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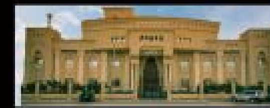

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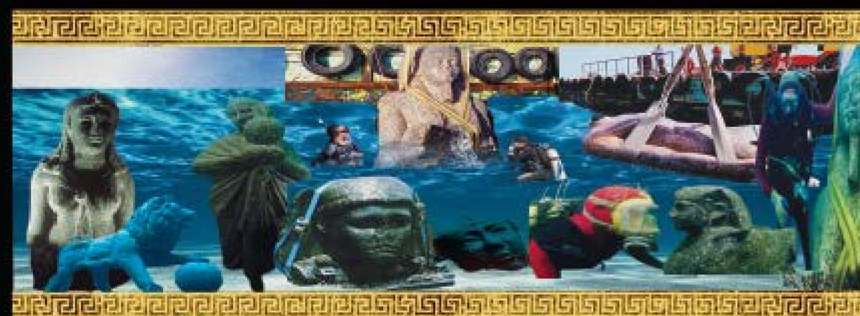

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In Memory of Kamel Abou el-Saadat

The Pioneer of Underwater Archeological Excavation

MESSAGE FROM THE EDITOR-IN-CHIEF

In Memory of Kamel Abou el-Saadat, the Pioneer of Underwater Archeological Excavation

Issuing a special issue entitled «Maritime and Underwater Cultural Heritage in the Arab Region» is in memory of Kamel Hussein Abou el-Saadat, the first Egyptian to employ fishing and diving to excavate underwater antiquities in Alexandria. He was a professional diver and a primary source of archaeological information about sites, antiquities, and archaeological treasures underwater on the coast of Alexandria. Thus, he was praised by archaeologists who compared him to the French diver and researcher «Gondet»

Abou el-Saadat began diving in 1960 at the age of twenty after mastering underwater fishing and diving to great depths, which enabled him to excavate many of Alexandria's underwater treasures. It was my honor at the age of nine to meet Abou el-Saadat for the first time in 1961 in the Casino de Mont-Carlo in Alexandria, Egypt, with my father, Ismail Yaseen (actor), and Abdel Fattah al-Qasri (actor) at a dinner invitation by Abdel Moneim Alba who was a senior party caterer in Alexandria. Alba introduced Abou el-Saadat as a professional diver who invited us for lunch on the following day. From a young age, my favorite hobby was fishing. My father had two Nile rafts, Nº.62 and Nº.64, on Gabalaya Street in Zamalek. I was keen to collect leftover food for fish in the Nile, as I enjoyed seeing the fish gather around the leftover food.

Then, I used my hook to catch fish. Thus, I waited enthusiastically for the next day's lunch to meet the professional diver Abou el-Saadat, who sat beside me, showing the difference between fishing in the Nile and the sea. He provided me with much information about fishing arts, especially underwater fishing. Then, Abou el-Saadat told the audience about underwater treasures, believing that ancient Alexandria was underwater as its ruins were still visible, including ports, locations, and treasures. His information and observations impressed the audience as if he had a complete map of ancient Alexandria. This was the only time I met him.

I was keen to keep up to date with Abou el-Saadat's underwater archaeological discoveries and achievements, such as discovering a giant red-granite statue lying next to Al Silsilah, a huge statue of a Ptolemaic queen dressed like goddess Isis, the underwater remains of the ancient Eastern Harbor and its famous Lighthouse at Qaitbay site while working as an expert with UNESCO in 1968 assisted by the Egyptian Navy, and of Isis Pharia next to the Citadel of Qaitbay. Abou el-Saadat continued his archaeological excavations by the 1980s when he found—as he believed—a marine barrier, a number of stony anchors in Maamoura, as well as several marine quays around Nelson Island in Abu Qir Bay. He was then able to locate some ships of the French fleet that had sunk in Abu Qir Bay. Thus, he assisted Jack Doma, 1983-1984, in his excavation of studying and salvaging a part of Napoleon Bonaparte's fleet.

