SOMA 2024

Proceedings of the 25th Symposium on Mediterranean Archaeology

Edited by
Mladen Pešić, Luka Bratović
and Doris Kurtov



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Proceedings of the 25th Symposium on Mediterranean Archaeology

Mediterranean – History as it once has been

Zadar, 25-27 April, 2024

Edited by
Mladen Pešić, Luka Bratović
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About SOMA 2024

This interdisciplinary meeting examined navigation and its relationship to cultural and material heritage, fostering deeper insight into the historical, cultural, and economic contexts of the Mediterranean. The conference emphasized innovative approaches to the conservation and interpretation of cultural heritage, engaging related fields such as art history, numismatics, and epigraphy.

Supported by the Ministry of Culture and Media of the Republic of Croatia, the plenary sessions were held at the Education and Presentation Centre for Underwater Archaeology St. Nicholas, within the International Centre for Underwater Archaeology in Zadar (ICUA Zadar). The event was jointly organized by ICUA Zadar; the General Association for Mediterranean Archaeology (GAMA); the Department of Archaeology at the University of Zadar; the Museum of Ancient Glass in Zadar; and the Archaeological Museum Zadar.

As an established international scientific forum, SOMA brings together archaeologists from across the Mediterranean. Previous conferences have been hosted in Turkey, Italy, Slovenia, Spain, Ireland, Russia, Poland, and the United Kingdom, in cooperation with local partners. Its overarching aim is to promote the exchange of knowledge and ideas on the study, protection, and preservation of Mediterranean cultural heritage.

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Legislation management and interpretation of cultural heritage

State management of underwater cultural heritage in Mediterranean waters: the case of the Mazarron 2 shipwreck

Paloma Sánchez Gómez[1] and Rafael Sabio González[2]

Abstract

The aim of the paper is to address the management of Spanish underwater cultural heritage by the Spanish Ministry of Culture, within the specific context of the maritime waters of the Mediterranean. To this end, firstly, we will analyse some generalities about its sphere of competence and the management of the National Plan for the Protection of Underwater Archaeological Heritage. Secondly, and as a specific case, the following will be addressed of the project for the extraction and conservation of the Phoenician-period ship called Mazarrón 2 (Region of Murcia, Spain), which is a good example of the collaboration between the Spanish National Administration and one of the seventeenth regional administrations in the country.

Keywords: underwater archaeology, Mazarron 2, Ministry of Culture, Phoenicians

The management of underwater cultural heritage within the sphere of the Ministry of Culture of Spain

Underwater cultural heritage faces a very particular difficulties, as is the place where it is located: the specific peculiarities of the marine (or aquatic) environment. But not only from a technical point of view, but also from an administrative one. The management of underwater cultural heritage is particularly complex: from identification, to protection, conservation and intervention, to ownership and jurisdiction, at a legal and administrative level.

In Spain, moreover, this context becomes a little more complicated if we consider the territorial organization and the distribution of responsibilities between public administrations. Without going into details, it should be stated that in Spain the jurisdiction of culture[3] are shared between the territorial administrations and the central government, affecting archaeological heritage in particular. It should also be added that the Autonomous Communities, the regional authorities, are responsible for the management of their interior waters and territorial sea, with some exceptions.

On the other hand, Spain, due to its geographical location between two seas, has been a place of passage for civilizations since ancient times. This means that the waters off the Spanish coast, especially on the Mediterranean coast, are home to a large number of shipwrecks and wrecks from all periods. If we leave the Mediterranean area, Spanish Underwater Cultural Heritage (hereinafter UCH) faces another particularity and that is the number of wrecks and shipwrecks of Spanish ships all over the world.

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[3] Articles 148 and 149 of the Spanish Constitution.

Although it is outside the Mediterranean, it exemplifies the difficulty of managing this heritage for the Spanish administration and the need to create specific tools.

The national plan for the protection of underwater archaeological heritage

The National Plan or National Strategy (hereinafter NP) arose because of Spain's ratification of the 2001 UNESCO Convention for the Protection of the Underwater Cultural Heritage. The approval of this Convention was not easy. It was motivated by the doubts that had come up from the 1982 UN Convention on the Law of the Sea (UNCLOS), a text that establishes the rules governing the maritime traffic, rights and obligations of States over the sea and its resources, widely ratified by 169 countries around the world (with notable absences, such as, for example, Colombia or the United States). This text left out, or did not focus sufficiently on underwater heritage, so the UN Culture section drafted a text that took years to be approved and even longer to enter into force. The Convention was adopted on 3 November 2001 at the 31st session of the UNESCO General Assembly. It did not enter into force until 2009, when it was ratified by 20 countries. This shows the difficulty of ratifying this text, which today has 76 Member States (with notable absences, such as Colombia, the United States and a large number of European countries). And this difficulty stems from the obligations deriving from a text that, in many cases, contravenes some countries' own legislation. Only countries with a long tradition in the management of cultural heritage in general consider the ratification of this Convention as something fundamental and in line with internal procedures for action. Moreover, the research and conservation of this heritage requires a large economic investment, which is not always accessible. It is therefore not possible in many countries to adopt a text that excludes or severely limits the involvement of private companies. Even so, great efforts have been made and we find broad ratification in the Latin American countries group, with 21 countries out of 33, and in the Arab countries[4] .

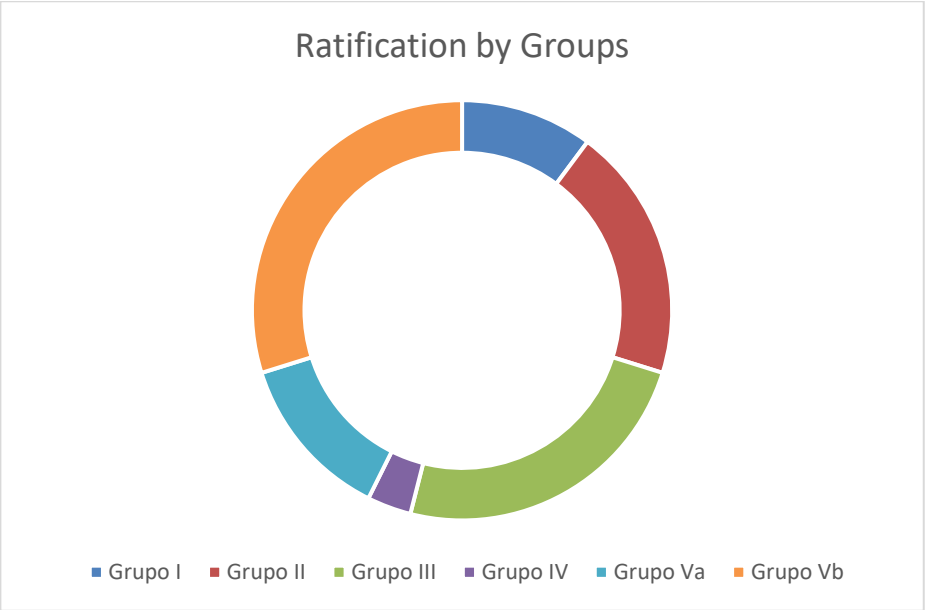


Table 1. Ratifications by Groups

[4] From Group Vb, Arab States, 16 out of 47 have ratified.

Spain was one of the first countries to ratify the Convention, in 2005. From that moment on, a commission was set up to draft the National Plan, which was approved at the Historical Heritage Council[5] held in Cartagena (Murcia) in October 2007, and subsequently approved by the Council of Ministers. The basis for the National Plan was the *Decalogue of measures for the protection of underwater archaeological heritage*.



Figure 1. National Plan cover, with the picture of Mazarron 2 shipwreck.

From there, a Technical Coordination Commission was created, consisting of representatives of the Autonomous Communities, the Armada, the Civil Guard[6], the Ministry of Culture and experts in underwater archaeology. It agreed on the creation of a Working Group for the drafting of the Plan,

[5] This is a coordinating body between the National Administration and the Autonomous Communities, for consensual decision-making in matters of historical heritage. It meets twice a year in plenary session.

[6] Civil Guard is one the national police that exist in Spain. It is the more specialized task force, with a specific group to fight against illicit trafficking of cultural goods and another specific group about underwater activities.

which culminated in the publication of the *Green Book for the National Plan for the Protection of Underwater Cultural Heritage* in 2011. Finally, the drafting and publication of the text of the NP took place in 2015 (Figure 1).

Objectives and basic lines. Structure

The National Plan was based on the *Decalogue*. Work continued on these initial points until the Plan was put into operation. That has been the turning point in the management of underwater cultural heritage in Spain. The fundamental aim is to become the main tool for coordination between public administrations.

The basic lines that constitutes the Plan are those subscribed to in the *Decalogue of measures for the protection of* underwater *archaeological heritage:*

1. *Documentation and inventory*: underwater archaeological mapping throughout the country.
2. Creation of an Integrated *Geographic Information System* for Underwater Cultural Heritage (GIS).
3. Commitment by all Public Administrations to declare the most emblematic underwater archaeological areas of our coastline as *Cultural Interest Assets* (or BIC[7] in Spanish)
4. *Physical and legal protection*: development of a surveillance programme in coordination with the State Security Forces to prevent the looting and destruction of UCH sites.
5. *Training and capacity building*: it is essential to promote training plans in Underwater Archaeological Heritage. To this end, the ARQVA in Cartagena should become a national and international reference training centre in the medium term.
6. *Sufficiency of resources*: adequate budget allocations are needed for the Underwater Archaeology Centres in order to have sufficient human and material resources.
7. *Coordination*: an Interdepartmental Commission will be created to coordinate actions in both the territorial sea and the continental shelf, including the Ministries of the Interior, Defence, Transport and the Ecological Transition.
8. Drawing up an action protocol for *port infrastructure* works.
9. Two *agreements*: the Ministry of Culture and the Ministry of Defence will work together to protect the UCH; and, on the other hand, the Ministry of Culture and the Ministry of Foreign Affairs will collaborate to defend Spanish interests in third country or international waters.
10. *Dissemination-awareness-raising*: an effective policy of awareness-raising, dissemination and revaluation of the UCH needs to be developed.

In many cases, these lines have been maintained, strengthened and given substance. At other points, it has been more complicated to develop them, but always with the aim of continuing to work in this direction.

[7] Bien de Interés Cultural (Cultural Interest Asset): the highest level of protection for Spanish historical heritage assets.

In addition to this Decalogue, two main objectives are set that involve great difficulty and need to be organised: the protection of underwater heritage in Spanish jurisdictional waters and the protection of Spanish underwater heritage in third country or international waters. These two premises give rise to legal, competence and ownership issues within and outside Spain, which make the management of underwater heritage one of the most exciting and complex issues that can be dealt with within the field of culture.

Green Paper and development of the National Plan text

A Green Paper is a tool that sets out the guidelines for action and protocols to be followed in a specific area. This document is the agreed commitment of all the institutions involved and the Autonomous Communities to develop programmes for the documentation, conservation, intervention and dissemination of underwater heritage, as well as its legal protection. All of this, following the provisions of the Annex to the UNESCO Convention on Underwater Cultural Heritage. It also points out the importance of training future generations of archaeologists and specialists. The Green Paper of the National Plan for the Protection of Underwater Cultural Heritage was presented to the Historical Heritage Council meeting in Mallorca on 16 and 17 July 2009, where it was approved.

It is structured according to the points stipulates in the Decalogue, to which it proposes specific actions, possible variables and short-term objectives. It is a document that has been found to be very useful, although it needs updating and a more specific definition in some areas. At the end of the text there are proposals for priority action made up of 32 points and structured in 8 thematic blocks, ranging from the provision of infrastructure to the institutions responsible for management and intervention in underwater cultural heritage, to dissemination and monitoring. These are starting points which, although ambitious, mark out essential lines of action. Currently, like the whole text, it is under revision, although we can affirm that many of these objectives have been fulfilled and/or are under development. It is available on the website of the Ministry of Culture, both in Spanish and English[8] .

Establishment of the Scientific Monitoring Commission and the Interdepartmental Commission

The National Plan includes the creation of an Interdepartmental Commission which is articulated within the need for coordination.

> *"6. Interdepartmental coordination commission.*
>
> *The Government, at the initiative of the Ministry of Culture, shall set up within three months an interdepartmental Commission for the coordination of actions in the territorial sea or continental shelf carried out by the competent Ministries so that these activities always take into account the protection of Underwater Cultural Heritage".*

[8] Versión en español: https://www.cultura.gob.es/dam/jcr:efac46e1-09d0-4abd-8d76-e42868c5b129/green-paper--national-plan-for-the-protection-of-u.pdf.

English version: https://www.cultura.gob.es/dam/jcr:efac46e1-09d0-4abd-8d76-e42868c5b129/green-paper--national-plan-for-the-protection-of-u.pdf

In addition, the establishment of a Scientific Monitoring Commission for the NP is provided for in the Green Paper (Libro Verde: 99).

> *H. Monitoring.*
>
> *32. The Ministry of Culture, with the aim of continuously monitoring the achievement of these proposals and, in general, of the principles set out in the Green Paper, will set up a Monitoring Commission for the National Underwater Archaeology Plan.*

Both commissions are tools for cooperation, collaboration and communication between the different administrations involved. They are also mechanisms for the approval and ratification of projects and decisions in the field of underwater heritage. They have proved to be really useful, as they provide information on the actions carried out in this area, as well as on the most conflictive points of concern.

Starting with the Scientific Monitoring Commission. The first meeting took place on 15 June 2010 at the National Museum of Underwater Archaeology ARQVA (hereinafter ARQVA). It is currently chaired by the person in charge of the Directorate General of Cultural Heritage and Fine Arts, Mr. Isaac Sastre de Diego, with the Deputy Director General for the Management and Coordination of Cultural Assets as vice-chair, Ms. María Agúndez Lería. The members are divided between the director of ARQVA, Rafael Sabio González, the heads of the Underwater Archaeology Centres of the Autonomous Communities, Rut Geli for Catalonia, Asunción Fernández for the Community of Valencia and Milagros Alzaga for Andalusia, as well as the heads of AECID, Mr. Santiago Sierra, and three external experts[9]. This Commission meets twice a year, dealing with all matters of interest related to underwater heritage. Its composition is currently under review, in order to give more presence to key institutions such as the Guardia Civil (or Civil Guard) and the Armada, as well as to give more weight to the presence of members of Culture, other sectors involved, such as national archives, and other ministries, such as those related to the environment and climate change.

The Interdepartmental Commission, however, meets once a year. Its purpose is to follow up on the partnership agreements signed within the framework of the NP between different ministries.

Basic content of the Plan. Point to point

Moving forward on the content of the NP, we will make an analysis of the current situation, as well as those items that have been developed and those that require further implementation.

Collaboration

As already mentioned, collaboration between public administrations for this type of heritage is a key point. To this end, collaboration agreements have been signed with several public administrations:

- With the Autonomous Communities: mainly focused on the preparation of underwater archaeological maps, which is generally the jurisdiction of the Autonomous Communities. The National Plan offers collaboration, both in terms of technical and economic resources.

[9] Currently the experts are: Mariano Aznar Gómez, Carlos de Juan and Rafael Ruiz Manteca.

- With the Ministry of Defence, and in particular the Armada, a key player in the management of the UCH. According to both UNCLOS and the Maritime Navigation Act[10], State-flag ships are Armada vessels, as well as warships and maritime tombs. Which makes it necessary to have the Armada's authorisation and involvement for research or access of any kind[11]. The Armada, through its Institute of Naval History and its Archives, has a huge amount of documentation on wrecked ships and vessels, as well as specialists and equipment to carry out underwater interventions, to which the professionals of the Armada's Diving Centre are attached.

- With the Ministry of the Interior, aimed mainly at the application of the SIVE programme (Integral System of External Surveillance) to the protection of underwater archaeological heritage. This agreement has given rise to a close relationship of collaboration with different units of the Guardia Civil. With the Central Operational Unit, we work hand in hand when there are criminal indications on underwater heritage. It is the Guardia Civil that has the jurisdiction to act on criminal activities at sea and on the protection of historical heritage, which is why they are a main ally. In addition, the UAS (in their Spanish initials), the Underwater Activities Unit, currently collaborates closely in the verification, inspection and monitoring of sites and casual discoveries of underwater archaeological material, together with the technicians of the Ministry of Culture.

- With the Ministry of Foreign Affairs, European Union and Cooperation. This agreement serves as a framework for establishing permanent collaboration and coordination mechanisms in the area of UCH protection, especially when it is in international waters or in waters subject to the sovereignty or jurisdiction of third countries. The large presence of ships in the territorial waters and continental shelves of different countries requires the action of Spanish diplomacy and the signing of collaboration agreements, in the form of Memorandum of Understanding, with numerous states. Spain currently has agreements of this type on underwater heritage with, for example, Mexico, the US NOAA Agency, Panama and Croatia.

Documentation and inventory and GIS

This is one of the most complicated items to comply with, due to the division of powers between the State and the Autonomous Communities. Many Autonomous Communities have worked intensively on their underwater archaeological maps, achieving great results. In others, less progress has been made. As far as the National Administration is concerned, two important milestones have been achieved in recent years in terms of the creation of inventories and databases. On the one hand, a database has been created as a result of archival research that gathers information on the wrecks of Spanish state ships sunk all over the world. In addition to a database, it has been translated into a GIS. On the other hand, the sites present in Spanish continental waters and in the Hydrographic Confederations[12] have been documented and inventoried, also in a database and a GIS. Both tools are basic and highly operational. Gradually, progress will be made towards a more complete map of the sites, shipwrecks and submerged infrastructures of Spanish heritage.

[10] Law 14/2014, of 24 July, on Maritime Navigation.

[12] Administration in charge of the management of rivers.



Figure 2. Campaign of documentation of an archaeological find in Cartagena (Carlos Andrés).

In addition, the Ministry of Culture has launched a project to review and update the data in the archaeological map of the Region of Murcia (Figure 2), through the verification of anomalies detected by multibeam survey and through the inspection of findings made by civil society and reported to administrations. To date, the project is only being applied in the Region of Murcia, as this is where the ARQVA is located, but the Ministry offers its collaboration to all the Autonomous Regions to carry out this work in their territories.

Training and capacity building

Since the publication of the Plan, numerous training courses have been held, both theoretical and practical, aimed at personnel from the Armada, the Civil Guard, students and archaeologists from all over the world. The last of these courses was the *II Interministerial Course on the Protection of Underwater Cultural Heritage*, held in Cartagena on 27 and 28 June 2023. The course was a success, recognized by all the attendees and speakers, making clear the vocation for collaboration that arises from the implementation of the Plan.

However, the practical training of Ministry of Culture staff is also of particular importance. Due to the increase in staff in recent years in the Ministry of Culture, with a greater presence of archaeologists, it

was decided to create a group of technicians to be trained in underwater archaeologist. This allows the National Administration to have its own resources, without having to resort to external contracting, which means a more efficient management of public resources. Gradually, a group of six archaeologists is being trained to complement the existing staff. This training is being carried out with the invaluable collaboration of the GEAS[13] of the Guardia Civil.

Sufficiency of resources, Centres for Underwater Archaeology (CAS) and collaboration with the Autonomous Regions

The Centres for Underwater Archaeology (CAS) do excellent and exemplary work in the protection and management of this heritage. As coordinators of the NP it is our duty to support the work of the CAS.

In this sense, it is worth mentioning the ARQVA, a fundamental pillar in the management of underwater heritage. Great professionals work in its facilities, from the point of view of museum management as well as from the ARQVATec research and restoration centre. Currently, this museum is the main point of dissemination and awareness of underwater cultural heritage, but not only. It is also a research centre, from which they participate in prospecting and excavation campaigns of shipwrecks; it is the reference institution when it comes to issuing technical reports on issues related to the treatment of materials from the underwater environment.

ARQVATec has latest technology equipment for the treatment of submerged materials, recently the Ministry of Culture has acquired a freeze-dryer over 5 meters long and almost two meters in diameter. And when there is none equipment, it is created, such as the computer which was created specifically for the identification and inventory of the coins from the frigate Nuestra Señora de las Mercedes. The aim of this National Plan is to provide ARQVA with the resources to act as the Underwater Archaeology Centre of the National Administration, as the technical-executing arm of interventions in underwater heritage. ARQVA also acts as a support centre for interventions both on sites and directly on submerged cultural assets, when required by other administrations. And let's not forget that it has been recognised as Best Practice by the 2001 Convention in 2021.

Collaboration with Ports

This section is the weak point of the National Plan. According to Law 16/85 of 25 June 1985 on Spanish Historical Heritage, historical heritage assets, including underwater archaeological sites, within the boundaries of National Ports are the responsibility of the National Administration, in this case, the Ministry of Culture. Article 42 of the same law establishes that any archaeological intervention must be authorised by the competent administration. In the case of National Ports, again by the Ministry of Culture. However, the complexity of the organisation of National Ports and the fact that they are bodies that act autonomously makes it complicated to have protocols for action for all ports: in some cases, we work in collaboration; in others, we do not manage to obtain a response from them.

However, knowing that this is one of the undeveloped aspects of the Plan, it is also one of the strong items to be reinforced and on which to focus the lines of work.

[13] GEAS are in their Spanish initials: Grupo Especial de Actividades Subacuáticas or Special Force for Underwater Activities.

Outreach-awareness-raising

Finally, the dissemination and awareness of the National Plan is the most developed and most rewarding section. Through courses, conferences, exhibitions and activities of all kinds, the underwater cultural heritage is disseminated among society, creating the awareness that it is more than the "pirate treasure" that we have seen hundreds of times in the cinema or on television.



Figure 3. Poster of the exhibition held in ICUA, Zadar (Croatia).

ARQVA, through its exhibitions and dissemination activities, is the main supporter of this line of action. Exhibitions such as *Science versus Looting*, in 2018, or the exhibition on Nuestra Fragata de las Mercedes held at the National Archaeological Museum in Madrid in 2015[14] . In 2023, the international project on the frigate Nuestra Señora de las Mercedes was launched, in collaboration with Uruguay, Chile, Bolivia and Mexico, which will culminate in 2025, *Nuestra Señora de las Mercedes. A common history* (Sabio et alii 2024)[15].

And not only through these activities. Through its publications it disseminates aspects related to underwater heritage, such as the *Cuadernos de Arqueología Marítima*¸ which were published between the 1990s and the first decade of the 2000s. Or the new NANS, *Noticiario sobre Arqueología Náutica y Subacuática* (Nautical and Underwater Archaeology Newsletter), which brings together contributions from experts on subjects related to underwater archaeology (Sabio and Ramírez 2022).

The Deputy Directorate for the Management and Coordination of Cultural Assets also works actively to disseminate underwater archaeological heritage through a responsible approach to heritage, which values the work of recovery and research, as well as its protection against looting and treasure hunters. The exhibition on *La Flota de Nueva España: the search for Nuestra Señora del Juncal*[16] , which took place at the Archivo General de Indias in Seville between 2021 and 2022, and at the Museo de América in 2022. This exhibition, the most visited at the Archivo de Indias, was held in collaboration with AECID, AC/E and the Mexican INAH, as well as with the collaboration and loan of pieces from numerous Spanish museums. Other projects to raise the visibility of the UCH in the international level, such as the exhibition of *Good Practices of Underwater Cultural Heritage of the 2001 Convention* at the ICUA in Zadar, Croatia, between June and August 2024[17] (Figure 3).

Courses, international congresses and meetings complete a range of activities to disseminate and raise awareness of this heritage. Currently, one of the objectives of the plan is to disseminate Spanish underwater heritage beyond our borders. Thus, the Ministry of Culture is participating in international forums, such as the *Congress on the Spanish Armada* held in Sligo (Ireland) in May 2023. Or the organisation of the *Western Europe and North America Regional Meeting of the 2001 Convention* held in June 2024 in Madrid.

We believe that the NP has paid off in terms of social awareness in Spain. This can be seen in the numerous notifications received by the public administrations regarding the presence of cultural property in the marine environment, from recreational divers and private individuals. In this regard, the work done by organisations such as the GEAS with private diving centres should be highlighted. For this reason, it is a priority to achieve this level of awareness outside Spain. And we are on the right track.

[14] *The last voyage of the frigate Mercedes. A cultural treasure* recovered¸ https://www.man.es/man/exposicion/exposiciones-temporales/historico/2011-2020/2014/nsmercedes.html. English version: https://www.man.es/man/en/exposicion/exposiciones-temporales/historico/2011-2020/2014/nsmercedes.html

[15] Our Lady of Mercy. Una historia en común (English version): https://www.cultura.gob.es/mnarqua/en/actividades/exposiciones-temporales/historico-exposiciones-temporales/2023/exposicion-mercedes-historia-comun.html

[16] Spanish version: https://www.cultura.gob.es/cultura/areas/patrimonio/mc/patrimonio-subacuatico/actuaciones/juncal.html

[17] https://www.icua.hr/en/article/opening-of-the-exhibition-best-practices-for-the-safeguarding-of-underwater-cultural-heritage/611

We cannot fail to mention the Good Practice projects recognised by the 2001 Convention, of which Spain has six of the twelve projects included. This recognition involves the promotion of a series of research and dissemination projects to show society the value of underwater heritage.

Conclusions: review and options for improvement

Throughout the text, the specific points on which the National Plan for the Protection of Underwater Cultural Heritage focuses have been described. Its creation and implementation has been outlined, based on all the organisations and administrations working on it. It has been a turning point, has been praised by the Secretariat of the 2001 Convention and has served and continues to serve as a reference for similar documents in European and Latin American countries.

But it is not perfect. We know where it is lacking, where there is room for improvement and where it has been left out or poorly drawn. The National Plans must be living and dynamic documents, not static and fixed. They must adapt to legislative changes and, above all, to changes in the paradigm of underwater heritage. Spain's position, as a State administration, and the resources currently dedicated to this heritage are many and this must be reflected in the National Plan. For this reason, its text and implementation tools, such as the Monitoring Commission, are currently under review.

Most of what was defined as priority lines of action in the Green Paper thirteen years ago are still in place. And new ones have been created. Among them, the following should be highlighted:

- To strengthen ARQVA's role as the National Administration's Underwater Archaeology Centre, as a support centre for interventions and actions in underwater heritage throughout the country and beyond. For this, technical and human resources are mainly necessary.
- Strengthen the relationship with other National Administration bodies, such as the State Ports and the Hydrographic Confederations.
- Promote the development of underwater archaeological maps and the creation of inventories.
- Generate own resources within the administration itself, in order to reduce dependence on private institutions and personnel.
- Create protocols for action in underwater interventions that, following the Annex to the Convention, ensure the presence of all the necessary professionals to guarantee quality projects.
- To protect underwater heritage beyond the maritime heritage, that which is present in inland waters, through specific action protocols, interventions and monitored follow-up for the periods in which it emerges and in which it is submerged.

These objectives are not new, they are present throughout the text, from beginning to end. Currently, the Ministry of Culture has more resources for the implementation of the Plan. Resources that are not merely economic, but also in terms of personnel dedicated to underwater heritage. This has made it possible to apply the competences that the legislation grants to the State Administration.

But underwater heritage cannot be seen as limited areas for intervention. Its universal character, its presence in an environment that knows no borders, means that collaboration continues to be the main line of defence and protection of heritage. And the National Plan is the main ally.

The ship Mazarrón 2 as an example of collaboration in the state framework

The project for the extraction and conservation of the Shipwreck Mazarrón 2 is, without a doubt, one of the most active lines of work at present, within the national scope. As well as a good example of coordination of the National Administration with the Autonomous Communities which, from a general point of view, currently receive the majority of the competences in archaeological matters in Spain. The wreck is located in the Autonomous Community of the Region of Murcia, which is the owner of the wreck, responsible for its declaration as an Asset of Cultural Interest and, ultimately, the body with the power to decide where it should be deposited after its extraction. Nevertheless, in an exemplary and uninterrupted manner, this administration has demonstrated a firm will to make decisions in a joint and coordinated manner with the National Administration.

The ship in question consists of a shallow-draught vessel about 8 metres long, which has been dated to between the 7th and 6th centuries BC (Negueruela 2004; Negueruela, 2014; Miñano 2014). Both for the period and the construction technique, it has tended to be associated with Phoenician culture, although it would have been used to move loads over short distances, although it is not ruled out that it belongs to an indigenous culture or that it was made locally by western Phoenicians (Pomey and Rieth 2005; De Juan 2017; De Juan 2023).

The wreck was found in 1994, on the beach of La Isla, in the Murcian municipality of Mazarrón, from which it derives its name. In the same place, in 1988, a team of archaeologists from the then National Museum of Maritime Archaeology and National Centre for Maritime Archaeological Research discovered a vessel of similar characteristics, but in a more partial state of preservation (Negueruela et alii 1995). It was precisely during the work related to the extraction of what was known as the Mazarrón 1 wreck when, in a visual exploration of the surroundings, the remains of this new ship were located. In order to safeguard the unique ensemble, it was decided to protect it with a metallic structure that would facilitate the excavation process of the site, between 1999 and 2001, as well as the conservation of the ship in the medium term (Negueruela 2000).

During the excavation process, an area was detected in which there had possibly been an action of spoliation, partially affecting the stratigraphy that covered the remains of the ship (Negueruela 2004: 233). In contrast, in the rest of the ship, this stratigraphy was completely preserved, revealing a level of *posidonia oceanica* of ancient chronology that evidenced the rapid process of silting up of the wreck, which could justify its good state of preservation. Below the wreck, a coherent group of cargo and associated ship's gear and accoutrements was documented.

The cargo consisted almost entirely of a set of litharge blocks of local origin, which must have been used to transport the vessel at the time it sank. In relation to the belongings associated with the crew, we should mention the presence of ceramic and basketry pieces, very possibly intended for storing the provisions. Outside the ship and also covered by the protective structure, an interesting example of an anchor is revealed, which is among the earliest preserved, already associated with the forms and elements of the types used during the following centuries (Sabio 2024: 43). It would have been composed of two curved pieces of wood which, joined together, would have formed the shank and the two arms. A third piece of wood would pass through the two previous ones, acting as a trap. Both the nails at the end of the arms and the trap would be filled with lead, which would make them easier to sink and at the same time make them sturdy. During the excavation process, all the elements associated with the cargo and belongings would be removed, while the remains of the vessel and the anchor would be kept in situ.

After the end of the excavation campaigns, the ship was protected and the box was closed, and a series of regular inspections were carried out between 2001 and 2005 to evaluate its evolution. In 2008,

coinciding with the inauguration of the new ARQVA, the box was opened and a complete photogrammetry and drawing of the vessel was carried out. From this moment until 2019, the inspections would be more punctual, with periodic inspections being recovered from that year onwards until the present day.

In order to define the perspectives on the treatment to be given to the remains of the ship Mazarrón 2 in the long term, the Ministry of Culture would plan the organisation at ARQVA of the so-called International Meeting of Experts on the extraction and conservation of the wreck Mazarrón 2 (hereinafter RIE). These would take place in May 2022, with the attendance of many national and international professionals, who would address, after a preliminary session and over five sessions, issues such as ethics and deontology, international projects, Spanish projects, the extraction and conservation of archaeological vessels (Buendía, Pérez and Castillo 2022; Castillo, Pérez and Buendía 2022; Buendía, Castillo, Pérez and Sabio in press).

Among the conclusions reached, it was agreed that the extraction of the wreck was necessary, due to the risk to its conservation posed by changes in the coastal dynamics, together with the effect of the virulent climatic events of the DANA type[18], which have been witnessed in the area. In relation to the extraction procedure, different alternatives would be shown, ranging from block extraction to fragmentation, the latter under different options. With regard to museum display, the preferred option for the representatives of both the regional and state administrations was the presentation of the group in the ARQVA museum, together with the remains of the Mazarrón 1 wreck, which are already on display there. Finally, emphasis would be placed on the monitoring of the ship both during its treatment and later during its public exhibition. The proceedings of the meeting would be published by the Ministry of Culture in 2023 (Arcos, Castillo and Cantero 2023).

As a result of the RIE, and as a tool for coordinating the work, a working group was set up comprising the Ministry of Culture, the ARQVA museum, the Autonomous Community of the Region of Murcia and a series of external experts. At the same time, a series of preliminary studies were to be carried out on the wreck, mainly aimed at carrying out a new photogrammetric study of the ship's structure, as well as taking samples, both of the wreck and of the environment in which it was found. Part of the conclusions drawn from both studies would allow the precise determination of the extraction system to be used on the wreck.

After various imponderables, the works were finally carried out in May 2023, by means of an agreement established between the Autonomous Community of Murcia and the University of Valencia, with the archaeologist Carlos de Juan in charge of the direction of the works. The Ministry of Culture would also be represented by two ARQVA technicians: the archaeologist Rocío Castillo and the restorer Milagros Buendía. During the two weeks that the intervention lasted, the first few days were devoted to the complex reopening of the box, as well as to the removal of the contributions that had been used to protect the boat (Figure 4). Once the entire structure had been uncovered, photogrammetry of the vessel was carried out. At the same time, tests were carried out with two types of moulds: rigid ones, made of carbon fibre, by Marco Ciabattoni, from the Higher Institute for Conservation and Restoration in Rome; and other soft ones made of silicone, by Luis Carlos Zambrano, from the Museum of Cádiz. Ultimately, ARQVA technicians would carry out the sampling necessary to obtain data on the environment of the wreck and the characterisation of the ship's wood.

[18] Heavy cold drop storm.

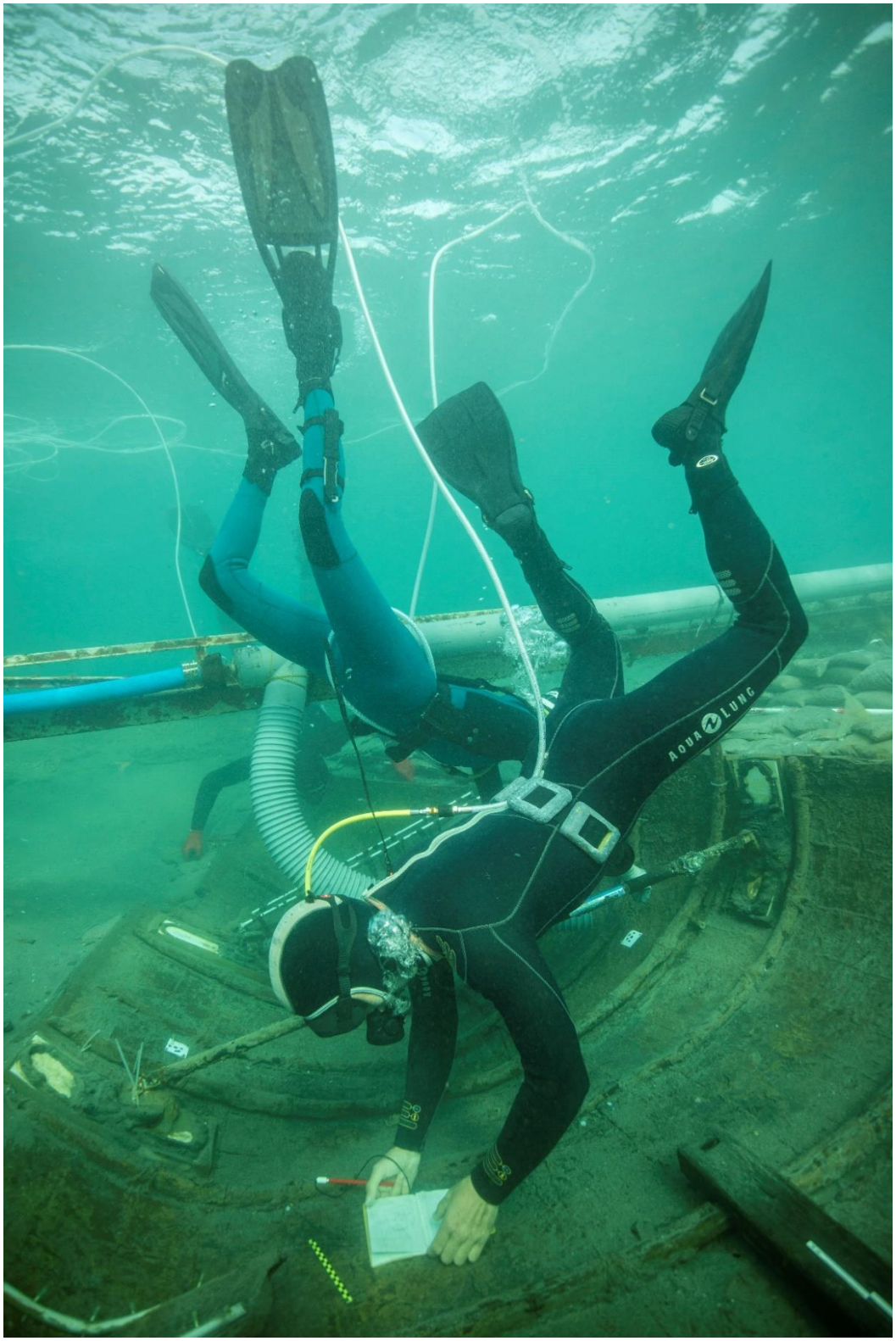


Figure 4. Preliminary studies campaign on the Mazarrón 2 wreck, in May 2023 (José Antonio Moya University of Alicante).

In relation to sampling, the analysis of the environment would be divided into two parallel tasks: on the one hand, Nuria Guasch, from the University of Barcelona, would be entrusted with the analysis of the sediment and the geological substratum. At the same time, Teresa Doménech, from the Polytechnic University of Valencia, would be responsible for the analysis of the aqueous medium (Doménech et alii 2024). As far as the characterisation of the wood was concerned, it would end up falling to the team led by Juan Ignacio Fernández-Golfin Seco, from the Consejo Superior de Investigaciones Científicas (Spanish National Research Council). In parallel to this work, José Luis Casabán reprocessed the photogrammetry carried out in 2008 (Casabán 2008).

The extraction project, drafted by Carlos de Juan, would follow on from the previous studies and would be completed in late 2023. In the project, it was finally decided to extract the ship in fragments. This would be based on the multiple fractures that could be documented in its structure during the photogrammetry work carried out in May 2023. After their detailed analysis, a mapping of those fissures that best suited the configuration of the total of 22 fragments in which the extraction of the ship is planned (Figure 5) would be generated. Similarly, and after considering the data obtained from the previous test on the structure of the ship, it was decided to use the rigid carbon fibre moulds proposed by Marco Ciabattoni for the extraction of the stem, the sternpost and the longitudinal centre of the wreck (keel, cockpit and rigging strakes). At the same time, the frames, together with the remains of the bindings, will be extracted by means of a resin bandage formwork.

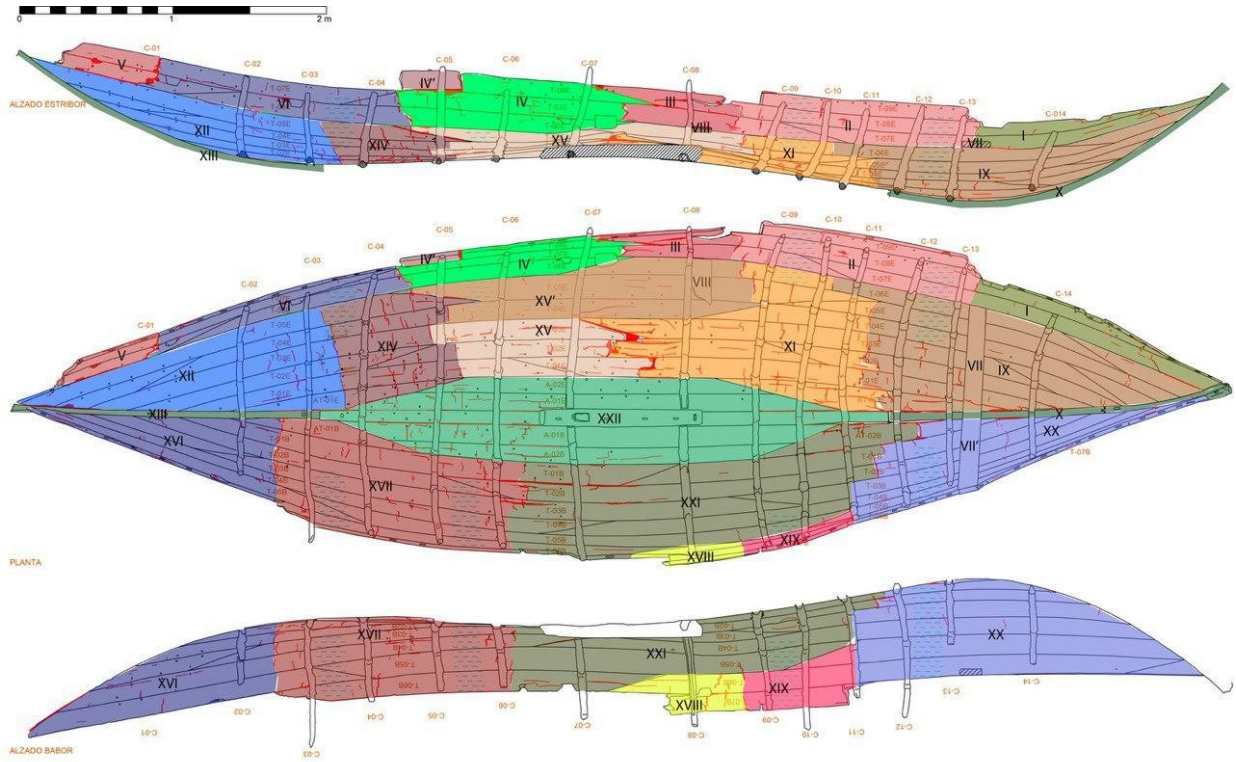


Figure 5. Mapping of the fragments in which the Mazarrón 2 wreck is to be extracted (Carlos de Juan University of Valencia).

In parallel to the drafting of the extraction project, the team from the University of Valencia and the management of ARQVA began to coordinate with the aim of defining the needs derived from the conservation treatment of the ship in the facilities of the latter institution, and more specifically in the laboratories of its headquarters in the Cabezo Beaza industrial estate: ARQVAtec (Figure 6). An imponderable derived from the extraction system adopted would be the possibility of subjecting the remains of the ship to a freeze-drying treatment. The limited capacity of the ARQVA freeze-dryer, together with its obsolescence, led to the decision by the Directorate General for Cultural Heritage and Fine Arts of the Ministry of Culture to invite tenders for the design and construction of a new one, through the Ministry's Department of Cultural Infrastructure and Equipment. The timeframe for the freeze-drying of the ship, after its extraction, exceeds two years, which allows for the execution of this ambitious project, which will provide ARQVA with one of the most modern and highest capacity archaeological freeze-drying equipment in the world.



Figure 6. General view of the ARQVAtec restoration laboratory (Lorenzo Plana ARQVA Photographic Archive).

Other issues of more immediate resolution, but also subject to their necessary provision in a shorter period of time, would be the adaptation of ARQVAtec's facilities and equipment to the arrival of the ship, as well as the necessary supply of the necessary products or the presence of support personnel for specific tasks during the treatment. With regard to equipment, the Deputy Directorate General for the Management and Coordination of Cultural Heritage of the Ministry of Culture has managed the acquisition of a new filtering system for the tanks in which the ship will be desalinated and impregnated during the first phases of its treatment. Likewise, the Deputy Directorate General of State Museums has been in charge of adapting the tanks to the new filtering system, as well as the acquisition of a new loader that will allow the handling of the frames through which the fragments of the wreck will be introduced into the aforementioned tanks. As far as the products or human resources are concerned, the Deputy Directorate General for the Management and Coordination of Cultural Heritage, with funds from the National Plan, is developing the tender for a project that will allow the external contracting of a company capable of satisfying both needs simultaneously, for the total number of years that the treatment of the ship will last.

The phases following the extraction of the boat by the University of Valencia team and its transfer to ARQVAtec will therefore consist of its gradual desalination and impregnation in polyethylene glycol (PEG) for approximately 2-3 years. After that, the whole will undergo freeze-drying treatment. Once all these operations have been completed, the owner of the object, the Autonomous Community of the Region of Murcia, will have to decide on its final destination. In the case of ARQVA, the renovation of its museographic discourse will have to be studied in order to contemplate the integration of the Mazarrón 2 ship. The ideas being considered in this respect are its inclusion in the current permanent exhibition rooms, if not the creation of a new space specifically for the exhibition of the ensemble, made up of the two Mazarrón ships (Roldán and Sabio 2023). In any case, the process to achieve this final objective is still a long one, and the joint efforts of the administrations involved must be focused on the success of the phases linked to the extraction and treatment of the ensemble.

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Last chance harbour – unveiling Lagos underwater heritage

Nuno Costa[1] and Andreia Romão[2]

Abstract

The municipality of Lagos boasts a rich and diverse history, with one of the oldest maritime connections in southern Portugal. Due to its strategic geography, this territory has served as a significant harbour for over 2000 years, witnessing the passage of time and the ebb and flow of civilizations.

An in-depth examination of maritime routes and historical records reveals the unique relationship between Lagos and the sea. Evidence from Roman Empire Mediterranean trade, voyages to North Africa, the Portuguese Age of Discoveries, naval battles involving foreign nations, and heritage connected to the First and Second World Wars, lies beneath the waters of Lagos, contributing to a complex and diverse archaeological record.

Is this heritage relevant? Does it bear witness to the city's resilience and adaptability amidst the challenges of globalization? Moreover, what actions are being taken by key stakeholders as part of Portugal's commitment to the UNESCO Convention to ensure the integrity and accessibility of this underwater cultural heritage?

This study will explore the specific measures implemented by Portugal to protect Lagos' underwater cultural heritage, addressing the challenges and threats involved. It will also illuminate the complexities of balancing sustainable development with the preservation of Lagos' rich underwater heritage.

Keywords: southern Portugal, Mediterranean trade, underwater cultural heritage, history, Lagos, preservation

Introduction

Lagos, a city with one of the oldest maritime connections in southern Portugal, has played a crucial role as a harbour for over 2000 years, deeply intertwined with the sea and the estuaries that surround it. Located at the southwestern tip of the Iberian Peninsula, Lagos stands out for its strategic geography combined with a coastline of approximately 15 kilometres and a unique extensive bay that has made the city an important waypoint for maritime routes.

Witnessing the passage of time and the influence of various cultures, Lagos has served as a convergence point for numerous civilisations and earned a place in history for its role in the intricate network of maritime routes. From the ancient Phoenician and Roman Empire's Mediterranean trade routes to exploratory voyages along the West African coast to the Portuguese Age of Discoveries, Lagos has

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witnessed the rise and fall of empires, the dynamism of trade, the tumult of naval battles involving foreign powers, and the remnants of activities from the First and Second World Wars.

This rich maritime history is reflected in the diverse and complex underwater archaeological record that lies in its waters, a testament to the many cultures and historical events that have shaped the region and played an important role in the city's cultural identity.

UNESCO has long recognized the importance of protecting such cultural heritage. As defined in its Medium-Term Plan for 1990-1995, cultural heritage encompasses "the entire corpus of material signs – either artistic or symbolic – handed on by the past to each culture and, therefore, to the whole of humankind." This definition underscores the need to protect and preserve historical sites, structures, and archaeological finds that contribute to our understanding and appreciation of a place's history and culture. In this context, the underwater cultural heritage of Lagos, along its 15 kilometres coastline, represents an invaluable resource, both for its historical significance and for its potential to deepen our understanding of the past.

This introduction sets the stage for a detailed analysis of the maritime and underwater cultural heritage of Lagos, exploring the historical significance of its archaeological sites, the challenges they face, and the efforts being made to preserve this important legacy for future generations. The study also considers Portugal's commitment to the UNESCO Convention on the Protection of Underwater Cultural Heritage, evaluating the effectiveness of current preservation measures and the ongoing need for comprehensive protection strategies.

Geographical context

Lagos County experiences a thermo-Mediterranean climate with subtropical characteristics (Cunha 1988), as it is situated on the boundary between the pre-Mediterranean coastal and Mediterranean regions (Alcoforado *et al.* 1993). The average annual temperature is 16.5ºC. The yearly thermal amplitude is low (11.5ºC), with average temperatures of 11ºC in the coldest month (January) and 22.6ºC in the warmest month (August).

To achieve a better understanding of the Lagos coastal landscape through a geomorphological approach, we separated the western sector of the Algarve region into two sections: (1) from Sagres to Ponta da Piedade, and (2) the eastern section, which includes the Bay of Lagos and the estuaries of Arade and Alvor rivers, which are specifically due to the Portimão Fault (Terrinha 1998).

Situated on the southwest end of the Algarve's Barlavento, the culminating platform of the São Vicente and Sagres Capes overlooks the sea at an altitude of approximately 30 to 80 meters. This platform represents a sizable abrasion surface that may be Middle Pliocene in age. It was created in the Jurassic (limestones) and Carboniferous (phyllites and metagreywackes), two resistant lithologies that transition eastward into the Cretaceous and Miocene successions. From Lagos to Portimão we can find Pliocene cliffs with quartz sands on top of Miocene biocalcarenites as well as features like caves, galleries, arches, portals, and sea stacks that are evidence of marine erosion, more visible in the Ponta da Piedade Cape. The coast near Cape São Vicente experiences stronger wave action due to maritime disturbances caused by the North Atlantic and despite the existence of a few natural harbours, none offers the conditions of Lagos Bay that in contrast, facing south, is more sheltered and has more modest waves.



Figure 1. Lagos geographic location – Google Earth Pro 7.3.6, (2022) Algarve, Lagos 38° 29.660'N 6° 15.359'W Altitude 1.656 km [viewed 15 April 2024].

West of the bay, the Ponta da Piedade Cape is located in the Ribeiras do Algarve basin, where three watercourses converge: the Odiáxere-Bensafrim River, the Alvor (or Arão) River, and the Arade River (Relvas and Loureiro 1976). These rivers significantly influence the sediment dynamics and coastal conditions of Lagos Bay.

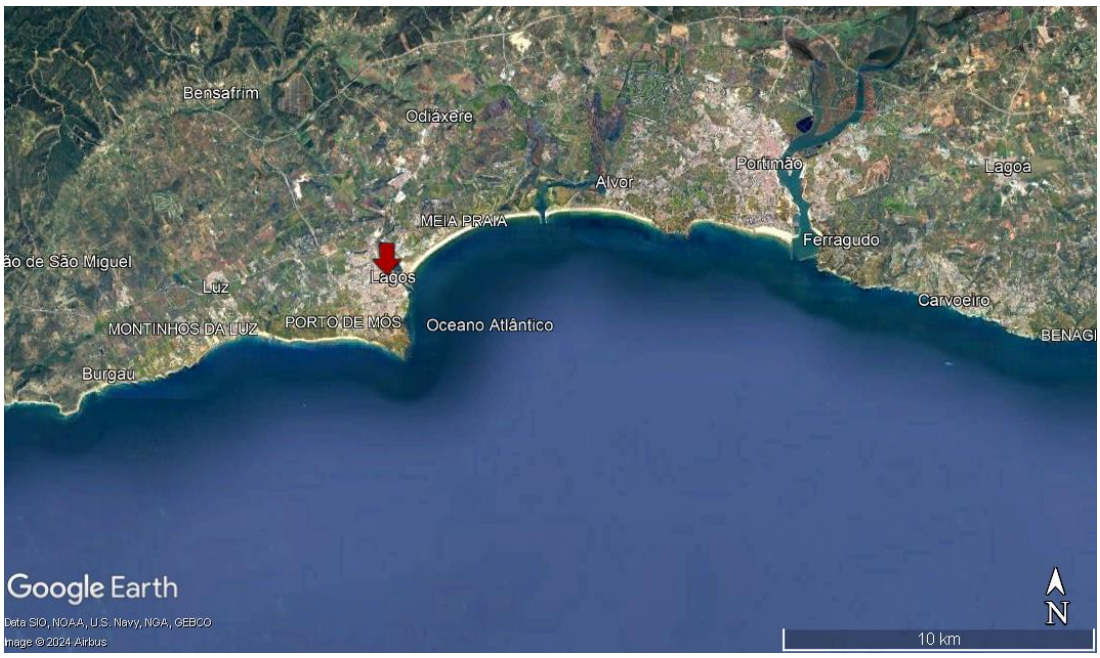


Figure 2. Lagos Bay satellite view – Google Earth Pro 7.3.6, (2022) Ponta da Piedade, Lagos 37°05.28'N 8°36.958'W, Altitude 30 km. [viewed 15 April 2024].

In addition to the watercourses, other factors influencing the hydromorphology of Lagos Bay include weather conditions, which are affected by latitude, orography, the Atlantic Ocean, continentality, the coastline, and the annual migration of the polar front. The bay's depth gradually decreases over 2,5km to 40m, with rocky outcrops of considerable length and small to medium breadth, the bottom is mainly composed of medium and fine lithobioclastic sand and medium-grained biolitoclastic lodose sediments pockets extending from the coast to deeper areas. In opposition, the bathymetry near Ponta da Piedade Cape rapidly drops to 30m in less than 1km with a bottom showing medium rocky outcrops and medium lithobioclastic sand pockets.

The average annual precipitation in Lagos County varies throughout the year, with Barrocal regions experiencing an average of 75 days with ≥1mm of precipitation, while less than 70 days have ≥1mm.

Winds vary throughout the year, with prevailing northwesterly winds between March and May and southwesterly winds between June and August. Due to the configuration of Lagos Bay, northwesterly winds do not generate significant swells, creating ideal conditions for nautical activities. This situation persists until about half a mile south of Ponta da Piedade, where the bay no longer provides protection. Conversely, southwesterly winds produce larger swells.

According to the Meteorological Institute, the average annual sea temperature is 17ºC, consistent with typical values for the Algarve region.

These geographical and climatic features have positioned Lagos as a pivotal centre for economic and social development, initially through Mediterranean maritime trade and later as a key player in Atlantic commerce.

Lagos maritime and cultural heritage

The historical relationship with the sea is ancient, extending beyond documented records of economic ties with North Africa, exploration of the West African coast, and active participation in the Age of Discovery. Tiago Fraga's archaeological work on the Underwater Archaeological Map of the Municipality of Lagos and the Underwater Archaeological Map of the Bay of Lagos confirmed this ancestry. Lead stocks from Roman vessels discovered on the sea bottom attest to their presence in the urban space and highlight significant archaeological terrestrial sites like Monte Molião and the Roman Baths at Praia da Luz.

The favourable mooring conditions of Lagos' maritime-fluvial environment, along with the discovery of artifacts in the Bensafrim stream, have led academics to conclude the existence of a pre-Roman maritime metropolis. Some even suggest it was one of the primary ports of antiquity in the western Algarve, considering its marine significance in various ancient writings (Formosinho 1992).

Lagos' prominence as a coastal city in the western Algarve made it a popular stopping point for sailors, not only for trade but also for supplies, despite the silting of the Bensafrim stream, which limited its capacity to penetrate the interior of the territory.

The study of the Bay of Lagos' evolution, particularly Tiago Fraga's proposal for the migration of anchorage sites (Fraga *et al*. 2014), shows that, despite significant geomorphological changes, Lagos has continued to play an important role in the region's maritime activities.

During the Roman period, Lagos also became a port of call on international trade routes, connecting the Iberian Peninsula and the Mediterranean to major mercantile cities in North Africa (Loureiro 1991,

2008). This trade relations continued even after North African countries came under Muslim control (Loureiro 1991, 2008).

In the fifteenth century, Lagos earned the famous title of the "City of Discoveries" serving as the maritime base from which the voyages of discovery set sail (Coelho 1992). It also served as a support port for Morocco's strongholds (Barbosa 1993), with the first trading post houses overseeing the trading posts of Arguim and Mina. During this period, Lagos became the most important city among all national ports in trade with the West African coast south of Cape Boujdour, sustaining its economic growth and urban expansion through maritime trade with the African continent.

This period of economic prosperity lasted only until the end of the fifteenth century, when the Casa da Guiné and other trading companies were transferred to Lisbon (Paula 1992), a process that began gradually after the death of Prince Henry, the Navigator. Despite this setback, the geomorphology of the Bay of Lagos ensured that the city remained the best-equipped anchorage in the western Algarve, capable of welcoming Mediterranean ships before they ventured into the Atlantic (Barbosa 1993).

In 1522, King Manuel I decreed that «all maritime nations may allow their vessels to take on water at the spout of *Porta Nova* (on the site of the current Old Town Hall building), where boats could easily reach» (Paula 1992). Between the 16th and 18th centuries, Lagos transitioned from a commercial hub to a military fortress, alongside Portimão, becoming the major stronghold of the western Algarve (Iria 1976). Once again, coastal geomorphology played a key role in facilitating the construction of forts and batteries, which were strategically advantageous in defending against threats such as privateers, as the harbour provided a vast anchorage area with fire support from the coast. In the eighteenth century, Lagos was described as a cove sheltered from the North and Northwest winds, with a harbour capable of sheltering multiple fleets and a navigable river with a draft of up to 17 palms ("Fontes Setecentistas" 1996).

The earthquake of 1775 was the decisive factor in Lagos' decline as the primary maritime city in the Algarve, due to the destruction of the urban core and maritime port infrastructure, as well as the silting up of the inner harbour ("Fontes Setecentistas" 1996).

It was only with the arrival of the canning industry at the end of the nineteenth century that Lagos experienced a resurgence in socioeconomic activity, which lasted until the end of World War II, when demand for canned goods plummeted and the fishing sector began to lose relevance. This decline continued until the late 1980s, when European Union regulations further exacerbated the situation. The tourism sector, which has been growing since the 1960s, has since become the city's new economic engine, with a focus on Lagos' maritime spaces.

Archaeological framework

It is impossible to discuss the history of Lagos without addressing the extensive use of the Sea-Estuary-Bensafrim stream interface, which has been utilized by humans over a long and varied period and is the source of the city's underwater archaeological heritage.

Three key phases stand out in the study of Lagos' underwater heritage. The first began in 1979 with the efforts of CEMAL (Centre for Maritime and Archaeological Explorations of Lagos) and GEO (Ocean Studies Group), which promoted underwater prospecting activities in Lagos Bay. CEMAL's work led to the first discoveries and typological identifications, while GEO focused on monitoring serendipitous finds. In the 1980s, the National Museum of Archaeology became involved, and a team led by Francisco

Alves was sent to Lagos to validate some of the findings *in situ* as part of the survey for Portugal's Underwater Archaeological Map.

The second phase took place between 2006 and 2014, under two projects: the Underwater Archaeological Map Project of the Municipality of Lagos (2006-2010) and the Underwater Archaeological Map Project of the Bay of Lagos and Surroundings (2012-2014). The goals of these projects were, respectively, to understand the impact of underwater cultural heritage on the evolution and coastal dynamics of Lagos and its surroundings (Fraga 2010), and to address issues related to maritime cultural landscapes, including the implementation of safeguarding measures (Fraga and Baço 2014), based on the model used in the Municipality of Cascais' Underwater Archaeological Map Project (Freire, 2013).

These efforts resulted in the discovery of over 300 artefacts, 107 of which are anchors (Fraga 2013).



Figure 3. Lagos underwater archeologic sites – Google Earth Pro 7.3.6, (2022) Ponta da Piedade, Lagos 37°05.711'N 8°39.889'W, Altitude 9,5Km. [viewed 15 April 2024].

Lagos underwater archaeological heritage sites

Endovélico[3] lists 70 underwater sites in Lagos, many of which are merely documented shipwrecks, but there is no information on the Archaeologist's Portal regarding the implementation of safeguarding measures. When we compare this with the public results of the 2006 and 2012 campaigns, we are aware that significant work remains to be done, both in terms of document organization and prospecting. More importantly, there is a notable lack of implementation of the previously identified safeguarding measures for the underwater heritage.

Is safeguarding being neglected, despite Portugal's ratification of the UNESCO Convention for the Protection of Underwater Cultural Heritage? UNESCO has promoted various safeguarding initiatives in response to the growing threats posed by increased human activity in maritime spaces and the

[3] The Endovélico - Archaeological Management and Information System is currently the main archaeological management and storage instrument in Portugal. https://arqueologia.patrimoniocultural.pt

acceleration of climate change, but most of these safeguarding strategies are not directly applicable to the complex panorama of Lagos' underwater archaeological heritage.

Legal framework

This year marks the 50th anniversary of the Carnation Revolution in Portugal, a military coup that overthrew a despotic government on 25 April 1974, ending more than 40 years of dictatorship and the longest-surviving authoritarian regime in Europe. It is important to recognize that democracy brought not only new legislation but also new ideas and approaches to understanding and managing cultural heritage, including underwater heritage.

Prior to 1970, any underwater discovery required the involvement of the regional governor and maritime authorities, who were responsible for determining whether the find was valuable to the state. If deemed unimportant, it would be returned to the original discoverer. Undoubtedly, many of these evaluations were conducted by individuals lacking any background in history, art, or archaeology.

Before the revolution, Decree-Law 416/70 distinguished underwater archaeological finds "of scientific or artistic interest" from others. Six years later, Decree-Law 577/76 increased the legal protection of underwater cultural heritage by declaring it state property.

Between 1993 and 1995, the government introduced a new legal regime for underwater cultural heritage with Decree-Law 289/93 and Ordinance 568/95, which included regulations for underwater archaeological work.

In opposition to the global efforts led by UNESCO, in which the Portuguese state was participating, Ordinance 568/95 sought to legalize the commercial exploitation of underwater archaeological activity at the expense of the scientific contextualization of cultural heritage.

Ultimately, these laws were repealed before the end of 1995 due to opposition from various groups within Portuguese society, particularly archaeologists and those interested in heritage protection. This action by the Portuguese state was a clear demonstration of its leadership in creating a legislative framework to protect underwater cultural heritage.

A few years later, Decree-Law 164/97 established a new legislative framework for Portugal's archaeological heritage, coinciding with the creation of the Portuguese Institute of Archaeology in 1997. With the enactment of this law, the regulations governing underwater and terrestrial archaeological work were harmonized. Any intervention in underwater archaeological heritage is now limited to scientific research, safeguarding, dissemination, and public enjoyment.

This legal framework was further reinforced by the UNESCO Convention on the Protection of the Underwater Cultural Heritage, ratified by Portugal in 2006 through a Resolution of the Assembly of the Portuguese Republic. However, the ratified text was only republished in 2012 with a new translation through Notice 6/2012.

As will be demonstrated, despite all the efforts made to establish a robust legal framework, laws alone are insufficient to adequately safeguard archaeological sites. Adequate investment in equipment and human resources is essential to ensure that Portugal's underwater territory is properly protected.

In terms of public dissemination and enjoyment, internal policy decisions by state authorities that impose secrecy on archaeological sites have hindered efforts to increase interest in and awareness of underwater archaeological heritage.

This has led some underwater archaeologists to publicly criticize the Portuguese state for failing to meet its obligations under the UNESCO Convention it has ratified. For instance, in a 2017 statement to National Geographic Portugal, archaeologist Jorge Freire expressed this concern: "It's no secret that Portugal is currently in breach of the UNESCO Convention on safeguarding submerged cultural heritage," explains Freire. "There are no resources to conduct ongoing research in this area, nor to guarantee the protection of known sites. So, in fact, the country is in violation of the convention it signed up to."

Civic intervention in the safeguarding problematic

The Neptune Search Association was founded in 2021 when, following the epidemic, it was discovered that increased strain on maritime space and changes in seabed dynamics were causing damage to underwater cultural objects. The basic goal was to be able to protect the underwater history by legally framing the group in a civic intervention, i.e., the formation of a cultural, independent, and non-profit organisation.

From this, a project evolved that could validate all the heritage previously submitted to the Directorate-General for Cultural Heritage/National Centre for Nautical and Underwater Archaeology, as well as their present state of conservation, thereby contributing to an updated understanding of the underwater archaeological legacy existent in Lagos and, eventually, of the national territory.

The plan was to create a monitoring programme that would collect data for the purpose of analysing changes in its conservation status, namely the impact of environmental changes or human intervention. This research aims to understand the evolution of degradation, specifically corrosion, as well as the degradation of contexts due to climate change. This observation will enable the development of mathematical models for measuring corrosion percentages, which can be expressed in millimetres of corrosion each year, allowing for future projections of the conservation state.

These actions require the absence of invasive actions, such as excavation. Throughout the monitoring process, the artefacts will not be removed from their context or their state of homeostasis altered, as this would jeopardise their stability, and the data collected will allow the necessary conditions to be established for the preservation of the objects *in situ*.

On the other hand, the monitoring data will allow us to understand the evolution of concretions over the course of the year, allowing us to present in a final report a set of tools capable of interrupting or slowing down the degradation process, such as a model of an in situ electrochemical passivation system, ensuring conservation without jeopardising the relevant underwater archaeological context. Solution that can be used in a future project.

For the time being, monitoring efforts have centred on climatic change, with frequent water temperature measurements and benthic growth verification and collecting data to establish a risk assessment matrix to be applied in a selected pilot area of Lagos.

Risk management can be used as a tool to contribute to the conservation, management and preservation of underwater archaeological sites. Since we already have identified the risks (R), main threats (H) and

vulnerabilities (V) as described in Figure 4, we are gathering information over a 2-year span hoping to produce a quantitative evaluation based on exposure and frequency of threats. This information will be crucial to provide risk mitigation strategies according to their magnitude

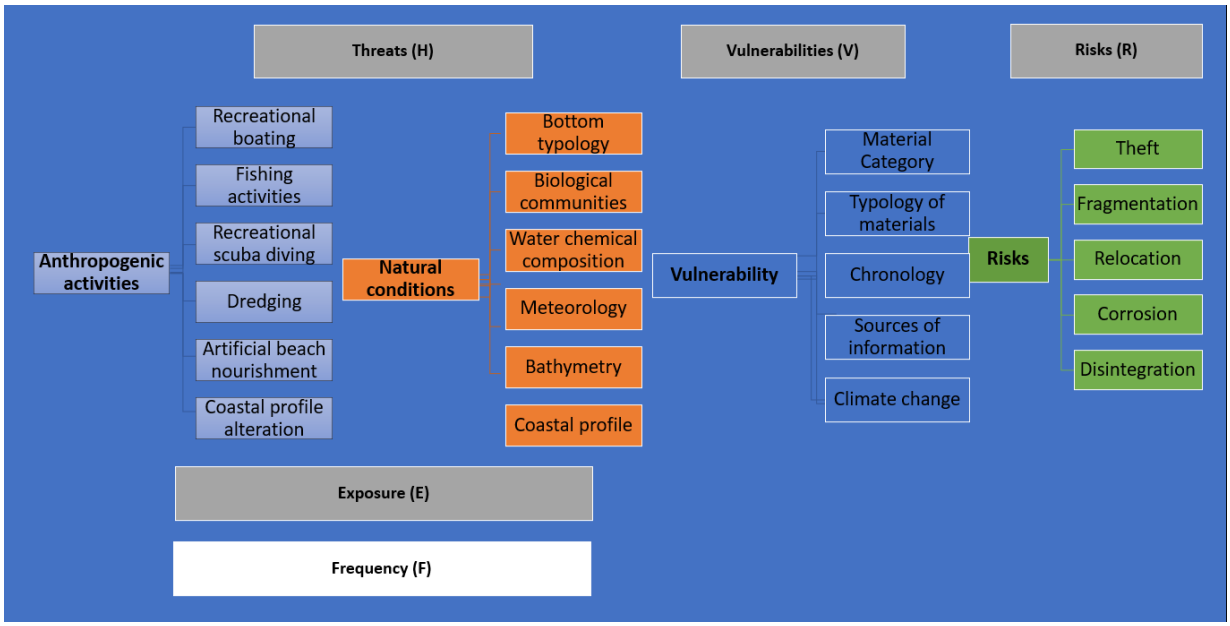


Figure 4. Risk assessment parameters.

The remaining protection and safeguarding procedures are concerned with promoting their value and enjoyment, specifically through diffusion and display efforts. Given that its location restricts access to specific groups formed for this purpose: researchers, restorers, divers, and specialised institutions, it is believed that its enjoyment and educational functions should be achieved through activities that directly engage the community, both intellectually and emotionally. Thus, the team working on this project wants to showcase and disseminate existing undersea history to the local public, with a focus on the school community and sea-related agents such as divers, fisherman, and maritime-tourism companies.

Thus, in accordance with the spirit of the UNESCO convention, the in-situ preservation of underwater archaeological heritage, and the general public's use of these sites, we seek to implement protection and safeguarding measures aimed not only at the stability of the artefacts, but also at their enjoyment. The priority is the preservation of underwater archaeological artefacts, with analyses coordinated by a conservator-restorer and based on a multidisciplinary foundation developed from archaeological research and work carried out by heritage technicians, biologists, and divers, all of whom specialise in this type of context.

Monitoring methodology

Three sampling points, LAQUA.P-01, LAQUA.P-02, and LAQUA.P-03, were selected and georeferenced. The sampling stations were chosen to statistically compare the many parameters analysed in the water body, considering three primary sections. Sampling was conducted during a seasonal period. The first was carried out in August 2022 (a less rainy season), with an average high temperature of 26°C and a

low of 19°C, no precipitation, and 340 hours of insolation. The second sampling was conducted in November 2022 (the rainiest month), with average maximum temperatures of 17°C and minimum temperatures of 12°C, with rainfall of 138.7 mm (IPMA 2022).



Figure 5. Polygons definition with high archaeological sensitivity for sampling points Lagos using Software QGIS 3.32.0.

This sample occurred simultaneously at three data collecting stations during a 12-hour period, with intervals every 90 minutes, during a tidal cycle that began at 6:00 a.m. and ended at 6:00 p.m. Each collection was done manually in polyethylene bottles of varying sizes, which were thoroughly washed and sterilised. pH and conductivity measurements were taken using WTW's COND 3310 SET1. The electrical conductivity analysis was included because it is a parameter that can show changes in the composition of the bodies, which is important for analysing the state of conservation of the heritage elements because they are metallic, and there is a statistical correlation between water conductivity and the concentration of several elements and ions. Conductivity, on the other hand, is determined by geochemical properties and environmental conditions.

To the degree that temperature is connected to the other factors, it was one of the data collected during the studies. Temperature fluctuations are connected to depth, seasons, and times of day. Temperature was monitored in the field with a Lowrance Elite 5 digital thermometer and transducer.

The flame emission photometer was used, together with correctly calibrated equipment, to analyse sodium (Na), calcium (Ca), and potassium (K).

The results were systematised using descriptive statistics, which included tabulating the median and standard deviation. The two-factor analysis of variance (ANOVA) test with repetition was used to compare data.

In addition to these findings, a visual examination of the conservation status of the heritage elements chosen as references (LAQUA.P-01, LAQUA.P-02, and LAQUA.P-03) was conducted.

Other unmonitored artefacts' conservation status is assessed, including structural stability, physical and chemical hazard, and the possibility of dissociation or loss due to anthropogenic or natural causes, as well as the development of a specific safeguard plan for each artefact, taking into account the actions recommended by Pearson (2014), Hamilton (1999), and MacLeod (1989, 2002).

Discussion

The Neptune Search Association's work can be crucial in advancing our understanding and protection of Lagos' underwater cultural heritage. Neptune Search has embarked on an ambitious project to validate and monitor the conservation status of underwater archaeological sites in Lagos. This project aligns with the principles set forth by the UNESCO Convention, particularly emphasizing the *in situ* preservation of underwater heritage as the preferred method and the importance of training, information sharing, and community involvement.

The legal framework in Portugal, defined by the legislative instruments, ostensibly supports the protection of underwater archaeological heritage. However, the practical implementation of these laws, especially concerning Lagos, reveals significant challenges. Despite the robust legal foundation, there is a discernible gap between legislation and action, as the responsible authorities often limit the scope of research and preservation efforts. This disjunction is particularly evident when comparing the goals of the Neptune Search project with the constraints imposed by governmental bodies.

The Neptune Search project has meticulously focused on non-invasive monitoring methodologies to preserve the stability and integrity of submerged artifacts. By establishing a series of georeferenced sampling points and conducting seasonal analyses of environmental factors like temperature, pH, and conductivity, the project aims to create mathematical models for predicting corrosion rates and other forms of degradation. Such data-driven approaches are crucial for developing targeted conservation strategies that align with the best practices recommended by experts like Pearson, Hamilton, and MacLeod.

Moreover, the project's emphasis on the visual examination of selected heritage elements provides invaluable insights into their current state of preservation, further contributing to the overall understanding of the underwater cultural landscape in Lagos. These tools not only aid in monitoring and preserving underwater sites but also offer new opportunities for public engagement through educational programs and underwater tourism.

However, despite these advancements, the limited cooperation from official bodies in Portugal hinders the full potential of such projects. The legislation, while comprehensive on paper, does not always translate into actionable support for initiatives like those of Neptune Search. This disconnect raises critical questions about Portugal's commitment to the UNESCO Convention and the long-term sustainability of its underwater heritage conservation efforts. The reluctance to fully embrace and support *in situ* preservation, as advocated by the Neptune Search Association, underscores the need for a more proactive and collaborative approach from all stakeholders involved.

Conclusion

In conclusion, the coastal and underwater archaeological heritage of Lagos represents a critical link to understanding the city's rich maritime history and its significant role in regional, national, and global contexts. Given the high maritime traffic and the ongoing risks of degradation, it is imperative that focused underwater surveys continue to be conducted. These surveys not only aid in the preservation of invaluable artifacts but also provide crucial scientific and archaeological data that deepen our comprehension of the civilizations that once thrived in Lagos.

Furthermore, effectively communicating these findings to the public is essential. By highlighting the extent of maritime trade and its impact on Lagos, we can underscore the city's historical importance and its contributions to cultural and economic developments far beyond its borders.

However, despite Portugal's ratification of the UNESCO Convention on the Protection of the Underwater Cultural Heritage and the subsequent implementation of related legislation, there are significant gaps in fully safeguarding this heritage. Addressing these shortcomings should be a priority to ensure that the underwater archaeological wealth of Lagos. The Neptune Search Association's efforts could represent a significant step forward in the preservation of Lagos' underwater cultural heritage, embodying the principles of *in situ* preservation and community engagement promoted by UNESCO. However, the challenges posed by limited official support highlight the need for a more integrated approach to safeguarding this invaluable heritage. By overcoming these barriers, Portugal can better fulfil its obligations under the UNESCO Convention, ensuring that the underwater archaeological legacy of Lagos is preserved not only for the present generation but also for future generations while continuing to provide understanding of our past.

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Blue Culture Technology Excellence Hubs within the EU Blue Economy

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Abstract

Despite concentrated efforts to promote the Blue Growth of underwater cultural heritage (UCH) sites in a sustainable manner, lack of co-operation, investment and aligned strategies have afflicted this industry. The Blue Culture Technology Excellence Hubs in EU Widening Member States (BCThubs) project seeks to introduce a new sphere within the Blue Economy: Blue Culture Technologies (BCT). These technologies are aligned to the specialised requirements and needs of the cultural heritage sector. Promotion, valorisation, and accessibility to UCH is a paramount objective of this project, along

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with the creation of a sustainable and holistic framework within which entrepreneurship, economic viability and cultural heritage values can co-exist. This project is led by a consortium of fifteen partners from Greece, Bulgaria, Malta, and Italy, who have joined forces to establish three BCT Hubs in Greece, Bulgaria, and Malta. This European collaboration seeks to establish an ecosystem founded on scientific and technological research and aims to address the issues mentioned above. Finally, the BCThubs project will encourage new members and stakeholders to join these three Hubs and will also facilitate the development of similar Hubs in other coastal regions across the Mediterranean and marginal seas, thus making the ambitious goals of the BCThubs project more likely to be achieved.

Keywords: underwater cultural heritage, blue economy, technology, Excellence Hubs, dive safety

Introduction

UCH 'is made up of finite and non-renewable cultural resources including coastal or submerged prehistoric and indigenous archaeological sites and landscapes, historic waterfront structures, the remnants of seagoing vessels, and the maritime traditions and lifeways of the past and present' (Claesson 2011). Three million shipwrecks are hosted on the ocean seabed floor (UNESCO, 2001), providing evidence of humanity's past, from ancient times to more recent episodes. UCH assets present snapshots of life and death, revealing valuable information on war, trade, innovation, and migration. Particularly, the European seas are host to cargo deposits, remnants of ancient trade routes, shipwrecks, and aircraft remains of World Wars. Currently, only 15% of the ocean has been scientifically surveyed (Mayer *et al*. 2018).

These underwater sites are part of this vast unknown, raising the issue that there is still unknown scientific knowledge and untapped potential surrounding these assets. UCH is part of a complex and multi-dimensional ecosystem of cross-sectoral actors (i.e. scientific community, archaeologists, policy makers, enterprises, businesses, citizens) involved in activities related to this maritime sphere: scientific research, conservation, protection, preservation in situ, accessibility, management and promotion, awareness, and research funding are all aspects of this. Technology is the main reference and linking point in these activities.

As a new field within the Blue Economy, BCT is being introduced through the BCThubs project. BCThubs promotes innovative technologies developed to support UCH in terms of scientific research, accessibility, and valorisation. Recognising the poor state of our knowledge of underwater sites, BCThubs is driven by the following needs: to effectively protect underwater cultural and natural resources from threats such as climate change, marine pollution, urbanisation, aggregate extraction, looting, physical degradation and other anthropogenic threats; to preserve archaeological assets in-situ including the surrounding natural heritage; to increase sustainability and opportunity for Blue Growth through the valorisation of UCH; and to ensure accessibility of underwater sites to divers and non-divers. Respective policy drivers have supported these needs, but the potential remains untapped, as very few underwater sites can be considered mature and readily available for academic and cultural tourism development.

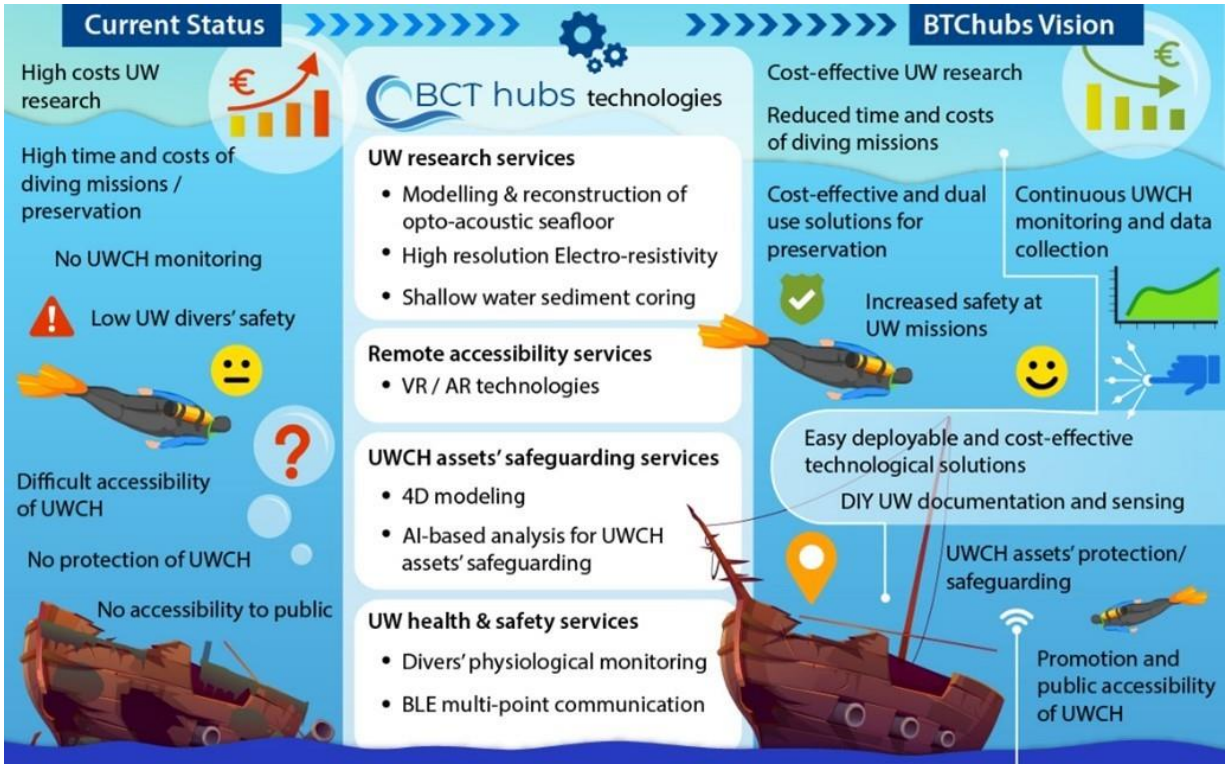


Figure 1. The BCThubs vision is mapped out above, showing the current situation in contrast to the BCThubs vision. The technologies, services and proposed infrastructure amendments are delineated.

The BCThubs project is currently operating within Greece, Bulgaria, and Malta. Three individual BCT Hubs have been set up in these respective countries. Each Hub faces common challenges which dictate a set of common goals to be pursued through the implementation of the project's goals. To this end, a joint Research & Innovation Strategy (R&I Strategy) has been designed, considering the compliance of the Strategy with respective regional, national, European Union (EU) and international related policies; the maximisation of opportunities to pursue synergies; and joint co-development and co-validation of foreseen R&I actions across the Hubs and among the Hub's ecosystem members.

This paper seeks to introduce the project's rationale and structure and discuss the benefits of establishing pan-European Hubs specialising in services and capabilities dedicated to UCH management and archaeological interventions sustained through technology and innovation. This paper is therefore presented with relevance to underwater archaeology and its study. Services, technologies, and innovation to better develop and enhance the researcher's role within the subaquatic world are delineated, with emphasis placed on the sustainability of this partnership beyond the project's conclusion. Finally, discussion on how UCH can operate within the Blue Economy and within the 2030 Agenda for Sustainable Development will be presented as well.

The BCT Excellence Hubs breakthrough

What is BCT?

BCT as an acronym stands for Blue Culture Technologies. This is a new sphere of blue technology aimed specifically at supporting research and development within cultural heritage, whilst operating within the Blue Economy. Blue technology is a burgeoning sphere within the Blue Economy (Pauli 2010), with this technology seeking to enhance and create a new ocean economic model centred on sustainability and the decoupling of traditional maritime economies from further environmental degradation (Spalding 2016). Considering this, BCT aims at building upon the new Blue Economy by addressing technology and research gaps within the maritime, coastal, and underwater cultural heritage sphere.

Four core principles form the *forma mentis* of BCT. The effective and holistic protection of underwater cultural and natural resources from threats such as climate change (European Commission, Directorate-General for Research and Innovation, 2021), marine pollution, urbanisation, aggregate extraction (European Commission, Executive Agency for Small and Medium-sized Enterprises *et al*. 2018), looting, physical degradation, and other anthropogenic threats are of primary concern. Several technologies and techniques are being developed to address the above issues, namely through the creation of three regional Hubs that intertwine and interlock societal, academic, governmental and industry partners. This approach, termed the quadruple-helix approach, seeks to bring all relevant actors together. The preservation of UCH and assets in-situ is the second principle by which BCT abides by. The importance of this principle is echoed by several international charters (UNESCO, 2001) and can also be found enshrined within local legislation as well. Nonetheless, BCT aims to create technology that will better assist in the full preservation of cultural heritage.

The third principal centres on the need for further opportunity for sustainable blue growth (United Nations 2023). This is to be achieved through the valorisation of UCH assets namely through the development of new technologies and creation of new methodologies that would better equip archaeologists, researchers, and cultural heritage managers. BCT also aims to ensure accessibility of underwater sites to divers and non-divers alike. By bringing the subaqueous world to the public, more appreciation and care for these sites will be engendered, therefore leading to a more sustainable and holistic approach to the preservation and enjoyment of these sites.

Whilst several policy drivers, both regional and international, have supported these needs the potential remains untapped, as very few sites can be considered studied, documented, preserved, valorised and accessible in a mature manner. These sites' accessibility to cultural heritage managers, and researchers and as products within the cultural tourism economy cannot be considered as viable yet.

BCThubs has identified the following factors as challenges that Blue Culture Technologies face. These challenges are placed within the sphere of the cultural heritage sector, as well as within the wider Blue Economy. One challenge as perceived by BCThubs is that there is a lack of customised and specialised technologies that address specific needs for the mature study and presentation of UCH sites and assets. Another is that Blue Culture (and the burgeoning Blue Culture Technologies) is a new and niche market with scarce players in Europe and beyond. This therefore leads to a fragmented approach to BCT, with a lack of co-operation between the respective actors. The few inroads into this sphere are supported by EU-funded projects, with a lack of national funding strategy observed within several European countries. These efforts should be supported holistically and fully, to achieve sustainability and appropriate success. The BCThubs project is seeking to address this issue through the implementation and execution of this project, which will lead to the formation of three mature Hubs across the

Mediterranean and the Black Sea. These Hubs will become best-practice models for other Hubs within this region.

There is also limited awareness of the Blue Culture potential for the sustainable growth of local coastal economies. Blue Culture is here being termed as cultural heritage that incorporates maritime, marine, coastal, and underwater cultural heritage, both of tangible and intangible properties. The benefits of cultural heritage in correspondence to the livelihood and commercial success of businesses within the Blue Economy has already been studied, although sporadically (Barianaki *et al.* 2024; Firth 2016). This is further reflected within the Research and Innovation Strategies for Smart Specialisation (RIS3) and within the national smart specialisation strategies in many coastal regions and countries as they do not include underwater, coastal, or marine cultural heritage in their policy priorities and funding instruments (Barianaki *et al.* 2024). This therefore leads to legislation barriers that do not allow the sustainable Blue Growth of these underwater cultural sites.

It is evident that there is a need for the setting up a long-term European partnership of quadruple helix actors, supported by a solid permanent structure, so to allow this new field of BCT to evolve for the benefit of coastal communities and sustainable development both at local and European level.

The BCT Excellence Hubs

The main goal of the BCThubs project is to reinforce innovation excellence, aiming at the protection, preservation, promotion, and valorisation of UCH. Through the creation of regional Blue Culture Technology Excellence Hubs and the establishment of cross-border collaborations within and among the Hubs and the different actors involved, this model aims to develop innovative research and innovation prototype solutions of BCT; joint strategies and action plans aligned with smart specialisation strategies and EU policies; support the sustainable management and promotion of UCH assets; and address the gaps in national and regional legislative framework. The rationale of the BCThubs project is to enhance accessibility, increase innovation, mobilise underwater research capacity, and increase knowledge on UCH. This will then contribute to raising the public awareness on such assets, which will thusly lead to further protection.

The establishment of BCT Excellence Hubs further targets sustainable tourism development and Blue Growth through the responsible promotion of UCH sites in coastal and island areas where such resources are often unknown and remain neglected and unexploited. Towards the Blue Culture and Blue Economy development, it is necessary to focus on the sustainable management and accessibility of sites. The BCThubs project aims to support this by establishing innovative research Hubs, scoped locally, and aimed at accelerating excellence. The development of innovative technologies will support the research, accessibility, and valorisation of underwater sites, contributing to the in-situ preservation and the protection of these submerged cultural remains and the marine environment, as well as raising awareness and increasing access to divers and non-divers alike.

By introducing a new approach that focuses on building R&I capacities in the Blue Economy sector, BCThubs project aims to establish BCT Excellence Hubs as pilots within three different regions. With the participation of the quadruple-helix regional and national stakeholders active in different blue sectors, each Excellence Hub will follow a joint strategy, with the aim of introducing and pilot testing innovative R&I solutions. The ultimate objective is to provide access to excellence for all actors involved, to reinforce knowledge transfer and to drive innovation in Blue Culture Technologies and the Blue Economy.

Blue Culture Technology, The Blue Economy and BCThubs

The concept of the Blue Economy originates from the 2012 United Nations Conference on Sustainable Development and is defined as being the sustainable industrialisation and commercialisation of the oceans to the benefit of all (Smith-Godfrey 2016). Several aspects make up this Blue Economy, or Blue Growth, with coastal tourism being a salient aspect identified as one of the six key factors that traditionally contribute to this economy (European Commission, Directorate-General for Maritime Affairs and Fisheries, Joint Research Centre 2019). Cultural heritage is a key contributor to coastal tourism and can also be considered as 'indispensable for a balanced and complete life' (Government of Malta 2002). Despite Blue Culture being a niche market, it has great potential for sustainable growth. Nonetheless, the lack of technologies customised to assist for the effective research and responsible promotion of these sites, coupled with the limited awareness among stakeholders, does not favour the evolvement of this new field.

An interdisciplinary approach to the collaboration between the quadruple helix actors and encouraging the active involvement of stakeholders in the blue sector and the Blue Economy underpins the BCThubs project approach. Capacity building and smart strategies specialisation are core aspects for the sustainability goals of the project. These developments are based on both research and innovation within the UCH sphere, with lobbying for the inclusion of these cultural assets within policy priorities, like Maritime Spatial Planning (MSP) among several others. Interventions at local, regional, and national level, whilst fostering interdisciplinary collaborations and cross-border synergies among actors, will address common strategic needs, therefore creating and facilitating a sustainable framework within which BCT, research, cultural tourism, and the Blue Economy can operate in.

The main pillars of the BCThubs project and in parallel the expected outcomes and impacts of the BCT Excellence Hubs are:

Establishment of three BCT Excellence Hubs in Greece, Malta, and Bulgaria.

The BCT Excellence Hubs are innovative R&I ecosystems, that aim to provide actors with access to innovation excellence, thus transferring information and exchanging experiences (e.g. through training) within the Hub, among the Hubs' members and across the EU. Therefore, even though the BCT Excellence Hubs are established regionally, they are interconnected and are pursuing cross-border collaborations on common strategic goals and new value chains. The establishment of the BCT Excellence Hubs addresses regional innovation excellence and cross fertilisation of knowledge, thereby reinforcing R&I ecosystems in critical BCT fields, including underwater surveying and documentation, diver health and safety, and the accessibility, awareness, and promotion of these cultural assets. Capacity building and the intensification of synergies among the various actors operating within the academic, industry, governmental and societal sectors within the Blue Economy will further mobilise the preservation and protection of UCH.

Development of a cross-border joint R&I Strategy to support sustainability of the Hubs' operation in the long term.

The development of a joint strategy for the BCT Excellence Hubs aims to improve the commercial aspects of BCT. The individualised R&I investment strategies and the deployment of BCT at intra- and inter-Hub levels will achieve the long-term sustainability goals of a pan-European BCT cluster. The enhancement of competencies and skills development for researchers, entrepreneurs and professionals will not only promote underwater research, innovative technology products and services being created among the Blue Economy actors, but also facilitate the development of synergies across the quadruple helix stakeholders, thereby building links and collaboration opportunities between academia, government, and industry. In parallel, the R&I strategies will address perceived lacuna within regional legislation. This will be achieved by introducing key elements related to the accessibility and sustainable management and promotion of underwater cultural heritage, aligned with RIS3 strategies and other EU policies.

Preparation of an Investment Strategy & Plan for the implementation of the joint R&I Strategy.

Investment plans have been developed for the BCT Excellence Hubs to support regional and cross-border efforts (i.e. infrastructures and technologies), as well as to leverage funds and investments beyond the BCThubs project lifetime. Actions including the creation of a BCT marketplace and the development of business models in each Hub, which will further promote the sustainable exploitation of the emerging BCT. As a result, investment strategy and planning will further support the uptake of new scientific knowledge in BCT Excellence Hubs areas. The investment strategy will also facilitate R&I efforts and partnerships among the public and private sectors through the acceleration of BCT businesses, following with the creation of new employment opportunities in the BCT sector and in the Blue Economy in general.

Implementation of specific innovative R&I products and services, critical for underwater cultural heritage research in the BCT Excellence Hubs' regions.

By promoting joint efforts and interdisciplinary collaboration, the BCT Excellence Hubs are developing prototype solutions and services to facilitate technological development in UCH research. These solutions and services will be accessible with market potential, such as 3D modelling, reconstruction, creation of photomosaics, and Augmented Reality (AR) and Virtual Reality (VR) diving systems. As a result, both the actors within the Hubs and stakeholders outside the Hubs at regional, national, and international level will benefit and share new knowledge on several scientific and innovation fields whilst improving the Hubs' capacity to implement the joint strategy and investment plans. The R&I products and services being created aim to be effective solutions for the preservation, monitoring and safeguarding of UCH sites. Greater awareness and accessibility will also be achieved through these products and services via virtual and augmented diving, allowing the inclusion of both divers and non-divers. The dual use of R&I solutions is cost-effective, creating economies of scale and reduced costs for traditionally prohibitive and costly efforts such as underwater archaeological excavations. In addition, the development of R&I products and services within the Hubs will facilitate the uptake of innovative technologies within the Blue Economy, the cultural heritage industry, the tourism industry, and the maritime industry. As a result, the BCT solutions will have high market potential and will create new

Blue Economy value chains, thus providing several stakeholders and actors with access to financing and business acceleration schemes.

Engagement in the Excellence Ecosystems and Replicability of the BCT Excellence Hubs.

A key role of the BCT Excellence Hubs is the enhancement of citizens' and stakeholders' participation and engagement in the Hubs. To this end, focus is placed on cohesion, outreach, and dissemination activities. These include BCT skills development and entrepreneurship training, networking, and technology transfer. Another important aspect of the Hubs establishment and pilot operation is to effectuate new BCT Excellence Hubs in other areas. The replicability of these three Hubs within other countries rich in UCH is vital for the creation of a European BCT cluster. Another aspect within the engagement and replicability plans for the BCT Excellence Hubs is the lobbying for the inclusion of UCH as a vital and important maritime source within the Blue Economy and within the respective RIS3 strategies. The preservation, management, and valorisation of UCH, placed within a sustainable framework will lead to self-sustaining growth. To examine and support the replicability potential of the BCThubs approach in other regions, there will be an analysis of needs and a development of a BCT Excellence Hubs roadmap with milestones.

The Hubs' BCT and R&I strategy within the wider Blue Economy

Overview of the BCT Hubs R&I Strategy

BCThubs will directly impact on different European strategies defining a state-of-the-art approach to support UCH in terms of scientific research, accessibility, and valorisation. The project contributes directly to important EU policy priorities, strategies, and initiatives such as the United Nation's (UN) Sustainable Development Goals (SDGs), especially SDG Goal 14: Life Below Water which relates to the conservation and sustainable use of oceans, seas and marine resources (United Nations 2023); the EU Green Deal Action on climate change as a threat to our cultural heritage (European Commission, Directorate-General for Research and Innovation 2021); Blue Growth Strategy and MSP for addressing increasing competition among sea users and mitigating pressures on the marine environment, both natural and cultural (European Commission *et al*. 2018); the UN's global declaration of 2021-2030 as the Decade of Ocean Science for Sustainable Development; Regional RIS3 and related European Regional Development Fund (ERDF) investments to cultural tourism, diving tourism, related scientific research, and many others. This Joint R&I Strategy will be the foundational blocks for the individual R&I Strategy within each Hub, creating permanent structures towards the establishment of the EU-wide BCT Cluster and is structured around the following four pillars.

The first pillar is dedicated to underwater research supporting services and Information and Communication Technology (ICT) capabilities. This pillar includes technologies aimed at modelling and reconstruction of opto-acoustic seafloor Digital Terrain Models (DTMs); photomosaics integrating remote sensing; and 3D underwater modelling of UCH assets. These will be coupled with Artificial Intelligence (AI) algorithms which will support the fusion of information from various inputs namely from acoustic and optical sensors, Geographical Information System (GIS) data, and inertial sensors. The objective is to provide a uniform and coherent 3D and 4D representation of the underwater seabed, and any remains and sites.

High resolution electro-resistivity methods will be developed to support underwater archaeological research, based on adaptation and improvement of existing hardware. This will achieve high-precision measurement density and detailed stratigraphical research and documentation of zones of archaeological interest and their 3D and 4D visualisation.

Small-scale drilling devices, employed for shallow water sediment coring, are being designed. This will make this tool more affordable and easily operable from a small research support vessel in shallow waters. The contraption is based on a combination of gravity corer and vibro-corer run by hydraulic motors.

Improvement to underwater navigation and positioning will be consolidated. Building upon existing navigation and positioning software and hardware assets such as tablets, smartphones, diver propulsion vehicles, Ultra-Short-Baseline (USBL) positioning, and other similar types of technology, these will be improved upon by the Hub's members.

Digital Twinning AI-models of UCH sites are being researched and prototyped, combining 3D models of sites and augmented through fusion of sensing data (i.e., soft, and hard sensing, inclusive of environmental parameters), offering a two-way interface between the digital-physical worlds. Digital Twinning feeds decision making and policy-design, therefore becoming a valuable tool.

An important element is dedicated to improving methods and technologies for underwater restoration and conservation. Most of the Hubs' members have worked in the UCH field in restoring and conserving these assets and sites. These interventions include first aid and long-term conservation treatment. Furthermore, the Hubs' researchers have been developing ad-hoc methods for preserving underwater archaeological monuments, movable or immovable, waterlogged organic or inorganic artefacts. Such knowledge needs to be cross-fertilised among the Hubs and coupled with basic procurement of required electro-mechanical tools. A methodology based on real-life scenarios will be implemented and established across the Hubs.

The final element belonging to this pillar is the creation of a BCThubs online repository for storing and sharing field-data. An online repository will become an instrumental tool for archaeologists and could be used by each Hub ecosystem for recording and storing field data during missions.

The second pillar is dedicated to the establishment of services for improving on-site and remote accessibility. Exploring VR to further enable remote accessibility to UCH sites is a key element of this second pillar. This will be achieved through the establishment of a cloud-based VR platform enabling users to simulate the underwater exploration of submerged sites from a scuba diver's point of view.

Additional to VR, augmented diving capabilities, based on acoustic communication and localisation will be developed. Building upon waterproof cases integrated with environmental sensors and acoustic geo-localisation facilities, this will enable mobile devices to capture images, video, and data for monitoring. An element of citizen science can be introduced here as well. The importance of democratising scientific research and promoting the overall goal for the preservation of culture and the environment is equitable. (de Sherbini *et al*. 2021).

The second pillar involves the implementation of models and strategies for the holistic management and operation of underwater cultural sites. This will include multi-faceted modelling transforming these sites into sustainable cultural tourism destinations, considering multiple objectives, such as cultural, environmental, societal, economic constraints, unique assets and strengths of the regions and sites. Finally, Knowledge Awareness Centres (KACs) empowering UCH research and management will

be founded. The establishment and operation of a KAC in each BCT Hub, as a central point of promotion of the sites within the Hub's region, will be coupled with the establishment of the BCT Hub. Such KACs could also be instrumental to offer a dry-dive immersive experience to visitors related to the actual sites.

The penultimate pillar relates to the safeguarding services and capabilities of UCH assets. The first element focuses on the continuous monitoring of these sites using uninterrupted data streaming. This will be achieved through the integration of relevant outputs from Hubs' members. These will be complemented by available commercial underwater monitoring and data streaming systems, combining software and hardware assets. 4D models and real-time streams, combined with AI-based comparative analysis for UCH asset safeguarding will integrate deep learning models coupled with GIS data inclusive of DTMs modelling, and photomosaics. This forms part of the second element within the third pillar and will enable auto-comparison of synthesised images, videos and photomosaics of the monitored sites, enabling the detection of looting and the degradation of these assets.

The final pillar is dedicated to underwater health and safety services and capabilities. This pillar will be achieved through the mapping of safety protocols and Hazard Identification and Risk Assessment (HIRA) protocols. Identification of hazards at each site in each BCT Hub will be undertaken, and analysis of each involved risk together with associated risk mitigations will be developed. Training in and deployment of HIRA methods and protocols will therefore be generated, with progressive attainment of HIRA certifications (HIRA-1 to HIRA-3).

The second element involves the physiological monitoring of divers. Experimentation, development and use of suits or wearable t-shirts equipped with sensors will extract multiple physiological parameters during scheduled dives. This data will include electro-cardio, breath rate related data, and other parameters. These datasets will be consolidated, processed, and communicated to surface control centres for increased health and safety monitoring during and after diving missions. The final element is the capitulation of the previous factor. Bluetooth Low Energy (BLE) multi-point communication and Decompression Risk Analysis (DRA) will be developed to synthesise the abovementioned datasets. Diving related data during underwater missions will be collected using BLE technology for multipoint data communication. This will also enable the operation of an underwater Internet of Things (IoT) network. Such data will be visualised, along with results of real-time DRA; and transmitted to control centres using nano-acoustic modem technology.

The realisation of the above joint R&I Strategy through these four pillars is expected to produce several proof-of-concepts or prototypes. These will undergo a maturity process according to the technology readiness level (TRL) maturity pathways.

New Technologies

The Blue Culture Technologies identified within the BCThubs project address several critical needs, including protecting underwater cultural and natural resources from threats like climate change, marine pollution, looting, and urbanisation. They also focus on preserving in-situ archaeological assets in their surrounding natural heritage, promoting sustainable Blue Growth through the valorisation of UCH, and ensuring these sites are accessible both to divers and non-divers. To achieve these objectives, the BCThubs partners are implementing specific R&I prototype solutions to empower the capabilities of the Hubs.

Robotic Platform

An advanced robotic platform was developed to enhance underwater 3D modelling capabilities. By integrating various sensors, including optical, acoustic, navigational, and inertial sensors, the platform can capture different environmental data (Seberino *et al.* 2023). This data can be combined using advanced data fusion algorithms and multimodal artificial intelligence models to create more detailed and accurate representations of the underwater environment compared to the traditional methods based on single-sensor data. The platform is designed to be easily mounted on Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs), allowing it to be used in various underwater explorations, from shallow coastal waters to deep-sea. Currently, it includes a hybrid ROV (H-ROV) capable of autonomously operating underwater up to 1,000m. It is equipped with a photogrammetry sensor system (RSP) composed of a stereo camera and a monocular camera. In addition, it comprises an external lighting system capable of providing 20,000lm to support photogrammetry surveys in deep waters. The stereo-camera system runs advanced computer vision algorithms, enhancing underwater images and providing 2.5D contour representations of isobaths. This setup enables real-time 3D reconstructions, with the stereo-camera providing metric information and the monocular camera delivering high-resolution images. Finally, the platform also supports Simultaneous Localisation and Mapping (SLAM) for consistent bathymetric reconstructions and integrates navigation sensors like a Doppler Velocity Log (DVL) and an Attitude and Heading Reference System (AHRS) for precise geo-referencing of data. These capabilities are crucial for navigation and manipulation, offering enhanced situational awareness.

High-resolution Electro-Resistivity

The focus lies in developing a methodology for High-resolution Electro-Resistivity (HRER) prospecting for underwater archaeology sites based on adaptation and improvement of existing hardware. Using innovative technological developments in hardware, the BCThubs project aims to develop methodology for achieving HRER measurements applicable for detailed geomorphological surveys of archaeological sites, as well as for surveys in compromised areas where traditional methods are not effective. The methodology allows two modes of use. The first is a static mode of scanning for object detection and ultra-detailed geomorphological surveys. The second incorporates a dynamic mode for searching for buried objects and global geomorphological study. Currently, appropriate equipment has been successfully identified and delivered, and preliminary tests have been conducted. In static mode, the methodology demonstrated excellent results by successfully differentiating existing stratigraphic units in a section, located near an ongoing underwater archaeological excavation trench. Another success was the identification of a buried artificial object, possibly a shipwreck within the Bulgarian Sea Basin.

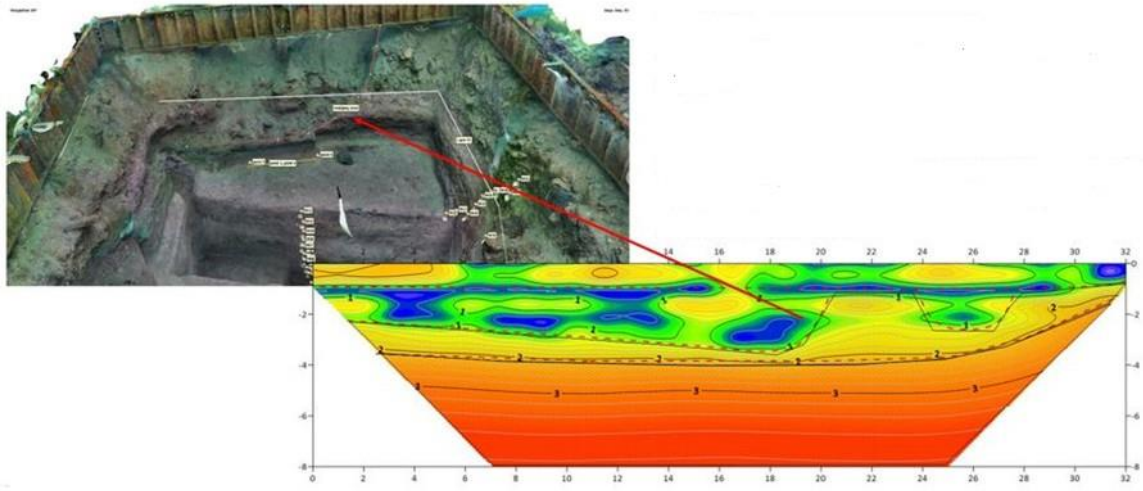


Figure 2. Static test of HRER at an archaeological trench in Sozopol Harbour, Bulgaria. Top left shows a 3D photogrammetry model of an archaeological trench which indicates the stratigraphic units in section. Bottom right image shows the electro-resistivity section measurements taken in proximity to the trench, with an interpretation of the stratigraphic layer structure.

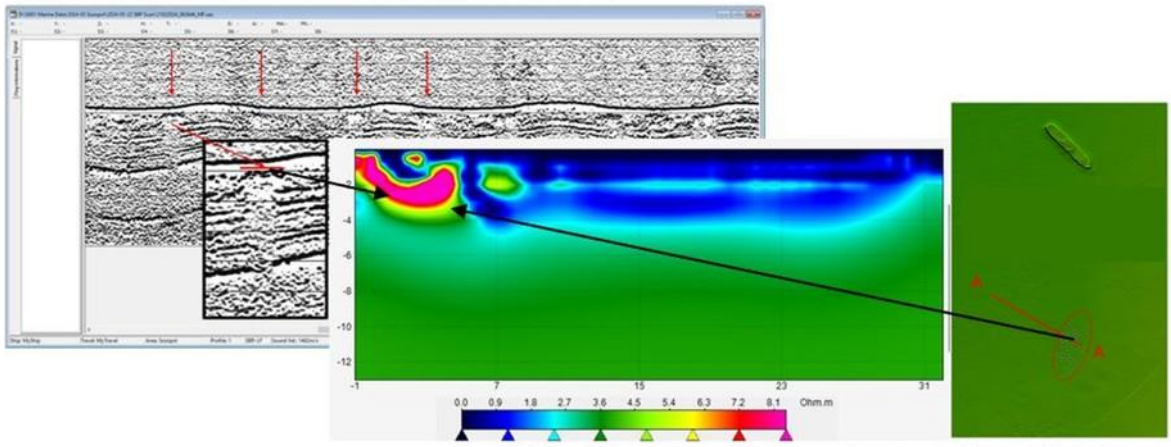


Figure 3. Static test of HRER showing a buried artificial object, possibly a shipwreck, in Sozopol Harbour, Bulgaria. Top right image depicts the sub bottom cross section, showing the identified buried object. Centre image depicts results from the electro-resistivity scanning section over the anomaly zone, along line A-A, showing the buried object. Inset image to right is a plan view showing the position of the measure section A-A.

Shallow water sediment coring system

The main objective is to develop an innovative underwater mechatronic tool to effectively core the seabed and collect samples, deployed from a small research ship in shallow water. Initially, a wide-scale study of the available vibro-coring devices, mechanisms and coring heads was conducted. The device designed by the BCThubs partners is based on a combination of gravity corer and vibrocorer run by

hydraulic motors that can be employed in various scientific or commercial applications and become a routine research device for field research.

Virtual Diving

VR Technology has proven its effectiveness in increasing the value of cultural heritage and in the last years has been effectively applied for the exploitation of UCH. The main aim of the BCThubs Virtual Diving application is to improve remote accessibility to these sites by capitalising on the results of the iMARECulture project[20], where a VR solution demonstrated its potential in raising awareness on UCH (Bruno *et al.* 2019). Within the BCThubs project, a cloud-based VR application has been developed to allow final users (i.e. visitors, stakeholders, etc.) to enjoy the experience of diving among the remains of ancient civilizations or shipwrecks. The virtual scenario depicts the actual conditions of the underwater archaeological area and the surrounding seabed, thanks to the integration of the digital replica of the underwater cultural assets, taken by means of photogrammetric or acoustic acquisition techniques. These 3D scenes are populated and completed with 3D models of the flora and fauna typical of the marine ecosystem, such as fish, sponges, and seagrass. Moreover, visual and audio effects simulating the underwater environment are added to make the experience more immersive. Multimedia content such as texts and audio in various languages provide extra information about the site, its history, and additional details by employing a digital storytelling approach. The application is compatible with the latest Head-Mounted displays and implements a smooth interaction by means of the provided handheld controllers. The gamification approach is addressed thanks to a virtual diving buddy who will guide the user during the exploration. Preparation for VR diving tours are currently underway, with a site identified in Malta related to a deposit of Carystian marble columns being an initial demonstration site (Superintendence of Cultural Heritage 2003).



Figure 4. Image on left showing one of the Carystian marble columns in profile. Image on the right demonstrating virtual diving technology.

Augmented Diving

To enhance exploration and accessibility of UCH Sites an UnderWater Augmented Reality (UWAR) system has been developed. It includes an acoustic localisation system based on the USBL positioning method for tracking divers' position, and a custom application that delivers a comprehensive and

[20] The iMARECulture project received funding from the European Union's Horizon 2020 research and innovation programme. This project sought to enhance and produce immersive virtual diving experiences. https://imareculture.eu/

immersive diving experience by implementing several functionalities. The application runs on a tablet or smartphone enclosed in a waterproof case, capable of operation at depths of up to 60m, with which divers can interact using a magnetic button panel. Through the application, the UWAR system provides the divers with a dynamic map of the underwater site, showing its current position and orientation, the route taken and the location of points of interests (POIs). It also allows the diver to visualise augmented content by using AR, such as the historical reconstructions of shipwrecks or other information related to naturalistic and historical contexts. In addition, divers can document the site in real time by capturing geo-localised data, such as HD photographs and text notes, as well as environmental data from sensors. Finally, users can communicate with control station operators based on shore or on a support vessel. Thus, the UWAR system improves the sites' exploration and accessibility by exploiting acoustic localisation and an AR-based application.



Figure 5. The augmented diving app used in tests in a controlled environment.

4D Modelling and AI-based Analysis for Safeguarding Underwater Cultural Heritage Assets

This technology focuses on the protection of UCH assets through advanced 3D and 4D modelling and real-time video streaming. The approach begins with 3D reconstruction using techniques Structure-from-Motion (SfM), applied to real-world underwater datasets. These models are enhanced through various methods, such as multiview integration, iterative closest point techniques, and stereo vision for calculating disparity and depth maps. The development includes a novel evaluation methodology to assess the quality of 3D reconstructions in the absence of ground truth data. Real-time video streaming capabilities are integrated to enable continuous monitoring of these sites. Advanced machine learning (ML) and AI algorithms are employed to analyse video input alongside the 3D models through time. These algorithms are designed to detect and compare potential looting or degradation, providing a proactive measure for asset protection. The technology leverages deep learning (DL) to improve feature matching, using hardware acceleration (GPU-CUDA) and preprocessing techniques to optimize

performance. This comprehensive system offers a robust solution for preserving and monitoring, ensuring protection against both natural and human-induced threats.

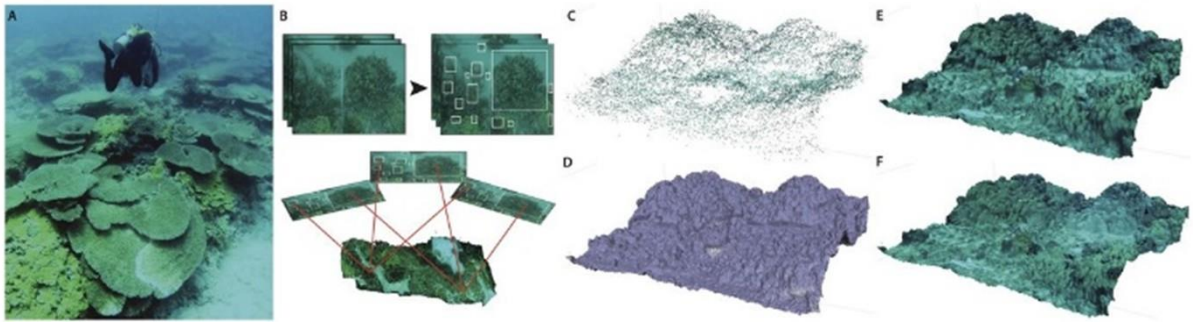


Figure 6. 4D modelling and AI-based analysis methodology.

Underwater health and safety services

Nowadays, underwater data transmission for physiological monitoring represents the latest advancement in diving research. Real-time acquisition serves various goals: primarily safety, followed by data acquisition. Enhancing safety is a key objective for all dive computer brands. In recent years, there have been notable changes in design and display readability, but updates are still needed in the mathematical models for Decompression Sickness prevention. The system developed within the project consists of four different devices: a cardiac chest brand, the DiveSense, a buoy, and a web portal. The cardiac chest band continuously acquires heart rate (HR) and inter-beat (RR) time and sends it every 2 seconds to DiveSense. Communication between the chest band and the DiveSense is via Bluetooth Low Energy (BLE). DiveSense is at the core of the system, receiving data from the chest band, reading depth and temperature from dedicated sensors, storing data in flash memory, displaying data to the diver on a 2.8inch TFT Display, and sending aggregated data acoustically to the surface buoy, also known as the Anchor. The Anchor floats on the water surface and receives data from the acoustic modem. Upon receiving an acoustic packet, it checks the integrity of the data. If the data is correct, it parses and sends it to the following nodes; if the data is corrupted, it discards it immediately.

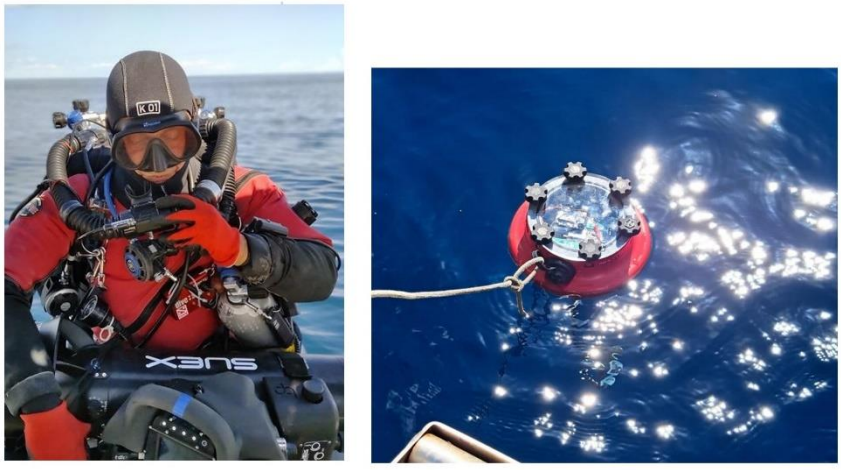


Figure 7. Diver demonstrating the BLE DiveSense wearable, with the Anchor shown on the right.

BCT Hub establishment in Greece, Bulgaria, And Malta

The BCThubs project aims to build Blue Culture Technology Excellence Hubs in the participating widening countries, Greece, Bulgaria, and Malta. These Excellence Hubs will serve as permanent structures supporting new innovative solutions and products for the sustainable protection, restoration, valorisation, management, accessibility, and promotion of UCH.

Although the new Hubs will be scoped regionally, they will be interconnected and oriented towards national and international synergies, pursuing cross-border collaborations on common strategic goals and alongside value-added chains. Each Excellence Hub will bring together all regional and national actors related to Blue Culture and UCH, including research, academia, businesses, public sector, and societal actors, employing the quadruple-helix approach. This approach underpins the BCT Ecosystem Development and will mutually reinforce capacities and effectiveness towards raising innovation excellence in sustainable Blue Economy and Blue Culture in the respective regions.

BCT Ecosystem Development

The BCT Ecosystem Development includes an in-depth stakeholder mapping of the existing BCT clusters, and an analysis of the capacities and capabilities of these clusters, followed by a presentation of stakeholder engagement and monitoring plans.

A sustainable cooperative approach is envisioned, addressing the quadruple-helix framework of the clusters. These place-based ecosystems will evolve and mature to form permanent strategic-partnerships and a solid supporting structure – the EU-wide BCT cluster. The maturation of the Hubs will set the basis for the European BCT cluster, ensuring sustainability and continuation of the project through innovation, growth, employment, and the future uptake of similar models within other European regions. The establishment of the BCT Hub within each country will be reinforced with the creation of a physical space to host the project's activities, during the lifetime of the project and beyond, and through the uptake of stakeholder's agreement and understanding of the project's goals. To this end, an understanding of the different legislative landscapes within each Hub is also required to facilitate the deployment of the necessary rules for their establishment.

The quadruple-helix approach depends on four factors: building structure, fostering interaction, creating value, and learning (Schroth and Häußermann 2021). These four key terms have been adopted and adapted to give definition and guidance to the overall scope of the quadruple-helix stakeholder mapping. Following this assessment of Blue Culture and Blue Economy stakeholders within the respective Hubs, 76 endorsed partnerships have been created, surpassing the initial expectations outlined in the project proposal. These partnerships have become BCT Hubs Members, and will help foster sustainability, policy cohesion and continuation of the EU-wide BCT cluster.

An assessment of the needs, digital maturity, and availability of tools and infrastructure of the Hub members (stakeholders and participants within the BCT quadruple-helix collaboration) will be the focus of this assessment. This assessment will indicate the readiness level of each Hub to support archaeological missions (underwater documentation, excavation, safeguarding, promotion, accessibility, amongst other tasks) inclusive of Small and Medium-sized Enterprises (SME) service provisions as well. To this end, a survey will be conducted, providing a detailed view of the main technical support needs and digital maturity level of the value-chain actors and ecosystem members.

This will be translated into a roadmap of the actions to be pursued to increase maturity and readiness levels.

BCT Physical Space within the Hubs

An identification exercise for the physical hosting space, representing the BCT Hubs, was undertaken. These spaces ideally occupy a location close to sea which would allow easy access for underwater missions and accessibility for technology demonstrations. These spaces should also be able to host lecturers and meetings, whilst also providing an appropriate customer interface between new potential users and Hub members. This has been achieved with the identification of three physical spaces within the Greek, Bulgarian and Maltese Hubs.

The Greek Hub will be initially housed in the premises of the Department of History, Archaeology and Social Anthropology within the School of Humanities and Social Sciences, a faculty within the University of Thessaly in Volos. Parallel efforts are being made for finding a space for possible allocation, while the possibility of purchasing a used vessel that will function as the floating leg of the Greek Hub is being explored.

In particular, the purchasing of a used vessel could facilitate many of the predefined supplementary activities of the Greek Hub, namely field testing of technologies being developed in Work Package 2 and Work Package 3, such as: underwater navigation and positioning; methods and technologies for UCH restoration and conservation; modelling and reconstruction of seabed using appropriate maritime acoustic technologies; continuous testing and validation for scaling up of technological proof of concepts developed as part of the R&I Strategy of the Greek Hub; training of stakeholders in the field and demonstration of Hub's technologies in the context of awareness raising events.



Figure 8. The two proposed BCT Hubs physical spaces for the Greek Hub. Image on the left shows the University of Thessaly's Roza Imbrioti Building, while the left shows the proposed research vessel, both in Volos, Greece.

Within the framework of the BCThubs project, the Bulgarian Hub envisages the rehabilitation of part of the Centre for Underwater Archaeology's premises in Sozopol to create a physical space to house the Hub's activities. The space is already engaged for underwater missions, and therefore it was identified as an ample and adequate space to host the BCT Bulgarian Hub. The goal is to create a fully functional

room for year-round work, for meetings, presentations, office, and laboratory activities. Towards the end of 2023, an architectural project was prepared, and in 2024, the premises will be renovated.



Figure 9. The current premises dedicated to UCH, within the remit of the Centre for Underwater Archaeology, will be renovated to become the BCT Hub in Bulgaria. Image on the left shows current state, with an architectural render depicted on the right.

The current space proposed for the Malta BCT Hub is the ITS Campus, located in Qala, Gozo. Its proximity to notable UCH sites, protected marine landscapes, as well as its location within Gozo, make it an ideal space for the establishment of the Hub. The Qala ITS Campus will be utilised by the Maltese BCT Hub until 2026, as state of the art premises in SmartCity Kalkara, Malta is currently under construction. These new premises will become the established and physical presence of the BCThubs, beyond the completion of the project.

The current premises hosts a fully functional and equipped scuba diving facility centre, a medical research room, and is an ideal location for all underwater and aquatic related activities envisioned within the BCThubs project. The future premises in Kalkara comprise of an indoor-pool facility suitable for contained testing, a medical room, a hyperbaric chamber, meeting rooms, lecture rooms, and on-site accommodation. The Kalkara premises will also be reachable by vehicles of all types and sizes. This will allow the delivery of any diving equipment and other specialised equipment.

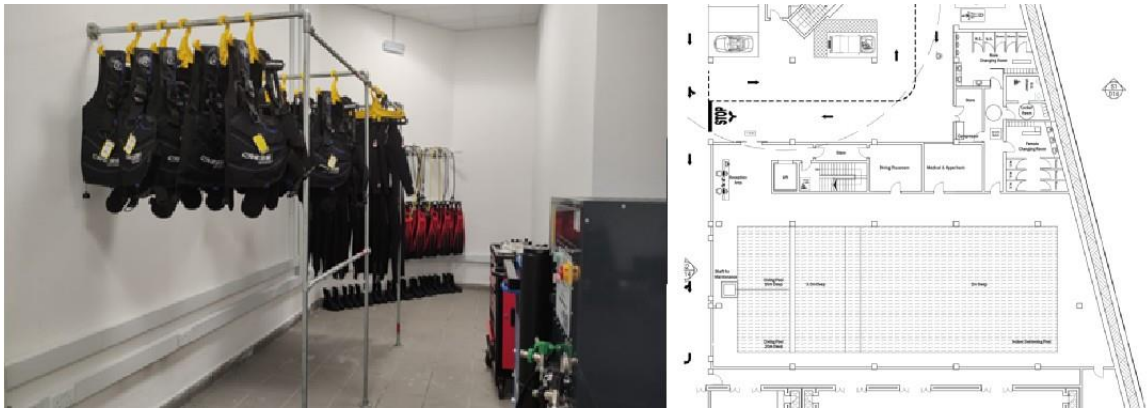


Figure 10. The Maltese Hub is currently operating from the ISDSM ITS Qala Campus, in Gozo Malta. It is equipped with lecture rooms, meeting rooms, storage space and a medical research room, as shown in the image on the left. The image on the right contains architectural plans for the future Maltese BCT Hub, which will be housed in the new ITS campus in Kalkara, Malta. These premises will additionally house an indoor pool reaching a depth of 20m, a children hyperbaric chamber, and additional meeting spaces. These new premises will be completed by 2026.

Conclusion

BCT, as a concept, is a novel addition to the new Blue Economy. It seeks to marry the technological advances and capabilities of traditional maritime sectors with the needs and requirements of the cultural heritage sphere. The marine and maritime environment have both a social and an economic value (Firth, 2016) which should be used and protected in a sustainable manner. BCT aims to propagate sustainable and cohesive measures for the valorisation and management of UCH.

With the introduction of a state-of-the-art approach that focuses on BCT, BCThubs is aiming at strengthening research and innovation capacities in the Blue Economy sector and supporting the research, protection, and sustainable valorisation of UCH. This will be achieved through the establishment of BCT Excellence Hubs, initially within Greece, Bulgaria and Malta, and the development of innovative technological solutions for the preservation, management, and promotion of these assets. The novelty of the BCT Excellence Hubs model is their development as a solid technological and business framework. Their effectiveness lies in the fact that despite their regional focus of intervention, their common strategic goals engender the creation of synergies and cross-border collaborations aimed at addressing common goals in alignment with national and EU strategies.

This collaboration will affect scientific, societal, economic, and technical spheres of each region, allowing for regional innovation excellence, cross-fertilisation of knowledge at inter-Hub level, reinforced scientific and innovation ecosystems in critical BCT areas, increase in capacity building and upskilling, promotion of regional UCH assets, and awareness of pan-European values on cultural heritage. In each Hub, detailed mapping of the existing quadruple helix stakeholders related to Blue Economy and Blue Culture was undertaken. Methodologies, tools, and definitions for this task were identified and developed. Following this, an iterative endorsement campaign was developed and launched. Furthermore, activities providing access to excellence for R&I actors will be implemented. These activities include trend-watching, technology scouting, brokerage, value-chain reinforcement, inclusive of knowledge transfer such as training and secondments, and development of entrepreneurial skills including new competencies and skills for researchers, entrepreneurs, and professionals in Blue Culture R&I.

The Joint BCT R&I Strategy will be aligned with EU policy priorities and will be oriented towards the following four dimensions. Research Development and Innovation will focus on joint pre-competitive Research and Development (R&D) in selected topics, readiness assessment, and proof of concept development. Infrastructure will focus on access to infrastructure and technological platforms and tools. Technical facilitation of scale up will focus on protocols and facilities for concept validation, and prototyping. Validation will focus on protocols and scenarios for product demonstration, in-lab validation, and validation by end-users in the field. The development of a cross-border joint R&I Strategy will support and assist in the sustainability of the Hubs' operation in the long term, assisting in the establishment of BCT Excellence Hubs in Greece, Bulgaria, and Malta.

For thousands of years the ocean has been a source of life and intrigue. Scientists and archaeologist have long endeavoured to probe and understand this essential part of our world. The BCThubs projects seeks to contribute to this through the creation of R&I strategies, investment plans, and the enhancement of technology in order to assist in this research. Operating within the Blue Economy, BCThubs endeavours to address this through the enactment of three operational BCT Hubs, spread across the Mediterranean and Black Sea. This article has made a case for the continued and renewed need for collaboration from all sectors of society to preserve, enhance and promote the myriads of

assets found within the Blue Cultural sphere. Various practical steps have been discussed, with numerous technological advances proposed, making this more achievable.

Acknowledgements

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Conflict of interest

The authors declare no conflicts of interest.

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Ports, harbours and anchorages

Ephesus: Reconstruction of the Harbour City of Ancient Rome in the East

Ahmet Denker[1] and Hakan Oniz[2]

Abstract

Ephesus was once Imperial Rome's most prominent harbour city in the East. It was established as a major urban centre on the plateau between Mt. Coressus (Bulbul Dagh) and Mt. Pion (Panayir Dagh), with most surviving structures reflecting Roman architecture atop Hellenistic foundations. Under Augustus, Ephesus became the capital of the province of Asia, symbolizing its status within the empire. This project aims to digitally reconstruct the port of Ephesus and its surrounding areas, bringing to life the harbour district as it was in its heyday. Although Ephesus is no longer connected to the sea—its harbour closed off centuries ago by silt from the Cayster River—during its peak, the port served as a vital maritime hub. It was central to the trade network that fuelled Rome's vast empire. Using ancient texts, lithographs, architectural plans, photographs, and digital images, this study reconstructs Ephesus's harbour and the neighbouring landmark structures and restores them to their original state in the Roman era.

Keywords: Ephesus, port of Ephesus, virtual heritage, digital reconstructions, virtual reality

Introduction

Ephesus, once Imperial Rome's greatest port in the East, lies over a thousand miles from Rome and now two miles inland from Turkey's Aegean coast (Figure 1). Conquered by Rome in the 2nd century BC, Ephesus grew into a thriving metropolis. Much of what remains today reflects Roman structures atop earlier Hellenistic foundations, and under Augustus, the city was named capital of the province of Asia. This work aims to digitally reconstruct Ephesus's Roman port and its surroundings, restoring an ancient landscape once frequented by Alexander the Great, Augustus, Antony, Cleopatra, St. Paul, and the Apostle John.

The once-prosperous harbour of Ephesus silted over centuries ago, gradually cut off from the sea by deposits from the Cayster River (Blackman 1982). In its prime, however, it was a crucial maritime hub within the Roman Empire, part of a vast network of ports across the Mediterranean (Steskal 2014). This digital reconstruction revives the ancient harbour city, beginning at the Harbor Gate, the entryway to Ephesus for countless voyagers. Originally settled by Greek Ionians fleeing Greece's Dark Age collapse, the city flourished on this beautiful stretch of the Aegean.

Stretching from the Harbor Gate was the Arcadian Way, a grand marble avenue that led to the Great Theatre. This wide, column-lined road was illuminated by lanterns, bordered by shops and mosaic walkways. The Great Theatre itself, built on the site of a Hellenistic predecessor, was among the largest

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of its time, famous for its role in early Christianity. Here, St. Paul preached to Ephesians, facing opposition from worshippers of Artemis (known in Rome as Diana). This ancient goddess was once celebrated with a grand temple, later one of the Seven Wonders of the Ancient World, said to house a meteorite deemed a divine gift.



Figure 1. Ephesus lies over a thousand miles from Rome and now two miles inland from Turkey's Aegean coast.

Continuing along the Arcadian Way led to the Agora and, next to it, the iconic Library of Celsus. Built in the 2nd century AD by the son of Roman proconsul Celsus, the library featured a theatre-like facade and enshrined statues representing Wisdom, Excellence, Judgment, and Expertise. Celsus was entombed beneath this beautiful edifice, a memorial of his life and legacy.

This project reconstructs Ephesus's landmark structures through a blend of ancient texts, lithographs, architectural plans, and modern imaging, allowing a glimpse into the city as it stood in the Roman era.

Roman harbour of Ephesus

Nestled between Mt. Coressus (Bulbul Dagh) and Mt. Pion (Panayir Dagh), the plateau of Ephesus became the Roman East's preeminent metropolis (Figure 2). Much of what survives today consists of Roman structures built upon Hellenistic foundations. When Rome acquired the Province of Asia from the Attalids in 133 BC the former royal capital of Pergamon was generally regarded as the leading city, but

there was no fixed provincial capital. Under Augustus, Ephesus was made capital of the province of Asia (Thomas 2007).

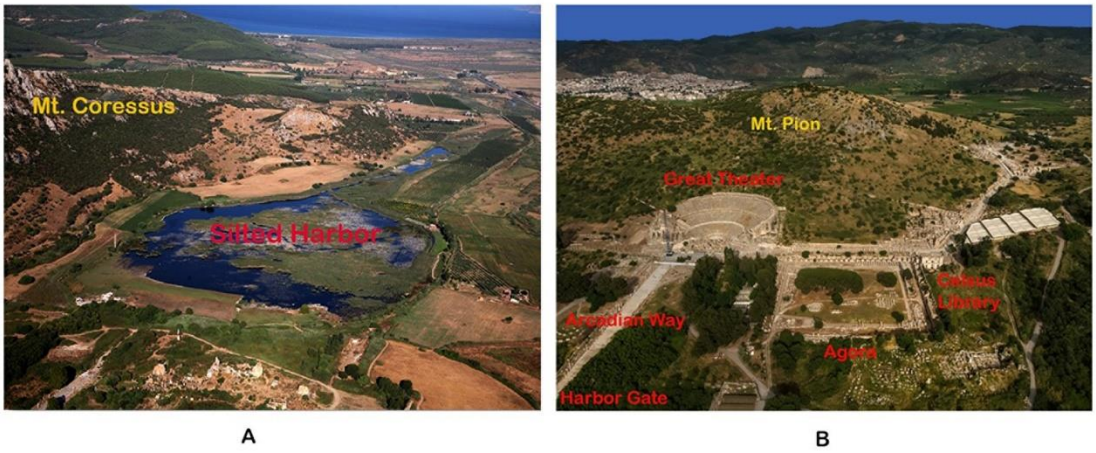


Figure 2. Nestled between Mt. Coressus (Bulbul Dagh) and Mt. Pion (Panayir Dagh), the plateau of Ephesus became the Roman East's preeminent metropolis.

From the heights of the Great Theatre, one can gaze over the silted remains of what was once Imperial Rome's most vital eastern port. This vantage point offers a striking view of the marshland that now covers the ancient harbour, highlighting how natural forces ultimately severed Ephesus from the sea (Figure 3). Despite persistent challenges with silting, the harbour remained active until the 4th century, functioning as a critical commercial hub for the empire. Together with ports like Carthage, Leptis Magna, and Massalia, Ephesus played a crucial role in an expansive trade network, moving goods and resources to Rome from across the Mediterranean. Maintaining access to the sea proved to be one of the crucial issues in the history of Ephesus. It is a battle against the changing landscape that is lost in the end.

Ephesus was also the endpoint of a major caravan route that carried products from Asia Minor and the Near East, which were then distributed throughout the empire. The city's prosperity—and that of the Roman Empire—was intricately linked to the harbour's activity and the flow of goods it facilitated.



Figure 3. From the heights of the Great Theatre, one can gaze over the silted remains of what was once Imperial Rome's most vital eastern port.

Today, Ephesus is isolated from the sea by a wide plain where the harbour once thrived. The Cayster River's centuries-long deposition of silt created marshlands that now obscure the ancient harbour, with only remnants left to hint at the city's once-central role in Roman trade.

Part of the city which is neighbouring the harbour and reconstructed in this work is shown in Figure 3. A monumental building project surrounding the harbour took place at the end of the 2nd century A.D. when the Harbor Gate was erected (Wilberg 1923). Those who came to Ephesus by sea entered the city through the Harbor Gate. Imagine that we have travelled through time via Metaverse platform and came to Ephesus in the 2nd century. We enter the city through this gate. In ancient times when the Greek Ionians first came from Athens perhaps as long ago as 1000 BC, this was probably the spot where they landed. They were fleeing dark age conditions back in mainland Greece after the collapse of the Bronze Age. They found new homes in this the beautiful central stretch of the Eastern Aegean coast where the sun seemed warm, the breezes seemed delightful, and the land was green.



Figure 4. Reconstructed area and landmark buildings.

Under the Roman Empire, the Greek cities of Asia Minor vied for prestigious titles: "the largest," "the most beautiful," or "the loveliest in all Asia." These claims were often validated by the splendour of their architecture. When Augustus granted Ephesus the honour of becoming the capital of the province of Asia, he created a stage upon which the city could assert its status against its rivals, Pergamon and Smyrna, each seeking to claim similar esteem. Ephesians, with their connections to both European heritage and exotic Asian lineages, strove to elevate their city's reputation above all others.

In this environment, monumental architecture became central to these civic rivalries, as cities measured greatness by the scale and prominence of their structures. To stand out among the many cities of the empire, Ephesus needed to present itself as unparalleled: a city of architectural harmony, cultural richness, and ethnic diversity, with influence that reached far beyond its borders.

Digital technology and visualization of Ephesus

Virtual Archaeology

Until 1990s, historical and archaeological content was mainly conveyed in book forms or lecture-style documentaries. There was no room for illusion in the presentation. Documentaries had to be pure, without manipulation, without artificial accessories. It had to reflect pure reality. In the 1990s, there was a notable paradigm shift in conveying historical and archaeological content towards a more visually oriented approach. An increasing audience sought not just scientific facts but also vivid visualizations of historical contexts. Virtual archaeology is a term introduced in 1990 by archaeologist and computer scientist Paul Reilly to describe the use of computer technology in conveying the outcomes of archaeological excavations visually.

Since that time, the focus of the term has been extended to incorporate methods that increase the visibility of archaeology.

The prime documentary broadcasters like BBC or ZDF were looking for adequate visualization technologies for their major topics. Hollywood relied on huge budgets and gigantic movie sets. Construction of scenes were dependent on models and the production of the film models alone was already on the edge of a realistic movie production budget. A realistic model of Cheops pyramid, a large Egyptian tomb complex, a large temple with ancillary buildings, for example were quite expensive and no one outside Hollywood could not afford more than 1-2 large models. To top it off, filming technology was complicated, and the process was time-consuming. Filming technique was based on analogue compositing which meant painstakingly cutting out the models frame by frame and positioning them in the backdrop sets.

It is this drastic change in the visual narrative style that has made computer-generated imagery an important component in the illusion machine of the historical and archaeological scenes. With the emergence of computer-generated imagery virtual reconstruction of historical and archaeological realities has gained a quality that was previously reserved for Hollywood productions

Virtual Archaeology vs Digital Archaeology

The terms Digital and Virtual Archaeology are largely used synonymously. Digital describes materiality as "dissolved in digits" or "based on digits" Virtual refers to a content which "exists as a possibility".

While digital thus describes materiality, the concept of the virtual is based on a reference to reality in terms of content.

3D reconstructions in the realm of Digital archaeology or Virtual Archaeology are digital reconstructions created with the help of the computer and thus differ from the long tradition of physical reconstructions of buildings and artifacts as well as paper-based reconstructions such as architectural drawings.

In short both Digital Archaeology and Virtual Archaeology imply using digital technology for visual imagination of the past.

The digital reconstruction of previously existing architecture is *de facto* based on the initially developed ability to digitally generate visualization of not yet existing architecture, and we are talking about computer-aided design (CAD), which was first developed in the 1960s within the engineering and construction industries.

Before digital reconstruction of previously existing architecture the aim was to develop the ability to digitally generate visualization of not yet existing architecture. Initially, it was primarily geared towards the future. We are talking about computer-aided design (CAD), which was first developed in the 1960s within the engineering and construction industries. 1960s were the years when humanity directed their gaze towards space. CAD technology developed rapidly in this environment. Initially, CAD only enabled the production of two-dimensional models, but soon it was also able to handle the third dimension.

The second origin in the practices of visual and pictorial reconstruction of the past is in the European Renaissance. It began with the revival of the interest in the architecture of antiquity. A strand of tradition developed to create images of the lost temples and other landmark buildings.

Digital 3D Model

Digital 3D reconstruction is not only a digital tool but also a working technique for investigating questions in archaeology and cultural heritage. While the source material and artefacts belong to archaeology and cultural heritage, the investigated questions originate from the historical sciences and art history as well as other disciplines (Figure 5).

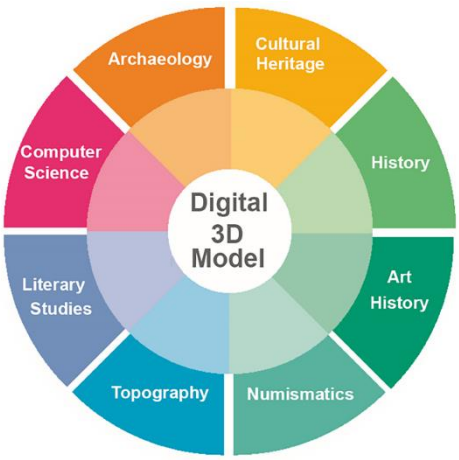


Figure 5. Digital 3D model is based on many different sources.

Reconstruction Visualization Simulation

Reconstruction involves creating a model of a building, often using computer-aided methods that adopt a comprehensive approach. This process begins with empirical data, source analysis, and theoretical foundations, extending into the spatial realm. Through reconstruction, contradictions and gaps in current knowledge are exposed, and ideally, a more complete understanding of the building emerges as its components are reassembled. Visualization then serves as a means of communicating the insights gained from this reconstruction. In historical building research, simulation can further illuminate architectural concepts of structures that are either lost or only partially preserved.

Reconstructions and visualizations

By using ancient writings, lithographs, architectural plans, pictures, and digital images as data to create digital reconstructions of these landmark buildings were created and restored to their original state during the Roman era.

Stretching from the Harbor Gate (Figure 6) to the site of the Great Theatre is the Arcadian Way – a marble avenue 35 feet wide and half a mile long. In the past, it was lined with columns, lanterns lighted this marble thoroughfare, and broad mosaic walkways trailed along the colonnades. The colonnades opened onto shops (Figure 7).



Figure 6. Harbor Gate.

Roman monumental architecture reconstructed in this work are among the most impressive and conspicuous legacies of the ancient city of Ephesus. The buildings from Harbor Gate to the Hadrian Gate were reconstructed.

To the people of antiquity who visited Ephesus in the Roman era they were an absorbing and fascinating sight, because of their physical size and beauty.



Figure 7. Stretching from the Harbor Gate to the site of the Great Theatre is the Arcadian Way.

The Great theatre (Figure 8) was built at the site of its Hellenistic predecessor on the west slope of Mt. Pion. Ephesus' theatre was one of the largest theatres in the Greco-Roman World. It is also accepted as the birthplace of Christianity. When Saint Paul first revealed the new faith to Ephesians in this theatre, they responded shouting "Great is Diana." Diana is the Roman name of Artemis. She was great indeed. She was the most powerful divinity in the place. In the distant past a meteorite had smashed into the surface of the earth somewhere near Ephesus, and the local people had regarded it as a gift from heaven, a statue of the goddess herself. They built a temple for her, and this was counted as one of the Seven wonders of the antique world.

As the street moves out of the Great theatre, we see on our right Agora. Next to it is a towering façade, resembling a theatre stage. This is the library of Celsus. Celsus was the Roman proconsul in the 2nd century AD, Ephesus was the unofficial capital of Rome in the East in those years. When he died his son had this library built for people to come and worship and commemorate him. Celsus was entombed beneath the library. A broad flight of steps runs up to several doorways. Elaborate carved marble niches hold the marble statues of four beautiful women. These statues represent four qualities of the human character.

Near the Library of Celsus stood a gateway built in honour of Emperor Hadrian. As in other cities of Asia Minor, triumphal arches or gateways were commissioned in Hadrian's name during the 120s by

prominent senatorial families. The Gate of Hadrian at Ephesus was likely completed in time to welcome the emperor during his visit to the city in the summer of 124. Its façade featured two stories of columns. Each story's central opening was crowned by a semicircular arch, elegantly placed above the lateral entablatures (Figure 9).



Figure 8. The Great Theatre.



Figure 9. Hadrian Gate (left) and Celsus Library (centre).

Behind the Celsus library is the Serapion, built in the 2nd century AD as a temple dedicated to the Egyptian god Serapis (Figure 10).

Finally, a bird's eye view or the harbour city Ephesus is seen in Figure 11.



Figure 10. Serapion.



Figure 11. Bird's Eye View of the Harbor City of Ephesus.

Conclusion

Ephesus, once a vital harbour city of the Roman Empire, embodied the grandeur and complexity of Roman Asia Minor. Elevated to the status of provincial capital under Augustus, Ephesus symbolized Imperial Rome's strength, architectural ambition, and cultural integration. Through the use of computer-aided reconstruction and visualization, we have attempted to reconstruct the Roman Harbor and other monumental buildings near it as they were in antiquity.

This project's approach is rooted in empirical data, historical texts, and digital archaeology, enabling meticulous recreation of the harbour and neighbouring monumental structures. Reconstruction and visualization communicate these findings to a broad audience, bridging past and present. Visualization results in fresh perspectives on lost or altered architectural concepts, allowing us to understand Ephesus's cultural and architectural achievements within their original context.

Through digital reconstructions, we can appreciate how Ephesus's architectural innovations reflected its competition with rival cities and its aspiration to be known as the "most beautiful" in Asia. More than a mere collection of ruins, Ephesus emerges as a vibrant polis of architectural harmony and cultural depth, its influence resonating throughout the ancient world and offering invaluable insights for contemporary research in virtual heritage and historical preservation.

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Return to San Gottardo. Underwater archaeological research in the Grado Island waters

Massimo Capulli[1]

Abstract

The island of Grado separates the top part of the Adriatic Sea from the lagoon of the same name which, due to the rise in sea level, now covers part of what was the outskirts of Aquileia in Roman times. In fact, in the lagoon the passage of goods took place from the larger ships to the flat-bottomed ones which could more easily reach the urban port or travel the internal routes that connected the entire region.

Until recently there was only a few evidence of ships passing through this area, but this changed in 2022 with the discovery of two new shipwrecks. So, in the summer of 2023 the research continued and not only on the wrecks, but it was decided to conduct an extensive survey to better understand the area and the relationship between the two sites. But specially to investigate the site, a submerged monumental structure first observed exactly 90 years earlier.

The presentation will be an overview about the relationship between the sea and Grado lagoon in Roman era, but mostly I would like to illustrate the last two years of research and in particular the news on the San Gottardo structure.

Keywords: Grado Island, San Gottardo, underwater archaeology, submerged structure, Roman archaeology

Introduction

A few hundred meters from the seafront of the town of Grado, located on the barrier island that separates the lagoon with the same name from the upper Adriatic Sea, in 2019 Stefano Caressa detected the presence of a side scan sonar anomaly. The Superintendency of Archaeology, Fine Arts and Landscape of Friuli Venezia Giulia then followed up on the report with an inspection that allowed them to identify and recover a lead anchor stock from the Roman era.[2] The same office subsequently submitted a request for scientific collaboration to the Department of Humanistic Studies and Cultural Heritage of the University of Udine, which in July 2022 carried out an initial scientific investigation campaign to better understand its location context.[3] This made it possible to determine the presence of

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[2] The news appeared in the local newspaper Il Piccolo on August 3, 2020 with the title 'A Roman anchor emerges from the sea of Grado' written by Pietro Spirito.

[3] It was initially hypothesized that a part of planking found washed up on the coast of Grado in 2021 could come from this area (Costa and Gaddi 2023: 123-131). However - unlike the naval remains found here - this has been dated to the 3rd-4th century AD and above all belongs to a vessel built using the sewing technique (Pomey and Boetto 2019: 5-51).

a new wreck, called Grado 5[4], built according to the mortise and tenon technique[5] and dating back to the 2nd-early 1st century BC (Capulli 2022: 221-226). In the same days, only 2km away, but in this case inside the lagoon, other wooden elements were located by the Carabinieri Divers.[6] These, already in the contextual verification by the same team from the University of Udine, were recognized as the remains of a second and completely unpublished shipwreck of the Roman age, later called Grado 6, also built according to the mortise and tenon technique, but datable to the 3rd-4th century AD (Capulli 2023a: 497-504).

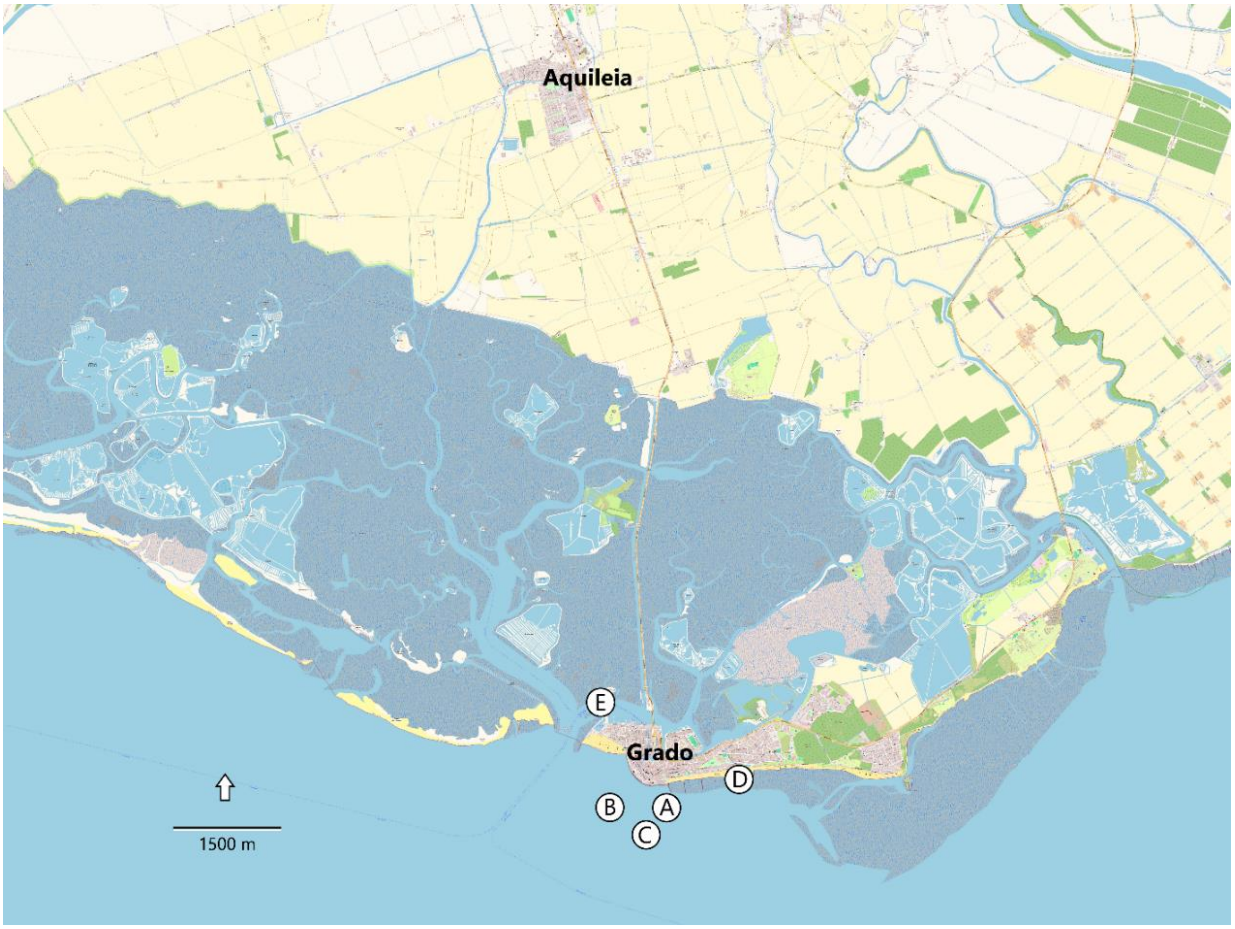


Figure 1. Location of the cited sites: A) Piere di San Gottardo; B) Piere di Sant'Agata; C) Grado 5 Shipwreck; D) Beached plank; E) Grado 6 Shipwreck. (Created by Massimo Capulli, background OpenStreetMap).

