραφία, Ιστορία και Γλώσσαα της Κύπρου από των αρχαιοτάτων χρόνων μέχρι σήμερον.* Available : *Ψηφιακή Πλατφόρμα Κυπριακής Βιβλιοθήκης* http://www.cyprusdigitallibrary.org.cy/items/show/78 Last accessed June 4, 2021. Theodoulou, T. (2006). Ναυτική Δραστηριότητα στην Κλασικη Κύπρο. Το λιμενικό δίκτυο στα τέλη του 4ου αι. π.Χ. Unpublished PhD thesis of the University of Cyprus.

FIGURES

Figure 1 : Location of Kyrenia's harbour-city (J.Gatt 2021).

Figure 2 : Aerial photo of the east and west harbour of Kyrenia taken in 1943 (Theodoulou 2006 : fig.133)



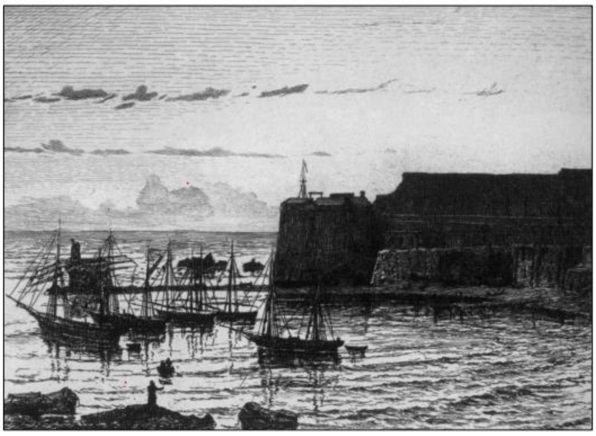


Figure 3 : Left-Map of Kyrenia in 1849 by T. Graves (Stylianou & Stylianou 1980, fig. 194a) Right-Drawing of Kyrenias west harbour, harbour entrance area by Ellis 1878 (Papanikola-Bakirtzi & Iacovou 1997 : 270).

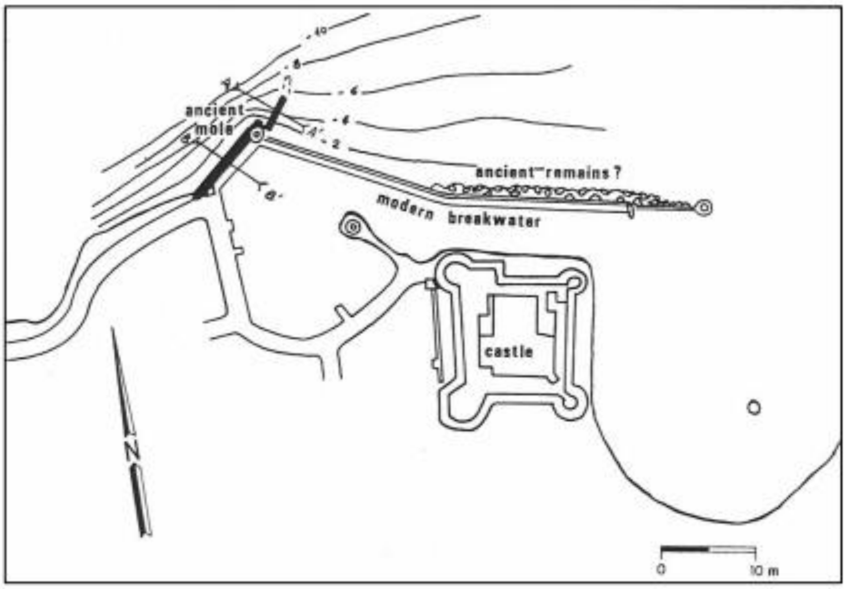


Figure 4 : Raban's plan of Kyrenias ancient harbour remains (Raban 1995 : fig.41a)

VIII. LAPITHOS

LOCATION

Lapithos is located on the north coast of Cyprus 14 km west of Kyrenia (**Fig.1**).

HISTORY AND TOPOGRAPHY

Habitation is attested in the area since the Late Bronze age and the Early Cyprogeometric period. Lapithos was a Cypriot polity since the 6th century BC. Its location is still not clear however it is proposed by Myres (1945 : 71-78) to have been located near the Troulin hill near the Acheiropoietos monastery. It is one of the first kingdoms to have produced coins from the 6th century BC. In addition, Its relation with Kyrenia is still not clear. One theory supports that Kyrenia was a secondary, satellite settlement for Lapithos (Satraki 2012: 160, 268-272).The harbour is completely artificial. The city walls extend to the beach however it is not clear if they continued along the breakwater-moles. Raban and

Linder (1995: 165) hypothesize the existence of a second harbour basin north of Troulin hill, between the two complexes of ancient fish tanks (Raban 1995 : 165 ; Theodoulou 2006: 200) (**Fig. 2**).

ANCIENT WRITERS AND TRAVELLERS

Pseudo-Scylax (77.103) refers to the harbour as desserted «λιμένας ἐρήμους». Strabo refers to the harbour-city as possesing an yfirmos and neoria (XIV.6.3) while Stadiasmos again refers to the harbour as yfirmos (315).

TYPOLOGY, FUNCTION, AND CONFIGURATION

The harbour basin of Lapithos consists of an artificial construction which probably harboured shipsheds (according to Strabon's description). Raban characterized the harbour as a closed harbour (Raban 1995 : 165) due to the probable extension of the city-walls along the brekawater-moles. It must have served the needs of the settlement of Lapithos (either military or commercial) although for now it is difficult to identify a specific function. The entrance of the harbour is estimated to be 100 meters wide.

PREVIOUS RESEARCH

The harbour of Lapithos was described by Nicolaou and Flinder in the article concerning the fishtanks of Lapithos (Nicolaou & Flinder 1976 : 135). It was also visited during the survey of Raban and Linder (1973) followed by a small survey of Theodoulou (2006 : 200-202).

HARBOUR STRUCTURES

MOLES

Nicolaou in his research between 1957-1959 describes Lapithos as having a north mole and a south mole. The north mole was 155 meters long with a width of 10 meters while the south breakwater (NW-SE) was 40 meters long and 3.6 meters wide. Linder and Raban in 1971 reffered once more to the remaining harbour structures (Raban 1995: 165; Nicolaou 1966: 98 ; Nicolaou and Flinder 1976: 135 ; Theodoulou 2006: 198-202) (**Fig. 3**).

HARBOUR CONSTRUCTION METHODS

It is thought that for the building of the north mole (direction west and then a curve SW) was entirley built on a rubble foundation of 50m wide while the less effected from the wind, was also built on a rubble foundation but with a narrower width. These ancient structures according to Nicolaou were reinforced and covered with modern blocks in the 1960s. Raban and Linder identified two building phases in the north mole. The first one is described as a careful construction with ashlar blocks related to the so called Phoenician technique, while the second phase is dated to the Roman period and is attested through scattered ashlar blocks 1.5X1.5X1.5m. No other indicators for the distinction of the two construction phases, or the masonry implemented have been reported. Concerning the south mole, mortar was identified on the sturcture (Raban 1995: 165 ; Theodoulou 2006: 200).

MARITIME FORTIFICATION

At the beginning of the north breakwater-mole, the remains of a tower (**Fig. 4**) have been identified which is dated after the Hellenistic period based on the presence of LR pottery (Theodoulou 2006: 201). A second tower (now destroyed) which is documented by a photo taken by Foscolo was also located near the south breakwater (Theodoulou 2006: 201, fig. 165).

RELATED INSTALLATIONS

This is the only time were a clear reference to neoria is made in ancient sources. Strabo (XIV.6.3) refers to their existance although no archaeological evidence has been found yet.

RELATIVE SEA LEVEL CHANGE

The harbour structures seem to attest zero change in the sea level as the basin seemed to function till the 1960's (prior to thr modern harbourworks) after which a channel was opend in the north mole resulting into the siltation of the basin. Flemming to did not idetify any change in the sea level of the site (Flemming 1981 : 415 ; Theodoulou 2006 : 202).

GEOHAZARDS AND OTHER FACTORS

The ancient harbour structures have been covered by modern harbouworks and therefore their documentation today remains challenging (Theodoulou 2006 : 199 ; Nicolaou & Flinder 1976, 135). Lapithos harbour is a perfect example of the mastery ancient harbour engineers possessed. The main wind was north/north-west so they extended the north breakwater-mole to the west with a curve to the southwest protecting the harbour from siltation. Comparing an aerial photo of 1963, with a recent one indicates that engineers opened a channel 10-15 m wide in the north modern breakwater which resulted quicly to the siltation of the basin (**Fig.5**) (Theodoulou 2006: 200, 275).

OTHER FINDS

West of the settlement, fish tanks (**Fig.2**) were recorded by Nicolaou and Flinder (1976 : 133-141). The main fish tank had 27x14m dimension which was connected to secondary basins and water circultion was controlled through sluice gates. Sea water was supplied through wave power (Flinder 1987 : 173-178). Along the rocky beach of the area, to the west of the harbour quarries had been also identified (Nicolaou & Flinder 1976, 133).

CHRONOLOGY

Pseudo-Scylax refers to the harbour as abandoned however the harbour structures and the references of Strabo and Stadiasmos indicate the existence of an active harbour. The construction phases identified by Raban and Linder may indicate the two phases that also the ancient sources seem to refer to. No exact datation has been proposed but it can be proposed that the harbour was built prior to the 4th century BC when Pseudo-Scylax observed its « abandonment » (Raban 1995 : 165 ; Theodoulou 2006 : 201-202).

SOURCES

References in ancient literature	Strab. XIV.6.3 Stad.315 Pseud. 77.103
Insert in database	https://www2.rgzm.de/Navis2/Harbours/Athen/Lapethos/LapethosUK.htm
Other references	Flemming, N.C. (1978). Holocene eustatic changes and coastal tectonics in the Northeast Mediterranean: Implications for models of crustal consumption, Phil. Trans. of Royal Society. Myres, J. L. (1945). Excavations in Cyprus 1913, BSA 41 (1940-45), pp. 71-78. Nicolaou, K. (1966). Αρχαίοι λιμένες εν Κύπρω, Δελτίον Τμήματος πολιτιστικής Αναπτύξεως Υπουργείου Παιδείας. pp. 95-99.

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FIGURES

Figure 1 : Location of ancient Lapithos (J.Gatt 2021).

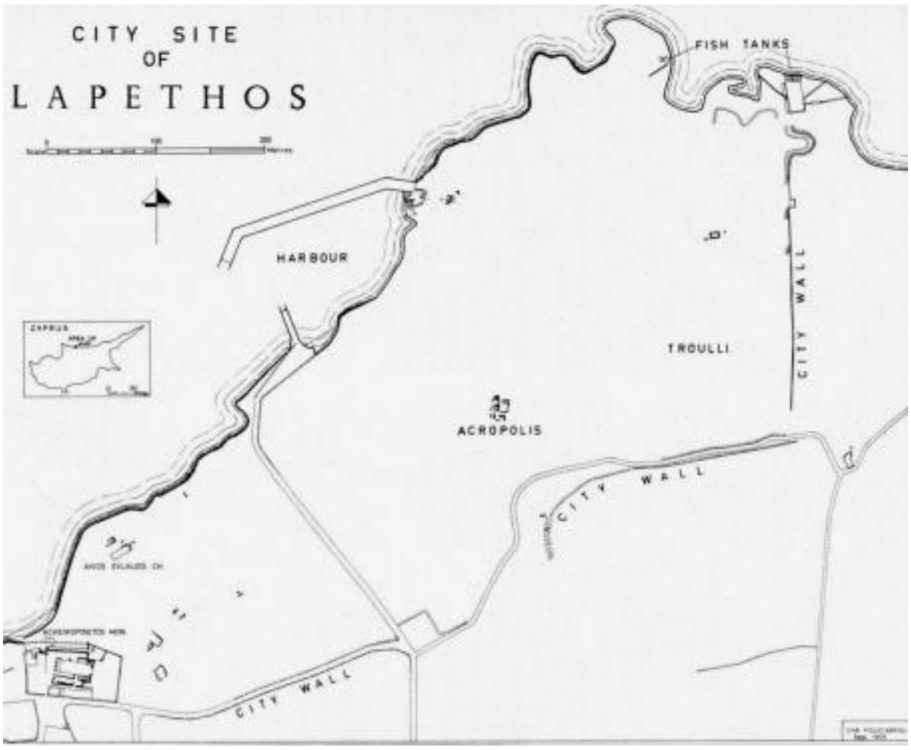

Figure 2 : Plan of the site of Lapithos by Nicolaou and Flinder (1976, fig.1).

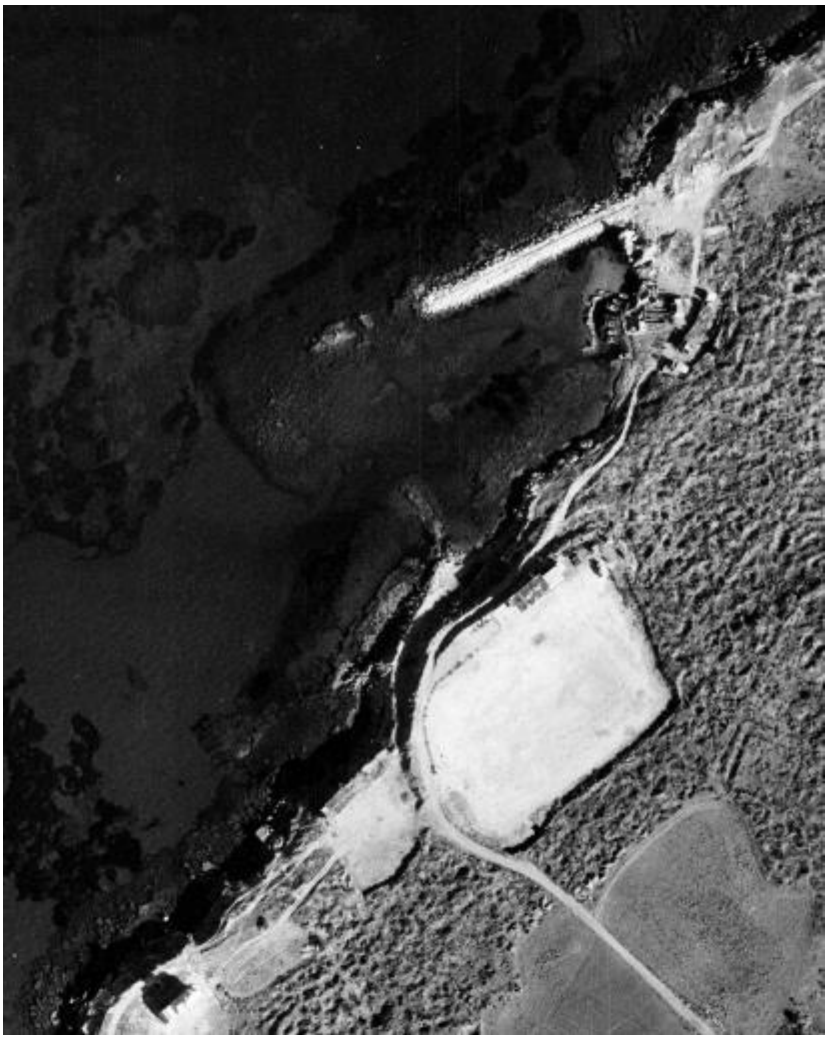

Figure 3 : Aerial photos of Lapithos harbour taken in 1963 (Theodoulou 2006 : fig. 159).

Figure 4 : Left-Photo of tower located in the begining of the north breakwater (Theodoulou 2006 : fig. 164). Right –Photo of west tower taken by J. Foscolo (Malekos 1992).

Figure 5 : Aerial photo taken in 2006 via google earth (Theodoulou 2006 : fig.160).

IX. MARION

LOCATION

The cypriot-polity of Marion was located to the west of river Xrisoxous, on two elevated plateaus on the west coast of Cyprus near the copper mines of Limnis (**Fig. 1**).

HISTORY AND TOPOGRAPHY OF THE HARBOUR CITY

Ceramic distribution, building material, and tombs attest habitation in the area from the Late bronze age up to the Byzantine period (Childs 1997, 37-39 ; Nicolaou 1966: 9). On the eastern plateau (north-east of today's city of polis Xrisoxous) called Peristeries, the remains of an archaic temple dating to the 7-6th century BC has been found (with a number of rich offerings, figurines jewelry and metal objects).

In the 5th century BC, this temple was destroyed. Remains of the workshop and a settlement with roads surrounding the temple, have been also unearthed through a geophysical survey. An “archaic palace” in the area was also uncovered were ceramics from Athens, Corinth, and Eastern Greece was found dating from the archaic to the classical period) (Papalexandrou 2006: 233 ; Papalexandrou 2008: 253-254). On the second plateau, a temple dating to the 5th century BC has been found that was destroyed in the 4th century BC. In it, terracotta figurines and statues were found. The city walls were located north of the temple. The existence of the Cypriot-polities of Marion is attested from the coins of the 5th century BC and Diodorus Siculus reference to its siege by Kimon in 449 BC (Diod. XII.2.3). Ptolemaios I Soter in 312 BC destroyed the city and moved its inhabitants to Nea Paphos as it was an ally of Antigonus. Afterwards, Ptolemaios II Philadelfos (270 -273 BC) built Arsinoe in the same place as ancient Marion (Satraki 2012: 160, 178, 280-288 ; Theodoulou 2006: 100-102).

The location of the so-called Hellenistic harbour is to the west of Marion’s Cypriot Polity. While the location of the Classical harbour still remains under debate. According to Theodoulou based on aerial photos and the study of the coastline he suggests that it might have been located at today’s Xrisoxous camping site which was in the past near the mouth of river Xrisoxous. This location of the harbour is not far away from the settlement of Marion, and the area since the 20th century was referred to as a lagoon /marsh that was dried according to a drawing by an English Engineer dating to 1902 (**Fig. 2**) (Theodoulou 2006: 100-116 ; Theodoulou 2005).

ANCIENT WRITERS

In ancient texts, Pseudo-Scylax (77.103) in the 4th century BC refers to the harbour as *limenas erimous* meaning abandoned harbour. Marion was referred also in Strabo and Ptolemy but with no reference to the harbour. Only Stadiasmos (297-317) this time referring to Arsinoe states the fact that the basin was abandoned (Theodoulou 2006: 103).

TYPOLOGY, FUNCTION AND CONFIGURATION

According to Theodoulou the harbour of Marion was destined to ba a closed harbour however, its construction was never completed (Theodoulou 2006 :109). The function and configuration of the basin remain undetermined. The city of Marion must have had an important role from the Bronze Age till the beginning of the Hellenistic period as there was no other (known to us) neighboring harbour that would facilitate copper trade or other maritime activity in the area until the harbour of Nea Paphos was built.

PREVIOUS RESEARCH

The first reference to the harbour of Marion was made by Nicolaou (1966 : 97) in the article *Ancient harbours of Cyprus* (Αρχαίοι λιμένες εν Κύπρω). The Department of Antiquities also conducted in the 1960’s a documentation of the ancient harbour remains prior to the construction of the Marina (Theodoulou 2006 : 104). Raban and Linder in 1971 visited also the harbour site and proposed a plan of the harbour’s configuration (Raban 1995 : 165). Their documentation however has a series of mistakes identified by Theodoulou. Finally, Theodoulou in the framework of his PhD thesis visited the site and photographed the ancient blocks of the breakwater-mole (?) (Theodoulou 2006 : 100-116).

HARBOUR STRUCTURES

According to Nicolaou, a breakwater-mole (?) was built of well-structured ashlar blocks. According to Raban and Linder there were two stucutres a west mole with a direction to the north (40m long) and a north breakwaters-mole with an east to west direction (**Fig.3**). On the leeward side of the north breakwater a platform of 2 m width in two sections (of 30 and 58m in lenght were identified) was identified. These observations were contradicted by those of Theodoulou based on the aerial photos taken and plans created prior to the construction of the marina. The breakwater-mole (?) started from the bay and extended to the north for 50m and then turned from a northwest to a southeast direction for 130m. The width of the structure was approximatley 50m (Raban 1995: 165 ; Nicolaou 1966: 97 ; Theodoulou 2006 : 103-109). The misinterpretation of the site by Raban and Linder was due to the modern structures that obstructed a clear understanding of the site.

HARBOUR CONSTRUCTION METHODS

The breakwater-mole (?) was built partially on a rocky foundation (reef) and a rubble foundation and the upper structure seems to have been built with ashlar blocks (**Fig.4**). Concerning the rubble foundation, a section that has been cut recently on the west modern breakwater-mole (?) built on the ancient remains allows a better understanding of the building technique of the rubble foundation. This indicated the application of two layers the first one consisting small stones while the second large stone blocks. Regarding the upperstructure according to the Departemnt of Antiquities plan (**Fig.5**) an alteration of rows of headers and strechers seem to had existed. Nicolaou refers to the use of blocks of dimensions around 2.50x1.00x0.70 m while Linder and Raban estimated the ashlar blocks dimensions as 0.8x0.8x2.0 m. The dovetail clamps identified in the west mole by Raban and Linder weren't anymore visible to Theodoulou since they were covered by the modern structure. Concerning the so-called north breakwater of Raban and Linder and the concentration of blocks which were identifed also by Theodoulou correspond probably to the breakwater's rubble construction on the angle of the breakwater-mole (?). The platform (probably mole remains) located by Raban and Linder weren't identified by Theodoulou and therefore their construction remains unknown (Theodoulou 2006 : 103-109 ; Raban 1995 : 165).

MARITIME FORTIFICATION

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RELATED INSTALLATIONS

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RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

In the 1960's a documentation of the harbour structure remains by the Department of Antiquities reveals that prior to the construction of the modern breakwater ashlar blocks were still visible on the surface of the sea therefore there doesn't seem to have been any significant rise of the sea level (Theodoulou 2006: 104).

GEOHAZARDS AND OTHER ISSUES

The ancient breakwater-mole (?) has been covered by the modern structures of the fishing harbour known today as Latsi Marina. According to Nicolaou (1966 : 97) and Theodoulou's observation, the basin had been highly influenced by siltation (Theodolou 2006 : 108).

OTHER FINDS

In the harbour basin during a dregging operation in 2006 a marble column was found and is exhibited today in the local museum (similar to that of Nea Paphos and Dreamer's Bay-Akrotiri) (Theodoulou 2006: 106-107).

CHRONOLOGY

This breakwater-mole (?) is thought to be dated in the Hellenistic period. Theodoulou in his P.h.D. thesis presented two arguments for which this construction should be dated to this period. A) The use of metallic clamps and B) The fact that it seems to be an uncompleted project since it wasn't sufficently protected from the northern winds. This fact was attested in other harbours of the island (Theodoulou 2006 : 258, 260).

SOURCES

References in ancient literature	Pseud. 77.103 Strab. XIV 6.3 Stad. 297-317
Inserts in database	http://limenoscope.ntua.gr/ports/view/cyprus-marion https://www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Marion
Other references	Nicolaou, K. (1966). Αρχαιοι λιμένες εν Κύπρω, *Δελτίον Τμιματος πολιτιστικής Αναπτύξεως Υπουργείου Παιδείας.* pp.95-99. Papalexandrou, N. (2006). A Cypro-Archaic Public Building at Polis tis Chrysochou, 1999-2003: Prelimenary report. *RDAC.* pp. 223-237. Papalexandrou, N. (2008) A Cypro-Archaic Public Building at Polis Chrysochou, 2006-2007: Interim report. *RDAC.*pp.251-262. Raban, A. (1995). The heritage of Ancient Harbour Engineering in Cyprus and the Levant. In: Karageorghis, V. and Michaelides, D. (eds.), *Cyprus and the Sea.* Nicosia: University of Cyprus. pp.139-190. Theodoulou, T. (2005). "Looking for the harbour of the Classical kingdom of Marion" in H.Tzalas (ed.), *Tropis IX. Proceedings of the 9th International Symposium on Ship Construction in Antiquity*, Ag. Napa, Cyprus 25-29 August 2005, Hellenic Institute for the Preservation of Nautical Tradition, Athens (υπό έκδοση) Theodoulou, T. (2006). *Ναυτική Δρραστηριότητα στην Κλασική Κύπρο. Το λιμενικό δίκτυο στα τέλη του 4ου αι. π.Χ.* Unpublished PhD thesis of the University of Cyprus.

FIGURES

Figure 1 : Location of the ancient harbour of Marion (J.Gatt 2021).

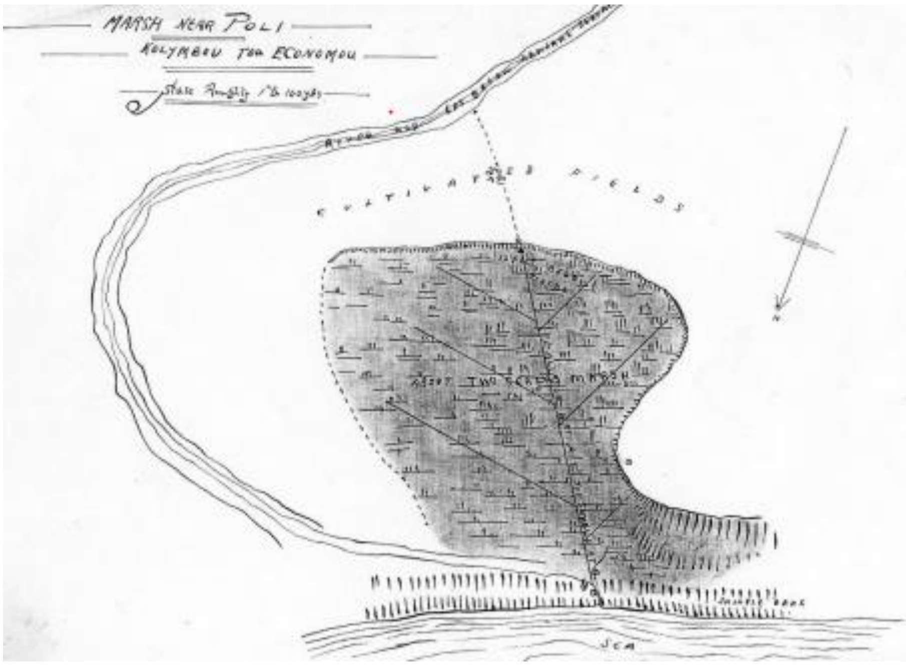

Figure 2 : Sketch of english engineer in 1902 for the drying of the Marsh in Polis Chrysous (Theodoulou 2006 : fig.25).

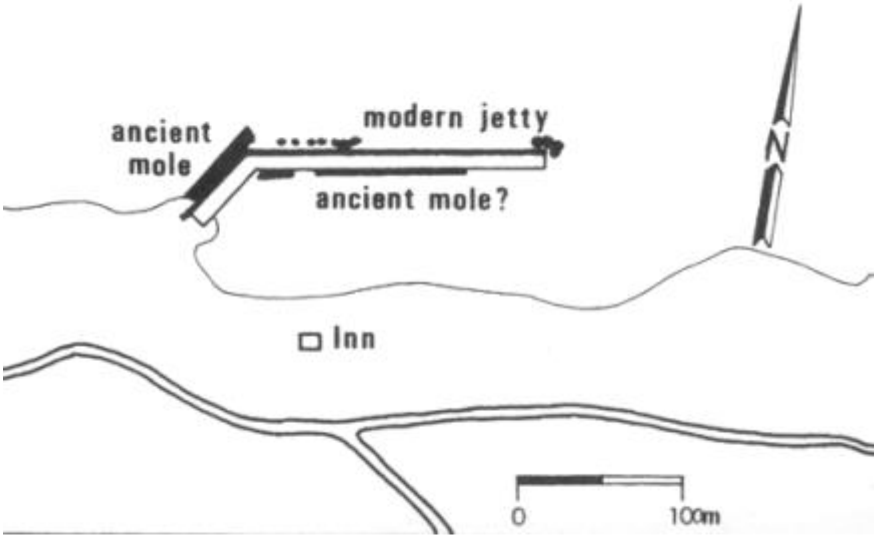

Figure 3 : Plan of Marion harbour based on Raban's observations (Raban 1995 : 164, fig.38).

Figure 4 : Aerial photo of Marion ancient breakwater-mole (?) prior to the construction of the modern marina (THeodoulou 2006 : fig.9).

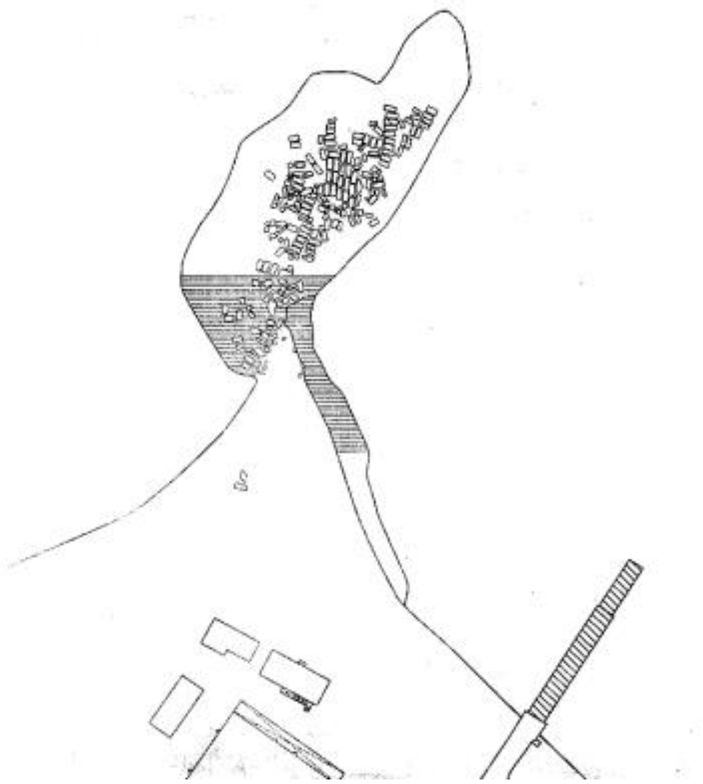

Figure 5 : Plan of the Department of Antiquities of the ancient remains produced in 1960 (Theodoulou 2006 : fig.8).

X. NEA PAPHOS

LOCATION

Nea Paphos is located on the southwest coast of Cyprus, west of the cypriot Polity of Paphos (Palaepaphos) (**Fig.1**).

HISTORY AND TOPOGRAPHY

Habitation in the area is attested from the Classical period through a settlement whose name is thought to have been Erythrai. This city of Paphos though was erected by the end of the Classical and the beginning of the Hellenistic period. There are three theories regarding how and when the city was erected. A) By the end of the 4th century BC Nikoklis, the king of the cypriot-polity of Palaepaphos (old Paphos) built the city of Nea Paphos (New Paphos) due to the siltation of the harbour of Palaepaphos, but then Ptolemy forced him to suicide due to his collaboration with Antigonus and continued the construction of the city where Nikoklis had left it (Mitford 1960: 198, 204-5 ; Nicolaou 1966 : 564 ; Daszewski 1987 : 171-175 ; Młynarczyk 1990 : 23-25) B) Ptolemy I Sotiras collaborated with Nikoklis and built the city between 320-310 BC. (Daszewski 1987 : 174 ; Hohlfelder & Leonard 1994 : 46) C) The last interpretation is that Ptolemaios I Sotiras built the city in 294 BC by himself (Bekker-Nielsen 2000 : 200-202). In brief, one of these two personalities must have initiated this project. Either Nikoklis who needed a new harbour as probably the harbour of Paphos was silted or Ptolemy I who needed a base beyond Alexandria so as to be able to benefit from its raw materials as well as its strategic position

(Theodoulou 2006: 122-125). The city of Nea Paphos surrounded the harbour basin and flourished in the Hellenistic period as the rich archaeological remains indicate such as the harbour, the agora, the theater (the most ancient known theater of Cyprus), the gymnasium, the temples, and the city walls (Vitas 2015) and continues to be intensly inhabited till today.

ANCIENT WRITERS AND TRAVELLERS

Strabo refers to the existence of a good harbour (Εἶκ'ἡ Πάφος, κτίσμα Ἀγαπινορος καὶ λιμένα ἔχουσα καὶ ἱερὰ εὖ κατασκευασμένα) (Strab.XIV.6.3), while Stadiasmos (297) refers to Nea Paphos as having a triple harbour basin (...ἔχει λιμένα τριπλοῦν παντὶ ἀνέμῳ καὶ ἱερὸν Ἀφροδίτης). In the acts of the Apostles (XIII.13) an indirect reference to the harbour of Paphos was made describing the arrival of St. Paul to the island «Ἀναχθέντες δὲ ἀπὸ τῆς Πάφου οἱ περὶ τὸν Παῦλον ἦλθον εἱς Πέργην τῆς Παμφυλίας». Hogarth too described the remains of the ancient harbour structures (Hogarth 1889 : 7) while Sakkelarios refers to the problem of siltation of the basin (Sakellarios 1890 : 102). A traveller of the 19th century, named Jeffery describes the west side of the promontory as a swamp indicating the gradual siltation of the ancient west basin (Wladyka and Miszk 2016: 13).

TYPOLOGY, CONFIGURATION AND FUNCTION

The harbour of Nea Paphos is considered to have been a *Kleistos Limen* since probably the fortification extended on the breakwater-moles and a narrow entrance (55m) to the southwest flanked with towers had existed (Nicolaou 1966 : 567 ; Leonard & Hohlfelder 1993 : 365, 367 ; Hohlfelder 1995 : 199).

According to Stadiasmos the harbour of Neas Paphos had three basins. The location of these basins remains in question. The possible remains of ancient jetties (?) extending along the contour of today's basin according to survey's conducted indicate the division of the basin in three sections (Daszewski 1981 : 4-5 ; Leonard & Hohlfelder 1993 : 376). The coastal progradation that was first noted by Nicolaou and later on by the geoarchaeological study of the PAHEP project indicated that the land was further inland and therefore the possibilty of multiple basins existed. The geoarchaeological study indicated the existance of two not three basins due to a natural rocky formation that extended (now silted) towards the basin and divided it in two (Leonard et al. 1998). The latest research conducted by the Jagnolian University was a geophysical survey that aimed in locating the basins of Nea Paphos harbour based on the reference of Stadiasmos. The research located on the east side of a promontory a depression now silted that may indicate a basin. Nevertheless, the result of this study is in need of further investigation (Miszk and Wladyka 2016: 12-16) (**Fig.2,3**)

PREVIOUS RESEARCH

In 1959 and 1961 a British army exercise took place in Nea Paphos harbour. Findings were retrieved but never published. Only a report titled *Operation Aphrodite* written by one of the divers was handed out to the department of antiquities (Leonard 2008: 131). In 1965, Dasweski recorded the ancient remains before important modern changes took place at the harbour (Dasweski 1987: 171-175). A series of important research by Nicolaou's in 1966 on the Topography of Nea Paphos and Młynarczyk P.h.D. thesis on Nea Paphos in the Hellenistic period published in 1990 adressed the construction of the harbour. These were followed by Hohlfelder's coaring and documentation of the harbour structures between 1991 and 1996 in the framework of PAHEP project (Hohlfelder 1995: 196- 197 ; Hohlfelder & Leonard 1994). Recently, the Jagiellonian University has revisited the Nea Paphos harbour to study the potential west harbour of Nea Paphos (Theodoulou 2006: 129-130 ; Wladyka and Miszk 2016: 1-19).

HARBOUR STRUCTURES

The harbour of Nea Paphos preserves a series of harbour structures. Two breakwater-moles (?) that enclosed the open bay, a parralel east breakwater and a spur extending from the west breakwater-mole (?).

West breakwater-mole (?)

The west breakwater-mole (?) had a curved shape with an orientation to the east. It is estimated to have been around 170-280 meters long by the different researchers. It is difficult to document its exact length, due to the modern breakwater-moles. The width is thought to have been approximately 5-15 meters. The breakwater-mole's (?) height is estimated to have been 4.5 to 5.8 meters above sea level including the height of the walls that extended on the mole so as to truly offer protection to the harbour (Hohlfelder 1995: 198-199). At the edge of the breakwater- mole (?), the remains of a tower or lighthouse were identified through a concentration of blocks in the area (Hohlfelder 1995 : 199 ; Leonard 1998).

Spur

At the angle/ curve of the west breakwater-mole (?), a concentration of blocks 70-50 meters long was connected to the main harbour structure. This concentration has been interpreted as a technique to protect the entrance since its location is not considered to have been favourable due to the direction of the prevailing currents and winds. Also it was a mechanisim to diminsh the siltation of the basin (Daszewski 1981: 3-4 ; Leonard & Hohlfelder 1993: 376-378).

East breakwater-mole (?)