Thanks to his considerable achievements in underwater archaeological excavation, Abou el-Saadat was a guide and expert for several missions working on underwater archaeological excavation of sites in Alexandria. Therefore, he was always honored and appreciated by all international and regional organizations. Unfortunately, he died as a martyr in the service of the Egyptian national heritage on Friday, June 22, 1984, in mysterious circumstances when he was on a diving trip on board Le Bon Pasteur, a French ship, during his participation in the search project for Napoleon’s fleet in (1984-1985). His death was unjustifiable, heartbreaking news as he was a skilled diver and swimmer.

Whatever the reasons for his death, Kamel Hussein Abou el-Saadat will remain the pioneer of the archaeological survey of underwater antiquities. He left a huge scientific school of underwater antiquities, currently led by his students who became masters of this science and succeeded in completing the process of archaeological excavation in all seaports in Egypt, including Prof./ Emad Khalil, Dr./ Osama Al-Nahhas, Dr./ Ibrahim Darwish, Dr./ Mohamed Mustafa, and others who will continue the search for Egypt's underwater treasures.

Finally, I express my heartfelt gratitude and appreciation to Prof./ Emad Khalil, the executive director of Alexandria Centre for Maritime Archaeology & Underwater Cultural Heritage, and Dr./ Osama Al-Nahhas, heritage expert at UNESCO, for their outstanding efforts and keen interest in editing this distinguished issue «Maritime and Underwater Cultural Heritage in the Arab Region» in memory of the deceased Kamel Hussein Abou el-Saadat, the pioneer of underwater archaeological survey.

Prof. Mohamed Mohamed El kahlawey

Cairo, 20/05/2024

INTRODUCTION

The Arab region is the birthplace of some of humanity's most ancient civilizations. Flourishing in North Africa, Mesopotamia, the Levantine coast, and the Arabian Peninsula, these societies included the Egyptians, Canaanites, Phoenicians, Assyrians, Hittites, Babylonians and Nabataeans. As a result, the Arab world boasts an unparalleled wealth of material culture inherited from these bygone eras.

Throughout history, the Arab world has been inextricably linked to water. The shores of the Eastern Mediterranean, Red Sea, Arabian Gulf, and the banks of the Nile, Tigris, and Euphrates Rivers have all borne witness to thriving maritime cultures. These seafaring societies have passed down to us a vast and fascinating legacy of maritime and underwater archaeology.

Oceans of the world, encompassing vast and enigmatic depths, serves not only as a reservoir of marine biodiversity but also as a repository of human history. Underwater Cultural Heritage (UCH) encompasses a diverse array of remains, ranging from shipwrecks and ancient harbours to submerged settlements and landscapes. These submerged sites offer invaluable insights into past societies, trade networks, and technological advancements, acting as witness to part ears.

This edited volume delves into the captivating realm of UCH, showcasing the multifaceted nature of underwater archaeological research across the Mediterranean Sea and beyond. Divided into eight papers, the volume explores a rich tapestry of topics, reflecting the breadth and depth of contemporary UCH studies.

The opening paper by Alaa Ababneh provides a timely review of emerging technologies poised to revolutionize the field of underwater archaeology. By examining cutting-edge tools and methodologies, Ababneh lays the groundwork for future exploration and discovery, propelling the discipline forward.

Subsequent papers delve into specific geographical regions and archaeological sites. Emad Khalil sheds light on the ancient anchorage of Zygris/Ladamantia (Marsa Bagoush) on the northwest coast of Egypt, illuminating maritime activities in the region. Ikram Harouni shifts focus to the vestiges of the First World War in Algeria, highlighting the potential of underwater sites to document more recent historical events, thus expanding the temporal scope of UCH research. Jafar Anbar offers a comprehensive review of harbour and coastal archaeology in Syria, drawing on past and recent archaeological and geoarchaeological surveys, providing a holistic understanding of past maritime landscapes.