[4] As per scientific practice, the shipwreck was numbered only according to the date of discovery and without this implying any chronological reference (Capulli *et al.* 2016: 47-63).

[5] This is the most widespread technique used in hulls, first the shell and then, to make the planking solid, by creating grooves in the thickness of the planks in which to insert wooden plates in order to connect them to each other (Gianfrotta and Pomey 1981: 238-241).

[6] The Carabinieri are the national gendarmerie of Italy who primarily carry out domestic and foreign policing duties, moreover who have a specialized branch for combatting art and antiquities crimes (Carabinieri Command for the Protection of Cultural Heritage).

In light of what had been emerging and given the specific interest of the Department of Humanistic Studies and Cultural Heritage, both for the topographical layout of Aquileia and for underwater archaeological research in the Upper Adriatic[7], in 2023 an application for a Concession for non-invasive investigations was submitted to the competent Superintendency, having as its object a part of the water territory of the municipality of Grado astride the island-city, or which extended both on the marine and lagoon sides, to include both the new wrecks, as well as some other sites known from literature (Figure 1).

Objectives, limits and research strategy

The surveys of the Underwater Archaeology Unit of the University of Udine, although carried out within a broad chronological span, between July and September 2023, consisted of 21 working days, three of which were spent providing scientific assistance to the Carabinieri Unit for the Protection of Cultural Heritage of Udine and four of weather/technical construction site shutdown. It follows, therefore, that the days dedicated exclusively to research dives were fourteen, with an overall daily average of 278 minutes of diving[8], compared to a concession surface of 7sq km. As anticipated, the choice to investigate such a vast water space was suggested by the discoveries in 2022 of new wrecks from the Roman era. In particular, there was on one hand the need to better define the relationship between the two sites and on the other to acquire more general information on the submerged archaeological landscape of this transition area between the sea and the lagoon. The two hulls, in fact, although built with the same mortise and tenon technique, present chronologies that recall very distant and different historical moments, one the late Republican age and the other the middle and late Imperial age, but at the same time together with other archaeological clues they seem to contribute to the definition of a privileged route used to reach the port of Aquileia through the Grado lagoon (Capulli 2023b: 101-122).

The objective of the new investigations was therefore not to study a single site, but, in the face of limited resources and sacrificing the scientific desire to better understand the shipwrecks of Grado 5 and/or Grado 6, to favour a sort of horizontal research that would lay more solid foundations for future research. The fortuitous discoveries and occasional research accumulated in this stretch of sea over the years had led to putting some 'dots' on paper, but the basic information was often missing.

The strategy used was to acquire published and unpublished documentation, and to import the various maps produced into a GIS. These were georeferenced as best as possible, taking into account that the cartographic base used in the past was not always optimal, in order to narrow down the areas to be subjected to direct underwater survey. However, the extension of the area was such that total coverage would have required many days even for a remote sensing campaign and therefore the searches were concentrated in a series of points that, based on the screening of the information in our possession, seemed more promising. Thus, proceeding in addition to the two known wrecks, seven sites were identified and then more correctly positioned via multi-channel GNSS (estimated error less than 2m). Once the precise coordinates were established, video-photographic documentation of the *status quo* was then carried out and, depending on the nature of the site, different levels of investigation were carried out, however always remaining within the limits of the concession for non-invasive investigations.

[7] Cfr. *infra*.

[8] Four people from the University of Udine, as well as the technician from the Superintendency, participated in the underwater research, and in the fourteen days at sea they totalled 3890 minutes - just under 65 hours of immersion - with an individual daily average of around 56 minutes.

What has emerged from the underwater surveys is a rich and complex reality, which alternates shipwrecks with specific sites, which have appeared to have considerable informative potential, and above all submerged structures of still uncertain definition, but which can certainly be defined as monumental. This is the case of the Piere di Sant'Agata[9], a work created with stone elements of small dimensions, on average less than 50cm on the longest side (Figure 2), which although placed together without any apparent order, form a sort of 'T'-shaped structure[10] oriented 323 degrees north, with the long side of 115m and the short side of 45m. In the absence of more in-depth investigations, it is not currently possible to advance certain hypotheses on its function[11], while the artefacts visible on the surface and whose original position is unknown can only provide a circumstantial chronology of the Roman era. Less than seven hundred meters east of the Sant'Agata, with almost the same latitude, there is another, more well-known structure: the so-called Piere di San Gottardo.[12]



Figure 2. The Piere di Sant'Agata (Picture of Massimo Capulli).

[9] The Piere di Sant'Agata have never been the object of archaeological research, despite having been known for decades. Even though they lack a description, we find them listed on the map with the indication 'ruin' in 1952 (cfr. Figure 1 in De Grassi 1952: 27-28), followed in more recent years by surveys conducted for biological research on the Posidonia oceanica population in the upper Adriatic Sea (Caressa *et al*. 1995: 162 and Figure 8C in Marocco 2009: 80).

[10] The pile rests on a sandy bottom at a maximum depth of 5m, from which it rises approximately 2m.

[11] Recently Dario Gaddi has hypothesized that it could have been a wall to protect from the Sirocco wind and a large landing place west of Grado (Costa, Gaddi 2023: 124).

[12] The name San Gottardo comes from an error in identifying the submerged structures with a 17th century church that was obliterated over time, but which was located immediately south of the town of Grado (cfr.: Marocco 1990: 11-16; Marocco 2000: 228-242).

The Piere di San Gottardo: history of research

The so-called Piere di San Gottardo are a site of extraordinary interest that first appeared in archaeological literature in 1950[13], even though the article actually deals with an intervention that dates back to thirteen years earlier. However, it must have been known to some extent, in fact in a second article from 1952 by the same author focused only on San Gottardo he recalls how these are visible from the boat, especially during the winter with clear water (De Grassi 1952: 27-28) and therefore it is more than likely that the fishermen were aware of this pile even in previous eras. As proof of this there would also be an indication 'felsen', that is to say rocks/cliffs, which can be clearly read on the Austrian Map of 1867, in a position compatible with the site of San Gottardo.



Figure 3. The epigraphs recovered from San Gottardo, now exhibited near the Basilica of Santa Eufemia (Picture of Massimo Capulli).

The fact is that the first autopsy of that submerged presence is due to the will of the engineer De Grassi, who, as he underlines in his paper (De Grassi 1952: 32), in order to verify the nature of that place took advantage of the opportunity to have at his disposal for another construction site both a means for maritime works, and above all a helmet diver. The latter, always in De Grassi's story, inspected the pile

[13] In particular, the position appears on a map of the sites of Grado (Figure 1 in De Grassi 1950: 7-8), while the structure is expressly mentioned only in the caption of an image (Figure 4 in De Grassi 1950: 12).

on an afternoon of an unspecified Sunday in 1933 and having recognized three stone elements with inscriptions, he guided their recovery.[14] Once brought to the surface, the epigraphs were placed on the northern side of the Basilica of Sant Eufemia[15], where they still remain today (Figure 3).

After the pioneering research of the 1930s, it was not until 1974 that San Gottardo was the subject of a new investigation, and this time it would be of an eminently topographical nature. A group of divers from Princess Alexandra's Royal Air Force Hospital of London under the command of a certain Studd (Schmiedt 1980: 32) in August of that year carried out a sufficiently precise positioning of the San Gottardo heap.

Three slides from this activity remain, preserved at the National Archaeological Museum of Aquileia. The first, dated 22 August 1974, consists of a topographical overview at a scale of 1:10 of the site with respect to the Grado seafront promenade; in fact, there are no references in absolute coordinates, while the distance and angles from the western pier are reported. The second slide, dated 2 September 1974, represents at a scale of 1:100 with considerable approximation the plan view of the entire archaeological area, while the third slide, which unlike the others is not dated, represents at a scale of 1:50 the southernmost area of the mound.[16]

In the summer of 1982, new research was conducted by the Institute of Archaeology of the University of Padua with the support of the Centro Subacqueo Nord Italia of Vicenza. Unfortunately, there is no trace of this work in the archives[17] and all that remains is a short article (Marchiori 1982: 318-320), where it is stated that the structures have an almost rectilinear trend in an east-west direction parallel to the current Grado seafront and occupy a surface area of approximately 8000sq m, data that is absolutely incorrect as we will see, while the part that reports that the blocks, some with signs of workmanship, emerge from a predominantly sandy seabed and above all that in some sections they are arranged according to alignments, but that for the most part they are stacked in a predominantly incoherent manner is true.

In July 1985, the competent Superintendency entrusted the Marine Survey Company of Stefano Caressa with the task of carrying out some prospecting, surveying, underwater excavation and recovery of any finds in the San Gottardo area (Lopreato 1985: 453). On that occasion, the first detailed bathymetric mapping of the stretch of sea cantered on the aforementioned ruins was carried out, for an extension of about 650m from the shore and for a width of about 250m. Subsequently, a test excavation was also carried out along the southern side of the ruins, consisting of more or less squared blocks where it was more likely possible to identify a structure '*in situ*'. This was carried out with the air dredge. The removal of the sand revealed a series of architectural blocks, funerary altars, blocks belonging to sepulchral monuments, together with various sandstone slabs sometimes without any apparent connection between them. Most of the underwater work was dedicated to the various operations necessary for a precise survey of the southern area of the mound, where some blocks with inscriptions or mouldings were found, which, like the previous epigraphs, were recovered and placed near the Basilica of Sant'Eufemia (Lopreato 1989: 53).

[14] This is clearly a methodologically incorrect operation, but in those years, it was perhaps the only viable path (cfr.: Capulli 2019: 183).

[15] These epigraphs were studied by Giovanni Brusin and are collected in a posthumous volume: Brusin 1993.

[16] This documentation has recently been made public in Capulli et al. 2023: 71-86.

[17] The protagonists, contacted by email, were unable to add further information.

The ruins of San Gottardo, however, are not only a site of archaeological interest, they are in fact home to the only known living clods of Posidonia Oceanica in the Italian part of the Adriatic[18], between the Gulf of Trieste and the mouth of the Po River.

Precisely because of the environmental value of the site, the Piere di San Gottardo have also been the subject of remote sensing within the framework of two Interreg Italy-Slovenia Projects[19]. In particular, the use of the Multibeam, although not for archaeological purposes, has returned the bathymetric layout of the site, defining in good detail the three-dimensional distribution of the stone remains.

Return to San Gottardo: the new investigations of the University of Udine

The University of Udine has returned to the Piere di San Gottardo exactly 90 years after the first underwater explorations (Figure 4). As anticipated, it was non-invasive research and on a larger body of water, of which this site has seen the work team engaged for just over a week. In particular, the activities consisted of a general visual reconnaissance and cleaning and documentation of the southernmost sector.



Figure 4. The support boat on the NW edge of San Gottardo and in the background the nearby historic center of Grado (Picture of Massimo Capulli by drone).

[18] Cfr. Caressa *et al.* 1995: 160-173.

[19] TRETAMARA and TRECap – 'Trezze, Tegnue and Marine Environments of the Upper Adriatic: Management/Capitalization Proposals', Priority Axis 3, Protection and Promotion of Natural and Cultural Resources, Lead Partner: The National Institute of Oceanography and Experimental Geophysics – OGS.

For the latter, as has been the practice in recent years, we also used the Computer Vision (Structure from Motion) technique, which allows the construction of a three-dimensional model starting from a cloud of photographic pixels (Yamafune et al. 2016: 703-725), in our case thanks to the use of the Agisoft Metashape software. However, given the size of the site and above all the morphological complexity of the pile, consisting of large blocks stacked mostly in an irregular manner, a first sample area was chosen to verify the validity of this methodological choice.

The results of this experiment were, in truth, only partially satisfactory. While on the one hand a good quality photogrammetric survey was obtained (Figure 5), on the other it should be emphasized that to cover a surface of only 36sq m 1462 images were needed[20], which to be processed then required many hours of processing by a workstation used exclusively for this calculation.[21] It can be deduced that to cover the entire structure numerous cleaning campaigns and photographic acquisitions would be needed which, considering the seasonality of the underwater activity, would translate into many years of research.[22]

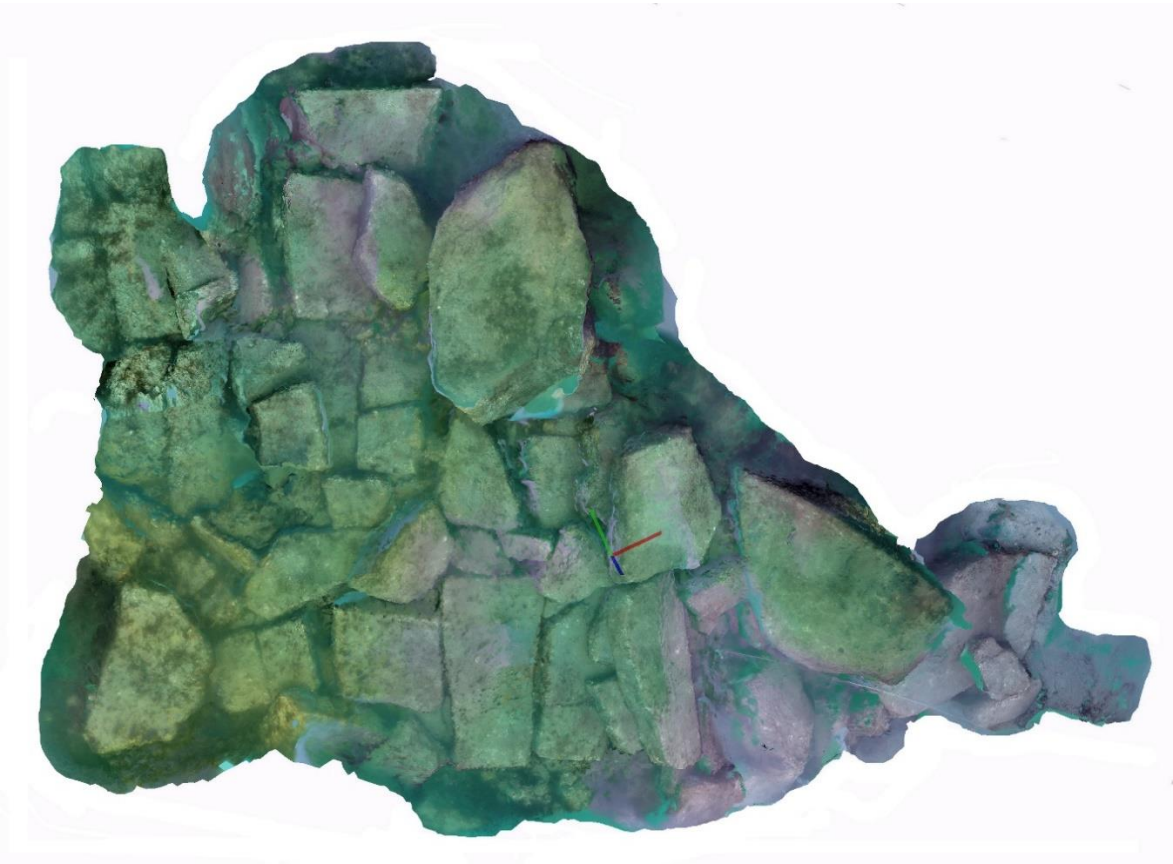


Figure 5. Orthophoto of the sample area obtained from modelling with Agisoft Metashape software (Created by Massimo Capulli).

[20] This high number of images is due both to the general lower visibility of the underwater environment compared to the air environment, and to the specific conditions of poor visibility typical of the waters of Grado.

[21] The machine used was equipped with an eleventh generation Intel(R) Core(TM) i9 processor with 32 GB of RAM.

[22] Based on the OGS multibeam survey, the total area corresponds to approximately 1650sq m and therefore in the 2023 campaign the photogrammetric model obtained covers only a little more than two percent of the entire site.

As regards the general reconnaissance, a new element identified should be noted (Figure 6). It is a block that rests 'isolated'[23] directly on the sandy bottom at a depth of about 4m along the western side of the structure; oriented 30 degrees north, it has a length (which given the current horizontal position corresponds to the original height) of 115cm, a height from the bottom of about 60cm and a width that varies from about 67cm at the NW end to 76cm at the SE end. The presence of a significant concavity in the NW end and of a face delimited by a moulding and probably inscribed, seem to legitimately suggest that it is a funerary altar. Unfortunately, the worked part is facing downwards and therefore it is not possible to provide further information at the moment.

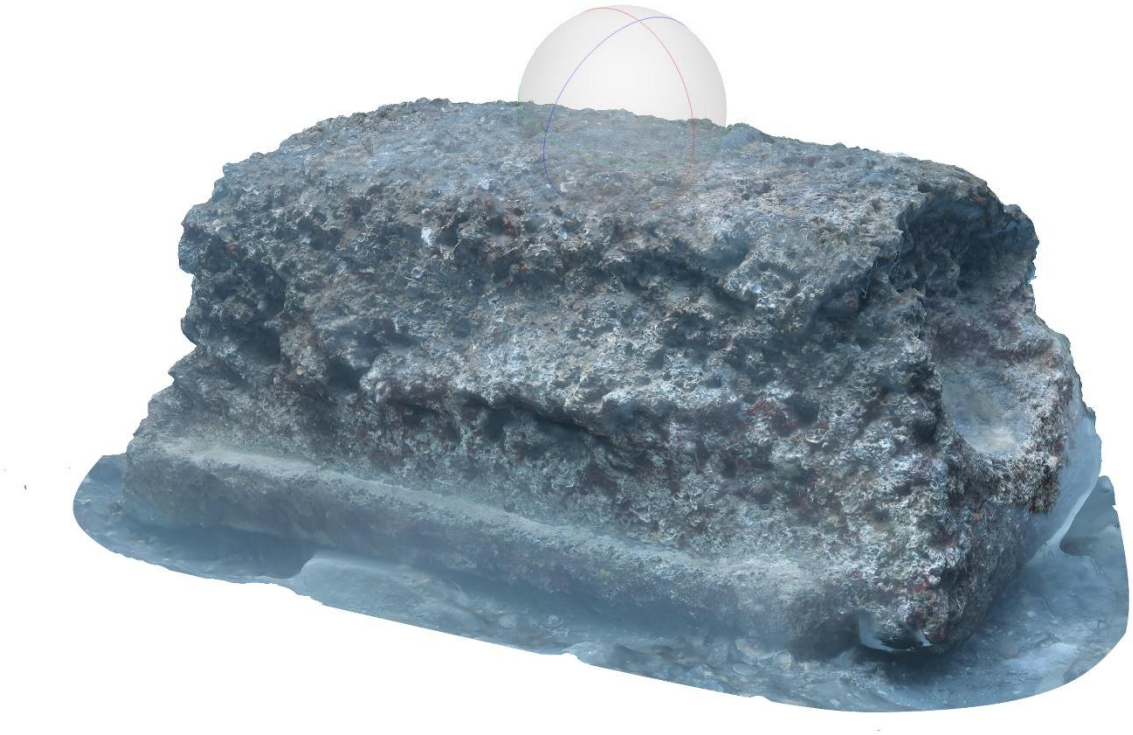


Figure 6. 3D model of the new funerary altar identified during the 2023 survey (Picture of Massimo Capulli).

Preliminary considerations

The development of underwater discipline first and then of survey techniques have meant that today we can have a comprehensive image of what once could only be partially perceived from the surface. The submerged ruins of San Gottardo are still difficult to understand, even if some regular characteristics emerge. In particular, the mound shows a roughly rhomboid shape with sides of 38/40m, rotated by about 30 degrees, that is to say with the four sides almost perfectly perpendicular to the

[23] By isolated here we mean that it is not in direct contact with any other stone element, but is surrounded a few dozen centimeters by other blocks.

mistral, grecale, sirocco and libeccio winds. On the other hand, the density is very variable, with a greater concentration in the southern corner and a sort of large depression in the central area, more offset towards the NE, where equally large patches of sand have been observed, which would appear to be totally devoid of archaeological material[24]. It should be noted, on the other hand, that the area of greatest density, as clearly observable from the chromatic gradient of the OGS document, is also the one that rises the most from the seabed. Although the bathymetry shows a slight increase in slope, as is natural as one moves away from the coast, that is to say that from north to south it goes from -4.1m to -4.6m, it is precisely at the southern end that the shallowest blocks are found and that they are found at a depth of only -2.3m (Figure 7). In the same area, a juxtaposition of stone elements is also more clearly observable (Figure 8), which are not at all random even in their orientation, which in fact follows that of the sides of the deposit. Furthermore, the specific underwater checks conducted here have allowed us to note that some of them show clear traces of workmanship that would suggest an original architectural function. In fact, not only parallelepiped blocks, up to 3m long, but also moulded elements or with recesses for joints.

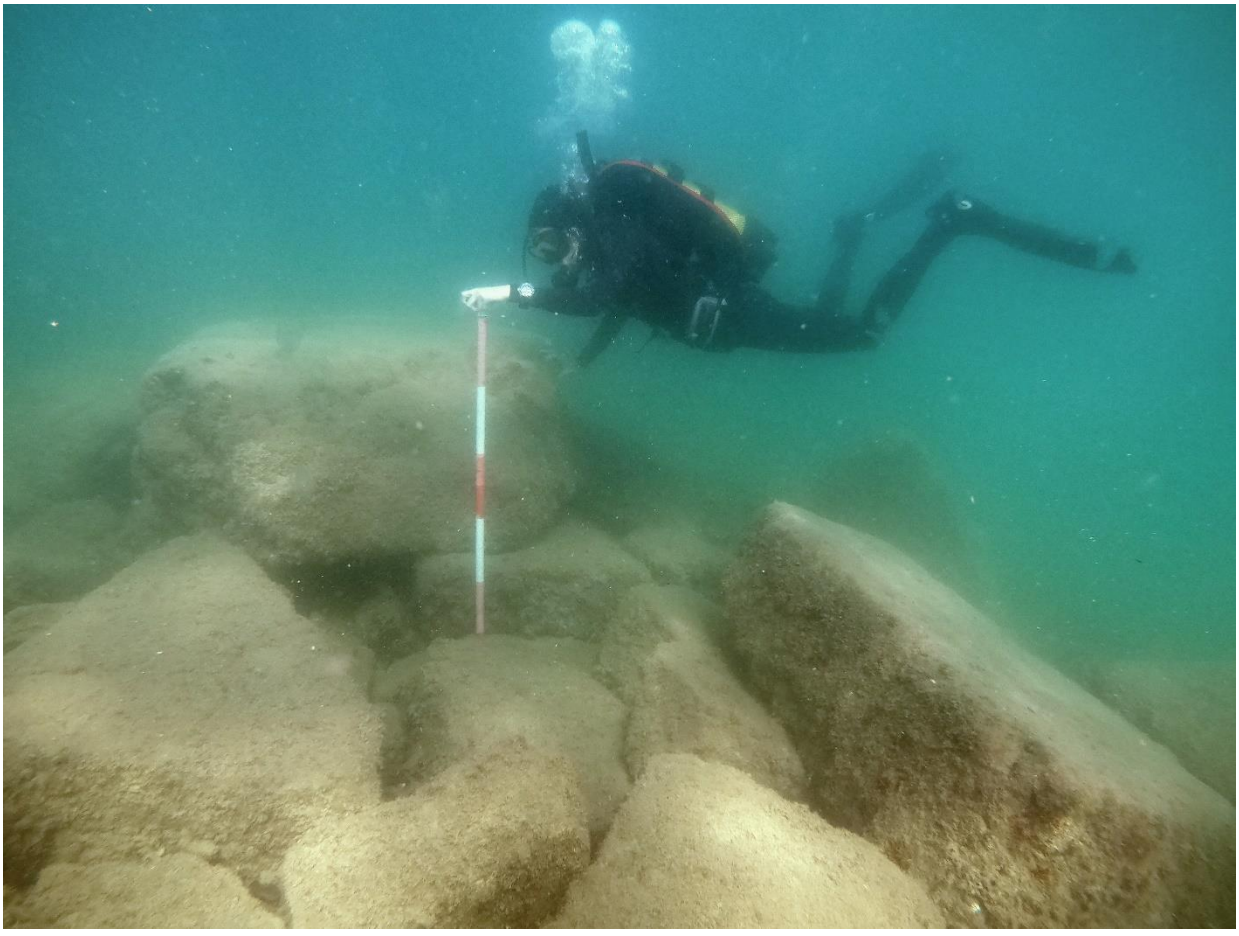


Figure 7. The ruins of San Gottardo (Picture of Massimo Capulli).

[24] The verification of any buried material is planned for future research, as well as petrographic analyses of some samples.

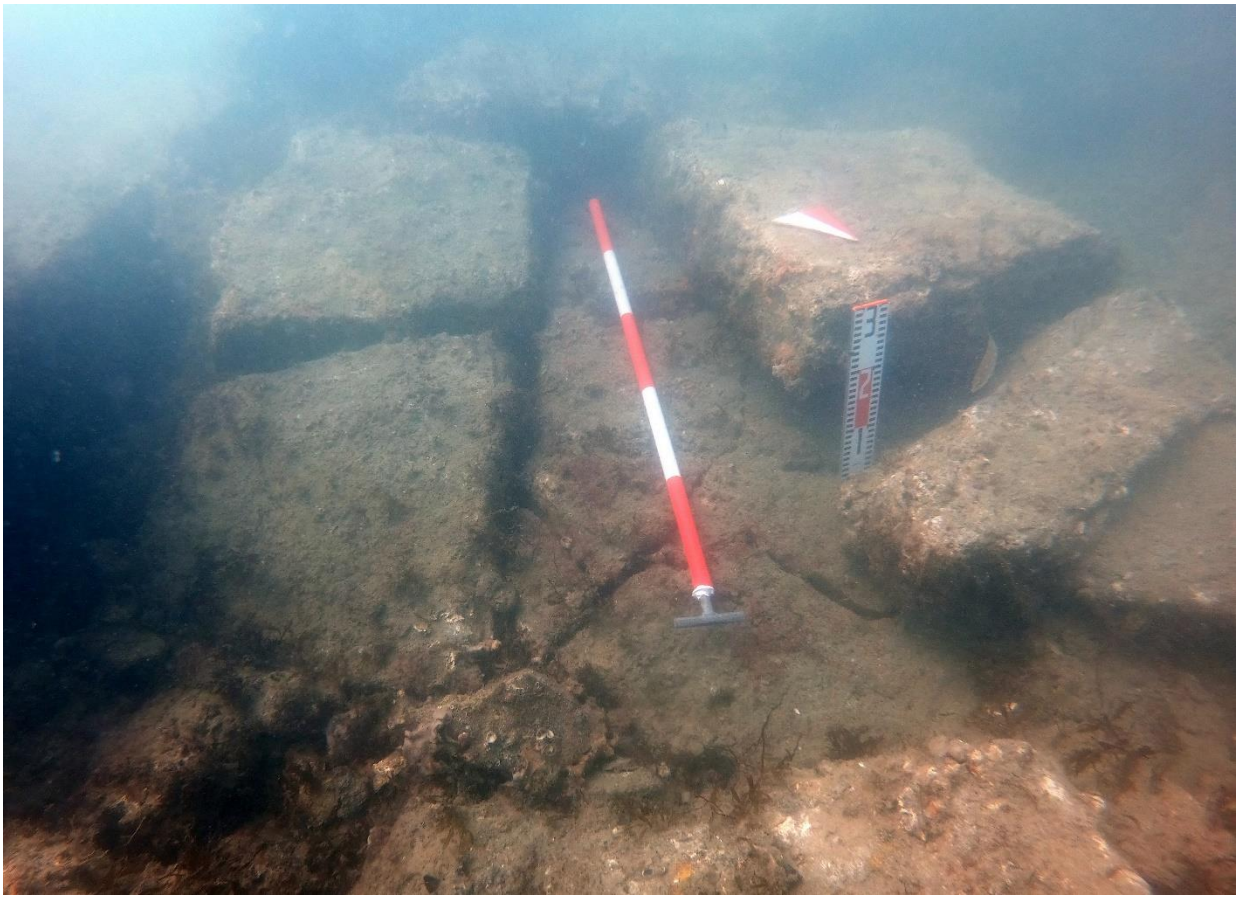


Figure 8. Some juxtaposed stone elements (Picture of Massimo Capulli).

At the moment, however, it is not certain whether all, or only in part, could be reused materials. If in fact the linear elements could have been used for the first time in what appears to be a maritime work, this is less likely for the worked ones and quite unlikely for the funerary monuments. As anticipated, these are five altars recovered in two different phases, four in the 1930s and one in 1985, together with four slabs of a burial enclosure with an inscription in a square capital. To these should also be added the new element, always similar to an altar, which was identified precisely in the 2023 investigations and in the same area where the one of others comes from.

Currently there are many more questions than answers and what can honestly be said[25] is only that the so-called Piere di San Gottardo represent what remains of a work built after the middle of the 3rd century AD[26] with a function in some way connected to the port of the Grado-Aquileia system.

[25] Despite the various studies on the evolution of the coastline in the upper Adriatic (Brambati *et al.* 1998: 145-161; Marocco 1991: 223-232; Marocco 2009: 69-86; Fontana, Ronchi 2021: 12-37), at the moment there is not enough precise data to establish whether the structure was built on the edge of the coast or in the open sea.

[26] This is a chronological determination based solely on the dating of the epigraphs, since the mobile finds were recovered out of context. Furthermore, in the shallow waters of Grado it is common to find in all the outcrops artefacts from the Roman era together with contemporary materials, which the currents and the waves have dragged to the bottom.

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Geomorphology and Geoarchaeology Changes for Kallias submerged Roman harbours site between Ras Abo Hashfa and Ras Alam El-Rum areas, NW coast of Egypt by R.S and GIS

Samah Moustafa Abo Zeid[1], Magdy Torab[2] and Adel Elsadany[3]

Abstract

Kallias, Kalamaion, and Calamaeo are submerged harbours located between Marsa Bagoush and the Ras Alam El-Rum area of Egypt's NW coast. Some geoarchaeological remains were discovered by researchers underwater during a survey on the eastern side of the Ras Hawala coastline on the NW coast of Egypt, east of Matruh city, about 37.6 km, in the same location of the above submerged harbour, as described by another early writer. On the western coast of Ras Hawala, the authors found a Roman anchor that Paleo-tsunami waves had cut from a submerged platform in 365 BC. We studied the geomorphological characteristics for their location, noting that coastal erosion, other geomorphic processes, and the Holocene Sea level change have altered the coastline from the Greek and Roman periods to the present. Alternating Quaternary limestone, part of an eroded carbonate coastal ridge, occupies the study area. We observed geomorphic coastal landforms along the shore, such as multi-level marine notches, platforms, and caves. These features were created at the Holocene relative sea level. We also observed solution micro-landforms such as holes, channels, pits, and residual pinnacles. Sea water sculpted these features on carbonate rocks.

Keywords: geoarchaeology, Roman Anchor, Greek harbour, Holocene Sea level change, Ras Hawala, Paleo- tsunami, Kallias harbour, Egypt

Introduction

Kallias was among the largest and most active ancient anchorages along Egypt's northwest coast (Figure 1 and Figure 2). Following the melting of the Late Glacial ice, eustatic sea level rise has created submerged seashores, rivers, and inland landscapes. Submerged environments around the world offer a wealth of time-specific documents that hold untold stories. There are particularly a large number of archaeological sites in regions such as Egypt, the Levant, and Southeast Asia, whose civilizations share many cultural traits from ancient times. To facilitate further detailed studies and recreation, we must list and process these submerged environments. To address this, we conducted an integrated radar, bathymetric, and seismic geophysical surveying campaign along Egypt's northwest coast, ranging from the shallowest Kallias site to the final of the submerged platform for the harbour.

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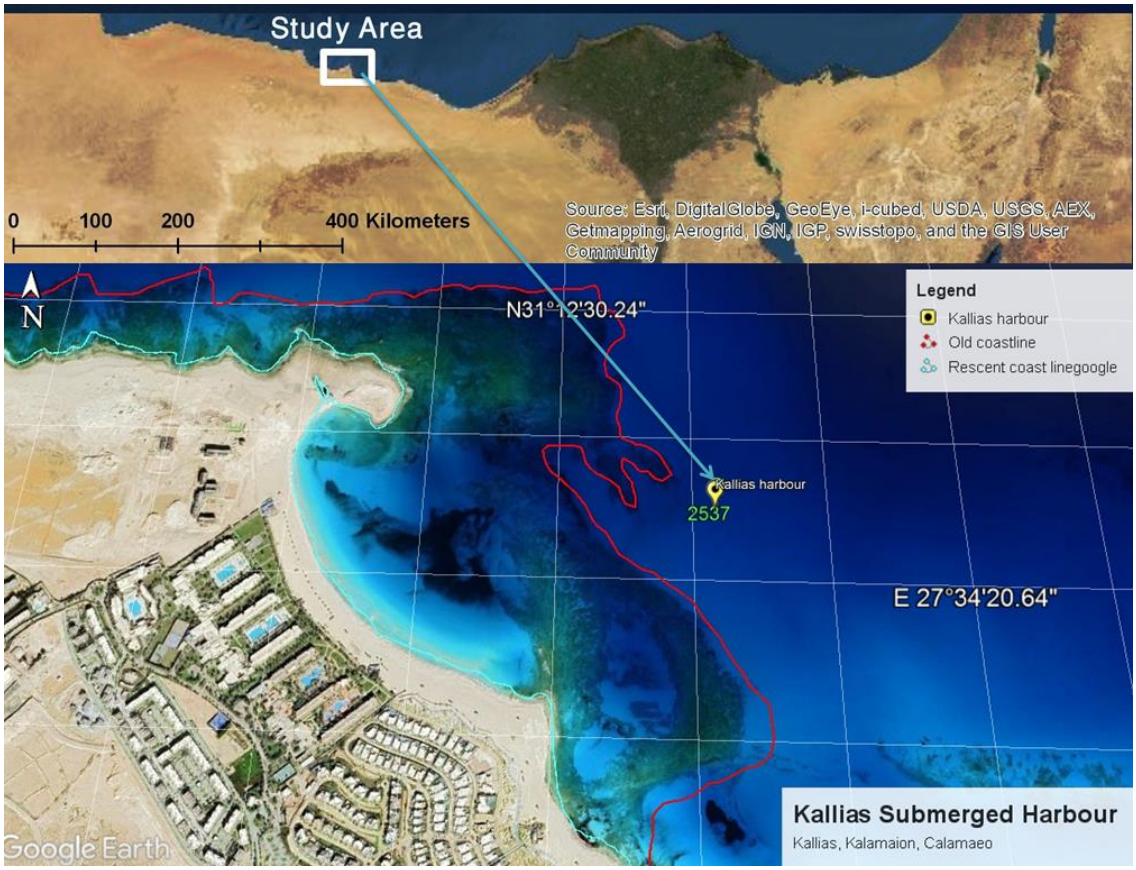


Figure 1. General location of the study area.



Figure 2. Detailed location of Kallias submerged harbour, with photo for the harbour.
http://www.ancientharboursantiques.com/the-catalogue/egypt-libya

The Kallias site is well-known because of the large amounts of stone architectural blocks, drums of columns, pillars, statues, and mundane pottery found by divers carrying out illegal treasure hunts in the early 20th century. The 5th-century BC writings mention an ancient harbour on the same gulf, and remnants found along the current coast suggest its location. The remnants date back to Roman times. Such harbours ceased to function due to the seismic disturbances and gradual uplift of the northwestern margin of the gulf; a combination of geological (Figure 3) and anthropogenic factors likely led to their abandonment during the Arab conquest.

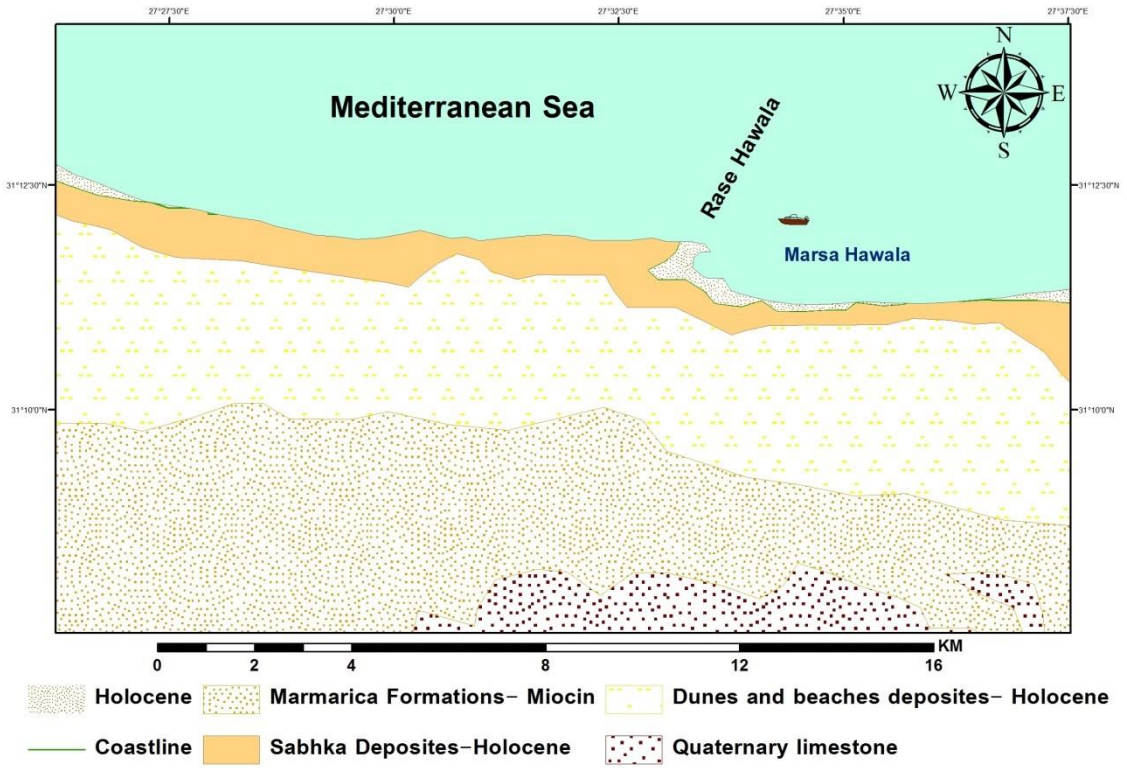


Figure 3. Geology map for Killias harbour area.

Background and Rationale

During Roman times, the cardinal position of Egypt and the North African coast on the ancient trading routes encouraged the establishment of harbours, which became the primary spaces of assimilation and amalgamation of the cultures of the greater Mediterranean basin. The northwestern part of the Egyptian coast, along with the Eastern Mediterranean Zone of Cultural Interaction, served as a strategic geographical funnel between Europe and Asia for ancient traders. The Roman Empire initially acknowledged their importance, establishing numerous harbours such as Alexandria, the two Kallias, and Hawara to cater to the commercial trade. In addition to, the cardinal position of Egypt and the North African coast on the ancient trading routes encouraged the establishment of harbours, which became the primary spaces of assimilation and amalgamation of the cultures of the greater Mediterranean basin. The northwestern part of the Egyptian coast, along with the Eastern

Mediterranean Zone of Cultural Interaction, served as a strategic geographical funnel between Europe and Asia for ancient traders. The Roman Empire was the first to acknowledge their importance, developing various harbours such as Alexandria, the two Kallias, and Hawara to cater to the commercial trade.

Research Objectives and Questions

The objective of current study is to define the geomorphological and geoarchaelological characteristics of some submerged harbours sites from Ras Alam El-Rum to Marsa Abu Hashafa (Marsa Bagoush) and What is the changes which happened during last 10 years; Focusing on the harbour of Kallias and what is the effect of The Holocene sea level change on its geomorphology and geoarchaelogy, by using Landsat image for doing some analyses to do map for the area collect all of changes which happened for these submerged harbours by doing change deduction analysis, by RS and GIs techniques to measure erosion rate of the coastline and effective on the submerged harbours, break marine, the marine headlands and Islands during last century.

The study aims to describe the geological features and geo-archaeological evidence of the Kallias Submerged Harbour, as well as investigate the impact of sea level changes during the Holocene on the study area. The western coastline consists of Pleistocene, separated polygons of limestone sheets, and fossil limestone, where there are coastal platforms, fluvial forms, and solution holes. We define the remains of the harbour's ancient breakwaters. We have discovered some submerged Greek and Roman harbours near the coastline in the study area (Figure 4).



Figure 4. Some collected Greek and Roman Amphora near the coastline of the study area.

The research delves into the circumstances that led to Kallias Harbourbor's initial shelter and subsequent abandonment. To uncover the latest changes to this area, we used submersible-cut geoarchaeological digs. The primary goal of our research was to investigate the geomorphological changes at the submerged Kallias Roman harbour complex, located east of Matruh city, about 37.6 km in the NW coast of Egypt.

Geomorphological Features of Kallias Harbour

Several types of geomorphological features, such as shorelines, coastal dunes, and a well-preserved coastline, characterize the harbour sites of Kallias. We mapped the geomorphological features using ArcGIS software. The field survey revealed that thick, fine sand covered the offshore areas, resting on a dense pack of sandy silt. Located on one of the headland marines along Egypt's northwest coast, the site is considered a maritime archaeologically sensitive location. Many of the processes that deposit materials in the study area affect the shape of the underwater harbour. These include the tides, combined wave action, longshore drift, wind erosion, and erosion caused by humans (Figure 5).

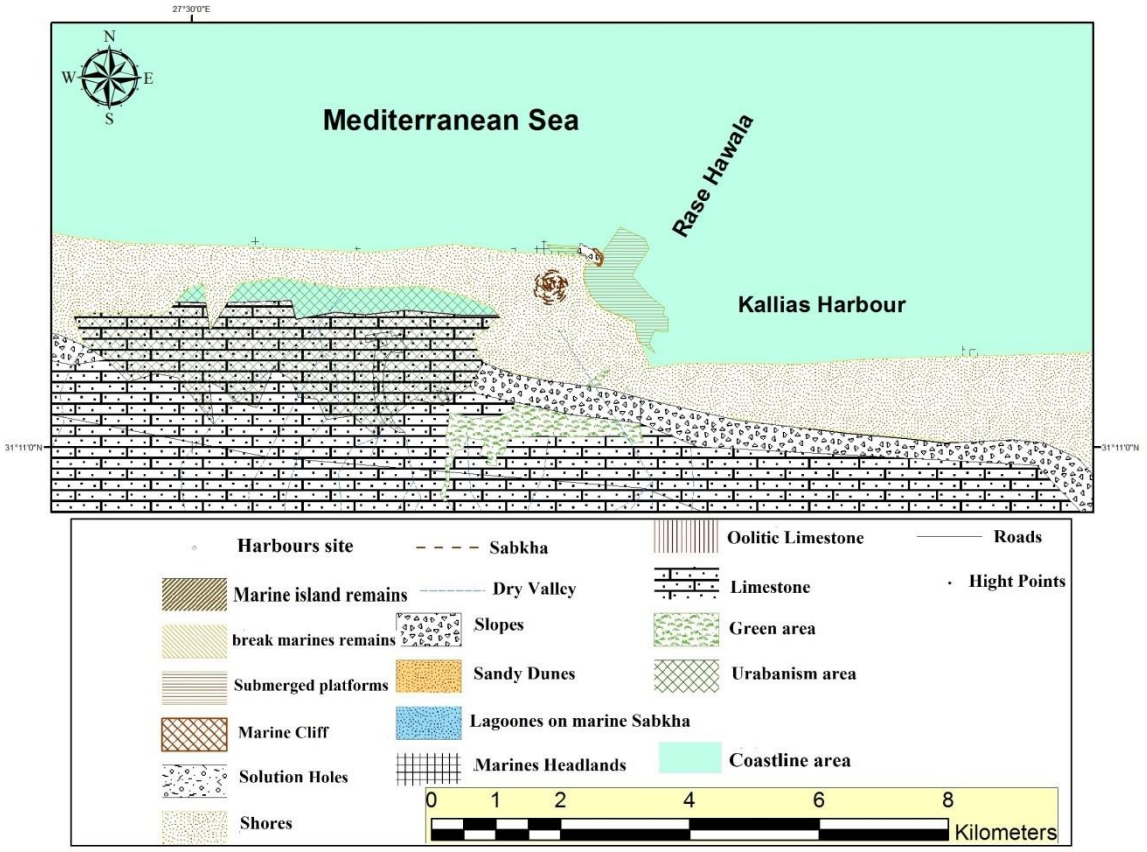


Figure 5. Geomorphological map of the study area.

There are sandy dunes in the area, and aerial photos show their migration. Ancient tsunami waves uprooted a group of massive rocks from the sunken harbour dock, transforming them into a rocky beach. The tidal waves and storms also created an enclosed coastal lagoon south of the sea headland, with a depth of up to 70 cm. Weathering processes, whether mechanical or chemical, create numerous solution phenomena in the pure white limestone. Marine, water (rainwater), and wind erosion processes then play a role in removing the remnants of weathering processes and revealing the area in a new form.

Description of the Site

Natural and human modifications, along with some large-scale environmental interactions, have affected Kallias' ancient harbour. The Romans built several harbours on the northwest coast. In addition to reusing some of the harbours that remained from the Greek era, the Romans left their mark on them, changed the size of ships, and carved out the natural quays to use as anchorages. Oral records and sources reveal that despite the richness of maritime activity, the harbours lacked the necessary protection to withstand harsh weather.

Geological Setting

A rapid succession of different types of landforms marks the geomorphological characteristics of the North African coastline, reflecting contrasting environmental settings. The North African coastline exhibits a high rate of tectonic and climatic subsidence, as well as the ongoing rise of Mediterranean Sea water. Analysing the geomorphological aspects and defining the geomorphological characteristics of the submerged archaeological layers can provide evidence for these aspects. The Libyan and Egyptian study cases are located in an area of representative geomorphological and geological significance at the southeastern margin of the Mediterranean Sea, between the Eastern De Luca Plateau and the central Nile Delta.

Geoarchaeological Significance

The necessity for the present study comes not only from the geomorphological changes that are occurring along the coast but also off the coast. The cross-section surveys of the sea bottom reveal that the offshore Kallias harbour has transformed into a stone and sand trap, accumulating countless tens of thousands of stones of diverse sizes and types from archaeological or maritime incidents. Consequently, the enormous quantities of the aforementioned sediments buried the limited organic tissues used as time indicators, linking the harbour to historical events and ancient sources during Roman times.

Ancient sources identify Kallias as one of the largest and most active ancient anchorages along the northern coast of Egypt, where they found a jar from Kos from the beginning of the second century BC and an iron anchor from the seventh and ninth centuries AD in this bay. Researchers also noted the presence of walls that extended towards the coast. (Abd El Maguid) We studied the geomorphological characteristics for location, but coastal erosion and other geomorphic processes, along with the Holocene Sea level change, have altered the coastline from the Greek and Roman periods to recent times.

Geoarchaeology: Definition and Scope

Geoarchaeology is the study of the interaction between human cultures and the natural world. As an interdisciplinary field that draws upon the combined expertise of archaeology, Earth Science (geology,

geomorphology, and soil science), ecology, geography, and other disciplines, geoarchaeology, as a methodology, applies the concepts, information, and analytical techniques of Earth Science to answer archaeological questions comprehensively in order to facilitate the work of archaeologists and efficiently carry out archaeological research. The field provides critical knowledge that contributes to the interpretation of all phases of a culture or civilization's development, as well as its interaction with and alteration of the environment. Although geoarchaeological applications are broad, research typically focuses on archaeological sites, environmental contexts, and geological records.

Geoarchaeologists study things like sediments, soils, and stratigraphy. They also look at micro- and macro-stratigraphic evidence of natural and cultural processes, as well as the time and space scales over which these happen. Archaeological site formation often serves as the primary focus due to its crucial role in the creation and survival of archaeological deposits, the interpretation of these features, and their impact on the research process. Geoarchaeologists, as researchers, have the investigatory tools to address scientific and resource management issues, and the need for preservation of archaeological sites demands that archaeologists and Earth scientists collaborate on a common understanding needed to inform both research and development planning efforts (Donald 1996).

Importance of Geoarchaeology at Submerged Sites

Geoarchaeology is an interdisciplinary applied field that focuses on studies in which natural environmental factors, as well as intentional or unintentional human intervention, shape sediments and processes. Geoarchaeology tries to clarify the interactions that occurred between past societies and their surrounding specific environmental contexts. The results of these studies attempt to interpret the sequences and changes by dominantly pinpointing the role of both anthropogenic factors and natural environmental factors, as well as their interactions. We approach this by utilizing a variety of archaeology-related concepts, theories, and methods that bear resemblance to the subfield of geography known as physical geoarchaeology. We also conduct research in various earth sciences fields, including pedology (soil science, land use), phytosociology (paleo-ecology), climatology (paleo-climate), hydrology (geomorphology, paleo-hydrology), and sedimentology.

Furthermore, when conducting an archaeological study, it is crucial to give special attention to geoarchaeology and comprehend the notion of "cultural resource management." Recognizing and utilizing the imharbourance of geoarchaeological methods to fully investigate different sites before planning any interventions can help us find hidden evidence and avoid the need for expensive excavations. As a result, we can save significant amounts of money, energy, and time. Furthermore, scientific preliminary studies play a crucial role in assisting decision-makers in considering necessary implementations, providing evidence and results that can predict restoration and maintenance interventions, and potentially leading to further protection at the targeted archaeological sites. In general, by combining the skills and knowledge of various earth sciences with those of archaeology teams, geoarchaeology should be primarily considered and utilized as an innovative interdisciplinary research approach in any archaeological investigation process (Donald 1996).

Methodology

We conducted a ground survey within the submerged harbours to map the area's geomorphology and identify any visible remains. We then incorporated the results into the GIS. In addition to the geophysical survey, we also used a geological column of the entire submerged harbour area to look at the order of deposition and when these sediment changes occurred. We used the survey field to examine the transformation of the fossil landscape towards the current underwater seabed of the study area and to assess the accessibility of any man-made structures below the water depths.

A regional GIS database incorporated information from both contemporary and ancient sources, including geographical texts, charts and maps, ancient harbours, and a GIS database of archaeological evidence, which included aerial images, satellite images, and landscape data. The authors supplemented this data with historical aerial photographs, management books, reharbours, publication archives, and personal observations from previous shore-based surveys. The geoarchaeological survey and the diachronic method used in the regional GIS-based database make it clear that there are many unexpected stratigraphic results that were not known before. They also show how the submerged Roman harbour structures in the catchment area began and changed over time. Additionally, the study explores the nature of the modifications made to the adjacent underwater seabeds during historical periods.

Results and interpretations

Water levels rose after the Roman period. The water level rose by a meter or more across the Mediterranean, and the changes in Kallias' harbour have diminished over a more recent period. In comparison, the area has experienced significant tectonic activity, such as subsidence movements that have submerged the harbours on Egypt's northwestern coast over the past two millennia, creating sunken quays that now border it to the north and are more than a kilometre wide. Which affected the depth and degree of slope of the port bottom. Figure 6 shows a model of the degree of depth decrease, and a map of the degrees of slope in the sunken port.

Geomorphological Changes Over Time

Marsa Hawala, or Hawala Bay, is a submerged archaeological harbour site on the northwestern coast of Egypt. Over the past decade, underwater exploration in this area has added to historical discoveries, in addition to the other discoveries which I referred to in the section on "Geoarchaeological Significance". The author also observed walls extending toward the coast and discovered a ship landing site, the remains of Amphora, and sunken pier explorations between 2022 and 2023. Rising sea levels submerged an active and busy harbour for centuries, revealing the remains of the docks, multiple anchors, and broken jars.

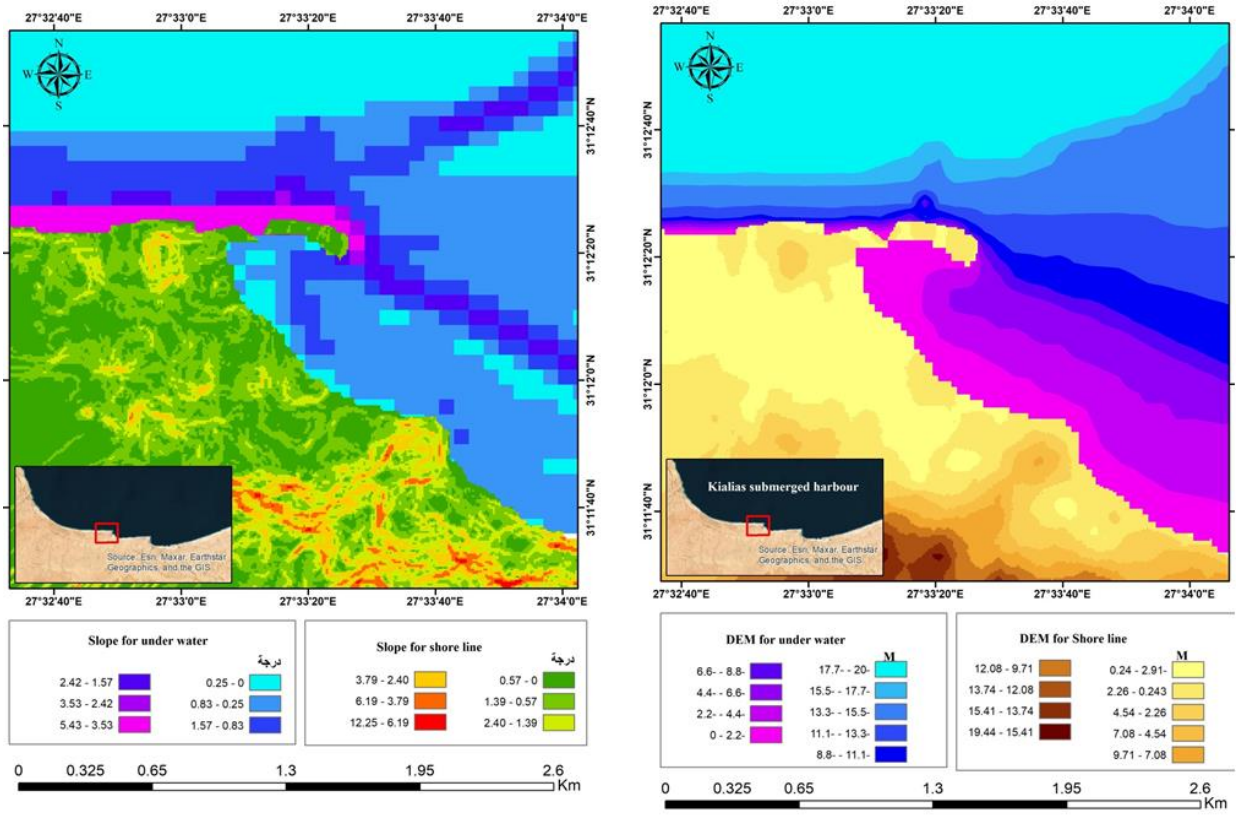


Figure 6. Slopes and DEM for Kallias harbour.

Over the past six thousand years, the mighty Nile River has helped the Nile Delta build its terminus and receive earthen materials. The Nile Delta, a low-ceilinged basin (LCEB), contains a significant concentration of historical human cultural artifacts, as evidenced by the submerged archaeological sites discovered through marine geological and paleo-environmental studies surrounding the Nile Delta. At least thirty thousand years ago in the geological past, the former Nile Delta first advanced toward the sea, only to begin flooding when global sea levels rose after the glacial maximum. The past six thousand years have seen the Nile Delta form and build up to its present form. However, changing nature has led to flooding and the complete loss of these ancient cities.

Geoarchaeological Discoveries

The three field campaigns' underwater archaeological investigation reveals that Kallias' submerged harbour experienced active development from approximately the 2nd century BC to the 2nd century AD. On the surface, the study collected and documented pottery evidence from these periods. Surveys and diving revealed that the main axis of the Roman dry docks ran parallel to the prevailing northerly wave direction. Alternating Quaternary limestone, part of an eroded carbonate coastal ridge, occupies the study area. We saw some geomorphic coastal landforms on the shore, like multi-level marine notches, platforms, and caves, which were made by the Holocene Sea level, and some solution micro-

landforms, like solution holes, channels, pits, and residual pinnacles, which were made by sea water on carbonate rocks (Figure 7).

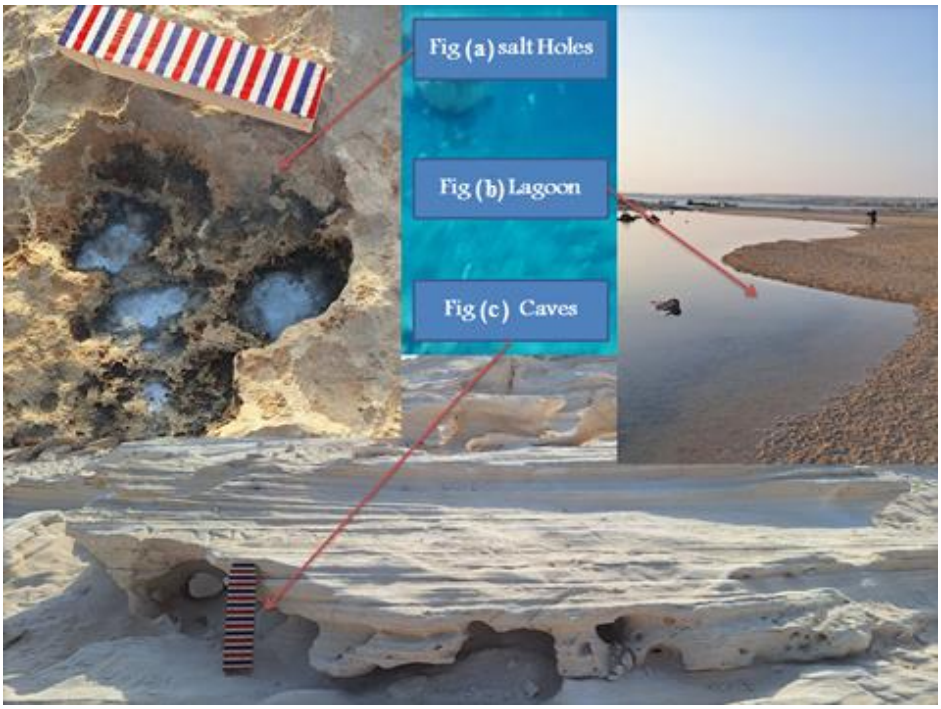


Figure 7. Geomorphic coastal landforms formed by the Holocene relative sea level.

Discussion

The investigation revealed that the establishment of Kallias harbours, comprising Facies I, II, and III, took place from the 2nd century BC to the 2nd century AD. The researcher also found archaeological remains (Amphora) dating back to the fourth century, which is considered the beginning of the late Roman era, according to the examination and analysis by Dr. Muhammad Mustafa Abdul Majeed[4] September 2023. The researcher the researcher discovered that the widespread use of the name Hawala extended to historians and ultimately to us as a result of the movement of goods from the surrounding community to this harbour. During the Greek and Roman eras, the cultural harbour gained widespread recognition and was further expanded during the British occupation. The Bedouins, who inhabited the area from their ancestors, recounted those camels' carried goods to the ships, and they exchanged the most imported goods with the people's provisions (barley and olives).

They also stole sheep. During the British occupation, the coal train was the means of transharbouring. The British constructed a paved road to facilitate the transportation of goods by train, but the owners of Almaza Beach village demolished the road and erased its features. The harbour coastline is receding due to increasing wave and erosion activity, as shown in Figure 8. Ras Hawala protects the narrow bay

[4] He is the former head of the Central Administration for Underwater Antiquities, an expert in antiquities, and a lecturer in the Department of Underwater Antiquities, Alexandria University.

where the harbour is located, but erosion processes have repeatedly eroded this cape, making it insufficient to shield the harbour from northwesterly winds. As a result, the harbour no longer meets the natural criteria to remain stable.



Figure 8. Map of the field survey of the harbour of Kallias (Ras and Marsa Hawala)

Implications of Findings

This study has illustrated how Kallias Harbour evolved in the NW coast's dynamic marine coastal environment. The harbour transitioned from an early amphitheatre structure, adorned with natural external breakwater formations on its NW and partially NE basin sides, to a comprehensive overview that depicts the harbour's development over three distinct periods. The design establishment is associated, respectively, with Ptolemaic-Roman, Persian, and Byzantine times. The coast overlooks sandy and rocky beaches in areas that are susceptible to rapid retreat or change. These areas include the general bay areas and the Capes that do not overlook the sea due to their cliff faces, such as Ras Hawala.

It is located west of Ras Abu Hashfa and consists of a sandy beach with fine sand mixed with coarse sand. It is a bay characterized by sandy ripples under its transparent water. Its slop The bay's slope is gentle, but as we approach Ras Hawala, which protects it and represents a tembol extending into the water above it, we encounter rocky sediments. These sediments are a mixture of shapes formed by weathering processes, material movement on slopes, and marine erosion factors. Out of that tombolo, we find two

rocky bays characterized by the accumulation of boulders that storm waves Paleo- tsunami, uprooted from the barriers and sunken docks as a result of the ancient tsunami (Figure 9).

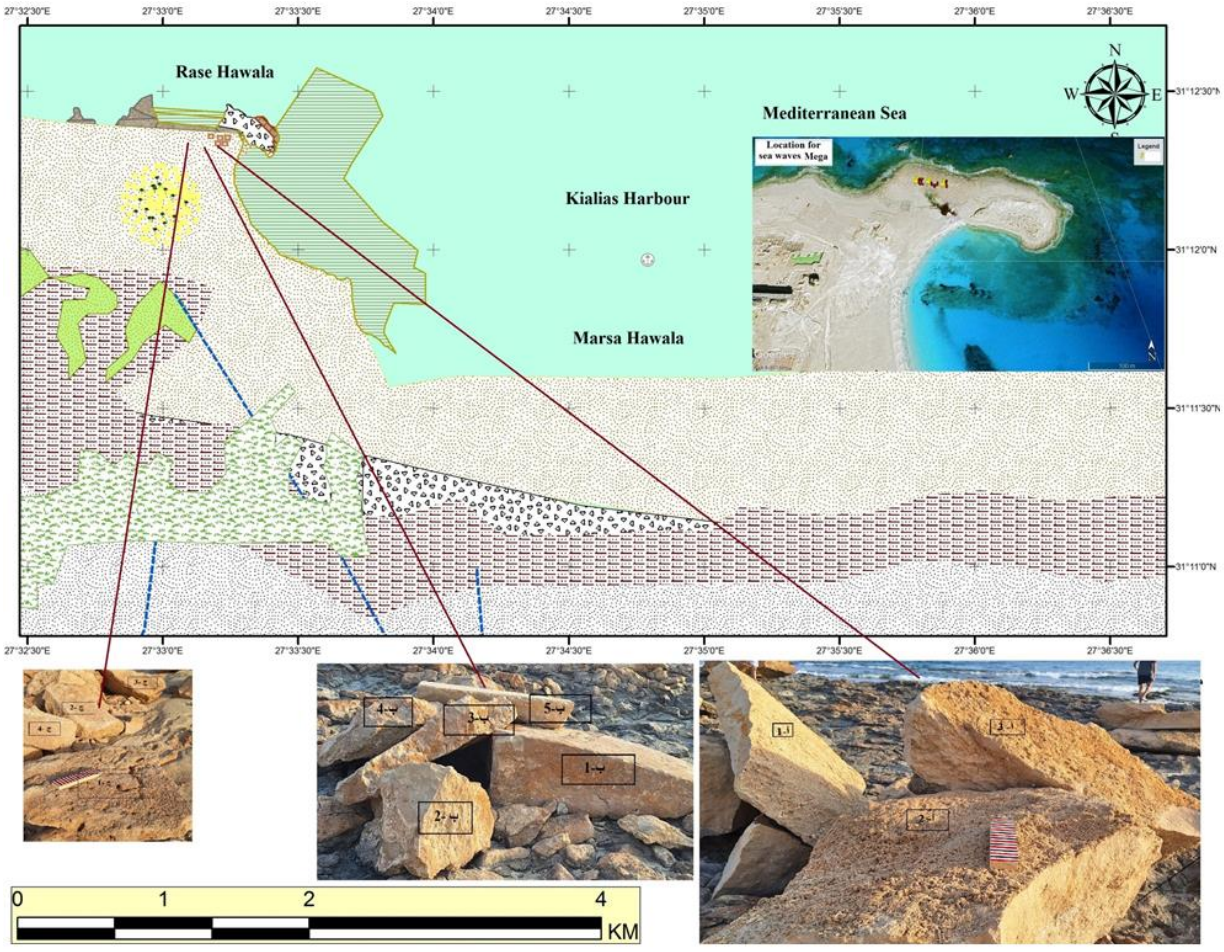


Figure 9. Coastal boulders and rock deposits provide evidence of significant wave impacts on Egypt's Mediterranean coast, as well as the impact of the Paleo-tsunami.

These blocks, with their varying sizes, blend with the sand to the south. The size of the blocks decreases as you move away from the coastline. Wind erosion factors have shaped and revealed the pure white sand dunes above Ras Hawala, where a group of hummus gathers. The contour maps display a digital elevation model, a depth model at the harbour, elevation ranges in the locations surrounding the sunken harbour, and the corresponding depressions. We use these maps to identify the elevation and depression ranges of various phenomena, including the extensions of the successive chains of the Botrokhian limestone hills parallel to the coastline. These extensions are evident by the longitudinal depressions that surround them on the sectors whose axes extend between the bottom of the plateau and the coastline.

In addition to the headlands that do not overlook the sea with cliff faces like Ras Hawala, the coast in the headlands areas overlooks sandy and rocky beaches in areas that are candidates for rapid rates of

retreat (change), which are generally bay areas. For many marine archaeologists, describing Kallias was always a dream. However, previous studies conducted at Kallias did not fully present the geomorphological and geoarchaeological changes. This was primarily due to the site's isolation from advanced research and the use of geomorphological and geophysical methods to study similar sites on land around the Mediterranean Basin.

The Romans occupied the northwestern coast, stretching from Alexandria to Umm El-Rukham, relying on the natural elements of these harbours without the need for construction or development. Therefore, the Romans took advantage of the hardened rocks found on top of the limestone layers and carved their mark on them. They carved anchors in the natural dock's body, drilling longitudinal holes to tie ships and fix them in these locations. These holes appeared in two of the previously mentioned harbour locations, and their numbers ranged from one to three. They carefully selected areas with quays that extended almost straight and had suitable dimensions, along with other components of the harbour, to optimize the utilization of Egypt's natural resources rather than constructing, developing, and depleting them. On the contrary, two famous emperors from the Roman Empire, one in Palestine and the other in Libya, which was their birthplace, built quays, commercial warehouses, sea barriers, and rooms (arsenal) for ship maintenance, according to some ancient historians, and Dr. Emad Khalil (2012) quoted them.

No one has ever excavated or dredged such significant marine constructions on Egypt's NW coast. It is thought that the maternal geological coast interacts with the Egyptian coast. Changes in sea level affect much of the harbour's development, and human activities and choices about harbour defence affect the coastline. This study reviewed the findings and elaborated on their implications, while typifying the harbour phases, defending stratification, environmental factors, and marine sediment succession. The study methodologically resolved the subaltern archaeological and coastal geomorphological problems related to the harbour and suggested solutions for human harbour protection. We have utilized the insights from Sri Lankan ancient hydraulic societies to describe the Nile deltaic and coastal geomorphological discoveries in NW Egypt, contributing to a broader scientific advancement.

Comparison with Other Roman Harbours

The geomorphological setting of the Kallias site is a combination of fluvial and submarine environments. It does not correspond to the typical fully submerged Roman commercial harbours and fleet stations with large structures or installations, such as amphora kilns. Despite this, we can compare the geomorphological, archaeological, and historical evidence from Kallias to only one other fully submerged harbour, the Erythraean harbour off the coast of Abu Quir in the Rosetta region. F. Goddio and his team conducted archaeological investigations during the seasons 2001–2002 and 2002–2003. Other submerged sites primarily link their evidence to either natural (subsided) or geological landform processes, or they may lack cumulative evidence. Specifically, researchers have not yet discovered habitation deposits or sediments associated with the built and occupied harbour facilities, nor the volume of alluvium and sediments deposited inside the buildings. This allows Kallias to be considered the only fully submerged heliopolitan site accessible from the sea.

Comparing Kallias to the fully submerged harbour site off Abu Quir is inappropriate in all aspects because only at Kallias are the geological, geomorphological, coastal, and quaternary settings reconstructed in reasonably acceptable detail. The sea level rise shaped the site, while glacio-eustatic changes caused sea level fluctuations to form the lowered northern plateau and the Abu Qair submerged plateau off the Rosette coast.

Conclusion

We have measured some geomorphological and geoarchaeological indicators in the ancient harbour site on the eastern side of the Ras Hawala area. Some emergent notches and platforms, in addition to marine terraces and caves, indicated sea level change. Waves on the beach accumulated some archaeology remains from the Roman period, indicating a change in sea level at a depth of about 4–5 m in Kailias harbour.

This paper aimed to investigate the changes at the site by applying these available independent scientific tools without making any intervention, such as the complete excavation of remains or preparing any theoretical models. We applied only relatively low-cost geophysics, remote sensing, and field survey tools. The results concluded that Kallias' sunken environment and coastal events, which situate the site in a shallow atmosphere since the Hellenistic and Roman times, shaped it. Evaporites, rip-rap, stretches on nearby offshore mudbanks, liquefaction, and slides still play very influential roles in the status of the remains of the site, and they need more future monitoring or site order conservation.

This underscores the stark contrast between the site's "as if nothing happened" scenario and its actual circumstances. The bespoke stato-dynamical condition of Kallias, with its seaface utilizing the descriptive and protective functions of some soil types, makes it a case study for the present research intent. The outcomes of the integrated approach can be considered a blueprint that may be useful for future geomorphological-based research into submerged archaeological areas.

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Port as a complex system of relationships: some preliminary notes on the Roman cases of *Altium* and *Iulia Concordia*

Elisabetta Rosatti[1]

Abstract

The Roman cities of *Altinum* and *Iulia Concordia*, located near the ancient lagoons of Venice and Caorle in the Northern Adriatic region (Italy), played a key role in connecting river, lagoon and sea trade. They were inland port cities with distinctive features, surrounded and crossed by a network of natural and artificial waterways, along which quays and storehouses were established.

According to recent interpretative models, ports are systems composed of three areas, shaped by interactions with their users, namely goods and boats. This paper presents an ongoing research project that examines the inland ports of *Altinum* and *Iulia Concordia* from this perspective.

Current investigations combine archival research to gather published and unpublished excavation data; a coring campaign providing crucial evidence on paleochannels, essential for navigation analysis; and the development of a GIS framework to integrate heterogeneous datasets. Collectively, these efforts enable the reconstruction of port spaces and mark a first step toward understanding how the two port systems functioned.

Keywords: Roman era, Northern Adriatic, inland port, archive research, coring, GIS

Introduction

Altinum and *Iulia Concordia* (Figure 1) were Roman cities of pre-Roman origin, developed in the Italian Northern Adriatic area, part of the so-called *X Regio Venetia et Histria*.

According to the well-known topographical description by Pliny (*Nat. Hist.* 3, 126) from the 1st century AD, this region was characterized by various settlements in close connections to rivers, often featuring ports at their mouths.

Much like today, several rivers originating from hilly areas traversed floodplains and flowed mostly into lagoons, which were more extensive at that time, according to Strabo (5, 1, 5).[2] As is common in preindustrial societies, these rivers were probably used as waterways, sometimes facilitated by their resurgent regime, ensuring the hinterlands with waterborne connections to the Adriatic Sea through the lagoons.

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[2] An almost continuous belt of proper lagoons, ponds, swamps, river mouths and coastal lakes extended between Ravenna to the south and Aquileia to the northeast. The possibility of reaching these two cities via an inland, mainly lagoonal, route, known as the '*via endolagunare*' or '*endolitoranea*', remains debatable and lacks definitive archaeological evidence, especially between *Altinum* and Aquileia. It is expected to follow the curvature of the coast from afar, and some *fossae per transversum* should connect the different bodies of water, making it a continuous route (Bosio 1991; Dorigo 1994; Medas 2013 and ref.; Uggeri 1997).

A dense road network, developing pre-Roman paths, enhanced the region from the 2nd century AD onward, integrating with the river network and including the main cities into East-West and North-South terrestrial routes (Bosio 1991).

Altinum and *Iulia Concordia*

In this context, *Altinum* and *Iulia Concordia* (Figure 1) developed respectively near the ancient lagoon of Venice and next to the paleo-lagoon of Caorle. The first one faced almost directly the lagoon, whose local inner edge was approximately the same as today (Primon and Mozzi 2023), while the paleo-lagoon of Caorle was way closer to the city of *Iulia Concordia* (Ronchi et al. 2021).[3]

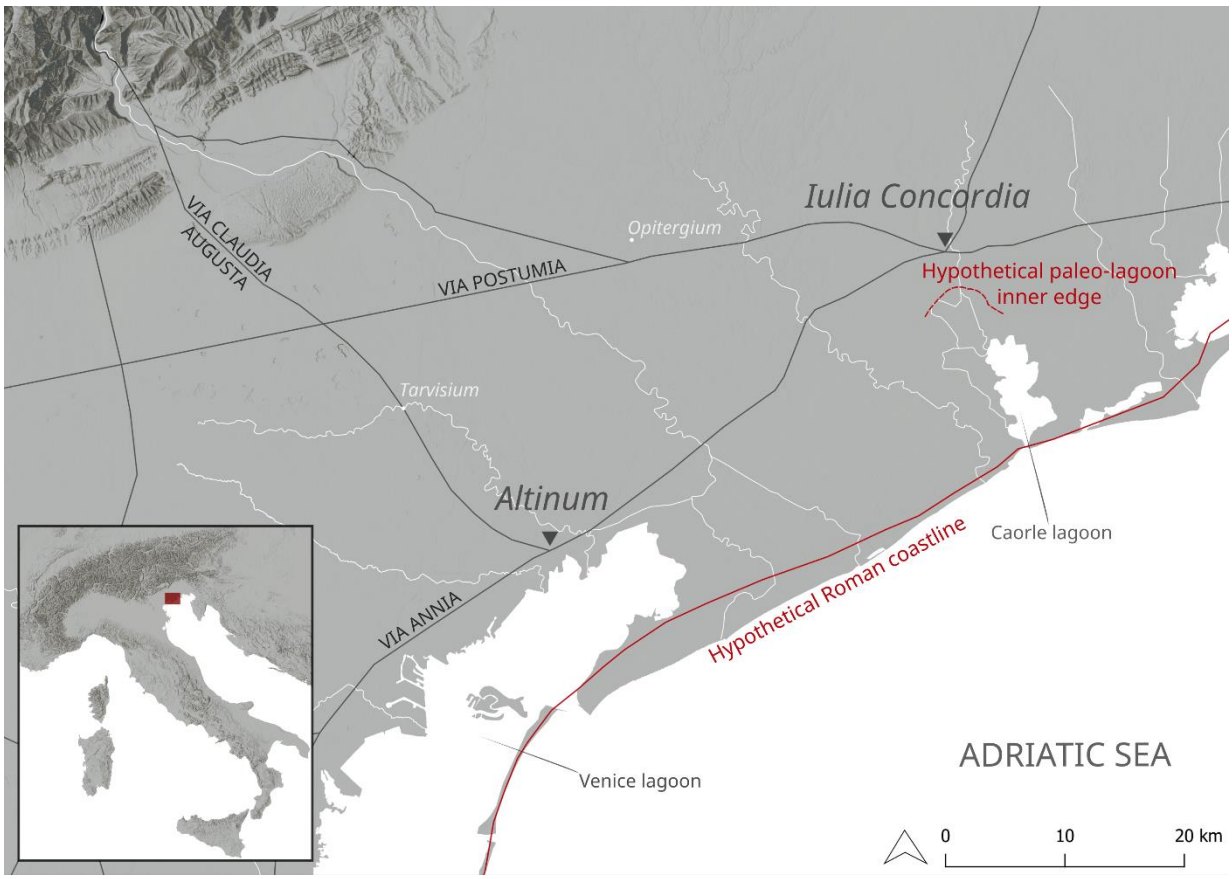


Figure 1. *Altinum* and *Iulia Concordia* in the Italian Northern Adriatic region. The map displays the current geography, with the Roman-era coastline (Salomon and Rousse 2022 Figure 3), the hypothetical inner edge of the Caorle paleo-lagoon (Annibaletto 2010) and the ancient road network (Barrington Atlas).

[3] The ancient lagoon area was significantly reduced by a progressive swamping process that began at least during the 17th century with the Venetians, and the reclamation efforts made in the 19th and 20th centuries definitively altered its aspect (Fontana 2004).

They were surrounded from afar by a net of fluvial waterways: *Altinum* by the Zero, Dese, and Sile rivers, the latter following its original course before the Venetians diverted it in the 17th century; *Iulia Concordia*, by the paleo-Reghena[4] and Lemene rivers.

They were reached by main roads, which guaranteed excellent connections by land with the rest of the Peninsula and the Northern region (Bosio 1991; Busana e Vacilotto 2022): 1) the *Via Annia* which joined them with *Patavium* to the south and Aquileia to the east, 2) the *Via Postumia* coming from *Opitergium* and connecting *Iulia Concordia* with the West 3) the *Via Claudia Augusta* leaving from *Altinum* '*usque ad flumen Danuvium'* (CIL, V, 8002), and 4) at least one road leading to the *Noricum* region from the northern *suburbium* of *Iulia Concordia.*

Therefore, at the junction between water routes and a terrestrial road network, *Altinum* and *Iulia Concordia* were pivotal points between the transalpine and Mediterranean worlds.

Ports with distinctive features

As shared in the *X Regio*, from the process of Romanization onwards, a systematic network of artificial canals was gradually excavated mainly at the base of the micro-reliefs on which the cities developed (Rousse 2014). As a result, *Altinum* (Tirelli 2011a) and *Iulia Concordia* (Annibaletto and Pettenò 2012) appeared surrounded and crossed by watercourses which were joined with the natural belt of fluvial waterways previously mentioned (Figure 2; Figure 3), matching the 'island-cities' description by Strabo (5, 1, 5).

The functions of this water network are also suggested by Strabo (5, 1, 5): on the one hand, the canals contributed to the drainage of land essential for agricultural activities and consequently to the *salubritas* of this land, as also noted by Vitruvius (1, 4, 1); on the other hand, many of them were used also for navigation, bringing river, lagoon and maritime traffic directly into the cities.

Spread and along the urban canals, different structures for landing have been archaeologically attested (Annibaletto 2010; Tirelli 2001), perfectly fitting with the model that can be recognised also in Aquileia (Carre e Maselli Scotti 2001). They consisted mainly of quays, in some cases stair-quays, either of stones or bricks, probably more frequent than what is now attested and standing generally on a wooden palisade. In *Altinum,* a monumental door with towers is also considered a landing place given its position, facing a canal, and a huge L-shaped trace, detected with remote sensing and geophysical techniques, is interpreted as a harbour and is now under further investigations (Beltrame, Negrelli, and Mozzi 2023)

At last, certain buildings immediately next to the landing structures, are most likely warehouses characterized by recognizable portico façades in *Altinum* (Tirelli 2001) and concentrated mainly on the east and south-east part of the city in *Iulia Concordia* (Sandrini 2001).

Canals network; quays; warehouses: following the *tryptique portuaire* model, all these elements together define a port. Indeed, according to this interpretative reading developed by the geographer

[4] Currently, the Reghena River flows into the Lemene River near Portogruaro before reaching Concordia. In Roman times, however, it flowed directly to the city, bordering it to the west.

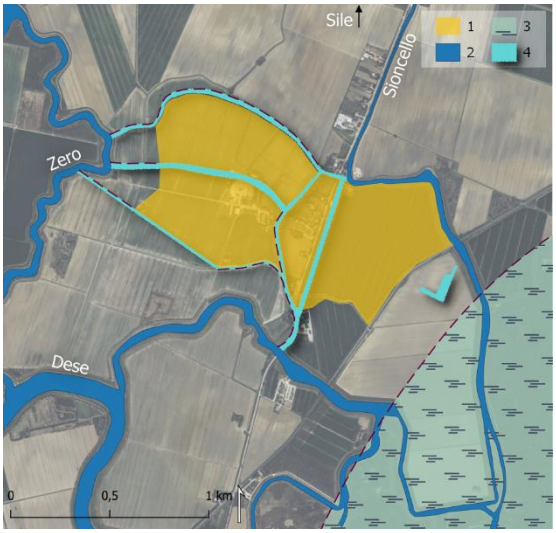


Figure 2. The urban hydrographic network of *Altinum*. 1. The Roman urban area (Tirelli 2011); 2. Current hydrography; 3. Hypothetical margin lagoon (Primon and Mozzi 2023); 4. Ancient canals: attested and hypothetical (Tirelli 2011).

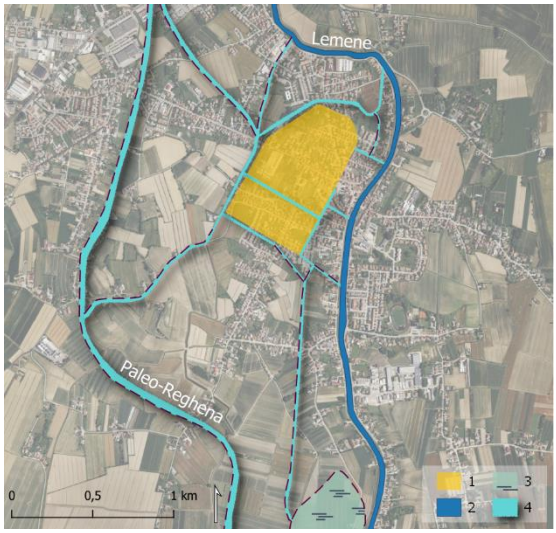


Figure 3. The urban hydrographic network of *Iulia Concordia*. 1. The Roman urban area (Annibaletto 2010); 2. Current hydrography; 3. Hypothetical margin lagoon (Annibaletto 2012); 4. Ancient canals: attested and hypothetical (Busana and Vacilotto 2022).

A. Vigarié and then applied in the archaeological field (Mouchard 2020), ports are made of three essential components, each with a specific function: the water space for landing and navigation (canals); the waterfront for landing and un/loading (quays); an inland area for storage and redistribution (warehouses). As a result, both *Altinum* and *Iulia Concordia* cities seem to work collectively as ports.

Beyond their urban scale, they were likely part of larger port systems extending through the lagoon areas to the inlets. Here, other facilities could have served as shelters for load breaks or facilitated lagoon and coastal navigation: in Venice Lagoon, for example, facing the main lagoonal channel which led to *Altinum*, well-cisterns for freshwater, one immediately next to a pier (Beltrame *et al.* 2023), and a presumed *villa* (Beltrame and Mozzi 2024) seem to confirm this configuration.

The research

This research focuses specifically on the urban scale of these unique port systems and aims to understand their functioning beyond the simple – though essential – reconstruction of spaces. It draws from the idea that in the study of economic spaces, movements, physical constraints, and accessibility are critical issues to be studied, as they allow a better assessment of the scale and economic importance of these infrastructures in the city's economy or in comparison with others (Keay *et al.* 2021). This means reconstructing the lost and invisible relationships between spaces and their users, which requires research that can deal with different sources, methods and techniques (Volpe 2015).

Notably, the current work explores the entire operational chain of both ports, encompassing inland water navigation, boat landing, cargo loading and unloading, and goods storage. Therefore, the study will analyse 1) the spatial configuration of the two ports following the *tryptique portuaire* model, 2) their "users," including people, goods, and vessels that circulated within them, and 3) the interactions between these components.

Reconstructing port spaces: the first step of the ongoing research

The initial phase of this research focuses on reconstructing the port spaces of both sites, which entails collecting and reprocessing various data types. It required diverse analysis, including archival research, which is essential to collect mainly archaeological data, and a coring campaign specifically to study the water space. A GIS project was eventually deemed crucial for managing, visualising, and coherently analysing this information.

Archival research

Archival research was identified as a crucial approach at the outset of the bibliographical review, given that both sites have been studied since at least the 19th century, thus resulting in fragmented and stratified knowledge. The primary research was conducted in the archives of the Museo Nazionale e Area Archeologica di Altino (MANA) and the Museo Nazionale Concordiese di Portogruaro (MNCP) to collect excavation documents and have access to the raw data. Additionally, the investigation extended to the archives of the Istituto Veneto di Scienze, Lettere ed Arti and the Fondazione Fioroni, following the trail of specific research dating back to the 1930s in *Altinum*.

Most on-field investigations regarding the three port spaces date to the 1990s in *Iulia Concordia* and the 1970s in *Altinum*, with some issues concerning the quality of the excavation methodologies and, consequently, the documentation. Not all archaeological contexts have been published: in many cases, publications consist of only brief annotations.

All these collected data are currently being studied, and the effort is already proving worthwhile across various cases, as summarised here.

In well-documented situations, this research is critical for assessing the reliability of specific reconstructions or information by verifying them against actual material data or tracing them back to the primary source.

For example, in the 1930s, a monumental Roman stone quay, nearly 200 meters long, was unearthed in *Altinum* on the western bank of the Sioncello canal, which is believed to have been excavated by the Romans (Tirelli 2011b). As visible in a famous photograph of the discovery (Tombolani 1985 Figure 48), the quay was composed of stone resting on two or three rows of wooden poles. Based on this evidence, Tombolani (1987) proposed a parallel with the Roman quay of *Eporedia* – at that time recently discovered – on which he suggested a reconstruction of the missing parts, always mentioned in subsequent publications.

However, upon closer examination, it became evident that the existing knowledge largely relies on that photograph and a single-sentence description in a 1932 letter housed in the MANA archive. Indeed, although part of the excavation journal from that period survives, it is of limited use, as it primarily consists of a list of materials.[5]

A more substantial piece of evidence was discovered in the archive of the Fondazione Fioroni: a brief handwritten description of the quay, authored by A. De Bon, who most likely also took the earlier photograph. It states that the quay featured two rows of slabs resembling the quay of Aquileia, and

[5] The journal records the length of one wooden pole, extracted for further analysis, a detail that has remained previously overlooked.

although this description probably dates from a few years after the excavation, it is written by someone who was on the field.

Upon closer inspection, the actual configuration of the quays is then an unresolved issue, and the understanding previously crystallised could be challenged and refined. Efforts are now focused on deepening this inquiry by exploring new archival materials relating to the original investigations to re-evaluate the quay's structure and usage.

Another situation is when reviewing the documentation of already known context, even if partially published, leads to some "re-discoveries".

For example, in the southwestern part of *Altinum*, an area known as Fornasotti, a late Republican porticoed warehouse was uncovered in the 1960s adjacent to a structure initially identified as a tower and later reinterpreted as a bridgehead (Tombolani 1985). Upon reviewing the excavation journal, sketches and photographs and comparing them with existing publications, an unrecorded structure was identified, positioned at some distance facing the portico to the south. Between the portico and this "new" structure, there was probably an ancient canal, whose presence is also suggested by an agricultural boundary – likely a canal – coherent to the archaeological structures, documented on various maps until 1887, after which it was probably buried (Tirelli 2005).

If this is accurate, given the position of the newly identified structure relative to the waterway, it is plausible to consider it a landing facility. This finding requires further investigation but could help estimate the canal width, impacting the comprehension of navigation in this sector.

The third and final context in which this research yields interesting results involves data from small-scale preventive and rescue archaeological work, much of which remains unpublished. The contextualisation of these findings within a broader framework improves the overall picture, particularly of the hydrographic network, by effectively connecting the dots.

Coring campaign

Reconstructing water spaces as navigation areas necessitates targeted investigations, especially if the context is buried and no longer visible (Salomon and Rousse 2023). While some urban water canals have been uncovered through archaeological excavations, most of the water network, particularly in *Altinum*, has been identified via remote sensing and geophysical techniques (Mozzi *et al.* 2016; Ninfo *et al.* 2009). However, these methods often need to be improved to provide crucial information such as the chronology, depth, and even width of the channels – indispensable elements for determining whether and how these waterways were designed for navigation. Understanding such factors is essential to assessing the periods during which the canals were operational, the types of boats that could navigate based on their draught, and the capacity for simultaneous navigation.

A viable and effective option to obtain this critical data is core drilling, a minimally invasive and relatively inexpensive analysis. Therefore, in conjunction with the ongoing archival work, a core campaign has been organized in *Altinum*, where the current rural asset still permits such investigations. This ongoing research has two main objectives: 1) verifying on the ground the existence of some of those paleo-canals only seen with remote sensing, and 2) determining their navigational characteristics. Besides that, geological and palynological analyses are also planned and coordinated by professors P. Mozzi (University of Padova) and A. Bertini (University of Firenze). The campaign is indeed part of broader research coordinated by Professor C. Beltrame, as its Principal Investigator, which

focuses on the settlement dynamics, adaptive behaviours, and paleoenvironmental reconstructions of the Lagoon of Venice.[6]

The campaign – authorised by the Direzione Regionale Musei del Veneto – commenced[7] in February 2024 from the so-called "Area Nord" characterized to the north by the previously mentioned late Republican water gate, known as 'Porta-Approdo', which faced a canal partially investigated in previous excavations (Gambacurta 1992); to the south-west by a brick quay connected to a porticoed warehouse identified in the 1970s (Tombolani 1985), also facing a canal that has yet to be thoroughly investigated.

One cross-section of ten manual cores was conducted on the 'Porta-Approdo' canal, and another one of nine cores on the canal adjacent to the brick quay. These investigations have enabled the reconstruction of a channel width of at least 24 meters in the first case and 18 meters in the second. Unfortunately, the north bank of the 'Porta-Approdo' canal was not reached, as it likely extends into a private garden. Nevertheless, the findings support the initial suggestion of a substantial width, as indicated by the slope of the stratigraphic layers observed during the previous excavations. In the case of the brick quay canal, the obtained data refer to a width that exceeds the 10 meters previously supposed, and this better aligns with the hypothesis that this watercourse was intended for navigation.

Regrettably, in neither case was the bottom reached, so the section with the channel fill layers is only a preliminary reconstruction. In many cores, at the lowest points accessed, there were sandy layers, and the limitations of manual coring instruments, coupled with the presence of the water table, prevented the recovery of the sediment and the in-depth survey. The campaign has been thus recently implemented with some semi-automatic drillings, and it is already proving effective in overcoming this issue.

GIS project

Eventually, a GIS project has been developed to manage the heterogeneous, fragmented, and voluminous information. It is structured to integrate three primary types of data: 1) archaeological data from archival and bibliographic research; 2) geoarchaeological data, predominantly derived from the coring campaign; and 3) aerial and satellite imagery, cartographic materials, and historical maps, which are crucial for studying the landscape modifications and particularly reconstructing the hydrographic evolution. This work is part of a broader GIS developed for the CHANGES project coordinated by Professor C. Beltrame on the Northern Lagoon of Venice,[8] and its structure draws inspiration from the Italian Geoportal for Archaeology (GNA) and the digital archaeological map of the MANA.[9]

Thus far, it has proven invaluable in integrating and analysing diverse sources at a detailed level, as in the previous Fornasotti case, facilitating a comprehensive understanding of the port spaces and their

[6] The PRIN project (code: 2022C24YSJ) is entitled "The Lagoon of Venice in Antiquity. Settlement dynamics, adaptive behaviours, paleoenvironmental reconstructions".

[7] The campaign has been conducted with S. Rampin, a research fellow in geomorphology at the University of Padova.

[8] Its implementation required significant collaboration with C. Lucarini, who is currently developing this GIS work in the CHANGES PNRR Spoke one project '*Paesaggi storici, tradizioni e identità culturali*' coordinated by Professor C. Beltrame for the Venice research team.

[9] E. Delpozzo developed this precious work as her PhD research.

historical development. At this moment, it is also a helpful tool for systematising all data, but upon completion, it will provide a unified and diachronic perspective of the port spaces of both cities.

Conclusion

The ongoing research on *Altinum* and *Iulia Concordia*, which aims at clarifying how these distinctly featured Roman ports functioned, follows a three-step workflow focused on port spaces, their users and the interactions between these two components. Here, the first step of the research has been briefly presented.

At this stage, the results must be considered highly provisional. The main effort has been devoted to gathering as much information as possible within a fragmented and stratified context of studies. While this allowed some rediscoveries and refinements of specific data, the most substantial and original insights are expected from their final and comprehensive reading through the lens of the *tryptique portuaire* model.

The study will then move to the following two phases, where analysing the relationships between spaces and users will be central. This approach will help not only in reconstructing operational chains but also in refining or challenging current interpretations of specific structures. Since some hypotheses proved uncertain during this first research step, examining how people, boats, and goods interacted with these structures may be decisive in confirming or revising their interpretations.

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The underwater surveys by MPM project in Cyprus (Limassol)[1]

Serafino Caggiano[2]

Abstract

The underwater surveys by MPM Project in Cyprus (Limassol) have been concentrated on two specific sites which have been found during the geo-morphological and archaeological underwater research.

The main two sites are respectively located to the west and to the east of the mouth of the river of the Bay of Agios Georgios Alamanos (Monagroulli, Limassol District), which formed in antiquity a wide estuary with a strong port vocation.

The two sites are both extremely interesting, although chronologically quite far. The first site is located along the cliffs to the west of the river. It presents several structures which are arranged on part of the cliffs which collapsed for erosion and are now maximum 3m deep.

The structures are quite difficult to date, because of the lack of diagnostic finds, apart from a grinding basin, whose typology could give some help in dating the activities of a workshop.

At the moment the building techniques may suggest dating to the early Iron Age. The second site is a large limestone quarry, which is located to the east of the river mouth. The site presents a wide and long artificial channel for hauling ships and evident marks of quarrying activities, with blocks and slabs still in situ, attesting a use of this quarry between late Hellenistic and Roman periods.

Keywords: underwater survey, MPM project, Cyprus, Limassol

The underwater surveys by MPM project in Cyprus (Limassol)

The present work is part of a large project (MPM Project[3]) of the University G. d'Annunzio of Chieti-Pescara, which is still in progress in Cyprus, in the eastern district of Limassol. The project has been presented in several papers (Menozzi and Mancini 2012: 195-201; Menozzi et al. 2018: 95-135; Menozzi et al. 2019: 30-34; Agostini et al. 2022: 2-47) as preliminary reports and at the moment a complete volume is forthcoming.

The underwater surveys have been concentrated on two specific sites (n.5 and n.6 in Figure 1) which have been found during the geo-morphological survey in the previous seasons, respectively located to the west and to the east of the mouth of the river of the Bay of Agios Georgios and forming in antiquity an estuary in the area named in the geological map Korakas. The two sites are both extremely

[1] The present papers represent an abstract of a presentation and a poster concerning the underwater project within MPM, which has been presented in 2017 at the CAARI in Nicosia by the author together with O. Menozzi, M.V. Carniel, G. Di Camillo and M. Yamasaki. It is therefore important to mention all the authors of the original paper and poster. Moreover, it has been published in a shorter version in Menozzi et alii 2019, in part. pp.32 and 33.

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[3] Moni, Pyrgos, Monagroulli and Pentakomo Project.

interesting, but chronologically quite far, although certainly well integrated with the finds from their contexts.

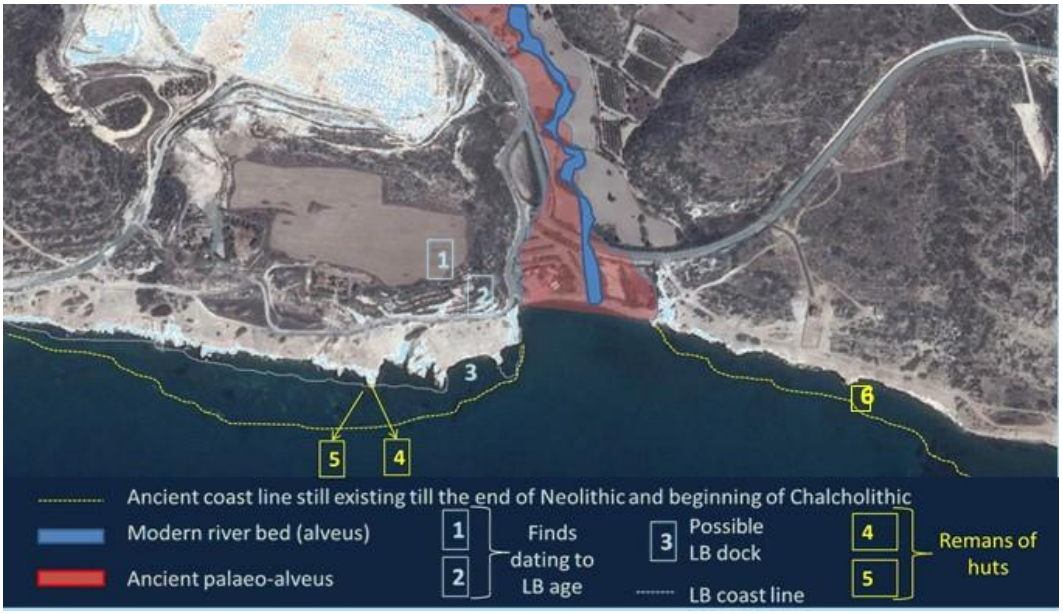


Figure 1. General map of the main sites in the area of Agios Georgios Alamanos (Credits: Archive MPM of Chieti University).

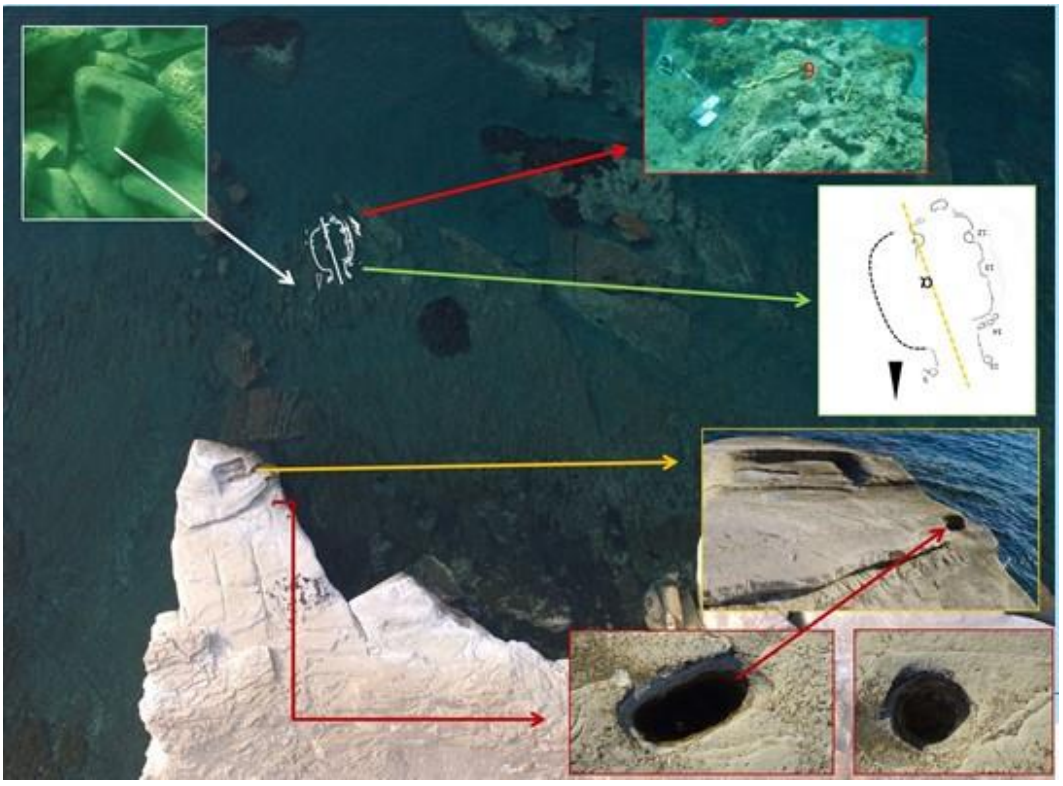


Figure 2. Drawing and photos of the main structures of the workshop (Photo: Archive MPM Project-Chieti University and edited in Menozzi et alii 2019, as Figure 3).

The first site (n.5 in Figure 1) is located along the cliffs to the west of the river mouth (N34°42.336'-E33°13.935'. It presents several structures which are arranged on part of the cliffs which collapsed for erosion and are now maximum 3m deep. Three structures have been mapped together with a large working area (Figure 2, Archive MPM Project-Chieti University).

The structures are characterized by a series of post-holes, which formed the skeleton of the buildings, included within a low wall realized with river pebbles and plaster, which were used as foundation and basement of the buildings. Very poor re-mains of the walls are preserved, measuring in thicknessabout 35cm for external walls and 25cm for inner structures. The structures are quite difficult to date, because ofthe lack at the moment of diagnostic finds, apart for a grinding-basin (Figure 3), whose typology could give some help in dating the activities. At the moment the buildingtechniques and the typology of the grinding-basin may suggest dating to the early Iron Age, butit is now important to look for parallels of the structuresand of the grinding basin to narrow the range of dating.

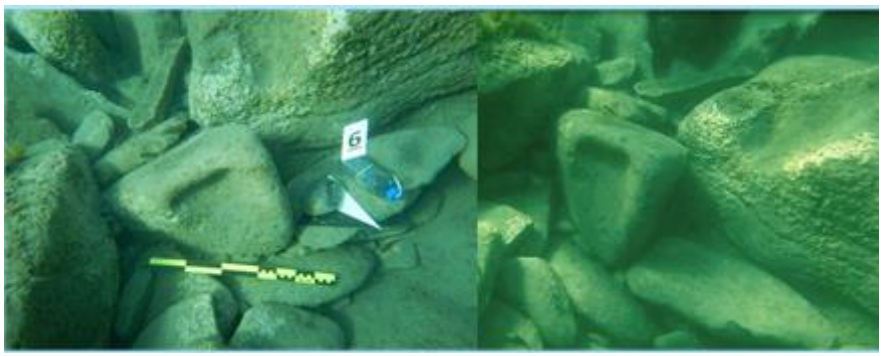


Figure 3. Drawing and photos of the main structures of the workshop (Photo: Archive MPM Project-Chieti University and edited in Menozzi et alii 2019, as Figure 3).

The cliffs around still preserve part of this workshoparea (see Figure 2), with a rectangular structure which has been strongly eroded because exposed to the external weathering (mainly wind and waves).

Surveying intensively this area of the cliffs, most of the finds seems to be represented by late Geometric and Archaic pottery.

The second site (6 in Figure 1) is located to the east of the river mouth at the geographic coordinates 34°42.270'N-33°14.713'E.

The local toponimous attested by the geologicalmap is Kapsali and Korakas; in the site is preserved at a deepness going from -1 to -7,05. It represents a quite peculiar area because it is the only part of this territory presenting not only soft Havara limestone, but also a harder and more compact kind of limestone lythotype, which appears stratigraphically located just below the Havara layers.



Figure 4. Some of the moments of the surveys. In particular here the author is measuring one of the blocks in the quarry (Photo: G. Di Camillo).

The site presents evident marks of quarrying, with blocks still in situ, attesting,both the blocks (Figure 4) and the marks of quarrying (Figure 5-6), a use of the limestoneduring the Roman period. The chronology, within the Hellenistic and Roman periods, has been defined on the basis of the measurements of the blocks and of the tool marks. Moreover, the sherds which have been found during the judgmental surveys just around the site dating tothe Roman period.

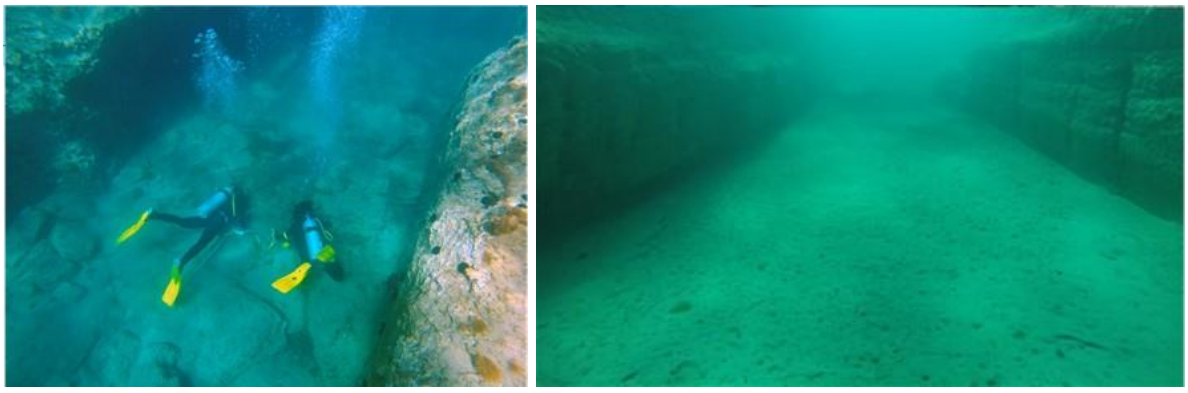


Figure 5. Some of the moments of the surveys. In particular, here the author and M. Yamasaki are mapping the artificial channel of the quarry (Photo: G. Di Camillo).

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Seafaring and navigation

Small but gold: the flourishing mariners of Chryssi island

Katerina Famprikatzi[1]

Abstract

The significance of maritime activities in Late Minoan Crete is well-established, yet a comprehensive understanding of the structure, agency and status of the groups of people engaging with the sea remains elusive. The following paper explores these topics, employing as a case study the islet of Chryssi, which was situated close to the southern coast of Crete, at a nodal location in the maritime network of the region. During the Late Bronze Age Chryssi evidenced a major expansion, accommodating a small but flourishing settlement, where at least three distinct groups of 'mariners'— fishermen, artisans and sailors (or marine traders)—coexisted and cooperated. This paper endeavours to illuminate the socio-economic dynamics of these maritime groups on Chryssi. The detection and definition of these sea-oriented groups is attempted through assessing the archaeological evidence from Chryssi's Late Bronze Age contexts. Furthermore, the importance, status and roles of Chryssi's mariners within the Late Minoan society are discussed. Finally, the intricate relationship of these groups with the opposite Cretan shore is laid out along with approaches on the settlement's potential social organization.

Keywords: Late Bronze Age, Minoan Crete, Neopalatial period, economy, social organization

Introduction

Given their crucial role in maritime connectivity, social, economic and political developments, Minoan coastal sites constitute an alluring field for researching the socioeconomic dynamics of Minoan Crete. Nevertheless, we still possess limited knowledge of the groups and individuals engaging in maritime activities during the Bronze Age. People across the island made their living from the sea, specializing in their domains and acquiring impressive skills (Berg 2013; Sauvage 2012; Mylona 2016; Mylona 2020; Powell 1996; Theodoropoulou 2012; Theodoropoulou 2014). During the Late Bronze Age, many of these activities were fundamental for the economic development of the settlements and often penetrated into various domains of the Late Minoan society (Apostolakou *et al.* 2014; Apostolakou *et al.* 2016; Chalikias 2015; Driessen 2013; Haysom 2011; Mylona 2020; Platon 2010; Wiener 1991).

This paper will focus on Chryssi, a small island in the Libyan Sea, situated 13km off the southern coast of Crete and opposite the modern town of Ierapetra. During the Late Bronze Age Chryssi was distinctive by its nodal location in the interaction network of the region, its topography and a flourishing Minoan settlement with a specialized economic character. During the Neopalatial period (16th and 15th century BC- Middle Minoan III- Late Minoan IB, for the detailed chronology see also Table 1), at least three distinct groups of 'mariners'—fishermen, artisans and sailors (or marine traders)—coexisted and cooperated on Chryssi, all aiming to exploit the marine wealth and opportunities of the surrounding coastscape. In the following pages an effort will take place to locate and define these mariners, based on the available archaeological evidence from Chryssi's Late Bronze Age contexts. Their importance

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and status, along with their socio-economic dynamics, will be discussed within the framework of the Neopalatial small maritime world of Southeastern Crete as well as the local coastscape.

Chronology Table of Minoan Crete			
Early Minoan I	Early Bronze Age	Prepalatial Period	3000 B.C.
Early Minoan IIA			
Early Minoan IIB			
Early Minoan III			
Middle Minoan IA	Middle Bronze Age		
Middle Minoan IB		Protopalatial Period	1900 B.C.
Middle Minoan IIA			
Middle Minoan IIB			
Middle Minoan IIIA		Neopalatial Period	1700 B.C.
Middle Minoan IIIB			
Late Minoan IA	Late Bronze Age		
Late Minoan IB			
Late Minoan II		Final Palatial Period	1450 B.C.
Late Minoan IIIA		Postpalatial Period	1370 B.C.
Late Minoan IIIB			
Late Minoan IIIC			

Table 1. Chronology Table of the Bronze Age Crete.

The abovementioned terms, coastscape and small maritime world, constitute the first two scales of interaction defined by Tom Tartaton (Tartaton 2013: 8-9, 186, 188-98; Tartaton 2018: 73-75). Coastscapes are the coastal zones 'defined by habitation, interaction, practice, and perception' (Tartaton 2013: 188). They encompass coastlines, anchorages, settlements and exploitable coastal lowland, inshore waters and an entire field of vision, including the dense network of local maritime connections of the surrounding area. It is the scale of everyday interaction and the place of operation of both non-specialists and specialists on maritime activities. A small maritime world is a network defined as a 'microregional interaction sphere that forms as aggregates of many neighbouring coastscapes'. It is a

fundamental place for mariners' activities, both specialists and non- specialists, and a space of habitual, dense interaction that promotes cohesion, along with economic interests and social ties.

Chryssi during the Neopalatial period

Chryssi is part of a group of small islands located all around Crete, whose direct interaction with the Cretan 'mainland' resulted in close connection and convergent developments over time (Kopaka and Kossyva 1999: 435, 439). The sea route to the island is considered a windswept one and potentially dangerous for small vessels, despite Chryssi's small distance from the Cretan shore (Mylona 2020: 188). The western side of the island is relatively flat and fertile, while the eastern part is covered with sand and juniper trees (Apostolakou *et al.* 2012: 179).

Signs of habitation begin from the Final Neolithic and continue to the Bronze Age, Hellenistic, Roman and Early Byzantine period (Apostolakou *et al.* 2012: 179; Sofianou 2020: 3). The Neopalatial is regarded the main period of the island's permanent habitation. This Neopalatial 'boom' evidenced on Chryssi, where 16 sites have been identified, is considered part of a general phenomenon of intensification of offshore islands exploitation during the period (Apostolakou *et al.* 2016: 200; Chalikias 2013: 11, 27, 49, 61-68; Chalikias 2015: 42; Chalikias 2023: 29). Chryssi's small size and lack of resources would have made the islet's settlement dependent on the opposite south Cretan coast and more specifically the region of Ierapetra (Apostolakou *et al.* 2012; Brogan *et al.* 2019: 97-98; Chalikias 2013: 2015). The island's maritime activities were located mainly on the north coast, which offered safe harbourage, access to water and marine resources, as well as a good visibility to the surrounding seascape (Chalikias 2013: 11, 57, 61, 65, 67; 2015: 41). Site 1, the largest among them, is a flourishing harbour settlement, specialized in purple dye production that reached its full development during the early phases of the Late Bronze Age (Apostolakou *et al.* 2016: 200; Brogan *et al.* 2019: 97-98; Chalikias 2013: 8, 11, 12, 26, 49, 57; Chalikias 2015: 42; Morgan *et al.* 2009-2010: 171; Mylona 2020: 189; Sofianou 2020: 3). Excavations on the site have uncovered so far parts of five Late Minoan I (16th and 15th century BC) houses, while traces of 10-15 more are visible on the surface (Apostolakou *et al.* 2010: 147; Apostolakou *et al.* 2012; Brogan *et al.* 2019: 97-99; Chalikias 2013: 26; 2015: 41). The evidence from Site 1 - architectural characteristics, imported goods, pottery, tools, glass and stone artifacts, hoards of metal, silver and gold jewellery and sealstones - suggest living standards above the level of mere subsistence and indicate intense socioeconomic interactions with the opposite, southeastern coast of Crete (Apostolakou *et al.* 2010: 147; Apostolakou *et al.* 2016: 204; Brogan *et al.* 2019: 98-99; Chalikias 2013: 4, 8, 49; Chalikias 2015: 41, 43; Morgan *et al.* 2009-2010: 171; Mylona 2020: 189; Sofianou 2020: 4; Spencer and Whitelaw 2022: 49).

The 'mariners' of Chryssi

Fishermen

Chryssi is referred by its excavators as a Late Bronze Age 'specialized fishing village'; a characterization strongly supported by the abundance of marine wealth and the archaeologically recorded intensity of fishing (Brogan *et al.* 2019: 97-98; Mylona 2020: 193). Groups of fishermen on Chryssi seemed to engage in intensive and specialized fishing and harvesting of invertebrates in deeper waters, with a more professional character and possible supervision or control from a central authority on the Cretan coast (Brogan *et al.* 2019: 105; Chalikias 2013: 27; Mylona 2020: 191). Fishing implements, such as fishhooks, floats and fishing net weights as well as fish and shellfish remains, were retrieved from various contexts

within the settlement (Apostolakou *et al.* 2016: 202; Brogan *et al.* 2019: 99-100, 105; Mylona 2020: 189-191). Fishhooks were found in Houses A1, A2 and B2, along with a collection of small bronze fish hooks found wrapped together, possibly representing the hand line with multiple small hooks fishing method (Apostolakou *et al.* 2010: 148; Brogan *et al.* 2019: 100; Chalikias 2013: 28, 46; Sofianou 2020: 4). Fish remains, include a variety of small inshore species, while the few deeper water species identified, among them a small white shark, bear testament to the high skill level of the fishermen (Brogan *et al.* 2019: 100, 105). Edible shellfish species such as limpets, top shells and sea urchins are found in large quantities along with other molluskans in much smaller numbers (Brogan *et al.* 2019: 99-100, 105; Mylona 2020: 189-91).

Many of the site's marine resources, such as sponges, corals and various other mollusks indicate extensive deep-water diving (Apostolakou *et al.* 2014: 328; Brogan *et al.* 2019: 105; Chalikias 2013: 5, 28, 46; Chalikias 2015: 42; Chalikias 2023; Mylona 2020: 191; Powell 1996: 83). The intensive scale of purple shells and tritons' fishing would have taken place in deeper waters and required more complex methods and skills, such as fishing with traps and diving (Apostolakou *et al.* 2014: 327-328; Apostolakou *et al.* 2016: 202; Brogan *et al.* 2019: 104-105; Mylona 2020: 191, 203; Powell 1996: 94). The similar fishing strategies of purple shells and tritons has lead to believe that they were complementary activities on the island (Apostolakou *et al.* 2014: 328, 331; Apostolakou *et al.* 2016: 202; Brogan *et al.* 2019: 104-5). Purple shells were found whole and crushed in thousands near Houses A3 and B1, while indications exist that they were being kept alive in captivity in order to provide ready supply for the industry (Apostolakou *et al.* 2016: 200, 202; Brogan *et al.* 2019: 104; Chalikias 2013: 27). The challenging methods and intensity of fishing on Chryssi, especially of purple shells, is what proves the operation of specialized fishermen (Apostolakou *et al.* 2014: 328; Brogan *et al.* 2019: 99, 105; Chalikias 2013: 5, 28, 46; 2015: 42; Chalikias 2023; Mylona 2020: 191; Powel 1992: 313; Powel 1996: 83, 99-100). Moreover, the large assemblage of bioarchaeological evidence was directly related to the purple dye production activities taking place on the site, a matter that will be discussed later.

The largest part of the fishermen's activities takes place within the local coastscape. These activities, however, were strongly intertwined with the interactions of the small maritime world of the southeast coast of Crete. As mentioned in previous research, the fact that during the Late Bronze Age, the exploitation of the marine wealth around the island reached levels that serve industrial and commercial purposes is one of the main hints to the existence of the control of Chryssi's maritime activities by a superior Cretan authority (Chalikias 2013: 27; Chalikias 2015: 42-43; Mylona 2016: 67-68). The links, the material culture of Site 1 appears to have with the opposite coast, mirror this relationship of dependence, along with the Neopalatial being regarded the main period of the island's permanent habitation (Brogan *et al.* 2019: 105; Chalikias 2013: 27; Chalikias 2015: 42-43; Tartaron 2013: 190). Therefore, the specialized fishermen were an important aspect of the local interaction network. Additionally, in contrast to viewing fishing and fishermen as of low socioeconomic status, the prosperity of the Neopalatial site, discussed in more detail below, supports their possibly good living standards and certain social status within the settlement (Mylona 2020: 204).

Artisans

Chryssi's favourable access to marine wealth allowed the development of specialized processing activities, with most prominent the production of purple dye, a material widely reported as a source of wealth for the elite (Alberti 2013: 33; Apostolakou *et al.* 2014: 327; 2016: 199; Chalikias 2015: 41-43; Haysom 2011: 81-82; Mylona 2020: 191; Reese 2019: 59; Sofianou and Brogan 2012: 332). The complex

process of the purple dye production entailed an in-depth knowledge of the species' qualities and people with specialized and refined skills (Apostolakou *et al.* 2016: 200-3; Betancourt *et al.* 2012: 185; Mylona 2020: 191). The density of crushed purple shells on Chryssi provides clear evidence of purple dye production, on a recurrent, medium scale (Mylona 2020: 191).

A purple dye workshop was identified at House B1, dating to the Late Minoan I period. This building is unique for the quantity of organic marine remains, including primarily huge amounts of crushed purple shells (Apostolakou *et al.* 2010: 148; Apostolakou *et al.* 2012: 180; Apostolakou *et al.* 2014: 326; Apostolakou *et al.* 2016: 200; Brogan *et al.* 2019: 104). Out of the 11 rooms of the house, rooms one to four (1-4) constituted the industrial space, encompassing activities such as preparation and main production (Apostolakou *et al.* 2010: 148; 2012: 180-181; 2014: 326; Apostolakou *et al.* 2016: 203; Brogan *et al.* 2019: 101-103; Chalikias 2013: 28; Morgan *et al.* 2009-2010: 171). Room 3 is the heart of the workshop and the largest space, possessing two hearths associated with cooking pots, triton shells, stone tools, pounding stones and pottery. The room's floor was covered by burnt soil, broken shells, almonds and olives, materials most likely imported from the southern part of the Ierapetra Isthmus and interpreted as fuel. Sorting and preparation of the shells took place probably in the adjacent room 2. The building's western half (rooms 5 to 11) seems to have a domestic character with spaces for food preparation, storage and weaving; the contrast in function can be traced by the smaller amount of whole purple shellfish and caches of tritons, used for nutritional purposes (Apostolakou *et al.* 2012: 180-181; Apostolakou *et al.* 2014: 326; Apostolakou *et al.* 2016: 204; Brogan *et al.* 2019: 103; Mylona 2020: 191). Houses A3 and B2 have also been connected with purple dye preparation, even though the evidence is not as conclusive as for House B1 (Apostolakou *et al.* 2010: 148; Chalikias 2013: 13, 27; Morgan *et al.* 2009-2010: 171).

Tritons are also linked with modification endeavours in specialized workshops that require supply organization and work specialization (Apostolakou *et al.* 2014: 327; Brogan *et al.* 2019: 99, 104; Sofianou and Brogan 2012). House B1 produced 23 complete tritons in total along with several fragmented specimens; the ones found in room 5 were associated with tools and potentially pointed to unfinished modification activities of artisanal character (Apostolakou *et al.* 2014: 326. 329-30; Brogan *et al.* 2019: 104; Mylona 2020: 191-3, 198- 200; 2016: 69).

The operations of Chryssi's craftsmen were taking place fully within the coastscape. Their specialized knowledge and skills and their contribution to the settlement's economy must have set them apart in some way (Mylona 2020: 204). This distinction could have been dictated, additionally, by the challenges of purple dye production or even connected with the less appealing traits of this activity, such as its foul odour (Mylona 2020: 193). The relative topographic isolation of House B1, one of the smallest in size (*c.* 120 m²), placed right next to the sea, could be connected to that (Apostolakou *et al.* 2010: 148; Chalikias 2013: 26). When it comes to the socio-economic status of the artisans, no signs of remarkable wealth have been observed; the workshop of House B1 contained an average Late Minoan IB household assemblage (Apostolakou *et al.* 2012: 180-181; Apostolakou *et al.* 2016: 204; Brogan *et al.* 2019: 103). The artisans' activities on Chryssi, however, had important implications on the scale of the small maritime world of the area. The links between purple dye production and more permanent habitation on the island begin from the Middle Bronze Age and it has been consecutively stated that the main reason behind the establishment of the Late Bronze Age settlement was the production of purple dye (Chalikias 2009-2010; Chalikias 2013; Chalikias 2015; Sofianou 2020: 3). During the Late Bronze Age, therefore, the ferrying of Chryssi's products to the Cretan coast must have intensified significantly, along with the needs of the settlement for subsistence goods.

Sailors and marine traders

Chryssi seemed to be one of the main trading centres for aquaculture goods within the small maritime world of the region of the Southeast Crete (Apostolakou *et al*. 2016: 202; Brogan *et al*. 2019: 103; Chalikias 2013: 28). Chryssi's position at the route along the south coast of Crete, possibly facilitating boat traffic to and from major harbours, like Diaskari, Myrtos, Kommos and possibly Ierapetra, and offering protected anchorages, would have consolidated the island's participation in multiple interaction scales (Chalikias 2013: 28, 49; Chalikias 2015: 42-43). This key position was certainly one of the stimulants of the, initially seasonal and later permanent, settling on Site 1 (Chalikias 2013: 28; Chalikias 2015: 42-43; Knappett 2022: 56). Sailors and marine traders were the ones commuting back and forth from Chryssi to the Cretan mainland, ferrying goods, people and ideas and enhancing the livelihood capacity as well as the social connectivity of the island (Tartaron 2013: 192-193). An efficient and organized Neopalatial network of communication routes and harbours along the southern Ierapetra Isthmus was liable for the dispersion of Chryssi's goods (Chalikias 2009-2010: 41; Chalikias 2013: 13-14, 27-28, 30, 49; Chalikias 2015: 42-43). The prevailing Neopalatial pottery on the island, entirely imported from East Crete, constitutes the main evidence for the operation of this network and confirms Chryssi's strong links with the opposite coast (Chalikias 2009-2010: 41; Chalikias 2013: 4, 13-14, 27-28, 30, 49; Chalikias 2015: 42-43).

Site 1 is the main harbour of Chryssi, a settlement on a promontory, with a small cove immediately to the west, offering safe anchorage to small vessels (Chalikias 2013: 8, 11-12, 26, 57). The settlement's location on the northwestern coast of Chryssi, directly facing the Ierapetra area, demonstrates orientation to the local interaction network (Tartaron 2013: 189). Some other, yet unexcavated, Late Minoan sites of the island seem to have similar orientation (Chalikias 2013: 11, 61, 65, 67; Chalikias 2015: 41). The vessels that were able to be facilitated by the site's harbor, according to Chalikias' research sited above, reflected the routine travelling that characterizes small maritime worlds; fishing boats, rowboats, coasting vessels and small cargo vessels (Tartaron 2013: 192, 195). The absence of a major harbor on Chryssi offers support of its role as an extension of another larger and higher-ranking site on the Cretan coast, in charge of facilitating bigger vessels and longer range contacts (Tartaron 2013: 195). Therefore, Chryssi was a basic but not central node in the region's small maritime world, reliant to the economic and political circumstances of the Ierapetra area.

From a coastscape perspective, sailors and sea traders could be considered as the least spatially tied to Chryssi, given the almost constant communication with the opposite coast. However, the majority of the sailors and the sea traders of Chryssi rendered one of the site's main economic groups and not a distinguishable social unit coming from a faraway place (Hulin and German 2018: 359). Additionally, due to the quite homogenized (material) culture of the area, the seamen and sea traders reaching Chryssi from sites of the Cretan coast, given they operate within the scales under discussion, would have been hard to distinguish in the archaeological record and would have coexisted rather smoothly with the locals. The social ties that keep together a small maritime world must have created a sense of kinship (Tartaron 2013: 191-192).

Moreover, Chryssi does not seem to have been participating in long range travelling. Based on the examination of the architecture, town planning and finds of Site 1, in addition to the absence of a large port, it becomes clear that the right conditions for the development of certain areas inhabited especially by sailors and sea traders conducting long range travelling do not exist (Hulin and German 2016: 11; Hulin and German 2018: 359, 361). In Site 1, therefore, sailors' quarters for the moment do not seem observable (Hulin and German 2018: 359).

The site has also provided indications for the activities and the higher economic and social status of the inhabitants. House B2, a large building with over 20 rooms, produced palatial style pottery and impressive architecture, as well as two hoards of metals, including copper and tin ingots, jewellery, an ape shaped amulet and an agate seal depicting a ship (Sofianou 2020: 3-4; Christakis 2019-2020: 89). House A2, another wealthy residence of large dimensions (*c.* 300m^2), offers indications for an upper story as well as rich finds, including palatial style pottery, stone vases, silver and bronze implements and faience beads (Apostolakou *et al.* 2010: 148; Chalikias 2013: 26, 28). The finds, architecture and scale of Houses B2 and A2 suggest that their owners could be local administrators, wealthy merchants of moderate status engaging in marine trade, who possessed close ties with, or were dispatched from a site of the opposite coast and facilitated Chryssi's economic activities (Apostolakou *et al.* 2010: 148; Christakis 2019-2020: 89; Chalikias 2013: 26, 30; Morgan *et al.* 2009-2010: 171; Mylona 2020: 189; Sofianou 2020: 4).

Chryssi and the opposite coast

What was the situation on the Cretan shore, then? The intensive interaction with Chryssi during the Neopalatial period is regarded as the result of a reorganization of the settlement patterns along the south Ierapetra Isthmus and the emergence of Late Minoan sites that actively engage in maritime activities, operating as harbours and nodes in the local interaction network (Apostolakou *et al.* 2021; Chalikias 2009-2010: 39-41; Chalikias 2013: 20, 26, 29-31; Christakis 2019-2020; Knappett 2022: 59; Spencer and Whitelaw 2022: 47-49, 51). Chryssi's Neopalatial prosperity has been interpreted as the 'colonization' efforts of a nearby Cretan site, converting the island into its 'expansion' or offshore segment, aiming to exploit its marine wealth (Chalikias 2009-2010: 36; Chalikias 2013: 49; Chalikias 2015: 37-38, 43). The settlement's contexts indeed demonstrate very strong ties with the Cretan coast, as suggested by the imported Cretan pottery and organic materials, that do not exist on the islet itself, as well as the domestic assemblages typical of the Neopalatial material culture on Cretan sites (Apostolakou *et al.* 2016: 204; Brogan *et al.* 2019: 98, 103; Chalikias 2013: 4, 13-14, 27; Morgan *et al.* 2009-2010: 171; Ntinou 2021: 18-20; Sofianou 2020). This makes the Neopalatial settlement on Chryssi a somewhat strategically 'artificial' site, with prominent economic character and groups whose main aim would have been to exploit the island's marine wealth. Until this day however, there has not been a specific site on the southeastern coast of Crete that can be explicitly connected to Chryssi as a superior authority (Chalikias 2009-2010; Chalikias 2013; Chalikias 2015; Chalikias and Cantoro 2015; Knappett 2022; Spencer and Whitelaw 2022). Nevertheless, research on the area around the south Ierapetra Isthmus has provided some indications for the existence of a main Late Minoan centre in Ierapetra, a dominant settlement that controlled the area's economic activities and facilitated communication and trade (Apostolakou *et al.* 2021: 4-6; Brogan 2021: 121; Chalikias 2013; 2015: 43; Christakis 2019–2020; Knappett 2022: 59; Spencer and Whitelaw 2022: 49). Chryssi itself being the largest and most specialized site in the wider area is one of the main indications for the existence of such a site on the opposite coast (Chalikias 2009-2010: 36, 41; Chalikias 2013: 30; Chalikias 2015: 43; Spencer and Whitelaw 2022: 49; Knappett 2022: 59).

Finally, imported auxiliary resources present on Chryssi, such as wood and organic materials, whether interpreted as fuel for the workshops or material for shipbuilding/ repair, aimed to the uninterrupted operation of the mariner's activities (Ntinou 2021: 18-20). Furthermore, the abundance of pine wood provides clear evidence of the ties with other Neopalatial sites of the Ierapetra region and more specifically the mountainous ones (Ntinou 2021: 18-20; Chalikias 2009-2010: 41). One such site is Gaidourofas, where the presence of an important Late Minoan IB building with possible administrative

function suggests it controlled the exploitation of mountainous resources, the production of goods and their mobility towards the lowlands (Papadatos and Chalikias 2019; Knappett 2022: 59; Kalantzopoulou 2022: 30, 35). Gaidourofas could be seen as the mountainous parallel to Chryssi. Both are specialized sites on the margins of the same interaction network that has its centre at a yet undiscovered Neopalatial major settlement in Ierapetra. Their foundation seems implemented by this higher authority existing in the area and their purpose was to manage the exploitation of natural resources and channel the products they collect to that centre on the coast (Papadatos and Chalikias 2019: 86, 93).

Chryssi's social organization

The current absence of a final publication on Chryssi fuddles any efforts to approach the social organization of the islet's communities. The prominent economic element of the site raises questions on the form of the social units that cooperated to meet the requirements of the local market. What we know is that almost every house excavated at Site 1 is linked to maritime activities and that purple dye production took place within the limits of a household (House B1), with its dwellers living and working in it. The size of the excavated houses (*c.* 100 m²–300 m²) and the fact that at least one of them, House A2, had an upper story could hint that the basic social unit operating on the island was an extended family or a cohabitation of cooperative nature of families and individuals oriented towards these specific maritime activities (Chalikias 2013: 26).

Permanent habitation on Chryssi is not rooted way back in time but refined characteristics and luxurious items are present in many dwellings of Site 1, even though a specific elite area or elite architecture does not seem to be present in the settlement. Contexts, like those from House B2 and A2, provide evidence of administration of some level, or at least of higher economic ranking within the settlement, but still of a modest scale compared to the wealth of other Neopalatial sites (Chalikias 2013: 30).

Could a variation of the 'House' be present at Late Bronze Age Chryssi? The 'House' is a form of social organization, a 'malleable, dynamic and flexible concept that allows addressing a variety of residential and community relations' (Driessen and Relaki 2020: 2). The 'House' is described as a multi- and intergenerational, locus bounded social formation, that consisted of kinship and economic relations and possessed its own 'biography' and spiritual dimension, including heirlooms, while encompassing social, economic and value-oriented functions (Driessen 2010: 40, 43-57).

To address the possibility that a social formation such as the 'House' was present on Chryssi, it is important to take multiple factors into account: the specialized economic character and orientation of the islet's settlement as well as the reckoned changes of the 'House's' nature during the Neopalatial period (Letesson and Driessen 2020: 16-17). One of these changes is considered to be the disintegration of locus-boundness. In Chryssi, the permanent Neopalatial habitation and the wealth of the settlement could have had its roots on the prosperity of the site that initiated the island's colonization. The contexts of Houses A2 or B2 could represent the transfer of such social units from the southern coast of Crete to Chryssi, to continue their socioeconomic reproduction while exploiting the opportunities of the natural wealth of the island and incorporating the different socioeconomic groups working on the island: the fishermen, the artisans, the sailors and the sea traders. Additionally, if indeed such a social organization was present at Chryssi, it is possible that the concept would be lacking many of its initial characteristics related to its historical and spiritual dimension and had a more intense economic orientation (Driessen 2010: 40, 42).

The original 'House' definition is production oriented; nevertheless, the existence of a successful trade orientation of this organization must not be excluded (Knappett 2023: 121). Carl Knappett (2023) in one of his recent publications attempts to introduce the concept of a '"House" society successfully oriented towards commodity exchange at the regional level' and proposes the possibility of 'Houses' specialized in trade in a more entrepreneurial manner, while addressing the potential tension between the 'House' society and an interventionist territorial state, such as Knossos during the Neopalatial period (Knappett 2023: 121). Thus, the inhabitants of Houses A2 or B2 could be wealthy merchants, ranking higher within the postulated cooperative organization existing on Chryssi. That being said, hierarchy is another 'House' characteristic to be addressed (Driessen 2010: 40). The existence of contexts such as the ones from House B1, the workshop/ residence of a group of artisans, which do not present the luxury level found in other houses on the site, could be evidence of the multiplicity of households, ranking variously within the hierarchy of the social unit. Therefore, it could cautiously be suggested that part of Site 1, or even its entirety, could form a variation of a 'House', operating within the Neopalatial society and its complex sociopolitical state (Knappett 2023: 121). Chryssi's importance in commodity exchange at a regional level is a testimony to the successful operation of this 'House' of 'mariners' within the smaller scales of interaction discussed here (Knappett 2023: 121).

Discussion and conclusions

Specific cases, like Chryssi's, are invaluable in untangling the socioeconomic status of mariners. A more fitting description for Chryssi's Site 1 seems to be 'mariners' village', given the variety of sea related activities evidenced on the island, instead of exclusively 'fishing village'. The permanent habitation of Chryssi during the Late Bronze Age allowed the formation of groups of specialists, engaged in an organized and intensive exploitation of the marine wealth for industrial and commercial purposes. The significance of Chryssi's marine wealth triggered an intense and challenging operation and constant support from an administrative centre on the Cretan coast (Mylona 2020: 193), with socioeconomic implications for the professionals carrying out the maritime activities. Some final observations can be made on the importance and roles of Chryssi's mariners, within the local and broader Neopalatial contexts.

Fishermen's activities on Chryssi seemed to have the character of an organized and intensive operation aiming to exploit the marine wealth, both for industrial and for commercial purposes and not solely the character of casual fishing to simply supplement the nutrition of the community in a predominantly agro-pastoral economy, as the Minoan is thought to be (Haysom 2011: 79). The general importance of fishing as an economic activity is impossible to be precisely determined at the scale of the entire Minoan society with the present data. However, Chryssi's example provides some important clues on the potential social and economic status of professional fishermen. The complex skills they had to possess in order to procure the quantities demanded would have set them apart from the rest of the island's population, as an economic group fundamental for the growth of the settlement yet interconnected to the rest of the site's activities. Additionally, it is possible that they acquired the potential to advance economically and socially. Their importance for the previously discussed centre on the Cretan coast could provide them an easier access to wealth but also entail dependence from this central authority that possibly directed their activities to meet its supply needs. It is important to state, however, that the dependence of fishing activities from a palatial or central authority cannot be supported for the entirety of the Late Minoan Crete, as contexts and power balances vary around the island. Nevertheless, the situation on this small island helps colour the picture of the power balances and the level of interference a central authority could have on maritime activities.

Purple dye production, on the other hand, is an activity intertwined with the fishing taking place on the island and has much clearer connections to society's higher ranks. As mentioned before, the exploitation of purple dye must have been the number one reason for the 'colonization' of Chryssi during the Neopalatial period. Therefore, a main Cretan centre would have required command over the island's purple dye production (Chalikias 2013: 27). The artisans of Chryssi, however, were not evidently wealthy.

Large amounts of purple shells were present on the site long before the Late Bronze Age production activities and it is possible that Chryssi was part of an organized network involved in production and distribution of purple dye since the Middle Bronze Age (Apostolakou *et al.* 2016: 203-204; Brogan *et al.* 2019: 101-102; Chalikias 2013: 27; Chalikias 2015: 41-42;). A possible connection with the elite who operated the dying workshop at Middle Minoan IIB Pefka- Pacheia Ammos, on the northern part of the Ierapetra Isthmus, could indicate the interest of the Cretan 'mainland' in exploiting and channeling maritime products from Chryssi to Crete, long before the intensification and systematization of the endeavours during the Neopalatial period (Apostolakou *et al.* 2010; Apostolakou *et al.* 2016; Betancourt *et al.* 2012; Chalikias 2013: 26-27; Chalikias 2015; Mylona 2020). The above also indicates the gradual development of groups with deep knowledge on the processing techniques and specialized skills related to the purple dye production, passed down to next generations.

Sailing in a small maritime world does not require specialization and Chryssi, being the 'extension' of an already developed Cretan settlement, constitutes an idiosyncratic case. It is hard to distinguish a specific and/or specialized group of sailors residing and operating on Chryssi and that is because it was not founded to act as a big port. Even fishermen or purple dye producers could have participated in the ferrying of their products to Crete, indicating the potential multiplicity of their socioeconomic identities. However, the sea trade between Chryssi and the Cretan coast was certainly conducted on a frequent scale and seemed to be supervised by a main centre on Crete. Thus, the intensive communication necessary for the island's supplementation and the channelization of the goods towards Crete must have been conducted in a more structured way. The existence of open communication routes and harbour sites operating on the southeast coast of Crete during this period supports that. The wealthy inhabitants of Houses A2 and B2 could have been the people administering these transport operations on-site.

In conclusion, this article has been an effort to locate and define the groups engaging in maritime activities on the island of Chryssi and place them within the context of the small maritime world of Southeast Crete. The 'mariners' of Chryssi, during the Neopalatial period, coexisted and cooperated on the island, possibly functioning under the auspices of a social unit comprised mainly of these socioeconomic groups, with inner hierarchy and differentiation, the ultimate aim of which was the exploitation of the marine wealth and opportunities of the surrounding coastscape**.** The Neopalatial contexts confirm the 'rural' character but also the importance of the aquaculture of Site 1, a specialized settlement on the margins of an interaction network centered at a yet undiscovered Neopalatial site in Ierapetra. It is expected that further excavations at Chryssi will provide additional evidence of the mariners and give the opportunity to compare their activity with that of other coastal sites, in order to better assess their respective and varied roles and their importance and status during the Late Bronze Age.

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A retrospection on cistern-boats and a potential reappraisal of their journeys

Thomas Iossifidis[1]

Abstract

The cistern-boats were merchant ships constructed in such a way, that the central part of their hull was occupied by oversized pithoi-like vessels, the *dolia*. The *dolia* were ceramic containers of immense capacity, made for storing and transporting edible and potable products in the Roman domain. The cistern-boats' confirmed usage was the maritime transportation of the vin ordinaire, a wine of moderate quality and low price, on the western part of the Roman Empire from the 1st century BC until the middle of the 3rd century AD.

Keywords: cistern boats, shipbuilding, maritime routes, dolia

Introduction

Since the prehistoric era, the residents of the Mediterranean region developed methods for the preservation, storage, and transportation of goods in liquid form. The maritime transport of bulky ceramic vessels as means of storage and transportation, primarily of liquid products in the Mediterranean waters, is evidenced by shipwrecks since the Bronze Age. The Romans, through the innovation of building cistern-boats, unified the *dolia* ceramic vessels with the boat vessel itself into an inseparable structure. This shipbuilding contrivance resulted in a dramatic increase in the liquid cargo volume and the rise of a new perception of the maritime wine trade. The cistern-boat shipwrecks reveal valuable information about their sophisticated shipbuilding method, the ancient maritime trade routes, and the economic and cultural interactions of the Mediterranean region.

The cistern-boats: the first tanker in the history of maritime trade

The cistern-boats (Figure 1), were merchant ships built so that the central part of their hull was occupied by oversized *dolia* which functioned as permanent tanks (Rice 2016: 176). They are also known as bâteaux-cîternes (fr.) (Carre 2020: 201), Roman tankers, tanker ships (Anastasi 2015: 30; Knapp & Demesticha 2017: 92), wine *dolia* freighters (Olesson 2008: 152), *dolia*-ships and bulk carriers (Paterson 1988: 243). Their naval architecture constituted a shipbuilding innovation. and an alternative option for the maritime transportation of wine instead of using only amphorae. Their main and established use was summed up in the transport of vin ordinaire, an economical wine of moderate quality (Rickman 2008: 9). The maritime transport of wine by the cistern-boats suggests the development of a sophisticated commercial and economic perception based on the concept of logistics and taking into consideration the issues of storage and transportation. Their appearance in the Western Mediterranean

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Sea began around the 1st century BC and their short-lived activity is believed to have ended in the middle of the 3rd century AD.



Figure 1. Hypothetical maquette of a cistern-boat (Musée gallo-romain de Lyon, 2004). Source: AlMare-Own work, CC BY-SA 3.0 (2007), <https://commons.wikimedia.org/w/index.php?curid=8841211> (Retrieved 03/03/2024).

The appearance of the cistern-boats was consequential to the historical events that determined the evolution of the Roman economy since the 1st century BC. By the late Republican period wine drinking had become a fixed habit in the life of the citizens of Rome, regardless of social stratification (Purpura 2022: 125). During the civil wars, that marked the transition from the Republican to the Imperial period (27 BC), the quality of winemaking practices in the Italian area was degraded which led to the increase

of low-quality wine production for mass consumption. The eruption of Vesuvius (79 AD) brought about the destruction of many vineyards in Campania and, by extension, a shortage of wine in the markets for the following years, affecting also the shipping of wine by sea (Rodd 2022: 444). From the 1st century AD viticulture and winemaking flourished in Gaul and Spain. These regions were to quickly surpass Italy in wine production and emerge as the largest wine producing regions of the Mediterranean (Rodd 2022: 443).

The *dolia* ships proved themselves as the ideal boat vessels for an economical bulk transport of wine by sea (Strauss 2006: 104; Bevan 2014: 395). The demand for increased wine cargo capacity (tonnage) was partially satisfied by the emergence of the Roman tankers, which yielded greater profits in the given time of shipping activity (Strauss 2006: 105). The annual duration of maritime activity during the Roman period was between April and October (Cartwright 2018). The appearance of cistern boats also responded to the augmented wine production volume and transport within the empire as a result of the Roman expansion (Marlier and Sibella 2002: 161). Nevertheless, amphorae remained the main container for transporting wine throughout the Roman era (Gazda 2003: 286). Cistern-boats carried cargoes of between 45 and 50 tons and participated in a well-organized trading system, which is confirmed to have connected the northern shores of the Western Mediterranean (Rice 2016: 179).

A question that remains unanswered is the ownership status of the cistern boats. They were possibly constructed and then sold to individual ship owners and merchants. However, the most likely answer, is that they belonged to the Piranus family (*gens Pirani*). The *dolia* vessels frequently bear relief stamps on their shoulder inscribed with the name of the specialized ceramist who made them. The sealed *dolia* found in cistern boat wrecks are inscribed only with the names of the Piranus family, the local *dolia* potters of Minturnae. Two questions occurred whether the Piranus family was exclusively involved in the production of *dolia* intended for this use, or whether they were also involved in the construction of tankers. The stamps recorded five names of freedmen of the Piranus family, thought to correspond to at least three generations of Pirani (Corsi-Sciallano and Liou 1985: 173-74) between the end of the 1st century BC until the middle of the 1st century AD (Caroll 2022: 237).

The *dolia* found in cistern-boats are classified into two morphological types, the ovoid (Figure 2.1) and the cylindrical ones (Figure 2.2). Regarding their height, two types of *dolia* could be also distinguished. The first *dolia* type constituted of small *dolia*, called *doliola (sing. doliolum),* with a height restriction of one meter.[2] The second type comprised vessels taller than one meter, which did not exceed 1,65m in height (Strauss 2006: 104).

The ceramic tanks' load is evaluated to be limited to liquid products. This consideration is grounded in the observation that the volumetric measurement indications on the *dolia* vessels are expressed in cullei and that *dolia* retrieved from cinstern-boat wrecks contained wine sourced from the wine-producing regions of Campania (Italy) and Hispania Tarraconensis (Spain) (Strauss 2006: 104). The fact that the only way to empty the *dolia* interior was by pumping, precluded the transfer of semi-liquid products, like the garum sauce, which could clog the pump.

The maximum number of *dolia* used as permanent tanks in a cistern-boat is believed to have been 24 (eg Ladispoli A wreck) (Strauss 2006: 105). The interpretation of the wrecks' remnants indicates that the cistern-boats could carry up to 21,000 litres of liquid cargo. Accordingly, merchant ships of the same

[2] *Doliolum*: Small-sized *dolium* (πιθάριον, πιθίσκος. Koumanoudis 1884: 238) of limited capacity that were placed on the sides of the ship filling the gaps and adding extra storage space (Marlier and Sibella 2002: 162; see wrecks (Ouest) Giraglia 2 and Cala di li Francesi).

size carrying wine in amphorae did not exceed a cargo capacity of 12,400 litres (Strauss 2006: 104). Apart from the *dolia*, the cargo of the cistern boats was certainly supplemented by amphorae of the Dressel type 2-4 (originating from Italy and Spain, Figure 2.3) (Strauss 2006: 137) and possibly of the Pascual I, Lamboglia II types (Ferreras et al. 2015: 287; Dell'amico & Pallarés 2005).

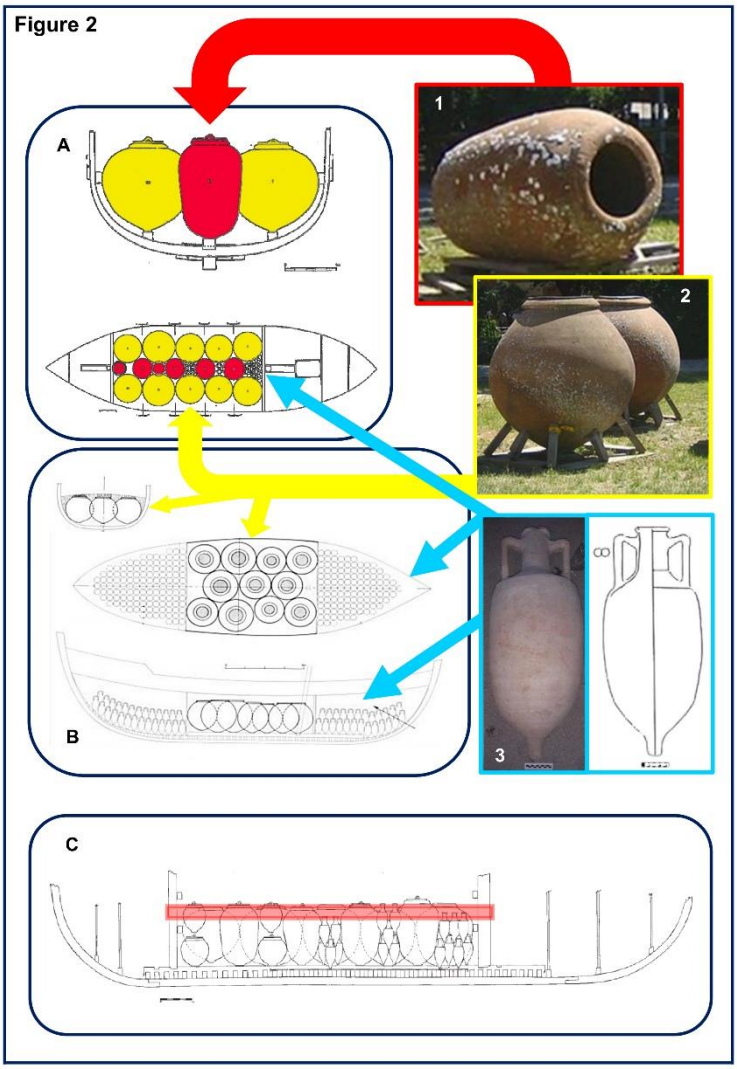


Figure 2. Depiction of the ceramic cargo of a cistern boat. (1) Cylindrical dolium (Ostia Antica), (2) ovoid- spherical dolium (Ostia Antica) and (3) Dressel 2-4 amphorae and their hypothetical position in the (A, C) Diano Marina and the (B) Grand Ribaud D cistern boat wrecks. (C) Hypothetical depiction of the wooden hull structure (bulkhead) that stabilized the dolia in the centre of the Diano Marina hull.[3]

[3] Sources: figures 2.1, 2.2: AlMare - Own work, CC BY-SA 3.0 (2007), https://upload.wikimedia.org/wikipedia/commons/4/44/Ostia_Antica_Dolia.jpg (Retrieved 05/0/2024), figure 2.3: N. in. 33591, https://books.openedition.org/efr/docannexe/image/48732/img-17-small517.jpg (Retrieved 05/0/2024), figures 2.A: Dell'amico & Pallarés 2005, fig.6 (p. 77), fig. 7 (p. 80), figure 2.B: Hesnard et al. 1988, p. XLIX., figure 1C: Dell'Amico & Pallarés 2005, Figure 5, p. 73.