The east breakwater-mole (?) had an east to west orientation. It is estimated to be about 350-500 meters long with a 5-10 meters width. At the west extremity of the structure the remains of a concentration of rubble was identified. This structure is destroyed and is preserved in segments. This led to the creation of a « natural channel » 30m wide. The creation of this so called channel remains undated (Leonard & Hohlfelder 1993 : 375-376 ; Hohlfelder 1995 : 197-225).

Parallel east breakwater

Parallel to the eastern mole 30 meters south of it a second mole was built 199 meters long with a width of 5 meters at a depth of 4-4.4 meters. This structure was made to be submerged and might have been a later addition (in the Roman period). This may had also played a role in protecting the basin from silting since an opening (« channel ») in the breakwater-mole (?) was made (Leonard & Hohlfelder 1993 : 375 ; Hohlfelder 1995 : 204-205).

Jetties (?)

Adjacent to today's quay along the coast, there are two concentrations of blocks that probably belong to jetties that divided the harbour into sections.

HARBOUR CONSTRUCTION METHODS

Concerning the west breakwater-mole (?) a rubble foundation may have had been prepared above which the mole and city-walls was constructed. Although the masonry used for the mole remains unclear the blocks sizes have been estimated around 1.80-2.70X0.90-1.40X0.70-1.00 m. The spur survives at the curve/angle of the breakwater were rubble is still visible (consisiting of blocks of 1.80-2.70X1.60-2.70X0.85-1.15m. and 0.32-0.45X0.20-0.22X0.16-0.21m). Probably blocks used in the construction of the mole were integrated in the castle construction as also possible remains of the mole are identified to the north of the medieval castle (**Fig.4**). Mettalic clamps by Hogarth and mortar by Dasweski were identified in the construction. A similar construction for the east breakwater-moles with blocks of 0.90-1.40X0.74-0.95X0.40-0.60 meter may had existed although the masonry remains undocumented. The only observation made on the construction of this structure was the use of smaller blocks on the leeward side in comparison to the seaward side of the breakwater-mole (?) (Hohlfelder 1995: 195; Theodoulou 2006:130-139).

MARITIME FORTIFICATION

The extension of the city's fortifications towards the harbour has been attested by several rescue excavations. The north side of the harbour was located further inland and attest fortifications that were located on the interface (Nicolaou 1966 : 567 ; Leonard & Hohlfelder 1993 : 365, 367 ; Leonard et al. 1998 : 146) (**Fig. 5**). However, no clear evidence of the fortifications on the harbour structures seem to survive due to the intense modifications the harbour underwent since antiquity.

RELATED INSTALLATIONS

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RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

The Geoarchaeological study of the harbour basin as also that of the west coast offered ample information on the relative sea level change in the region. The PAHEP project indicated that a rise in sea level approxaimatley 1-0.50m took place due to the tectonic movments. However, this rise in sea level has not been dated (Leonard et al. 1998 : 154- 155). Currently the harbour structures are submerged 2-4m below current sea level (east breakwater-mole (?) and parralel breakwater).). A significant coastal progradation has been also attested since the interface seems to have been located further inland (140-150m). The coastal progradation is attributed to the activity of a stream in the area which filled the basin with sediments (Leonard et al. 1998).

GEOHAZARDS AND OTHER FACTORS

The harbour underwent several phases of repairs and reconstructions. It is currently still in use which renders the continuation of its study complicated.

OTHER FINDS

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CHRONOLOGY

Based on the ancient sources and the descriptions of the harbour structures the first phase of construction of the harbour can be dated by the end of the 4th century BC. The harbour however continues to be in use during the roman and medieval period till today (Theodoulou 2006 : 139).

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Vitas, D.A. (2013). Νέα Πάφος - Σαλαμίνα : Η τοπογραφία και η πολεοδομική τους ανάπτυξη κατά την ελληνιστική περίοδο. Unpublished PhD thesis of the Univeristy of Cyprus.

FIGURES

Figure 1 : Location of the ancient harbour of Nea Paphos (J.Gatt 2021).

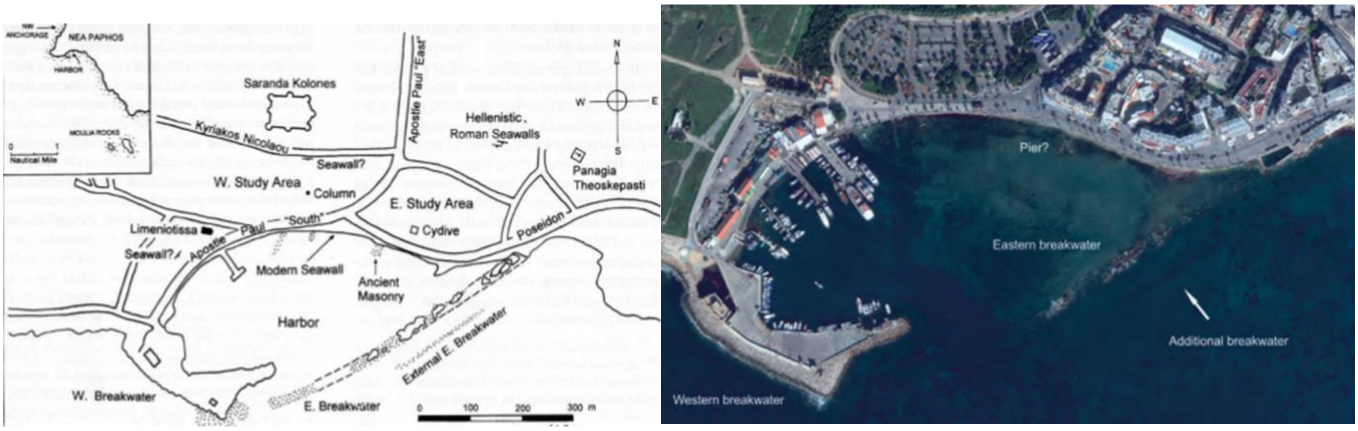

Figure 2: left- A plan of Nea Paphos ancient harbour by Leonard made in 1996. Right-An aerial photo of the harbour today indicating the location of the ancient harbour remains (left-Leonard et al. 1998: 144, fig. 1 ;right- Misžk – Papuci-Władyka 2016: 10, fig.3).

Figure 3: Left- Digital Terrain Model probably indicating the West silted basin by Ł. Miszk and W. Ostrowski (Misžk – Papuci-Władyka 2016: 14, fig.5). Right- Aerial photo of Nea Paphos today (https://www.bing.com/maps Last acessed 9th of June).

Figure 4: Ancinet blocks of the west breakwater-mole. (Left) Insitu. (Right) ashlar slabs integrated in the west wall of the

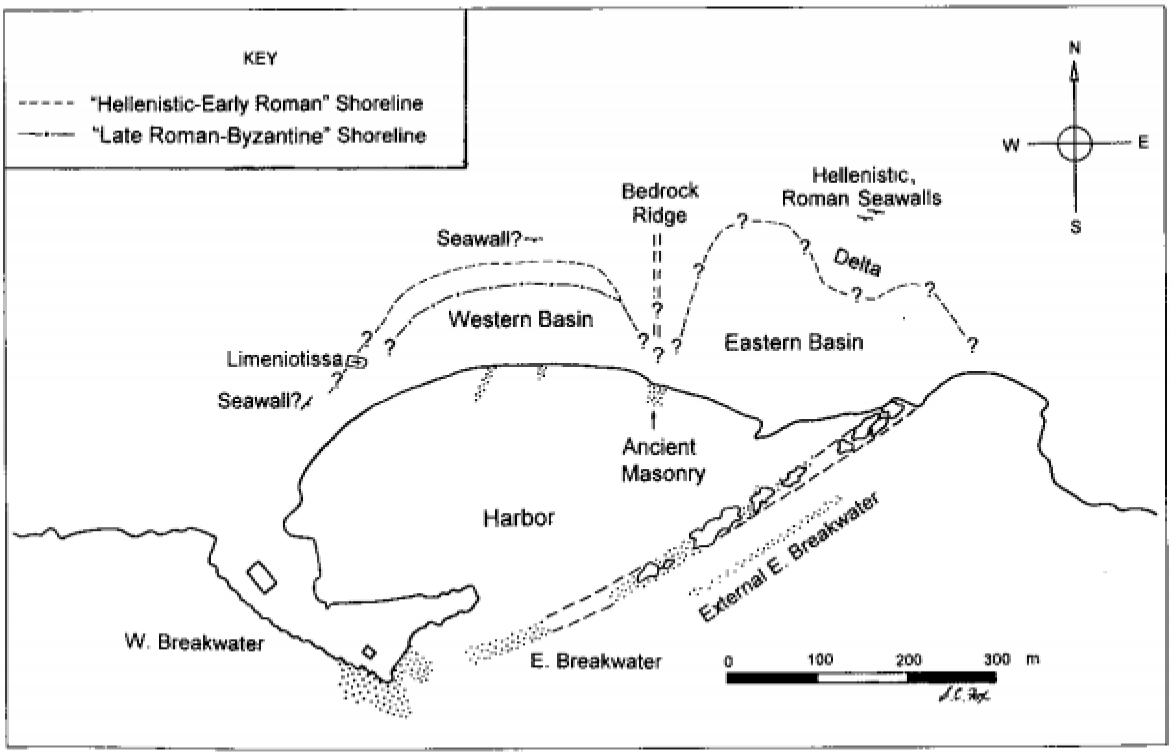

Fig. 5 : Plan of the location of the ancient coastline from the Hellenistic period till today (Leonard et al. 1998 : 151, fig. 4)

XI. SALAMINA

LOCATION

Salamina is located on the south east coast of Cyprus, on the delta of river Pedieos. Today Salamina is located in the occupied area of Cyprus (**Fig. 1**).

HISTORY

The foundation of the city of Salamina is dated to the Cyprogeometric Period (11th century BC). It is located 2km north-east of Enkomi (a bronze age coastal settlement dated to the 1600-1100 BC) and it was built due to coastal progradation instigated by Pedieos river so as to cater Enkomi with a new harbour (Lagarce 1993: 31). A temple of a male goddess (11th-6th century BC), a road and a complex of walled rooms with burials dating to the Cyprogeometric period have been excavated (Satraki 2012: 155-156). In the Cyproarchaic period, we have the first built tombs, such as Tomb I with a rich offering of 5 horses. The city is listed in the stele of Esarchadon and many of its kings had played important roles in ancient Cypriot history. Evelthon the first known to us king of Salamis who had lived in the 6th century BC, Onisilos who revolted against the Persians, Evagoras A who helped the Athenians against the Spartans and then unified all Cypriot polities and revolted against the Persians, and Pnitagoras who was given the throne by Alexander the Great and Nikokreon who became an ally with Ptolemy I Soter. In the Hellenistic period Salamina joined Ptolemy I in 312 BC to destroy Marion. In the 3rd century BC (274 BC), another settlement, Arsinoe was built to the south perhaps due to the siltation of the harbour of Salamis. This city was named after the wife of Ptolemy Philadelphos. The excavations of the city started in 1964 by the French school of Athens, but were interrupted in 1974 due to the Turkish invasion and thus, our knowledge on Enkomi, Salamis and Arsinoe is very limited. Salamis was inhabited till the 7th century AD. Then Famagusta in the medieval period, 10km south was established (Iacovou 2007: 25-28 ; Satraki 2012: 214-223 ; Maragkou 2012: 76-77).

The harbour of Salamis was located to the west of the city. Two potential harbour basins were located by Raban and Linder (**Fig. 2**). The first one is detemined by a reef (rocky formation) that runs parallel to the coastline (3km) at a distance of 100m from the coastline with a direction to the north (towards the gymnasium of the city).This reef creates a shelterd basin, with a lagoon like enviroment according to Raban. This harbour basin was interpreted as the harbour were the shipsheds were located (Raban 1995 : 163-164). Flemming during his survey identified a series of structures in the basin pointing out that perhaps part of the area considered as a basin was in reality part of the dry land (**Fig 3**) (Flemming : 163-173 ; Theodoulou 2006: 177-178). The second basin is located to the south of the 'lagoonal basin'. Its formed by a man-made east breakwater mole that extends from the south side of the reef (rocky formation) towards the south and ended with a curve to the west. This basin had an entrance of 200m and is considered to be the commercial harbour (Theodoulou 2006: 179-180). Raban and Linder consider the existance of a third secret harbour basin, (a cothon) however no archaeological evidence was presented nor a proposed location was expressed (Raban 1995 : 163-164 ; Theodoulou 2006: 178). Aerial photos (**Fig. 4**) have identified other potential sites such as a possible breakwater-mole to the south of the Pedieos delta which could probably be a harbour structure belonging to the harbour of Arsinoe. However, as no survey has been conducted the area its difficult to verify the information and to understand the configuration of the harbour basins of Salamis (Theodoulou 2006: 181).

ANCIENT WRITERS AND TRAVELLERS

According to Isocrates, Evagoras A' king of Salamis built a harbour, the city walls, and invested in a naval fleet (Isoc. 9.47). Diodorus Siculus mentions also that during the conflict with the Persians the city-owned 200 ships (Diod. Sic.XV.2.4-3.2). Pseudo-Scylax describes Salamis's harbour as a closed winter harbour (λιμένα ἔχουσα κλειστὸν χειμειρινὸν) (Pseud. 77.103). Strabon refers to Arsinoe and not Salamis as having a harbour (… εἶκ' αἱ Καρπάσιαι νῆσοι, καὶ μετ ὰ ταῦτα ἡ Σαλαμὶς, ὄκεν ἦν Ἄρις τοσ ὀ συγγραφευς. εἶτ' Αρσινόη πόλις καὶ λιμην) (Strab. XIV.6.3). Stadiasmos, on the other hand, refers to the deserted harbour of Ammochostos and Salamis simply as a harbour city (…πόλις ἐςτὶν ἔρημος λεγομένα Ἀμμόχωςτος. ἔχει δὲ λιμένα παντὶ ἀνέμῳ. ἔχει δὲ ἐν καταγωγὴ χοιράδες. διαφυλάττου. Ἀπὸ τῶν νήσων εἰσ Σαλαμίνα στάδιοι ν'. πόλις ἔστὶ, λιμένα ἔχει) (Stad.306). In the Acts of the Apostles. Barnabas and Paul were sent from Antioch (Seleucia harbour) to Salamis (Acts.XIII, 4-5).

Sakellarios (1890: 175) mentions the remains of a quay built with ashlar blocks built the coast while Hogarth (1889, 61) describes the impact of Pedieos river on the harbour "The whole seaward side of the site is a succession of hillocks, clogged with drifted sand, which at the northern end has raised all to a common level, while upon the south is a marsh formed by those deposits of the Pediaeus which have silted up the harbour, and left faint traces only of its quays and piers above ground". Pockocke (1745: 253-254) refers also to the location of the harbour as south to the city and north of the river mouth of Pedieos. His description was accompanied by a plan of the harbour (Theodoulou 2006: 170-175).

TYPOLOGY, FUNCTION, CONFIGURATION

According to Pseudo-Scylax Salamis had a closed harbour. The main question that concerns the harbour of Salamis is how many harbour basins did it possess as no reference by ancient writers has been made to multiple basins. The possibility that maritime fortifications extended on the harboirworks lead to the inclusion of this basin in the *kleistos limen* typology. Nevertheless the function of the basins remains still to be determined as it seems that each basin had a different role (i.e. military, commercial).

PREVIOUS RESEARCH

In the 1960's divers of the royal air force reported submerged ruins in the area (Flemming 1980). The first research that took place on the harbour of Salamis was conducted by Linder and Raban. Their work was followed by the research of Flemming with the purpose to understand neotectonic activity and coastal change in the area. As a result, Raban and Linder's survey were put into question. In the context of the PhD thesis of Theodoulou the site was visited and the east breakwater-mole was photographed (Theodoulou 2006). Devillers geological study in the region attempted (although the constraints of the occupied area) to interpret the coastal progradation in the area (Devillers 2008). Finally, the book of Marangou (1997) *The harbours of Cyprus* (Τα λιμάνια της Κύπρου) dedicated a chapter to Salamis harbour were she meticiously narrates the history of the site from antiquity to the modern era.

HARBOUR STRUCTURES

Two important features of the harbour of Salamis are the reef (rocky formation) that rans parallel to the coastline and the man-made breakwater-mole. Starting with the man-made breakwater-mole (**Fig. 5)** of the south harbour it is estimated to have been 250 meters long. Opposite to the east breakwater-mole (to the west) on the beach sarcophagi and remains of walls were found (maybe these remains were built on the now silted hypothetical west mole). This harbour is thought to have been the commercial harbour. However, Flemming noted that no quays or jetties were found in the south harbour (Flemming 1974: 166-167 ; Theodoulou 2006 : 179-180).

HARBOUR CONSTRUCTION METHODS

The only documneted harbour structure of this site is the east breakwater-mole of the south harbour. The beginning of the breakwater-mole was also based on a reef while the rest on a rubble foundation. The outer side of the east breakwater-mole was built of large boulders positioned in a tilting direction so as to lower the dynamic of the waves, while the inner part was vertical made out of ashlar blocks whose gaps in between were filled with small stones (Theodoulou 2006 : 179-180).

MARITIME FORTIFICATION

Raban considers that walls were built on the reef of the lagoonal basin and on the breakwater of the south harbour basin, therefore supporting that the harbours of Salamis were included in the city's fortification. Flemming identified at the beginnig of the east breakwater mole a wall made of massive blocks (Theodoulou 2007: 179 ; Flemming 1974 : 170 ; Raban 1995: 163-164). However, this fact must be verified on the field since no photos or documentation has been conducted regarding this wall.

RELATED INSTALLATIONS

Shipsheds

Recent studies conducted by Davies identified at the north part of the north (lagoon) basin through photos and visual reconnaissance remains that have been interpreted as shipsheds. Ashlar blocks, with a north to south direction that belonged to the city's wall (probably), and columns with tiles that roofed the shipsheds outside the wall and along the coast were located. However, these remains are in need of further investigation (Davies 2016: 1-4).

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

Coastal progradation is evident in Salamis due to Pedieos river as the west breakwater of the south harbour is probably silted. Both the north and south harbour basins are heavily silted (Flemming 1974, 164). In addition, the reef of the north harbour seems to be, according to Flemming the paleoshorline. Salamis is considered to be 1.80-2m below current sea level as two submerged roads located in the so called north harbour (according to Raban) along with rectangular structures were documented by Flemming (Flemming 1974 : 166-169). This submersion is considered to be caused by the major earthquake of 342 AD. (Flemming 1974 : 170-173).

GEOHAZARDS AND OTHER FACTORS

The site is located in the occupied area and is visited by tourists. The siltation of the area preserves many of the findings however due to the political situation research is not possible to continue on the field.

OTHER FINDS

On the the west side of the east breakwater mole of the south basin, roman sarcophags were identified during Theodoulou's survey in the area (Theodoulou 2007 : 181).

CHRONOLOGY

Although the polis of Salamis was established in the Archaic period it is unknown when the first harbour structures were built. According to Isocrates Evagoras A had built a harbour. The breakwater-mole of the south harbour has no evidence for dating nor the north basin. It is generaly considered that the harbour dates to the Classical/Hellenistic period with no clear arguments (Theodoulou 2006: 175-184 ; Raban 1995: 163-164 ; Flemming 1974: 166-167).

SOURCES

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Inserts in databases	**https://www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Salamis**
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FIGURES

Figure 1: Location of the harbour of Salamis (J.Gatt 2021).

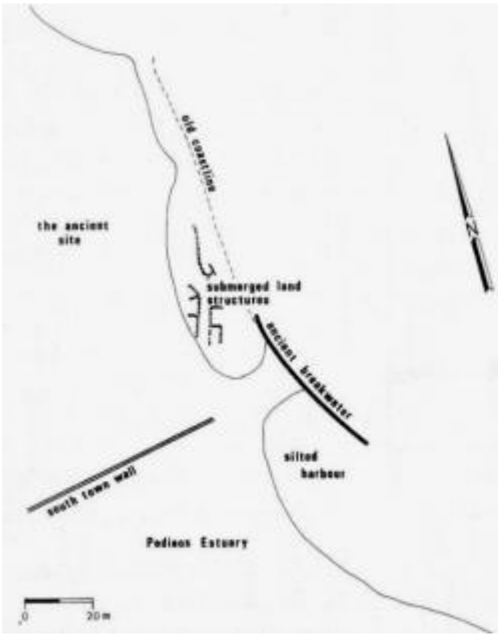

Figure 2: Plan of the harbour of Salamis by Raban and Linder in 1971 (Raban 1995, fig. 36).

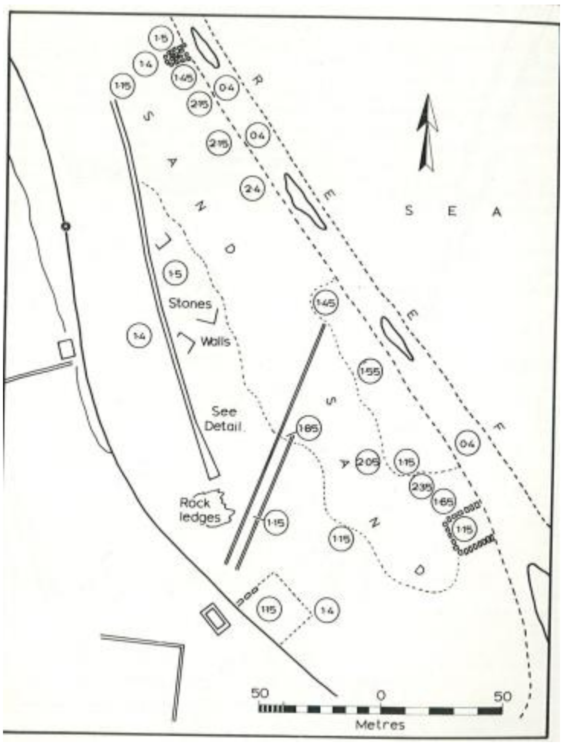

Figure 3: Surveyed area of the North basin with measurments (Flemming 1974 : 167, fig. 3).

Figure 4 : Aerial photo taken in 1963 indicating probable submerged harbour structures located to the south of Pedieos river.

Figure 5: Remains of the west breakwater-mole of the south harbour. Photo taken by Theodoulou (Theodoulou 2006: 77, fig.121).

XII. SOLOI

LOCATION

Soloi is located on the southwest coast of Morphou. It posseses a strategic location as it is near the copper sources of Foukassas, Skouriotisa and Tamassos, and less than 10km away from the Troodos forest. The Cypriot-polity was also surrounded by two rivers, Kambous (to the west) and Xerou (to the east) (**Fig.1**).

HISTORY AND TOPOGRAPHY OF THE HARBOUR-CITY

Early habitation on the site is attested through tombs and pottery since the Late Bronze Age. A settlement dating to the Cyproarchaic period was discovered extending from the acropolis towards the beach dating to the 5th century BC. The settlement was surrounded by walls that ended all the way up to the moles of the harbour, which currently is silted (**Fig. 2**). To the west of the acropolis of Soloi, the site of Vouni hill is located. There a temple of Athena dating to the classical period was excavated. Below the temple a palace was discovered dating between 500-380 BC, nevertheless, the relation between Vouni hill and the acropolis of Soloi is still not clear. Soloi participated in the Ionic revolution and it was the last city to subcome the Persian rule after a siege. It is also known for assisting Alexander during the siege of Tyre (Arr. An.2.20.3). Evnostos was the last known king of Soloi whose daughter married Ptolemy I Soter. The city thrieved in the roman period with the building of a nympheum, theater and agora and its habitation continued till the Byzantine period as the Basilica indicates (Satraki 2012: 159, 272-280 ; De Gagniers 1985; De Gagniers 1967).

The area preserves the toponym *Karavostasis* which indicates the existence of an anchorage in the area. Also the installation of the Cyprus mines Corporation in the area were probably the ancient harbour was located indicates the strategic location of the settlement for the exportation of metals (Theodoulou 2006: 206).

ANCIENT WRITERS AND TRAVELLERS

According to Pseudo-Scylax the harbour was a limena xeimrιnon (λιμένα…χειμερινòν) (77.103) meaning a winter harbour perhaps reffering to a closed harbour. According to Strabon (XIV.6.3) Soloi had a harbour and a river (πόλις λιμένα ἔχουσα καὶ ποταμὸν) (XIV.6.3) while Stadiasmos refers to Soloi as alimenos (πόλις ἐστὶν ἀλίμενος) (309) meaning without harbour. In later periods the area was more known as a lagoon for ships with low draught. According to Sakellarios (1890: 131-132) the locals remember that it was once a lagoon-marshy area where eal was fished and small boats had access to. (Theodoulou 2006: 206-209). Archimandriti Kyprianou (1788: 40) also recollects the memory of a good harbour which was now only accesible to small ships.

TYPOLOGY, FUNCTION, AND CONFIGURATION OF THE HARBOUR

According to Westholm's description Westholm (1936: 12) it seems that the harbour was a *kleistos limen* due to the fact that the city's fortifications extended on the moles. In addition, Pseudo-Scylax description (77.103) point out to this fact also. The harbour may have functioned as a commercial harbour for the Cypriot Polity of Soloi.

PREVIOUS RESEARCH

The Swedish expedition was the first to identify the location of the harbor Westholm (1936: 12). Nicolaou included Soloi's harbour in his article *Ancient harbours of Cyprus* (Αρχαίοι λιμένες εν Κύπρω) published in 1966. Raban and Linder (1995) visited during their survey the site. Finally the site was visited and photographed by Theotokis Theodoulou in the framework of his PhD thesis (Theodoulou 2006: 203-210).

HARBOUR STRUCTURES

Westholm (1936: 12) refers to the visible remains of the west and east mole that formed the entrance of the harbour. Raban and Linder refer to the existence of the two moles that extend to the sea for 180 meters (Raban 1995: 165) (**Fig.3**). According to Theodoulou, the east mole is not more than 110 meters, while the west mole is not more than 80 meters long (Theodoulou 2006: 208). Also according to Sakellarios (1890: 131-132) on the southwest area of the ancient harbour basin a wall was referred to by the local community as the old prokymaia (old quay) however no remains are preserved today.

HARBOUR CONSTRUCTION METHODS

The moles that extended towards the sea were built with large ashlar blocks. Their average size ranges around 0.6 (height) X0.6 (width) X2 (lenght) m although the masonry and joints haven't been documented (Theodoulou 2006: 208 ; Raban 1995: 165).

MARITIME FORTIFICATION:

According to Westholm, the city walls extended to the sea and were built with ashlar blocks (Westholm 1936: 12). For more information on the city's fortifications consult the PhD thesis of Balandier (1999).

RELATED INSTALLATIONS

Foundation of buildings were described by the locals along the beach west of the basin. They could have probably been used as warehouses (Theodoulou 2006: 209).

RELATIVE SEA LEVEL CHANGE AND GEOARCHAEOLOGY

According to Flemming's survey no change in the sea level has been detected (Flemming 1978: 416).

GEOHAZARDS AND OTHER ISSUES

The infrastructure of the Greek Metal Company (**Fig. 3**) traverses the area of the ancient harbour basin. In addition, the harbour basin is today a cultivated area due to the heavy siltation the basin underwent (Theodoulou 2006 : 209).

OTHER FINDS

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CHRONOLOGY

Based only on textual evidence (Pseud. 77.103) it is believed that the harbour is dated to the 5th-4th century BC. The gradual disuse of the harbour basin is probably connected with the abandonment of the mines of Skouriotissa and Foukassas in the 4th century AD (Hill 1940 : 12). This consequntivley led to the neglect of the basin which seems to have been highly affected by the siltation caused by the neighbouring rivers. Nevertheless the harbour continued to be used for low draught ships as the toponym *Karavostasti* (boat station) indicates (Archimandriti 1788 : 40 ; Sakellarion 1890: 131-132).

SOURCES

References in ancient literature	Pseud.77.103 Stad. 309 Strab. XIV.6.3
Insert in database	**https://www2.rgzm.de/Navis2/Home/HarbourFullTextOutput.cfm?HarbourNR=Soloi**
Indicative bibliography	Archimandritis, K. (1971). *Ἱστορία χρονολογικὴ τῆς νήσου Κύπρου, Βενετία* (2nd ed.). Κυπρολογική Βιβλιοθήκη 1, Κέντρο Επιστημονικών Ερευνών Κύπρου, Nicosia. (Original work published in 1788) Des Gagniers, J. (1985). Soloi : Dix campagnes de fouilles (1964-1974) I., L'Universit Laval, Sainte-Foy. Des Gagniers, J. et al., (1967). Trois campagnes de fouilles à Soloi, RDAC, pp. 50-58. Hill, G. (1940). *A history of Cyprus*, v. 1, The University Press : Cambridge, p. 12 Nicolaou, K. (1966a). "Ἀρχαίοι λιμένες ἐν Κύπρῳ", Δελτίον Τμήματος Πολιτιστικῆς Ἀναπτύξεως Ὑπουργείου Παιδείας Κύπρου 6-7, Λευκωσία, pp. 95-99 Raban, A. (1995). The Heritage of Ancient Harbour Engineering in Cyprus and the Levant. In V. Karageorghis and D. Michaelides (eds.), *Cyprus and the Sea*, Proceedings of the International Symposium organized by the University of Cyprus and Cyprus Ports Authority, Nicosia 25-26 Nov. 1993, Nicosia, pp. 139-190 Theodoulou, T. (2006). *Ναυτική Δραστηριότητα στην Κλασική Κύπρο. Το λιμενικό δίκτυο στα τέλη του 4ου αι. π.Χ.* Unpublished PhD thesis of the University of Cyprus. Westholm, A. (1936). *The Temples of Soli* , SCE III, p.12

FIGURES

Figure 1 : Location of ancient Soloi harbour (J.Gatt 2021).

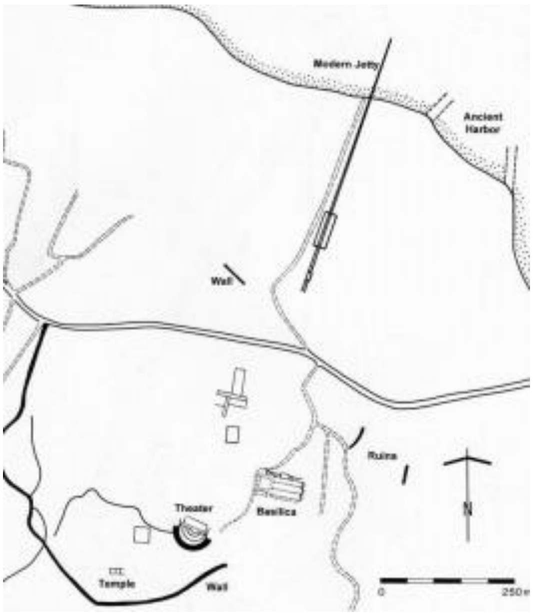

Figure 2 : Plan of ancient Soloi remains (Leonard 1997 : fig. 8).

Figure 3 : Aerial photo of Soloi taken in 1963. In dotted lines the proposed extent of the silted basin and the remains of the infrastructure of the Greek metal company (Theodoulou 2006 : fig.170).

CATALOGUE OF THE HARBOUR STRUCTURES OF THE EASTERN MEDITERRANEAN AND THE AEGEAN

GUIDELINES

NAME OF HARBOUR CITY	Location, very short reference to the sites history
HARBOUR TYPOLOGY, FUNCTION AND GENERAL DESCRIPTION	A general reference to the type of harbour (closed harbour, artificial), function (naval or military), and description of shape, size, accesibility when possible.
DESCRIPITON OF HARBOUR STRUCTURES	A general description of the harbourworks (scale, orientation etc.)
HARBOUR CONSTRUCTION TECHNIQUES	A brief description of the techniques attested
INDICATIVE BIBLIOGRAPHY	A selective bibliography that would lead the reader to further information on the subject
FIGURES	Plans, Photos, Sections (from publications)

XIII. TAPOSIRIS MAGNA

Taposiris Magna is located on the northwest coast of Lake Maeriotis to the west of the River Nile delta, 45km west of Alexandria. Taposisris dates according to inscriptions found on the site (see Boussac & El-Amouri 2010: 72-73 for inscription) to the Hellenistic period (4th-3rd century BC) although few are the archaeological remains that date the site to this period. The city thrieved in the Roman times and is considered to be an important linking point between the north west coast of Africa and Alexandria and an avant-port of Alexandria from the 1st century BC (Boussac 2007: 445-450 ; Boussac 2009: 123, 136).

Harbour typology, function and general description:

Taposiris Magna's harbour is a closed artificial basin of 8 hectares which to the north was confined by the taenia ridge (which separates the lake from the Mediterraeanean sea) and to the south by an artificial ridge (Tronchere 2014: 391). The construction of this basin dates to the Imperial period (1st BC).The entrance to the basin is located in the southwest and is defined by the existence of a bridge. Along the north shoreline, foundations of warehouses and shops were excavated. The basin cannot be dated prior the 2nd century BC and several dregging and digging operations according to geological studies were conducted to keep it functioning. A second entrance to the east was defined by a mole (Boussac 2015: 202 ; Boussac 2007: 453-560 ; Boussac 2009: 133). The artificial ridge is 1,700m long and has 6 openings which remain to be confirmed if indeed they were on purpose or were caused by the failure of the retaining walls that surrounded the artificial ridge (Boussac & El Amouri 2010 : 87 ; Crepy & Boussac 2021 : 40-42). (plan of site) 454pg boussac 2006 Ancient sources do not offer any helpful information on the harbour. Strabo (XVII, 1, 14) refers to the city of Taposiris as not located on the sea, Ptolemy (IV.5.34) refers simply to its location (with coordinates) and finally Stadiasmos (4) refers to Taposiris as harbourless. The harbour basin in relation to the terrestrial archaeological remains must have had a commercial use as the restricted entrance must have been used for the control and taxation of goods (Boussac 2015 : 202 ; Boussac 2007 : 453-560 ; Boussac 2009:133) (**Fig.1**).

The Harbour structures and construction techniques

East Mole

To the west a stone bridge (**Fig.2**) and to the east a mole (**Fig. 3**) defined two different entrances (Boussac 2009:128). These are the only published structures that are related to the harbour configuration. Since this dissertation focuses solely on the harbour structures only the mole of Taposiris Magna will be presented. The mole was 200m long and six meters wide with butresses on both sides (16 on the east side and 11 on the west side- in total 27 butresses) is located on the east side of the artificial bassin. The butresses are on average 0.50-0.60 m wide and protrude for about 0.30 m to stabilize the entire mole (Boussac 2009:131). It preserves openings that travers its width and were closable or had filters so as to control the circulation of water in the bassin. These openings are interpreted as two flushing channels (one near the south extremity of the mole and the other to the north) and a water supply channel (Boussac 2006:460). The mole created the east entrance (100m wide) of the artificial basin. On the interiror side of the mole (the site looking towards the basin) two structures, a hoop-shaped basin and a fish-tank were attached to the mole and the water supply channel (Boussac 2007 : 459 fig.6b ; Boussac et al. 2010: 91-96). The datation of the mole remains unclear however it cannot be dated later than the 4th century AD (Boussac et al. 2010 : 100).

The foundation level of this structure remains undetermined. The use of stretchers and headers is attested in the structure. The dimensions of the used blocks have an average size of 0.50m (lenght) x 0.20m (width) x 0.25m (height) (Boussac 2009:131). Four courses are preserved. A pattern in the positioning of the blocks is identified. Every course of strecher is followed by a course of headers which is followed by a course of alternating blocks of stretchers and headers (Boussac 2009: 131). No evidence of clamps was found but the use of mortar was identified as a binding material (Boussac & Amouri 2010: 96). Two rows of blocks separated by a space whose nature remains undescribed in the publication consist the structure (perhaps compact soil?). In addition, the use of buttresses remains an unfamiliar characteristic (when comparing with other sites). It is interesting to note that the east side of the structure facing the open water received more attention in the construction since the majority of buttresses are located on this side (Boussac 2010: 91-95). This is very interesting since although the context in which this structure is located is relatively low energy enviroment (lake) a protection of the mole with abutments was still needed, a fact which reflects the water dynamics (currents) of the ancient lake that today may not be evident.