Moving beyond the traditional confines of underwater sites, Marwa Abdel Aziz embarks on a captivating exploration of the iconography present in nobles' tombs in Egypt. Her analysis reveals how the study of Old Kingdom ship steering devices can extend beyond the iconographic representations, aiming to enrich our understanding of ancient maritime technology. Marwan Mady investigates the origins of dovetail joints in ancient Egyptian boats and ships, offering insights into shipbuilding techniques and technological advancements.

The following papers explore written records in conjunction with physical remains. Mohamed Abdelmaguid and Mohamed Al-Sharkawy analyze the «Autobiography of Weni»," focusing on the expedition to Hatnub. This crucial source of information serves to illuminate ancient Egyptian maritime activities, providing a textual counterpart to the archaeological record.

Finally, Zakia Chabane takes us back in time, examining the relationship between early modern humans and the marine environment through the lens of the Iberomaurusian culture. This paper broadens the chronological scope of the volume, demonstrating the potential of UCH research to shed light on early human interactions with the maritime world.

This edited volume brings together the expertise of leading scholars in the field of maritime and underwater archaeology. By showcasing a range of methodologies, geographical areas, and historical periods, the volume underscores the critical role of maritime archaeological research in enriching our understanding of the past. As we continue to explore the depths of our oceans, the potential for unraveling the mysteries of human history seems truly boundless.

We invite readers, both seasoned researchers and those new to the field, to embark on this captivating exploration of maritime and underwater cultural heritage.

Emad Khalil
UNESCO Chair, Underwater Cultural Heritage
Vice-President, Misr University for Science and Technology

Almost three decades of extensive underwater and coastal excavations in the waters of the Arab region uncovered thousands of sunken artifacts and submerged heritage sites. This richness of artifacts and structures emphasizes the vital role of the region in forming ancient civilizations and writing the crucial chapters of the history of humanity. This abundance of sunken structures and artifacts provides invaluable insights into the technological accomplishments, economic networks, military struggles, and cultural interactions of ancient civilizations.

From the submerged harbors and sunken ships of ancient Egypt, Syria, and the Levant to the shipwrecks of medieval and modern trade vessels along the coast of the Arabian Gulf and Indian Ocean, these discoveries encouraged archaeologists from the Arab world to enter a new era of underwater heritage research to decipher the clues of this hidden and enigmatic world.

The dream came true when the Arab Archaeologists Union decided to dedicate a special edition of its journal to maritime and underwater heritage in the Arab region and its surroundings. This thematic collection is a milestone in our efforts to identify and illuminate the rich, diversified heritage that lies alongside and beneath our seas, rivers, and lakes.

This special issue contains a number of innovative research papers that represent a wide variety of topics, including the future of innovative technologies in underwater excavation, maritime activities along the northwest coast of Egypt, interpretation of maritime trade networks, textual and iconographic evidence of maritime activities, shipwrecks of the world war, and finally the management of underwater and maritime cultural heritage as a tool to achieve sustainable development goals. The contributions reflect the efforts of archaeologists, historians, and scientists from the Arab world and beyond to emphasize the importance of our underwater and maritime heritage throughout history.

We are most grateful to all our contributors, reviewers, and editorial team for their hard work and professionalism that have made this special issue possible. We hope that, while reading the researches of this special issue, you will be inspired by the discoveries and discussions presented here. We are looking forward to preserving and sustaining the rich underwater and maritime heritage of the Arab world for the benefit of future generations and humanity.