The *dolia* ships were likely constructed in a shipyard at the port of Minturnae (Rice 2016: 177), at the mouth of the Garigliano River (Guérout 2002: 435). Information on the basic shipbuilding principles used in the construction of this type of ship derived from wrecked cistern-boats (Grand Ribaud D, Ladispoli A, Diano Marina, La Giraglia 1, La Giraglia 2) with salvaged hull remains. Their length is estimated at 20 meters and their width at ≤ five meters. The construction of cistern-boats was consistent with the shipbuilding art of the Roman period. The shipbuilding of the *dolia* ships followed the shell-first process and the mortise-and-tenons joints technique, which were the dominant shipbuilding methods of the Roman era.

The cistern-boats had a distinctive flat bottom (Figure 2.C), which resulted in the augmentation of their capacity. The main feature that differentiates the tanker ship from the other merchant ships of antiquity was the structure in which the *dolia* were stabilized in the central sector of the hull. Although, the stabilization technique of the ceramic containers is still under investigation, it is believed that the *dolia* ships possessed a reinforced transverse hull structure to support a load of up to 24 *dolia*. This structure resembled a wooden bulkhead. Another shipbuilding particularity of the cistern boats was the methodical strengthening of the hull to cope with the correspondingly increased weight of the cargo. The frame's ribs had a dense alignment, which became denser in the centre of the hull under the aforementioned structure (Marlier 2020).

In 1989, during the excavation of the Le Grand Ribaud D wreck, the discovery of two strakes, that may have belonged to the frame that held the *dolia* in their preselected position, provided a potential solution to the *dolia* stabilization technique issue. The two wooden beams had rectangular cross-sections and one was placed transversely and the other one was located along the hull. It has been hypothesised that the frame was at the height of the *dolia* shoulders or a little lower (Figure 2.C). The hypothesis is still disputed, as neither the function nor the original location of the beams in the hull has been verified. Part of the corresponding construction has been preserved in bad condition in the Diano Marina wreck. It is widely acknowledged that the *dolia* were deployed in three parallel lines in the centre of the hull along the length of the boat, parallel to the keel (Figures 2.A, 2.B). The cargo was supplemented by amphorae (Figure 2.3, 2.A, 2.B), which were placed in the free spaces between the *dolia* bulkhead and the two extremes of the boat (stern and bow). The result was that the *dolia* became a cohesive part of the ship's hull, and after construction was completed, they could not be moved or removed (Parker 1992: 203; Hesnard et al. 1988).

Considering the *dolia* tanks as an inextricable segment with a distinctive and given functional value in the purpose of cistern boats and a major shipbuilding component, the next chapter will comprise a brief presentation of the *dolia* ceramic vessels.

The *dolia* ceramic vessels

Dolia (sing. *Dolium,* Figure 3.A) are considered the largest clay storage vessels for edible and potable products in antiquity (Figure 1/1) (Carrato 2013: 1172; Carrato et al. 2019: 69). The capacity of a *dolium*, based on the vessels found so far, ranged between 1,436 and 3,000 litres (Broekaert 2013: 379), with a maximum height of between one and 1.90 meters (Knapp and Demesticha 2017: 92). Palladius mentions the existence of *dolia* with a liquid capacity of 200 *congii* (Palladius: Rust. 10.11), equivalent to 1,496 litres (Strauss 2006: 104) or 184 American gallons. Meanwhile, *Columella* recorded the existence of *sesquicullaria dolia* that could hold liquid loads equivalent to 1½ *cullei*, corresponding to the capacity of 30 amphorae (Columella: Rust. 12.18, extr.). *Dolia* appeared in two characteristic shapes: cylindrical and ovoid-spherical (Figures 2.1, 2.2). They had a rudimentary or nearly nonexistent neck and a wide mouth

with bulky and flattened lips on the upper side. Their openings were typically sealed with two consecutive lids (*opercula doliorum*), namely the *operculum*, placed on the lips, and the *tectarium*, a dome-shaped or conical ceramic cover placed over the operculum, providing additional protection for the contents from sun and rain. *Dolia* did not have handles, and they lacked any form of decoration.[4] Occasionally, they were sealed on the shoulder with the name of their ceramic manufacturer.

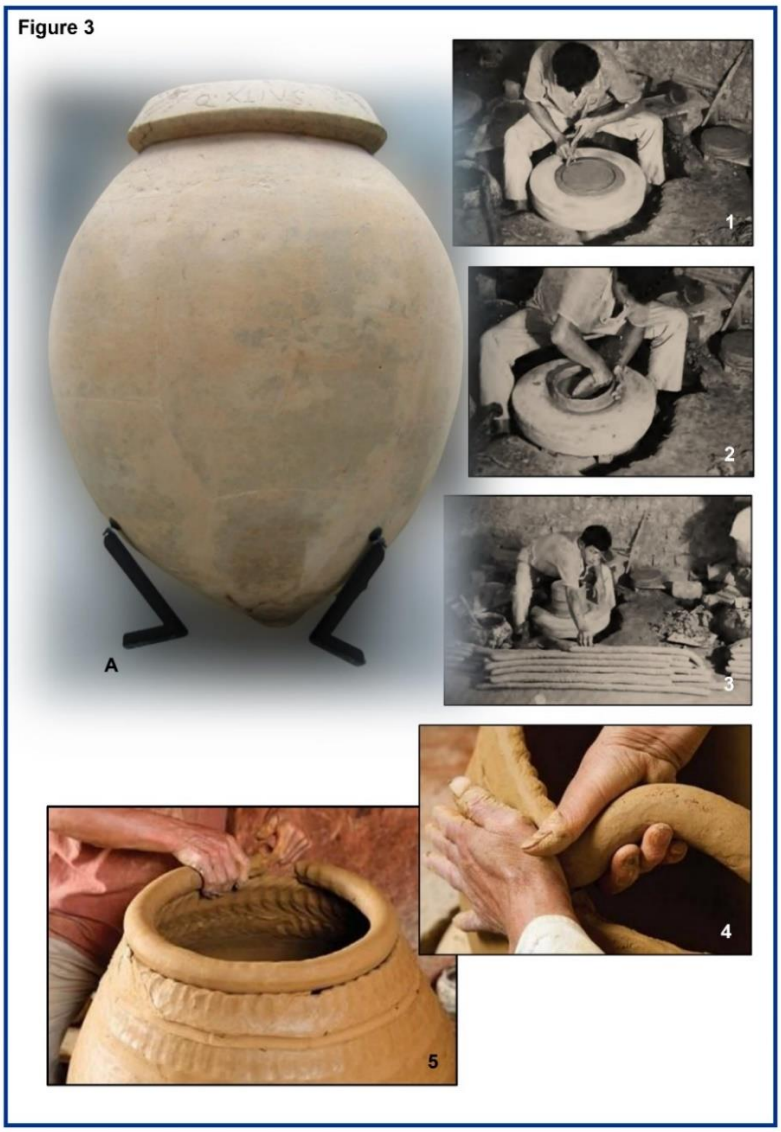


Figure 3. (A) Dolium, Museo Archelogico della Sibaritide, Sibari, Calabria, Italy. (1-5) The photographic documentation of the phases of the onggi manufacturing process has greatly enhanced our understanding of the stages associated with dolia construction. The base of the dolium is considered το have been handmade and its sides were built up by continuous depositions of layers upon layers of clay strips (coil building technique).[5]

[4] The only exceptions are a few unique perforated *dolia* recovered in the littoral of Kaštel Sućurac, Croatia (Radić Rossi & Ruff 2015: 12).

[5] Sources: figure 3.A: AlMare-Own work, CC BY-SA 3.0 (2002), https://commons.wikimedia.org/wiki/File:Museo_Archeologico_della_Sibaritide_Dolium.jpg (Retrieved 06/09/2024), figures

The *dolia* are considered descendants of the Georgian *Kvevri*/ *Qvevri* (ქვევრი) and the Armenian *Karas* (կարաս) vessels, the traditional Caucasian earthenware. The oldest *Kvevri* and *Karas* that have been found, are dated between the 6th and 5th millennium BC. The Caucasian containers had corresponding dimensions and use to the *dolia* and were manufactured correspondingly. This knowledge exchange is considered to have occurred through trade contacts between Phoenicians and European populations, mainly Etruscans. The assumption is supported by the fact that clay vessels were used for the fermentation of alcoholic beverages along the Canaanite and Phoenician coasts during the Bronze Age. It has been hypothesized that the westward transfer of the Caucasian grapes, wine-making and ceramic production techniques took place in a period that may have exceeded a thousand years before the Roman conquest of the wider Caucasus region (Romans occupied modern Georgian territory in 66 BC (Curtis 1994: xv) and Armenia in 118 AD (Mommsen 1886: 60, f- 71 f.)). The final form of the Roman *dolia* is believed to appeared in Gaul in the 4th century BC and derived from the combination of earlier types of vessels originating from the Hellenic region and Etruria (Carrato et al. 2019: 70).

The volume of *dolia* necessitated their permanent installation, either buried in the ground (*dolia defossa*) or placed on the floor in indoor or protected outdoor areas. For the same reason, their use as portable wine containers is considered unlikely (Smith 1882: 1202). The *dolium*, as a by-product of Roman culture and society, was widely distributed throughout the empire. It is typically found in households, farms, public spaces, food markets (*macellum*) (Waelkens 2007: 322-323), and port locations,[6] as well as in shipwrecks. In the 1st century BC, the advantage of the oversized storage space that the *dolia* provided and the contemporary boosting of olive oil production and viticulture evoked the spread of *dolia* in southern and central Europe. In the subsequent imperial times, their dissemination and use reached their higher peak.

Dolia were multi-purpose ceramic vessels, with uses ranging from winemaking, storage, food preparation and sea transport of wine to uses related to Roman daily habits and craft production. These ceramic containers provided an ideal airtight environment without significant temperature alterations for the gradual fermentation (e.g. production of the famous Roman sauces *garum* and *liquamen*) (Curtis 2017: 1, 2) and maintenance of edible and potable products (wine, hot water, etc. in thermopolia restaurants). Their main use was to store olive oil (*dolia olearia* (Menchelli 2012: 29) or *dolia olectria* (Smith 1870: 266)) (Cato 10: 4) and wine (*dolia vinaria* (Menchelli 2012: 29)) (Carrato et al. 2019: 69). They were also used to store grain (*dolia frumentaria)*, by-products of olive oil production (*dolia amurcaria*) (Menchelli 2012: 29), grapes (*dolia occinaria*) (Giovangiulio 2012: 254), fruits (pears, apples, figs, etc.), cereals and vegetables preserved in vinegar and salt (pickles) (Menchelli 2012: 29; Foxhall 2015: 2). The olive oil was stored in storehouses (*cella olearia*) and the wine in warehouses (*cella vinaria*) within *dolia*, in order to avoid being exposed to temperature fluctuations (Cato 13; Smith 1882: 1202). The domestic storage areas of *dolia* were called the *doliaria* (sing. *doliarium*) (Manca et al. 2016: 695). In order to be used as storing and fermentation containers, the *dolia* were buried in the earth by ⅔ (Smith 1882: 1202) or half or only with their mouth protruding. The buried vessels were called *dolia defossa* (or *dolia demersal*, or *dolia depressa*) (Manca et al. 2016: 695).

Titus Lucretius Carus (94-55 BC) mentions the term *dolia curta* to name the urinals that were placed in narrow streets, between houses, providing relief to passers-by (Carus 4: 1026). Gaius Plinius Secundus

3.1- 3,3: Sayers & Rinzler 1987, fig. 24a-f (pp. 97-100), figures 3.4, 3.5:
https://www.korea.net/upload/content/editImage/140617_korea_pottery_2.jpg

[6] An indicative example is the *dolia* of the warehouses *(horreae*) of the Roman port of Caesaria Maritima in Israel (Strauss 2006).

(23/24-79 AD) reported the transformation of *dolia* into cages for breeding and fattening rodents intended for consumption (*vivaria in doliis*) (G. Plinius Secundus, Naturalis Historia 13: 211, 224; Meléndez and Campos Carrasco 2023). The finding of *dolia* near Roman Baths could be related to their use as means of storing and heating water (eg. the Karnak thermal baths) (Boraik et al. 2017: 230).

The *dolia,* as portable ceramic carriers (containers) of wine, were transferred as an inextricable part of the cistern-boats through the extensive maritime Roman transport and, possibly, river network.[7] Their overland transportation is thought to have been very difficult, if not impossible, due to their size, shape and construction material, which made them unwieldy and vulnerable (Bevan 2014: 395). However, if such an attempt was made it is assumed that it would have been accomplished by oxen, horse or mule-drawn carriages (Blancou and Parsonson 2008: 20).

The technical training necessary for the production of dolia exemplifies the skill and expertise of Roman potters, who successfully crafted large-scale clay vessels that were both functional and aesthetically pleasing. The term *opus doliare* did not refer exclusively to the work of making dolia. It is assumed that the term was used to describe the whole of clay production (Parker 1876: 43) or it was related to the construction procedures of bricks creations (*opus testaceum*) and the specialized production of heavy clay constructions, such as *dolia*, clay *sarcophagi*, *mortaria* etc. (Manca et al. 2016: 698). The entire production process was time-consuming and high-cost (Domínguez 2018: 246).

The fact that the *dolia* are usually found in a poor state of preservation does not allow safe conclusions to be drawn about their manufacturing techniques (Cheung et al. 2020: 798). Due to their large size, it is considered that their construction was not based on the use of a ceramic wheel (Cheung et al. 2020: 799), which combined with the fact that the *dolia* production was of high-cost lead to the conclusion that that *dolia* were not mass produced (Domínguez 2018: 247). According to the most likely and accepted hypothesis, the *dolia* were made by specialized potters, the *doliarii* (Peck 1898: 533). Each *dolium* required large quantities of coarse architectural clay for its production (Cheung et al. 2020: 799), with abundant inclusions which guaranteed the cohesion and durability of the ceramic material (Domínguez 2018: 246). The *doliarii* worked either as itinerant artisans who practiced their art wherever they were called to or they worked in the famous *figlinae* (sin. *figlina*), the specialized *dolia* production laboratories (Domínguez 2018: 246).

In order to reconstruct the method of production of the *dolia*, modern researchers have relied on the relevant philological sources[8] and ethnographic parallels. Combining the two sources, they concluded that the *dolia* production used to take place on a heated spot just above the ground (Geoponics 6: 30), according to the coil-building technique of the large clay containers (Caroll 2022: 228). The ethnographic research of the modern *tinajas* (Spain), *talhas* (Portugal), *kvevri* (Georgia), *Karas* (Armenia) and *Onggi* (Korea) ceramic vessels contributed a lot to understanding the way the *dolia* were constructed (Figure 3.1-5). The high economic and utilitarian value of *dolia* did not allow them to be abandoned in case of wear and tear. Lead (or lead alloys) (Caroll 2022: 226) stapling plates or clamps were used to repair breaks or cracks on the *dolia* surface (Cheung 2023a: 89).

The *figlinae* workshops appeared for the first time at the end of the 2nd century BC (Manca et al. 2016: 698). They were divided into "urban" and "regional" or "provincial" (semantic rendering of the term

[7] Rice 2016: 176; Strauss 2006:104 - wreck at Rhone Delta location

[8] Cato 23(1); Geoponics 6: 5; G. Plinius Secundus, Naturalis Historia 14.134; L. Iunius Moderatus Columella, Res rustica 12(18): 5-7.

"extra-urban") figlinae. The “urban” ones were located along the Tiber River at a maximum distance of 50 kms from Rome and supplied *dolia* to the markets of the wider area of the capital. The figlinae located outside the aforementioned restricted area were called ”regional” and equipped the respective markets with the massive containers (Manca et al. 2016: 698). Figlinae have been discovered in the Provincia Lusitana (Portugal), Provincia Hispania Baetica (SW Spain) (Carrato 2013: 1184-1185), Provincia Hispania Tarraconensis (Central & Western Spain) (Carrato et al. 2009: 70), Provincia Gallia Narbonensis (Cheung 2023b: 7; Carrato 2013: 1184-1185) and in the Italian peninsula (32 figlinae) (Cheung 2023b: 8-9).

It is noteworthy that the archaeometric analyses of *dolia* fragments from the Western Mediterranean evince a sophisticated level of the know-how and economic management of *dolia* production. The raw materials were selected in order to lower the production cost and, simultaneously, to provide massive and durable end products (Carrato et al. 2009: 76-77). *Dolia defossa* from the San Giovanni site of the island of Elba (Tuscany, Italy) included deliberately added materials, like clinopyroxene crystals, which enhanced the hardening of the clay raw material. The petrological and mineralogical analyses traced back the origin of clay and its additives to Monti Cimini (Tuscany), the wider area of Rome (Monti Vulsini, Vico volcano) and the site of Minturnae (SW Tuscany, N. Latium) (Manca et al. 2016: 693). The systematic archaeometric analyses of *dolia* from central Italy and Apulia pointed out the Tiber and Garigliano valleys as their production areas (Carroll 2022: 233). It should be mentioned that the *dolia* were, often, seal-branded with insignia of the figlinae they were produced in.[9] *Dolia* from 9 cistern-boats wrecks bare stamps of the Piranus family, also denoting the city of Minturnae as the area of their manufacture.

Cistern-boats’ mobility: the aquatic transport routes of *dolia*

Considering Minturnae as the cradle of cistern boats’ *dolia* and the *dolia* ships’ area of origin, it will axiomatically be considered the port of departure or return of every Roman tanker’s voyage. Up to the present, it is affirmed that the cistern boats followed a maritime route that connected Minturnae, Marseilles and the Spanish province (Figure 4). The existence of this maritime route is supported by the identification of *dolia*-making workshops, wine-making structures and wine warehouses at its start, its end and along it. The aforementioned warehouses filled the *dolia* tanks and the amphorae of the cistern boats with wine or received wine from the same containers. This extended maritime route came about after the geographical alignment of the related wreck sites and it could be distinguished into three minor routes. The first one connected Minturnae with Marseilles, the second one conjoined Marseilles with Hispania Tarraconensis and the last route linked Hispania Tarraconensis and Minturnae (Marlier 2008: 165; Davis 2009: 84, 83).

Around the beginning of the 21st century, official and unofficial references started to disperse about *dolia* located on the sea bottom of the Central[10] and the Eastern Mediterranean Sea (Kampbell 2013: 243). Almost all the reports and the found *dolia* came from the Adriatic Sea and only one *dolium* was detected

[9] It has been proposed that on some occasions these stamps might function as certifications of compliance with specific quality and size standards. Borgers 2015: 70.

[10] Anastasi 2015; Jurišić 2000:73, 130; Jurišić 2006: 187; Pešić 2008: 68, 69; Ritondale 2022, wreck nr 306; Strauss 2013, wreck nr 340, 7342; The Oxford Roman Economy Project: Grado (Julia Felix).

in the Caesaria Maritima, W. Israel (it is confirmed that the boat vessel was a *navis lapidaria*).[11] The only, so far, documented report of two, morphologically similar to *dolia*, sunken pithoi in the Greek seas comes from the coastal village of Afyssos in the Pagasitikos Gulf (Figure 7). It should be mentioned that there is a reference on a *dolium* fragment in the Roman port of Skiathos island in the central Aegean Sea (Greece) (Ginalis and Athanasoula 2018: 4).



Figure 4. Cartographic representation of the confirmed maritime routes of the cistern boats in the Western Mediterranean Sea. Source: T. Iossifidis 2024, GoogleEarth Pro.

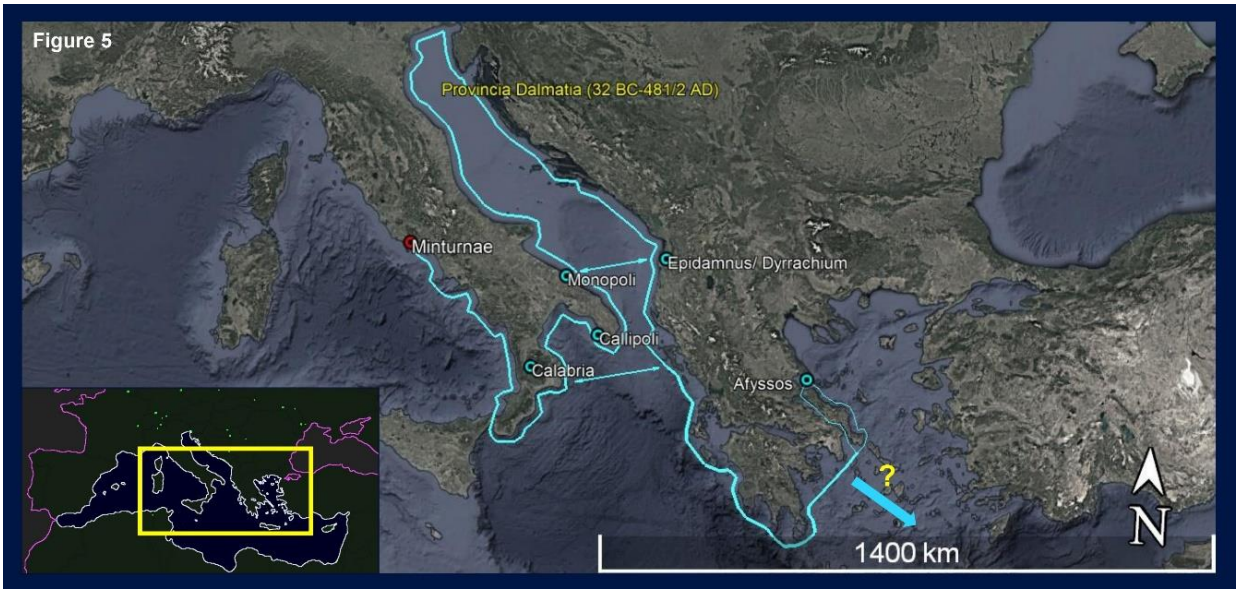


Figure 5. Cartographic representation of the potential maritime routes of the cistern boats in the Central and Eastern Mediterranean Sea. Source: T. Iossifidis 2024, GoogleEarth Pro.

[11] Parker 1992: 413, wreck nr 1115.

These reports gave rise to debates about the existence of additional maritime routes of the cistern boats to the East. The potential eastern sea routes, starting from Minturnae, reached the Balkans either by crossing the Adriatic Sea or following coastal navigation from the Italian to the Balkan Peninsula (Anastasi 2015: 166). The *dolia* ships, after circumnavigating the Peloponnese, passing by the Attica region of Greece and crossing the Aegean Sea, could navigate to the Asian Mediterranean coasts and reach the rich ports of the East (Figure 5). In correspondence to the western routes, the cistern boats could dock to the large Adriatic, Greek and Asia Minor ports for commercial transactions and supplies.

Due to their construction, it has been presumed that cistern boats extended their mobility in rivers, which they entered by their estuaries in the Mediterranean (Figure 6). The most likely river route, supported by archaeological findings, is that of the *Flumen Rubricatum* (Plin. HN 3.4) known today as the Llobregat River. The river is certain to have been navigable in Roman times from its mouth in the Mediterranean to the modern town of Martorell. The relevant archaeological evidences include mooring piers on both banks of the river, two pottery workshops near the river coast and six wrecks (The Les Sorres C wreck transported *dolia*) at Les Sorres site in Llobregat Estuary (The Les Sorres C wreck transported *dolia*) (Vidal 2008: 2). It was also suggested that the cistern-boats entered Rhone River (*Flumen Rhodanus*) and moved along the river up to Lyons (Broekaert 2013: 380).

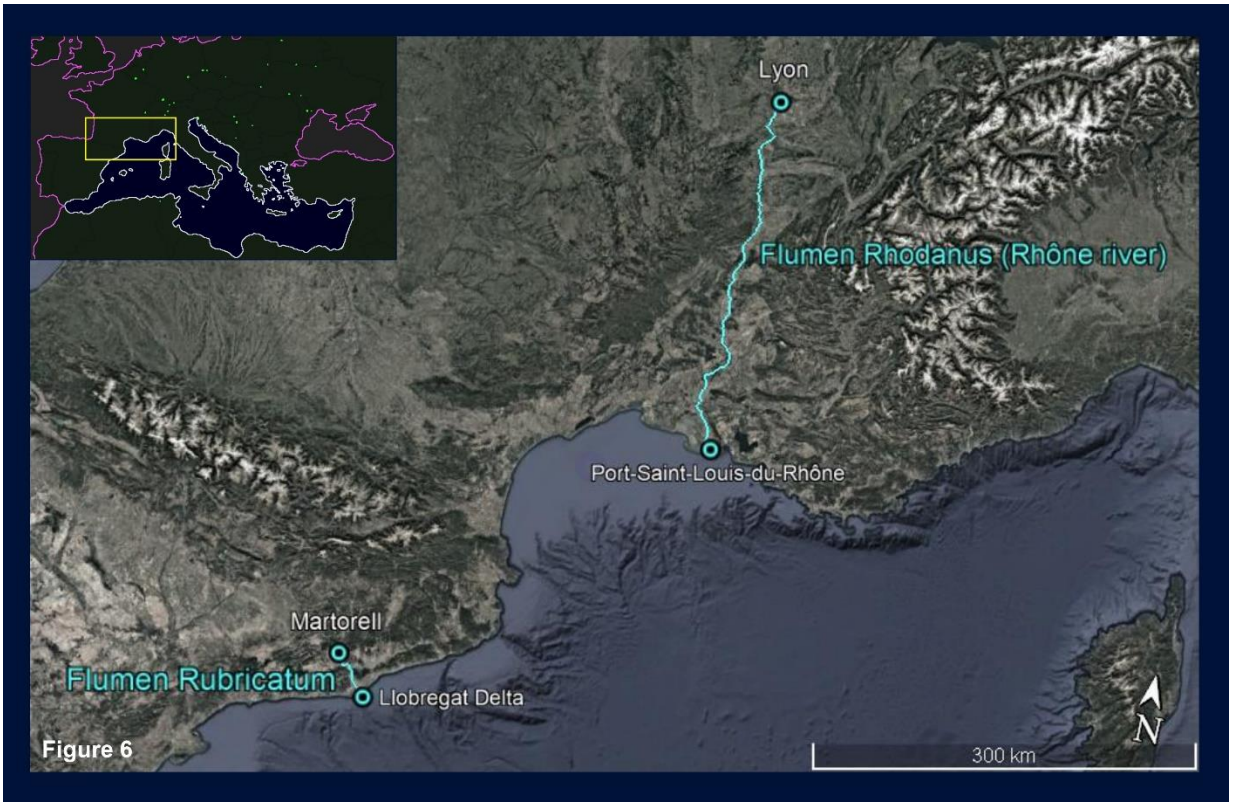


Figure 6. Cartographic representation of the potential river routes of the cistern boats. Source: T. Iossifidis 2024, GoogleEarth Pro.

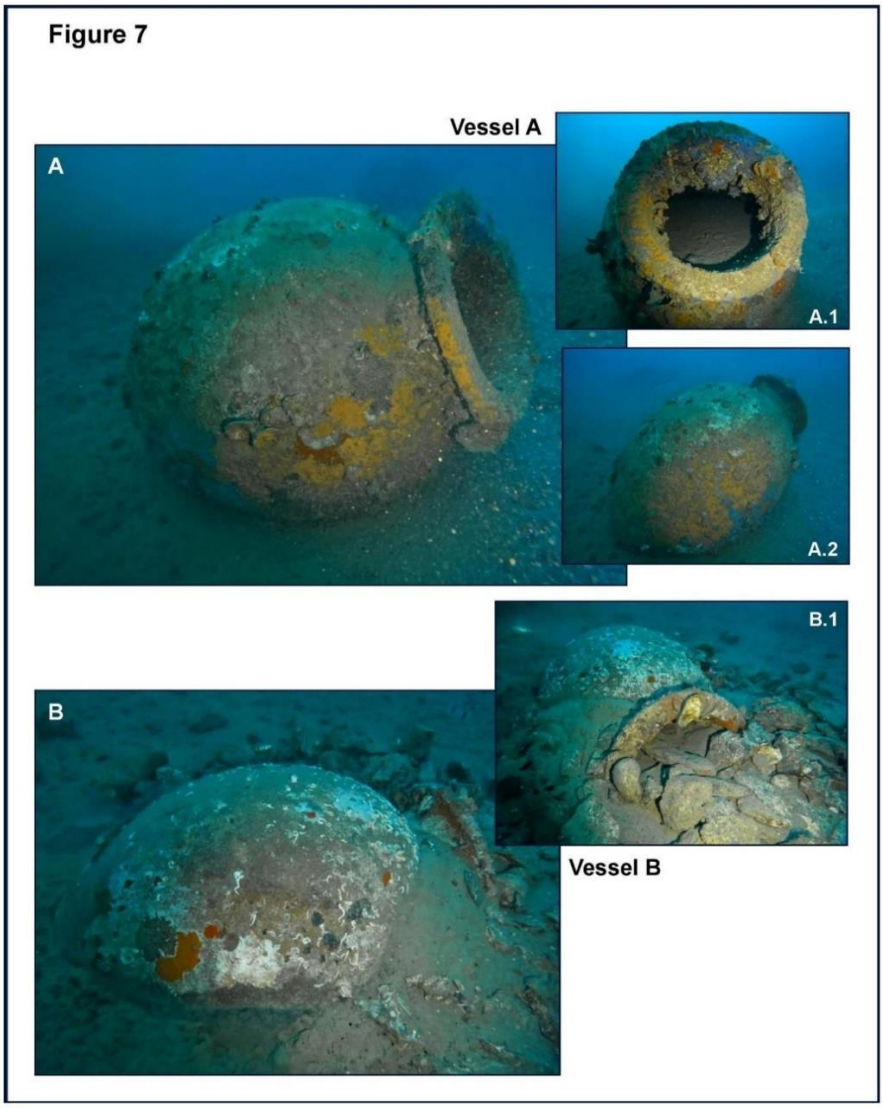


Figure 7. Since the first five years of the 1990s, rumours have been spread about two dolia-like ceramic vessels (A, B) on the littoral of Afyssos in the Pagassetic Gulf (Greece). The author with a specialized research group of divers tracked down the vessels and held an autopsy of the site, as part of his Master's thesis. The team measured the ceramic vessels and proceeded to photographic and photogrammetry documentation. The dimensions of the two containers fall within the range typically associated with dolia, and they exhibit traits commonly found in dolia (A). They have an ovoid shape and are devoid of decorations or handles. They possess broad mouths characterized by prominent massive lips, which feature a flat upper surface (A.1), and a prominently shaped neck from which the mouth lips protruded sharply at a right angle. Dolia usually do not have a neck and the lips of their mouths start directly from the upper point of the shoulders. Also, dolia, although ovoid, ordinarily have a swollen body to the point of appearing spherical. The two containers' shape, although ovoid, is overall more elongated (A.2). The vessels exhibit significant differences in shape compared to the dolia commonly produced in the Western Mediterranean (Hispania Tarraconensis, Gallia Narbonensis, Italian peninsula). A limited number of dolia have been identified on board ships, which are believed to have served either as containers for freshwater or for the storage of personal belongings by the crew. In these cases, the vessels had a hybrid shape between pithoi and dolia. The two clay pots from Afyssos exhibit morphological characteristics that reflect elements of both containers, they are likely products of a regional (extra-urban) figlina of the Eastern Mediterranean region.[12]

[12] Source: figures A, A.1, A.2, B, B.1: C. Zoumbos 2023.

Conclusion

The Roman tankers were the first merchant ships to transport bulk wine between the 1st century BC and the middle of the 3rd century AD. The cistern boats phenomenon is a multifaceted issue that requires a multi-prismatic approach. Therefore, the study of *dolia* ships presupposes the research of their naval architecture, the consideration of their contribution in the development of the maritime commercial activity along with the study of the production and the use of the *dolia* ceramic vessels. An issue that preoccupies and, as it seems, will continue to concern the research community, possibly, even more intensely in the future, is the maritime itinerary that the *dolia* ships followed. It is taken for granted that they were active in the western Mediterranean Sea following specific routes. The reports of finding *dolia* in sites of the central and eastern Mediterranean raised expectations of a find that would change the conventional perception of the mediterranean maritime trade history.

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Patron deities and sacred places of ancient seafarers in the Adriatic

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Abstract

The dangers of navigation in the Mediterranean generated religious beliefs and cult practices of seafarers that were not shared by other members of their society on the mainland. Numerous inscriptions along with ancient literary sources give us insight which gods and goddesses were worshipped on the Adriatic. The Greek Aphrodite and the Roman Venus were very popular in this area. The cult of Zeus/Jupiter was widespread in the Strait of Otranto, where he was equated with several other deities, for example the Messapian Batis/Batas. The cult of the Greek hero Diomedes is documented both in literary sources and in archaeological excavations at numerous sites in the Adriatic, where he was worshipped as a god. Archaeological excavations on the island of Palagruža and Cape Ploča confirmed his cult for the first time and revealed his close connection to seafarers.

Keywords: seafarers, maritime religion, patron deities, sanctuaries, Adriatic Sea

Introduction

The seafarers faced uncertainties and fears brought about by the literal and psychological boundaries of the sea. The physical environment had an enormous impact on seafaring and the dangerous nature of their profession made it the most hazardous occupation of all (Morton 2001: 1). Human societies have countered the physical dangers with various technological innovations (different types of ships, anchors, sails, sounding leads, etc.) and the transmission of knowledge - seafaring has very often been a family business for generations (Casson 1995: 159-167, 245-249; Casson 1991: 140-142; Gabrielsen 1997: 103-105). But how do you deal with the psychological aspect? The dangers of sailing the Mediterranean generated specialized religious beliefs and rituals performed by seafarers that were not shared by members of their society who had never left the mainland. Although this maritime aspect of religion is only a part of the general religious beliefs and cultic practices in ancient societies, it is really specialized religion that arose from the unique uncertainties and dangers faced while living and voyaging at sea. These beliefs and practices are exclusive because they are based on professions and roles of seafarers within their society (Brody 2008: 9; McNiven 2004: 332-345). Aaron Brody has developed a framework for studying the religious beliefs and cultic practices of Phoenician seafarers based on comparative studies of the maritime religions of Greek and Roman cultures and anthropological studies of the religions of modern traditional seafaring communities. There are several common elements in what we might call maritime religion: 1) patron deities with special maritime, celestial, or meteorological attributes important to the well-being of seafarers; 2) seaside temples and shrines with special associations for mariners; 3) religious ceremonies performed by seafarers to ensure the safety of the voyage; 4) the notion that the ship itself has a divine spirit and sacred spaces on board; 5) burial practices and death rituals with connections to the sea (Brody 1998: 4; Brody 2021). I would suggest one more element: the need to name the places that are particularly important to seafarers ("places used

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are places named", McNiven 2008: 152). This could be the naming of the sea or a part of the sea, usually related to certain meteorological conditions (Arnaud 2005: 149-153), or the naming the specific places such as capes, islands, landings, rocks, hills, mountain tops, etc., which usually have a characteristic colour and are of particular importance for navigation. Very often these places were named after deities who were worshipped at these locations (examples in Morton 2001: 68-85,189-193). The Adriatic was always perceived as a wild and dangerous sea (*minacis Hadriatici* Catullus Carm. 4. 6-9). In the early Greek sources, the term was limited to the northern part of the Golf, which is still considered one of the most dangerous parts of the Mediterranean for sailing, because of the notorious north-easterly wind, the bora. Over the centuries, the name spread to the south and became synonymous with the modern term Adriatic Sea, although ancient sailors still considered the Ionian Sea and the Adriatic to be the same. Which gods did the ancient sailors invoke when they faced dangers on their journey through the Adriatic? In this article, I shall examine which patron deities were worshipped by the seafarers of the Adriatic and where they were worshipped.

Patron deities and sacred places

In general, seafarers worshipped numerous deities, in fact any god or goddess they believed would help them on their journey. Most important, however, were deities who could control the weather, especially winds and storms, who could provide safety and make navigation successful, and those who could guard a sailor from the spiritual dangers of the depths (Brody 1998: 9; Brody, 2008: 2). Goddesses played an important role in protecting sailors. Aphrodite, the goddess of the sea and sky, who helped with navigation, was particularly popular. The seafarers worshiped her under epithet Euploia, goddess of Good Sailing. This cult originated in Cnidus and was widespread throughout the Mediterranean. In Cnidus she was also known as Akraia - of the Headland (Paus. Perieg. 1.1). However, she was also called Limenia or Epilemenia, the goddess of the harbour, who was worshipped on the island of Aegina (Polinskaya 2013: 197), also as Pontia – She of the Sea and Eutyches – She of Good Luck (Larson 2007: 123). Her Roman counterpart was the goddess Venus, so often mentioned in the Roman Republican and Imperial periods, but very often with Greek epithets (Rougé 1981: 197).

In the Adriatic, several different sources indicate that the cult of Aphrodite and her Roman counterpart Venus was very important for both foreign traders and local seafaring communities. Dedications to Venus Sosandra have been found on the small island of Santa Eufemia/Eugenia on the north side of Monte Gargano, which guards the entrance to the port of Vieste (probably the ancient Urium). Her sanctuary in the cave was visited from the 3rd/2nd century BC until the late Roman period (Russi 1998). She is related to the Greek Aphrodite Sosandra (Saviour of Man), who is known from Greek bronze sculpture and later Roman marble copies and is described by Lucian of Samostata in his work A Portrait Study (Luc. Imag. 4.6). The poet Juvenal (Juv. Sat. 4.39-40) speaks of a temple of Venus at Ancona in the 2nd century AD, but the cult of Aphrodite of Cnidus at Ancona was already well known to the 1st century BC poet Catullus (Carm. 36.11-15), who also associates the goddess with ports at Urium and Dyrrachium on the Adriatic (Cellini 2004: 357-367; Coppola 1993: 189-191). The coins of Ancona from the 3rd/2nd century BC show on the obverse the bust of the goddess, who was the patron deity of the city, and on the reverse an inscription with the Greek name AGKON and a bent elbow representing the position of the cape enclosing the harbour (Head 1977: 23). In Potirna on the island of Korčula, an inscription dedicated to Venus Pelagia was found in the context of a Roman villa (CIL III 3066 = 10083). It is dated to the 2nd century AD. It mentions a temple and a statue of the goddess. Although the text says nothing about the maritime cult, the Greek epithet Pelagia - Seafaring - indicates the maritime aspect of this deity, who is known in Greek myths and legends as Aphrodite Cnidus or simply Euploia.

Another place associated with the goddess Venus is the Promontory of Iapygia. Legend has it that Aeneas himself first set foot in Italy at the headland named after Minerva (the Greek goddess Athena). This place offers a harbour in summer, which has since been called the Harbor of Venus (Dion. Halicar. Ant. Rom. 1.51.3.). Here Strabo (Str. Geog. 6.3.6.) mentions the rich temple of Athena, and on the Tabula Peuntingeriana (Tab. Peuting. Pars VIII, Segmentorum VII, VIII) there is a place called Castrum Minervae, today Castro. Archaeological excavations have confirmed the existence of the temple of the goddess Athena (preview of the archaeological excavations of the Athenaion in Castro in D'Andria 2020; 2021) and she was another deity to whom seafarers turned in their distress. Although she is considered the protector of carpenters and is thought to have built the first ship (Burkert 1985: 141) and Brody therefore sees her as the protector of shipbuilders (Brody 2008: 3), I would suggest that her role as protector of seafarers was much broader and more closely related to meteorological conditions. Pausanias (Perieg. 4.35) describes her role in the city of Mothone, where there is a temple to Athena of the Winds, with a statue said to have been dedicated by Diomedes, who gave the goddess her name. As the land was hit by violent and untimely storms, Diomedes prayed to the goddess, and since then no more misfortune caused by the winds has befallen the land. Here she is the protector from the winds, something we find in common to the most maritime deities. As Burkert suggests, she is on hand wherever difficulties disappear and the impossible becomes possible (Burkert 1985: 141). Her Roman counterpart, the goddess Minerva, was also worshipped by seafarers in the Imperial period (Rougé 1981: 197).

In the region of Picenum (the Picentinian land), Strabo mentions the temple of Cupra, which was established by the Etruscans. He says that they called Hera Cupra (Str. 5.4.2.), who is also known as the Etruscan goddess Uni. Dedications to this deity are known from port Gravisca (Johnston, Pandolfini 2000: no. 375, 75-76). The temple of Cupra is also mentioned by Silius Italicus (Sil. Ital. Pun. 8.433). Pliny the Elder (Plin. Nat. hist. 3.18.9) speaks of the site of Cupra, which is identified as Cupra Maritima. Excavations point to the site near the church of S. Martino di Grottamare, where architectural remains from the Roman imperial period have been found. The inscription (CIL IX, 529) from Hadrian's time mentions the name of the goddess and the restoration of the temple (detailed Capriotti 2010: 119-159). There are also other interpretations that associate Cupra with the goddess Venus and the Greek Aphrodite Cypria (Collona 1993: 18-20).

Although Hera was considered the goddess of fertility and marriage, she was also worshipped by seafarers in the central and eastern Mediterranean (Burkert 1985: 131). Her role as the patron deity of mariners is best described in the Argonautica (e.g. Apoll. Argo. 4.640-648). She is the one who guides the Argonauts through the dangers, because Jason is her favourite (Hom. Od. 12. 59-72). Numerous sanctuaries were dedicated to Hera. Pseudo Scylax (13) mentions a famous sanctuary of Hera on the Lacinian cape (today capo Colonna) near Croton, which is one of the most important sanctuaries in southern Italy. For seafarers, this cape, together with the Iapygian cape (today Leuca), which surrounds the Gulf of Taranto, was a very important reference point on the sea route from Greece to the West (Maddoli 1983: 345-366). The votive offerings in the sanctuary of Hera Lacinia also included a bronze ship model (Spadea 1997: 249, 250, Figure 15.). Here she was worshipped together with Thetis, the goddess of the sea, another deity with power over stormy winds (Lycophr. Alex. 856; Hdt. 7. 178.1). When describing Aeneas' arrival in Italy at the temple of Juno/Hera, he left behind, among other things, a bronze patera on which an ancient inscription identifies his name as the one who dedicated it to the goddess (Dion. Halicar. Antiq. Rom. 1.51.3.). She was worshipped by seafarers in the in the territory of Corinth. An archaic sanctuary was excavated in Perachora, which has only been confirmed by archaeology. Here she was called Hera Akraia (of the Headland) in ancient sources, an allusion to the headland of Perachora, where the sanctuary was located near a small harbour. But since the 6th century

BC there have been dedications to Hera Limenia - of the Harbour - on a terrace above the harbour (Larson 2007: 34). On the island of Tasos she is known as Hera Epilemenia (IG XII, 8 - IG XII Suppl. 409). In the great temple of Hera on the island of Samos, some of the votive offerings of the maritime Hera were left behind, as well as in Larisa in Asia Minor, on Delos, in Inatos on Crete, Aegina, Corinth, Ismia, Athens (Acropolis), on Pithecusa (De Polignac 1997: 114, Figure 1.). In the Etruscan sanctuary and harbour of Gravisca, numerous dedications to this Greek goddess have been incised into the surface of vessels (Johnston, Pandolfini 2000: 17, no. 4-46). Given the maritime location of the sanctuary and the role of the goddess Aphrodite or Hera in the context of maritime religion, we should consider this local deity and her connection to seafaring (Galiè 2013: 13-40). In the sanctuary at Iapygian Cape (Santa Maria di Leuca) there is a dedication in Greek to Aphrodite Eutyches and Ino Eutyches, Godesses of Good Fortune (Cremonesi et al. 1978: 198, 205-206).

Ino Eutyches, to whom the mariners prayed, was actually Ino Leucothea (The White Goddess). Originally, she was a mortal princess named Ino, a daughter of King Cadmus of Thebes. She incurred the wrath of Hera when she raised the infant god Dionysus. This event is best described by Pseudo-Apollodorus in Bibliotheca (3.28): Zeus gave birth to Dionysus, whom he entrusted to Hermes. Hermes brought him to Ino and her husband Athamas and persuaded them to bring him up like a girl. Incensed, Hera inflicted madness on them, so Athamas pursued and killed his elder son Learkhos, believing him to be a deer, while Ino threw Melikertes into a basin of boiling water and then carrying both the basin and the corpse of the boy, she jumped to the bottom of the sea. She is now called Leukothea and her son Palaemon. They were given these names by seafarers because they help sailors who are beset by storms.

Zeus, the god of the sky and weather with his ability to create storms and mountainous waves, was very important to seafarers (Dowden 2006: 54, 55; Hom. Od. 3. 286-290). He was worshipped in the central and western Mediterranean as Zeus Soter - Saviour. In the Athenian port city of Piraeus, he shared his temple with Athena Soteria, and sailors made offerings to them on their return from dangerous voyages (Larson 2007: 20). In the central and eastern Mediterranean, he was also worshipped as Zeus Kasios, the Hellenized equivalent of the Canaanite Ba'l Zaphon (Brody 2008: 2). Numerous lead anchors bearing his name were found in the waters around Sicily. Some of the inscriptions were in Greek, others in Latin, and there are also dedications to Zeus Kasius and Aphrodite or their Roman counterparts Jupiter and Venus (Tito 2012: 81-102). The Zeus/Jupiter cult was particularly popular in the Strait of Otranto (Fenet 2005). On the island of Corfu, Pliny the Elder mentions the city of Casiope and the temple of Iupiter Casius (Plin. Nat. hist. 4.52 ...oppido Cassiope temploque Cassi Iovis). Procopius says that the city of Kasope was named after the epithet of this deity (Procop. Bell. Goth. 8.22.24-26). On the opposite side in Butrint, today's Albania, a votive epigram of a certain Barbaros states that he dedicates two ships to Zeus Kasius and when he becomes rich, he will also dedicate the third ship (Fenet 2005: 44). There is no cult of Zeus Kasios on the Italian coast, but the ancient Messapian deity was worshipped here. At the cape of Iapigia (Leuca), in the Porcinara cave, there are several inscriptions dedicated to the Greek Zeus, but we find different versions of the name. The Messapian god was called Batis–Batas, Zis-Batas, as a Greek-Messapian syncretism or a version of the deity Zeus Batios. In later times we find Iupitter, Batius, Kyrios Bateios, Iuppiter Vatius in the Latin version. Inscriptions clearly equate the Greek Zeus and the Roman Jupiter with this indigenous deity (Cremonesi et al. 1978: 218; Pagliara 1991: 510-511). There are two inscriptions dedicated to Jupiter from this site and the dedicatees are members of the ship's crew (pleroma). The names of the ships are given: Medaurus, Rhedon and Aphrodite. These are clearly the names of deities to whom the ships are dedicated. While Aphrodite is a famous Greek goddess, Meduarus and Rhedon are little-known protagonists of Illyrian mythology. The name Rhedon (Rhedonos) is known from coins from the city of Lissos in northern Albania. The male figure depicted on the obverse with causia was initially associated with King Gentius and the god Hermes, but later analyses suggest

that it is a local hero or god of the city of Lissos (Rendić-Miočević 1989: 296, 297, 301). The name Medaurus is attested in Risinium (Rhizon in Greek) in present-day Monte Negro and in metrical inscriptions from Lambaesis in North Africa (Numidia), which are dated to the 2nd century AD. It was consecrated by a legate of the legion III Augusta. It was originally believed that the inscription was found in the temple of the god Asclepius and that this deity was associated with healing and medicine. The latest interpretations associate this deity with Mars, the god of war. Considering that both names of Illyrian deities are the names of ships and are found in the maritime context of the sanctuary, we should also consider their connection to the weather elements or aid in navigation (Rendić-Miočević 1989: 523-527; Dyczek et al. 2014).

Several sanctuaries dedicated to various deities are known from the Salentine peninsula. The Poesia cave near Rocca Vecchia is dedicated to a local male god known as Taotor Andirahas, Tutor Antraio, Andraius, Anderaus or Andreus in Latin (Pagliara 1991: 521-522). A little further south, in the bay of Torre dell'Orso, there are two sites with votive dedications of mariners, one of them in the cave of San Cristoforo with inscriptions in Greek and Latin from the 6th century BC until 13 century AD. Of particular interest is the inscription in which the dedicatee asks an unknown deity for safe passage through the mouth of the strait (os vadi) of Otranto (Lamboley 1996: 196-197). At another nearby site on the north side of the bay, a poorly preserved Latin inscription dedicated to Jupiter was found, as well as the dedication of a crew member of the liburna named Hamon (Fenet 2005: 43-44; Auriemma, Frisone 2018: 284-285). In the south, near Castro in the Zinzulusa cave, small ceramic vessels and a statuette of the goddess Aphrodite were discovered (Lamboley 1996: 446).

An inscription dedicated to Iuppiter Serenus (CIL XI 6312) was found in the place of Gabicce, north of Pesaro. The original site was thought to be at Cape S. Marina Focara and it is assumed that it is connected to a successful voyage. Here the Roman Jupiter was equated with the Greek Zeus Horius - the god of fine weather (Cresci Marrone 1982: 253-254, Taf. VII d.; Braccesi 1977: 66, Rossignoli 2004: 389-391).

In the bay of Grammata (Gjiri i Gramës), in Albania on the eastern side of the Otranto Canal, more than 1500 inscriptions have been found, dating from the 3rd century BC onwards (CIGIME 3 2016: 160-161). Of particular interest are the dedications from the Hellenistic and Roman periods to the Dioscuri. This is the only place where their maritime cult has been confirmed. Sometimes they are also referred to as Gods. There are also dedications to the goddess Isis, the patron goddess of sailors, and to Agathe Tyche, the goddess of Good Fortune (CIGIME 3 2016: 168-196). The twin brothers Castor and Polydeuces, also known as the youths of Zeus, Dios kouroi (Burkert 1985: 212, 213), were very popular with Greek sailors as saviours from dangers at sea. They were able to control favourable winds, and Greek sailors set course of their ships at night by the light of their constellation (Rougé 1981: 197). In the Hymn to the Dioscuri (H.H.Ap.33) we read of their power to calm the stormy winds and the sea. In Hellenistic times and later in the Roman Imperial period, we find among these Greek gods two Hellenized Egyptian gods who were very important protectors of seafarers: Isis and Serapis. The festival dedicated to Isis even marks the beginning of the sailing season at the beginning of March, the Ploiaphesia (Greek) or navigium Isidis (Latin), and she is referred to as the ruler of the sea (Apul. Met. 11.5). She is often worshipped under the epithet Pelagia (Seagoing), Fortuna (She of the Good luck) or her Greek counterpart Tyche. We also find these epithets very frequently in connection with the goddess Venus, especially in the Roman Imperial period. Two bronze statues of Isis Fortuna were found in Istria (Girardi Jurkić 2012: 146-147). In a recently found inscription from the bay of Caska on the island of Pag, she is referred to as Mistress of the Earth and the Sea (Terrae Marisque Dominatrix), a dedication that is also known from a Greek inscription from Cius (Grisonic et alii. 2022: 233-235). Serapis, the Greek-Egyptian god of abundance and resurrection, very soon became the patron god of seafarers. And although his cult only began in the 3rd

century BC, it becomes widespread during the Imperial period. He was worshipped above all in the ports of the Mediterranean such as Alexandria and Athens, but also in Salona on the Adriatic, as an inscription from Aeternum attests, where the shipowner (nauclerus) Lucius Cassius Hermodorus, a member of the collegium of Serapis in Salona, died (CIL IX, 3337; Rougé 1981: 197, 198).

In addition to the deities, seafarers often asked for help and protection from famous heroes who were worshipped as gods in some parts of the Mediterranean. Very often these heroes would ask their own patron gods for help in times of need, but at some point, they would become divine protectors themselves. Many headlands, islands and harbours were dedicated to Heracles. The best known are the Pillars of Heracles and the Sacred Cape (Str. Geog. 3.1.3-4). These are two promontories of ancient Iberia (Europe) which, together with Libya (Africa), flank the entrance to the Mediterranean from the Atlantic. There was no temple or altar dedicated to Heracles here, just stones lying in groups of three and four in many places. It was a local custom for visitors to turn them over and then put them back after a libation. In describing the eastern Adriatic coast, Pseudo-Scylax (22) mentions a Hellenic city called Heraclea with a harbour, but its location remains a mystery (on this problem in detail Kirigin 1990: 294-295). Heracles' son Hyllus is also associated with the Adriatic; the port of the ancient city of Kerkyra (Corfu) is named after him (Apol. Argonaut. 4. 1124-1125), as is the headland Hyllis (paeninsully Hyllis) in present-day Dalmatia (Plin. Nat. hist. 3.141; Katičić 1995: 387-398; Čače 1997: 30-33).

In the Greek myth, Cadmus was sent by his father to search for his sister Europa, who had been abducted by Zeus. During his journey, a great storm arose and he swore to Poseidon to found the temple after his safe arrival in the port of Rhodes (Diod. Sic. 5.58.2). Although he asks the sea god for help here, he eventually becomes the protector of seafarers himself. In the Adriatic, his sanctuary is mentioned by Pseudo Skylax (24) somewhere between the rivers Arion and Rhizous as the Stones of Cadmus and Harmonia. However, the exact location of this sanctuary is still unknown (Suić, 1953: 111-129; Suić 1955: 121-185; Katičić 1995: 252-255).

Another famous Greek hero, Diomedes, is closely associated with the Adriatic region in the literary sources (Katičić 1995: 333-386). His fate was sealed during the Trojan War when, in a moment of rage, he wounded the goddess Aphrodite and drove her from the battlefield. Her revenge awaited him on his return to Argos. His wife Aigialeia plotted with her young lover to assassinate the king. He narrowly escaped by finding asylum as a supplicant at the altar of Hera and fled to Italy with his fellow warriors. There he found refuge with Daunos, the king of Daunia (Apulia), and in one version of the story the king killed him. In another, happier version, the king asked Diomedes for help against his enemies, which he granted him, thus becoming the successor of Daunos himself and his son-in-law. Many stories in Apulia make Diomedes the founder of cities in the area such as Brundisium, Argos Hippion (later Argirippa or Arpi), Venusia, Canusium, Cynegeticum, Beneventum, Venafrum and Sipontum (D'Ercole 2000: 11-16). However, the most popular stories about Diomedes related to his death, his tomb on an island named after him, where he was worshipped as a god and his comrades-in-arms were miraculously transformed into birds (Kirigin, Čače 1998: 66-70). The earliest stories about Diomedes in Daunia and its island are dated to the late 7th and 6th centuries BC. In addition to Daunia and the island or islands of Diomedes, other places around the Adriatic are also associated with the hero in literary sources: Adria, Spina, the people of Ombrici, the people of Veneti, the river and port of Timavo and the promontory of Diomedes. The legends also link him to Kerkyra (today Corfu), the most important port of call for entering the Adriatic (Kirigin, Čače, 1998: 70-71; Malkin 1998: 234-257). Although he is mentioned in numerous sources and some explicitly indicate that he was worshipped as a god, no literary source tells us anything about his connection to seafaring or why he became the protector of seafarers in the Adriatic. The only description of the Adria foundation seems to link Diomedes with the power to control the

winds and storms, a pattern we also see in other patron deities of seafarers. Etymologicum Magnum under the name Atria i.e. Adria says that it was a city in Etruria founded by Diomedes, who gave it the name Áithria because it calmed down when he arrived there during a storm. The only other connection of Diomedes to weather conditions can be found in Pausanias' description of the city of Mothone (Perieg. 4.35) and a temple of Athena of the Winds. He was the one who inaugurated it with a statue and gave the goddess her name. He prayed to the goddess and asked for her protection. Since then, no misfortune caused by the winds has befallen the land. The other connection between Diomedes and his role as protector of seafarers is not clear from the literature. He was worshipped by the Ombrici people, as Pseudo Skylax (16) suggests, and modern authors locate his sanctuary in the city of Ancona, thus linking him to navigation and the sea, but there is no evidence for this as yet (Braccesi 1977: 60; Coppola 1993: 189-191). Another place where Diomedes was worshipped is the mouth of the Timavus, the river that was considered the mother of the Adriatic, as Strabo reports (Geog. 5, 1, 8). Here his sanctuary is connected to the harbour, the river and the beautiful grove. Although it is still very difficult to discuss all aspects of the cult of Diomedes in the Adriatic, recent archaeological excavations at two sites in Croatia have revealed that the island of Palagruža (Diomedes Islands) and cape Ploča (Promontory of Diomedes) offer a much better insight into the maritime aspect of the cult in particular. Promunturium Diomedis is a cape on the Hyllean peninsula (Plin. Nat. hist. 3.141), a very significant topographical feature exposed to strong winds and the high sea. It has always had a bad reputation among sailors. Archaeological research in the 1990s brought the existence of the Hellenistic sanctuary to light. Numerous pottery fragments, coins and jewellery were found (Čače, Šešelj 2005). Particularly important are votive inscriptions, graffiti confirming that guardian deity of this cape was the Greek hero Diomedes and that the visitors were seafarers, the crew of ships and their captains (Čače et al. 2022: 13-102). Palagruža is a small archipelago in the middle of the Adriatic. Archaeological excavations were carried out at the site of Salmandrija on the largest island. Pottery fragments, coins and other small objects date the site to the end of the 6th century BC (Kirigin et al. 2010). Inscriptions on pottery confirm that these artefacts were part of the sanctuary dedicated to Diomedes, and some specifically mention that they were dedicated by seafarers (Čače et al. 2022: 139-220). It was used well into the 1st century AD.

Discussion

It is very confusing to see all these different deities that were worshipped by seafarers and it is hard not to ask the question, is there any god that they did not worship? The answer is probably that they worshipped any god they believed would help them on their voyage. To understand this concept and why they worshipped so many different deities in very different places, we must first understand how the seafarers perceived their voyaging. The best description and explanation comes from poetry: "Blest god of the harbour, accompany with gentle breeze the departing sails of Archelaus through the undisturbed water as far as the open sea, and thou who rulest over the extreme point of the beach, save him on his voyage as far as the Pythian shrine. From thence, if all we singers are dear to Phoebus, I will sail trusting in the fair western gale" (Anth. Pal, 10.17). It is clear from these lines that they first invoke the patron of the harbour, who provides a favourable wind so that the ship can leave the port (Roberts 1995: 312-314). After leaving the domain of the harbour deity, they turn to the god of the farthest tip of the beach, who provides protection on the open sea as far as the Apollo's sanctuary in Delphi. This is seen as a transitional point in the voyage where a mariner must take a new direction, actually round the cape and head for the open sea (Morton 2001: 177-180). It is important to understand that seafarers perceived their journey as a series of transitions, in fact a rite of passage. Rituals take place at points of transition: in port before the voyage, on board when leaving port, when passing a cape, headland or

landmark, when entering port after arrival or in times of danger (Brody 2008: 6; Kapitän 1985: 147-148; Van Gennep 1977: 15, 18, 24, 25). The sea itself is a liminal zone, an in-between place, and those who are at sea were considered neither dead nor alive. At these transition points, they perform libation: ritual drinking and pouring of wine. The libation itself is a transition rite, actually a rite of incorporation, intended to ensure the safety and protection of the patron deity. It is actually a preparation for the transition phase and with this rite the sailor ensures that his ship and crew are safe during the voyage (Van Gennep 1977: 20-21, 24). If we look at the voyage from this perspective, then it is easier to understand why they visited all these sanctuaries in the harbour itself, above the harbour, on the hills, on capes, in caves near the landing places, etc. This is the way they assured themselves of their safety and that the tutelary deity would watch over them and help them in times of danger.

Although some of these sanctuaries are not situated near the sea, they are important for seafarer because they provide a visual aid to navigation. For example, sanctuaries on the tops of mountains are often visible from a great distance at sea and are important landmarks, especially when approaching a danger zone. This also applies to the sanctuaries above the harbour itself, which are usually located on the slopes or at the top of the hill. They provide a visual guide for safe entry into the harbour. The sanctuary in the harbour itself is usually only visible once you have entered it. These harbour shrines exist literarily in every port, whether it is a home port, a port of call or a port of destination. But it is important to emphasize here that these sanctuaries were not exclusively maritime shrines. On the contrary, they usually belong to the local community and have other functions, but they are visited by seafarers and thus also served as maritime sanctuaries. We recognize such places when they are explicitly mentioned in literary sources or we recognize the material remains of maritime votive offerings, such as anchors, ship models or votive inscriptions by seafarers. The patron deity of these sanctuaries in ports usually bears epithets such as Limenia - of the Port, Epaktaios - of the Coast. Patron deities on the terrace above the port or on the top of the hill overlooking the harbour usually bear the epithet Akraia - of the Headland. Those on the capes and remote islands that watch over the open sea usually bear the epithets Pelagios - the Seagoing or Pontios - of the Sea, and also Akraia, which can mean of the Promontory. Sometimes temples were built at these remote locations, which then served as a visual aid to navigation (Morton 2001: 201-206), but more often the sanctuaries were founded on capes without buildings. They jut out from the mainland into the sea and are thus visible and serve as landmarks. We must also bear in mind that seafarers visualize important places in other ways, they are marked on their mental map and they are constantly aware of these places, especially the dangerous ones, whether they are visible in their surroundings or not (Gladwin 1970: 33-34). And in the minds of sailors, such a place serves as a navigational reference as much as any visible structure.

Sanctuaries on promontories and remote islands are known mainly from literary sources and are rarely recorded archaeologically, perhaps because their isolated location make them difficult to discover (Brody 1998: 41). What we know about maritime ritual activities comes mainly from sanctuaries in ports that are not exclusively maritime; they are only occasionally visited by seafarers. Therefore, remote sites such as the cave sanctuaries on the Salentine Peninsula, the islands of St. Eufemia and Palagruža, and cape Ploča are of great importance for the study of the history of maritime religion and maritime sanctuaries not only in the Adriatic, but throughout the Mediterranean. These remote sites are very important because, as we already know from literary sources, they continue the connection of sailors to their patron gods outside the harbour, but they also mark particularly dangerous areas, offer help with navigation, can point to fresh water sources, change of weather conditions etc.

Conclusion

Maritime religion is a specialized religion closely linked to the dangerous profession of seafaring. The mariners of the Adriatic faced the same uncertainties and dangers as other sailors of the Mediterranean. This led to similar religious beliefs and cultic practices, which can be deduced from literary texts, inscriptions and archaeological finds among Greek, Roman and indigenous seafarers. Analyses of the material remains of maritime sanctuaries in the Adriatic confirm this and provide a better insight into ritual practices. As such sites are rarely excavated and published, the Adriatic sanctuaries, especially the Greek ones, are a great opportunity to better understand the issues of seafaring, cult and maritime rituals. The goddess Aphrodite/Venus and the Greek hero Diomedes, who was worshipped as a god, were popular patron deities of sailors on the Adriatic. The cult of Zeus was particularly important in the Strait of Otranto, where the cult of the Dioscuri is also attested, as well as that of Isis and Serapis in later times. These deities are generally worshipped in open-air sanctuaries and in caves on headlands and islands. They are often associated with favourable landings along their sea routes and freshwater springs. Inscriptions attest that local divinities were worshipped and associated with various Greek, Etruscan and later Roman gods who eventually became protectors of seafarers, such as Bathis, Medaurus, Rhedon and possibly Cupra. The maritime cult of Diomedes in the Adriatic was certainly introduced by Greek seafarers, first on the island of Palagruža in the late 6th century BC and spread throughout the Adriatic, lasting at least until the time of Augustus. It is still not known where this cult came from and why Diomedes was chosen as the patron god of Greek sailors in the Adriatic, but we can assume that his role was due to his connection to weather conditions, especially the winds, and his power to control them. It is unlikely that Diomedes was an unknown indigenous deity merged with a Greek hero as suggested in the literature, at least not in his role as a seafaring deity.

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Shipwrecks

A Tripolitanian cargo in the Salento waters

Rita Auriemma[1]

Abstract

In Porto Cesareo Marine Protected Area, Ionian Sea (province of Lecce), new evidence has been added to the many already known: some spectacular formations made up in a unique way of cemented shards of Tripolitanian amphorae (2nd century AD). They appear to be large concretions of amphora fragments cemented together and to rocky outcrops on the seabed; due to environmental erosion, in six cases they have acquired a distinctive morphology, reminiscent of giant mushrooms, with a reduced base and elongated "hats".

The homogeneity of the fragments - all North African amphorae from the province of Tripolitania, classified as Tripolitan II, Bonifay 2004 type B - confirms that they belong to a single ship's cargo of considerable volume, given the number of fragments and the extent of the seabed affected, i.e. an area of around 2-300 m².

It therefore seems to have been a "direct" transport from the place of production to the place of consumption: a "supertanker" travelling with a full load of "wholesale" goods, probably heading east towards the ports of the eastern Mediterranean, whose voyage was tragically interrupted at the end of the Ionian crossing between Crotone and Porto Cesareo.

Keywords: Ionian Sea, Porto Cesareo MPA, shipwreck, cargo, Tripolitan amphorae

Introduction

In the waters around Porto Cesareo, submerged and semi-submerged archaeological remains have recently been discovered thanks to preliminary research carried out in close collaboration with the management of the local Marine Protected Area and the 'Coordinamento Ambientalisti pro Porto Cesareo O.d.V.' association.

The surveys, which started in 2020, were carried out by the Department of Cultural Heritage of the University of Salento (coordinated by R. Auriemma) as part of the UnderwaterMuse project (Italy-Croatia 2014-2020 cooperation programme). The research has added new evidence to the numerous discoveries already made and has implemented a webGIS that is part of the wider Geographic Information system of the Underwater Archaeological Map of Southern Apulia, curated by the Department (Pasanisi 1997; Auriemma 2004, II: 13-14; Alfonso *et al.* 2012; Mastronuzzi *et al.* 2017; Auriemma, Strafella 2020; Auriemma *et al.* 2021, 2022; Auriemma and Buccolieri 2021) (Figure 1).

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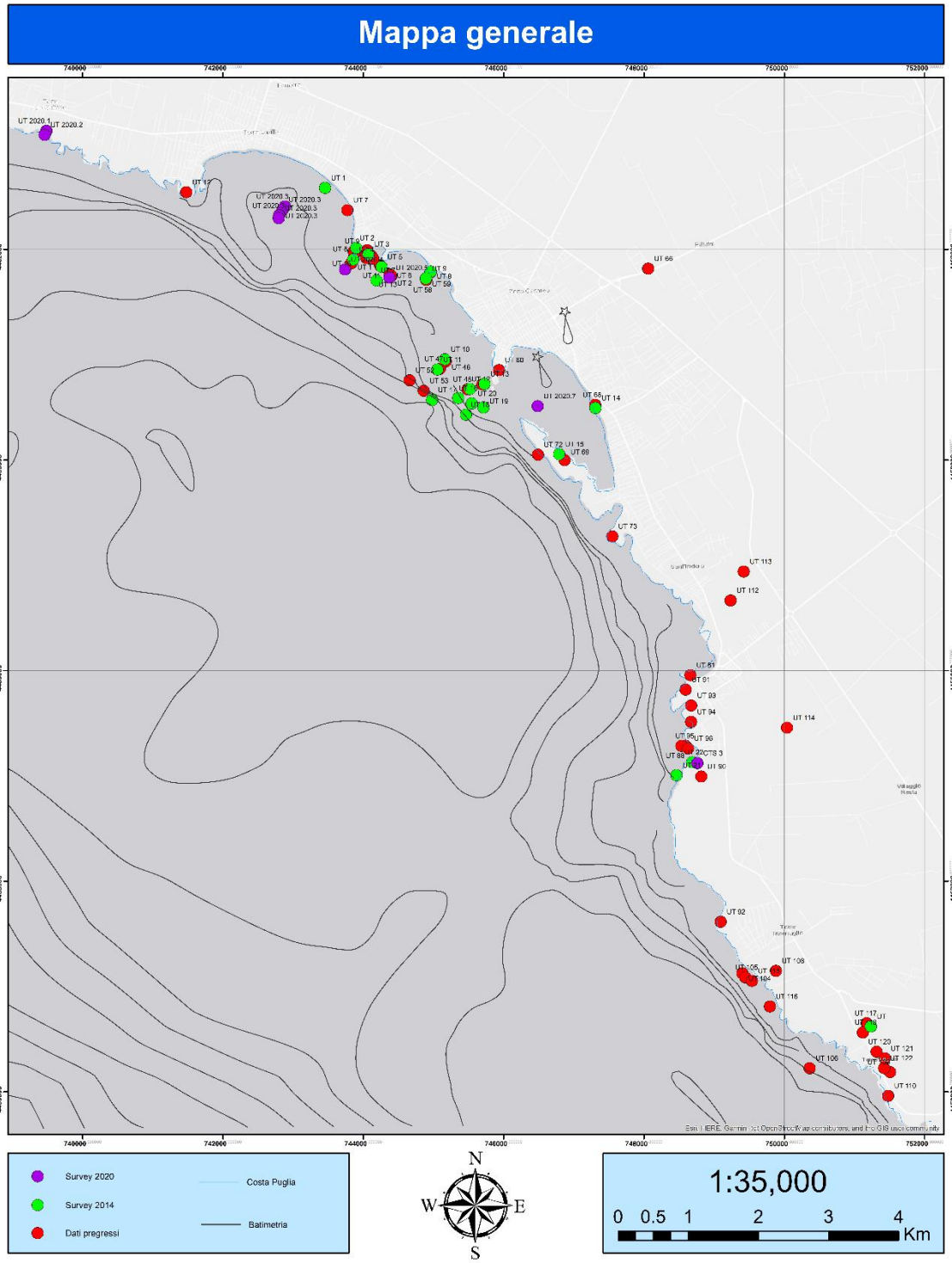


Figure 1. P. Cesareo MPA. Coastal and underwater archaeological map.

The seascapes of this area are dense with heterogeneous evidence by nature, function and chronology, an excellent potential for the creation of an organism capable of implementing strategies for the cultural redevelopment of the area, such as a "diffuse museum", an Underwater Archaeological Park on the model of the one in Baia, which also coincides with the MPA, or rather was created at the same time (Figure 2). The Porto Cesareo Underwater and Coastal Park project was developed by the Underwater Archaeology Group of the University of Salento in collaboration with the MPA, the Municipality of Porto Cesareo and, above all, the environmental associations that have been working for years to protect and promote the environmental and cultural resources of Porto Cesareo. Funded by the Region of Puglia, the project will create underwater itineraries between nature and culture, accessible to the general public in various ways: snorkelling, diving, sailing (glass-bottomed boats), kayaking, SUP, but also through the narrative and communicative use of VR/AR/MR, for a wider accessibility.[2]

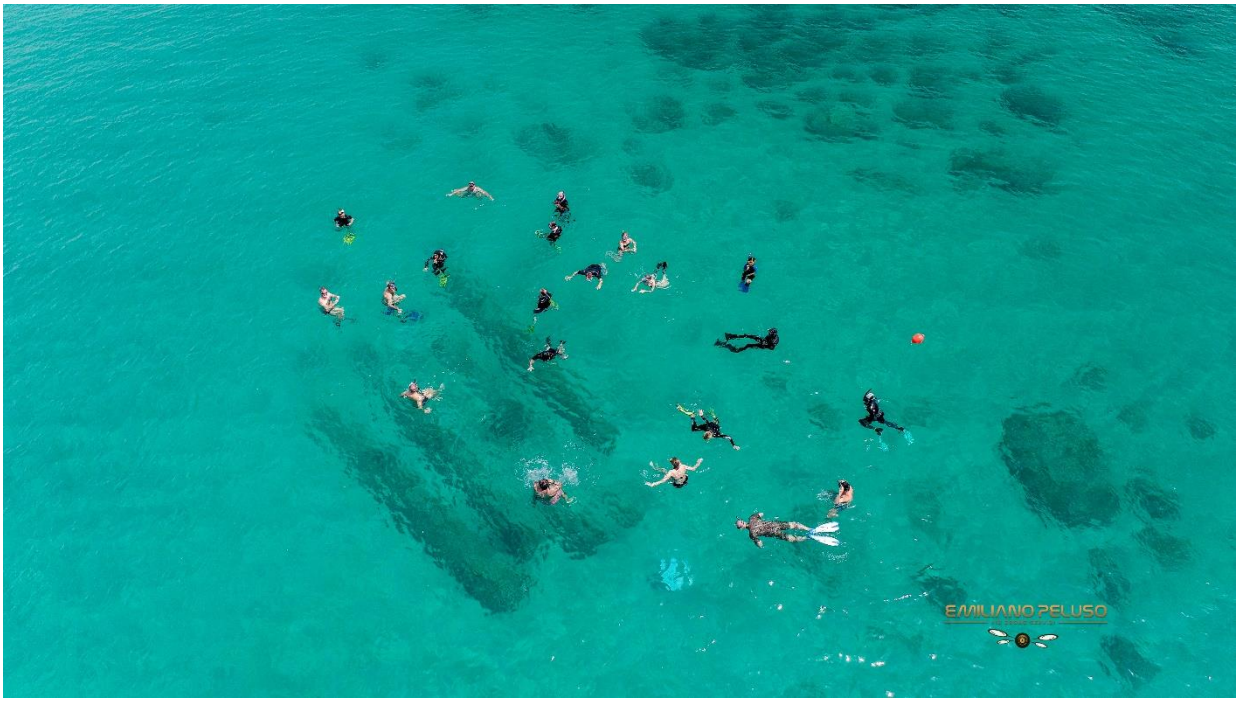


Figure 2. P. Cesareo MPA. Snorkelling on the Columns shipwreck in 2022 (Photo: E. Peluso).

Methods, techniques and tools

The stretch of coast overlooked by Porto Cesareo is characterised by a lagoon-like geomorphology, with two main bays closed by narrow and elongated peninsulas dotted with islets and rocky outcrops (De Pippo *et al.* 2004).

In accordance with the holistic approach and the methodological protocol of the global archaeology of landscapes, in this case coastal and underwater, or rather *seascapes*, instrumental survey was carried out in the MPA by means of UAV/drone, thanks to the support of the Geomatics Laboratory and the Environmental Engineering Laboratory of the Polytechnic of Turin. A direct survey was also carried out,

[2] Auriemma *et al.* 2023: implementation of an immersive application in the framework of the project *Puglia Seascapes - looking at Apulia from an underwater perspective*, funded by the Region of Puglia.

both underwater and on land, limited at this stage to checking for anomalies and indicative information up to a bathymetric depth of 6 metres (Auriemma *et al.* 2021; Picciolo *et al.* 2022).

The structures and mobile artefacts identified were precisely located by topographic survey using a total station and differential GPS, making it possible to georeference the photogrammetric surveys that were gradually carried out (elaborations obtained through the use of specific software such as Agisoft PhotoScan and Metashape). The photogrammetric survey of submerged structures also provided an opportunity to experiment with some innovative practices, such as the use of underwater sensors for GPS positioning.

The photogrammetric filming at sea was carried out using Nikon Coolpix W300 and Olympus Stylus TG-6 Tough cameras, while the aerial images of the coastline were obtained using the DJI Phantom 4 Pro drone, which is capable of acquiring RGB and multispectral formats, the latter being used to detect anomalies corresponding to ancient structures.

The geo-localisation of the evidence studied, together with the high level of detail provided by the photogrammetric survey, exponentially expands the previous documentary base and, at the same time, offers the possibility of broadening the spectrum of reconstructive hypotheses concerning the historical-topographical character of the contexts analysed.

The Tripolitanian cargo

In the sea area called "La Pierta", which is the broad bay between Torre Chianca (to the south) and Torre Lapillo (to the north), at 600 to 800 m from the coast and at a depth of 3.5 to 4.5 m, on a rocky platform marked to the east – on the landward side – by a steep drop to a depth of 5.5 - 6 m, some spectacular evidence have recently been discovered by Mino Buccolieri (Coordinamento Ambientalisti) (Figure 3); they appear to be large concretions of amphora fragments - handles, bases, rims and walls - cemented together and to rocky outcrops on the seabed (Figures 4a-b).

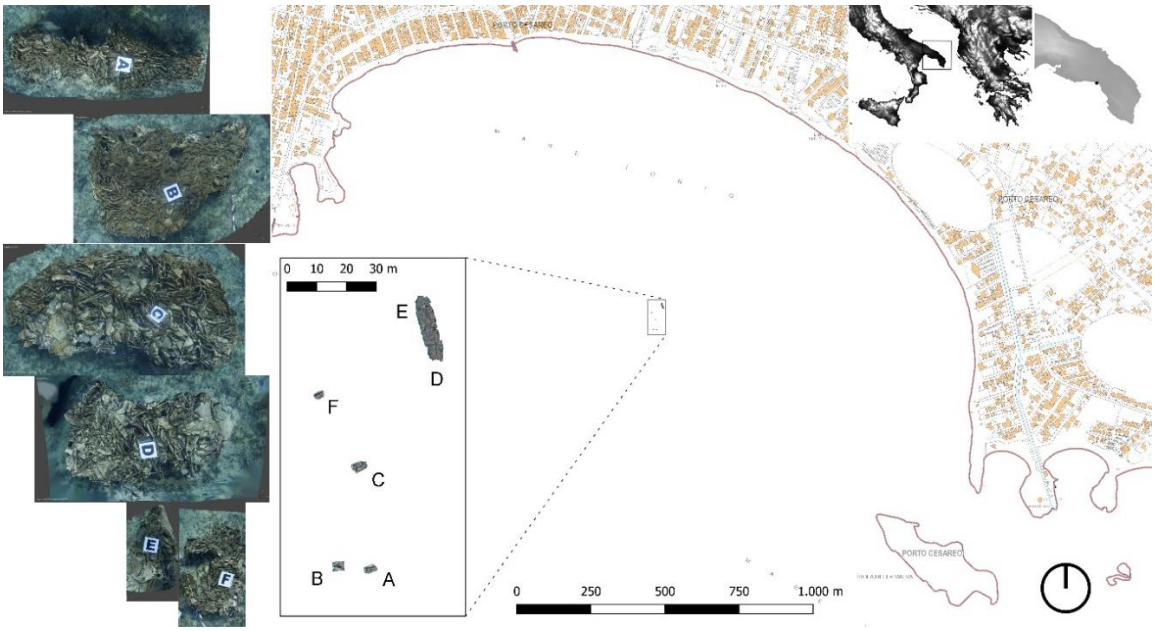


Figure 3. Tripolitanian amphorae cargo. Location and ortophoto from photogrammetry of the largest concretions (Elaboration: A. Calantropio, L. Coluccia).

As a result of environmental erosion, in six cases they have acquired a distinctive morphology reminiscent of giant mushrooms, with a reduced base and elongated "hats". The dimensions range from 126 x 78 cm (block E, the smallest) to 330 x 160 cm (block C, the largest). The height above the seabed varies between 75 and 100 cm, except for blocks E and F, which are only about 30 cm higher (block E is located in a small depression) (Figure 3).

Fragments of the same type can also be found in small groups on the seabed between the blocks and especially in cavities or depressions on the edge of the platform, at the foot of the rocky descent. In the latter, the fragments appear firmly cemented at the edges, or occupy a large part of the hollows.




Figure 4a-b. The concretions of amphorae fragments (Photo: M. Buccolieri).

In the larger sand-filled depressions there are also loose and more mobile fragments, often hidden by the sediment (Figures 5a-b).




Figure 5a-b. Fragments in the hollows of the seabed (Photo: M. Buccolieri).

Most of the fragments belong to North African amphorae from the province of Tripolitania, classified as *Tripolitana II*, Bonifay 2004 Type B (Bonifay 2004: 89-92) (Figures 6-7).



Figure 6. Detail of a handle (Photo M. Buccolieri).

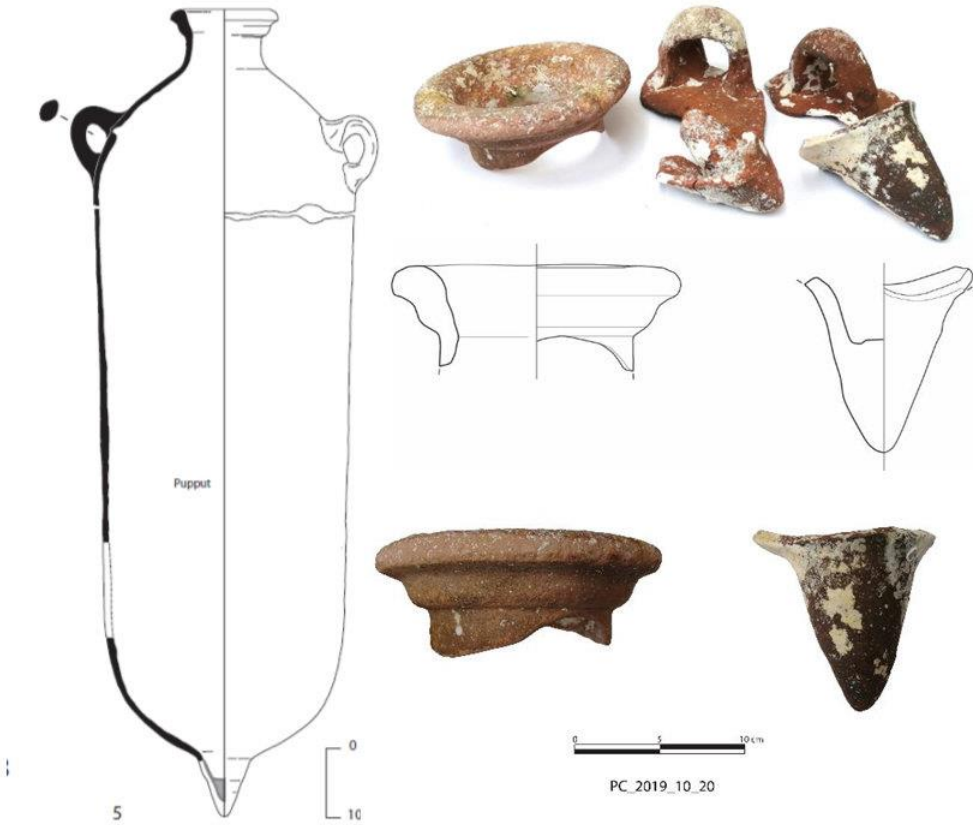


Figure 7. Example form Pupput (from Bonifay 2004, Figure 47.5) and fragments recovered from the cargo (Photo: L. Coluccia, drawings: F. Malinconico).

The production, developed on the model of the amphorae of Punic tradition Van der Werff 3, was detected for the first time among the materials of the Terme del Nuotatore in Ostia and is mainly attested in contexts of the advanced 2nd century[3]. This amphora was manufactured in Tripolitania (modern Libya), where several kiln sites are known at Gargaresh near Oea, Sidi as Sid and Ain Scersiara (Panella 1973; Arthur 1982). In Tripolitana, the form certainly lasted until the end of the 4th century, as shown by the stratigraphies of the Eastern Baths of Lepcis Magna (covering the period from the mid-3rd to the end of the 4th century), although with a morphological evolution that mainly concerned the rim. The archaeometric study of the materials from the 4 contexts of the Baths classifies the fabric of Tripolitana II in group A2 (Fine Tripolitanian ware, '*rares inclusions sableuses très grossières*'), which also shows similarities with that of the Cooking Pottery (Bonifay and Capelli 2013). The vessel has the typical characteristics of Punic amphorae: a cylindrical body, surmounted by a short neck and a rim with a double stepped moulding, handles placed on the shoulder and a massive conical foot[4]. The development proposed by M. Bonifay does not seem entirely convincing[5]. The Porto Cesareo specimens seem to belong to the "classical" form, similar to the Pupput specimens from the end of the second century AD, with a short neck that was to become longer in the following century[6].

Various specimens are coated with bitumen or pitch, which suggests that they contained fish sauces[7] or preserves or wine, although oil cannot be excluded, as some examples from Monte Testaccio in Rome seem to testify, as well as an intact specimen found in an oil mill in the territory of *Lepcis Magna* (Revilla Calvo 2007: 274; Barker *et al.* 1996: 279-280, Figure 9.11.). The Porto Cesareo specimens do not seem to have been coated. The concretions and the other area of scattered sherds don't include any other types of amphorae or vessel, whether common or fine ware.

The remains are therefore attributable to a homogeneous cargo of considerable volume, given the number of fragments and the extent of the seabed affected, i.e. an area of about 2-300 m².

This therefore seems to be a "direct" shipment from the place of production to the place of consumption (Boetto 2012): a "supertanker" traveling fully loaded with a "wholesale" shipment, probably headed east, towards the ports of the Adriatic, especially Northern. The amphora Tripolitana II is not so widespread: its distribution mainly concerns the western Mediterranean, particularly Libya (*Leptis Magna*, Misurata), Tunisia (Pupput), Spain (Tarragona, Empúries), south of France (Toulon, Anse Gerbal/Port Vendres), Italy (*Ostia*, Rome), although this form also occurs in the eastern Mediterranean (for example Israel, Atlit, etc.)[8].

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[3] Panella 1972: 562, Ostia III, forma XXIV; Panella and Rizzo 2014: 10 (Ostia VI): evidence appears from Period 4 - Phase 2 of the Ostian stratigraphies of the Terme del Nuotatore (120-140/160 d.C.) and Period 3 - Phase 2 of the Domus dei pesci, also in Ostia (150-200 AD).

[4] The Tripolitana II shown in Ostia III: 628, Figure 21, contains 53,47 lt: Rizzo 2003.

[5] C. Panella believes that some of the specimens referred to by Bonifay in the articulation of the evolutionary sequence should be referred to different forms: Panella and Rizzo 2014: 270-271.

[6] Bonifay 2004: 90, Figure. 47, nn. 4-5. Some similar examples have been found in the most ancient of the 4 contexts excavated in the Eastern bath at *Lepcis Magna*, a layer of abandonment dated back to c. 250-260: Bonifay and Capelli 2013: 121 (context 1), Figure 5, nn. 25-26.

[7] A clue to this is also the large circular hole drilled in the shoulder of the Pupput specimen, to extract semi-solid contents: Bonifay 2004: 90, Figure 47, n. 5 (see also 468).

[8] Panella 1973; Carandini, Panella 1981; Zemer 1978; Bonifay, Capelli 2024: 318-319 (a specimen from the harbour dump of Anse Gerbal, Gulf of Lyon).

Rarely found in Adriatic, the form is missing from the corpus of the Underwater Map of the Salento (Auriemma 2004, II); it is present in the fills of the Canale Anfora di Aquileia with 10 specimens, distributed along the entire stratigraphic sequence (Gaddi 2017: 387), but also in other contexts of the biggest hub of the Northern Adriatic: from the River port (Rousse 2007: 613), the storehouse of the harbour (Carre and Zaccaria 2004), '*Grandi terme*' and *Domus of Titus Macer* (Dobreva 2023: 292-293). It is worth mentioning the group of amphorae Tripolitana I reused in the cargo of the Grado 1 wreck for the transport of preserved fish, in this case mackerel (Auriemma 2000).

Other option is the route to the ports of the eastern Mediterranean, where there are also more numerous underwater testimonies, especially along the direct route to Athens or the island of Euboea or even further afield, towards the eastern Aegean, even if they are always Tripolitana I, in the wrecks of Petousi, Demakos, Makronesos (Koutsouflakis and Argiri 2015: 5-8). Both the routes could be plausible for the Butrint 2 shipwreck, along the Albanian coast, again including Tripolitana I (Royal 2012: 411-416). A single specimen, probably Tripolitana II, likely used for ship store, has been found in the Plavac A wreck, and a few examples of the same type come from Zlarin and Brijuni in Croatia (Vrsalović 1974(41): 238-240; Parker 1992: 318; Jurisić 2000: 12, 14, 24, 71).



Figure 8. The Forlimpopoli A2 type amphora neck (Photo: M. Bardashov).

Recently, the upper part of a specimen similar to the Forlimpopoli A2 type was discovered (Figure 8), detached from the concretion C due to a traumatic event (the "tear" caused by an anchor?). The isolated find, however contemporary with the amphorae of the cargo, could be related to the onboard equipment and could suggest that the ship was used to sail the route to the northern Adriatic, even though the Italic flat-bottomed amphora had a wide distribution (Rizzo and Molari 2023).

The voyage was tragically cut short at the end of the Ionian route between Crotone and Porto Cesareo. It cannot be ruled out that the original route of the ship was further south, between Capo Lacinio and Capo Iapigio, and that the same storm that led to its sinking pushed it northwards.

Hypotheses about the dynamics of the formation of this site are still under discussion. The cargo was clearly fragmented by the impact on the seabed and perhaps by the devastating environmental energy of the waves; the constant hydrodynamic movement then grouped the fragments on the seabed, collecting them both near rocky outcrops and in depressions. The shape of these blocks, ovoid with rounded edges, probably derives from the depressions in the seabed that trapped the fragments; with the consumption of the seabed, the cemented formations have been completely exposed; their "foot" is the part of the calcareous plateau that has not eroded because protected by the concretions (Figure 9). In the sandbanks, the remains were captured and hidden by sediments. To summarize, the erosion has helped to create the spectacular formations that we see today, spread over an area of about 2-300 m².

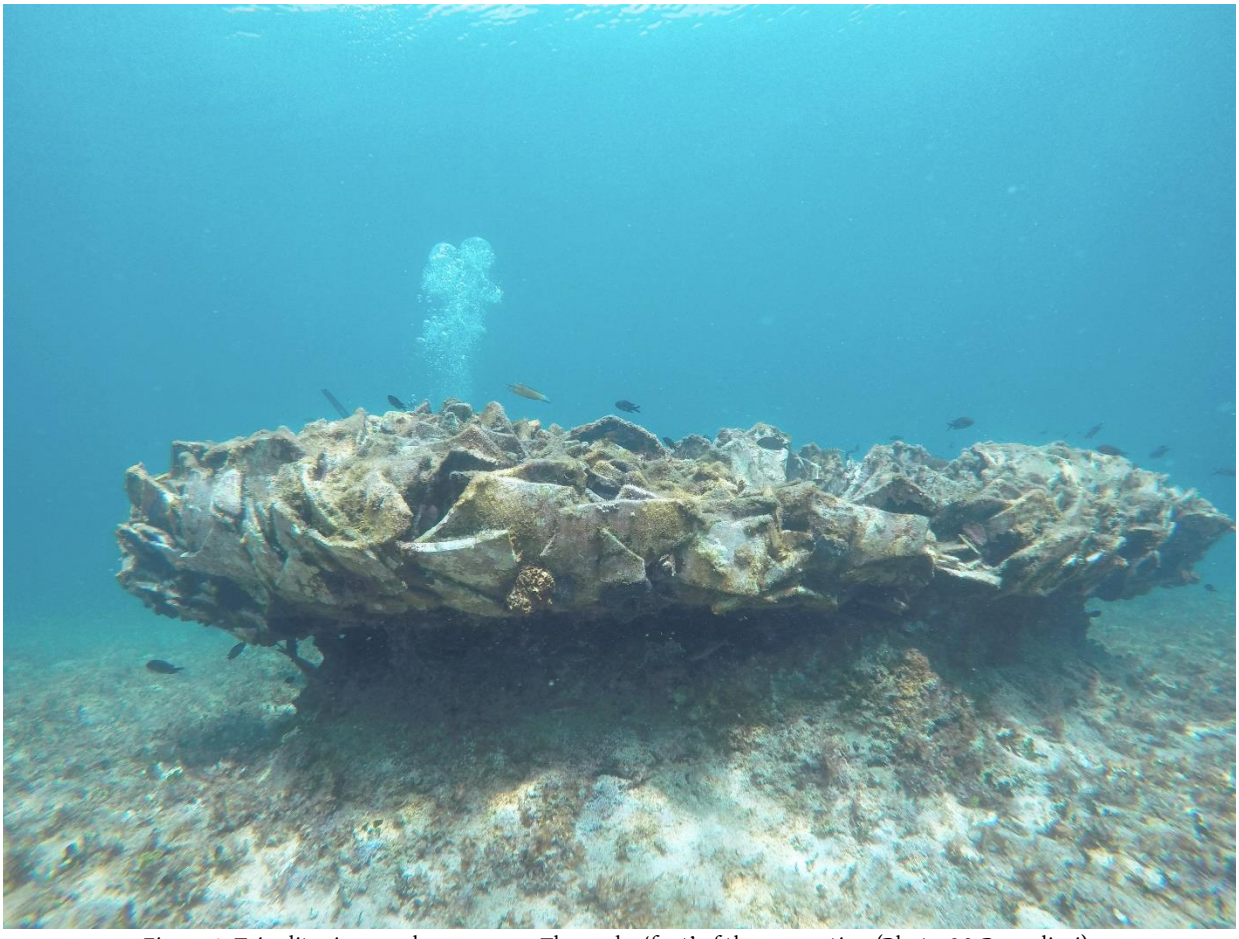


Figure 9. Tripolitanian amphorae cargo. The rocky 'foot' of the concretion (Photo: M. Buccolieri).

Biological aspects

The 'cement' that concreted the amphora fragments consists of bioconstructions, such as aggregates of Vermetid mollusc shells, calcareous tubes of polychaetes and aggregates of Balani shells. Associated with these are some encrusting red algae. When thalli of calcareous red algae (Corallinaceae, Rhodophyta) or parts of them come into contact with each other, they can anastomose, i.e. fuse together. If these thalli adhere to a hard substrate, due to a natural biotic synergy between the component species, they can form a bioconstruction. The thalli can therefore occupy a remarkable volume and have specific morphological, biological and geological characteristics. Bryozoans are also very abundant and, with around 480 species, represent an important group of Mediterranean benthic

fauna. They are particularly important in the infralittoral and circalittoral. Many species have a more or less mineralised carbonate skeleton and form relatively large colonies. These mostly multi-specific formations are thus the result of the slow growth, overlapping and subsequent fossilisation of the thalli[9].

Acknowledgements

I would like to thank A. Picciolo (who curated the biological aspects), M. Buccolieri (President of 'Coordinamento Ambientalisti pro Porto Cesareo O.d.V.'), the Centro di Educazione Ambientale – CEA, the Marine Protected Area Porto Cesareo, the Company 'Natura dal vivo', the Geomatics Laboratory and the Environmental Engineering Laboratory of the Polytechnic of Turin.

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Tools and methods (excavation, documentation, conservation, restoration)

Two Upper Adriatic pottery skyphoi from the Vilina špilja shrine overlooking the source of the Ombla River: traces of ancient repair and modern intervention

Martina Ćurković Madiraca[1], Zdenka Vrgoč[2] and Domagoj Perkić[3]

Abstract

Vilina špilja is a cave set in a steep rocky slope overlooking the source of the Ombla River in the Rijeka Dubrovačka district near the ancient core of Dubrovnik. The cave has long been known as a major prehistoric site, but recent archaeological investigation has revealed numerous potsherds dated largely to the late 5th and 4th centuries BCE when the cave was used as a local Illyrian shrine. The interpretation of the cave's use as a shrine is supported by the discovery of the finest and most valued vessels of the period; of Greek provenance (from the workshops of Attica, and of southern and northern Italy), and used solely for wine drinking. This paper discusses two large skyphoi of the Upper Adriatic ("Alto Adriatico") pottery group, i.e., ceramic ware produced in northern Adriatic workshops around Picenum, Spina, and Adria. These artefacts have small holes along the fracture lines, traces of ancient repair, which testify to their value and exclusivity. Conservation and restoration work saw the reassembly of the artefacts, reconstructed to their full height. The interesting geometric decoration is fully reproduced on the integrated areas and provides a complete visual experience.

Keywords: upper Adriatic pottery, skyphoi, ancient repair, conservation, modern intervention

Introduction

Vilina špilja is located near Dubrovnik, in the southern end of the Adriatic east coast. Access to the mouth of this cave, set in a steep cliff overlooking the source of the Ombla River, is difficult. The Vilina špilja archaeological site covers only a small portion of the cave (58 by 12 m), while the cave system as a whole extends at least three kilometres and reaches depth of 192 m. The cave saw human occupation from the Early Neolithic to the Roman period. Systematic archaeological investigation was performed in 2014 and 2015 under the leadership of Domagoj Perkić PhD.

The Vilina špilja archaeological site presents two distinct archaeological contexts. The first covers the earlier prehistoric period, between the Early Neolithic and Middle Bronze Ages, when the cave was used intermittently. The second archaeological context at Vilina špilja covers the Late Iron Age period of the late 5th and the whole of the 4th century BCE, when the cave was used as a shrine by the Illyrians and from which we have primarily Greek pottery. Notable among the pottery recovered from the period of the Illyrian shrine is ware of Greek provenance: black glaze pottery, red-figure pottery with owl motifs (referred to as glaukes [glaux] or owl skyphoi), Upper Adriatic and Gnathia ware, Saint-Valentin class kantharoi of the Athenian workshops, common fine pottery, and Corinthian type B amphorae, while

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local Illyrian ware is represented by numerous miniature vessels (Perkić 2010, Perkić 2021 and Perkić 2022). The two Upper Adriatic skyphoi discussed here are among the finest Greek period vessels found in the Adriatic area.



Figure 1. The location of the Vilina špilja site (Photo: D. Perkić). Part of Figure 1. source: d.maps <https://d-maps.com/carte.php?num_car=2224&lang=en>.

Upper Adriatic skyphoi

Upper Adriatic ("Alto Adriatico") pottery is painted ware that emerged in north Adriatic workshops in the Picenum, Spina, and Adria area late in the 5th c. BCE in imitation of red-figure pottery. The key characteristic of this ware is the use of a black, dark brown, or reddish slip applied to the lighter coloured ceramic substrate. Upper Adriatic pottery is characterised by painted motifs of women's heads in profile, stylised palm leaves, and a variety of vegetal and geometric patterns. The forms of the vessels are also adapted from red-figure ware of Attic and Apulian production. Upper Adriatic pottery dates to the period of the late 5th to early 3rd c. BCE (Miše 2012).

Investigation of the Vilina špilja cave site yielded the recovery of a significant quantity of Upper Adriatic pottery. This includes at least 52 large skyphoi. A common characteristic of these skyphoi are their approximate dimensions; they stand about 11 to 14 cm high and are about 10 to 12 cm wide. There is a high degree of similarity in the composition of the motifs, i.e., the manner in which they were painted. There is usually a particular geometric pattern, or a combination of geometric patterns, just under the rim of the skyphoi. These include combinations of squares and short lines, meanders and squares with dots, hanging triangles with or without dots, vertical lines or darts, and chequerboard, wave, and other patterns. Below the geometric pattern(s) is a thin horizontal line, followed by a wider black horizontal line, and below it the central motif bordered by two thin horizontal lines. The central motifs are usually also geometric: meanders and squares with dots, grid patterns with a dark vertical band and zigzag lines with dots, vertical lines and dots, rhomboids, spirals, and, at times, vegetal motifs such as ivy and other foliage, tendrils, and so forth. Below the central motif there usually follows a broad painted band, sometimes combined with a further one or two narrow bands. The bases of skyphoi are always dark in colour (Perkić 2021).



Figure 2. Drawing, and skyphos DUM AM 7118 following conservation and restoration work (By: Sanja Pujo).

The two Upper Adriatic skyphoi that are the subject of this paper have been assigned inventory codes DUM AM 7118 and DUM AM 7119. Both date to the 4th c. BCE, have pairs of horizontal handles and a ring foot, and are decorated with black painting against a light background, while the insides are entirely covered in a dark brown slip (Perkić 2017). Skyphos DUM AM 7118 stands 13.8 cm tall, with a mouth diameter of 15.2 cm, a base diameter of 9.7 cm, and walls measuring 0.4 cm thick. Below the rim is a painted decoration forming a horizontal series of hanging squares. Between and opposite these are single short upright rods rising from a narrow horizontal line, below which is a broader dark brown band. The central motif is situated between two narrow horizontal lines and consists of alternating hanging and standing hollow triangles, bordered by a thin-lined triangle that extends to the perimetral lines. Between the central motif and the base is a broad, horizontal, dark brown band, followed by two narrower reddish bands, followed in turn by another dark brown band that ends at the ring foot of the skyphos. Skyphos DUM AM 7119 stands 12 cm tall, with a mouth diameter of 14.9 cm, a base diameter of 10.3 cm, and walls measuring 0.4 cm thick. Below the rim is a painted decoration forming a horizontal series of meanders or squares, with the squares filled out with an oblique cross with rhomboid arms, each of which contain one black dot. Below these we see in succession one narrow and one broad dark brown band. The central motif, set between two narrow horizontal lines, consists of a horizontal series of joined elongated rhomboids. Between the central motif and the base are two dark brown horizontal bands, the lower of these extends to the ring base of this skyphos.

What set skyphoi DUM AM 7118 and DUM AM 7119 apart from the other Upper Adriatic skyphoi recovered at the Vilina špilja site are the traces of ancient repair discussed below.



Figure 3. Drawing, and skyphos DUM AM 7119 following conservation and restoration work (By: Sanja Pujo).

Ancient repair of two skyphoi

Attempts to reassemble fragments of broken objects date back to prehistory; broken objects were mended to restore them to a usable condition by joining fragments using various forms of binding. Examples of "restoration" using systems of metal staples, wires, and stitching with the purpose of restoring the utility of an object are known to us from as far back as the period of the Etruscans, who "restored" valuable Greek vases such as the kraters of the Brygos Painter (late 5th c. BCE) and Euphronios (late 6th–early 5th c. BCE), where recent conservation and restoration work has revealed bronze rivets used to join the fragments (Pergoli Campanelli 2010). We very often find examples among artefacts of the antique Greek and Roman periods of fragments that were drilled and then joined using metal rivets. The technique of drilling was used throughout the historical periods and into the modern era. A hand drill was used to create holes along the break line of fragments that were to be joined. There were a number of joining techniques, some of which involved drilling through the entire cross-section of a ceramic fragment creating a hole through which metal wire, leather cord, string, or a complex system of metal staples was passed, while in other cases the pottery was drilled to a certain depth to provide better purchase for metal staples. Stitching was usually done with bronze, iron, or lead (Ćurković 2013).

Traces of ancient repair on skyphoi DUM AM 7118 and DUM AM 7119 from the Vilina špilja site are evident as small holes along the break lines. On these two skyphoi it is evident that the places to be drilled were carefully selected in order that the "restoration", i.e., the joining of broken fragments, compromised the vessel's visual identity to the least possible extent. It seems that drill points were chosen in order to have a minimal impact on the decorative elements of the skyphoi. All of the holes in the fragments have the same diameter of about three millimetres. The holes were drilled with a sharp instrument and were set about two centimetres apart. The skyphoi found at the Vilina špilja site were joined using lead clamps, as borne out by a potsherd with a surviving intact lead clamp having a length of 1.8 cm.

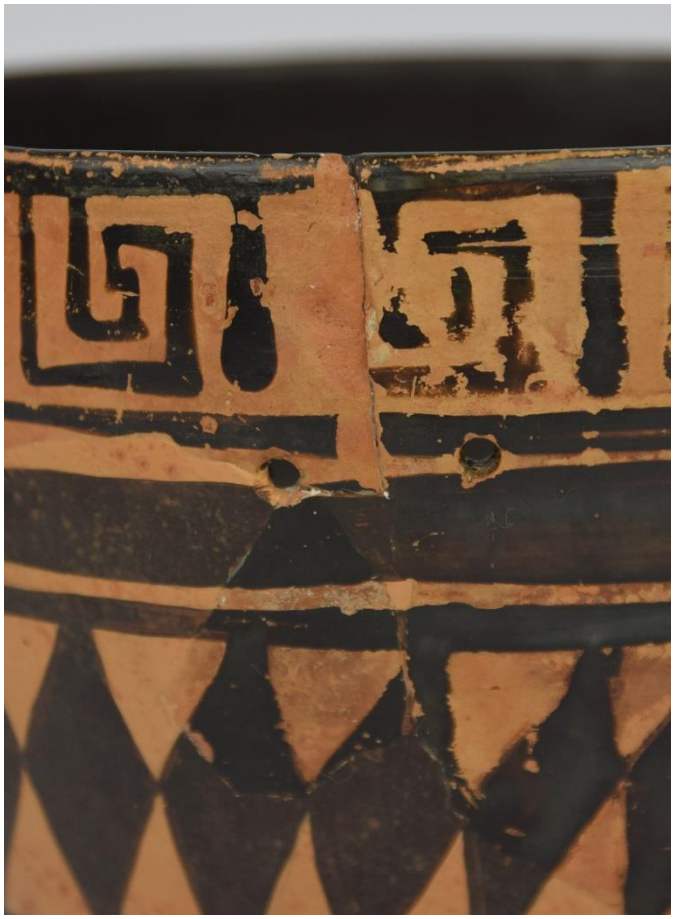


Figure 4. Traces of drilling on skyphos DUM AM 7119 (Photo: M.Ć. Madiraca).

In his work Gianpaolo Nadalini (Nadalini 2007) proposes four methods used to join ceramic fragments with clamps: ingot stitching, rivet stitching, channel stitching (a channel is carved to one side of a ceramic fragment), and opposed channel stitching (a channel is carved to both sides of a ceramic fragment). Based on the sherd recovered from the Vilina špilja site we can conclude that the skyphoi were joined using the ingot stitching method.

Ancient repairs bear witness to the significance and role of these skyphoi as a part of the inventory of a 4th c. BCE Illyrian shrine at Vilina špilja. The meticulously crafted and painted skyphoi, intended originally to serve as wine drinking-cups, were at the time considered exclusive goods in terms of both their aesthetic value and worth. This is borne out in their earliest restoration, which required both significant effort and a high degree of skill to restore valuable and precious objects to their original appearance so that they could be set in a shrine as a worthy votive offering to the gods.

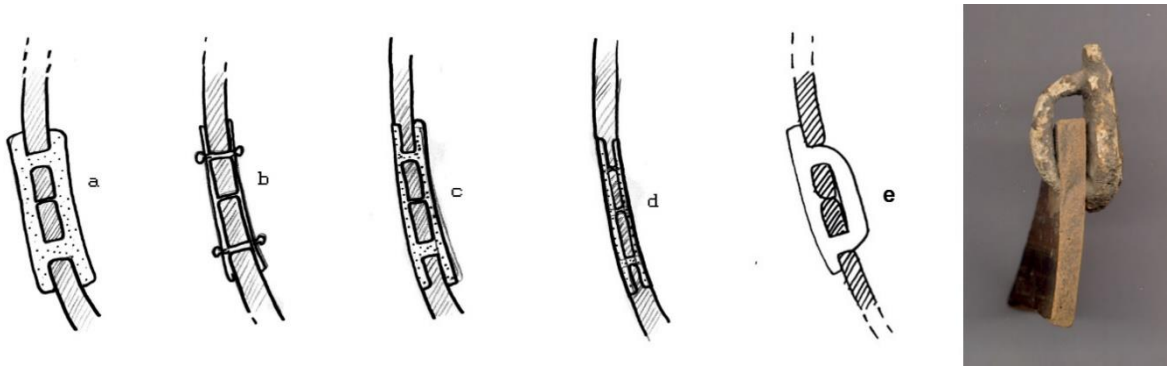


Figure 5. The four repair systems proposed by Gianpaolo Nadalini: (a) ingot stitching, (b) rivet stitching, (c) channel stitching, (d) opposed channel stitching (a channel is carved to both sides of a ceramic fragment); (e) ingot stitching found at the Vilina špilja site (Drawing: M.Ć. Madiraca), potsherd with lead staple from Vilina špilja (Photo: D. Perkić).

Modern conservation-restoration treatment

New conservation and restoration work on Upper Adriatic skyphoi DUM AM 7118 and DUM AM 7119 was performed in 2019 at The Conservation and Restoration Department of the International Centre for Underwater Archaeology in Zadar. All conservation and restoration interventions on the artefacts were performed by conservator-restorers Martina Ćurković Madiraca and Zdenka Vrgoč. These modern interventions to the artefacts were preceded by detailed photographic documentation and records of the condition of the vessels as received. Traces of previous restoration were quickly observed and were noted, marked, and documented. It was also observed that many sections of the skyphoi were missing. The sherds were covered in dirt and calcareous deposits. Following the documentation of the conservation condition of the skyphoi as received, the conservator-restorers proposed and agreed with the archaeologist in charge the following conservation and restoration procedures: cleaning, consolidation, bonding (gluing), integration, and retouching.

The first phase of conservation and restoration work saw the skyphoi sherds mechanically cleaned using scalpels under magnification (microscope and/or loupe). Dirt and calcareous deposits were removed from the surfaces of the fragments. Particular care was exercised in this very sensitive phase of conservation to avoid damaging the delicate pottery and painted slip. Fragments of the skyphoi that had previously been glued were separated using Acetone as a solvent.

This was followed by consolidation of the fragments, achieved by immersion in a 5% solution of Paraloid B72 in acetone and subsequent air-drying of the consolidant. Drying was followed by preliminary joining of the fragments into larger units using adhesive tape, followed by permanent joining using glue. The adhesive used was a 50% solution of Paraloid B72 in acetone; the fragments were fixed in place using adhesive paper tape and small grip clamps until the glue had fully hardened.

Given that most sections of the skyphoi were missing, the approach to the reconstruction, i.e., integration, of the artefacts involved the creation of full plaster reconstructions of the skyphoi on a potter's wheel using templates derived from technical drawings of the artefacts. The integration was performed using Alabaster plaster. The original skyphoi fragments were then located to and fixed in their original positions using plaster. All excess plaster was removed while still wet, and the integration was later finely worked with sandpaper of the finest grit. This was followed by the removal of residual plaster and dust and the final protection of the original surface of the skyphoi by the application of a coat of a 7% solution of Paraloid B72 in acetone. This was followed by the retouching of the integrations.

The whole of the integrated surface was first coloured using acrylic paint to a base colour tinted lighter than the colour of the original pottery. This was followed by a partial reconstruction of the painted decoration of the skyphoi to the extent that the original decoration could be confidently identified. Detailed textual and photographic documentation was kept during and following the restoration and conservation of the skyphoi.



Figure 6. The skyphoi during conservation and restoration treatment (Photo: M.Ć. Madiraca).

Conclusion

Traces of the ancient repair of the two skyphoi found at the Vilina špilja site bear witness to early attempts to restore and reinstate the functionality of artefacts deemed significant both in terms of their history and their status. The present-day, modern approach to conservation and restoration work is based on a somewhat different view, one that does not prioritise the reinstatement of function, but focuses rather on preservation, protection, and an appreciation of the original appearance of an object as such, concentrating on the observer's visual experience and speaking to past times in an informative and evocative way.

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The effects of the mediterranean climate over the southern sites of Ephesos Terrace House 2 and recommended conservation strategies

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Abstract

Located in the centre of the ancient city of Ephesos in the province of Izmir, Turkey, the Terrace House 2 residential–complex is a seven-housed insula built on three terraces of phyllate bedrock on the northern slope of Bülbül Mountain. The conservation work on Terrace House 2 started together with the excavations. Conservation work at the site continues today with systematic multidisciplinary practices. The temporary roofs built for conservation purposes and the subsequent conservation structures have ensured that most of the insula, which covers an area of approximately 4000 m^2, has survived in situ. The existing protective structure, which was completed in the early 2000s, provides a continuous air flow in the area. However, it has been determined that this air flow is relatively very low along the southern side of the residential complex and that the relative humidity is higher in these areas compared to the middle and lower terraces. As a result of this, many deteriorations such as salt efflorescence, microorganism growths, crumbling and delamination were detected, especially on the southern sides of these rooms. This study aims to discuss the existing conservation problems of the upper terrace rooms in the south of the Terrace House 2 residential complex and to present conservation strategies for the solution of these problems.

Keywords: Ephesos, Wall paintings, Preventive conservation, Remedial conservation, Restoration, Salt efflorescence, Microbial deterioration

Ephesos

Ephesus, one of the most important cities in the Roman Province of Asia, is located in the western part of modern-day Turkey, within the district of Selçuk in İzmir province. The city has long captured the interest of historians, archaeologists, and travellers, not only for its rich cultural and architectural heritage but also for its strategic role in ancient trade and religion. In the 1860s, John Wood, an engineer working in western Anatolia, initiated a search for the Artemision or Temple of Diana of the Ephesians. To that date, the Artemision was known only from history and not from actual site location or excavation. After repeated failures, Wood discovered an inscription in marble near the location of the Theatre of Ephesos in the Hellenistic Roman city of Ephesos. The inscription alluded to processions along the Sacred Way (Via Sacra) via the Magnesian Gate of the southeastern walls of the city of Ephesos

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and then across the plain to the Artemision. With this clue, Wood and his workmen proceeded to dig trenches along the edge of the marble paved roadway from the Magnesian Gate skirting around the base of Mount Pion and then to the Artemision. In fact, Wood was following the Via Sacra of early Roman Imperial time. This sacred road extended from the Magnesian Gate around the eastern flank of Mount Pion to the Artemision and back to Ephesos along the northern flank of Mount Pion (Kraft et al. 2006: 129-130). One of the most notable features of Ephesos' history is its strong connection to the worship of the Greek goddess Artemis. The Temple of Artemis, or Artemision, recognized as one of the Seven Wonders of the Ancient World, stands as a symbol of the city's profound religious importance.

During the early Hellenistic period, King Lysimachus (c. 360 BC - 281 BC) relocated the city from its Archaic-Classical site near the Artemision to the western slope of Mount Pion (*Panayır Dağı*) and the northern side of Mount Preon (*Bülbül Dağı*) (Ladstatter 2013: 16-24). This new location became the foundation for the large Hellenistic-Roman city of Ephesos (Figure 1). Its strategic position along the Aegean coast made the city a vibrant centre for commerce and cultural exchange. Over time, the city's importance continued to grow, emerging as a major hub of the Hellenistic world and later serving as a crucial Roman provincial capital. The over three-thousand-year history of the city serves as further evidence of humanity's enduring roots. Throughout various civilizations, Ephesos maintained its significance as a major hub of commerce, culture, and religion, integrating its history with that of the Mediterranean World (Zimmermann and Ladstatter 2010: 28-30; Kraft et al. 2006: 130; Weiss 2010: 67-72).

After Pergamom, Ephesus, the capital of the Roman Empire's Province of Asia, became one of the largest cities in the region. Its strategic location, opening to key land and sea routes, made the city a central hub for trade and communication with surrounding cities and regions. The reign of Emperor Augustus (Caius Caesar Octavius), who ascended to the throne in 27 BC, marked a period of rapid development and prosperity for Ephesus (Zimmermann and Ladstätter 2011: 37). This era was also characterized by extensive building and construction activities. Public structures such as cult centres, agoras, and other political spaces were funded by donations from wealthy citizens (Ladstätter 2013: 25). These benefactors not only contributed to the construction of the city's grand silhouette but also initiated the development of private residences on the hillsides (Ladstätter 2013: 25).

In terms of artistic style, Ephesus was influenced by both Eastern elements and the prevailing artistic traditions of Rome. As a result, the city integrated architectural and mural design principles from both traditions. After Pompeii, Ephesus became one of the most significant and reliable sources for the study of Roman-period painting. Excavations and research conducted to date have revealed the largest collection of wall paintings, particularly from the Terrace House 2, an insula comprised of seven residential units surrounding a peristyle courtyard (Zimmermann and Ladstätter 2011: 15).

Terrace house 2

In the period of Roman Empire, Ephesos flourished rapidly during the reign of Augustus (Gaius Caesar Octavianus) and swiftly became one of the powerful metropolises of the era. (Ladstätter 2013: 16- 37). Thanks to various factors such as the absence of modern urban development in the area, the city has been largely excavated in situ despite the significant destruction caused by earthquakes. Within the scope of the Ephesus excavations, Terrace House 2 was uncovered, revealing its construction on the northern slope of Mount Preon (*Bülbül Dağı*). It is bordered to the south by the Terrace House Street, which runs east to west, and to the north by Curetes Street (Figure 1), one of the major thoroughfares of the ancient city (Eskici et al. 2023, 51-55). Located at the centre of the ancient city of Ephesus, this

insula spans an area of approximately 4000 square meters and consists of seven residential units built on three terraces (Figure 2). Established during the Augustus-Tiberius periods, and it was inhabited until the early 7th century. In addition, Terrace House 2 has more than 75 rooms where wall paintings have been uncovered and preserved in situ (Gürçay Yılmaz 2023: 23). Although it is known that other building complexes with similar characteristics exist in the vicinity of Terrace House 2, these areas have yet to be excavated, leaving their full significance and details unexplored.



Figure 1. Left, İzmir province, Selçuk district, Turkey and right, the location of Terrace House 2 in Ephesos (URL 1).

Excavations at the Terrace House complex began in 1962, and by 1967, the pace of excavation and research had significantly increased. Under the leadership of Hermann Vetters, the focus was on large-scale uncovering and investigation of the structures. The initial excavation phase, which lasted until 1985, revealed numerous wall paintings from various construction phases (Eichler 1963: 52; Eichler 1968: 85-90; Vetters 1970: 7-17; Vetters 1988: 98; Gürçay Yılmaz 2023: 22-24). In 1986, the first excavations and surveys beneath the ground level were initiated, prompted by the necessity to construct a protective structure and covering for Terrace House 2 (Figure 3). These initial sub-level investigations were primarily focused on ensuring the long-term preservation of the site. Later, in 2004, further excavations conducted below ground level not only expanded our understanding of the complex but also led to significant revisions in the chronological framework of the insula. The findings from this period reshaped previous interpretations of the construction phases and the historical development of the area (Ladstätter et al. 2005: 247-248; Eskici et al. 2023: 51-55; Gürçay Yılmaz 2023: 21-30). On the other hand, conservation practices at Terrace House 2 began concurrently with the excavations and continue to be carried out systematically and through multidisciplinary approaches to this day (Gürçay Yılmaz 2023:53-77).

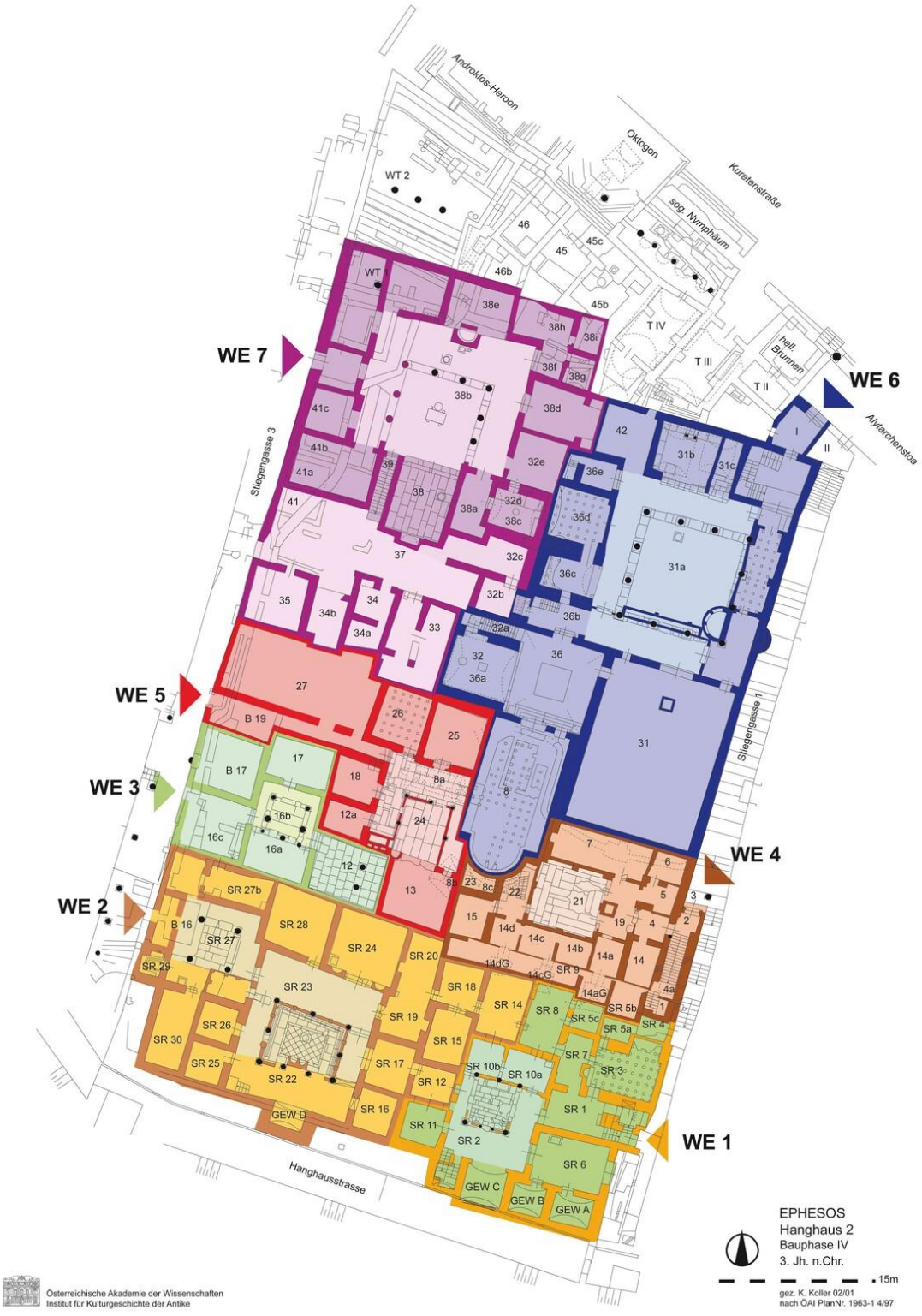


Figure 2. Ephesos Terrace House 2 residential plan (ÖAI Archives).



Figure 3. Left, view of Terrace House 2 from Mount Pion (Panayır Dağı) (URL 2) and right, view of the facade slats and cover of the protective structure.

Location and climate characteristics

Ephesos is situated within the subtropical climatic zone (Kottek et al. 2006: 261). The area experiences hot and arid summers, and mild rainy winters, indicative of a maritime climate. The geographical location of Terrace House 2 exposes it to high temperatures during the summer months and high relative humidity values during the winter months. Furthermore, spaces located to the south of the residential complex may exhibit higher relative humidity levels compared to outdoor areas and lower terraces, even during the warm summer months.

Due to Protective Structure of Terrace House 2, residential units are largely preserved from atmospheric conditions and rainfall. The effects of rainfall, particularly intensified during the autumn and winter months, are minimized by the existing protective structure. However, it is important to note that the drainage system of the protective structure, as well as the ventilation openings on the roof and facade, and potential issues on the roof, could pose risk factors that may directly affect the residential units. Additionally, it is observed that the protective structure's architecture provides limited and insufficient air flow in the southern spaces of the upper terrace.

Water, relative humidity and their effects on south spaces of Terrace House 2

Although the effects of rainfall, which increases especially in the last autumn and winter months, are minimized by the existing protective structure, problems that may occur in the drainage system, ventilation openings and roof of the protective structure carry high-risk factors that may directly affect most of the residential units. The green phyllate bedrock on which Terrace House 2 is built allows groundwater to easily seep into the residential units (Gürçay Yılmaz, 2023, pp. 81-83). Field surveys have documented that the areas most severely affected by groundwater infiltration into the housing units due to bedrock and protective structure problems are residential unit 1 (WE 1) and residential unit 2 (WE 2) on the upper terrace in the south of the residential complex (Figure 4).

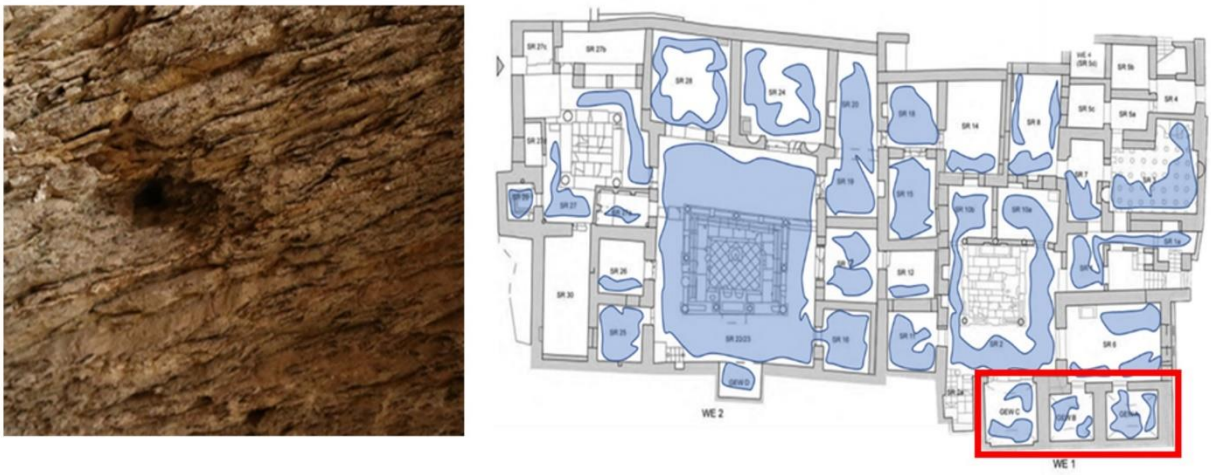


Figure 4. Left, phyllate rock in unit 4, space 14dG; right, some areas where water seepage from the upper terrace affected units 1 and 2 (Gürçay Yılmaz 2023:81-82).

Through field research, it has been documented that the environmental climate conditions, groundwater seepage, and inadequate air circulation issues have the most severe impact on residential units 1 (WE 1) and 2 (WE 2), located in the southern part of the insula. The effects in question increase along the southern line located on the upper terrace of the residential units. In these areas, wet areas can be observed on the surface of the wall paintings and mosaic floors even during the dry summer months. Moreover, water rising from the ground due to capillarity may the main cause of many deteriorations seen on wall paintings. Water seeping from the hillside is drawn into the protective structure due to drainage and structural problems. On the other hand, the air flow provided inside the protective structure by facade panels and roof openings does not prevent the formation of condensation on the cover of the protective structure during seasonal periods when relative humidity values are high. Small water droplets accumulated by condensation on the cover of the protection structure collect at some concave points of the roof and drip into the residential units.

Apart from the aforementioned factors, the geographical location of Terrace House 2 causes the residential unit to be subjected to high temperatures in the summer and high relative humidity in the winter. On the other hand, the airflow provided by the protective structure is insufficient for the southern rooms of the upper terrace, and in these places of residential unit, high relative humidity levels can be observed even during the hot summer months compared to outdoor areas and lower terraces. In 2023, as part of the wall painting conservation and restoration projects conducted in collaboration with ÖAI and Ankara Hacı Bayram Veli University- Department of Conservation and Restoration of Cultural Properties, dataloggers were placed in selected areas of the residential units and an outdoor reference point to monitor annual relative humidity and temperature data. Initial measurements used to evaluate approximately one month of relative humidity and temperature data during the hot summer months indicated that the relative humidity values in the southern rooms of the upper terrace were higher than those of the outdoor reference. The annual data obtained from the dataloggers will be presented in studies evaluating the data collected between September 2023 and September 2024.

Relative humidity - related conservation issues

The climate conditions within the protective structure of Terrace House 2 exhibit temperature and humidity levels that are highly conducive to the growth of microorganisms and plants. Winds entering through the openings of the protective structure can carry various plant pollens and spores. Additionally, seeds of herbaceous or rooted plants transported by animals, for example through feces, can also thrive in this favourable environment. This situation may lead to the emergence of unwanted biological activities and vegetation within the area.

The growth of microorganisms is largely inhibited by the architectural design and airflow provided by the protective structure. However, areas where air circulation is insufficient and humidity levels are relatively higher create favourable conditions for microorganism growth. Particularly, areas affected by water seeping from the hillside and those exposed to water dripping due to condensation on the covering are more susceptible to the development of microorganisms and plants (Figure 5). These environments, which provide the necessary moisture and temperature conditions for the proliferation of microorganisms and plants, require special attention.



Figure 5. Unit 7, 32e, microorganism growth on the floor mosaic in the area affected by dripping water from the roof (Gürçay Yılmaz 2023: 97).

Plants can damage the connection between the ground and the wall through their root development, and they can also cause separation between the construction layers of wall paintings. Furthermore, plants require water to sustain their growth; they absorb water through their roots and leaves, which leads to increased moisture levels in the environment and the ground, as well as temperature

fluctuations. This situation results in indirect wetting-drying processes, and in the presence of soluble salts, dissolution-crystallization, in addition to the effects of hillside water. Also, the protective structure of Terrace House 2 creates an ideal fauna for insects and animals such as birds, cats, foxes, ferrets and martens. Organic waste resulting from the life cycles of these, can lead to irreversible chemical degradation.

As a result of the wetting-evaporation (wet-dry) cycle following water leakage, the salts carried by the cycle may crystallize on the surface. These salts can crystallize between layers in wall paintings and mosaics, resulting in separation of the layers. The dissolution-crystallization cycle of salts can lead to increased porosity in mortars with porous structures, decreased strength in construction layers, cracks, hairline cracks, white veil, bulge, crumbling, loss of paint layers, surface and piece loss etc. (Mora et al. 1984: 178; Arnold and Zehnder 1987: 103-135; Baglioni et al. 2015: 63-64).

Conservation recommendations

Regulations and decisions made by ethical committees regarding the conservation and restoration of cultural heritage should be binding for experts and management teams involved in conservation and restoration interventions. The Venice Charter of 1964 (ICOMOS 1964) forms the foundation of conservation and restoration practices and contemporary professional limitations. This charter establishes standards for the preservation of historical buildings and artifacts, ensuring that interventions are carried out within the framework of scientific and ethical principles. Adherence to these principles by experts and management teams guarantees the sustainable preservation of cultural heritage and its transmission to future generations. As stated in Article 13 of the Nara Document on Authenticity (1994), the judgment of authenticity is dependent on the nature and cultural context of a monument or site, and relies on a variety of information sources. These sources include design and form, materials and substance, use and function, traditions and techniques, location and setting, spirit and feeling, as well as original design and historical evolution. These sources may be found within the work itself or outside of it. Utilizing these sources allows for the identification of cultural heritage in its artistic, technical, historical, and social dimensions (ICOMOS 1994: 2). The physical reflection of this article is evident in the excavations and conservation-restoration works of Terrace House 2. The Venice Charter, the Nara Document on Authenticity, the 1990 Charter for the Protection and Management of the Archaeological Heritage, and the 2023 ICOMOS Principles for the Preservation and Conservation-Restoration of Wall Paintings serve as fundamental guides and limitations for the conservation and restoration of the wall paintings in Terrace House 2. Since the inception of excavations on the site, conservation processes such as consolidation, cleaning, and integration have aimed to achieve the most effective preservation with the least possible intervention. The primary limitation of all restoration practices has been to ensure the preservation of authenticity and to prevent damage to archaeological remains during restoration activities.

In the conservation and restoration practices of Terrace House 2, the primary objectives of the conservation and restoration staff, who possess comprehensive training and specialized expertise, are to assess the current condition of the cultural heritage, improve its current state while preserving its authenticity, and identify and eliminate agents that cause or could potentially cause conservation issues. The wall paintings of Terrace House 2 should be considered from a holistic perspective along with the structural elements of the residential complex and the flooring components. Therefore, if there are structural issues with the supporting vaults or walls, they should be resolved first. The current condition of the mosaics and floor coverings in the areas where wall painting conservation and

restoration will be carried out should be assessed, and if necessary, the conservation and restoration of the flooring and floor decoration elements should be completed prior to the wall painting conservation and restoration practices. Therefore, prior to planning the conservation and restoration of wall paintings, it is essential to identify the structure where the wall painting is located, the technique used to create the wall painting, any repairs it has undergone, its current state of preservation, and the sources of deterioration. In other words, the initial activities of a conservation and restoration specialist dealing with wall paintings should involve recognition, identification, and examination (Eskici and Eryurt 2021: 131). The process of recognition, identification and investigation, often referred to as diagnosis, is of great importance in the formulation of conservation and restoration strategies. These involve multidisciplinary research and documentation practices that develop from the basics of visual on-site survey, instrumental investigation and laboratory analysis.

Conservation and restoration projects for wall paintings are based on documentation practices that involve examination through phenomenological approaches (Weyer et al. 2015: 230-231). Through a comprehensive evaluation and examination of data obtained under a phenomenological approach, the original structure, current condition, and deterioration factors of wall paintings can be identified. This enables the development of conservation plans for the present, past, and potential future, the diagnosis of current conservation issues, and the implementation of appropriate conservation and restoration interventions. Investigations and research conducted with attention to the integrity of the structure to which the wall paintings belong ensure that intervention priorities are correctly determined (Eskici and Eryurt, 2021: 131-132).

Preventive conservation

The term of preventive conservation (Özdemir 2023: 404-410; 410) encompasses all measures and actions aimed at eliminating or minimizing the potential risk of deterioration. Its effects on wall paintings are indirect, involving practices that do not interfere with the original material and structure or alter their current appearance. Preventive conservation activities include monitoring environmental factors (such as temperature and relative humidity, air pollution, light, and other environmental conditions), climate control, condition assessment and regular surveys, proper handling and emergency planning, staff training, raising public awareness, and implementing legal measures (ICOM-CC 2008: 1-2). Considering the conservation practices of past years, it can be said that the success of preventive conservation planning for cultural heritage as a whole depends on its implementation and monitoring by qualified conservation professionals. Therefore, the development and execution of preventive conservation strategies by conservation specialists are of great importance. Preventive conservation efforts do not involve direct intervention in the artifact; they require specialized training and the expertise to design complex, long-term management plans. These efforts encompass multidisciplinary approaches and represent a long-term process that may require repetition following continuous monitoring (Özdemir 2023: 414).

Monitoring environmental factors inside the protective structure

With the exception of remote monitoring, there are no systems installed for remote condition monitoring, tracking or surveillance in the Terrace House 2 residential complex and protective structure. This lack of automated monitoring systems necessitates the continuous presence of specialized personnel on-site, capable of regularly inspecting the condition of the structures and

manually overseeing any condition-monitoring devices that may be in place. These experts would be responsible for implementing condition assessment protocols, identifying potential issues within the structure, and taking the necessary preventive measures in a timely manner.

In addition to this, a separate team of specialists should be tasked with conducting periodic maintenance of the buildings. Their role would be crucial in ensuring the success of any remedial conservation interventions. However, it is essential that all maintenance and inspection activities avoid causing any damage to the original architectural elements of the structures or altering their aesthetic appearance. Regular condition assessments, along with the monitoring of environmental factors that could lead to deterioration, form the cornerstone of preventive conservation strategies, which are vital for the long-term preservation of the site. Unlike preventive conservation, remedial conservation may involve direct intervention. Some remedial conservation processes, such as desalination, salt extraction, and treatments to address microorganism and plant growth, may result in visible changes to the appearance of wall paintings after these procedures are carried out. Interventions targeting biological deterioration factors, as well as techniques like consolidation, stabilization, salt removal, and the drying of damp areas, are crucial aspects of restoration and conservation measures that need to be implemented as part of a broader effort to conserve and restore wall paintings. These interventions are essential to halt ongoing deterioration and ensure long-term preservation (ICOM-CC 2008: 2).

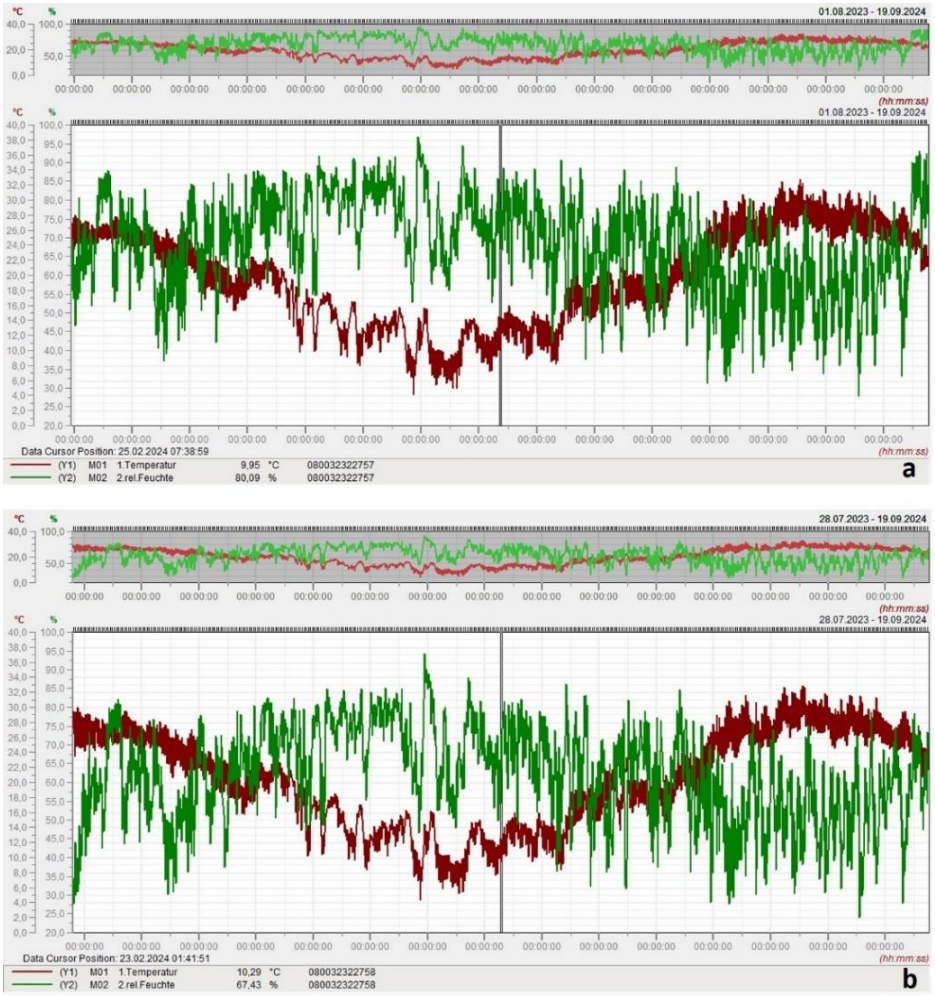


Figure 6. Annual datalogger graphs of Terrace House 2 (a: third terrace, b: first terrace).

A total of eight devices were installed at Terrace House 2. This included seven devices placed on the southern façades of various spaces across three terraces, as well as one datalogger for outdoor reference measurements. These dataloggers are utilized to conduct annual measurements of relative humidity and temperature.

The initial annual data on relative humidity and temperature collected by the installed dataloggers was obtained during the 2024 Wall Painting Conservation and Restoration Project, and the annual maintenance of the dataloggers has been conducted. The annual data obtained from the dataloggers indicate that the measurement points on the southern façade of the third (upper) terrace experience approximately 15% higher relative humidity on average throughout the year compared to the measurements taken on the second (middle) and first (lower) terraces (Figure 6).

Condition survey planning and maintenance

Condition survey activities conducted by experts play a crucial role in the rapid identification of deterioration factors and the associated conservation challenges. In addition, condition survey facilitates the planning and implementation of the most effective remedial conservation, preventive conservation, and restoration strategies. Under normal circumstances, such processes should be carried out at least once every six months or, at the latest, annually. However, it is imperative that macroscopic periodic inspections of the entire insula and the maintenance of protective structure components occur at more frequent intervals. For instance, the cleaning of the visitor route through Terrace House 2, which remains open to the public throughout the year, may need to be performed every other day, depending on the level of use. The condition of the modern elements within the protective structure that make up the visitor route should be monitored on a weekly or monthly basis, with immediate interventions carried out if deemed necessary. Ensuring the regular maintenance of both the structure and visitor pathways is critical to preserving the site's integrity and enhancing the visitor experience.

The implementation of condition survey activities within a strategically planned program by experts is of utmost importance. As part of this program, a wide range of parameters must be monitored. These include checking for the presence of any water leakage from the roof, the maintenance and waterproofing of the protective structure, joint openings, the functionality of the drainage system, structural risks, visible cracks and new crack formations, water leakage from the main rock, and the presence of wet and moisture traces on the floor or walls. Other factors include salt efflorescence, microbial activity, animal movements, thermohygrometric values, air quality measurements, and lighting conditions. Additionally, it is critical to regularly monitor potential water seepage from the hillside, assess structural risks, and detect signs of moisture or dampness in the floors and walls of the units. All these critical factors must be periodically observed (Eskici and Eryurt 2021: 136-137; Gürçay Yılmaz 2023: 121). The data collected from these condition survey activities should be carefully documented, both in written and visual formats, ensuring a comprehensive record for future analysis (Gürçay Yılmaz 2023: 170-173). The systematic evaluation of the data and observations gathered from regular, periodic monitoring efforts will enable experts to prioritize interventions and determine the urgency of necessary actions in the planning of wall painting conservation and restoration projects.

Control of biological deterioration agents

Biological deterioration factors can be identified through regular condition monitoring and surveillance activities carried out as part of preventive conservation efforts. These factors can be mitigated or prevented through periodic maintenance interventions. Within this framework, the types of microorganisms, plants, and insects present in the area can be detected with periodic survey, allowing for appropriate and targeted interventions using suitable materials. Periodic condition monitoring provides data that can be used to select appropriate biocides, herbicides, and pesticides depending on the types of microorganisms, plants, and insects detected. For microorganism control, specific biocides may be employed, while herbicides can be selected based on plant species, and pesticides can be applied for insect management according to the insect type. If the use of any biocide, herbicide, or pesticide is deemed necessary by conservators, it is recommended that the selection of these products be overseen by conservation experts. These experts could consult with professionals from various fields to ensure the correct materials are chosen and applied. However, despite these interventions, it may not be possible to completely eliminate the risks of microorganism and plant growth if underlying environmental issues, such as moisture and water leakage, are not adequately addressed.

In field surveys and annual condition monitoring studies, it has been determined that the spaces on the southern facade of Terrace House 2 exhibit relatively higher levels of biodetorations. In order to prevent the spread of spores, pollen, and plant seeds, which form the basis of microorganism and plant activity and are carried by wind through openings in the protective structure, as well as those introduced by animals via feces, it is necessary to filter the fresh air entering the protective building and secure ventilation openings to prevent animal entry. Although it is not currently possible to establish a fully sanitized, climate-controlled environment within the residential complex, the most effective and appropriate biocides and herbicides can be applied in response to identified biological threats. These measures can be implemented in conjunction with periodic maintenance activities, based on condition monitoring protocols. Such planned interventions are essential to minimizing the risks of biological degradation and supporting long-term conservation strategies for the site.

To address biological deterioration factors, the interventions should aim for sustainable and long-term results. It is recommended that efforts, such as identifying and eliminating moisture sources like structural issues, improving climate control, and detecting and mitigating biological activity, be carried out through research, planning, and implementation processes in collaboration with experts from various disciplines. Terrace House 2, located beneath the protective structure, functions as a faunal ecosystem due to its geographical position and the temperature and relative humidity levels within the protective structure. This area provides favourable living conditions and a sheltered environment for a wide range of species, from microfauna to mammal predators like cats, foxes, ferrets etc. Removing a specific group from this ecosystem could disrupt the balance of the life cycle and lead to the uncontrolled growth of certain populations within the site's biodiversity. Therefore, the measures taken to control biological deterioration must be determined through a multidisciplinary approach to ensure the ecological balance is maintained.

Restoration

Restoration encompasses all interventions directly applied to a cultural asset with the aim of enhancing its value, comprehensibility, sustainability, and usability. These actions are rooted in respect for the integrity and authenticity of the original material, and any modifications must align with the historical

and cultural significance and authenticity of the object. While restoration often results in changes to the visual or structural appearance of the item, all such interventions must be approached with great care to preserve the essence and authenticity of the object. The goal of restoration is not to obscure or alter the original features but rather to preserve and stabilize the object's current state, ensuring its stability for both the present and future generations. Ultimately, restoration serves to make an artifact accessible and meaningful to contemporary audiences while safeguarding its historical integrity.

Intervening to address microbial activity, reducing salt accumulation, and consolidating the weakened wall paintings and structural elements are critically important for improving and preserving the current state of the southern sections of Terrace House 2. These interventions are essential not only for stabilizing the sensitive surfaces and supporting materials but also for mitigating the risk of further deterioration. Without such measures, the integrity of the wall paintings and the surrounding architecture would continue to degrade, potentially leading to irreversible damage. The comprehensive restoration plan for the southern section of Terrace House 2 must involve targeted interventions that address both biological factors and conservation issues and their consequences, ensuring the long-term preservation of these culturally significant areas.

During the Wall Painting Conservation and Restoration projects at Terrace House 2, annual condition monitoring activities are conducted as part of the preservation strategy. The condition survey conducted in 2022 revealed that the southern spaces of Unit 1 and Unit 2, located on the upper terrace, required immediate conservation planning due to their deteriorating condition. Additionally, in the spaces labelled GEW A and GEW B, situated on the southeastern façade of Terrace House 2, significant microbial activity and salt efflorescence were detected. As a result, these areas were prioritized for inclusion in an emergency intervention program. This prioritization was deemed critical to address the accelerated degradation and prevent further detorations to the wall paintings and architectural structures within these spaces. The findings emphasize the necessity of regular condition assessments in identifying urgent conservation needs and ensuring the long-term preservation of the site's cultural heritage. The conservation and restoration program carried out in 2023 in the GEW A and GEW B rooms was planned based on the condition surveying conducted in 2022 and the subsequent evaluation of the results. These efforts primarily focused on addressing the significant salt efflorescence and controlling microbial growth, particularly on the southern walls of both rooms. Following these interventions, comprehensive consolidation treatments were implemented to stabilize the affected areas.

Salt reduction

The dissolution and crystallization cycle of salts can lead to increased porosity in mortars with a porous structure, reduced strength in construction layers, formation of capillary cracks, crumbling, loss of the paint layer, separation between layers, and surface and fragment loss (Figure 7). Therefore, it is essential to continuously monitor temperature and relative humidity values in the area through periodic condition surveys. Additionally, it is crucial to implement remedial conservation practices in residential units and apply regular maintenance programs for the protective structure. Regular condition assessments and maintenance schedules will ensure the preservation and longevity of the structures.



Figure 7. Detail, Unit 1, GEW A, salt efflorescence and layer formations on the southern wall.

In the southern spaces of the upper terrace of Terrace House 2, particularly in areas close to the bedrock and the exterior façade of the protective structure, it is difficult to ensure the long-term effectiveness of salt extraction and desalination interventions without first addressing underlying issues. Without resolving these factors, any interventions aimed at removing salts from the surfaces are likely to be temporary at best. As a result, areas such as GEW A and GEW B, where salt extraction and desalination measures have been implemented, will need to be closely monitored over time. Unfortunately, in such environments, the reapplication of salt removal treatments may be necessary at regular intervals. Therefore, it is strongly recommended to prioritize the elimination of the sources causing salinization before proceeding with any desalination and cleaning procedures. This approach will not only enhance the efficacy of the conservation processes but also help mitigate the recurrence of salt-related degradation in the long term, contributing to the overall preservation of the site.

The methods to be applied in practice should be determined based on the existing salinization, the source and origin of the salt layer, and the current condition of the wall painting. Accordingly, mechanical cleaning methods can be employed in the presence of soluble salts (Gürçay Yılmaz 2023: 128-130); salt efflorescence and the resulting white haze layer can be addressed using solvents such as distilled water, impregnated in cellulose pulp, special clays like sepiolite and Japanese Paper (Figure 8). In the presence of sulfate salts, neutralization with barium hydroxide and ion-exchange resins is recommended (Botticelli 2003: 91-94, Weyer et al. 2015: 307; Gürçay Yılmaz 2023: 136-138). The origin of the salt efflorescence will determine the intervention procedures. Therefore, in case of salinization during condition survey studies, the priority should be identifying the source and composition of the

salt. Salt reduction interventions may require controlled and repeated applications; thus, the planning, execution, and monitoring of the intervention process should be carried out by conservation specialists (Figure 9).