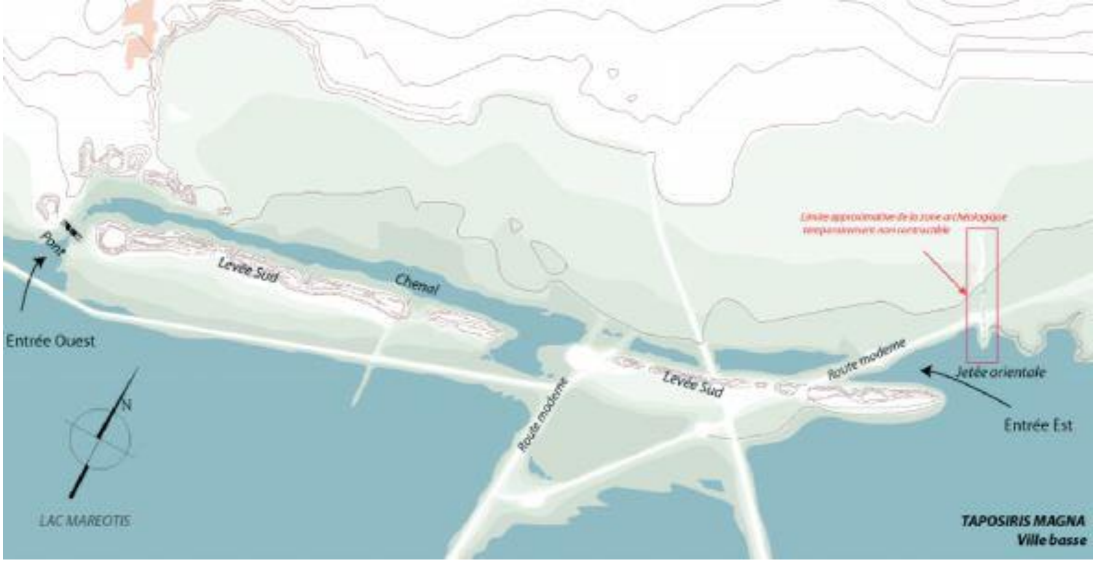

Figure 1 : Plan of the harbour site of Taposiris Magna (Boussac 2007 : 454,fig.4).

Figure 2 : Photo of the bridge in the the west entrance of the basin (Boussac 2009 : 130, fig.6).

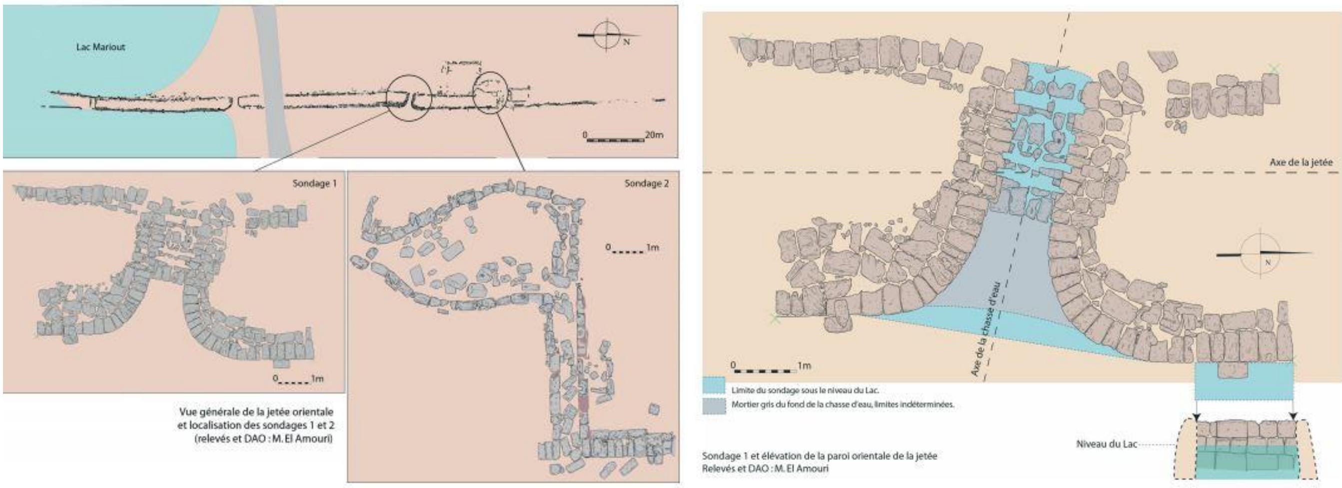

Figure 3 : Photo of the east mole (above), plan of mole (right) section of mole (left) (Boussac 2009 : 131, fig.8 ; Boussac 2007 : 458-459, fig.6a)

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XIV. ALEXANDRIA

Alexandria founded in 331 BC by Alexander the Great, is located on the west side of the Nile's Delta. It posseses the most prominent harbours of the Hellenistic period which served as the emporium and the naval station of the Ptolemies. These harbours consist of the Megas Limen (Great Harbour), Evnostos Harbour, Kibotos Harbour (?) and Pharos Island Harbour (Goddio and Fabre 2010: 53). The harbour city of Alexandria thrieved in the Hellenistic and Roman times and underwent continuous development. It is difficult archaeologically to attest the first use of the area as a harbour but from wood remains discovered on Antirhodos island the first harbourworks seem to had appeared in the Classical period (Belov 2014: 10).

Harbour typology, function and general description:

The shaping of the multibasin harbour complex of Alexandria was achieved through large scale harbour works and the existence of natural forms that enhanced the harbour protection (i.e. islets, reef). Alexander the Great had constructed the Heptastadium which connected Pharos Island with the mainland, while during the Ptolemaic reign several harbour works took place to organize the spaces of the basin and enhance their protection. Four harbour basins existed, the Megas Limen was located to the east of the Heptastadium while Evnostos harbour to the west, while to the south of Evnostos the so-called Kibotos harbour existed. A brief description of each harbour basin will follow (**Fig. 1**).

The Megas Limen (**Fig.2**) (Great Harbour) consists of a natural open bay of 600 hectares (Belov 2014: 1) which is protected from the North West by Pharos Island and from the West by the Heptastadium (now silted). This basin was subdivided into four smaller basins with the construction of breakwater-moles, jetties and quays as also the use of natural features (such as reefs, promontories and islets). The first harbour basin was located to the west of Cape Lochias. It was "dug into the rock" and was a royal port for the galleys of Ptolemy according to Strabo (Strab. Geog. XVII, I.6-10). This harbour basin size did not exceed the 7 hectares. The entrance was located to the NW. The harbour had to the south-west a jetty which extended in the sea from Cape Lochias with a west-east direction. A « seawall» divided the harbour basin into two sections (110m long x 20 meters wide) while to the north-west probably a harbour structure may have existed today currently under the modern structures. To the west reefs limited the wave force (Fabre & Goddio 2010 : 56).

The second harbour basin was located further south and is considered to be also a military harbour. Its basin size was around 15 hectares. It was protected by a series of reefs located on the north west side. To the north, the southwest jetty was located and to the south a breakwater protruding from the Posiedium peninsula towards the north was located. A narrow entrance on the NW side between the breakwater and the Northwest reef was also located. Along the breakwater three jetties extended to the north (Goddio and Fabre 2010 : 56 ; Brandon et al 2014 : 86).

The third harbour basin was located between the Poseidium peninsula and the Anthirodos island and covered an area of 16 hectares making it the largest of all basins. This was divided in an inner (south east) and outer basin. The outer basin was formed by a seawall protruding from Anthirodos island towards the north for 340 meters with a width of 30 meters, while the breakwater of Posiedium peninsula was located to the east. The inner basin was created by an L shaped jetty that protrudes from the south of Anthirodos island with a north south, to west east direction (130 long and 30m wide) and created the inner basin. Along the south coast of Anthirodos island remains of quays (« seawalls») are attested. Two entrances to this basin are identified one on the southwest (40m) and the second north east (80m). According to Strabo this consisted the Royal port (XVII, I.9) (Goddio and Fabio 2010 : 55-59 ; Belov 2014 : 16).

The fourth harbour basin of the Megas Limen is located on the silted side of the harbour, in the so called areas of Tikka port, Yatch club center and Ball trap sector where the heptastadium was once built. This basin was located through geophysical and archaeological survey. A harbour consisting of multiple basins was uncovered. Four islets with jetties seem to have created a series of basins. According to Strabo (XVII 50,9) on this side the harbour commercial activities took place (Goddio and Fabio 2010 : 59-62).

The Eunostos Harbour study is extremely complicated due to its continuous use, and its pollution (thick layer of black oil on the seabed). This harbour seems to have communicated with the Megas Limen through the Heptastadium. It was probably also connected through a channel with Lake Maeriotis according to Strabo (XVII I.10). The harbour's main function was commercial (Belov 2014: 17-18). This harbour was mainly protected from the North, Northwest winds by the north breakwater that extended with a northeast to southwest direction (NE-SW specifically). This breakwater was additionaly protected by reefs which were interpreted by Jondet as man-made structures which the current research verified as not (McKenzie 2003 : 39-41 ; Belov 2014 : 8-9).

The Kibotos Harbour, according to Strabo (Strabo (XVII I.10) was a harbour dug by hand (artificial harbour) where shipsheds were located and connected Lake Maeriotis with Eunostos Harbour (Goddio and Fabio 2010: 65 ; Goddio 2011: 134). However, according to the archaeological research there was no such harbour. Probably Strabo may had been reffering to the harbour described by Jondet located on the NW of Pharos island (Jondet 1916: 30, 298 ; Mckenzie 2007: 176). The only remains related to a harbour, located south of Evnostos harbour, were an ancient jetty in Lake Mareotis and channel that connected the lake with the Mediterranean sea. These were documented in the 19th century and today are not visible anymore (Mckenzie 2003: 40).

The harbour structures and their construction techniques

The harbour structures of Megas Limen

Several harbour structures have been identified and excavated in the harbour basins of Alexandria. Here below a short description of the best documeted harbour structures will be presented. However, prior to that two facts must be underline. First of all, the chronology of these harbour structures remains under discussion. For instance, although the majority of harbour structures seem to date to the Roman times a harbour structure in Anthirodos island seems to date to an earlier phase. A piece of timber from the planks that formed the cassons was dated with radiocarbon dating (C14) at around 250 +/- 45 BC. If this is correct the so called roman technique of cassons building can be attributed to the Hellenistic period. However, this theory was questioned by the Romacons Project since it did not bring any further evidence sustaining this early dating (Brandon et al. 2014 : 87-89 ; Mckenzie 2003 : 39). Second point, few are the harbour structures which have been documented in detail and therefore our knowledge remains limited.

The SW jetty of Cape Lochias (250m long and 10m wide) was built with limestone and mortar. A counter-dyke of limestone gravel was excavated to the south of this jetty however its exact location on the map remains unclear as also its connection with the jetty. The same material was used for the construction of the seawall made from limestone blocks of different sizes (Goddio and Fabre 2010 : 55-56).

In the second harbour basin the breakwater (PF) extending to the north from Posiedium peninsula was (images Goddio and Fabre page 57-58) built with cassons (made of wooden planks) to sustain the heart of the structure which was made of limestone blocks and mortar (Goddio and Fabre 2010 : 56 ; Brandon et al 2014 : 86) (**Fig. 3**). The third harbour L-shaped jetty is described as built from limestone blocks. To the south of the Anthirodos island remains of quays (« seawall ») built with ashlar blocks extend along the coast (Fabre & Goddio 2010 : 58-59). The fourth harbour basin of the Megas Limen had jetties made out of limestone blocks. A rock-cut structure whose location hasn‘t been specified was also identified. In the «Yatch club center and the Ball trap sector » a quay built with the use of cassons made out of wooden planks that sustained the limestone blocks and mortar structure was covered with blocks (Goddio and Fabre 2010 : 59-62).

The Evnostos Harbour north breakwater (**Fig. 4**) was built on a reef, which lies at a depth of 8–10 m. It consisted of two parallel walls (40-60m apart) which were filled in between with gravel. It was built with large limestone blocks, roughly cut, with dimensions that range from more than 2 m long, 1.5–2 m wide and 0.8–1 meter high. Circular openings, probably lifting mortaise (or maybe also mooring stones) of about 10 cm in diameter were found in the edges of most of the blocks (Belov 2019 : 8-9). The lenght and width of the structure remain unknown.

In general, the given descriptions of the harbour structures of the Megas Limen focus mainly on the material used than the construction techniques. In addition, most harbour structures may date to the Roman times as the Romacons Project indicated (Brandon et al. 2014: 89). However, since its difficult to differentiate the pre-roman harbour construction techniques all the structures described were presented. The use of timber cassons made of wooden planks filled with limestone blocks and lime mortar as also the use of ashlar blocks for the upper part of the structure seems to be the main construction technique. In addition, the use of rubble as in the case of Cape Lochias harbour is probably also attested. However, these techniques mainly reflect the harbour construction techniques of the Roman period. In general, the coarings of Romacons project indicate a great similarity wiith the harbour structures of Caesaria Maritime which dates these structures to the Augustan era

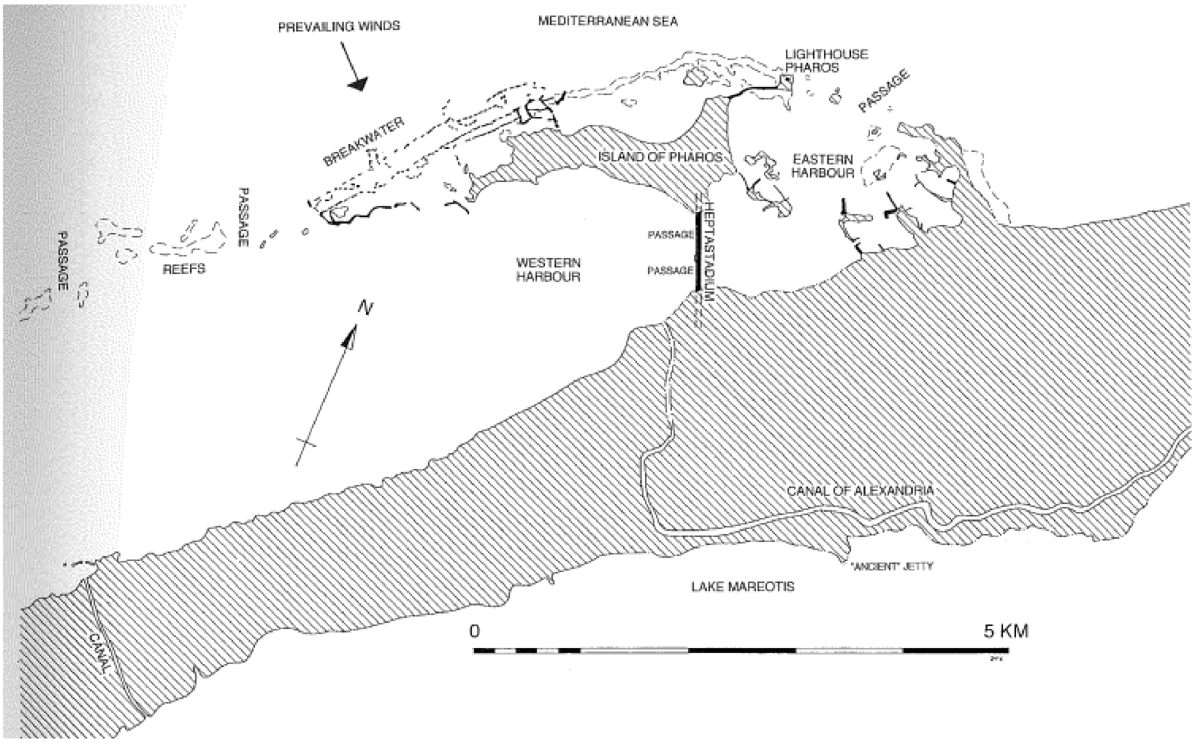

Figure 1 : Plan of the location of the harbours of Alexandria (Mckenzie 2003 : 37, fig.2).

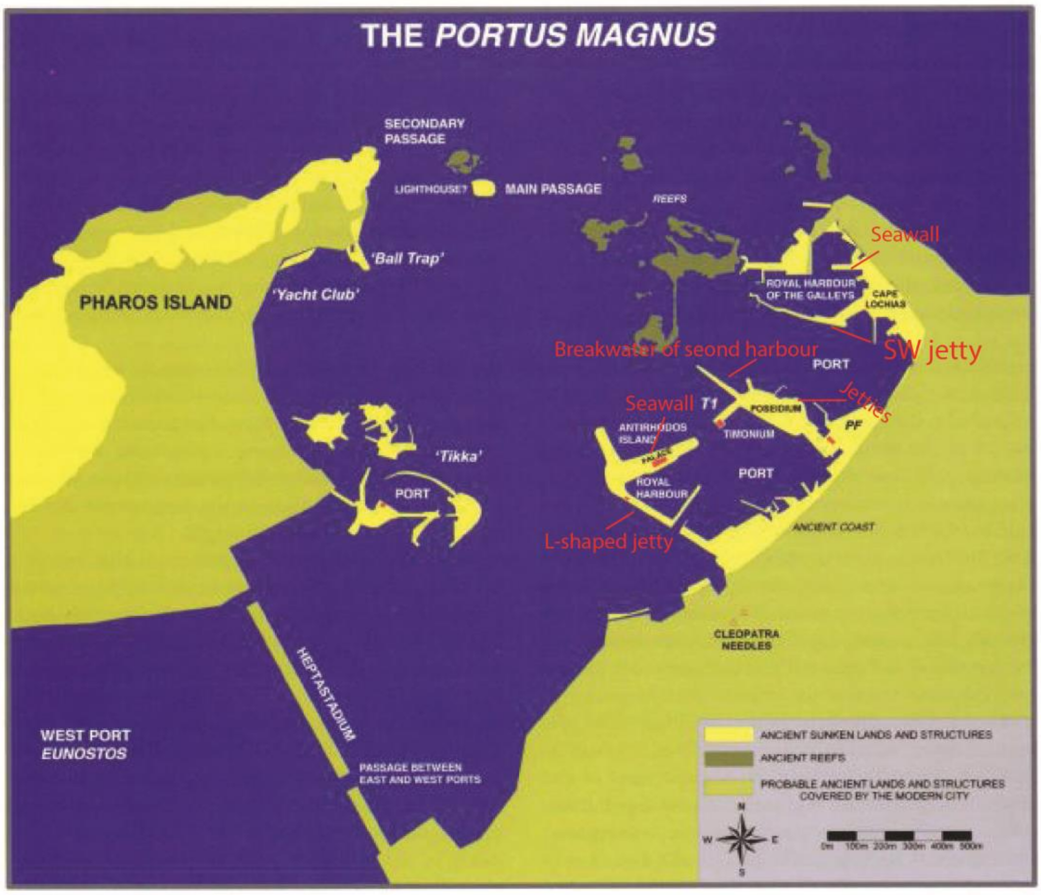

Figure 2 : Plan of the Alexandria's Mega Limen harbour, with complimentary lables based on Fabre and Goddio's harbour description (Fabre & Goddio 2010 : 53, 5.1.).

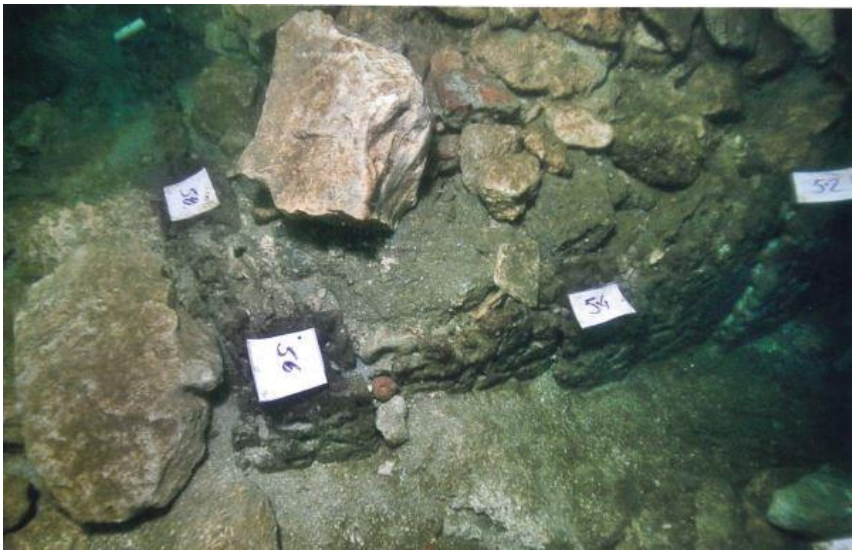

Figure 3: Photo of the wooden caissons found in the third harbour basin of Megas Limen (Fabre & Goddio : 58 Fig.5.5).

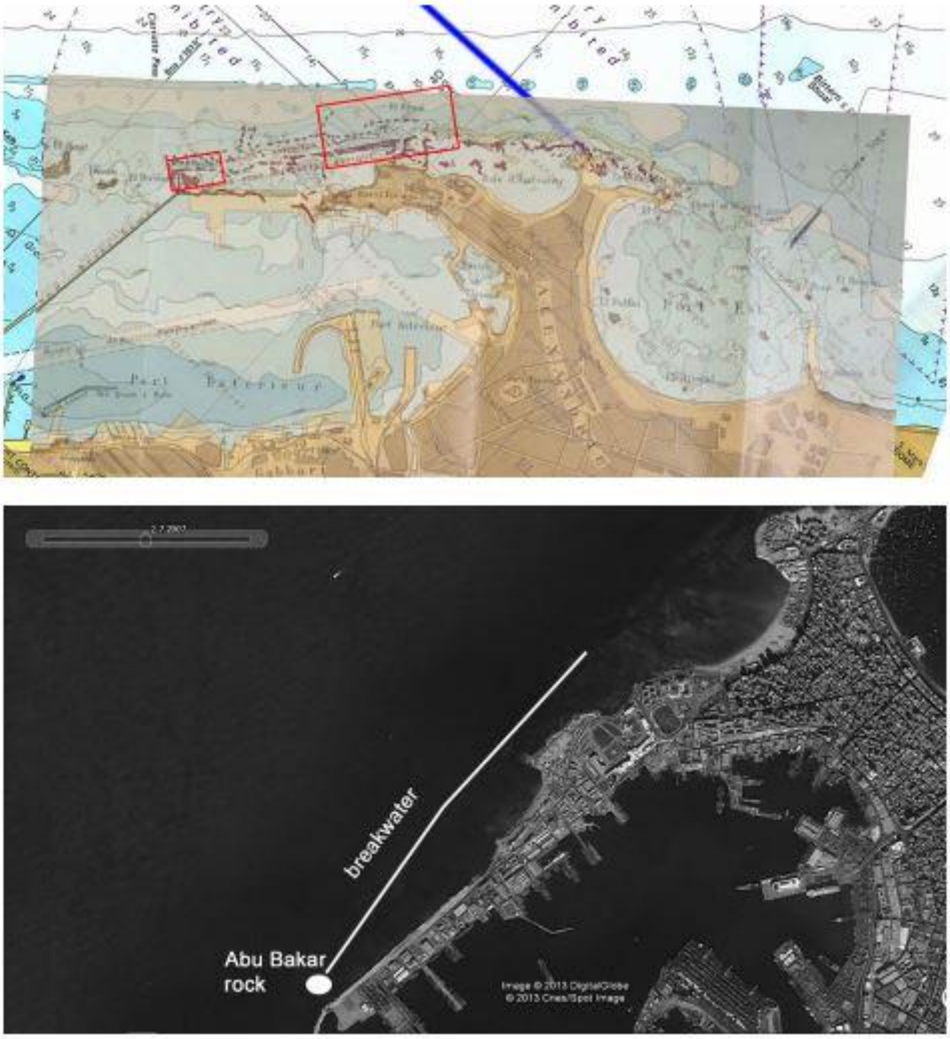

Figure 4 : Plan of the location of the Evnostos breakwater (Belov 2019 : 11, fig. 9,10)

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XV. TYRE

Tyr is located on the Levantine coastline. The first settlement is identified on the rocky paleoisland today connected with the harbour through a tombolo (Marriner et al. 2007 : 1294). Mother of Carthage and one of the greatest Phoenician city-states, Tyre's golden age spanned between the 9th to 6th centuries BC, during which period it enjoyed an extensive zone of influence incorporating large areas of the Mediterranean basin. Although Tyre lost its hegemony after 572/3 BC, when it fell under Persian influence, the city continued to prosper through the Hellenistic, Roman and Byzantine periods as attested by the archaeological remains (Marriner et al. 2005 : 1302). An important event was the siege of Tyre by Alexander the Great (Quintus Curtius Rufus 4.4.10-21 ; Polyaenus, 3.4) (Noureddine et al. 2005 : 112-113 ; Shipley et al. 2006: 680-682), which led to the construction of a causeway that joined the mainland with Tyre.

Harbour typology, function, and general description

Numeorus ancient sources refer to the harbours of Tyre (Arrian, An. II, 16, 7e27, 7; Diodorus of Sicily, XVII, 40, 2e47, 6 ; Plutarch, Alex. XXIVeXXV and Strabo, XVI, 2, 23). The northern harbour looking towards Sidon, Beirut and Byblos (referred to also as the Sidonian harbour), the southern anchorage looking towards Egypt, outer harbours along the island protected by the sandstone ridges and a series of basins along the coast of the mainland (Marriner et al. 2008 : 1282, 1305-1307 ; Carayon 2005 : 54) (**Fig. 1**).

The northern harbour is located beneath the medieval and modern city center covered by 8-10m of sediment. This basin was twice as large as that of today. Coastal progradation of 100-150m took place (Marriner et al. 2008 : 1282-1283). Accroding to Strabo the North harbour was a closed harbour (XVI, 2, 23) while according to Pseudo-scylax (104) it was surrounded by walls. The south harbour identified by Poidebard was in the end a submerged quarter of the city according to the current research (Marriner et al. 2008 : 1297-1298 ; El amouri et al. 2005 : 52, 106). However Renan proposed a second location for the south harbour which geoarchaeologically is more plausabile, further south-west (Marriner et al. 2008 : 1304 ; Carayon 2005 : 56).

Harbour structures and construction techniques:

The only harbour structures that have been documented in detail consist the north-east mole (?) (**Fig.2**) of the North-Sidonian harbour basin. The mole extends from east to west beneath the modern jetty. This harbour structure has been preserved in fragments and for this reason its remains were named wall I-V. Walls I-III were made of large blocks (headers) 2.25x 0.45 x 0.55 and five courses are preserved (reaching a height of 2.5m). Wall I and III have a distance of 8m. The extent of this complex of walls is around 95m. This structure based on its construction was dated to the Classical period. Wall IV-V are two structures formed by several rows of blocks of different sizes (for Wall IV 1.90x0.45x0.55 and Wall V 1.60x0.75x0.55) and represent the construction technique stones laid across(El amouri et al. 2005 : 115-126). The relation of Walls IV-V with walls I-III remains unclear. Descamps has attributed the mole (?) to the Hellenistic or Roman periods while according to the recent documentation it may even date back to the Classical period (Marriner et al. 2008 : 1284-1285). Columns were found to the south of walls I-III along with large construction blocks. These structures seem to have been built on a foundation of rubble which extends for around 400m.

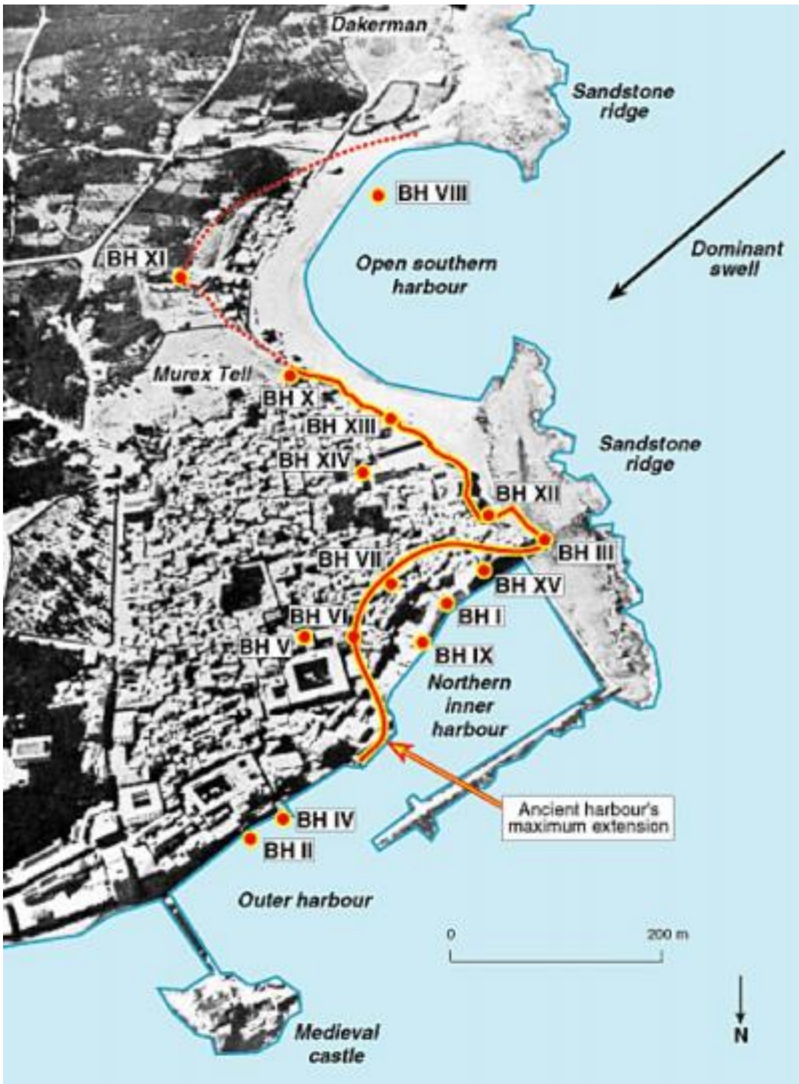

Figure 1 : The harbours of Tyre (Marriner & Mohrange 2005 : 188, fig.6).

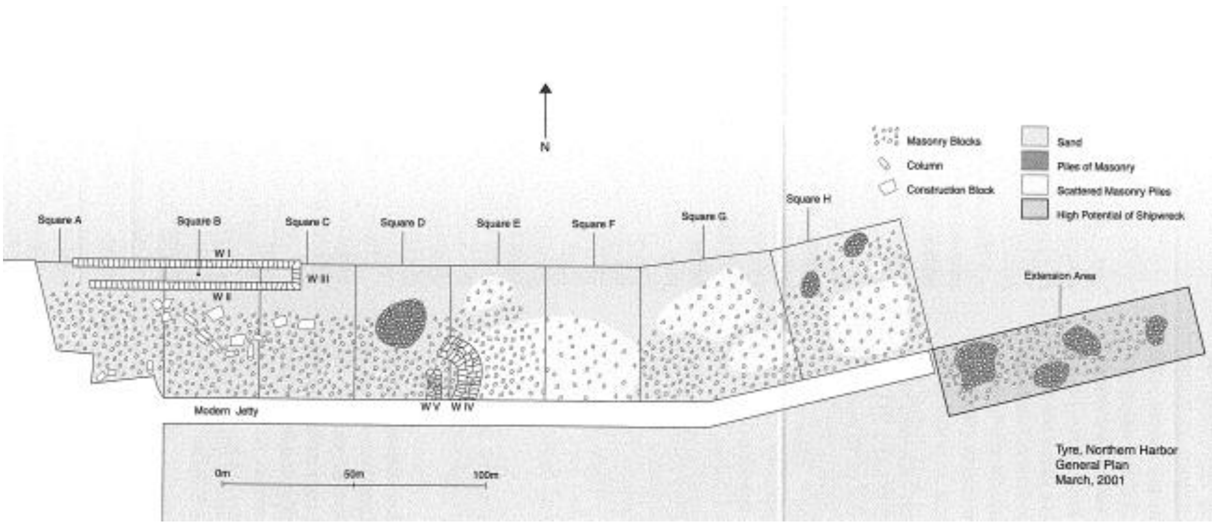

Figure 2 : Plan of the north-east jetty (Noureddine & El Helou 2015 : 114, fig.1).

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XVI. CAESARIA MARITIMA - CAESARIA STRATONIS

The harbour of Caesaria Maritima is located on a straight rocky coastline, to the North of river Hadera (Braton & Oleson 1992 : 49). It is a harbour well known for its Roman phase however it existed since the Hellenistis period (**Fig. 1**). The Pre-herodian (pre-roman) settlment or the so-called Straton's tower was founded by Straton I of Sidon between 376-371 BC. This hellenistic harbour can be placed in the context of the Syrian Wars. The successors of Alexander's diadochi, Ptolemy IX who was expelled from Egypt and sent to Cyprus (he then became king of Cyprus between 143-81 BC) and Antigonus Kyzikenos (116-96 BC) who was busy with a fight between the successors of the Seleucian dynasty showed an interest for this settlement which was at that time governed by Zoilus the tyrant who had fortified the settlement with walls (Joseph. 13.324). Ptolemy IX invaded and took into his hand the region (including Straton's tower) as it was menaced by the power's expansion of Alexander Jannaeus (king of the Hasmonean Kingdom). In the end, Straton's tower was taken over by Alexander Jannaeus as he bought it from Ptolemy IX for 400 silver talents. When the Romans expanded in the Eastern mediterraenan it was under the control of Pompeius and in 30 BC it was handed over to the kingdom of Judah whose king Herod would later on build the Roman harbour (Raban et al. 2009: 15 ; Raban 1983: 250-251 ; Raban 1996: 629-630; Carayon 2008 : 335-337 ; Roller et al. 1983 : 61-68 ; Raban 1992 : 7 ; Graigner 2010: 394-397 ; Roller 1992 : 23-25).

Harbour typology and general description:

The fortified Hellenistic city had two natural basins the north and south basin. The south harbour (or inner basin) was protected by a rocky promotory on which the city's wall extended (to the south) and an island "the so called citadel of the city" (to the west). It remains unclear if the island was connected with the land (Raban et al. 2009: 37). However the basin seems to have been excavated (rock-cut) so as to create a more spacious basin. The estimated dimension of the basin is around 250x100m (Hadjidaki 1996: 54).The fact that a submerged round tower was located this basin may indicate to a fortified/closed harbour basin although the connection of the tower with the land remains unclear (Raban et al. 2009 : 27-32, 37-38). The north harbour was protected by a series of reefs on which probably the city walls extended. In this basin (area J) a quay and a series of rock cut chambers probably functioned as warehouses were located. Pottery found during the excavation of the quay dates the structure to the 2nd century BC (Carayon 2008: 336-338).

Harbour structures and construction techniques:

Hellenistic quay

The archaeological evidence for this period is very limited and difficult to interpret. The only surviving harbour structure of Pre-Roman times to this period is a quay (**Fig. 2**). It is estimated to have been 30 meters long. The quay consisting of two parallel rows of ashlar blocks had an east to west direction. It was built on a rocky sea-bottom. The headers average dimension are 1.20x 0.20-0.40mx 0.42-0.46m (Raban 1981: 293). The south row preserves an irregular alteration of strechers and headers. A dry constuction with no joint or material is attested for this quay. Parralel to this quay to the south, a wall of ashlar blocks (of larger dimensions from that of the quays 1.6-1.7x0.90-1.05x0.6m) retains traces of dovetail clamps and is also dated to this period however its relation to the quay hasn't been determined (Raban & Oleson 1989: 144-145). The quay does not survive to its actual height and seems to have been affected by later byzantine constuctions in the area. The quay was dated to this period through ceramics as also through its construction method (which is identified on other sites of this period i.e. Tyre) and its similarity with the submerged tower in area T (south basin) which is also dated to this period (Raban et al. 2009: 17-19).

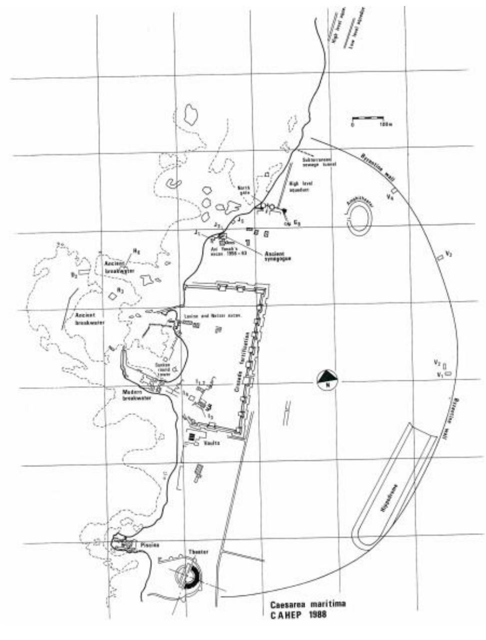

Figure 1 : Plan of Caesaria's harbour (Van Lindey : 8, fig.1).