Dr./ Osama El Nahas

Heritage Expert at ICESCO

Maritime and Underwater
Cultural Heritage in the Arab Region

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REVIEW FUTURE TECHNOLOGIES IN UNDERWATER CULTURAL HERITAGE

Article 1

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REVIEW FUTURE TECHNOLOGIES IN UNDERWATER CULTURAL HERITAGE

ABSTRACT

[AR] **مراجعة التقنيات المستقبلية في التراث الثقافي المغمور بالمياه**

يحمل التراث الثقافي المغمور بالمياه، الذي يشمل التحف الأثرية المغمورة بالمياه وحطام السفن والمواقع الأثرية، قيمة تاريخية وثقافية وعلمية هائلة. إن التقدم في تقنيات الذكاء الاصطناعي (AI) لديه القدرة على إحداث ثورة في استكشاف هذه الكنوز المغمورة والحفاظ عليها وفهمها. تتناول هذه المقالة المراجعة الوضع الحالي والآفاق المستقبلية لتقنيات الذكاء الاصطناعي في التراث الثقافي المغمور بالمياه. حيث نقوم بمسح كثير من التطبيقات المعتمدة على الذكاء الاصطناعي، بما في ذلك اكتشاف الأشياء وتصنيفها، والنمذجة التنبؤية، وتحليل البيانات، والمركبات المستقلة تحت الماء. كما نناقش تحديات وقيود الذكاء الاصطناعي في هذا المجال، مثل عدم وجود مجموعات بيانات مصنفة تحت الماء، ونسلط الضوء على تقنيات الذكاء الاصطناعي الناشئة، مثل التعلم العميق، والتعلم المعزز، والنماذج التوليدية، وإمكاناتها لتعزيز أبحاث التراث الثقافي المغمور بالمياه. بالإضافة إلى ذلك، نستكشف تكامل الذكاء الاصطناعي مع التقنيات المتطورة الأخرى مثل الروبوتات، ورؤية الحاسوب، وأنظمة الاستشعار تحت الماء، والتي يمكن أن تفتح إمكانيات جديدة للاستكشاف والتوثيق تحت الماء. أخيرًا، نسلط الضوء على الحاجة إلى تعاون متعدد التخصصات بين علماء الآثار والبحار والحاسوب وخبراء الذكاء الاصطناعي لمواجهة التحديات الفريدة وتسخير الإمكانات الكاملة لتقنيات الذكاء الاصطناعي في التراث الثقافي المغمور بالمياه. تهدف هذه المراجعة إلى إلهام الأبحاث المستقبلية، ودفع التقدم التكنولوجي، والمساهمة في الحفاظ على تراثنا الثقافي المغمور بالمياه وتقديره .

[EN] The exploration, preservation, and understanding of underwater cultural heritage, which includes submerged artifacts, shipwrecks, and archaeological sites, are greatly enhanced by the advancement of artificial intelligence (AI) technologies. This article overviews the current state and future potential of (AI) technologies in the field of underwater cultural heritage, examines various (AI)-driven applications, including object detection and classification, predictive modeling, data analysis, and autonomous underwater vehicles, and explores their implications for this domain. Several challenges and limitations are addressed to fully leverage (AI) in underwater cultural heritage. These challenges include the scarcity of labeled underwater datasets, the influence of environmental variability on data collection and analysis, and the complexities of deploying (AI) systems in underwater environments. Despite these obstacles, emerging (AI) techniques, such as deep learning, reinforcement learning, and generative models show promise in overcoming these challenges and advancing the capabilities of underwater cultural heritage research. Integrating (AI) with other cutting-edge technologies like robotics, computer vision, and underwater sensing systems presents exciting opportunities for underwater exploration and documentation. By combining (AI) algorithms with underwater robots and imaging systems, researchers can efficiently map, and document submerged archaeological sites, identify and classify artifacts, and predict the future condition of underwater cultural heritage. Interdisciplinary collaborations between archaeologists, marine scientists, computer scientists, and (AI) experts are crucial for driving progress in this field. By sharing expertise and knowledge, these collaborations address the unique challenges of underwater cultural heritage and unlock the full potential of (AI) technologies. This review aims to inspire future research, foster technological advancements, and contribute to preserving and appreciating our underwater cultural heritage. Through the integration of (AI) technologies, we uncover hidden historical monuments, deepen our understanding of the past, and ensure the preservation of these valuable underwater resources for future generations.