Figure 8. Unit 1 GEW A, 2023 wall painting conservation and restoration project - salt reduction with Japanese paper.



Figure 9. Terrace House 2 Wall Painting Conservation Project 2024, salt reduction with sepiolite.

Consolidation

In the southern sections of Terrace House 2, specifically within Unit 1 and Unit 2, elevated relative humidity levels, water seepage from the bedrock, and other related factors have led to destructive forms of deterioration. These include delamination between structural layers, increased porosity in mortar layers, formation of calcite layers, surface erosion, salt efflorescence, and microbial growth, all of which are destructive detorations the integrity of the structural elements, wall paintings, and mosaics. The severity of this degradation lies in its potential to escalate if not promptly addressed. Without immediate intervention to halt these processes and improve the current conditions, the original structures risk losing their structural integrity at a micro level, eventually resulting in surface loss, fragmentation, cracks, and even breakage.

Consolidation processes are aimed at restoring and enhancing the mechanical strength and structural integrity of architectural elements such as walls and vaults, as well as decorative features like wall paintings and mosaics. These treatments are crucial for stabilizing both structural and decorative components that have been weakened over time. Within the conservation programs at Terrace House 2, various consolidation techniques have been employed, including temporary consolidation, grout injection, and the consolidation of mortar and paint layers in wall paintings, as well as mortar restoration within the construction layers. These interventions function as both restoration and remedial conservation processes, designed to address immediate stabilization needs and long-term preservation, ensuring the durability and integrity of the site's architectural and decorative elements.

In temporary consolidation applications, the materials used are expected to be fully reversible, non-reactive with the treated surface, and free of residual deposits. These interventions aim to preserve and temporarily stabilize the original structure until long-term consolidation treatments can be implemented. Various materials and techniques may be employed for temporary consolidation, depending on factors such as the condition of the cultural asset and the specific characteristics of the area being treated (Gürçay Yılmaz 2023: 130-142). Cyclododecane, in both solid and spray forms, has been used effectively in the southern sections of Terrace House 2, providing consolidation on treated surfaces for a minimum of one to two weeks, depending on the thickness of the applied material. The use of cyclododecane in today's temporary consolidation practices is recommended due to its ability to provide sufficient time for long-term treatments, enhance the structural integrity of the surface, and sublimate without leaving any residue. However, the effectiveness of cyclododecane products varies depending on the manufacturer, so it is crucial to choose the appropriate product and form (solid or spray) based on the specific characteristics and conservation needs of the area requiring treatment.

The loss of structural integrity caused by delamination requires a consolidation process that reestablishes adhesion between the layers using appropriate conservation and restoration materials (Botticelli 2003: 103-105). In areas where separation has been detected between the support, mortar, plaster, and paint layers, liquid mortar injections can be applied through small cracks, holes, or gaps along lacunae or the edges of borders. To prevent potential risks during this process, it is essential that the water content and physico-chemical properties of the injection mortar are compatible with the area being treated. In other words, the injection materials must be selected according to the specific characteristics of the structure—whether it be a wall, vault, mural, mosaic, or other feature—and their properties should be fully understood. The PLM series is utilized in the field due to its transparent composition, absence of salt content, and performance values that adhere to standard limits (Figure 10a). Continued use of this product is recommended for its effectiveness in restoration. Additionally, it is important to monitor the development of higher-performing products that may result from

comparative research and material development studies on commercial injection mortars. These advancements could provide more effective solutions for future consolidation treatments.

Consolidation practices in conservation are in constant development and transformation, driven by research on materials and practical experience. For many years, acrylic resins have been widely used for various applications such as consolidation, adhesion, and surface coating. However, issues arising from the use of these resins have started to be observed over the course of decades. Research studies focusing on the use of these materials have strengthened the calls for discontinuing their use, particularly in the consolidation of wall paintings (Baglioni et al. 2015: 18-19; Gürçay Yılmaz 2023: 145-148).

In the conservation work on the wall paintings of Terrace House 2, the lime matrix areas, such as plaster and paint layers, are treated by considering factors like the porosity of the cultural heritage material and its material composition. Nano-lime products, specifically the CaLoSiL series (Ziegenbalg et al. 2018: 135; 164-165) and the Nanorestore series (Baglioni et al. 2015: 30), continue to be used, and it is recommended to maintain the use of nano-lime materials for the consolidation of lime matrix elements. Nano-lime dispersions can be applied using common techniques such as spraying, immersion, or injection (Figure 10b). The ideal method should be determined by the condition of the original material, the characteristics of the underlying layers, and the results of spot tests. The selected application technique may be adapted to specific circumstances. It is essential to take into account recommendations for some standard techniques in the application of nano-lime dispersions (Ziegenbalg and Dietze 2018: 416).

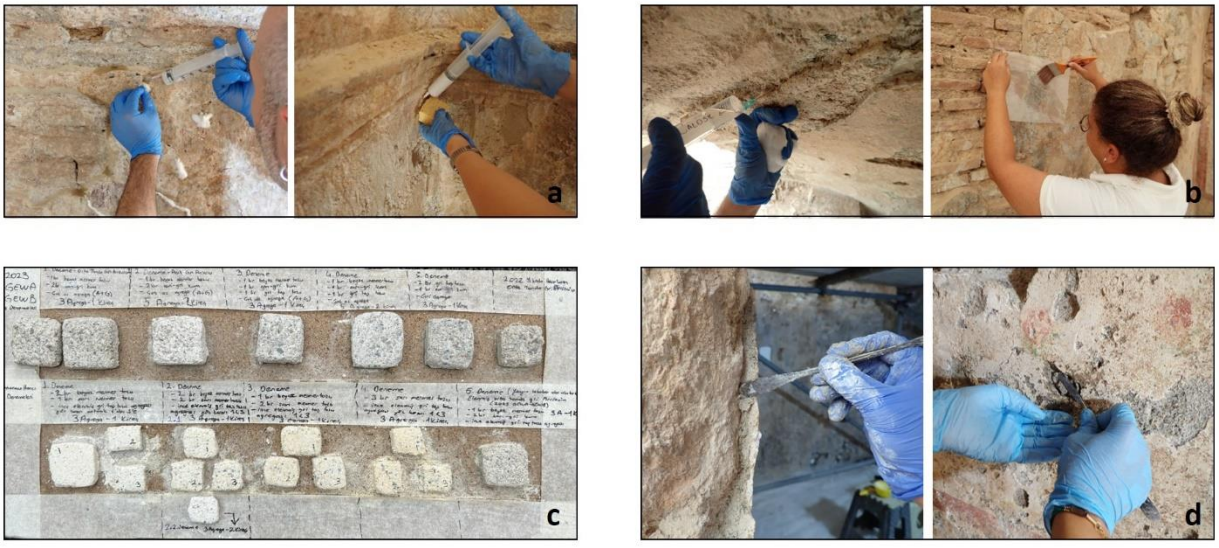


Figure 10. 2023, consolidation in GEW A and GEW B wall paintings (a: injection mortar use; b: nano lime CaloSİL E25 use for mortars and Nanorestore PlusPropanol 5 use for painting surfaces; c: mortar restoration testing set; d: border mortar application and lacuna filling.

Joints, cracks, lacunae, and other areas where the structural integrity of architectural or decorative elements has been compromised—such as weak fresco edges and gaps in the mortar—may require consolidation with repair mortar (Weyer et al. 2015: 319). In the ongoing conservation and restoration efforts at Terrace House 2, areas requiring mortar repair are carefully identified by conservation specialists, and localized mortar applications are made without covering the original mortar layer when

present. The repair mortar selected for these interventions must be physically, chemically, and aesthetically compatible with the original material and should be one tone lighter than the original layer. In mortar conservation interventions, a specific set of mortars must be prepared for the application area (Figure 10c-d) (Botticelli, 2003: 107; Eskici et al. 2023: 58). In areas where consolidating the original mortar with nano-lime dispersions is sufficient, covering the original layer with repair mortar should be avoided. Such actions could be considered 'over-application' in the context of Terrace House 2's current preservation environment, potentially disrupting the perception of the original mortar and creating a misleading appearance.

Conclusion

The cessation of ÖAI's operations in 2017-2018 and the global pandemic of 2020-2021 interrupted conservation, restoration, and maintenance activities in the field. One of the consequences of the disrupted maintenance activities has been water leakage in the concrete floor, cover, and drainage line of the protective building. Cracks and gaps in the reinforced concrete exterior of the protective building were repaired in the 2023 season through maintenance work carried out by ÖAI, and the drainage lines close to the façade were relocated and connected to the sewer system. However, preventing underground water seepage from the main rock remains challenging. As a result, the spaces located on the southern façade of units 1 and 2 are directly affected by water leaking and the pooling of rainwater. In spaces close to the leakage points and main rock (such as GEW A; GEW B, GEW C, GEW D, etc.), salt efflorescence and layer separation issues are more intense compared to other rooms. Therefore, it is recommended that these spaces be closely monitored continuously. On the other hand, the inspection and maintenance work of the protective structure should be carried out regularly throughout the year without interruption for any reason.

The subtropical climate conditions present year-round inside the protective structure, along with water leaks affecting the residential unit, can provide sufficient resources for microorganism growth and salt efflorescence. In most spaces without mosaic, stone, or ceramic floor coverings, the rapid absorption of dripping water into the soil likely makes the macroscopic identification of all drip points from the covering more difficult. However, continuous condition monitoring activities throughout the year will enable the detection of these areas.

Monitoring environmental factors inside the protective building should include tracking and assessing visible changes and deteriorations that affect the residential complex, environmental conditions, as well as the structure's decorative elements, mosaics, and wall paintings. Regional climate (URL 3, URL 4) and air pollution control should be considered in environmental management efforts. Additionally, it should encompass the installation, monitoring, periodic maintenance, and inspection of systems such as climate control, ventilation, humidification-dehumidification, filtration, lighting, drainage, fire alarms, and more (Weyer et al. 2015: 297). These systems must be continuously monitored, managed, and maintained by specialized personnel. Broad and multidisciplinary environmental management systems, from thermohygrometric to static parameters, fire suppression, and climate control, can be tracked and controlled either manually or through remote monitoring.

The intensified preservation issues caused by relative humidity and temperature values, which more severely affect the southern façade of Terrace House 2, can be diagnosed through periodic condition monitoring activities, allowing for the planning and implementation of appropriate interventions. These interventions may primarily need to focus on remedial conservation measures, such as salt reduction and consolidation. However, it should not be overlooked that, if the factors causing

deterioration are not eliminated, these remedial conservation measures may need to be repeated at regular intervals based on the condition monitoring results.

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Corrosion studies on WWI metallic ship Baron Gautsch and strategies to protect the shipwreck

Zdenka Vrgoč[1], Roko Surić[2] and Ian D. MacLeod[3]

Abstract

The metallic ship Baron Gautsch sank into the waters of the northern Adriatic in 1914. The ship was built in the Scotland's Dundee in 1908, having a length of 84.5m and a beam of 12m. International Centre for Underwater Archaeology in Zadar launched a systematic monitoring project in 2021 that includes investigation and tests aimed at determining the current condition of the wreck and identifying solutions for long-term protection against the further deterioration of the wreck. During 2021-2022 data was collected from the wreck by measuring corrosion potential and pH values at different points on the metal parts of the wreck, with these values also measured on the seabed. Corrosion potential was measured using a multimeter with a silver chloride (AgCl) reference electrode, while pH values were recorded using a calibrated pH flat surface electrode. Both instruments were housed in an aluminium alloy measurement enclosure adapted for underwater use. Also, the samples of metal were taken from the wreck and analysed at a laboratory to determine the remaining thickness of the walls and to assess the corrosion damage of the samples.

Keywords: metallic shipwreck, WWI, corrosion studies, corrosion measurement, cathodic protection

Introduction

The cultural heritage of Croatia is one of the most impressive in the world, as attested annually by thousands of visiting tourists. It is also reflected in its many underwater sites, some of which are numbered among the world's most notable examples of cultural heritage. Because of its attractive nature, many underwater sites are visited by a great number of divers. That results in the creation of a new branch for cultural tourism and it generates many benefits for the local community. One of the most alluring diving locations in the Adriatic Sea is the wreck of the Baron Gautsch ship. It is listed in The Register of Cultural Property under number Z-98 as immovable cultural property. Metallic shipwrecks are threatened with collapse due to corrosion in the marine environment which is dependent on water movement and the concentration of dissolved oxygen; the effects of time and, even more, by the acceleration of deterioration due to global warming.

Monitoring and corrosion studies on the shipwreck *Baron Gautsch*

The ship *Baron Gautsch* was once the pride of the Austrian passenger fleet, during its illustrious past it was plying the Trieste to Kotor line for the Österreichischer Lloyd steamship company (Figure 1). It was

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built in Dundee, Scotland, in 1908. The ship was 84.5 metres long, 11.64 metres wide, its maximum draft was 7.5 metres and a beam just shy of 12 metres (Pocedić 2014). It had three heated steam boilers that powered three bronze propellers via one steam engine. On 13 August 1914 it hit an underwater mine between Pula and Rovinj enroute to Trieste with passengers on board. Around 200 people, including many children and women, died as the ship sank in the waters of the northern Adriatic. It lies at a depth of 41m about 7 nautical miles from the nearest coast, between Rovinj and Pula in Istria. It stands upright on the sandy seabed, and its highest part is the upper deck, which is located at a depth of 28m. The ship hull on the port side, at the waterline's height, has a gaping hole of size 2x2m caused by a mine explosion which provides divers with a unique view of the impact of underwater explosions.



Figure 1. Baron Gautsch ship during navigation (From: Pocedić 2014).

Only the diving centre that has been granted permission to organize diving on the wreck is authorized to do so. Baron Gautsch wreck is visited by many because it is located at a depth accessible to recreational divers. It is visually attractive and is also rich in marine life which receives stimulation from the corroding iron structure. The shipwreck's corroding iron structure provides a habitat for a diverse range of marine life, making it an attractive destination for underwater exploration (Figure 2). Visibility at the site is between 8 and 12m. The temperature of the sea at the site varies from 12°C from December to April and 17°C in the autumn months.

Considering the importance of the site itself and the large number of divers who visit it annually, as well as the inevitable disintegration that comes with time, it is crucial to establish the level of decay and the estimated time left for the wreck. The recent threatening signals and frequent reports from the local diving clubs of new parts of the ship deck collapsing alarmed the community. That prompted the International Centre for Underwater Archaeology in Zadar to launch a multiannual systematic monitoring project (Surić 2021: 20-24), that includes investigation and tests aimed at determining the current condition of the wreck and identifying solutions for long-term protection against its further deterioration. The visual inspection of the state of the wreck was additionally enhanced by the creation of photogrammetric models of the parts on which more recent deterioration was observed. For the purposes of determining the state of preservation, small metallographic samples of parts of the ship were also taken.



Figure 2. An image of the wreck of the Baron Gautsch (Image courtesy of: D. Frka).

The samples were taken from multiple places on the wreck in the course of the first survey of the condition of the Baron Gautsch in 2021. The metallic elements were analysed at the ReCorrTech laboratory of the University of Zagreb's Faculty of Chemical Engineering and Technology. The objective of the analysis was to determine the remaining thickness of the walls and to assess the corrosion damage of the samples. The analysis showed severe degradation of the metal, in particular caused by the action of anaerobic sulphate-reducing bacteria. The metal walls covered by fouling have been highly thinned in places, i.e., significantly consumed by corrosion processes.

In the following inspection of the ship, in 2022 and 2023, data was collected from the Baron Gautsch wreck by measuring corrosion potential and pH values at different points on the metal parts of the wreck, with these values also measured on the seabed. Each measurement was attended by a record of the precise depth and temperature of the sea (Figure 3). Corrosion potential was measured using a multimeter with a silver chloride (AgCl) reference electrode, while pH values were recorded using a calibrated pH flat surface electrode. Both instruments were housed in a custom-built meter box adapted for underwater use. Table 1 shows the measured values.



Figure 3. Divers taking measurements (Photo: R. Surić).

Location	E_{corr}	pH	Depth (m)
Baron Gautsch, bow plating	-0.603	4.90	34.5
	-0.506	-	33
Baron Gautsch, amidship, plating	-0.396	-	33.0
Baron Gautsch, stern deck	-0.594	4.45	30.4
Baron Gautsch, ship's interior - machines	-0.596	-	30.4

Table 1. Corrosion potential and pH value (By: Z. Vrgoč).

Drawings of the Baron Gautsch found at the archives of the City of Dundee in Scotland, where the ship was built, were also very helpful in determining the wreck's current conservation condition. From the drawings we see that the thickness of the plating amidships averaged from 7.62 to 11.43mm, while at lower parts of the ship it was somewhat thicker, averaging 12.70mm.

A comparison of *Baron Gautsch* with WWII shipwrecks in Chuuk Lagoon, Federated States of Micronesia

Corrosion of iron in the marine environment is dependent on water movement and the concentration of dissolved oxygen. Together these variables combine to create a flux of dissolved oxygen which has been shown to drop off with depth, so that there is a logarithmic lowering of rates of deterioration with water depth. The impact of temperature on shipwreck corrosion is roughly neutral for as the water gets warmer it holds less oxygen and the protective nature of marine growth increases, since the marine organisms grow thicker and faster at the mean temperature of 28 ± 1.5°C in Chuuk Lagoon compared with the on-site depth of the *Baron Gautsch* at 14°C. Although the cooler water of the Adriatic has more dissolved oxygen the amount of water movement at the depth of the site means that the impact of the lowered temperature on corrosion rate is not large (MacLeod 2016).

After more than 75 years in the marine environment the Chuuk wrecks have largely lost their deck plates and at typical water depths of 20m the corrosion rates are 0.08mm/year much of the superstructure of the bridge plating has corroded away. The iconic *Fujikawa Maru* is located on the floor of the lagoon at a depth of 29 metres and the decay rate is much the same as the calculated value for the *Baron Gautsch* at 0.055mm/year. The reason why the Adriatic wreck is corroding faster than the Chuuk wrecks is due to the much lower water movement inside the tropical lagoon and to the much-reduced cover of encrusting marine organisms in the deeper and colder Adriatic Sea. For the shipwrecks in Chuuk Lagoon the added complication is that typhoons impact on the shipwrecks and this can result in spontaneous deconcreting of the protective marine growth, which accelerates the rate of decay (MacLeoud 2017) (Figure 4). In addition, the use of recovered high explosives from the 1944 US bombing from the carrier borne strike forces for illegal fishing has a dramatic impact on the corrosion of the wrecks. The *Fujikawa Maru* wreck has suffered multiple deconcreting events which has given it a 33% higher corrosion rate than would have been expected (MacLeod, Richards and Beger 2011).

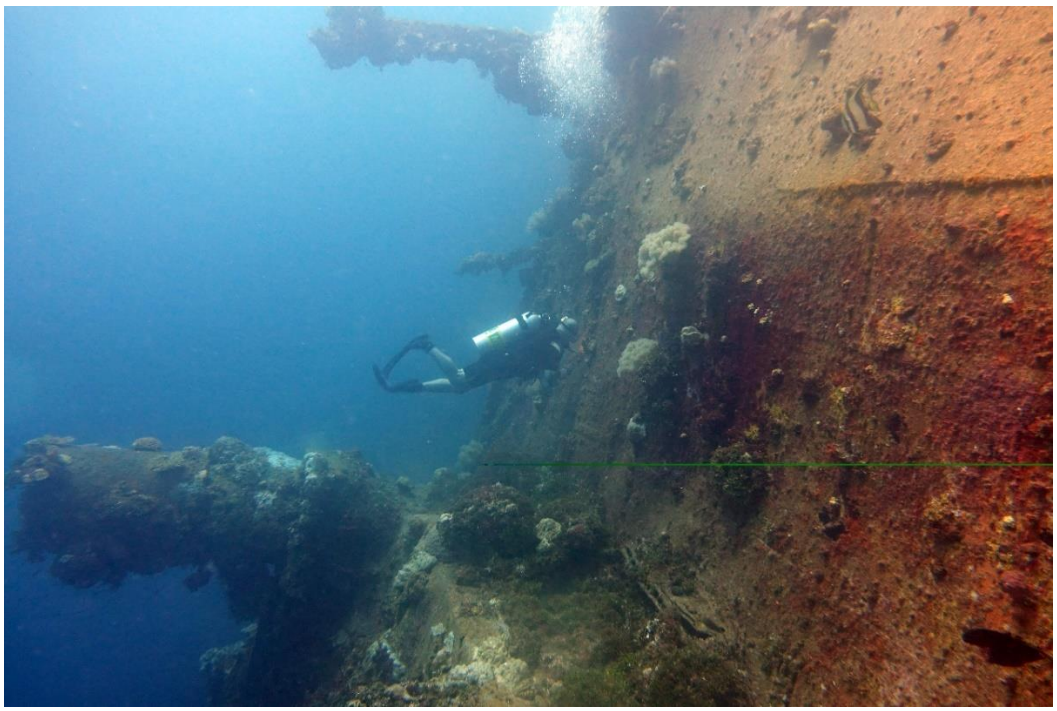


Figure 4. Rio de Janeiro showing concretion loss after typhoon (Photo: A. Selman).

From the specifications of the *Baron Gautsch* the deck is at 30m and the plating at this location was 7.6mm so at the calculated rate of 0.08mm/year it is expected that most of the metal thickness has gone and so all that is left on some areas of the wreck are just a matrix of corrosion products and marine encrustations. The good management news is that the observed rates of decay match those calculated using equations developed for iron corrosion in open ocean waters. At present the awning deck and stiffeners between the decks are at risk but the deeper waters around the bottom of the vessel should still have a few mm of solid metal left in them. The data reported from this year's measurements are all consistent with the corrosion model for this culturally significant object.

Plots of the pH versus water depth shows that the acidity, which is a direct measure of the corrosion rate, fell by 0.08 per metre, which is consistent with the lowered amount of flux of dissolved oxygen. The underlying acidity comes from reaction of the primary iron (II) corrosion products with water i.e., the metal ions transition from being mobile free ferrous chloride complexes to insoluble iron (III) corrosion products. Owing to the encapsulating nature of the concretions, the acidity from these reactions is trapped and just waiting for diving conservators to come and measure it. Data on the corrosion potentials are more limited but the voltages show as systematic decrease for the bow plating, the stern deck and the ship's interior as the water depth increases. The fall in the voltage is due to the corrosion rate dropping off as the flux of dissolved oxygen decreases with increasing water depth. The good news is that the in-situ data on the Baron Gautsch exhibits standard behaviour which means those charged with its protection and management can proceed with proposed interventions with confidence.

Intervention with cathodic protection by sacrificial anodes

Previous studies by Ian D. MacLeod have shown that the application of sacrificial anodes to iron objects of cultural significance., like the carronade and anchor from the wreck of HMS *Sirius* (1790) on Norfolk Island, results in vastly improved conservation outcomes. Instead of taking six years to conserve in a steel tank using electrolysis in caustic solutions, the pre-treated carronade was stabilised in six months after recovery from the surf zone. During the in-situ treatment more than 73kg of chloride or roughly 17 wt% of the gun was extracted by the current moving from the anode, through the cable and attaching bracket, into the carronade.

The current flow caused the chloride ions to forgo their initial attraction to corroding iron and return to the marine environment (MacLeod 1996). The largest application of zinc anodes to an iron shipwreck took place in the Sea of Marmara, Turkey in 2017 when ten tonnes of anodes were attached as three separate clumps to the bow, amidships and the stern of the remains of HMAS *AE2* (1915) at the depth of 71m.

The technical diving needed involved trimix gases of helium, oxygen and nitrogen but the initial results showed that within four days the treatment was working. Further trips to the site have been hampered by logistical challenges associated with the dual sovereignty covering the wreck and the high cost of mounting an expedition. However, this work has been planned to assume that no additional anodes would be needed until after 30-years (MacLeod 2017). This research programme has validated cathodic protection as a sustainable method of protection of wrecks against collapsing.

Conclusion

Sampling and in situ measurement of corrosion potential and pH values on Baron Gautsch wreck yielded data that should be used as a warning sign for authorities. At the upper parts of the ship and the deck, where the plating is thinner, the metal has been entirely consumed by corrosion, and what remains is simply a matrix of corrosion products and marine encrustations. The good news is that there is still "healthy" metal at the lower parts of the ship, where the metal structural elements are thicker, and that in situ measurements have shown that the wreck is decaying in the standard manner. This means that it is technically feasible to develop a suitable system of protection for Baron Gautsch from the ravages of time and decay. In order to stop the corrosion of metallic shipwrecks, cathodic protection by sacrificial anodes is a relevant alternative and could be effectively applied to this invaluable shipwreck.

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Detecting, mapping and interpreting archaeological evidence in dynamic shallow-water environment: towards a systematic methodology

Giuseppe Avola[1], Livio Nardò[2], Sara Finale[3], Serafino Caggiano[4], Filippo Barthelemy[5] and Tecla Zucchi[6]

Abstract

In underwater archaeological research methodology, direct survey is often still considered as an extensive and preventive procedure functional to the identification of consistent material assemblages, where investigations can therefore be deepened through excavation. However, the main goal of survey should be the collection of reliable data from both a quantitative and qualitative perspective. This requires the use of investigation techniques able to maximize data collection in the field, even when covering very large areas. An innovative transect survey methodology is based on systematically sampling targeted seabed areas using predetermined spatial units that are differentiated by environmental features, such as sand, seagrass, and reef. This approach integrates the counting of non-diagnostic pottery sherds with detailed georeferencing techniques that transition from field data to digital formats, allowing for the precise positioning of diagnostic artefacts - those with identifiable typological and chronological features. At the seabed surface level, this methodology enables the collection of fundamental information for interpreting post-depositional processes, including the transport, dispersion, and re-clustering of cultural material in dynamic shallow-water environments. It also facilitates the isolation and identification of primary or secondary depositional contexts, as well as the reconstruction of the topographic and diachronic evolution of maritime spaces that have been used over long periods as anchorages, natural landings, and traffic areas. The paper explores the topic of shallow-water systematic survey from its theoretical setting through on-field technical approaches, with a special focus on the use of various informatic applications (ArcGIS, Global Mapper, Agisoft Photoscan, Google Earth Pro) for GIS based data visualization and post-processing spatial analysis.

Keywords: underwater archaeology, survey methodology, archaeological theory, GIS applications, spatial analysis

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Interpreting underwater archaeological evidence in shallow seabed areas: theory, application and advantages of a systematic direct survey methodology[7]

Following the poster presentation titled 'Developing a Systematic Methodology for Underwater Archaeological Survey: Theoretical Approaches, Field Techniques, and Informatic Applications' at the XXV SOMA Conference held in Zadar in April 2024, this paper aims to discuss in greater detail the theory, applications, advantages, and functionalities of a newly developed underwater archaeological survey methodology. This methodology is based on systematic sampling, precision field-to-digital mapping techniques, with a focus on post-depositional processes. It is designed to homogeneously detect and comprehensively interpret maritime cultural evidence in dynamic, shallow-water seabed. Subcostal areas with the latter characteristics may often include protected bays intensively used in different periods as anchorages or natural ports as well as shallow reefs, close to the shore and dangerous for navigation. Rather than coherent, isolated single-period shipwreck depositions commonly found in deep waters, these shallow-water areas often preserve multiple-period, variable-nature and mixed-material cultural assemblages. Furthermore, as products of disintegration, redistribution, and re-clustering caused by dynamic post-depositional processes in shallow-water, transformative environments, multiple shipwreck deposits may overlap, interrelate, and interact with other archaeological materials of different origins. These can include seafaring ceramic remains, evidence of ship lightening such as ballast stone piles, and even materials washed over from coastal sites. The dynamics of transport, dispersal, and temporary re-deposition in these shallow-water environments, affected by strong and rapidly changing submarine currents, sediment removal, accumulation, and movement, can expose, conceal, or disturb scattered materials as well as more cohesive contexts. These processes, along with modern human activities, are highly intrusive factors that can alter the primary configuration of underwater archaeological assemblages and the original positions of individual artefact deposits (Avola 2018: 249-251). A single diagnostic artefact, found in connection with ongoing post-depositional modifications of primary or secondary depositional contexts, could be directly associated with and used to date these contexts. However, it could also be the result of transport processes from other, potentially distant contexts. Isolated artefacts which do not exhibit any relations with primary or secondary depositions, may either represent individual depositional events, as well as the result of operating processes of material dispersal and re-deposition from homogeneous assemblages. In the scenarios proposed, the long-term interaction between continuously evolving shallow-water environments and the rapidly changing post-depositional dynamics of originally distinct or individually identifiable material assemblages, or single artefacts, can create entirely new mixed contexts. Today, this newly generated evidence must first be thoroughly detected, broken down using a feature-oriented documentation approach and precision mapping techniques. It should then be analysed with a phenomenological focus, considering the environmental dynamics that shaped it and the potentially diverse yet interrelated origins of its components. Ultimately, this process allows the evidence to be identified as a discrete depositional event, whether a

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consistent material assemblage or a single artefact, and reconnected to its original contextual and topographic setting.

Recent underwater archaeological survey fieldwork and training experience in southern Sicily, related to intense and multiple-nature maritime activity in subcostal areas, allowed to exemplify and compare some of the main post-depositional process transformations featuring shallow-water environmental dynamics-affected archaeological contexts (see Bartos *et al.* forthcoming). Evidence from multiple, overlapping, and interacting post-depositional processes, affecting both homogeneously preserved and irregularly distributed, heavily disturbed ballast pile concentrations, has allowed for the identification of at least three distinct classes of depositional features within mixed-material cultural assemblages. These are: primary depositions, characterized by the original, more homogeneous agglomerations of ballast stones; secondary depositions, resulting from local post-depositional dynamics that cause the gradual structural decay of more consistent and homogeneous contexts, while remaining associated with their primary deposition nucleus; and irregular depositions, involving concentrations of materials that either stem from the redistribution of secondary deposits across the seabed or represent independent depositional events. The seabed structure strongly affects directions of transported sediment and debris as well as determining their clustering dynamics by points of convergence (e.g. base of rocky or vegetation outcrops, slopes, sandy regions, seagrass beds etc.), influencing environmental-based archaeological visibility in shallow-water areas. Reading the intensity of material culture depositional evidence may not indicate direct higher or lower use of maritime spaces and seabed areas, but mostly reflects results of post-depositional processes. Primary depositions are often physically adapted to the seabed morphological features, and for this reason, these can sometimes model transformation processes during the post-depositional phase. The progressively changing morphological structure of primary depositions can therefore condition the consequent processes of decay of the context's original structure, from which different types of secondary depositions and as many subsequent modifications may derive. Going through the process, different mechanisms may influence homogeneous contexts deposited near seabed outcrops, reefs or seagrass banks compared to those deposited on more exposed sandy areas. The topographic relationships of these contexts with outcrops and/or slopes located on the proximal seabed may generate a more contained redistribution of the secondary deposition elements, bound by the same seabed morphology which hinders their transport processes. Both consistent and irregular depositional contexts located on the open sandy bottom are instead more sensitive to the transformative dynamics of a more exposed environment. Since they are not protected by particular morphological constraints, they may be subject to a greater extent to the action of currents, sediment mobility and clustering processes, which contribute to a wider dispersion of the secondary depositions. The progressive decay of the original nucleus, which was structurally more consistent, results in a temporary re-deposition of its elements onto the surrounding seabed. As secondary depositions lose their physical cohesion with the more homogeneous primary contexts, they become subject to the invasive effects of post-depositional processes. These elements are transported across the seabed and re-deposited elsewhere, where they may disperse or contaminate the archaeological record of other contexts. Analysing the transformative processes occurring during post-depositional modifications, along with the seabed topography and artefact typology, enables differentiation between cultural material related to the same depositional event and material that is unrelated. This approach helps to identify and separate elements that belong to the same event from those that do not, even when they are irregularly – or even more densely – distributed over a circumscribed seabed area.

Reconstructing the transformative dynamics of depositional contexts can help determine, for instance, whether two distant assemblages are part of the same cultural context or if two adjacent and potentially

overlapping assemblages belong to different depositional events. Alongside ballast stone concentrations, which may be irregularly scattered or related to seabed topographic features—either as isolated occurrences or in series - ceramic evidence is commonly found in sub coastal areas used for anchorage, landing, or other maritime activities. This evidence is often accompanied by other maritime materials, such as wooden remains, iron or stone anchors, and deposits related to fishing industries. In areas with multiple-period coastal sites serving various functions, ceramics deposited on the shallow seabed can vary in chronology. They may represent specific phases of site use or contribute to long-term chronological records that do not fully align with periods documented by terrestrial investigations. Consequently, underwater archaeological surveys of shallow seabed areas can reveal new diachronic trends, contributing to a broader understanding of maritime landscape evolution at various scales. Looking at previous examples, ceramic items as consistent artefacts or scattered fragments (those last even diagnostic or not, as body sherds) can be found associated to primary or secondary depositional contexts (e.g. ballast stone piles or scattering) as well as extensively dispersed, both in large sandy areas or deposited in proximity of seabed outcrops, slopes and seagrass banks. However, the direct association with consistent and not-in-most-quantity ceramic items-based single depositional contexts cannot be confirmed just with in-proximity or overlaying positioning, since post-depositional processes could have transported cultural material from other, topographically connected, but not morphologically divided, seabed areas, pushing sediment, debris, and artefacts to the former location. Ceramic evidence that lacks clear depositional, topographic, or typological connections with well-defined contexts can also be found as variously assembled diagnostic artefacts or incoherently distributed coarse fragments. These might originate from opportunistic seafaring remains, sunken ceramic cargoes, or the progressive erosion of seaside slopes that preserve archaeological evidence from coastal site activities up to the currently submerged shoreline levels. An alternative scenario consists in shipwrecks, particularly those with amphora cargoes deposited over shallow bays reef outcrops. Over time, these assemblages mix with post-depositional elements from different contexts, such as overwashed materials from coastal sites of varying periods, natures, and material cultures. In such cases, typologically similar artefacts from the original depositional context may mix with ceramics from various phases, both from offshore and shoreline sites affected by erosion and maritime activities. Different material-class and typological evidence from various periods, coming from several primary contexts located both underwater and on-shore (basically onto the changing land-water interface affected by sea-level rise and subsidence), interrelate in shallow water areas by continuously redepositing and redistributing due to post-depositional processes effects moved by submarine currents and sediment mobility, leading to endless new different positions and environmental co-relations. Addressing these post-depositional complexities in shallow-water sites has prompted questions central to developing a systematic methodological approach to underwater archaeological survey. Key questions include: Can these processes be traced back in time and space to identify the topographic and contextual origin of current depositional evidence? What data needs to be recorded on the seabed, and how, or through which parameters, should they be analysed to understand modifications in shallow-water material culture?

While scholars already proposed reconstructive models of scattered wreck contexts dynamics (Muckelroy 1975; Parker 1981; O'Shea 2002), mixed-material assemblages from long-term maritime activities (Özdaş et al. 2022) or single, coherent shipwrecks post-depositional transformations (Beltrame 1997 and 1998), focusing tough on the present archaeological context as a result of processual dynamics, and not as static evidence to be just positioned, typologically identified and dated, available archaeological literature has not defined yet common methodologies to investigate these transformative shallow areas.

Traditional underwater survey methodologies face limitations due to their reliance on spatial sampling procedures that often lack coverage homogeneity and precision. For instance, single-point circular tracks do not uniformly cover investigation areas unless multiple passes are made, and they fail to reflect topographic sampling scales. Additionally, traditional methods do not adequately address the need for fast yet precise recording of even small or partially obscured archaeological evidence. Common practices such as manually conducted traverse lines and large transects, which involve two divers working side by side, may not efficiently capture detailed data (Figure 1c). Traditional underwater surveys often overlook non-invasive seabed investigations as a method to be geographically and thematically planned. Furthermore, they tend not to treat field documentation as a data record that can be utilized through advanced mapping technologies and informatic applications. This limits their ability to analyse post-depositional processes based on environmental sampling units, interpret the nature, spaces, and dynamics of maritime material culture, and reconstruct complex, mixed-material, and multi-period maritime landscapes.

In contrast, the shallow-water depositional feature-based methodological approach presented here delves deeply into the archaeological record to explore relational spatial models among various material classes and artefact groups. This approach isolates and quantifies individual cultural items, whether they are part of consistent assemblages or single artefact deposits, and reconnects them to their original depositional events and topographic provenance.

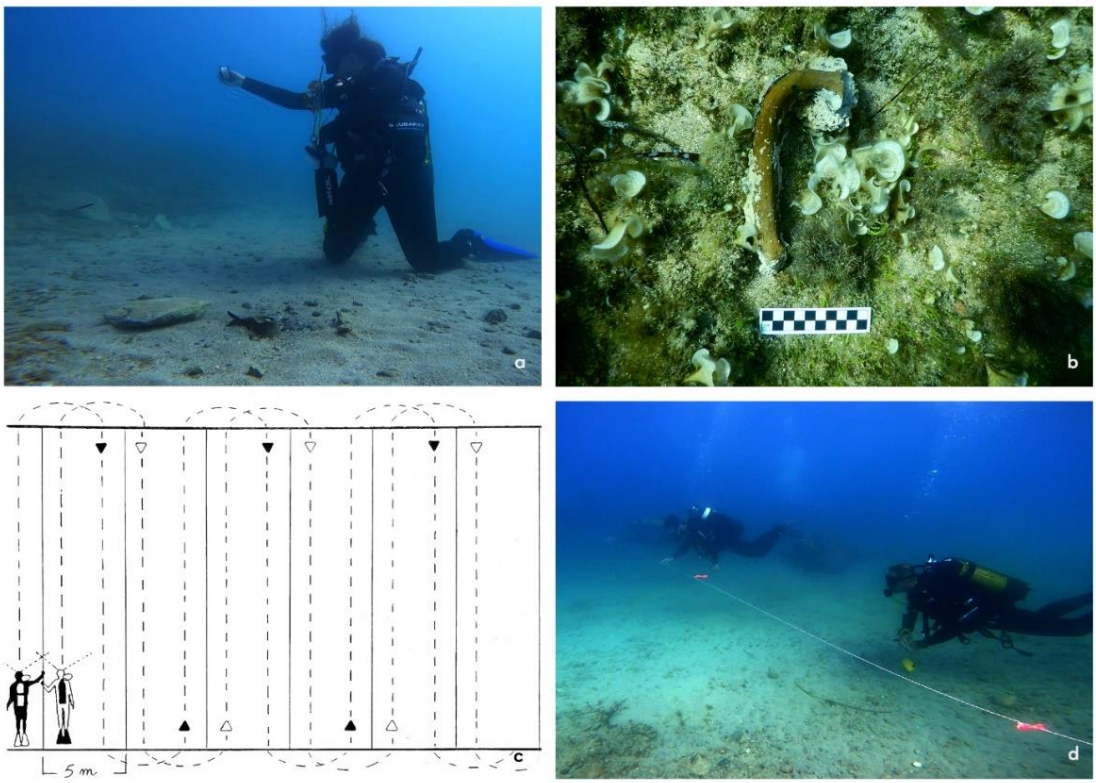


Figure 1. a) Survey operator deploys a lift-bag marker for GPS mapping of a diagnostic ceramic artefact found on a sandy seabed (photo G. Avola); b) Overhead photo documentation of an amphora handle with scale and profile for identification (photo G. Avola); c) Diver traverse lines for extensive survey, as shown in Felici 2002; d) Multi-diver survey with predetermined headings and a shared reference line to progressively mark the commonly sampled area (Photo: S. Caggiano).

By integrating precision georeferencing techniques and GIS applications, this systematic underwater survey approach collects and spatially analyses reliable data from both quantitative and qualitative perspectives. New seabed sampling systems are employed to record extensive data while maintaining proportional coverage of investigated areas. The methodology emphasises defining interacting topographic categories and subcategories from field investigations to informatic processing, thus functionalizing recorded data for comprehensive GIS spatial analysis.

Applying a systematic underwater archaeological survey methodology: from field recording procedures to digital mapping techniques and GIS data processing

The systematic survey methodology is built upon a continuous interplay between fieldwork and digital processes, incorporating precise data collection, mapping techniques, and a range of integrated software tools (e.g., Google Earth, Global Mapper, ArcGIS). These tools are employed from the preparation and execution of archaeological data recording procedures to the post-processing of GIS-based spatial analyses. Investigation areas, broadly defined, may segment selected subcostal seascapes into various geographic sectors, depending on shoreline morphology and topographic features (e.g., a natural harbour divided into two protected bays by an islet), the distribution of known coastal sites from bibliographic research (e.g., sites that may have influenced nearby shallow areas), and bathymetric variability. Remote sensing of shallow-water areas via satellite imagery helps identify changes in depth and seabed morphology, which are crucial for planning diving logistics and field technical topographic trends (e.g., marking the interfaces between rocky outcrops and sandy seabed visible both remotely and at shallow depths) and the initial delineation of broad survey areas within a large-scale maritime landscape. In parallel with the preliminary space-mapping procedure, bathymetric data and high-resolution geographic basemaps may already be acquired at this stage. These can be used to integrate detailed, manually-drawn digital topographies of the seabed to be surveyed, along with progressively collected archaeological markers. Rather than relying on low-resolution, freely available satellite imagery from ArcGIS or QGIS, Google Earth offers updated and improved, multi-date resolution geographic maps. These maps can be manually ortho-rectified in zenithal view and georeferenced by transferring absolute angular spatial coordinates from a .png image to a .geotiff layer using the Global Mapper software's manual georeferencing toolkit. Isobathic curves can be digitally acquired by overlaying image-based, detailed, and zoomed-in seabed bathymetry mosaics (e.g., from Navionics' freely available online sonar charts) onto Google Earth. These mosaics can be anchored to the interface using shoreline trend references. The next step involves manually tracing individual lines using digital drawing tools and grouping layers, each named according to the indicated depth (e.g., 0.5m, 1m, 1.5m, etc.), into a single folder. These line-based layer groups can then be extracted in .kml format and subsequently transferred into GIS platforms as .shp (shapefile) format. Once the GIS database is prepared to integrate spatial data collected from direct underwater surveys and subsequent digital mapping operations, using high-resolution maps as base-layer interfaces for the subdivision of the investigation space into seascape sectors-based polygons (also extracted from the Google Earth survey planning phase and converted to .shp format in GIS software), the next step in the systematic survey procedure involves identifying sites, contexts, and artefacts through a geographically planned extensive survey. Within selected investigation areas, sites are identified as spaces delineated by the presence of contexts and artefacts, which may be distributed more or less homogeneously on the seabed. Extensive survey units are defined by areas with a lower density of contexts and finds spread over larger spaces. Systematic sampling techniques are then applied to sites with higher concentrations of ceramic finds and multiple depositional contexts, distributed over more

clearly defined seabed areas. Both categories of survey units serve as topographic markers, characterising the visibility and intensity of archaeological finds in shallow water sea beds. The extensive survey procedure begins with spatial planning in Google Earth, marking areas to be investigated without intensive artefact recording operations by individual diver-based transects. This approach primarily serves to identify targeted areas where systematic on-field survey methodologies can be applied. Initially, extensive survey units are manually drawn using Google Earth's polygon-based tools to define the space to be investigated. By digitally mapping large-scale units according to the planned direction of the extensive survey, two signal buoys are then deployed on-site at selected GPS coordinates to mark the start lines. Divers swim in parallel and at visible distances, following a common compass heading to maintain the planned direction (Figure 1d).

During the extensive survey, divers document general seabed features and mark the most visible archaeological finds and depositional evidence. Lift-bag markers may be sent to the surface to signal topographic or environmental changes, significant artifacts, various material assemblages, or clusters of ceramic fragments (Figure 1a). Divers also deploy markers to indicate the end of each surveyed distance, after which a mobile-mounted GPS captures detailed coordinates of the seabed markers. Once back at the Google Earth display, the field-acquired coordinates are uploaded as digital markers to indicate where the survey line ended, allowing comparison with the previously planned extensive survey unit. If the survey unit has not been completely covered, GPS points can be used to mark a new start line for the next extensive survey. Conversely, if the survey line extends beyond the predetermined investigation area, the extensive survey unit may be elongated or enlarged, as divers may cover areas outside the initially drawn unit without physical underwater references. Units covered by extensive survey procedures can form mosaics of interconnected investigation areas, their profiles depending on the number of available divers, time constraints at particular spots, and even smaller, non-linear survey areas deployed right under the shoreline seabed (Figure 2a). The primary procedural approach in systematic survey methodology is to achieve total coverage of selected seabed areas. Extensive survey units may change in shape or orientation, and systematic survey units can be overlaid onto them, also serving as topographic markers, separating groups of extensive survey areas. Survey units, whether extensive or systematic, are sequentially numbered in the GIS database (e.g., U1, U2, U3). As will be discussed later, intensive survey broad units—smaller in scale than extensive ones—are numbered by individual transects and/or sub-transect IDs (e.g., U1D1, U1D2 for transects; U1D1.1, U1D1.2 for sub-transects) through which they are subdivided. As previously mentioned, the extensive survey is used to identify assemblages of cultural material of varying nature and depositional context, where systematic direct survey field approaches can then be applied. This approach is based on an environmental sampling transect survey methodology designed to reconstruct complex, mixed-material, and multi-phase maritime cultural landscapes. These landscapes include irregularly distributed, transformation-affected, and various human activity-originated underwater archaeological evidence spread over the seabed. Spatial data collected during the extensive survey, once uploaded to the Google Earth interface, allow for visualising concentrations and distribution patterns of archaeological finds and consistent contexts (Figure 2b). The initial spatial-cultural items recorded, which form the foundation of the GIS database and will later be supplemented by the more extensive data gathered from intensive transect surveys, serve as the primary spatial elements for planning the scale and orientation of subsequent systematic survey units. Within these systematic survey units, a complete coverage of the investigation area is achieved by sampling as uniformly as possible to detect the majority of identifiable evidence. This also allows for the recording of artefact visibility and distribution across different seabed environmental features. Transects are laid out parallel to each other along the longer side, forming primarily longitudinal sampling grids. The standard size

for a single transect is 10x50 metres, assuming that a diver can visually cover a distance of 5 metres on either side under optimal visibility conditions. However, this scale can vary—for example, from 20x50 metres to 5x70 metres—depending on factors such as the seabed's morphological features, the level of detail required in the documentation process (based on data from previous extensive survey), or the number of divers available (typically between 3 and 5, ideally 4). Each systematic survey unit is composed of groups of transects that share the same width and length dimensions. In some cases, where the systematic survey needs to extend into surrounding areas beyond the main concentration of archaeological finds, adjacent sampling grids may use the same vertex of the original unit to extend in length. Inside these units, transect dimensions may vary based on the intensity and distribution of the finds. As with the deployment of extensive survey units, the scale and orientation of transect survey sampling grids are initially planned and digitally drawn on Google Earth software. The process begins with a single spatial baseline extended longitudinally to cover the intensive survey area. This baseline is then divided proportionally based on the number of divers and the width of individual transects. The sampling grid is designed on Google Earth with its final length, ensuring clean space within each transect (Figure 2c). The vertices of the digitally drawn baseline are extracted as GPS coordinates to guide boat navigation for deploying buoys, which mark the primary length of the area where the systematic survey baseline will be located. Unlike the extensive survey procedure, direct systematic survey involves the use of physical sampling grids in the field, providing a strict reference for diver-based investigations on the seabed. Divers manually extend the sampling grids from the already marked survey start baseline to the end of the unit, using buoy-marked points extracted from the digital drawing software. The starting and ending baselines of the intensive survey are subdivided by coloured tape markers, with metre increments indicated (e.g., at 5m, 10m, 15m, etc.) to define the width of each transect. Divers then extend a separating line for each transect from the starting baseline to the end of the survey line, following markers with the corresponding measurements. Each pair of transects shares at least one tape measure reference that runs from the start to the end of the survey unit. This allows divers to mark topographic and environmental changes on the seabed by noting the distance from the starting point along the transect. As in the extensive survey, divers deploy a lift bag at the end of each day's fieldwork to mark where the survey ended. However, unlike in the extensive survey, these end-survey markers are used to resume investigations from that point at a later date, rather than to modify the scale of the sampling grid.[8] During the systematic transect survey, divers simultaneously document depositional, topographic, and material classes items by detailed photo recording and note-taking, along with counting non-diagnostic ceramic fragments across different seabed environments.[9] The direct documentation of significant artefacts involves precise scale-reference positioning and the use of zenithal photography, which allows for the identification of object typology also without the need for recovery (Figure 1b). This process includes capturing all necessary functional data for identification, with multiple additional photos taken from the top and sides of the artefact. Alongside typological identification photography, divers document environmental and topographic aspects related to the

[8] The sampling grid has already been designed and is ready to be populated with environmental-based sub-transect polygons and digital markers from georeferenced items. Multiple, eventually attached and equally-scaled intensive transects-based sampling grids help to improve consistency of systematic survey methodology through transversal applications and tests in differently characterized seabed areas.

[9] In addition to non-diagnostic ceramic sherds, divers count the number of tiles and brick fragments along each sub-transect. Quantifying this distinct material classes—building materials from structures, ship cargoes, or equipment—helps differentiate various origins of archaeological records on the shallow seabed. These fragments depositional evidence can be linked to specific maritime activities or to submerged or eroded coastal contexts.

object's current depositional dynamics, which are crucial during data post-processing and interpretation of cultural material record relational aspects.

While counting non-diagnostic fragments along transects, when a significant artefact is discovered and thoroughly recorded, divers deploy a lift-bag to the surface, noting the artefact ID to which it relates. At the end of the survey operations, a diver geo-references each lift-bag to its corresponding artefact using a precision GPS tool while swimming on the surface, followed by a mobile buoy. The need for highly precise absolute positioning arises from the necessity to map closely spaced cultural items that must appear spatially distinct for distributional analysis on the GIS platform. It also ensures accurate geolocation of survey unit vertices, which, once acquired in the field via GPS, can be compared to the already drawn polygons, recalibrated, and manually corrected using digital mapping tools. The same procedure is employed for georeferencing significant contexts or irregular but circumscribed assemblages. In homogeneous depositional contexts with similar dispersion patterns, a primary GPS point is taken at the centre of their extension area. However, other items within the same mixed-material assemblage, such as individual ceramic pieces or large artefacts of various material classes, may also require georeferencing. Single lift-bags are deployed on each significant artefact within a depositional context (typically, typologically and chronologically identifiable ceramics, but also wood, iron, or other artefact classes), which are then positioned on the surface using a mobile GPS platform. In this case, while primary depositions are geolocated, nearby decaying and associated secondary depositions are not, but artefacts distributed along the dispersal trail must be positioned for spatial analysis directed to post-depositional processes investigations. Integrated with on-field mapping operations, documentation procedures in significant contexts include recording, through detailed photography and possibly direct drawing and measurement, various depositional features. These features include the physical relationship to seabed morphology, environmental-based post-depositional and ongoing modifications, primary deposition decay, and secondary deposition distribution trends and directions. They also document the level and modes of association between artefacts and the main and dispersing parts of the assemblage. Photogrammetric mapping is extremely useful in these cases, as it allows for a more in-depth investigation of the physical features of depositional contexts and the remote, digital positioning of associated cultural items, ranging from secondary deposits to large or small diagnostic artefacts. To proceed in this manner, direct photogrammetry must include at least two mobile GPS-located Ground Control Points (GCPs) within the photographic sequence, which are essential for geo-referencing the digital map processed from the orthophoto plan using absolute coordinates. 3D model-based morphological analysis using software like Agisoft Photoscan or Rhinoceros can significantly enhance the understanding of decay processes and the progressive dispersal and redistribution of secondary deposits from the main concentration of cultural material assemblages. Once the photomosaic is acquired, the manual georeferencing procedure within Global Mapper software utilises GPS-derived absolute spatial coordinates to mark the visible GCPs in the image. The software automatically scales and orients the orthophoto layer in space. However, GPS coordinates obtained under wavy sea conditions, combined with potential distance errors from the referencing tool, may result in less precise orthophoto map geolocation (a common issue when mapping in-field contexts and significant artefacts). After extracting the orthophoto plan in .geotiff format from Global Mapper, it can be overlaid onto high-resolution, remotely-sensed shallow seabed topography in Google Earth and manually repositioned using pre-drawn line-based rock-sand interfaces or other environmental spatial markers.

Once correctly positioned, georeferenced photogrammetric mapping can be integrated into the GIS database as a new basemap layer, allowing for overlays with bathymetric line vectors, digitally drawn seabed topography, and other raster-based interfaces. By zooming into the photomosaic, single

artefacts and other items can be precisely located using coordinate acquisition tools, transforming them into new informatic spatial data. This process can be carried out on Global Mapper, after calibrating positions in Google Earth or in post-processing in a GIS platform. Accurately positioning photomosaics within the GIS database enhances relational spatial analysis between closely located but distinct depositional contexts. It aids in understanding the interplay between assemblage contamination, overlapping post-depositional processes, and how these contexts adapt over time to seabed morphology and environmental visibility features. However, the utility of georeferenced photogrammetry extends beyond analysing consistent depositional contexts and associated or nearby significant artefacts. In areas with clusters of non-diagnostic fragments or within depositional contexts that contain associated or unassociated significant artefacts, small to mid-sized diagnostic remnants of larger ceramic artefacts, such as handles, rims, or bases, are often found. These remnants, even if not included in the on-field precise georeferencing procedure to map individual items, can significantly contribute to artefacts typology-based spatial analysis. They help reconstruct the original assemblage and trace scattered items back to their primary depositional features.[10] Applying photogrammetric surveys in areas with non-consistent depositional evidence, such as open sandy seabed near eroded coastal contexts, requires careful mapping due to the lack of large, easily identifiable material-based spatial references. In these contexts, ceramic fragments, along with small to mid-sized diagnostic materials and more substantial artefacts, may be scattered. To map these, at least two Ground Control Points (GCPs) are positioned along the seabed. Photo sequences are conducted at progressively lower altitudes from the surface to capture even the smallest diagnostic artefacts. Coloured markers can be placed on the seabed to reference materials during post-processing. From the georeferenced photomosaic, it is possible to acquire precise spatial positions of each identifiable diagnostic artefact, even those that are not large-scale, for use in distributional dynamics analysis centred on GIS models that integrate multiple parameters. Georeferenced depositional contexts and diagnostic artefacts can be transferred into GIS software to create spatially interrogable formats as .csv tables or directly as .shp (shapefile) files.

The current methodological framework aims to streamline data processing by uploading spatial layers in .shp format to the GIS platform and creating tables that include fields and columns for parameters using the layout editor toolkit. One challenge in creating .shp format layers from a .csv table is transferring absolute coordinates. Instead of manually copying and converting coordinates from a mobile GPS tool into a format readable by GIS software, digital markers already placed in space and grouped in folders in Google Earth can be uploaded in .kml format to QGIS. These can then be extracted as .shp files, re-uploaded to the platform and even used across different GIS software.[11] By QGIS software toolkit is then possible to extend the .kml file integrated table (which is based on the two Google Earth digital marker fields, Name—applied at the single vector naming into a multiple-vector-based layer—and Description) generating new informatic fields to integrate attributes as site, unit, transect and subtransect (componing spatial provenance from topographic IDs), as well as typology and chronology for georeferenced artefacts or depositional class (irregular or homogeneous) for consistent contexts.

[10] Small to midsize diagnostic artefacts are, however, systematically recorded by being recovered in sub-transects-based and progressive numerical object IDs-marked bags for post-field catalogue drawing, photo recording, and conservation. Single diagnostic artefacts IDs are composed by Survey Project-Date-Site_Unit/Transect/Subtransect-Context (when in direct depositional association)-Flag Number (when also georeferenced)-Lot Number (progressive in the catalogue).

[11] Spatial layers extracted from Google Earth digital mapping layout in .kml format need to be transformed in shapefiles first on QGis or Global Mapper software (which read the .kml file) to be then uploaded in ArcGIS, since this last does not read the .kml format and, for this reason, it is usually operated by integrated .csv format table-based vectors.

The same procedure applies to polygons resulting from the environmental subdivision of systematic survey unit transects. Measurements recorded in the field, such as distances from the starting intensive investigation baseline using tape measures, are used as markers to digitally draw shorter polygons within the pre-existing Google Earth layer (Figure 2d). By using digital measuring tools, a new line is extended from a baseline vertex to the recorded distance, following the seabed's environmental changes. A polygon is then drawn, connecting these points, and this process is repeated for each recorded sub-transect. These polygons, once accurately positioned within the survey unit layer, are grouped into a single folder-layer (e.g., U3). This folder can then be transferred to GIS software, where all sub-transects are integrated into a single vector (e.g., U3D1.2, U3D4.3, etc.). In GIS, these polygonal vectors are supplemented with quantitative and measurement parameters, filled manually into attribute tables using the layout editor tools. The final step in the GIS systematic survey data processing involves uploading point vectors of georeferenced diagnostic artefacts and consistent depositional contexts by transferring .kml format folder layers from Google Earth to QGIS, extracting them as .shp files, and re-uploading them into the same software or ArcGIS. Integrated attribute tables can also include detailed environmental photos of contexts and depositional features, along with comments and other recorded notes, by adding informatic fields. In this way, all data and files related to individual archaeological evidence are consolidated and accessible within the GIS database, where the information becomes easily accessible and analysable.

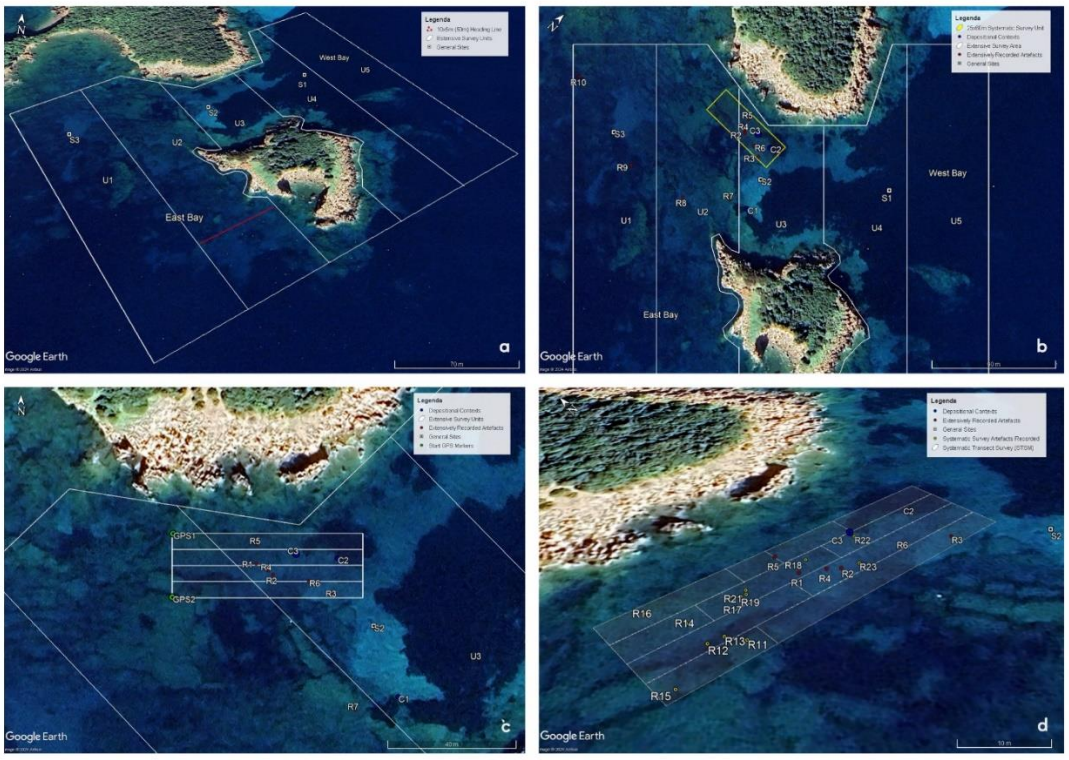


Figure 2. Simulated digital mapping for systematic survey planning and application: a) Broad investigation area divided by geographic sectors, general sites (S1, S2, S3), and a 50m-wide survey grid for five divers; b) Hypothetical survey results showing depositional contexts (e.g., C2), consistent artefacts (e.g., R3), and areas of intensive finds (yellow); c) Preliminary digital plan for systematic transect survey, with four 5x60m transects (20m unit width) and two GPS-marked baseline points; d) Hypothetical first-day survey results, with recorded transect distances, sub-transect divisions, and new artefact finds (yellow markers).

Modelling and interpreting post-depositional dynamics in shallow-water environment: quantitative, material-class and typological integrated spatial analysis

Conducting a systematic survey of shallow seabed archaeological evidence goes beyond merely recording cultural items. It involves using a theoretically modelled data processing system, supported by digital technology and informatic applications, to make cultural records functional for GIS-based, multi-parameter spatial analysis, from field collection to the interpretation of complex maritime landscapes. Systematic survey procedures, indeed, are meticulously planned and not conducted randomly. The spatial database, designed to link documentation such as files and photos from archives with geo-informatic elements, enables the consistent and simultaneous management and control of survey data on a GIS platform. By selecting individual spatial items, it becomes possible to display all related information in a single table (derived from the general layer-attached attribute table) for each point (context or artefact) or polygonal vector (unit, transect, or sub-transect). Interrogating the attribute table from spatial layers containing multiple vectors allows for comparing cultural items within the same material or topographic category-based group of data (e.g. contexts, consistent artefacts, or transects and sub-transects into the same unit). This is achieved by filling informatic fields with identification parameters, either textual or numeric. These parameters may correspond to various data types, including topographic, environmental, depositional-oriented, quantitative or from-identification-obtained IDs. For example, systematic survey units can be queried to highlight sub-transects with shared environmental features on the GIS display, using selected colour shading. Sub-transects that are not part of the query remain unhighlighted on the map. Attribute tables can be enriched with additional fields to improve the precision of multi-parameter data. For instance, in systematic survey units, environmental features such as seagrass, rocky outcrops, or sandy areas can be linked to fields that specify coverage density (as a percentage of the topographic item) or the intensity and type of sediment debris (e.g., surface sediment composition). Transect and sub-transect survey units integrate attribute tables with quantitative data fields, where the count of scattered ceramic sherds from field investigations is recorded as a numerical parameter. This spatial variability in ceramic fragment density can be visualised on GIS by querying the attribute table and applying a colour scale that reflects the range of counts. Polygons will then be coloured according to their relative position on the scale, making patterns of fragment dispersion and clustering clear. This result, processed from raw field data, can be used in theoretical post-depositional dynamic models for interpretation. In this way, fragments scattering and re-clustering processes become clearly visible as new data and functional in interpreting the context by applying theoretical post-depositional dynamic-based models. This procedure may be repeated with the same progressive colour scale in each systematic survey unit included on GIS, to then operate comparative analyses of various seabed areas based on environmental features. Consistent contexts associated with various cultural material assemblages are identified as featured informatic spatial data based on depositional consistency, categorised as homogeneous or irregular. Attribute tables for these contexts can be further refined to include fields that account for secondary deposition evidence in homogeneous contexts, or clustering and scattering dynamics in irregular contexts. All parameter-based information integrated into the attribute table creates a network of interconnected IDs that can be displayed at various correlative levels. For example, when visualising irregular contexts, it is possible to also display the quantity of associated cultural items, whether higher or lower, for each context. To differentiate point vector identities on the GIS display, the symbology for depositional contexts should differ from that of consistent artefacts (e.g., using triangle symbols for contexts and circular ones for artefacts). Consistent artefacts can also be represented using different colour shapes based on typological or chronological parameters integrated into the attribute table. These parameters, included as IDs, can indicate periods

(e.g., 'ER' for Early Roman, 'EM' for Early Medieval), which form the basis for parameter-featured artefact distributional-spatial analysis (Figure 3c). Software interrogation facilities allow to eventually mark with manually selected colour for each parameter's symbology; or automatic colour scales can be applied. GIS databases, once performed with all labelled data collected from field investigation, become a versatile tool to visualise and informatize cultural spatial elements whether while appearing in their unfeatured distributional relations (Figure 3a).

Quantifying scattered ceramic fragments within environmental-based spatial units helps identify the directions of post-depositional transport, scattering, and re-clustering dynamics in different seabed areas, as well as their interactions with morphological features like rocky outcrops, seagrass beds, and submerged reefs (Figure 3b). Processes of cultural items mobility in shallow-water areas can be examined through typological and chronological matches between identified artefacts, whether found within homogeneous deposits or mixed with secondary or irregular contexts, and consistent artefacts scattered at a distance. This spatial modelling approach reveals intra-site mobility networks potentially originating from single or multiple related depositional events. By integrating the symbology of chronological parameters with the depositional context and artefact distribution dynamics model into the quantitative-based, environmental features-determined fragments depositional intensity analysis, it is possible to conduct comparative spatial analysis of post-depositional processes (Figure 3d). This involves comparing the mobility dynamics of artefacts across the shallow seabed, analysing the convergence or divergence of transport patterns. In large-scale, mixed-material and multi-period post-depositional scenarios—including primary and secondary contexts from jettisons, shipwrecks, or coastal erosion—artefacts of the same typology may initially be grouped by their coherence within the depositional dynamics. Artefacts from a specific period, directly associated with a primary depositional context and used for dating purposes, can serve as markers for tracing the provenance of similarly dated or typologically related artefacts, even those found progressively further away. Artefacts found along the trajectory of a secondary depositional scatter - linked to a homogeneous concentration by topographic or material-class parameters (e.g., elements gradually distancing from the original nucleus or ballast stones of similar mineral composition) - can indicate a potential broader redistribution of the same typological group. This redistribution can often be traced back to the original primary context. The distance of consistent and dated depositional contexts can influence the relationship between the distributional dynamics of artefacts and physical evidence of their original position on the seabed. Shallow-water depositional areas containing various material-class artefacts may be the result of opportunistic sailing, repairs and other trade-related maritime activities along the shore, potentially influenced by multiple coastal sites with different periods of occupation and use. When individual artefacts or irregularly distributed groups of identified ceramic typologies cannot be clearly associated with consistent cultural deposits on the seabed, they may be linked to such activities while still connected to homogeneously identifiable but scattered contexts, such as shipwrecks with single-type ceramic cargoes. A higher concentration of fragments might reflect sediment transport dynamics from other seabed areas or localised depositional features. Comparing the distribution of consistent artefacts with the mobility of fragment clusters helps to better define the processes driving depositional evidence transport trends. Through comparative quantitative and identified artefact distribution spatial analysis, an integrated geo-informatic model can be developed to trace the transformation of cultural assemblages influenced by morphological and environmental mobility. By defining the origin of scattered archaeological material and connecting various depositional evidence through integrated quantity, material-class, and typology-based spatial analysis on GIS, it is possible to virtually isolate primary depositional events and quantify original deposits on the seabed.

Identifying consistent assemblages, or even scattered but coherent cultural material records as individual depositional events, allows for the investigation of spatial relationships between variously distributed contexts. This helps to understand how these contexts interrelate, both with each other and with the geomorphology of the surrounding seabed and coastal landscape. GIS-based spatial and temporal analysis, enabled by grouping data based on contextual, typological, and chronological parameters, along with topographic characterization of sampled areas and digital mapping of seabed features, allows for the simultaneous delineation of the nature, timing, and modes of activity within broader maritime landscapes.

The distribution analysis of dated primary depositional contexts and identified diagnostic artifacts in GIS enables the creation of models for how these spaces were used in individual periods. By comparing spatial data displayed chronologically, these models can also be analysed diachronically. Integrating spatial models of depositional contexts with seabed geomorphology and coastline trends, informed by advanced remote sensing and mapping techniques, enables a comprehensive reconstruction of complex maritime landscapes shaped by multiple periods of activity and continuously evolving underwater archaeological records.

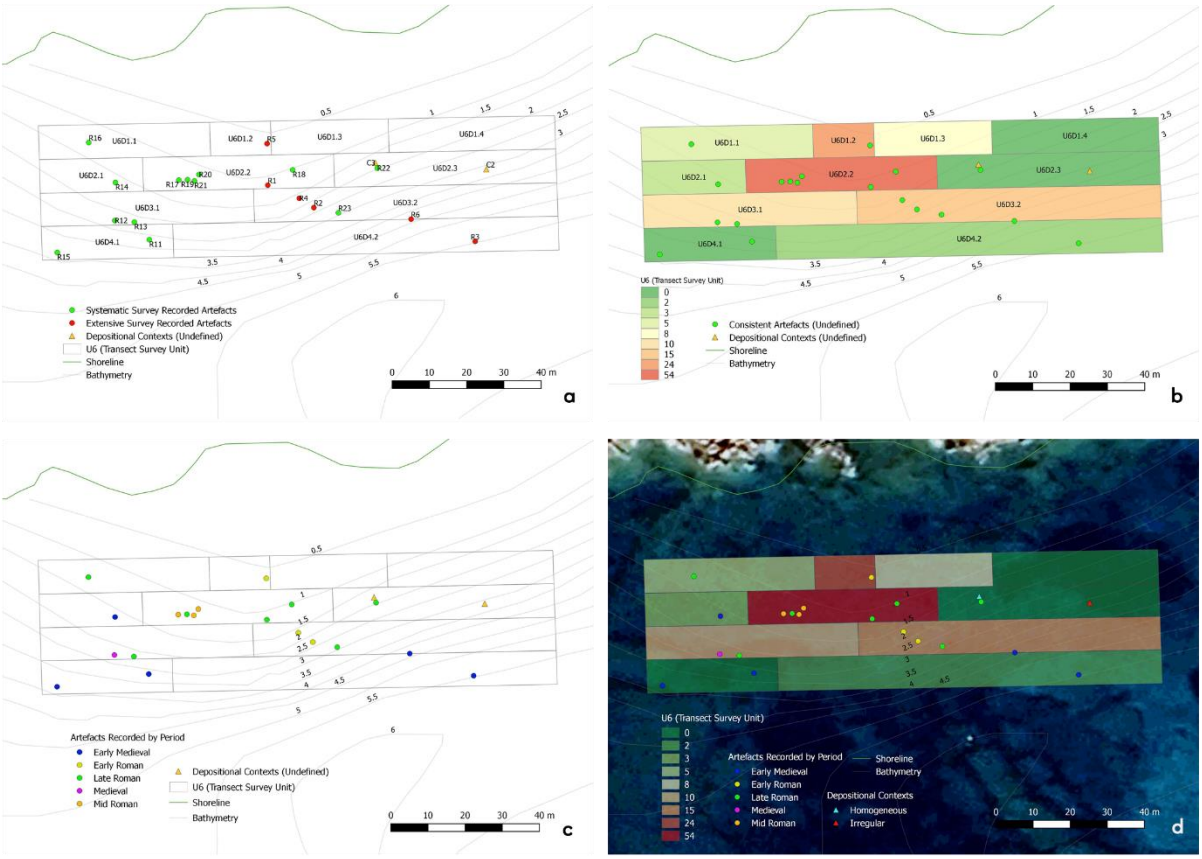


Figure 3. Simulated GIS-based post-processing and spatial analysis: a) On-field data transferred as ID-featured vectors in QGIS for preliminary database setup; b) Parameter-based symbology map showing contexts and artefact distribution, with colour-coded sub-transects divided by environmental variations; c) Spatial analysis of artefact distribution by chronological period, based on typological identification; d) Comparative analysis of scattered finds intensity against consistent artefacts and large depositional contexts position to interpret post-depositional transport and re-clustering processes on the shallow seabed.

Associating interpreted depositional events (e.g., ballast dumping, movement of ceramic containers) with shallow seabed geomorphology, sometimes preserving ancient sea-level markers, helps reconstruct the original topography of maritime spaces. The precise positioning of underwater archaeological evidence, once chronologically identified, well provides spatial markers to date stages of sea-level changes (see Auriemma and Solinas 2009). This integration of chronology, nature of archaeological context, and geo-environmental markers like sudden depth changes, vegetation types, or sediment composition allows for a deeper understanding of subcoastal area use. Ultimately, archaeological contexts, once traced to their depositional origins, serve as markers of long-term changes in maritime landscapes, reflecting the dynamic interplay between human activity and environmental processes.

To conclude, the big challenge of reading intensive systematic survey-based data by space and time values, on geo-informatic platforms, concerns the correct integration of detailed field documentation to help discriminate real evidence of space use through time, from physical results of ongoing post-depositional dynamics. Interpreting the archaeology of shallow water environments means, indeed, performing advanced scientific approaches to field documentation which, once organising data from archive to informatic software, may be used to fulfil diachronic to topographic gaps by previously hidden or misunderstood cultural evidence. From a single shallow bay to a broader system of maritime landscapes, the systematic survey methodology aims to move beyond intra-site spatial analysis and interpretation of archaeological processes in shallow water-environments. It seeks to enable large-scale reconstructions, particularly in regions where remnants of trade routes intersect with the exploitation of natural harbours and marine resources.

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Maritime cultural landscapes

Paths in visible waterscapes: Milesia, Maeander Valley and Kuşadası bay during the Late Bronze Age[1]

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Abstract

This study examines settlements in the geologically active regions of Milesia, the Maeander Valley, and Kuşadası during the Late Bronze Age (LBA). The Maeander Valley spans 25,000 km², with its 548 km river connecting key archaeological sites, including Miletus, Kadıkalesi (Anaia), Göztepe/Kuşadası, and Çine-Tepecik. These settlements reveal connectivity between the Aegean and southern Western Anatolia through harbors, settlement structures, and material culture. Rivers linked the southern coast to inland Anatolia, shaping regional waterscapes.

Viewshed (VS) and Least Cost Path (LCP) analyses evaluate patterns of connectivity, settlement distribution, and material flow, considering geography and geomorphology. These analyses highlight the impact of distance, river connections, visibility, and coastline features, offering insights into the political and economic dynamics beyond geography. The results map LBA sites and confirm correlations between geographical conditions, material culture, and historical geography.

Keywords: least cost path, viewshed, coastal landscape, Western Anatolia, Late Bronze Age

Introduction

The Maeander basin covers an area of 25.000 km2, while the river is 548 km long and connects sites to creeks, rivulets, rivers, and the sea (Akdeniz 2002: 1). The basin today's borders of Türkiye, involves three cities of inland Western Anatolia, namely Afyonkarahisar, Denizli, Uşak, as well as Aydın in the coastal region of Milesia. The river comes out from Afyonkarahisar and combined with smaller creeks, reaches out Uşak and confluences with Banaz rivulet in Uşak, and other creeks that feed the river in Denizli. It disembogues to the sea in Balat district where Miletus located (Figure 1).[3] Considering the geographical conditions and material distribution of the LBA, Miletus, Değirmentepe/Miletus, Çine-Tepecik, Bahçetepe, Şeytan Deresi, Teichiussa, Pekmez Höyük/Aphrodisias, seven sites on the Milesia territory, and Göztepe/Kuşadası and Kadıkalesi (Anaia) on the Kuşadası Bay will be discussed. The sites in the Maeander basin will not be covered all since the focus of the analyses are limited to the peninsula area, but Beycesultan and Laodikeia Asopos (Denizli city) Hill will partially be included as path crossing points between the river and the inland sites.

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[3] All the figures are produced by the author.

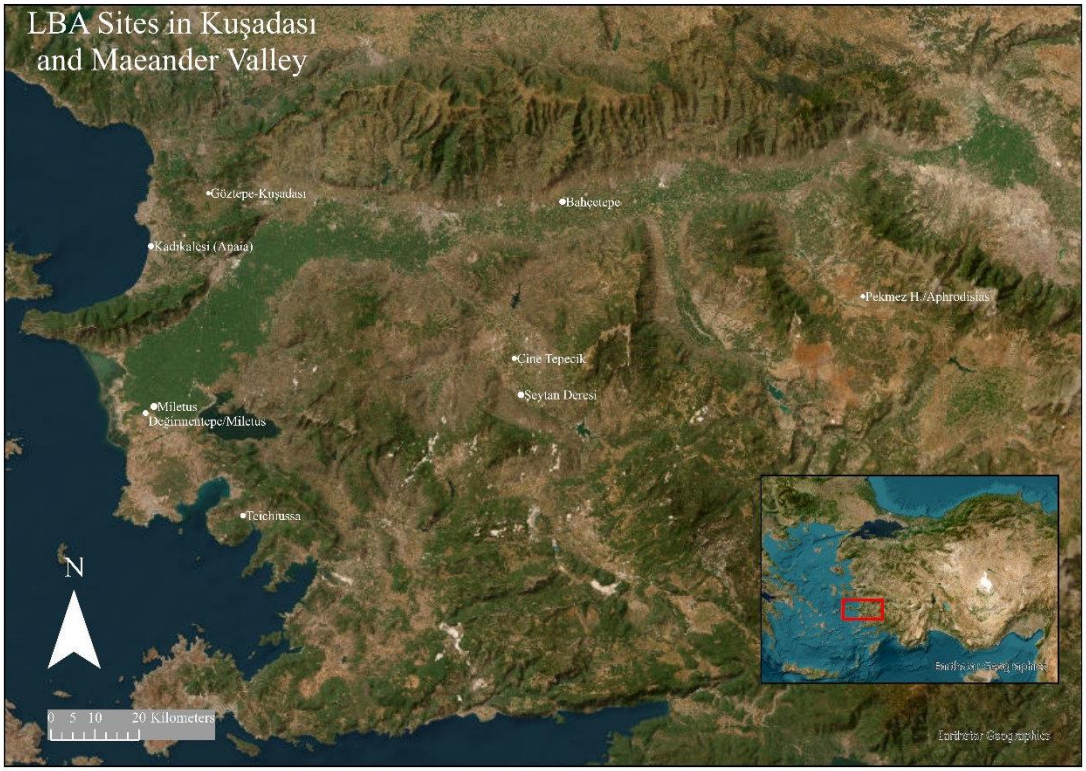


Figure 1. The main Late Bronze Age sites that were excavated or surveyed in the Maeander Valley as the data of this research. Those specific sites created a connection from the southern shore to inland Western Anatolia via the rivers.

The Kuşadası Bay in Aydın has direct connection with the Maeander River, south of İzmir. Two sites, Kadıkalesi and Göztepe/Kuşadası are located on the central part of this bay. Kadıkalesi is surrounded by Mycale Mountains in the south and faces to Samos Island. Nowadays, Mycale Mountains run from the Dilek Peninsula along the Maeander. During the LBA, the region was one of the main zones in Western Anatolia for networking between the inland and the coastal areas with the south Aegean islands. Local features in material culture, such as pottery production (technology, shapes), working of various raw materials (metals), along with settlement structures and construction methods in architecture, were transferred both from the Aegean along the coastal Western Anatolia and in the opposite direction (Marchese 1976: 411; Gates 1995: 289; Akdeniz 2002: 23-26). Along with the staple products, precious objects and the fractures above became requested. Paths and cultural interactions were not limited to geographical challenges, however, need for accessing from one site to another, especially to coastal sites, required alternative ways that developed in the period.

The sea and riverways as waterscapes and the serpentine and mountainous characteristic of Western Anatolia created also differences in the same region. The coastal area was culturally closer to the Aegean due to its geographical location. Examining those elements on the same page requires to consider the LBA geomorphological conditions. VS and least cost path analysis (LCP) in Geographical Information System (GIS) are depending on modern digital elevation model (DEM). Geomorphological data is applied to visualize and interpret the results in this model considering LBA. With that data these analyses contribute to map settlement patterns and paths and network in the region (Figures 2-5). They bring out not only routes and patterns, but also rotations, layers of the connectivity of those patterns, and gaps in those patterns that should be questioned. The gap here emphasizes the areas and/or coordinates

that might had settlements on these routes, but not determined yet, and hubs that took place in the network. Details of the database, parameters, and system that were applied for the analyses, will be given in the article together with the results.

Geomorphology of Milesia, the Maeander and Kuşadasi Bay

The Maeander graben is a geologically active area that changed over the centuries. The mountain series, erosions, floodings, changes of riverbeds, land and marine deposits, silting activities that resulted coastline changes have been researched. This article considers the above changes during the Late Holocene (from 4200 BP to present) for undertaking a precise study of the LBA settlement patterns using the GIS.

The graben covers around 2200 km2 and from the Aegean Sea to Denizli city is 140 km long. The city is on the starting of the Maeander Valley where Maeander River continues independently from the main water sources and arms from inland Western Anatolia. The river carried alluvial sediments from this inland area to the sea, as it is surrounded by the following mountain series: Mycale on the northwest, the Menteşe mountains on the south – in southeast-northwest direction unlike other mountains –, and the Aydın mountains on the north. The Maeander graben also connects to Çine rivulet and Bozdağan and Karacasu grabens (Özpolat et al. 2020: 406-8, 416). The Middle (7000-5000 BP) and Late Holocene changes due to tectonic activities and most importantly the silting in the southern part of the Maeander basin resulted an extremely fruitful landscape. This had an impact on the settlement distribution, harbours, and geographical and cultural network.

Söke debris cone, which is also the name of the area on the north of the Maeander that the cone is located, comes together from its south to the Maeander Delta. The occurrence of the cone had changed geography of the Maeander graben and is associated to changes in the coastline. Söke basin as rest of the coastal area of Western Anatolia and the Maeander basin was divided into sloping and alluvial areas, valleys, debris cone, and the delta plain (İlhan and Öner 2012: 119). Rivers in different size and depth scales carried the silt which created the cone through the Maeander Graben, to the direction of south. The surface elevation of drilling points in geological research in the area is between 10-17 meters. Micro and macro fossils also show different waterscapes: swamp areas, brackish environments, and marine layers (İlhan and Öner 2012: 123-35). The sea was further inland through the east of Söke, a part of the sites from Bronze Age to Roman periods that located around the Maeander River of today were directly connected to this bay of the Maeander (Figure 2) and some of them remained under alluvial deposits. The direction of landlocking of the south arm of the Maeander from west to east was most probably because the main tributary moved forward from the south of Söke. This is because from the front of Söke, old Söke creek that filled the sea in the Maeander, had increased with the debris cone on the new valley pushed the Maeander to the south (Erol 1996: 20-22).

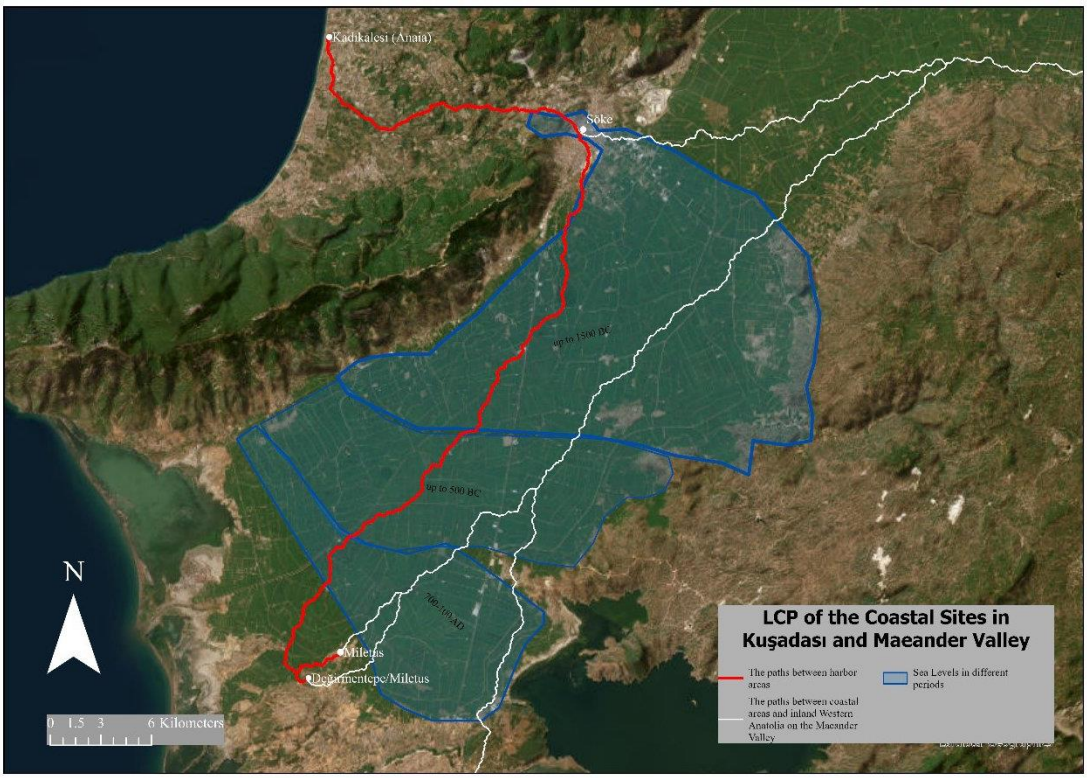


Figure 2. Geomorphology of the Maeander Valley. Drawings are based on geomorphological investigations mentioned in the text. The map shows the change in the sea level and landscape limits from the Bronze Age to the 500-700 AD.

Western Anatolia, Maeander especially, has great amounts of area of the river terraces with alluvial fans that the sites located along. River terraces had no pattern in distribution on the geography due to the local faulting activities. At the same time, the graben was filling densely by the alluvial shifting. The sea level transgression caused this process in the Holocene. The coastline that along the floodplain suggests that the graben floodplain extended towards the Aegean Sea, had formed Maeander graben during the Late Holocene (Özpolat et al. 2020: 416).

The sea level decreased -2m around the 3rd millennium BC, and after that increasing of sea level resulted deeper water in the coastline and the Maeander in later periods (Kayan 1988: 205-18). The sea level of the aligned Aegean coastline increased, delta propagation slowed down and waterscape as passageway in this delta became deeper and wider. At the time of the first centuries of AD, increasing of sea level change was much lower, so that the delta propagation might have obstructed the passage of ships. Until 300-600 BC, while dislocation of the Maeander River in the north, the sea along the south line was until where the Bafa Lake (Latmian Gulf) is today. Around the 1st millennium BC – 1st millennium AD Miletus was connected to the mainland, while Herakleia of Latmos remained on the front of newly occurred Bafa Lake (Erol 1996: 18-21).

Before the Lade Island and the Latmian Gulf turned to be a part of the mainland and became a lake, the Milesian peninsula was not only a harbour for trade and cultural networks, but also a safety for the ship anchoring (Brückner 1997: 67). The Athena Temple/Athena Harbor area during the LBA was still a part of the island. Miletus has started to get connected with the mainland later, first with a sandbar by silting up and currents along the coastline (Brückner et al. 2017: 881-84). The geological research shows that

occupation at Miletus/Athena Temple goes back to the 4th millennium BC (Chalcolithic-Miletus I), and around 2500 BC, namely in Early Bronze Age II late-III (Miletus II), the Milesian area was an archipelago. In the 2nd millennium BC (Middle-Late Bronze Age), the sea level decreased, and the Milesian archipelago turned to a peninsula. Two of the smaller islets of the archipelago, today's Miletus, where the Athena Temple is located, and Humei Tepe were occupied in later periods (Niemeier 2007; Brückner et al. 2006; 2017: 881-84). Athena and Theatre harbours were the main ones for many periods including the Bronze Age; more specifically the Theatre Harbor was a shelter against west winds by Lade Island (Kleiner 1968: 48; Greaves 2003: 24). The Lade Island is consisting by a hill series now called Batmaz Tepeleri (Batmaz Hills), 2 km away from the coastline and 2.5 km away from Miletus. Lade Island located at the southern mouth of the gulf and had access to Miletus that might gave a strategic importance to the island with the connection to other islets and islands in the Maeander area (Brückner et al. 2017: 881-82).

Değirmentepe, the cemetery area of Miletus, 1.5 km apart from Miletus, was also located on an island. Değirmentepe distant 1.5km from Miletus. The Maeander River dislocated to the south and west towards the Aegean Sea and due to silting process Miletus is currently 7 km away from the coastline. The lowland coastal area moved 10-17km inward, especially between 500 BC-500 AD. Around 600-700 AD the process ended with sand humps arisen parallel to the shore (Mee 1978: 133; Greaves 2003: 17-8; Köknar, 2020: 91). Macro- and micro-faunal variety shows a marine environment in the Theatre Hill strata and just west of them the Mycenaean settlement is located (Brückner 1997: 67).

Kadıkalesi was located on the coastal plain, 200m away from the coastline. The main sea level change had stopped around 6000 BC, despite some small scale later changes (Karadaş et al. 2021: 31-33). The form of the coastline finalized during the Late Holocene after the area was filled by sediments (Karadaş et al. 2020: 530-31). The coastline received its final form during the Late Holocene, when the area was filled by sediments. Geomorphological research on the coastal plain, Kuşadası-Davutlar, shed light on different levels of transgressions in the Holocene. Beginning from the 5m deep, marine environments had started. The research in the different depths on the mound itself show marine environments started between the 5-12m and the bedrock. Also, in different directions of the mound, for example, in the east, micro- and macro- fossils show a variety of species that lived together in fresh and brackish water environments. The results emphasize the north, south, and west sides of the mound involved marine sediments, but the east part was marsh, fresh and brackish water area. The geologists conclude that in the Middle Holocene the site was connected to the land as a peninsula from. Since it was the period that the sea inlet moved further inland (1-2km) and at the highest level so both sides of the peninsula were serving as harbours (Karadaş et al. 2020: 530-45; 2021: 35).

Çine-Tepecik lies 5km west of Çine (Marsyas). The site is on the Maeander plain and connected to the Çine rivulet. Çine depression -elevation underneath its surrounding environment- had occurred to silting activities of the river and colluvial material from the hillsides (İlhan et al. 2022: 2087). Geomorphological research undertaken in different areas of the Maeander Basin showed changes in the topography of the area. Tepecik mound, which is now located in the inland, was during the LBA part of the Maeander area where the sea extended inland. The drilling results of 2018-2022 present that the east of the mound was a swamp or lake. This swamp or lake became deeper and wider towards south and extended on the north-south direction (İlhan et al. 2022: 2098-100). In the west side of the site following through the excavation area, they accessed an ash layer of Thera volcanic eruption (İlhan et al. 2018: 864; 2022: 2101).

The Late Bronze Age material evidence: pottery as a tool for defining cultural zones

Miletus was during the LBA and its preceding and subsequent periods one of the most significant port cities in southwestern Anatolia, maintaining connections with both the coastal and inland Western Anatolia as well as the Aegean. Although Miletus, like the other mentioned areas in this article, housed a variety of cultural materials, the pottery will serve as a concise summary of these cultural interactions. Local pottery here offers a broad range. Light coloured fabric, burnished as from pinkish purple to orange as coarse wares and red wash wares with the same fabric in many forms: conical and small bowl cups (bowls and cups with also S-shape profile), carinated bowls, cooking pots, plates, large bowls, including the forms that are common in Minoan kitchen wares (Kaiser and Zurbach 2015: 559-66). Miletus was also one the main bridges between the Aegean and Western Anatolia. Both local and imported productions were Mycenaean in LBA vastly. 5% of the unearthed pottery, was totally Anatolian, but not more than around 10% of the Mycenaean pottery were imports. The forms varied as kylix, goblet, alabastron, pyxis, stirrup jars, deep bowls, pitchers, small cups, amphora as known from other Western Anatolian sites. Değirmentepe cemetery of Miletus contains a few imported pottery from the Aegean dated to Late Helladic IIIB-IIIC (1400-1100 BC) (Mee 1978: 133-37; 2008: 373; Mountjoy 1998: 54-5; Greaves 2003: 83; İslam and Aslan 2015: 382; Köknar 2020: 93-4).

Local ceramics in Çine-Tepecik were common in the entire Western Anatolia for the 2nd millennium BC. Fine, medium-fine, and coarse wares had a variety of forms and designs. Buff and reddish-buff ceramics, with S-shape profile, carinated wares, plates as well as fine and light brown, coarse ware jugs were found in the site (Günel 1999a; Günel 1999b: 51-2; 2012: 57; 2015: 632-35). Local pottery is the predominant find from the last phases of LBA at Çine-Tepecik. In these phases, features were both painted pottery and a significant quantity of local wares, including medium-fine, yellowish-buff and coarse wares. The buff and yellowish-buff wares, particularly bowls and cups, reflect the Western Anatolian pottery tradition. Mycenaean decorated pottery, making up about 10% of the total sherd amount, occurs to this layer as fine and medium-fine wares. as fine and medium-fine wares. Additionally, a fine grey pattern-burnished ware, characterized by a dark-grey slip and pattern burnishing with parallel vertical lines or zigzags, is also present in the earlier phases along with buff and yellowish-buff wares. This technique, seen in the grey ware from Çine Tepecik, is similar to that of vessels from Troy and Beycesultan, indicating a parallel chronological development with Western Anatolia (Günel 2010: 28). On the same river way thorough the south of the site, the site at Şeytan Deresi was discovered in survey that provided buff and grey wares dating to the 2nd millennium BC (Günel 2004: 327-28).

Another site situated in the Maeander plain, with the Aydın Mountain ranges to its north, is Bahçetepe Höyük. This mound rises 8 meters above the plain to the west and 9 meters to the east. The substantial group of ceramics from this field on the northern part are of medium-quality, wheel-made bowl fragments with a slip and burnished surface in light-brown and yellowish-brown colours. Bowls in this site had conical bodies, sharp profiles, inward curved rims, and thickened outer edges, which first appeared at the end of the Early Bronze Age (EBA) and continue in MBA and LBA as a characteristic of the zone. These bowls were also seen in Troy and its surrounding areas in the north to Panaztepe and Liman Tepe in the İzmir region, and as far south as Beycesultan in the Maeander Valley. Additionally, the same types were found in close to Western Anatolia located East Aegean islands such as Chios, Samos, and Lesbos (Lamb 1936: 159; Blegen et al. 1953: 159-60; Milojcic 1961: 50, 66, 72, 75; Lloyd and Mellaart 1965: 82; French 1969: 68, 72; Hood 1982: 570; Joukowsky 1986: 621; Günel 1999b: 51-2; 2003: 59-62). Other common pottery in Western Anatolia for MBA and LBA that were found are fine quality, wheel made bowls with slip and burnished surfaces in yellowish-buff colours; medium quality bowls in

reddish-buff slip and a highly micaceous clay with thickened rims; a group of pottery with rounded body and relatively short neck with thickened outward rim in medium quality with stone, mica, quartz inclusions in yellowish-buff colour (Günel 2003: 59-62).

Kadıkalesi is known through excavations in the south of the Byzantine castle that revealed that the castle was built directly over the protohistoric mound. In this area, Mycenaean pottery, micaceous silver and gold wash wares from the 2nd millennium BC were found. A Hittite figurine was also found in the same area with contemporary pottery sherds (Mercangöz et al. 2008: 452; Mercangöz and Uhri 2008: 5-6). Another site in Kuşadası is Göztepe, identified in the survey documented with pottery fragments of inward rims from the 2nd millennium BC (Meriç 1988: 386).

As much as local traditions of pottery were commonly shared in Western Anatolia, sub-regional differences along with the coastal and inland differentiation of mixed traditions were produced. The painted pottery in southwest of inland Western Anatolia spans from the early 16th century BC. to the 11th century BC. Red, brown, or black painted designs on gold wash ware were discovered at Beycesultan, Laodikeia Asopos Tepesi, and Pekmez Höyük/Aphrodisias. These potteries were incorporated into the LBA repertoire. Especially the late phases of LBA are the focus here as the peak time of this type of pottery. The pottery from these sites featured similar gold-washed wares with consistent motifs. These appeared especially in Laodikeia Asopos Tepesi V and Aphrodisias IVa dated to early 14th-12th century BC (Kadish 1971: 23; Marchese 1976: 399-401; Joukowsky 1986: 149-50; Dedeoğlu and Konakçı 2015). Light brown or buff wares, red-brown or red wares, brown wares, and gold and silver wash wares were common. The common forms were bowls, beak-spouted jugs, jars, and jugs. In Pekmez Höyük/Aphrodisias, although the archaeological context lacks widespread architectural structures, it does include an oven, floor, and stone foundations within a specific deposit. Additionally, the Theatre Hill at the site was occupied in the Bronze Ages until 1600 BC as shown by a settlement layer with a megaron-like building and low amount of pottery from the LBA. At Laodikeia Asopos Tepesi, walls, compacted earth floors, and garbage pits were associated with domestic buildings comprised painted pottery (Marchese 1976: 399-401; Joukowsky 1986: Eren 2016: 157; 149-50; Dedeoğlu and Konakçı 2015).

Viewshed analysis

Viewshed analysis was applied to discern the visibility between sites as well as the visibility between settlements and cemeteries, and their relation to harbour areas. It contributes to examining also possible site placement patterns in proximity to the rivers, creeks, and specific routes, and the degree of geographical control of the sites in their landscapes. The visibility tool was used for VS with the different parameters given below, based on characteristics of geography and material and settlement distribution. The results of the analysis and the archaeological data from the sites were applied in junction to develop and provide new information for settlement patterns, controlling area, and connectivity. The output of the visibility analysis shows a map of the visible and invisible parts. The parameters for the VS analysis were changed, based on the sub-zones and their geomorphology. The distance parameters chosen for the visibility were limited to 2.5km, 5km, and 35km. The first two parameters were applied to closer sites and/or groups of sites that have a direct connection and/or are situated in the same area during the LBA. It is helpful to investigate, if there is a continuation and alteration in the use of settlements in these periods. The distance parameter of 35km was applied for defining and describing regional landmarks, that may have been used for connections through sea and/or rivers. For the above analysis, the coordinates of the highest points of settlement and/or cemeteries were taken into consideration.

In the visibility analysis shown on the map the positions and settlement patterns of sites within 2.5 and 8km areas reveal that the settlements were in certain distances to each other around and between river branches in the region (Figure 3). When looking at the 8km area considering the LBA geography, Miletus controls the entrance at the sea mouth of the Maeander region. The location of the Değirmentepe cemetery as directing towards the Miletus harbour suggests that one of the reasons of locational preference of the cemetery during the period when it was an island was navigational. In 35km area of the visibility in Miletus covers until Söke where near the sea limits in the Bronze Age in further inland. Since it is known that today's Maeander Valley was part of the sea with islands and islets, it is possible that they had vision for seamarks and coastal sites when travelling from/to the Aegean Sea. This area is also a known geographical limit of the inland sites in which Aegean materials were found (Figure 4).

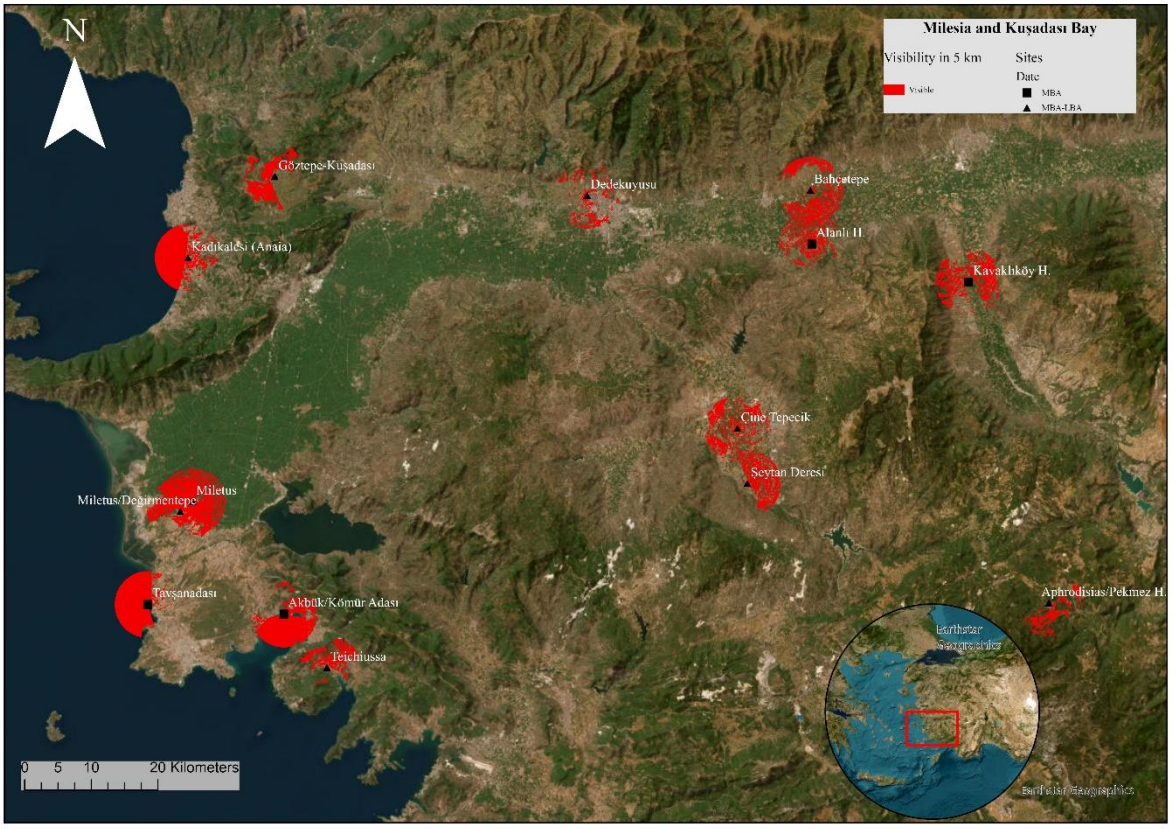


Figure 3. Milesia and Kusadasi Bay: the positions and settlement patterns of sites.

From the other sites in this article, Göztepe-Kuşadası, Kadıkalesi (Anaia), Bahçetepe, Şeytan Deresi, and Çine-Tepecik are considered about the regions's network and paths by including the VS analysis. Göztepe-Kuşadası site directly connected to the sea, even from today in a clear day, had visibility to the island of Samos and Kadıkalesi (Anaia). This visible area in 35km parameter can determine landmarks and connection with Samos and Kadıkalesi (Anaia), but it is also important that it had view through Ephesus landscape and Lebedos Bay. Ephesus and Göztepe-Kuşadası were in the same landscape area of the Kuşadası Bay. Lebedos Bay had connectivity with the Icarian Sea and north of Kolophon (LBA cemetery). Kadıkalesi (Anaia) on the coastline of Kuşadası Bay had direct view to Samos, Göztepe-Kuşadası landscape, and north of the Mycale Mountains. The west part in the visible area at the north

of Mycale Mountains covers a possible path during the LBA from the site to Miletus via the sea where now is the Maeander Valley (Figure 3).

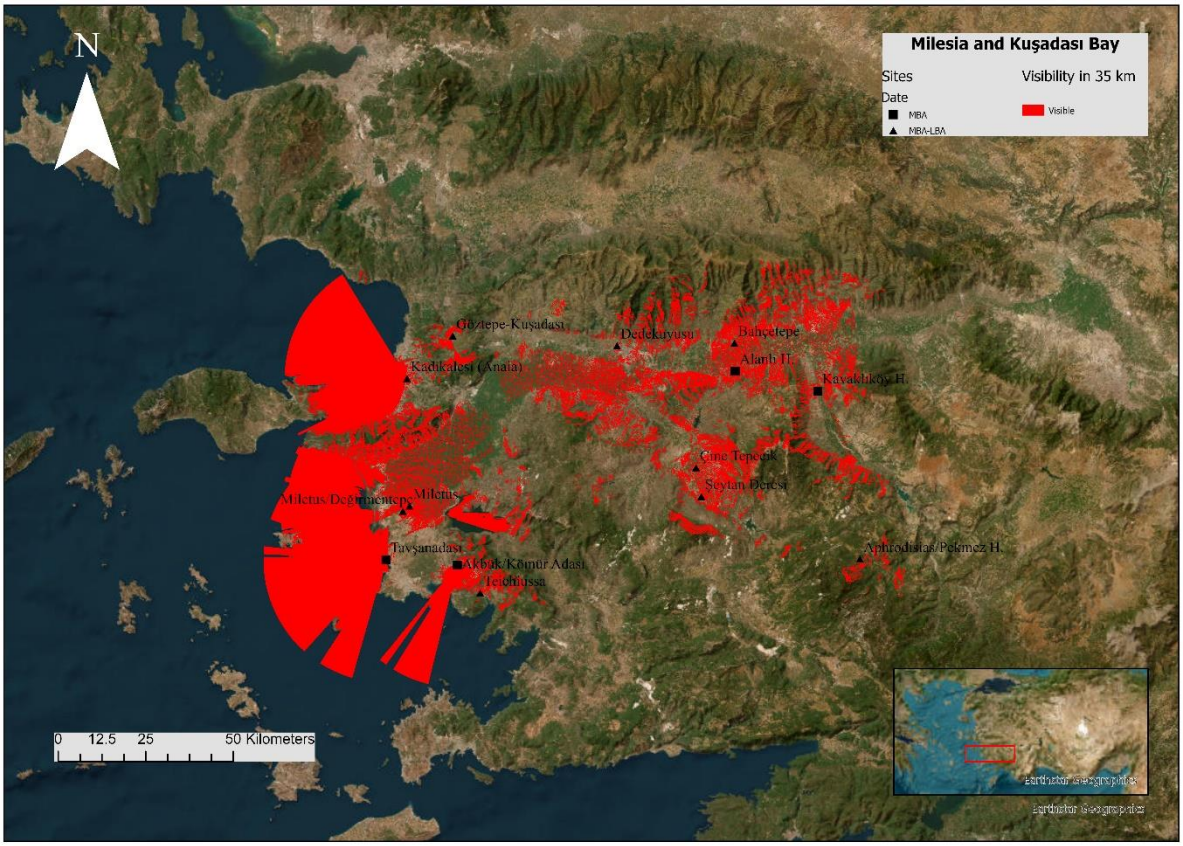


Figure 4. Milesia and Kusadasi Bay: a known geographical limit of the inland sites in which Aegean materials were found.

Bahçetepe offers a view extending on the east of the Maeander Valley, to the sites of Çine-Tepecik and Şeytan Deresi, and was strategically positioned within a 35km radius to facilitate a wide network of connections within the Maeander Valley. It also dominates in visibility the MBA settlement of Alanlı, located within an 8km radius to the south, and another MBA site, Dedekuyusu, within an 8km radius to the west. Bahçetepe and Dedekuyusu were potentially on the western route of the Göztepe-Kuşadası coastal settlement to the inland sites. Given the distribution of materials, it is worth questioning whether Alanlı and Dedekuyusu, which were abandoned after MBA, might have had connections due to their proximity to Bahçetepe with the site itself and whether they were part of the central city's (Çine-Tepecik) sphere of influence. A migration from those sites to Çine-Tepecik should not be neglected. Çine-Tepecik and the small settlement at Şeytan Deresi, at the same river extension of the south of the Maeander, were in the same radius of 5km. Çine-Tepecik, as one of the central sites and connection knots between the coastal and inland southwestern Anatolia in the valley, most possibly had direct sight through the Maeander River when it was the sea during LBA (Figure 2-4).

Least cost path analysis

The LCP analysis is crucial for the connections between the sites in the region. The LCP analysis, considering the geomorphological research for the LBA, suggests potential crossing points, river routes, and sea travel paths of the period. Identifying these routes, alongside the visibility analysis, illustrates how people utilized the landscape to form the era's cultural, commercial, and political connections. The examining of the distribution of settlements and materials enables to identify routes that do not align with geographic distributions in the analysis. This sheds light on alternative reasons for the formation of cultural connections and landscape usage stemming from political and commercial networks, bringing new ideas and questions.

Despite the reliability of the parameters entered in the LCP analysis, the results may not always be accurate when considering geographical features, settlement patterns, and material distributions. The route seen on the map (Figure 5) directly connecting Göztepe-Kuşadası to Hacıkebir Höyük (Kütahya) was disregarded because the alternative route was deemed more appropriate for the reasons mentioned above.



Figure 5. Maender Basin: paths between the inland and coastal sites.

Primarily, the regions within inland Western Anatolia, such as Kütahya, Uşak, and Afyonkarahisar, were considered since they fall within the Maeander Basin, with the main water sources of the Maeander River passing through these areas. The Banaz and Değirmen rivulets (the northeastern sources of the Maeander River), Işıklı lake (where Küfü rivulet connects and forms the mouth of the Maeander River),

and Küfü rivulet are crucial water sources that converge and flow into the Aegean Sea from Denizli city, uniting near Beycesultan.

The coloured routes seen on the map overlap each other. Upon reaching Denizli, the routes from Afyonkarahisar, Kütahya, and Uşak converge and proceed through Honaz Höyük (Kolossai) and Laodekeia Asopos Tepesi to Bahçetepe in the Maeander Valley (Figure 5). Pekmez Höyük/Aphrodisias is situated on the southern slopes of Babadağ in the southern inland Western Anatolia on the upper Meander basin. This part of the basin acts as a conduit connecting inland Western Anatolia to the sea via several valleys and passes. As a part of it Pekmez Höyük (Aphrodisias) seems as ending of the valley, further southern among Maeander sites, such as Çine-Tepecik and farther from the sea in the LBA. Additionally, the routes extending to the port cities, marked in purple, follow the same paths from the mentioned port cities to the inland Western Anatolian cities, although the legend only provides Afyonkarahisar as an example.

An alternative route in turquoise colour starting from the area containing Kediyünü and Elmacık mounds joins the Maeander River from a more northern direction, yet still approaches Bahçetepe. Both the internal routes within the Maeander Valley and the probable paths connecting it to inland Western Anatolia show that settlements like Çine-Tepecik, Bahçetepe, Şeytan Deresi, and Pekmez Höyük/Aphrodisias are interconnected, with distances generally between 5-8km radius and located along lines that link the Maeander inland sea to their river segments.

Similarly, it is possible to consider that the inland Western Anatolian sites around the mentioned streams and lakes also had similarly dense settlements, even more so after the MBA settlements were abandoned. LBA settlements in these areas became more central and expansive. It is important to note that LBA settlements continued to exist by expanding around or relocating within the same mound area unless there was a change in the river's flow or bed.

In addition to Çine-Tepecik, Bahçetepe might have been directly connected to the inland sea during the LBA period. When examining the material characteristics of these two settlements, as discussed in the previous sections, it can be inferred that they stood on opposite shores and had clear cultural and navigational connections. Considering Çine-Tepecik as a central hub, Bahçetepe can be thought of as a stop along the inland seacoast used during that period. Moreover, as indicated in the last discussion and visibility on the next map (Figure 6), the nearest settlement to Bahçetepe that is relatively more accessible is indeed Çine-Tepecik. The path to Çine-Tepecik from Göztepe-Kuşadası which partially was seen in visibility analysis mentioned in the previous section and these sites connected to each other. This connection was via the MBA site at Dedekuyusu possible, so, it brought questions about the connectivity and functions of Bahçetepe, Dedekuyusu, and Çine-Tepecik as inland sea sites during LBA. The map also shows (in blue path line) that the connectivity among those sites was more plausible pass sailing near the coastline of the inland sea, instead of land travelling (Figure 6). Moreover, the landscape of Göztepe-Kuşadası with Ephesus had also route connectivity among them that is not included in this article and requires further research, especially to examine sub-regions.

Miletus and its cemetery Değirmentepe and Kadıkalesi (Anaia) as a part of central harbor sites in southwestern Anatolia, paths should be considered with the inland sea. However, for analysis on the Maeander, it should be remembered that not all geomorphological data are accessible or researched. Kadıkalesi (Anaia) besides its direct connection with Samos, the path between the site and Miletus was more possible from the inland sea, west of Mycale Mountains, which were not completely formed.



Figure 6. Maender Valley sites.

In inland Western Anatolia connections towards or from Miletus, the position of Çine-Tepecik stands out significantly for both directions. This settlement is not only advanced in terms of urban development for the period but also evidently integrated into trade networks through its material culture. The strategic location of Çine-Tepecik, considering the inland sea during a long journey, underscores its importance. As previously mentioned, the position of Değirmentepe relative to Miletus, both being nearly or still islands during the LBA, and considering an inland sea that includes the lake known today as Latmos and extending to Söke, highlights its strategic importance. Değirmentepe's orientation towards the Miletus port and the view it offers of the islands and coastlines within the inland sea from both points underline Miletus's advantageous position in trade and political networks. This advantage is evident not only in Miletus's established role as a central power but also in its network within the Maeander basin and the Kuşadası region, as indicated by the aforementioned routes. This geographic and strategic positioning must have significantly contributed to its prominence and influence.

Conclusion

Based on the GIS analytical results and the distribution of pottery, the following sub-regions must be considered for connectivity and sharing the landscape: Kuşadası and Ephesus, Çine-Tepecik with Pekmez Höyük/Aphrodisias and Bahçetepe, inland sites connected to the Maeander basin as settlement clusters with specific riverways, and Miletus with Kadıkalesi (Anaia), Çine-Tepecik up to Söke.

Although no excavation has yet been carried out in the LBA layer at Kadıkalesi (Anaia), Mycenaean materials have been found. Its proximity to Samos Island and its visibility within the Aegean during sea voyages, in addition to its communication with Samos, suggest that it likely served as a connection point in its own region, including to the north of the Mykale mountains and the Göztepe-Kuşadası settlement. Visibility analysis together with LCP results indicate that it was likely an inland sea route connected to Miletus. Therefore, it may be necessary to reconsider the relationship between such central coastal areas and the Aegean, and how this relationship reflected on Western Anatolia, particularly in the context of the networks formed in the Maeander and Kuşadası sub-regions. Consequently, although Kadıkalesi appears to be outside the Milesia region, its position and influence from Ephesus to Miletus, where Mycenaean materials are similar and contemporary, are significant.

As one of the most central settlements, Çine-Tepecik must have not only served as the most likely transit port but also connected the Maeander Basin as one of the most important bridges between the Aegean and the southern Western Anatolia. Moreover, the geographical proximity between this site and the small-scale surrounding settlements, as well as the fact that these areas followed a similar settlement distribution, indicate that they had a cultural and commercial network within each other's sub-regional boundaries, as we can see when combining Visibility and LCP analysis.

Along with the impact of geography on the landscape use, building ports, and maritime activities, the cultural, commercial, and political connections and needs that arose in the Milesia and Kuşadası regions also influenced the settlement locations and landscape use in this geography. The fact that Değirmentepe cemetery was an islet in a position usable for navigation, directing towards the Miletus harbour, and that both areas had connectivity with the settlements on the coastline and rivers nearby the coastline of the inland sea that mentioned in the article recognizing these as landmarks and the islets as seamarks; and the LCP analysis showing these routes as the most favourable paths, should also be taken into account.

The main lakes and streams in the Maeander basin that serve as water sources for the Maeander River, the LBA settlements clustered around these wetlands and other regional rivers such as Banaz rivulet, and streams within their own regions follow the same routes within their sub-regions. As the paths approach the Maeander Valley from these settlements converge along the Laodikeia Asopos Tepesi, Honaz Höyük (Aphrodisias), and Beycesultan route lines. Although these channels were suitable as routes, no commonality in terms of material distribution, local goods, and architectural elements has been observed yet. This aspect, which should also be evaluated within the context of the Arzawa region, is further expanded upon in my doctoral thesis as a separate research topic.

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Paleo-geomorphology of Pharos Island, Alexandria, Egypt by using geomorphological and submerged archaeological evidence[1]

Magdy Torab[2]

Abstract

The city of Alexandria is located on the western edge of the Nile River Delta. Alexander the Great constructed it in 331 BC. The ancient island of Pharos borders the city to the north, where Alexander the Great built a massive lighthouse reaching a height of more than 100 meters. Three earthquakes between 956 and 1323 AD destroyed it, making it one of the Seven Wonders of the Ancient World. The Heptastadion, a mole spanning more than 1,200 meters, later connected Pharos Island. The ancient Pharos Lighthouse, built in the 15th century, served as the foundation for Qaitbay Fort. The purpose of this paper is to describe the paleo-geomorphological map, the geomorphological evolution, and the stability of Pharos Island's coastline area as part of Alexandria, an ancient city. It will also talk about the relationship between land and sea as a result of tectonic movements, climate changes, and human activities over the last 2,000 years, based on evidence found underwater from the Greco-Roman and Ptolemaic periods. These criteria include local subsidence or uplifting, relative sea-level rise (RSLR), land topography, width of lagoon barriers, beach-face slope, high-elevated features such as sea cliffs, stacks, benches, and notches, eroding and accrediting coastlines, and ancient protection works. These criteria include features such as sea cliffs, stacks, benches, and notches; eroding and accrediting coastlines; and ancient protection works.

Keywords: paleo-geomorphology, Pharos Island, Qaitbay fort, Alexandria City, submerged archaeology

Introduction

Alexander the Great built Alexandria on the Mediterranean Sea's shores in 332 B.C. The world recognized the city for its immense Royal Library, established during Ptolemy II's reign at the start of the 3rd century BC, and the Pharos Island lighthouse, one of the Seven Wonders of the Ancient World, built early in the Ptolemaic era. Most of Alexandria's royal and civic quarters sank beneath the harbour due to earthquake subsidence; a part of the ancient city of Alexandria lies 6 to 8 meters underwater as a result of modern climatic sea level rises in addition to tectonic subsidence (LA Riche 1979). Pharos, a small, rocky island (Figure 1), is notable for being the site of Alexandria's ancient lighthouse. Scholars have extensively researched and written about the island's history, focusing on its archaeological, historical, and religious aspects (McKenzie, 2003). Recently, various disciplines, particularly earth scientists, have acknowledged the island's potential to integrate into their fields. The geomorphology of the ancient lighthouse, one of the Seven Wonders of the Ancient World, interests us. Herodotus's histories describe the link between Pharos and Egypt as a rocky island.

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Background of Pharos Island

Alexandria is Egypt's largest city, extending from east to west along the northern coast. It is located between the Mediterranean Sea from the north and Mariut Lake from the south, in the eastern sector of the Mediterranean Sea. Pharos was a small, rocky island located on the western edge of the Nile Delta, facing Alexandria City; its coordinates are 31°12′53″N 29°53′10″E. (Figure 1).

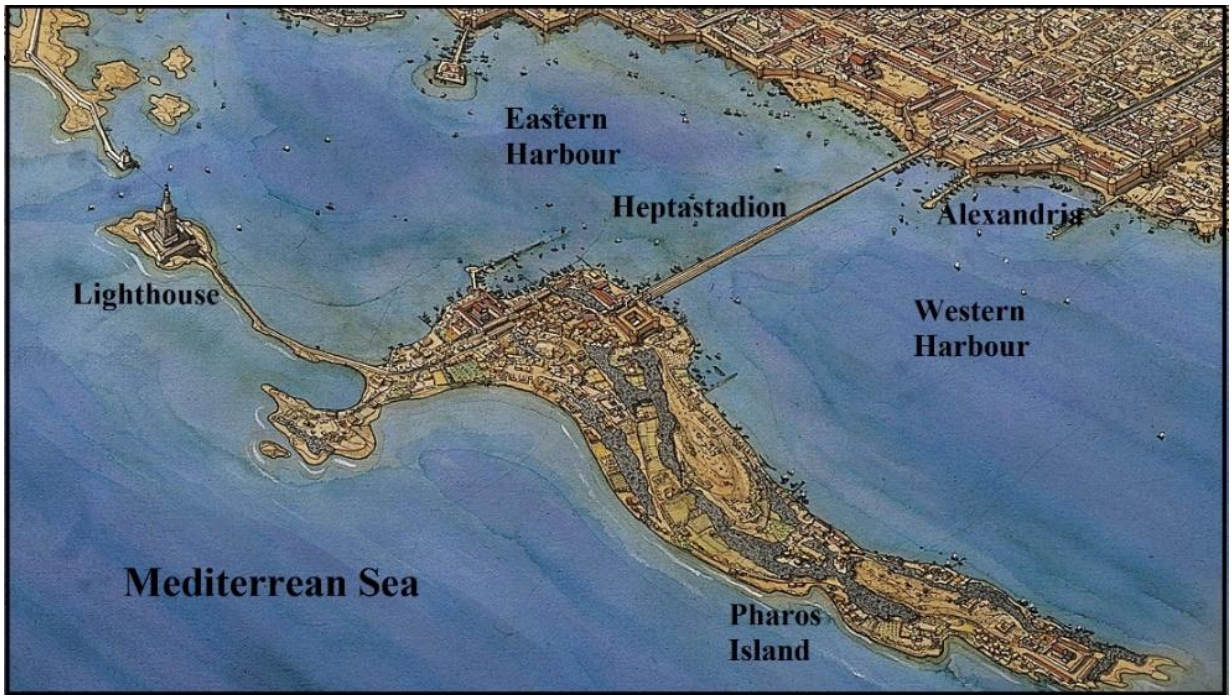


Figure 1. Pharos Island lies north of Alexandria City and Mariut Lake (http://jeanclaudegolvin.com).

We can divide Egypt's north coast into two pivotal geographical areas: the western north coast, which stretches from El-Arish to El-Alamein, and the northern coast area, which stretches from El-Alamein to the eastern edge of Alexandria. The former western north coast is geologically simple, consisting of a carbonated shelf broken up by major wadis, but the latter is tectonically and structurally complex. The island itself is an artificial buildup of debris resulting from more than 23 centuries of continuous human colonization and construction. Longshore drift patterns and wave climates, particularly the powerful winter storm waves, also exert an influence on the island. These environmental factors have not only caused the island to grow and retract many times larger than its current size, but they have also caused irreparable destruction to the ancient eastern section of the island, including the famous Pharos Lighthouse, which collapsed after several earthquakes from 956–1323 AD. The lighthouse remains, located offshore from the island's easternmost tip, are currently under water. Today, the island is experiencing erosion and coastal retreat, particularly in the west. There have been several attempts to stabilize the shoreline. In 1974, the most recent attempt involved artificially grading the western shoreline with concrete rubble and elevating the entire island, except the eastern tip, by one meter using beach nourishment techniques (Empereur 1998). These methods proved ineffective, as did the ongoing degradation of the island.

The Role of Geomorphology in Archaeology

Geomorphology is a science that can help study human history. It provides the foundation for rebuilding landscapes as they once were. This is particularly important for reconstructing the world of ancient societies from different periods (archaeology), as the physical landscape, also known as the "frame of life," provides insight into the nature of the physical environment these societies lived in and the constraints it imposed on their activities. Furthermore, the physical landscape speaks to the specifics of the terrain's geological history, be it geological, hydrological, or geomorphological—information that the population may not even be aware of. Furthermore, the physical landscape may have exerted certain attractive elements on a specific population category, either in the short or long term, depending on the natural conditions evoked by this landscape.

Therefore, accurately interpreting archaeological sites, including those abandoned or destroyed, requires an understanding of the landscape's history and dynamics. We can discern the reasons for abandonment from the use of the terrain, such as Galex Town in Alexandria, and understand how natural agents or locals themselves caused site destruction. Furthermore, the remnants of the distant past fall under the category of finds and vestures. This is the rationale behind the establishment of a synergistic relationship between geomorphology and archaeology, bringing together two closely related and complementary disciplines like natural and human studies to create a more comprehensive representation of historical events (Brierley et al. 2021).

Objective

This paper presents a detailed study of Pharos Island, particularly the Quaternary geomorphological evolution and the associated environmental changes in the studied region. In addition to submerged archaeological evidence, the study uses data from the literature, including previous geological, geomorphological, and archaeological studies, as well as direct, detailed field investigations of coastal cliffs, inland deposits, and underwater deposits. The study's main objectives are to establish the chronology of the geomorphological record and archaeologically significant sites. Finally, the research objectives, as stated above, are to reconstruct a paleo-geomorphological map of Pharos Island, which was part of Alexandria City before Alexander the Great built it in 331 BC, using submerged archaeological and geomorphic evidence. Submerged archaeological and geomorphic evidence.

Previous work

Empereur (1998), Goiran (2001), Mckenzie (2003) and Ashton (2004) have studied the submerged archaeological sites of ancient Alexandria. Researchers have conducted studies in earth science and paleo-geography (Goiran 2001), stratigraphy (Goiran et al. 2022), underwater archaeology (by the Hellenic Institute for the Preservation of Nautical Tradition and the Hellenic Institute for Ancient and Mediaeval Alexandrian Studies 2000), and sedimentology (Goiran 2001; Stanley et al. 1996 and 2006). Each of these disciplines has studied the Alexandria region.

Methods

We used several submarine archaeological surveys to identify Alexandria city remains in the eastern harbour and reconstruct a paleo-geomorphological map of the study area. These methods include figuring out what satellite pictures and old topographic maps mean, as well as field surveys, the results of a side scan sonar survey (Schwartz, 2021), an eco-sound survey (Empereur 1998), geoarchaeological settlement dating (Goddio, 1998), and sedimentary boring (Goiran 2001; Stanley et al. 1996 and 2006).

To show that the city sank, we will use side scan sonar surveys (Schwartz 2021), eco-sound surveys (Empereur 1998), geoarchaeological settlement dating (Goddio 1998), sedimentary boring (Goiran 2001; Stanley et al. 1996 and 2006), and comparisons with the underwater archaeological ruins in Alexandria's east harbour. In 1997, a team of geographers and marine biologists began to investigate this specific phenomenon, both underwater and in the silt deposits on either side of the Heptastadion. The analysis of the side scan revealed some geomorphic features that survived (Chalari et al. 2009). Since the end of the 20th century, researchers have taken a series of cores to define the eustatic sea level change and tectonic subsidence that occurred during this period, during which the earth's crust in Alexandria's eastern harbour sank between 6 and 8 meters.

Data and material

Paleo-geomorphological and archaeological investigations often yield similar landscape settings and landforms, particularly those related to sea-level change. These two types of data highlight the importance of collaboration between researchers specializing in archaeology and their colleagues specializing in paleogeomorphology. This collaboration facilitates the integration of new findings and a proposal to illuminate possible settings for former human activities. However, undertaking interdisciplinary research is a challenging task that occurs only occasionally. The study focused on Pharos Island, submerged in shallow waters along a Pliocene and Miocene shoreline. It is situated in a bay in the western basin of the eastern Mediterranean Sea, which is currently the location of the large Nile delta. In ancient Alexandria, the Nile ran into the sea. The preliminary results show that the processes of Neogene coastal changes in this sub-area of the Mediterranean can shed new light on the formation of the delta area. Additionally, they provide background information on the development of river- or canal-like building activity in a vast plain.

Results and discussion

Geographical characteristics

Pharos Island is located in the northwestern part of Alexandria. The island is about 1350 m long and 200 m wide. A causeway connects the island to the northern mainland. In 290 BC, the Ptolemaic Kingdom began construction of the Great Lighthouse, which was 100 m high and estimated to be 106 meters from sea level. Three earthquakes, the last of which occurred in 1303, destroyed the three-tiered building. Pharos Island is the western extension of the Delta region's anticlinal axis. A series of sea cliffs around the island shore expose these limestone beds, which dip 5–10 degrees towards the north. At the island's northeastern tip, longshore drift and beach exposure reveal a gravel-sand layer overlying the limestone. The limestone and gravel layers have a complex relationship on the northeast and east sides

of the island, where a series of faults have caused local damming of the Nile silt. This has produced a number of small basins where marshland has developed and recently receded due to infilling for urban and tourist expansion. The Nile silt damming has caused a lowering of the groundwater table in these areas, as well as subsequent saltwater intrusion from the nearby Mediterranean (Figure 2).

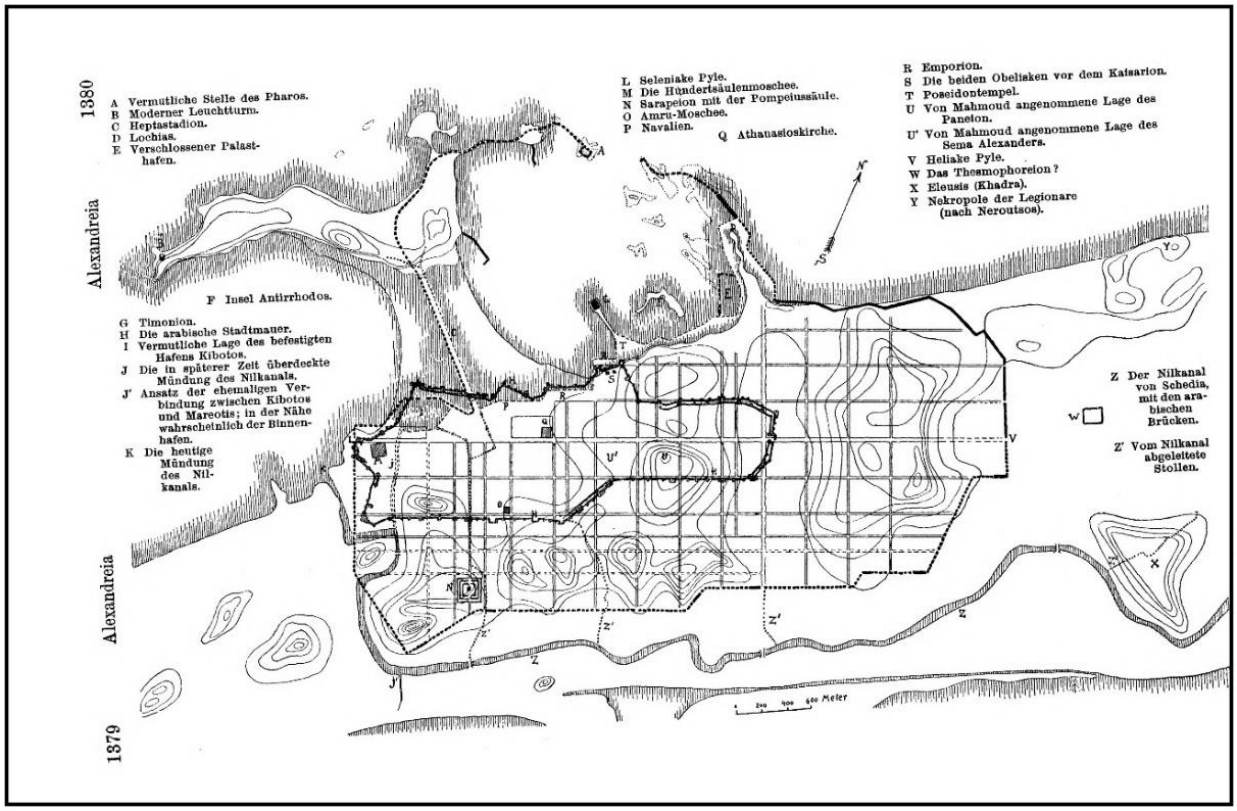


Figure 2. Historical topography of Alexandria and Pharos Island site (Paulys 1893).

Geological formation

Three geological formations make up Pharos Island: the first consists of old, brittle rocks, including the surrounding shoals of crystalline rocks. The other two formations are younger and made of relatively soft rocks. During the Middle Miocene, at depths of 120–150 meters, calcareous sandstones and marls formed the second formation, which became visible 3,000 years ago. Under nominal waters, a Quaternary sand and gravel formation, composed of calcareous sandstone layers, constitutes the third formation. Their stones are not very hard, and they appear to contain shell fossils. According to Fahmy et al. (2022), Hamouda et al. (2023), and Hamouda et al. (2024), the stones appear to contain shell fossils. The exposed rocks on Pharos Island revealed a variety of rock textures, including massive, bedded, lenticular (laminated), laminated, and pisolitic quartz sandstones. Among the identified textures are ripple marks, wavy (wavy bedding or wavy laminations), plane laminations, and lenticular (laminated) textures with some calcareous and/or ferruginous coatings. We also record the occurrence of hardgrounds (paleosols) at certain points within the studied rock exposures. We can observe some of the described textures and sedimentary structures concurrently, representing sediments deposited under the same flow conditions but varying in grain size. Goiran (2001) identified Ras el Tin's north-

dipping thrust fault, which heads towards the Pharos Island area and is the same fault that caused the Pleistocene submergence of the land known as the Mena retreat discussed. This retreat is believed to have submerged a major portion of ancient buildings in Alexandria City and the eastern end of Pharos Island, which now lies under several meters of water. The land on modern Pharos Island is only a fraction of its former extent (Figure 3).

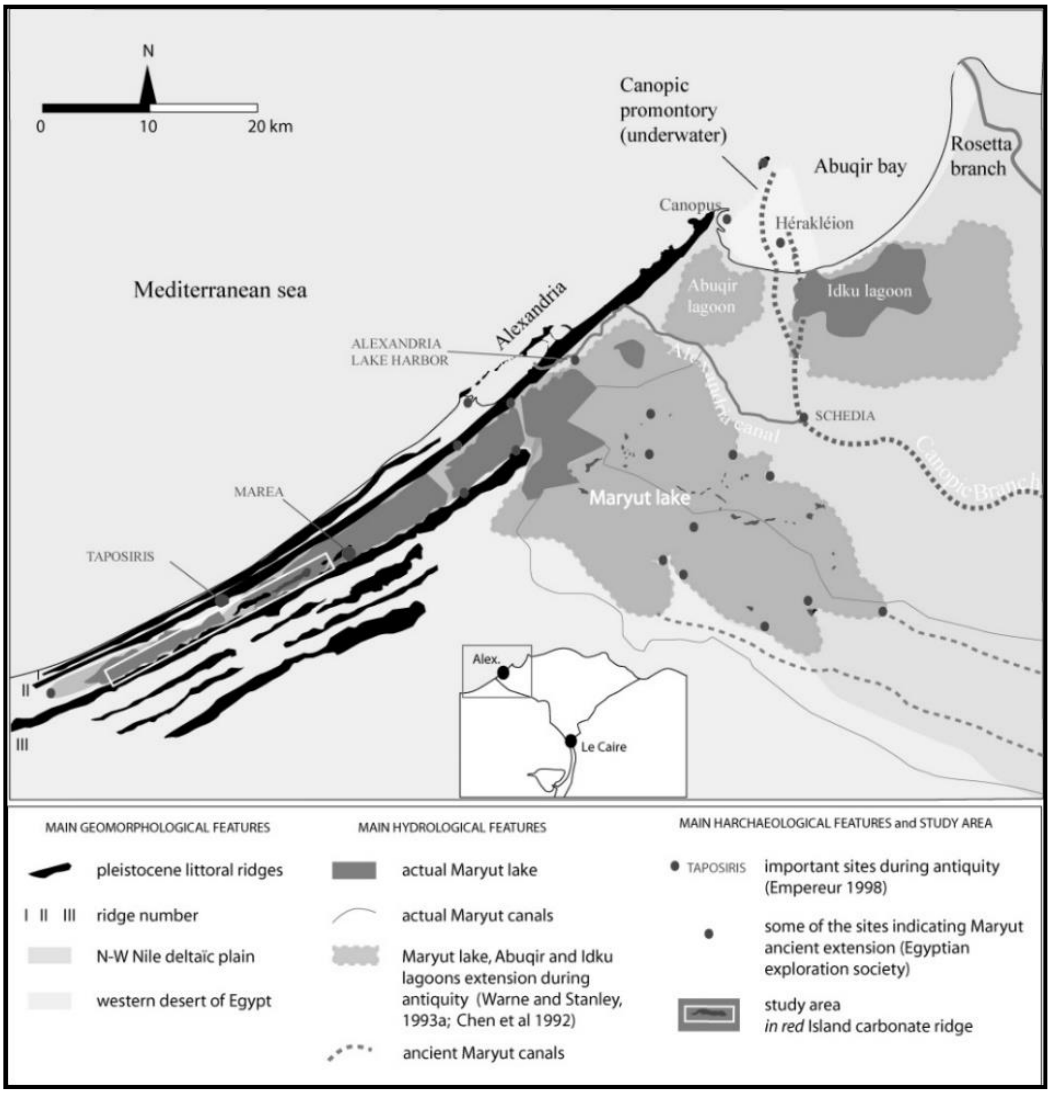


Figure 3. Relationships between Alexandria city site and limestone coastal ridges and Paleo-Mariut Lake shorelines (after: Flaux et al. 2011).

Alexandria before Alexander

The analysis of Alexandria harbour core sediments has revealed that Alexander the Great did not find the Egyptian city of Alexandria; he just rebranded it. Véron et al. (2006) and Goiran et al. (2022) dated new geochemical data using seashell pieces found in cores. These data show that Alexandria had high levels of lead contamination during the Egyptian Old Kingdom, from 2686 to 2181 B.C., and again during

the Iron Age, from 1000 to 800 B.C., at the end of the prosperous Ramses dynasties. This means that people lived there 4,500 years ago, more than 2,000 years before Alexander; the city of Alexandria was originally named Rhakotis.

Coastal erosion significantly impacts the island's landscape

Coastal denudation eroded the island during the 15th century, causing the land to subside and eventually flooding it. If it weren't for the lighthouse ruins submerged in local waters, historical records would have overlooked this event. Historical texts effectively document the history of sea level changes in this location, thanks to this fascinating geological period. This creates a dynamic model for examining landforms caused by changes in relative sea level.

The island's geomorphological landscape

A strait to the east, known as the 'Mahmoudiyah Canal', divides Pharos Island into two branches and connects it to the Mediterranean Sea. The main courses are the northwestern rap of specialized harbours and are proposed to be a result of karstification. A variety of factors, including their position, composition, geological structural position, hydrogeological systems, climatic conditions, and human activity, influence the appearance and evolution of these forms. These features enable us to classify the eastern basin as a relatively unstable karstic area. The findings described the geomorphology of the terraces, as well as the appearance of the island's lithology and structural (geological) signature.

Historically, extensive deforestation and overexploitation of this resource have led to the absence of natural olive tree forests in Egypt and elsewhere in the world. This remarkable event has gradually altered the landscape by reducing the ISs (Olive Tree) ecosystem; some of the resulting evidence can still be seen in the modern geo-archaeological landscape of Pharos Island. It is characterized by a relatively limited range of landforms, such as those formed by wall rock outcropping, buried or talus-covered rocks, horizon wicks, and paleosoil, as well as man-made buildings, walls, and narrow confines and channels. The morphometric sinking at Catharto-Kaisaro archaeological sites clearly indicates a significantly high net export of raw silt and clay to the archaeological sites (Hamouda et al. 2023).

Recent geomorphological landscape

Wave action and currents control the depositional and erosional features in the study area. Waves are eroding the eastern part of the island, depositing the eroded material near the western part. Additionally, during high wave action, deposition occurs in the northeastern part of the island due to the presence of berm-like depositional features along the shoreline, or possibly due to the placement of a submarine cement object for protection against land erosion hazards. These common depositional features safeguard the land areas during low-energy wave conditions, but they weaken and lose their effectiveness during higher waves as bed erosion begins in the eastern part. Currently, these are active and recurrent erosion and deposition processes that occur annually in the form of migrating beach bars. During calm sea conditions, the coastal bars form at a shallow water depth of approximately 4 meters, just beyond the wave base. The sources for this information include Darwish et al. (2021) and El-Gohary (2023). Studies by Fahmy et al. in 2022 and Chugg in 2024 support this information.

Marine terraces

Five successive sea terraces on Pharos Island demonstrate how the island's coasts influenced sea level changes during the Quaternary. The remarkable five terraces of Pharos Island are considered to be the most precise in situ relatively high-stand surfaces in the Alexandria city area and provide an opportunity to assess the regional dynamic processes of the lower Nile Delta River. Additionally, Pharos Island is one of the most important places in the northwest Nile Delta River area to study how landscapes changed over the Quaternary period and in the past. We can use geomorphological and rough-stratigraphic tools to interpret the ancient geographic and geological landscapes, revealing the numerous changes that have occurred. It is a very precious and unique ancient landscape, as well as a gateway to understanding the history and dynamics of oceanographic and landform processes. The island maintains a multi-stage geomorphological structure with incised, proper lower delta sedimentation features. The presence of multiple high-stand terraces in situ makes the area an excellent candidate for further study as a paleo-environmental reconstruction site to identify and monitor future regional and global climate changes. Scholars like Schwartz (2021); Darwish (2021); Meyer (2023); Higgins (2023); Hamouda et al. (2024); and Chugg (2024) have extensively studied the area.

Submerged platforms in the eastern harbour

Location of submerged platforms (Figures 10 and 11) show that the harbour platforms are currently below the current mean sea level (MSL) of 5 to 6.5 meters. This is despite the fact that the eustatic sea level in Roman times was less than two meters (Pirazzoli 1991). This means that over the last two hundred years, the rate of erosion and tectonic subsidence has ranged between 3 and 4.5 meters (Figure 4).

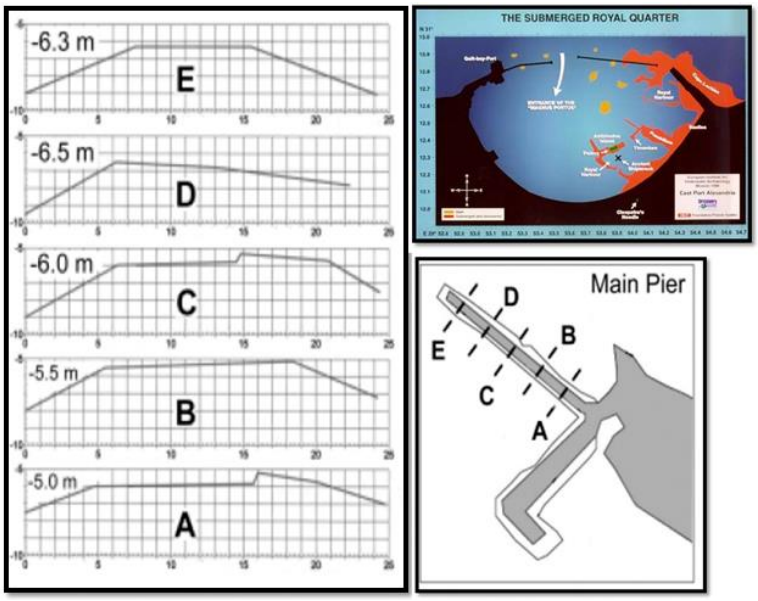


Figure 4. Topographic profiles on the submerged main pier of the eastern harbour (after Goddio 1998).

Geomorphological evolution of Pharos Island

Wave action and currents control the depositional and erosional features in the study area. Waves are eroding the eastern part of the island, depositing the eroded material near the western part. Additionally, the presence of berm-like depositional features along the shoreline, or perhaps the placement of a submarine cement object for protection against land erosion hazards, causes deposition in the northeastern part of the island during high wave action. These common depositional features safeguard the land areas during low-energy wave conditions, but they weaken and lose their effectiveness during higher waves as bed erosion begins in the eastern part. Currently, these are active and recurrent erosion and deposition processes that occur annually in the form of migrating beach bars. During calm sea conditions, the bars form at a shallow water depth of approximately 4 meters, just beyond the wave base.

Active sedimentation processes inside the eastern port led to the growth of the bridge connecting the beach and Pharos Island, and tectonic subsidence and sea level rise since the Roman era contributed to submerging the docks of the ancient port of Alexandria.

Underwater digs, side scan sonar surveys (Schwartz 2021), eco-sound surveys (Empereur 1998), geoarchaeological settlement dating (Goddio 1998), sedimentary boring (Stanley et al. 1996 and 2006; Goiran et al. 2022), and comparisons with the underwater archaeological ruins in Alexandria's east harbour have all shown that the city has sunk. In 1997, a team of geographers and marine biologists began to investigate this specific phenomenon, both underwater and in the silt deposits on either side of the Heptastadion. The analysis of the side scan revealed some geomorphic features (Chalari et al. 2009). Researchers have used a series of cores to define both eustatic sea level change and tectonic subsidence since the end of the 20th century, when the earth's crust in Alexandria's eastern harbour sank between 6 and 8 meters.

Paleo-environmental Reconstruction

The present-day outline of ancient Alexandria's submerged Pharos, a lighthouse also known as the Tower of Heroes, still dominates the waters of Alexandria's eastern harbour. Ancient historians such as Strabo and geographers such as Claudius Ptolemy and Agathodaemon mentioned this Hellenistic town on Pharos Island, and as a result, the area is ideal for exploring ancient landscapes. To complete the investigation of Pharos Island's limits, it is necessary to elucidate the history of its seafloor. The drowned Pharos, a case of retrieval and public presentation of a sunken underwater site, provides for such an investigation. Examining the paleoenvironment of the area yields a deeper understanding of the landscape present in ancient times. Specifically, the paleo-geography of the area around the Eastern Harbor and its greatest curiosity, Pharos Island—the man-made island just off the entrance to the harbour—become a new question that is relevant for future bathymetric endeavours as well as terrestrial explorations of the island.

Several characteristics may have influenced Pharos Island's paleoenvironment and its immediate surroundings. Due to relevant insolation-dependent fluctuations in Earth's orbit, extensive fluctuations in global sea level have occurred over million-year time scales and through the mid-late Holocene. The time period's flora and fauna may also provide clear clues as to the nature of the surroundings. Changes to harbour infrastructure may also help reconstruct the environment, specifically changes in ports and harbours from human-induced silting or the increased depth of submerged submarine ports.

A change in habitat may cause evolutionary adaptations in species and other taxa. For such a reconstruction, microfaunal studies would be critical. Consistent with an ever-changing sea level, a shifting climate may induce significant vegetation transitions. Signed changes typically occur under one or more of the following conditions: changing climate, vapor generation of large amounts of water, or establishment near a desert (desert margins). In such instances, we can use the vegetation composition to discern seasonality in the climate and establish regional boundaries. Given an adequately long period of time, a stable system will show an increase in tree cover, and new floral species may continue to arrive in the region. Trees, grass, and shrubs have evolved changes in their reproductive systems that will allow them to adapt to the environment. Tree-ring techniques provide knowledge that enables the reconstruction of paleoclimatic conditions from trees residing on or close to their species boundaries. Furthermore, we can use tree rings in submerged or seasonal environments to reconstruct localized flooding patterns (Aref 2023).

Submerged Archaeological Evidence

The submerged archaeological evidence around Pharos Island is very rare. Man and geological processes along the coasts once combined to submerge the sites. Thus, detailed geomorphological studies are required to provide as much information as possible. Submerged sites are particularly important, providing a unique paradigm of human life for thousands of years. Around such submerged ancient cosmopolitan cities, the study of underwater archaeology is the only source of ancient urban statistical life. Geophysics, hydrography, and underwater excavation are all critical methodologies for exploring underwater archaeological sites. Barbot et al. used marine geophysical techniques to investigate underwater archaeology in the Eastern Harbor. To obtain precise measurements in the field, it was necessary to meet conditions such as sandy and shallow-water areas. Secondly, we had to establish a maximum degree of overlap between the planned airphoto grid and the line spacing for the magnetometer and side-scan sonar to ensure the sensor captured as much dragnet area as possible. Next, we had to get the positioning sensors to work with the bathymetry. To record regional seismic reflection profiles in situ, we changed the side-scan sonar's coordinates and placed the sensor at "height-of-tide." Finally, we had to shut off the AC electrical power in cases of tidal interactions and position the electrodes to prevent cable strangulation in others. For 3D heritage documentation, geophysical and hydrographical multi-beam echo sounder methods are essential in archaeological surveys (Nicolaides 2022).

Historical evolution of Pharos Island

We used notes, maps, ancient documents, bequeathed plans, aerial photographs, and other analytical investigations to provide a comprehensive timeline of events in Pharos since its separation from the main rigid land of Alexandria.

Understanding the roots of this evocative identity, which is the purpose of one's research, requires a chronological date and an analytical methodology to reconstruct them in a way that illustrates the characteristics and historical buildings of Pharos Island.

During the years 1517–1917, Pharos Island stood on the Alexandria Corniche like a silent and immortal sovereign, witnessing a succession of cultures that married to mix their civilizations and then sent it back from this fading reminiscence to the open sea. The island was a sophisticated historical crossroads

of immense value, marking a profound bond between the Mediterranean world in terms of the city of Alexandria and the Nile Delta.

The Ottoman-Turkish empire lost the Battle of Tel El-Kebir in 1882, setting the stage for World War I and the British occupation of Egypt (Anson 2021).

In 1798, Napoleon built an observation point standing on more than forty Egyptian soldiers' helmets. The Ottoman-Turkish army defeated Ibrahim Pasha throughout his campaign, capitalized on Alexandria's occupation, and bombed the Citadel and El-Muncara with heavy artillery, leaving the castle walls and towers in poor condition. The Ottoman-Turkish army abandoned Qait Bay and El Muncara's cannons. The extended Egyptian costumes and the arrival of foreign naval observers also contribute to this. (North, 2023).