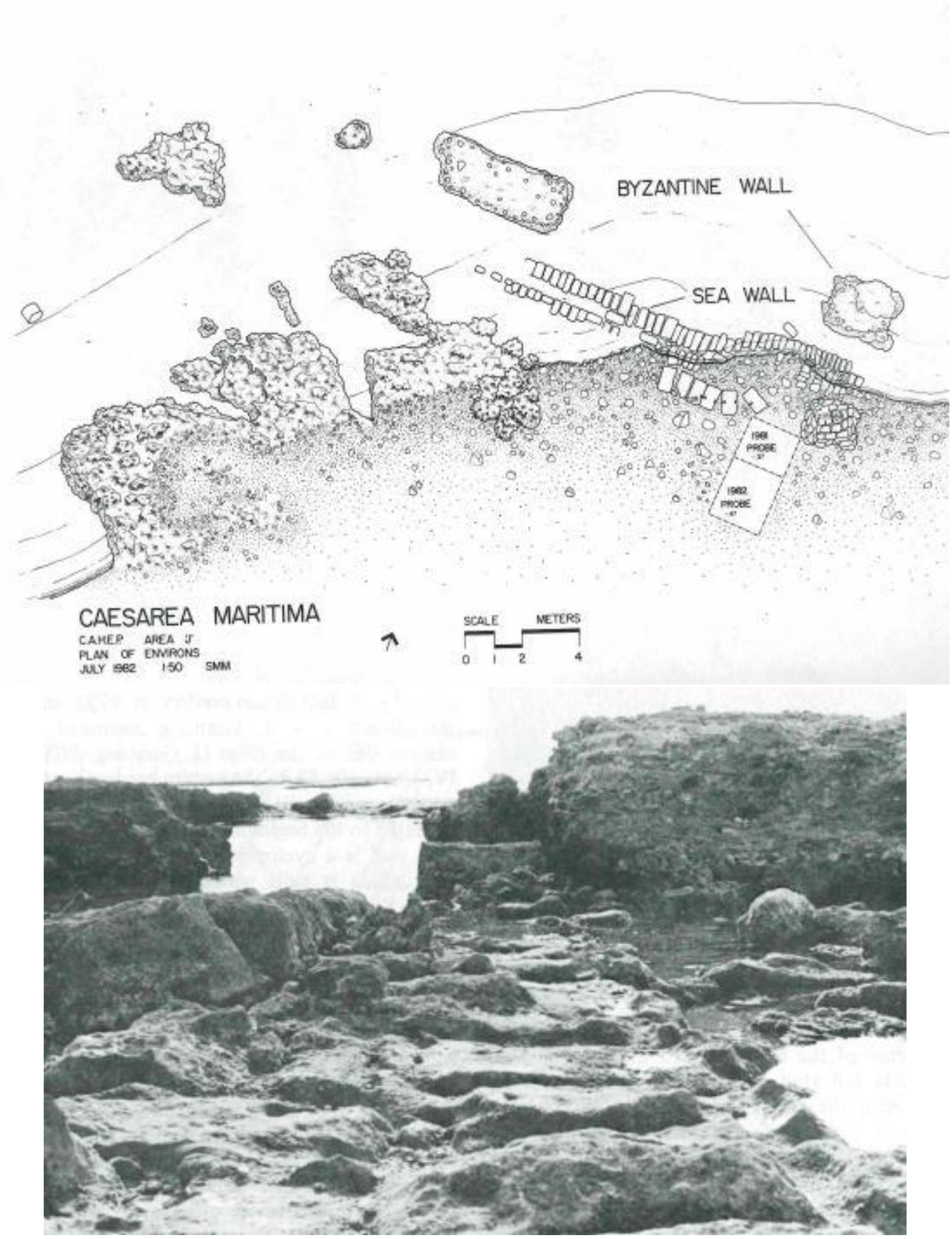

Figure 2 : Plan and photo of the Hellenistic quay (Raban 1989 : 429, fig. III.92 ; Raban 1981: 298, fig.13).

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XVII. SELEUCIA PIERIA

Seleucia Pieria is located on the bay of Antioch, near the mouth of Orontes and Degirmendere river, in Southern Turkey. The harbour was built by Seleucus Nicator by the end of the 4th century BC. It was captured by Ptolemy Euergetes, during the Third Syrian War (between 246-241 BC) and then by Antiochus III the Great. The siltation of the inner basin led to several dregging operations in Roman times (see Libanus 20, 18 ; 11, 158-162 ; 19, 45-46). The earthquake in the 6th century AD led to the loss of the importance of the harbour in trade however, it was still in function in the 19th century according to Chesny's description (Pamir 2014: 178, 190, 196-197 ; Erol & Pirazzoli 1992: 317). Several travelers refer to the harbour of Seleucia Pieria and offered vivid descriptions of the ancient remains (Pococke 1745: 182-184).

Harbour typology, function and general description:

The harbour consists of an outer port, and an inland basin which were connected by a culvert (channel) (457 m long and 60m wide) (**Fig. 1**). However, the connection between both basins through the channel remains unclear (Pamir 2014: 186). The inner harbour dating to the 4th century BC (4600m from north to south and 600m from east to west) was a natural lagoon located southwest of the ancient city surrounded by fortification walls. Its entrance is flanked by two moles (piers referred to in the publication) City plan pamir pg 182 and it was used for commercial and military activities according to ancient sources (Pol. 5, 59 ; Liv. 33, 41). The outer basin was constructed in the 4th century AD by Constantius (Lib. 2, 263-264) and was formed by two moles. A rock-cut tower to the north of the outer harbour and a second tower to the northwest seem to have protected and controlled the entrance to the inner harbour (Pamir 2014: 178-194).

The channel is an interesting feature of the harbour. The so called flushing technique was used to clean the channel from silt. Water was accumulated in the Vespasianus Titus Tunnel (dating to the 2nd century AD) and then released in the channel creating a strong wave that flushed the silt out. This complex mechanisim controlled also the water supply in the inner harbour and protected the inner basin from flooding (Pamir 2014: 178-194 ; Allen 1853: 157).

Harbour structures and construction techniques:

The outer basin consisted of two breakwaters-moles (a north and a south) around 177m meters apart from each other. The north breakwater-mole (c.80m long) is not well preserved in comparison with the south mole. The south mole had a northwest direction (123 meters long with a width of c. 12m) and had a slightly curved form. This basin covered an area of around 3 hectares. For the inner harbour, no documentation of the harbour structures have been conducted for now. The fortification walls in pseudo-isodomic construction surrounded the basin and moles today covered by vegetation defined the harbour's entrance (Allen 1853: 157-161 ; Pirazzoli and Erol 1992: 317, 325 ; Parmi 2014: 186-185).

South breakwater of outer basin

Only for the south breakwater of the outer harbour (**Fig.2**) a detailed documentation has been conducted. The breakwater is made out of large irregular blocks of stone (headers) with a maximum lenght of around 6m length and 2m width (dimensions retrived from published plan via scale). The stones were connected with iron clamps. On the lower courses larger blocks (headers) were used on both sides of the breakwater while in the center of the structure, smaller blocks were used. "After a few courses" smaller blocks (headers) are used on both sides and in the middle larger blocks (strechers). Nevertheless, the given description does not seem to correspond to the published plan and section of the breakwater. (Allen 1853: 157 ; Pirazzoli and Erol 1992: 325 ; Parmi 2014: 193). This structure is dated to the 4th century AD.

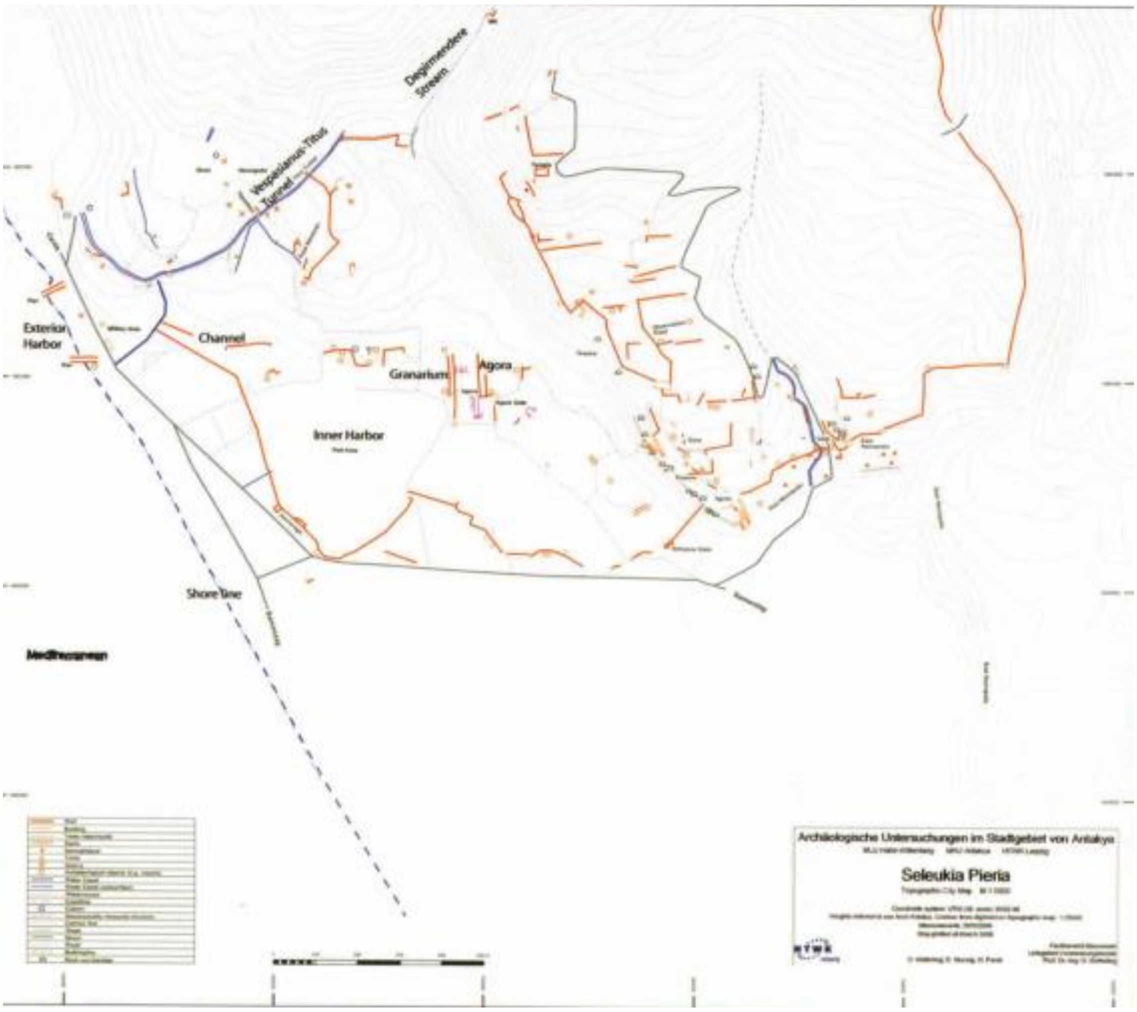

Figure 1 : Plan of the harbours of Seleucia Pieria (Parmi 2014 : 182, fig.5).

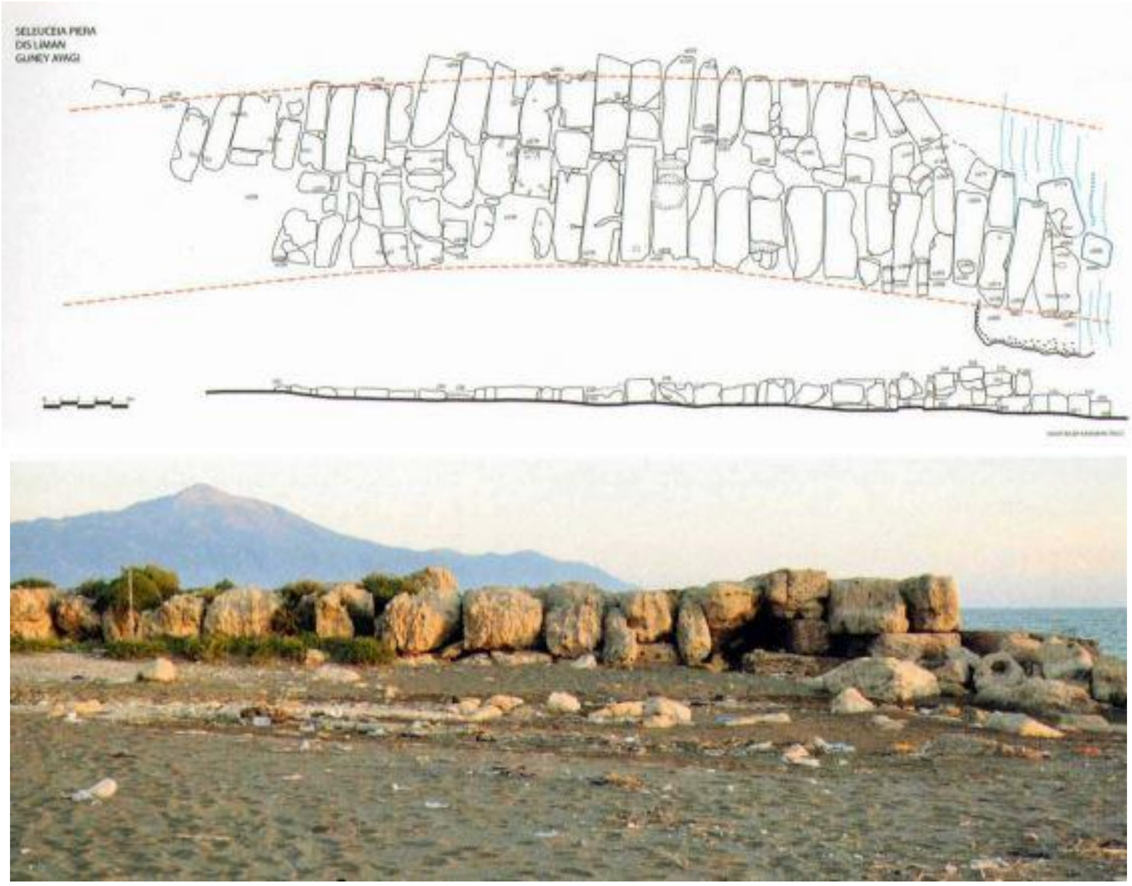

Figure 2 : Plan and photo of the south breakwater of the outer basin of Seleucia Pieria (Parmi 2014 : 193, fig. 25,26)

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XVIII. ELAIA

Elaia is located east of Kaikos River, surrounded by a series of mountain ranges (Kozak, Karadag, Yuntdag mountains) on the west coast of Asia Minor. In the Archaic and Classical period the settlement was of minor importance but during the Diadochi wars Elaia became the main harbour of the

Pergamon kingdom. Elaia was located in an area of interst for Lysimachus, Seleucus and Antigonus during the Diadochi wars. After the death of Seleucus and Lysimachus the kingdom of Pergamon was founded in the area by Philetaerus. According to Strabo (XIII, 1, 67 and XIII, 3, 5) Elaia was the commercial harbour of Pergamon but it was also used as a military base of the Attalids (Pint et al. 2015: 340-343).

Harbour typology, function and general description:

The harbour of Elaia consisted of a closed (with a narrow entrance of 50 meters) basin, an open harbour and an open bay (**Fig.1**). The closed basin was situated at the foot of the city's acropolis in the central northern part of the Gulf of Elaia and it is dated to the first half of the 3rd century BC. The harbour basin covered an area of 4.8 hectares which was defined by two moles (Seeliger et al. 2018: 1; Seeliger et al. 2013: 70-73). The second consisted an open harbour 250m long which was located between the closed harbour and the diatichisma. In this the shipsheds pg 32 seeliger 2006 were probably located as a buried building built on the paleoshorline (today land), was identified through geophysical survey (Shumilovskikh 2016: 4 ; Pint et al. 2015: 343). Finally, a second open harbour (so called beach harbour) was located between the diatichisma and the southeast end of the city wall. It was probably the temporal residence for foriegners, merchants and sailors that visited Elaia (Seeliger 2016: 9, 143 ; Seeliger 2018: 60). Image pg 9 seeliger 2016. As mentioned above, the harbour of Elaia served as the commercial and military base of the Attalids (Pint et al. 2015: 340-343).

Harbour structures and Harbour construction techniques

It's only surviving harbour structures are located in the closed harbour. A mole on the west side survives (**Fig. 2**), but only the upper row is visible. The east mole was identified through geophysical survey but has not been excavated (Seeliger 2016: 124 ; Seeliger et al. 2013: 73).

West mole

The west mole was built on a foundation made of stone debris, broken bricks and ceramics. The foundation had a width of nearly 8 m and a height of more than 2m. Above a massive wall of sandstone ashlar blocks (1.70 x 0.80 x 0.40 m) joined together by wooden dove-tail clamps. No reference has been made concerning the blocks positioning however from photos of published articles it seems that there is an alteration between headers and strechers (Seeliger et al. 2013: 72). Its tilting profile on the seaward side diminished wave energy while the vertical profile on the interior side created opportunities to anchor ships image. The clamps, as well as the lack of presence of hydrolic cement, dates the mole to pre-Roman times, most probably built in the early 3rd century BC (Seeliger 2016: 124 ; Seeliger et al. 2013: 73).

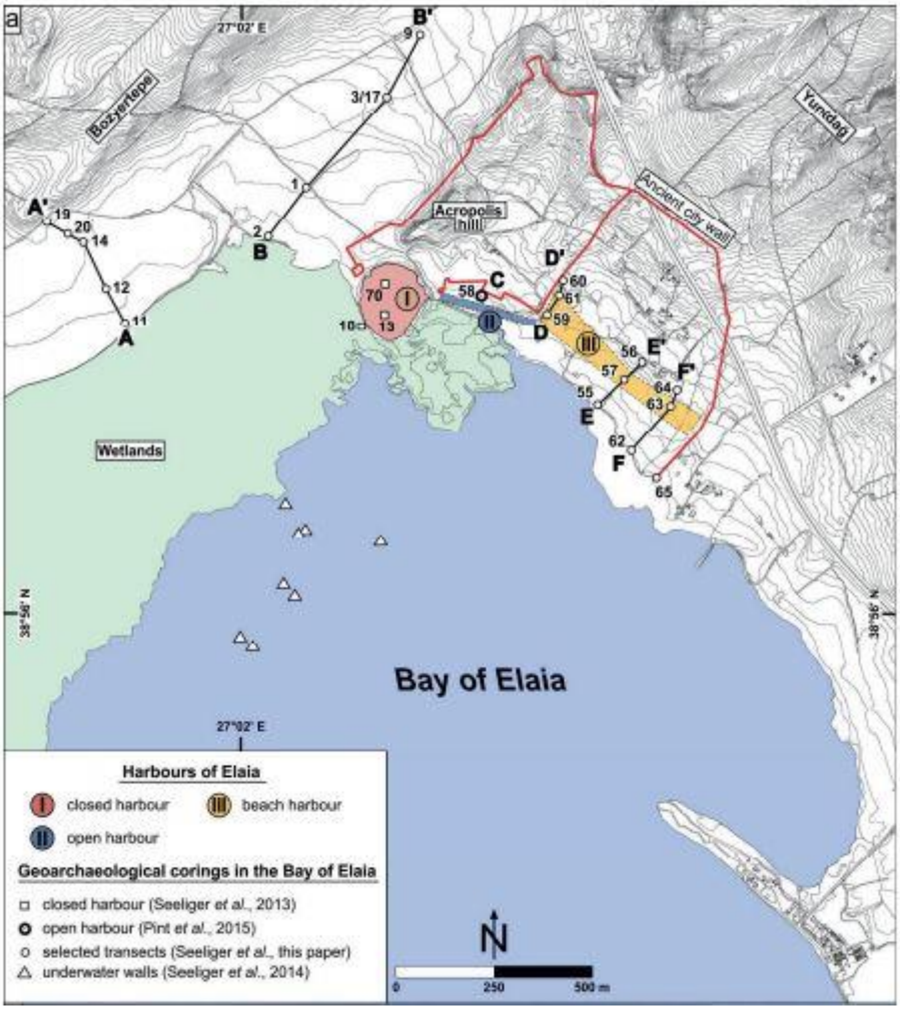

Figure 1 : Plan of the harbours of Elaia (Seeliger et al. 2019 : 67,Fig.2)

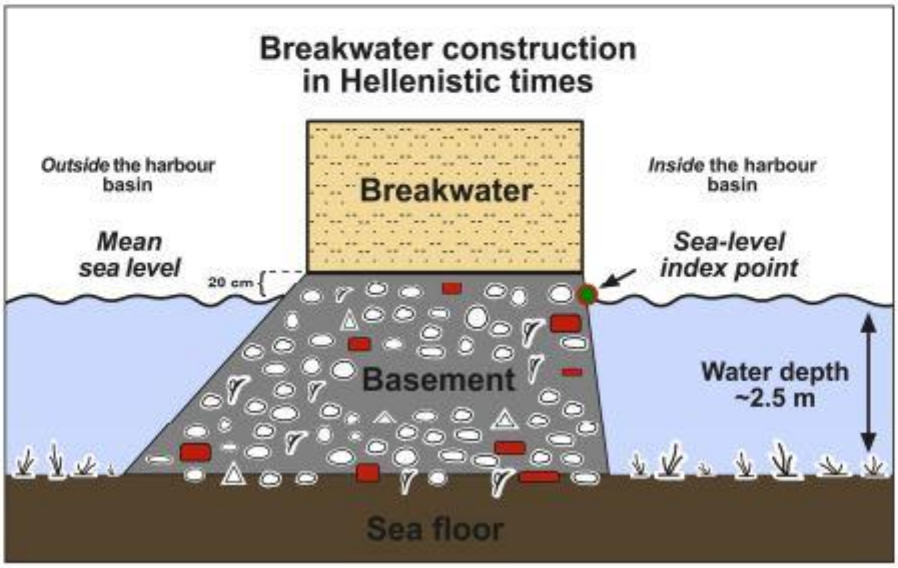

Figure 2 : Photo and section of the west breakwater-mole (Seeliger 2016 : 124, fig. 7).

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XIX. NEA CNIDUS

Cnidus is located in ancient Caria, today Tekir Burnu in the southwestern corner of Asia Minor, on Datca Peninsula between the islands of Cos and Rhodes (Büyüközer 2012: 24). The harbours of Nea Cnidus are formed by the tip of Datca's peninsula and the island of Cap Krio which today is connected through a tombolo. During, the Archaic period the city had an important role in the trade of the region (Büyüközer 2012: 27) due to its location between the Mediterranean and Aegean (Greene 2019: 103 ; Blackman 1982: 187). With the reorganisation (city plan based on the Hippodamian plan and the construction of the city's fortification) of Cnidus in the 4th century B.C., it gained a prominent power in the Datca peninsula. In 285 BC, after Alexander the Great's death Cnidus passed to the Ptolemaian ruling were its connection with Egypt is reflected through inscriptions and pottery (Greene 2019: 119 ; Büyüközer 2012: 29-30).

Harbour typology, function and general description

Cnidus had two harbour basins formed by the Cap Krio island and the Datca Peninsula (**Fig. 1**). The basin located to the west the so called "Small Harbour" due to its dimensions was a military harbour according to Strabo (XIV. 656) that could accommodate 20 trirems (no shipsheds have been identified yet). It covered a surface of around 2 hectares. The military harbour's entrance to the north was defined by a breakwater. The harbour on the east was called the "Great Harbour" due to the dimensions (13 hectares) or "Commercial Harbour" in terms of function (Buyukozer 2012: 41, 103). The entrance of the Great harbour was 120 meters wide, formed by two breakwaters (south and north). Quays seem to have surrounded the confinments on the east side.

According to Strabo (XIV. 656) a breakwater-mole divided the two basins leaving an entrance that connected the military to the commercial basin. The channel/entrance is estimated to be around 20m wide and 7 m long. Today this area is silted creating a tombolo and closing the connection between the basins (Büyüközer 2012: 122-123 ; 2019: 215).

Harbour structures and construction tehniques:

The breakwater-moles and quays of the Commercial harbour

The South breakwater-mole extended from the east side of Kap Krio island towards the peninsula. It still can be seen on the surface and has a length of 120-160 meters, while the North breakwater which extended from the peninsula toward Kap Crio island (180 m long) is currently submerged. According to the ceramics identified around the breakwater-moles they were dated to the 4th century BC (Blackman 1982: 196 ; Büyüközer 2019: 221 ; 2012: 41-42, 48). Three quays were also identified. The first one is on the north east side of the basin, with a north-south direction, and preserves a length of 27, 20 m. The second one is located three metres to the south of the first one, with a north-south direction and has almost the same dimensions as the first one. The third quay is much smaller than both of them, and is located 30 metres south of the second quay. They probably date also to the Hellenistic times or earlier (Blackman 1982: 202 ; Büyüközer 2012: 61-63, 95).

The breakwater-moles were built with rubble (roughly cut stones) and its upper structure with ashlar blocks in a pseudoisodomic construction connected with clamps (**Fig. 2**). The rubble was placed at a depth of 30m on a sandy foundation. It was wider in the bottom (50m) and narrowed upwards (20m). The rubble foundation had an inclination to disperse the waves strenght (Blackman 1982: 196, 198 ; Büyüközer 2012: 44,46-47). It remains unclear how the upper structure was built on the rubble foundation since no plans or sections of the breakwater-mole have been published to the authors knowledge. On the other hand the quays found in the commercial harbour were rock-cut (**Fig.3**) (Büyüközer 2019: 220).

The breakwater of the Military harbour

The north breakwater (**Fig. 4**) is estimated to have been 80m long and around 40m wide and its entrance was flanked by towers (Blackman 2008: 655; Büyüközer 2019; 2012: 34, 104-108). The dating of breakwater is also to the 4th century BC (Büyüközer 2019: 230). No description of the harbour structure in terms of construction though has been published.

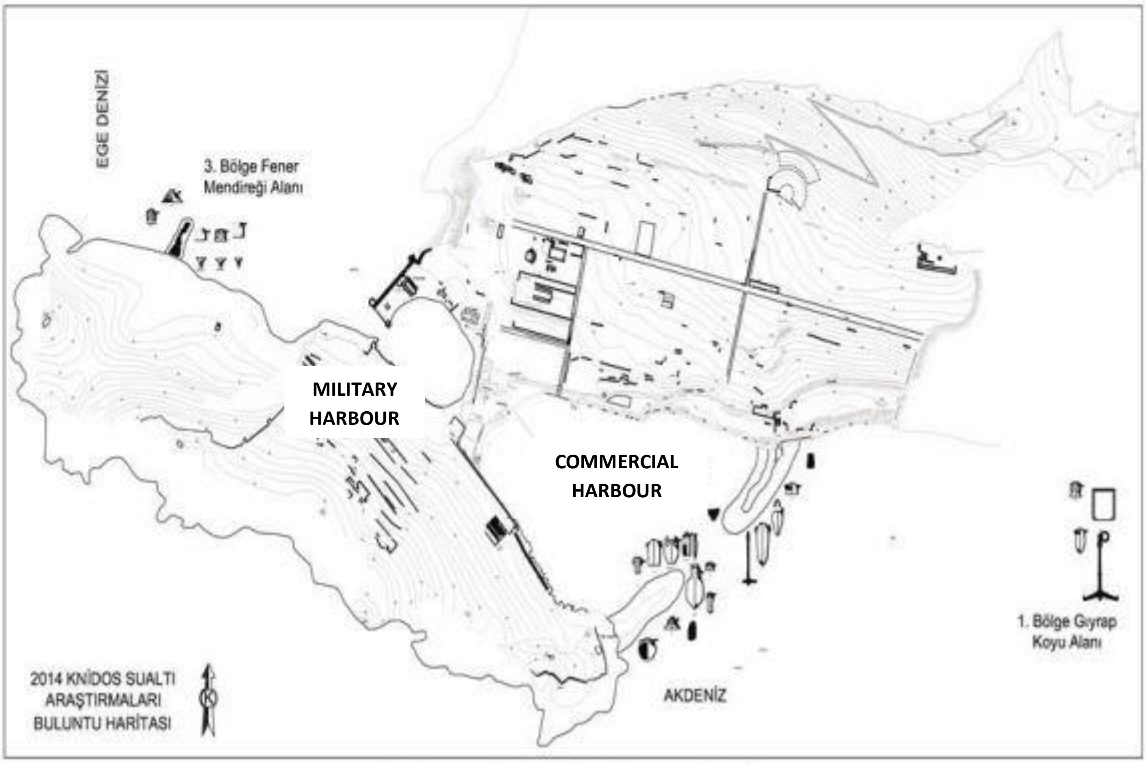

Figure 1 : Plan of the site (Aslan 2015: 103, fig.1)

Figure 2 : Photo of the submerged north breakwater (Büyüközer 2012 : Levha 14, fig.1).

Figure 3 : Rock-cut quays of the commercial harbour (Büyüközer 2012 : Levha 19, fig.2).

Figure 4 : Breakwater of the North military harbour (Büyüközer 2019 : 223, fig.10).

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XX. HALICARNASSUS

Halicarnassus is located in Caria in the southwest coast of Turkey, in today's Bodrum. Halicarnassus had joined the Athenian Confederacy in the 5th century BC until the end of the Peloponisian war. Mausolous in the 4th century, a Persian satrap transferred his residence from Mylasa to Halicarnassus making it the capital of Caria (Özdaş et al. 2019: 54). Alexander the Great sieged the city leading to its total destruction. The city never seems to have recuperated since Alexander's siege.During the Diadochi wars, Halicarnassus passed through the hands of Antigonus, Lysimachus and finally Ptolemy. It remained under Ptolemaic control until the Roman's expansion in the region (Bean & Cook 1955 : 95-96).

Harbour typology, function and general description

The harbour is located in a natural basin formed by an isthmus that connected the island of Zephyrium with the mainland. According to ancient sources, Halicarnassus possessed a small harbour, a commercial harbour and a secret/closed harbour. The commercial harbour is located in the modern harbour of Halicarnassus and two breakwaters, today buried under the modern harbour works formed the entrance of the ancientn commercial basin to the south according to Spratt and Newton (Özdaş et al. 2019: 55). PseudoScylax (99.1) refers to Halicarnassus as having a closed harbor, and a second harbor located near « an island and a river » while Vitrivius (II.8.11, 13-14) refers to the existance of a commercial, a secret (naval), and a smaller harbour that connected to the open sea via a channel (Özdaş et al. 2019: 53-55) (**Fig.1**).

The congifuration of the harbour and the location of the secret harbour is still under discussion. According to Vitruvius description it was located probably south of the Crusader's castle were a rock-cut installation (30m long) interpreted as a shipshed was identified (Özdaş et al. 2019: 65 ; Blackman 2013 : 555-557). On the other hand, on the east side of the basin a submerged structure in today's harbour is according to Spratt, Newton and Pedersen the breakwater that seperated the commercial from the so called «secret harbour» described by Vitruvius (Pedersen 1994 : 219). The role of this submerged mole which consists of two parts is still under discussion (Özdaş et al. 2019: 65).

Harbour structures and construction techniques:

Submerged breakwater-mole (?)

Since the ancient harbour continues to function till today only the submerged structure located to the east of the basin remains visible. It has been interpreted as a breakwater-mole (?). The submerged breakwater-mole (?) (**Fig.2**), has a north to south orientation and has two separate sections (east and west). The eastern part is approximately 120 m in length, 27 m in width (in the southern end) and 13 - 14 m width at the northern end. The western section is 110 m long, and 7 m wide. The distance between the two sections is approximately 15 m. The form of the breakwater-mole (?) has been altered since from an aerial photo of 1967 this structure (its north end) was once connected to the coast. Hydraulic mortar mixed with ceramic sherds and rubble stone were used to build the breakwater-mole (?). The foundation level was built with rubble, while the upper part was built with « material » (remains undetermined in the publication) mixed with mortar. On the southeast on the breakwater mole (?) a platform that was probably the foundation of a building probably, a tower (2 rows are preserved) that delimited the entrance to the naval harbour. The average dimensions of the blocks of this foundation are 2.0 x 1.5 x 0.5 m. In general this submerged breakwater-mole (?) is unique in the region (Özdaş et al. 2019: 52, 61-63, 65).

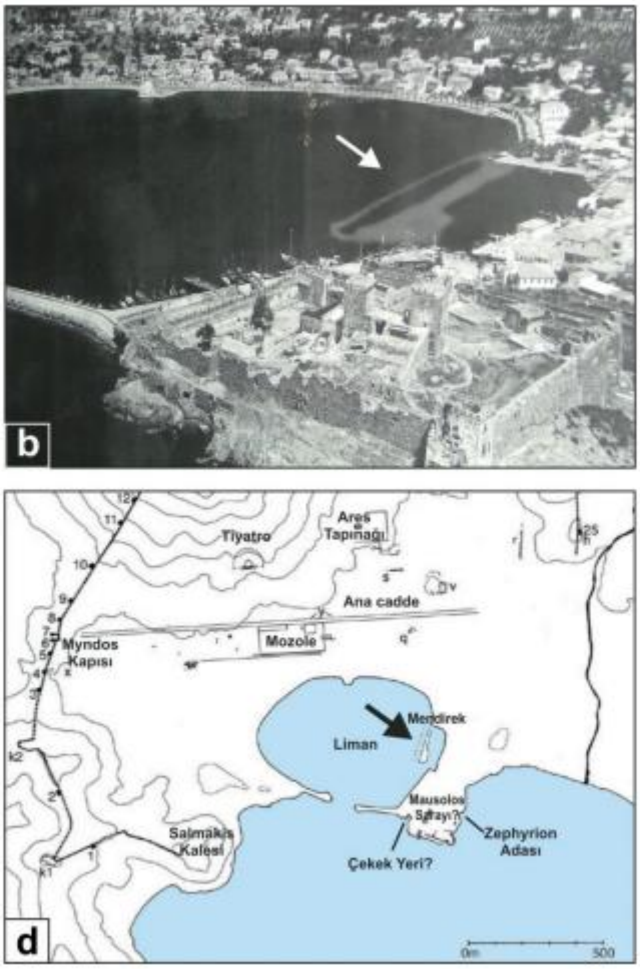

Figure 1 : Plan of the ancient harbour of Halicarnassus and aerial photo of the submerged stucture (Ozdas & Kizildig 2019 : 53, fig.1).

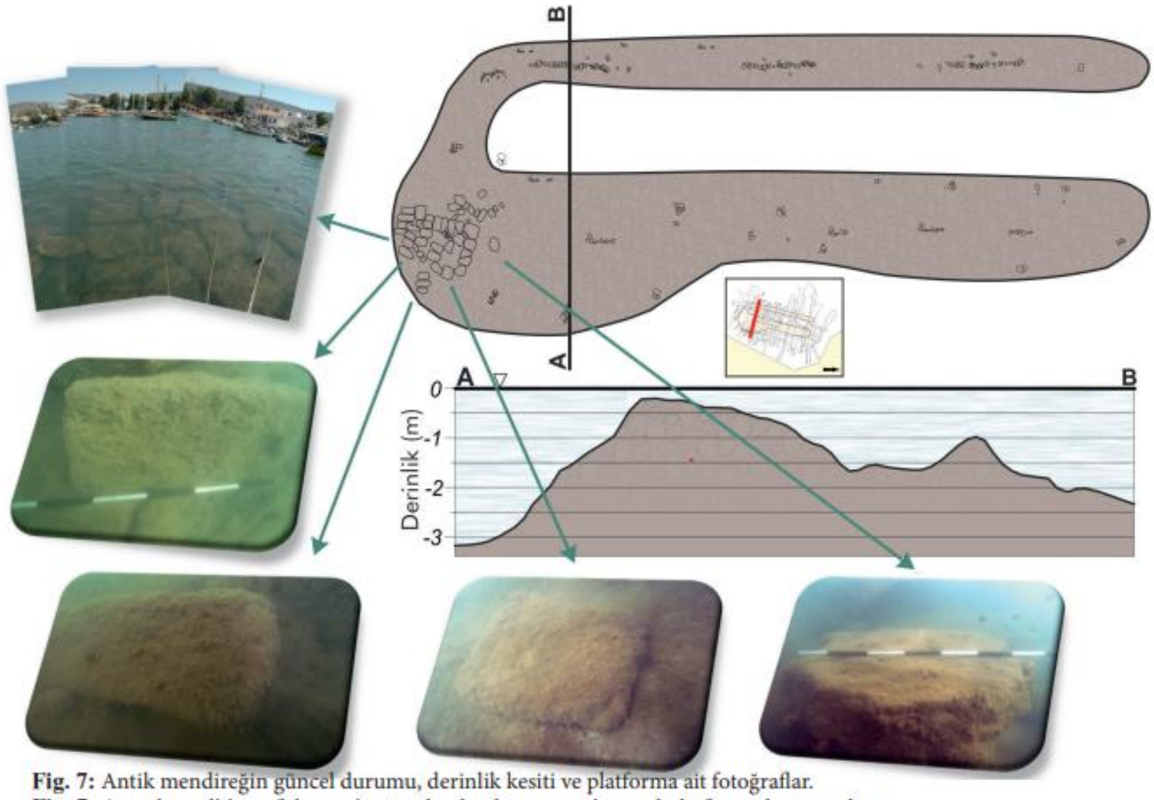

Fig. 7: Antik mendireğin güncel durumu, derinlik kesiti ve platforma ait fotoğraflar.
Fig. 7: Actual condition of the ancient mole, depth cros section and platform photography.