KEYWORDS: Underwater cultural heritage (UCH), artificial intelligence (AI), augmented reality (AR), future technologies, preservation.

I. INTRODUCTION

Artificial Intelligence (AI) has revolutionized the field of underwater exploration by introducing new research methods and technologies. Traditional approaches, such as human divers and remotely operated vehicles (ROVs), have limitations in terms of the depth they can reach, how long they can operate without interruption, and their overall efficiency. AI-powered Robotics and Virtual Reality (VR) have emerged as game-changers in oceanography. Self-navigating robots are equipped with advanced sensors and machine-learning algorithms, allowing them to explore the depths autonomously[1].

Without human intervention, they collect valuable data about underwater ecosystems, geological formations, and sunken shipwrecks[2]. The advancement of digital technologies, including 3D, artificial intelligence (AI), machine learning, cloud computing, data technologies, virtual reality, and augmented reality, has opened unprecedented opportunities for digitization, online access, and digital preservation of cultural resources[3]. One of the most exciting applications of (AI) in underwater exploration is underwater imaging and object recognition[4]. In the past, capturing images in the deep ocean resulted in poor visibility and low-quality images; (AI) algorithms now process and enhance these images, uncovering hidden details[5].

(AI) systems accurately identify and classify marine life and underwater structures. They can distinguish different fish species, identify coral formations, and even detect man-made objects on the ocean floor; this capability contributes to scientific research and has implications for environmental conservation and archaeological discoveries[6]. (AI) has significantly impacted underwater exploration by leveraging technologies such as deep learning and neural networks. These advanced algorithms mimic the human brain's ability to process information and effectively analyze vast datasets[7]. Deep learning enables (AI) systems to recognize patterns, make predictions, and identify anomalies in ocean currents, changes in marine life populations, and even predict underwater geological events like earthquakes and volcanic eruptions[8]. Real-time data analysis is crucial in underwater exploration, and (AI) has made this task more efficient and accurate. (AI)-powered Autonomous Underwater Vehicles (AUVs) process data on the spot and transmit vital information to researchers in real-time[9].

This capability allows scientists to respond promptly to emerging situations like oil spills, tracking endangered species, and monitoring underwater research stations[10].

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[1] PEHLIVANIDES et al. 2020: 8.
[2] GAMBIN et al. 2021: 12.
[3] BRÄUER-BURCHARDT et al. 2023: 7.
[4] BRUNO et al. 2019: 16.
[5] MOGSTAD et al. 2020: 10.
[6] ARGYROU & AGAPIOU 2022: 5.
[7] AMIN 2017: 6.
[8] BROWNE & RAFF 2023: 3.
[9] PEHLIVANIDES et al. 2020: 8.
[10] ARGYROU & AGAPIOU 2022: 5.

(AI) also plays a vital role in environmental conservation. (AI)-powered monitoring systems help track the movements of endangered species, providing critical data for their protection. (AI) algorithms analyze the impact of human activities on marine ecosystems, enabling scientists to develop strategies to mitigate threats and preserve the oceans[11]. To make underwater cultural heritage accessible to the public, multimedia technologies are crucial. Digitizing and creating three-dimensional models of underwater sites allow people who cannot physically dive to experience virtual dives. Researchers use photogrammetry, capturing still shots with an affordable underwater camera, to generate detailed 3D models that provide an immersive and interactive experience[12].

Accessible tools and techniques allow underwater archaeologists to create these models without relying on computer engineers. This approach makes the process more inclusive and promotes eco-friendly tourism[13]. Visitor centers strategically place android robots, virtual reality headsets, and other interactive tools to spark tourists' interest in local marine biodiversity and ecotourism. By leveraging multimedia technologies and immersive experiences, the goal is to bring underwater heritage to wider audiences and encourage sustainable tourism practices[14].