Following the construction of the breakwaters and the introduction of Plummet No. 1, land reclamation activities primarily extended beyond the boundaries of El-Qait Bey fort. The citadel saw the construction of some poor houses, while the fort became a residence for military officers. Across the rest of Pharaoh Island, the dunes continued to form a sand desert (Figure 5).

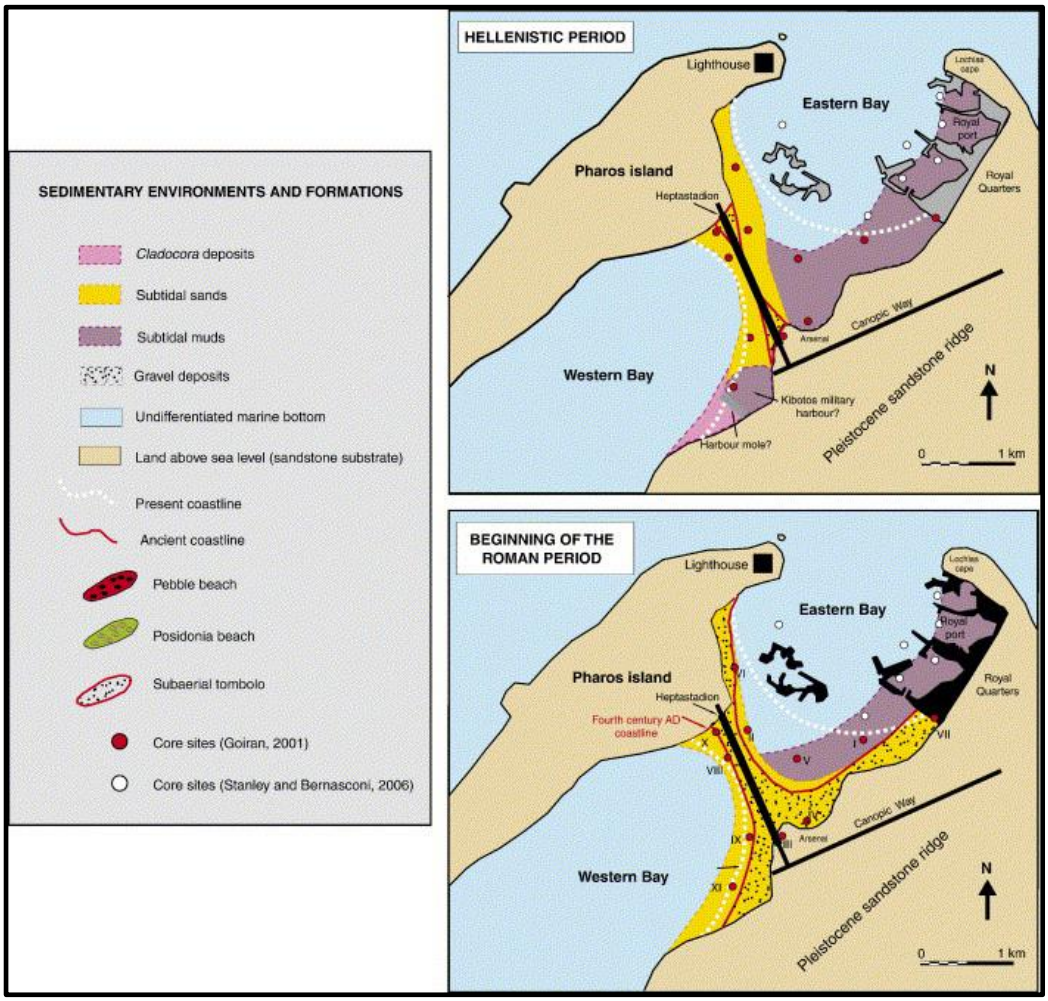


Figure 5. Geomorphological evolution of Pharos Island during Hellenistic and Roman periods (After: Goiran et al. 2022).

Human Impact and Urban Development

Pharos has witnessed exceptional urban development activities. The city expanded at the expense of the surrounding land and sea. When the Suez Canal was completed in 1869, the landscape predominantly consisted of light settlements, vast expanses of open land, lagoonal fishponds, salt pans, cultivated lands, and extensive stretches of dunes. The construction of the harbours, the excavation of the Pharos Island waterfront, and later the constant urban growth transformed a large number of alluvial terraces into urban and industrial areas, archaeological zones, tourism facilities, and busy roads that accommodated numerous buses. On backwaters, we built the large residential quarters of Sidi Gaber, Choueifat, Eskanderia, and Sidi Bishr, which included some wetlands of critical importance for the coastal environment. The island's new functions and continuous urban and industrial development have explicitly altered the coastal, marine, ecological, and archaeological systems.

Pharos Island (Faros) has been experiencing unprecedented urban growth and remarkable land reclamation activities at the expense of its marine and coastal environments. Since the 1970s, the island has experienced strong urban and economic growth, which has significantly impacted the various geomorphological formations. The population's rapid increase, fuelled by the ambitious goals of urbanization and industrialization, primarily leads to these activities, which include improving coastal construction and expansions, implementing new approaches, building quays and housing, and engaging in industrial construction and fishing activities.

The Lighthouse

Native Egyptians built a lighthouse for the first time in Egyptian history around 290 BC, during Ptolemy II's Pharaonic rule. The small island of Pharos is now the most crowded part of Alexandria. Many ancient geographers and authors mentioned the Pharos lighthouse, one of the most important ancient lighthouses. They named the island that encompassed the lighthouse on Pharos Island. A series of earthquakes between the 8th and the 14th centuries severely damaged the lighthouse. The island suffered severe damage at that time, reducing it to a small, rocky area that could not support any construction. The sea claimed the lighthouse after its remains collapsed. The 14th century finally saw it completely submerged (Belov 2020; Fahmy et al. 2022).

A paleo-geomorphological map

The above results allow us to estimate the paleo-geomorphological map of the Alexandria site before the city's construction in 331 BC (Figure 6). The map reveals two submerged shorelines that predate the city's construction (dated about 5.6 ka BP); Pharos Island and Agami Peninsula, part of the first limestone ridge, were larger than they are today; Mariut Lake was larger than it is today; some interior harbours were larger than they are today; and some interior harbours were located on its northern beach.

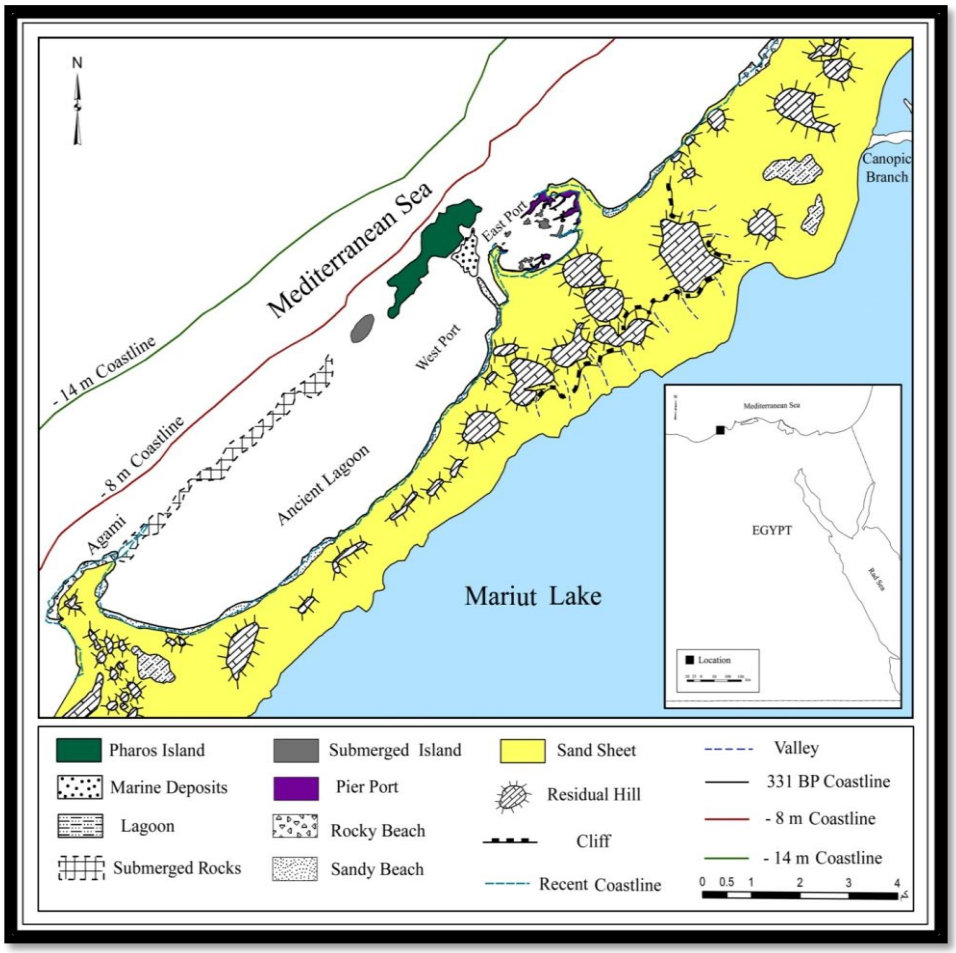


Figure 6. Suggested paleo-geomorphological of Alexandria site on 331 BC.

Conclusion

Alexandria's unique location is due to several physical and human factors, but it has also suffered some risks throughout its long history, including earthquakes, tsunamis, tectonic subsidence, and sea level rise, which may have drowned the city. Using field observations, the present study has provided detailed geomorphological and geochronological data on Pharos Island's landforms. Our investigation's results shed light on the sequence, processes, and structural dynamics involved in the island's construction, paving the way for the reconstruction of a detailed Quaternary model of northwest Alexandria city. The resulting comprehensive data will help regional researchers infer the development of the Nile Delta River and, of course, other deltas that may have experienced similar block-tectonic setting situations as well. While future research is expected to reveal complex environments, associated processes, and global sea-level changes, we believe that the present work has successfully taken the first step in accomplishing these goals, which are essential for assessing, evaluating, and addressing the risks posed by ongoing global climate change.

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Monasteries, land and water viability: the case of Brescia's territory

Carolina Simeoni[1]

Abstract

In Medieval Ages, road links and proximity to key points in trade network have often been fundamental for foundation and development of monastic communities. Routes, both land tracks and waterways, were exploited by cenobs to move products and people through territories and agricultural estates, even exploiting parallel and personal trade circuits; in this way, monasteries could develop actively road capillarity and boost medium and short-range exchanges. Moreover, proximity to a road was fundamental for other kind of institutions like religious buildings and hospital for pilgrims; parishes and churches had to be in reachable point for believers and at the same time, the creation of a place of prayer acted as a motor for the development of a community and consequently, a net of road communication. At the same way, hospitals and hospices mostly were located at well access points along main route traffic, so monasteries could perform sacred duty of caring of people and practicing hospitality towards needy. It has been observed that these interconnection between monasteries' faces (foundation places and possessions) and topographic features or elements of ancient landscape was valid for Brescia's territory. During first centuries of Middle Ages, some of the most important cenobs started to expand on these lands, exploiting a dense network of roads and trade routes, made of land and navigation tracks. Properties were collected along these links, covering a vast and heterogeneous territory between Garda and Iseo lake, the heights and the lowlands.

Keywords: monasteries, land routes, inland waterways, landings, trades, ancient topography, ancient environment, commercial circuits, monastic economies.

The transition between Late Ancient and Early Medieval Ages was characterized by a series of changes that deeply affected on the economic structure and on spatial organization of human settlements. Between the 5th and the 6th century BC symptoms of a general difficulty and then a crisis due to a series of political upheavals, like the Gothic war and the gradual Lombard conquest of the mainland Italy, emerged on different levels of the society, with different results depending on the geographical context in which they were produced.[2] In the North of Italy, these events had several consequences as territorial fragmentation and contraction of market economies, characterized by more simplified productions, decrease in imports, local trades and commercial exchanges mostly at medium and short range; traces of a first economic recovery appeared from 8th/9th century AD, not uniformly and depending on territory.[3] Even spatial planning and morphology of settlements suffered of a series of changes which could be synthesized in the following dynamics: deconstruction of settlements; impoverishment of

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[2] Chris Wickham, 'Per uno studio del mutamento socio-economico di lungo termine in Occidente durante i secoli V-VIII', Quaderni DPM: Dottorato 1 (Bologna: Clueb, 2003).

[3] Chris Wickham, 'Le società dell'Alto Medioevo. Europa e Mediterraneo, secoli V-VIII', La storia. Saggi 2 (Roma: Viella, 2010, 2nd ed.): 766-780.

dwellings and building techniques; collapse of older systems (roman *villae* system) and re-use of sites; new forms of occupation of the territory (fortified buildings, religious buildings) and appearance of new aggregation poles.[4]

Political fragmentation and the lack of a centralized state power caused also the collapse of some infrastructures as in the case of *cursus publicus,* the public system of road network, built and enhanced during the Roman Empire. In the plain areas, this and other system like hydraulic structures and regulation of the waters were no longer object of a general and programmatic maintenance, given by a unitary government and this caused the decay of road network, swamping of large territories and flooding of streams. Moreover, a period of climate changes between the 5th and the 7th century BC, featured by an increase of rainfall, contributed to worse this hydrogeological instability.[5] In Middle Ages, the disappearance of efficiency in land connections increased the use of waterways (rivers, streams, navigable canals) considered safer and faster for travel and hill routes to avoid the lowland.[6]

In first centuries of high Middle Ages, monastic communities moved against the background of all these changes and started to exploit and modified landscapes where they established their dominions, by adopting different strategies. Features and resources of these landscapes had to be suited to the needs of monks, in order to ensure the economic support. First of all, the right place to found a monastery had to have some key qualities so that the community could start its growth and support itself with everything it needed. Some of these features, which included the presence of continuous water sources, woods and arable lands were considered so essential for the success of a community that it was necessary to include them among the precepts of the monastic rules, as in the case of the Benedictine Order.[7] A reference to favourable conditions that should govern the establishment of a monastery is contained in a commentary to the Rule of Sain Benedict written by Hildemar,[8] a benedictine monk from Corbie which contributed in translating the precepts of the Rule into practical customs for monks. Into the chapter 66,[9] Hildemar makes explicit reference to natural resources necessary for the sustenance of

[4] For a preview and exhaustive synthesis see Cristina La Rocca, 'La trasformazione del territorio in Occidente' in Morfologie sociali e culturali in Europa fra Tarda Antichità e Alto Medioevo, Settimane di studio del centro italiano di studi sull'alto medioevo XLV (Spoleto: Centro italiano di studi sull'alto medioevo): 258-290 and Gian Pietro Brogiolo, Alexandra Chavarría Arnau, Aristocrazia e campagne nell'Occidente da Costantino a Carlo Magno, metodi e temi dell'archeologia medievale 1 (Sesto Fiorentino: All'Insegna del Giglio, 2005).

[5] Pier Luigi Dall'Aglio, 'Il diluvium di Paolo Diacono e le modificazioni ambientali tardoantiche: un problema di metodo', Ocnus 5(1997): 97–104;

[6] Giovanni Uggeri, 'La navigazione interna della Cisalpina in età romana', Antichità Altoadriatiche XXIX, 2 (Trieste: EUT, 1987): 347-348; Stella Patitucci Uggeri, 'La viabilità nell'Italia medievale: questioni di metodo' in La Salaria in età tardo antica e altomedievale, Atti del Convegno di studi (Rieti, Cascia, Norcia, Ascoli Piceno, 28-30 settembre 200), ed. E. Catani, G. Paci (Roma, 2007): 325; Stefano Medas, 'Le vie d'acqua. La navigazione lungo le idrovie padane in epoca romana' in On the road. Via Aemilia. 187 A. C.» 2017, ed. G. Cantoni, A. Capurso (Parma: Grafiche step editrice, 2017): 149.

[7] Michel Lauwers, '"Opus Manuum" et "Labor Agrorum". À propos de l'organisation socio-spatiale de la production et de l'approvisionnement des monastères dans l'Occident médiéval', in Monachesimi d'Oriente e d'Occidente nell'Alto Medioevo, LXIV, Atti delle settimane di studio (Spoleto, 31 marzo- 6 aprile 2016), (Spoleto: Centro italiano di studi sull'alto medioevo, 2017): 882.

[8] Hildemar, *Expositio Regulae:* www.hildemar.org (with english translation). For the printed version of latin text see Ruppert Mittermüller, *Expositio Regulae ab Hildemaro tradita*, Regensburg: Pustet 1880.

[9] « Si autem talis est jam ille locus, ut nil de his habeat, i.e. aqua, molendinum, pistrinum et rel., quae S. Benedictus dicit, nullo modo debet construi. Verum tamen sciendum est, quia ille, qui construit monasterium, debet illum locum providere et considerare congruentias et contrarietates illius loci ante, et omnia insuper debet constructor inspicere [...]. Deinde etiam

monastic life, like water and woods, *aqua* and *silva;* moreover, monks had to have a dedicated space to gardens and cultivations and own tools for grain processing like mills, so that religious were self-sustaining and they didn't have to look for anything outside monastery's space.[10] Often these environmental features (water, wood, agricultural areas, crops) reoccurs in physiognomy of ancient landscape occupied by monastic realities and it's possible to observe this tendence for High Middel Ages monasteries founded in territories of Po' valley. For example, paleoenvironmental surveys revealed that the benedictine monastery of Nonantola was established in a location characterized by water resources, agricultural land, crops and woodlands;[11] the abbey of Leno, in Brescia's province, developed in a territory characterized for the medieval period, by the presence of springs, forests, grazing fields and water abundance.[12]

In addition to the environmental setting, even topographic features of foundation places could bring benefits to monasteries especially when occupied territories were part of a well-established network of road links or monasteries were found in strategic poles of this network. The foundation place could be settled near an important road route or at confluence point of different road connections, both in the case of land roads and waterways. The proximity to a road link offered a series of advantages like the strategic position in relation to traffic routes, both from trade and services point of view. Strategic foundations could have also a political value for the consolidation of a territorial power, royal or ecclesiastical, especially in case where sites were crossing point or natural boundaries between two territories, like mountain passes.[13] This is the case of some important monastic institutions, founded during Lombard and Carolingian kingdom, which arose along connecting route between major and minor centres in North Italy, along the way of ancient itineraries, roman consular roads or important pilgrimage routes.[14] The presence of a route network was fundamental at the time when the monastery

debet considerari locus ille, si est aqua, silva et cetera, sicut necessarium est monachis, ut non pro tali occasioni sit necessitas foras frequenter eundi» Hildemar, Expositio Regulae, cap. 66, ed. R. Mittelmüller (Regensburg: Pustet, 1880): 606-607.

[10] Michel Lauwers, "Interiora" et "Exteriora", ou la construction monastique d'un espace social en Occident entre le Ve et Le XIIe Siècle' in La società monastica nei secoli VI-XII. Sentieri di ricerca., ed. M. Bottazzi et al., Atti 10 (Atelier jeunes chercheurs sur le monachisme médiéval: Roma, 12-13 giungo 2014), (Udine: Centro Europeo Ricerche Medievali, 2016): 60–61.

[11] Sauro Gelichi, 'Il monastero di Nonantola e le sue terre. Controllo del territorio e organizzazione dell'insediamento nel medioevo' in De re monastica - I. Committenza, scelte insediative e organizzazione patrimoniale nel medioevo, Atti del convegno di studio (Tergu, 15-17 settembre 2006), ed. L. Ermini Pani (Spoleto: Centro italiano di studi sull'alto medioevo, 2007): 328-336.

[12] Maria Bosco, 'Le analisi archeobotaniche e pollinologiche presso il sito di San Benedetto di Leno', in Il monastero di San Benedetto di Leno. Archeologia di un paesaggio in Età Medievale, ed. F. Saggioro, A. Breda and M. Bosco, Storie Di Paesaggi Medievali 2 (Sesto Fiorentino (FI): All'Insegna del Giglio, 2019): 296-300.

[13] Giuseppe Sergi, 'Monasteri sulle strade del potere. Progetti di intervento sul paesaggio politico medievale fra le alpi e la pianura', Quaderni Storici 21, no. 61(1) (1986): 33–56.

[14] E. g., the monastery of *Sant'Ambrogio* of Milano was settled just outside the city, along the way for Novara and Vercelli (Ross Balzeretti, 'The Land of Saint Ambrose: the acquisition, organization and exploitation of landed property in North-Western Lombardy by the Monastery of Sant'Ambrogio, Milano, c. 780-1000' (PhD dissertation., University of London, 1989): 86); San Zeno's abbey of Verona was founded near a crossing point between the way of two important consular roads: *Via Postumia,* from Genova to Aquileia and *Via Gallica,* from Milano to Verona, on the right bank of river Adige (Fabio Coden, Tiziana Franco, 'La basilica di San Zeno' (Verona: Cierre edizioni, 2019), 5-11); the monastery of Bobbio had a very favorable position along one of the main route towards Rome, since it was an important sanctuary and point of reference for regional and extra-regional pilgrimages (Eleonora Destefanis, 'Il monastero di Bobbio in età altomedievale: un santuario sulla via francigena' in Fonti archeologiche e iconografiche per la storia e la cultura degli insediamenti nell'Altomedioevo, ed. S. Lusuardi Siena, Contributi di archeologia 3 (Milano: Vita e Pensiero, 2003): 133–134).

started growing and expanding on a given territory and it allowed the community to maintain different kind of contacts with the external world, which could be economic, management or social-assistance nature.[15] From the economic point of view, links with the surrounding territory allowed institutions to provide goods and manage more efficiently properties, which sometimes could be in peripheral areas, several kilometres away from the monastic centre.[16] It's well known that for these purposes, monks exploited a mixed land and water road system, to transport estates' products towards markets and towards monastic centres for community's supply or to exchange goods between properties.[17] So, even market places had to be located in easy access points for the viability; in city centre, just outside the city gates or located directly on monastic lands, where monks could sell and exchange surplus products of their estates, in local or daily markets.[18] Monasteries also had fixed stands in principal urban markets, granted by the authorities and this allowed them to have a solid and perpetual position into dynamics of trade systems.[19]

In addition to these circuits, monasteries could exploit water viability to stock up of raw materials and products directly at source or in trade areas, where they had own means and intermediaries for business negotiations. On this "private circuits", they could enjoy particularly privileged positions, thanks to concessions, rights of navigation and tax exemptions given by rulers since the period of Lombard domination.[20] It's possible to observe these dynamics in trade network of lake basins and rivers, where monasteries owned ships, personal flotillas and harbours and where they could get goods, like fish products and oil, through a personal merchant network, without intermediaries and without being subject to precariousness of trade.[21] This active presence in management of commercial trade meant that monasteries could create new trading posts in route and waterways circuits and develop themselves road capillarity. Along the banks of rivers, they owned different possessions as lands, farms,

[15] Gisella Cantino Wataghin, Eleonora Destefanis, Sofia Uggé, 'Monasteri e territorio: l'Italia settentrionale nell'alto medioevo' in II Congresso Nazionale di Archeologia Medievale (Brescia, 28 settembre – 1° ottobre, 2000), ed. G.P. Brogiolo (Sesto Fiorentino: All'Insegna del Giglio, 2000).

[16] Distances between cenobites and estates could be important as in the case of Bobbio's properties in Lombardy, at Bardolino on rivers of Garda Lake and in Liguria (Valeria Polonio, ' «*Bobiensis Ecclesia*»: un vescovado peculiare tra XI e XII secolo' in La diocesi di Bobbio, formazione e sviluppi di una diocesi millenaria, ed. E. Destefanis, P. Guglielmotti, Reti Medievali 23 (Firenze: Firenze University Press, 2015): 202-204).

[17] Jean-Pierre Devroey, 'Monastic Economics in the Carolingian Age' in The Cambridge history of medieval monasticism in the Latin West, II. The Carolingians to the Eleventh Century, ed. A. Beach, I. Cochelin (Cambridge: Cambridge University Press, 2020): 474-478.

[18] Aldo Settia, "Per Foros italiae" in Mercati e mercanti nell'Alto Medioevo: l'area euroasiatica e l'area mediterranea, Settimane di studio del centro italiano di studi sull'alto medioevo XL (Spoleto: Centro italiano di studi sull'alto medioevo, 1993): 191-192, 223.

[19] For example, monasteries of Nonantola and Saint Ambrose owned fixed stands in market places, granted by the royal power (see Francesca Bocchi, 'Città e mercati nell'Italia padana' in Mercati e mercanti nell'Alto Medioevo: l'area euroasiatica e l'area mediterranea, Settimane di studio del centro italiano di studi sull'alto medioevo XL (Spoleto: Centro italiano di studi sull'alto medioevo, 1993): 157-159;

[20] For further details, see Gina Fasoli, 'Navigazione fluviale – Porti e navi sul fiume Po" in La navigazione mediterranea nell'Alto Medioevo II, Settimane di studio del centro italiano di studi sull'Alto Medioevo XXV, II, (Spoleto: Centro italiano di studi sull'alto medioevo, 1978): 567, 578-579, 596-597, 602-603 and Pierre Racine, 'Poteri medievali e percorsi fluviali', Quaderni Storici 21, no. 61(1) (1986): 12-18.

[21] E. g. Benedictine abbey of Novalesa had private river fleet and ports, in addition to private means of land transport to bring products to stores or annual markets. (Aldo Settia, "Per Foros Italie" ...': 202-203).

estates, watermills, fishponds, but especially ships, personal ports and docks associated with properties. The presence of these harbours attracted goods' arrival and allowed creation of new circuits, with the develop of a network of stopovers and river nodes much larger and widespread outside the urban contexts.[22]

As already mentioned, along traffic routes and streets monasteries owned and managed different kind of properties as agricultural estates (*curtes*) but also clerical buildings (churches, parishes, chapels) and care facilities for pilgrims, travellers and needy. In case of religious buildings, proximity to a major road artery allow believers to easily reach the place of prayer and at the same time the creation of a place of prayer could act as a motor for the development of a community and consequently, a net of road communication.[23] In studies of ancient topography, researchers used worship's places to reconstruct hypothetical ancient road routes, since buildings with a particular dedication may be a clue for the passage of a road, a river's crossing or significant waypoint for the viability. The correspondence between the dedication to a saint and the passage of a road rests on the fact that in hagiography tradition, miracles or specific events of saint's life could happened near a road, a river, a crossroads or at the point of bridges and fords; so, a church or a chapel, localized near to these places, created a connection between elements of the landscape in narrative and concrete elements in real landscape, increasing devotion power for believers.[24] *San Martino* and *San Cristoforo* dedication are usually used in topographical studies, in relation to the presence of a road axis, while references to river crossing, watercourses and their dangers like floods are in dedication to *San Donnino*, even protector for travellers and pilgrims on road; *San Ginesio* and *San Zeno*, are invoked in the popular tradition as protector from floods and of all those figures who worked on the waterways such as fishermen, boatmen and ship-owners.[25]

Other buildings managed by monastic communities and closely linked to the viability were hospitals and hospices for travellers and needy, which mostly were located at key points both in road and waterway network[26]. Through them religious institutions could perform a duty imposed by sacred rules like caring of sick and poor people and practicing hospitality and charity towards needy.[27]

[22] Roberto Greci, 'Porti fluviali e ponti in Età Medievale: Il Po' e l'Area Padana', Hortus Artium Medievalium 22(2016): 240-242.

[23] About the relation between churches, settlement and road routes see Aldo Settia, 'Chiese, strade e fortezze nell'Italia Medievale', Italia Sacra. Studi e documenti di storia ecclesiastica 46 (Roma: Herder ed., 1991): 4-26, 167-270 and Gian Pietro Brogiolo, 'Santo Stefano di Garlate e la cristianizzazione delle campagne' in Testimonianze archeologiche in Santo Stefano di Garlate, ed. G.P. Brogiolo, G. Bellosi, L. Vigo Doriatiotto (Lecco: Parrocchia di S. Stefano, 2002): 285-286.

[24] Pierluigi Dall'Aglio, 'Agiografia e topografia antica', Journal of Ancient Topography, 1(1992): 57-58.

[25] Pierluigi Dall'Aglio, 'Agiografia. ...': 58-70.

[26] Eleonora Destefanis, 'Structures d'accueil et monastères. Sources écrites et sources archéologiques entre les Alpes et l'Italie centrale au haut Moyen Âge' in La vie de quotidienne des moines en Orient ed en Occident (IV-X siècle), ed. O. Delouis, M. Mossakowska-Gaubert (Institut français d'archéologie orientale, École française d'Athènes, 2019): 54-55.

[27] Hospitality is carefully regulated in Rule of Saint Benedectine both in practical attitude of monks towards pilgrims and spaces dedicated to hospitality within the same monasteries (see Eleonora Destefanis, 'Monasteri e ospitalità nel primo altomedioevo italiano: riflessioni sulle fonti del secolo VI', De Strata Francigena XXV/1 (2017): 87-91.

From the analysis of the monastic realities[28] on Brescia's territory, it has been noted that this deep interconnection between monasteries' faces (foundation places and possessions) and topographic features or elements of ancient landscape was valid. In first centuries of High Middle Ages, monks of different congregations started to expand on this territory by acquiring rural properties, founding outposts along main route traffic and exploiting sources with different strategies, depending on the environmental contexts.

From a morphologic point of view, Brescia's territory is characterized by the presence of different natural environments, spread on a very wide province which develop in the northern most sector of the alluvial plain, called "Pianura Padana". At east and west ends, the province is bordered of two important lake basins, Iseo and Garda Lake, which act as transition areas with the alpine sector. At south, there are the lowlands of Po' valley, featured by abundance of water sources, large agricultural spaces and crossing by a dense water network. Towards north, lowland is bounded by a foothill belt connecting plain's lands with the pre-Alpine reliefs; mountain valleys and villages at the foot of reliefs featured the northern most sector of this territory. The city of Brescia is settled at the centre of this system, located at the foot of the hills, near to the mouth of mountain valleys and in direct connection with all these natural sectors, through the modern road. In Middle Ages, it's possible to assume that Brescia's territory had in broad terms a similar regional planning, with different kind of settlements which gravitated around five sectors: the mountain, the high and the lowland, the hills and the lake basins. Unlike the Modern Age, wooded and wet areas had to be much larger and fluvial capillarity much denser; in general, wet areas and landscapes featured by a strong presence of water connoted territories of Po' valley between Late Ancient and Early Medieval Ages, because of a series of changes in climatic condition which caused an increase in rainfall and consequently rising of riverbeds and flood events.[29] Forests covered mountains and hilly areas and since the roman period, they were the primary source of supply for domestic use and construction timber. Campaigns, foothill belt and lake areas provided wide spaces suitable for pastures and polycultures like vines, fruit trees, olive trees, especially near lakes where climate is more favourable, and cereal crops (e.g. rye, wheat).[30] In transition between Late Ancient and Early Medieval period, even settlements of these territories underwent significant changes; archaeological data indicate that from 5th to 7th century AD, with aftermath in following periods, inhabited spaces underwent a significant reorganization, featured by contraction and breakup of fabric settlement, shifting of communities, reoccupation of older sites and creation of new forms of defence and territorial control (fortified villages and *castra*).[31] In relation to these dynamics, religious

[28] Four important monastic institutions have been considered for the analysis, founded in a period between the 8th and 11th century AD: Monastery of Santa Giulia; Abbey of Leno; Monastery of San Pietro in Monte di Serle and Monastery of S. Eufemia della Fonte.

[29] For more details see Antonio Veggiani, 'Variazioni climatiche e dissesti idrogeologici nell'alto medioevo in Lombardia e la rifondazione di Lodi', *Sibrium,* 16(1982): 200-206.

[30] François Menant. Campagnes lombardes du Moyen Âge. L'économie et la société rurales dans la région de Bergame, de Crémone et de Brescia du Xe au XIIIe siècle (Rome: École française de Rome, 1993): 17-23.

[31] For more details see: Jacopo Ortalli, 'La fine delle ville romane: esperienze locali e problemi generali', in La fine delle ville romane: trasformazione nelle campagne fra tarda antichità e alto medioevo, 1° convegno archeologico del Garda (Gardone Riviera, 14 settembre 1995), ed. G.P. Brogiolo (Mantova: SAP, 1996): 15-16; Gian Pietro Brogiolo, 'Le campagne italiane tra tardo antico e altomedioevo nella ricerca archeologica' in Forme del popolamento rurale nell'Europa Medievale: l'apporto dell'archeologia, ed. P. Galetti (Bologna: Clueb, 2006): 14-27. For rural and lake areas: Gian Pietro Brogiolo, 'Lettura archeologica di un territorio pievano: l'esempio gardesano' in Cristianizzazione ed organizzazione ecclesiastica delle campagne nell'alto medioevo: espansione e resistenze, atti della XXVIII settimana di studio (Spoleto: Centro italiano di studi sull'Alto Medioevo, 1982); Nicola Mancassola, Fabio Saggioro, 'Insediamento rurale e campagne fra tarda antichità. Territori fra Verona, Brescia e Mantova', Antiquité Tardive 9 (2001): 312-326; Fabio Saggioro, 'Insediamenti, proprietà ed economie nei territori di pianura fra

structures as churches, parishes and monasteries had a significant role as they acted like aggregation poles for creation of settlements and communities.[32] It's clear that exploitation of road links to attract the faithful was a method to reach communities and spread Christian faith in the most direct and efficient way possible, as suggested by foundations of rural churches, baptisteries and places of warship nearby main traffic ways.[33]

In Brescia's territory, it's possible to observe this tendence even for foundation of the most important monastic institutions which settled in urban core and province, in period between the Lombard domination and the *Regnum Italicum* (8th-11th century AD). In the city centre and in suburb area, two benedictine monasteries were found, at a distance of four centuries, along an important route traffic of the Roman Period, which connected major regional centres of North Italy, starting its way from *Gradum*, on the Adriatic Sea and passing through *Patavium, Vicetia, Verona, Brixia, Bergomum, Mediolanum* and *Augusta Taurinorum*, where it ended;[34] it's about the urban monastery of Santa Giulia, established by Lombard imperial will in AD 753 and the monastery of Sant'Eufemia della Fonte, founded at the beginning of 11th century by the bishop of Brescia Landolfo II, at the foot of the mountains, just outside the urban core.[35] For the first one, the wide area occupied by its fabrics was bordered at the south by the main axis *decumano*, which crossed the city and then continued eastwards by connecting Brescia and its eastern suburb with lower area of Garda Lake and Verona.[36] Sant'Eufemia's monastery was in proximity of this route, established outside the city gates and nearby the remains of an ancient roman site, probably a sacred area,[37] along the right bank of an artificial channel, called Naviglio Grande

Adda e Adige (VII-IX secolo)' in Dopo la fine delle ville: evoluzione nelle campagne dal VI al IX secolo. 11° Seminario sul tardo antico e l'alto Medioevo (Gavi, 8-10 maggio 2004), ed. G.P. Brogiolo, A. Chavarría Arnau, M. Valenti (Mantova: SAP, 2005): 87-91.

[32] About relation beetween rural settlement and religious buildings see Aldo Settia, 'Pievi e cappelle nelle dinamiche del popolamento rurale' in Cristianizzazione ed organizzazione ecclesiastica delle campagne nell'alto medioevo (Spoleto: Centro italiano di studi sull'Alto Medioevo, 1982): 460-470 and Gian Pietro Brogiolo, Alexandra Chavarría, 'Chiese e insediamenti fra V e VI secolo: Italia settentrionale, *Gallia* meridionale e *Hispania*' in Chiese e insediamenti nelle campagne tra V e VI secolo, 9° Seminario sul Tardoantico e l'Altomedioevo in Italia centrosettentrionale (Garlate, 26-28 settembre 2002), ed. G.P. Brogiolo (Mantova: SAP, 2003): 9-37.

[33] Examples from Brescia's territory: Santa Maria of Pontenove in Bedizzole, a baptismal and mother church founded along the ancient road which led to Verona, near a passage on Chiese river, and church of San Lorenzo in Desenzano, located along the connecting route between Desenzano, on Lake Garda and Mantova (Gian Pietro Brogiolo, Alexandra Chavarría Arnau, 'Chiese e insediamenti rurali fra V e VIII secolo: prospettive della ricerca archeologica' in Ipsam nolam barbari vastaverunt: l'Italia e il Mediterraneo occidentale fra il V secolo e la metà del VI, Atti del Convegno internazionale di studi (Cimitile-Nola-Santa Maria Capua Vetere, 18-19 giugno 2009), eds. C. Ebanista, M. Rotili (Cimitile: Tavolario Edizioni, 2010), 52; for other examples, see catalogue edited by Valerio Fiocchi Nicolai, Sauro Gelichi, 'Battisteri e chiese rurali (IV-VII secolo)' in L'edificio battesimale in Italia: aspetti e problemi, Atti dell'VIII congresso nazionale di archeologia cristiana (Genova, Sarzana, Albenga, Finale Ligure, Ventimiglia, 21-26 settembre 1998), ed. D. Gandolfi (Bordighera: Istituto internazionale di studi liguri, 2001): 303-384.

[34] The route is illustrated on ancient map of *Tabula Peutingeriana* (Tab. Peut. segm.III, 3) and described into the Late Ancient itineraries *Itinerarium Burdigalense* (It. Burdig. 558, 8-11) and *Itinerarium Antonini* (It. Ant.127, 11-12). For a detailed description of road stages between *Brixia* (Brescia) and *Verona* see Luciano Bosio, Le strade romane della *Venetia* e dell'*Histria* (Padova: Esedra editrice, 1997): 94-97.

[35] Giancarlo Piovanelli and Piercarlo Morandi, Il monastero benedettino e la parrocchia di Sant'Eufemia della Fonte, dalle origini ad oggi (Brescia: Parrocchia di Sant'Eufemia della Fonte, 1985).

[36] Ruggero Boschi, Giacomo Lechi, Gaetano Panazza. 'Per una storia del complesso architettonico del monastero' in San Salvatore di Brescia. Materiali per un museo. I, volume secondo (Brescia: Grafo edizioni, 1978): 14-18.

[37] Nearby this area were found numerous epigraphic monuments with dedications to God Mercury, protector of trade and travellers and this points out that this site, since the roman period, has developed in close connection with a commercial traffic

Bresciano. In these two cases, the passage of a main route, much frequented and in direct connection with a territory very active in trade as Garda Lake basin, allowed the institutions to keep in touch with well attended traffics lines of people and products.[38] A similar motivation had to lead the foundation of the monastery of San Pietro in Monte at Serle, at the beginning of 11th century, whose strategic position on the heights above Brescia, allowed to control transit routes for the alpine valleys (Val Sabbia and Val Trompia) and territories the Lombardy side of Lake Garda. The origins of this monastery are not clear, but it may have been founded on a site of ancient trading, in a land topographically isolated, but well connected with neighbouring territories as suggested by the system of parishes, hospitals and markets spread on areas directly controlled by the monastic district.[39] Moving to the lowland, another important benedictine foundation, established by the Lombard king Desiderio in AD 758, was the abbey of Leno. As already mentioned, the environmental context chosen to insert the religious spaces were very rich in natural resources and in a strategic position, near to roman minor road track, which linked centres of Manerbio, Calvisano and Leno and guarding a river route.[40]

Relationship between viability and strategic places was also valid for the numerous monastic properties which were spread on wide areas in Brescia's territory, including river plains at south-east and west of the city, basins of Garda and Iseo Lake, mountains and valleys of the pre-alpine sector and hill area at the foot of the heights. Topography of these places and the lists of ecclesiastic possessions can be found in different kind of documents as royal diploma, legal documents about bills of sale, donations, contracts and disputes between abbots and people who lived in those places and inventories of estates, lands and infrastructures owned by monasteries. These documents are very precious since they're rich in information about the environmental aspect and features of ancient landscape, especially in case of legal documents, where locations are described in a very detail way and provide information about ancient toponymy (names of places and hydrographic elements) and ancient topography (presence and distributions of settlements, buildings and road links).

Observing the geographic distribution of heritages (Figure 1), it's possible to note that these monasteries tent to concentrate most of their possessions in the same territories, nearby the same places and often these places are well integrated into a network of both land and water links.[41] In the

artery; for more details see Serena Solano, Furio Sacchi, 'sacerdoti e offerenti nel territorio bresciano' in *Sacrum facere.* Atti del IV Seminario di Archeologia del Sacro (Trieste: 2018): 263-294.

[38] The monastery of Santa Giulia managed at its headquarter a hospital for pilgrims and travelers (Boschi, Lechi, Panazza, 'Per una storia ...': 21-22).

[39] Aldo Settia, 'Uomini, ambienti, istituzioni nei documenti di S. Pietro in Monte' in Le carte del Monastero di San Pietro in Monte di Serle (Brescia) 1039-1200, Codice Diplomatico Bresciano I, ed. E. Barbieri, E. Cau (Brescia: Fondazione civiltà bresciana, 2000): 86-90; Gabriele Archetti, 'Il Grande Cammino: pellegrini e pellegrinaggio nel Medioevo' in Lungo le strade della fede. Pellegrini e pellegrinaggio nel bresciano, Atti della giornata di studio (Brescia, 16 dicembre 200), ed. G. Archetti (Brescia: Associazione per la storia della chiesa, 2001): 53-55.

[40] Andrea Breda, Maria Bosco, Fabio Saggioro, 'L'evoluzione del complesso monastico (aree sud e nord)' in Il monastero di San Benedetto di Leno. Archeologia di un paesaggio in età medievale, ed. F. Saggioro, A. Breda, M. Bosco, (Sesto Fiorentino: All'insegna del Giglio, 2019): 226; A. Baronio, 'Tra archeologia, paleografia e storia. Leno un piccolo miracolo italiano' in Il monastero di San Benedetto di Leno. Archeologia di un paesaggio in età medievale, eds. F. Saggioro, A. Breda, M. Bosco, (Sesto Fiorentino: All'Insegna del Giglio, 2019): 14-15.

[41] The analysis was carried out using different sources to find and locate properties of the monastic institutions (royal diploma, inventories and lists of ecclesiastic possession, archaeological maps, specific bibliography). For *Sant'Eufemia*, see *Diploma* of king Callisto II (Luisa Bezzi Martini, Boschi Ruggero and Navarrini Roberto, Presenze benedettine nel Bresciano dai documenti dell'Archivio di Stato, catalogo mostra (Cripta della Chiesa di S. Afra in S. Eufemia, Brescia, 5-16 novembre 1980), 75); for Leno's abbey, see *Diploma* of king Berengario II in *Codex Diplomaticus Longobardiae, Historiae patriae monumenta edita iussu regis Caroli*

fluvial plain, which extends towards river Chiese, at east of Brescia's city, monasteries managed *curtes,* lands and various buildings as churches, parishes, chapels and *castra* in centres along main and secondary route traffic which led to the mountain areas (Val Sabbia) and Lake Garda. In broad terms, it's possible to follow the course of these itineraries thank to the presence of a fair number of churches and chapels dedicated to Saint Martin, distributed along the east-west axis which led to



Figure 1. Detail of Brescia's province (eastern and north-eastern sector) with localization of monasteries' properties and places of worship of Saint Martin (Image reworked by: C. Simeoni).

lake area (heir of ancient *Via Gallica*) and near the track of a secondary roads which detached from the main axis, crossed the plain in a north-east direction and went towards foothill valleys and mountain centers.[42] In addition to settlements, these areas had to be locations of exchanges and marketplace as

Alberti 13 (Torino: Stamperia reale, 1873), 1073-1074 (doc. DCXXVI) and Angelo Baronio, 'Il "dominatus" dell'abbazia di San Benedetto di Leno. Prime ipotesi di ricostruzione' in L'abbazia di San Benedetto di Leno. Mille anni nel cuore della pianura Padana, Atti della giornata di studio (Leno, Villa Seccamani, 26 maggio 2001), ed. A. Baronio, Brixia sacra I (Brescia, 2002): 50-53; for Santa Giulia, see Ezio Barbieri, Irene Rapisarda, Gianmarco Cossandi. 'Le carte del monastero di Santa Giulia di Brescia I (759-1170)' in Codice Diplomatico della Lombardia Medievale (secoli VIII-XII), (2008) and Gianfranco Pasquali, 'La distribuzione geografica delle cappelle e delle aziende rurali descritte nell'inventario altomedievale del monastero di S. Giulia di Brescia' in San Salvatore di Brescia. Materiali per un museo I, II (Brescia: Grafo edizioni,1978): 142-167; for San Pietro in Monte, see Paolo Guerrini, 'Il monastero benedettino di San Pietro in Monte di Serle: notizie e documenti inediti (sec. XI – XV)', Memorie storiche della diocesi di Brescia, serie seconda (Brescia, 1931) and Ezio Barbieri, Ettore Cau, 'Le carte del Monastero di San Pietro in Monte di Serle (Brescia). 1039-1200', Codice Diplomatico Bresciano, I (Brescia: Fondazione civiltà bresciana, 2000); for archaological sites matching with *curtes* centers see Carta Archeologica della Lombardia – La provincia di Brescia, ed. Filli Rossi (Modena: 1991), in particular, sites of Nuvolera (n. 1147, 1931), Nuvolento (n. 1141), Rezzato (n. 1424, 1430), Calcinato (n. 203), Serle (n. 1575).

[42] These secondary routes date back to the roman period; for more details see Luciano Bosio, 'Le strade romane ...': 100 and Paolo Catterina, 'La *questio* della strada romana Treponti-Gavardo' in Annali del Museo 1985-1988, 16 (Gavardo: Museo Archeologico della Valle Sabbia, 1988).

suggested from some documents of monastery of San Pietro, where it's cited the market of Gavardo, in lower district of Val Sabbia, where a "Saint Peter road" led directly to the monastery.[43] Traffics along these itineraries were enhanced also by the presence of waterways, exploit for agricultural and productive activities, transport of products and raw materials. Along river Chiese, monasteries owned buildings, plots of land, channels of derivation and water mills, as registered in archive documents.[44] One of its derivations, which diverges from the main course in Gavardo, is the canal Naviglio Grande Bresciano[45] which was exploited mostly for irrigation and transport of material as woods, agricultural products and building material (sand and, maybe, marble).[46] Traces of ports and harbours, located in different point along its way, are documented by archaeological and written sources: near the city, just outside the gate;[47] at south, close to the ancient street which led to Mantova and where the monastery of Sant'Eufemia managed an hospital for pilgrims[48] and in Nuvolento, in Chiese river's plain.[49] Near the city walls, the channel continued its course southward, passing through the suburban locality of San Zeno Naviglio and crossing Po' valley, until it flows into river Oglio, after several kilometres.

In the lowlands, Oglio itself was an important waterway for transport of people and goods and for trade network which developed on main axis of Po' river.[50] Along banks of these water links and in way point

[43] Aldo Settia, 'Uomini, ambienti, istituzioni...': 97-98; for market place and locations in Val Sabbia see Ugo Vaglia, I mercati della Valle Sabbia (Milano: Società storica Lombarda, 1961).

[44] For example, monastery of S. Pietro had on river Chiese some watermills using for production activities (doc. 115 of archive in Ezio Barbieri and Ettore Cau, 'Le carte del monastero ... ': 328-329).

[45] This channel is a derivation of river Chiese, which flows through the fluvial plain at east of Brescia's city and it was said that it's one of the water regulation works made by benedictine orders during first medieval centuries, to exploit new land for cultivations and for transport of materials (Paolo Guerrini, 'Il monastero benedettino di San Pietro ...': 173, *endnote* 4).

[46] For Naviglio Grande see Antonio Bianchi *et al.*, Le acque del Chiese e il riconoscimento delle quattro grandi utenze (Brescia, 1922): 33-36, 77; Antonio Robecchi, Aqua Brixiana (Brescia: Graffo, 1996): 115-117. For more detail on quarrying activities and transport of hard materials: Massimo Tedeschi, Il bosco, la vigna, la pietra. Botticino nella storia (Brescia: Comune di Botticino, 1988): 33-34; Natale Bottazzi, Le Chiusure di Brescia e Bassa Val Trompia, Toponomastica Bresciana 1 (Brescia, 1948): 22; Angela Guglielmetti, Serena Solano, 'Lo sfruttamento della pietra nelle vallate alpine lombarde in età antica' in Le vie della pietra: Estrazione e diffusione delle pietre da opera alpine dall'età romana all'età moderna, Atti del Convegno in occasione del decennale dell'Ecomuseo del Granito di Montorfano (Mergozzo, 28-29 ottobre 2017), (Mergozzo: GAM; Museo GranUM Baveno, 2019): 85-89.

[47] Remains of an imponent fluvial dock, dated to the Gothic period, were found at south-east of the old town of Brescia and probably it's a landing place of the ancient course of Naviglio (for more details see Mario Mirabella Roberti, 'Archeologia ed arte di Brescia' in Storia di Brescia, I. Dalle origini alla caduta della signoria viscontea (Brescia, 1963): 278-280 and Giuliana Cavalieri Manasse, 'Il monumento funerario romano di Via Mantova a Brescia' in Studi e Ricerche sulla Gallia Cisalpina 2, ed. G. Bandelli and M. Verzár Bass (Quasar, 1990).

[48] The hospital was called *Hospitale Sancti Pauli de Portazolum,* located at south of the city, near the district of *Portazolum/Portezolum*, a toponym which suggests the presence of a little harbour along banks of southern branch of Naviglio (Antonio Robecchi, Aqua Brixiana ...: 116). In addition, on the road to Mantova, monastery of S. Eufemia managed the hospital of San Giacomo to support travelers along a way considered particularly danger (Paolo Guerini, 'Diaconie, Zenodochi e Ospizi medioevali della città e del territorio bresciano' in Miscellanea Bresciana I, ed. Paolo Guerini, Monografia di storia bresciana XLIII (Brescia, 1953): 11-12.

[49] A "*portum*" is indicated as a border of a landholding in Nuvolento, next to properties of San Pietro; it was probably along Naviglio or Rudone, a minor stream which flows into Naviglio near Rezzato (doc. 182 in Ezio Barbieri and Ettore Cau, 'Le carte del monastero ...': 463).

[50] The importance of this circuit in ancient time is underline by different kind of sources, both archaeological and documental; for a previous view on harbors, trades and fluvial navigation of Po' river and its tributaries see Gina Fasoli, 'Navigazione fluviale

considered particularly strategic, monasteries of Santa Giulia and Leno had several *curtes,* fish ponds, private ports and ships as documented in lists of possessions.[51] These personal infrastructures allowed monks to place surplus products into local trade and, at the same time, to be part of exchange circuits at medium and long-range. This is the case of salt trade coming from Comacchio, on the Adriatic Sea, a production centre and location of an important store which had a particularly thriving period and economic vitality during first centuries of Hight Middle Ages.[52] At the mouth of river Po', near Comacchio, abbey of Leno had largest saline and exercised a fiscal control over goods and landing charges in ports of its property, along the entire circuit of Po' trade system.[53] On Oglio and river Mincio, Santa Giulia had estates, harbours, docks, fisheries, ships and handled goods' traffic as salt and grain;[54] in addition, it could enjoy fiscal benefits as toll collection from port and bridge's passage on river Po', near Piacenza, granted by Lombard King Desiderio.[55]

To end up, even lake basins were much frequented by the ecclesiastic institutions, because they were home of important regional markets and areas of exchange between the valleys and the plain, well attended and very rich in resources.[56] Even in this case, monasteries took part in trade circuits using own means and collecting properties near lake areas, in order to obtain goods, as oil and fish products, directly at the source and without intermediaries.[57] For example, at Vello, on Lake Iseo, monastery of Sant'Eufemia built the homonymous church and established the basis of a personal flotilla, using it for fishery and transport of products.[58] On the same lake and around basin of Lake Garda, monastery of Santa Giulia and Leno owned *curtes*, lands, oil trees, harbours, ships and fisheries, in strategic and well-located access point as near to principal markets.[59] In addition to properties closely related to economic

…', 581-607; Giovanni Uggeri, 'Aspetti archeologici della navigazione interna della Cisalpina', Antichità Altoadriatiche XXXVI (1990), 175-169; Roberto Greci, 'Porti fluviali …'; Stefano Medas, 'Le vie d'acqua ….': 146-161.

[51] Angelo Baronio, ' il «dominatus» dell'Abbazia di San Benedetto di Leno …': 41-43; see *note 54*.

[52] This flourishing and more in general, exchanges vitality of fluvial trades in Po' valley emerged from laws, diploma capitulars and imperial constitutions of Lombard, Carolingian and post-Carolingian period whose aim was to regulate taxes, duties, permits and dynamics of Po' valley port system (for an in-depth analysis of documents see Gina Fasoli, 'Navigazione fluviale …').

[53] It was authorized from imperial authority to collect duties, both *teloneo* and *repatico,* in ports of its property in Ferrara and along the course of Po's branch which led to Comacchio (*Diploma* of king Berengario II in *Codex Diplomaticus …*' doc. DCXXVI).

[54] On banks of river Oglio, the monastery managed *curtis* of *Insula*, with one port and one military ship, *curtis* of *Bissarissu*, with one port and six ships and *curtis* of *Alfiano*, with one port and three ships and where even Leno's abbey had some properties; on river Mincio it had curtis of Rivalta, with three ships and some fishponds (analysis of documents '*Breve de terris'* and *'Diploma* of Lotario I and Ludovico II' in Barbieri *et al.,* 'Le carte del monastero di S. Giulia I …' .

[55] Stella Patitucci Uggeri, 'La viabilità di terra ed acqua nell'Italia medievale', Quaderni di Archeologia Medievale IV (Sesto Fiorentino: All'insegna del Giglio, 2002): 35.

[56] Aldo Settia, 'Per Foros Italiae … ': 207-208.

[57] Enzo Abeni, La storia bresciana: il frammento e l'insieme, Il Medioevo 2 (Brescia: Edizioni del Moretto, Brescia, 1987): 205.

[58] Giancarlo Piovanelli and Piercarlo Morandi, 'Il monastero benedettino e la parrocchia di Sant'Eufemia … ': 25.

[59] Details of *Breve de terris* with description of properties and their rents: "In curte Iseis casas .IIII., caminatas .III. (…) portum .I., unde venit in anno ad censum de argento sol(idos) (…) piscatione, et reddunt in anno pisces .MCC. (…)", in Barbieri et al., 'Le carte del monastero di S. Giulia …' ; (…); Contract of Santa Giulia's abbess for a transfer of ownership in Iseo: "(…) peciola una de terra cun edificiis casarum quibus esse videntur in loco et fundo Isex prope mercato publico ipsius loci (…)" *in Codex Diplomaticus Longobardiae*, doc. 987, 1737; *diploma* of king Ludovico II which confirms possesion of a fishery in Sarnico (Iseo): "… concedimus curtem Turingam et Gabianum, Lauretum cum pertinentiis earum et piscaria de Sarnega cum pertinentiis de

activities, in lake areas monks also managed numerous hospices for pilgrims and travellers which could be located near to the coasts or along trails which ascended towards the heights, in direction of the alpine valleys.[60]

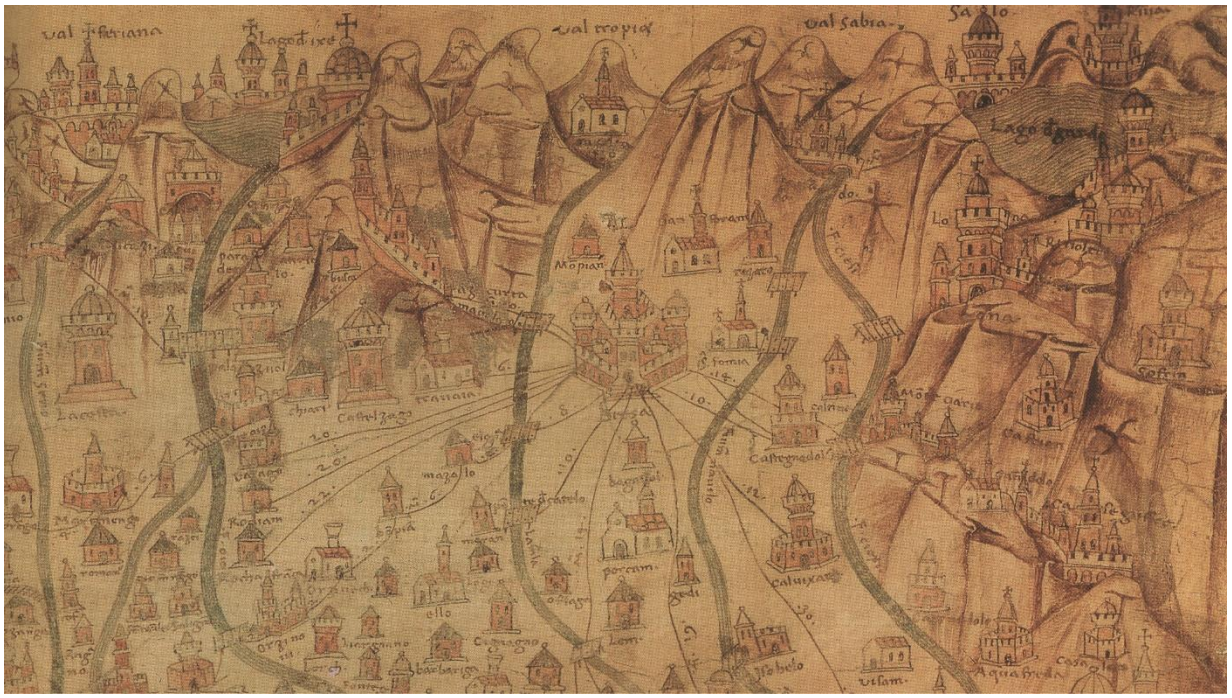


Figure 2. Ancient map of Brescia's territory with the city and its land routes and waterways (detail of Lombardia's region map of first half of the 15th century; image from the volume 'Brescia e il suo territorio', ed. Giorgio Rumi, Gianni Mezzanotte and Alberto Cova, Milano: Cariplo, 1998).

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eodem loco..." in Barbieri *et al.,* 'Le carte del monastero di S. Giulia ...'; for abbey of Leno see Angelo Baronio, 'il «dominatus» dell'Abbazia ...': 38.

[60] E.g., Hospice of Santa Maria de Jugo, above Iseo, managed by S. Eufemia; on Garda Lake, there were hospices controlled by abbey of Leno in Salò (Sonsacco), Campione and Limone. For further information see Paolo Guerini, 'Diaconie, Zenodochi e Ospizi medioevali ...': 28-30; 41-45.

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Fishing in troubled water? The Lesser Syrtis under East Roman rule (6th-7th century CE)

Tommaso Giuliodoro[1] and Néhémie Strupler[2]

Abstract

The Byzantine period of North Africa (6th–7th century CE) has long been dismissed as merely the final phase of Roman presence in the area. Along with the reorganisation of the Mediterranean economic space following the establishment of the Vandal Kingdom, it has been assumed that the economy of North Africa was significantly diminished and lacked dynamism. While economic activities decreased in the northern part of North Africa (e.g., Carthage), there was growth in other regions. In this paper, we demonstrate the rising importance of the coast of Byzacena, particularly the Gulf of Gabès. We show that, despite its poor reputation, the natural setting and location of the Gulf offered many advantages that were subtly turned into strengths. We review the archaeological and textual evidence to present a new portrait of the Lesser Syrtis and its unique dynamics.

Keywords*:* economy, Byzantine North Africa, commerce, port cities, trade routes

Introduction[3]

The Gulf of Gabès, a stretch of coastline located on the south-eastern border of Tunisia (Figure 1), was a vital hub for regional and trans-regional trade since the Punic period. It was known throughout Antiquity as the Lesser Syrtis (*Syrtis Minor*) to distinguish it from the Greater Syrtis (*Syrtis Major*), which corresponds to the Libyan Gulf[4]. The Lesser Syrtis was a strategic location between the pre-desert Libyan valleys and the maritime trade routes crossing the Mediterranean basin. This role persisted after Roman Empire's gradual conquest of North Africa (2nd century BCE–1st century CE), a process through which the Gulf's cities were progressively integrated into the commercial and fiscal network operating in the *mare nostrum*.[5] Following the pivotal Diocletian administrative reforms in the Roman Empire (late 3rd–early 4th century CE), North Africa was divided into smaller provinces. The northern sector of the

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[3] This paper is part of the current project on the Byzantine Military Strategy of North Africa (Anna Leone – PI) which involves Dan Lawrence, Tommaso Giuliodoro, Néhémie Strupler (all Durham University) and Vivien Prigent (École française de Rome) funded by Leverhulme Trust. The idea for this paper developed through discussion with project PI Anna Leone, who also provided some information on the pottery. Strupler has worked on the ecosystems and completed the figures for the paper, while Giuliodoro has worked on the historical interpretation and analysis; they both contributed to the editing of the text.

[4] The Latin term "*Syrtis*" (sing.), meaning "quicksand" or "bog", likely has a Semitic etymology, possibly traced back to the Punic settlers who inhabited the area as far back as the 6th century BC (see Mastino 1990: 16-17). The plural "*Syrtes*" is used to designate both gulfs.

[5] The scholarship on the subject is collected in Mastino 1990; Rebuffat 1990; Trousset 1992; Slim et al. 2004: 15-21; Cordovana 2016.

Lesser Syrtis was included in the province of Byzacena, while the southern sector was attached to Tripolitania.[6]

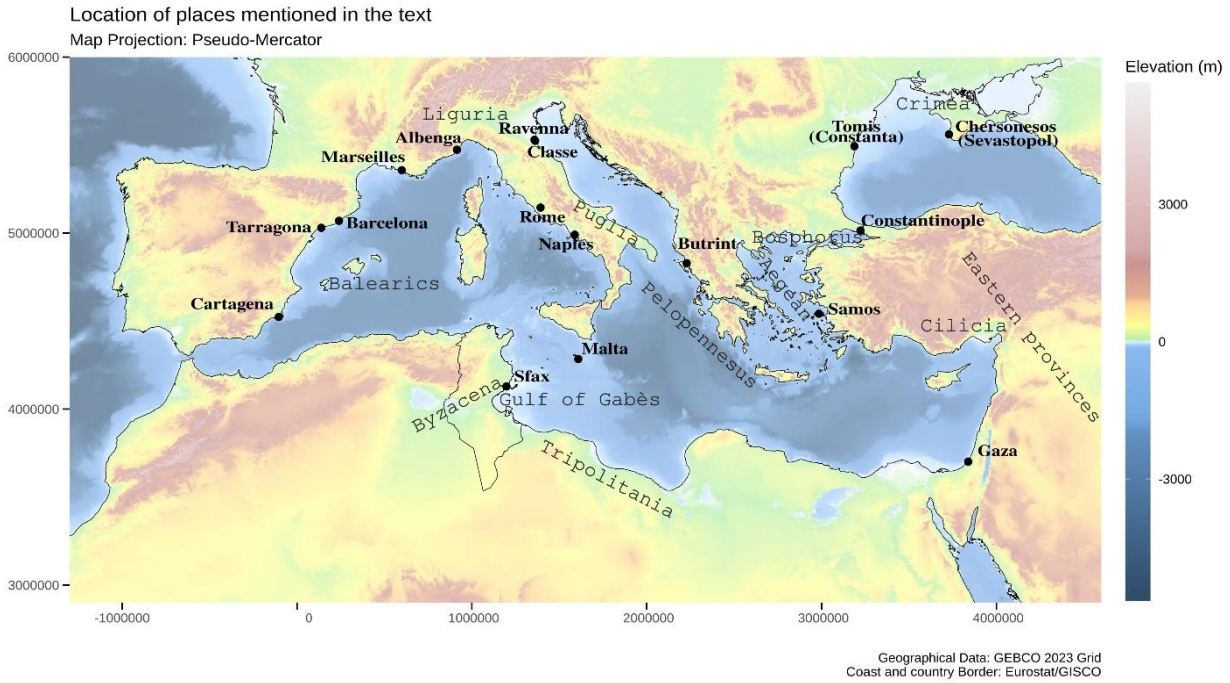


Figure 1. Geographical map of the Mediterranean showing the main sites and geographical designations outside the Gulf of Gabès mentioned in the text (Map realised by: N. Strupler with R).

Despite the Vandal conquest of North Africa and their settlement in the region, substantial evidence indicates that the economy and the settlement system of 5th-century North Africa were not entirely disrupted. Instead, a high level of vitality was maintained.[7] Surprisingly, however, the development of the maritime cities of the Lesser Syrtis during Late Antiquity has never been investigated in detail. In particular, the role of this region during the East Roman rule of North Africa (534–698 CE), a period of great upheavals for both North Africa and the Empire as a whole, remains to be further explored. One reason for this lack of thorough reconsideration lies in the general approach to the study of Ancient and Late Antique North Africa. This field of research, established during the French colonial rule over the Maghreb, traditionally favoured the study of the Punic and Roman periods. As a result, the Byzantine period of North Africa has long been dismissed as merely the final phase of Roman presence

[6] The North African province of *Valeria Byzacena,* established after Diocletian's reforms initially comprised the modern-day territories of central and southern Tunisia. It stretched from Gabès (initially attached to Tripolitania) to Hammamet on the coast, and from Gafsa to Maktar in the hinterland (Desanges 1992). Although its borders evolved over the period considered (Modéran 1999), the province's structure survived both the Vandal and the Byzantine conquest of North Africa. It continued to function as a military and administrative district as late as the mid-7th century. See Morrisson, Prigent 2018: 1821-1833; Price et al. 2014: 169.

[7] See Modéran 1996; Leone 2007, with further relevant bibliography.

in the area, receiving only occasional examination.[8] Indeed, most historical and archaeological investigations conducted on the Lesser Syrtis have focussed on the Punic and Roman imperial periods. Aside from research conducted on key paleo-Christian buildings, the late antique phases of occupation and exploitation preceding the Islamic conquests have yet to be fully investigated in all their complexities.[9]

We aim in this contribution to shed new light on a previously overlooked coastal area of the Mediterranean from the 6th–7th century, which corresponds to the phase of Byzantine presence in North Africa. First, we present the natural features of the Gulf and its evolution over this historical period. We then reconsider the available textual evidence, incorporating the renewed theoretical framework of the history and archaeology of harbours, maritime environments and their networks between Late Antiquity and the Middle Ages.[10] Moreover, we base our investigation on Iunci, a major city that flourished during that time on the coast of the Gulf of Gabès.[11] Based on this comprehensive analysis of the available evidence, we critically reconsider the organisation of the littoral settlements in the region and their cultural, political and commercial role in the development and management of the network systems linking southern Byzacena to other North African districts and the broader Mediterranean region. By offering a fresh perspective on the role of the cities of the Lesser Syrtis under Byzantine rule and highlighting their changing fortunes and strategic importance in an evolving maritime landscape, we demonstrate that understanding the place of Byzacena's southern shores in late antique exchange networks also illuminates North Africa's contribution to the broader Mediterranean economy at the dawn of Antiquity.

A unique but challenging setting: high tide, shallow depth, rich ecosystem

The Roman denominated Lesser Syrtis region corresponds to a stretch of coastline of the Gulf of Gabès, at the south-eastern border of Tunisia. This region is flanked by the large Kerkennah Islands to the north and the island of Jerba to the south (Figure 2). Its coastline stretches for almost 700 km, and hosts several major modern towns, such as Gabès and Sfax. This latter is the second-most populous city in the country, following the capital city of Tunis, and is the fastest-growing economic centre of the country (Bousnina 2015).

[8] The most comprehensive analysis of the history and archaeology of Byzantine North Africa is still represented by Charles Diehl's *L'Afrique Byzantine* (1896). Note, however, that from the 1980s scholarly attention to this topic has increased, and several studies and research projects have been devoted to the examination of North African society, economy and politics during the 6th and 7th centuries. See as an example Durliat 1981; Pringle 1981; Leone 2007; Stevens, Conant 2016; Bockman, Leone, Von Rummel 2019; Merrills 2023.

[9] Concerning the archaeology of the Late Roman Christian buildings, see the catalogue composed by Baratte et al. 2014: 239-263, with further relevant bibliography. An exception to this situation is represented by the work carried out since 2017 by a Tunisian-French research team at the site of Thenae, see Othman et al. 2023.

[10] See as an example the papers collected in Preiser-Kapeller, Dam 2015; Preiser-Kapeller, Kolias, Dam 2021; Ginalis 2024.

[11] The project in collaboration between Durham University (PI Prof. Anna Leone), and the Institut National du Patrimoine de Tunisie (INP), Ammar Othman, started in 2017 and it is ongoing. The excavation has been co-ordinated by Dr. Maurizio Marinato, the survey by Dr. Marco Nebbia. The pottery was studied between 2017 and 2019 by Michel Bonifay, and is currently being studied by Sami Ben Tahar (INP – Roman and Byzantine pottery) and Chokri Tohiri (INP – Medieval pottery).



Figure 2. Geographical map of the Gulf of Gabes with the main sites and geographical designations mentioned in the text. The dashed lines indicate the reconstructed Roman road system (based on the Barrington Atlas). Map realised by: N. Strupler with R.

The coastal morphology of the Gulf is varied and includes both beaches and cliffs, which can exceed 8 metres in height (Oueslati 2004). Work conducted by scholars in the 1990s has shown that coastal areas have experienced significant changes over time, related to rising sea levels and deteriorating coastlines (Slim et al. 2004: 22). Since Antiquity, the sea level has risen, affecting archaeological sites that were located just above the former sea level (Oueslati 1995: 2022).

Contrary to the typical characteristics of the Mediterranean Basin, which is known to be oligotrophic, the Gulf of Gabès is very rich in fish and marine resources (Béjaoui et al. 2019). Until recently, and before the impact of large-scale industrial pollution (El Kateb et al. 2018), the Gulf of Gabès was an excellent place for fishing and the exploitation of maritime resources. In the Gulf of Gabès, the tides are unusually high, among the highest in the Mediterranean Sea, reaching up to 2 m (Othmani et al. 2017). The central part of the Gulf (i.e., at the latitude of Gabès) has the greatest difference between high and low tides, reaching up to 2.3 m during the spring tide. This impressive tidal range results from the flat underwater terrain and shallow sea depth. The water depth is less than 50 m up to 110 km from the coast. The shallow nature of the Gulf makes navigation hazardous for ships, as many sand ridges loom close to the

coast, and the flat underwater terrain increases sensitivity to winds. This combination of high tidal ranges, shallow marine waters with numerous sand ridges, and challenging winds contributed to the Gulf's negative reputation among foreign sailors, despite its rich natural resources (Slim et al. 2004: 15–25).

As an example, Pomponius Mela, known as the earliest Roman geographer (active in mid-1st century CE) emphasises the absence of ports, or at least the difficult accessibility of this coast (Slim et al. 2004: 17). The bad reputation is not only attested in antiquity, though. The difficulty of navigating the Gulf for foreigners is well documented in modern times, as many maps from the 17th and 18th centuries CE indicate that the Gulf was unknown because it could not be explored (Figure 3).

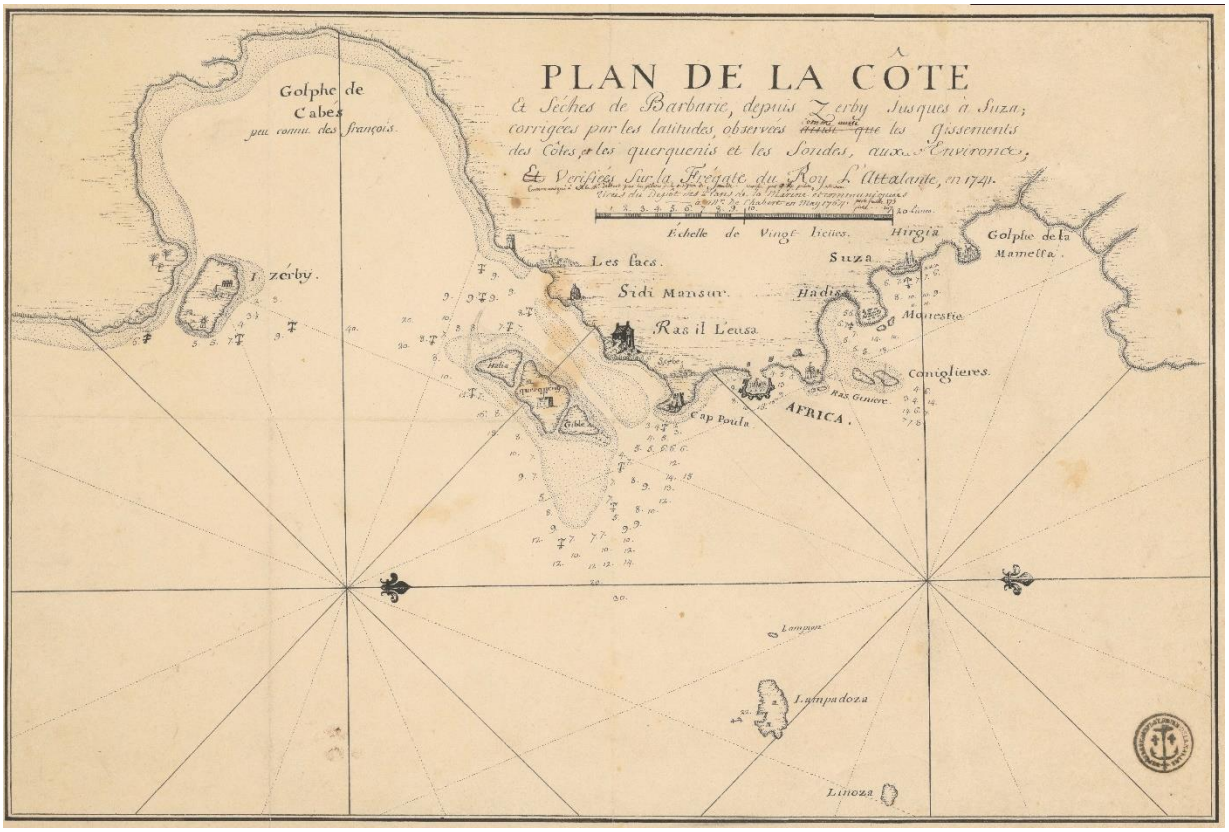


Figure 3. Map dated 1741 of the Gulf of Gabès (north is on the right, with the island of Jerba in the top left corner and the Kerkennah Islands approximately in the center). In the Gulf of Gabès (top left of the image) there is an indication: "Golphe de Cabés peu connu des françois" (which can be roughly translated as "Gulf of Gabès, almost unknown to the French"). Bibliothèque nationale de France, département Cartes et plans, GE SH 18 PF 105.

A window of opportunity

Despite these negative connotations, the coastal archaeological survey conducted in the 1990s brought to light the economic importance of the industry related to the sea's resources in the Gulf during Late Antiquity (Slim et al. 2004). These remains attest that the Gulf offers many advantages from the perspective of those living on the coast, with local knowledge of navigating and fishing in its waters. If some areas of the coast are hardly accessible, this has been turned into an advantage for certain cities,

which could monopolise maritime and terrestrial trade routes to become major nodal points during particular time periods. Recent archaeological data show the extensive exploitation of fish at various sites. The Lesser Syrtis was a strategic location where fishing and fish-related products, such as the extraction of purple dye and the production of fish sauces, constituted significant economic activities. Complementary to this, the inland steppe-like environment was exploited for the cultivation of olive trees and pasturage.[12] According to archaeological and epigraphical investigations conducted in the area, up to the early 5th century, the city of Thenae was the major centre in the Lesser Syrtis for the export of goods, such as olive oil, grain, purple dye, *garum* or *salsamenta*. Located on the northern tip of the Syrtis Gulf (Figure 2, approximately 12 km south of Sfax), Thenae was closely connected with other inland and coastal cities via imperial commercial routes. As a harbour, it was also linked to the major ports of the Western Roman Mediterranean.[13] Other commercial hubs operated in the Gulf before the Byzantine conquest. Centres such as Gigthis (Figure 2), located in the south-eastern section of the Gulf and equipped with significant port facilities, were also integrated into the maritime and terrestrial networks of exchange of the central Mediterranean basin.[14]

The multimodal connections of the Lesser Syrtis in the 6th and 7th century: an analysis based on textual evidence

After the Vandal conquest cut North Africa out of the Roman fiscal system (5th century CE), the provincial commercial and exchange networks progressively adapted to the evolving situation. This impacted the organisation of the coastal settlements of the Lesser Syrtis.[15] The first signs of this adaption appear in the written record in the early 6th century, when new centres had already consolidated their positions. In a passage of his *Vandalic War*, Procopius recounts the episode when in 533 Justinian's fleet of over 500 ships sailed towards North Africa to capture it from the Vandals.[16] He reports a speech purportedly given by Archelaus, prefect for military expenses, to the army officers aboard Belisarius' ship. Archelaus claimed that only Carthage, on the Northern coast, and Iunci, in the Lesser Syrtis, were safe ports for the Eastern Roman navy along the Tunisian coast.[17] Even if Belisarius eventually chose to disembark the Roman army in Caput Vada (modern La Chebba), around 100 km

[12] Overviews in Courtois et al. 1952; Hitchner et al. 1990: 244-245; Lassère 1984; Slim et al. 2004: 19-21; Wilson 2006: 525-528; Strupler, Giuliodoro, Leone, in press.

[13] On the vitality of Thenae's maritime connections see Desanges et al. 2010: 232-233; Othman et al. 2023; Belmabrouk et al. 2023: 184-187.

[14] Ennabli 1976a; Slim et al. 2004: 19-20. The port facilities of Gightis, dating to the late 1st–early 2nd century CE, are discussed in Slim et al. 2004: 25-26.

[15] On the end of the fiscal connection between Rome and North Africa following the Vandal conquest of Carthage (439) and the death of the emperor Valentinianus III (455) see Wickham 2005: 87-93; Caliri 2007; Merrills, Miles 2010: 141-176; Tedesco 2011: 115-125; Von Rummel 2011.

[16] The fleet is described in Proc. *Bell. Vand*., I, 11. According to Procopius, Belisarius had 592 ships at his disposal, of which only 92 were equipped for maritime warfare. Procopius defines this latter group of smaller and faster vessels with the term "*δρόμων*", meaning "runner", see Pryor, Jeffreys 2006: 125-128.

[17] Proc. *Bell. Vand*., I, 15: 8-9: "Have you not then heard that this promontory – I mean from Carthage to Iunci (*δε είς Ἰούχην εκ Καρχηδόνος*) – extends, they say, for a journey of nine days, altogether without harbours and lying open to the wind from whatever quarter it may blow?" Being employed by the general as his advisor, Procopius was present at the meeting held on Belisarius' ship.

north of Iunci, clearly, the port of Iunci had a good reputation with the administration in Constantinople and high officials like Archelaus. Given that merchants from the East were part of the imperial intelligence network, Archelaus' knowledge about Iunci probably indicates not only that Iunci was already a famous major port, but also that it had strong trade links with the East.[18]

Iunci, previously known as Macomades Minores, was a medium-sized town in the northern Lesser Syrtis, about 35 km south of Thenae (Figure 2).[19] According to Procopius' account, Iunci was the major port city in the Lesser Syrtis at the dawn of the East Roman rule over North Africa. However, other cities from the Gulf appear to have participated in the region's maritime network. Lariscus, located along the shores south of Iunci, represents one of such cases, being mentioned, along with Iunci, in Corippus' *Iohannis* (Figure 2).[20]

Corippus, a North African poet active in the mid-6th century, was not particularly interested in describing the coastal settlements of the Gulf, but he mentions that Lariscus and Iunci received military supplies through their harbours in 548 CE. These were sent from Carthage to Eastern Roman troops campaigning against local indigenous groups (labelled *Mauri* in the textual evidence). Corippus also mentions that Lariscus provided shelter for the provincial fleet supporting the field army.[21] These indications illustrate the value the port cities of the Lesser Syrties retained for the Byzantine administration of North Africa. Thanks to their harbours, Lariscus and Iunci represented suitable points of entry for the army to control the southern borderlands of the recently conquered province. Additionally, Corippus' account provides evidence of the interconnectedness of the maritime cities of the northern sector of the Lesser Syrtis, both within the Lesser Syrtis and with more distant North African port cities like Carthage.

The textual evidence even allows us to observe differences in the development of the cities of the Gulf. Lariscus vanishes from the corpus of written sources after serving as a shelter for the provincial fleet in 548 CE. In contrast, Iunci starts to be prominent. Following the conflicts against Byzacenian and Tripolitanian indigenous groups in the mid-6th century, which severely affected the city and its hinterland[22], Iunci received significant imperial investments. In the 570s, the Byzantines fortified the

[18] The role of Eastern Mediterranean merchants operating in North Africa and Sicily as intelligence providers for Belisarius' campaign is explicitly mentioned in Zach. Rhet. *Hist. Eccl*. 9, 17; Proc. *Bell. Vand*. I, 20. See also Modéran 2003: 581-583; Cristini 2023.

[19] On the identification of Iunci with Macomades Minores, see Poinssot 1944; Trousset 2003; Desanges et al., 2010: 160-161. Unfortunately, there is no information on the process which resulted in the change of the toponym, but by 411 the city name had already changed (*Gesta Conlationis Carthaginiensis anno 411*, I, 187: 78-79). On the form "Iunci", currently adopted in the scholarship to refer to our city, see Desanges et al. 2010: 160.

[20] The settlement of Lariscus remains unidentified. A location around 35 km south of Iunci has been suggested, in an area now known as La Skhira, where two late antique Christian basilicas and several necropolises have been uncovered and excavated since the 1960s (Fendri 1961; Ennabli 1976b; Pringle 1981: 207-208). However, as noted by Duval 1973, Oueslati et al. 1992 and Slim et al. 2004: 115-116, it appears more appropriate to identify these ruins with the site of Benfas/Bennefa, whose location in relation to Iunci is expressly described in the *Vita Fulgentii* (XII, 29: 186) and whose bishops are known up to 484 CE. On the other hand, no bishop of Lariscus is known; see Maier 1973: 114. The location of Lariscus, between Iunci and Tacapes (modern Gabès), is suggested by Corippus: Cor. *Ioh*. VIII, 30-31.

[21] Cor. *Ioh*., VIII, 30-31; 45-48. See also Durliat 1998: 64; Merrills 2023: 184-185.

[22] On the 535-550 CE conflicts against Byzacenian and Tripolitanian indigenous groups, see Modéran 2003: 565-643; Merrils 2023.

city by building or renovating the city walls, and stationed a provincial army garrison there.[23] Clearly, the empire needed to ensure the control of Iunci and the Lesser Syrtis in the face of recurrent indigenous unrest. By strengthening its presence in Iunci, however, the East Roman Empire could also better exploit both the Mediterranean trade routes and the highly productive agricultural land of southern Byzacena. Thanks to its strategic location, a rare suitable interface between land and sea in the Gulf, Iunci became the most important economic and administrative centre of the Lesser Syrtis.

The importance of Iunci's interface should also be taken into account when interpreting the textual evidence. Procopius reports in his *Secret History* that around 540 CE, during the reign of Emperor Justinian (527–565 CE), ship-owners (*ναύκληροι*/*navicularii*) from North Africa arrived in the capital city Constantinople with provincial tax revenues from North Africa. They then returned with goods purchased in Constantinople.[24] Procopius does not specify the city from which the *navicularii* and their fleet sailed to the capital, or the city to which they returned. However, with the prominence of Iunci in the Byzantine administration of Southern Byzacena, it is reasonable to speculate that this city was somehow involved. This would mean that Iunci was used to ship directly to and from Constantinople. This would include the provincial fiscal revenue (including the *annona,* a tax dedicated to supplying the empire) going one way, but also the eastern goods purchased in Constantinople for North Africa on the return.

Even if this remains hypothetical at the moment because no written record allows us to directly connect Iunci to Procopius's account on the North African *ναύκληροι*/*navicularii,* this would fit in with the general picture of the evolution of the Western territories of the Empire between the 6th–7th centuries. Other port cities benefitting from imperial interest were integrated into extra-regional communication and trade routes,[25] and we think this was the case also for Iunci. Indeed, Procopius' *Vandalic War* describes a sailing route connecting the northern sector of the Lesser Syrtis to the East and the imperial capital, Constantinople. This route operated at least from the early 6th century, and possibly even earlier. It began in central Byzacena, passed by Malta, south-eastern Sicily, Puglia, the southern coasts of the Peloponnesus, and the northern Aegean (Figure 1). Belisarius used this route in 533 to move the imperial fleet of 500 ships from Constantinople to the Gulf. Mid to late 7th-century texts, such as the *Doctrina Jacoby* and the *Miracula Sancti Demetrii*, show that this seaway remained in use, or at least well-known, until the late 7th century.[26] This indicates its importance over more than 200 years. It was along

[23] Concerning Iunci's city walls, see *C.I.L*, VIII, n. 10498; Leone, Giuliodoro 2022, with further bibliography. For the possibility that the city hosted a garrison, see Georg. Cypr. *Descr*., 644; Cosentino 2022.

[24] Proc. *Secr. Hist*., III, 25, 8-9. The dating of this passage is discussed in Stein 1949: 442, n. 1. During the period under consideration, *ναύκληροι*/*navicularii* were private ship-owners who, in specific moments of the year, were required by the imperial administration to manage the shipment of imperial taxes (in particular the *annona*). See also Reynolds 2016: 139. A different analysis has been proposed by Vera 2010: 10, according to whom the *navicularii* described by Procopius were private merchants operating outside the imperial fiscal system. Although this might be the case, it is clear from the same passage of the *Secret History* that the North Africa ship-owners played a role in the management of the imperial fiscal system, although probably not so willingly: "... he (the officer charged with the supervision of Constantinople's port taxation) ... forced them (the *navicularii*) to report for service in North Africa...". The service North African ship-owners were required to perform is undoubtedly to be identified in transporting provincial tax revenues (including the *annona*) to the capital.

[25] The case of Naples appears paradigmatic, see Arthur 2002. Other known examples are represented both by major urban centres such as Syracuse, Ravenna, and Butrint, and by smaller settlements, like S. Antonino di Perti and Torcello.

[26] Belisarius' fleet travel from Constantinople to central Byzacena (Caput Vada): Proc. *Bell. Vand*., I, 13. The same route, ending however in Thenae, c. 75 km south of Caput Vada, was used by the Jewish merchant Jacob, who travelled back and forth from Constantinople in 632 and 634 (*Doctr. Jac. Nup. Bapt*., V, 20; Dagron 1991: 238-240) and by the bishop Kyprianos of Thenae, whose travel to Constantinople is to be placed in the second half of the 7th century, probably *ante* 665 CE (*Mir. Sanct. Dem*., VI, 307-317;

this route that most of the Lesser Syrtis communicated with the wider Mediterranean basin. If correct, this should be visible in the archaeological record.

Corroborating the dynamics of exchanges: Late Antique ceramic assemblages from the Lesser Syrtis

Although the Lesser Syrtis remains poorly explored archaeologically and the picture is incomplete, there is enough evidence to trace its evolution. Since the 1990s, surveys have been conducted along the gulf shores, while fieldwork at the sites of Iunci and Thenae, first started as early as the early 20th century, has been ongoing since 2017.[27]

In the 4th and much of the 5th century, the Gulf trade was concentrated on the Western Mediterranean. However, by the 6th and 7th century, trade networks expanded towards the East (Pieri 2005: 167-168; Reynolds 2016: 140-145). The ceramic assemblages from Iunci reflect well this expansion and Eastern Mediterranean materials dominate the finds at Iunci. Naturally, pottery analyses attest to the presence of substantial quantities of local productions from the late 5th to the mid-7th century such as North African red slip wares (ARS), amphorae from Proconsularis (mainly Nabeul and Carthage area) and amphorae from southern Byzacena. However, material studies reveal large numbers of amphorae from Cilicia (LR1), Argolid (LR2), Samos (LR8), Gaza (LR4), along with cooking wares from Constantinople and the Aegean area. The best represented types are LR1 and LR2 dating to the 6th–7th century.[28] The presence of these types of amphorae along the Danube frontier was linked to the supply of the imperial army.[29] Accordingly, this could also be the case at Iunci, and the presence of a garrison of the provincial troops stationed in the city since 570's CE would be a matching outlet for these typologies of amphorae. However, the impressive quantity of material suggests that private consumption was also a driving force in the transport of these amphorae from Cilicia and the Argolid to Iunci. Overall, it is clear is that Iunci must have been a central hub for imperial and private distribution systems between North Africa and the Eastern Mediterranean in the late 6th and early 7th centuries.[30]

To better understand the rise of Iunci as seen in the textual evidence in the North African context, it is instructive to compare it with the ceramic record of Carthage as outlined by Fulford and Peacock. As the capital and main port of Late Roman, Vandal and Byzantine Africa, Carthage consistently received large quantities of Eastern Mediterranean goods throughout Late Antiquity. In the early 5th century (400-425) Eastern Mediterranean amphorae accounted for 10% of imports. This figure doubled to 20% by 475–500 and reached almost 30% by Belisarius' conquest in 533. During the second part of the 6th

Lemerle 1981: 168-169). As underlined by Clay 1992: 350, this was the safest and fastest route for a traveller coming from the East, but as proved by the available sources it was equally favourable for travelling from North Africa to the East. See also McCormick 2001: 502-508, who discusses a section of this same route still connecting south-eastern Sicily to Constantinople in the 8th and 9th centuries.

[27] See *infra*, notes 3-6.

[28] Bonifay et al. 2002; Mabrouk et al. in press. No quantitative data on the assemblages from Iunci is available yet.

[29] Karagiorgou 2001: 149-156; See however Reynolds 2010: 265-271 for the necessary caveats concerning the interpretation of these findings as a clear marker of the imperial supply system (*annona*); Mabrouk et al. in press.

[30] Slim et al. 2004: 105-125. For an assessment of the coexistence and mutual relationships of private trade with the Early Byzantine imperial exchange network, still a hotly debated topic, see the works of Wickham 2005: 70-73; Vera 2010 and Cosentino 2021; 2024.

century, however, this figure steadily decreases, dropping to less than 10% by the late 6th– mid 7th century.[31] In contrast, the data from Iunci record exactly the opposite trend. Although absolute and relative percentages regarding the ceramic findings from the site have not been established yet, the pottery assemblages suggest that imports of Eastern Mediterranean amphorae increased from the second half of the 6th century, indicating Iunci's growing importance in trade networks under East Roman rule.[32] Beyond Iunci, Eastern Mediterranean amphorae (mostly LR1 and LR2) have been found in moderate quantities at several coastal sites in the Lesser Syrtis, from Meninx (Djerba Island) to Sidi Mansour (Sfax district)[33]. As Iunci was the largest port in the Gulf of Gabès, it is likely that it represented the main hub for the redistribution of goods across the Lesser Syrtis (Mabrouk et al.). Beside substantial quantities of Eastern Mediterranean amphorae, Iunci holds the second-largest amount of Eastern Mediterranean cooking wares in North Africa, surpassed only by Carthage (Fulford 1984; Mabrouk et al.). The quantity of such materials certainly attests to the regularity of the exchanges with the Eastern Mediterranean and to the attractiveness of Iunci's market. Overall, imports suggest that Iunci's exchanges with the East were highly relevant in the general trade networks of the Mediterranean, probably matching the role of Carthage itself.

If Iunci was a major importer of goods from the Eastern Mediterranean region, what does the distribution of North African ceramics reveal? From the late 6th to early 7th century Tunisian exports declined.[34] This has been interpreted as a sign of a general economic downturn in North Africa. Fulford suggested that Byzantine governance partly caused this (Fulford 1980: 75-76). Indeed, Justinian ordered that the provincial army and administration should be supplied with locally produced goods, which likely reduced North African exports after 534 CE.[35] Despite this decline, however, significant amounts of North African exports have been uncovered both in Eastern and Western Mediterranean coastal sites.

Amphorae from Nabeul (Keay 35A, 35B, 55-57) and southern Byzacena (Keay 8B) have been found together at several Eastern Mediterranean sites, including Constantinople, Alexandria, and even the major ports of the Black Sea, such as Tomis and Chersonesos (Figure 1).[36] As Iunci is the only North African site where these vessels have been found together in significant quantities alongside 6th and

[31] Data and percentages of Eastern amphorae imports to Carthage are given in Fulford 1980: 71; Peacock, Fulford 1984: 258-262. See also Clay 1992: 350-352; Bonifay 2013: 532-533.

[32] See Bonifay 2004: 457, in particular his remarks concerning the relationship between the Byzacenian and Carthaginian networks of exchange over the period considered: "On a donc l'impression, en examinant la céramique africaine de Marseille, d'assister très schématiquement à un jeu de balancier entre la région de Carthage et la Byzacène, l'une ou l'autre de ces deux régions devenant tour à tour dominante au sein des échanges".

[33] LR1 and LR2 amphorae have been identified in Meninx, the island of Jerba (Slim et al. 2004: 99-100; Fontana 2000); at Nadour (north of Gabès; Slim et al. 2004: 11-114); Zabouza, probably corresponding to ancient Ad Oleastrum (Slim et al. 2004: 117); on the three islands composing the Kneiss archipelago, 15 km south of Iunci (Slim et al. 2004: 118-120); Sidi Mansour, in the northern Sfax district (Slim et al. 2004: 130-133). The same typologies of eastern amphorae have also been retrieved from the sites of Jebeniana, Chebba (ancient Caput Vada), and Salakta/Syllechtum, but their location on the Byzacenian north-central coast makes it uncertain if these settlements received Eastern materials from Iunci. See also Bonifay et al. 2002: 128-12.

[34] Fulford 1980: 75-76; Clay 1992; Reynolds 2016: 140-141. See however Reynolds' comments on the need to recalibrate this interpretation by including the new available evidence in the analysis (in particular at p. 141, n. 50). See also Bonifay 2019: 305, according to whom it is not before the mid-7th century that "la diffusion des céramiques africaines semble limitée à quelques grandes villes: Constantinople, Rome, Marseille …".

[35] *Cod. Iust.*, I, 27, 2, 18.

[36] Hayes 1992 (Constantinople); Bonifay, Leffy, Capelli, Pieri 2002 (Alexandria); Mabrouk et al. in press, with further relevant bibliography on the findings from the Black Sea port cities.

7th century pottery, these goods were most likely loaded there for transport to the Eastern Mediterranean region. This marks a shift from the 4th and 5th centuries, when Carthage and major Byzacenian ports such as Hadrumentum, Syllechtum and Thenae exported the majority of North African goods (Bonifay 2004: 452-455; Mabrouk et al.).

Exchanges with the Western Mediterranean region are also attested during the 6th and the 7th centuries (Fulford 1980; Reynolds 2016). We find significant quantities of North African goods (Keay 1984; Bonifay 2004; Reynolds 2016), including Byzacenian amphorae (Keay 8B and Keay 61) in many parts of the Empire such as the Balearic Islands, Sardinia, Sicily and the Byzantine possessions in Italy, but also far beyond the Empire and reaching places such as Frankish Marseilles, Visigothic Tarragona and Barcelona.[37] The considerable presence of these types in Iunci and the Lesser Syrtis testifies of the contribution of this region to the Mediterranean commercial space, exporting its surpluses not only to eastern, but also to Western Mediterranean markets.[38]

Overall, the ceramic material from the Gulf shows that the Lesser Syrtis, far from being on the periphery of the economic space of Byzantine Africa, appears to have been integrated into and contributed to the overseas trade networks with the east and the west. Iunci's importance, especially in the late 6th and the 7th centuries, potentially rivalled that of Carthage.

Conclusion

The Byzantine rule over North Africa began with a reorganisation of the territory, its administration, and Mediterranean trade networks. While researchers once believed this restored a Roman-like system centred on Carthage, we instead show a gradual yet significant restructuring of North African production and trade. By the late 5th century, the Lesser Syrtis formed strong commercial ties with both North Africa and the East. This indicates a shift in economic activities from Northern Tunisia toward the Eastern Tunisian coast, exactly near the location of today's largest and booming economic Tunisian centre, Sfax. Evidence, both textual and archaeological, reveals that Iunci rose to prominence on the Gulf of Gabès, becoming a key hub that redistributed imports and managed inland goods like oil and grains, and probably taxes sent to Constantinople. For this reason, the empire also invested in the defence and control of the area, a productive yet contested region near the imperial border threatened by different confederations of indigenous groups. Besides imperial investments, Iunci's growth likely benefited also from its geographic position and climatic events such as coastal erosion and tsunamis, which disadvantaged previously dominant cities like Thenae, Syllechtum, or Hadrumentum.[39] The

[37] Keay 8B distribution in the Western Mediterranean: Keay 1984 (Tarragona); Bonifay 1998 (Marseille); Pallarès 1987 (Albenga); Cirelli 2021 (Ravenna, Classe). Once thought to originate from the hinterland of Iunci, its production is now more plausibly attributed to the atelier of Majoura, located approximately 100 km west of the city, see Bonifay 2004: 132; Mabrouk et al. in press. For the Keay 61 centres of production, identified in the southern Tunisian Sahel, see Bonifay 2019: 302. For the findings in Iunci see Mabrouk et al. in press; for its distribution in the sites of the Tunisian eastern and northern coast and in the harbours of the Western Mediterranean, see Bonifay 2004: 140-141; Bonifay 2013: 535-536; Mabrouk et al. in press.

[38] For the content of the Keay 8B see Bonifay 2004: 132. On the other hand, the content of the Keay 61 is not known with certainty. As noted by Bonifay 2013: 535, the patterns of distribution of these vessels in North African coastal sites (Keay 8B: Carthage; Rusguniae. Keay 61: Jebeniana; Cherchell; Rusguniae; Djerba; Sabratha; Leptis Magna) attest also to the vitality of the coastal intra-regional commerce.

[39] The natural factors at play in the modification of the shores of the Eastern Tunisian coast, including the Lesser Syrtis, over the late antique period, to be probably connected with a series of high-energy events (earthquakes, tsunamis), have been examined in Kamoun et alii 2020; Bahrouni et alii 2024; Kamoun et al. 2024. In particular, Kamoun et al. 2020 investigated the

distribution of southern Byzacenian amphorae across the Mediterranean further proves Iunci's economic role, demonstrating that substantial North African exports were not solely handled by Carthage. Future research should explore land management and the influence of private and imperial enterprises in the region's rise under Byzantine rule and its transformation after the Islamic conquest.

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decline, occurred over the 5th century, of Acholla's harbour, to be ascribed to natural factors and, as argued by Cosentino 2021, to the impossibility for the city municipal authorities to invest in the refurbishment of the harbour, leading to its dismissal. According to Kamoun et al. 2024, the same situation is emerging also for Thenae, where a high energy event occurred in the late 4th century accelerated the process of degradation of city' sea shores, probably contributing to the dismissal of the harbour. Although no such data are available for other port cities of the Byzacenian coast, as argued by Bahrouni et al. 2024, a similar fate could have also impaired the capabilities of the harbours of Syllechtum and Hadrumentum, to name a few. As argued by Consentino 2021: 5, this situation and the general decline of the municipal authorities responsible for the maintenance of the harbours prompted a "diminution in the number of towns being able to offer port facilities for market activities".

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Material culture and trade

Stages of purple dye processing and ancient laboratory facilities in the Eastern Mediterranean area

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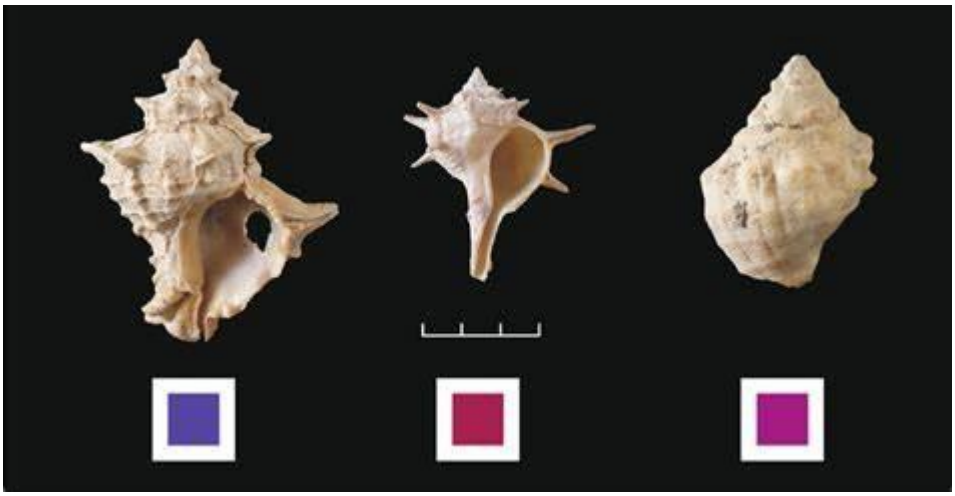


Figure 1. (Veropoulidou 2011, Figure 2.13).

Abstract

The research aims to highlight the multiple uses of the muricidae purple dye in antiquity, the stages of its processing, as well as to show the sites, in the Eastern Mediterranean area, where found remains of ancient laboratory facilities for purple shells processing. The various types of purple shells are also mentioned, as well as the colour shades of pigments produced by each of them individually. The research presents the commercial trade in purple in the Eastern Mediterranean by the Phoenicians and explains the reasons why purple dye was a product of high economic and social value. In terms of methodology, the research was based on the study of the ancient written sources, the modern scientific literature and the epigraphic references dating back to 1250 BC. The problem of the research is the fact that the process and recipes of the Phoenicians are not precisely known, since there was great secrecy around the subject, but written sources and modern experimental work allow, to some extent, to reconstruct the chain of purple production. One of the results of the research, is the fact that in the last three decades, due to climate change and rising water temperatures, the oyster has been threatened with extinction in its attempt to adapt. However, due to the indelible nature of the dyeing of the purple, the pigment has managed to survive in the material archaeological remains up to the present day.

Keywords: Hexaplex trunculus, Bolinus brandaris, Stramonita haemostoma, Murex brandaris, purple dye

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Introduction

Purple was one of the main products produced and traded by the Phoenicians (Marston 2002: 28). The bright and indelible colour of purple dye had a wide variety of shades, from yellowish, greenish and blue to lilac, mauve or violet. The finest and most expensive was the purple of Tyre, dark in colour, like congealed blood, with shiny reflections (Veropoulidou 2012: 103). From a linguistic point of view, it is argued that the word purple (*porphyra* in greek) is directly related to the Greek verb "*πορφυρώ*" meaning "to boil". It refers to 'something that is about to boil'. It is known, moreover, that before being immersed in the liquid purple dye, the textiles had to be boiled over a strong fire for several days (Καραλή 2021). The Greek term is still used, albeit rarely, to describe deep purple, as in *porphyro potami* (the purple river) or deep crimson, as in *porphyro haema* (deep red blood) (Ruscillo 2005: 99). The purple dye is also considered to be referred in some Greek inscriptions and literary sources as *halourgos* (ἁλουργός), which derives from the Greek words 'ἅλς' (hals: sea/salt) and 'ἔργον' (ergon: work). The original meaning of *halourgos* can therefore be translated as 'made from the sea' or 'made from/with salt' (Brøns and Droß-Krüpe 2018).

Purple was used mainly for dyeing textiles, which were made from the most famous materials of antiquity, such as the "white wool" from Syria and the wool of the Arabs, the flax of Egypt and later the silk imported from Persia. Phoenician purple textiles, made from high-quality threads, decorated with lavish designs, were in great demand (Veropoulidou 2012: 103). For the production and marketing of purple dye and dyed textiles, the Phoenicians established many colonies from the Aegean to the Canary Islands and the Atlantic coast in Spain. The dye was not only suitable for fabrics, but also for dyeing palaces or even women's facial cosmetics (Δαμιανός 2010).

During the 4th century BC, the shell, the source of purple, was depicted on Phoenician coins, which shows the great commercial and economic value of the product. The written sources even mention that "it was worth its weight in silver" (Theopompus, frag. 117.4 in Jacoby 1923-1958: 536-617).

Why was purple a product of such high economic and social value? Most researchers agree that this is because it was an indelible dye, but also due to its manufacturing process, which was complicated and costly.

In the Mediterranean, purple was produced from the liquid contained in the chromatophore gland of certain species of molluscs (sea snails), including Hexaplex trunculus, Bolinus brandaris and Stramonita haemostoma (Veropoulidou 2012: 103). Purple molluscs belong to the gastropods (gastropoda), so called because their foot is located under their abdomen (the gaster). Their head is fleshy and quite developed. On the top of the head, they have two pairs of antennae. In the first pair are the organs of touch, while in the second pair are the eyes. The connection between the animal and the shell is made with very strong muscles. They are also hermaphroditic organisms (Δαμιανός 2010). Each purple mollusc gland gave a small quantity of liquid, thus hundreds or even thousands of molluscs were needed to produce the large quantities of dye and purple textiles required by the demand across the Mediterranean. To dye one single garment required about twelve thousand shells (Veropoulidou 2012: 103). Experiments, like those of Jensen and Jensen (1965) revealed that 100 M. brandaris shells could produce 6.8–12 mg of dye.

Although the process and the Phoenician recipes are not entirely known, since there was great secrecy surrounding the subject, the written sources and modern experimental work allow to some extent to reconstruct the chain of purple manufacture (Veropoulidou 2012: 103).

Stages in the processing of purple



Figure 2. Crushed purple shells (Hexaplex trunculus) from Toumba of Thessaloniki, 1200-1100 BC. (Veropoulidou 2011: Figure 8.8).

Initially, the molluscs were collected from the sea. The collection of the shells was done by hand, with traps containing baits or with nets or even by divers. The choice of species depended on the desired shade of the dye, as the trunculus species gives blue and mauve tones, while the brandaris species gives red tones (Figure 1. Veropoulidou 2012: 103-104).

Since the shells are carnivorous, the collectors, were using woven baskets with various baits (e.g. mussels). However, there are other, easier techniques, such as the skin-pointing of animals and dead fish, where the shells are collected in a great amount (for more detailed information about ancient muricidae fishing, see Alfaro and Mylona 2016). Collectors then, separated them into species and sizes (Πρωτοπαππάς and Γκάτσος 2011).

This was followed by the preservation of the purple. Until processing, the molluscs had to be kept alive, otherwise the valuable fluid contained in the gland was lost. They were probably placed in sea water vessels or in 'tanks' on the shore.

Then, the pigment gland of the purple shell was extracted. For the extraction, a hole was drilled with a pointed instrument at the last manoeuvre of the shell, i.e. at the point where the gland is, or the shell was completely crushed. The crushing of the shell did not require a complicated instrumentation, as a percussion instrument or a percussion rod and a solid surface were all that was needed (Veropoulidou 2011: 405). The gland was removed by a suitable instantaneous breaking of the shell and with the organism alive so that it would not spread through the body and lose its dye (Veropoulidou 2012: 104). Although the extraction of the chromatophore gland was a simple procedure, the study of the size of the fragments clearly shows that the technique evolved over time. Gradually, the gland was extracted with fewer breaks, which made the process less time-consuming (Veropoulidou 2011: 405).

This was followed by the drying and the fine powdering in a mortar. Preservation of the dye could be done with the help of honey in sealed jars and was thus preserved for up to 6 weeks (Pekridou 1993: 47). For example, fragments of clay beehives for honey were found in the purple laboratory facilities at ancient Trageaia on Agathonisi (Τριανταφυλλίδης 2012: 637-638; For more information about the excavations on Agathonisi, also see Triantafyllidis 2015). The gland was removed from each mollusc and then placed together with salt water in vases, water-tight pits or tanks in order to start the fermentation of the raw material.



Figure 3. Crushed purple shells: apertures (γ), fragments of different dimensions (δ, ε), hole at gland point (στ), Toumpa of Thessaloniki. (Veropoulidou 2011: Figure 8.8).

The mixture was stored for a few days or, to speed up the fermentation process, was heated to a constant temperature of around 40-50 °C. The chemical fermentation of the mixture and its conversion into dye was probably carried out by adding ash. Pliny (*The Natural History* 3) mentions that the purple was left for 3 days in salt water and then simmered in lead cauldrons for 10 days to improve dissolution and minimise the mass as porridge. During this process, unnecessary material such as flesh residues or small pieces of shells were removed (Τσουρινάκη 2017: 68). However, the results of the experiments carried out by Ruscillo in 2001 with Murex trunculus, in southern Crete, showed that steeping for more than three days is unnecessary (for the results of the experiments, see Ruscillo 2005: 105-106). During the boiling process, cleaned wool was dipped several times as a test to see if the desired colour tone had

been achieved (Pekridou 1993: 47). Ruscillo (2005: 105) also points out that the wool absorbed the most dye and attained the deepest shades. Pure cotton, and probably linen, do not achieve a pleasing colour through these methods and the processed silk produces the nicest colours, by today's standards.

The process continued with the production of the colour from the purple. The change of colour was gradual. Initially, the juice produced a white-yellowish liquid with a creamy texture, which, in contact with air and sunlight, acquired different shades (Veropoulidou 2012: 104). At first, yellowish like lemon, then greenish, then violet and mauve, and finally deep red (purple). The red became more and more intense, at the same time creating a penetrating smell, reminiscent of garlic (Pekridou 1993: 47). Perfume would likely have been required on new garments (Ruscillo 2005: 105). The ladder of colour tones was wide and included a multitude of shades, ranging from bright red to almost black. By skilfully mixing the pigmented juices of different kinds of shells it was possible to create the most varied green tones (Pekridou 1993: 47).

Chemists Dr. Stavros Protopapas and Vassilis Gatsos (2011) more specifically, report that the dye could not dye directly, since it was insoluble in rainwater. It had to be converted first into a bleaching agent which was soluble in water. In fact, an intramolecular 'mutation' to leuco-indicotine takes place, and is then, restored to its original form by oxidation. This leucogenesis was created in containers by reduction processes, i.e. with the aid of alkali and ammonia. To create the alkaline solution, they used slaked lime (Ca(OH),2) and wood ash (lye) to create potassium hydroxide or seaweed ash to create sodium hydroxide. It also appears that wheat or oat bran was used as a reducing agent. Old urine was used to make ammonia. The bacteria in the urine require oxygen to survive and eventually provide an ammonia solution in 2-3 weeks. This was the reason why the dye houses were located far from the city, because of the strong unpleasant smell from the old urine, which along with the decomposition of the flesh of the shell, created an unbearable smell that permeated skin and clothing. Such urine storage facilities were found in the excavations at Raches in Isthmia (4th century BC) and at Kerameikos (1st century BC)."

Vitruvius (*De Architectura* 7.13), inspired by Aristotle and Pliny, says that the purple shells differ in the colour they give, depending on the place where they live. And he uses the term *ostro* (from the greek *ὄστρεον* or *ὄστρειον*, a purple colour produced by shells) against the term *purpurissum* (purple) (Τσουρινάκη 2017: 67): "Let us now speak of ostreon, the most famous and the most beautiful and graceful of all these colours. It comes from the shells that produce this purple dye and, to those who study the phenomena of nature, it causes no less admiration than others, for its colour is not the same in all places but varies naturally according to the path of the sun. That which is gathered in Pontus and Gaul is black, because these countries are nearer to the north. Moving from north to west the colour becomes lighter. What they collect from the eastern and western equatorial regions, is a violet colour. But in the southern regions it has a red tinge, as for example in Rhodes and other areas closer to the sun's orbit... And because it comes from pieces of seashell, they call it ostreon (shell)."

Finally, we move on to the dyeing of the fabrics. Little is known about the dye fixatives, although it is certain that some were used, such as honey and ammonia from urine. The fabrics or fibres were soaked in the dye vats for several hours, depending on the desired tone and intensity of the colour. Generally, the longer the fibres or textiles were left in contact with oxygen, the darker the colour. By repeated dipping and using dye from either one type of shell or a mixture of several, they achieved a wide variety of shades from pink to blue. Most famous were the purple textiles of Tyre, which were dyed very dark after double dipping in the dye (Veropoulidou 2012: 104). Ruscillo (2005: 105) mentions that purple dyed pieces retained their colour and odour even after washing, and dyed hands remained coloured for six weeks until the nails grew out.



Figure 4. Shade samples from Bolinus brandaris, Hexaplex trunculus and Thais haemastoma. Photo from an exhibition at the Natural History Museum in Vienna.

Identification of laboratory sites for the processing of purple dye

The main archaeological find indicating the manufacture of the purple dye at a site is the crushed purple seashells. Rarer are other finds, such as vessels with dye residues, percussion and fracturing surfaces with traces of crushed shells and dye, tanks for fermenting the dye or dipping the textiles.

From an archaeological point of view, it is argued that the Aegean inhabitants were the first to use the purple. The Minoans of Crete, Kythera, Santorini and all Minoan settlements in the Aegean caught the three specific species of molluscs: Murex brandaris, Thais haemastoma and Murex trunculus (Καραλή 1988).

The oldest evidence comes from Crete in the Palaeopalatial period (1900-1700 BC). Workshops have been identified at Palaikastro, Koufonissi, Kommos, Kato Zakros and Pacheia Ammos. At Palaikastro in particular, there are many Muricidae shells mixed with pottery of the Middle Minoan and Late Minoan periods (Τσουρινάκη 2017: 66). Remains of Middle to Late Minoan period workshops have also been identified on Chryssi island and at the region of Pefka, near Pacheia Ammos (Apostolakou *et al 2016:199)*.

The earliest references are found on tablets of Linear B of Knossos, dating from around 1250. Tablet KN X976 mentions the term *po-pu-re-jo*, meaning purple (i.e. purple tunic), and tablet KN L474 mentions the term *po-pu-re-ja*, probably meaning female purple-dyers. The modern word purple for Murecidæ species has a similar phonetic value to the term *po-pu-re-jo* in Linear B, indicating a direct connection with antiquity. The term *wa-na-ka-te-po-po-pu-ou-re* (royal purple) on the Knossos tablets refers to the king's

purple garments, perhaps connecting purple for the first time with what was called 'royal purple' (Τσουρινάκη 2017: 66).



Figure 5. Map of Eastern Mediterranean Sea which depicts sites, mentioned in the text, where remains of ancient purple laboratory facilities have been identified (Mouteveli).



Figure 6. Female crocus gatherer at Akrotiri of Thera, 1650 BC. Museum of Prehistoric Thera. Spectroscopic research has shown that the violet colour of the mural composition is purple.

Pausanias (*Description of Greece* 2.21.6) points out that the most suitable purple shells are found in the sea surrounding Laconia and give the best dye after those coming out of the sea of Phoenicia.

In the Aegean, there were several workshops for the manufacturing and use of dye. Among them, the islands of Crete, Rhodes, Kos, Amorgos, Nisyros (which had the ancient name Porphyry), Chios and the western coast of Asia Minor, Phocaea, Lydia and Phrygia, and in the Peloponnese, Laconia, Corinth and Hermione (Πρωτοπαπάς and Γκάτσος 2011).

Evidence has also been found in other settlements of the Aegean dating to the late Middle and Late Bronze Age (1700-1100 BC), such as Akrotiri of Thera, Kythera, Aghios Kosmas of Attica, Aegina, Mitros and Kinos of Locris, Aghios Mamas of Halkidiki, Toumba of Thessaloniki and Troy (Veropoulidou 2012: 105). Additional remains of workshops can be found at Tyre and Sidon in Lebanon (12th century BC) and at Sarepta in Lebanon (14th-13th century BC). The areas of Ancient Phoenicia with remains of purple workshops, also include Minet el-Beida (15th-13th centuries BC), Tel 'Akko and Tel Keisan (11th century BC), Tel Dor. (Karmon and Spanier 1988: 184). Purple dye was also produced during the Iron Age (1100-750 BC) in many settlements in the Aegean, such as Methoni in Pieria and Toumba in Thessaloniki.

During the 6th century BC, there are purple workshops in Ermioni in Argolida, which continued to operate until the 6th century AD. The Murex-brandaris type shell is considered a basic species of the Hermione region and produced the characteristic colour of amethyst. Crushed or broken Murex shells have been found also in several sites as Aghia Eirene, Asine, Eleusis, Iklaina, Kynthos, Delos, Hala Sultan Tekke in Cyprus, Tel Mor and D' jerba (ancient Meninx) in Tunisia. (for a more extensive list of sites, see Reese 1980, 81–83).

The dyeing workshops needed rainwater and therefore storage cisterns. At Bisti in Ermioni there are several, most of them carved into rocks. Also, the facilities necessarily had to include chemical containers, such as caustic soda or potash, soap dispensers, etc., as well as storage facilities for old urine. Standard dyed yarns as samples and mixing vessels, scales, etc. have always been present in the purple dye laboratory facilities. Their existence justifies the findings and the peculiar utensils found at the site of Raches in Isthmia, where excavations were carried out in a large ancient dye house (Πρωτοπαπάς and Γκάτσος 2011).

Conclusions

If we accept that the workshops operated for about 1000 years with an average processing of 10,000 shells per day, then during their operation, about 2 to 3 billion shells were processed.

The purple dye continued to be just as important in subsequent historical times, when it was given an imperial connotation. During the Industrial Revolution, chemical paints were invented and so the purple dye was forgotten. Nowadays, in an age of vibrant synthetic colours, which are much more affordable, people are no longer willing to submit to the difficulties of muricidae dye production, nor endure the over-powering smell of these garments.

After all, climate change, which we are experiencing in our time, probably would not favour the continuation of the practice, since it has been an important factor in changing the rate of growth and spawning of purple dye murex (for more about climate change and murex, see Lahbib, Abidli and Trigui El Menif 2010).

However, due to the indelible nature of purple dyeing, we are able to admire the colour which has managed to survive in the material archaeological remains up to the present day. Royal purple, like many ancient wonders, will remain a part of the glorious past. We could say that this is a kind of justification for the billions of purple dye molluscs used over the centuries.

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Religious life of ancient sailors in the eastern Adriatic, traces of religious ship rituals

Ivana Jadrić-Kučan[1]

Abstract

Ancient sailors faced numerous dangers and fears associated with the sea and navigation. Because of the safer journey, they turned to the deities who accompanied them during the voyage and protected them from numerous possible adversities at sea. Accordingly, they also cultivated special religious beliefs and practices that were believed to ensure their happy outcome and the safety of navigation. Divine protectors were worshipped in port and on the capes. It is thought that part of these rituals were performed on the ship itself, as evidenced by the remains of ancient shipwrecks, i.e., parts of the ship's inventory to which a religious role can be attributed. These include the ship's altar luterion. Several examples of luteria originate from the Adriatic Sea. Everyday dishes could be used for libation, but richer ships used specially made luxury items. A patera with a lion's head and a bronze wine jug (oinochoe) with a handle decorated with a human image from a shipwreck near the island of Ilovik is a confirmation of the above. The bronze simpulum comes from a shipwreck in Vela Svitnja on the island of Vis. Oil lamps in the form of the god Priapus, the patron saint of successful navigation, were found in several locations on the Adriatic. In addition to the above, some parts of the ship's equipment were marked with various symbols that were supposed to aect them favourably. For example, anchors from shipwrecks in Vela Svitnja Bay and Glavat Cape near the island of Mljet have a relief of four astragalus (knuckle bones) in combination with the luckiest throw iactuc Veneris.

In addition to entire ships, individual objects also ended up in the sea, which is also an indicator of the spiritual beliefs of ancient sailors. Seeing that the ship was on the verge of disaster because the sea was probably flooding it and was losing its ability to manoeuvre, the crew sometimes also threw valuable objects as a suitable sacrifice to try to appease the sea deities and calm the enraged sea. Evidence of this is probably the famous bronze statue of a young athlete found near Cape Orjula, near Mali Lošinj. The power of belief in supernatural beings and the possibility of turning around a difficult situation brought hope and trust, and the sea gods would help if they were adequately bribed and appeased.

Keywords: ancient sailors, Luterion, Adriatic Sea, Ilovik, Vela Svitnja, Priapus, astragalus, Cape Orjula, Bronze statue of Athlete with Strigilis

For the ancient Greeks and Romans, religion was an essential and integral part of everyday life, including maritime life. As in the present day, sailors faced numerous dangers and fears from the sea and navigation. To make their journey as safe as possible, they turned to the deities who accompanied them during navigation and protected them from numerous adversities at sea. Accordingly, they nurtured extraordinary religious beliefs and actions that ensured their happy outcome and the safety of navigation.

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The Greeks prayed to the god Poseidon before traveling across the sea and believed that their safe sailing was subject to his whims and fancies. Homer brings us the story of the famous Odysseus, one of the main heroes of the Trojan War, who blinded Poseidon's son, the Cyclops Polyphemus, which caused a storm to hit his ship and delayed his return to his native Ithaca. Odysseus, after returning to his home, was told that he would have to go on another journey before he could lead a happy and peaceful life, and the famous sorcerer Tiresias advised him to worship the god on the island and thus alleviate his anger (Hom. *Od*. XI: 130-131).

Although the eastern coast of the Adriatic Sea, due to its indentation and the number of islands and channels, provided sailors with protection from the open sea and was thus more suitable for navigation than the western coast, it still hid many dangers for them. Sudden changes in weather conditions were especially dangerous (Bilić 2012: 81–93; Marelić 2016: 211–236), often hidden in the restless sea of invisible shoals and rocks, as well as piracy by local communities (Jurišić 2000; Cambi 2009: 136). Divine protectors were venerated in the harbour and along the headlands. It is thought that some of these rituals were performed on the ships, as suggested by the remains of ancient shipwrecks and items from the ship's inventory that appear to have had a religious purpose (Figure 1).

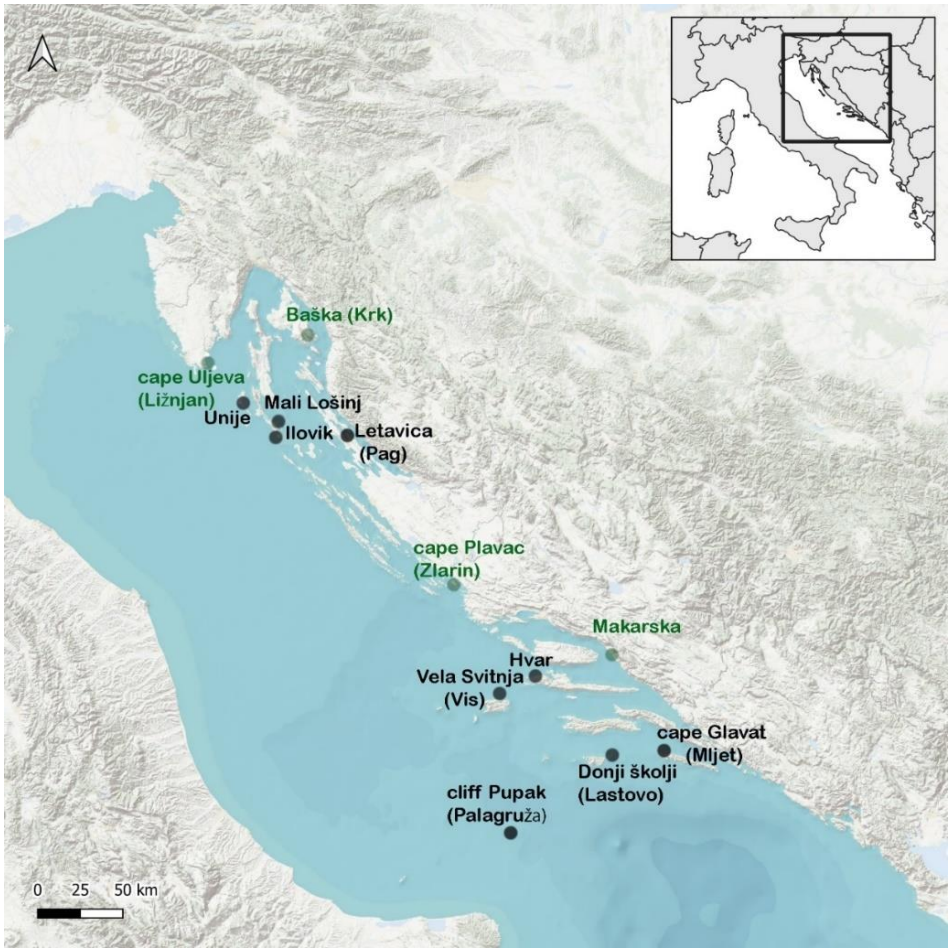


Figure 1. Eastern Adriatic with indicated parts of the ship's inventory that can be attributed to a religious role (By: I. Jadrić-Kučan).

They primarily include louterion (Greek *louterion*, Latin *labrum*) which had the shape of a round tray on a tall cylindrical leg with an extended profiled base. They had a wide purpose, as shown by their depictions on Attic and Apulian red-figure vases from the 5th and 4th centuries BC (Figure 2).



Figure 2. Attic Red Figure, e. g. 480 BC, side A: athlete washing at a louterion, STAATLICHE MUSEEN ZU BERLIN, ANTIKENSAMMLUNG / Johannes Laurentius, CC BY-SA 4.0, inventory number: V.I. 4560.

They were used on land for profane purposes as vessels for bathing water, as part of fountains, for mixing and crushing grain, simple decoration inside the atrium of houses, etc., or sacred as sprinklers at the entrances to temples (*perirrhanterion*), baptismal font (Ginouvès1962: 77-79), and on ships as altars for libations, sacrifices or burnt offerings (Kapitän 1979: 114; Radić 1988a: 35, 37; Tusa et al. 2021). The earliest louterions were recorded in the Middle East and Greece and were used from the 7th to the 2nd century BC, and by sea trade, they reached the Italian soil. Greek louterions were produced in two basic types: *Corinthian*, specific for its red clay and cream coating and prominent rim drawn outwards and bent downwards, and *Attic*, which differs in its texture, coating colour, and simpler rim. At the same time, they were produced in Sicily and southern Italy, from where they spread to the Adriatic area, dating mainly from the 4th to the 2nd century BC. Their round base characterizes louterion from Sicily and those from Calabria by Corinthian influence and local characteristics (Kapitän 1979: 97, 99-101; Radić 1988a: 38). The foregoing shows that there was great diversity in the execution and decoration of louterions, stone specimens were mainly architecturally designed, while ceramic ones could be decorated with painted, engraved or relief ornaments, and figural representations.

The Greek philosopher Epictetus (*The Discourses of Epictetus* 3, 21, 127) and the Roman historians Arrian (*Kynegetikos* 53. 2) and *Livy* (XXIX 27.1–5) state that no ship left port without its crew first performing a religious act to their happy homecoming. Presumably, before the departure of the ship, the ceremonial washing of the hands in the louterion could have preceded the libation of wine, and also a sacrifice like the one recorded in Syracuse, during which a cup with different offerings was immersed in the sea at the moment when the ship was sailing or had already left the port (Kapitän 1979: 114; Brody 2008: 444-454). The famous German archaeologist Gerhard Kapitän, who first published the findings of louterions in the Mediterranean in 1979. concludes that they were not part of the ship's cargo intended for trade but rather were objects used by the ship's crew to perform religious ceremonies since one or two specimens are always found in the context of shipwrecks, and they are also very luxurious objects that would hardly be in everyday use (Kapitän 1979: 114-116).

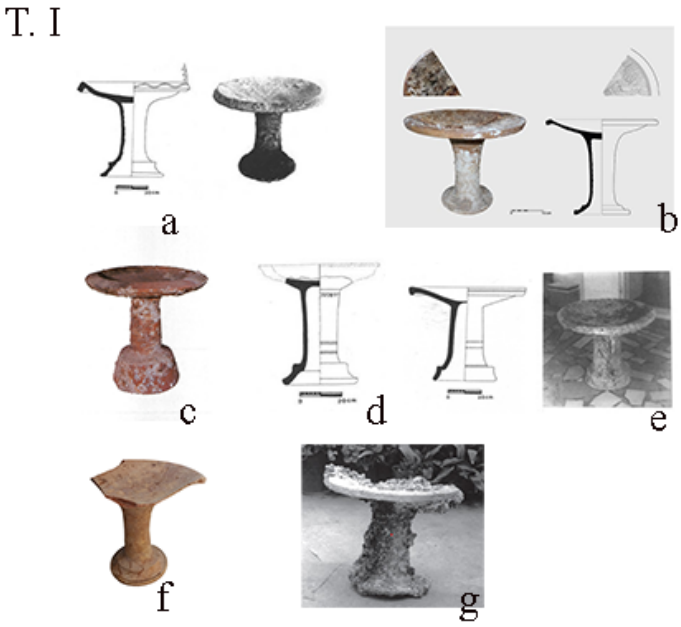


Table I – Louterions from Eastern Adriatic coast (By: I. Jadrić-Kučan).

The use of louterion on ships is also evidenced by seven specimens from the seabed of the eastern coast of the Adriatic. They were found in different contexts; all were made of clay, and two wholly preserved ones stand out among them. The first of them was found at a depth of 35m and is part of an undamaged shipwreck near the islet of Donji školji near the island of Lastovo. It is made of darker brown clay and is completely covered with marine incrustation (Table I: a). It is 60 cm high, tray diameter of 70 cm, tray inner diameter of 65 cm, tray depth of 9 cm, base height of 9 cm, base diameter of 40 cm, and leg diameter of 16-21 cm. His tray is decorated with incised waves arranged in three parallel rows along the rim, while a spiral decoration is incised along the edge itself. It is kept in Lastovo.

It belonged to a smaller ship carrying cargo with several hundred amphorae of the Lamboglia 2 type, dating to the end of the 2nd century BC. Since the louterion stands out from the rest of the ship's cargo, it is considered that it was not an object of trade, but was used as a ship's altar. In addition to it, two smaller jugs were found, one of which was lying in the immediate vicinity, so it is possible that it was used for ritual pouring or pouring of liquid from it (Radić 1988a: 41; Radić 1988b: 44-45; Radić Rossi 1991: 158, Fig 6; Radić Rossi 2001: 228-230).

Another completely preserved louterion was found in the sea at an unknown location; it is kept in the private collection of Mr. Miljenko Vladimir in Grgurići near Slano near Dubrovnik (Figure 4). It is 59 cm high, the diameter of the tray is 70 cm, the inner diameter of the tray is 63 cm, and the diameter of the stand is 37 cm. It is decorated with seven incised parallel lines located along the edge of the tray's rim, and below them follows a series of diagonally placed smaller holes that together form a zigzag decoration and cover the entire surface of the tray. According to the assumed dating of the previous lutherium from Lastovo, at the end of the 2nd century BC and the one from the Unije in the 3rd – 2nd centuries BC and this one from Slano can be dated to the same time period (Perkić 2021: 81, 83) (Table I: b).

Other louterions from the Adriatic Sea come from the vicinity of Hvar, Mali Lošinj, Unije, and Palagruža. The Hvar louterion was found as an independent find in the undersea channel between Hvar and Pakleni islands. It is 72cm high, tray diameter of 72cm, tray inner diameter of 56cm, tray depth of 8cm, base height of 20cm, base diameter of 55cm, and leg diameter of 17-20cm. It is made of dark red clay and a lighter coating, with horizontal incisions on the rim and lower part. Its shape and texture belong to Corinthian louterions created in the 5th century BC (Cambi 1969: 229; Vrsalović 1974:104, no.7, Figure 7/D and 10; Vrsalović 1979: 322, T 50/5 and 92/1; Radić 1988a:39), while G. Kapitän dates it to the 4th century BC and connects it with the foundation of the Greek settlement of Pharos and the greater intensity of navigation of that period (Kapitän 1979: 104, Figure 10). It is preserved in the Underwater Archeology Collection of the Hvar Heritage Museum in Hvar (Table I: c).

Louterions from Mali Lošinj and Palagruža share similarities in construction but date back earlier. According to the amphora finds, Lošinj dates back to the 3rd century BC. It has not been completely preserved; part of the tray is missing. Its height is 51 cm, the height of the base is 10 cm, and the diameter of the base is 36 cm. It is decorated with two rows of three horizontal lines, each in the lower part of the leg, and two parallel lines are engraved on the horizontal shoulder of the pedestal. Traces of an unrecognizable ornament can be seen under the tray. It is kept in the private collection of an Italian diver (Kapitän, 1979: 104-106, no. 8, Figure 11 and 12; Radić 1988a, 39-40, T. 2; 1, 2) (Table I: d).

Louterion from Palagruža is 57 cm high, tray diameter 70 cm, tray inner diameter 62 cm, tray depth 8 cm, base height 8 cm, base diameter 38 cm, and leg diameter 19-26 cm. It is made of ocher clay, which is reddish in colour, without coarser admixtures. It is decorated with three parallel incised lines on the tray's rim, while the leg is decorated with two parallel lines arranged in three rows. It dates back to the 1st century BC and is kept in a private collection in Komiža on Vis (Radić 1988a, 41, T 3: 1,2). Regardless of the time difference between the aforementioned louterions, Irena Radić Rossi assumes their common origin from the southern Italian production centre (Radić 1988a: 43-44) (Table I: e).

The next louterion was found in the sea near the island of Unije near Lošinj at a depth of 30m. It was brought to the Split Archaeological Museum in 1960. without accompanying findings. Its base and leg were damaged, while one-third of the tray was preserved. It is 65 cm high, tray diameter of 80 cm, tray inner diameter of 72 cm, tray depth of 8 cm, base height of 9 cm, base diameter of 40 cm, and leg diameter of 19-22 cm. It has a fine, brownish texture. The tray's surface is decorated with seven thin parallel lines, i.e., concentric circles about 2.5 cm from the outer edge, and further, towards the centre, there are depressions with a diameter of about 2 mm. They are arranged in several angled rows and form a zigzag decoration. It dates back to the 3rd– 2nd centuries BC (Vrsalović 1979: 322, T 50/6 and 82/2; Radić 1988a: 40; Radić Rossi 1991: 155–156, Figure 2) (Table I: f).

The last example of a louterion was found at the site of Veli škoji near Mljet. The information about it is based on the only photograph brought by Domagoj Perkić, which shows that it is partially preserved and that it is quite similar to the aforementioned louterions from Lastovo and Slano (Perkić 2021: 83, Figure 3[2]) (Table I: g).

When the ship set sail for the purpose of a happy return, a libation (lat. *libatio*) was performed, i.e. a sacrifice of libations. It is a sacred act performed to honour the gods and was an integral part of every celebration. It consisted of pouring wine, but oil, honey, or even water could also be used (Burkert 1985: 72; Scheid 2007: 264). Among the Greeks, the libation differed according to its performance, *sponde* was carried out in a controlled manner, i.e., only a specific part of the liquid was poured onto the altar from a smaller vessel that was held in hand. In contrast, with *choe* it was poured entirely, and it was most often used in the cult of the dead and chthonic deities (Burkert 1985: 70-71). After mixing the wine with water, it was drunk and then poured into the sea from the stern of the ship. Part of the act was performed by the crew on the boat and part by the regiment on the shore with prayers, songs, and wishes for a happy outcome of the journey. Prayer was an integral part of every religious act, including libation. It had to be performed according to exactly established rules. It would begin with the invocation of the deity with outstretched hands towards the sky, the earth[3] or a cult image of the deity, during which some effective divine nicknames were often used, and after making contact with him, a prayer would follow, an integral part of which could also be a vow that was made publicly in front of witnesses (Scheid 2007: 263). The departure could also be accompanied by the throwing of garlands from the ship into the sea. The sailors also tried to obtain safety during the voyage with sacrifices and gifts, and the vows were fulfilled after the successful return in the same way, with libation and prayer. Everyday dishes could be used for libation, but richer ships used specially made luxury items. From the

[2] Louterion was taken illegally from the sea, after which it allegedly disappeared on the black art market in Germany

[3] Depending on whether it was addressed to a heavenly or underground deity.

shipwreck in Vela Svitnja cove on the island of Vis (Vrsalović 2011: 119; Čargo 2003: 429-432) comes a small bronze vessel or ladle with a long handle *simpulum* or *simpuvium* (Cambi 1972: 80-82; Radić Rossi 2005: 151; Čargo). 2018: Cat. 13), which could serve the stated purposes (**Figure 3**). The remains of the sunken ship were found at a depth of 30–35m. During the research, 554 whole or almost whole amphorae and 86 amphora necks, all but one of which belong to the Lamboglia 2 type, dating to the end of the 2nd century BC or the beginning of the 1st century BC were taken out. According to the discovered findings, it is considered that the ship perished immediately after setting sail from its home port of Vis (Radić 1990: 72; Vrsalović 2011: 120).



Figure 3. Simpulum from Vela Svitnja, Vis, Archaeological Museum of Split, Inv. No AMS-7355, photo: B. Čargo.

From the second shipwreck near the island of St. Petar near the island of Ilovik comes from a round bronze vessel (*patera*) with a long handle decorated with a head in the shape of a panther or a lioness and a bronze ritual jug (*urceus*) (Figure 4 and 5).

They belonged to the ship's inventory of a 25m long merchant ship that was carrying around 1,500 to 2,000 wine amphorae and sank in a shipwreck in the middle of the 2nd century on the navigation route between Dalmatia and Istria. The patera is completely preserved; its diameter is 20 cm, its height is 5.4 cm, and its handle is 12 cm long. It was used to pour water intended for ritual washing and washing before performing cultic and religious activities (*ablutio*). A jug with a handle decorated with the head of Eros, height 20 cm, diameter 12 cm, was found with it and probably used for the said ritual pouring of water. It is the only example of bronze vessels known at all from the explored shipwrecks of the early

imperial period, which at least suggests that they were not standard merchants' equipment and belonged to the inventory of a sunken merchant ship and served for ritual purposes. It is assumed that the bronze statue of the Athlete With Strigilis – Strigilis Cleaner also belonged to this ship since it is the only bronze found on the eastern coast of the Adriatic, and it was also found a little further away, but this will be discussed later.



Figure 4. Bronze jug – urceus from the shipwreck near the island of Ilovik, Maritime and Historical Museum of the Croatian Coast Rijeka, Inv. No. PPMHP 103111



Figure 5. Bronze plate from the shipwreck near the island of Ilovik, Maritime and Historical Museum of the Croatian Coast Rijeka, Inv. No. PPMHP 1031122

Successful and happy sailing for sailors was also ensured by Priapus, a deity traditionally associated with the fertility of fields, gardens, livestock, and male potency, and depicted as a man with a large phallus. Ancient written sources mention him as the protector of navigation and sailors, especially those who were engaged in maritime trade, which is confirmed by the findings with his depiction or symbol on the shipwrecks of Pisa E, Planier A and Rhine (Neilson 2002: 248-253; Radić Rossi 2005: 145; Brody 2008: 3), and those found on the eastern coast of the Adriatic, which will be discussed now. An oil lamp in the form of an ithyphallic Priapus, which may have been part of a ship's inventory, was retrieved from a fishing net from the seabed of the island of Krk, near Cape Škuljica near Baška (Dugonjić 2010: 220-2219). It has been preserved almost completely; it is made of clay and is 20 cm high and 20 cm long. A similar oil lamp was found at the bottom of the sea near Makarska; it is in a private collection (Cambi 2002: 194, F. 304). On both oil lamps, on their front ithyphalic part, there was a wick for kindling (Figure 6).

From the shipwreck at Cape Uljeva (Uljeva A) near Ližnjan in Istria came several fragments of a ceramic vessel entirely in the shape of a large phallus. It is hollow, closed in shape, and is most likely part of a uniquely made oil lamp (Bekić 2020: 36, Figure 33a-c) (Figure 7).



Figure 6. Oil lamp in the form of the ithyphallic Priapus, the island of Krk, downloaded: P. Dugonjić 2010: F. 23.



Figure 7. Fragments of an oil lamp in the shape of a phallus, Brodolom near the cape Uljeva (Uljeva A), photo: L. Bekić.

Furthermore, the oil lamp, associated with the shape of a phallus, originates from the shipwreck near Cape Plavac near Zlarin. It was made of clay and has been preserved almost entirely. One end is made in the shape of a phallus, and the other in the shape of a stylized female head decorated with a geometric ornament, while in the central part, female breasts and stylized arms are formed. According to the findings, it is considered that the ship sank in the 1st century. On the way home after leaving today's channel of St. Ante near Šibenik, he was hit by a strong storm that threw him onto the rocks of Cape Plavac, where he sank. (Podrug et al. 2016: 57-58, Figure 11) (Figure 8).



Figure 8. Oil lamp in the form of a phallus and a stylized female head with breasts, Museum of the city of Šibenik, MGŠ 1279.

In addition to the above, some parts of the ship's equipment could be marked with various symbols or deities' dedications that were supposed to favourably affect them. Thus, on the anchor, a very important element of the ship's equipment, on which in many cases the fate of the ship and its crew depended, relief representations of the four astragals were sometimes made. Confirmation of this is shown by the anchor bars found under the sea of the island of Vis, which have the above image on the sides. The first anchor bar was found at a depth of 27m in the bay of Vis. It belongs to a simple form without a transverse beam inside the opening for planting the wooden part of the anchor; its length is 165cm, and the maximum height is 16 cm. It is made of solid lead, and the central frame and one arm are slightly deformed (Radić 1990: 68). On the side, in shallow relief, astragals are visible, which are

made with a complete appearance, and not with balls, and on the central part of the crossbar, at the point of thickening, there are three hemispheres placed in the shape of a triangle.[4]

Due to the deposits of lead oxide and marine debris after the crossbar was removed from the sea, the representations above were not visible, which is why they were not even described in the first publication of the monument (Radić 1990: 68). A hundred meters from it in the northeast direction, at a depth of 30m, there was another anchor bar. Both rungs were found without accompanying findings and elements of the ship's construction, but since 300m from them, intact remains of the aforementioned ancient shipwreck were found in Vela Svitnja Bay (Cambi 1972: 80-82), I. Radić Rossi assumes that they could be mutually related findings, i.e., that they could have belonged to the mentioned shipwreck, knowing the custom that several pieces of them were found on ancient ship anchors (Radić 1990: 74) (Figures 9).



Figure 9. Lead stock of Roman anchor with a relief depiction of Astragalus, The north coast of the island Vis, Vela Svitnja Bay, Archaeological Museum of Split, Archaeological collection of Issa. AMS-44646.

[4] Many thanks to Boris Čargo, museum advisor of the Split Archaeological Museum, for his selfless help, valuable information, and photos.

In the Archaeological Collection of Issa, two smaller lead anchor bars were found in 2003 in Vela Svitnja Cove at a depth of 35m. One of them shows an astragals (Čargo 2003: 425, Figure 31b). Also, the lead crossbar anchor from the wreck of a Roman merchant ship near Cape Glavat on Mljet (Figure 10) has a decoration in the form of four astragals in the combination of the luckiest throw *iactus Veneris* (Venus' throw) on the arm on the side of the limiter, where each astragals is placed on a different side (Kisić 2000: 10; Radić Rossi 2003: 28); Radić Rossi and Borzić 2022: 176, cat. no. 1082), and we find the same lucky combination on a lead bar from a shipwreck near Cape Letavica on the island of Pag (Radić Rossi and Dorušić 2019: 660-662; Radić Rossi and Yamafune 2022: 182; Radić Rossi and Dorušić 2023: 237).



Figure 10. Lead stock of Roman anchor with a relief depiction of Astragalus, Glavat cape near the island of Mljet, DUM PM2261.

In addition to entire ships, individual objects also ended up in the sea, which is also an indicator of the spiritual beliefs of ancient sailors. Seeing that the boat was on the verge of disaster because the sea was probably flooding it and losing its ability to manoeuvre, the crew sometimes also threw valuable objects as a suitable sacrifice to appease the sea deities and calm the enraged sea. The power of belief in supernatural beings and the possibility of turning around a difficult situation brought hope and trust, and the sea gods would help if they were adequately bribed and appeased. According to Nenad Cambi, evidence of this is probably the famous bronze statue of the young Athlete With Strigilis – Strigilis Cleaner, found in 1999 near Cape Glavičin on the island of Vela Orjula near Mali Lošinj at a depth of 45m (Cambi 2007: 105) (Figure 11). This thesis is supported by the fact that he was found alone in a lying position on his back on a slope among the rocks, and only minor remains of broken amphorae and one anchor were found about 10m southeast of him, which does not indicate either a shipwreck or a common affiliation.

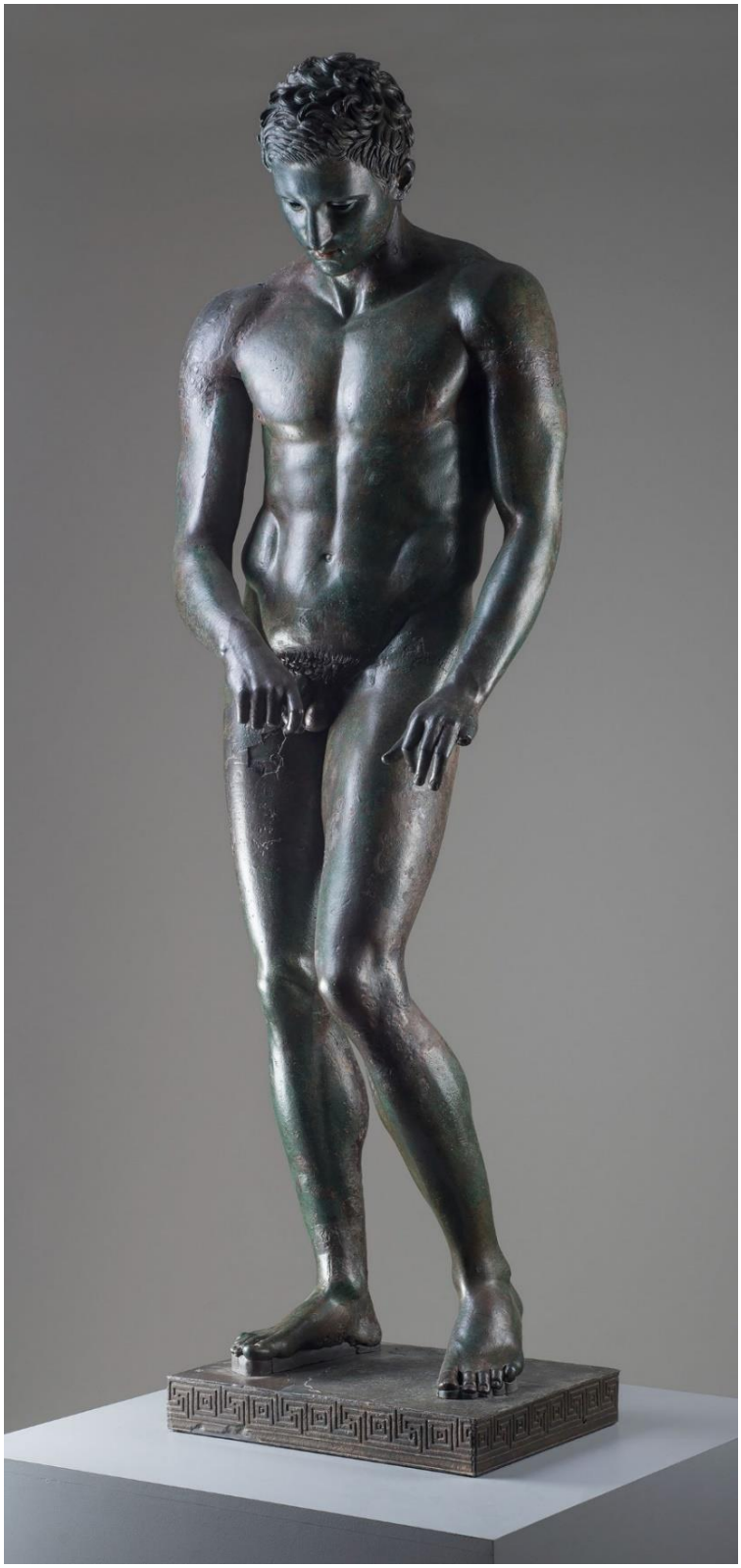


Figure 11. Bronze statue of Athlete with Strigilis – Strigilis Cleaner, near Vele Orjule, Museum of Apoxyomenos, Mali Lošinj, photo: I. Dorotić, M. Bosnić.

However, according to the opinion of Marijan Orlić, it is possible that a Roman shipwreck in a bit further vicinity was still connected with it (Orlić 1986: 10-11). Namely, in 1962, at the northern entrance to the channel between the island of Ilovik and the islet of Sv. Petra, a well-preserved cargo of a sunken Roman ship, was discovered with several hundred types of amphorae of different types (between 1,500 and 2,000 amphorae), among which the most numerous are those of the Forlimpopoli type, in which wine was probably transported from southern Italy, and it sank in the middle of the 2nd century. The inventory of this ship also included the previously mentioned round bronze vessel (*patera*) with a long handle decorated with a head in the form of a panther or a lioness and a bronze ritual jug (*urceus*) decorated with the head of Eros at the bottom of the handle. Furthermore, the previously mentioned anchor probably belonged to him, one of the arms of which was deformed, as if it had been exposed to an enormously strong force at the moment it was lost, which would exclude the possibility that the anchor or the statue of the athlete was thrown away to lighten the load or to appease the sea gods. According to the opinion of Irene Radić Rossi and Bridget Buxton, the ship carrying the athlete's statue back to Italy lost control of maneuvering in the face of a strong northeast wind (storm). The anchor was thrown into the sea in the last attempts to save the ship and anchor it safely behind the scarce shelter of Vela Orjule; however, it, unfortunately, did not last. It is possible that the desperate sailors may have wrapped the anchor chain around the statue to give it more weight and threw them both together into the sea in an attempt to survive while being driven by the storm, but unfortunately, this does not stop the ship, and the storm carries it further towards St. Peter, where he finally sinks (Radić Rossi and Buxton 2022: 106-115; Radić Rossi and Buxton 2023: 271-281).