Figure 2: Photo and Plan of the submerged structure in tha harbour of Halicarnassus (Ozdas & Kizildig 2019 : 62, fig.7)

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XXI. MYNDOS

Myndos is located on the west side of Bodrum peninsula. Myndos was one of the many ancient cities of Caria (with Halicarnassus and Cnidus). It propospered in the 4th century when Persian satrap

Mausolus rebuilt the city. However, it was besieged by Alexander and after his death it was controlled by Lysimachus and Ptolemy consequitivly. In 316 BC, the city gained its independence and minted for the first time its own coins. However, it soon came under the control of Pergamon Kingdom. With the death of Attalos in 133 BC Myndos control was transferred to the Romans (Dumankaya 2016a: 10-14, 33).

Harbour typology, function and general description

According to ancient writers (Str. XIV, 2.20) Myndos possessed two harbour basins (Dumankaya et al. 2016a: 1,11-13). The main harbour is formed and protected by Asar island (southeast) and Kocadag hill (southwest) which is connected to the mainland through an isthmus. The west harbour recently discovered although not mentioned by the ancient sources was identified on the opposite side of the isthmus through a submerged breakwater (Dumankaya et al 2016b: 5-7) (**Fig. 1**).

Concerning the east harbour, from the east side of Kocadağ hill a breakwater extends towards Asar island. The harbor entrance is estimated to have been 117 m long. In addition, an element probably for closing the harbour's entrance (Kleithira) was found on the side of the east breakwater mole. More specifically, a stone block with a rectangular shape (1.15 x 0.83 m) and two double holes (0.27 m diameter), while on Asar Island the foundation of a tower was found. These elements lead to the interpretation of a closed harbour (Dumankaya 2016a: 15-20).

Harbour structures and construction techniques:

The harbour structures of the west harbour

The west harbour consists of a breakwater to the North with a North-East direction. It has a trapezoidal form, its length is 76.56 m, and its width is 34.15 m. It was built with rubble and has a tilting profile on both sides. The dating of this structure is relatively difficult however the identification of two wrecks on the breakwater dating to the 1st-3rd century AD give a terminus ante quem for the harbours construction (Dumankaya et al 2016b: 4-5, 14-15, 21-22, 26-28).

The harbour structures of the east harbour

The East harbour breakwater-mole dimensions are 27.88 m in width and 37.50 m in length. It is made out of a layer of rubble and on this uneven foundation the upper structure was built. The southwest and southeast front of the breakwater-mole preserve an ashlar built structure built in a pseudoisodomic technique (**Fig. 2**). The form of the upper structure took a trapezoidal shape. Evidence of clamps were found. Mortar was identified in this breakwater, probably part of some repair phase. It dates back to the 5th century BC based on the pottery identified in the rubble (Dumankaya 2016a: 14-21, 31-33, 37).

South of Asar island (**Fig.3**) a quay with a length of 43.45 m was identified. The lower part was a rubble foundation, up to 12 m height while its upper structure was made of 2.40x0.70 m headers which were positioned like those of the south mole of Amathus (see Dumankaya et al. 2016a).

Figure 1 : Plan of the site of Myndos (Dumankaya & Gunduz 2016 : 2, fig.2).

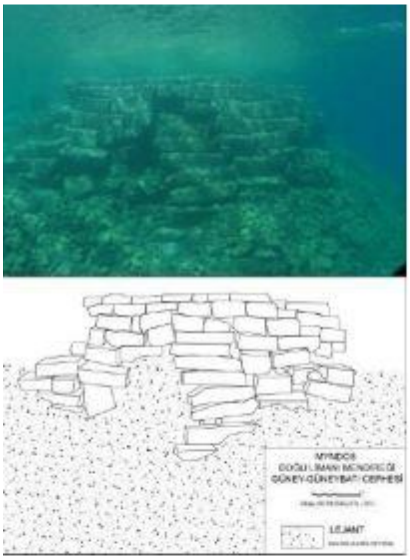

Figure 2 : Photo and section of the east breakwater of the commercial harbour (Dumankaya & Gunduz 2016 : 16, fig.15).

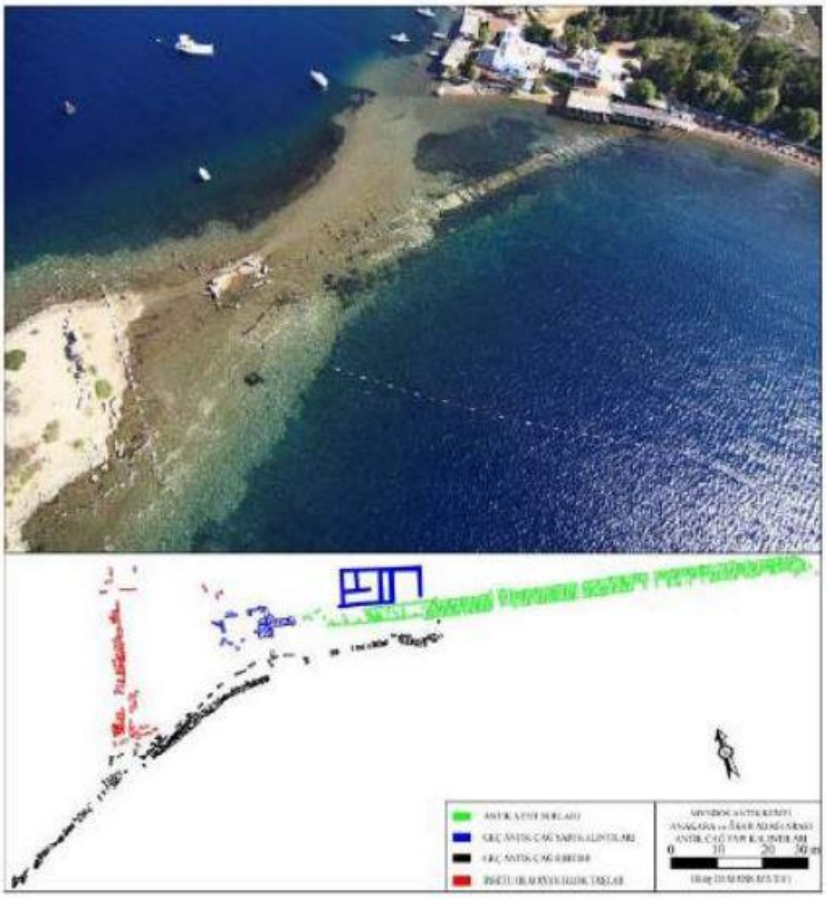

Figure 3 : Plan of the quay of Myndos (Dumankaya & Gunduz 2016 : 25, fig. 37)

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XXII. RHODES

Rhodes was founded in 408/7 BC as a result of a synoikismos between Ialysos, Kameiros and Lindos. The city controlled the entire island and was a prominent center of trade thanks to its location in major sea trade routes (Blackmann 1982: 187). During the Diadochi wars the city became an ally in 316 BC with Ptolemy. In 304 BC it was seiged by Demetrius Poliorcites (Diod. Sic.XX.82-88). The siege ended with a treaty (305 BC) were the city would be an ally with Antigonus except when in conflict with Ptolemy. With the expansion of the Roman empire in the Aegean, Delos prominence in trade led to the loss of its role as a major center of commerce (Walbank 1999: 75-76 ; Baika 2009: 509 ; Gerding 2013: 509).

Harbour typology, function and general description

This city had five harbours (**Fig. 1**) some of which were interconnected via channels. The harbours are the following: The north-west harbour, Mandaraki Harbour (Small harbour) which served as the military harbour and dockyard (as the remains of shipsheds indicate), the Great harbour (Akantia harbour) which was used for commercial purposes, the open harbour and the south harbour. The great harbour and the small harbour (Mandaraki Harbour) were fortified (Diod. Sic.XX. 86). The small harbour was protected by the extension of the city's walls and this leads to the characterization of Mandraki Harbour as a closed harbour (Gerding 2013: 509-516; Baika 2013: 200; Baika 2009: 438). The connection between the harbours as also with the city (acropolis, sanctuary etc.) was possible through the well-organized street network. The harbours were integrated into the city plan as they are aligned with the city's grid based on the Hippodamian system (Baika 2013: 187, 200).

Harbour structures and Construction techniques

The Mandraki bay was enclosed by two breakwater-moles(?) (east and west) whose remains are today covered by the modern breakwater-moles. According to Mouterde two breakwater-moles enclosed the basin (Mouterde 1951: 23) although the remains today are covered by the modern structures.The east breakwater-mole of the Mandraki (military) harbour is estimated to have been 500m long were according to some (see Hoepfner 2007: 111) on its edge the so-called Kolossos stood. This harbour structure consisted of a rubble construction and an ashlar built upper structure (Ntella-Manousou 2009: 67). These archaeological remains can be related to Diodorus description of the siege of Rhodes by Demetrius Poliorcetes refers to the attack towards the harbour of Rhodes, the attempt of the Rhodians to construct a wall along the mole and the crucial role it had in the attacks (Diod. Sic.XX.82-88).

Other harbour structures that survived is a jetty (?) (**Fig.2**) in the north-west harbour (now silted) (Konstantinopoulos 1986: 209). It extended from the coast (from the road Akti Miaouli) for 28 m with a width of 2.80m and a northwest direction. It was contstructed with a strechers on the outer sides and in the interior of the structure headers were placed. This structure extended with a Northsouth direction however its preservation does not allow a study or interpretation of the structure. Another structure in the northwest basin with a west-east direction was interpreted as a quay. It is 2.80-3.10m wide and is preserved at a height of 0.50-0.60m which were constructed with headers. Its location between Kazoulis and Basilopaidos road couldn't be verified on todays plans, therefore its location in the west basin is not well understood (Mazarakis 1992: 97-98).

In southwest basin (open or south harbour) a mole or wall was identified. It was 5.30m long and 3.20 wide. The wall continues further to the south for 28 m and has a width of 0.80m (Mazarakis 1992: 97-98).

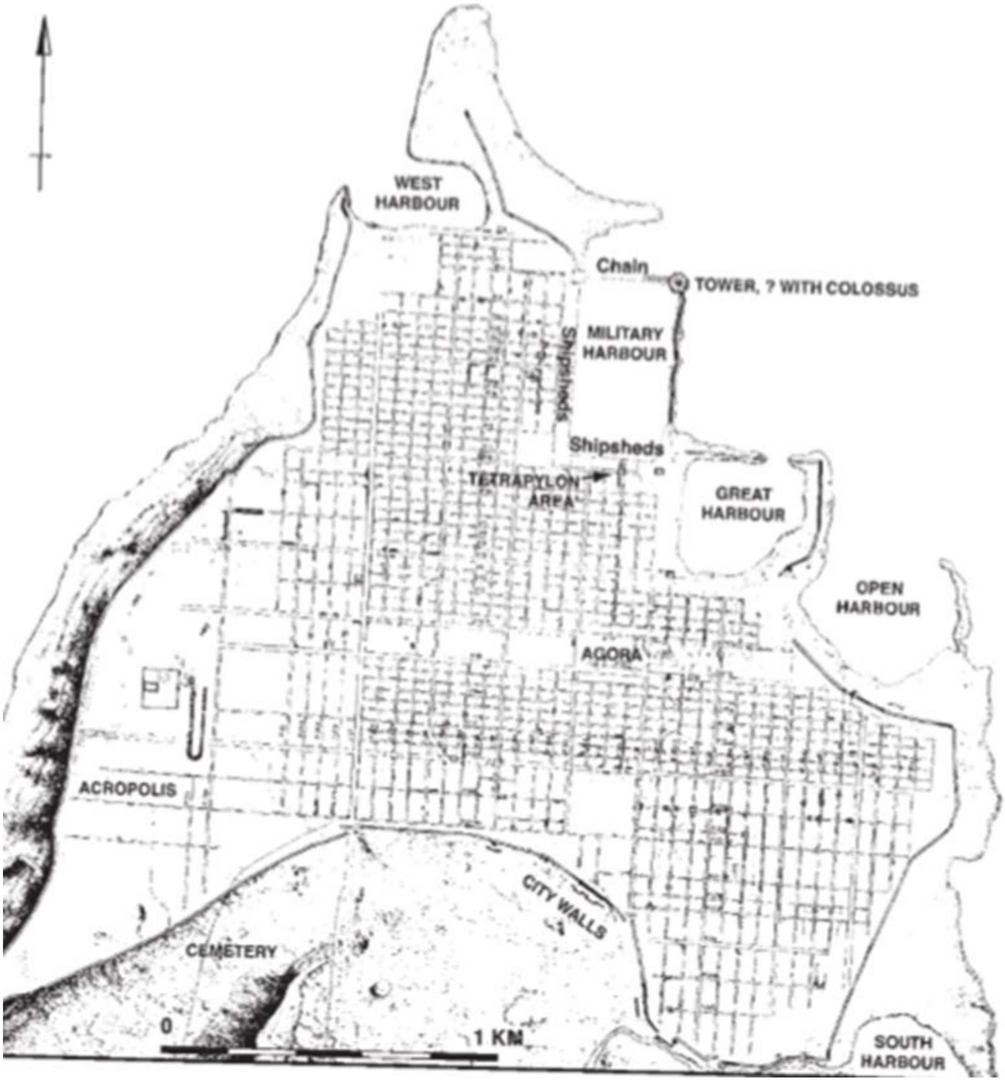

Figure 1 : Plan of the harbours of Rhodes (Baika 2013: 510, fig.B20.1).

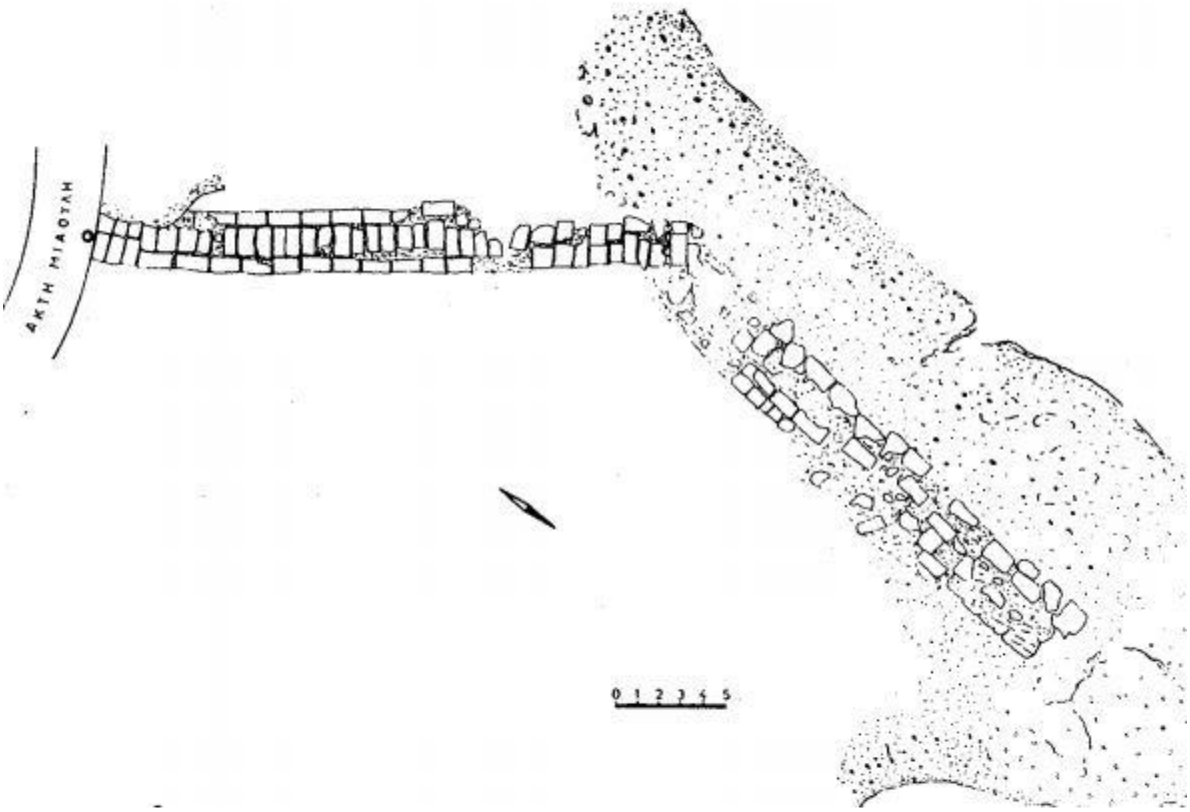

Figure 2 : Plan of jetty northwest harbour (Mazarakis 1992 : fig.192).

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XXIII. DELOS

Delos is located in the center of the Cyclades. It was inhabited since the 3rd millennium but thrivied as an emporium in the Hellenistic and Roman times due to its sanctuaries, harbour infrastructure, and strategic location. The island housed the treasury of the Delian league In 167 BC, Delos became a tax free harbour which enhanced even more the commercial activities especially the slave commerce. According to Strabo (XIV 5,2), Delos could receive dozens of thousands of slaves daily. The harbour in the 1st century BC was gradually abandoned starting from the 1st century BC (Duchene et al. 2001: 127 ; Desruelles et al. 2007: 231 ; Desruelles 2015 ; Shipley 2006: 260-261).

Harbour typology, function and general description

Delos possesd numerous harbour basins which had different functionalities. The **main harbourworks** are located on the west coast of the island were breakwater-moles and quays were constructed so as to create different harbour basins. The basin to the west of the temple of Apollo is the so called sacred harbour that was mainly used by the pilgrims while the other basins to the north and south are characterized as harbours destined for commercial activities according to the warehouses and shops located along the coast (**Fig.1**) (Desruelles et al. 2007: 230-231).

Harbour structures and harbour construction techniques

The first basin is located to the west of the sanctuary of Apollo. Two breakwaters (north and south) defined the sacred harbour. The largest breakwater (**Fig. 2**) (it is not a continuous structure) extended from the House of the hill (Maison au flanc de la Colline) towards the sacred harbour. It is built partially on a reef and it was mainly constructed by rubble. The breakwater is around 100m long and it forms a curved angel protecting the basin from the western and northern winds. Three structures whose interpretation still remains in question were located on it. Probably they were markers for the harbour's entrance. The structure's date remains in question although archaic pottery was found in the rubble. It is nevertheless considered as one of the first large-scale attempts to improve the natural configuration of a bay in the Aegean (Duchene et al. 2001: 53 ; Mazarakis 1992: 14-15). The latest publication identified different construction methods, it was not built in a homogenous manner. To the north the area infront of the Maison au flanc de la Colline was constructed by ashlar blocks (headers). XII-XIII While to the south, two other methods of construction are identified that of rubble (was built first with a layer of gravel 80-50 cm followed by granite blocks) and the third at the extremity of the breakwater polygonal masonry (**Fig. 3**). This mole is not a continuous structure (Baika 2009: 431; Duchene 2001: 67-68, 92-93 ; Ardailon 1896: 430-431).

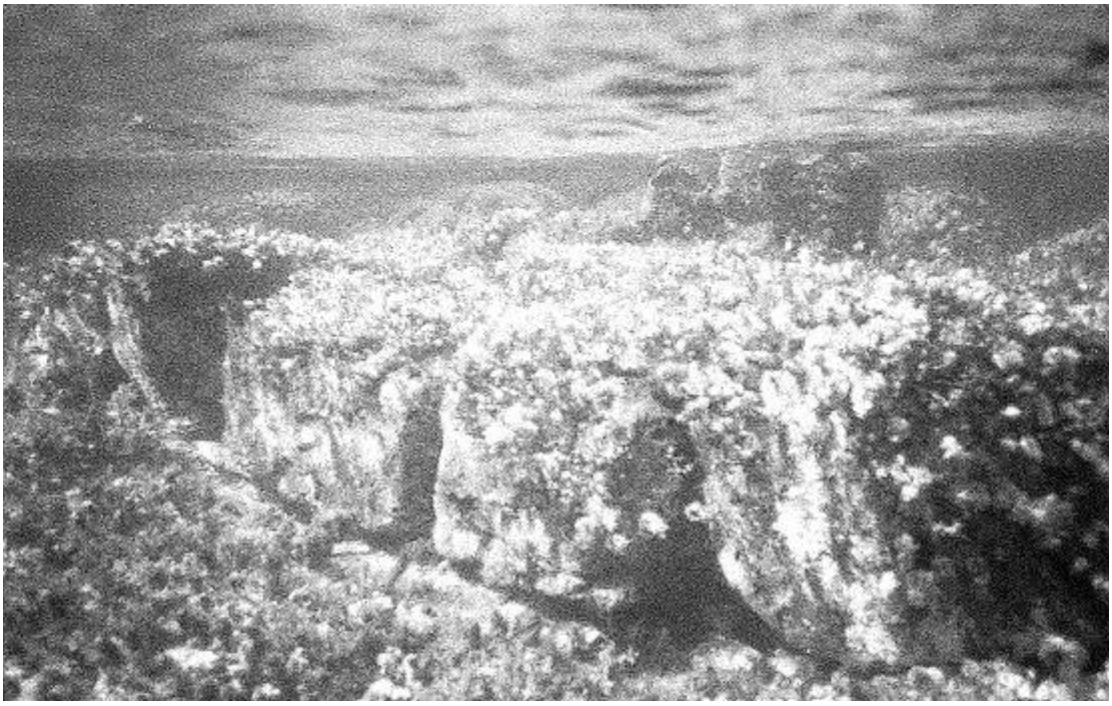
A second smaller breakwater to the south protects the south part of the harbour according to Paris (1916: 25-26). It was 30 m long and 10m wide (in its begging) and 6m wide at its extremity. This structure was made out of rubble too but of smaller sized stones than the north one (Mazarakis 1992: 14-15).

To the south of the sacred harbour the commercial harbour basins were located. Four smaller artificial basin were shaped with the help of moles built on a foundation of rubble according to Paris (1916: 26-33) (30-60 meters long and 15-150m wide). Nevertheless, the latest basin seems to not have existed (Mazarakis 1992: 15-16 ; Duchene et al. 2001: 114-117). North of the sacred harbour at the bay of Skardana, a mole was identified with an east to west direction preserved at a height of 0.50m. The construction consisted mainly of rubble (of small granite blocks) covered by ashlar blocks (Mazarakis 1992: 20 ; Duchene et al. 2001: 122).

A pathway/quay that ran along the coast (with interruption) was identified between the "Pointe des Pilastres" and the "Magasin aux Colonnes", built by the end of the 2nd century BC and the beginning of the 1st century BC. Probably to this structure ships were moored (along the quay a number of mooring stones are conserved) (Desruelles et al. 2007: 237). It extends in an area of a length of 1700-1800m and its width is between 2-20m. The quay was built in some areas on a foundation of rubble while in other on a natural rock formation (**Fig.4**). This was then followed by a gravel construction covered with blocks (Duchene et al. 2001: 63-64, 95-96, 118 ; Mazarakis 1992: 16-17).

Figure 1 : Plan of the harbours of Delos (http://www.ancientportsantiques.com/a-few-ports/delos/).

Figure 2 : Location of the breakwater extending from the maison de la colline (house of the hill) to the sacred harbour (Mourtzas 2012 : 7, fig.3).



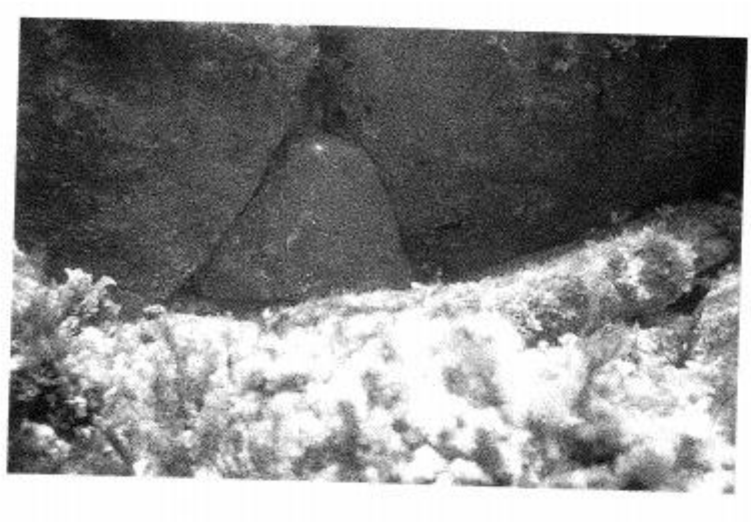


Figure 3 : Masonry preserved of the breakwater (north blocks), south polygonal masonry (Duchene & Fraisse 2001 : planche III, fig.2 ; XXXIV, fig.1).

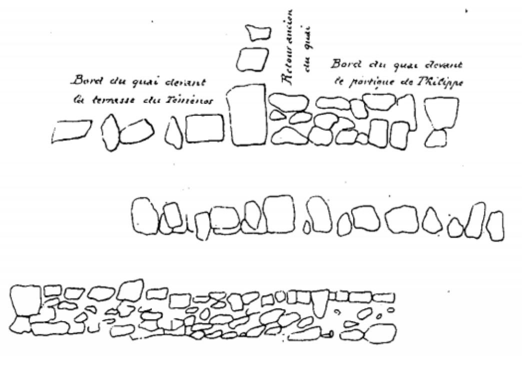


Figure 4 : Plan of Delos quay's by Paris M.J. 1916 (Mazarakis 1992 : fig.34).

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XXIV. LESBOS

Lesbos is located in the Northwest Aegean. It profited from the strategic location between the Hellespont and the Aegean, Asia Minor and Greece. From the Archaic period the prominence of the island is attested by Herodotus (I. 143, 5) reference to the naval power of the harbour-cities of Lesbos, Mytilene, Eressos, Mythimna, Antissa and Pyrra (**Fig. 1**). During the Peloponisian war Lesbos supported both Athens and Sparta in different times and had a prominent role in several naval battles such as those of Mikalis and Salamis. It was also one of the privileged members of the First Athenian League. During Alexander the Great reign Lesbos thrieved according to the numismatic evidence. Following his death Lesbos was under the control of Lysymachus and then under the control of Ptolemy till the end of the 3rd century BC. An inscription attests the presence of Ptolemain influence, in detail, a cult in honour of Ptolemy was conducted annualy. Several other honorific inscriptions in Mytilene and Eressos testify this connection as ambassadors and games in honour of Ptolemy were ongoing. Also an Egyptian Papyrus referring to possesions outside Egypt states that Lesbos was paying some form of tax to the

Ptolemies. With the expansion of the Romans in the east Lesbos thrieved once more as the various public works (i.e. aqueducts, public buildings) attest (Brun 1991: 99-113 ; Theodoulou & Kourtzellis 2019 : 56-58, 64-68, 86).

Harbour typology, function, general description

Pseudo- Scylax (Pseud.78) and Strabon (XIII 2.2) refer to the harbour-cities of the island by name. Mytilene possessed two harbour basins, one to the north and another to the south of an island now connected to the land through a tombolo, creating two distinct bays. The North basin was the commercial harbour formed by two moles (east and west) that formed an entrance of 300 meters wide and to the south was the naval basin and both were connected to each other through a natural euripous. Mythimna, the second prevailing harbour city of the island possessed a harbour basin that was protected by breakwater and a mole now covered by the modern harbour structures. The entrance of the harbour was probably located at the south west. According to Koldeway this was a military harbour. Antissa probably possesed more than one harbour basin. However, the only one identified with certainty is that located southeast of the promontory through a submerged breakwater-mole. Finally, Eressos possesed a harbour basin south of the city formed by a breakwater that extended towards an islet. This jetty did not form an enclosed basin, nor did the city's fortification extend on it, therefore it must not had a military character. It seems to have had more of a commercial function (Theodoulou & Kourtzellis 2019 ; Theodoulou 2011).

Harbour structures and construction techniques:

Mytilene

The harbour structures of the north harbour

The north commercial harbour of Mytilene, preserves the most fascinating structures. Two moles (**Fig.2**) dating to the 5th-4th century BC (although they probably date back also to the Archaic period) are found. The length of the eastern mole was 350 with a width of 8 m and of the west mole 85m long and 9 m wide. Every around 38 meters arched shaped openings traversed the moles. The west has 2 and the east at least 7 openings. In the west mole the opening is 1,55 m wide and in the east 1,80-2.20m. These channles have been interpreted as useful for the circulation of water and the reduction of the impact of the wave on the structure. These two harbour structures are built on a foundation of rubble. Above blocks with dimensions of 2.8x1.30x0.70 m (measurement of blocks from eastern mole) were used to build two parallel walls whose interior was filled with debris and amorphous stones (dry construction-emplekton- ashlar piers in rubble walls with headers and strechers). On the west mole, traces of clamps were found, but on the east no evidence of such use was found. The walls were built with isodomic masonry . Robert Koldewey believes that for the upper structure hydraulic cement was used as joining material but it is not sure if this is the case (Theodoulou & Kourtzellis 2019: 88-100 ; Theodoulou 2011 : 95-97 ; Theodoulou 2010 : 134-137 ; Theodoulou & Kourtzelis 2011: 135 ; Koldeway 1890: 3-16).

The harbour structures of the south harbour

In the south basin, the so-called military harbour according to Strabon (XIII 2.2) existed and could harbour 50 trirems. Unfortunatley, modern constructions have covered all ancient structures. On the east side of the harbour basin according to Koldeway remains of shipsheds were found and a quay is still visible but the ancient breakwater was buried under modern construction (Theodoulou & Kourtzellis 2019: 111-115 ; Theodoulou 2011 : 97 ; Koldeway 1890: 3-16).

The harbour structures of the evripous

An evripos, a natural channel reffered to by Diodorus (XIII, 79) existed between the paleoisland and the land. The channel was 178 meters long and 30 meters wide. It connected the two basins and is today silted. A land excavation on the south beach of the north harbour discovered the evripos entrance gate, a quay and a jetty (**Fig. 3**). The jetty constructed with the isodomic construction system was preserved in two parts. The first part was preserved at a length of 14,70 m and width of 6,10 while the second 3,40 and 5,70m respectivley. Only the outer blocks were joined with clamps but not the blocks in the interior of the structure. The quay was 28,20 m long and 1,65m wide and is also constructed in the isodomic construction system with no clamps but in some areas repairs are identified with hydraulic cement. The quay ended in a semicircular shape marking probably the entrance to the euripous. Since the structure was built on a sandy foundation to stabilize the structure wooden poles were placed along the structure (Theodoulou & Kourtzellis 2019: 102-106, 116-118).

Mythimna

In Mythimna, the ancient harbour is today buried under the modern structures leaving little space for the study of the harbour structures. According to Koldeway (1890 : Tafel 4) to the west an L-shaped breakwater-mole was built probably partially on a reef and partially on a foundation of rubble and enhanced on the seaward side with the use of rubble. This however is difficult to verify since the modern breakwater-mole covers this area. Only on the north west side of the modern structure remains of rubble probably indicate the existance of a breakwater in the area. However, the recent archaeological research identified to the southeast of the modern breakwater-mole, a mole with isodomic masonry construction. It has a width of 6m, a length 2,50m and a height 1,29m. Built from two walls and in the interior filled with gravel (as in Mytelene). Use of clamps is attested. It is dated to the 4th century BC. A mooring stone at the extremity of this structure or a stone for the chain to close the harbours entrance was found. Although this was reffered to as the military harbour according to Koldeway (Koldewey 1890 : 17) shipsheds or other facilities that indicate this function were not found (Theodoulou & Kourtzellis 2019: 120-132) (**Fig.4**).

Antissa

In Antissa a curved breakwater-mole (?) in the south east side of the natural bay is preserved (**Fig.5**). The breakwater-mole extended from the coast on a rocky formation and when this was abscent on a platform of rubble. Above the rubble foundation the mole was builtupper structure was probably built as the dispersion of ashlar blocks indicates. At the beginning of the mole a wall with polygonal masonry a technique attested also in the city's fortification, and in Eressos is attested. This may have extended on the breakwater-mole and comprised the upper part of the harbour structure. The use of Polygonal masonry in the upper structure leads to the date it to the Archaic period (Theodoulou and Kourtzellis 2011: 129-146 ; Theodoulou 2011: 93-102).

Around 2km east of Antissa in the location Tsamour or Laspolimano a submerged breakwater, of unknown chronology was located east of the natural bay. It is estimated to be 300 meters long and 15m wide made out of boulders (similar to that of the breakwater of Lemnos). This breakwater created an entrance of 20-25 m. According to Simossi(1998) who documented the structure this is thought to have been the naval station of Antissa but not enough evidence can support this theory (Theodoulou and Kourtzellis 2019: 132-140 ; Simossi 2000: 147-156).

Eressos

Eressos harbour consists of a mole that stretched from the shore towards a rocky formation, creating an L shaped structure (**Fig.6**). It is estimated to have been 140m long and 7 meters wide. The foundation of the structure was made from rubble and the upper structure with lesbian masonry like in Antissa. This structure also dates to the archaic period (Theodoulou and Kourtzellis 2019: 142-148).

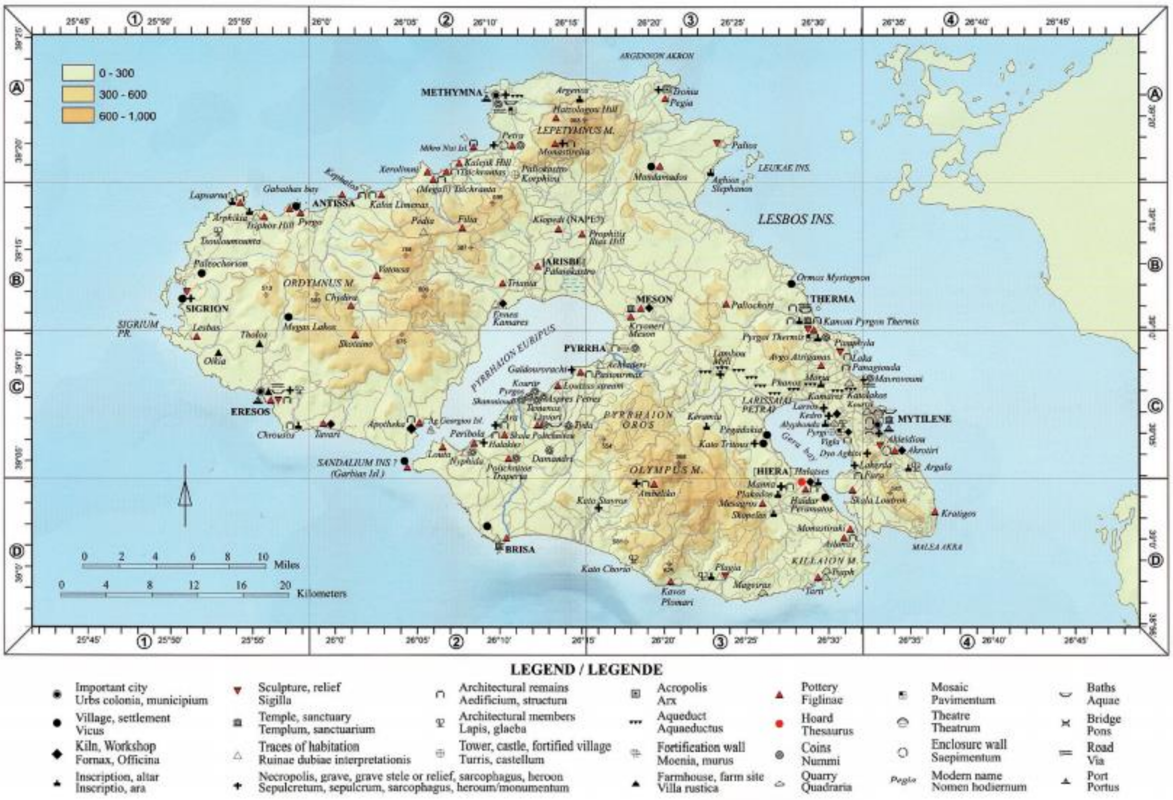
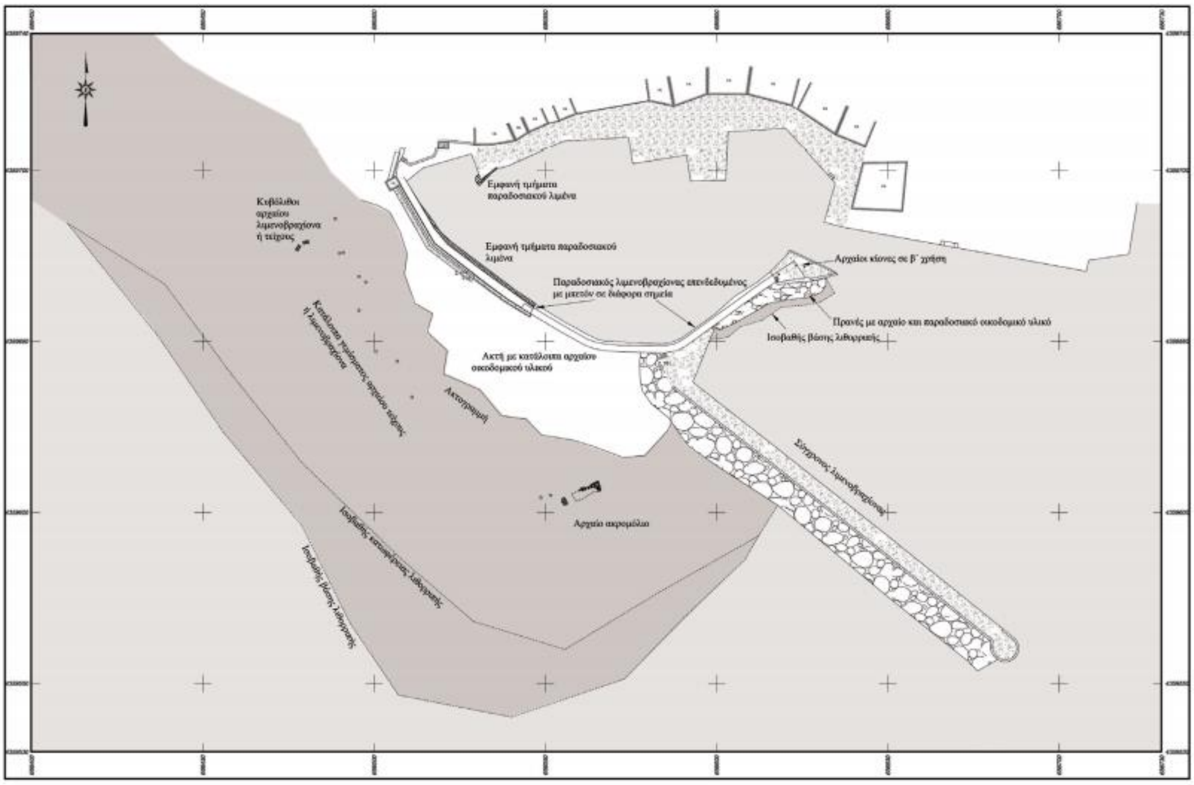


Figure 1 : Map of Lesbos and the location of the harbours under study (Theodoulou 2011 : 494, fig.1).