The future of (AI) in underwater exploration holds promising prospects. AI-driven AUVs continuously evolve to reach greater depths, enabling the exploration of the ocean's deepest trenches. Improved communication systems will facilitate real-time data transmission from remote locations[15]. (AI) also contributes to sustainable resource management by monitoring fishing activities, mitigating overfishing, and supporting responsible aquaculture practices[16].

Efficiently applying (AI) in the public cultural domain requires investment in various areas, such as infrastructure, equipment, and highly skilled human labor. Human expertise is crucial as (AI) relies on high-quality data for training and performing its tasks effectively[17]. Interoperability and appropriate metadata are essential for valuable and easily shared data. Resolving copyright issues associated with the use of such data is necessary, and cultural heritage professionals need to acquire the skills required to navigate this complex landscape adeptly[18].

The paper aims to review and analyze future technologies in the context of underwater cultural heritage. It seeks to explore innovative technologies that have the potential to revolutionize the study, preservation, and accessibility of underwater cultural heritage sites. One significant research gap in this field is the limited exploration and

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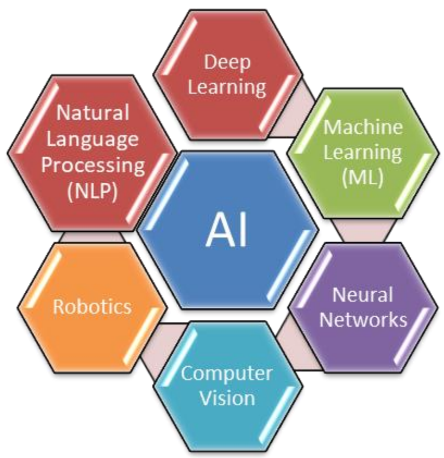
[11] BERGANZO-BESGA et al. 2021: 6.
[12] EL-TAWAB et al. 2020: 8.
[13] BREEN et al. 2021: 10.
[14] BRÄUER-BURCHARDT et al. 2023: 6.
[15] RICCA et al. 2020: 10.
[16] HENDERSON 2019: 2.
[17] ARGYROPOULOS & STRATIGEA 2019: 9.
[18] RICCA et al. 2020: 10.

utilization of emerging technologies for underwater cultural heritage[19]. While there have been advancements in technologies like virtual reality, augmented reality, and artificial intelligence, their specific applications and potential in the context of underwater cultural heritage are not fully explored[20].

Artificial Intelligence in Cultural Heritage

Various studies have highlighted the benefits of incorporating artificial intelligence into archaeological research and excavation; studies emphasize that (AI) significantly reduces the cost and time associated with these processes, particularly in limited archaeological areas. One approach that has shown promise is the use of deep learning (DL) algorithms in analyzing imagery captured by Unmanned Aerial Vehicles (UAVs)[21]. By applying computer vision techniques, (DL) algorithms identify and classify artifacts, structures, and other archaeological features in cost-effective and efficient manners[22]. This technology has the potential to revolutionize archaeological field research, providing support for future projects, especially those operating under tight schedules **[FIGURE 1]**.



[FIGURE 1]: Types of (AI) © Done by the researcher.

Recent advancements in (AI), particularly in computer vision and machine learning, hold promise of transforming the way archaeological research handles vast amounts of data covering large areas; this minimizes reliance on human resources and significantly enhances the speed and accuracy of analysis. Berganzo Besga et al[23] have improved an (AI) algorithm that uses LiDAR and multispectral satellite data for large-scale automatic detection of archaeological tombs, which are common structures of interest. Such automated detection methods offer viable alternatives to manual identification, enabling more efficient and accurate identification of archaeological remains.