Finally, the power of belief in divine beings and the possibility of turning around difficult situations brought hope and trust, and the gods of the sea would help if they were bribed and appeased adequately. The mediator between them and the people was a priest, who would say a prayer on behalf of those present, so we can assume that the ship's captain did this on behalf of his crew.

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Pottery sequence of the Lake Van basin within the cultural and political framework of the highland of eastern Anatolia: from the Chalcolithic Period to the Late Iron Age (Achaemenid)

Aynur Özfırat[1]

Abstract

The article aims to present pottery traditions in the Lake Van basin from the Late Chalcolithic Period to the Late Iron Age within the framework of the highland of eastern Anatolia. The research is based on material from excavations at mounds and cemeteries and Lake Van basin survey sites. Lake Van basin, the heartland of the Urartian Kingdom, provides the most striking data about the pottery sequence in eastern Anatolia due to its liveable environment and central location between the southern Caucasus, Iran, Mesopotamia, and Anatolia.

Keywords: eastern Anatolia, Chalcolithic, Early Bronze Age, Middle Bronze Age, Lake Van

Introduction

The pottery sequence of the Lake Van basin from the Late Chalcolithic Period to the Late Iron Age (Achaemenid) has been studied within the cultural and political framework of the highland of eastern Anatolia, east of the Upper Euphrates Valley, based on material from excavations and our intensive survey of the basin.

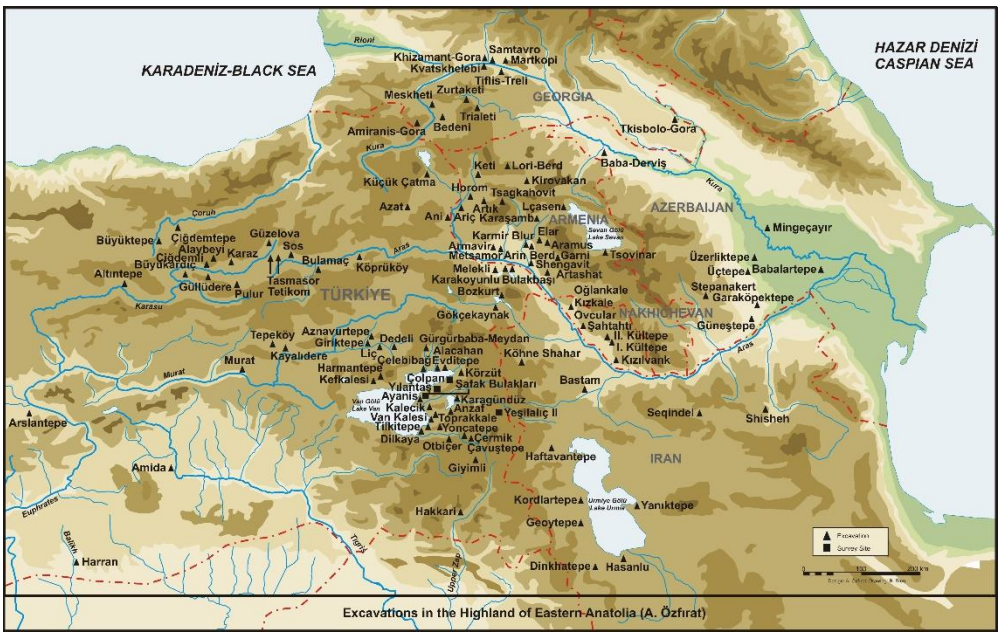


Figure 1. Excavations in the highland of eastern Anatolia.

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The landscape of the highland of eastern Anatolia is defined by the Nemrut, Süphan, Aladağ and Tendürek volcanoes and the high mountain range of the Southeastern Taurus and lies in the northern part of the Near East. The Lake Van basin, with small sheltered coastal plains and river valleys in the lowlands and volcanic lakes, high plateaus, and rich pastures in the highlands, plays a crucial role in determining the socio-economic structure and livestock patterns.

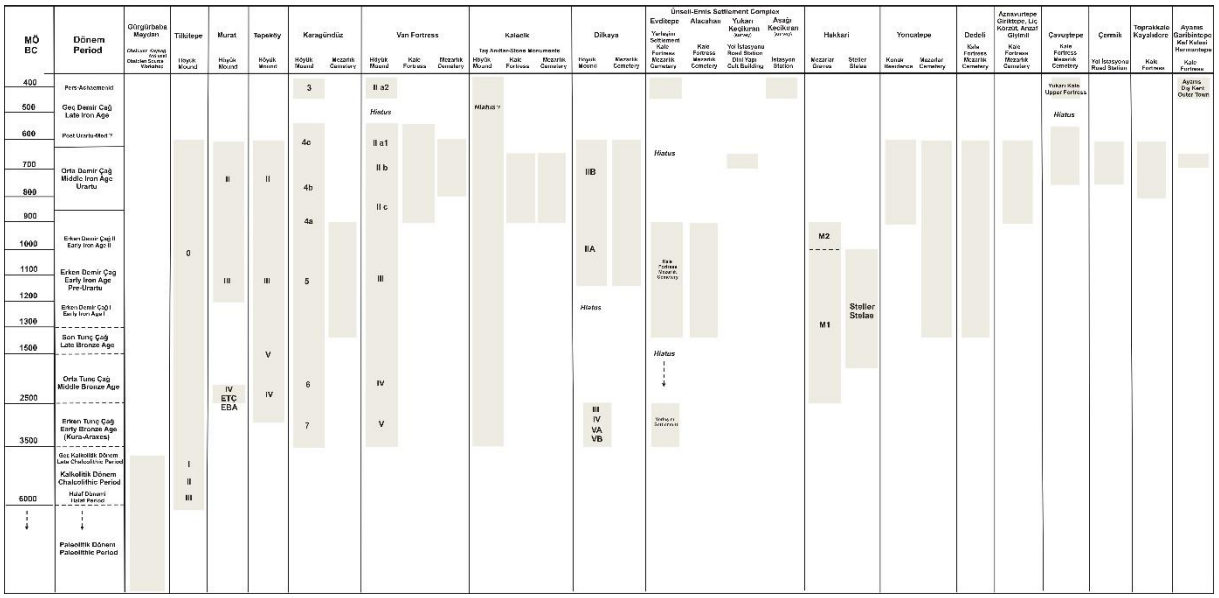


Figure 2. Stratigraphy of excavations in the Lake Van basin.

The highland of eastern Anatolia is part of the cultural zone of southern Caucasia and northwestern Iran, which is on the northern border of Greater Mesopotamia. It has three main subregions: Southeastern Taurus-Hakkari, Lake Van basin, and Northeastern Anatolia. Hakkari and Northeastern Anatolia lie on the western periphery of this cultural area, which has strong local character. Lake Van basin and Mt Ağrı-Middle Aras Valley, extending northeast, are centrally located. The Lake Van basin is important for its liveable environment and location at the crossroads between Mesopotamia, Anatolia, southern Caucasia and northwestern Iran. The northern and eastern parts of Lake Van have special characteristics due to the presence of important natural habitats in the plains along river valleys and lakeshores and on the main communication routes.

The primary markers of the settlement system in this mountainous area are that artificial mounds are almost non-existent here, with the exceptions of the plains around Lake Van and Kura, Aras, and Murat River basins. The existing ones are also small in size. In this vast mountainous terrain, the sites are situated on low or high rocky outcrops and lack thick stratified layers, even at large settlements, or fortress cities with a long sequence of occupation. The scarcity of stratified evidence, such as old excavations, the weakness of the levels in the mounds, and the absence of fortress city excavations, make it difficult to define the chronology and cultural characteristics of the highland of eastern Anatolia.

So far, no evidence from the Neolithic Period has been found in the basin. Paleogeographic research seems necessary to answer this question.

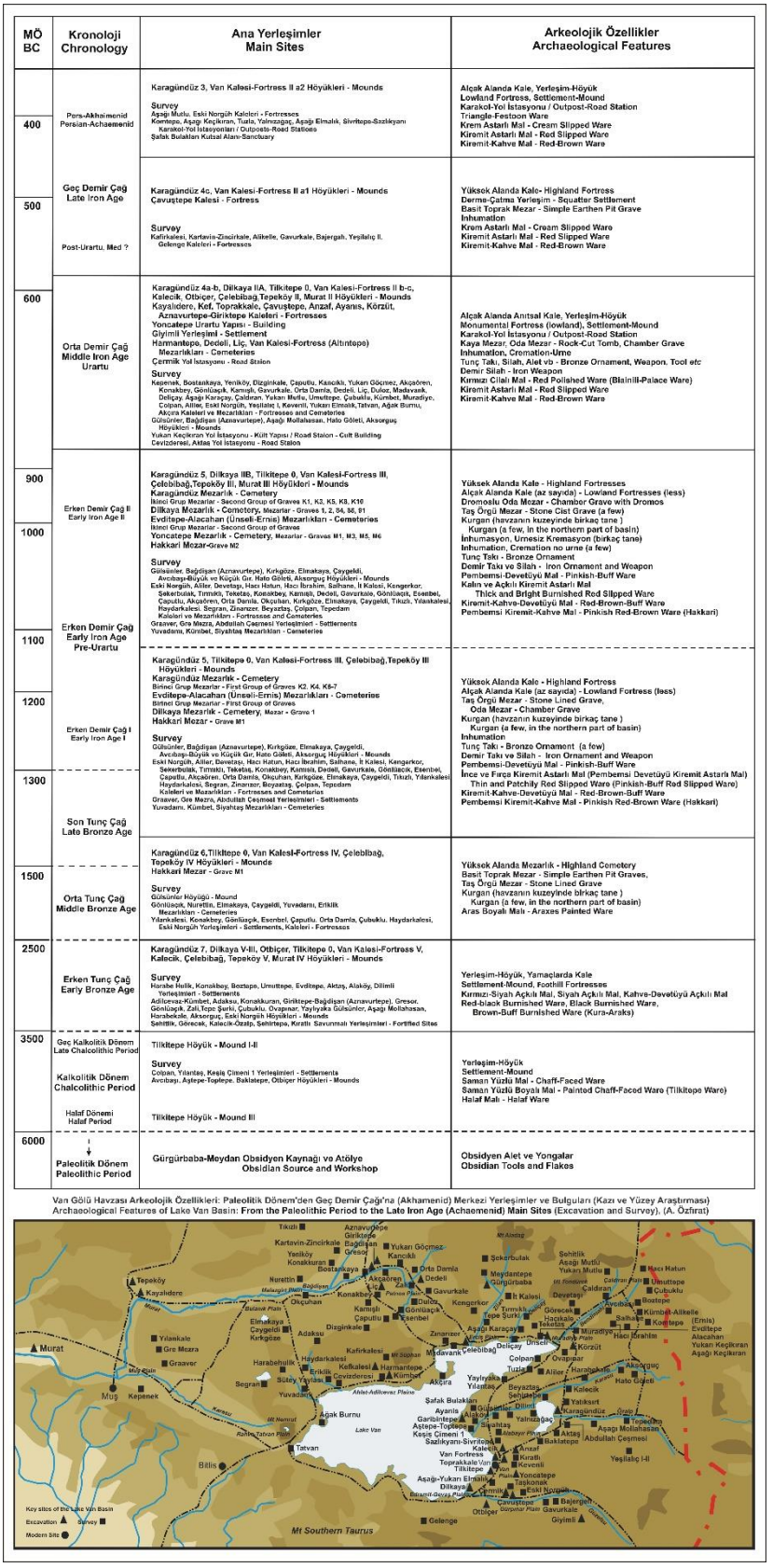


Figure 3. Archaeological features of the Lake Van basin.

The Chalcolithic Period (*c.* 6500-3500 BC)

The sites of the Chalcolithic Period in the highland of eastern Anatolia are few and small in size. They are mainly situated in mounds and single-layer settlements on the plains and river valleys. Excavations for this period were only carried out at the Tilkitepe I-III (Korfmann 1982: 41-44, 150-179) mound (Van Plain) on the southeastern shore of Lake Van. Unfortunately, the stratigraphic sequence of Tilkitepe is roughly outlined due to insufficient records from old excavations. The other settlements we will mention here were examined in the survey. The Chalcolithic sites of the Lake Van basin are found mainly on the eastern shore of Lake Van near Tilkitepe (Fugures 1-3) (Özfırat 2021a).

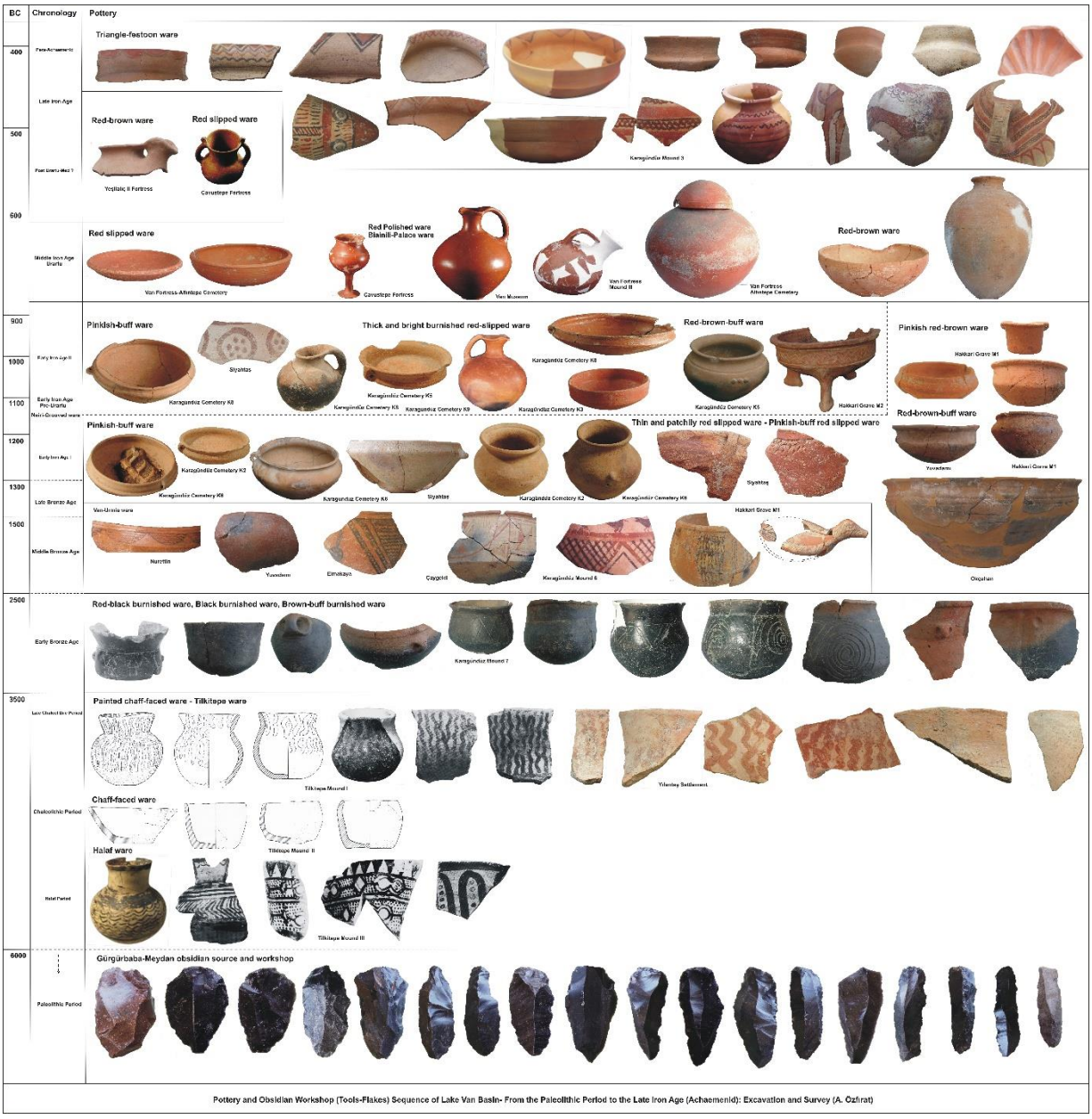


Figure 4. From Chalcolithic to the Late Iron Age the main pottery groups of the Lake Van basin.

The evidence from the Chalcolithic Period in the highland of eastern Anatolia is almost only unstratified pottery. Radiocarbon readings come from northeastern Anatolia: Alaybeyi (4721-4553 BC), Middle Chalcolithic (Işıklı 2019: 145-148), Pulur (4042-4075 BC) (Işıklı 2008: 272) and Sos VA (3500-3000 BC) (Sagona 2000: 332-333; Sagona 2017: 204, 227-230, 242; Sagona and Sagona 2000: 58-63) date to the Late Chalcolithic Period. The region has various regional pottery groups (Figure 5): Halaf ware, chaff-faced ware and chaff-faced painted ware (Tilkitepe ware) in the basin of Lake Van; chaff-faced ware and Sioni ware in the southern part of Middle Aras Valley-Mt Ağrı region (Özfırat 2021a; Özfırat 2022a: 35-40; Özfırat 2023); drab late chalcolithic wares, black burnished ware, proto Kura-Araxes and Late Sioni ware in northeastern Anatolia.

Chalcolithic Period pottery in the Lake Van basin lies in the chaff-faced ware horizon. (Figures 4-5.1). Chaff-faced ware, related to northern Mesopotamia, spread to the southern Caucasus, north-western Iran and southern areas of eastern Anatolia, extending up the Upper Euphrates Valley (Marro 2011; Palumbi 2011; Sagona 2017: 133-137, 182-189). A couple of local chaff-faced ware were found in the Muş Plain on the western part of the Lake Van basin. Halaf ware, typical chaff-faced and chaff-faced painted ware (Tilkitepe I ware) were found on the eastern coastline. The majority of evidence comes from the Tilkitepe mound and the single-layered flat sites of Yılantaş and Çolpan. Tilkitepe II contains chaff-faced ware. A large amount of painted and unpainted samples of Tilkitepe I ware were collected at Yılantaş. Tilkitepe ware, a regional painted group of chaff-faced ware, is distinguished from the classical chaff-faced ware by its shiny-burnished surface and painted decoration. The existence of only a group of painted wares and the absence of chaff-faced ware in Yılantaş is remarkable. On the contrary, only chaff-faced ware is found in other settlements apart from Tilkitepe, which has both groups.

The earliest pottery in the Lake Van basin and the whole region is Tilkitepe III Halaf ware. Halaf pottery must have been related to pastoralism, raw materials such as metal and mainly the obsidian deposits of the basin, which indicates trade among the northern Mesopotamian groups. The large obsidian deposits and workshop of the Palaeolithic and most probably Chalcolithic at Gürgürtepe-Meydan Dağ (Aladağ) volcano to the north of Lake Van are important for the dynamics of this system, about which we have no information (Uslu et al. 2020).

Early Bronze Age (Kura-Aras culture) (*c.* 3500-2500 BC)

Although there are a great number of Early Bronze Age (EBA, Kura-Araxes Culture) settlements, the ones that have been excavated are fewer in the highland of eastern Anatolia. There is also insufficient data due to excavations carried out in small areas, most of which are old excavations.

Excavations were carried out on mounds at Dilkaya (Kozbe 1990; Çilingiroğlu 2012: 85-89), Tilkitepe 0 (Korfman 1982: 177-179), Van Fortress Mound (Tuşpa) V (Tarhan and Sevin 1994: 852; Konyar et al. 2018: 148), Kalecik (Korfman 1982: 185-188, 197-202), Otbiçer (Uslu et al. 2023), Karagündüz 7 (Sevin and Özfırat 2001), Çelebibağ (Uluçam 2000: 14-15, 53-54; Çavuşoğlu 2011), Tepeköy V (Erdoğan et al. 2023) and Murat IV (Özdemir et al. 2021) in Lake Van basin (Figures 1-3). Karagündüz 7 (second half of the 3rd Millenium BC, 2561-2481 BC and 2444-2298 BC), Tepeköy V (2900-1900 BC), and Murat IV (EBA III, 2500-2200 BC) provide C14 dating and information even though not excavated in large areas. The radiocarbon dating from northeastern Anatolia are as follows: Çiğdemtepe (Late Chalcolithic-EBA I: 3132 to 2913 BC; EBA I: 3096-2913 BC) (Parlıtı and Akyüz 2022: 4), Pulur (3026 to 2902 BC) (Işıklı 2008: 272; Akarsu and Genç 2024: 432-437) and Sos Vb-d (3000-2200 BC) (Sagona 2000: 332-333; Sagona 2017: 204, 227-230, 242; Sagona and Sagona 2000: 58-63).

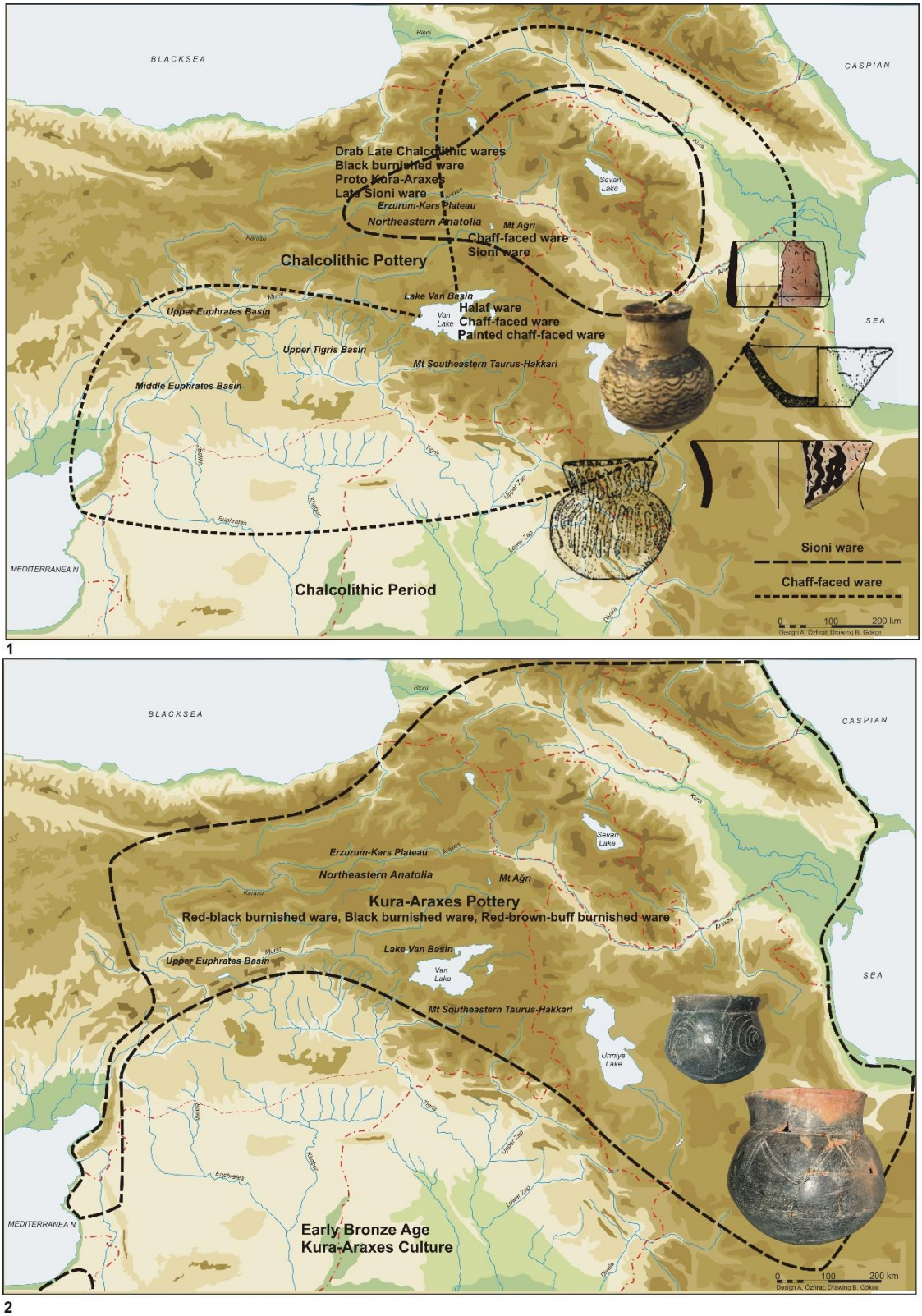


Figure 5. Pottery zones of the Chalcolithic and Early Bronze Age in the highland of eastern Anatolia.

The Lake Van basin was settled more densely during the EBA than during the Chalcolithic Period, as in the entire region (Özfırat 2021b; Özfırat 2022b). The plains of river valleys, lake shores, and surrounding terraces were all inhabited, indicating sedentary lifestyle characteristics in the lowlands during the Kura-Araxes Period. Single-layer settlements and fewer fortified sites were located on the terraces of the surrounding foothills. Some graves and settlements were situated on the highlands (Özfırat 2021c). No EBA fortified settlements were found outside the eastern side of Lake Van in eastern Anatolia so far (only Kalecik-Suluçem around Mt Ağrı).

Early Bronze Age pottery is represented by the Kura-Araxes tradition in eastern Anatolia (Highland and Upper Euphrates), (Figures 4, 5.2). The homogeneity of the Kura-Araxes culture is also evident in pottery. More or less differences are seen in subregions. The pottery is divided mainly into red-black burnished ware, black burnished ware and fewer numbers of red-brown-buff burnished ware. A general description of the wares is given here because the pottery has subgroups and there are chronological differences due to local differences within the vast geography where the Kura-Aras culture spread.

The Middle Bronze Age (c. 2500-1500 BC)

The distinctive features of the Middle Bronze Age (MBA) are a noticeable reduction in the number of agricultural settlements in the lowlands; vast cemeteries on the high pasturelands, unrelated to any settlement; a pastoralist lifestyle in contrast to the Kura-Araxes Period; and a new painted pottery tradition (Aras Painted ware). The stratigraphic evidence for the MBA comes from limited studies and weak or flimsy levels in the whole region. The significant point to be considered is that the Kura-Araxes Culture displayed local differences and that the later transition to the pre-Urartian Period (LBA-EIA) followed local development throughout diverse regions of this wide cultural zone. The transition period of the Early Kurgan Period (Martkopi-Bedeni, EBAIV-MBAI, *c.* 2500-2000 BC) can be observed in the northern part of the region (Figures 4, 6.1). This period was only investigated in Sos Vd (EBA III, 2500-2200 BC).

In the Lake Van basin, MBA levels were excavated at the mounds of Karagündüz 6 (Sevin and Özfırat 2001: 142-143); Tilkitepe 0 (Korfmann 1982: 179-184), Van Fortress Mound IV (Tarhan and Sevin 1994: 852), Kalecik (Korfman 1982: 185-188, 197-202), Çelebibağ (Çavuşoğlu 2011: 5-6) and Tepeköy IV (Erdoğan et al. 2021: 68-69) (Figures 1-3). There are no architectural remains of these lowland sites. Tepeköy IV separates with its rural architectural remains and location on the highland. Only some sherds were found in deposits, except for some flimsy remains of Karagündüz 6. No precise stratigraphic records came from old excavations at Tilkitepe 0 and Kalecik mounds. Radiocarbon samples are from Tepeköy IV (2000-1200 BC). The Late EBA of Karagündüz 7 (C14 readings: 2561-2481 BC and 2444-2298 BC) gives a *terminus post quem*.

Hakkari Grave M1 contains Khabur ware, Van-Urmia ware and Early Nairi-Grooved ware (LBA-EIA I) (Özfırat 2002a; Özfırat 2002b.). It was used from the Early MBA to the EIA I. The C14 analysis of the human bones in grave M1 gives the dates of 1885-1745, 1995-1690, 1950-1835 and 2030-1780 BC. C14 readings from north-eastern Anatolia are as follows: Altıntepe 6a (20-18. Centuries BC) (Yılmaz 2020; Yılmaz and Karaosmanoğlu 2023: 195-198.), Pulur (1993-1827 BC) (Akarsu and Genç 2023: 451) and Sos IVa-b (2200-1500 BC) (Sagona and Sagona 2000: 64-65; Sagona 2000: 336-339). Due to insufficient stratigraphic data and the lack of cemetery excavations, apart from the Bozkurt kurgans, the most important documentation of this culture is the pottery (Özfırat 2001; Özfırat 2008). A large amount of pottery, which comes from cemeteries, is scattered in many Turkish museums.

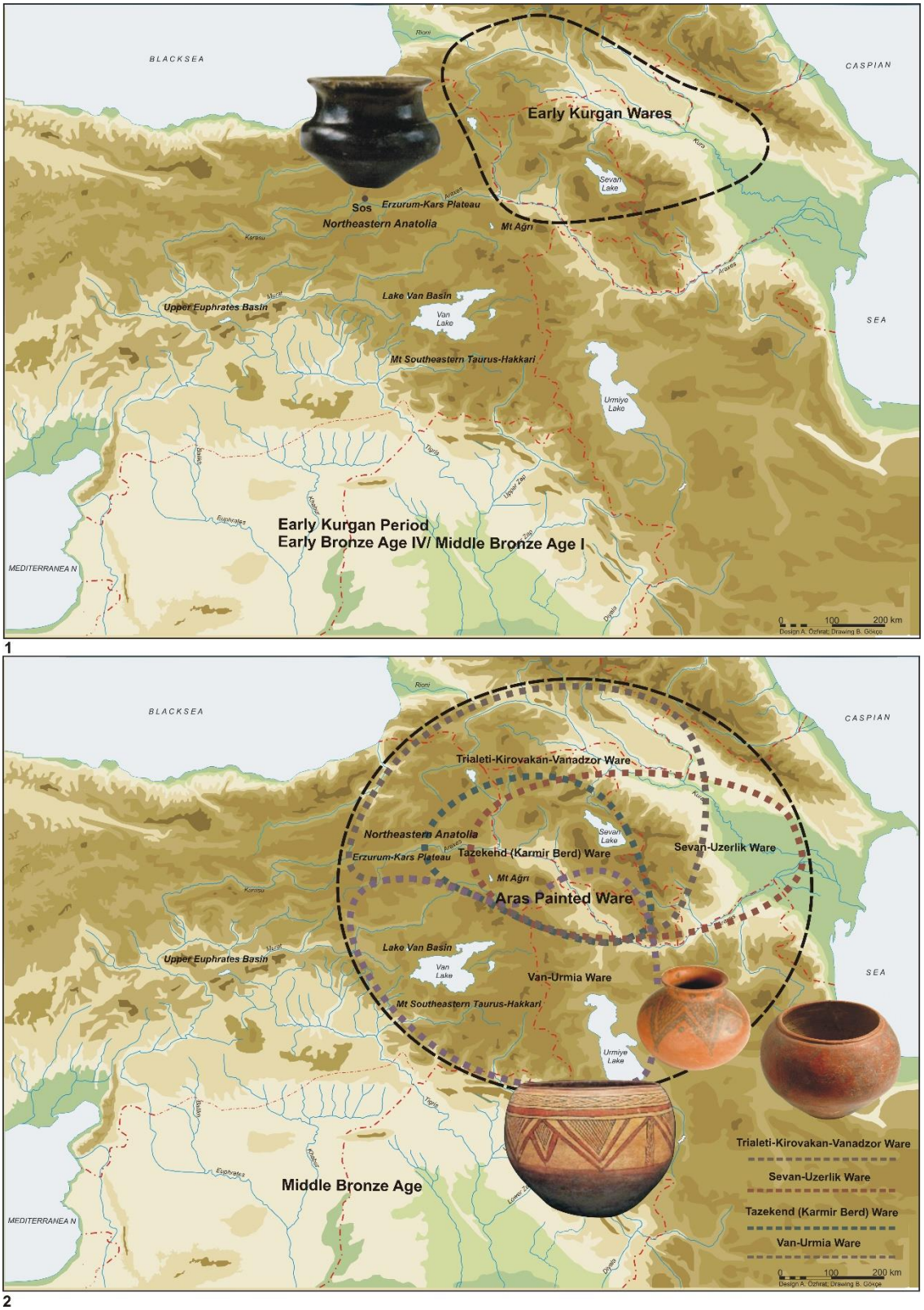


Figure 6. Pottery zones of the Middle Bronze Age in the highland of eastern Anatolia.

Middle Bronze Age pottery is divided into two main groups in the highland of eastern Anatolia: Aras painted ware (monochrome-polychrome painted) and black burnished ware. The pottery has regional features, mainly in their decoration styles (Figures 4, 6.2): 'Trialeti-Kirovakan-Vanadzor', 'Sevan-Üzerlik', 'Tazekent (Karmir Berd)' and 'Van-Urmia-Kızıl Burun (Kızıl Vank) (Martirosyan 1969: 47-73; Abibullaev 1982; Edwards 1986; Aliev 1991; Kushnareva 1997: 81-150; Sagona 2017: 298-377; Rubinson 2018). The boundaries and chronology of these cultural groups are distinctive even through transitions. Black burnished and monochrome painted wares of the 'Trialeti-Kirovakan', 'Sevan-Üzerlik', and 'Tazekent (Karmir Berd)' groups dominate northeastern Anatolia. Monochrome painted ware is less common in this region. Monochrome and polychrome painted pottery and unpainted types of the Van-Urmia group lie in the southern part of the region. However, unlike other groups, the Trialeti monochrome painted pottery tradition is widely spread throughout the region, even on the Van-Urmia horizon.

The Lake Van basin and Hakkari region are located in the zone of the 'Van-Urmia' tradition. While the pottery from the flimsy architectural levels of mounds in the river valleys and coastal plains of the basin is few in number, the cemeteries on the highland pastures of Mt Süphan investigated in the survey contain plenty of Van-Urmia sherds. This group is red-brown ware. The ornaments are of two types: monochrome and polychrome painted. The motifs are black on a red-brown slip in the monochrome painted vessels. A separate thick cream slip is applied under the decoration on the upper part of the polychrome painted vessels. The motifs are applied in one or two colours (black or red), mainly in two colours, with black and red painted on a cream slip.

Van-Urmia ware is clearly distinguished from other areas by the presence of polychrome painted ware and the absence of black burnished ware. The late phase of Van-Urmia ware, polychrome painted pottery, appears to have continued throughout the LBA in the basin into Nairi-Grooved ware. The painted pottery tradition of MBA continued during LBA and decreased throughout the EIA in Nakhichevan and northwestern Iran. Combinations of LBA-EIA shapes and the polychrome painting style occur more or less in the Van-Urmia zone. A similar development seems to have existed in the Lake Van basin and Hakkari, as well as some pieces from Karagündüz 5, Tilkitepe 0 and Hakkari Grave M1, and the EIA cemeteries of Karagündüz[2] and Yoncatepe (Belli and Konyar 2001: Figs. 41-42). Despite the absence of stratigraphic context, our study of more than a thousand vessels in Turkish museums indicates richly decorated polychrome ornaments applied on some new forms in the EIA.

Late Bronze-Early Iron Age (Pre-Urartu), (*c.* 1500-850 BC)

The main characteristics of the Late Bronze-Early Iron Age (LBA-EIA) are as follows: the appearance of local polities and hierarchical social structure, the emergence of fortress cities, a sedentary lifestyle with agropastoralism; and a new pottery tradition of grooved ware. The region was shared by small local polities of pre-Urartians named Nairi and Uruatri, small kingdoms or chiefdoms gathered around fortress cities. The LBA-EIA levels are non-existent or comprise flimsy architecture in the mounds on the river valleys-plains. These rural settlements must be related to the fortress cities on the foothills connected to the plains.

[2] Unpublished material.

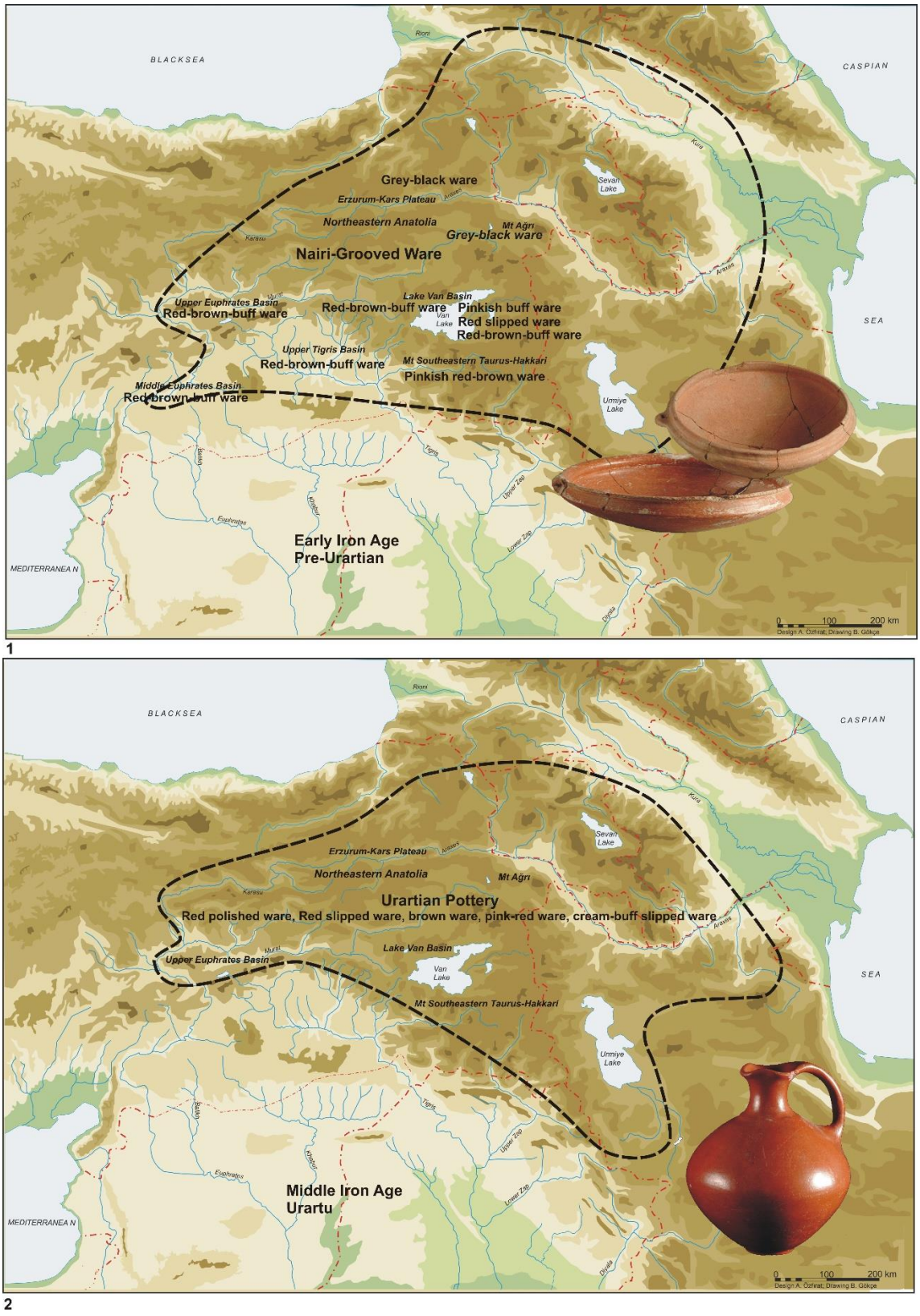


Figure 7. Pottery zones of the Early Iron Age (Pre-Urartu) and Middle Iron Age (Urartu).

Nairi-grooved ware defines the pre-Urartian local communities of Nairi-Uruatri lands (pre-Urartu) (Guardicci 2019; Özfırat 2022c). This new pottery tradition, showing cultural unity, expanded over a vast area, coexisting with other distinct pottery groups in peripheries on the exact borderline as the fortified settlements of Nairi and Uruatri lands. According to the political situation at the end of LBA (*c.* 1200 BC), Nairi-grooved ware seems to have spread later to the Euphrates and Tigris valleys in the west and south, indicating the entry of agro-pastoral groups from the highland of eastern Anatolia. It spread to the Upper Euphrates Valley in the west and also beyond the Southeastern Taurus for a while between the northern part of the Middle Euphrates Valley, in the gap between Hittite Empire and Neo-Hittite, and Middle and Neo Assyrians in the Upper Tigris valleys in the south. From there it spread into the northern Mesopotamia cultural zone, outside the geographical and cultural boundaries of the fortified site zone of eastern Anatolia. EIA levels in the mounds were examined and weak architectural remains were found in these valleys.

The Lake Van basin contains the major settlements of pre-Urartians and Urartians in the eastern and northern parts of the basin (Figures 1-3). Excavations at cemeteries and mounds in the basin are as follows: Evditepe and Alacahan (Ernis-Ünseli) cemeteries (connected with contemporary fortresses) (Erzen et al. 1963 (1965): 34; Korfmann 1982: 188-189; Sevin 1996; Sevin 2004: 358-362; Sevin 2014; Özfırat 2018: 151-160; Özfırat 2021c), Karagündüz mound 5 and cemetery (Sevin and Kavaklı 1996; Sevin 1999; Sevin 2004: 362-373; Sevin and Özfırat 2001; Özfırat 2018: 160-168), Dilkaya mound IIB and cemetery (Çilingiroğlu 1991; Sağlamtimur 1984; Özfırat 2018: 169), Yoncatepe cemetery (Belli 2009; Özfırat 2018: 169-172), Van Fortress mound III (Sevin 1994: 222; Konyar et al. 2018: 148), Tilkitepe O (Korfmann 1982: 179-184), Çelebibağ (Çavuşoğlu 2011: 6), Tepeköy III (Erdoğan et al. 2021: 65) and Murat III (Özdemir and Özdemir 2021: 37-38) mounds and the great number LBA-EIA highland fortresses-cemeteries listed in the survey. No fortified settlements were excavated in the basin, even in eastern Anatolia. C14 readings for the basin are as follows: Karagündüz 5 (1092-956), Karagündüz Grave K6 (1250-1120 BC), Murat III (12-10. Centuries BC), Tepeköy III (1200-1000 BC); Northeastern Anatolia: Pulur (1376-1267 BC, 1228-1050 BC) (Işıklı 2008: 271; Işıklı 2013; Akarsu and Genç 2023: 447-458; Akarsu and Genç 2024: 430-432), Alaybeyi **(**1001-844 BC) (Altunkaynak and Özdemir 2019: 183-274), Sos IIA (1200-855, MÖ 1220-800) and Sos IIA (1000-800 BC) (Sagona and Sagona 2000: 66-67; Sagona 2012: 255-258).

The Late Bronze Age-Early Iron Age pottery, named Nairi-grooved ware, is seen in the whole region and subregions, starting in the final stage of LBA in the central area and during the EIA, from the c. 13th-12th centuries to the 9th century BC. It continued decreasing until the 7th century BC during the MIA. The grooved ware and changing settlement system shows the spread of Nairi-Uruatri communities to the south and west after the Hittite and Middle Assyrian Emperies. Regional differences are seen in the chronology due to the cultural and political developments in the subregions, such as the hegemony of the Hittite Empire in the Upper-Middle Euphrates Valley or the Middle Assyrian Empire in the Upper Tigris Valley in the LBA. Nairi-grooved ware continued to disappear slowly and changed to a new version of MIA types related to Urartu in the central area.[3]

Nairi-grooved ware is characterised by monochrome vessels with horizontal grooves around the rim. Subgroups are as follows (Figures 4, 7.1): grey-black ware in north-eastern Anatolia, pinkish-buff, red

[3] (Sevin 1987: 285-286; Sevin 2014: 359-360; Erdem 2009.) Nairi-Grooved ware continued to decrease into the Urartian Period, with some changes in form and technique, as suggested first by Sevin (1987: 285-286). However, their form and fabric, which have MIA features, differ entirely from those in the EIA. The claim that Karagündüz, Dilkaya and Yoncatepe pottery, which are EIA cemeteries in Köroğlu and Konyar (2008), are Urartu is not possible. For a more detailed explanation, see Sevin 2014: 359-360; Özfırat 2022c: Fn 22.

slipped and red-brown-buff wares in the basin of Lake Van, pinkish red-brown ware in Hakkari, red-brown-buff ware in Upper-Middle Euphrates, and red-brown-buff-pink ware Upper Tigris valleys.

The LBA-EIA pottery of the Lake Van basin is dominated by subgroups of pinkish-buff ware, red slipped ware, and red-brown-buff ware. The distribution of subgroups is remarkable: red-brown-buff ware existed in the whole basin, pinkish-buff ware and red slipped ware are found only in the northern and eastern parts of the basin. Pinkish-buff and red-brown-buff ware are the main groups throughout the EIA (I-II). Red slipped ware belongs to the last phase, indicating some features of Urartian form and technique (EIA II). This group, with its thick red burnished slip and forms closer to Urartian pottery, differs from the classical red-slipped and burnished wares of the Urartian Kingdom in terms of technique and form. It has a combination of EIA forms, ware characteristics, and Urartian features.

The grooved pottery from Hakkari graves shows continuity and local characteristics (Sevin 2015; Özfırat 2018: 172-177). Grave M1, which was used for around three hundred years, contains an earlier group of grooved wares (pinkish red-brown ware), that is fewer in number than Khabur and Van-Urmia wares. Grave M2 has a later phase of grooved pottery (EIA II).

The Lake Van basin, particularly the northern and eastern parts (Uruatri land), seems to be the core area for grooved pottery due to density, subgroups and fine wares. Red slipped ware of the pre-Urartians located on the eastern side of the basin represents a transitional phase to Urartu, a prototype of the Urartian red polished ware. The northern and eastern parts of Lake Van, where major pre-Urartian and Urartian sites and the capital of the Urartian Kingdom were located, were most probably the heartland of grooved ware. This development is also the most striking evidence of the continuity between pre-Urartu and Urartu and the role of the pre-Urartians (Uruatri) on the eastern coast of the basin in establishing the Urartian Kingdom.

Middle Iron Age (Urartu), (*c.* 850-640/630 BC)

The establishment of the Urartian Kingdom, a central authority, is clearly demonstrated in the advanced architecture, structuring, settlement system, and planning of land use, materials, pottery, etc. The entire land is densely inhabited by settlements with various functions in both lowlands and highlands. The primary markers of the Urartian land are fortified cities developed by the pre-Urartians. The central area of the kingdom, the eastern shore of Lake Van, stands out from the rest of the region with a large number of more elaborate fortress cities, religious centres, etc. Because of the abundance of Urartian settlements and their prominence, a list is not given here (Figures 1-3).

Middle Iron Age pottery was mass-produced with higher quality, new forms, and wares were manufactured in official workshops of the Urartians (Figures 4, 7.2) (Erdem 2012; Erdem 2014). Urartian pottery greatly differs from the pre-Urartian pottery, showing standard character. Only the continuation of some features of grooved pottery and the transformation of red slipped ware to red polished ware were seen in state production. The fine wares, including red polished, shiny groups of red slipped and brown ware, are of the highest quality in Urartian pottery. Red polished ware (Toprakkale ware, Palace ware, Biainili ware) has the highest quality in Urartian pottery. This shiny red pottery, which first appeared as prototypes in the second phase of EIA II on the eastern shore of Lake Van basin, is one of the markers of the kingdom of Urartu. Outside the central area of the kingdom, the country is dominated by MIA local pottery groups, which developed from the pre-Urartu pottery tradition. The classical Urartian pottery is found in constructions built by the kingdom in these regions.

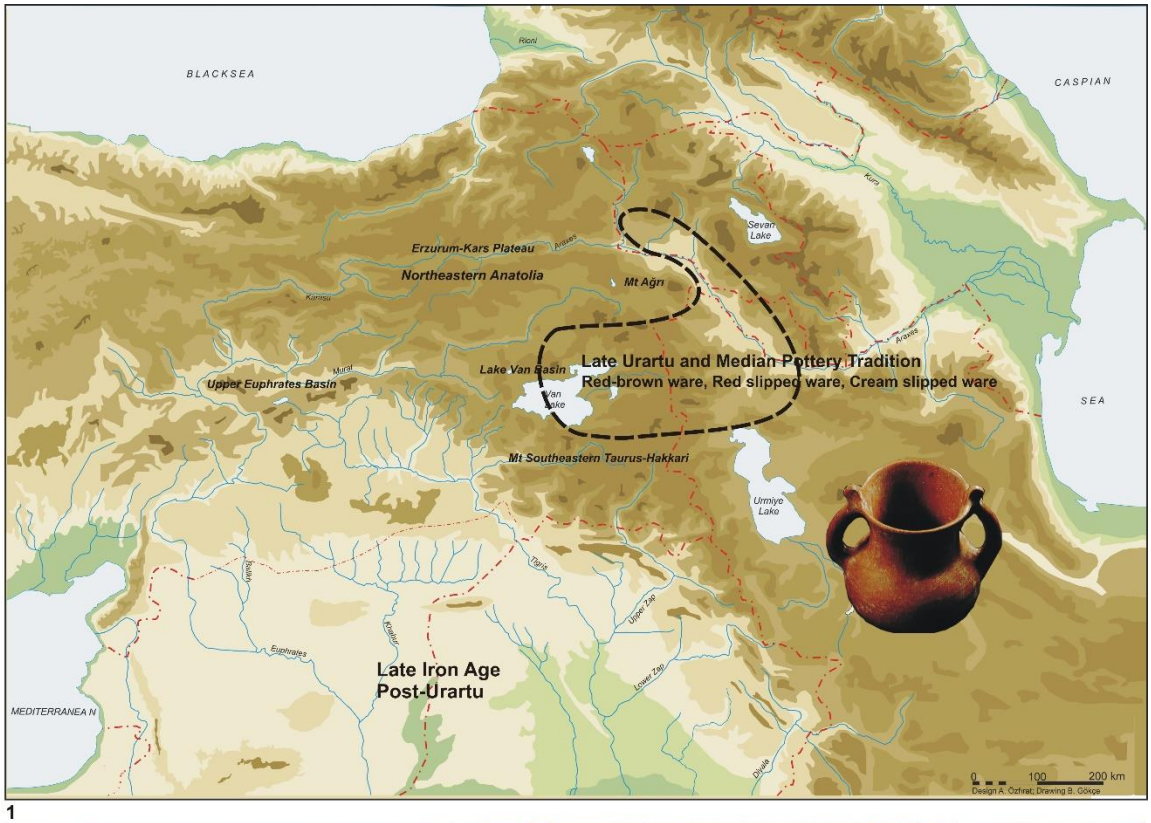
Urartian pottery is found mainly on the eastern and northern shores of Lake Van, which is the heartland of the kingdom. However, this typical Urartian pottery of red slipped and fine brown ware, that represents the official character of the kingdom, can be seen in lesser amounts in the rest of the country. Classical Urartian pottery is found only in centres founded by Urartians outside the capital area. The pottery shows strong local traditions, which continue from the pre-Urartians with some Urartian characteristics. The continuity of the EIA pottery is more distinctive on the far borders of the kingdom.

Late Iron Age: Post-Urartu (*c.* 640/630-450/400 BC; Late Achaemenid c. 450/400-330 BC)

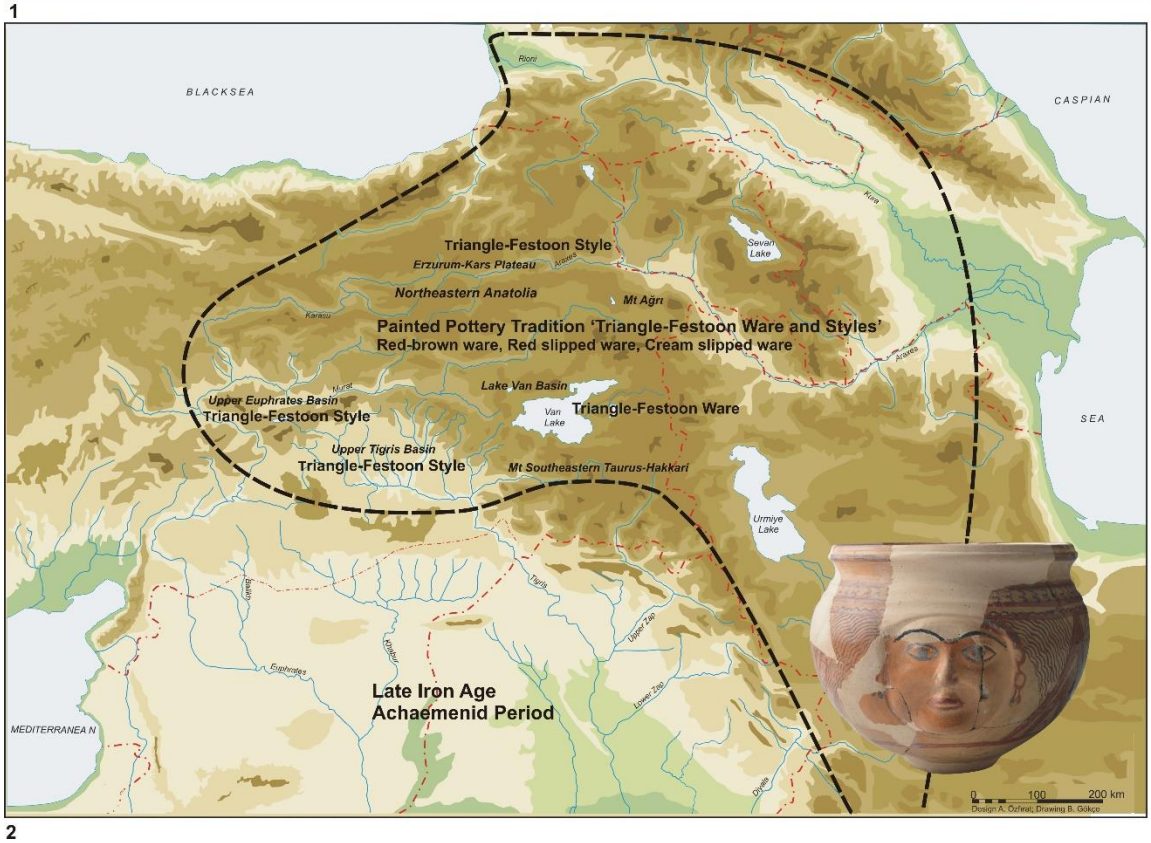
This period includes the collapse of the Urartian Kingdom to the end of the Persian Empire, from the mid-7th century BC until the late 4th century BC. The Late Iron Age (LIA) is divided into two phases in the basin of Lake Van: the Post-Urartian or Late Urartian Period (c. 640/630-450/400 BC) and the Late Achaemenid Period (*c.* 450/400-330 BC) (Figures 2-4).[4] Following the end of the Urartian Kingdom in eastern Anatolia, uncertain Median hegemony or most probably, the Achaemenids reigned in the post-Urartian Period and later (Kroll 1984; Kroll et al. 2012; Zimansky 2005; Salvini 2017; Fuchs 2012; Helwag 2012; Sevin 2012; Sevin 2019; Hamdollahzadeh et al. 2023). No evidence in eastern Anatolia supports the historical and archaeological knowledge of Medes dominance. According to written documents from the Nabonidus Chronicle II 16. (Rollinger 2008: 57; Rollinger and Kellner 2019), the view that the Urartian Kingdom somehow continued to exist until 547 is supported by archaeological evidence (Rollinger 2008: 56-61; Rollinger and Kellner 2019; Salvini 2017: 441-442; Sevin 2012: 351-353, 362-363; Herles 2017: 133). The post-Urartian Period continued for around two hundred years in the highland of eastern Anatolia, from the collapse of the Urartian kingdom to the emergence of the triangle-festoon ware. Although Persian hegemony following the post-Urartian Period dated between 550-330 BC politically (Achaemenid Period), the material culture of the region didn't change until the appearance of triangle-festoon ware in the Late Achaemenid Period (*c.* MÖ 450/400-330). The Achaemenid Dynasty seems to have existed in the region with a management approach over local communities, indicated by the limited evidence and structures of Persian influence and the continuity of local cultures.

There is insufficient archaeological and epigraphic data for both periods of the LIA in eastern Anatolia. The lack of written sources about the end of the Urartian Kingdom and the reign of the Persian Empire and the scarcity of archaeological material makes it difficult to picture the period. Most evidence comes from the Lake Van basin. Sites from both periods are concentrated in the north and east of Lake Van. The main Urartian fortresses were not settled again after the collapse of the kingdom. The land seems to be inhabited by the remnants of the Urartian kingdom and local groups. The remnants of the Urartians continued their existence with a smaller, less powerful force in the capital area of the kingdom.

[4] In eastern Anatolia studies, there is confusion in describing the LIA phases. The LIA materials are mostly defined as the Median and Achaemenid periods or only LIA. The evidence is mainly related to the local cultures of the Achaemenid Period. Another terminology problem is that both post-Urartu and Achaemenid periods are called post-Urartu. For both periods in eastern Anatolia, see Sevin 2012; Sevin 2019; Özfırat 2019a; Özfırat 2019b.



1



2

Figure 8. Pottery zones of the Late Iron Age (Post-Urartu and Pers-Achaemenid).

The Post-Urartian Period (*c.* 640/630-450/400 BC)

The sites from the Post-Urartian Period were investigated in the eastern and northern sides of the Lake Van basin (Figures 1-3) (Özfırat 2019a). Outside this region, the post-Urartian Period was only examined in Altıntepe 4b (Urartian Fortress) in northeastern Anatolia (Yılmaz and Karaosmanoğlu 2019; Yılmaz and Karaosmanoğlu 2023: 202-203). The post-Urartian sites show no interruption of a few major Urartian settlements around the capital in the basin of Lake Van, while the main Urartian fortresses were abandoned. The evidence comes from squatter occupations and graves at Van Fortress Mound IIa1 (Tuşpa)[5], Karagündüz Mound 4c (Sevin 2012) and Çavuştepe Fortress II (Sardurihininili) (Sevin 2012; Çavuşoğlu et al. 2016: 363) excavations, and highland fortresses which were investigated in our survey. Highland fortresses, which have Urartian and some LIA architectural characteristics, are built on high hills that are quite difficult to reach, overlooking all terrain. No pottery was found in the highland fortresses (except for the only fortress at Yeşilalıç II, which is located on low rocky outcrop but in a very isolated location, Figure 1). The remnants of the Urartian Kingdom who attempted to survive in these Urartian settlements most probably retreated to the highland fortresses from time to time due to some challenges.

Post-Urartian Period pottery has Urartian and Median or Eastern features (Figures 4, 8.1). The pottery is much smaller than in previous periods because the material comes from squatter settlements and Yeşilalıç II fortress (survey site). The pottery of the Lake Van basin is monochrome in three main groups: red-brown ware, cream-buff slipped ware, and red slipped ware. No distinctive decoration elements are seen. Red slipped ware from this period refers to those in Urartian pottery; however, the red polished ware of the kingdom of Urartu is not seen at post-Urartian levels. The Post-Urartian Period was also investigated in the Urmia and Erivan Plains (Middle Aras Valley).

Post-Urartian pottery is seen in the area where the capital and central provinces of the Urartian Kingdom were located, in the eastern part of the Lake Van basin, the Urmia and Erivan plains. Although this pottery is small in number, it is notable for indicating the continuity of cultural identity in the central area of the Urartian Kingdom. In the rest of the former Urartian land, local cultures continued as in the previous period.

The Achaemenid Period (550-330 BC)

There is insufficient archaeological material about the Achaemenid identity and no epigraphic evidence about the exact date when the Persian kings arrived in eastern Anatolia, only the rock-cut inscription of Xerxes I in Van Fortress (Tuşpa) (Sevin 2019; Özfırat 2019b). Some weak or flimsy levels of the Late Achaemenid Period, represented by triangle ware, indicate that a new culture started to emerge in the mounds of Aras Valley in northeastern Anatolia, Lake Van basin, Upper Euphrates and Upper Tigris valleys in eastern and southeastern Anatolia. The Late Achaemenid Period sites are small in number, and no characteristics or monumental sites are seen in eastern Anatolia. LIA evidence from northeastern Anatolia, Upper Euphrates and Upper Tigris Valleys comes from the mounds. Besides

[5] (Sevin 2012) The pottery of Urartian red polished ware, post-Urartian pottery (from graves and flimsy architecture which was destroyed by medieval graves) and Triangle ware were found in the deposit between the Urartian structures and post-Urartian graves in the 3rd excavation campaign of Van Fortress Mound. This level was defined as the Post-Urartian/Late Iron Age. The red polished ware from this deposit is dated to the post-Urartian Period. The presence of the finds reaching from Urartu to triangle ware in this mixed deposit and the suggestion of continuation of the red polished ware or the palace ware in the post-Urartian Period are controversial due to stratigraphic problems, see Konyar 2018; Konyar *et al.* 2018: 143-145.

these rural settlements, triangle-festoon style was found in Altıntepe Urartian Fortress 3-Saztepe (Cimin I-II) (Summers 1993; Işıklı and Özdemir 2019) in the Karasu Valley-Erzincan Plain and Karakoyunlu II Urartian Fortress (Minuahinili)-Melekli in the Mt Ağrı-Middle Aras Valley in northeastern Anatolia (Özfırat 2019b: 284, 291-292), (Figure 1).

In the Lake Van basin, the Late Achaemenid sites (triangle-festoon ware), contrary to the post-Urartians, are located in lower areas, mainly on the main route along the eastern shore (Figures 1-3). The triangle-festoon ware was examined in some squatter levels and some triangle-festoon ware mostly out of context after a long hiatus following the post-Urartian Period in the former Urartian sites at Karagündüz Mound 3 (Sevin 1998; Sevin 2002), Van Fortress Mound IIa2 (Sevin 1998: 716-717; Sevin 2002: 476-479; Konyar 2108; Konyar et al. 2018: 143-145) and Çavuştepe Upper Fortress II (Sevin 1998: 716-717; Sevin 2002: 476-479). Triangle-festoon ware was also found in the soundings of the Şabaniye Tumulus excavation in the Van Plain (Yılmaz et al. 2024). Additionally, a few fortresses, stations and an ateshgadah of Şafak Bulakları (Figure 1) were investigated in our survey (Özfırat 2019b: 287-288), (Figure 1-3). These single-layered settlements are located directly above or next to the former central sites around the capital of Urartu.

Late Achaemenid Period pottery is a new pottery tradition of triangle-festoon ware and triangle-festoon styles, coexisting with local wares (Figures 4, 8.2). The pottery from this period can be classified as local wares, local production of triangle-festoon ware and triangle-festoon style in sub-regions. Triangle-festoon ware or triangle-festoon styles coexisted with local pottery, which strongly continued in eastern Anatolia. During the Late Achaemenid Period, triangle-festoon ware and its regional styles expanded in eastern and southeastern Anatolia, northwestern Iran and southern Caucasus. Classic examples of triangle-festoon ware were found on the western side of Lake Urmia and the east side of the Lake Van in the whole region. The painted pottery from other areas can be classified as triangle-festoon style.

Triangle-festoon ware appeared without a prototype after a hiatus in the post-Urartian levels of the Lake Van basin. This group is fine ware with monochrome or polychrome painted decoration on a burnished surface. The largest and fine ware group of triangle-festoon ware was encountered in Karagündüz level 3 in the basin. Triangle-festoon ware or triangle-festoon styles coexisted with local pottery, which strongly continued in eastern Anatolia. Classical triangle-festoon ware is only seen on the northern-eastern side of Lake Van, mainly around the capital area of Urartu. Triangle-Festoon Style, seen outside the northern-eastern part of the Lake Van basin, has a monochrome painted decoration with local characteristics. The triangle-festoon ware of Lake Van basin has close ties with Lake Urmia Classical triangle ware. Excavations in the Lake Van basin found no Classical Period pottery; however, painted pottery continued from the Late Achaemenid Period into the Hellenistic Period in northeastern Anatolia, Upper Euphrates and Upper Tigris valleys as in the southern Caucasus and north-western Iran.

Conclusion

The central geographical location of the Lake Van basin is clearly reflected in the nature and density of the settlements and materials. The pottery from the Chalcolithic, Bronze and Iron Ages in the northern and eastern parts of Lake Van, which contain the major sites of the basin, are separated from the rest of the region by special pottery groups and fine wares. This material shows central area characteristics throughout all periods. As a result, the capital area of the Urartian Kingdom has the most significant

evidence of pottery sequence in the whole region. The dynamics of establishing the Urartian Kingdom show strong relations with pre-Urartians to the east of the lake. The continuity between the pre-Urartu and Urartu region is very distinctive in terms of pottery, material, settlement system, etc.

On the other hand, local pottery traditions strongly continued to coexist with the pottery related to the new cultural and political changes. The local cultures of the pre-Urartians were as strong as before, even around central areas, but especially in the distant regions and borderlands of the Urartian Kingdom. Similarly, except for some central areas, the continuity of the local cultures was retained during the post-Urartu and Achaemenid periods. The presence of Medes in the old Urartian heartland was limited to their pottery influence. Similarly, triangle-festoon ware seems to represent a cultural change rather than Achaemenid hegemony in the Late Achaemenid Period.

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Tracing money in pre-Imperial period: sea routes in the Adriatic, a case study of northern Dalmatia

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Abstract

The period from the 4th to the 1st century BC is characterised on the Adriatic by the increase in trade and the intensification of relations with the Hellenized parts of the Mediterranean. This trade exchange is mainly conducted by sea, on local, regional, and wider Mediterranean scope. There is insufficient evidence in ancient literary sources about maritime affairs, so our main source of information is archaeology. The coins found in northern Dalmatia (ancient southern Liburnia) are a mystery that has yet to be solved. Most of the coins come from very distant overseas regions, such as North Africa. Coins from Carthage and Numidia dominate in terms of quantity, followed by numismatic finds from the Roman Republic. Ptolemaic coins, coins from the Greek colonies in central Dalmatia and Albania, the Illyrian kingdom, Greek cities and states from Greece itself, Macedonia and Thrace as well as southern Italy and Sicily are found. Rare Hispanic coins are also present, as well as Celtic coins. Most of the coins in Dalmatia were found on the coast or on the islands, which indicates that the seaways were an important access route to this region. The numismatic finds from the maritime sanctuary at Cape Ploča, located directly on the longitudinal routes, give us first-class information about the type of coins that came to the eastern Adriatic at the time. The eastern Adriatic route, for example, can be linked to the Gulf of Corinth, be it the city of Corinth or other important ports in the region, as well as Greek cities in present-day Albania and central Dalmatia. The other trans-Adriatic route, confirmed by numismatic finds from the island of Molat, is the shortest connection between Italy and northern Dalmatia.

Keywords: coins, sea routes, Adriatic Sea, Liburnia, maritime sanctuary, northern Dalmatia.

The Hellenistic period in the Adriatic was characterised by an increase in maritime trade and strengthened connections with the central and eastern Mediterranean. This trade was mainly carried out by sea, at the local and regional level as well as in the wider Mediterranean. There is insufficient evidence of maritime trade in ancient literary sources, so our main source of information is archaeology. Movable finds such as pottery and coins are particularly interesting in terms of their provenance and the information they can reveal, as well as the study of ports, maritime sanctuaries and shipwrecks. The period under consideration for the emergence of money in the Liburnian area covers the period from the 4th century BC to the coinage reform of Augustus and the emergence of imperial coinage, which led to significant political and economic changes in the eastern Adriatic region. In the last fifteen years, numismatic finds from this region have been systematically studied and published, with a focus on individual finds from hillfort settlements on the mainland and islands (Šešelj and Ilkić 2014; 2015; Ilkić and Čelhar 2017). These finds are important indicators of the use and circulation of money. In this paper, we will provide an overview of recent research on the numismatic finds focused on northern Dalmatia, the heart of ancient Liburnia, by analysing their presence, provenance, typology,

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dating, and attribution to specific archaeological contexts. The topography of these numismatic finds will be used to highlight important sea routes used for exchange between the Liburnian coast and the wider Adriatic and Mediterranean area. The focus is on numismatic finds on islands and important ports along the sea routes, as well as on finds in the maritime sanctuary at Cape Ploča, which perfectly reflects the numismatic situation at northern Dalmatian sites and is part of the major commercial seaway connecting Central Europe with the wider Mediterranean (Čače and Šešelj 2005: 167-168; Šešelj and Ilkić 2015: 174-177).

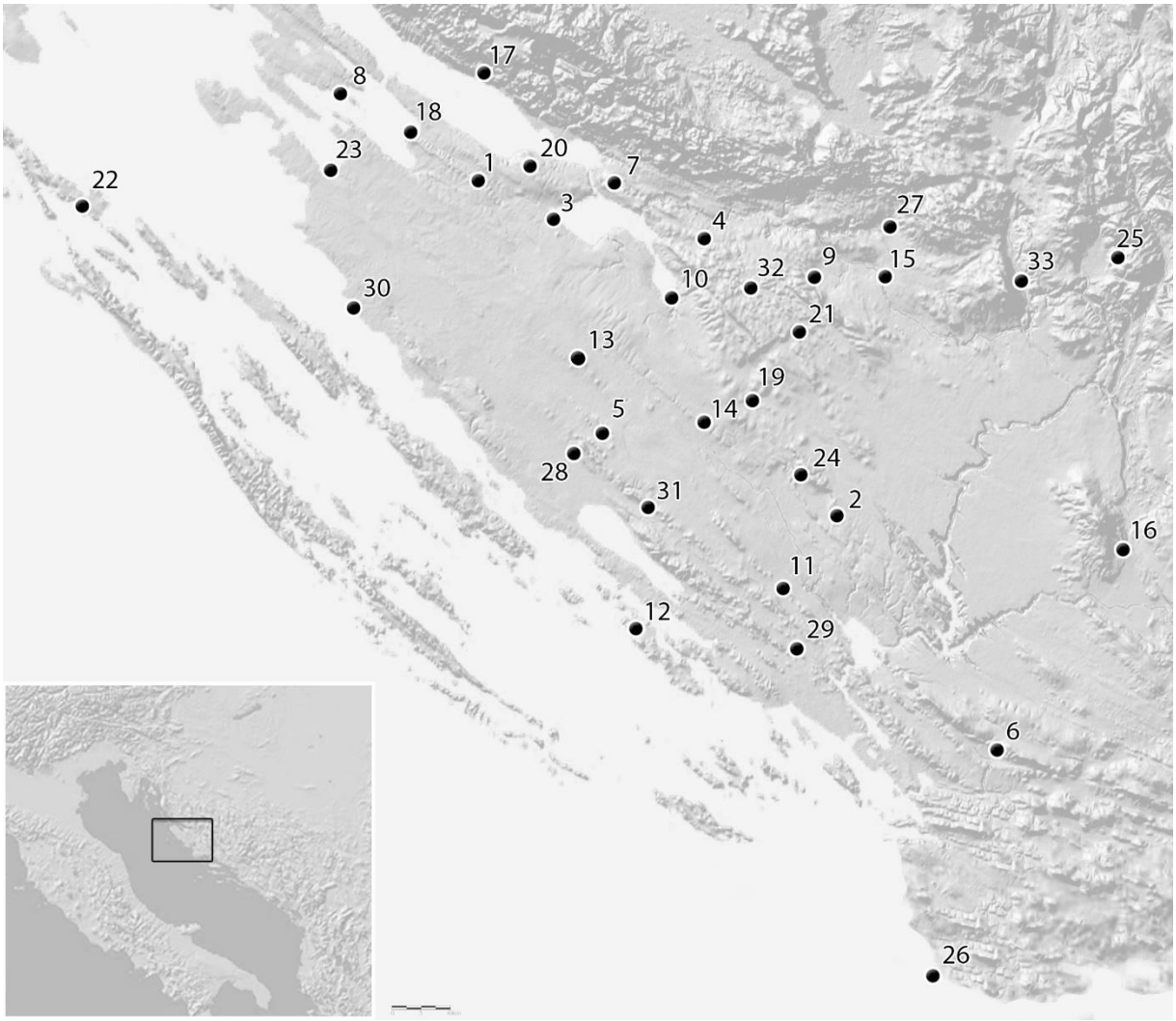


Figure 1. Topography of the individual finds of pre-imperial coins in northern Dalmatia (Map: D. Vujević - University of Zadar): 1. Beretinova gradina - Radovin, 2. Bribir, 3. Budim - Posedarje, 4. Cvijina gradina - Kruševo, 5. Ćosina gradina - Gornja Jagodnja, 6. Danilo, 7. Dračevac - Jasenice, 8. Gradac - Smokvica, 9. Gradina - Bogatnik, 10. Gradina - Donji Karin, 11. Gradina - Dragišići, 12. Gradina - Murter, 13. Gradina - Nadin, 14. Gradina - Podgrađe (Asseria), 15. Gradina - Prndelji, 16. Gradina - Tepljuh, 17. Gradina above Sv. Trojica, 18. Gradina at Cape Ljubljana - Ljubač, 19. Jarebnjak - Brgud, 20. Lergova gradina - Slivnica Gornja, 21. Medviđa, 22. Molat, 23. Nin, 24. Ostrovica, 25. Plavno, 26. Cape Ploča, 27. Smokovac - Krupa, 28. Trojan - Stabanj, 29. Velika Mrdakovica, 30. Zadar, 31. Zamina, 32. Zelengradina, 33. Zvonigrad.

In the last fifteen years, great efforts have been made to collect and analyse numismatic evidence from Liburnian sites. The focus has been on individual finds from the settlement context, which are a very

important indicator of the widespread use of coins as a means of exchange among the Liburnians (Batović 2011: 7-45; Dubolnić Glavan and Glavaš 2011: 95-121; Ilkić 2013: 87-94; Šeparović 2013: 525-536; Bertol 2014: 111-142; Šešelj and Ilkić 2014: 43-53; Ilkić et al. 2014: 65-75; Šešelj and Ilkić 2015: 419-433; Ilkić 2016: 99-105; Ilkić 2017: 152-181, 300-301; Ilkić and Čelhar 2017: 489-492; Ilkić and Kožul 2017: 89-96; Ilkić and Šešelj 2017: 281-302; Ilkić 2018: 57-66; Visonà 2018: 107-122; Čelhar and Ilkić 2019: 33-55; Ilkić and Šešelj 2024: 353-367; Ilkić et al. 2020: 181-226; Ilkić and Vučić 2022: 190-203; Šešelj and Ilkić 2022: 163-188; Ilkić and Šeparović: 2023). Until recently, numismatic studies in this area have focused on the problem of hoards, which are known from the 19th century and have been interpreted as a way of assaying metals (Mirnik 1981: 33-49; Čače 1985: 484-498; Crawford 1985: 222-223). So far, we have noted 1506 coins from 33 known sites in the south Liburnia, most of which are kept in museums and private collections and have not yet been published (Figure 1).

The largest concentration of numismatic finds is found in northern Dalmatia, one of the most fertile and water-rich areas on the eastern Adriatic coast, where the densest concentration of archaeological sites is also recorded. Preliminary analyses (Figure 2) clearly show that coins from North Africa dominate in absolute terms (73%).

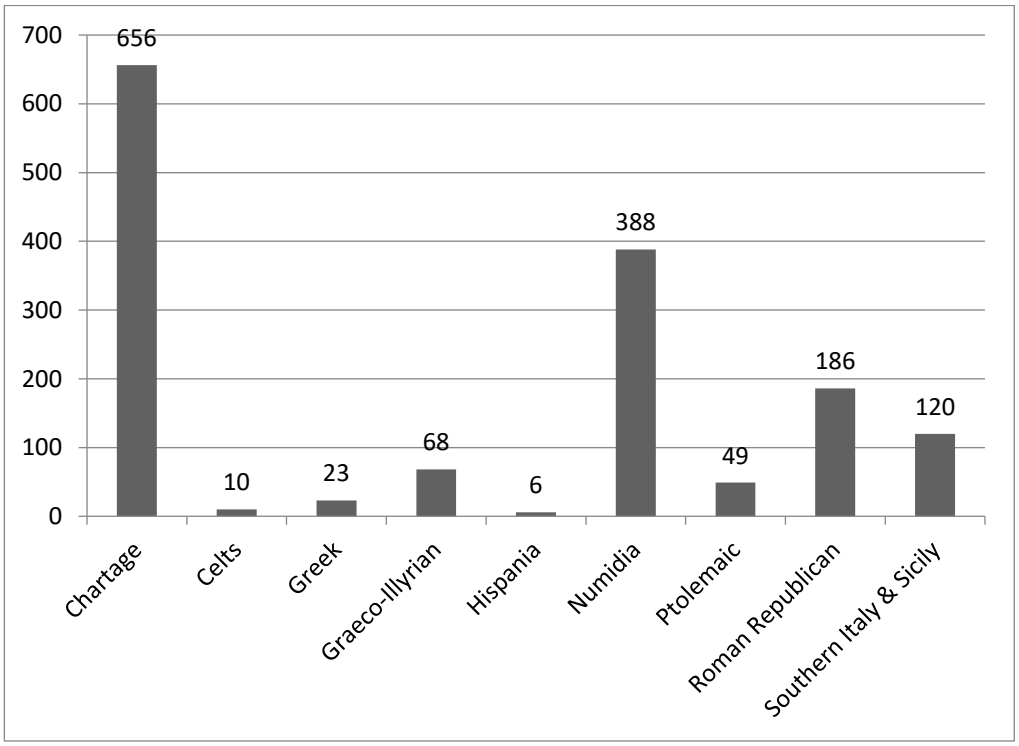


Figure 2. Share of Liburnian individual coin finds based on provenance (Diagram by: M. Ilkić).

Most Carthaginian coins date from the period of the Second and Third Punic Wars (ca. 221-146 BC) and account for 44% of all finds, followed by Numidian coins with 26%. Coins from the Italian peninsula account for 12% of Roman Republican coins and 8% from Magna Graecia and Sicily. These are the most widespread coins in the entire region. Other coins found in smaller quantities (10%) are: Ptolemaic, Greek colonies in modern Albania (Apollonia and Dyrrhachium), Greek colonies in central Dalmatia (Issa, Heracleia, Pharos, Corcyra Melaina), coins from the Illyrian kingdom, from Greece (Corcyra,

Achaean League, Aetolian League, Thesalian League, Acarnania), the coin of the Macedonian king Antigonus Gonatus and Greek cities in Thrace. It is noteworthy that Apulian city coins, rare Hispanic and Celtic coins also appear in this area. Most of these coins are made of bronze, while silver coins are very rare. The pre-imperial coin finds in southern Liburnia are a phenomenon that has not yet been satisfactorily explained. This small area stands out in the entire Adriatic region and even in the wider Mediterranean in terms of its coinage structure (Craword 1985: 140). The location of Liburnia and its maritime role in the eastern Adriatic is particularly important for understanding archaeological phenomena that can be traced back to the last millennium BC, including the appearance of very specific coin forms. If we look at the typology, we can see that the most common type is the late Carthaginian coin from the last quarter of the 3rd century BC and the first half of the 2nd century BC, with the head of Tanit/Persephone and the horse standing to the right (cat. no. 1-2, Pl. I, 1-2) or the horse standing to the right with its head turned (cat. no. 3-4, Pl. I, 3-4). These bronze coins were found at almost all sites. The Numidian coins always show a laureate bearded head on the obverse and a horse standing to the left on the reverse. They are dated to the end of the 3rd and 2nd century BC (cat. no 32-34, Pl. III, 4-6). The coins of Juba I were also found (cat. no. 35, Pl. III, 7). There are also coins of the rulers of the Ptolemaic dynasty in several denominations made of a copper alloy. Most of them bear a depiction of Zeus Amon on the obverse and an eagle on the reverse. Most of these finds were struck in Alexandria (cat. no. 36, Pl. III, 8) and Cyrene (cat. no. 37, Pl. III, 9). Roman Republican coins are present in Liburnia from the middle of the 3rd century BC, they were used throughout the period and are very common in the region. Early means of payment have also been found, including ramo secco (Ilkić and Šešelj 2024, 356, 359, cat. no. 31 and 32, Figure 31 and 32) and aes marked with crescent and circle with cross, examples from Dračevac (cat. no. 38, Pl. III, 10) and the hillfort near Smokvica on the island of Pag (Ilkić and Kožul 2017: 89, cat. no. 1). There are several examples of aes signatum that were used as a means of payment in the Roman Republic in the first half of the 3rd century BC. These are cast ingots with various depictions, for example the caduceus and the trident (Ilkić and Kožul 2017: 89-90, cat. no. 2). This is followed chronologically by aes grave in several denominations, such as anonimus semis from the hillfort Ljubljana above Ljubač (Ilkić 2017: 154-155, cat. no. 87). The silver coins are dated to the late 3rd century BC. They date to the 2nd century BC. They are victoriati with the standard depiction of an Iupiter's head and a Victoria crowns trophy, as shown by the example from Gradina in Donji Karin (cat. no. 39, Pl. III, 11) and from the hillfort near Smokvica (Ilkić and Kožul 2017: 90, cat. no. 4). There are numerous Republican coins made of a copper alloy from the first half of the 2nd century BC. These are mostly ases with the depiction of Janus and the prow of a ship. Silver coins with various depictions are frequently found from the second half of the 2nd and 1st century BC. One of these is the denarius from Velika Mrdakovica (cat. no. 40, Pl. III, 12).

Greek coins found in this area belong to Greek cities on the Adriatic, e.g. coins of the Issa type with the head of the goddess Athena with a Corinthian helmet and a goat on the reverse (cat. no. 13-14, Pl. I, 13-14), but also variants with deer on the reverse such as the samle from the hillfort Trojan (Ilkić et al. 2020: 182, cat. no. 1) and the sanctuary of Diomedes at Cape Ploča (Bonačić Mandinić 2004: 152, Figure 3). In northern Dalmatia, the coin of the Greek colony of Pharos (Stari Grad on the island of Hvar) with the depiction of a head on the obverse and a kantharos on the reverse (cat. no. 12, Pl. I, 12). The coins of the unknown Greek Adriatic colony of Heracleia are represented by two variants. A larger coin with the head of Heracles on the obverse and his attributes bow and club on the reverse, which is dated to around the second half of the 4th century BC (cat. no. 10, Pl. I, 10). The other Heracleian coin dated to the early Hellenistic period, bears the head of Artemis on the obverse and a dolphin on the reverse (cat. no. 11, Pl. I, 11). The extremely rare coin of Korykira (Corcyra Nigra) with the head of Apollo on the obverse and an ear of wheat accompanied by the abbreviation KOP (cat. no. 9, Pl. I, 9) is also recorded

for the first time in Liburnia (Ilkić 2016). Coins of the Illyrian kings Ballaios are widespread in northern Dalmatia. They belong to the type the head of the ruler and Arthemis, as for example from Ostrovica (cat. no. 15, Pl. II, 1). A smaller number of coins from the Greek colonies of Dyrrhachium (cat. no. 8, Pl. I, 8) and Apollonia from the 2nd century BC are recorded (Ilkić and Šešelj 2017: 287, cat. no. 47). Other Greek coins belong to the known bronze types of the Achaean (3rd/2nd century BC), Aetolian and Thesalian League, Acarnania and Corcyra (cat. no. 7, Pl. I, 7). There are several silver coins of the Achaean League from Cape Ploča (cat. no. 6, Pl. I, 6). The coin of the Macedonian king Antigonus Gonatus and the Greek cities of Maroneia and Odessa in Thrace are rare finds in this area (Šešelj and Ilkić 2022: 163-188). Coins from southern Italy and Sicily account for 8% of all pre-imperial numismatic finds. These are specimens with different denominations and a wide variety of motifs. They mainly belong to the 3rd century BC, although some are from a slightly earlier and some from a later period. We present a selection in this article. Coins from various monetary centers in Apulia have been found in northern Dalmatia. For example, Arpi, mostly with depictions of the head of Zeus and the Chalcedonian boar (cat. no. 18, Pl. II, 4). The city of Asculum is represented by one example, with depictions of the head of Hercules and Nike with a palm branch (Ilkić and Čelhar 2017: 489, Figure 2). Coin with depictions of the head of Athena and a wheel from Luceria (cat. no. 22, Pl. II, 8), coin with the head of Apollo and horse from Salapia (cat. no. 25-26, Pl. II, 11-12). A coin with the head of Zeus and a Chalcedonian boar was minted in this Apulian city (Ilkić 2017: 154, cat. no. 6). The head of Athena and an owl belong to the city of Teate (cat. no. 28, Pl. II, 14). There are several coins from Bruttium, mostly belonging to the Brettii. To this Italic population belong large coin with depictions of the head of Ares and Hera Hoplosomia (Šešelj and Ilkić 2013: 48, Figure 19; Ilkić and Čelhar 2017: 489, Figure 7) and smaller nominal head of Nike and biga (cat. no. 19, Pl. II, 5).

Various coins come from Calabria. The city of Brundisium is represented by a specimen with the head of Poseidon and a dolphin with a rider (cat. no. 20, Pl. II, 6). A coin with the head of Zeus and two eagles comes from Graxa (cat. no. 21, Pl. II, 7). The city of Tarentum is represented by 17 different coins, two of which were made of silver. The stater with depictions of dolphin riders and horsemen was pierced, which indicates that it was worn as a pendant in secondary use (Ilkić et al. 2020: 184, cat. no. 12). Then there is a diobol with depictions of the head of Athena and Heracles fighting with a lion (Ilkić and Kožul 2017: 90, cat. no. 11).

Fifteen coins made of a copper alloy also come from Tarentum. There are three types. The obverses of the larger specimens depict the lauratic head of Zeus. The reverses show Nike holding a thunderbolt (Ilkić et al. 2020: 184, cat. no. 13) or placing a shield on the trophy (Ilkić et al. 2020: 184, cat. no. 14-23). Depictions of Athena with a Corinthian helmet and Heracles with a club are on the smaller specimens (cat. no. 27, Pl. II, 13).

A coin from Campania is also found in northern Dalmatia (Ilkić and Čelhar 2017: 490). The Frentani are represented by two coins belonging to the city of Larinum. The quincunx depicts a head with helmet and a galloping horseman with spear and shield (cat. no. 23, Pl. II, 9). Depictions of the head of Heracles and a centaur can be found on the quadrans (Ilkić and Čelhar 2017: 490, Figure 13). There were also some coins from Lucania. The city of Laos is represented by coins bearing frontal depictions of a female head on the obverse and two crows on the reverse (Ilkić et al. 2020: 184, cat. no. 10). Coins with the heads of Leucippus and Demeter (cat. no. 24, Pl. II, 10) originate from the city of Metapontum, as do those with depictions of the head of Heracles and an ear of wheat (Ilkić and Čelhar 2017: 490, Figure 14).

The majority of the coins from Sicily can be attributed to Syracuse. One example with the head of Athena and a hippocampus belongs to the period of the Third Republic (345 – 317 BC) (cat. no. 29, Pl. III, 1). All the others belong to the 3rd century BC and were mainly minted during the reign of Hieron II

(274 – 216 BC). Only coins with the head of Poseidon on the obverse and the trident on the reverse have been found (cat. no. 30-31, Pl. III, 2-3). This type was overstruck by Carthage and the Roman Republic. Several examples of such coins have been found in southern Liburnia and Iapodia, which have not yet been published. Coins from the Fifth Syracusan Republic (215 – 212 BC), which show the head of Apollo on the obverse and the Dioscuri on the reverse, are rare in northern Dalmatia (Ilkić et al. 2014: 66, cat. no. 10). There are also two finds of bronze alloy coins from the late 3rd century BC from Sicily. The specimen from Zelengradina with depictions of the head of Apollo and a warrior's head belongs to Messana, i.e. to the Mamertines. It was not published, nor was the coin from Gradina near Prndelji, which shows the head of Demeter / a horse with a palm tree in the background and was minted in Morgantina under Punic occupation.

Celtic coins are quite rare, only 9 specimens have been found so far at 5 Liburnian sites and they all belong to the well-known Noricum type of tetradrachm with male head/Apollo and the horse (cat. no. 5, Pl. I, 5).

The rare Hispanic coins in Liburnia are represented by 5 coins and all come from the city of Castulo (Castulo Tarraconensis) in a rich mining area. The type with the head of a man on the obverse and the sphix on the reverse was found (cat. no. 16-17, Pl. II, 2-3).

The pre-Imperial numismatic finds from the eastern Adriatic coast and its deeper hinterland show us that the communities of this region were not connected by a uniform monetary pattern. In central and southern Dalmatia, Greek coins dominate, especially those minted in the Greek colonies in present-day Dalmatia, Albania, southern Italy and Sicily. Characteristic for northern Dalmatia (Liburnian territory) and today's Lika (Iapodian territory) is the use of early Italic pre-monetary forms as well as a large number of North African coins from Carthage and Numidia. This unusual phenomenon was noticed a long time ago in connection with hoard finds, but it has not yet been extensively studied (Čače 1985: 494). Recent research on the numismatic phenomena in the regions of Liburnia and Iapodia aims at numerous and diverse individual numismatic finds in settlement contexts, which provide new perspectives and a better understanding of this phenomenon.

One of the crucial questions is when and how these coins reached northern Dalmatia and spread further inland? All considerations that these types of coins came to the region point to northern Dalmatia or southern Liburnia. The argument so far has focused on interpreting the role of Liburnia in the overseas contacts and exchanges evidenced by various types of archaeological material in the earlier period. This is supported by the historical events in the Apennine Peninsula such as the Carthaginian invasion and the presence of North African coins at the Italian sites. These types of coins in Hellenistic maritime sanctuary in the Croatian part of the Adriatic are a clear confirmation of the direction of the distribution of this type of material. The topography of numismatic finds in the region of northern Dalmatia confirms the Adriatic influx by further arguments, which we will discuss in more detail.

Liburnia lies on an important sea route in the eastern Adriatic, connecting the Mediterranean and the upper Adriatic with Central Europe. Since the 2nd century BC, Aquileia with its complex port system was the most important trading centre (Str. *Geog.* 5.1.8). But centuries before its foundation by the Romans, there were already numerous scattered ports and landing places, such as those on the river Timavo, in Altinum and Atria, to name but a few. This route has been known as part of the famous Amber Road since at least since the Late Bronze Age. Liburnian graves rich in amber bear witness to this (Batović 1981; 1987). In addition to these longitudinal routes along the eastern Adriatic, trans-Adriatic routes during the Iron Age are also well documented archaeologically, especially with the Po Delta, Picenum and Apulia (Batović, 1976; 1987). Ancient literary sources mention several important

ports on Liburnian territory, such as Iader, the modern city of Zadar, Scardona (Skradin), Colentum (Murter), Apsorus (Osor), Senia (Senj), Curicta (Krk) (Čače and Šešelj 2005: 167-168). Recent underwater archaeological finds give us an insight into the appearance of the first Liburnian harbour from the late Iron Age. The location of Liburnia and its maritime role on the eastern Adriatic is particularly important for understanding the emergence of certain coin issues analysed in this article.

In Greek literary sources, the sea along the southern part of Liburnia was considered dangerous for navigation. The hundreds of islands, islets, cliffs and straits known as the Liburnian archipelago (today the archipelago of Zadar and Šibenik) make navigation in this area a very risky endeavour (Peljar I 1982: 176-177; Čače 2015: 16, 19). For this reason, Greek seafarers who sailed to the northern Adriatic and were unfamiliar with these waters hired local pilots to steer their ships safely through this part of the sea route.



Figure 3. Promunturium Diomedis, Cape Ploča (Photo: Šibenik City Museum - T. Šmid).

In his description of navigation through the Liburnian land, Ps. Scylax (*Periplus* 22) says that the voyage takes two days, actually he emphases that this stretch of sea is dangerous for night navigation. Greek sailors heading for the northern Adriatic used local pilots, the Hylleians, to guide them through this part of the Adriatic.

Now the heroes, when their return seemed safe for them, fared onward and made their hawsers fast to the land of the Hylleans. For the islands lay thick in the river and made the path dangerous for those who sailed thereby. Nor, as aforetime, did the Hylleans devise their hurt, but of their own accord furthered their passage, winning as guerdon a mighty tripod of Apollo (Apoll. *Argo*. 4, 522-528).

Hylleans or Hylli inhabited a headland named after them (*paeninsully Hyllis*, mentioned by Plin. *Nat. hist.* 3.141), which borders on southern Liburnia. Greek legends associated them with Heracles' son Hyllus, who was even killed by Liburnian people called Mentores (Apoll. *Argo*. 4, 551; Katičić 1995: 387-398; Čače 1997: 30-33; Kirigin and Čače 1998: 74). The other place associated with legends about Heracles in this part of the eastern Adriatic coast is mentioned by Ps. Scylax (22), a Hellenic city called Heracleia with a harbour. Although some scholars have attempted to link it to Hylleans and its land, the location remains a mystery (on this problem in detail Kirigin 1990: 294-295). Although one can argue about the sources in which the unknown Greek Adriatic colony is mentioned, the coins of Heracleia found along the Dalmatian coast and on the islands are solid evidence for the existence of such a place in the Late Classical/Early Hellenistic period.

The most prominent part of the Hyllean (Hyllis) peninsula is Cape Ploča (Figure 3). A maritime sanctuary dedicated to the Greek hero Diomedes, the protector of sailors in the Adriatic, was located here from the late 4th to the end of the 1st century BC (Šešelj 2009; Šešelj 2012: 355-364). The cape is known in ancient literary sources as promonturium Diomedis (Plin. *Nat. hist.* 3.141). The sanctuary is located at the most dangerous point of the eastern Adriatic route, on the border of weather systems that often collide here, so that sudden weather changes, collisions of winds and waves are to be expected, and is still a synonym for danger for sailors of all eras. It was the same for the Greeks who founded the sanctuary. For them, too, it was a gateway to the hostile Liburnian waters. At least in the Greek literary tradition, they were described as enemies (Čače 2002: 83-100). Although this may be true in some cases, archaeological evidence suggests that contacts and trade with the Greeks existed at least since the 6th century BC and intensified over the centuries, especially in the Hellenistic period (Šešelj and Silvestrelli 2013; Kolega 2013: 290-296; Šešelj and Ilkić 2015; Čondić and Vuković 2017: 84-99). Maritime trade was the most important factor in the relations between the Liburnians and the foreigners who entered their territory, and they obviously found common interests that overcame hostilities. A good example of this is the shipwreck of the island of Žirje in Liburnian waters, which dates back to the 4th century BC (Miliša et al. 2022).

Archaeological excavations have shown that the sanctuary was regularly visited by travellers on the eastern Adriatic route until the Augustan period. Finds of graffiti on pottery and votive inscriptions have confirmed that this promontory was indeed dedicated to Diomedes and that its visitors, at least those who left written testimonies, were Greek sailors (Čače et al. 2022: 13-102). It is very interesting that the numismatic finds from this sanctuary have a similar structure to those from Liburnia. The highest concentration comes from western Greece (Leuca, Kerkyra, Argos, Achean League), Greek colonies in the Adriatic (Issa, Apollonia, Dyrrachium), then Italy (Ancona, Roman Republican) and North Africa (Carthage, Numidia, Ptolemaic) (Bonačić Mandinić 2004; Šešelj and Ilkić 2015: 175, Figure 6). Considering that the coins were votive offerings of the sailors, we can assume that they were brought to the sanctuary from the successful voyages and intentionally left behind, possibly as a testimony of their sailing destinations for which they sought the god's favour (Šešelj 2009). These finds are also evidence that this money was in circulation at that time and was used in the region of the northern part of the eastern Adriatic id est Liburnia. If we look at the spatial distribution of coin types, we can see that on the central Dalmatian islands the local coins of the Greek poleis (especially Issa and Pharos) dominate, but we also find issues associated with the Illyrian zone (Apollonia, Dyrrachium, Illyrian

kings). There are also coins from southern Italy and Sicily, as well as from Greece itself, especially from Kerkyra (today Corfu). In general, in central and southern Dalmatia we can observe a very strong connection with the southeast, despite a strong penetration of Roman Republican money from the late 3rd century BC. In contrast to this area, various types of Celtic coins dominate the Alpine and Pannonian area, and from Italy the Roman Republican coins gradually spread throughout the region. Between these major monetary systems lies the Liburnian-Iapodian region, where North African money dominated (Čače 1985: 494). How can we explain this phenomenon?

Along this route, at the entrance to the Liburnian waters, lay the island of Murter (the ancient Colentum). Fragments of Lamboglia 2 amphorae and Hellenistic pottery fragments (Gnathia) were found on the site of Gradina. Decades ago, coins from Heraclea from the 4th century BC were discovered on the island. During excavations of Roman cisterns at the foot of Gradina, fragments of Hellenistic pottery were found in disturbed layers, one of which bears a graffiti with Greek letters (Čače et al. 2022: 11-12). The eastern Adriatic route is linked to ports in northwestern Greece, probably in the Gulf of Corinth, the Ambracian Gulf and Korkyra, as shown by the coins of Greek cities found at Cape Ploča and further on in Liburnia. Coins of Illyrian kings and Greek colonies in Albania are further evidence of this connection. This route has been partially confirmed in written sources. Strabo (Str. *Geog.* 7.5.9.) quotes Theopompus, who says that the voyage from the country of the Liburnians (today's northern Dalmatia) to the Ceraunian Mountains (in Albania) takes six days with recess, i.e. a little more than two thousand stadia. This is the distance from northern Dalmatia to the exit of the Strait of Otranto, the actual entrance to the Ionian Sea. The northern part of this route is confirmed by Pliny the Elder (Plin. *Nat. hist.* 3.129), who mentions the distance of 2000 stadia from Aquileia to the river Titius (today Krka), which was regarded as the end of Liburnia and the beginning of Dalmatia.

Trans-Adriatic contacts are attested for the entire 1st millennium BC. Jewelry and especially matt-painted pottery originating from Apulian workshops from the 9th century BC onwards have been found on the coast in Histria, Liburnia, central and southern Dalmatia (Batović 1976: Karta 5; D'Ercole 2006: 95, Figure 3; Šešelj 2009: 433-434; Čondić and Vuković 2017: 74-83). Humans and artifacts crossed the Adriatic long ago. Although we know very little about the nature of these contacts and the deeds of these maritime connections, it is a fact that they existed long before the Greek written sources that inform us about them. Interpretation has focused on the role of the Liburnians in the trans-Adriatic contacts and exchanges known from earlier times through various types of archeological material. Historical events on the Apennine Peninsula, such as the Carthaginian invasion, and the appearance of North African coins at Italian sites also support this. The topography of the numismatic finds in northern Dalmatia confirms the Adriatic influx with additional arguments.

The numismatic finds from the island of Molat date from the 3rd century BC and include coins from Syracuse, the Ptolemies and the Roman Republic (cat. no. 36, Pl. III. 8; Ilkić and Šeparović 2023: 129). Molat is an outer island of the Zadar archipelago, and in seafaring this passage is known as Sedmovraće, the shortest overseas route between two coasts connecting Zadar and Ancona. This trans-Adriatic route has been confirmed by later written sources (Arnaud 2005: 203-205). Coin types similar to those found in Liburnia have been discovered in the Ancona area, including coins from Numidia, the Ptolemies and the Roman Republic (Friedlaender 1877: 333, note 4; Collivicchi 2002: 456-457; Visonà 2013: 131).



Figure 4. View of the hill fort Budim near Posedarje with the shore (Photo: L. Bogdanić - University of Zadar).



Figure 5. Underwater photograph of an archaeological wooden beam in the structure of a stone embankment, Budim (Photo M. Parica - University of Zadar).

The topography of the finds suggests that part of the sea route ran through the Vir Sea towards the Velebit Channel and ended in the Novigrad Sea, where the remains of a harbor in Budim were discovered (Parica 2023: 120-123). A number of hillforts from this period have been discovered along this sea route, including Gradac on Pag (Smokvica), where numismatic finds from the early Hellenistic period have been found (Ilkić and Kožul 2017: 89-96). The coins were mainly distributed to important centers on the coast, which also served as ports for trade with the hinterland. Some of these Liburnian settlements (Nin, Ljubljana - Ljubač, Gradina above Sv. Trojica, Lergova gradina, Dračevac, Gradina Gornji Karin) are located in positions that control maritime traffic through internal channels and seas. Roads connect these maritime centers with the inland. The topography of the numismatic finds clearly indicates that the sites where coins were found are important indigenous centers located on important traffic routes connecting northern Dalmatia (southern Liburnia) with the transvelebit Lika region (southeastern Iapodia). For example, opposite modern Posedarje is an archeological site called Budim (Figure 4). It is protected to the south by a high and massive rampart, with lower and narrower defensive embankments on the sides and deep, partly steep ravines. This vast Liburnian hillfort extends about 600 meters north to the west coast of the Novigrad Sea, which is partially submerged in it. In 2017, archeological traces of a Liburnian port were discovered here (Figure 5). Judging by more precisely dated movable finds, it appears to have been used from the late 4th century BC until at least the middle of the 2nd century BC. A calibrated date (371-199 BC), obtained by radiocarbon analysis of a wood sample belonging to part of the harbor construction, points to this period, as do the pottery finds (Figure 6).

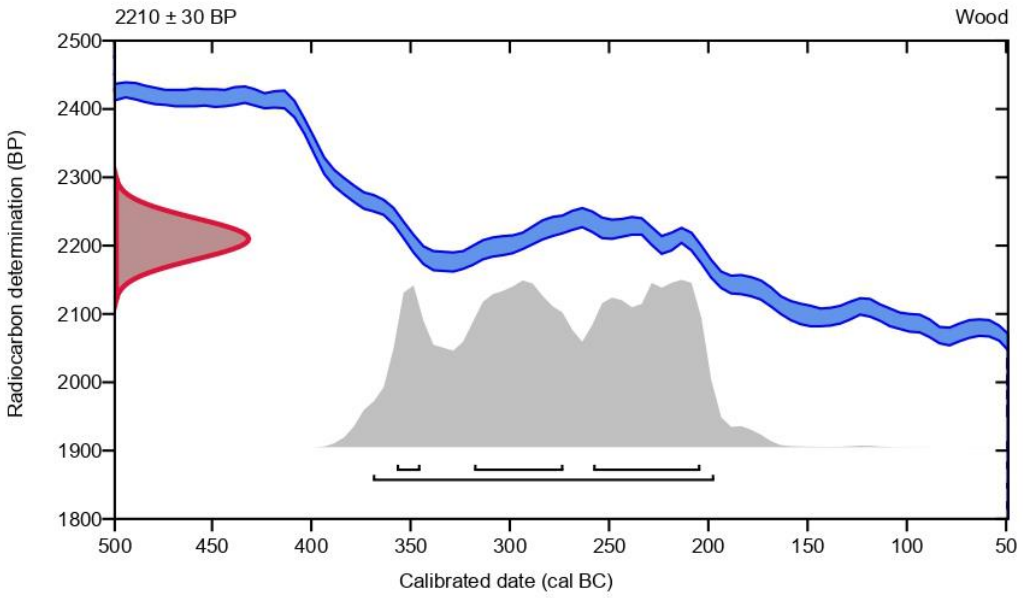


Figure 6. Radiocarbon dating results of a wooden sample from the Liburnian port of Budim.

To summarize, we can say that money reached Liburnia via the sea routes, either along the Adriatic route, which connected it to the Greek regions to the south such as the Gulf of Corinth, important ports in present-day Albania or Greek colonies in central Dalmatia; or the trans-Adriatic route, which connected it to important ports in Italy such as Ancona or important Apulian ports in the Manfredonian Gulf such as Salapia or perhaps Brundisium, as evidenced by the influx of coins. The early coins can be

traced back to the 4th century BC, but the influx into the region intensified during the Second and Third Punic Wars, when most of the money can be attributed to the North Africa.

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Catalogue

1 Carthage, 221 – 210 BC, AE, 4.91 g, 22 mm, 11 h, SNG Cop, 302-306. Gradina (Donji Karin). Unpublished. Department of Archaeology, University of Zadar. Pl. I, 1.

2 Carthage, 221 – 210 BC, AE, 3.83 g, 20 mm, 12 h, SNG Cop, 302-306. Trojan (Stabanj). Unpublished. Han Vrana Agency. Pl. I, 2.

3 Carthage, *c*. 200 – 146 BC, AE, 18.47 g, 28.5 mm, 12 h, SNG Cop, 409-413. Budim (Posedarje). Unpublished. Department of Archaeology, University of Zadar. Pl. I, 3.

4 Carthage, *c*. 200 – 146 BC, AE, 18.11 g, 29 mm, 1 h. SNG Cop, 409-413. Zvonigrad. Unpublished. Archaeological Museum in Zagreb, inv. no. A 5489. Pl. I, 4.

5 Celts, East Noricum, Taurisk tetradrachm type Samobor B, 10.34 g, 24 mm, second half of the 2nd century BC, TKN 36-98. Gradina (Dragišići), found during surway in 1970. Unpublished. The Šibenik City Museum, inv. no. MGŠ-856. Pl. I, 5.

6 Achean League, Aegium, 275 BC, hemidrachm, 1.92 g, 16 mm, SNG Cop. Vol. 3, 235. Cape Ploča. Publ.: Bonačić Mandinić 2004: 154, Figure 9. The Šibenik City Museum. Pl. I, 6.

7 Korkyra, 4th century BC, AE, 2.45 g, 18 mm, 12 h, SNG Evelpidis, 1893. Ćosina gradina (Gornja Jagodnja). Unpublished. Han Vrana agency. Pl. I, 7.

8 Dyrrhachium, late 4th – mid 1st century BC, AE, 2.63 g, 14 mm, SNG München, 460. Unpublished. Danilo. The Šibenik City Museum, inv. no. 21786. Pl. I, 8.

9 Korkyra (Corcyra Nigra), after 250 BC, AE, 5.78 g, 21.5 mm, 1 h; Brunšmid 1998: no. 1 var. Budim (Posedarje). Publ.: Ilkić 2016: 99-105, Figure 1; Ilkić and Šešelj 2017: 286, cat. no. 21, Pl. II, 9; Ilkić and Šeparović 2023: 160, T. XVIII, Posedarje - Budim 21. Department of Archaeology, University of Zadar. Pl. I, 9.

10 Heracleia, 4th century BC, AE, 7.54, g, 20 mm, 5 h, Brunšmid 1998: no. 15; SNG Cop, 535-537. Bribir - Postjenje. Publ.: Šeparović 2020: 139, The Šibenik City Museum. Pl. 10.

11 Heracleia, *c*. 350th – 320th BC, AE, 4.44 g, 18 mm, Brunšmid 1998: no. 16. Murter. Publ.: Ilkić and Šešelj 2017: 285, cat. no. 10, Pl. I, 10. Collection B. Živaljić. Pl. I, 11.

12 Pharos, late 3rd – early 2nd century BC (?), AE, 5.29 g, 19 mm, 2 h, Brunšmid 1998: no. 32-33. Beretinova gradina (Radovin). Publ.: Ilkić and Šešelj 2017: 285, cat. no. 1, Pl. I, 1; Ilkić and Šeparović 2023: 172, Pl. XIX, Radovin - Beretini - Gradina 1. Department of Archaeology, University of Zadar. Pl. I, 12.

13 Issa, 3rd century BC, AE, 7.78 g, 23 mm, Brunšmid 1998: no. 12; SNG München, 476. Gradac (Smokvica). Publ.: Ilkić and Kožul 2017: 91, cat. no. 13; Ilkić and Šešelj 2017: 285, cat. no. 15, T. II, 3; Ilkić and Šeparović 2023: 157, Pl. XVI, Smokvica - Gradac 2. Department of Archaeology, University of Zadar. Pl. I, 13.

14 Issa, 3rd century BC, AE, 6.55 g, 22 mm, 12 h, Brunšmid 1998: no. 15. Plavno. Publ.: Šeparović 2002: 545-547; Šeparović 2003: 418-419, cat. no. 1, Figure 1; Šeparović 2013: 526, cat. no. 7; Ilkić and Šešelj 2017: 285, cat. no. 14, Pl. II, 2; Šeparović 2020: 112. The Museum of Croatian Archaeological Monuments in Split, inv. no. 1322. Pl. I, 14.

15 Ballaios, second half of the 3rd century or 195/190 – 175 BC (SNG München, 470-473) or 167 – 135 BC (Brunšmid 1998: no. 15-16), AE, 2.79 g, 17 mm. Ostrovica, Šolajina Draga. Publ.: Mirnik 1987: 90, Pl. 1, 2;

Delonga and Burić 1998: 6; Šeparović 2013: 528, cat. no. 27; Šešelj and Ilkić 2014: 47, Figure 13; Ilkić and Šešelj 2017: 286-287, cat. no. 42, Pl. IV, 4; Ilkić and Šeparović 2023: 48, T. III, Ostrovica - Šolajina draga 1. Benkovac Regional Museum. Pl. II, 1.

16 Hispania, Castulo, *c*. 150 – 100 BC (SNG Dreer, 38) or 165 – 80 BC (Ripollès and Abascal 2000: 735-793), AE, 27 mm. Jerebinjak (Brgud). Publ.: Ilkić et al. 2014: 66, cat. no. 2; Čelhar and Ilkić 2019: 36, cat. no. 16, Pl. II. 4; Ilkić and Šeparović 2023: 28, T. II, Brgud - Jarebnjak 1. Private collection. Pl. II, 2.

17 Hispania, Castulo, 165 – 80 BC, AE, 8.57 g, 27.5 mm, Ripollès and Abascal 2000: 735-793. Zamina (Radašinovci). Unpublished. Han Vrana Agency. Pl. II, 3.

18 Apulia, Arpi, 3rd century BC, AE, 6.22 g, 19.7 mm, 1 h, SNG Cop 603-605; SNG Dreer, 103-104. Smokovac (Krupa). Unpublished. Private collection. Pl. II, 4.

19 Bruttium, Brettii, 204 – 203 BC (SNG Milano, 136-139) or 282 – 203 BC (SNG Cop, 1689), AE, 2.67 g, 16 mm, 1 h. Gradina (Prndelji). Unpublished. Private collection. Pl. II, 5.

20 Calabria, Brundisium, 200 – 89 BC, semis, 7.71 g, 19 mm, SNG Dreer, 149. Asseria (Podgrađe). Publ.: Šešelj and Ilkić 2014: 48, Figure 18; Ilkić et al. 2014: 66, cat. no. 7; Ilkić and Šeparović 2023: 52, T. V, Podgrađe 37. Private collection. Pl. II, 6.

21 Calabria, Graxa, 200 – 170 BC, quadrans, 2.84 g, 16 mm, 12 h, SNG Cop. 747-748 var. Gradina (Bogatnik). Publ.: Ilkić and Šeparović 2023: 87, T. IX, Bogatnik - Gradina 1. Private collection. Pl. II, 7.

22 Apulia, Luceria, before 217 BC, quincunx, 14.34 g, 27 mm, SNG Cop. 659; SNG Dreer, 122. Asseria (Podgrađe). Publ.: Šešelj and Ilkić 2014: 48, Figure 16; Ilkić et al. 2014: 66, cat. no. 5; Ilkić and Šeparović 2023: 52, T. V, 36. Private collection. Pl. II, 8.

23 Frentani, Larinum, after 268 BC, quincunx, 11.54 g, 25.5 mm, 7 h, SNG Dreer, 44. Gradina (Prndelji). Publ.: Ilkić and Čelhar 2017: 490-491, Figure 12; Ilkić and Šeparović 2023: 91, Prndelji - Gradina 37, Private collection. Pl. II, 9.

24 Lucania, Metapont, 4th – 3rd century BC, AE, 4.27 g, 17 mm, 4 h, BMC, no. 196; SNG Cop, 1249. Ljubljana (Ljubač). Publ.: Ilkić 2017: 154, cat. no. 7; Ilkić and Šeparović 2023: 123, T. XIII, Ljubač - Gradina Ljubljana 2. Department of Archaeology, University of Zadar. Pl. II, 10.

25 Apulia, Salapia, *c*. 225 – 210 BC, AE, 25 mm, BMC no. 9-10. Gradina (Nadin), square B, June 1, 2019. Unpublished. Department of Archaeology, University of Zadar. Pl. II, 11.

26 Apulia, Salapia, *c*. 225 – 210 BC, AE, 20.5 mm, 5 h, BMC no. 11. Promona (Tepljuh). Unpublished. Private collection of Ilija Buzov. Pl. II, 12.

27 Calabria, Tarentum, *c*. 280 BC, AE, 16 mm, 4.48 g, 3 h; BMC no. 476; Historia Numorum Italy, 996 var.; D'Andrea et al. 2023: no. 1306. Ćosina gradina (Jagodnja Gornja). Publ.: Ilkić and Čelhar 2017: 489–492, Figure 11; Ilkić et al. 2020: 184, cat. no. 24; Ilkić and Šeparović 2023: 36, T. III, Gornja Jagodnja - Ćosina gradina 3. Department of Archaeology, University of Zadar. Pl. II, 13.

28 Apulia, Teate, *c*. 217 BC, quadrans, 23 mm, 9 h, SNG Dreer, 133. Gradina (Medviđa). Unpublished. Private collection. Pl. II, 14.

29 Sicily, Syracuse, Third Democracy, 345 – 317 BC (Timoleon, 345 – 336 BC), AE, 8.33 g, 20 mm, 3 h, SNG Dreer, 500. Lergova gradina (Slivnica Gornja). Unpublished. Department of Archaeology, University of Zadar. Pl. III, 1.

30 Sicily, Syracuse, Hiero II, 274 – 216 BC, AE, 5.94 g, 19 mm, 2 h, SNG Dreer, 538-545. Cvijina gradina (Kruševo). Publ.: Ilkić et al. 2014: 66, cat. no. 8; Ilkić and Šeparović 2023: 99, T. XII, Kruševo 2. Private collection. Pl. III, 2.

31 Sicily, Syracuse, Hiero II, 274 – 216 BC, AE, 4.82g, 17 mm, SNG Dreer, 538-545. Gradina above Sv. Trojica, square 4. Publ.: Tonc and Radman-Livaja 2014: 142, Figure 3; Bertol 2014: 113, 130, cat. no 46. Archaeological Museum in Zagreb. Pl. III, 3.

32 Numidia, Masinissa and his successors, 208-148 BC and later, AE, 13.57 g, 27 mm, 12 h, SNG Cop., 508. Nin, Sv. Križ, 1970, square 11, depth 175 cm. Publ.: Ilkić 2013: 87, cat. D1; Ilkić and Šeparović 2023: 149, T. XVI, Nin - Sv. Križ 1, Archaeological Museum in Zadar. Pl. III, 4.

33 Numidia, Masinissa and his successors, 208-148 BC and later, AE, 11.59 g, 26 mm, 12 h, SNG Cop., 504-507. Zadar, archaeological excavation on the market, square B 6, S J 210, P N 165, 25. 01. 2019. Publ.: Ilkić and Šeparović 2023: 256, T. XXIII, Zadar - Poluotok 1. Archaeological Museum in Zadar. Pl. III, 5.

34 Numidia, Masinissa and his successors, 208-148 BC and later, AE, 10.71 g, 25.5 mm, 12 h, SNG Cop., 504-507. Zelengradina, found during site surway on the northern slope. Publ.: Vrkić, Maurin, 2013, 57-58, Sl. 3, T. III, 1. Obrovac Homeland Museum. T. III, 6.

35 Numidia, Iuba I, 60 – 46 BC, AR, 3.76 g, 18 mm, 7 h, SNG Cop. 523. Trojan. Unpublished. Private collection. Pl. III, 7.

36 Ptolemy III Euergetes, 247/6 – 221/20 BC, AE, 41.74 g, 37 mm, Alexandria, Svoronos 974 var. Molat. Lit.: Ilkić and Šeparović 2023: 129, T. XV, Molat 2. Private collection. Pl. III, 8.

37 Ptolemy VIII Euergetes II, 144 – 116 BC, AE 47.70 g, 45 mm, 11 h, Cyrene, Svoronos. Gradina (Prndelji). Publ.: Asolati 2016: 12; Ilkić and Šeparović 2023: 91, T. X, Prndelji - Gradina 9. Private collection. Pl. III, 9.

38 Italy, aes, marked with crescent and circle with cross, 31.37 g, 24 x 19 x 16 mm, Vecchi, no. 2.1 (7-3 century BC). Dračevac (Jasenice). Unpublished. Private collection. Pl. III, 10.

39 Roman Republic, anonymous, 211 – 208 BC, victoriatus, 2.85 g, 15.8 mm, 1 h, mint of Sicily, RRC, 67. Gradina (Donji Karin). Unpublished. Department of Archaeology, University of Zadar. Pl. III, 11.

40 Roman Republic, L. Flaminius Chilo, 109 – 108 BC, denarius, 3.67 g, 18.3 mm, Roma, RRC 302/1. Velika Mrdakovica, settlement, room P 19, excavations in 2019. Publ.: Brajković and Ilkić 2022: 23-24, cat. no. 5. Šibenik City Museum, inv. no. 1577. Pl. III, 12.



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A group of glass vessels from the Van archaeology museum

Elif Hanar[1]

Abstract

One of the oldest cities in the world, the city of Van is located in the Lake Van Basin in the Eastern Anatolia region of Turkey. When we look at the Lake Van Basin, we see that this region has hosted numerous successive civilizations from the earliest ages to the present day (from the Palaeolithic period to the Ottoman periods). The Van Archaeology Museum's collection encompasses a wide range of artifacts from this extensive historical period. Among the current artifact groups in the museum are glass findings dating back to the Roman Period. The significant quantity and typological diversity of glass artifacts in the museum's collection provide crucial insights into the use of glass products of Roman origin in settlement areas within the Eastern Anatolia Region. However, when we examine the archaeological excavations and surface surveys conducted throughout the Lake Van Basin, we observe that the region contains only faint traces related to the Roman periods. It is known that with the discovery of the blowing technique during the Roman Period, the production of glass containers used for daily purposes, containers storing personal care products, and glass materials used as accessories became a popular industry in all Roman-influenced settlements. While the glass findings from the Lake Van Basin exhibit local characteristics, they generally reflect the broader nature of the Roman Period glass industry. These glass findings, introduced into the museum collection through purchases and donations, and originating from the Roman periods, are significant evidence regarding the use of the Roman Period glass industry in settlement areas within the Lake Van Basin. This study aims to investigate nine glass vessels in the forms of Jars, Lens-Shaped Bottles, and Miniature Flasks in the museum's collection from various perspectives, such as production techniques, areas of use, and functions. By doing so, it seeks to determine the origin relationship of these glass vessels, which reflect the Roman character of cultural structure in the Lake Van Basin, using parallel examples, and to reach the first scientific data on these glass vessels.

Keywords: Lake Van Basin, Roman period, glass, burial gift, jar

Introduction

Glass artifacts within the collections of Turkish museums have been meticulously and attentively studied by many researchers in recent years. Like many other museums, the Van Archaeology Museum also possesses a remarkable collection of glass artifacts, which it has acquired through purchases, confiscations, and donations. The glass collection of the Van Archaeology Museum is rich and diverse, represented by dozens of examples in various forms, including unguentaria, sprinklers, flagons, aryballoi, amphoriskoi, beakers, cups, bottles, jars, and flasks. This study aims to evaluate the origins and potential functions of nine glass containers in the forms of jars, lens-shaped bottles, and miniature flasks within the museum's collection. The issues of origin, form development, and dating of these artifacts will be addressed using a new and scientifically supported approach, through parallel examples identified in previous scientific studies.

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The content of the study includes the short history of the Eastern Anatolia Region and the Lake Van Basin, an introduction and brief history of glass material, the content of early period glass materials identified in the archaeological studies in the Lake Van Basin, and an evaluation of the jars, lens-shaped bottles, and miniature flasks, followed by the conclusions drawn from these evaluations.

The Van Archaeology Museum possesses a rich collection featuring numerous examples of the advanced and distinctive vessel forms of the Roman glass industry. The materials forming the subject of this study consist of nine Jar, Lens-Shaped Bottle and Miniature Flask selected from the museum's collection. The study examines the Van Museum's examples alongside glass artifacts from other regions that fall within the same chronological timeframe. The assessment of production techniques and form features aims to clarify questions of origin and function while presenting the first scientific data on these vessels.

Since the Jar, Lens-Shaped Bottle and Miniature Flask lack archaeological context, their dating has been established through analogy. Parallel examples from museums, private collections, and archaeological excavations both within and outside Anatolia have provided a foundation for chronological attribution. To determine their origins and functional purposes, we employed a methodological approach combining detailed literature review and stylistic analysis. The vessels were evaluated based on stylistic critique, current publications, and typological comparisons to establish a chronological framework.

The Van Archaeology Museum's glass collection, characterized by the large number of glass artifacts, the extensive use of glass items, and the typological diversity of their forms, serves as evidence that the glass products observed in many centres of Anatolia were also used by the peoples of the Van Lake Basin. This suggests that the inhabitants of this region integrated glass materials into many aspects of their lives. The glass artifacts recovered from this region, within the cultural geography of the Roman Empire, should be considered as valuable examples of different and distinguished types within the history of glassmaking, and it is worthwhile to examine the region's significance and place in the history of glassmaking.

Definition and history of glass

Generally, glass is defined as a transparent, translucent, or opaque, amorphous material that solidifies without crystallizing, created by the fusion of silica, potash or soda, lime, and other additives. After thousands of years of technological and artistic advancements, glass has become an integral part of modern life. It is entirely natural but is created with human intervention, symbolizing humankind's intelligence and creativity in utilizing natural resources (Saldern 1966: 4; Lightfoot 2007: 14; Biser 1899: 24; Davison 1989: 73, Öztürk 2013b: 21).

Although we do not know precisely where, how, and when it was produced, we learn about the earliest documented evidence related to glass production from ancient sources and cuneiform tablets. Shiny objects resembling glass have been used in the Near East since the 5th millennium BC (Saldern 1980: 24). The earliest records of glassmaking technology are found in cuneiform tablets from Mesopotamia, with the earliest tablet containing a formula for glazing discovered at Tell-Umar (Seleucia) on the Tigris River. This tablet, dating back to the 17th century BC, records that glassmaking was a well-structured tradition at that time (Davison 1989: 135; Tait 1991: 22; Goldstein 1979: 25; Gürler 2000: 1). Around the 3rd millennium BC, during the Bronze Age, the first glass was produced in Mesopotamia (Weinberg and McClellan 1992: 15; Shortland 2009: 1), and it is known that artificial glass was first used around 3500-3000 BC in Mesopotamia as a glaze coating on stone and ceramic beads. By 2500 BC, beads and amulets

were made entirely of glass (Canav 1985: 19; Tek 2005: 109; Eisen 1919: 87; Öztürk 2003: 69; Luckner 1994: 79). After 1500 BC, glass vessels were produced using the core-forming technique in Mesopotamia during the Mitanni Kingdom period, and it is known that glass vessels produced in Mesopotamia spread over a wide area including Iran, Elam, Babylon in Eastern Syria, Palestine on the Mediterranean coast, Cyprus, and Mycenae in Greece (Öztürk 2003: 70).

Thanks to the abundance of raw materials in Egypt, the glassmaking industry quickly developed, coinciding with the 15th century BC, when glass was recorded in cuneiform tablets in Mesopotamia. At the beginning of the 14th century BC, glass production centres were established in Malkata, Tell el-Amarna (the new capital of Akhenaten, also known as Amenhotep) during 1352-1336 BC, and at the beginning of the 12th century BC in Lisht and Qantir. It is also thought that the glass workshops in Egypt produced consumer goods for royal families and aristocrats, as well as exported large quantities of raw glass (Davison 1989: 18; Grossmann 2002: 6; Honey 1945: 16; Erten 2010: 60; Ikeda 2003: 6). Apart from Mesopotamia and Egypt, glass artifacts dating back to the 2nd millennium BC have been found in the Syria-Palestine region, Cyprus, Rhodes, and Crete (Weinberg and McClellan 1992: 17). The discovery of Mesopotamian-origin glass in centres in the Syria-Palestine region indicates that this area was on the route through which Mesopotamian glass was transported to Egypt (Barag 1985: 39).

The emergence of new political authorities and the establishment of young states around 900 BC led to a renewal in the fields of culture and art. In this period, the Late Babylonian Kingdom was established in Southern Mesopotamia and the Late Assyrian Kingdom in Northern Mesopotamia, and the Phoenicians in the Syria-Palestine region supported the formation of significant trade centres. While the Late Hittite, Urartu, Phrygian, and Lydian states predominated in Anatolia, the Hellenes ruled over Ionia and Greece. The takeover by the Achaemenid Kingdom in Iran laid the foundations for the Persian Empire, which would last until the 4th century BC and rule over Mesopotamia, Egypt, Anatolia, and Greece. The revival of the glass industry in the 9th century BC originated from a cultural resurgence that affected the Mediterranean world, the Levant (Lebanon and the Mediterranean coasts of Palestine), and all of Western Asia (Davison 1989:19; Tait 1991: 38).

The political and cultural impacts of the Hellenistic Period, which began around 330 BC after Alexander the Great's conquest of the Persian Empire, also laid the foundation for innovation in glass art. Although there was a decline in the aesthetics and production volume of glass produced in Mesopotamia, new vessel forms and decorative elements were developed and applied throughout the Hellenistic Period. Glass production during the Hellenistic Period took place in two centres: Phoenicia on the coast of Syria and Alexandria, the capital of the Ptolemaic Kingdom in Egypt (Lightfoot 2007: 15; Davison 1989: 21; Lightfoot and Arslan 1992: 4). In Alexandria, founded by Alexander the Great in 332 BC, the glass art that had lost its prominence in Egypt was revived, making Egypt an important glassmaking centre. Glass artisans of Asian origin trained in the glass workshops of Syria and Egypt migrated to popular centres such as Pergamon, Rhodes, Greece, and Italy in the 2nd century BC (Harden 1969: 44; Canav 1985: 19; Honey 1945: 16).

The glass industry in the Roman Period was shaped and gradually developed with the experience and inspiration taken from Hellenistic Period glass producers. It eventually became an independent and innovative industry, known in Western European settlements as well. With the development of this industry, glass could be produced more cheaply and on a larger scale. The factor that accelerated the glass industry was the accidental yet timely discovery of the glassblowing technique. Although we do not have precise information about the exact date of the discovery of the glassblowing technique or the circumstances that led to it (Lightfoot 1989: 73; Tait 1991: 62; Cline 1998: 67; Fino 2001: 18; Weinberg and McClellan 1992: 33; Israeli 1991: 46), this technique transitioned glass from being a luxury item to

becoming a widely used product (Luckner 1994: 81; Harden 1969: 45; Oliver 1980: 22; Tekkök 2013: 105; Honey 1945: 21; Lightfoot 2007: 16; Hayes 1975: 29; Grossmann 2002: 10; Lightfoot and Arslan 1992: 5).

This spread of glass production from Syria, regarded as the birthplace of the glassblowing technique, to the centre of the Roman Empire and to northern and western regions, was essentially observed to have developed better in the east-west direction of the Roman Empire (Gürler 2000: 3). After the division of the Roman Empire into two in 395, the glass industry was developed in the Western Roman Empire, while in the Eastern Roman (Byzantine) Empire, the previously used vessel forms and decorative elements continued to be used between the 5th and 7th centuries (Stern 1977: 158; Tait 1991: 98).

Glass finds in the lake Van Basin

During the Iron Age, there is evidence that glass material was known not only in the lands of Lydia and Phrygia in Western Anatolia but also in the Urartian Kingdom, an important power in Eastern Anatolia. The discovery of numerous glass beads in the Karagündüz Necropolis (Konyar and Köroğlu 2005: 34), dating between 1000-800 BC, attributed to a culture considered the origin of classical Urartian culture, demonstrates that glass was a significant material within the early Iron Age cultures of Eastern Anatolia. In the necropolis, 513 beads have been identified, some made of gold-glass and glass, and others of precious stones such as agate and carnelian. Around the neck of one of the corpses, a three-strand necklace with a pendant made of blue glass was found. This necklace is completely different in characteristics from the well-known stone and glass beads produced during the Urartian Kingdom period (Sevin 2012: 361-62; Sevin 2005: 364-65; Erten 2004: 104). These glass beads, which can be considered as the earliest evidence of glass usage in the Lake Van Basin, being found as grave finds, indicate that the peoples of Urartian lands used glass in burial rituals.

Another important find reflecting the use of glass in Urartian art is a lead figurine with red opaque glass and ivory inlays discovered in Toprakkale in AD 1880 (Erten 2004: 104). Chemical analyses of the glass pieces from the Toprakkale figurine revealed that they contain 25.48% lead oxide. This artifact, dating to the 8th century BC, is considered one of the earliest examples of using lead oxide in the production of red opaque glass. Additionally, disk-shaped inlays made of red opaque glass, also found in Toprakkale, are believed to have been applied to Urartian furniture or basalt slabs.

The earliest known examples of red opaque glass containing lead oxide come from Hasanlu, located on the shores of Lake Urmia in northwest Iran, dating to the late 9th century BC. These items are thought not to be locally produced in Hasanlu and may have originated in Mesopotamia. Furthermore, a written source from Boğazköy provides evidence for the use of lead in red glass production during the 2nd millennium BC (Erten 2004: 105).

In addition to the finds from Karagündüz and Toprakkale, a large number of glass beads have been discovered in other sites in the region, such as Van, Dilkaya, Yoncatepe, and the areas around Hakkari and Iğdır (Erten 2004: 104).

When we examine the excavation data from the Lake Van Basin, particularly regarding eastern Anatolia, we see that archaeological finds related to glass material from periods following the Iron Age have not yet been uncovered. The variety and quantity of glass vessels dating to the Roman period in the Van Archaeological Museum's collection clearly indicate that glass was known and used in this region since the Urartian Kingdom. The glass vessel discovered during the AD 2014 excavations at

Ayanis Fortress, which dates to the Roman period (Van Archaeological Museum Archive), is a significant piece of evidence that glass continued to be used as a material in vessel production in the region.

Jars

Small jars with spherical bodies are commonly found among the glass vessel forms in the regions of Syria and Palestine. These glass containers are known to have been used as perfume and ointment containers (Gürler 2000: 115). The Van Archaeology Museum's glass artifact collection includes four jars registered under inventory numbers 11/172/82, A/3444/09, A/3443/09, and A/3442/09. When we examine them:

The jar with the inventory number 11/172/82 (Figure 1) was produced using the free-blowing technique and shaped with tools. In terms of form, it has a wide and somewhat inclined rim that is outwardly pulled and then folded inward, creating a rounded top. It features a short, concave cylindrical neck, a spherical body, and a round base. There are noble marks on the bottom, and iridescence and limestone residue are present on both the interior and exterior of the body. To clarify the jar's origin and function, our source research supports it with numerous parallel examples for typological comparison concerning the mouth and body. The identified parallels (Isigns 1957: Form 70; Tavukçu 2007: Figure 6; Weinberg and McClellan 1992: Figure78; Lightfoot 2007: Figure 374; Barkoczi 1996: Figure 130; Canav 1985: Figure 49; Vessberg 1952: PL.7/12; Lightfoot 2017.242; Öztürk 2013a: Figure 14; Hanar 2018: Cat.421) suggest that the jar with number 11/172/82 dates back to the AD 2nd century.

The jar with the inventory number A/3444/09 (Figure 2) was also produced using the free-blowing technique and shaped with tools. In form, it has a wide rim that is outwardly pulled and then folded inward, creating a rounded top; a concave cylindrical neck; a distinctly outlined shoulder; an oval-shaped body; and a concave base. Zigzag decorations made with a glass trail are present between the mouth and shoulder on the upper part of the body, and there are small indentations as decorations on the lower part of the body. The jar is thick-walled with noble marks on the base and iridescence, limestone residue, and small air bubbles on both the interior and exterior surfaces. The jar with the inventory number A/3443/09 (Figure 3), also produced with the free-blowing technique and shaped with tools, features a similar wide rim, concave cylindrical neck, cylindrical body, and concave base. Zigzag decorations made with a glass trail are found between the mouth and shoulder on the upper portion of the body. This thick-walled jar has noble marks on the base and iridescence, limestone residues, and small air bubbles on both surfaces. The jar with the inventory number A/3442/09 (Figure 4), produced by the same technique, exhibits a wide rim, concave cylindrical neck, spherical body, and round base. It has two rows of zigzag decorations, made with a glass trail, on both the upper and lower portions of its body. Thick-walled, it also contains noble marks on the base and traces of iridescence, limestone residue, and small air bubbles on its interior and exterior surfaces. To clarify the origin and function of the jar, extensive research revealed numerous parallel examples with which it could be typologically compared regarding the mouth, body, and decorative elements. These parallels (Hayes 1975: PL:28/442-443; Oliver 1980: Figure 164-65; Whitehouse 1997: Figure 299; Lightfoot 2017: Cat.222) are attributed to the AD 3rd-4th centuries and share form and decorative similarities with the jars numbered A/3444/09, A/3443/09, and A/3442/09. This allows us to date the Van Archaeology Museum examples to the AD 3rd-4th century.

Lens-shaped bottle

There is one bottle with a lens-shaped body in the Van Museum's collection. This type of glass vessel with a similar structure is quite rare (Engle 1978: 74). The lens-shaped bottle with inventory number 9/169/82 (Figure 5) features a flat, pulled-out, funnel-shaped rim, and a short cylindrical neck marked by tools that becomes narrower toward the body. It has a lens-shaped body flattened by side pressing and a round concave bottom. Limestone residue, peeling, and scratch marks are discernible on its iridescent surface. In our investigation to clarify the bottle's origin and function, many parallel examples were identified, typologically comparable in terms of the rim, body, and decorative elements. These parallels, originating from the AD 3rd-4th century (Hayes 1975: Figure 171; Weinberg and Stern 2009: Figure 396; Kunina 1997: Figure 227; Gürler 2000: Figure 138; Stern 1989: Figure 14; Öztürk 2013b: Figure 20; Engle 1978: Figure 61; Lightfoot 2017: Cat.440; Hanar 2018: Cat.437), are similar to the lens-shaped bottle with number 9/169/82 in typology. This confirms that the example from the Van Archaeology Museum was produced in the AD 3rd-4th century.

Miniature flasks

In the early examples of miniature flasks with spherical bodies, there are instances where the rim is left flat, as well as examples where the rim is pulled outwards and folded inwards, creating a rounded top. These flasks typically have a spherical body, but bell-shaped and square-bodied examples also exist. Generally produced in a greenish colour, these flasks are known to have been produced intensively from the late AD 3rd century to the 4th century (Isigns 1957: 123-24). Additionally, it is known that AD 3rd-century glass vessels were decorated with ribbed elements. These vessels, which have examples with both bulbous and conical bodies, are fundamentally considered as 4th-century types. Some examples of these vessels have bases and necks that are structurally similar to earlier bottles and unguentaria (Isigns 1957: 119). There are numerous examples of glass vessels in the miniature flask form that vary in terms of rim design, body structure, and decorative elements. This variety can also be observed in the Van Archaeology Museum collection.

The miniature flask with inventory number 74/50/48 (Figure 6) was produced using the free-blowing technique and shaped with tools. Form-wise, it has a rounded lip, a partially conical and long cylindrical neck, a spherical body, and a round base. It is thin-walled and features noble marks on the base, iridescence on the inner and outer body surfaces, and limestone residues.

The miniature flask with inventory number 14/55/83 (Figure 7) was also produced using the free-blowing technique and then shaped with tools. In terms of form, it has a rim that was pulled outward, folded inward, and then rounded at the top, a partially conical and long cylindrical neck, a spherical body, and a round base. It has been observed that the entire body of the flask was decorated with a glass trail, some of which has broken off. The rim shows breaks and missing parts, the body has small breaks, the base has a pontil mark, and the inner and outer surfaces of the body have an iridescent layer and heavy calcite deposits. Our research, conducted to clarify the origin and function of the flask, identified numerous parallel examples that are typologically comparable in terms of the rim and body structure (Isigns 1957: Form 104-B; Lightfoot and Arslan 1992: Figure 121; Öztürk 2013b: Figure 27; Papanikola and Bakırtzi 2002: Figure 647; Gürler 2000: Figure 109; Oliver 1980: Figure 49; Olcay 2001: Figure 15/27; Hanar 2018: Cat.441). The fact that these parallel examples, dated to the AD 3rd-4th centuries, are typologically similar to the miniature flasks with numbers 74/50/48 and 14/55/83 suggests that the Van Archaeology Museum examples also date back to the AD 3rd-4th centuries.

The miniature flask with inventory number 74/50/20 (Figure 8) was produced using the free-blowing technique and then shaped with tools. In terms of form, it has a stepped rim that was pulled outward, folded inward, then pulled outward again and folded inward to round the top, a partially conical and long cylindrical neck, a spherical body, and a round base. The thin-walled flask has a pontil mark on the base, as well as iridescence and calcite deposits on both the inner and outer surfaces of the body. Our research, aimed at clarifying the origin and function of the flask, identified many parallel examples that are typologically comparable in terms of the rim and body structure. These parallel examples, dated to the AD 3rd-4th centuries (Isigns 1957: Form 101; Öztürk 2013a: Figure 62; Whitehouse 2001: Figure 678; Stern 1995: Figure 132; Hayes 1975: Figure 294; Simpson 2003: Figure 11; Hanar 2018: Cat.483), were found to be typologically similar to the miniature flask with number 74/50/20. This suggests that the Van Archaeology Museum example also dates back to the AD 3rd-4th centuries.

The miniature flask with inventory number A/3603/09 (Figure 9) was produced using the free-blowing technique and then shaped with tools. In terms of form, it has a stepped rim that was pulled outward, folded inward, then pulled outward again and folded inward to round the top, a partially conical and long cylindrical neck, a spherical body, and a round base. The thin-walled flask has ribbed decorations covering the entire body, a pontil mark on the base, and iridescence, calcite deposits, and small air bubbles on both the inner and outer surfaces of the body. Our research, conducted to clarify the origin and function of the flask, identified many parallel examples that are typologically comparable in terms of the rim, body, and decorative elements (Isigns 1957: Form 101; Öztürk 2013a: Figure 62; Whitehouse 2001: Figure 678; Stern 1995: Figure 132; Hayes 1975: Figure 294; Simpson 2003: Figure 12; Hanar 2018: Cat.530). The identified parallels are dated to the AD 3rd-4th centuries and are structurally similar to the miniature flask with number A/3603/09 in terms of both form and decorative elements. Based on this similarity, it is possible to date the Van Archaeology Museum example to the AD 3rd-4th centuries.

Conclusion

In the Van Lake Basin, one of the significant centres in eastern Anatolia, we observe that the findings of the Roman glass industry are represented by numerous examples. The glass vessels in the collection of the Van Archaeology Museum exemplify the most advanced and distinct forms of glassware from the Roman period in the region. This study examines jars, lens-shaped bottles, and miniature flasks from the museum's collection. These vessels, acquired through purchasing, donations, and seizures, were subjected to detailed literature reviews and stylistic critiques for origin determination. The works were evaluated based on stylistic critique and contextualized chronologically with information from current publications about the forms. The parallel examples used in the dating work show significant similarities with the pieces in our study. We can attribute small differences to the variations in workshops that produced these artifacts.

Proposals need to be made concerning the origin problem for these glass vessels, which are supported by excavation data and parallel examples, resembling those in the cultural and stylistic domain of the Roman Empire, clearly originating from the 1st-4th centuries. This is important as it brings a new and scientifically supported approach to the issues of origin development and dating of the Van Lake Basin artifacts.

Firstly, the necessary evaluations and dating studies of these glass vessels have been carried out. Our observations related to the examined vessels indicate the presence of development in glass production and decoration methods. This development shows variations across the vessels.

The fact that these glass vessels, acquired through means that make it difficult to establish their origin and chronological-period relationship, have been well-preserved in their entirety leads us to believe that they were obtained through illicit excavations and are grave finds. In this context, the production techniques, forms, decorative elements, and potential usage areas of the glass vessels that are the subject of our study, along with their corroboration with numerous parallel examples that are also grave finds, can be considered as factors strengthening the likelihood that these vessels are grave finds. This leads us to the conclusion that the people living in the Van Lake Basin used glass material in their social and religious lives.

The fact that the vessels we examined share similar characteristics with examples from Anatolia, the Mediterranean, and mainland Italy points to an extensive trade and cultural interaction network. This could also be considered a result of the dominant cultural influence of the Roman world, which controlled the region during the historical process.

Reviewing publications comparing similar examples of jars, lens-shaped bottles, and miniature flasks, these forms are noted to have originated from Syria, Palestine, Cyprus, or broadly speaking, the Eastern Mediterranean and Italy, spreading and evolving from these regions. No clear evidence yet exists for a direct glass trade between these regions and the cities of Anatolia, nor has a glass production kiln or workshop been identified in the area. However, recent studies on glass artifacts reveal similar examples are present in many Anatolian settlements. This information leads us to believe that the traditions of workshops from the Eastern Mediterranean and Italy were disseminated over a wide geography. Consequently, these artifacts also provide evidence that the products of the dominant cultures of the time were used in the region.

It is possible to find similar examples of the glass vessels we examined in many collections. Chronological data obtained from the settlements where similar materials were found clearly indicate that the Van Archaeology Museum examples were produced within the time frame spanning from the beginning of the AD 1st century to the 4th century.

The fact that the jars, lens-shaped bottles, and miniature flasks in the Van Museum's glass artifact collection are parallel in form and decoration with glass vessels of Italian, Eastern Mediterranean, Egyptian, and Mesopotamian origin allows us to interpret that the Van Lake Basin was part of or within the sphere of influence of a trade network encompassing Italy, the centre of the Roman Empire, the Eastern Mediterranean, and Mesopotamia during antiquity. It should also be noted that these artifacts might have been produced in local cities within the region, or they could have been brought to the region from different geographies.

		
Figure 1	Figure 2	Figure 3
		
Figure 4	Figure 5	Figure 6
		
Figure 7	Figure 8	Figure 9

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The maritime circulation of ceramic roofing materials in the Western Mediterranean of Roman era

Caterina Tomizza[1]

Abstract

Despite being among the most flourishing market segments in the Roman world, the ceramic roofing materials have rarely been subject of specific attention from the archaeologists, especially with regard to the aspects related to their circulation. It seems clear that, during the Roman period, most of these materials circulated by sea and probably through different forms of navigation, however, of 41 cargoes so far detected in the Mediterranean basin, only a few have been studied with a complete approach. Here, after a brief presentation of the different types of rooftiles that circulated in the Roman Western Mediterranean and the various distribution pathways followed by these materials, is proposed an analysis of the shipwrecks that includes an outlining – through some significant case studies - of the stocking methods employed.

To reconstruct the stowage techniques there has been carried out an analysis on the sites' documentation and the stowing patterns for these materials could be resumed in a scheme whereby the rooftiles are arranged in two or three parallel rows, positioned in the middle of the hull, with the bent tiles arranged in side stacks and inserted vertically in the gaps.

The orderly study of the shipwrecks led to the hypothesis that the diffusion of these materials took place on various scales and through different sailing modes, in contrast with the theories that considered rooftiles and bent tiles as ballast, or a low-value commodity for the return journey. Nevertheless, several questions remain about the maritime distribution of ceramic roofing materials, especially with regard to the handling of large cargoes and the reasons that led to their transport not only in a regional trade system but also in long-range distribution contexts and by direct, offshore navigation. Looking at the data available to date, the necessity of an updated database of rooftiles and bent tiles' production and distribution in the Roman Mediterranean became clear. It would be advisable, in fact, a systematic approach to this type of materials that starts from morphological and epigraphic analysis and necessarily passes through archaeometrical studies.

Keywords: maritime trade, ceramic building materials, roman economy

Introduction

Roof tiles and cover tiles are among the archaeological materials that are best preserved, most visible in underwater environment and have a high informative potential on the economic, political, social and administrative history of the Roman world (Shepherd 2015: 120-132; Maschek 2023: 1-14).

Starting from this assumption we can affirm that the weak presence of underwater cargoes of roof tiles is not an objective data but, rather, depends on their underrepresentation, which could depend on technical issues that may occur in the approach to underwater contexts, but, also on a lack of specifical

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interest for these materials. Candace Rice (Rice 2016: 165-192) appropriately claimed that ceramic roofing materials appeared as "unglamorous cargoes" for many scholars, even though there is a lot of information that may be obtained from them.

In this research there has been created a catalogue of the shipwrecks with cargoes of ceramic roofing materials in the Roman Mediterranean that successively was analysed, following some research questions that regard how did these materials circulated by sea; why did they circulated by sea (especially for the cargoes mobilized through long range routes); how were they stowed onboard; what types of vessels were employed in their transport and, finally, how much do we know about the maritime trade of these materials and which could be the best methods to deal with the data available to date.

The principal roof tile typologies and their routes of distribution

In the central area of the Roman Mediterranean there were two main typologies of roof tiles: the *risega* and the *incasso* type. The difference lays in the morphology of the cutout in the lower end of the flange which, in *incasso* roof tiles is shaped to overlap by hooking, while in *risega* ones, to overlap by sliding (Shepherd 2015: 120-132). Over the morphological distinction, there is a visible difference in their paths of distribution, as it can be noticed in the chart at Figure 1. The *incasso* roof tile, born in the Campanian area, appears rather more diffused throughout the Mediterranean's western basin than the *risega* one. This difference is probably due to cultural, economic and technical factors. In fact, the *risega* type was produced in *Latium* and was directly linked first to the senatorial elite and successively to the imperial power. On the other side, the Campanian roof tile, that had a greater economic success and was commercialized in a wider area, was initially produced in a region where some of the future settlers of many provinces learnt this technique of roof building and successively imported it (Graham 2006; Shepherd 2015: 120-132). The other factor to take in consideration is the technical aspect. In fact, the system of overlapping by hooking was self-locking and more resistant to the different climate adversities that were present in the northern provinces and this could be one of the one reason to prefer this typology.

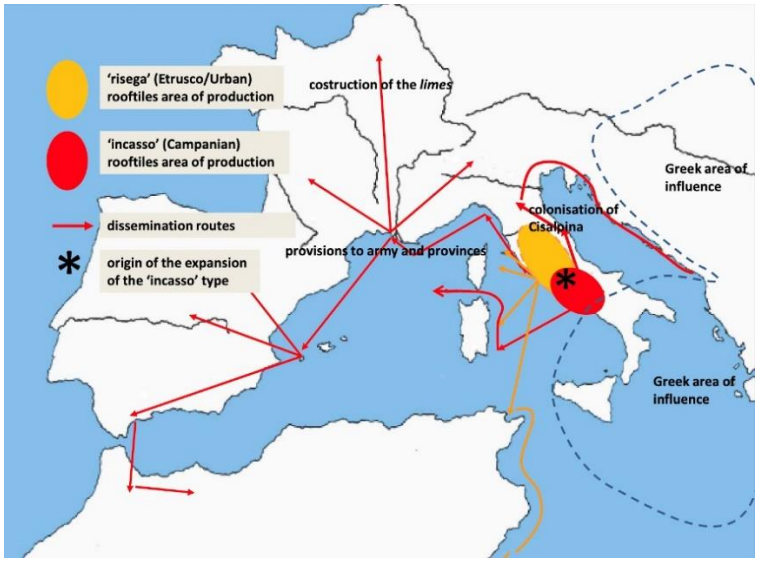


Figure 1. The distribution lines of the risega and incasso roof tiles in the Mediterranean of Roman period (From Shepherd 2006).

The maritime circulation of ceramic roofing materials

In the course of this research, a catalogue of the shipwrecks present in the Mediterranean with cargoes of roof tiles and cover tiles from the Roman period was drawn up. In this procedure, taking into account also the catalogues compiled previously (Parker, 1992; Rico 1995: 768-800; Strauss, 2007) An attempt was made to consider all factors of possible interest in the study of these contexts, namely: the site denomination , the country of discovery, the chronological placement, the roof tile typology, the measures of the roofing materials, their possible provenance, the cargo typology, the eventual presence and the typology of stamps and, finally, after a brief description of the site, the bibliographical references known to date.

Analysing the catalogue of the shipwrecks with cargoes of roof tiles and cover tiles it is possible to obtain a lot of information about their circulation in Roman period. It seems appropriate to premise, however, that the information which will be presented are derived from a database that is partial both in terms of the quality and quantity of the data available to us. In fact, some areas of the Mediterranean basin have been better investigated while, for other ones, only essential and extremely synthetic data are available.