Figure 2 : Photomosaic of the eastern mole of Mytelene north harbour (Theodoulou 2011 : 495, fig.2).

Figure 3 : Jetty of the Euripous of Mytelene (THeodoulou and Kourtzellis 2019 : 104, fig.55)



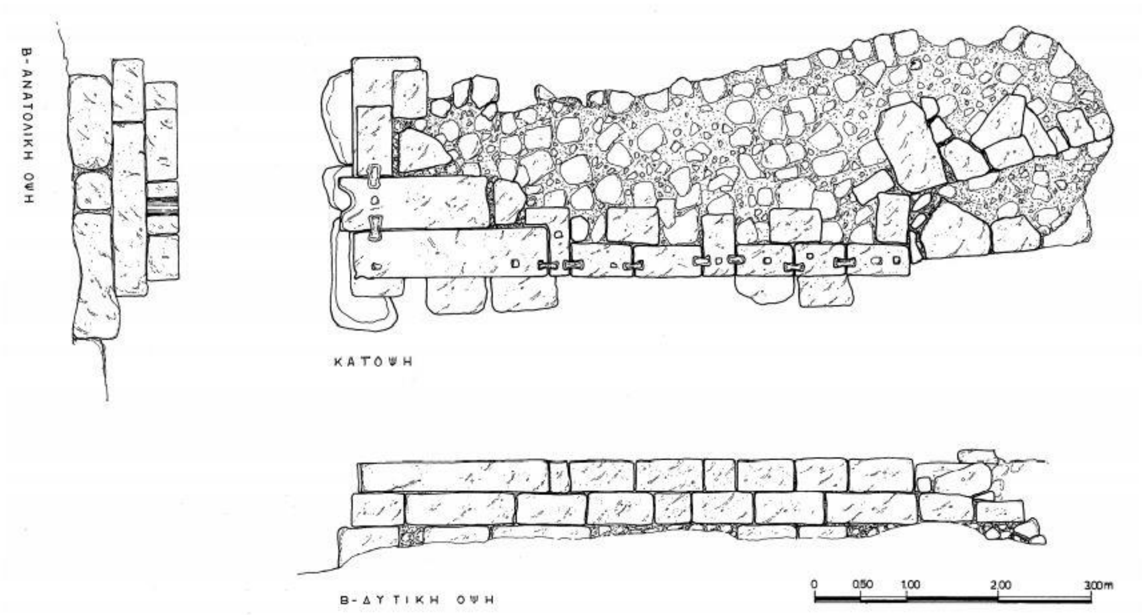


Figure 4 : Mythimna ancient harbour submerged remains (above) plan and section of submerged mole (?) (below) (Theodoulou 2011 : 498, fig.5-6).

Figure 5 : Antissa breakwater-mole (?) preserving polygonal masonry (Theodoulou 2011 : 501, fig.10).

Figure 6 : Eressos jetty built with polygonal masonry (Theodoulou 2011 : 503, fig.12).

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XXV. PHALASSARNA

The harbour of Phalassarna is located at Cap Grambousa in the Western tip of Crete. The site was inhabited since Minoan times, while graves from the Archaic period testify the continuation of habitation in the area. Coins of Phalassarna dating to the 4th-3rd century BC indicate that Phalassarna was an independent town. Phalassarna is often referred to as a pirate harbour-city which thrieved during the Hellenistic period (although this fact is not sustained by ancient sources) (Hadjidaki 1988:463, 467, 476). The harbour-city was probably destroyed during the campaigns of Metellus Creticus in 68-66 B.C., by a physical closing of its harbour (once more no ancient sources support this event) (Frost & Hadjidajki 1990 : 513) although ancient writers (i.e. Ptolemy) attest its use till the 2nd century AD (Pirazzoli et al. 1992 : 375). Several siesmic events took place (i.e. 66AD and 365 AD) that led to a considerable uplift of 6.6m, which is the largest detected uplift in the Mediterranean (Pirazzoli et al. 1992 : 385, 387, 390). However, the event of 365 AD was not sustained by Dominey-Howes research (Dominey-Howes 1998 : 343, 351).

Harbour typology, function and general description

Pseudo-Scylax(47) and Dionysius son of Kalliphone (118-122) had described Phalassarna as 'a closed harbour' while Stadiasmos (336) refers to it as a stopping place, a supply market, an ancient town (Hadjidaki 1988 : 375, 468). The harbour which consisted of two basisns encircled by the city's fortifications (for more info see Mazarakis 1992 : 85-89 ; Hadjidaki 1988: 468-474 ; Hadjidaki 2019 :169-171) and had an artificially rock-cut channel (10-12m wide and 120m long) that connected the main basin with the open sea (**Fig. 1**). A secondary channel too existed, to minimize siltation (desilting) (Hadjidaki 1988 : 475 ; Pirazzoli et al 1992 : 377). In 2015, a pair of holes carved in rock near the entrance of the harbour have been interpreted as part of the mechanisim used for the closing of the harbour entrance (**Fig.2**) (Hadjidaki 2019 : 173-174). The main harbour was a lagoon which was deepend by human intervention (Hadjidaki 1988 : 463). Today the main harbour is located 100m from the present seashore (Hadjidaki 1988 :466). Some scholars attributed the term of cothon however the harbour of Phalassarna although it reflects some of the carateristics of a cothon, remains a unique example in the Greek world since it was not entirely rock-cut (Hadjidaki 1988 : 478-479 ; Carayon 2008 : 639, 643). It had also a secondary harbour at the interior, probably a brackish natural lagoon, north of tower 3 (Frost & Hadjidajki 1990 : 527).

Harbour structures and construction techniques

The only survivng harbour structures are the quays (**Fig. 3**). Three sections of quays were identified in the eastern side of the port. The first is 17-m-long, called the northern quay, the eastern quay is 36 m long. From these quays mooring stones protruded (Hadjidaki 2015: 127-128; Hadjidaki 2019 : 171-173). The last section of the quay was 10.5 m long and seems to have been connected to Tower 4 but no mooring stones were identified. Five postholes were found on the ancient seabed, near the foundations of the quay which suggests the existence of a wooden platform perhaps burned by the

Romans in 69 BC, when the city of Phalasarna was destroyed. The length of the wooden jetty must have been c.9-10 m. and its width 3.5 m (Hadjidaki 2019: 173). The foundation level of the quay remains unknown although the upper structure was built with headers (Hadjidaki 2019: 61 ; Hadjidaki 2015 : 127).

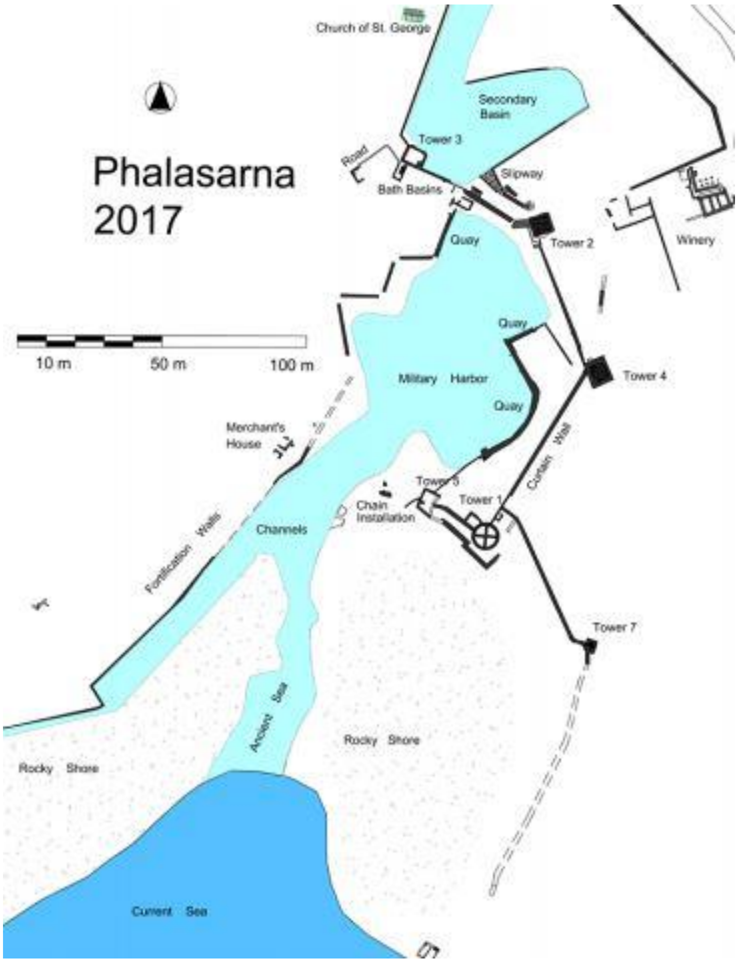

Figure 1 : Plan of Phalassarna harbour (Hatzidaki 2019 : 168, fig.4)

Figure 2 : Photo of the rock element used to support the chain that closed the harbour (Hadjidaki 2019 : fig11).

Figure 3 : North-east quay (Hatzidaki 2019 : 172, fig.9).

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XXVI. THASOS

Thasos was a colony founded by Paros in the 7th century BC in the northern Aegean. The settlement location on an island rich in gold mines contributed to its flourishing. After the Persian wars Thasos became a member of the Delian league. However, in 464 BC the city revolted against Athens and underwent a two year siege which ended with Thasos surrendering its trirems to Athens and the city walls being destroyed. During the Pelloponisian war the city was between the two rivalries (Athens and Sparta) but in 375BC Thasos entered the second Athenian Leauge in 375 BC. In 340 BC Philip II of Macedonia took over Thasos and remained under Macedonian influence till the Roman expansion in Greece (Shipley et al. 2006: 874).

Harbour typology, function, general description:

The harbours of Thasos are located on the west side of the city (Simossi 2000: 32-33).They consist of an inner and an outer basin (**Fig.1**). The outer basin is located to the north and is considered to be the commercial basin. It is formed by a breakwater-mole. The inner military basin is located in an open bay which was closed by two moles and was characterized as a closed harbour (*kleistos limen*) by Pseudoscylax (67). The military harbour had a quadrilingual shape and was fortified with walls which extended on the breakwater-moles. This harbour had shipsheds (for more information see Simossi

2000: 32-33 ; Baika 2013: 542-554). A second basin south of the naval harbour may have existed based on an inscription of the 3rd BC however it hasn't been verified archaeologically (Baika 2013: 545).

Harbour structures and Harbour construction techniques:

The mole of the commercial harbour

The mole of the commercial harbour has a length of 115 meters and a width of 18 meters wide and has a direction from east to west (**Fig.2**). Its western extremity has a circular shape (20m diameter). On the south side of the commercial mole ships would load and unload there goods. It has a 1m high foundation of rubble consisting of boulders (2-5kg) of schist and marble and ceramics dating to the 6th century BC. On this foundation two parallel walls extended and in between were filled with gravel. Three courses of blocks are preserved. The blocks average dimensions are around 2 m long, 1,50 m wide and 0,50m high. Strechers and headers were used. Similar construction of the breakwater-mole is attested in the military harbour (Empereur et al 1993 : 647-648 ; Kozelj & Kozelj 2000: 33-34). For images 1993 bch

The moles of the naval harbour

The military harbour underwent different phases of construction that date from the Archaic to the Late Roman times (**Fig. 3**). In the Archaic period, a mole with a curved form extended from the location of today's Phare vert towards the east. An excavation on the leeward side of the archaic mole indicated a foundation of beachrock and an alteration of layers of amorphous stones and blocks. The dating of this structure is based on the evidence of clamps that have been identified on other structures of Thasos that dated to the 6th BC (**Fig.4**). In addition, a mole extending from the east side of the bay to the west (sondage 28, 26, 24) reaching tower IV, is estimated to date back to the 6th-5th century AD due to the ceramics found. These two moles created an entrance of 100m (**Fig.5**). In the middle of the entrance however a squared structure under the current Phare rouge was identified dating back to the Archaic period (Empereur & Simossi 1990: 881-887 ; Empereur & Simossi 1988: 736-742 ; Sintès 2003 :128-130).

In the Classical period (4th century BC) a series of changes and additions in the military harbour took place. Two moles one to the east and one to west were built on which the city's fortifications extended creating a closed harbour. To the west a mole was built in the area of the archaic mole while under the modern east breakwater-mole, a second wall parallel to the archaic east mole connected the two classical circular towers. These two walls created a space between the two walls of schist and marble which was filled in between with gravel (like in the commercial mole). Traces of clamps on the walls were found too while also evidence of mortar dating to Late roman times was identified in sondage 25 (Empereur & Simossi 1990: 885-887 ; Empereur and Simossi 1992: 721-726 ; Sintes 2003: 132 ; Mazarakis 1992: 112-117).

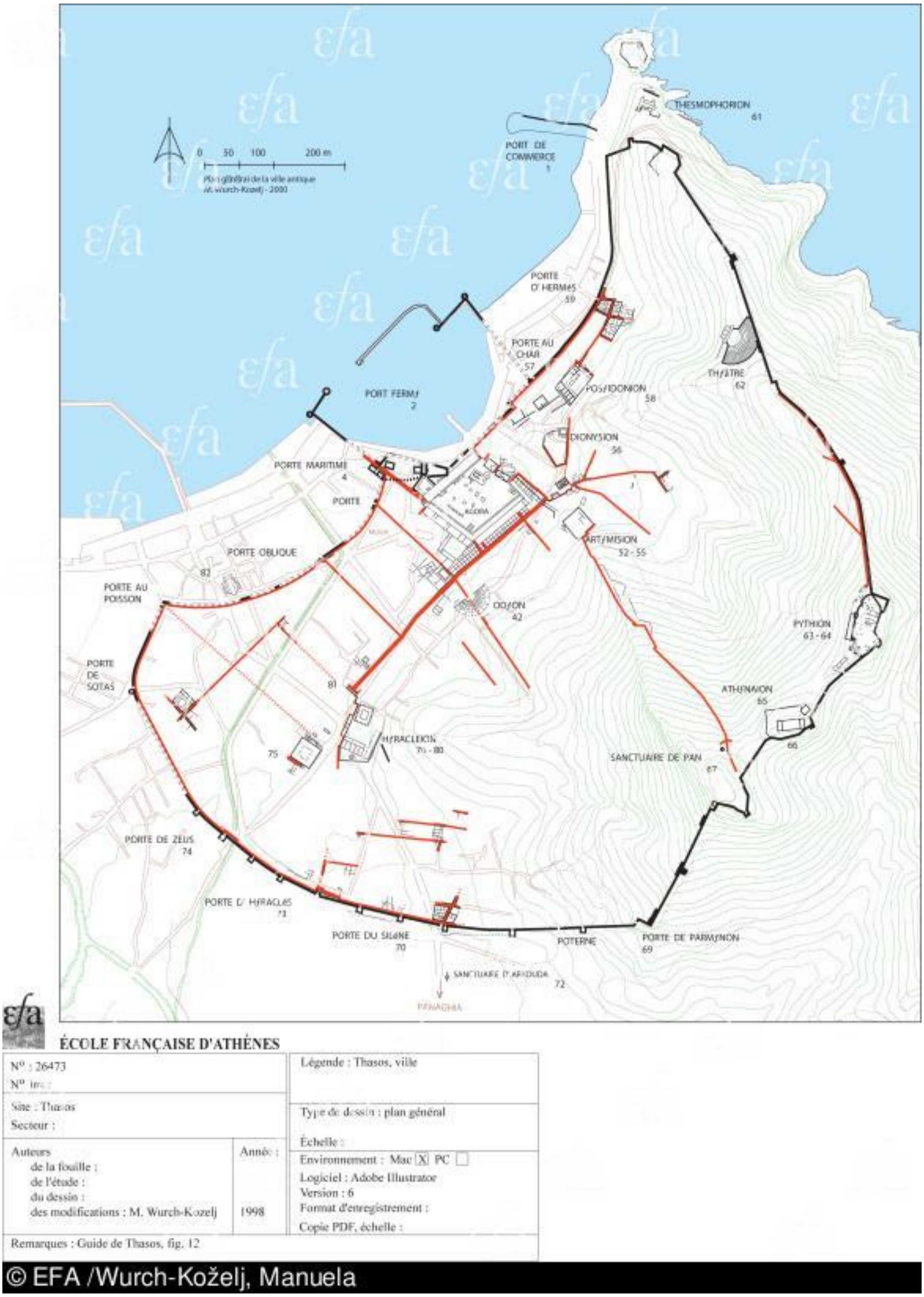


Figure 1 : Plan of the harbour city of Thasos (Retrived https://archimage.efa.gr/consulter-image-photo-plan.php?id=29940&title=Gr%C3%A8ce-Thasos-non_renseigne-26473 Last accessed 19th May 2021).

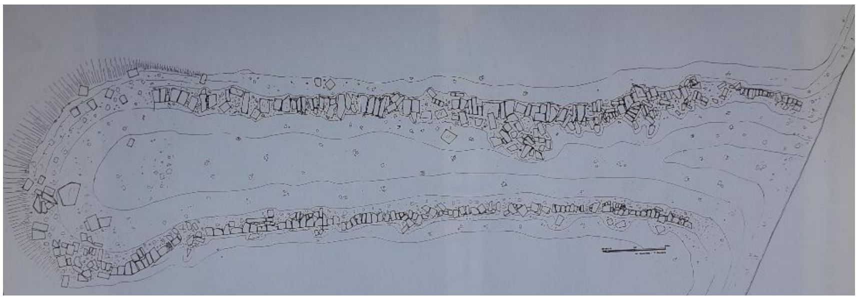


Figure 2 : Plan of the mole of the commercial harbour (Empereur et al. 1993 : Fig.2).

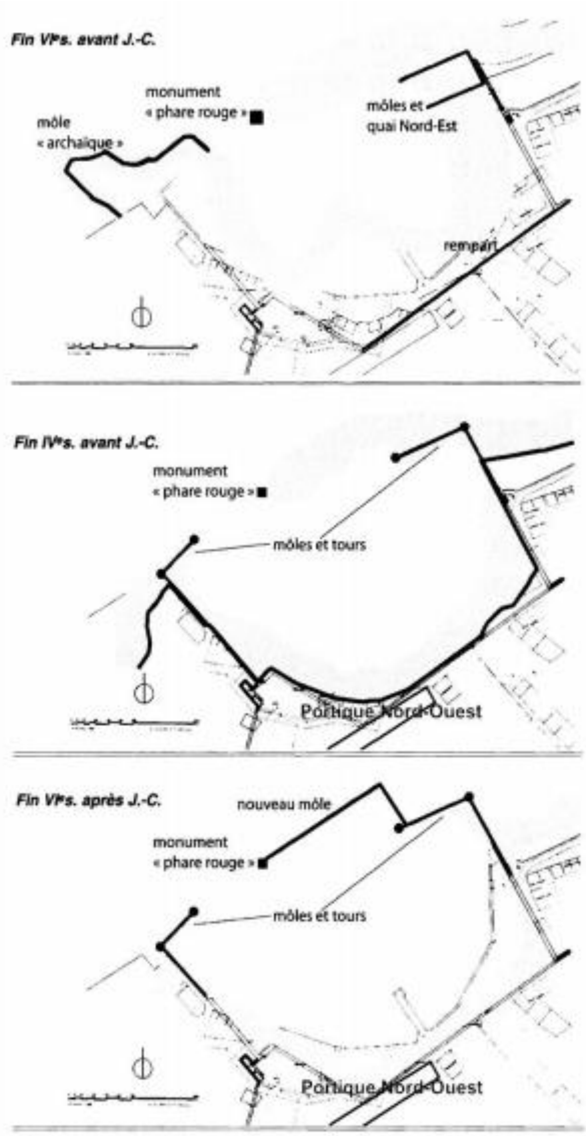


Figure 3 : The development of the naval harbour of Thasos from the Archaic period to the Late Roman period (Sintes 2003 : 135, fig.6).

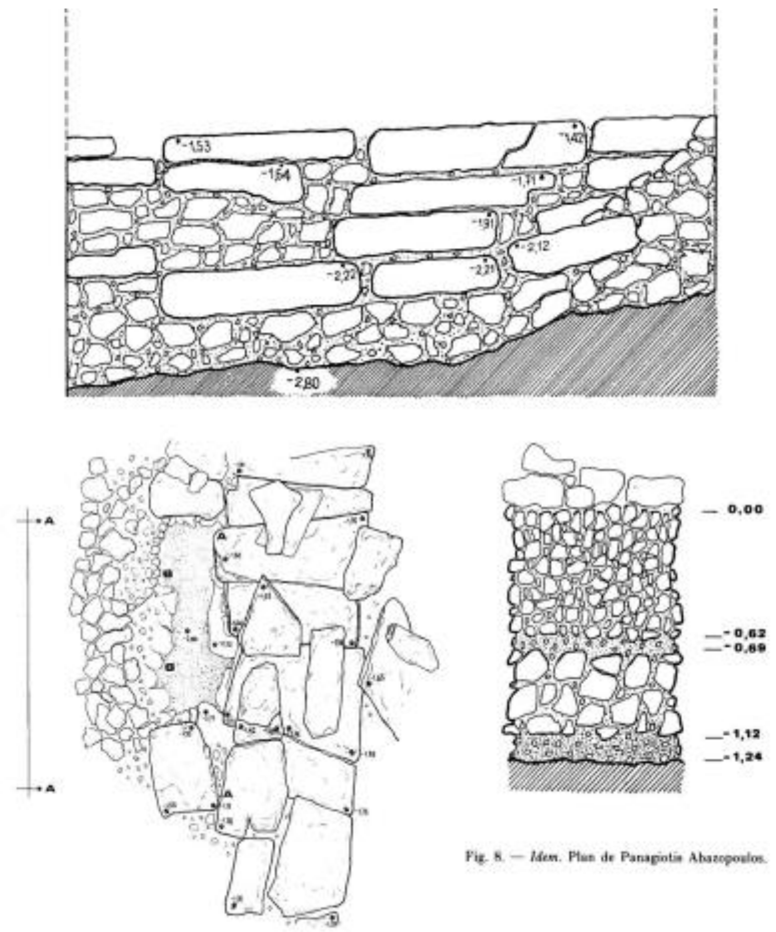
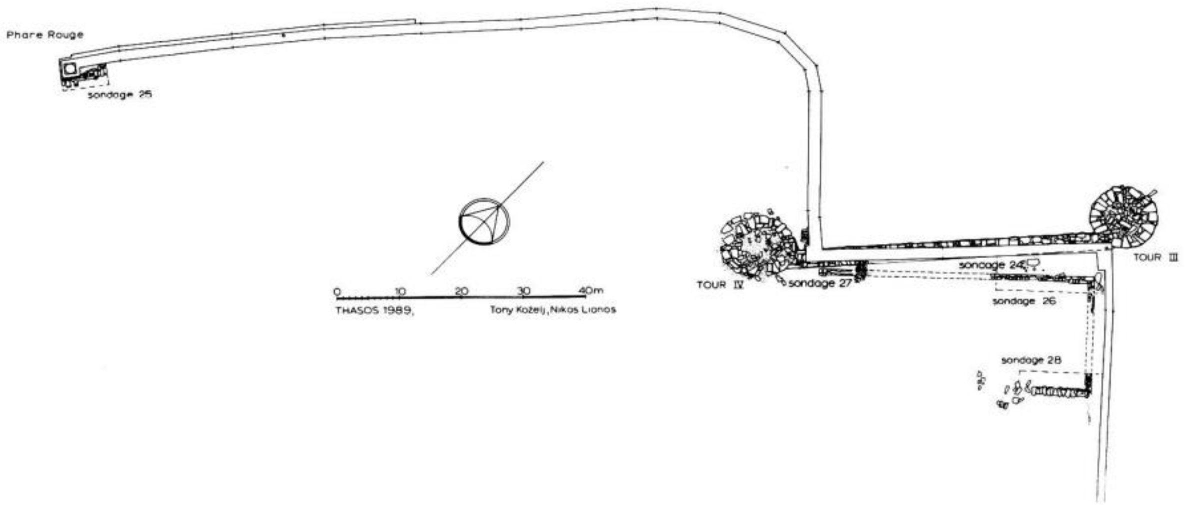


Figure 4 : Plan and section of Archaic mole of the naval harbour (Empereur & Simoissi 1988 : 738, fig.8)



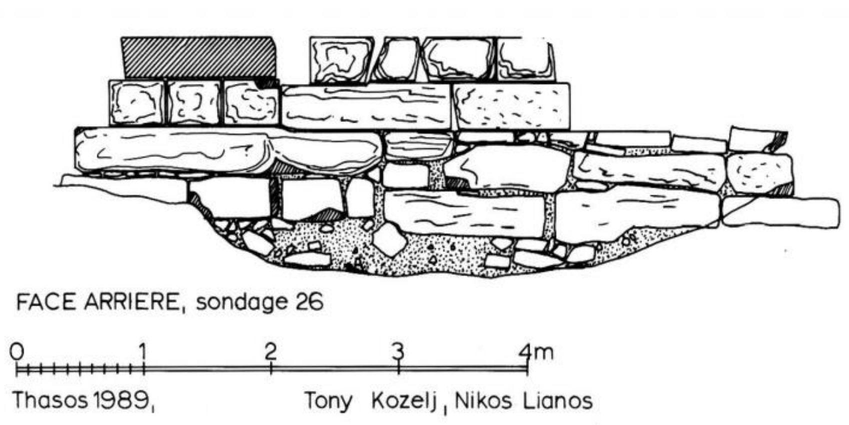


Figure 5 : Plan of the east mole of the naval harbour of Thasos and section of sondage 26 (Empereur & Simossi 1990 : 882-3, fig1-2).

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XXVII. AIGINA

In the Archaic and Classical period Aigina was an important naval power according to Herodotus (Herodotus, *Histories* 3.59). It participated in several naval battles (Salamis and Artemision) and minted its own coins since the 7th century BC. In 458 BC after Aigina's defeat in the naval battle of Kekryfaleia the Aiginitians were forced by the Athenians to demolish the walls of the city. During the 4th century BC the city underwent phases of rebuilding. As the rest of Greece, Aigina came under Macedonian control and in the Hellenistic period, the city was under Pergamenian rule. This led in 133 BC for the city to be handed over by Attalos to the Romans (Triantafilidis et al. 2017: 165 ; Gerding 2013: 284-285 ; Moutzas & Kolaiti, 2013: 420).

Harbour typology, function and general description

According to Pseudoscylax (53) the city had two harbours, the south (commercial) and north harbour (naval) (dated to the 5th century BC by Knoublauch). The north harbour was described as "Kryptos limen" according to Pausanias (2.29.6–9) located below the so called Kollona Hill. The naval harbour entrance is around 30m wide. In the north/naval harbour shipsheds were identified to the north and south of the basin (Gerding 2013: 284-293). The south commercial harbour is today still in use. As a result the ancient harbour structures are covered/destroyed by medieval and modern additions. According to Knoublauch this harbour too is dated to 480 BC (Knoublauch 1972: 52-57; Triantafillides et al. 2017: 169). Pausanias (II, 29, 6 ff) description on the difficulty to approach Aigina's harbours due to the cliffs lying in the seabed (Knoublauch 1972: 56) corresponds to the chain of cone shaped pilles that ran along the coastline. A third basin located north of the military basin consisted of a breakwater-mole. However, this basin seems to have been abandoned in the Archaic period due to change in the sea level (Mourtzas & Kolaiti 2013: 420) (**Fig.1**).

Harbour structures and harbour construction techniques:

North breakwater

In the northern bay a breakwater (**Fig.2**) extends for 350m with a NE to SW direction approximatleey 13-18m wide. This structure is divided into three sections due to different construction techniques. The east extremity consists of two parallel structures (walls) one to the north (33.65m long) and one to the south (14.40m long). The northern wall consisted of strechers and amorphous blocks in dry construction. However, a second phase of use is indicated by the use of mortar. The south wall consists of blocks worked from the three sides only. The filling between both structures has not been determined. The central part of the breakwater is 80m long and consists of rubble-“rockfill”, 20-45 m wide while the western end of the breakwater has a width from 13 to 18 m and extends for 210 m. It consists of rounded stones, not cemented together, which have a maximum size of 0.80 × 0.50 × 0.30m (Moutzas & Kolaiti, 2013: 414 ; Knoblauch, 1972: 63-72).

The cone shaped piles - man-made reefs

A series of man-made reefs (**Fig.1**) (otherwise called as cone shaped piles) extend from the north breakwater to the south parallel to the coast (approximately 1,100m long). They were suveryed in the 80’s but remain unpublished. A series of 53 reefs or cone-shaped piles in groups of five are preserved. The man-made reefs are built from irregular blocks. They have a height of 3-4 m and a circumference of 25-15m. This construction has no parrallel. Acccess channels opposite to the entrance of the military and commercial harbour was left for the ships to enter safley (Triantafillides et al. 2017 : 169-170 ; Moutzas & Kolaiti, 2013: 414,419).

Naval harbour breakwater-moles

The naval harbour is formed by two breakwater-moles which have been modified several times. The north breakwater of the basin has an L-shape. It extends from the land towards the west for 70m and then forms a 90 degree angle turning towards the south with a curve for 67m and then follows a straight line for 73m. This breakwater ends in a squared tower. Along the first section of this breakwater-mole the complex of shipsheds was identified. The preserved upper structure (wall) consists of three parallel rows of ashlar blocks of a thickness of 2.0m - 2.80m. The preserved height is 2 meters (6 courses of strechers). Both walls seem to have been laid on a man-made foundation of amorphous blocks. This mole seems to have spaces/openings and it has been interpreted as a result of different construction teams working on the structure (Mazarakis 1992: 2). To the south another breakwater defined the entrance. The remains consist of an entrance tower and a wall (60 m long). The basin surface is estimated to be 1.6 hectares (Moutzas & Kolaiti, 2013: 417-419 ; Kcnoublauch 1972: 76-77).

Commercial harbour

In the commercial harbour which today is still in use according to Knoublauch a series of quays in the south, east and north and partially also in the southwest have been covered by the modern constructions since the harbourworks of the 1960’s (Knoublauch 1972: 80-81 ; Triantafillidis & Koutsoumba, 2017: 169).

South breakwater

To the south of the commercial harbour (**Fig.1**) a south detached breakwater (a breakwater not linked with the coast) was also identified. It has an elipsoidale shape, around 317m long and 20-25m wide. It is formed by piles of boulders (rubble), up to 0.40 m × 0.80 m, and a large accumulation of potsherds is observed on its surface. The width of the west half reaches 25 m and decreases to 15 m in the east. (Mazarakis 1992: 4 ; Mourtzas & Kolaiti, 2013: 419).

The harbour structures are difficult to date since documentation has been preliminary and the techniques used seem to be repeated in time. The dating of the structures has been estimated by Knoublauch mainly through the estimation of the Relative Sea Level change and the historical evidence. According to Kcnoublauch a linear rise in sea level took place which led him to date the north breakwater around 1880 BC, when the sea level was −4.0 m to −3.55 m lower than today. He also considered that the harbors of the south coast were constructed around 480 BC, when the sea level was at −2.20 m to −2.50 m, and he dated the last reconstruction of the “closed harbor” in AD 250, with the sea level at −1.60m to −1.90m (Moutzas & Kolaiti, 2013: 419 ; Knoblauch, 1969, 1972).

In general, two main construction techniques are attested, the use of rubble for the foundation level of the breakwater-moles and for the construction of the west breakwater cone shaped piles od boulders while the use of ashlar blocks was used for the upper structure (whose masonry remains undetermined). Dry construction and mortar seem to have been the prevailing binding techniques.

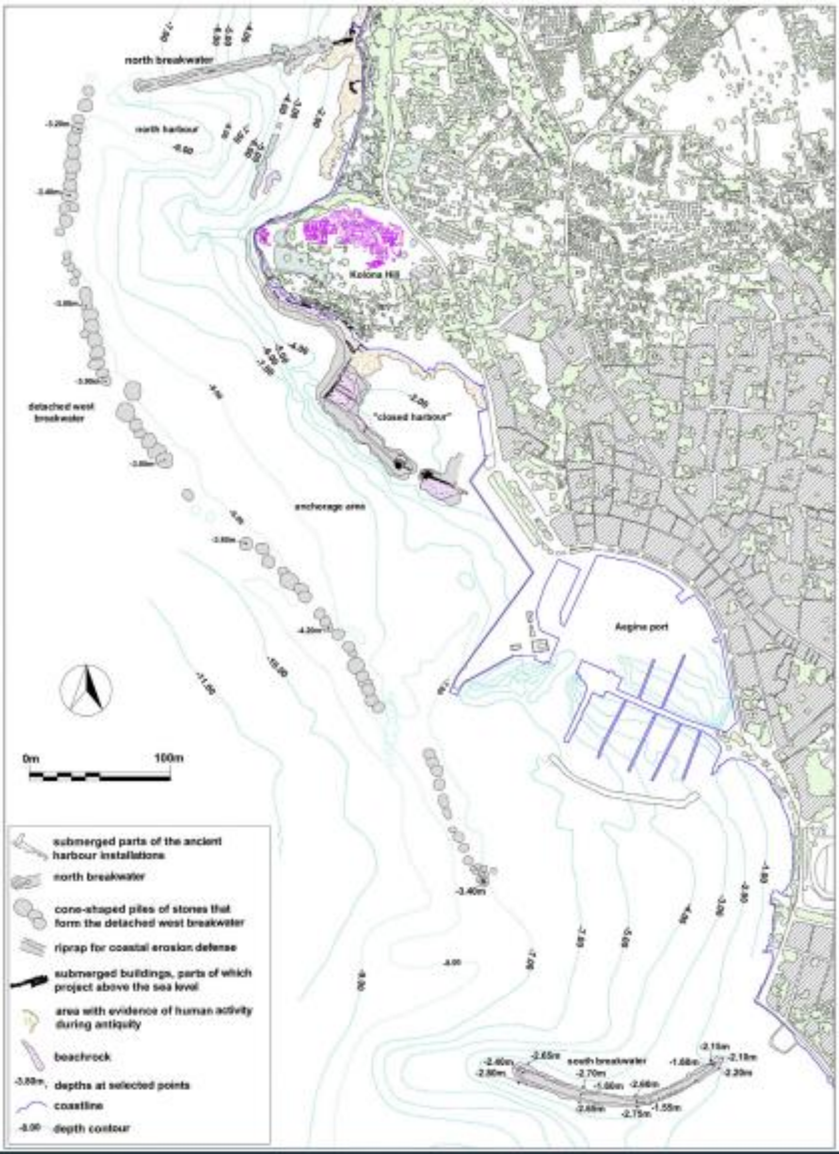

Figure 1 : Plan of the harbour of Aigina (Mourtzas & Kolaiti 2013 : 415, fig.2).