[19] MENNA et al. 2018: 6.
[20] BROWNE & RAFF 2023: 3.
[21] ČEJKA et al. 2020: 11.
[22] HAIRY et al. 2020: 11.
[23] BERGANZO-BESGA et al. 2021: 8.

Case Study

Over 2,000 years ago, Baiae stood as a magnificent resort town on the Italian peninsula. Volcanic activity eventually caused half of the town to sink beneath the Mediterranean, transforming Baiae into an underwater archaeological park.

Wireless internet is ineffective in water due to the interaction between water and electromagnetic waves[24]. Researchers have developed a network of acoustic modems and underwater wireless sensors that gather environmental data, which is transmitted to land in real time. This innovative system utilizes (AI) algorithms that continuously adapt to network protocol based on changing sea conditions[25]. As a result, signals travel up to two kilometers, achieving data transmission speeds ranging from kilobits per second to tens of megabits per second, depending on the distance between transmitters **[FIGURE 2]**[16].

[FIGURE 2]: Aided by algorithms, researchers explore the underwater ruin at Baiae. HENDERSON 2019:2.

The underwater internet system at Baiae enables remote and continuous monitoring of environmental conditions, such as PH levels and carbon dioxide concentrations, which affect the preservation of artifacts[26]. It allows divers to communicate with each other, and with colleagues on the surface who use this technology to accurately locate the divers; this advancement in underwater communication technology has significantly enhanced the ability to safeguard the archaeological site and facilitate collaborative exploration and research in this unique underwater landscape[27].

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[24] BERGANZO-BESGA et al. 2021: 10.

[25] CALLARIARCHIVE 2022: 1.

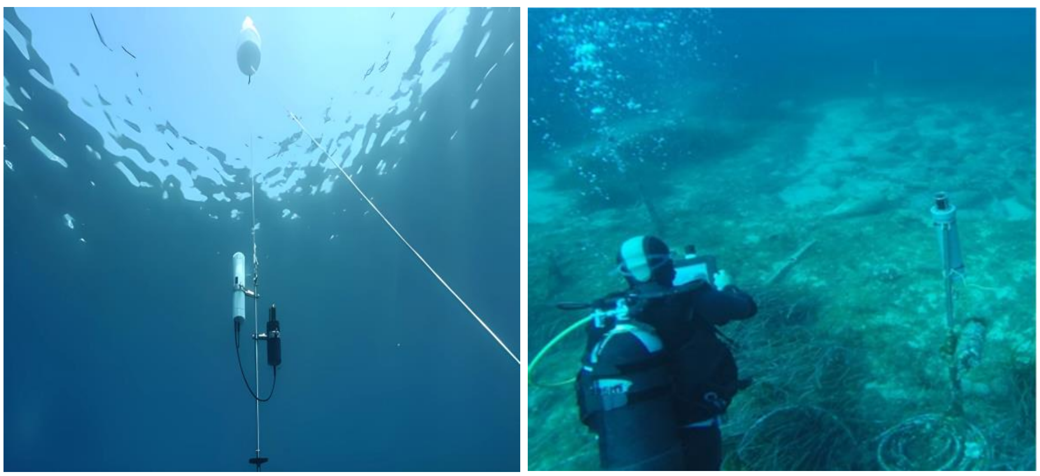
[26] FRIGERIO 2013: 3.

[27] BRUNO et al. 2019: 12.

II. UNDERWATER ACOUSTICS

In the context of underwater exploration, SONAR plays an important role in underwater acoustics systems. SONAR systems utilize the propagation of sound waves between transmitter and receiver to remotely sense the interior of bodies of water, including their floors and structures beneath them[28].

When sound waves encounter a surface interface between two media with different physical characteristics, such as seawater and sandy seabed, several phenomena occur[29]. Part of the sound energy is reflected, another part is refracted and continues to travel in the new medium but with a change in direction of propagation according to Snell's law, and the rest is scattered. By analyzing the energy returned to the sonar device, valuable information about the physical properties of underwater objects are obtained; the principles of modern SONAR have been known to humans for centuries **[FIGURE 3]**. SONAR plays a significant role in archaeological investigations of underwater environments.