Firstly, it seems clear that these materials circulated throughout the central and western Mediterranean basin but there are two cluster areas where we have an apparently higher concentration of shipwrecks with this type of cargoes: the French and the Croatian coasts.

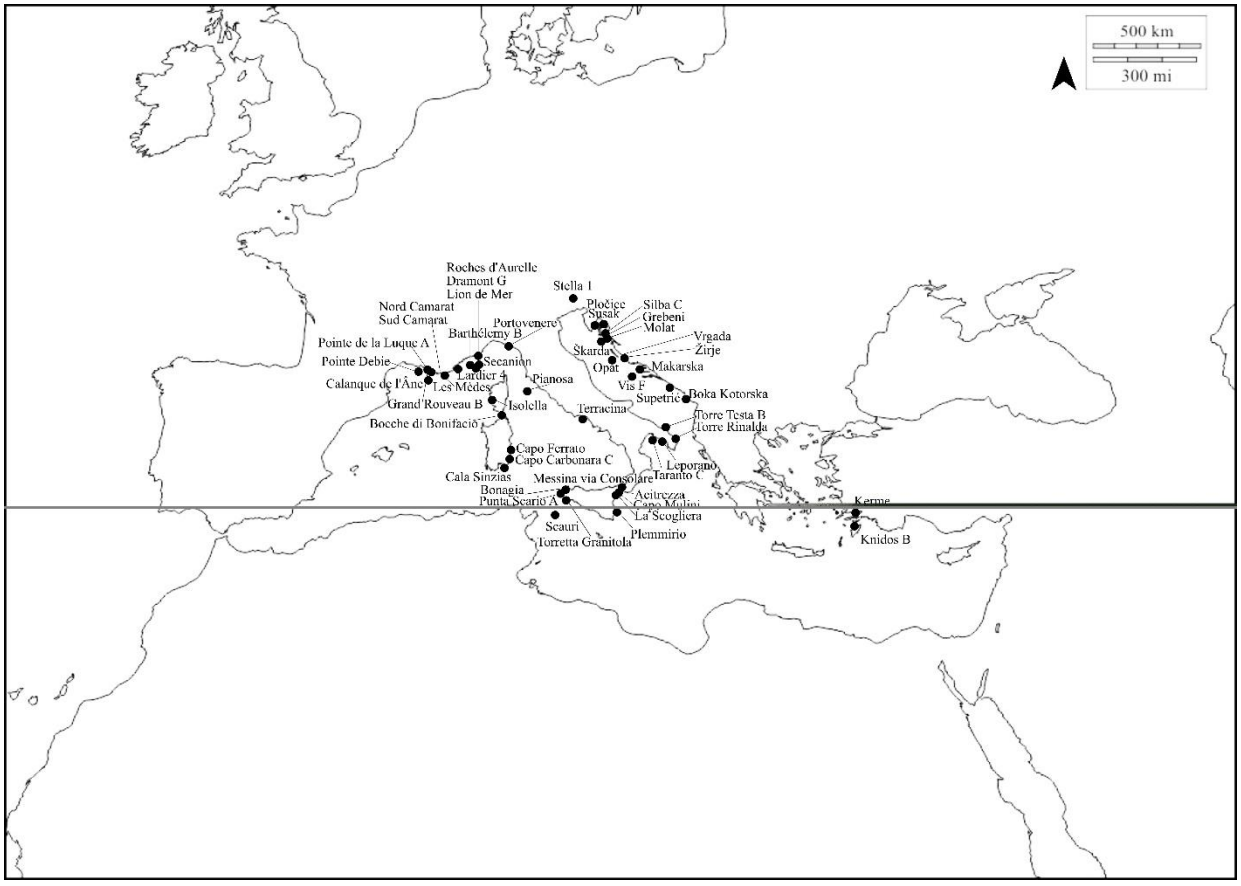


Figure 2. The maritime cargoes of roof tiles and cover tiles reported to date in the Roman Mediterranean.

Shifting to the chronological placing of these cargoes, it is possible to see a connection with the general trend of maritime trade represented in the graph of Figure 3. Indeed, there is a first, reduced, peak of recoveries between the 2° and the 1° century BC, while the period with greater attestations seems to be the 1° century AD, followed by a slight decrease in the 2° AD and by a fall to percentages clearly inferior in the successive centuries.

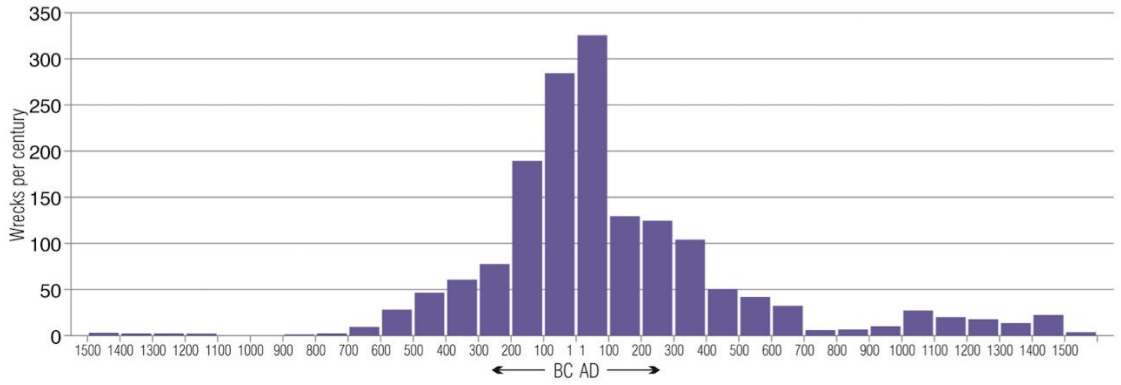


Figure 3. Graph showing the diachronical distribution of the shipwrecks reported in the Mediterranean of Roman era (From Wilson 2011).

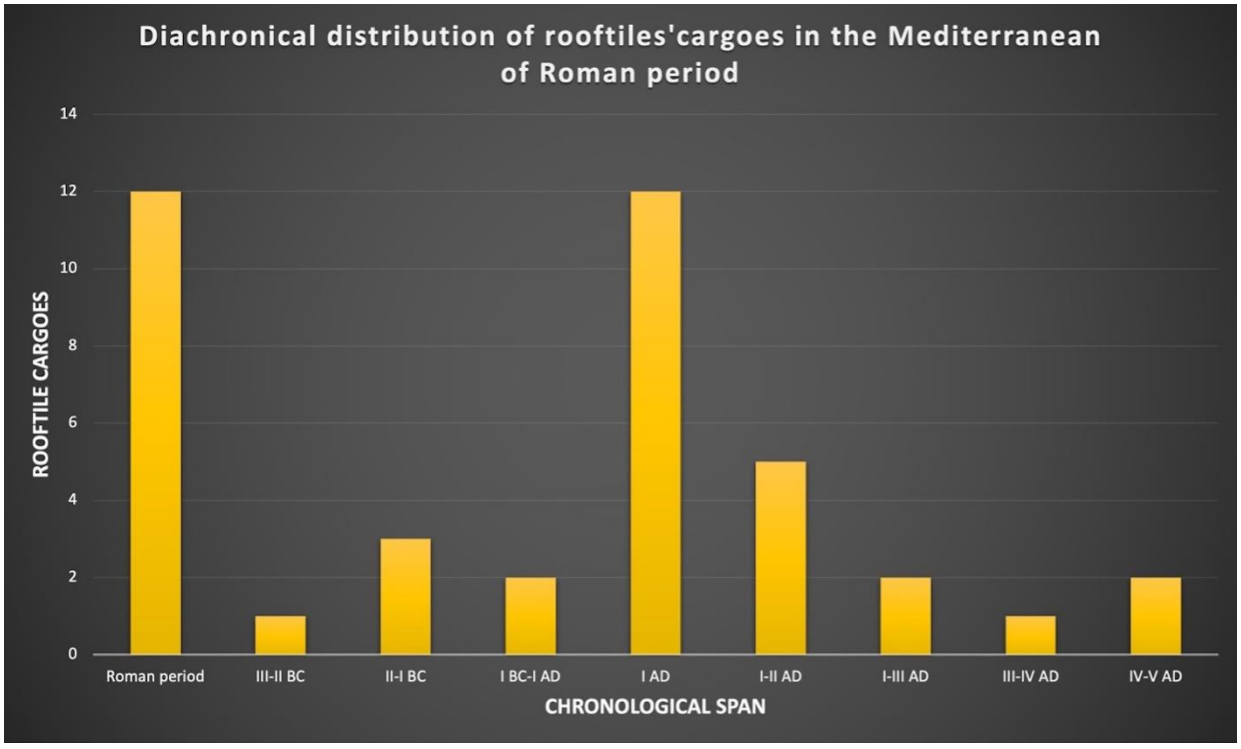


Figure 4. Graph showing the diachronical distribution of the roof tiles' cargoes object of this study.

On the other side, few and incomplete is the information about the typology of the roof tiles transported. As represented in the graph at Figure 5, there is a 17% of *risega* roof tiles, followed by a 28% of *incasso* ones, but the most interesting aspect is probably the 55% of "unknown" typology. Many questions rise about this data because, even if it isn't particularly complicated to detect the typology of a roof tile by its morphology, this information has been taken in consideration just in few cases, losing a great opportunity to better understand the contexts object of study.

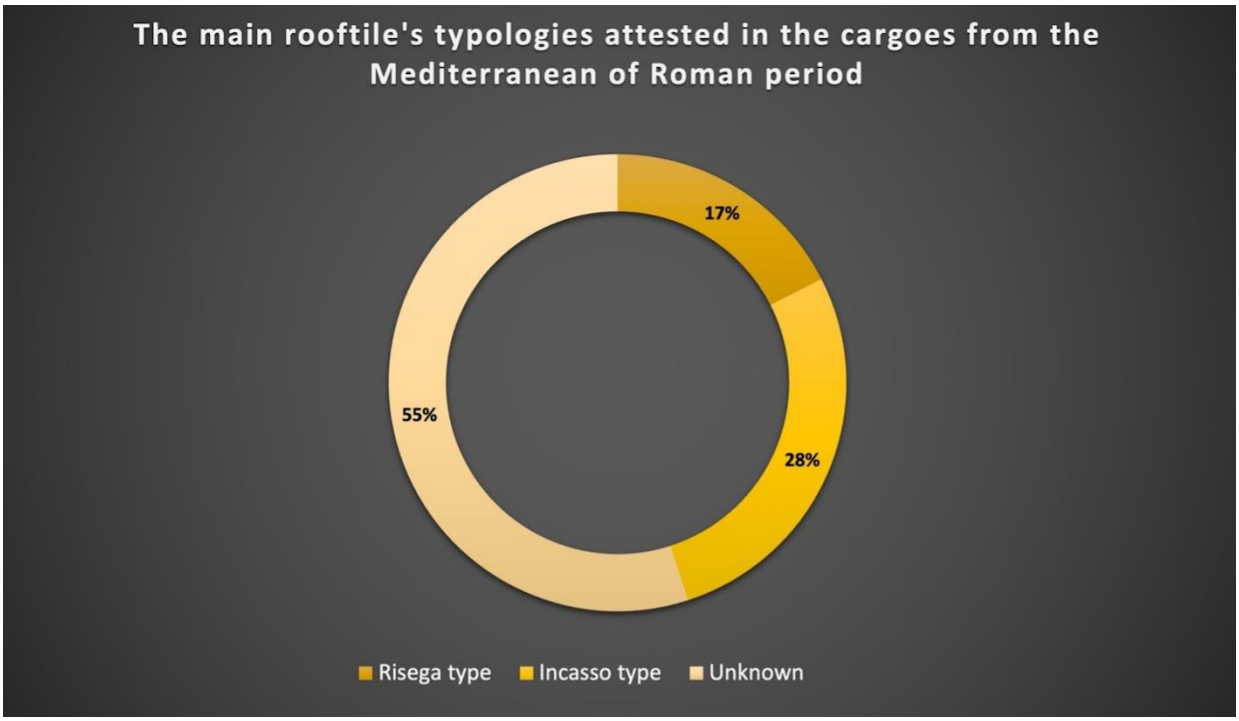


Figure 5. Graph showing the main roof tiles' typologies attested in the cargoes object of this study.

The stowing techniques

One of the main questions regarding the mechanisms of handling of these materials lays in the comprehension of the possible patterns in their stowage. This aspect is of particular interest since, from the analysis of the techniques employed for the disposition of roof tiles and cover tiles on board, it is possible to hypothesize factors such as the shape of the hull, the possible tonnage and size of the ship, the eventual presence of other components of the cargo and consequently its typology.

In the attempt of reconstruction of possible blueprints in the stowing techniques, there has been carried out an analysis on the sites' documentation, hereafter, some significant case studies will be illustrated.

The cargo of the shipwreck Barthélémy B, situated in the Var region along the southern coasts of France, was an exclusive cargo of ceramic roofing materials, theorized for this characteristic as the Barthélémy B model by Giulia Boetto (Boetto 2012: 153-173). The cargo is composed of two longitudinal rows of roof tiles that run parallel to the longitudinal axis of the hull, fixed at the ends by two stacks of cover tiles that prevent them from shifting or overturning. Laterally, four or five perpendicular rows of roof tiles occupy the space between the cargo and the side of the ship, while singular cover tiles are inserted in the empty spaces (Joncheray and Joncheray 2004: 5-134).

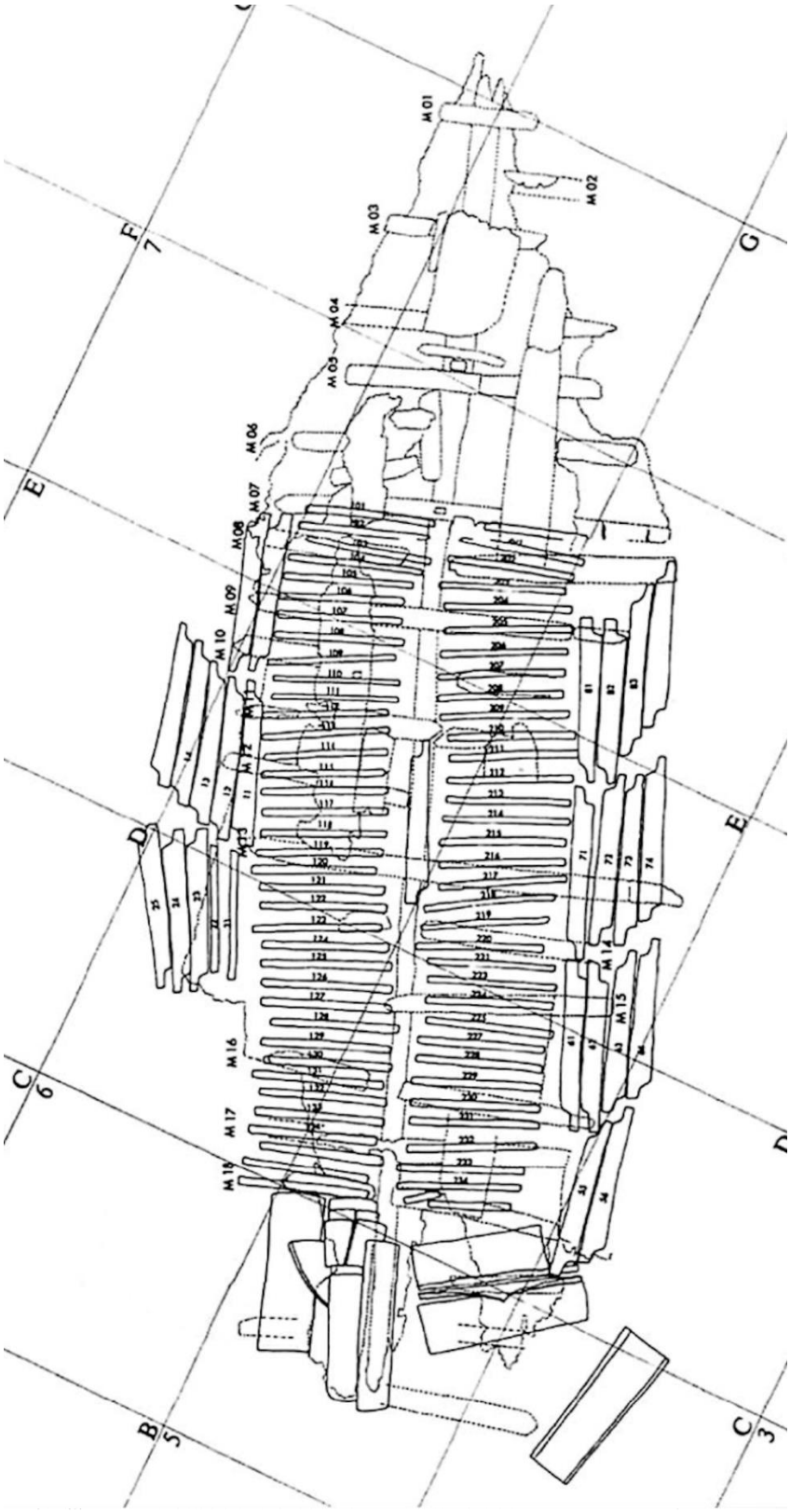


Figure 6. Plan of the shipwreck Barthélémy B (From Joncheray and Joncheray 2004).

In the case of the Lardier 4 cargo, located in the same area of the previous, we can outline the other possible stowing scheme noticed so far for these materials. In this context, several rows of roof tiles parallel to each other appear arranged perpendicularly to the longitudinal axis of the hull and rest, on the long side, in at least two overlapping levels (Joncheray and Joncheray 2004: 5-134). To protect these rows are, again, placed vertically some cover tiles. The same arrangement has been noticed in the shipwrecks of Roches d'Aurelle, Dramont G and Secanion, all found in the same area (Var region) and at a relatively short distance from each other (Joncheray and Joncheray 2012: 57-69).

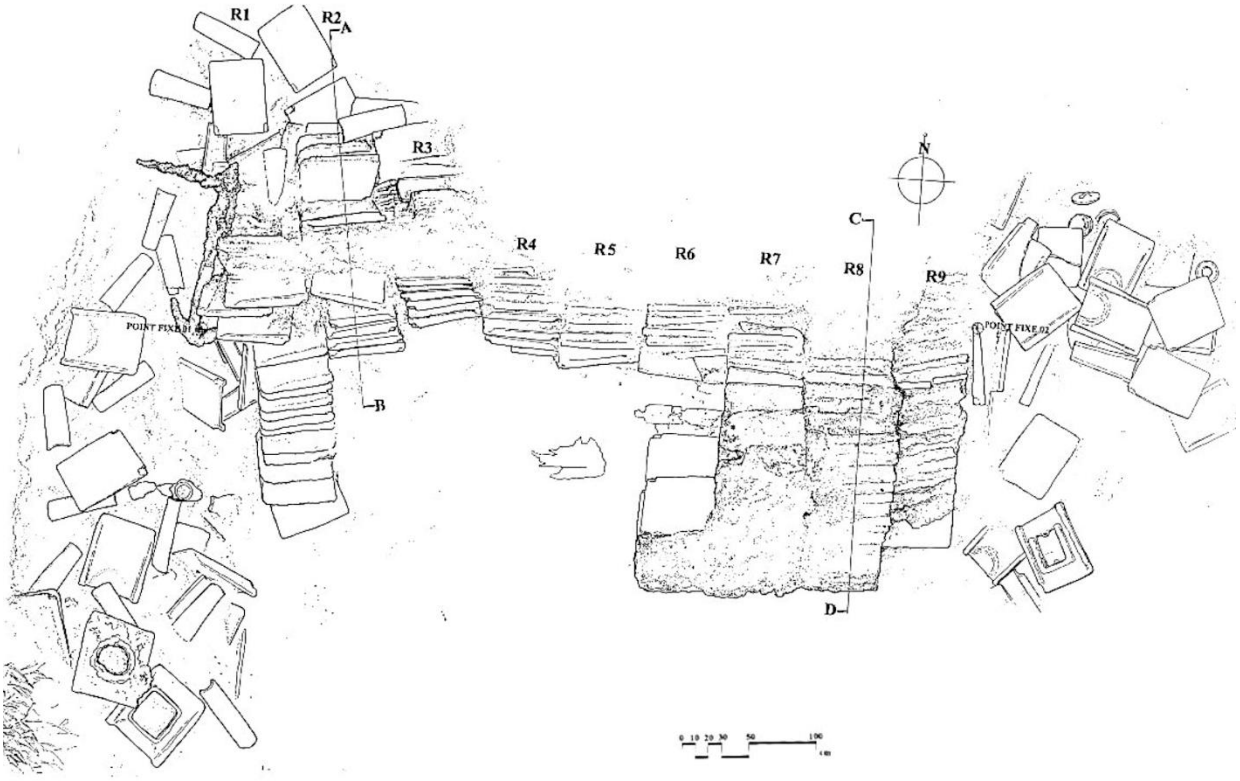


Figure 7. Plan of the shipwreck Lardier 4 (From Joncheray and Joncheray 2004).

Shifting to the East, with the huge cargo of Boka Kotorska (Montenegro) we are in front of an apparently "mixed solution". Indeed, observing the site plan (Royal 2012: 405-460) one can notice that the roof tiles are resting vertically on their shorter side, covered by an additional layer of scattered and probably overturned pieces. In this context there could be hypothesized an organization where at least two rows of roof tiles are positioned perpendicularly to the longitudinal axis of the hull and, running parallel to the previous, there are ten shorter rows, all resting vertically on their shorter side.

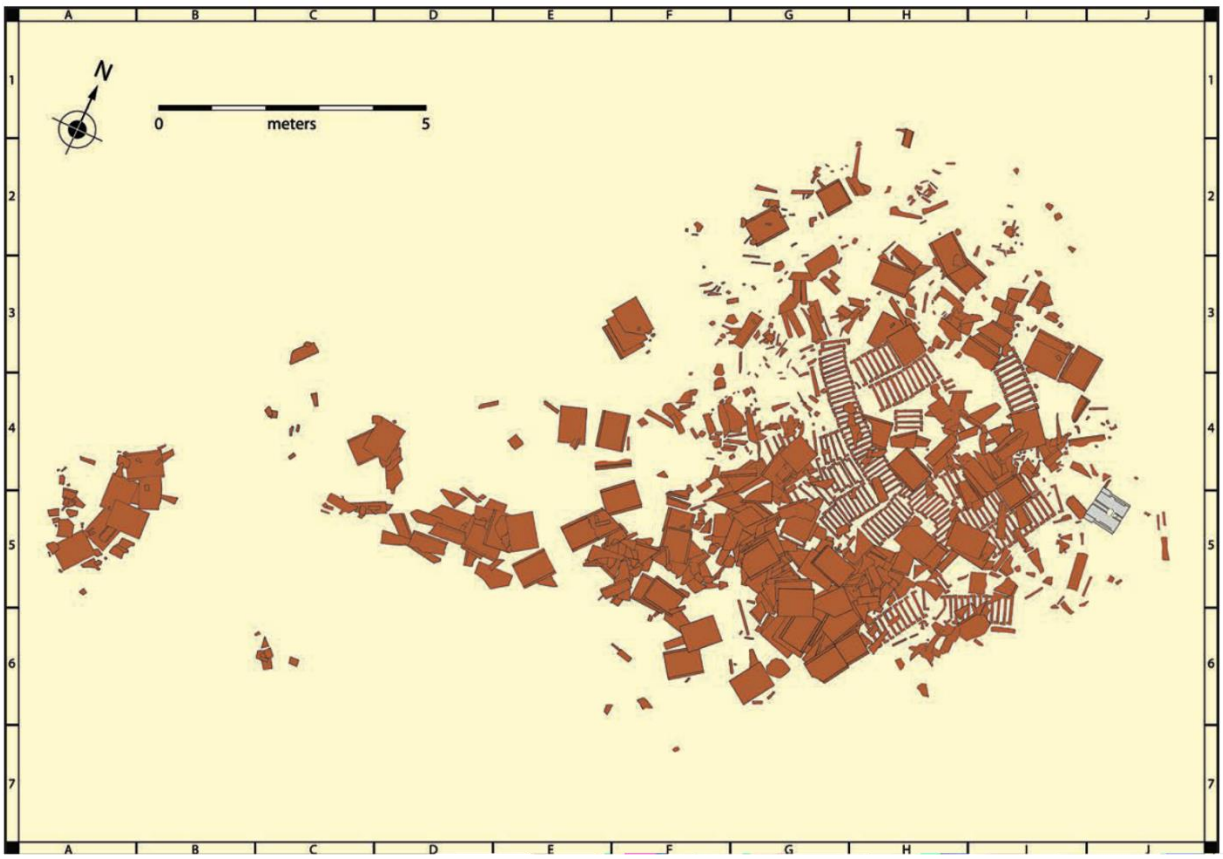


Figure 8. Site plan of Boka Kotorska shipwreck (From Royal 2012).

The shipwreck of Pianosa (Dae27), 642 meters deep in the Tyrrhenian Sea, is of particular interest both for the methodological aspect and for the potentially great preservation of the components of the cargo at such depths. The study of this site by the team of Ca' Foscari University in collaboration with Azionemare Foundation is still ongoing (Costa *et al.* 2022: 2106-2022). In this case, we are in front of a mixed cargo where the roof tiles, that travelled with Dressel 1 a-c amphoras, occupy the centre of the context and seem to be arranged in several rows. The previous seem to be parallel both to each other and in relation to the longitudinal axis of the hull, always on at least three overlapping levels. Instead, due to their scattered position, it seems still difficult to reconstruct the original position of the cover tiles.

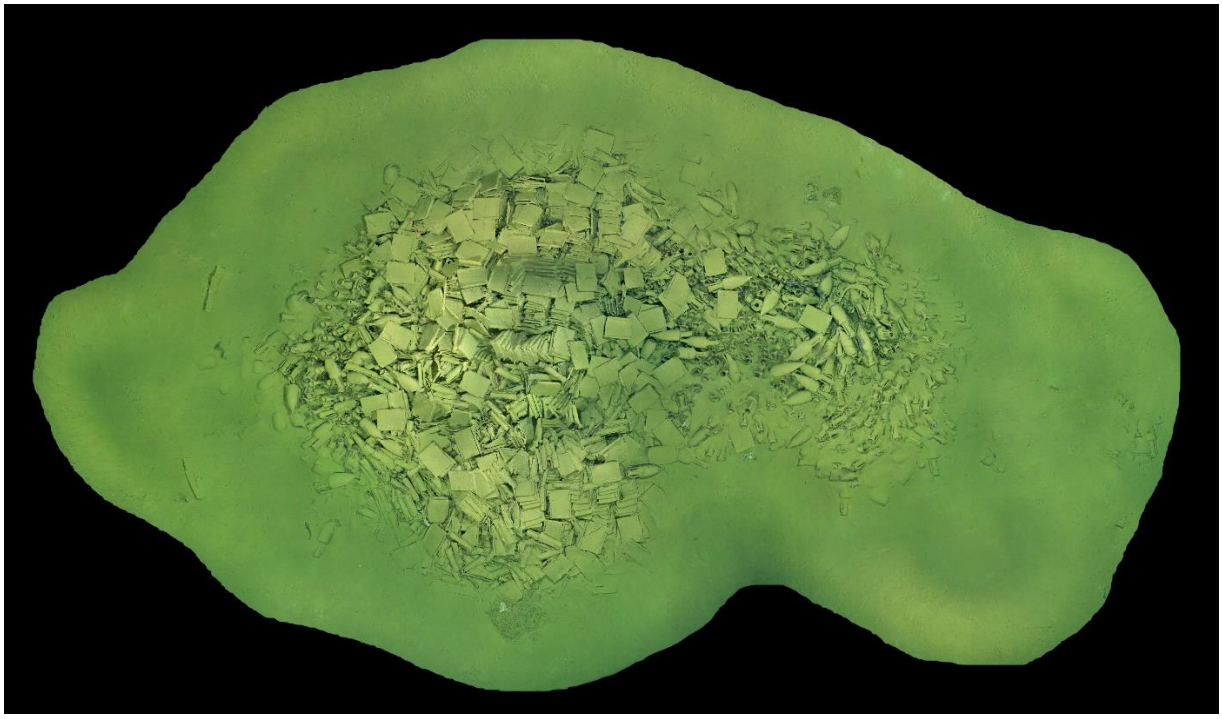


Figure 9. Orthophoto of the cargo of Pianosa (Dae 27) (elab. E. Costa).

The vessels employed

With regard to the analysis of the vessels involved in the circulation of ceramic roofing materials, the first thing to say is that a lot of work still needs to be done. In fact, also for this aspect, few and inhomogeneous is the information available to date.

There has been carried out a precise and systematic study of the hulls linked to the roof tile's cargoes discovered in the Var region, along the southern French coasts. Here, there has been hypothesized that the hull remains belonged to medium-small vessels, suitable for coastal cabotage, with an average length of about 10-12 meters and characterized by a small tonnage (Joncheray and Joncheray 2012: 57-69; Wicha 2004: 135-143).

A particular fortune has occurred concerning the riverine circulation, in fact, a remarkable context has been studied in the Stella river, situated in the northern Adriatic area. It has been possible to hypothesize that the Stella 1 shipwreck was a small, flat bottomed river barge about 5 meters long (at least as far as can be deduced from the preserved portion), assembled according to local sewing tradition (Capulli 2016: 29-41).

We do not have a lot of information about the ships employed for the transport of large cargoes (Boka Kotorska, Punta Scario A, Pianosa) and employed through offshore navigation. It is important to point out that this is a great blurred point if we aim to outline a precise and scientifically objective picture of what was the maritime circulation of these materials.



Figure 10. Wooden model for the hull of Stella 1 shipwreck (From Capulli and Castro 2016).

Conclusion

The systematic study of the roof tiles' cargoes in Roman Mediterranean led to the hypothesis that the diffusion of these materials took place on various scales and through different sailing modes.

We can affirm that a regional circulation (Var Region cargoes; Stella 1) took place for small quantities of goods, transported in short routes - probably by cabotage - and produced in small, local centres. For this kind of circulation there were probably employed small to medium ships or small, flat bottomed river barges. At the same time occurred an interregional scale circulation (Pianosa, Bocche di Bonifacio, Capo Carbonara C), with cargoes that go from few units to thousands of pieces, handled through a navigation in open sea, or not exclusively characterized by small, coastal cabotage.

With regard to the stowing patterns observed, they could be resumed in a general scheme whereby the roof tiles are arranged in parallel rows positioned in the middle of the hull, with an orientation sometimes perpendicular, sometimes parallel to its longitudinal axis. The cover tiles, instead, were disposed in side stacks positioned around the roof tiles' rows and also inserted vertically in the gaps, probably to stabilize the cargo.

In the past studies, the ceramic roofing materials found in underwater contexts have often been interpreted as resalable ballast, loaded mainly in the return journeys. It is time to overcome this bias, related more to the consideration of these materials as lacking value than to an actual line of reasoning about cargoes. First of all, these materials are characterized by a high coefficient of stowage (McGrail 1989: 353-359) which means that in relation to their specifical weight they occupy a lot of space and this characteristic would have made them inconvenient to be loaded just as ballast. Secondly, there is no evidence that the transport of ceramic roofing materials was free from any fiscal interest (Thébert 2000: 341-356).

There has been hypothesized that the areas of maritime distribution of the ceramic roofing materials correspond in good measure with those of the Annona's routes (Gianfrotta 2015: 111-133) and, for this

reason, roof tiles and cover tiles could have been shipped systematically as profitable ballast in the Annona's merchantman. However, to value this charming assumption, further analysis would be necessary, to study the extent and variability in the volume of the materials handled and the mechanisms that regulated the availability of this sort of goods for the different shipping carriers in the storage and redistribution centres.

Looking at the general framework generated by now, we have to point out that there is a great lack of data and several questions still remain, especially regarding the vessels employed in the handling of large cargoes (Kerme, Boka Kotorska) - used probably for direct, offshore circulation - and the reasons that led to the transport of these materials not only in a regional trade system but also in long-range distribution contexts.

The necessity of an updated database of roof tiles and cover tiles production and distribution in the Roman Mediterranean appears clear. The previous should be based on a systematic study of this type of materials that starts from morphological and epigraphic analysis and necessarily passes through archaeometrical studies. These should include fabrics characterization, a cross study of the data from ceramic roofing materials and the other components of the cargoes, but also the employ of the multivariate analysis or PCA (Principal Components Analysis) to build a differentiation model that allows to establish relations of belonging between a large number of materials, relying on common chemical-physical and petrographic properties.

Finally, it would be desirable to make a systematization of the capillarized data from the production and storage facilities, in order to be able to discuss on the connections and the different relations with the materials object of our study between these contexts, the harbours and the redistributive infrastructures of the Roman Mediterranean.

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Mugs and beakers by the sea. Thin-Walled Pottery in Ionian-Adriatic area

Rita Auriemma[1] and Carlo De Mitri[2]

Abstract

Thin-Walled Pottery, while underrepresented in the Salento peninsula, has gained attention through studies of materials found in the waters of Torre Santa Sabina near Brindisi, southern Apulia. These studies have expanded our understanding and defined two principal groups of this ceramic type. The first group, linked to a Late Republican shipwreck, includes beakers inspired by Tyrrhenian designs but likely produced in the Ionian arc or in the Taranto area. The second group, featuring grey gloss cups, relates to early Imperial Adriatic productions. The connection of these to another wreck is still under discussion. This data initiated a comparative study of similar finds in other wrecks and a detailed analysis of Torre Santa Sabina materials in relation to the Ionian-Adriatic area.

Keywords: Thin-Walled Pottery, trade, shipwreck, Adriatic Sea, late Hellenistic pottery, Roman pottery

The Thin-Walled Pottery in shipwrecks

One of the most distinctive types of fine ware from the Roman period is Thin-Walled Pottery (TWP). Its production began in the 2nd century BC in various centres on the Italian peninsula. The production of TWP spread rapidly to different regions of the Mediterranean, experiencing a flourishing period of circulation that lasted until the 2nd century AD. Although TWP production was organised in regional centres, archaeological evidence suggests that these vessels were transported over considerable distances despite their fragility. The earliest examples of this ceramic class are well documented in the necropolis of Taranto, where they are probably locally produced. However, in the rest of the Salento peninsula, these ceramics are less represented. Even during the period of the Roman Empire, this ceramic class remained relatively rare in southern Apulia, in contrast to northern Apulia, where local production is also documented.[3]

In wrecks, both as onboard material and as cargo, Thin-Walled Pottery is not very common. Records are found mostly in the Western Mediterranean: along the coasts of southern France, and sporadically along the Tyrrhenian coast of central Italy. In the Adriatic, at the moment, apart from the material from the Torre Santa Sabina wreck, only one specimen as onboard equipment from Uljeva A wreck is known.

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[3] See Leone 2021 for a summary on TWP; refer to Millet 1993 for notes on its widespread distribution. For the situation in Apulia, see the following paragraphs.



Figure 1. Map of shipwrecks with the presence of Thin-Walled Pottery.

Notably, only in a few cases is it possible to ascertain the relevance of Thin-Walled Pottery finds to the cargo of a vessel. The only certain case is that of the Cala Culip IV wreck, located in the northeast of Catalonia, on the northern side of the Cap de Creus promontory (Nieto 1986; Nieto et al. 1989; Puig 1989; Parker 1992; Millet 1993; Nieto and Puig 2001). Here, the remains of a vessel lying at a depth of 7 meters were investigated. It was a small vessel (approximately 10 meters long and 3 meters wide) redistributing a cargo of just over twenty tons, mainly composed of Dressel 20 oil amphorae from Baetica and more than 4000 fine tableware ceramics.

These included about 2000 plain South Gaulish Sigillata Pottery, among which 800 decorated ones, and about 1500 pieces of Thin-Walled Pottery of Baetican production, mainly consisting of beakers of Mayet XLII A type, bowls of Mayet XXXV-XXXVII type, and two handled cups of Mayet XXXIX type. The study of the cargo allowed for a chronology to be established between 70-80 AD. The Cap Culip IV case seems to be the only one with a primary cargo of Thin-Walled Pottery; in other contexts, only supplementary cargoes or smaller batches/lots are observed, such as in the following cases.

The wreck of "La Tradelière" in Antibes (Liou 1973: 603-604, Figures 36-37; Fiori and Joncheray 1975; Pollino 1986) features a mixed cargo predominantly composed of transport containers: Italic amphorae, with a small number of Dressel 1B and a large presence of Lamboglia 2, Eastern amphorae, with Dressel 2-4 from Kos in various forms, the most represented type in the deposit, comprising 50% of the cargo,

but also Chian, late Rhodian and the Syro-Palestinian Kingsholm 117 type. Iberian amphorae, with Dressel 9, were found in significantly smaller numbers.

Alongside the amphorae, there are other materials: a group of Thin-Walled Pottery of Baetican production, with cups and mugs transported nested or stacked; guttus and amphoriskoi; Pompeian red slip plates, and a batch of glassware consisting mainly of footless coloured glass cups (blue, green, purple, amber, and rarely white).

The main cargo appears to have consisted of hazelnuts, probably transported in sacks but in the investigations were recovered dates, possibly as ship provisions (in Dressel 2-4 specimen), "biacca" or lead white, a pigment used for painting (in Dressel 9), and probably sage-flavoured wine (maybe in Dressel 2-4). It seems to be a secondary formation cargo, with goods from the eastern Mediterranean, later reassembled in a Tyrrhenian Italian port, as suggested by the ceramic materials, the Dressel 1 amphorae, and the Pompeian red slip plates, as well as organic materials like the hazelnuts, if their origin from Campania is confirmed. For chronology, some amphorae suggest the mid-decades of the 1st century BC, but the Thin-Walled Pottery points to the last years of the 1st century BC.

In the wreck of Port Vendres II (Colls et al. 1977; Parker and Price 1981), one item of the cargo consists of pure white tin ingots, weighing between 3 and 8 kg, of heterogeneous shape, with numerous stamps; on 12 of the 18 recovered, the name *Lucius Valerius Augustae libertus a commentariis*, He was an imperial official under the provincial procurator, freedman of Valeria Messalina, wife of Claudius or Claudius himself (terminus post quem 41-42 AD). The ingots probably came from Extremadura or western Lusitania, from the Albuquerque region, and had then followed a route by land to Merida and then to the Guadalquivir, where they were loaded, together with amphorae.

The same cargo includes disc-shaped bronze ingots and lead ingots (Domergue type I) from the mines of the Sierra Morena. There were also amphorae: Dressel 20 amphorae, with numerous stamps and tituli picti; Haltern 70 amphorae, with *tituli picti* proving the content was wine, *defr(utum) excel(lens),* Pompei VII amphorae for fish preserves, Dressel 28. Complementary to the cargo was a small batch of Thin-Walled Pottery of Baetican production (except one probably Italic specimen): about sixty 'eggshell' fragments and about twenty (13-14 minimum number of individuals) sandblasted or decorated à la barbotine.

The wreck of Diano Marino, perhaps the most informative dolia vessel, which also contained a batch of Tarraconian amphorae from the Lower Llobregat kilns, revealed the presence of numerous fragments of TWP beakers, mugs and cups: 8 in the bow area and 68 in the stern, where the presence of a 'kitchen-cabin' is assumed. Also found in the stern area were 35 fragments of Terra Sigillata Aretina and Italica and, above all, 278 fragments of Common Ware (jugs, pitchers, *olpai*, pots, urns, etc.), some with burnt marks, and 76 fragments of Cooking Pottery, as well as other clay and metal objects and fishing equipment. These numbers seem indicative not so much of ship's equipment (to which the classes of fine tableware were referred), but of small lots of accompanying goods. The dating by Dell'Amico and Pallarés to the mid-first century AD has been raised by Berni to the years between 15 and 30 and by Cibecchini to the decade 30-40 AD (D'Amico and Pallarés 2005; D'Amico and Pallarés 2011; Navigia 1983: 69-118 (95-97: catalogue Thin-Walled specimens); Berni 2015; Cibecchini 2020: 175).

In most contexts, Thin-Walled Pottery is instead pertinent to the ship's equipment, as in shipwrecks, such as in the following cases (the list doesn't pretend to be exhaustive).

At Roches d'Aurelle, the remains of a vessel transporting roof tiles, Gauloise 5 and 2 type amphorae, and tableware lie at 72 m of depth (Pollino 1987). The study of all the materials allowed their attribution to

workshops of the Var region, which confirms the homogeneity of the deposit and the existence of short-range coastal trade that distributed products from various potters, grouped together, produced in the Argens valley, loaded in Frejus, and directed to a port in eastern Provence or Liguria. Despite looting, it is estimated that the cargo comprised about a thousand vases, sixty amphorae, and 250 bricks. The few pieces of the ship's equipment, including a Deneuve VA / Bailey B II volute lamp, a South Gaulish Sigillata from La Graufesenque, a Thin-Walled Pottery mug type Mayet XLII, and a Dressel 20 amphora, date the shipwreck to the late 1st century AD.

At Calanque de l'Ane, a cargo mainly consisting of *tegulae* and *imbrices* was found. The site yielded numerous Common ware, possibly also part of the cargo, and various fragments of onboard material: Dressel 20, Gauloise 4, and Gauloise 7 amphorae, Terra Sigillata from southern Gaul, Thin-Walled Pottery and Grey Pottery. Coins of Titus and Domitian date the shipwreck to the late 1st century AD or at most the early years of the 2nd century AD; notable similarities exist with the wrecks of Roches d'Aurelle and Dramont G. (Parker 1992: 92-93; Ximénès and Moerman 1992; Ximénès and Moerman 1994). In the Albenga famous shipwreck, the more recent investigations (2019), carried out in the area of the bilge well, recovered a double-handled cup[4]

At Ladispoli, the cargo materials included dolia, with *planta pedis* stamps of the *Piranii*, and some fragmentary amphorae, including italic Dressel 2-4 amphorae (Campanian production), sealed with cork stoppers covered by a thin layer of clay. Among the ship's equipment were a little lot of Haltern 70 amphorae and Arretine Terra Sigillata, Thin-Walled Pottery, Pompeian Red Slip ware, household ware and a small medical kit. The chronology is well fixed to the early years of the 1st century AD (D'Atri and Gianfrotta 1986; Gianfrotta and Hesnard 1987; Gianfrotta 1989; Carre 1993; Cibecchini 2020:181-182). Finally, terrestrial contexts strongly connected to underwater ones are represented by the stratigraphy of the port of Naples, which contain a wide range of TWP, mainly from *Neapolis* and Campanian areas, but also from extra regional production sites (e.g., southern Tuscany or the Arno valley), dated between the Late Republican period and the 2nd cent. AD (Faga 2008; Faga 2010; Guarino et al. 2016).

The Uljeva A wreck, one of the Roman wrecks discovered near Cape Uljeva, in the south-eastern part of the Istrian peninsula in Croatia, is dated to the middle or, more precisely, the second half of the 1st century B.C. The main cargo consisted of about a hundred wine amphorae, mainly of the Lamboglia 2 type, with a smaller number of Dressel 6A and funnel-neck amphorae.

The ship's equipment included cooking pots, such as the *olle ad impasto refrattario*, made in the Padanian area. Also found were plates of Eastern Slip Ware A, Black Gloss Campanian ware, a Priapus-shaped plastic oil lamp and a body sherd of a thin-walled beaker with barbotine decoration, Marabini type I. Other notable small objects in glass and stone used by the crew were also discovered (Bekić 2020: 21-61).

The analysed findings all refer to ships sunk mainly between the 1st century BC and the 2nd century AD, and the Thin-Walled Pottery artifacts primarily come from Baetica or Gaul or from Italian Tyrrhenian workshops.

The case of Torre S. Sabina stands out as unique, both due to the presence in one or possibly two underwater deposits and for the early chronology of one of the two identified contexts.

R.A.

[4] The type is PAR-FIN 10 = Atlante II, tipo 2/316 = Marabini XXV = Mayet X; Trigona et al. 2023: 120.

Torre Santa Sabina underwater investigations

Located approximately 25 km north of Brindisi, the bay of Torre Santa Sabina (Auriemma 2004: 66-81; Auriemma 2014) (Figure 2) was the subject of the first surveys and recoveries of numerous materials as early as 1972, thanks to a group of local young divers led by L. Zongoli. These were followed, from the same year until 1976, by systematic interventions by the Experimental Center of Underwater Archaeology of Albenga, promoted by the Directorate of the Provincial Museum of Brindisi. This marked the beginning of research carried out in the following years, also thanks to the commitment of the "N. Lamboglia" group, composed of volunteer divers collaborating with the Museum and the Superintendent's Office.

After Lamboglia's death, the founding father of underwater archaeology in Italy and Europe, the company Itinera (later Aquarius), again commissioned by the Provincial Administration, continued the investigations in the bay in 1978 and 1983. The subsequent decade of stagnation was interrupted in 1992 with the documentation and protection intervention of the wreck Torre S. Sabina 1, again carried out by the "N. Lamboglia" group, on behalf of the Superintendency for Archaeological Heritage of Apulia.

In the 1990s, and more systematically since 2004, surveys and measurements have been carried out as part of the research program "Ports and Harbors" of the CNR Strategic Project - University of Lecce 251100 and the Underwater Archaeology course at the University of Salento, as well as a review of the entire substantial quantity of material stored in the museum deposits of Brindisi.

Torre S. Sabina has become the setting for a pilot intervention within the international project UnderwaterMuse, aimed at enhancing and making accessible the substantial submerged heritage of the involved areas, otherwise invisible or reserved for few, through the creation of underwater archaeological parks and the narrative and communicative use of virtual reality. The Project, funded under the Interreg V-A Italy-Croatia 2014-2020 Cross-Border Cooperation Program, sees the Apulia Region - Department of Tourism, Cultural Economy, and Territory Enhancement among the partners, along with ERPAC - Regional Institution for Cultural Heritage of the Autonomous Region of Friuli Venezia Giulia (Lead Partner), Ca' Foscari University of Venice, Public Institution for Coordination and Development of Split - Dalmatia County RERA S.D., and the Municipality of Kastela (Croatia).

The analysis of both new and old findings (Auriemma, Antonazzo and De Mitri 2025) has allowed the identification of three definite wrecks: one from the late 6th to early 5th century BC; one from the late 2nd to early 1st century BC; and one from the late 5th to early 6th century AD.

R.A.

The Thin-Walled Pottery in Torre Santa Sabina Wreck 4

The examination of new and old data has allowed for a significant number of objects to be attributed to the cargo of a late Republican ship, dating to the last quarter of the 2nd century BC. The artifacts recovered from excavations and investigations conducted in the waters of the Bay of Torre Santa Sabina over the years represent only a small portion of the original underwater deposit, yet they provide insights for reconstructing the cargo.[5]

[5] All quantitative indications and information regarding ceramic materials are derived from the various contributions present in Auriemma, Antonazzo and De Mitri 2025.



Figure 2. Torre Santa Sabina: bay and map of submerged and partially submerged evidence.

Based on the materials found, the cargo consisted of amphorae (27%), intended for the transport of organic products, and pottery intended for various uses, mainly the consumption of food (55%) and, to a lesser extent, its preparation and cooking (15%). Additionally, lamps (2.7%) and ointments (0.3%) were recovered (Figure 3).

The detailed study has also allowed for hypotheses to be made regarding the presumed on-board material, which could have belonged to both the crew of the vessel and any potential passengers. Out of a total of approximately 550 amphorae, the majority, 86%, are local, produced in the Roman *Calabria*-Salento area, predominantly of the transitional form between late Greco-Italic and Lamboglia 2. In addition to other local containers (especially oil amphorae) that resemble forms made in the artisanal workshops of the Brindisi hinterland, there are also some Aegean containers, with Rhodian amphorae being the most numerous among them. Additionally, a few Tyrrhenian containers, such as Dressel 1 and Dressel 2-4, are present.

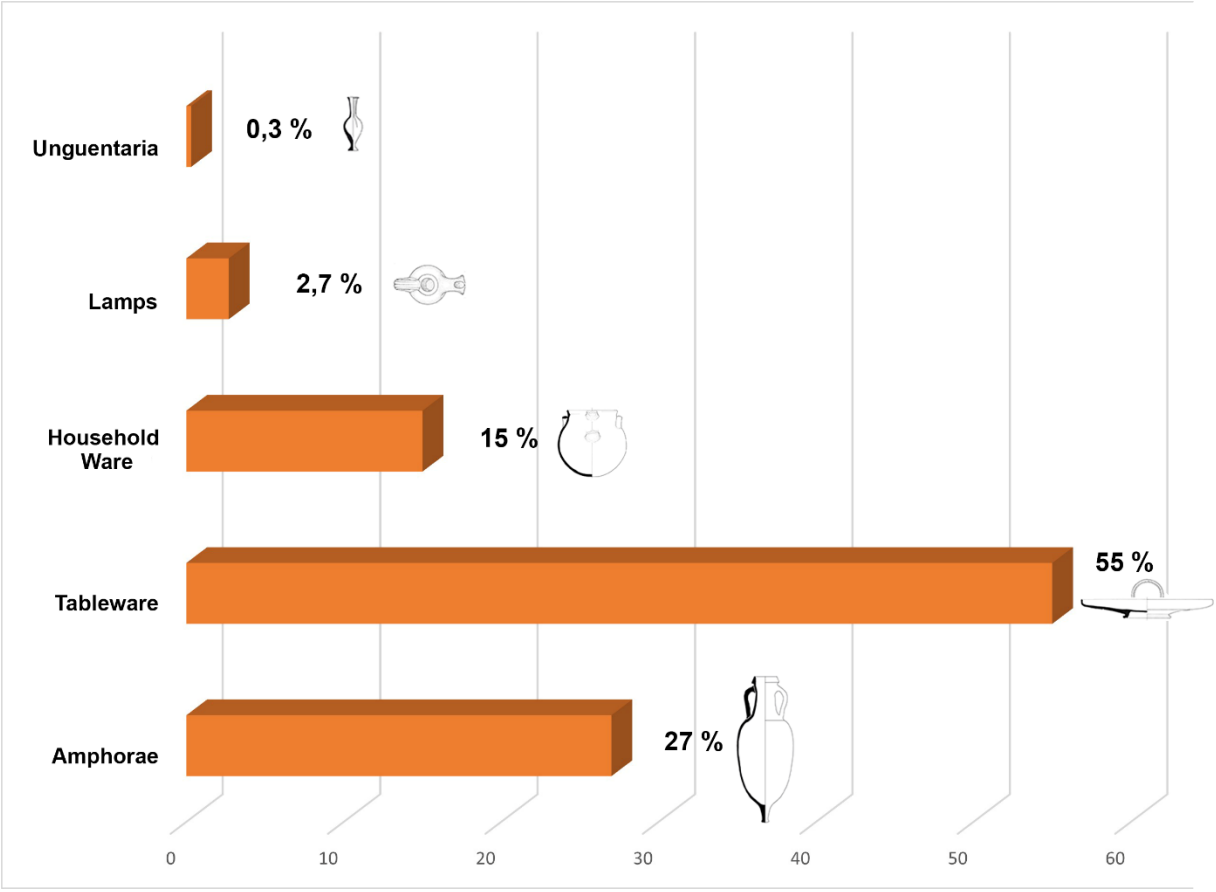


Figure 3. Percentages of ceramic groups attributed to the cargo of Torre Santa Sabina 4 wreck.

The number of pottery pieces is very high, approximately 1,400 specimens, of which 21% belong to the functional group of household ware, while 79% fall into the functional group of fine tableware.

Within this group of pottery, several families of ceramics can be distinguished: Black Gloss Ware, produced in both Tyrrhenian and Ionian-Adriatic regions; Grey Ware, almost exclusively of Apulo-Lucanian production; Red Slip Ware and Mould-Made Relief Ware, with objects from Ionian-Adriatic and Levantine production; and finally, Thin-Walled Pottery.

Thin-Walled Pottery is a diverse category in which it is now possible to identify a wide range of productions from various locations around the Mediterranean, spanning from the late Republican to the late Imperial periods.[6]



Figure 4. First generation of TWP: 1-7. Deep beakers (Drawings: Fabiola Malinconico).

[6] For initial information regarding the presence of Thin-Walled Pottery in Torre Santa Sabina, see Antonazzo 2014: 191-192.

Recent studies have summarized the main aspects of this category, but a unified classification is still needed, although Julie Leone's work in Musarna, despite some challenges, has attempted to update the framework on the typological proposal of Italic productions.[7]

Regarding the material attributable to the cargo of the late Republican wreck, there are approximately seventy specimens of Thin-Walled Pottery. These are mostly beakers, usually unslipped, often with decoration à la barbotine applied, rarely with incised decoration. Only in a few specimens are traces of slip recognized.

The most frequently attested form is the deep beaker, with a height between 10 and 12 cm, which can have an ovoid, fusiform, or, rarely, cylindrical body with an everted rim and moulded lip, type Marabini I (Figure 4.1-2), simple everted rim, type Marabini III (Figure 4. 3), or vertical and swelling rim type Marabini IV (Figure 4.4, 6).

This is followed by the shallow beaker, with two different groups: the first group is similar to the deep beakers but with a smaller size module, less than 10 cm in height (Figure 4.7; Figure 5.1-4); the specimens of the second group have a globular body, type Marabini V-VI, rarely cylindrical, with thorn decorations or partially slipped (Figure 5.5-6; Figure 6).

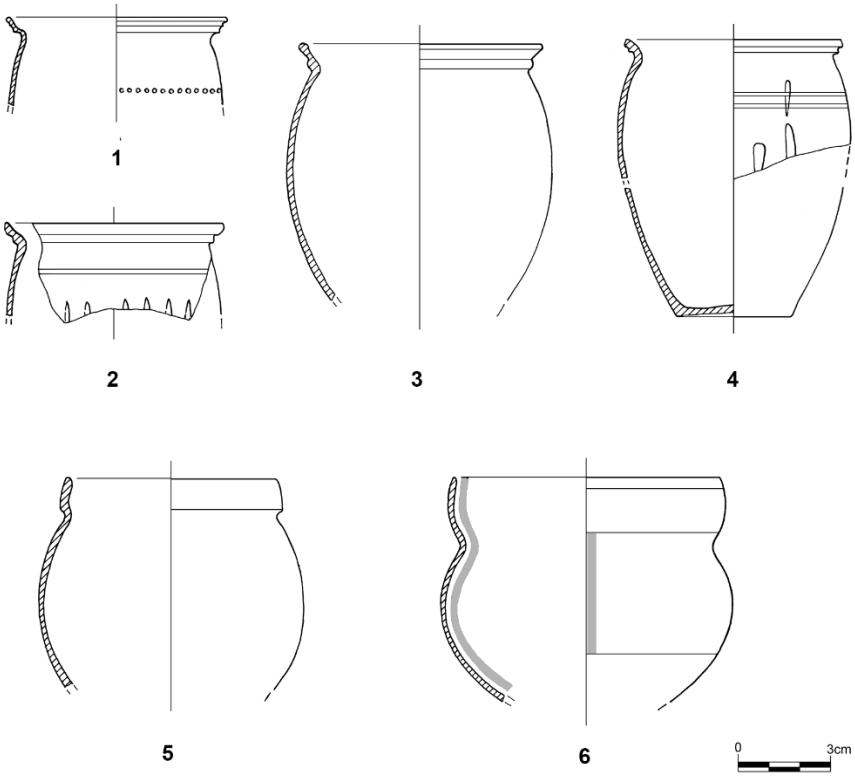


Figure 5. First generation of TWP: 1-6. Shallow beakers (Drawings: Fabiola Malinconico).

[7] A summary has been proposed in Gervasini 2005 and Tassinari 2019, now updated in Leone 2021, where a typological classification is created that attempts to include the historical ones: Marabini Moevs 1973, Mayet 1975 and Ricci 1985.

The Thin-Walled Pottery specimens presented here constitute a homogeneous complex in terms of technical and manufacturing characteristics, and fall within the morphological repertoire of the late Republican period, with forms and types attested at various Mediterranean sites between the second half of the 2nd century and the early 1st century BC.



Figure 6. First generation of TWP: 1-4. Shallow beakers (Drawings: Fabiola Malinconico).

In the absence of specific analyses on the clays, it is difficult to indicate the production sites of these objects, yet the close similarity with materials found in the necropolises of Taranto suggests a similar provenance (Hempel 2001: 115-116 and Colivicchi 2001). In the Ionian arc, manufacturing facilities were active, producing various ceramic objects, and Taranto and Heraclea were among the centres that produced, among other pottery, Thin-Walled Pottery.[8]

C.D.M.

The first generation of Thin-Walled Pottery: the attestation in the Ionian-Adriatic Sea and beyond

In an initial study on the presence of Italic ceramics in the Eastern Mediterranean during the Late Hellenistic period, Lund aimed to define the extent of such attestations; in relation to this first generation of Thin-Walled Pottery, he also touched upon the issue of possible non-Italic productions that could be attributed to Aegean-Eastern manufacturing centres.[9]

The update of this distribution map (Figure 7) shows a good spread of these objects, though still limited to an extremely low number of specimens.

In the northern Adriatic area, during the early phase of attestation, TWP findings have been recorded in Aquileia, Sevegliano, and Adria, with the exclusive presence of hemispherical cups that seem to be of mid-Adriatic production, specifically from the Adria area (Donat 2010(2): 50).

In the central Adriatic, in Jesi, the ancient colony of Aesis, ceramic production was active since the early phases of its foundation in the second half of the 3rd century BC.

Among the various ceramic classes, TWP was also produced, although this production seems to increase mainly between the late 2nd and 1st centuries BC. Therefore, the oldest attestations from the mid-2nd century BC, also recorded in Ancona in funerary contexts, might pertain more to imports than to local productions.[10]

Regarding southeastern Italy, in addition to the already mentioned possible production centres in Taranto and Heraclea, Thin-Walled Pottery specimens are documented in Torre Santa Sabina and Ugento.[11] In other sites, including Brindisi and Vaste, "hybrids" are attested as they adopt the morphological repertoire of TWP but share technical characteristics with household ware made of refractory clay. These objects are primarily documented in funerary and cultic contexts (De Mitri 2016).

[8] The hypothesis of a manufacturing centre in Taranto is supported by the analysis of pottery found primarily in the necropoleis (Colivicchi 2001 and Hempel 2001) and in wastes from the settlement (unpublished pieces exhibited at MARTA), although for some specimens, an import from the central Italian area cannot be excluded (Leone 2021). For Herakleia as well, a centre with a strong manufacturing vocation in the 2nd century BC, observations on the material in the necropolis lead to this interpretative proposal (Giardino 1990).

[9] Lund 2004: 6-8; The Aegean-Eastern productions are discussed in Peignard-Giros 2013 for Delos and in Elaigne 2014 for Alexandria.

[10] For Jesi: Brecciaroli Taborelli 1998 and Tassinari 2019: 100; for Ancona: Colivicchi 2002.

[11] For Ugento: Caggia c.s.

On the opposite shore, the attestations are somewhat sporadic, in Lissos, Orikos, Ambracia, and inland in Kephalochori in Thesprotia[12]; in the inland of Albania in Selcë e Poshtme (Ceka 1985); in the Macedonian area in Thessaloniki, and inland in Heraclea Lyncestis and Stobi.[13] The findings in Corinth, Athens, and especially Delos seem to connect[14] with the attestations in the Eastern Mediterranean, both on the Anatolian coast[15] in Pergamon and Ephesus, and in the Levantine area[16] in Paphos, Beirut, Tel Anafa, and Alexandria; finally, findings in Cyrenaica in Berenice (Kenrick1985: 307-309) are also noted.



Figure 7. Map with presence of first generation of Thin-Walled Pottery in Aegean and Eastern Mediterranean.

[12] For Lissos: Kögler 2019; for Orikos: De Mitri and Loprieno 2019; for Ambracia: Antoniadis and Pliakou 2022: 531; for Kephalochori: Riginos 1997: 103-105.

[13] For Tessalonica: Tsimbidou – Avlonitou 1994; for the inland sites of Macedonia, Heraklea Lyncestis and Stobi see: Anderson-Stojanović 1992: 35-37.

[14] For Corinth: James 2020; for Athens: Rotroff 1997: 105 Figure 5,2 and Hayes 2008; for Delos: Xantzidakis 1997 and Peignard-Giros 2013 with previous bibliography.

[15] For Pergamon and Ephesus see Japp 1999 and Meriç 2002: 72 pl. 32–33 K372–373.K376; 74, pl. 36, K424.

[16] For Paphos: Hayes 1991: 59–60 Figure 22,1–4; for Beirut and Alessandria: Elaigne 2014; for Tel Anafa: Slane 1997: 350-353.

The distribution map of this first generation, created using QGIS, highlights how the spread coincides with the expansion of the Roman market. The macroscopic characteristics of the clays and the morphological repertoire suggest that these specimens belong to Italic productions.

This is the first generation of Thin-Walled Pottery, whose production centres are mainly sought in Italy. However, this production seems to already be finding success in other areas of the Mediterranean, still in a phase from the late 2nd to early 1st century BCE.

Based on these conclusions, it is not possible to determine the exact places of origin of the TWP, but it cannot be excluded that some specimens are imported from Southern Italy, where the workshops of Taranto and Heraclea were presumably active. Furthermore, some questions arise, such as whether the consumption of new beverages in territories under Roman control or where Italic traders operated, and whether new drinks were to be drunk in deep beakers, perhaps because they were fermented and frothy beverages.[17]

A more careful study of the materials and contexts of their discovery could perhaps lead to a distinction between an initial phase, dating from the mid-2nd century to the Sullan age, in which Italic materials probably used by Italics themselves, who were by then frequenting the Aegean-Eastern Mediterranean, are predominant, and a subsequent post-Sullan phase, in which such objects begin to be produced also in non-Italic workshops, as seen in the cases of the production centres in Egypt and Asia Minor at Knidos, Pergamon, and Paphos on the island of Cyprus.

C.D.M.

Second generation of Thin-Walled Pottery: an early-imperial ghost cargo

About thirty specimens belong to the second generation of TWP to be placed in the early Imperial period. These are mainly bowls (Figure 8.1-4), mugs (Figure 8.5) and two-handled cups (Figure 8.6-8).

Among the various types, a recurring production can be identified: the grey one with clay and slip grey (Figure 9). This is the most widespread class of Thin-Walled Pottery in the early Imperial period on both shores of the Adriatic basin, extending to the southern Adriatic as evidenced by the data from Salapia (De Mitri 2022). The occurrences become less frequent in sites overlooking the Strait of Otranto, becoming sporadic in the Aegean Mediterranean. It is a production with medium-range circulation, produced in various workshops located on both sides of the Adriatic.[18] Other materials thus seem to provide clues to define the presence of another wreck from the early Imperial period[19] with different material, where pottery from the central-northern Adriatic area predominates, such Italic Sigillata, with Aco beakers (Figure 10.2) Sarius cups (Figure 10.3) and bowls of Padanian Sigillata (De Mitri 2025) (Figure 10.4), lamps "a volute" (Giannotta 2025) (Figure 10.5-6) and a small batch of amphorae (Auriemma 2025) (Figure 10.1).

[17] For a summary on the use of fermented beverages in antiquity and a recent bibliography on both socio-anthropological issues and case studies, see Michler 2024.

[18] For the possibility of a mid-Adriatic production, see Menozzi 1995 and Tassinari 2019: 100-102; for a production in Dalmatia, see: Ožanić Roguljić 2019.

[19] See Auriemma, Antonazzo and De Mitri 2025.

C.D.M.

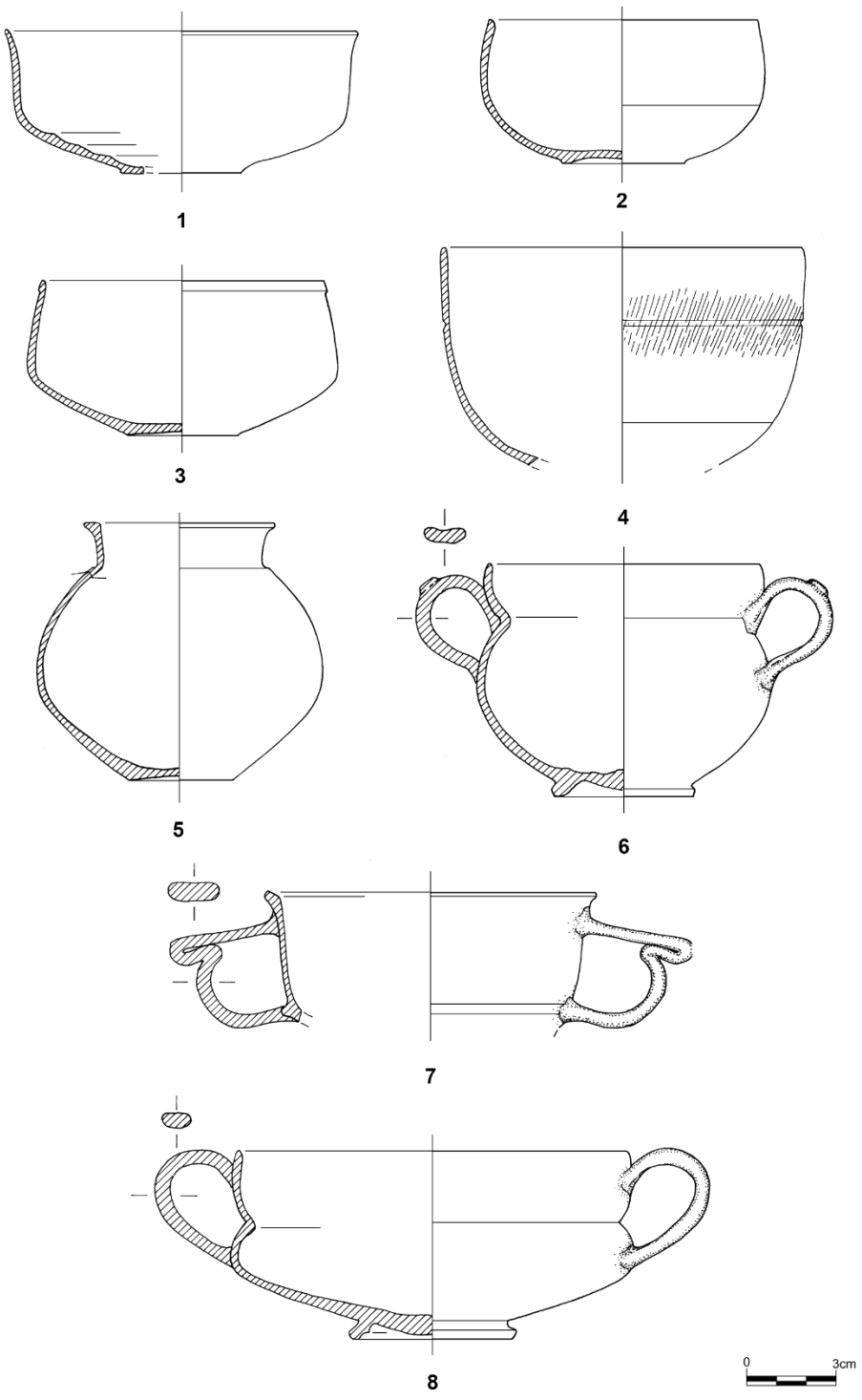


Figure 8. Second generation of Thin-Walled Pottery: 1-4. Bowls; 5. Mug; 6-8. Two handled cups (Drawings: Fabiola Malinconico).



Figure 9. Second generation of Thin-Walled Pottery: 1-2. Bowls; 3-4. Two handled cups (Drawings: Fabiola Malinconico).

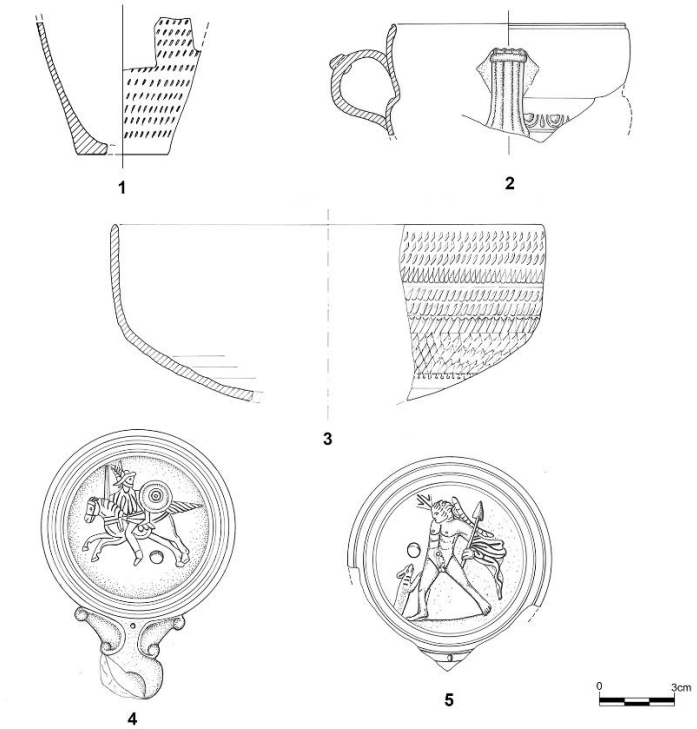


Figure 10. Selected specimens of the cargo of "ghost" Early-Roman Imperial shipwreck (drawings Fabiola Malinconico).

Conclusion

We can therefore state that the Late Republican period wreck 4 of Torre Santa Sabina was a cargo of goods 'in transition', that we can define as 'secondary formation load', assembled in a port, with materials coming from the Aegean and the eastern Adriatic, along with those from Apulia: amphorae, Black-Gloss Ware, Grey Ware and presumably Thin-Walled Pottery. This could represent a specific case-study, the only maritime context of a lot of TWP of Apulian production in the Late Republic.

It is possible to assume that Brindisi was the *port de rupture de charge* and the formation of the new cargo; it was a port of trade, a strategic hub of Mediterranean maritime connections in the Roman era and closely linked to Rome via the Appian Way. Additionally, it is plausible that this ship was heading for the Northern Adriatic.

Finally, the second group of Thin-Walled Pottery seems to be part of cargo of a "ghost" shipwreck from the early Imperial period. This vessel was carrying material mainly from the central and northern Adriatic regions, and it was heading for a port in the Ionian-Adriatic basin, possibly Brindisi. In both cases, the journey of these ships was abruptly interrupted in front of the 'trap bay' of Torre Santa Sabina.

R.A.

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Exploring maritime trade: roman glass amphorae in the Mediterranean

Berislav Štefanac[1]

Abstract

The paper deals with a special type of glass amphora with pointed ends used by the Romans used to transport perishable goods over long distances. These vessels are homogeneous and of small capacity, and their specific shape offers an interesting scope for studying their stored contents. This type of recipient can clearly be classified as a Mediterranean production based on archaeological findings. Glass amphorae are incredibly rare finds, and they are almost exclusively found on the coast of northern Africa, in the Levant, in the Black Sea region and on the eastern Adriatic coast. The specimens confirmed along the eastern Adriatic coast contribute greatly to knowledge of this type of early imperial glass vessel, especially in terms of its chronology and distribution.

Keywords: Roman Empire, maritime trade, roman glass amphorae

Introduction

Mediterranean trade and travel transformed the Roman Empire, facilitating its expansion and economic development. Maritime routes allowed for the easier movement of various products, and high-value merchandise found its way to distant regions. During the second half of the 1st century and at the beginning of the 2nd century various products made of glass circulated in the Mediterranean basin. The increased demand for glass vessels contributed to the development of a large number of production centres along the main trade routes.

Archaeological finds from the Croatian part of the eastern Adriatic coast are also indicative of extensive trade throughout ancient times. Numerous goods were imported from different parts of the Roman Empire to the wider area of the Roman colonies of Pola (now Pula), Iader (now Zadar), Salona (now Solin near Split) and Narona (now Vid, near Metković). Ancient ports played an important role in this process of importing, which received various products from old artisanal and artistic workshops from the East and the West. The multitude of maritime and commercial activities along the coast is also confirmed by the large number of exceptionally rich underwater finds of sunken ships with various types of cargo from the ancient period.

Spindle-shaped amphorae with pointed ends

In this paper, the production and distribution of pointed glass amphorae, which were used by the Romans to transport perishable goods over long distances, is examined. These amphorae are homogeneous containers of small capacity, and their specific shape offers an interesting scope for the study of their stored contents. The shape of these glass containers is likely inspired by ceramic transport

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amphorae, roughly similar to the tall cylindrical amphorae of the Dressel 1 type and other related amphorae from the late republican and early imperial periods.



Map 1. Distribution of roman glass amphorae in the Mediterranean: 1. Pula – Pola (cat. no. 1); 2. Zadar – Iader (cat. no. 2–4); 3. Skradin – Scardona (cat. no. 5); 4. Butrint – Buthrotum (Tartari 1996); 5. Constanţa – Tomis (Bucovala 1968); 6. Kerch – Pantikapaion (Kunina 1997), 7. Syro-Palestinian coast (Kirchner-Schwarz and Helbing 1914); 8. Sfax – Thenae (Yacoub, M. 1971-1972); 9. Vienne (Colombier-Gougouzian, A. 2014); 10. Albenga – Albingaunum (Massabò 1999), 11. Pompeii (Taborelli 1993-1994).

This type of glass recipient can clearly be classified as a Mediterranean production based on archaeological findings. Pointed-bottomed glass amphorae are among the rarest finds, and they are associated with the wider Mediterranean area,[2] including the Black Sea area,[3] the coast of the Ionian

[2] Taborelli 1993-1994: 2 (Pompeii, Italy); Massabò 1999, 98 (ancient Albingaunum, Italy); Yacoub 1971-1972: 32–33 (ancient Thaenae, Tunisia), Cf. Kirchner -Schwarz and Helbing 1914: no. 90, T. 3; Antonaras 2013: 141, no. 195, Foy and Zaibi 2023: nos. 15–17.

[3] Bucovalà 1968: 131, no. 272 (Constanţa, Romania); Kunina 1997: 321, no. 336–337 (ancient Panticapaeum, Crimea).

Sea[4] and the eastern Adriatic (Fadić 2000: 550–551) (Map 1). Their presence has also been recorded in trading centers connected to the Mediterranean by river ports.[5] Knowledge of this type of early imperial glass vessels has been greatly expanded by specimens attested along the eastern Adriatic coast, especially regarding their chronology and distribution.



Figure 1. Small glass amphora with pointed ends, Skradin (Scardona), 1st century.

[4] Tartari 1996: 111, no. 242, form 33 (ancient Butrint, Albania).

[5] Colombier-Gougouzian 2014: 290–291 (Vienne, France); Foy, Mocci, Granier, Lattard 2016: 23, type F.

The vessels in question are, essentially, elongated spindle-shaped amphorae with pointed ends (Figure 1). They are characterized by pointed tops that served as droppers, two handles and a pseudo-rim with a circular cross-section additionally applied to the neck. They are relatively small in volume, 22 to 27 cm high, and all were made using the free-blowing technique. Most of these recipients are made of transparent, naturally colored bluish-green glass (cat. nos. 1–2, 3, 5), while specimens made of amber-brown or olive-green glass have also been documented, albeit to a lesser extent (cat. no. 4).

This type of amphora has been recorded at only a few sites along the eastern Adriatic coast. Finds have been documented in Pula (ancient Pola) (cat. no. 1), Zadar (ancient Jader) (cat. no. 2–4) and Skradin (ancient Scardona) (Figure 1; cat. no. 5). For a more precise chronology, it is worth highlighting specimens from the ancient necropolis in Zadar. The amphorae from Zadar were discovered in cremation graves dated to the second half of the 1st century (cat. no. 2–4). The noted datation correlates with analogous finds throughout the Mediterranean.

It is important to highlight a find discovered during archaeological research in 1989 at the Relja site in Zadar (cat. no. 3). A fragmented glass amphora was found in a cremation grave (grave no. 220) along with numerous other glass and ceramic grave goods. Beside a stone urn with a glass olla, in addition to the amphora, there was a glass ladle with a horizontal handle (*trulla*), four small square juglets (form Isings 50), two conical bowls on a ring foot, a shallow glass plate, a thin-walled ceramic bowl, a ceramic lamp, and an iron ring. The abundance of grave goods, mostly of the tableware variety, indicates that the grave belonged to a person of higher social status, further confirmed by the presence of rare glass forms. Furthermore, an anthropological analysis has demonstrated that a man aged 18 to 20 was buried in the grave (Gluščević 2023: 358).

Small glass amphorae with pointed ends offer many considerations regarding their purpose. The usage of glass containers for transport allowed for the better protection and preservation of their contents because glass does not react with foods and liquids, is resistant to corrosion, and does not absorb any odours (Štefanac 2024: 88–92). The shape of the vessel suggests that they were used to transport specific contents, probably spicy seasoning liquids such as garum, high-quality wines or essential oils, such as extracts of silphium and spikenard.[6]

Most glass amphorae show broken tops and bottoms, which could indicate that the vessels were intended for single use. It is clearly visible on the originally preserved openings of the Skradin glass amphora (Figure 1; cat. no. 5) that the conical ends were not sealed with glass. Therefore, it follows that the narrow openings on these amphorae were probably sealed with resin or wax or some other similar adhesive material (Foy and Zaibi 2023: nos. 15–17). The hermetic closure of these containers ensured the integrity of the contents and could have served as a protection against forgery or fraud. The fact that amphorae of uniform shape are found throughout the Mediterranean coastal belt clearly speaks to the importance of glass packaging in the trade of expensive liquid contents.

[6] For more on the topic, see Taborelli 1993-1994: 2–3; Massabò 1999: 98; Fadić 2000: 550–551; Starac 2023: 117.

Conclusion

Examples of glass amphorae with a pointed top from the eastern Adriatic coast offer a more complete understanding of this group of recipients in the context of the production and distribution of Mediterranean glass. In typological and chronological terms, the finds from Zadar, Skradin and Pula fully correspond to analogous examples from other Mediterranean regions. Specific decorative details visible on one vessel from Zadar (cat. no. 3) are completely comparable to examples documented in Tunisia. As for workshop affiliation, it is currently not possible to draw final conclusions, because the confirmed morphological variations and wide distribution indicate potential production in several glass workshops throughout the Mediterranean.

Glass amphorae with pointed ends offer numerous considerations regarding their function. It is undeniable that the amphora with a dropper at the bottom served for the moderate dosing of their contents. Judging by their shape, they probably served to transport a specific content, probably a spiced liquid such as garum, high-quality wines, or high-quality essential oils, such as silphium and spikenard extracts. The grave inventory from the Zadar necropolis, in which amphorae are found among tableware sets, suggests that they were used in the serving of food and drink.

In addition to their everyday use, pointed amphorae may have had a special religious role. Similar small amphorae made of precious metals and ceramics were used in rituals as vessels for offerings to the gods from the Hellenistic period onward. This religious tradition is particularly well-illustrated in an intaglio medal from the Capitoline Museum in Rome showing a priestess holding a small, pointed amphora in one hand while standing next to the altar of Apollo.[7] Ultimately, the conclusion is that many glass amphorae from grave context can be seen as part of religious inventory during the libation ritual and offering sacrificial gifts to the gods.

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[7] Capitoline Museum inv. Med06763. https://www.museicapitolini.org/it/opera/medaglione-con-intaglio-sacerdotessa-e-statuetta-di-apollo-su-pilastro

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Catalogue

Cat. No. 1

Site: Pula (Lat. *Pola*) or a nearby location

Location: Pula, Archaeological Museum of Istria, inv. no. AMI-A-4895

Production technique: free blowing

Description: A spindle-shaped amphora with pointed ends, of which only the upper part has been preserved. The handles with wavy tendrils, bent at right angles, are connected at the shoulder and lower part of the neck (below the applied ring). Transparent greenish glass.

Preserved height = 17 cm; width = 7.6 cm

Date: Second half of the 1st century

Bibliography: Starac 2023: 222, cat. no. 139.

Cat. No. 2

Site: Zadar (Lat. *Iader*), ancient necropolis, archaeological survey in 1975, cremation grave 12 (stone urn)

Location: Zadar, Museum of Ancient Glass, inv. no. A6396

Production technique: free blowing

Description: Spindle-shaped amphora with pointed ends. Both conical segments have a very narrow opening. The handles, bent at an acute angle, are attached to the shoulder and lower part of the neck (below the applied ring). Small pieces of the body are missing. Transparent bluish-green glass.

Height = 24.5 cm; width = 6.3 cm

Date: Second half of the 1st century

Bibliography: Nedved 1980: 351; Fadić 1997: 211, no. 222.

Cat. No. 3

Site: Zadar (Lat. *Iader*), ancient necropolis, archaeological survey in 1989, cremation grave 220 (stone urn)

Location: Zadar, Archaeological Museum, inv. no. A8034

Production technique: free blowing

Description: Spindle-shaped amphora with pointed ends. Both conical segments have a very narrow opening. The handles, bent at a sharp angle, are attached to the shoulder and the lower part of the neck (below the applied ring). On the mid-section there are two incised horizontal strips, each containing

three to four very fine incised lines (wheel-cut lines). Smaller pieces of the body are missing. Transparent bluish-green glass.

Height = 24.6 cm

Date: Second half of the 1st century

Bibliography: Giunio 2016: 90, cat. no. 103; Gluščević 2023: 357–358.

Cat. No. 4

Site: Zadar (Lat. *Iader*), ancient necropolis, archaeological survey in 2005, destroyed cremation grave 121

Location: Zadar, Museum of Ancient Glass, inv. no. A9187

Production technique: free blowing

Description: Spindle-shaped amphora with pointed ends, of which only the neck and a small part of the body are preserved. Parts of the handle are preserved on the lower part of the neck, under the applied ring. Transparent greenish-brown glass.

Preserved height = 10 cm

Date: Second half of the 1st century

Bibliography: Unpublished

Cat. No. 5

Site: Skradin (Lat. *Scardona*), ancient necropolis (locality of Maraguša), archaeological survey from the end of the 20th century.

Location: Šibenik, Šibenik City Museum, inv. no. 11826

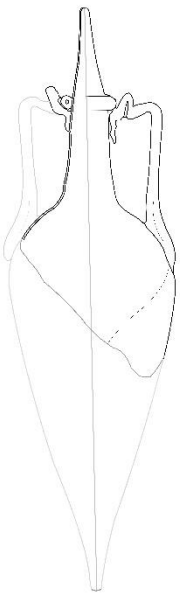
Production technique: free blowing

Description: Spindle-shaped amphora with pointed ends. There is a very narrow opening on both conical segments (no damage). The handles with wavy projections, bent at right angles, are connected at the shoulder and lower part of the neck (below the applied ring). Transparent bluish-greenish glass.

Height = 27 cm; width = 7.6 cm

Date: Second half of the 1st century

Bibliography: Pedišić 2001: 74.



Cat. no. 1



Cat. no. 2



Cat. no. 3



Cat. no. 4



Cat. no. 5

African cooking ware from the 2021 underwater excavations at Fizine (Slovenia)

Danica Mitrova[1] and Saša Koren[2]

Abstract

This article examines African cooking ware uncovered during recent underwater excavations of the Late Roman phase of the ancient settlement complex at Fizine (Slovenia). The study aims to provide reliable qualitative and quantitative data on their forms, extent, and origin through a technological and typo-chronological framework. The assemblage comprises both Central and North Tunisian products, with a notable predominance of North Tunisian examples, while a small number may be linked to regional workshops. Their chronological range spans from the mid-3rd to the mid-5th century, with most specimens dating to the 4th and early 5th centuries. The African cooking ware was primarily found as part of a larger concentration of material in an area likely serving as a mooring for smaller fishing and trading vessels during the Late Roman period, suggesting the presence of anchorage debris.

Keywords: Adriatic, Slovenia, Fizine, harbour, African cooking ware, ceramic technology, Late Roman period.

Introduction

The Roman settlement in a shallow bay at the site now known as Fizine, near Portorož, is well documented (Figure 1). It is characterised by three distinct features: a mixed commercial and residential building complex on the eastern side of the bay, remains of *piscina vivaria* structures along the shore, and a recently excavated Roman harbour with a possible jetty and moorings on the western side of the bay. Current research suggests that the area was inhabited from the second half of the 1st century BC to the 6th century AD, experiencing its greatest prosperity in the 4th and first half of the 5th century AD (Gaspari *et al.* 2006; Gaspari *et al.* 2007; Gaspari *et al.* 2023).

In 2021, underwater excavations revealed additional remains from the Late Roman phase (see Figure 1 for the area outlined in yellow). Disused sailing and rigging elements, building materials, as well as various ceramic finds and organic remains were unearthed. Pottery proved to be the most common find, consisting mainly of imported fine tableware, coarse ware, and amphorae (Gaspari *et al.* 2023: 652-654). In this paper, we examine a portion of the coarse ware, concentrating on North African cooking ware within a technological and typo-chronological framework. The aim of the study is to obtain reliable qualitative and quantitative data on the forms, extent, and provenance of the vessels in question, to complement the general interpretative picture of the site and better understand its integration into the broader economic flows and distribution networks of the empire.

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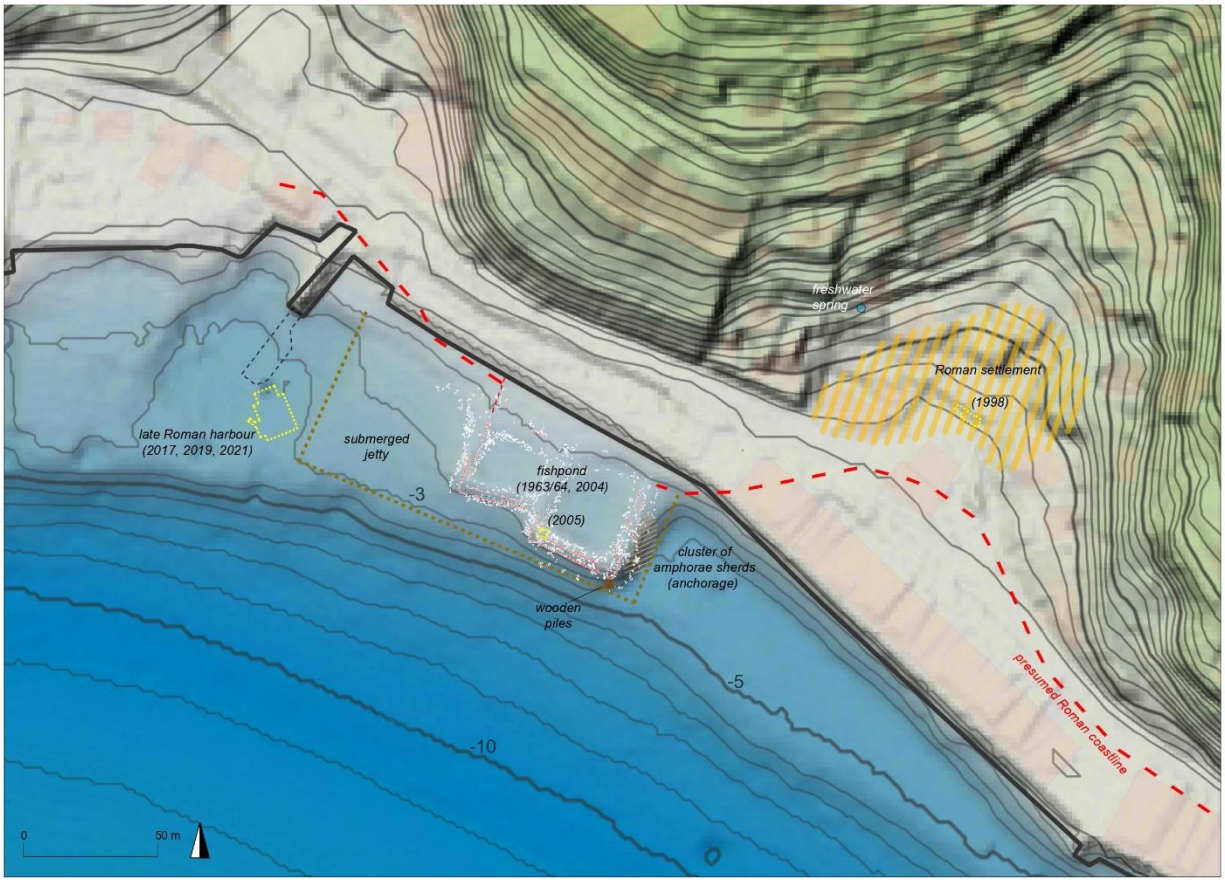


Figure 1. The ancient settlement complex at Fizine: excavation timeline and significant features (Gaspari et al. 2023: Figure 2).

Methodology

The ceramic technology analysis builds on guidelines introduced by Milena Horvat (1999) and Clive Orton and Michael Hughes (2013). The composition of the pottery paste, forming techniques, surface treatment, firing atmosphere and characteristics (hardness, colour), as well as other visible traces were recorded by macroscopic examination of the surfaces and the fresh break of the fragments with the naked eye and a stereomicroscope.[3] Pottery paste description included identity, size, frequency, and shape of particles and voids. Hardness was defined using the Mohs scale, colour was determined according to the Munsell system (2009, rev. 2023) accompanied by a brief verbal description. Specimens sharing characteristics were understood to represent the same fabric group, whereby those with minor deviations were further divided into subgroups. Fabric groups were coded using a uniform system for all finds of the site, modelled after FACEM (2020). The codes consist of abbreviations for the site or region of production, the type of ware to which the fabric belongs, and a consecutive number, in places followed by an alphabetical notation indicating a subdivision (e.g., AFR-GK-1a, where GK denotes coarse ware in Slovene). The obtained fabric groups were then compared with existing fabric descriptions from

[3] Leica Stereomicroscope EZ4, at the Laboratory for Material Analysis, Department of Archaeology, Faculty of Arts, University of Ljubljana.

various productions to ascertain their area of origin. The typological and chronological classifications were correlated with established typological and chronological schemes.

Technological and typo-chronological assessment

The assemblage of coarse ware consists of approximately 219 fragments, representing 64 individual vessels (maximum vessels represented; see Orton 1989). Based on their technological characteristics, 24 fabric groups were defined, originating from four different production zones: Italic (IT-GK-1), North African (AFR-GK-1 to AFR-GK-14), Pantellerian (COSS-GK-1, COSS-GK-2), and Aegean (AEG-GK-1 to AEG-GK-4), with a few of uncertain origin (IGN-GK-1 to IGN-GK-3). The results indicate that North African products predominate, while Pantellerian and Aegean products account for a significantly smaller number, and Italic products are almost negligible.

North African fabric groups were cross-referenced with the three major production categories – A, B, and C – established according to their origin and mode of production, especially surface treatment and appearance, and are often associated with certain vessel forms. Production A originates in northern Tunisia, corroborated by petrographic analyses that indicate its fabric is identical to and comparable with that of African Red Slip Ware A. Although no workshops have been discovered, they are considered to have been situated in the Carthage area. Production B, documented in Byzacena, is characterised by a stripe-burnished slip on either the internal or external walls of vessels. Production C originated in northern Tunisia (C/A) and in certain workshops in the central-west and central-southwest of Byzacena (C/B), as well as in Tripolitania (C/T). It comprises vessels featuring a characteristic blackened rim (*orlo annerito*) or upper exterior surface (*patina cenerognola*), which likely resulted from the way vessels were stacked in kilns and the subsequent changes in the firing atmosphere (Atlante I: 208-211; Bonifay 2004: 67, 210-211; Bonifay 2016: 528-533; Ikäheimo 2003: 98-100).

Within the examined repertoire of 45 individual vessels, four principal vessel forms are identified. Lids[4] represent the largest segment, constituting 55% of the total. Casseroles follow at 32%, while pans and *marmites* account for the smallest portions, at 9% and 4%, respectively.

Production A

Only one fabric group – AFR-GK-3 – is attributable to production A (Figure 2). The very fine-grained pottery paste consists mainly of non-calcareous particles. Translucent and subrounded quartz is frequent in size 0.25mm or smaller, larger grains are rare and do not exceed 0.5mm. Also rare are dark subrounded and dark red rounded or irregularly shaped non-calcareous grains, approximately 0.5mm in size. Carbonate elements, microfossils, and pseudomorphs are rare and less than 0.5mm in size. Rare, rounded voids not exceeding 0.5mm are visible on the surface. The ceramic body was fired in oxidising conditions, resulting in a yellowish-red fracture (5YR 4/6) and an outer surface ranging from very pale brown, pale brown, to brown (10YR 7/4, 7.5YR 6/4, 5/4). Additionally, it is hard (Mohs hardness 4) with a smooth texture. The inner surface appears to be thinly slipped, or possibly self-slipped (see Ikäheimo

[4] See Ikäheimo 2003: 75-79 for a discussion on their ambiguous function.

2003: 52, 95), exhibiting irregular shades of very pale brown, pale brown to brown (10YR 7/3, 6/3, 5/4). The outer surface features horizontal stripes of a dull, reddish-brown slip (5YR 4/3-4/4).[5]

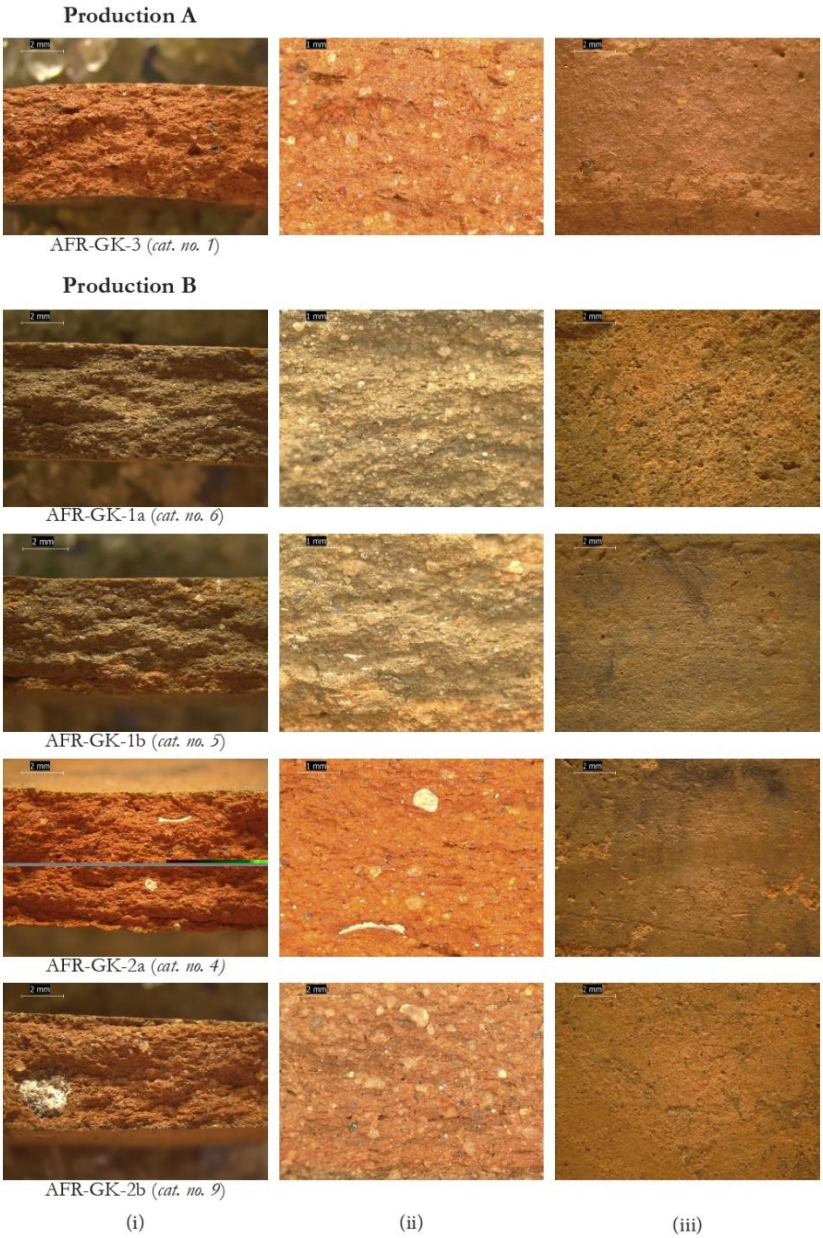


Figure 2. Fizine: representative samples of African cooking ware fabric groups associated with productions A and B, depicting (i) fracture surface at 8x magnification, (ii) fracture surface at 16x magnification, and (iii) inner/outer surface appearance at 8x magnification.

[5] It doesn't appear polished; it can be scratched with a needle.

AFR-GK-3 was sampled from a Hayes 23 shallow casserole of the variant A (Figure 3: 1) with a plain rim and almost flat, ridged bottom (Hayes 1972: 45-48). This variant may have appeared as early as the Claudian period but is mostly attested from the end of the 1st to the mid-3rd century, with examples from the 4th and 5th centuries likely being residual (Atlante I: 217; Bonifay 2004: 211; Ikäheimo 2003: 52). Analogies are known from nearby sites such as Školarice (Žerjal 2008: 165), Ajdovščina (Vidrih Perko and Žbona Trkman 2005: 281), Simonov zaliv, and Hrušica (Pröttel 1996 *passim*). In Aquileia, it has been attested in contexts from the 3rd and 4th centuries, and in Trieste, from the 3rd and 5th centuries (summarised by Mannocci 2021: 5, with cited bibliography).

Production B

Four fabric groups – AFR-GK-1a-b, AFR-GK-2, AFR-GK-12, and AFR-GK-13 – are correlated with production B (Figures 2 and 4).

AFR-GK-1 is very fine-grained, characterised primarily by the presence of subangular and subrounded quartz up to 1mm in size. Grains larger than 0.25mm are rare to singular and are translucent, while smaller grains are frequent, ranging in colour from translucent colourless to translucent pink. Singular silver mica may be visible on the surface. Voids are rare; those measuring 0.25mm are rounded, while larger ones (1mm) are elongated or irregularly shaped. Due to minor variations, this fabric group is divided into subgroups 1a and 1b. AFR-GK-1a contains rare calcium carbonate bodies (0.25-0.5mm) and dark bluish subrounded to rounded, undefined particles (possibly Fe-oxides or clay pellets). The latter are rare at sizes 0.5-1mm and singular at 2mm. These particles are absent in AFR-GK-1b, which also differs in its carbonate content. In this second subgroup, rare carbonate bodies reach sizes of 0.5-1mm, accompanied by rare, smaller (0.25-0.5mm) elongated, and hard elements, likely microfossils. Generally, the ceramic body was fired in either a reducing or an irregularly oxidising atmosphere, resulting in a dark grey surface (GLEY 1 N 4/). It is hard (Mohs hardness 3), and in some instances, feels harsh to the touch, likely due to post-depositional microdamage to the surface. The fracture of subgroup 1a displays an uneven dark grey and brown colour (2.5Y 4/1, 7.5YR 5/4-10YR 5/3). The fracture of subgroup 1b features a grey core (2.5Y 4/1) with brown margins (7.5YR 4/4). Both the inner and outer surfaces are covered with a thin, dull coating (cf. Ikäheimo 2003: 48-49) in shades of very pale brown, light grey, and light yellowish brown (10YR 8/2, 8/3, 7/2, 7/3, 7/4, 6/4, 7.5YR 5/4).

AFR-GK-1 is represented by three Hayes 181 pans and one Hayes 185 lid.

Two of the three Hayes 181 pans (Figure 3: 2-3) have a quarter-round profile and a slightly inward-curving rim, which Michel Bonifay (2004: 213-214, Figure 114) classifies as variant C in the morphological development of the form, dating it from the end of the 2nd and into the 3rd century, with a possible extension of the closing date to the early 4th century. Similar examples in Aquileia are known from 3rd- and 4th-century deposits (Mannocci 2021: 14, with cited bibliography). The shift of the inflection point towards the base in the third Hayes 181 pan, resulting in vertically straightened walls (Figure 3: 5), aligns this specimen with variant D, the final developmental stage of the form, dated from the second half of the 4th to the first half of the 5th century (Bonifay 2004: 214). A fragment from Aquileia, found in a layer from the second half of the 3rd century (Mannocci 2021: 14), suggests a wider chronological frame. Analogous examples have also been identified at Ajdovščina and Hrušica (Pröttel 1996: 219, 225).

The Hayes 185 lid (Figure 3: 6), described by John W. Hayes (1972, 204) as having a ‘shallow dome’ shape, features a seamless transition from the walls to a slightly thicker, rounded rim. It is comparable to lids

from Pupput and Nabeul, classified as variant C and documented from the late 2nd to the mid-3rd century (Bonifay 2004: 221, Figure 118: 7).

The fine-grained pottery paste of AFR-GK-2 is composed of both non-calcareous and calcareous particles. Translucent, subrounded quartz is frequent up to 0.25mm in size, moderate up to 0.5mm, and rare up to 1mm. Notable variations in carbonate elements allow for the distinction of two subgroups, 2a and 2b. In subgroup AFR-GK-2a, white to grey pseudomorphs smaller than 0.25mm are frequent, while those ranging from 0.5 to 2mm are rare to singular. Additionally, rare elongated and crescent-shaped microfossils, possibly from molluscs, are observed in sizes around 0.5mm and 1mm. Soft, rounded particles, rare and matching the colour of the ceramic body, are present on the surface in sizes around 0.5mm and 1mm, possibly indicating clay pellets. Subrounded voids ranging from 0.5 to 1mm are rarely visible in both the fracture and on the surface, with singular larger voids up to 2mm observed on the surface.

In subgroup AFR-GK-2b, white to grey rounded pseudomorphs smaller than 0.25mm are frequent, those reaching 0.5mm are rare, and bodies up to 3mm are singular. Clay pellets are not found. Rare subrounded voids up to 0.5mm are observed both in the fracture and on the surface, with additional rare voids up to 1mm present only on the surface. The ceramic body was generally fired in an oxidising atmosphere, resulting in variations in hardness and colour among the subgroups. Despite these differences, both subgroups feature a surface feel ranging from uniformly smooth to harsh. The softer ceramic body of subgroup 2a (Mohs hardness 2) exhibits yellowish red tones on the surface (5YR 5/8-4/6) and a more uniform coloration in the fracture (5YR 4/6). The inner surface is coated with a grey to very dark grey slip (2.5Y 5/1, 4/1, 3/1), which has been burnished to create semi-lustrous stripes. In contrast, the ceramic body of subgroup 2b (Mohs hardness 3) has a fracture with a reddish-brown core (5YR 4/4) and thin brown margins (10YR 5/3). The uneven surface shows shades of very pale brown, light yellowish brown, and yellowish brown (10YR 7/4, 6/4, 5/4). It appears to be finished with a grey to dark grey or very dark grey slip (2.5Y 5/1-4/1, GLEY 1 N 3/), possibly initially burnished. Distinguishing between smoothing, slipping, burnishing, salt scum (see Ikäheimo 2003: 100), and post-depositional surface alterations can be challenging.

Included in AFR-GK-2 are one Hayes 181 pan and two Hayes 182 lids.

The Hayes 181 pan (Figure 3: 4) is analogous to variant C of the form, with the closest resemblance presumed to be to its latest versions from the end of the 3rd or the beginning of the 4th century, owing to its thicker walls and rim, as well as the lower inflection point (Bonifay 2004: 213-214, Figure 114).

Hayes 182 lids are characterised by a flattened, dome-shaped body, an everted rim forming a hook with a more or less rounded tip, and an apodal bottom (Hayes 1972: 201; Ikäheimo 2003: 39). Of the two specimens from Fizine, the better-preserved example (Figure 3: 9) reveals an asymmetrical, oval shape and features two shallow grooves on the outer surface. Its slightly flattened rim with a tapered tip is consistent with the description of variant C, dated to the end of the 2nd and into the 3rd century (Bonifay 2004: 217). However, the body shape of the studied lid is more flattened and less curved compared to similar examples from Pupput and Nabeul, aligning more closely with the late variant D (cf. Bonifay 2004: Figure 115). The other specimen from Fizine (Figure 3: 10) has an even more rounded tip of the rim, typical of variant D, produced during the 4th century (Bonifay 2004: 217). To date, other late examples from the upper Adriatic have only been documented in Aquileia (Mannocci 2021: 11).

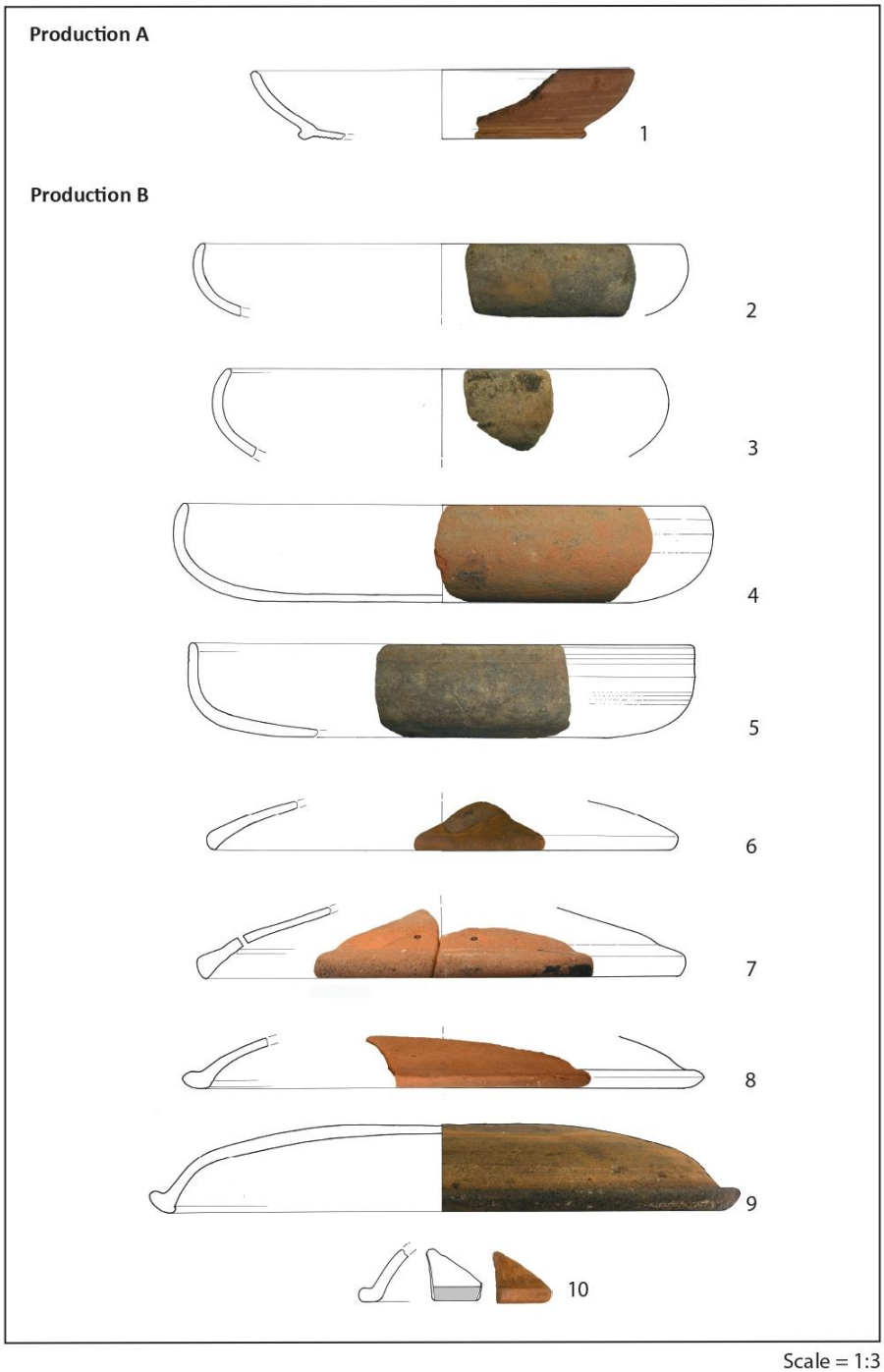


Figure 3. Fizine: types of African cooking ware from the 2021 underwater excavations. Production A; 1: Hayes 23 A (AFR-GK-3). Production B; 2-3: Hayes 181 C (AFR-GK-1a), 4: Hayes 181 C (AFR-GK-2a), 5: Hayes 181 D (AFR-GK-1b), 6: Hayes 185 C (AFR-GK-1a), 7: Hayes 185 C (AFR-GK-12), 8: Hayes 185 D (AFR-GK-13), 9-10: Hayes 182 D (AFR-GK-2b). Drawings by Ida Murgelj.

AFR-GK-12 has a fine-grained pottery paste, consisting of translucent colourless and whitish-grey quartz up to 2mm in size. Grains smaller than 0.25mm are frequent, those reaching up to 1mm are rare, and larger ones are singular. White, rounded, or irregularly shaped bodies are frequently found below 0.25mm, moderately between 0.26-0.5mm, rarely up to 1mm, and singularly up to 2mm. These bodies resemble reaction rims but are not completely hollow and do not react with hydrochloric acid. They are quite hard when scratched with a needle, indicating they may be non-calcareous microfossils, though their identity remains undefined. Singular dark, rounded, and soft grains, approximately 2mm in size, may represent Fe-oxides. Voids are rare and rounded, measuring about 0.5mm in the fracture and between 0.25 and 2mm on the surface. The ceramic body was fired in a fully oxidising atmosphere, producing a red fracture (2.5YR 4/8) and an uneven yellowish-red surface (5YR 5/6-5/8). Additionally, it is soft (Mohs hardness 2) and feels harsh to the touch, presumably due to microdamage on the original surface. An unevenly pinkish layer (7.5YR 8/4-7/4) of self-slip, slip, or salt scum covers both the inner and outer surfaces.

A Hayes 185 lid of variant C (Figure 3: 7), dated from the end of the 2nd to the mid-3rd century (Bonifay 2004: 221), is the sole specimen pertaining to AFR-GK-12. Unlike cat. no. 6 (AFR-GK-1), this lid has a slightly pronounced joint between the wall and rim due to the thickening of the rim, a characteristic reminiscent of the Hayes 169 type. This resemblance aligns with M. Bonifay's observation that variant C of the Hayes 185 lids developed under the influence of Hayes 169 (Bonifay 2004: 221). Notably, the Fizine specimen has four perforations, each 4mm in diameter, seemingly pierced through the walls *post cocturam*, possibly indicating a repair.

The very fine-grained AFR-GK-13 is composed of translucent, subrounded quartz, which is frequent in sizes below 0.25mm and rare up to 0.5mm. Rounded calcareous elements are moderately present bellow 0.25mm and rare up to 1mm. Additionally, rare dark brown clay pellets range from 0.5 to 1mm. This fabric groups mostly deviates from others within production B by its content of silver mica, which is moderate in size up to 0.25mm and rare up to 0.5mm. Voids, all irregularly shaped, are rare at 0.5mm and singular at 2mm. The ceramic body was fired in an oxidising atmosphere, producing a uniform yellowish-red fracture (5YR 5/8). Moreover, it is soft (Mohs hardness 2), with a smooth and slightly powdery feel. Both the inner and outer surfaces are coated with a dark grey to dark greyish-brown slip (2.5Y 5/1, 4/1, 10YR 4/2), along with a band of whitish salt scum on the rim.

Representing AFR-GK-13 is a Hayes 185 lid (Figure 3: 8) with a 'thickened rolled rim' (Hayes 1972: 204), corresponding to variant D of the form, which is documented in 4th-century contexts at El Jem (Bonifay 2004: 221).

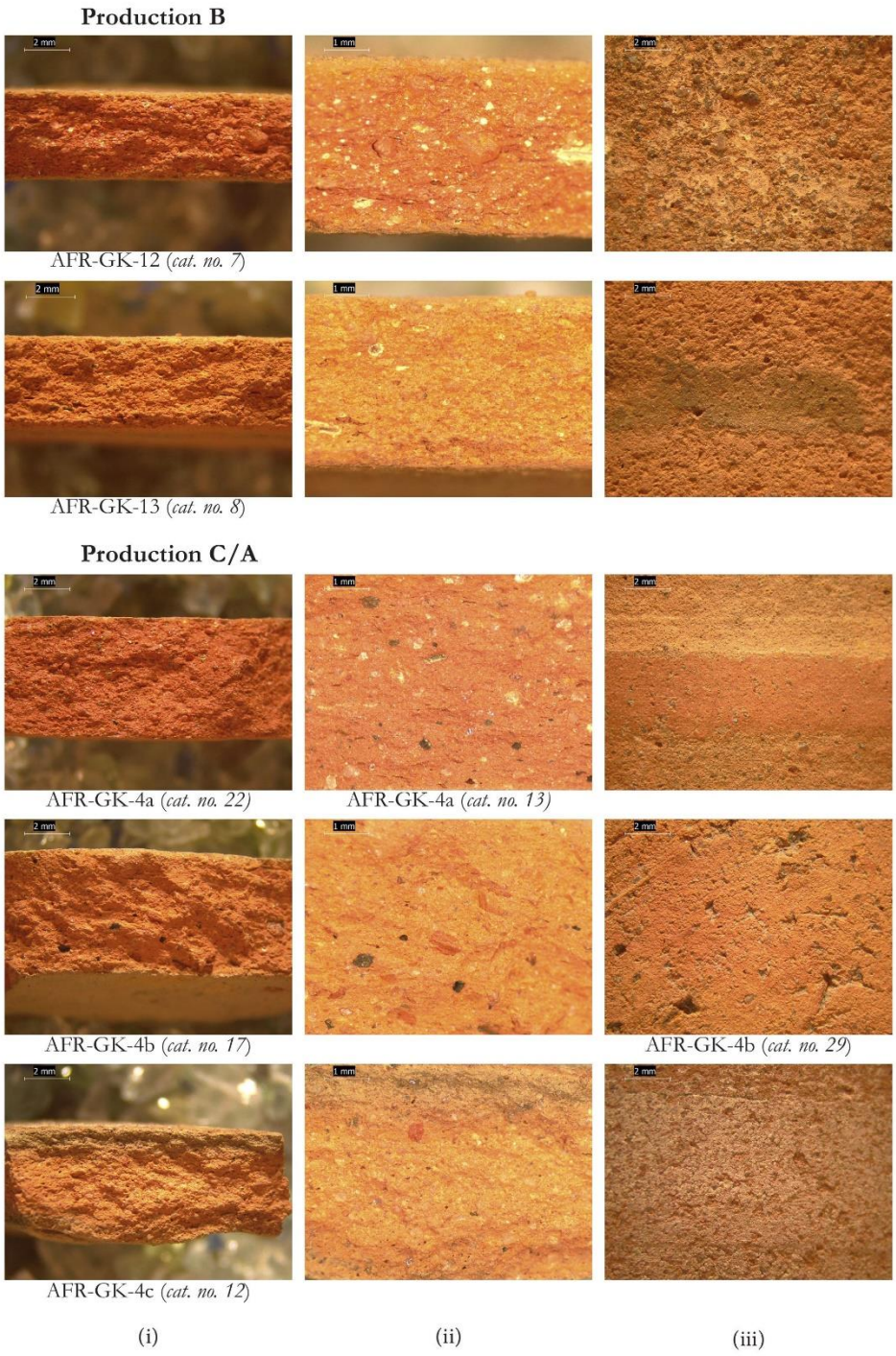


Figure 4. Fizine: representative samples of African cooking ware fabric groups associated with productions B and C/A, depicting (i) fracture surface at 8x magnification, (ii) fracture surface at 16x magnification, and (iii) inner/outer surface appearance at 8x magnification.

Production C/A

Production C/A, comprising five fabric groups and several subgroups – AFR-GK-4, AFR-GK-9, AFR-GK-10, AFR-GK-11, and AFR-GK-14 (Figures 4 and 6), is the most prevalent at the site.

AFR-GK-4 is further divided into four subgroups (4a-d), each with very fine-grained pottery pastes consisting of nearly identical components, differing mainly in size and frequency.

Subgroup AFR-GK-4a contains translucent to greyish-white subrounded and subangular quartz, frequently measuring up to 0.25mm and rarely reaching 0.5mm, with singular grains up to 1-2mm in size. Additionally, there are rare subrounded and subangular darker reddish particles, potentially rock fragments, which do not exceed 0.25mm in size, as well as singular Fe-oxides measuring up to 0.5mm. Also present are rare (sub)rounded and subangular blackish particles, varying from 0.25mm to 1mm. These particles do not react with hydrochloric acid and are quite hard when scratched with a needle. Voids are rare, generally subrounded or elongated and irregularly shaped, reaching up to 0.5mm, with singular ones as large as 2mm.

Subgroup AFR-GK-4b is distinct in the presence of the darker reddish particles, which are found moderately at sizes up to 0.5mm and rarely reach 1mm. At sizes smaller than 0.25mm, these particles are challenging to differentiate from Fe-oxides, as the rounded ones may belong to the latter.

In subgroup AFR-GK-4c, the quartz grains do not exceed 0.5mm, while the blackish particles are limited to sizes smaller than 0.25mm. The darker reddish particles are rare, usually up to 0.25mm, with singulars measuring 0.5mm. Furthermore, there are singular microfossils around 0.5mm in size.

Subgroup AFR-GK-4d primarily differs in the abundance of quartz grains smaller than 0.25mm, which are otherwise rare at sizes between 0.26 and 1mm. The blackish particles do not exceed 0.25mm in size, and the quantity of darker reddish particles remains consistent with that of subgroup 4c.

Generally, the ceramic body is defined by firing in an oxidising atmosphere, a Mohs hardness 3-4, and a smooth feel. The fracture colour displays a range of variations, including light red (2.5YR 6/8), various shades of red (2.5YR 5/8, 5/6, 4/8), and unevenly yellowish red to dark brown (5YR 4/6-7.5YR 3/2). In most samples, the surface colour translates into very thin margins within the fracture. An exception is subgroup 4c, which distinctly features a light red core (2.5YR 6/6-6/8) with greyish-brown margins (10YR 5/2). The surface colour exhibits even greater variability and is rarely uniform on both the inner and outer surfaces. The inner surface features shades of light red, reddish yellow, very pale brown, pale brown, light brownish grey, and dark grey.[6] In contrast, the outer surface includes shades of red, yellowish red, reddish yellow, light brown, very pale brown, pale brown, and light brownish grey.[7] In a few specimens, the colour is consistent on both sides, appearing in shades of light red, pink, yellowish red, light yellowish brown, light brown, brown, strong brown, greyish brown, and dark grey.[8] The disparity in colour uniformity between the inner and outer surfaces likely results from the finishing process of wet-smoothing the interior, which produces a self-slip commonly observed on most vessels. Occasionally, patches of self-slip are discernible on the exterior, which is otherwise covered with the characteristic *orlo annerito* and *patina cenerognola* in shades of dark greyish brown, grey, dark grey, and very dark grey (10YR 4/2, 4/1, 5/1, 6/1, GLEY 1 N 5/, 4/, 3/). When poorly preserved, the *orlo annerito*

[6] 2.5YR 6/8, 5/8, 5YR 6/6, 7.5YR 6/6, 10YR 7/3, 7/4, 6/3, 2.5Y 7/3, 6/2, 5/1, 4/1.

[7] 5YR 6/6, 7.5YR 6/6, 6/4, 6/3, 10YR 6/3, 2.5Y 6/2.

[8] 2.5YR 6/8, 5YR 7/4, 5/6, 5/8, 4/6, 7.5YR 6/4, 5/6, 5/4, 10YR 6/4, 5/3, 5/2, 4/1, 2.5Y 6/3, 6/4.

layer can be challenging to distinguish from soot deposition. In one instance, the *patina cenerognola* on the outer surface is substituted with salt scum, while in another, horizontal bands of a dull red slip (2.5YR 5/6) are present. Traces of a light-red to red or reddish-yellow dull slip (10R 5/6, 2.5YR 7/6, 6/6, 5/6, 5YR 7/6) sometimes appear on the inner surface of the base as uneven concentric brushstrokes or similar tool marks, while on the outer surface, it may manifest as larger and smaller drip marks.

AFR-GK-4 is represented by ten Hayes 197 casseroles, eight Hayes 196 lids, and one Hayes 195 lid.

Hayes 197 deep casseroles are recognisable by their thickened, almond-shaped rim with a lid seating, a convex, corrugated exterior bottom, and grooved interior walls (Hayes 1972: 209; Ikäheimo 2003: 60). Although ten specimens have been found at Fizine, just over half are fragments of bases and walls (e.g., Figure 5: 15-17). The better-preserved specimens demonstrate a heterogeneity in design, as none share close typological similarities. The classic Hayes 197 form is represented by cat. no. 12 (Figure 5). These casseroles, with a grooved lid-seating near the inner edge of the rim, were produced from the late 2nd to the first half of the 5th century, with *comparanda* from the Palatine East excavations in Rome indicating a major concentration during the late 3rd/early 4th-century phases (Ikäheimo 2003: 61, variant O.I). A similar example from Nabeul is attributed to the 3rd century (Bonifay 2004: 225, Figure 120: 3). The prevalence of classic Hayes 197 casseroles in the upper Adriatic is well-documented (Mannocci 2021: 23; Pröttel 1996 *passim*; Vidrih Perko and Žbona Trkman: Figure 5: 7; Žerjal 2008: 166). One fragment (Figure 5: 11) closely resembles a variant of the classic form from Nabeul, dated to the late 3rd or early 4th century (Bonifay 2004: 225, Figure 120: 5); however, the latter lacks a lid seating. The remaining specimen from AFR-GK-4 (Figure 5: 13) represents late variants of the form, marked by a wider grooved lid seating on the rim top. In these later derivations, the previously convex outer surface of the rim has evolved into a flat form, resulting in the loss of its almond shape. Cat. no. 13 is analogous to a particular variant from Oudhna dating to the end of the 4th century (Bonifay 2004: 225, Figure 120: 8), although it cannot be excluded that a broader chronological range extending into the 4th and 5th centuries exists for its production and distribution (Ikäheimo 2003: 62, variant O.V).

Hayes 196 lids are considered to be paired with Hayes 23 casseroles and likely complemented Hayes 197 casseroles as well (Bonifay 2004: 225; Hayes 1972: 208; Ikäheimo 2003: 35). Present in different variations and sizes (with varying rim diameters) at Fizine, their notable quantity exceeds that of both casserole forms. These lids are characterised by a dome-shaped body and a simple, rounded rim that progressively thickens over time, while the top can either be plainly rounded or shaped as a ring handle or a knob (Hayes 1972: 208; Ikäheimo 2003: 34). The earliest specimen in the assemblage has a slightly angular and wider rim relative to the vessel walls (Figure 7: 18), corresponding to the Ostia III, Figure 332 type, attested from the Trajanic/Hadrianic period to the second half of the 2nd century in Ostia, as well as in the 2nd century in Carthage (Atlante I: 212, pl. CIV: 3). In Nabeul, this type is classified as variant B of the classic form and is dated to the mid-3rd century (Bonifay 2004: 227, Figure 121). Material from Carthage and the Palatine East excavations (variant A.II) suggests production continued at least into the late 4th or early 5th century (Ikäheimo 2003: 36, pl. 3: 3). Examples from Aquileia also appear in 4th- and 5th-century contexts, in addition to being present from the end of 1st century onwards (Mannocci 2021: 18). Four specimens (e.g., Figure 7: 21-22, 24) have a visibly pronounced, thicker rim, identical to the Ostia I, Figure 261 type, documented in Ostia from the Antonine period and more commonly from the Severan period to the end of the 4th/beginning of 5th century (Atlante I: 212, pl. CIV: 5-6).

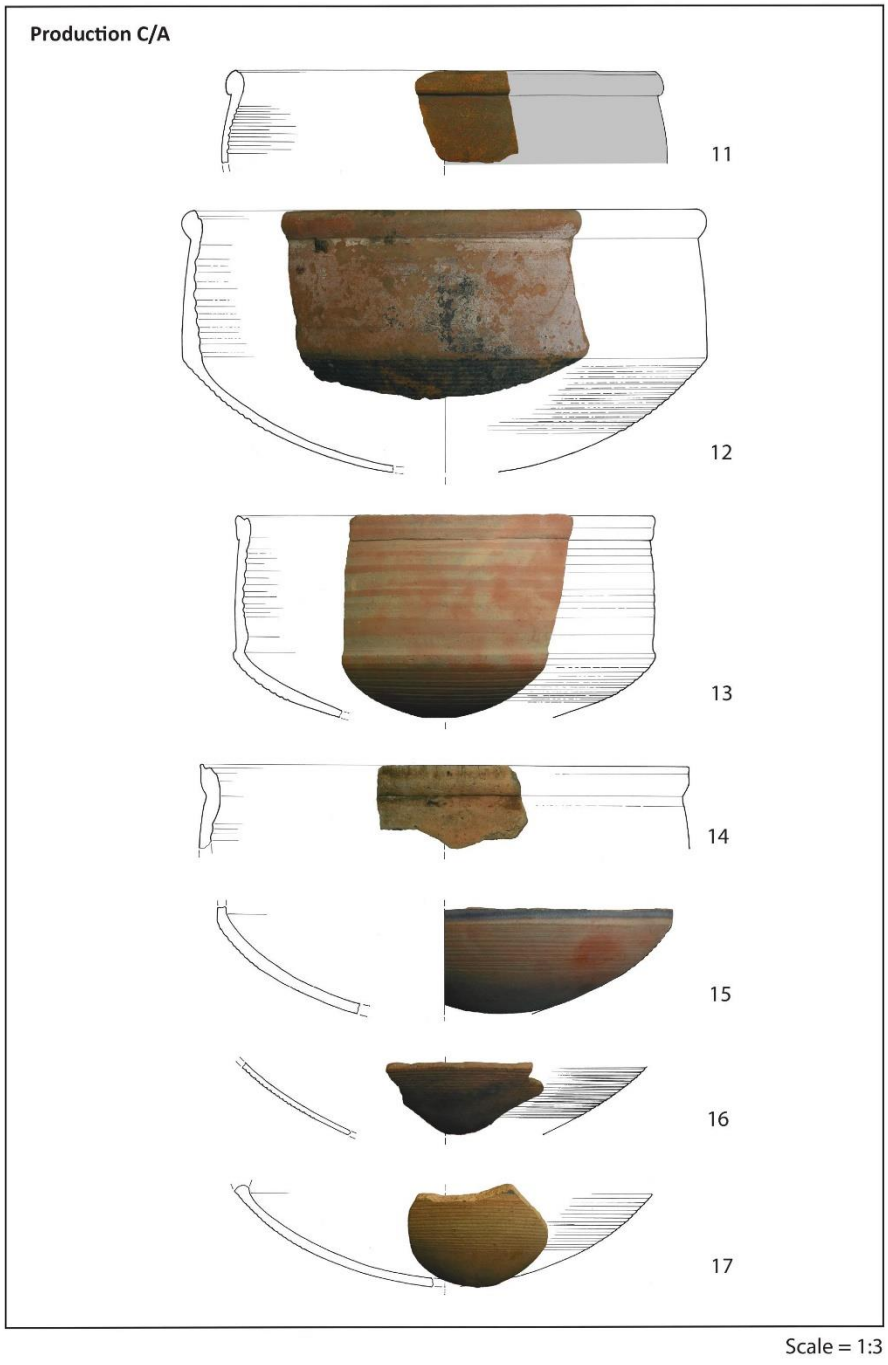


Figure 5. Fizine: types of African cooking ware from the 2021 underwater excavations. Production C/A; 11: Hayes 197, *variante de la forme classique* (AFR-GK-4a), 12: Hayes 197, *forme classique* (AFR-GK-4c), 13: Hayes 197, *variante tardive* (AFR-GK-4a), 14: Hayes 197, *variante tardive* (AFR-GK-9), 15-16: Hayes 197 (AFR-GK-4a), 17: Hayes 197 (AFR-GK-4b). Drawings by Ida Murgelj.

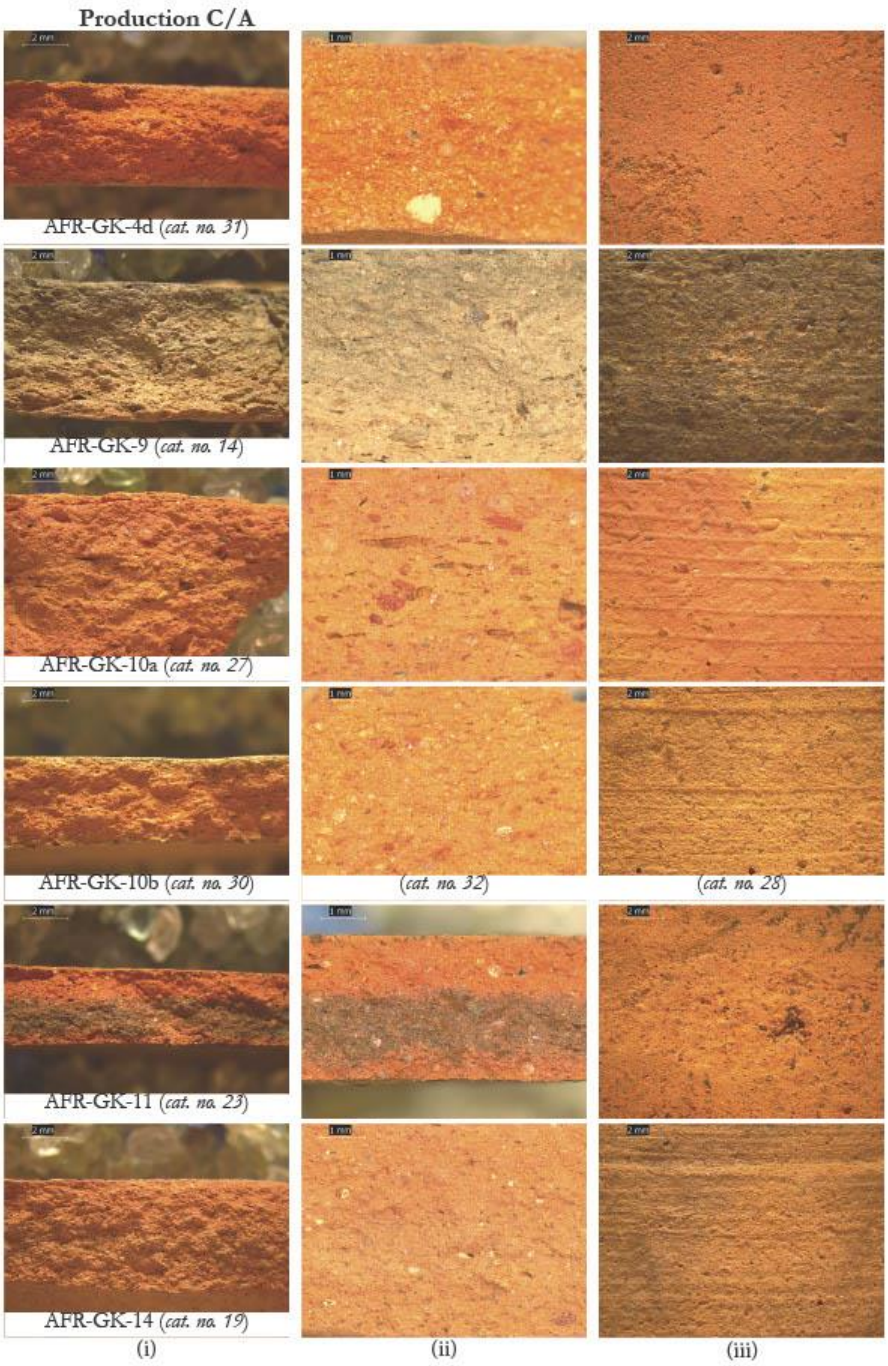


Figure 6. Fizine: representative samples of African cooking ware fabric groups associated with production C/A, depicting (i) fracture surface at 8x magnification, (ii) fracture surface at 16x magnification, and (iii) inner/outer surface appearance at 8x magnification.

According to Janne Ikäheimo's typology (2003: 32, 36, pl. 3: 4), these specimens most closely match the previously mentioned variant A.II, based on rim thickness not exceeding 14mm, although the Ostia I, Figure 261 type is cited as a *comparandum* for variant A.III (see description for cat. no. 6 in Ikäheimo 2003: pl. 3: 6). Two comparable instances have been reported from settlement deposits at Fizine, dated to the second half of the 4th and the first decades or mid-5th century (Gaspari *et al*. 2007: 203-204, pl. 6: 165; 9: 240). Analogies are known from other upper Adriatic sites (Pröttel 1996 *passim*), including Ajdovščina (Vidrih Perko and Žbona Trkman 2005: 281), Školarice (Žerjal 2008: 167) and Aquileia, ranging from the Flavian period to the 4th century (Mannocci 2021: 19-20). The rim thickness of two other specimens (Figure 7: 25-26) is even more pronounced, aligning with the late Ostia IV, Figure 60 type, dated to the 4th and the beginning of the 5th century (Atlante I: 212, pl. CIV: 8; Bonifay 2004: 227, Figure 121: *variante tardive*). Both specimens show differences in rim appearance and thickness and can be categorised as variant A.III within J. Ikäheimo's typology, which has a broader chronological range extending from the late 3rd to the mid-5th century (Ikäheimo 2003: 33, 37, pl. 3: 5-6).

It has been argued that equipping lids with knobs is characteristic of 1st and 2nd-century cookware lid production and reappeared in the late 5th/early 6th century, whereas ring-shaped handles were predominant in the 3rd and 4th centuries (Ikäheimo 2003: 46, with cited bibliography). At Fizine, only two lid handles were found (Figure 7: 29-30), both recorded independently of rim fragments. We associate these handles with Hayes 196 lids, given the prevalence of these lids at the site and the fact that the handles and the Hayes 196 lids share the same fabrics. Cat. no. 29 belongs to the fabric group AFR-GK-4, while cat. no. 30 is part of AFR-GK-10 (*infra*). Both handles are ring-shaped with an angular protrusion and pronounced edges, typical of variant F.II from the Palatine East excavations (Ikäheimo 2003: 47-48).

The last vessel form represented within AFR-GK-4 is a single Hayes 195 lid (Figure 9: 31). These lids are considered an unslipped version of Hayes 182 and a typical late Roman form of North Tunisian production (Hayes 1972: 208; Ikäheimo 2003: 39). Apart from the flattened dome-shaped body and the everted hook-shaped rim with a rounded tip, the studied specimen features a double groove at mid-body, a characteristic of earlier forms that, in some cases, persisted (Bonifay 2004: 227). Typologically, it corresponds to the Ostia I, Figure 264 type, generally dated to the end of the 4th and the first quarter of the 5th century (Bonifay 2004: 227; Bonifay 2016: 563). Examples from Ostia are rare and appear from the Severan period, while those attested in Carthage are noted as late antique (Atlante I: 214, pl. CV: 8). Analogous lids from Aquileia fit within a later chronology, spanning from the end of the 4th to the mid-5th century (Mannocci 2021: 21). It has been suggested that production in general may have begun as early as the late 2nd century, with widespread distribution during the 3rd and especially the 4th century, followed by a significant decline at the end of the 4th century, although production and distribution continued into the early 5th century (Ikäheimo 2003: 39).

The fine-grained pottery paste of AFR-GK-9 is composed of non-calcareous particles. Translucent colourless to translucent pink quartz, subrounded to subangular, is frequent in sizes up to 25mm, moderate up to 0.5mm, and rare up to 1mm. Rare grey subangular to subrounded grains, possibly rock fragments, range from 0.5 to 1mm, but occur moderately in sizes smaller than 0.25mm. Rare reddish-brown subangular and subrounded grains, also potentially rock fragments, measure approximately 0.5mm. Irregularly shaped, subrounded voids, not exceeding 0.25mm, are moderately visible in the fracture, while those on the surface are fairly rounded, ranging from 0.5 to 1mm. The ceramic body was fired in either a reducing or irregularly oxidising atmosphere, possibly at too high a temperature, as cracks are present on some areas of the vessel surface. Alternatively, these cracks may have resulted from secondary exposure to fire. Consequently, the fracture displays shades of dark grey to grey in its

inner half (GLEY 1 N 4/-5Y 6/1) and light brownish grey in its outer half (10YR 6/2). The hard ceramic body (Mohs hardness 3) is smooth, with an unevenly grey inner surface (GLEY 1 N 5/) and a reddish-yellow, light-brown, and grey outer surface (5YR 6/6, 7.5YR 6/4, GLEY 1 N 6/). Brown and pale brown patches of presumed self-slip cover the inner surface.

Representing AFR-GK-9 is a late variant of the Hayes 197 form (Figure 5: 14). It belongs to a group of casseroles distinguished by a prominent outer half of the bifid rim, which are assigned to the end of the 4th and the first half of the 5th century (Bonifay 2004: 225, Figure 120: 9; Ikäheimo 2003: 62, variant O.VI).

AFR-GK-10 is characterised by a very fine-grained pottery paste containing non-calcareous particles. Translucent, rounded to subrounded quartz is frequently observed in sizes of 0.25mm or smaller, with larger grains being rare and not exceeding 1mm. Deep red, brownish-red, and brown Fe-oxides are frequently found in sizes up to 0.25mm and rarely reach between 0.5 to 1mm. The presence of purplish-red, dark-red, and brownish subangular to subrounded grains, resembling argillaceous rock fragments, is also notable. Their varying frequency prompted the subdivision of the fabric group into AFR-GK-10a and AFR-GK-10b. In subgroup AFR-GK-10a, these non-calcareous particles occur moderately in sizes up to 0.5mm, rarely up to 1mm, and singularly up to 4mm, whereas in subgroup AFR-GK-10b, they are rare in sizes up to 0.5mm and singular at 1-2mm. Subgroup AFR-GK-10a further differs in the content of voids within the fracture, with irregularly shaped voids moderately present, up to 0.25mm in size. Rare voids are either irregularly shaped and subangular, measuring around 0.5mm, or elongated at approximately 1mm. In subgroup AFR-GK-10b, voids are rare, generally irregularly shaped at around 0.5mm or elongated at approximately 1mm. The ceramic body was fired in a fully oxidising atmosphere across all samples. The fracture of subgroup AFR-GK-10a displays a light yellowish-brown core (closest to 10YR 6/4) with light red margins (2.5YR 6/6), as well as unevenly pale brown inner and outer surfaces (2.5Y 8/4). The ceramic body of this subgroup is hard (Mohs hardness 4) and smooth to the touch. In contrast, the fracture of subgroup AFR-GK-10b features either a reddish-yellow core (5YR 6/6) with pale brown margins (10YR 6/3) or, more frequently, a light red core (closest to 2.5YR 6/8) with very thin, very pale brown margins (10YR 7/4). The surface colour may be uniform on both the inner and outer surfaces, exhibiting shades of unevenly pale brown and light brownish grey (2.5Y 7/3-7/4, 6/2), or very pale brown (closest to 10YR 7/4). However, most samples show variations in inner and outer surface tones, such as very pale brown, pale brown, light yellowish brown, or pink (2.5Y 8/3, 7/4, 7/3, 10YR 7/4, 7/3, 6/4, 5YR 7/4). The ceramic body of this subgroup is hard (Mohs hardness 3) and has a smooth, slightly powdery feel. Light red to red, light red, red (2.5YR 6/6-6/8, 5/6), or reddish-yellow (5YR 6/6) patches and spots are visible on both the inner and outer surfaces of nearly all samples from both subgroups. These features resemble traces of a dull slip but are more likely to be discolourations resulting from use or post-depositional processes. The characteristic *orlo annerito* is also observed in shades of light grey, grey, and/or dark grey (GLEY 1 N 7/, 5/, 4/, 10YR 4/1, 2.5Y 5/1).

AFR-GK-10 includes four Hayes 196 lids and three Hayes 195 lids.

A particularly fragmented Hayes 196 specimen with a rounded rim that is semi-circular in section (Figure 7: 20) appears most comparable to the Ostia I, Figure 263 type. This type is rarely found in Ostia, occurring in layers dating to the first half of the 3rd and the 4th century (Atlante I: 214, pl. CV: 9). Notably, a similar fragment from the Fondi Cossar site in Aquileia belongs to production B and is dated to AD 425-475. Additional examples from Aquileia are known from 4th-century contexts (Mannocci 2021: 12, with cited bibliography). Other Hayes 196 lids (Figure 7: 27-28) have thick rims, resembling the previously discussed late Ostia IV, Figure 60 type and the A.III variant.

The three Hayes 195 lids (Figure 9: 32-34) represent additional examples of the late Ostia I, Figure 264 type. Cat. nos. 32 and 34 share close similarities with cat. no. 31 from fabric group AFR-GK-4 in rim profile and thickness, while cat. no. 33 is set apart by a slightly thinner rim with a more pronounced hook shape.

AFR-GK-11 is very fine-grained and primarily composed of translucent, subrounded quartz, frequently measuring 0.25mm or smaller, with larger grains being rare and not exceeding 1mm. Dark reddish, subrounded non-calcareous particles, possibly rock fragments, measuring around 0.5mm in size are rarely found. Greyish, subrounded to rounded bodies – some hollow and resembling reaction rims – do not react with hydrochloric acid, suggesting they may be microfossils, though their exact identity remains undefined. These bodies are moderately present and reach up to 0.25mm. Rounded to subrounded voids are rarely observed within the fracture, measuring up to 0.25mm, while larger voids, ranging from 0.5 to 1mm, appear at the surface. The ceramic body was likely fired under uneven redox conditions, producing a very dark grey core (7.5YR 3/1) with red margins (2.5YR 4/8) in the fracture, while both the inner and outer surfaces are yellowish red (5YR 5/6-5/8). In addition to the ceramic body having a hard texture (Mohs hardness 3) and a smooth surface, the presence of the characteristic *orlo annerito* is also noted.

The sole specimen pertaining to AFR-GK-11 is a Hayes 196 lid (Figure 7: 23) with a thickened rim, corresponding more specifically to the aforementioned Ostia I, Figure 261 type and the A.II variant. Its exterior is largely soothed.

The very fine-grained pottery paste of AFR-GK-14 is predominately distinguished by frequent translucent, subrounded quartz up to 0.25mm in size, with rare grains reaching 0.5mm. Carbonate bodies, including reaction rims, are moderately present up to 0.25mm and occur only rarely in sizes between 0.26 and 0.5mm. Dark reddish, subangular particles, possibly rock fragments, are rarely found, ranging from 0.5 to 1mm. Notably, silver mica is also observed, occurring moderately up to 0.25mm and rarely reaching 0.5mm. Rare voids, generally rounded or irregularly shaped, are visible at the surface, measuring approximately 1mm, with singular irregularly shaped ones reaching up to 2mm. The ceramic body was fired in oxidising conditions, resulting in a hard texture (Mohs hardness 3) with a smooth feel. The fracture displays a light brown core (closest to 7.5YR 6/3) with red margins (2.5YR 5/6). The red inner and outer surfaces are covered with traces of light brown, pale brown to greyish brown (7.5YR 6/4-10YR 6/3, 2.5Y colours), possibly from a dull slip, self-slip, or salt scum, which extends over parts of the *orlo annerito*. The attribution of AFR-GK-14 to production C/A is not definitive.

Part of fabric group AFR-GK-14 is an individual Hayes 196 lid, distinguished by a seamless transition from the wall to the rim, the latter being rounded and wider compared to the former (Figure 7: 19). The closest analogy appears to be variant A of the classic form, documented in mid-3rd-century deposits from Nabeul, though it may have been produced as early as the second half of the 2nd century (Bonifay 2004: 227, Figure 121: 5). A similar type from Ostia, Ostia I, Figure 18, is dated to the first half of the 3rd century (Atlante I: 212, pl. CIV: 2).

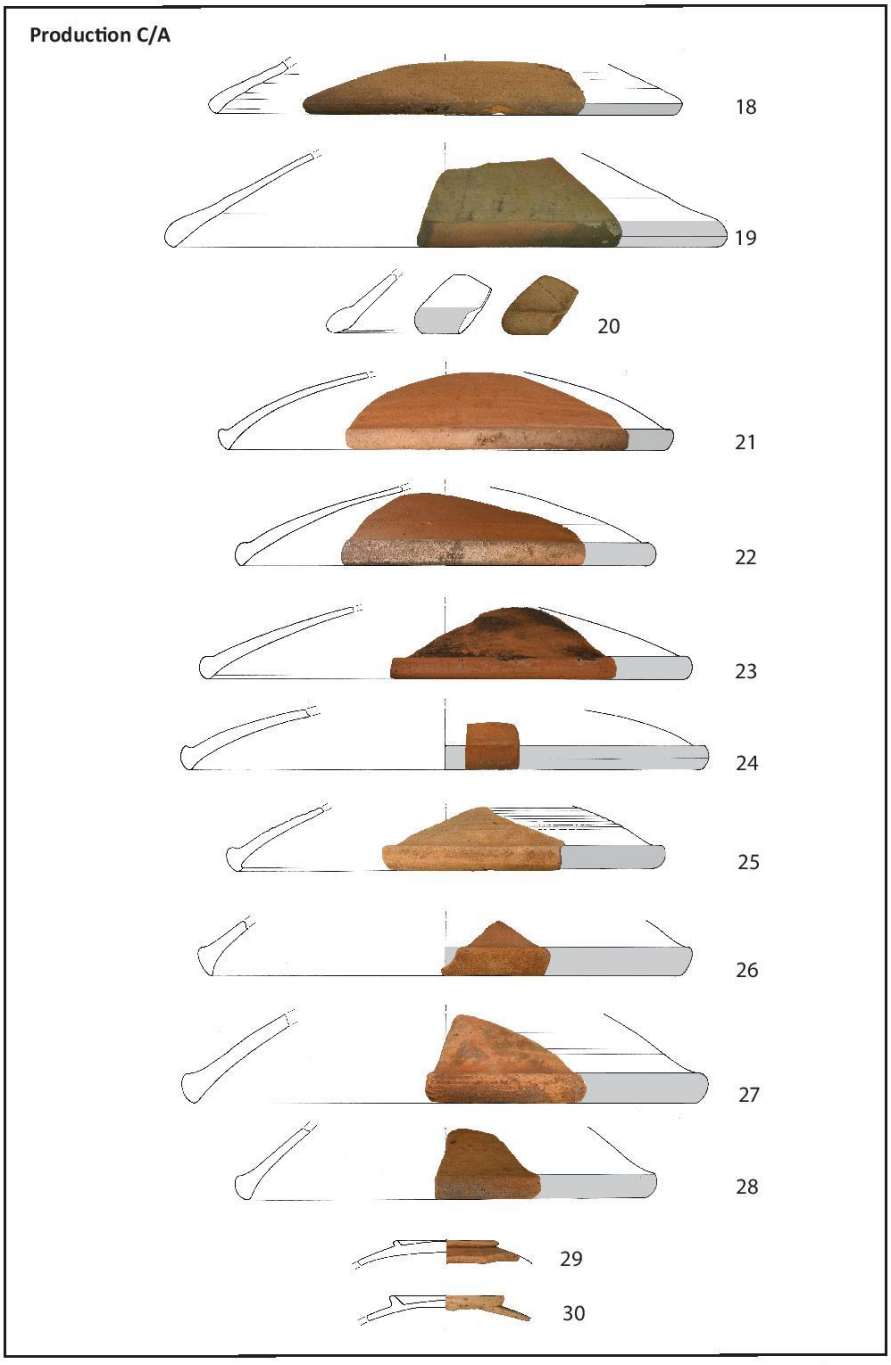


Figure 7. Fizine: types of African cooking ware from the 2021 underwater excavations. Production C/A; 18: Hayes 196/Ostia III, Figure 332 (AFR-GK-4a), 19: Hayes 196, *variante A de la forme classique* (AFR-GK-14), 20: Hayes 196/Ostia I, Figure 263 (AFR-GK-10b), 21-22, 24: Hayes 196/Ostia I, Figure 261 (AFR-GK-4a), 23: Hayes 196/Ostia I, Figure 261 (AFR-GK-11), 25-26: Hayes 196/Ostia IV, Figure 60 (AFR-GK-4a), 27: Hayes 196/Ostia IV, Figure 60 (AFR-GK-10a), 28: Hayes 196/Ostia IV, Figure 60 (AFR-GK-10b), 29: Hayes 196 (?) (AFR-GK-4b), 30: Hayes 196 (?) (AFR-GK-10b). Drawings by Ida Murgelj.

Production C

Four fabric groups – AFR-GK-5, AFR-GK-6, AFR-GK-7, and AFR-GK-8 – are classified under Production C but may be more closely associated with regional production CBR (Figure 8). This production, identified at sites in the Gulf of Hammamet and Cape Bon, includes forms that either imitated major productions or developed more original typologies, some of which exhibit limited Mediterranean distribution (Bonifay 2004: 231 ff; Bonifay 2016: 530, 532-533).