Figure 2 : North breakwater of Aigina (Mourtzas & Kolaiti 2013 : 417, fig.4c)

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XXVIII. ERETRIA

Eretria is located in Central Euboia. The settlement of Eretria dates back to an Early Helladic period (16-15th century BC). In the 9th century Eretria flourished as the inhabitants of Lefkandi moved to the settlement and the foundation of public buildings and metal-work is attested. It also participated in the establishment of colonies in Greece (Chalkis) and the west mediterranean (Pithikouses). In the 7th century BC the settlement continued to undergo some major works such as the diversion of the west stream and the construction of roads. Eretria, was a prominent naval power in the 6th-5th century BC and possesed a harbour. In 490 BC the city was destroyed by the Persians. Eretria underwent through conflict also with Athens but in the end it became part with the Delian Leauge. In the 4th century BC along with a major part of Greece, Eretria came under Macedonian control and in the begining of the 3rd century BC Antigonus Gonatas destroyed it. The city was again destroyed by the Romans in 198 BC and remained under Rome's control (Walter 2014 : 9, 280-281).

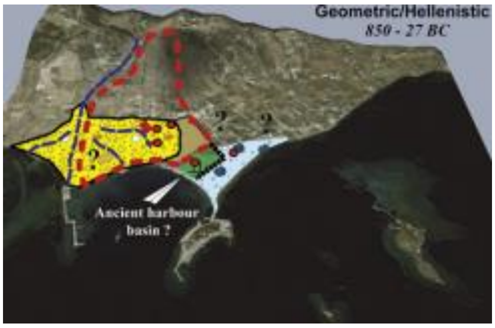
Harbour Typology, function and general description:

The existance of a harbour in Eretria was mentioned by Thucydides (Thuc. 8, 95) and Pseudo-scylax (Skyl. 58). The harbour consisted of two basins. The first basin lies in today's harbour of Eretria which was protected by the west breakwaterand Pezonisi island to the east. It had an entrance to the west, approximately 400m wide. To the Northeast of the basin a second entrance led to the interior basin today silted. According to an inscription (IG XII 9, No 191) dating to the the 4th century BC a drainage took place in a marshy area probably referring to the interior basin of Eretria (Mazarakis 1992 : 24).

The location of this military harbour has been investigated in the framework of a shoreline reconstruction project which indicate the potential location of this basin however, despite the proposition of the location an archaological investigation remians to take place (Ghilardi et al. 2014) (**Fig.1**).

Harbour structures and harbour construction techniques :

The only surviving harbour structures derive from the main harbour (exterior) basin of Eretria. The surviving harbour structures date mainly to the Classical and Hellenistic period. The west breakwater (**Fig. 2**) extends from the north towards the south and then turns towards the east to close the harbour basin. It has a lenght of 600m and approximately 8m width. This structure is dated to the Hellenisitc period (based on the pottery found in the rubble). A structure lying below the breakwater northern's extremity dates to the classical period built with rectangular blocks (similar to those of the city's fortification). To the south side of Pezonisi island also a breakwater (dating again to the Hellenistic period) extended from the south east to the west for around 70m. All the above mentioned structures were built on a sandy foundation from rubble.No further details on the upper structure has been collected (Mazarakis 1992 : 23-25).



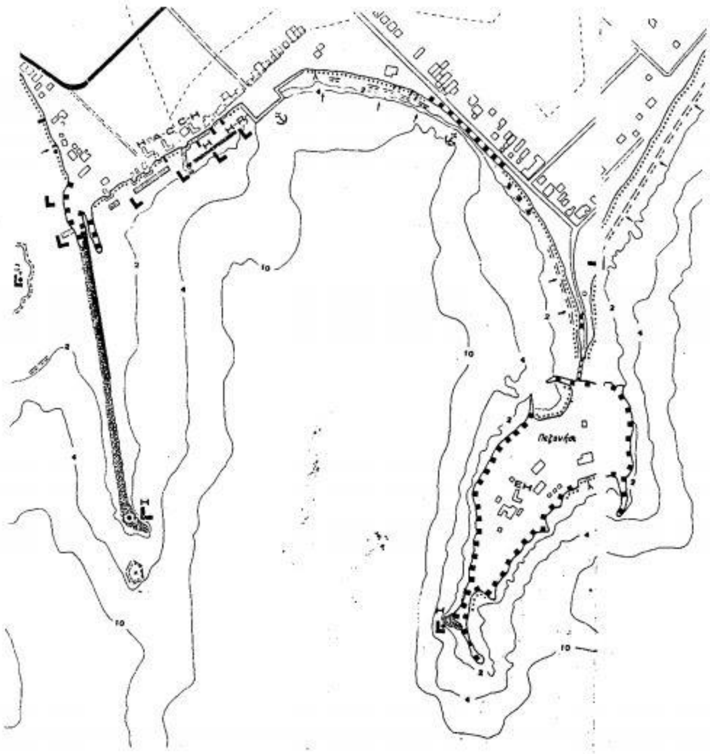


Figure 1 : Location of outer and inner basin (Ghilardi et al. 2014 : 234, fig.7 ; Mazarakis 1992 : fig.37)

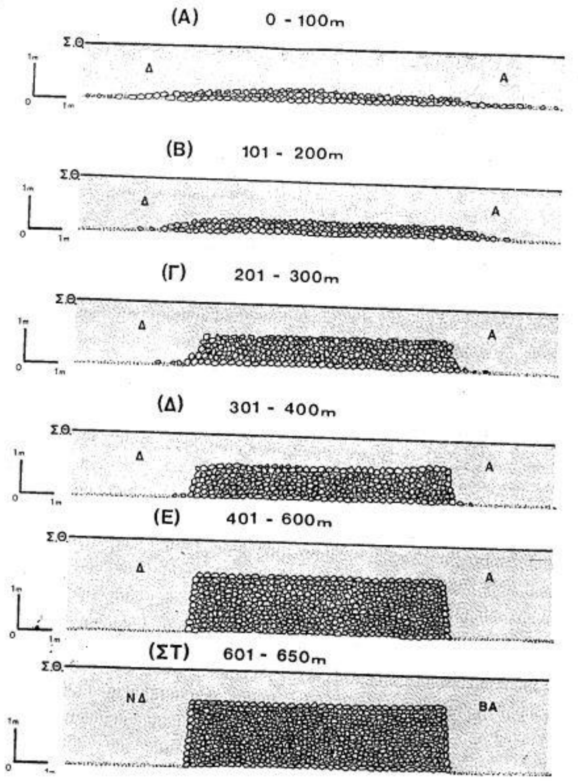


Figure 2 : Section ofthe west breakwater (Mazarakis 1992 : fig. 38)

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	https://thesis.ekt.gr/thesisBookReader/id/1135#page/16/mode/2up Last accesed 8th June 2021.

XXIX. PIRAEUS

Piraeus is situated on the west coastline of Attica peninsula, surrounded by the Saronic Gulf. The area was inhabited since the early prehistory. However, the systematic habitation of Piraeus started in the 5th century BC when Themistocles (according to Thucydides 1.93.3) fortified Athens with a well equipped and naturally protected harbour, that of Piraeus. As before only Phaleron, an open bay was used for anchorage (Ludlow 1883: 192-193). This ambitious plan was continued by Kimon and Pericles who connected Piraeus and Athens through the Long walls and organzied Piraeus based on the Hippodamian system by integrating also the harbours. These large scale projects led to the creation of an emporium, a harbour and a naval station for the city of Athens that would play a prominent role in the trade and politics of the Classical and Hellenistic period. With the end of the Peloponisian war Athens was forced by Sparta to hand over its trirems and to demolish the Long Walls. Gradually, the city was rebuilt and regained it naval power. During the Macedonian rule (3rd century BC) Piraeus became an important naval station. Under Roman occupation the city was independent till it sided with Mithridates VI of Pontus against Rome and Syllas in 86 BC which led to the loss of their prominent power. The harbour basins of Piraeus are still functioning till today a fact that leads the study of these harbours difficult (Rankov 2013: 420-423 ; Shipley et al. 2006: 102-105 ; 684-686).

Harbour typology, function, and general description:

The harbour of Piraeus consists of three naturally protected harbour basins around a headland (**Fig. 1**). Kantharos, Zea and Munichia. Kantharos was the commercial harbour while Zea and Munichia where exclusive naval bases. Kantharos by the end of the 6th and the beginning of the 5th century BC housed the Emporion, the main trade center in the east area and 96 ship sheds (in the south part of the harbour) in the 4th century BC when the size of the Athenian fleet increased. There was a quay along the shore with projecting jetties to the sea and horoi-boundary stones that divided the port into designated military and commercial areas. The harbour basin was divided into three sectors with jetties, the so-called Diamesou Choma, Diazevgma and Choma. Choma was used for ship inspection. Dia mesou Choma was used to support the wall that extended towards the sea and Diazevgma was a jetty that seperated in two the quay for commerce (Mazarakis 1992 : 72-82). Complimentary harbourworks such as stoas and banks were also identified around the basin (Baika 2009: 432-433). Its entrance was narrowed with two breakwater-moles. They had a length of 130m each leaving an entrance of 50 m. The commercial harbour of Piraeus covered an area of 250 x 1000m (Mazarakis 1992: 74).

Zea's basin enhanced its natural protection through fortyfying it with walls, offering protection from sea attacks and the city itself. Mounichia's entrance was created through man-made breakwaters-moles that were enhanced with fortification (Loven 2011: 9-14 ; Mazarakis-Ainian 1992: 72-81). Towers flanked the entrances of the harbour of Zea and Munichia as foundations of these structures are preserved (three towers in total). During the Peloponnesian War, the entrances of the three harbours of Piraeus were, according to Thucydides (2.94), fortified. The fortified breakwater-moles ended in towers forming a narrow harbour entrance. Chains probably stretched between the towers forming a so-called kleithron (Loven et al. 2007 : 62, 67-73).

An imporant harbour facility of these habours are the shipsheds. Zea could maintain 196 warships, 82 Munichia and 94 at Kantharos. According to ancient sources, 283 triremes were listed in Naval Inventory IG II2 1611, 3-9 (dated to 357/6 BC) while in 330/29 BC, according to Naval Inventories IG II2 1627, 398-405, a total of 372 shipsheds where housed in the three harbours of Piraeus (Loven et al. 2007 : 62 ; Loven 2011 : 9-14).

Harbour structures and construction techniques:

Due to the intense use of the harbour of Piraeus few are the remains of harbour structures since they are currently covered by the modern harbourworks. In addition, the research has been mainly focused on the shipsheds.

Mounichia preserves the remains of the north breakwater-mole (M-FM1) (**Fig.2**) under the modern harbour structures. Its remains consist of two courses of limestone ashlar blocks, preserved for a total length of 12.7 m. This can be traced under the modern quay towards Tower M-T1 (south). This was layed on a foundation of rubble that consisted of irregularly shaped stones layed on compact, sediments mixed with pebbles. Several limestone blocks too were found in this foundation layer however, it is unclear if they really belong to the foundation. The quays of Munichia that surrounded the basin seem to have been also built on a foundation of rubble (Loven & Nielsen 2011: 236-237 ; Loven & Nielsen 2009 : 172) (**Fig.3**).

Cantharos despite its intense use preserves few remains of the harbour structures. Two breakwater-moles projected into the sea in order to form a narrow entrance. These according to Shaw were constructed, in their upper part, with the use of rectangular large stones of local porous limestone (with a length of more than 3.30m) and were joined with clamps (Shaw 1972: 90-91 ; Mazarakis 1992: 72-82).

Ranckov proposed the idea of use of cofferdams for the creation of the moles (Rankov 2013 : 456-457) however Loven, considers that a more practical technique was with the use of cranes that would load the rubble on the seabed (Loven et al. 2019: 156).

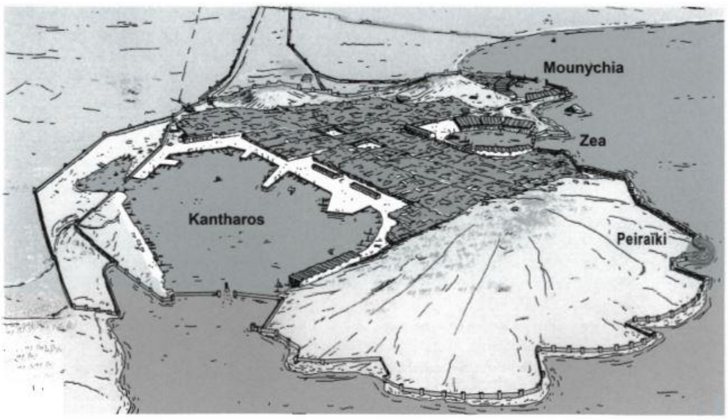

Figure 1 : Plan of th harbours of Piraeus (Loven et al. 2007 : 61, fig1)

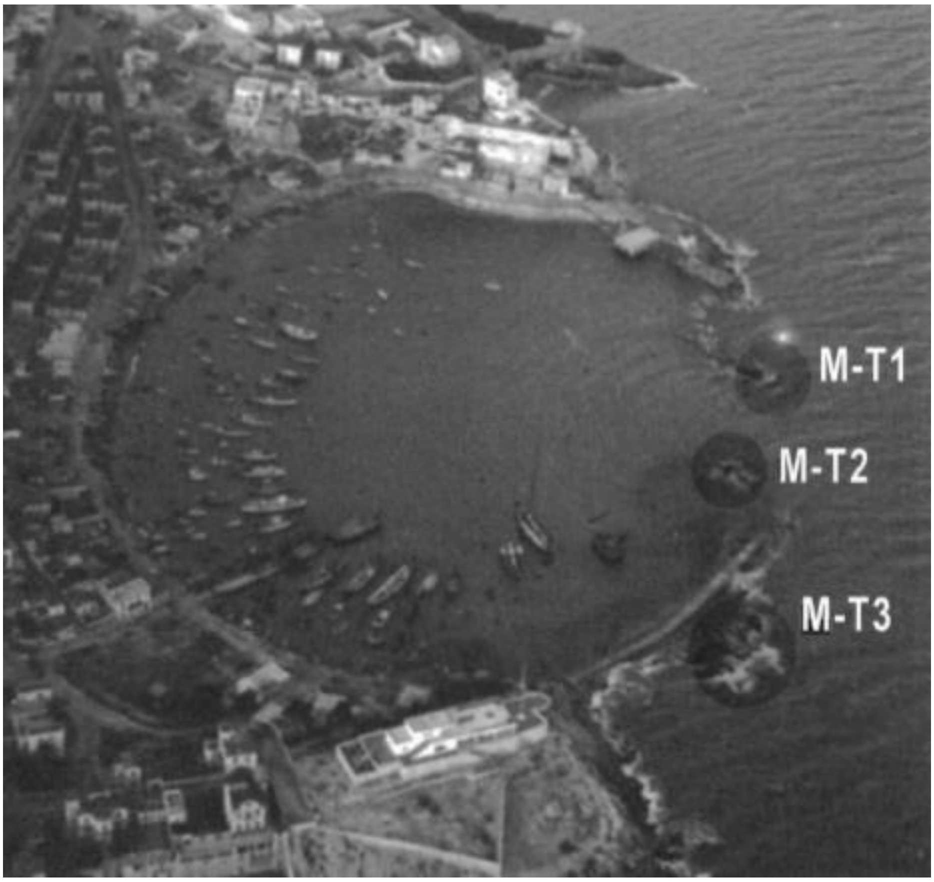

Figure 2 : Aerial photo of Mounichia and location of M-T1 (Loven et al. 2007 : fig.9)

Figure 3 : West side of the fortified mole M-FM1 (Loven & Nielsen 2011 : 238, fig.5)

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APPENDIX :

A. PRELIMINARY DATABASE FOR THE HARBOUR CONSTRUCTION TECHNIQUES

GENERAL INFORMATION			**FOUNDATION LEVEL**				**BUILDING MATERIAL OF UPPER STRUCTURE**							
No.	Harbour city name	Harbour structure	Natural Foundation	Absence of Foundation	Artifiical foundation	Mixed	Rubble	Gravel	Strechers	Headers	Blocks	Dimensions of blocks	Amorphous stones	Wooden elements
XIV	ALEXANDRIA	jetties and breakwaters of Megas Limen	-	x	-	-	x	x	-	-	x	-	X	x
		breakwater of Evnostos harbour	x (reefs)		-	-	-	x	-	-	x	2 m long, 1.5–2 m wide and 0.8–1 meter high	-	-
XIII	TAPOSIRIS MAGNA	jetty	?	?	?	-	-	-	x	x	-	0.50 x 0.20 x 0.25 m on average	-	-

IV	CARPASIA	north east quay	-	-	-	x	-	x	?	?	x	1X0.5X0.5m	-	-
		southwest mole	x (reef)	-	x(rubble)	-	-	-	?	?	x	-	-	-
VI	KOURION	breakwater	-	-	-	-	x	-	-	-	x	-	X	-
III	AMATHUS	south breakwater	-	x	-	-	x	x	x	x	-	2.96-0.51x 0.78-0.19x 0.58-0.31	X	-
		east breakwater	-	x	-	-	-	x	x	-	-	1-3x0.50-0.75 metersx0.25-0.56	-	-
		west breakwater	-	x	?	-	-	x	x	-	-	1.80-0.55x0.85-0.35x0.63-0.15	-	-
I	AKROTIRI DREAMER'S BAY	mole	x	x	-		-	-	?	?	x	-	X	-

II	ELAIA-KNIDOS	breakwater-mole	?	?	?	-	?	-	?	?	x	-	-	-
VII	KYRENIA	breakwater-mole	x	-	-	-	?	-	?	?	x	-	-	-
VIII	LAPITHOS	breakwater-moles	-	-	x(rubble)	-	x	-	-	-	-	-	-	-
IX	MARION	breakwater	x	-	?	x	?	-	?	?	x	-	-	-
X	NEA PAPHOS	west and east breakwater-mole	-	-	?	-	?	-	?	?	x	-	X	-
		east parallel breakwater				-						-		
		west extension of breakwater				-						-		
XI	SALAMINA	breakwater-mole	x	-	x(rubble)	x	x	-	?	?	x	-	-	-
XII	SOLOI	breakwater-mole	?	?	?	-	?	-	?	?	x	-	-	-

XVIII	ELAIA	west breakwater	-	-	x (stone debris, broken bricks and ceramics)	-	-	-	?	?	-	1.70 x 0.80 x 0.40 m	-	-
XVII	SELEUCIA PIERIA	south breakwater	?	?	?	-	-	-	x?	x?	-	around 6m length and 2m width	-	-
XXI	MYNDOS	breakwater of west harbour	-	-	x(rubble)	-	-	-	-	-	-	-	-	-
		breakwater of east harbour	-	-	x(rubble)	-	-	-	x	-	-	-	-	-
		quay	-	-	x(rubble)	-	-	-	-	x	-	2.40x0.70 m	-	-
XIX	CNIDUS	north and south breakwater	-	-	x(rubble)	-	-	-	?	?	-	-	-	-
		quays	-	-	-	-	-	-	-	-	-	-	-	-
XX	HALICARNASSUS	submerged	-	-	x(rubble)	-	x	-	-	-	x	2.0 x 1.5 x 0.5 m	x	-

		breakwater												
XXII	RHODES	south - west harbour jetty	?	?	?	-	-	-	x	x	-	-	-	-
XXIII	DELOS	sacred harbour north breakwater	x	-	x	x	x	x	-	x	x	-	-	-
		quay	x	-	x	-	x	x	?	?	-	-	-	-
XXIV	MYTILENE	North harbour west breakwater mole	-	-	x	-	x	x	x?	-	-	-	x	-
		north harbour east breakwater mole	-	-	x	-	x	x	x?	-	-	2.8x1.30x0.70 m	x	-
		isthmus jetty	-	x	-	-	-	x	x?	-	-	-	-	-
		isthmus quay	-	x	-	-	-	-	x?	-	-	-	-	x

XXIV	MYTHIMNA	breakwater mole ?	x	-	x	-	x	-	-	-	-	-	-	-
		south east breakwater mole	-	-	-	x	-	x	x?	-	-	-	-	-
XXIV	ANTISSA	south east curved breakwater mole	x (extended from a rocky formation)	-	x	x	x	-	-	-	x	-	-	-
XXIV	ERESSOS	Jetty	-	-	x	-	x	-	-	-	x	-	-	-
XXVI	THASOS	commercial breakwater	-	-	x	-	x	x	?	?	x	2 m long, 1,50 m wide and 0,50m high	-	-
		naval harbour west archaic mole	x (beachrock)	-	-	-	-	x	-	-	x	-	x	-
		naval harbour east mole	?	?	?	x	-	x	x?	x?	-	-	-	-

XXVII	AIGINA	north breakwater	?	?	?	-	x	-	x	-	-	-	x	-
		artificial reefs	-	-	-	-	x	-	-	-	-	-	x	-
		south breakwater	-	-	-	-	x	-	-	-	-	-	x	-
XXVIII	ERETRIA	west breakwater	?	?	?	-	x	-	-	-	-	-	-	-
XXIX	PIRAEUS	mounichia north mole (M-FM1)	-	-	x	-	-	-	-	-	x	-	-	-
		cantharos moles	?	?	?	-	-	-	-	-	x	more than 3.30m in lenght	-	-
XXV	PHALASSARNA	quays	?	?	?	-	-	-	x	x	-	-	-	x
XVI	CAESARIA MARITIMA	quay of north harbour	x	-	-	-	-	-	x	x	-	1.20x 0.20-0.40mx 0.42-0.46m	-	-

XV	TYRE	north east mole (?)	?	?	?	-	-	-	-	x	-	2.25x 0.45 x 0.55 1.90x0.45x0.55 1.60x0.75x0.55	-	-

No.	**MASONRY OF THE UPPER STRUCTURE**										
	Ashlar									Rock-cut	Rubble
	Masonry of the structure (facade)						Composition of the structure				
	Polygonal masonry	Alteration of courses of strechers and headers	Headers staggered between courses	Masonry with stacked joints	Irregular ashlar masonry	Isodomic /Pseudo isodomic construction	Ashlar piers in rubble walls with headers or strechers	Headers with a core of strechers or vice versa	Single or multiple rows of headers/strechers		
XIV	-	-	-	-	-	-	-	-	-	x	-
XIV	-	-	-	-	-	-	x	-	-	-	-
XIII	-	x	-	-	x	-	x	-	-	-	-

IV	-	-	-	-	-	-	-	x	-	-	-
IV	-	-	-	-	-	-	-	x	-	-	-
VI	-	-	-	-	-	-	-	-	-	-	x
III	-	x	x	-	-	-	-	-	x	-	x
III	-	-	x	-	-	-	x	-	x	-	-
III	-	-	x	-	-	-	x	-	x	-	-
I	-	-	x	-	-	?	-	x	-	-	-
II	-	-	-	-	-	?	-	-	-	-	?
VII	-	-	-	-	-	?	-	-	-	-	?
VIII	-	-	-	-	-	?	-	-	-	-	x
IX	-	-	-	-	-	?	-	-	-	-	?
X	-	-	-	-	-	?	-	-	-	-	x

X			-	-	-		-	-	-		
X			-	-	-		-	-	-		
XI	-	-	-	-	-	?	-	-	?	-	x
XII	-	-	-	-	-	?	-	-	?	-	?
XVIII	-	-	-	-	-	-	-	-	?	-	-
XVII	-	-	-	-	x	-	-	x	-	-	-
XXI	-	-	-	-	-	-	-	-	-	-	-
XXI	-	-	-	-	-	x	-	-	-	-	-
XXI	-	-	?	-	-	-	-	-	x	-	-
XIX	-	-	-	-	-	x	-	-	-	-	-
XIX	-	-	-	-	-	-	-	-	-	x	-
XX	-	-	-	-	-	-	-	-	-	-	-
XXII	-	-	-	-	x	-	-	x	-	-	-
XXIII	x	-	-	-	-	-	-	-	-	-	x
XXIII	-	-	?	-	-	-	-	-	x	-	-

XXIV	-	-	-	-	-	x	x	-	-	-	-
XXIV	-	-	-	-	-	x	x	-	-	-	-
XXIV	-	-	-	-	-	x	-	-	-	-	-
XXIV	-	-	-	--	-	x	-	-	-	-	-
XXIV	-	-	-		-	-	-	-	-	-	x
XXIV	-	-	-	-	-	x	x	-	-	-	-
XXIV	x	-	-	-	-	-	-	-	-	-	-
XXIV	x	-	-	-	-	-	-	-	-	-	-
XXVI	-	-	-	-	-	-	x	-	-	-	-
XXVI	-	-	-	x	-	-	x	-	-	-	-
XXVI	-	-	-	-	x	-	x	-	-	-	-
XXVII	-	-	-	-	-	-	x	-	-	-	x
XXVII	-	-	-	-	-	-	-	-	-	-	x
XXVII	-	-	-	-	-	-	-	-	-	-	x
XXVIII	-	-	-	-	-	-	-	-	-	-	x
XXIX	-	-	-	-	-	-	-	-	-	-	?
XXIX	-	-	-	-	-	-	-	-	-	-	?
XXV	-	x	-	-	-	-	-	-	x	-	-

XVI	-	-	?	-	-	-	-	-	-	-	-
XV	-	-	-	-	-	-	x	-	-	-	-

	MACHINERY TRACES	BINDING MATERIAL			DECORATIVE ELEMENTS	OTHER	
	Lifting mortaises	Mortar	Clamps	Dry construction	Columns	Channel	Date
XIV	-	x	-	-	x	-	Classical - Roman
XIV	with wholes	-	-	x	-	-	Classical
XIII	-	x	-	-	-	x	Roman?
IV	-	x	x	-	-	-	Hellenistic-Roman
IV	-	-	x	-	-	-	Hellenistic-Roman
VI	-	-	-	x	-	-	?

III		-	x	x	-	x	Hellenistic
III		-	-	x	-	-	Hellenistic
III	8 different types	-	-	x	-	-	Hellenistic
I	-	-	-	x	x		Hellenistic-Roman?
II	-	-	-	?	-		?
VII	-	-	-	?	-		Classical-Medieval
VIII	-	-	-	?	-		Classical-Roman?
IX	-	-	x	?	x		Hellenistic
X	-	x	x	?	-		Classical-Medieval?
X							
X							
XI	-	-	-	?	-		Classical-Hellenistic
XII	-	-	-	?	-		?

XVIII	-	-	x	-	-	-	Hellenistic
XVII	-	-	-	x	-	-	Late Roman
XXI	-	-	-	x	-	-	Roman ?
XXI	-	x	x	-	-	-	Classical
XXI	-	-	-	x	-	-	Classical ?
XIX	-	-	x		-	-	Classical
XIX	-	-	-		-	-	Hellenistic ?
XX	-	x	-		-	-	Classical-Roman?
XXII	-	-	-		-	-	?
XXIII	-	-	-		-	-	Archaic-?
XXIII	-	-	-		-	-	Hellenistic
XXIV	-	x	x		-	x	Classical-Hellenistic
XXIV	-	x	-		-	x	Classical-Hellenistic

XXIV	-	-	x		-	-	?
XXIV	-	x	-		-	-	?
XXIV	-	-	-		-	-	Classical?
XXIV	-	x	x		-	-	Classical?
XXIV	-	-	-		-	-	Archaic?
XXIV	-	-	-		-	-	Archaic?
XXVI	-	-	-		-	-	Archaic?
XXVI	-	-	x		-	-	Archaic
XXVI	-	x	x		-	-	Classical
XXVII	-	x	-		-	-	Classical
XXVII	-	-	-		-	-	?
XXVII	-	-	-		-	-	Classical
XXVIII	-	-	-		-	-	Hellenistic
XXIX	-	-	-		-	-	Classical
XXIX	-	-	x		-	-	
XXV	-	-	-		-	-	?

XVI	-	-	x found in reused blocks (dovetail type)		-	-	Hellenistic
XV	-	-	-		x	-	Classical-Roman

B. GLOSSARY

TERMINOLOGY APPLIED FOR HARBOUR SITES UNDER STUDY :

LOCATION	HARBOUR STRUCTURE AS NAMED BY PUBLICATIONS (in english)	HARBOUR STRUCTURE AS NAMED BASED ON THE TERMINOLOGY APPLIED
AKROTIRI-DREAMER'S BAY	Breakwater (Blue et al. 2018 ; Blue et al. 2019)	Mole
AKROTIRI – ELAIA/KNIDOS	Pier (Bouzek 1988)	Breakwater-mole (?)
AMATHUS	East/West/South Moles (Empereur et al. 2018a)	East mole, West mole, South breakwater-mole
CARPASIA	East mole and West mole (Taylor du Plat 1980 ; Taylor du Plat 1981)	East quay (?) West mole
KITION	Quay (Yon & Sourisseau 2010)	Quay
KOURION	Breakwater (Leonard 1995) or Mole (Leonard 1997)	Breakwater (?)
KYRENIA	Mole and Breakwater (Raban 1995)	Breakwater-moles (?)
LAPITHOS	Mole (Raban 1995 ; Nicolaou 1976)	North mole South mole
MARION	Mole (Raban 1995)	Breakwater-mole (?)
NEA PAPHOS	East breakwater West breakwater Spur Secondary breakwater (Hohlfelder 1995)	East breakwater-mole (?) West breakwaer-mole (?) Spur Parallel breakwater
SALAMINA	Breakwater (Raban 1995 ; Flemming 1974)	Breakwater-mole (?)
SOLOI	Moles (Raban 1995)	Moles
TAPOSIRIS MAGNA	Jetty (Boussac 2015 ;2007 ; 2005)	Mole
ALEXANDRIA	Breakwater –Evnostos harbour (Belov 2014)	Mole

TYRE	Mole (Noureddine et al. 2005 ; El-Amouri 2005)	Mole (?)
CAESARIA MARITIMA	Quay (Raban et al. 2009)	Quay
SELEUCIA PIERIA	Breakwater (Pamir 2014)	Mole
ELAIA	Breakwater (Seeliger 2013)	Mole
NEA CNIDUS	Dalgakıranı Mendirek (Büyüközer 2012)	Breakwater-mole (for commercial harbour) Breakwater (military harbour) Quay
HALICARNASSUS	Mendireğe / Mole (Ozdas & Kizildag 2019)	Breakwater-mole (?)
MYNDOS	Mendirek (Dumankaya & Ozdias 2016)	Breakwater (military harbour) Breakwater-mole (commercial harbour) Quay
RHODES	Môle, Jetée (Mazaraki 1997)	Breakwater-moles (?) Jetty (?)
DELOS	Môle (Duchene et al. 2001).	Breakwaters Moles Quays
MYTHIMNA	East /west mole Quay Jetty (Theodoulou 2014)	East /west mole Quay Jetty
MYTELENE	Breakwater Mole (Theodoulou 2014)	Breakwater (?) Mole
ANTISSA	Breakwater Mole/Quay (Theodoulou 2014)	Breakwater-mole (?)
ERESSOS	Jetty (Theodoulou 2014)	Mole
PHALASSARNA	Quay (Hatzidaki 2019)	Quay
AIGINA	North and south breakwater Moles of naval and Commercial basin (Montagu, 1799 ; Mourtzas & Kollaiti 2013) West breakwater	North and south breakwater Moles of naval and Commercial basin Cone shaped piles

	(Mourtzas & Kollaiti 2013)	
THASOS	Môle (Empereur et al. 1993)	Moles
ERETRIA	Môle (Mazarakis 1992)	Breakwater
PIRAEUS	Mole (Loven et al. 2014)	Breakwater-mole

GENERAL TERMINOLOGY APPLIED IN TEXT :

Harbour terminology

Harbourworks : They are the group of structures that define the harbour basin space and contribute to its protection and operability.

Harbour structures : A synonym for the word harbourworks. Harbour structures are artificial or semi-artificial harbourworks that define the space of a harbour basin, protect it, and facilitate its activities. These are breakwater-moles, quays, jetties.

Breakwater : In terms of consrtruction it is a harbourwork that consists of a rubble construction. There are two types of breakwaters natural (such as reefs) and man-made. A man-made breakwater can be seperated into two general categories : a **mound** and **composite breakwater**. The mound breakwater consists of a breakwater with a trapezoidal form (in section) built with rubble (boulders) and a composite breakwater assits other structures such as moles on their seaward side. This breakwater has a tilting direction. In terms of their function they are harbour structures that are usually aligned against the prevailing winds and currents so as to break the energy of the waves (Blackman 1982: 196-198 ; Mauro 2019: 46-49 ; CIRIA et al. 2007 : 793-802 ; HARE 2017 ; Raban et al. 2009 : 64).

Moles : In terms of their construction they are ashlar built structure (on a natural or artificial foundation level) in contrast with the breakwaters as they consist of rubble construction. In terms of function as the breakwaters, they are aligned against the direction of the prevailing winds and currents to break the waves energy but also as surfaces for loading and unloading goods and mooring. Moles and breakwaters can be found side by side in the form of a breakwater-mole were the breakwater is located on the seaward side and the mole on the leeward side (HARE 2017 ; Raban et al. 2009 : 64 ; Mauro 2019: 46-49 ; Blackman 1982: 196-198).

Quays : There main charateristic is that they are in direct contact with the land (parallel to the coast) and not projecting into the sea. In terms of construction it is usally ashlar built and in some cases rock-cut. Its main function is to facilitate loading and unloading of goods, mooring of ships while creating an interface between the sea and the shoreline (Blackman 1982: 202-204 ; Mauro 2019: 53-55 ; Raban et al. 2009 : 65-66 ; HARE 2017).

Jetties : Jetties are harbour structures that project from the shoreline (i.e from a quay or a beach) or even from a mole towards the sea. In terms of construction they are ashlar built.

They are constructued to create extra space for mooring in the harbour basin as also to divide the harbour basin into different areas of function such as in the case of Munichia's harbour of Piraeus (Raban et al. 2009 : 65-66 ; HAFEN 2017).

Bollards/Mooring Stones : They are elements (made of wood or stone) on which ships would moor to the moles and quays (Mauro 2019 : 53-54 ; NAVIS).

Shipsheds (neosoikos): A shipshed is the house of the ship and is included in the harbour facility category. It's the place were the ship is stored when it is not in time of use. The shipsheds are located along the shore (on the interface) which facilitated the beaching as also to be ready and easily launched in the sea in case of an emergency. It other words it was a covered slipway, a shed for the ships. They are mainly a charachteristic of a military harbour (Blackman 1982:204-206 ; Baika 2009: 435 ; Mauro 2019 : 55-59 ; NAVIS)

Shipyards (neorio) or Dock-yard: A shipyard is an area designated for the construction or repairing of ships. These areas have been identified with great difficulty as no unique structures can be attributed to this area. They were probably less permanent than most other harbour installations, like the timber grids and slips still seen in the Aegean today, and would have left little trace (Blackman 1982: 207 ; Baika 2009: 434 ; HAFEN 2017 ; NAVIS).

Anchorage : Anchorage is a naturally protected basin where ships tend to find shelter during long voyage or in time of strong winds. They are generaly not enhanced with any man-made harbour structures such as breakwaters-moles or quays. Nor are they forcley directly linked with a coastal settlement (HAFEN 2017).

Harbour : Harbour is the term used to adress man-made or semi-artificial harbour basins that where used for anchorage. A harbour is also directly linked with a coastal settlement (HAFEN 2017 ; NAVIS)

Closed Harbour : An extensive bibliography discusses the term λιμὴν κλειστός rendered in English as «closed/ closable/enclosed harbour». This term was used by the ancient navigators to describe a certain category of harbours located in the Aegean (i.e. Pseudo-Scylax). As the use of this term in ancient nautical texts remains to be clarified. The discussion on this term dates back to the 19th century (Ardaillon 1898: 33). Lehmann-Hartleben, defined a *λιμὴν κλειστός* as a harbour within the city walls, controlled by the city (Lehmann 1923 : 65-74). Von Gerkan interpreted the term as the extension of the city walls into the sea, eventually closed by chains (Gerkan 1924 : 113-114). Rougé was the first to associate the phrase with military harbours (Rouge 1966 : 116-117). Casson stated that the principal characteristic of a *λιμὴν κλειστός* was the harbour's fortifications, meaning that the city walls extendend on the moles ending in towers (Casson 1971 : 362-363). Similar interpretations of the term were given by Raban, Blackman, and Baika (Raban 1995 : 163 ; Blackman 2008 : 654 ; Baika 2009 : 435). The multiple definitions proposed led to a combination of interpretations. For instance, Moreschini based on Lehmann-Hartleben's, von Gerkan's, and Rougé's interpretations, stated that the term is associated with artificial basins equipped with defensive structures to close the entrance and possibly also linked with the city's fortifications (Moreschini 1997 : 344). Bonnier too based on pre-existing interpretations supported that this term reflects the harbour fortifications and military character of the harbour (Bonnier 2008 : 49-50 ; Mauro &

Gambish 2020 : 59-61). Despite the richness of this discussion, the definition that seems to prevail is a harbour basin included in the city's fortification.

Inner and Outer basin : Harbours with two or more harbour basins are divided into inner and outer basin. Inner basin is the one located towards the land (with an indrirect contact with the sea) and the outer is in direct access to the open sea (HAFEN 2017 ; NAVIS).

Access channel : It is the underwater channel that provides acces to a basin through the dreging or excavation of the seabed so to permit the navigation of ships in and out of the basin (CIRIA et al. 2007).

Construction of harbourworks terminology

Harbour construction techniques : They consist the masonry and material used for the construction of a harbour structure.

Foundation level : The foundation level of a harbouwork is the layer of preparation that provides a stable foundation on which the upper structure is located.

Upper structure : The upper structure of a harbourwork is the structure built above the foundation level that depasses the surface of the sea (i.e. a mole, a quay, a breakwater).

Polygonal masonry : Masonry identified in the lateral face of a structure where the blocks have multiple sides giving the form of a polygon to the profile of the block (Ginouves & Martin 1985 : 97-98 ; Orlandos 1968 : 139).

Isodomic masonry : Masonry in which all the courses, built of rectangular ashlared blocks, are of equal height (Ginouves & Martin 1985 : 98-99 ; Orlandos 1968 : 139).

Pseudoisodomic masonry : Masonry built of blocks of the same height within each course, but each course varies in height. (Ginouves & Martin 1985 : 98-99 ; Orlandos 1968 : 139).

Joints : Elements used to join, bind the ashlar blocks of the upperstructure (i.e. clamps, mortar) (Orlandos 1968 : 99-119).

Dry construction : Consists the deposition of the stones in such a way so as to create an interlocking effect offering a stability to the structure without the use of binding material (clamps, hydrolic cement etc.) (CIRIA et al. 2007 :778).

Rubble structure : A structure (i.e. breakwater) built solely of rubble.

Rock-cut is the technique of carving the natural stone so as to creates harbourworks (i.e. quays, seawalls) (Raban 1995).

Rows : Rows refer to the parallel lines of blocks.

Courses : Courses are consecutive horizontal layers of blocks.

Rubble : Consists of boulders, unworked stones of large dimensions.

Blocks : are worked stones (headers and strechers).

Clamps : were elements that used to join ashlar blocks for the construction of buildings in this case the upperstructure of breakwaters-moles. They could have been made from metal or wood. They are generaly dated between the Classical and the Hellenistic period and were gradually replaced with the introduction of hydrolicmortar.

Stones/ Amorphous stones: They are unworked blocks of stones of medium size.

Gravel/Debris : The debris from the cutting of the ashlar blocks, or fragments of unworked stones.

Ashlar blocks : They are worked, well cut stones that are usally used for the construction of the upper structrure of the mole or quay.

Strechers and headers: These are two types of arranging ashlar blocks for the construction of walls and other structures. Strechers are the blocks positioned on the wall with the longest sides visible. Headers are blocks positioned on the wall with their shortest side visible.

C. HARBOUR STURCTURE DOCUMENTATION WORKSHEET

HARBOUR DOCUMENTATION FORM

GENERAL INFORMATION ON THE SITE :

Site Name :	Location:	Date :

GENERAL DESCRIPTION OF THE HARBOUR STRUCTURE :

1) Type of harbour structure (quay, breakwater-mole, jetty etc.) :
2) Location and orientation :
3) Dimensions : Lenght, preserved height, width) :

CONSTRUCTION MATERIAL AND TECHNIQUES :

1) Harbour construction material (stone, gravel, wood etc.) :
2) Provenance of material :
3) Binding material (plaster, opus caementicium, clamps) :
4) Blocks positioning (strechers and headers):
5) Block dimensions :
6) Lifting mortises :
7) Foundation level description (height, width, nature) :
8) Upper structure description (height, width, number of rows etc.) :
9) Traces of tools :

CHRONOLOGY :

1) Indicators :
2) Estimation :
3) Phases of construction :

OTHER :

1) Relation to other structures, facilities (mooring stones, ramps etc.)
2) Functionality
3) Relation to fortifications :
4) Additional elements (channels, bastions etc.) :

METEOLOGICAL DATA :

1) Prevailing wind direction and wind scale :

2) Prevailing current direction :

3) Tide range :

GEOHAZARDS :

1) Description of geo-hazards (erosion, siltation etc.) :

GEO AND BIO DATA :

1) Presence of biological indicators :

2) Presence of geological indicators (i.e. beachrock) :

3) Below present sea level (upper part of preserved structure) :

4) Below present sea level (foundation level of preserved structure) :

5) Indications for uplift or submergance :

PLANS, SECTIONS AND PHOTOS (aerial and submerged) :

COMMENTS :

D. AN OVERVIEW OF THE ISLAND'S HISTORY AND ITS HARBOURS FROM THE BRONZE AGE TO THE ABOLISHION OF THE CYPRIOT POLITIES.

A brief introduction to the island's history from the Bronze Age to the Hellenistic period, parallel with a brief reference to the harbourworks dated to the periods under study. Why though from the Bronze Age to the Hellenistic period ? Despite the fact that harbourworks from the Bronze Age do not survive it is from this chronological period that we can identify the factors that led the inhabitants of the island to invest gradually in the construction of harbourworks. On the other hand, the Hellenistic period was chosen as an ending point to this brief introduction of the island's history as this study focuses on the Classical and Hellenistic harbourworks. The Hellenistic period is marked by an important political change, that of the abolishment of the Cypriot Polities which impacted the island's harbour network development. The « abandonment » of major harbourwork projects on the island (i.e. Amathus, Marion & Carpasia) according to Theodoulou (2006 : 230-231, 236, 239) and the spreading of the habitation outside the Cypriot polities of the Classical period leading to the establishment of new anchorage sites (Leidwagner 2013 : 223-228 ; Bekker-Nielsen 2004: 99–100, 230) justifies the disicion to end the introduction to this period.

PERIOD	DATE
FHILIA PHASE	**2500-2350 BC**
EARLY BRONZE AGE	**2400-2000 BC**
MIDDLE BRONZE AGE	**2000-1700 BC**
LATE BRONZE AGE	**1700-1050 BC**
GEOMETRIC PERIOD	**1050-750 BC**
ARCHAIC PERIOD	**750-475 BC**
CLASSICAL PERIOD	**475-310 BC**
HELLENISTIC PERIOD	**325-50 BC**

Table 2.2: Main chronological periods for Cyprus after Kardulias P. (2015) and Satraki, A. (2012).

The Cypriot Bronze Age starts with the **Filia Phase** which according to Porfyrios Dikaios, this was a period of transition from the Chalcolithic period, marked by a series of novelties in the sector of pottery, funerary customs and architecture. These changes have been attributed to either external factors (establishment of communities from Anatolia on the island) or internal changes of the island which were indirectly influenced by the surrounding region (Webb 2013b 61-62 ; Peltenburg 2007: 144). This phase was followed by the so-called **Early and Middle Bronze Age** (also called Prehistoric Bronze Age by Knapp in his book *The archaeology of Cyprus).* These periods are characterized by the first attempts of copper extraction and exportation (Webb 2018 : 2 ; Kassianidou 2017 : 113), as also an augmentation of settlements in the hinterland (near the copper sources) and the coastline. Mainly these two periods are studied through necropolis. Such are, Vasilia, Bellapais-Vounous, Lapithos-Vrysi toy Barba, Karmi-Lapatsa, Palealona, Dhenia-Kafkalla, Nicosia-Ayia Paraskevi, and Marki-Davari. However, some settlements of this period were also excavated such as Makri-Alonia and Kissonerga-Skalia. These necropolis and settlements reflect the first structured societies of the island. During this time in the Eastern Mediterranean more complex forms of societies prevailed such as the Minoan culture in Crete, Egypt's New Kingdom, Levantine coastal city-states (Byblos and Ougarit) and the Hittite empire. Nevertheless, during this time a network of exchange with the Aegean and the Eastern Mediterranean was gradually established where Cypriot pottery and copper was exported, on a rather small scale though (Satraki 2012: 57-62, 71-80 ; Iacovou 2005: 18-19 ; Charalampous 2020: 47-81 ; Bolger & Webb 2013: 50) (**Map 2.1**).

By the **end of the Middle bronze age and the beginning of the Late bronze Age** (Protohistoric Bronze Age by Knapp in his book *The archaeology of Cyprus*) a diminution in the Prehistoric Bronze Age settlements is attested while in the meantime the establishment of new settlements and forts, attest a period of transition from the prehistoric landscape (Keswani 2004 : 84-6, 154-7; Satraki 2012 : 100-1). There seems to be a classification of sites such as centres of trade, agriculture, and copper production. These new sites were Hala Sultan Tekke, Kition, Kalavassos-Ayios Dimitrios, Alassa, Episkopi Pampoula, Enkomi-Ayios Iakovos, Morphou-Toumba tou Skourou and Maroni-Vournes. These created the foundations for a social, economic and political system that would later on lead to the autonomous Cypriot polities, harbour cities. In addition, an augmentation of imported goods from the surrounding area as also the distribution of Cypriot goods attest the intensification of trade. This period of transition of two centuries led to the establishment of the Late Bronze Age settlements and a more clear settlement hierarchy (Satraki 2012: 81-84).

In the **Late Bronze Age** the distribution of Cypriot copper and pottery in the Mediterranean reaches a significant peak while monumental architecture in the form of public and sacred buildings appear by 1200BC in Kition and Paphos (Palaepaphos) (Webb 1999, 58–84, 292). An increase of coastal settlements can be also noticed. As an example Enkomi-Ayios Iakovos and Morphou Toumba tou Skourou, catered the need to import and export goods. Enkomi- Ayios Iakovos is an exemplary settlement for this period as it attests a fort, living quarters, sanctuaries, workshops and burials (Satraki 2012: 90-96). The driving force that led to the so-called "belated urbanization" (formation of Cypriot polities) was the intensification of need to extract and export copper. Parallel to that, the first form of inscription (Cypro-Minoan script) is identified on the island, in Enkomi (Iacovou 2005: 19). Textual evidence referring to the commercial role of Alashia (Cyprus) such as the Amarna letters, Mari, Babilonia and Alalakh texts testify the importance of the island in the Late Bronze Age commerce (Steel 2014 : 582 ; Mantzourani et al. 2019 : 96-7).

By the **end of the Late Bronze Age**, there are signs of destruction in certain sites of Cyprus such as in Kalavassos-Ayios Dimitrios, Enkomi and Hala Sultan Tekke a fact also attested in the rest of the Eastern Mediterranean. This was a result of the 13th century BC socio-political and environmental crisis in the Mediterranean which first diminished the need for cooper supply and therefore the need for the existence of certain settlements (Satraki 2012: 190-194 ; Iacovou 2014a: 661). Late Bronze Age sites continued to exist (i.e. Idalion, Kition, Palaepaphos) while at the same time the foundation of new settlements in the Early Cypro-geometric period that would later to be the so-called Cypriot polities was initiated (Knapp 2013: 447 ; Satraki 2012: 130-133 ; Iacovou 2005: 20). Trade continued as pottery inspired by the Levant is produced on the island, base-ring and White Slip pottery is exported to the Levantine coast, Egypt and the Aegean while Canaanite jars, Cretan and Mycenaean pottery are found on the island (Charalampous 2020: 199-202 ; Papadimitriou 2017 : 164-169). From this brief introduction of the island's history it has become evident that the sea had a major role in the transportation of goods, the arrival of conquerors and new influences on the island. Therefore, the existence of anchorages and harbours was imperative to assure safe arrival and departure.

The earliest evidence of a coastal settlement linked to an anchorage is that of Hala Sultan Tekke (**Fig**. **2.4**) that dates back to the end of the Middle Bronze Age and the beginning of the Late Bronze Age. Although this site does not preserve any kind of harbour structures, the quality and quantity of imported goods found on the site from the Aegean, Egypt and probably also Asia Minor (Fisher & Burge 2018 : 613-616), as well as the anchors (Astrom et al.) 2007 in combination with the protected lagoonal environment that the geoarchaeological studies have indicated (Devillers et al. 2014: 73-80 ; Gifford 1978) point towards the existence of an anchorage that served the import and export of goods via sea routes.

Moving on to the **Cypro-geometric period** (Early Iron Age), it is mainly attested through necropolis. The settlements established in this period are Kourion, Amathus, Marion, Soloi, and Lapithos. Salamis is one of the new settlements that due to the siltation of the navigable Pedaios river was founded to facilitate Enkomi with a harbour. Although information for the Cyprogeometric period is retrieved mainly from tombs, their richness in imported goods indicates the continuation of trade as well as the existence of a social hierarchy. Also, during this period an attempt to identify evidence for the establishment of the autonomous Cypriot polities is sought. This opens an important discussion concerning the formation and organization of the Cypriot polities. For some this social organization derives from the Greek world through the Mycenaeans that in the 12th century BC (Late Bronze Age) arrived as merchants on the island while for others the Phoenicians that controlled Kition as their colony in the 9th century BC influenced the political organization of the island (see Satraki 2012: 163-166 for bibliography). However, as Iacovou has supported in a series of articles "as long as a foreign model is sought to explain and describe Cypriot kingship, every effort is bound to fail" (Iacovou 2007 ; Cannavo 2008: 41). This new form of socio-political organization must be understood from the point of view of a long term process of social evolution that started since the Bronze Age (Iacovou 2007 ; Cannavo 2008: 41). In addition, during this time the so-called Cypro-minoan script evolves into the Cypro-sylabbic writing. Concerning trade, from the Cypro-geometric tombs it is evident that Cyprus had access to precious raw materials. Cyprus also exported metal artefacts (tripods, knives etc.) which were found in Crete, while Cypro-geometric pottery is found in the Levantine coast (mainly) and the Aegean (Iacovou 2014b: 801-804).

The **Cyproarchaic period** (750-475 BC) begins with the rise of the Assyrian Empire and the incorporation of the island under its control. However, the Cypriot Polities (**Map** 2.3) managed to keep their autonomy by functioning as centres of accumulation of goods. Important inscriptions from this period testify the existence of autonomous polities. For instance, the Sargon II stele, the Esarhadon, and the Assurbanipal prisms refer by name to the autonomous Cypriot polities as paying taxes to the Assyrian king. Although the names of the kingdoms have not been all identified and some attributions are still under discussion, we can understand the political organization of this island (Cannavo 2008: 41 ; Satraki 2012:187 ; Iacovou 2014b: 795-801). During this period Paphos, Salamis, Kourion, Amathus, Idalion, Kition, Lapithos, and Marion are the main settlements of the island of Cyprus and expansion of trade towards Northern Greece, Italy, the Ionian Coast of Asia Minor and the Levant is observed (Iacovou 2014b: 806-807). An Egyptian influence in the late 8th century on the material culture (sculpture, votive objects etc.) is also attested which is interpreted by some as Egyptian dominance over the island. However, this cannot be sustained by the archaeological record (Iacovou 2014b: 809-810). The fragmentary arcaheological visibility of the remains of the first phase of the Cypriot Polities do not allow any elaboration on the potential existance of harbourworks dating to this period.

In the **Cyproclassical period** (475-325 BC) the Cypriot polities continued to preserve their autonomy (despite their continuous revolt against the Persians), produced their own coins and were in continuous antagonism between each other (Kition and Idalion). An important event was the Ionic revolt 499/498 BC in which all the Cypriot polities (except Amathus) participated. King Onisilos of Salamis was a prominent figure in this event. He united all the kingdoms of the island against the Persians however, with no success as the rebellion ended with his death. The expedition of Kimon to free Cyprus from the Persian rule (450-449 BC), ended with the death of Kimon and the "peace of Kallia" which prohibited Athens to interfere with Cyprus (448 BC). However, King Evagoras B' of Salamis (411-343 BC) continued the battle against the Persians. His wars did not grant the expected freedom but the "peace of the Great King" (379 BC) was agreed under which king Evagoras B had to pay increased taxes to the Persians while preserving the autonomy of the Cypriot polities. The end of the Persian occupation on the island came with the wars of Alexander the Great against the Persian Empire. After the battle of Issos in 333 BC, the kingdoms of Cyprus became allies of Alexander the Great as he was the new supreme power in the area and supported his expeditions by supplying him with army and fleets (Iacovou 2014b: 812-815).

During this time, the first archaeological evidence of harbourworks on the island is visible in some of the Cypriot-Polities and other coastal settlements. Kition's shipsheds, the only excavated on the island, are dated to the Classical period and were in use up to the Roman times (Sourisseau & Yon 2010 ; Mckenzie 2013: 349-361). Soloi (Theodoulou 2006 : 209-210), Lapithos (Raban 1995 : 165 ; Theodoulou 2006 : 201-202), Elaia/Knidos (Theodoulou 2007:219), Salamis (Theodoulou 2006: 175-184 ; Raban 1995: 163-164 ; Flemming 1974: 166-167) and Kyrenia (Theodoulou 2006: 185-196) also preserve harbourworks that have been generally dated to the Classical period however this relies mainly on the references of ancient writers rather than substantial archaeological evidence.

In the **Hellenistic period** (325-50 BC), with the death of Alexander the Great, the Cypriot polities supported different generals of Alexander the Great (Satraki 2012: 204; Collombier 1993: 127-138) such as Ptolemy, Antigonus, and Perdiccas. In 321 BC Perdiccas found out that Salamis, Paphos, Soloi, and Amathus became allies with Ptolemy. According to Arrianus, Perdiccas sent forces to intervene in Cyprus however it is not known what was the outcome of the event (Arr. 80.1). What is clearly known to us is that the main powers that competed for Cyprus were Ptolemy and Antigonus (Balandier 2002: 329). In 315 BC, Ptolemy became an ally with Amathus, Salamis, Soloi, and Paphos, while Kition, Lapithos, Kyrenia, and Marion supported Antigonus. Menelaus and Seleucus were sent by Ptolemy to take under control the kingdoms that were allies with Antigonus. They managed to conquer all of them except Kition. This led in 312 BC to the killing of the King of Kition by Ptolemy, the arresting of the king of Lapithos and Kyrenia and the destruction of Marion. Salamis king, Nikokreontas became a stratigos of Ptolemy as he was the most faithful and trustworthy of the kings of Cyprus (Diod. 19.79). Ptolemy's reign was interrupted between 306-294 BC by Demetrius Poliorkites, Antigonus son. He landed in Carpasia's region and managed to take control of the rest of the island after the battle in Salamis. Once he took Cyprus under his control he attempted to conquer Rhodes and Egypt without any positive results. Ptolemy recaptured Cyprus in 294 BC, and it was under Ptolemaic control until the Roman occupation in 58 BC. Ptolemy's reign brought the autonomous Cypriot-kingdoms to a definite but gradual end (Iacovou 2014c: 163; Satraki 2012: 223-224 ; Theodoulou 2006: 241-244, 246-249, 231; Papantoniou 2013: 178-181). It must be underlined though that for Cyprus the Diadochi wars can be considered to last till 294 BC, when the Ptolemies take permanent control of the island. However, in the Eastern Mediterranean the conflict between the Diadochi continues in the form of the so-called Syrian Wars. The Ptolemaic control over the island "lifted for the first time the territorial boundaries of the Cypriot polities" (Iacovou 2007: 464). This led to the abolition of the Cypriot-Polities and the transition from the basiliea (the kings of each Cypriot polity) to stratigeia (strategos –representative of the Ptolemaic control on the island). Although the first strategos was based in Salamis the power was then later transferred to Nea Paphos as it was in closer proximity to Alexandria. This change in the socio-political organization of the island led to a gradual formation of the *koine* (Papantoniou 2012: 154) meaning a local identity that consisted of common traditions such as artistic patterns, architectural trends and common cults. Despite these significant changes Cyprus never seized to be an actor in the maritime trade. On the contrary it became a station for Alexandria that linked the Aegean with the Eastern Mediterranean (Dobosz 2013: 217; Michaelides & Papantoniou 2018).

Despite these turbulent times, a series of harbourworks have been dated to the Early Hellenistic period. Amathus outer harbour basin has been dated to the early 4th century BC (Empereur et al. 2018 a-b). Nea Paphos a city built by the end of the Classical period and the beginning of the Hellenistic period, posses a series of harbourworks dated to the Hellenistic period (Nicolaou 1966 ; Dasweski 1987 ; Hohlfelder 1995). Marion preserved a breakwater-mole (?) dating probably also to the Hellenistic period (Theodoulou 2006 : 258, 260) and Carpasia's harbourworks were also dated in the 4th century by Lehmann and Theodoulou (Lehmann 1923 : 257 ; Theodoulou 2006 : 228-229) although J. du Taylor (1980 : 228) dates the harbour to the Roman times. Finally, Dreamer's bay mole although the research is still ongoing according to the prelimenary reports it may date to the Hellenistic period (Blue et al. 2018 ; Blue et al. 2019) eventhough based on the coastal remains of the site it may also have been built in the Roman period.

This brief overview of the island's history points towards the fact that the cypriot polities were the dynamic that generated the need for the investment in harbour infrastructure. The political organization of the island consisting of autonomous polities led to the construction of major harbourworks along the coast that could reassure the safe arrival and departure of imports and exports. Having identified this many questions arise. Did each polity had its own harbour builders ? How were these projects financed and organized ? Unfortunatley the only still standing evidence of their existance, and the human effort that was invested remains only as a reflection in the harbourworks preserved till today.

E. RELATIVE SEA LEVEL CHANGE IN CYPRUS.

Sea level according to Lambeck and Purcell is « the position of the sea surface relative to the adjacent land » while the *sea level change «* is the measure of the relative shift in position of these two surfaces » (Purcell & Lambeck 2005 : 1969). This shift in the position of the two surfaces is triggered by the eustatic – isostatic sea level rise and the regional tectonic movements (Özdaş et al. 2019 : 19). These changes can be defined respectively as eustatic and relative. Eustatic changes « are driven by different processes that cause changes in the volume or mass of the world ocean and result in globally uniform mean sea level variations » and Relative changes are identified on a local level and are caused by « land uplift or subsidence that can result in, respectively, a fall or rise in sea level (Rovere et al. 2016 : 222).

Eustatic changes : Eustatic and Isostatic processes

Eustatic and Isostatic processes effect on a global and local level the sea-level. These processes are linked with the melting of the ice-caps during glacial effectl and interglacial periods. Although their impact and estimation has been under discussion (Lambeck 1995 ; Lambeck & Brad 2000 ; Lambeck et al. 2004) the extent of effect these process have on a local level is minimal. Eustatic processes refer to the factors that influence the quantity of water in the basin. Specifically, periods of glaciations are characterized by the formation of ice sheets on land, and lower water density in the basin while interglacial periods, which represent periods were the ice caps melt the quantity of water in the basin augments (Rovere et al. 2016 : 221). On the other hand, isostatic processes refer to the reaction of the earth triggered by the change of quantity of the water in the basin meaning « the uplift and/or the down warping of the marine basin » due to the eustatic processes (Rovere et al. 2016 : 222 ; Stewart & Mohrange 2009 : 390-393).

Relative changes : Tectonic movements

The Mediterranean Sea is an active tectonic area due to the multiple tectonic plates (such as the Eurasian, African and Nubian plate) and a number of sub-plates and crustal blocks (i.e. Alboran, Hyblean-Malta, Aegean, Anatolia and Sinai) that consist the basin (Stewart & Morhange 2009 : 388-389). The creation of the Mediterranean Sea itself was the result of the tectonic movements that took place 80 million years ago (Mohrange & Gassend 2007 : 19). This mobility, led to a series of sudden and gradual events such as the Messinian Salinity crisis which consisted of the shallowing of the Gibraltar strait that connected the Mediterranean with the Atlantic (around 5 million years ago), the volcanic eruption of Vesuvius and Santorini, and the +9m uplift on the west coast of Crete where Phalassarna's harbour was located. Numerous earthquakes have been documented by ancient sources, and are attested in the archaeological record.

Research on RSL change and coastal geomorphology research on the Island of Cyprus

Having taken into account the above-mentioned factors it is important to refer to the research that has been conducted on the island concerning the RSL change. Cyprus location between the two tectonic plates of the African and Eurasian plate (**Fig. E.1**), on the eastern end of the Hellenic arc renders the island under « intermittent seismic movement » (Flemming 1978 : 406) which leads to phenomenons of uplift and submergence. Parallel to that, the phenomenon of subsidence in the southeast Mediterranean affects a series of coastal sites (Fabre and Goddio 2010: 54-55). From a local point of view coastal progradation due to the active rivers in relation to the long shore drift altered significantly the coastline through the transportation of sediments.

This presentation of research will take place in terms of two geographical regions, the North and South coast of Cyprus. The research that has been conducted till now on the island investigated mainly two parameters the vertical movements (tectonics) through beach rock analysis, notches and marine deposits and the second parameter is the coastal progradation due to the sediment transportation which seems to affect mainly the South coast of the island.

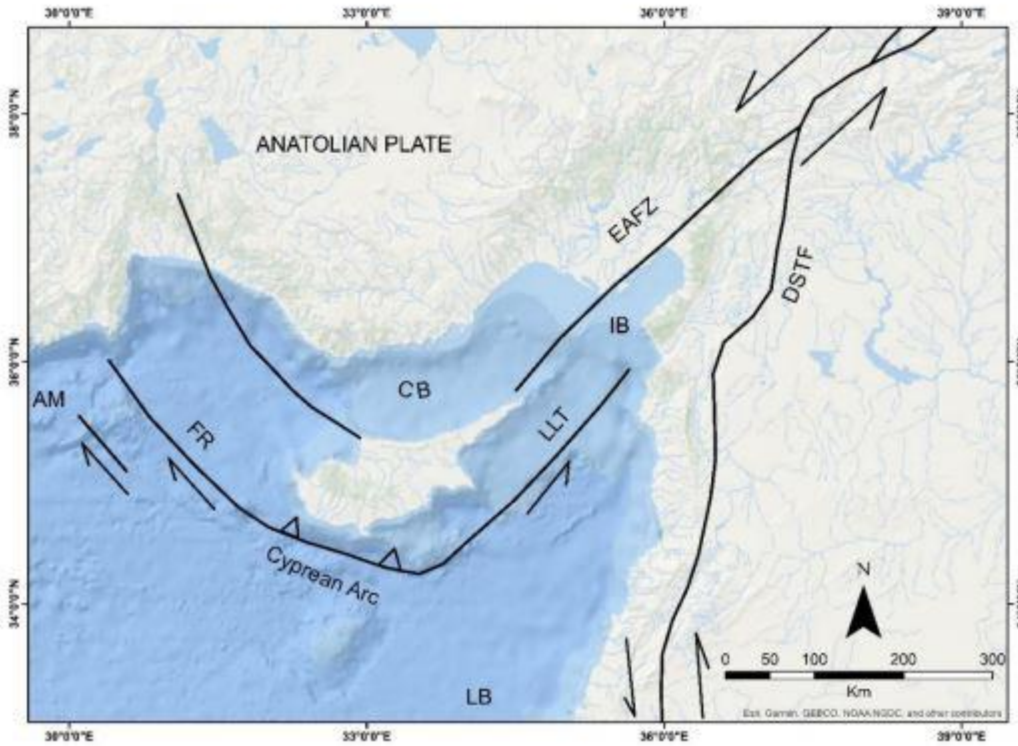

Figure E.1: Simplified tectonic framework of the eastern Mediterranean, (where AM is the Anaximader Mountains, CB is Cilica Basin, DSFZ the Dead Sea Transform Fault Zone, FR the Florence Rise, EAFZ the East

Anatolian Fault Zone, IB Iskenderun Bay, LLT Latakia–Larnaka–Tartus ridges, LB Levantine Basin) (Evelpidou et al. 2020: fig.4).

North Coast

Flemming's paper in 1978 titled *Holocene eustatic changes and coastal tectonics in the northeast Mediterranean: implications for models of crustal consumption* compiled the results of the first ever survey to be conducted along the entire coastline (in total 32 sites were visited) of the island. His measurements were based on geological indicators (i.e coastal deposits, notches) and still standing archaeological remains which were dating through ancient sources and pottery (Flemming 1978 : 410-420) **(Fig. 2.7)**.The north coast of Cyprus according to his results is relatively stable (Flemming 1978: 145). The sites taken into account were the following : Lapithos, Kyrenia, Soloi, Kormakiti and Carpasia. No submergence or uplift was detected. This is something which is not at all alarming since today archaeological remains such as the harbour structures of Carpasia remain visible in the surface. Similarly, Lapithos breakwater-mole was still visible in the surface in the 1960s prior to the modern harbourworks indicating no significant change in the sea level (Theodoulou 2006 : 202). Kyrenia's harbour structure however questions this fact. As Raban observed the ancient harbour structures and more specifically the so called « flat platform » of around 2 m height was located at -4 m depth from the present sea-level (Raban 1995 166 ; Theodoulou 2006 : 192-193) (see Catalogue entry VII).

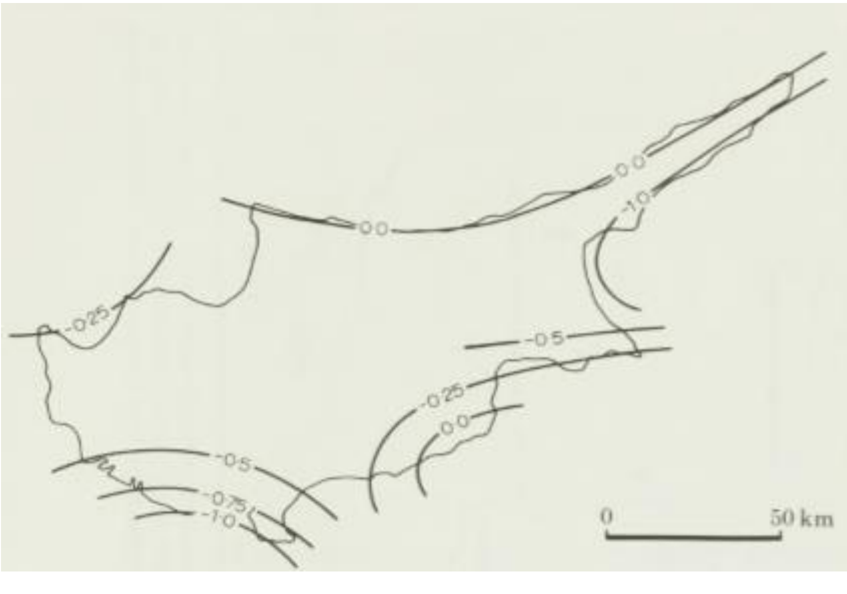

Figure E.2 : Coast displacment in Cyprus in meter per millennium according to Flemming (Flemming 1978: 435, fig.12).

Recent studies in the now occupied North Coast brought to light a more detailed understanding of the coast. The beachrock analysis conducted by Zeynel and Evren indicated that between 5.500-2.300 BP sea level was 1.5 m lower than the present. It gradually rose arriving to a relative stability (meaning the current sea-level) in 2000 BP (Zeynel & Evren 2015: 7) which corresponds to the period when the first harbour structures were built. Galili's survey was the second to take place along the entire coastline of Cyprus. He cross-referenced archaeological (i.e. fishtanks, submerged structures), geological (i.e beach deposits, notches) and biological (i.e. paleomolusc species) indicators and concluded that in the Holocene period along the North Coast a vertical uplift of around +0.6 m in Carpasia, +1.4 m on the North-East coast, and +0.2 m in the central part of the northern coast took place. While in the Late Holocene an uplift of +0.1 m on the Carpasia Peninsula, and approximately an uplift of +0.04 m on the northern central coast (Galili et al. 2015 : 213) was identified. Nevertheless, the method by which these measurements were produced remains unclear in the publication and should be used with care. In any case, these measurements do not point out to any dramatic change as Flemming had initially documented.

South Coast

Concerning, the southeast coast of Cyprus Flemming visited the following sites : Salamis, Kourion, Ammochostos, Capo Greco, Amathus, Dreamer's Bay, Nea Paphos, Lara, and Marion. Flemming's measurements between Dades and Amathus indicate a stability while for the rest of the coast a variety of measurments between -2 m and -0.10 cm indicated submergence (**Fig. 2.7**). The south coast underwent further study providing a more detailed understanding of the coastal evolution. Concerning the southeast coast (from Mazotos to Paralimni) based on the study Dalongeville, the radiocarbon dating of malacofauna retrieved from ancient beach deposits indicated the existance of three paleobeaches. It was estimated that the ancient sea-level (in relation to the present) around 4800 BP was + 2 m high, in 3000-2000 BP was +1 m high and 800-600 BP was +0,60 m higher than the present sea-level. (Dalongeville 2000: 13, 19). On the other hand, Galili's survey pointed out the vertical uplift in the Holocene, around +1 m in the west coast, +0.04 m on the southern coast, +1 m at Cape Greco and +0.1 m in Famagusta Bay. While in the Late Holocene very few changes in the sea level can be identified, about +0.2 m on the west coast, less than +1 cm on the south coast, around +0.2 m at Cape Greco and approximately +0.024 m at Famagusta Bay (Galili et al. 2015 : 213). Once more the measurements presented by Galili must be used with care since the method applied to conclude to these measurements remains unclear.

The south-west coast of Cyprus according to Giangrande's geomorphological study noted a coastal uplift. According to the study of molluscan fauna retrieved from the paleoshorlines located between Maa-Paleokastro and Lara, an uplift of the coastline (ranging from 100m to 0m above sea level) due to coastal tilting was observed (Giangrande 1987: 187-189). Zomenis PhD thesis titled *Quaternary Marine Terraces on Cyprus: Constraints on Uplift and Pedogenesis, and the Geoarchaeology of Palaipafos* analysed the coastal uplift of Palaipafos from the Pleistoscene to the Holocene through the study of marine terraces, soil deposits and geoarchaeological indicators. This resulted in identifying the highest uplift rate on the coastline with (0.35-0.65 mm/year) leading to the siltation and abandonment of the harbour/s of Palaipaphos (Zomeni 2012 : 271-273).

These recorded changes of the sea level are a product mainly of the seismic activity (Relative changes) that afflicted the island. As mentioned above, the location of Cyprus on the Hellenic Arc had indeed an impact on the coastal sites of the island. Indeed, ancient sources reference to the affliction of the island and the surrounding region by earthquakes (**Table 4.3**).Most affected areas of the island though, seem to be the south central coast of Cyprus as there a fault system (Trakhoni, Arakapas, Yerasa fault) is located which renders till today this area the most seismically active of the island (Soula 1999).

Coastal progradation on the island of Cyprus

On the other hand, we must not forget to mention the important studies which focused on the coastal progradation caused by the sediment input of the fluvial activity, and long-shore drift. Various ancient sites such as Enkomi, Salamis, Kition and Kourion underwent important coastal progradation due to the presence of rivers in their vicinity (Pediaos and Giallias, Tremithos, Kouris and Chrysous, respectivley) (Theodoulou 2006: 77-82). The PhD of Devillers (2014 :156-157) reflects the impact that the once active river Giallias of the island had on the east coast of the island. His research focused on the Giallias river which impacted the mobility of the settlements and their harbours due to the coastal progradation. The lack of studies on the rivers of Cyprus are an impediment to our understanding of the impact the coastline evolution had on the harbours of the island. Currently the study of the evolution of the Xeros river in the south coast of Cyprus in the framework of a research project entitled: "Reconstructing the Palaeoenvironment of the Xeros River valley in Cyprus: a geoarchaeological approach" (GeoArchX) has begun under the direction of Dr. Pantelitsa Mylona and hopefully will bring to light new information on the subjet. Two archaeological coastal sites though testify the intense progradation of the coastline, Hala Sultan Tekke (see Gifford 1985 ; Devilleres & Brown 2014) and Akrotiri peninsula (see Polidorou et al. 2020 ; Polidorou 2019 ; Salmon & Blue 2016 ; Salmon & Blue 2018 ; Salmon et al. 2015). In both cases their landscape was heavily altered by the sediment input of Tremithos and Kourion river respectivley.

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