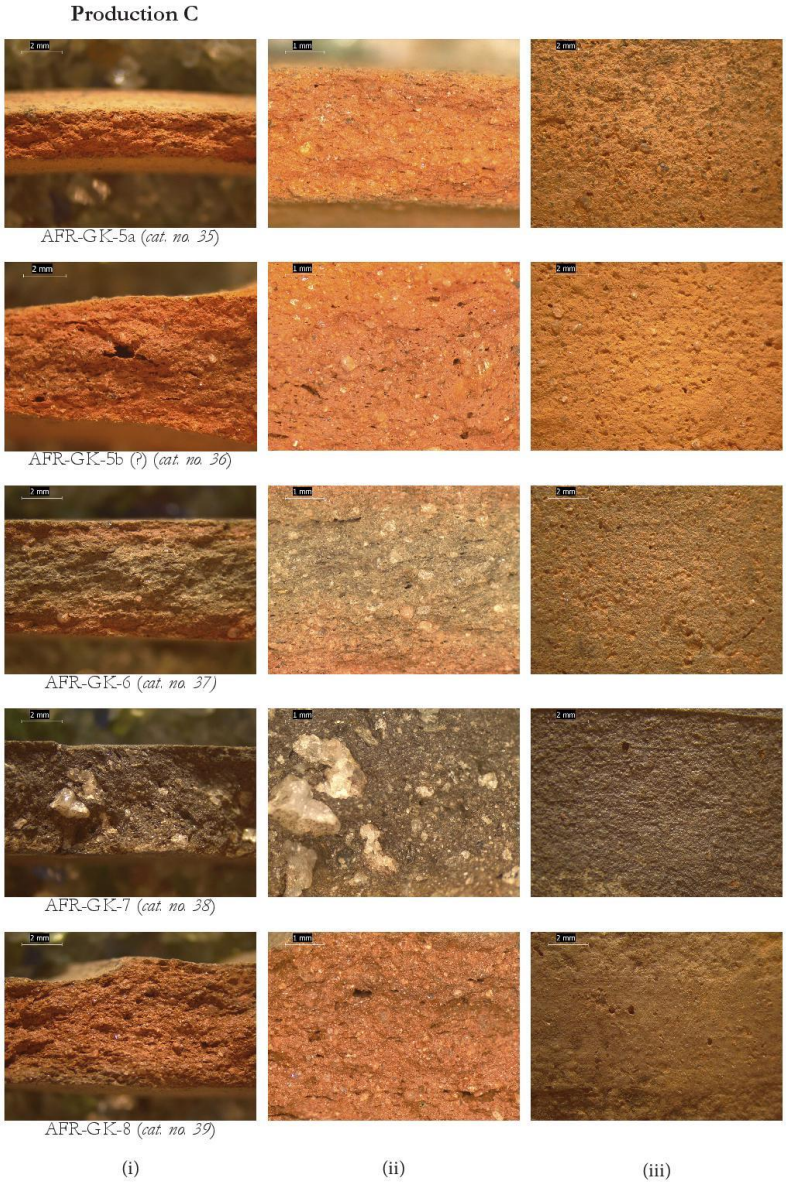


Figure 8. Fizine: representative samples of African cooking ware fabric groups associated with production C, depicting (i) fracture surface at 8x magnification, (ii) fracture surface at 16x magnification, and (iii) inner/outer surface appearance at 8x magnification.

AFR-GK-5 is divided into two subgroups, both with very fine-grained pottery pastes containing quartz, clay pellets, and undefined particles, but differing in the size and frequency of components, as well as other properties. However, it should be noted, that the second subgroup may differ significantly enough to be considered a separate fabric group; for the time being, it remains unclassified as such, pending further analysis.

In subgroup AFR-GK-5a, translucent, subrounded to rounded quartz grains are frequent up to 0.25mm and rare up to 0.5mm, while singular greyish-white, subangular grains measure approximately 3mm. Clay pellets are found rarely, ranging from 0.5 to 1mm in size. Also rare are blackish, fairly rounded particles and dark reddish, generally irregularly shaped particles, neither of which exceeds 0.25mm. In the fracture, moderately visible subrounded voids reach up to 0.25mm, alongside elongated voids measuring 0.5mm. Singular, larger ones, measuring around 2mm, are present both in the fracture and on the surfaces. The ceramic body was fired in an oxidising atmosphere and exhibits a soft texture (Mohs hardness 2) with a smooth to harsh, slightly powdery feel. The fracture displays a red colour (closest to 2.5YR 5/8), while the light brown to brown inner and outer surfaces (closest to 7.5YR 6/4-5/4) appear self-slipped.

In subgroup AFR-GK-5b, quartz grains are frequent up to 0.25mm and rare up to 1mm. The quantities of clay pellets and dark reddish particles remain consistent with those in the first subgroup, while the blackish particles, also not exceeding 0.25mm, are moderately present. AFR-GK-5b differs by its content of red Fe-oxides, which are singular and measure 0.5mm. Additionally, it features a greater number of voids, which are frequent, subrounded, and irregularly shaped, reaching up to 0.25mm, with rare elongated voids ranging from 0.5 to 1mm. The ceramic body was fired in irregularly oxidising conditions, resulting in a reddish-brown core (2.5YR 4/4) with red margins (2.5YR 5/8) within the fracture. Both surfaces exhibit an uneven tone that falls between reddish yellow and strong brown (between 7.5YR 6/6 and 5/6). The ceramic body is hard (Mohs hardness 3) with a harsh and slightly powdery feel. Additionally, black traces are observed on the rim; however, it is unclear whether these represent an *orlo annerito* or simply soot deposition.

Subgroup AFR-GK-5a was sampled from a single *marmite* featuring a thickened, outward-flaring rim, a convex bottom, and straight, grooved walls (Figure 9: 35). This specimen is comparable to an example from Carthage, attested in a chronologically undefined context (Atlante I: 220, pl. CVIII: 1). The morphological attributes of the studied specimen suggest a typological affiliation with the Sidi Jdidi 1/Culinaire (C) type 23 *marmites*, dated to the first half of the 3rd century (Bonifay 2004: 234, Figure 125: 1). However, its squarish rim profile and grooved walls align it more closely with the Sidi Jdidi 1/5 *marmites* from the second half of the 4th century (Mukai 2016: 29, Figure 12). Lastly, variant S.IV from the Palatine East excavation merits attention for its rectangularly thickened rim with a flat top, though it lacks grooved walls. This variant is ascribed to a central Tunisian production, active from the 2nd to the late 4th/early 5th century (Ikäheimo 2003: 68, pl. 15: 79). A potentially analogous example was recovered from a mid-4th to early 5th-century layer in the settlement area at Fizine (Gaspari *et al.* 2007: 201, pl. 6: 143). A similar vessel has also been discovered in Ajdovščina (Vidrih Perko and Žbona Trkman 2005: Figure 5: 3) and in a modern deposit in Aquileia (Mannocci 2021: 25).

Subgroup AFR-GK-5b is represented by a single lid with a triangularly thickened rim, a conical body with grooved walls, and a solid knob (Figure 9: 36). Although no exact analogy has been identified, a tentative connection may be drawn to the Fulford Lid 3 type. Examples of this type from Carthage date to the 5th and the first half of the 6th centuries, while those from Oudhna are attributed to the 6th century (Bonifay 2004: 242, Figure 131). Additionally, variant A.IV from the Palatine East excavations,

which have been subject to a contentious typological and chronological identification (Ikäheimo 2003: 38, pl. 4: 7), may also be related.

AFR-GK-6 has a fine-grained pottery paste composed mainly of translucent colourless and translucent pink, subrounded to rounded quartz. Grains smaller than 0.25mm are frequent; those ranging from 0.26 to 0.5mm are moderately present, while larger grains, up to 1mm, are singular. Reaction rims, measuring up to 0.25mm, are rare, while singulars reach a maximum of 0.5mm. Blackish, subrounded particles appear rarely, up to 0.25mm, while greyish, subrounded particles, 1-2mm in size, appear singularly; these remain undefined. Elongated voids, approximately 0.5mm in size, occur rarely. The ceramic body was fired in under uneven redox conditions, as evidenced by its sandwich structure; the fracture reveals a greenish-grey core (GLEY 2 10G 5/1) with reddish-brown to red margins (5YR 4/4-2.5YR 4/6). The inner and outer surfaces differ slightly in colour, with the inner surface displaying greyish-brown, light brown to grey (10YR 5/2, 7.5YR 6/4, GLEY 1 N 6/), while the outer surface shows grey, dark grey to brown (10YR and 2.5Y colours). The darker surface tones translate into very thin edges of the margins within the fracture. Additionally, the ceramic body is hard (Mohs hardness 3) and smooth to the touch.

A fragment of a convex base from a casserole or *marmite* (Figure 9: 37), featuring a corrugated upper half of the exterior surface, pertains to AFR-GK-6.

AFR-GK-7 is characterised by a very fine-grained pottery paste consisting of translucent, colourless to whitish-grey quartz up to 2mm in size; grains smaller than 0.25mm are abundant, while larger ones are rare. Bluish-grey, subrounded non-calcareous bodies, around 0.5mm in size, occur singularly. Rare blackish, rounded elements, possibly Fe-oxides, are observed in sizes up to 0.5mm, with singular larger ones reaching 1mm. Presumably rare silver mica, not exceeding 0.25mm, is also present. Rare subrounded voids, ranging from 0.5 to 1mm, appear at the surfaces. The ceramic body was fired in a reducing atmosphere, exhibiting a hard texture (Mohs hardness 4) and a smooth feel. The fracture features a very dark greyish-brown to very dark grey inner half (10YR 3/2-3/1) and a very dark grey to black outer half (GLEY 1 N 3/-2.5/). The inner surface is unevenly dark grey to very dark grey and brown (GLEY 1 N 4/-3/, 10YR 5/3), while the outer surface is unevenly dark grey to very dark grey (2.5Y 4/1-GLEY 1 N 3/).

AFR-GK-7 includes two convex base fragments (e.g., Figure 9: 38), presumably from different casseroles or *marmites*, both displaying a corrugated upper half of the exterior surface.

The fine-grained pottery paste of AFR-GK-8 is primarily composed of translucent, subangular and subrounded quartz, frequently found up to 0.25mm and rarely reaching 0.5mm. Singular grains, measuring approximately 1mm, are exclusively subangular. Reddish, subrounded particles ranging from 0.5 to 1mm are also present. Voids are rare; those visible in the fracture are irregularly shaped and measure 0.5mm, while those visible at the surfaces are larger (1mm) and generally subrounded. The ceramic body was fired in oxidising conditions, with a brief alternation either at the final stage or during the cooling period. Consequently, the fracture displays an uneven reddish-brown to red core (closest to 2.5YR 4/4-4/6) with very thin dark grey margins (10YR 4/1). Both surfaces exhibit uneven shades of grey to dark grey (10YR 5/1-4/1). Additionally, the ceramic body is hard (Mohs hardness 4) and has a smooth feel.

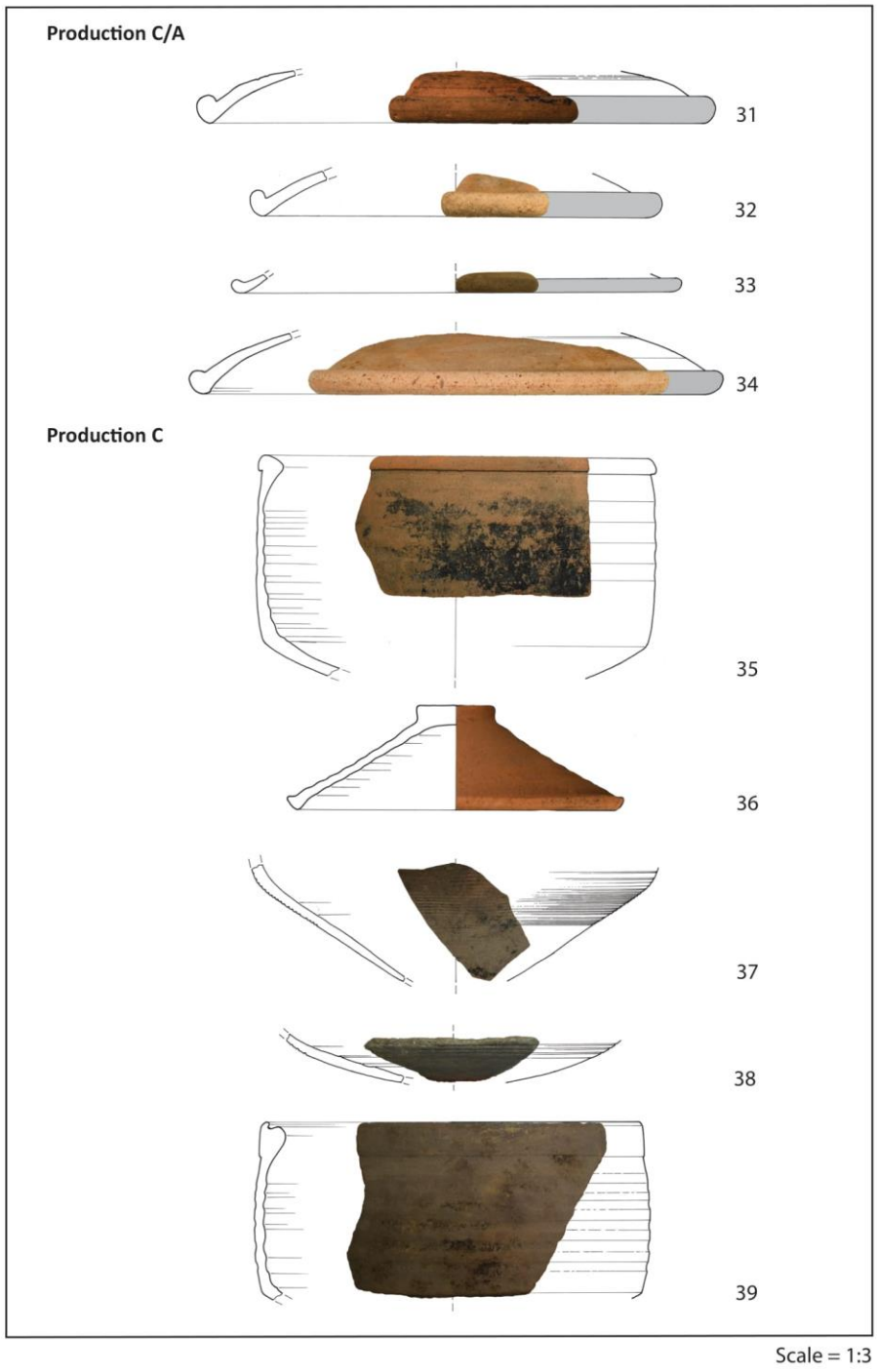


Figure 9. Fizine: types of African cooking ware from the 2021 underwater excavations. Production C/A; 31: Hayes 195/Ostia I, Figure 264 (AFR-GK-4d), 32-34: Hayes 195/Ostia I, Figure 264 (AFR-GK-10b). Production C; 35: Atlante CVIII, n. 1/Sidi Jdidi 1/5 (AFR-GK-5a), 36: Fulford Lid 3 (?) (AFR-GK-5b (?)), 37: casserole/*marmite* (AFR-GK-6), 38: casserole/*marmite* (AFR-GK-7), 39: Sidi Jdidi 4/*Culinaire* (C) type 31 (AFR-GK-8). Drawings by Ida Murgelj.

The representative vessel of AFR-GK-8 is a *marmite* (Figure 9: 39) with a thickened bifid rim, a convex bottom, and grooved walls, reminiscent of late Hayes 197 casseroles. However, technologically and typologically, it aligns more closely with later variants of the Sidi Jdidi 4/Culinaire (C) 31 type from the beginning of the 4th century (Bonifay 2004: 239, Figure 128: 5). Although initially classified within the local typology of Sidi Jdidi, the Culinaire (C) 31 type is now treated separately due to its limited presence at Sidi Jdidi and nearby sites, while being notably more common in Nabeul and Cape Bon (Bonifay 2004: 239; Mukai 2016: 29). Its production in general began in the first half or mid-3rd century, possibly in Cape Bon, and may have continued into the 5th century (Bonifay 2004: 67, 239; Bonifay 2016: 533, 565). The specimen from Fizine places the site among the few Western Mediterranean locations where the distribution of this type, presumably intended for a regional market, has been documented (Bonifay 2004: 239).

Conclusive remarks

The study of African cooking ware from Fizine provides insights into its technological and typological features, contributing to our understanding of ceramic usage and consumption in the northeastern Adriatic region, particularly during the Late Roman period. So far in present-day Slovenia, this ware is predominantly identified in lowland settlements and *Claustra* outposts, while it is absent from the material of hilltop settlements (Modrijan 2020: 585). The assemblage examined comprises both Central and North Tunisian products, with a notable predominance of vessels produced in North Tunisian workshops. It includes common types such as Hayes 181 pans, Hayes 182/195 and Hayes 196 lids, and Hayes 23 and Hayes 197 casseroles, represented by various derivations that demonstrate design heterogeneity. In contrast, a small number may be linked to regional production, such as Sidi Jdidi 1/5 and Sidi Jdidi 4 *marmites*. The repertoire fits within a broader chronological framework, spanning from the mid-3rd to the mid-5th century, with most specimens dating to the 4th and early 5th centuries (Table 1). This timeframe corresponds with existing observations that African cooking ware imports peaked during the 4th and 5th centuries in the Adriatic region (Biondani 2014: 525; Mannocci 2021: 2).

The diversity of type variations is complemented by notable technological variability, resulting in the subdivision of several fabric groups into subgroups. Some of these subgroups could differ significantly enough to be regarded as distinct fabric groups, which future archaeometric analyses may verify.

Furthermore, all analysed specimens display traces of use-wear, including carbonised organic deposition of varying degrees, such as resins and food residues. They were primarily found as part of a larger concentration of material, consisting of ceramic building materials, organic objects, plaster, mortar, stone fragments, as well as much of the remaining coarse ware and other pottery groups, suggesting the presence of anchorage debris (Gaspari *et al.* 2023: 652-653). Notably, the quantity of African cooking ware and coarse ware in general identified in this area exceeds that of the Late Roman coarse ware reported from the adjacent settlement (cf. Gaspari *et al.* 2007). Continued post-excavational investigations and analyses of the remaining finds promise to enhance our understanding of this area, which most likely served as a mooring for smaller fishing and trading vessels during the Late Roman period.

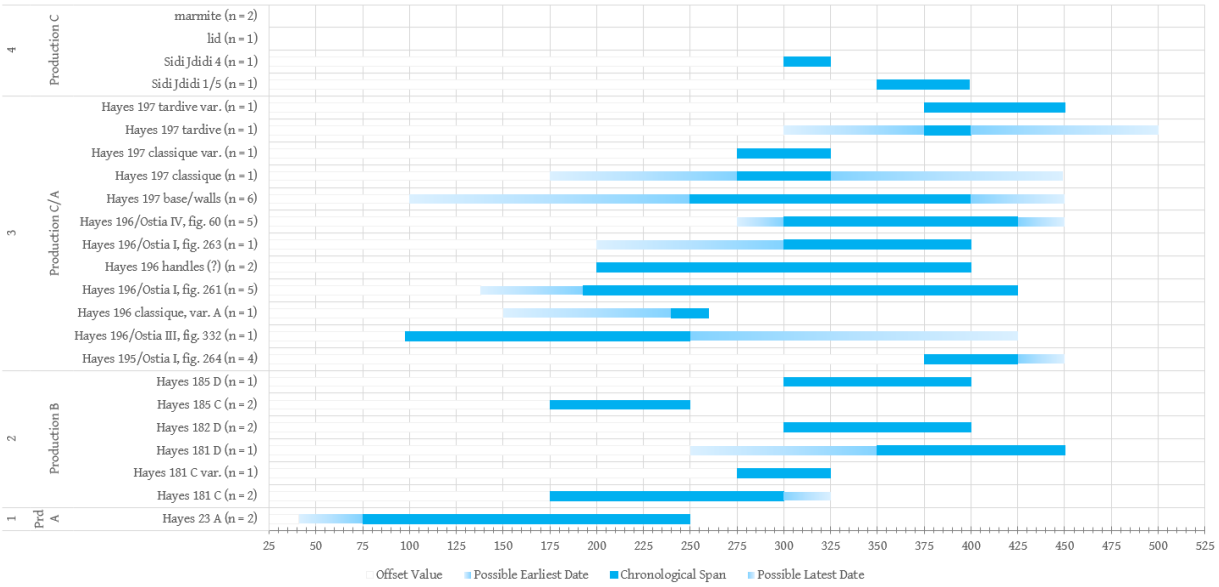


Table 1. Fizine: overview of African cooking ware by production, type, quantitative representation, and relative chronology.

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Terra, Mare, aut Fluvius: evaluating potential Roman stone trade routes leveraging geospatial models

Ines Ferjan[1]

Abstract

The transportation of stones from extraction sites to final destinations presents significant logistical challenges, to some extent still today. While stone transportation proved to be difficult over long distances throughout the entire Roman Empire, our research area focuses on the inland Balkans. Local stone production in the inland Balkans primarily supplied building materials, but it was insufficient for high-end commissions, necessitating the import of higher-quality stones from regional and Mediterranean sources. The study employs advanced analytical methods, including Least Cost Path analysis, Circuit Theory analysis, and Orbis, to assess potential transport routes. These geospatial models reveal the complexities and costs associated with stone transport in the research area, particularly highlighting the time-consuming nature of upstream transport on the Danube and the often-overlooked yet costly overland route from the Adriatic coast. The distribution of Mediterranean stone imports, especially in Roman villas and palaces, suggests that the most affluent buyers could prioritize faster delivery over cost, possibly diverging from standard commercial routes. This research underscores the need to critically evaluate modern analytical tools and complement their findings with additional archaeological evidence to better understand ancient stone trade logistics.

Keywords: stone transport, inland Balkans, ancient trade routes, geospatial analysis, Mediterranean Imports

Introduction

The study of ancient stone transport has been an ongoing topic in archaeological scholarship due to its complexities.[2] The process of moving stone cargo presented numerous logistical challenges, which varied greatly depending on the size and nature of the items being transported. To better understand these challenges, it is useful to categorise stone cargo into two main groups. The first group includes large stone blocks, sarcophagi, architectural elements such as columns, and other similar monumental objects. These items represent heavy cargo, often weighing many tonnes. The difficulty of transporting such massive objects was considerable and would have required specialised techniques and equipment, depending on the number and size of the objects. The second group comprises smaller stone objects, including statuary, smaller votive plates, stone slabs for veneering and decoration, and similar objects. These smaller objects, while still requiring careful handling, constituted lighter cargo compared to the monumental pieces. The methods and resources needed to transport lighter cargo would have been different, often less demanding in terms of scale and logistics. Understanding these categories helps clarify the diverse approaches and technologies employed in ancient stone transport.

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[2] For some general remarks on the transport of stone in antiquity, see Rockwell 1993: 166-177; Russell 2013: 95-140.

By examining the distribution patterns of white marble imports, we can gain an overview of stone trading in the inland Balkans. Through these comparisons, we can identify the materials that were in highest demand, determine the most suitable means of long-distance transport, and eventually recognise the buyers of specific types of stone. While the distribution provides much information on trade, our focus will be on analysing the potential transport routes, particularly from the Penteli quarries and Prokonnesos to *Sirmium*, and from the Penteli quarries to *Mursa*.

Methodology

The assessment of potential transport routes was conducted by analysing the results of Least Cost Path (LCP), Circuit Theory (CT), and Orbis.[3] It must be borne in mind that these tools provide suggested routes that require further assessment and interpretation, each having limitations that must be addressed. The LCP analysis, which is commonly used in archaeological research, calculates the optimal path between two given points. The result provides route based on the surface map, and this route can be further interpreted by comparing them with other archaeological data, such as examining if the suggested path corresponds to any archaeological material findings.[4] Additionally, the results can be calculated using more advanced tools for modelling mobility, such as CT and Orbis. It is important to note that LCP analysis, focusing solely on gradient, does not consider upstream or downstream travel, nor does it calculate the sea travel.[5] While it provides useful suggestions, it is most effective in areas where transport routes have been previously archaeologically assessed, where the transport network is very clear, or where there is a short distance between two desired locations.

Some limitations of LCP can be addressed with CT analysis, which considers multiple points (desired locations) and calculates potential routes between them. It is crucial to note that the set of provided routes are only potential and may not have been used during the Roman period. Therefore, here again, the results need detailed interpretation and comparison with archaeological evidence and other geospatial models. CT analysis requires appropriate input data, which need to be prepared in advance.[6] For this research, the Digital Elevation Model served as the resistance raster, while points of interest, in this study Roman settlements and quarries, were formed in polygon layers and rasterised. The calculation involves the voltage (V) formula corresponding to the current (I) multiplied by resistance (R). The higher is the resistance on the surface map, the lower is the current.[7]

The third geospatial model used for this research is Orbis (Stanford Geospatial Network Model of the Roman World).[8] The Orbis analysis was used to calculate the cheapest and fastest paths between

[3] For more on geospatial approaches for archaeologists: for Least Cost Path analysis (LCP), see White 2017; for Circuit Theory (CT), see McLean 2022, Chapter 3; for Orbis, see Scheidel 2014.

[4] The Digital Elevation Model (DEM) surface map has been used for the purpose of this research, both in the LCP analysis and CT.

[5] In addition to not considering river flow or sea navigation, another limitation of LCP is the interpretation and recognition of modern topographic changes (e.g., artificial lakes, canals).

[6] For a detailed explanation of CT for an archaeological audience, see McLean 2022, Chapter 3.

[7] Reading the results of CT can be challenging and requires some adjustments for easier readability. Similar to LCP analysis, one limitation is the interpretation and recognition of modern topographic changes (e.g., artificial lakes, canals).

[8] For the Orbis model, see https://orbis.stanford.edu/.

quarries and settlements. Orbis is an advanced tool for understanding Roman communication costs in terms of both time (influenced by winds, currents, and navigational capabilities) and expenses (based on the Prices Edict from AD 301). Orbis uses the main routes of the Roman road network, main navigable rivers (considering upstream and downstream travel), and sea routes in the Mediterranean, Black Sea, and coastal Adriatic. The user can customise the settings, such as season, modes, and means of transport. This model has been used to calculate the most cost effective and fastest routes between two points of interest.[9] It is important to explain how the software calculates the cheapest and fastest options: the fastest path is the route that takes the least time, while the cheapest is the route with the lowest cost, priced in denarii, based on selected transport modes, with wagon transport used for the most cost-effective routes, and ox-cart transport used to calculate the fastest routes. Calculating the fastest route in the case of cargo movement with ox-cart transport, equivalent to an average of 12 km per day, is therefore more suitable for heavy cargo; whereas the most cost-effective route, namely wagon travel, is more suitable for lighter cargo. This distinction is essential, as the choice of transport method significantly impacts the logistics of moving stone, affecting both the speed and cost of the transportation. Thus, the results are not directly comparable since settings differ between the fastest and cheapest path, but they still allow for a comparison between time efficiency and transportation cost. Additionally, the cost of travel is exemplified by grain, which, while different from the cost of transporting stone cargo, provides a reasonable estimate of the monetary expenditure for transporting cargo on a specific route.[10]

Case studies

The present study examines potential transport routes between the two significant white marble quarries in the Mediterranean and two settlements in the Balkans, namely *Sirmium* and *Mursa*. The quarries analysed are the Penteli quarries in Attica, near modern Athens, Greece, and the Prokonnesos quarry on modern Marmara Island, Turkey.[11] It is well-documented that marble from these quarries was extensively exported throughout the Roman Empire, with Prokonnesos marble particularly prevalent in the inland Balkans. While in this region the Penteli marble is often noted for its use in statuary, Prokonnesos marble was frequently employed in the architectural elements of the imperial palace in *Felix Romuliana* and for some sarcophagi.[12] The imperial palace in *Sirmium* likely also featured architecture using Prokonnesian marble; some of the architectural elements have been macroscopically identified as such.[13] In *Sirmium*, two artefacts possibly made from Penteli have been unearthed: a head

[9] The summer season, specifically July, was selected for both the fastest and cheapest path analyses, suggesting most transport occurred in warmer months (the most favourable season for sailing), though transport could happen in other seasons as well. The settings included road, river, coastal sea, and open sea, with the default prices in the geospatial network model set in denarii.

[10] Orbis results were georeferenced on the CT map, noting that minor errors may occur over larger distances. Despite these occasional anomalies, the results remain legible and were initially examined using the Orbis basemap to avoid distortion.

[11] For Penteli quarries, see Pike 2004 and Bernard 2010; for Prokonnesos, see Attanasio, Brill, and Bruno 2008: 1-2.

[12] For Prokonnesian material in *Felix Romuliana,* see Djurić *et al*. 2018, for Prokonnesian sarcophagi in the inland Balkans, see Koch 2013; for a garland sarcophagus from *Viminacium,* see Tomović 1991; for sarcophagi from *Dardania,* see Dobruna-Salihu 2012.

[13] Djurić *et al*. 2006: 117 note macroscopic examination of Prokonnesian material, though, as discussed in Maver 2009: 136, the hippodrome's Corinthian Asiatic capitals of light grey fine to medium-grained marble are generally believed to be Prokonnesian, but more detailed study of the capitals from the Tetrarchy period is needed.

of a statue, presumably representing Venus or Apollo, and a fragment of a hand, both found in the imperial palace.[14] Many statues and fragments of statues made from fine-grained, high-quality marble have been discovered at the site, suggesting that additional pieces may have been carved from Penteli marble, although this has yet to be confirmed.[15] The presence of Penteli marble in *Mursa* remains a subject of debate; however, there is a possibility that a statue of Cybele might be of Penteli origin.[16] These quality marble artefacts showcase the trade networks and the demand for premium materials in Roman urban centres.

This research focuses on calculations of potential transport routes between these quarries and settlements and aims to explore the connectivity for stone trade within these regions during antiquity. In assessing potential transport routes for imports from more distant locations, such as Mediterranean marble, the LCP analysis proves inadequate due to its reliance on elevation surface maps, which are not suited for navigating maritime environments. Consequently, CT and Orbis have been used to provide a comparative analysis of the results. These methods allow for a more comprehensive understanding of the connectivity and trade networks of marble across the Roman Empire. By integrating multiple analytical tools, this study provides an overview of ancient transportation logistics, showcasing the technological prowess and economic strategies employed to facilitate the distribution of marble.

Potential transport routes between the Penteli quarries, *Sirmium* and *Mursa*

To study the transport routes for marble imports from the Mediterranean to the inland Balkans, CT analysis was first employed. The results underscore the Danube River's pivotal role in facilitating the importation of Pentelic marble to this region. The most prominent pathway indicated by the CT analysis begins at the Penteli quarries on the Aegean Sea, proceeding through the Dardanelles Strait into the Sea of Marmara. The route continues via the Bosphorus and the Black Sea, ultimately reaching the Danube Delta. From this point, the marble would be transported upstream along the Danube River to reach *Sirmium*. However, the direct connection from the Danube to the settlement becomes less clear and is challenging to interpret. An alternative route considered involves maritime transport from the Adriatic Sea. Yet, in this scenario, none of the entry points provide a straightforward or direct continuation to *Sirmium*, further complicating the analysis of transport routes in this context (Figure 1).

When comparing the results from CT with those obtained using Orbis, notable differences in the suggested transport routes to *Sirmium* emerge. According to the Orbis analysis, the fastest route to *Sirmium* covers 1,379 km and takes approximately 41.2 days.[17] This route diverges significantly from the CT results, as it involves sailing through the Corinthian Gulf, entering the Adriatic Sea and sailing by the coast, docking at the port of *Narona*, and then continuing overland until reaching *Sirmium* (Figure

[14] For the head of a statue, see Popović 2012, no.9; for a fragment of a hand, see Popović 2012 43. The provenance of the fragment of a hand could be either Penteli quarries or Aphyon.

[15] A great number of marble sculptures from *Sirmium* have been published in catalogue by Popović in 2012. While many are confirmed to be of East Alpine origin, some may be Mediterranean imports, but further analyses are necessary to confirm this.

[16] The results of this analysis were presented by Djurić *et al.* at ASMOSIA XIII in Vienna in September 2022 (Conference Proceedings in press); however, in 2009 the results suggested either Aphyon or Penteli quarries.

[17] As Orbis uses only locations that are already inserted in the model, usually major Roman settlements, Athens was chosen as the starting point for the Penteli quarries.

1). By far the most time-consuming part of the journey is the last leg: overland transport from *Narona* to *Sirmium*, which would take approximately 30.1 days to cover 325 km. To compare a similar distance of this journey but on a sea route: the section from *Corinthus* to *Nicopolis*, sailing through *Delphi* and *Naupactus*, would last approximately 2.9 days to cover 335 km. Moreover, for transporting one kg of a wheat on the *Narona* to *Sirmium* route, one would have to pay 11.39 denarii, whereas for the 335 km sea route, the cost would be significantly lower, at 0.29 denarii. Conversely, the most cost-effective route involves circumnavigating the Peloponnese, sailing up the Adriatic to *Aquileia*, and then proceeding overland to *Virunum*. From *Virunum*, the journey continues downstream along the Drava and Danube rivers until reaching *Singidunum*, and finally proceeds upstream along the Sava River to *Sirmium* (Figure 1). This route covers a distance of 2,871 km and would take approximately 43 days. The entire journey includes four different modes of transport, which should be further examined to establish the affordability and time expenditure of each section (Figure 2). The most inconvenient legs of the journey are undoubtedly the overland and upstream sections. The section between *Aquileia* and *Virunum* is entirely overland and would take 6,5 days to cover 194 km, whereas the upstream section on the Sava River from *Singidunum* to *Sirmium* is 137 km and would last approximately 9.2 days. Thus, taking into account the topography of overland transport, which includes traversing the pre-Alpine region, one could cover approximately 29.8 km per day; whereas to travel upstream on the Sava, considering meanders, one could cover the distance of 14.9 km per day. Including the cost per kg of wheat for the entire section, which would be 6.79 denarii for the overland part and 0.94 for upstream, it is clear that overland transport is significantly faster compared to upstream, but considerably more expensive. The sea travel section is undoubtedly the most favourable, taking 16.1 days for 1,850 km and costing 1.61 denarii for wheat transport; followed by the downstream travel, where the 689 km long journey would take 11.2 days and cost 2.34 denarii per kg of wheat.

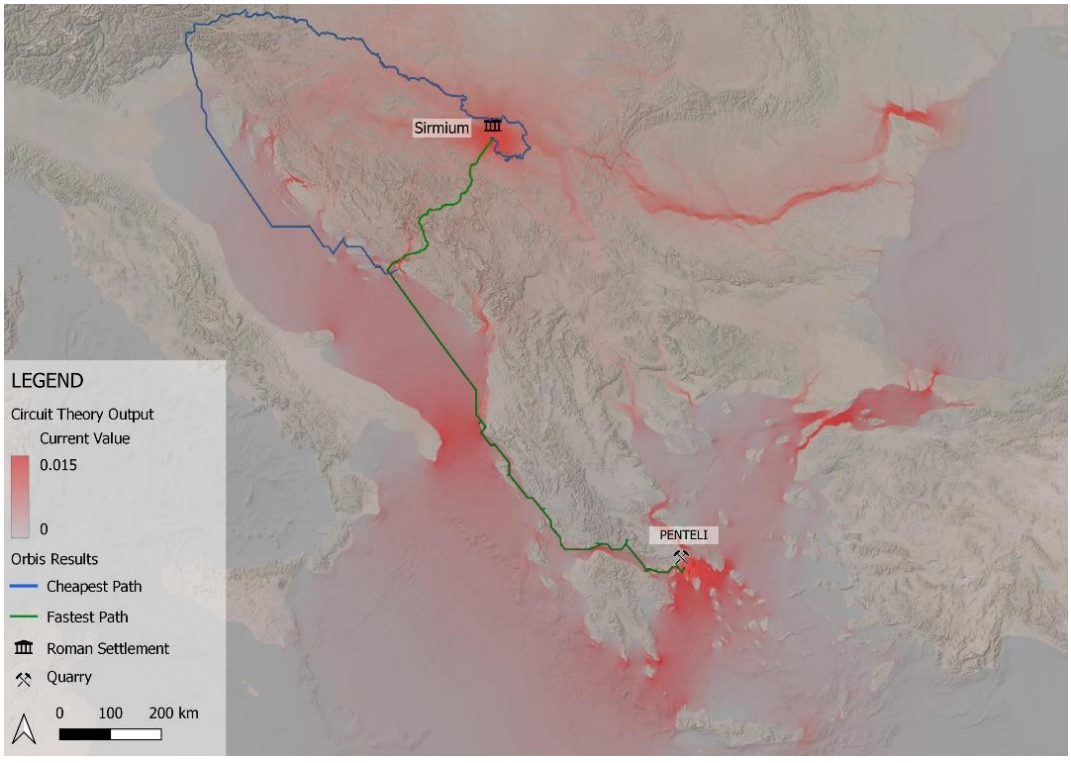


Figure 1. The results of CT analysis for transport routes from Penteli quarries and Orbis results for the cheapest and fastest path to Sirmium (Source: GIS, created by the author, April 2024).

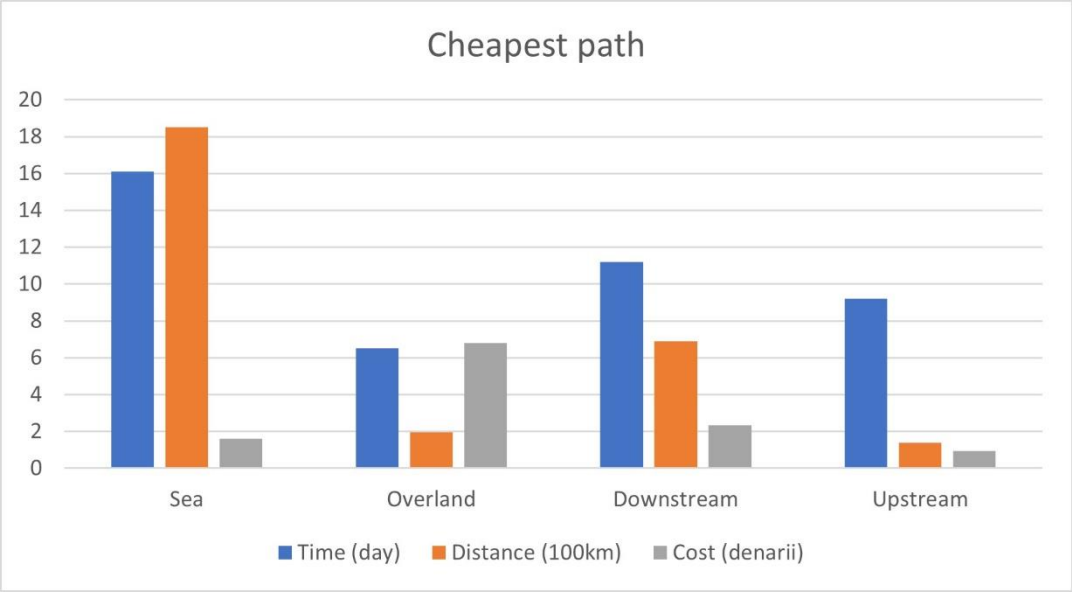


Figure 2. Graphical presentation of the cheapest path from Penteli quarries to Sirmium (Source: created by the author, April 2024).

Interestingly, the cheapest route to *Mursa* coincides with the fastest route to *Sirmium*, taking 29.6 days and covering 2,502 km (Figure 3). This route involves sailing to *Aquileia* first, and from there continuing overland to *Virunum*, and from *Virunum* downstream along the river Drava to *Mursa*. As previously established, the 194 km overland journey would take 6.5 days, costing 6.79 denarii, whereas the downstream travel is 457 km long and would take only half a day longer, costing only 1.61 denarii. This again confirms the convenience of downstream travel. Interestingly, the fastest route to *Mursa* shares the same initial legs as the previously discussed routes, which involve sailing in the Adriatic and disembarking at *Aquileia*. However, the continuation of the journey differs. From *Aquileia*, the route continues overland through *Emona*, *Celeia*, and *Poetovio*, before proceeding downstream along the Drava River to *Mursa*. The entire journey would take approximately 38.3 days, covering a distance of 2,046 km. At first sight, this route may not seem the fastest, as it takes longer compared to the cheapest path, but it is important to bear in mind that the mode of transport for the fastest path is an oxcart (whereas for the cheapest it is a wagon). Nevertheless, when modelling potential transport routes, this is a good example of how the weight of the cargo and the mode of transport make a significant difference, particularly during overland transportation. The journey from *Aquileia* to *Poetovio* would take 19.1 days to cover 229 km at a costly price of 8.04 denarii. The downstream leg would take 4.6 days for 301 km, costing 1.02 denarii. Considering the entire journey would cost approximately 11.21 denarii, by far the largest part of the expenditure is due to the overland section.

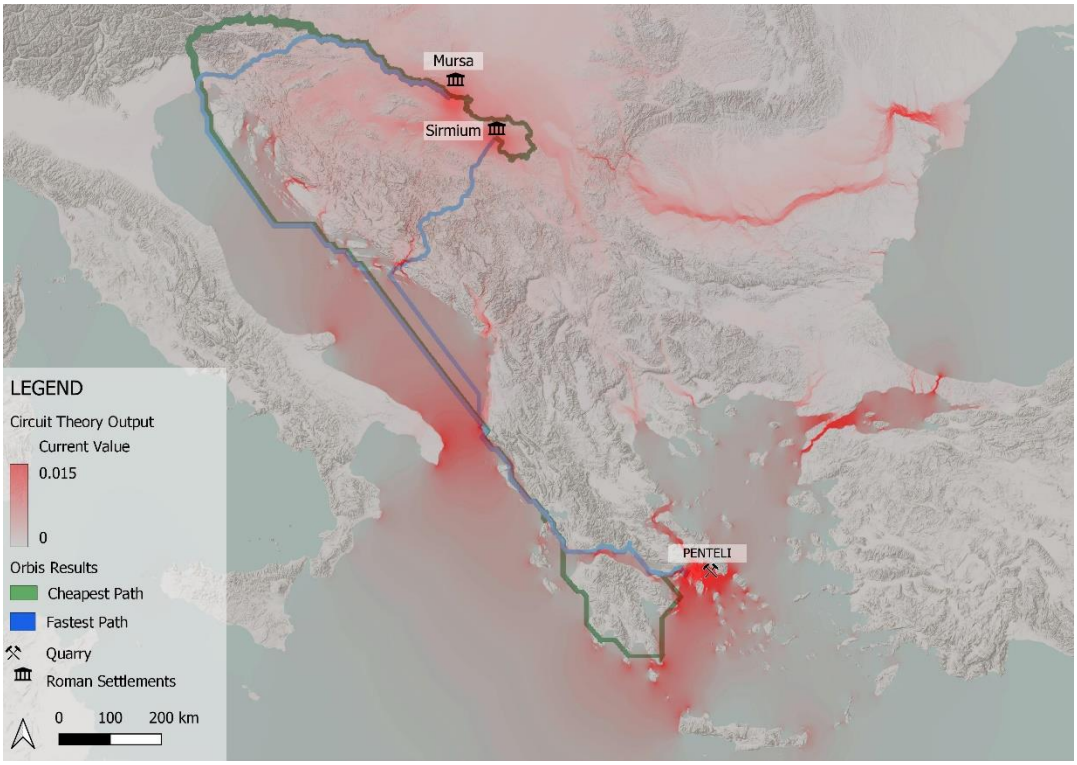


Figure 3. The results of CT analysis for transport routes from Penteli quarries to Sirmium and Mursa, and Orbis results for the cheapest and fastest path from Penteli quarries to Sirmiurm and Mursa (Source: GIS, created by the author, April 2024).

Potential transport routes between the Prokonnesos quarry and *Sirmium*

Conducting a CT analysis, the proposed transportation routes for Prokonnesian marble imports to *Sirmium* suggest an initial journey involving sailing in the Black Sea until reaching the delta of the Danube (Figure 4). However, the currents begin to lose their strength in the upper part of the Danube (somewhere before *Singidunum*), but they remain noticeable all the way to *Sirmium*. Upon careful examination of the results, and given that CT provides a set of potential transport routes, it evident that multiple options may exist. One route would involve travelling upstream along the Danube until reaching *Singidunum*, and from there continuing upstream along the Sava to *Sirmium*, while the other would include overland transport. This overland transport would likely start after the disembarkation at *Singidunum* and continue overland to reach *Sirmium* via the valleys of the Sava. While the Adriatic Sea provides alternative routes for accessing the inland Balkans, the analysis indicates limitations, particularly the challenging topography of the Dinarides, which complicates overland travel to settlements in the region.

The CT results were compared with those obtained from Orbis analysis to identify the most cost-effective and fastest routes for transporting Prokonnesian marble. The findings for the cheapest path align with the CT results: starting from Prokonnesos, the route involves sailing to *Cyzicus*, passing through the Bosphorus into the Black Sea, and then continuing until reaching the Danube Delta. From there, the route follows the course of the Danube until reaching *Drobeta*. Surprisingly, the route the transitions overland to *Taliata* before finally resuming along the Danube (Figure 4). This journey covers 2,006 km and would take 86 days. In contrast, the analysis of the fastest path reveals a significantly different path. To reach *Sirmium* in 46.7 days, this route covers a longer distance of 2,242 km. It involves

maritime travel from Prokonnesos westward across the Aegean Sea, navigating through the Gulf of Corinth, and entering the Adriatic Sea. The journey then continues along the eastern coast of the Adriatic to *Narona*, from where it transitions to an overland route leading to *Sirmium* (this overland path is the same as the last leg of the fastest journey from the Penteli quarries to *Sirmium,* see Figure 4).

The upstream navigation of the Danube has been discussed and confirmed in previous studies concerning the distribution of Mediterranean stones in the inland Balkans. However, the role of the Danube has primarily been analysed through the distribution of Prokonnesian material in settlements located along the river and in its lower course, such as in the territories of the provinces *Thrace, Moesia Inferior*, and *Moesia Superior*. Notably, another imperial palace in the inland Balkans, *Felix Romuliana* (modern Gamzigrad, Serbia), revealed an abundance of eastern Mediterranean white marbles used for various purposes, mainly architectural elements. It is presumed that Prokonnesian material arrived directly from the quarry, navigating the Black Sea, continuing along the Danube, and being reloaded at a strategic point (Djurić et al. 2023: 227-228).

Studies suggest two possible routes for this material: reversing the journey at the confluence with the Timok River and proceeding upstream to the imperial palace, or, more likely, reloading the cargo at *Ratiaria* (modern Arčar, Bulgaria) and continuing overland (Djurić et al. 2023: 228). Although this disembarkation point lies too far south to influence transport routes to *Sirmium*, it exemplifies the feasibility of transporting heavy cargo, such as architectural elements, upstream along the Danube. This also highlights the necessity of considering multiple options for further transport from the riverbank.

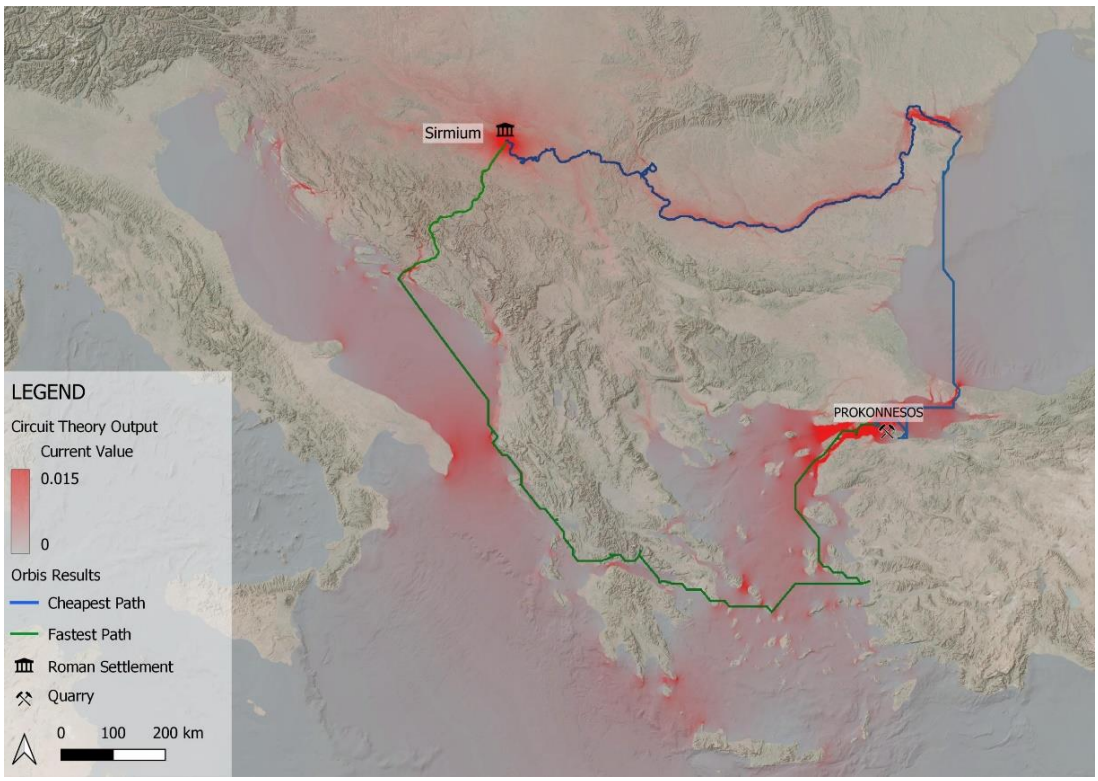


Figure 4. The results of CT analysis for transport routes from Prokonnesos to Sirmium, and Orbis results for the cheapest and fastest path from Prokonnesos to Sirmium (Source: GIS, created by the author, April 2024).

Given the logistical complexities and higher costs associated with overland routes from the Adriatic coast to the inland Balkans, this mode of transport might have been reserved for lighter cargo or commissions where financial expenditure was less critical than time efficiency. Therefore, further detailed study of the potential overland route from the Adriatic is warranted to fully understand its viability and historical usage.

Potential overland route for stone cargo between *Narona* and *Sirmium*

While overland transport appears to be the preferred option over upstream travel in terms of speed, it is imperative to note that two of the proposed transport routes – *Aquileia* to *Virunum* and *Narona* to *Sirmium* – involve traversing mountain ridges.[18] According to Orbis results, these routes align with established Roman roads that navigated such terrain via valleys. However, it is crucial to consider that the first route crosses the sub-Alpine region, while the second traverses the Dinarides, which may feature gradients exceeding five per cent. The logistics of transporting heavy loads across such steep gradients are highly complex. As Russell demonstrated in his book, even a slight incline of one per cent necessitates doubling the number of animals required to move a wagon or ox-cart on such terrain (Russell 2013: 101). This raises the question of whether the Dinarides constituted an impassable barrier or if the Roman road could have been utilised for transporting stone cargo.

In considering this overland trade route, the altar to Hercules found on Brač Island plays a significant role.[19] The altar, discovered in the Plate quarry on Brač Island, is a dedication to Hercules by Valerius Valerianus, a soldier responsible for setting up column capitals in the Licinian baths at *Sirmium*. Thus, it is reasonable to assume, that he was likely involved in the transport of stone from Brač island to *Sirmium*.[20] The Roman capitals have been studied in detail, and Brač limestone was not identified among the stone material from Sirmium.[21]

Despite the hypothesis regarding the *Narona* to *Sirmium* transport route and the results of Orbis analysis, it is essential to emphasise that crossing the Dinarides would present substantial challenges for transporting heavy cargo with oxen. To assess the steepness of the Roman road, which has been verified by the archaeological evidence, slope calculations have been conducted using a geospatial information system.[22] These calculations are vital as they help determine the feasibility of the route of heavy transport. As previously said, the steeper the gradient, the more animals would be required, which could significantly increase the cost and time needed for transport. Furthermore, the wear and tear on both animals and equipment would be considerable, requiring frequent repairs and replacements, adding to the logistical burden. As the lidar data for the area is not yet accessible, the Digital Elevation Model has been used as a topographical basemap. Undoubtedly, the results would be more accurate and

[18] The overland Roman road from *Aquileia* to *Virunum* has not been studied in detail for stone transportation in this research.

[19] Mirković 1971: 37, note 219a; Russell and Glicksman 2015: 234-235.

[20] Maver 2009: 136, note 84; Russell and Glicksman 2015: 234-235.

[21] Maver 2009: 136, note 85.

[22] Škrivanić 1977:139: The road starts at Narona, continues via the Neretva Valley, near the modern towns of Mostar and Ilidza (*Aquas*), to Sokolac and from there to *Argentaria*, to the station *Ad Drinum* and *Sirmium*. Remains of the cobbled road and traces of Roman mining in the area support the idea that this road was connected with the mining region (see note below, note 26). The importance of mineral resources in the Drina Valley, exploited at least from the time of Marcus Aurelius onwards, for the Roman road is also recognised in Wilkes 1969, 125, and Maver 2009, 135.

precise using lidar; this is something that needs to be redone once such data becomes available. Nevertheless, the tracking of the Roman road and the calculation of steepness, both in percentages and heights, show that the Roman road exceeds a five per cent gradient in many places (see Figure 5). This renders the transport of heavy cargo particularly difficult, if not impossible, though the possibility of carrying lighter cargo remains. Lighter cargo could be managed by using smaller wagons, although this would still pose significant challenges given the terrain.

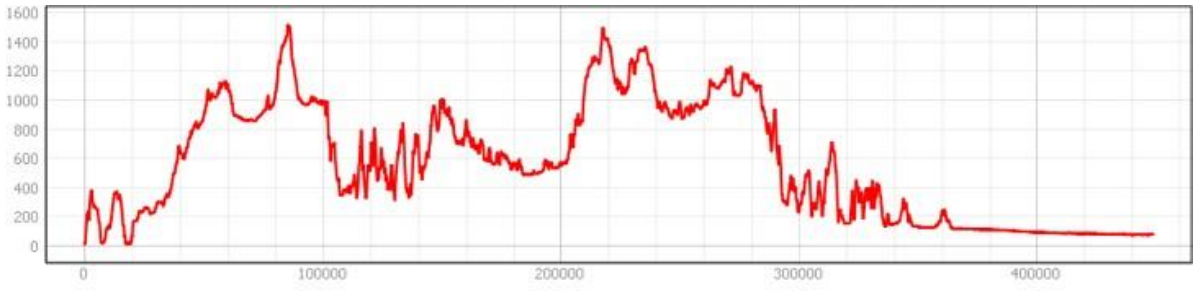


Figure 5. The results of steepness calculation of the Roman road between the Narona port and Sirmium, represented in heights (Source: GIS, created by the author, April 2024).

While the Roman army could control the gradient of the road by cutting the edges of hillslopes and managing the steepness, this would undoubtedly be a very demanding task and was likely reserved for routes necessary for transporting valuable materials. Such efforts to modify the landscape were significant undertaking that required extensive planning and resources. Thus, we cannot confirm if this could have been the case for the *Narona* to *Sirmium* overland route, although without any additional studies, it seems unlikely.[23] Another factor that needs to be considered is the time-efficiency of the route and the economics behind it. Although this overland transport proved to be very costly, we discuss imports found at the imperial palace or, in the case of the altar to Hercules, meant to be transported to the construction site of imperial baths. This raises the question of how to assess what would be too costly to commission an imperial order using a faster path instead of time-consuming upstream travel. The importance of economics in trade discussions is essential, and the availability of more than one transport route offers a different range of monetary expenditure. For instance, wealthier buyers or state-sponsored projects could afford the higher costs associated with faster overland transport, valuing speed over expense. Conversely, the majority of middle-class population would likely prefer slower, less costly mode of transport, resulting in the diverse economic strategies in ancient stone transport.

The same route was calculated using the LCP analysis between these two points (see Figure 6). The results suggest a longer route, but this path predominantly traverses valleys, making it a more suitable option for transporting stone given the topography. Valley routes, while potentially longer, often presented fewer obstacles (such as more stable weather conditions, easier access to water sources) and more manageable gradients.

[23] Silver and gold mines were situated in the Roman *Dalmatia*, warranting further study. The presumed location of one gold mine (modern Gornji Vakuf, Bosnia) and gold rinsing in the River Lastva is in close proximity of the Roman road *Narona – Sirmium*; see Škrivanić 1977: 118.

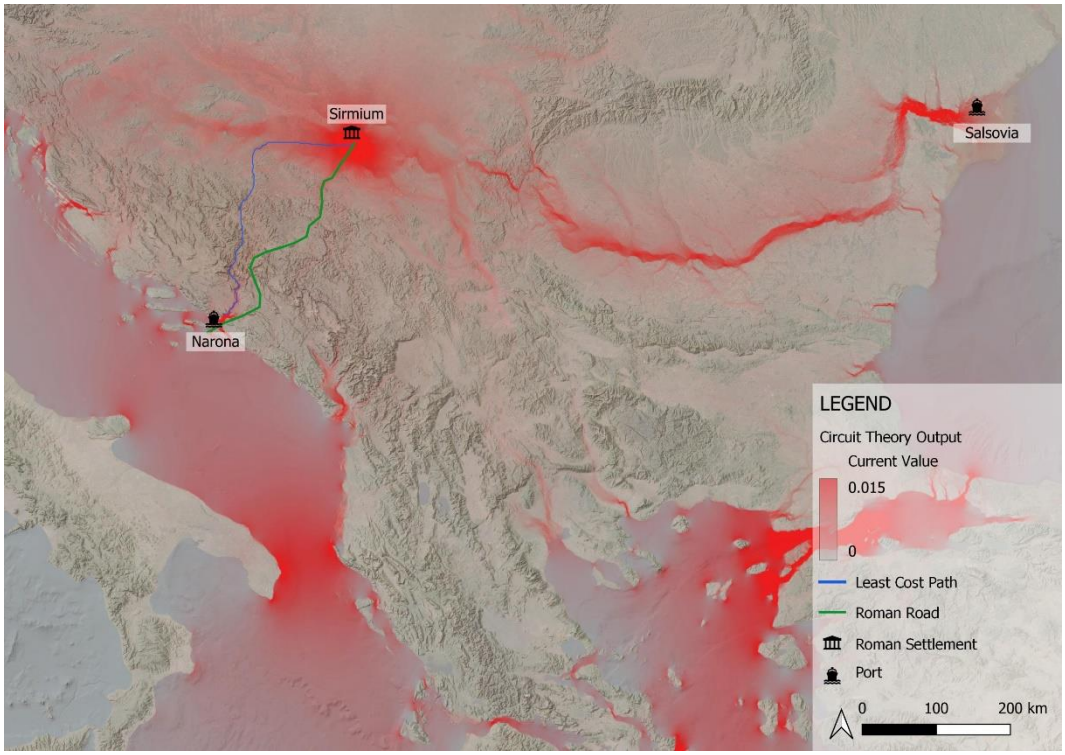


Figure 6. The LCP results and Roman road between Narona and Sirmium represented on CT basemap (Source: GIS, created by the author, April 2024).

Conclusion

This study highlights the significant difference in transport efficiencies between downstream and upstream travel on rivers. Downstream transport is consistently at least twice as fast as upstream transport, and this disparity can increase substantially depending on various factors such as topography, the presence of meanders, and the current strengths of the river. Moreover, the average distance travelled per day by river varies greatly, contingent upon the specific characteristics of the river section and the speed of the river flow. Sections with favourable topography and stronger river flow can significantly enhance travel speed and efficiency. Our analysis also indicates that overland transport, while considerably faster than upstream river transport, is the least cost-effective mode of transport. The higher costs are attributed to the increased logistical complexity, infrastructure requirements, and the availability and state of the draught animals required for overland transport.

To deepen this study, several areas warrant further investigation to improve transport modelling and efficiency. Although CT allows modelling for sea navigation, it has not been employed for this study. Critical area for improvement is the inclusion of transshipment processes in transport models, since the transshipment played a vital role influencing trade logistics. The role of ports in facilitating the transfer of stone and serving as central points in supply chains cannot be understated. Lastly, developing models tailored to different cost structures for various type of goods, such as cost of stone transport, will further refine transport strategies. Each type of cargo, but stone even more so, presents unique challenges and costs, and understanding and optimising these processes can lead to significant improvements in overall ancient transport studies.

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Numismatic finds from the antique period port at Barbir in Sukošan

Mladen Pešić[1] and Mato Ilkić[2]

Abstract

Since 2017 specialist staff of the International Centre for Underwater Archaeology in Zadar have led the systematic underwater archaeological investigation of an antique period port site at Barbir in Sukošan near Zadar. A significant number of archaeological trenches have been investigated over this period. Analysis of the archaeological finds shows that most are of mid-1st to early 5th century date. Radiocarbon 14C analyses date individual wooden elements to the same period. The structure of a 1st century ship was excavated over the course of the last three years. Thirty-one copper and copper alloy coins were discovered during the underwater investigation of the Roman port's archaeological remains. The condition of most of the numismatic material is good enough to allow for a narrow date range to be determined. Among the identified coins the oldest is a sestertius minted under the emperor Trajan (98–117). This is followed by numerous coins minted during the reigns of Constantine the Great's sons. Most are variants of the denomination known as centenionalis from approximately the last decade of the first half of the 4th century. The most recent coin was minted under Constantius II (337–361), and is from an issue struck between 351 and 355. Given that these late antique coins were found across a narrow area of the seabed and are from a brief date range they should be considered as an assemblage. This paper discusses numismatic finds made during the archaeological investigation and their relation to the use of the Barbir site port.

Keywords: Sukošan, Roman, antique port, underwater, coins

Introduction

The remains of massive walls remain visible to this day at the Barbir site, located at the south end of the Plitkača cape in Sukošan, a coastal settlement in the northern Dalmatia region about ten kilometres south from Zadar (Figure 1).[3] As noted by Don Luka Jelić these walls were identified in the 17th century by historian Šimun Ljubavac of Zadar, who posited the presence of a Roman period *villa rustica* (Jelić 1898: 112). The 1970s saw renewed interest in the underwater structures of the antique period port at Barbir, including the production of the first drawn documentation. Underwater archaeological reconnaissance performed by specialist staff of the Archaeological Museum of Zadar under the leadership of B. Ilakovac produced a detailed description of port installations of the antique period landing and drawings of the structures visible in shallow water (Ilakovac 1973: 2–6). Having recognised the significance of this underwater archaeological site the culture ministry in 2002 inscribed the remains of the antique period landing at the Barbir cove site between the Plitkača and Kažela capes into Croatia's cultural property register. Documentation and investigation was revived by specialist staff of

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[3] The map was created by Dario Vujević, for which we would like to thank him most sincerely.

the International Centre for Underwater Archaeology in Zadar, performing surveys of the antique period structures in 2013 and 2014 (Pešić 2013, 40–41). ICUA specialists have worked under the auspices of the culture ministry since 2017 to investigate and document the now submerged part of the port installations. The investigative work in 2018 also saw funding provided through the City of Zadar under the VirtualArch project, including detailed imaging and the production of a 3D model of the site. A wooden ship's structure was discovered in the course of investigative work in 2021, dated by radiocarbon analysis to the 1st to 2nd century CE (Pešić 2021, 26–27). Investigative work at the antique period port site in Sukošan also involved the work of a number of specialists from abroad, coming from the German Archaeological Institute, the Slovenian Institute for Underwater Archaeology, and the University of Oxford. Also taking part in the work were colleagues from the Archaeological Museum of Istria in Pula, the University of Zadar, the Han-Vrana Agency, and the Archaeological Museum of Zadar. The site is also a venue for international underwater archaeology courses, with collected archaeological material undergoing conservation treatment at the workshops of the International Centre for Underwater Archaeology in Zadar.[4]

Underwater site structures

The primary landing structure of the antique period port now lies submerged to the south of the Plitkača cape. It covers an area of about 100 by 50 metres of the east end of the site (Figure 1.). This structure has been designated Mole 1. It is a wide stone bank where we cannot now see the original faces of the antique period landing, as the whole of the structure has been quite widely broken up by wave action. The bank is comprised largely of rubble of varying sizes, ranging from about 10 to about 50 centimetres across. At the outer limits of the structure, we see large stone blocks sized about two-by-one-by-one metres, now scattered randomly across the bank. At the west end of the underwater site is a second structure, designated Mole 2. In comparison with the first mole, the second mole lies significantly lower and is less prominent. Mole 2 served as a breakwater protecting ships from westerly winds. Underwater sondage excavation provided partial insight into the manner in which the antique period port installations were built. It was found that the mole was built by first ramming wooden piles into the silt at intervals of from about 20 to 30 centimetres. These formed the southward facing side of the mole. The interior of the mole was then filled with layered wooden material (pine trunks and branches) atop which stone rubble of varying sizes was laid. The large stone blocks we now find along the outside of the mole served as additional protection from southerly winds. The construction of this antique period port has been associated with the presence of a Roman period villa; its archaeological remains are found in the immediate vicinity and have not to date seen comprehensive investigation. A part of the structures on land were discovered in the course of rescue archaeological work performed during the construction of residential buildings.[5] Based on our current knowledge, first phase construction of the antique period port occurred from the late 1st to mid-2nd century, when what was likely a smaller structure was built to dock and moor ships. The second phase of construction has been dated to the 4th century, when Mole 1 was significantly broadened and enlarged. A diverse range of artefacts bear witness to intensive traffic along the eastern Adriatic seaboard, including the port at Sukošan, during this period. These goods came by maritime routes from numerous production hubs in

[4] For more on the investigative work see: Pešić 2023.

[5] On land rescue archaeological investigation at the Barbir cape led by archaeologist S. Gluščević recovered 20 individual finds of Roman imperial coins. They date from the emperor Vespasian (69–79) to the emperor Theodosius (383–388). See: Ilkić, Šeparović 2024: 186–187, T. XXI, Sukošan-Barbir 13.

the Mediterranean, as borne out above all by a variety of recovered ceramic and glass artefacts manufactured in Italy, Greece, the Middle East, and the north of Africa. The port ceased to operate late in the 5th century, although there are indications that maritime traffic continued in the surrounding area to a reduced extent into the 6th century.



Figure 1. Location of Sukošan (By: D. Vujević).

Numismatic finds

This paper focuses on the many Roman imperial coins recovered in the course of the underwater archaeological investigation of the antique port at the Barbir cape site in Sukošan (cat. nos. 1–31, Pl. I, II).[6] Most of the finds were discovered in the layers of the trench ROV 1 and 2 during the excavations of the structure of Mole 1, and they were situated in quite narrow area, which could suggest that they were deposited or lost in the same time frame. Other coins can be sporadically found in other trenches, and they can be dated to different period of the existence of the Roman port.

[6] The photos on the boards were made by Antonija Jozić and Mladen Pešić.



Figure 2. Plan of the trenches (By: M. Kaleb).

The oldest among these is a sestertius struck in Rome during the reign of Trajan (98–117) (cat. no. 1, Pl. I, 1) (Pešić 2022: 29). This coin was found in Trench S (C5) during the excavation of the strata above the ship's structure (Figure 3). The coin was not in a direct connection with the wooden ship's structure, but its recovery testifies to the intensive use of the port in this period as its date corresponds with the first phase of the construction and use of the port at Sukošan. Coins minted under this emperor are a common find at many Roman period sites on land in the northern Dalmatia region. These coins have also been recovered during archaeological investigation of the antique period ports at Zaton[7] near Nin and in Pakoštane (Ilkić and Meštrov 2007: 341, Figure 1) near Biograd. One, for example, was found in the wreck of a Roman ship that sank off Ilovik (Jurišić 2000: 46).

The Trajan sestertius is followed by a long hiatus. The underwater archaeological investigation at the Roman period port in Sukošan to date has found that coin finds reappear in the late antique period (cat. nos. 2–31, Pl. I, 2–15, Pl. II, 1–16); the poor state of preservation of the most recent three precludes precise identification (Pešić 2018: 10, 11). These thirty late antique coins were recovered in the course of the investigation of Mole 1. Most are from a single stratum (cat. nos. 2–27, 29–31, Pl. I, 2–15, Pl. II, 1–12, 14–16), notably from a narrow area on the seabed in the ROV 1 zone, with only a single coin among the finds recovered from the other strata (cat. no. 28, Pl. II, 13). Sufficient text and/or imagery survives

[7] We learned of the find of a Trajan coin at the Roman period port in Zaton from an oral report of the late archaeologist Zdenko Brusić. For this Roman period port see: Gluščević 2007.

on most of the coins for a narrow chronological and typological identification, and in some cases a full identification based on the Roman Imperial Coinage standard catalogue. They are of a variety of regular types, issued from about 340 to, at the latest, 355. They are from the period not long after the death of Constantine the Great (307–337), when imperial authority was divided among his sons Constantine II (337–340), Constans I (337–350), and Constantius II (337–361). Many mints across the Roman empire struck coins for each of the brothers, and some issued coinage in memory of their posthumously deified father, also found at the Roman period port in Sukošan (cat. nos. 7–9, Pl. I, 7–9). Most of the late antique coins are of the later centenionalis types. Coins of this denomination were most likely minted from 317/318 to 348, containing copper and a small proportion of silver (Kos 1998: 66, 67). Mint marks survive on some of these coins, notably: Aquileia, Cyzicus (Kapu Dagh), Constantinopolis (Istanbul), and Roma (Rome). Coins from the first of these, Aquileia, are the most numerous, which is both logical and expected as this mint was both relatively near to Sukošan and very well connected to it by a maritime route along the eastern Adriatic seaboard. Among the centenionalis coins found at the Roman period port in Sukošan the oldest show a reverse image of two soldiers flanking a military standard (cat. nos. 2–4, Pl. I, 2–4); coins of this type are a very common find. Chronologically proximate is a much rarer coin from the Roma mint with a reverse image of the emperor in military dress with a spear and shield (cat. no. 5, Pl. I, 5), such as has also been found in Resnik (Siculi) on the western shore of the Kaštelanski bay (Ilkić 2019, 20, cat. no. 266). This is followed by a centenionalis struck in Constantinopolis with Victory on the reverse (cat. no. 6, Pl. I, 6). This, it appears, is the first such find in the north Dalmatia region. Most of the coins are from an issue with a reverse type showing two Victories (cat. nos. 10–21, Pl. I, 10–15, Pl. II, 1–6). As this is a very frequent coin type there is no need to cite analogies.[8] This is also true of centenionalis coins with a reverse type showing a votive inscription within a wreath (cat. nos. 22–26, Pl. II, 7–11). The most recent coin recovered in the course of the underwater archaeological investigation at the Sukošan site is from an issue with a depiction on the reverse of the emperor Constantius II in military dress holding two standards with the Christogram. It was struck in Sirmium (Sremska Mitrovica) between 351 and 355 (cat. no. 28, Pl. II, 13). According to the data available to us the nearest finds of coins with this reverse type, struck at only two other mints—Siscia (Sisak) and Thessalonica (Thessaloníki)—were made in Novalje[9] on the island of Pag and at the Smiljanovac site in Solin.[10]

Various late antique coins have been recovered at a number of other nearby Roman period ports. They have been found at sites in Novalja (Ilkić, Parica 2009: 115), Zaton (Ilkić and Šeparović 2024: 279, T. XXIII, Zaton-Roman Port 3), Nin and Kožino (Ilkić 2024: 16–31, cat. nos. 7–12) near Zadar, and at Bošana,[11] an archaeological site to the north of Biograd. These are individual finds dated over a broad chronological range, from the late 3rd to the early 5th century.

[8] In the eighth volume of the standard catalogue Roman Imperial Coinage, the minting of coins of this type in Aquileia and Siscia is dated to a short period (347–348) (RIC VIII, 322, 362-363). However, given that such coins from these mints are generally very numerous, we believe that Nikola Šipuš is probably right when he says that they were issued for a much longer period, probably from 342 (Šipuš 1985: 27-28).

[9] We learned of this specimen from the excellent numismatist Ivan Mirnik.

[10] We are grateful for this datum to archaeologist Slavko Galiot.

[11] We are grateful to Biograd Heritage Museum director Draženko Samardžić for providing access to unpublished numismatic material that includes a number of late antique coins recovered at Bošana, a coastal site with submerged archaeological remains of a Roman period port. For this site see: Ilkić and Pešić 2012: 639–647.

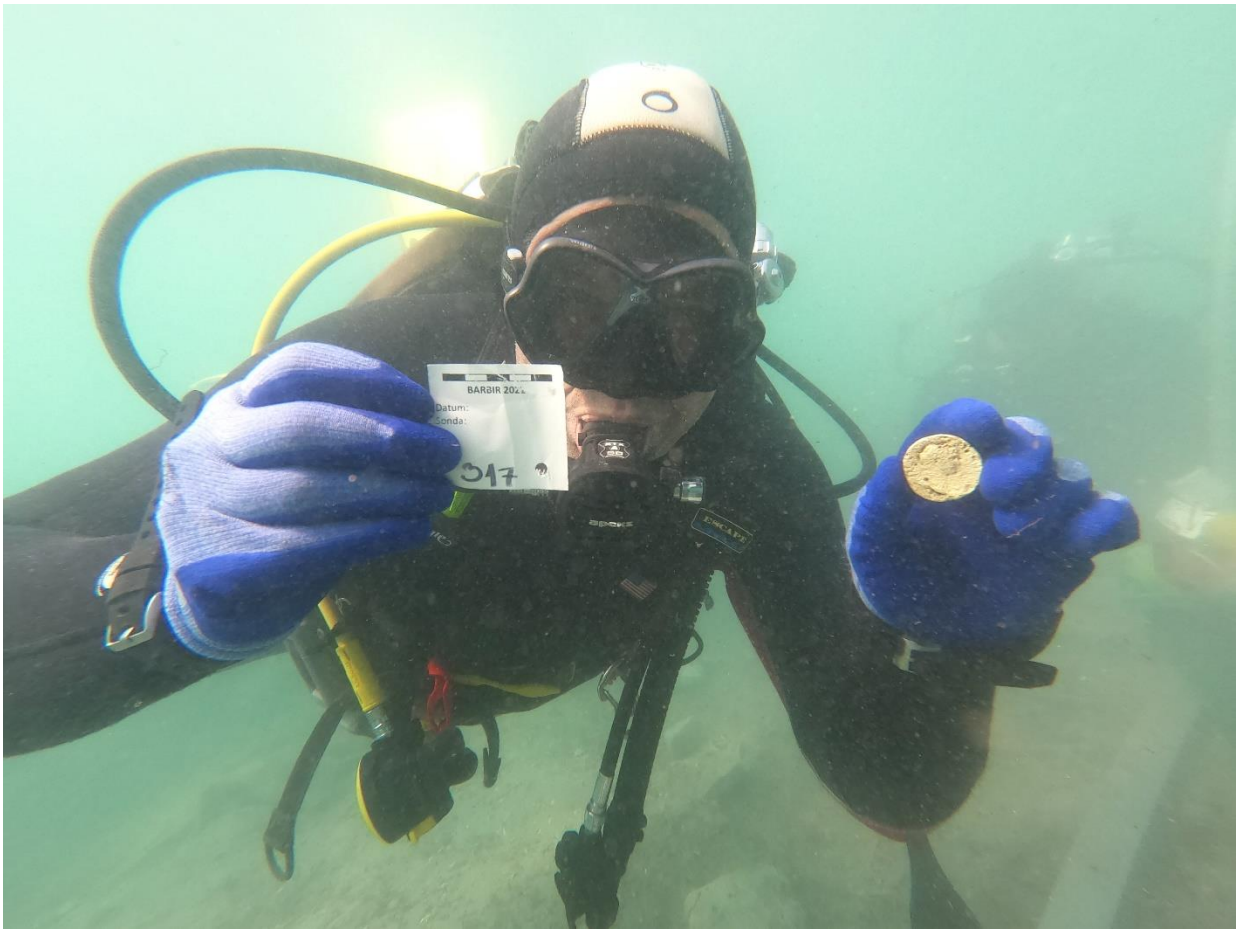


Figure 3. The find of an antiquity period coin minted under the emperor Trajan (Photo: M. Kaleb).

Conclusions

Based on our current understanding the numismatic material presented here is likely chronologically closely associated with the two phases of the construction of the Roman period port adjacent the Barbir cape in Sukošan. The sestertius minted under Trajan (cat. no. 1, Pl. I, 1) may have been in circulation at about the time associated with the construction of the first smaller dock structure. The much more recent coins from the period of the independent rule of the sons of Constantine the Great (cat. nos. 2–31, Pl. I, 2–15, Pl. II, 1–16) are from the port's second phase, which saw its significant expansion in the course of the 4th century. As noted above, 29 late antique coins (cat. nos. 2–27, 29–31, Pl. I, 2–15, Pl. II, 1–12, 14–16) were recovered from a narrow area. This, and the fact that they were issued over a brief period, suggests that they were originally held in a pouch of some kind and that they, likely by some accident, wound up on the seabed at some point near the end of the first half of the 4th century. It does, thus, seem warranted to consider this an assemblage.

Overall, the dispersion and abundance of the numismatic finds within the harbour can testify about the use of the Roman port in different period of its existence. This is in accordance with the discovery of other archaeological finds from the port that show begging of the sea trade and activities related to the transportation of different goods that starts during 1st century and continues towards the middle 4th

century when the port is significantly expanded, probably due to the higher necessity of port logistics in wider context of trade connections along eastern Adriatic coast.

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Catalogue

1. Trajan, 98. – 117., sestertius, 18,51 g, 29 mm, Roma, RIC II, 569.

Av. [IMP CAES NERVAE TRAIANO AVG GERM DAC P M TR P COS V P P]. Laureate head right.

Rv. [SPQR OPTIMO PRINCIPI]. Bridge over river. Down [S C].

Location: Sukošan - Barbir, underwater archaeological research 2022.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 317. Pl. I, 1.

2. Constans, 337. – 350., cententionalis (fragmentiran), 1,54 g, 15 mm, Aquileia, before April 340.; RIC VIII, 34.

Av. CON[STA]N-[S P F AVG]. Bust in drapery with diadem on head, to the right.

Rv. [GLOR]-IA [E]XE[RC-IT]VS. Two soldiers and battle sign between them with Christogram . In the exergue AQS.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 76. Pl. I, 2.

3. Constans, 337. – 350., cententionalis, 0,98 g, 17 mm, Roma, oko 340., RIC VIII, 3, 26, 38, 46A, 49, 52, 58.

Av. [D N] FL CON[STANS AV]G. Bust in drapery with diadem on head, to the right.

Rv. GLOR- [IA EXERC-ITVS]. Two soldiers and battle sign between them. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 117. Pl. I, 3.

4. Constantine II., 337. – 340. or Constantius II., 337. – 361., centenionalis, 0,42 g, 15 mm, mint (?), RIC VIII, (?).

Av. [---]. Head, to the right.

Rv. [GLORIA EXERCITVS]. Two soldiers and battle sign between them. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 79. Pl. I, 4.

5. Constantine II., 337. – 340. or Constantius II., 337. – 361., centenionalis, 0,75 g, 14 mm, Roma, before April 340., RIC VIII, 4-5, 14, 21, 32, 43, 47.

Av. [---]. Bust in armor, to the right.

Rv. [VIRTVS AVGVSTI]. Emperor, standing front, head right, holding spear and leaning on shield. In the exergue [--]P.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 118. Pl. I, 5.

6. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,41 g, 14 mm, Constantinopolis, oko 342.; RIC VIII, 63-66.

Av. [---]. Head with diadem, to the right.

Rv. [VICT-AVG]. Victory, facing left, holding wreath and palm branch. In the exergue CON[--].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 77. Pl. I, 6.

7. Commemorative posthumous issue for Constantine I., copper alloy, minted during the reigns of his sons, 1,14 g, 15 mm, Cyzicus (?), 347. – 348., RIC VIII, 46 (?).

Av. DV CONSTAN[TI]-NVS PT AVGG. Head of Constantine I. in death veil, to the right.

Rv. The Emperor in posthumous garb. In the field [VN-MR]. In the exergue SM[K- (?)].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 67. Pl. I, 7.

8. Commemorative posthumous issue for Constantine I., copper alloy, minted during the reigns of his sons, 1,56 g, 14 mm, mint (?), 347. – 348., RIC VIII, (?).

Av. [DV CONSTANTI-N]VS PT AVG[G]. Head of Constantine I. in death veil, to the right.

Rv. The Emperor in posthumous garb. In the field VN-MR. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 73. Pl. I, 8.

9. Commemorative posthumous issue for Constantine I., copper alloy, minted during the reigns of his sons, 1,02 g, 14 mm, mint (?), 347. – 348., RIC VIII, (?).

Av. [DV CONSTANTI-NVS PT AVGG]. Head of Constantine I. in death veil, to the right.

Rv. The Emperor in posthumous garb. In the field VN-[MR]. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 69. Pl. I., 9.

10. Constans, 337. – 350., cententionalis, 1,77 g, 15 mm, Aquileia, 347. – 348.; RIC VIII, 77.

Av. [C]O[NSTAN]- S P [F AVG]. Bust in drapery with diadem on head, to the right.

Rv. VI[CTO]RIAE DD AVG[G Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue AQT.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 119. Pl. I, 10.

11. Constans, 337. – 350., cententionalis, 1,15 g, 16 mm, Aquileia, 347.-348.; RIC VIII, 91.

Av. [C]O[NSTAN]- S P [F AVG]. Bust in drapery with diadem on head, to the right.

Rv. VI[CTO]RIAE DD AVG[G Q NN]. Two Victories, facing each other, each holding wreath and palm branch. Palm branch below at centre. In the exergue AQ[-].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. br. BAR 61. Pl. I, 11.

12. Constans, 337. – 350., cententionalis, 1,05 g, 13 mm, mint (?), RIC VIII, (?).

Av. [CON]STAN-[S P F AVG]. Bust in drapery with diadem on head, to the right.

Rv. [VICTORIAE] DD AVGG Q N[N]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 60. Pl. I, 12.

13. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 0,89 g, 14 mm, mint (?), RIC VIII, (?).

Av. [---]. Bust in drapery with diadem on head, to the right.

Rv. [VICTORIAE DD AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 62. Pl. I, 13.

14. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 0,85 g, 14 mm, mint (?), RIC VIII, (?).

Av. [---]. Barely visible bust in drapery with diadem on head, to the right.

Rv. [VICTORIAE DD AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 65. Pl. I, 14.

15. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,21 g, 16 mm, mint (?), RIC VIII, (?).

Av. CON[---]. Barely visible bust in drapery with diadem on head, to the right.

Rv. [VICTORIAE DD AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 66. Pl. I, 15.

16. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis (fragmentiran), 0,96 g, 13 mm, mint (?), RIC VIII, (?).

Av. [---] F AVG. Barely visible bust in drapery with diadem on head, to the right.

Rv. VICTO[RIAE DD AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 80. Pl. II, 1.

17. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,24 g, 14 mm, mint (?), RIC VIII, (?).

Av. [---]TAN[---]. Barely visible bust in drapery with diadem on head, to the right.

Rv. VICTO[RIAE DD AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 94. Pl. II, 2.

18. Constans, 337. – 350., cententionalis (fragmentiran), 0,88 g, 14 mm, mint (?), RIC VIII, (?).

Av. CONSTAN-[S P F AVG]. Bust in drapery with diadem on head, to the right.

Rv. [VI]CTOR[IA]E DD [AVGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 95. Pl. II, 3.

19. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,51 g, 14 mm, mint (?), RIC VIII, (?).

Av. [---]. Barely visible bust, to the right.

Rv. [VICTORIAE DD AVGG Q NN]. Partly visible two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 97. Pl. II, 4.

20. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,26 g, 16 mm, mint (?), RIC VIII, (?).

Av. CONS[---]. Bust in drapery with diadem on head, to the right.

Rv. [VI]CTORIAE DD A[VGG Q NN]. Two Victories, facing each other, each holding wreath and palm branch. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 116. Pl. II, 5.

21. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 1,12 g, 12 mm, mint (?), RIC VIII, (?).

Av. [---]. Barely visible bustto the right.

Rv. [---]. Barely visible two Victories. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 96. Pl. II, 6.

22. Constantius II., 337. – 361., cententionalis, 0,77 g, 16 mm, mint (?), 347. – 348.; RIC VIII, (?).

Av. [D N C]ONSTAN-[TIVS P F AVG]. Head with diadem, to the right.

Rv. In the wreath VOT/XX/[MVLT/XXX]. Down [---].

Location: Sukošan - Barbir, underwater archaeological research 2019.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 160. Pl. II, 7.

23. Constantius II., 337. – 361., cententionalis, 1,86 g, 15 mm, mint (?), 347. – 348.; RIC VIII, (?).

Av. D N CONSTAN-TI[VS P F AVG]. Head with diadem, to the right.

Rv. In the wreath VOT/XX/MVLT/XXX. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 63. Pl. II, 8.

24. Constantius II., 337. – 361., cententionalis, 1,28 g, 17 mm, Cyzicus, 347. – 348.; RIC VIII, 48.

Av. D N CONSTAN-TI[VS P F AVG]. Head with diadem, to the right.

Rv. In the wreath VOT/XX/MVLT/XXX. In the exergue SMKE.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 72. Pl. II, 9.

25. Constantius II., 337. – 361., cententionalis, 1,61 g, 14 mm, mint (?), 347. – 348.; RIC VIII, (?).

Av. [---]. Head with diadem, to the right.

Rv. In the wreath VOT/XX/MVLT/XXX. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 75. Pl. II, 10.

26. Constans, 337. – 350. or Constantius II., 337. – 361., cententionalis, 0,81 g, 15 mm, mint (?), RIC VIII, (?).

Av. [D N C]ONSTAN-[TIVS P F AVG]. Head with diadem, to the right.

Rv. In the wreath /[VOT/---]. Down [SM---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 64. Pl. II, 11.

27. Constans, 337. – 350. or Constantius II., 337. – 361., (?) AE, 1,09 g, 14 mm, mint (?), RIC VIII, (?).

Av. CONS[---]. Bust to the right.

Rv. [---]. The display is not visible. In the exergue [---].

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 98. Pl. II, 12.

28. Constantius II., 337. – 361., AE, 3,27 g, 23 mm, Sirmium, 351. – 355., RIC VIII, 21.

Av. D N [CONSTA]N-TIVS [P F AVG]. Bust in drapery with diadem on head, to the right. . Left A.

Rv. [CON]COR[DIA - MILIT]VM. Emperor in military dress, head left, star above head, holding two standards with Christogram. Left [III], In the exergue ∗SIRM.

Location: Sukošan - Barbir, underwater archaeological research 2019.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 152. Pl. II, 13.

29. Late Antique coin, AE (damaged), 1,23 g, 16 mm, mint (?), RIC VIII, (?).

Av. [---]. The display is not visible.

Rv. [---]. The display is not visible.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 78. Pl. II, 14.

30. Late Antique coin (?), AE, 1,17 g, 13 mm, mint (?), RIC VIII, (?).

Av. [---]. The display is not visible.

Rv. [---]. The display is not visible.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 105. Pl. II, 15.

31. Late Antique coin (?), AE (damaged), 0,91 g, 16 mm, mint (?), RIC VIII, (?).

Av. [---]. The display is not visible.

Rv. [---]. The display is not visible.

Location: Sukošan - Barbir, underwater archaeological research 2018.

Temporary storage: International Center for Underwater Archaeology in Zadar, inv. nr. BAR 123. Pl. II, 16.

PLATE I



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PLATE II



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16

Eastern Mediterranean amphora networks and maritime trade in Late Antiquity

Hikmet Kılınçoğlu[1] and Lucia Novakova[2]

Abstract

The study examines the distribution patterns and trade routes of amphoras during the Late Roman Period, with a focus on the Cilicia and Syria regions. The research highlights the prominence of maritime trade due to the rugged terrain and the risks associated with land routes. Amphoras, particularly types LR 1, LR 4, LR 5/6, Zemer 40, Zemer 41, and Agora M 334, serve as key indicators of these trade networks. The analysis reveals that amphoras were most concentrated near their production areas, with a noticeable decline in density over greater distances, reflecting the influence of ship development, trade route security, state needs, and inter-provincial relations. These finds offer insights into the economic and cultural interactions across the Mediterranean, emphasizing the regional dynamics of ancient trade.

Keywords: amphora distribution, Late Roman period, maritime trade, networks, trade routes

Introduction

This study examines the amphoras produced in Cilicia and Syria during Late Antiquity. These distinctive vessels were crucial in both maritime and land trade, facilitating the transport of goods to other Roman provinces across the Mediterranean. By analysing the regions they reached, the study attempts to outline the commercial relationships within the Mediterranean and provides a foundation for further research. Additionally, the research explores the regional economy shaped by the production of these containers. It identifies their distribution areas and assesses regional commercial activities. Published finds from Cilicia provide data on the production periods of these amphoras and the parallel development of agricultural production in the region. The study found that these vessels, particularly those used in maritime trade, were predominantly located in coastal settlements with ports. This underscores the significance of these coastal areas in commercial life and provides insights into the mobility of goods between provinces, offering a deeper understanding of the economic dynamics in the region.

Amphora production centres in Late Antiquity

Commercial amphora production continued uninterrupted from the Late Bronze Age to the Early Byzantine Period. During the Roman Imperial Period, Christianity was declared the state religion, and

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as Christianity spread through the Late Imperial and Early Byzantine Periods, interest in the holy lands increased, leading to the rise of pilgrimage journeys. These pilgrimages resulted in the transfer of products like olive oil and wine from the Levant Region to Roman provinces via commercial amphorae. Consequently, both agricultural and commercial amphora production surged in these provinces (Yaman 2018: 288). In addition to the Levant, the Cilicia Region also became a major production centre, particularly for olive oil, wine, and grain.

The region developed an advanced commercial system that relied on amphorae for the storage and distribution of these products, especially olive oil (Soydan 2023: 36). To improve maritime transportation efficiency, the design of commercial amphorae evolved to become thinner and longer. While typical ships carried between 2,000 and 3,000 amphorae, some ships were specially designed for specific products. Numerous shipwrecks in the Mediterranean and Aegean regions provide evidence of maritime trade and help identify production and consumption centres (Doğer 1991: 52-56). Amphora production in the Cilicia province developed in tandem with agricultural production. In the Late Antique Period, as trade expanded, amphora production facilities were established in various settlements. The construction of amphora kilns followed three basic principles: Firstly, areas suitable for growing olives and grapes were essential for agricultural production and needed to be near the production sites of olive oil and wine to facilitate easy bottling of liquid products (Öniz 2016: 26). Secondly, the availability of appropriate clay deposits in the region was necessary for producing high-quality amphorae (Doğer 1991: 65-67). Lastly, a nearby port was crucial for filling and marketing the amphorae produced (Öniz 2016: 26).

Cilicia province

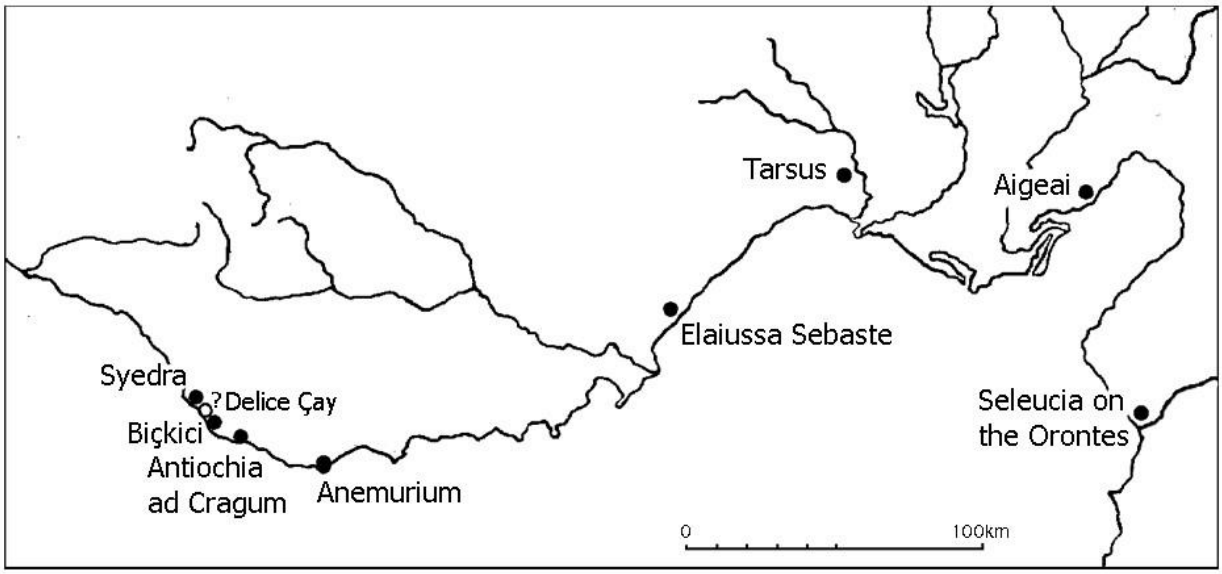


Figure 1. Map showing the locations of amphora kilns in Cilicia (after Autret 2012: 252, Figure 17.1).

The development of agricultural production in both Rough Cilicia and Lowland Cilicia led to the need to export surplus products (Bilir 2014: 92). Additionally, the rapidly growing olive oil and wine industries in the region created a demand for amphora production workshops for international trade

(Öniz 2016: 26). Consequently, amphora kilns were established in various parts of Cilicia, becoming a significant source of income for the Roman economy (Bilir 2014: 92). Three amphora kilns were discovered near Gazipaşa in Rough Cilicia. One kiln is located on a sand dune at the mouth of the Yeşilöz Stream, another at the mouth of the Bıçkıcı Stream, and a third was found in the village of Güney, in Antiocheia ad Cragum (Autret and Rauh 2010: 111). The most important amphora production area in the region is Anemurium, where six amphora kilns were unearthed during archaeological excavations (Keser 2019: 94-95). Surrounding these kilns, mortaria for crushing olives and lever press beds for extracting olive oil were identified, indicating the presence of production complexes in these areas (Autret and Rauh 2010: 115-116).

Syria province

The LR 4, LR 5/6, and Agora M 334 types of amphorae were produced in southern Palestine (Yaman 2018: 288). Seleucia Pieria, located near the Orontes River, served as a significant port. In this area, large fields contain amphora bothroi, indicating the presence of amphora kilns (Empereur and Picon 1989: 236-237). Subgroups of LR 1 amphorae have been found in shipwrecks and within the city, further suggesting local production (Alkaç 2013: 114). In the ruins of Rhosus, both amphora bothroi and remains of LR 1 amphorae have been identified (Demesticha 2013: 170; Empereur and Picon 1989: 237). This evidence indicates that LR 1 amphorae were likely produced in Rhosus, which remained inhabited during both the Roman Imperial and Byzantine periods (Demesticha 2013: 170). Ceramic production in Beirut existed from the 2nd century until the 7th century AD (Wicenciak 2016: 628). In northern Syria, Ras al-Bassit is notable for Late Antique workshops identified by Paul Courbin (Mills and Beaudry 2007: 745). Amphorae production also occurred in the coastal settlements of Amrit and Tartus in Northern Lebanon, both important export points with their own ports (Reynolds 2005: 568, 594, pl. 7, figures 46-54). In Jiyeh, ceramics were produced from the 1st until the 7th century AD (Wicenciak 2016: 628). In Akko, a coastal settlement in the Eastern Levant, ceramics were produced from the 3rd to the 7th century AD, specifically at the site known as the „7th workshop“ (Wicenciak 2016: 626-627).

Cyprus

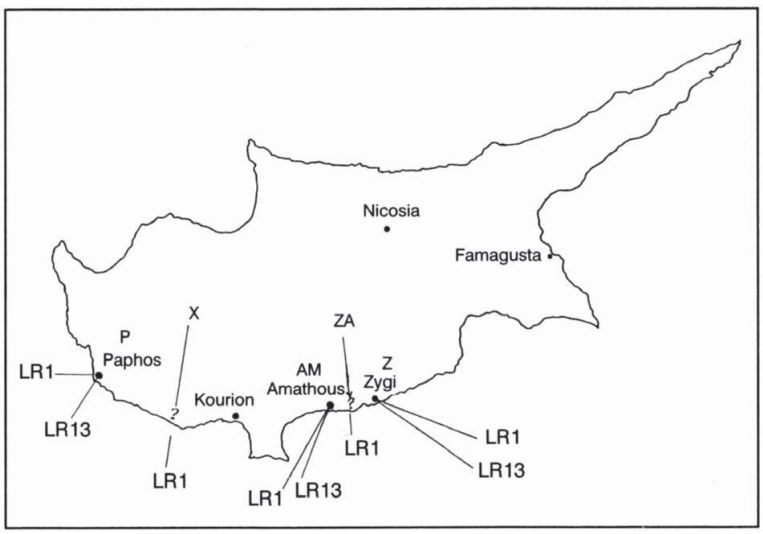


Figure 2. Map showing the production areas of LR 1 amphoras in Cyprus (after Pieri 2007a: 620, Figure 5).

Cyprus, situated adjacent to Cilicia and Syria in the Eastern Mediterranean, was a significant centre for maritime trade in the antiquity. Notably, LR 1 amphorae were produced in Cyprus. The identified production areas include the settlements of Zygi-Petrini, Paphos, Amathous, and Kourion (Taner 2022: 36; Demesticha 2013: 170-171). An LR 1 amphora kiln was unearthed on the southern shore of Kalavasos, within the borders of Zygi-Petrini (Rowe, 2004: 223). In Paphos, an amphora kiln was discovered in 1988. Around this kiln, LR 1 amphorae and amorphous ceramics were found, dating back to the 6th and 7th centuries AD (Taner 2022: 37-38). In Amathous, an amphora kiln and 15 LR 1 amphorae were identified by Empereur and Picon in 1989 (Demesticha 2014: 601, 605-606, Figures 1-4). Additionally, many wells filled with amorphous ceramics were found in Amathous Harbor (Empereur 2018: 183).

Amphorae types

Agora M 239 Amphorae

The Agora M 239 amphorae feature a rounded mouth profile that curves outward. They have a wide, short neck, and the short, thick, oval-shaped handles extend from the middle of the neck to the shoulder. The body of these amphorae is grooved, and they have a conical base with a hollow centre (Bilir 2014: 101). They were extensively produced between the 1st and 4th centuries AD (Alkaç 2013: 113). Similar examples have been discovered in locations such as Knidos (Sözel 2023: 273-274, 1070-1073, tab. 261-264, cat.nr. 815-819), Silifke (Alkaç, 2013: 113-114, Figure 8), Mersin (Şenol and Kerem 2000: 96, tab. 18, cat. nr. 20), Anemurium (Reynolds 2005: 564, 588, Figure 5), Phaselis (Orhan 2023: 58, cat.nr. 682), Türkler (Çaylak-Türker 2014: 271-272, 277, Figure 2, nr. 1), Kızılcaşehirkalesi (Çaylak-Türker 2014: 271-272, 277, Figure 2, nr. 12), Naula, Elikesik, Akkale, and İncekum (Çaylak-Türker 2014: 271-272, 277, Figure 3, nr. 1).

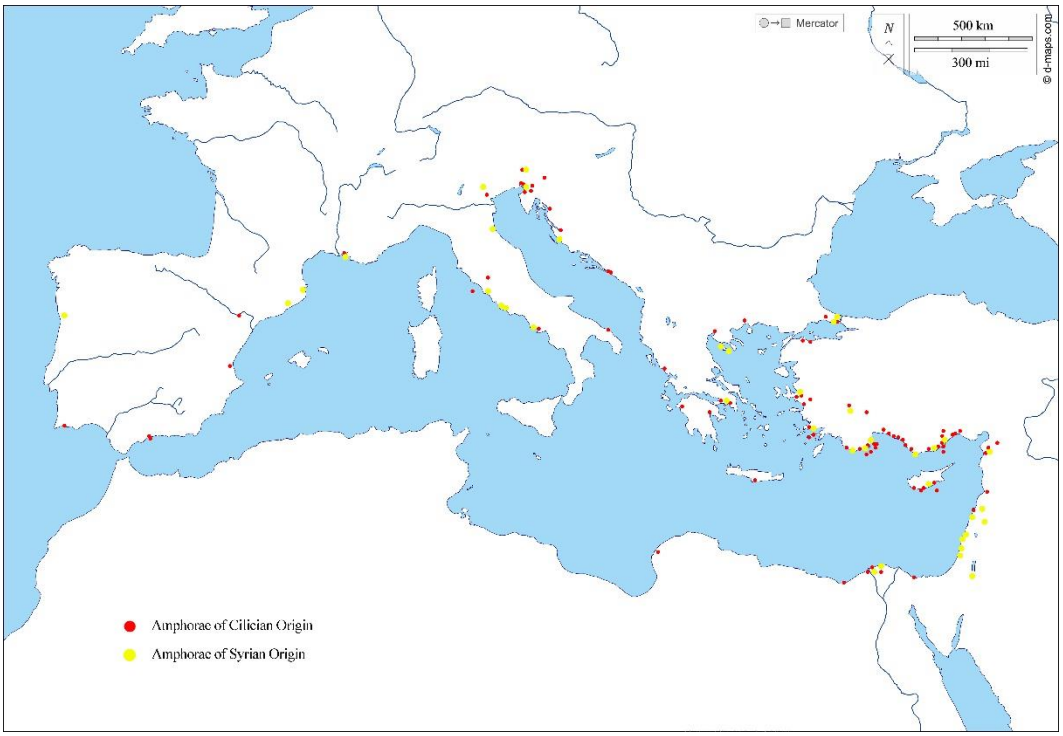


Figure 3. Map showing the distribution of Late Roman amphorae of Cilician and Syrian origin (Drawing: Hikmet Kılınçoğlu).

LR 1 Amphorae

LR 1 amphorae are distinguished by several characteristic features, including a rounded rim profile, an oval and grooved handle that begins below the lip, descends to the shoulder, and merges with the body, an ovoid body, and a simple protruding base (Çibuk 2019: 59). These amphorae are generally dated to between the 4th and 7th centuries AD. Demesticha categorized LR 1 amphorae into three subtypes: A, B, and C. LR 1A amphorae date from the 4th to the 5th century AD, LR 1B amphorae from the late 5th to the 6th century AD, and LR 1C amphorae to the 7th century AD (Demesticha 2013: 172-176). Examples of LR 1A amphorae were identified in Saraçhane (Hayes 1992: 64, 167, Figure 47, cat.nr. 156-157), Smyrna (Karcı-Ağlar 2015: 304-305, cat. nr. 291-293), Parion (Akkaş 2020: 399, cat. nr. 253-254), Kyzikos (Erdem 2023: 98, 114, Figure 4, nr. 2-3), Klazomenai (Gürbüzer 2018: 145, 176, Figure 15, nr. 59-60), Phokaia (Fırat 2023: 83-84, 102, Figure 3, Figure 6), Myra (Tomay 2023: 334-349, cat. nr. 107-134), Knidos (Doksanaltı 2020: 394, 415, Figure 8, nr. 45-47), Phaselis (Orhan 2023: 582-583, cat. nr. 683-685), Alacasu (Öniz 2016: 44), Kumluca (Shipwreck 1) (Öniz 2016: 53), Kekova Kuzu Island (Shipwreck) (Öniz 2016: 57), North Adrasan (Shipwreck) (Öniz 2016: 60), Kekova Bay (Shipwreck) (Öniz 2016: 68), Syedra (Şengül 2023: 50-51, 128-129, cat.nr. 120-121, 150, Figure 12), Elaiussa Sebaste (Ferrazzoli and Ricci 2010: 817, 823, Figure 4, 20, 21), Kelenderis (Tekocak and Zoroğlu 2013: 119-121, 139, Figures 12-27), Anemurium (Reynolds 2005: 566-567, 591, pl. 4, Figures 31-32), Soli-Pompeipolis (Autret, Yağcı and Rauh 2010: 205, 206, Figure 6), Dana Island (Shipwreck 1) (Öniz 2016: 130), Antiocheia (Kılınçoğlu 2019: 213, cat. nr. 129-130, tab. 24), Ras Al-Bassit (Mills and Reynolds 2014: 134, 138, Figure 4, nr. 11-12), Damascus (Tréglia and Berthier 2010: 867-868, 871, Figure 3, nr. 8), Beirut (Reynolds 2010: 110, Figure 7 u-v), Akrotiri (Leidwanger 2013: 182, Figure 1), Alexandria (Şenol, 2000: 313-317, cat. nr. 58-66; 369-370, cat. nr. 180-182), Barcelona (Dominguez 2005: 152, 161, Figure 3, cat. nr. 1-4), Bracara (Morais 2005: 56-57, 65, Figure 2, cat. nr 7), Carteia (Alvarez and Casasola 2007: 130, Figure 4, nr. 6), Septem (Alvarez and Casasola, 2007: 130, Figure 4, nr. 7), Gibraltar (Casasola 2007: 112, 116, Figure 4, nr. 7, 117, Figure 5, nr. 3-4), Marseille (Reynolds 2005: 566-567, 591, pl.4, Figure 33), Domus Tiberiana (Carboni 2010: 418, 423, Figure 8, nr. 1-3), Classe (Cirelli and Cannavicci 2014: 963, 970, Figure 6, nr. 1-2), Rodik (Perko and Zupancic 2005: 522), Gradina (Karadole and Borzic 2020: 67, 68, Figure 8), Oslje-Gradac (Karadole and Grbic 2022: 162, 197, pl. 16, nr. 2-4, 7-9), Banjace (Ozanic-Roguljic 2018: 152-154, 188, tab.1, nr. 1-4), Senia (Konestra and Glavas 2024: 59, 126, pl. 6, nr. 184), Grobnice (Borzic and Jadric 2007: 157-160, 168, pl. 5, nr. 3), Tonovcov Grad (Modrijan 2010: 687, 691, Figure 3, nr. 1), Philippi (Zachariadis 2014: 706, 711, Figure 8) and Kanistro (Vasiliou and Tsigarida 2014: 724, 732, Figure 5, nr. 1-3). Examples of LR 1B amphorae were identified in Parion (Akkaş 2020: 400, cat. nr. 255, 401, cat. nr. 256-257), Smyra (Karcı-Ağlar 2015: 309, cat. nr. 299), Klazomenai (Gürbüzer 2018: 145, 176, Figure 15, nr. 61), Knidos (Doksanaltı 2020: 394, 415, Figure 8, nr. 48-51), Myra (Tomay 2023: 349-378, cat. nr. 135-190), Limyra (Çömezoğlu 2014: 667, 674, Figure 8a; Vroom 2004: 294-296, Figure 3), Phaselis (Orhan 2023: 583-585, cat. nr. 686-689), Pırasa Island (Öniz 2016: 45), Finike (Shipwreck 4) (Öniz 2016: 48), Finike (Shipwreck 3) (Öniz 2016: 52), Alanya (Shipwreck 1) (Öniz 2016: 50), North Adrasan (Shipwreck) (Öniz 2016: 59), Gelidonia (Öniz 2016: 62), Kaladran (Öniz 2016: 76), Kaş North (Shipwreck 1) (Öniz 2016: 79), Kalkan (Shipwreck 1) (Öniz 2016: 94), Side (Alanyalı and Erkoç 2019: 3, Figure 2, nr. 6), Syedra (Şengül 2023: 50-51, 129-135, cat. nr. 122-131), Kelenderis (Tekocak and Zoroğlu 2013: 121-122, 140, Figure 28-34), Elaiussa Sebaste Soli-Pompeipolis (Ferrazzoli and Ricci 2007: 677, Figure 2), Korykos (Alkaç 2012: 333-334; 341-344, Figure 4-14), Anemurium (Korkmaz and Tekocak 2023: 29, 38, tab.5, nr. 20), Silifke Güvercin Island (Shipwreck 2) (Öniz 2016: 109), Antiocheia (Kılınçoğlu 2019: 214, cat. nr. 131, tab. 24), Ras Al-Bassit (Mills and Beaudry 2010: 863, Figure 4a), Sergilla and Qal'at Sem'an (Pieri 2005: 586, 594, Figure 7, nr. 39-50), Beirut (Pieri 2007b: 315-316, Figure 3-4), Panayia Ematousa (Jocobsen 2005: 626, 634, Figure 7), Amathous (Empereur 2018: 183-185, Figure 1-3), Paphos (Gabrielli, Jackson and Kaldelli 2007: 793, 800, Figure 4, nr. 6), Akrotiri (Leidwanger 2013: 183,

Figure 4), Cape Zevgari (Leidwanger 2013: 185 Figure 10), Alexandria (Şenol 2000: 371, cat. nr. 183, 401, cat. nr. 401, 458-464, cat. nr. 336-349), Valencia (Mesquida, Lacomba and Val 2010: 177, Figure 2), Bracara (Morais 2005: 57, 65, Figure 2, cat. nr. 8), Marseille (Bien 2007: 264, 272, Figure 2, nr. 30), Classe (Cirelli 2014: 552, Figure 9), Predloka and Piran (Perko and Zupancic 2005: 522-523, 532, Figure 532, cat. nr. 1-4), Rifnik (Bausovac 2010: 695, 700, Figure 3, nr. 1-5), Novae (Klenina 2010: 1006, 1014, Figure 7, nr. 1), Thessaloniki (Akrivopoulo and Slampeas 2014: 289, 295, Figure 10), Megara (Korosis 2014: 305, 309, Figure 4), Nicopolis (Reynolds and Pavlidis 2014: 452, 459, Figure 6, nr. 2-7), and Philippi (Zachariadis 2014: 706-707, 711-712, Figure 9, 13). Examples of LR 1C amphorae were identified in Yassıada (Leidwagner 2014: 897-901, 904, Figure 1, nr. 1-11), Knidos (Sözel 2023: 281-282, 1082-1085, tab. 273-276, cat. nr. 862-869), Naula and Gazipaşa (Çaylak-Türker 2014: 273, 277, Figure 2, nr. 3-4), Myra (Tomay 2023: 378-383, cat. nr. 191-200), Amathous (Empereur 2018: 182, tab. 1, 183-185), Limassol (Demesticha 2013: 173, 177, Figure 4), Marseille (Bien 2005: 292, Figure 3, cat. nr. 1-3, 297, Figure 8, cat. nr. 2), Kaldamaina (Poulou-Papadimitriou and Didioumi 2010: 742-743, Figure 7), Kephalos (Poulou-Papadimitriou and Didioumi 2010: 742-743, Figure 8) and Gortina (Portale 2014: 479, 489, Figure 16, nr. 10-11).

Zemer 40 Amphorae

Zemer 40 amphorae were produced in Cilicia and the Black Sea region. These amphorae feature a rounded mouth profile that projects outward, a long conical neck that widens from the mouth to the shoulder, and a grooved oval handle connecting the lower neck to the shoulder. They have a conical body and a hollow pointed base (Bilir 2014: 101-102). Similar carrot-shaped amphorae have been unearthed in excavations and shipwrecks in Egypt and Lebanon in the Eastern Mediterranean (Bilir 2017: 228). These amphorae date back to the 3rd and 4th centuries AD, with similar examples identified in Mersin (Şenol and Kerem 2000: 93, tab. 17, cat. nr. 16), Tripolis (Katırancı and Duman 2022: 341, 360, tab. 3, nr. 17) and Kelenderis (Tekocak and Zoroğlu 2013: 114-116, 138, Figure 8-10).

Zemer 41 Amphorae

Zemer 41 amphorae are characterized by an everted rim profile and short, cylindrical handles that sharply descend from the neck to the shoulder. The handles are vertically separated, extending from the center to the sides. The cylindrical body culminates in a mushroom-shaped base (Karcı-Ağlar 2015: 300-301). Examples outside the Western Mediterranean were identified in Gabbari Necropolis, Marima el-Alamein, Alexandria, Pelusium and Bouto, Athens, Ephesos, Benghazi, Beirut (Bilir 2014: 96-97), Pompei, Trieste, Aquileia, and Brindisi (Karcı-Ağlar 2015: 301-302). It was also found in Parion (Akkaş 2020: 369, 370, cat. nr. 241-242), Myra (Tomay 2023: 383-406, cat. nr. 201-246), Antalya Small Islands Area (Shipwreck) (Öniz 2016: 69), Kaladran (Öniz 2016: 75), Side (Aktaş Amphora Shipwrecks) (Öniz 2016: 123) and Kelenderis (Bilir 2014: 98; Tekocak and Zoroğlu 2013: 113-114, 137, Figure 4-7).

Amphorae of Syrian origin

LR 4 Amphorae

The characteristic features of LR 4 amphorae include a slightly everted rounded mouth profile, a long cylindrical body, and a grooved conical bottom. They also have short, oval-shaped, vertical, ear-like handles on the shoulder (Yaman 2018: 352). According to D. Pieri's 2005 evaluation, LR 4 amphorae are

classified into types A and B. Type A is further divided into A1 and A2, while Type B is divided into B1, B2, and B3 (Akkaş 2020: 410). These amphorae were produced from the 1st century AD until the mid-7th century AD, primarily in the Gaza region (Kızılarslanoğlu 2016: 198). Examples of LR 4 amphorae were identified in İstanbul (Yenikapı) (Wohmann 2016: 70, pl. 1, Figure. 10, pl. 12, Figure 1-17), Saraçhane (Hayes 1992: 67-68, 167, Figure 47, cat. nr. 168-169), Bathonea (Kara 2021: 80, 81, Figure 10), Parion (Akkaş 2020: 421-426, cat. nr. 271-271), Phokaia (Fırat 2023: 85-86, 102, Figure 4, 8), Knidos (Sözel 2023: 288-291, 1096-1099, tab. 287-290, cat. nr. 908-916), Bodrum (Alpözen, Özdaş und Berkaya 1999: 64), Arykanda (Yaman 2018: cat. nr. 460-468, tab. 69-70), Myra (Tomay 2023: 407-408, cat. nr. 248-250), Kovanlı Island (Shipwreck 2) (Öniz 2016: 85), Phaselis (Orhan 2023: 588, cat. nr. 696), Silifke Tisan (Shipwreck 4) (Öniz 2016: 104), Beirut (Pieri 2007b: 318, Figure 6), Amathous (Empereur 2018: 183, 187-188, Figures 4-5), Avdimou Gulf (Leidwanger 2013: 187, Figures 13-14), Alexandria (Şenol 2000: 336-339, cat. nr. 109-115), Caesarea (Reynolds 2005: 574, 606, Figures 140-144), Horvat Uza (Reynolds 2005: 574, 606, Figure 149), Carmel Coast (Kingsley 2002: 26, Figures 46, 28, Figure 47), Barcelona (Dominguez 2005: 153, 161, Figure 3, cat. nr. 9-13), Bracara (Morais 2005: 57, 66, Figure 3, cat. nr. 14-17), Marseille (Bien 2005: 292, Figure 3, cat. nr. 4-5), Trentino (Maurina and Capelli 2007: 482, 486, Figure 6, nr. 8-9), Domus Tiberiana (Carboni 2010: 418, 424, Figure 9, nr. 5), Tergeste (Degrassi et al. 2010: 580, 584, Figure 5, nr. 21), Classe (Cirelli 2014: 552, Figure 9), Koper (Perko and Zupancic 2005: 523, Figure 7, cat. nr. 7-9), Gradina (Karadole and Borzic 2020: 69-70), Oslje-Gradac (Karadole and Grbic 2022: 164, 197, pl. 18, nr. 4), Tonovcov (Modrijan 2010: 687, 691, Figure 3, nr. 2), Thessaloniki (Akrivopoulo and Slampeas 2014: 288, 293, Figure 3), Megara (Korosis 2014: 305, 310, Figure 9), Philippi (Zachariadis 2014: 706-707, 711-712, Figure 9, 12), Kanistro (Vasiliou and Tsigarida 2014: 724, 735, Figure 5, 10, nr. 10-11) and Athens (Opait 2021: 84, Figures 1a-b).

LR 5/6 Amphorae

These amphorae, commonly referred to as "Bag Shaped," are distinguished by their rounded high mouth profile, lack of a neck, ear-shaped double handles, bag-like body, and frequent horizontal grooves extending from the bottom of the mouth to the base. Riley, in his study of amphorae found at Caesarea Hippodrome, categorized these into LR 5 and LR 6 types. In 1977, Egloff further divided these amphorae into five distinct types, providing a more detailed analysis. LR 5/6 amphorae were produced between the 1st and 9th centuries AD (Tomay 2023: 88). Examples of LR 5/6 amphorae were identified in Parion (Akkaş 2020: 436-438, cat. nr. 282-287), Bodrum (Alpözen, Özdaş and Verkaya 1999: 65), Myra (Tomay 2023: 409-412, cat. nr. 251-257), Limyra (Marksteiner and Schuh 2008: 45, Figure 6), Finike-Gökliman (Shipwreck 2) (Öniz 2016: 51), Alanya (Shipwreck 1) (Öniz 2016: 49), Kaş - Kovanlı Island (Shipwreck 2) (Öniz 2016: 87), Naula (Çaylak-Türker 2014: 273, 277, Figure 2, nr. 6), Anemurium (Williams 1989: 98-99, Figure 60, cat. nr. 578), Dana Island (Shipwreck 1) (Öniz 2016: 112), Elaiussa Sebaste (Ferrazzoli and Ricci 2007: 679, Figure 4, nr. 4-5), Antiocheia (Pamir 2016: 307, 306, Figure 5), Beirut (Reynolds 2018: Figure 3, cat. nr. 9-10), Amathous (Empereur 2018: 183, 188-189, Figure 5), Caesarea (Gabrielli, Jackson and Kaldelli 2007: 793, 800, Figure 4., nr. 7), Carmel Coast (Kingsley 2002: 29, Figure 49, 3033, Figures 50-56), Alexandria (Şenol 2000: 344-347, cat. nr. 128-133), Iesso (Uscatescu and Jimenez 2005: 85, 100, Figure 3, cat. nr. 47), Marseille (Bien 2005: 292, Figure 3, cat. nr. 6-8, 297), Domus Tiberiana (Carboni 2010: 418, 424, Figure 9, nr. 6), Tergeste (Degrassi et al. 2010: 580, 584, Figure 5, nr. 20), Classe (Cirelli 2014: 552, Figure 9), Gradina (Karadole and Borzic 2020: 71), Tonovcov Grad (Modrijan 2010: 687, 691, Figure 3, nr. 7-9), Gortina (Portale 2014: 479, 489, Figure 16, nr. 12), Philippi (Zachariadis 2014: 706-707, 711-712, Figures 9, 14) and Pefkochori (Vasiliou and Tsigarida 2014: 724, 734, Figures 8, nr. 30).

Agora M 334 (LR 9/Beirut) Amphorae

Agora M 334 amphorae are characterized by their rounded necked mouth profile, cylindrical neck, oval-shaped vertical handles that curve from the mouth to the shoulder, and a grooved body that narrows from the shoulder to a hollow, carrot-shaped bottom (Yaman 2018: 292). These amphorae were produced between the 4th and 7th centuries AD (Yaman 2018: 292). Examples of Agora M 334 amphorae were identified in Tripolis (Katırancı 2020: 52, 275, cat. nr. 62-71, tab. 12), İstanbul (Reynolds 2005: 603, pl. 16, Figure 121), Parion (Akkaş 2020: 445-447, cat. nr. 288-293), Arykanda (Yaman 2018: cat. nr. 469, tab. 70), Myra (Tomay 2023: 412, cat. nr. 258), Elaiussa Sebaste (Ferrazzoli and Ricci 2007: 678, Figure 3, nr. 1-3), Anemurium (Korkmaz and Tekocak 2023: 29), Damascus (Tréglia and Berthier 2010: 867-868, 871, Figure 3, nr. 1-7), Akko (Reynolds 2005: 602, pl. 15, Figures 104-113), Chhim (Reynolds 2005: 603, pl. 16, Figures 117-118, 120), Beirut (Pieri 2007b: 321, Figure 9), Baalbek (Hamel 2010: 882, Figure 11), Domus Tiberiana (Carboni 2010: 418, 424, Figure 9, nr. 8), Tergeste (Degrassi et al. 2010: 580, 584, Figure 5, nr. 19), Neapolis (Carsana and Del Vecchio 2010: 459-460, 467, Figure 4, nr. 16), Classe (Cirelli and Cannavicci 2014: 963, 968, Figure 4, nr. 1-3) and Athens (Kouveli 2014: 751, 758, Figure 21).

Maritime trade routes and amphora distribution in the Late Roman Period

Amphorae are crucial for studying the economy of the Late Roman Period (Mitchell, 2016: 67). Maritime trade relied heavily on amphorae during the Late Antique Period. The mountainous and rugged terrains of the Cilicia and Syria regions made maritime trade the preferred method for exporting amphorae (Soydan, 2023: 18-19). Additionally, maritime trade was favoured due to the risks and extended duration of land trade, including the threat of plunder. The development of sea trade was driven by increased agricultural production in the provinces of Cilicia and Syria. During the Late Roman Period, olive oil and wine production peaked in both inland areas and coastal settlements with fertile plains. This agricultural boom was accompanied by the establishment of ceramic production centres in these regions. Cities and their surrounding areas were equipped with the necessary infrastructure for agricultural production, leading to significant urban development. The surplus agricultural products were promptly stored in amphorae, loaded onto ships, and exported to other provinces.

Analogical evaluations within this study identified nearly all similar examples in coastal settlements. Amphorae produced in both the Cilicia and Syria provinces help delineate the routes of maritime trade. Examining these routes, from the Levant Region to the Strait of Gibraltar, reveals the distribution areas of amphorae. Focusing on the distribution of Agora M 239 amphorae and their maritime trade routes, we find a concentration of similar examples in the Caria, Pamphylia, and Cilicia regions. This study confirmed the presence of these amphorae in 11 different settlements. Undoubtedly, the most common amphora form in the entire Mediterranean is LR 1. These amphorae, with similar examples identified in 78 different settlements, were the most popular carrying vessels of their time. Examining the subtypes typologically, the LR 1A type is found in 45 different settlements, the LR 1B type in 48 settlements, and the LR 1C type in 11 settlements. Notably, LR 1A and LR 1B types are often found together in locations such as Anemurium, Antiocheia, Alexandria, Elaiussa Sebaste, Klazomenai, Kelenderis, Knidos, Marseille, Myra, Parion, Phaselis, and Syedra. This suggests continuous trade in these regions from the beginning of the 4th century until the end of the 6th century AD. Additionally, the fact that some of these regions are amphora production centers indicates they were the starting points of this trade.

The number of settlements where subtypes of LR 1 amphoras were found corresponds to the peak period of commercial activity in the Roman Period. For instance, LR 1A amphoras, produced starting in the 4th and 5th centuries AD, spread extensively throughout the Mediterranean. Similarly, LR 1B amphoras, produced in the 5th and 6th centuries AD, were distributed widely across the Mediterranean, reflecting the economic expansion of Late Rome. However, trade significantly declined in the 7th century AD due to Arab raids and economic instability. This decline is evidenced by the limited distribution of LR 1C amphoras. Generally, amphorae were used in maritime trade in Western Europe, but the increasing use of barrels since the 2nd century resulted in fewer amphorae being unearthed in these regions. Specifically, amphorae were found in 29 settlements across Spain, Portugal, France, Italy, and the Adriatic coasts, compared to 90 settlements in Greece, Anatolia, and the Levant, highlighting both the data and interregional trade dynamics (Figure 3).

The distribution of Zemer 40 and 41 amphoras is more limited compared to LR 1 amphoras. Zemer 40 amphoras were primarily found in the Cilicia region and were scarce in other areas. In contrast, Zemer 41 amphoras were discovered not only in Cilicia but also in the Levant, Egypt, Greece, Italy, and along the Adriatic coast, indicating broader use in trade. Cilician amphorae were traded from the Eastern to the Western Mediterranean. LR 4 amphoras, specific to Syria and the Levant, were one of the two most produced types in these regions. These amphoras were used for approximately seven centuries and have been identified in various regions, highlighting their frequent use in trade. Their form evolved to become thinner and longer, making them more suitable for maritime trade by allowing the transport of more products with higher capacity. The transportation of the renowned Gaza wine in these amphoras further increased their popularity and functionality in trade. Therefore, LR 4 amphoras likely had a similar distribution and trade network as LR 1 amphoras.

The LR 5/6 amphoras, unique to Syria and the Levant, were used for approximately nine centuries. Their distribution pattern reveals important trade networks: they were rarely found in Western Europe, occasionally in Central Europe, but widely in Greece, Anatolia, and the Levant. This indicates a strong regional focus in their commercial use. Agora M 334 amphoras were predominantly found in Anatolia and the Levant, with fewer instances in Greece and Italy. This suggests that their use was more geographically restricted. These finds confirm that Syrian and Levantine amphoras were primarily traded from the Eastern to the Western Mediterranean. The amphoras discovered in various settlements, identified through analogical studies, not only illustrate trade routes but also provide evidence of interstate cultural and commercial interactions. However, the presence of these amphoras in certain settlements does not unequivocally prove they arrived solely through trade. While some may have been imported, others might have been locally produced imitations. Clay analyses are necessary to draw definitive conclusions. Regardless, even local imitations indicate that imported amphoras reached these regions in small numbers, underscoring the existence of trade. Additionally, analyzing residues found in amphoras can provide insights into the products that were exported to these regions.

Conclusion

The analysis of trade routes and inter-provincial relations based on amphora distribution reveals a clear pattern: amphoras are most densely concentrated near their production centres, with density decreasing over greater distances. This distribution indicates that trade networks were shaped by advancements in shipbuilding, the security of maritime routes, state economic needs, and the spatial relationships between provinces. Coastal settlements with ports played a crucial role in these trade networks, emphasizing their significance in the commercial activities of the period. The presence of

amphoras in various regions not only outlines trade routes but also reflects interstate cultural and commercial interactions. While some amphoras may have been locally produced imitations of imported types, their widespread distribution demonstrates the existence of active trade networks. This study highlights the complex and region-specific nature of ancient trade systems. The distribution of amphoras offers valuable insights into the economic dynamics of the Late Roman Period. Further research, including clay and residue analyses, could provide a deeper understanding of the traded products and the extent of commercial activities in the Mediterranean, thus enhancing our knowledge of ancient economic systems and their interconnectivity.

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The colour of empire: Andriake in the context of the link with murex and amphora

Beste Tomay[1]

Abstract

As a status indicator in antiquity, purple was a colour that was highly valued and used by the upper class in every period to make themselves special and different. The most vivid shades of this colour are obtained from some crustaceans living in the sea, especially from some murex species. The largest known production workshop in Anatolia for the production of purple dye obtained from murex crustaceans was uncovered during the excavations carried out in 2010 in Andriake, the harbour neighbourhood of Myra.

It was determined that the Andriake Harbour Agora was transformed into a comprehensive dye production facility in the 5th century AD. In this context, the north part of the agora was converted into a production area and the south part, which was dismantled at that time, was turned into a dumping area. During the excavations at Andriake, a large amount of amphora fragments was recovered among the murex shell wastes. It is known that the murex was transported in amphorae with sea water and kept alive in the amphorae until they were processed. The amphorae were broken in order to remove the murex adhering to the inner surface of the amphora, which explains the density of the amphora fragments recovered from the waste areas.

In this study, the amphorae discovered from the murex workshops at Andriake and apparently related to the transport of murex from the sea to the workshops were evaluated in terms of form, date, capacity, production centre and trade routes. The majority of the amphorae appear to have been produced contemporary with the murex workshops. The majority of the amphorae are LR-1 amphorae, while Samos Cistern Type, LR-2 and Zemer 41 forms were also identified. Due to the high number of LR-1 amphorae and their rather careless production, the data obtained from the archaeometric analyses carried out on some LR-1 samples prove the idea that this form was deliberately produced or preferred for the transport of murex. Considering the easy accessibility of the purple dye obtained from murex, the geopolitical position of Andriake and its commercial momentum, it is thought that the production was commissioned by the Empire and transported from here to the capital Constantinople and other centres of the empire. Since the Andriake amphorae are the strongest evidence for the transport of murexes in amphorae in Anatolia, this research is of great importance for the Mediterranean maritime trade.

Keywords: Andriake, Lycia, amphorae, murex, purple dye

Introduction

Myra, one of the most important cities of Central Lycia, was a very important centre from the Classical Period until the end of Late Antiquity (Figure 1). Andriake, which is the port quarter of Myra, was located in the same historical pattern with the main city Myra and was a very important trade centre

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until its last use. Andriake was built on the two shores where the Andriakos Stream, now known as Kokarçay, meets the Mediterranean Sea. The excavations, which have been carried out under the direction of Profesor Nevzat Çevik since 2009, have been carried out intensively in the southern part of Andriake. During the excavations carried out in the harbour, there are structures such as baths, churches, synagogue, shops and workshops for production for the use of sailors who only stopped by (Çevik and Bulut 2010; Çevik and Aygün 2019; Çevik and Bulut 2022). In addition, the fact that one of the two largest granariums of the region is located here emphasizes the importance of Andriake in maritime trade. In addition to the location of Andriake, the fact that one of the two largest granaria of the Lycia Region is located here emphasizes the importance of Andriake in maritime trade. The Port Agora, also referred to as (Borchhardt 1975: 64; Bayburtluoğlu 2004: 200; Çevik and Bulut 2010: 41) in ancient sources and in the notes of western travellers who first explored the region, was (Çevik 2021: 382), in the area just east of Horrea Hadriani, and is at the focus of the trade zone functioning in the centre of the southern settlement of Andriake Port[2].



Figure 1: Location of Myra and Andriake.

The intensity of trade in the harbour is evident from the increase in the construction activities of Emperor Hadrian. Horrea Hadriani, one of the two granarium structures of the Lycia Region, undoubtedly increased the commercial hinterland of Andriake to a great extent. It is obvious that the concept of annona militaris was important in Andriake. The fact that the function of the agora in Late Antiquity has become predominantly murex industry is also an important issue that needs to be discussed (Figure 2). In Anatolia, especially with such a geographical location, a large purple dye production industry has not been identified so far. The importance of purple dye from Antiquity onwards increased even more when it became the Imperial colour in Late Antiquity. Such a large production area and the thousands of amphorae found in the wastes suggest that this was done by the Empire. It has been determined by the studies that the highest number of amphorae were found in these areas.

[2] For the urbanistic of Andriake, see. Aygün 2018.



Figure 2: Andriake Harbor Agora and Murex Workshops (Myra-Andriake Excavations).

Transportation of murex in amphorae

The colour purple, which was considered the colour of royalty, nobility and divinity throughout antiquity, was obtained from shellfish belonging to the Muricidae family called Murex trunculus, Murex brandaris and Purpura haemastoma. The fact that only about one and a half grams of dyestuff was obtained from about twelve thousand crustaceans caused the colour to be included in the class of luxury goods, and for this reason, it became a status symbol indicating the ancestry of royal descendants. Research has shown that purple dye, identified with the Phoenicians, first appeared in Crete during the Middle Minoan Period (Reese 2010: 125).

The dye is produced in the hypobranchial gland of murex shellfish. This secretion is a kind of mucus that turns reddish-purple when it comes into contact with air and oxidizes. The living mollusc squirts a few drops of this liquid when disturbed. However, only a very small amount of dye can be collected in this way. The processing of murexes for industrial dye production begins by breaking them open to remove the glands that contain most of the dye. As the gland extends along the length of the mollusc within its coiled shell, the wall of the shell must be broken and separated from the shell in order to remove all of it. The gland is easily identified by the red veins on the shell and is cut away from the rest of the animal. Smaller molluscs are used by crushing them with their shells.

The most detailed information on the process of obtaining purple dye from Murex is given by the ancient writer Pliny. Pliny gives many details about the capture of crustaceans such as Murex Brandaris and Hexaples Trunculus, the dye production process, its application, and the seas of which centres provide the best purple (Aygün 2016: 4). Ancient sources also mention that murex was collected in spring in their breeding period[3].The collected murex were filled into amphorae with sea water and

[3] Plin. nat. hist. 9.60, 9.62; Aristot. hist. an. 5.15.

transported to the workshop where the dye was obtained. The fact that 12,000 murex shells were needed for 1.5 grams of paint shows how much material and labour was required in (Friedlander 1910: 247).

The use of purple-dyed clothing, which has always been in high demand by the rich and powerful and those who looked up to them, was generally restricted by law, especially in later periods, to imperial and religious officials. The first legal restriction on purple appears in the Lykurgos Reforms, which restricted luxury in Sparta in the 8th century BC[4], with the prohibition of the use of purple covers in homes. In the Roman period, Emperor Caligula tried to turn purple into an imperial symbol by imposing restrictions on its use by the public, and the emperor sentenced a vassal king to death for flaunting purple (Reinhold 1970: 49-50). In the mid-1st century, Nero for the first time-imposed restrictions on the trade in purple dye and its products, securing its status as an imperial symbol (Reese 1980: 85). A customs inscription found in Andriake and dated to the reign of Nero shows that purple was traded in the port of Andriake in the list of monopoly goods subject to special taxation. The customs inscription of Ephesus from the 1st century AD also includes purple in the tax list (Takmer 2006: 25-26).

During the Pax Romana in the 2nd century AD, the production and wearing of purple was largely free, and it was frequently used and traded by people who could afford it (Aygün 2016: 4). During this period, the murex dye industry in Anatolia also developed and guilded, as evidenced by epigraphic documents found in cities such as Hierapolis (Reinhold 1970: 57). And after during the reign of Diocletian, Tyros workshops were operated by the state. Theodosios II banned the use of some purple dyed clothes by the public (Aygün 2012: 11). This led to a decline in sales and the closure of some dye workshops. By this time, purple had become an imperial symbol and the concepts of adoratio purpurae and porphyrogennetos were well established. Around five hundred AD, a purple dye workshop was established in Constantinople, producing exclusively for the court. During this period, the industry was run by both state and private manufacturers. However, production for the Empire was still going on elsewhere, such as Tyros, Sidon and Tarentum[5] (Mango 2002: 168). In Justinian's reign, the articles regulating the use of purple dye in the imperial constitution were largely rewritten, and the ban was slightly relaxed by allowing women to wear purple clothes on special occasions. Nevertheless, in this period, efforts were made to monopolize the silk trade and state control over luxury consumer goods such as purple and silk was maintained.

In addition to obtaining purple dye from murex, it is known that murex molluscs, like many other sea creatures, were consumed as food in ancient times. In addition, a purple cloth is inserted into the ear for earache; the flesh of murex is used for head wounds, toothache and breast pain. Since it contains high levels of calcium, murex shell wastes can be used in lime production. Due to their irregular shape and durability, the shell waste can be used as a retaining material in mortar. In Aperlai, murex shell wastes were used in mortar in many buildings throughout the city, and researchers have interpreted the piles of shells accumulated in some places in the city for this purpose (Vann and Hohlfelder 1998: 449; Aygün 2012: 18). Infrastructure of the purple dye production workshop in Aperlai It is thought to have been developed during the reign of Diocletian (Leadbetter 2003: 132-133).

In Andriake, murex shell wastes were intensively used under the floor of many buildings such as churches, shops and granariums and in the filling mortar under the brick floor. In addition, it was determined that murex shards were used as additives in many amphorae dated to the 4th-6th century

[4] Plut. Lyk. 13.4.

[5] Cod. Iust. 4.40.1.

AD found in Andriake. In the production of purple dye at Andriake, Hexaples Trunculus species were mostly used in the wastes (Forstenpointner et al. 2007: 206-208, 211-212.). It is known that this species of shellfish was caught by diving and trapping methods, then stuffed into amphorae and transported to the workshops for the dye production process. The presence of a large number of amphora fragments is the result of this process. In order to obtain purple dye, it is important that the creatures are brought in the water without dying and put into the baking process. These shells, which have a sticky surface, have to be broken off from the amphorae. In the production of purple dye at Andriake, Hexaples Trunculus species were found to be mostly used in the wastes. It is known that this species of shellfish was caught by diving and trapping methods, then stuffed into amphorae and transported to the workshops for the dye production process. The presence of a large number of amphora fragments is the result of this process. In order to obtain purple dye, it is important that the creatures are brought in the water without dying and put into the baking process. These shells, which have a sticky surface, have to be broken off from the amphorae. This is evidenced by the large number of neck fragments found (Çevik and Bulut 2010: 42). Although it is thought that the presence of ceramic sherds in the murex wastes is to prevent dispersion and odour, it was understood that the wastes in Andriake were not carried far away but dumped in the parts that used to serve as the agora courtyard (Çevik and Bulut 2010: 42). During the excavations, it is seen that the murex wastes found inside the workshops and in the southeast and southwest of the agora formed a very high layer.

The large number of amphora sherds unearthed in the murex workshops, especially during the 2010 excavation season, has indeed documented a very intensive production of purple dye. The waste reserve measurements revealed a total of 300 m^3 of shell waste, which corresponds to 60 million pieces of murex (Aygün 2016: 41). A large part of the Andriake Harbor Agora was converted into an extensive paint production facility in the 5th century AD (Aygün 2012: 2). As mentioned in ancient sources, there are architectural remains of the entire production process. In addition, the materials used during the process, such as shovels and metal vessel fragments, have provided a very good understanding of the production process (Aygün 2012: 55). In this context, the northern wing of the agora was converted into a production area and the southern wing, which was dismantled at that time, was turned into a garbage dump. It can be calculated that the total volume of the waste piles is about one thousand one hundred and eighty-one cubic meters, and based on the average number of two hundred individuals per litre determined in the archaeozoological study, it is equivalent to a total of two hundred and fifty million murex for all waste (Aygün 2012: 51). During the excavations at Andriake, a large amount of amphora fragments was recovered among the murex shell waste. It is known that the murex was transported in amphorae with sea water and kept alive in the amphorae until they were processed. The breaking of the amphorae in order to remove the murex adhering to the inner surface of the amphora explains the density of the amphora fragments recovered from the waste areas.

Amphorae recovered from murex waste

The amphorae recovered from the Andriake murex workshops and apparently related to the transportation of murex from the sea to the workshops were evaluated in terms of form, date, capacity, production centre and trade routes. As for the amphorae evaluated in this study, the majority of the amphora fragments that were destroyed by the museum visitors and removed from the murex layer and thrown on the ground were brought to the excavation house and studied (Figure 3-4). The majority of the amphorae were dated to the Early Byzantine Period contemporary with the murex workshop. The majority of the amphorae were LR-1, but Samian Cistern Type, LR-2, Zemer 41 forms were also identified. Moreover, due to the high number of LR-1 amphorae and their rather sloppy production, the

data obtained from the archaeometric analyses performed on some LR-1 samples prove the idea that this form was deliberately produced or preferred for the transportation of murex. Secondary use terracotta stoppers were also found in the waste (Pl.III-4). In addition to these, there are also examples with incised technique. When these are analysed, graffiti and ligatures containing information about capacity are very important (Pl.II).



Figure 3: Murex Waste Dump (Writer).

LR-1 amphorae were produced intensively between the 4th-7th centuries AD and are one of the most produced amphora forms of Late Antiquity, with many different names and sub-variations in the literature. Morphologically speaking; the LR-1 form usually has a slightly flared mouth, a narrow, short and cylindrical neck, an oval and grooved handle starting just below the mouth, an oval and grooved body that rarely narrows, and a bottom that can be called a button or round form (Williams 2005: 616). The only type recovered from the site evaluated in this article is the LR-1 B form. It has a flaring rim with an average size of 10-12.5cm, a 2-2.5cm thick band protruding outwards on the rim, a narrow cylindrical neck and grooved handles starting from the rim and continuing to the bottom of the neck, which have become smaller and more steeply angled compared to the previous variation. The body is more ovoidal and shortened. They have an average capacity of 15-27 litres (Pieri 2005: 70-74). On this type, as on the other examples recovered from Andriake, there are amphorae with ligature as well as graffiti giving weight information. In line with the previous archaeometric analyses on this type, it has been observed that there is a clay match (Pl.I,Pl.II). In addition, the fact that murex shards were used as aggregate in some of the samples suggests that the amphorae were also produced to meet the amphora needs of this facility which produces purple dye intensively.



Figure 4: Amphorae from the Murex Waste Dump (Writer).

The Samian Cistern Type Amphorae, which were produced intensively in the 5th-6th century AD, have a short, wide and cylindrical neck with a simple flaring and slightly flattened rim and a band just below it, simple fluted handles, deep grooves on the body, a body that widens downwards and narrows towards the bottom, and a pointed or knobbed bottom filled with amphorae (Scorpan 1977; Arthur 1990: 282; Arthur 1998: 168; Pieri 2005: 133; Şenol 2009: 157), with an average length of 50-60cm (Arthur 1990: 282). This type of amphora found in the mentioned area also contains graffiti as in the other group. (Pl.III-1)

LR-2 amphorae, known to have been produced intensively in the Aegean and used especially for the transportation of olive oil and wine, were used extensively between the 2nd and 7th centuries AD (Şenol 2009: 148). The LR-2 form, which can be characterized by a flaring funnel-shaped rim with a hard transition from the neck to the shoulder, a rounded shoulder and oval handles between the shoulder and neck, a globular body and a simplified base356, is thought to have been produced for shorter distances357. It is understood that 5th century AD examples of this form were recovered from the Murex waste. A body sherd with a graffitied body with weight information, which appears to have been made after firing, was removed from the waste and thrown out by the visitors (PL.III.3).

Zemer 41 amphorae (Şenol-Cankardeş and Şenol 2003: 12) were produced extensively from the mid-1st century AD to the 4th century AD (Autret and Rauh 2012: 255) and are known as a type used especially for wine. The form of the amphorae is characterized by a flaring rim, a sharp carinated shoulder, a short and cylindrical neck, and a special handle structure called "Pinched Handle", which is formed by compressing two grooved dough and extends from below the lip down to the neck. The bottom ends in a pointed shape similar to a mushroom or a knob (Zemer 1977: 52). The capacity of the 1st type (Alpözen et al. 1995: 75) is between 19.3 litres and 36 litres, while the 2nd type (Zemer 1977: 52; Dyczek 2001: 161) is between 45.8 litres and 53 litres. Their heights are between 65-75cm (Williams and Lund 2013: 156). It

is known that resinous wine702 was produced and traded extensively in Cilicia during the Early Imperial Period (Williams 1989: 91).

This specimen recovered from the murex waste shows that this form was used in the transportation of murex as a secondary use. Considering the clay structure; the paste colour was found to be light red and reddish yellow tones attributed to the Cilician examples. (PL.III.2).

Graffiti on Amphorae (Pl.III.1,3,5,6,7,8).

The area with the highest concentration of graffito amphorae in Andriake is the murex workshop in the agora. It is not a coincidence that LR-1 amphorae, the form with the highest number of graffiti are also found here. In the researches conducted, it has been stated that graffito on LR-1 amphorae was very rarely applied, while dipinto was applied intensively (Kara 2019: 73). However, the situation in Andriake is exactly the opposite. Especially the graffito found mostly on LR1-B type coincides with the 5th century AD, which is the date of the murex workshops. However, it also raises the following question: If some of them were produced for the transportation of murex, even for single use, would the weight on the graffito correspond to this? Can the graffito on amphorae used for the transportation of murex as a secondary use provide a measurement of what may have been transported before? It is difficult to make sense of the scale indicated in the inscriptions on the amphorae (Pieri 2012: 44). However, researchers have tried to determine it based on different units of measurement according to the types of amphorae and some experimental research.

Conclusion

Regarding the production of purple dye obtained from murex, the fact that the largest known production workshop in Anatolia is located in Andriake, the port neighbourhood of Myra, and the fact that this colour was forbidden for ordinary people by the period, it is understood that purple dye was produced in Andriake for the Empire and transported to the capital by sea. Considering the easy accessibility of the purple dye obtained from murex, the geopolitical location of Andriake and its commercial momentum, it seems that the production was commissioned by the Empire and sent to the capital Constantinople and other centres of the Empire. Both in this respect and because the Andriake amphora samples are the strongest evidence in Anatolia for the transportation of murex in amphorae, the Andriake example shows the relationship between murex and amphora in all its stages and proves the importance of the port in Mediterranean maritime trade.

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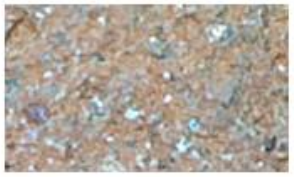
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PLATE I





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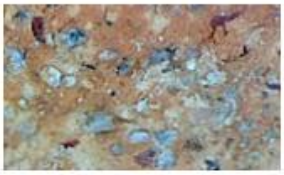




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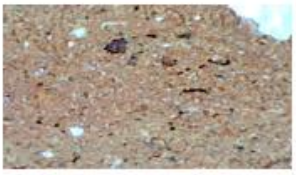
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PLATE I I

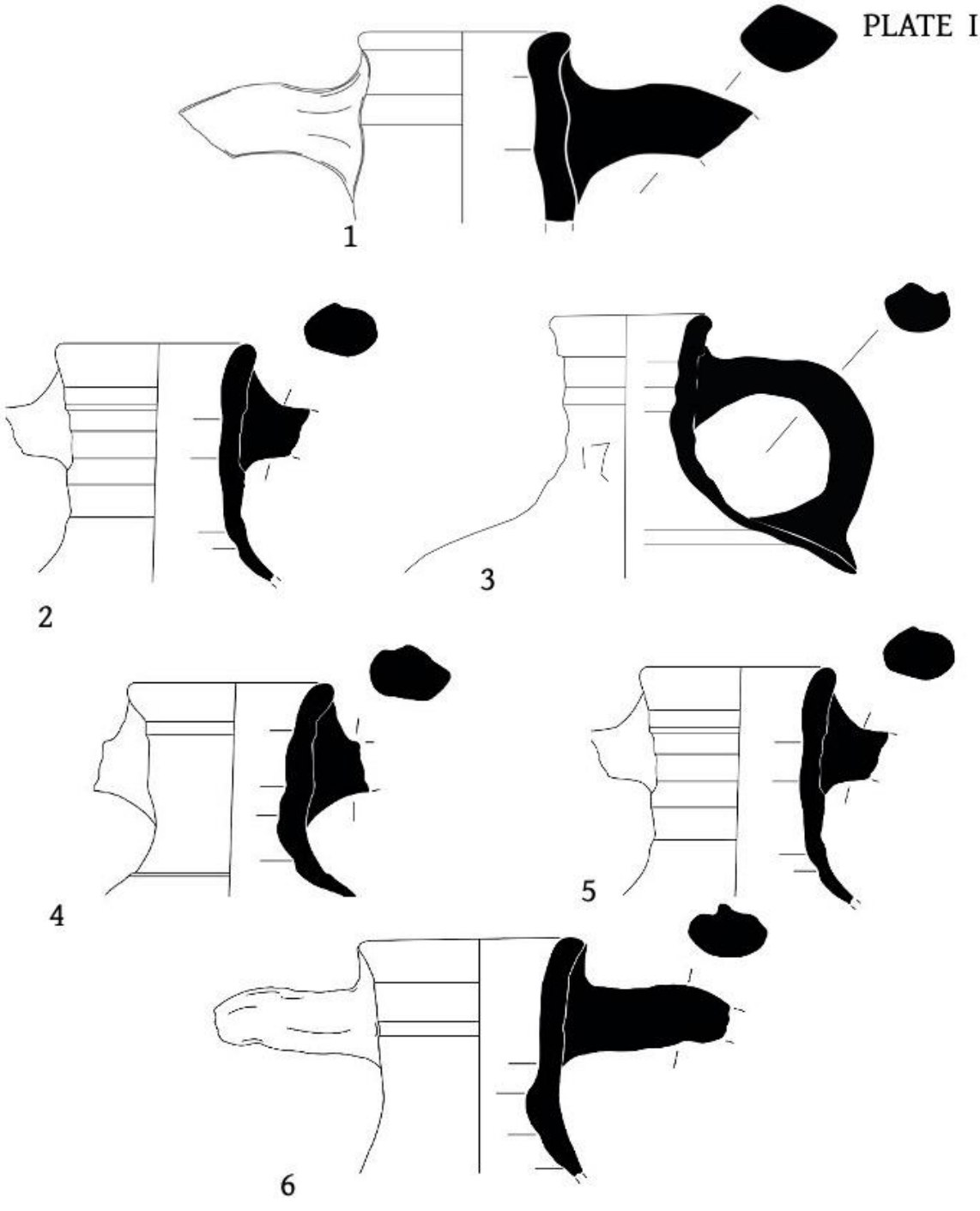


PLATE III



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