[FIGURE 3]: SONAR applying underwater. MENNA et al. 2018: 8.

In archaeological studies, knowing the position and orientation of objects concerning a global reference system (geo-referencing) is often crucial. Airborne or ship-mounted systems achieve direct geo-referencing through a GNSS-INS (Global Navigation Satellite System-Inertial Navigation System) setup[30]. Mobile systems like remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) are fully submerged and cannot rely on satellite-positioning systems. Instead, they integrate other sensors and techniques such as simultaneous localization and mapping (SLAM) and acoustic positioning systems to determine their position accurately underwater[31]. High-resolution surveys conducted in the local reference systems were later geo-referenced using reference points with known coordinates[32].

[28] MENNA et al. 2018: 8.
[29] EID et al. 2018: 5.
[30] LUPIA et al. 2023: 8-9.
[31] KAPETANOVIC et al. 2020: 4.
[32] UNESCO 2023: 2.

2. Limitations and Challenges

While underwater acoustics has proven to be a valuable tool in Underwater Cultural Heritage (UCH), certain limitations and challenges are associated with its usage[33]. Two significant limitations are the propagation and attenuation of sound waves in water [TABLE 1]. In contrast, sound waves travel long distances underwater, and are subject to absorption, scattering, and reflection, which decreases signal strength and limits the range and resolution of acoustic systems, especially in deep-sea environments or areas with poor acoustic conditions[34].

Another challenge in underwater acoustics is interference and noise in aquatic environments. Natural factors like biological activity and anthropogenic sources like ship traffic and ocean currents contribute to high background noise[35]. This interference hinders the accuracy and reliability of underwater acoustic measurements, making it challenging to extract meaningful information from the data collected[36].

Limitations and Challenges	Description
Attenuation	Sound waves in water experience higher attenuation, limiting the range of effective signal transmission.
Ambient Noise	Underwater environments are filled with various sources of ambient noise, which interfere with acoustic signal detection and interpretation.
Multipath Propagation	Multiple reflections, refractions, and scattering of sound waves cause signal distortion and interference.
Limited Bandwidth	Underwater acoustic communication has limited bandwidth, restricting data rate and capacity.
Environmental Variability	Changing environmental factors, such as temperature, salinity, and pressure, affect sound propagation characteristics.
Limited Localization Precision	Achieving precise and accurate localization of sound sources underwater is challenging due to complex propagation and environmental factors.
Doppler Effect	The motion of the sound source or receiver introduces frequent shifts in received signals, leading to errors and distortions.
Sensitivity to Underwater Geometry	Acoustic signal propagation is influenced by underwater objects, seafloor topography, and water layers, making modelling and prediction difficult.
Communication Interference	Interference between multiple underwater acoustic systems degrades performance and limits network capacity.
Cost and Deployment Challenges	Building, deploying, maintaining, and repairing underwater acoustic systems are costly and logistically challenging.

[TABLE 1]: Limitations and challenges of underwater acoustics © Done by the researcher

[33] SECCI 2017: 12.
[34] KAPETANOVIC et al. 2020: 9.
[35] MACLEOD et al. 2019: 6.
[36] RICC et al. 2020: 2.

Achieving high-resolution imaging using underwater acoustics is difficult. Wavelengths of sound restrict resolution, transducers' capabilities, and environmental conditions. These limitations make it challenging to capture fine details and distinguish small underwater features accurately[37]. Underwater acoustics remains valuable in UCH research and exploration despite these challenges.

Ongoing advancements in technology and techniques aim to overcome these limitations and improve the capabilities of aquatic acoustic systems, enhancing our understanding and preservation of underwater cultural heritage.

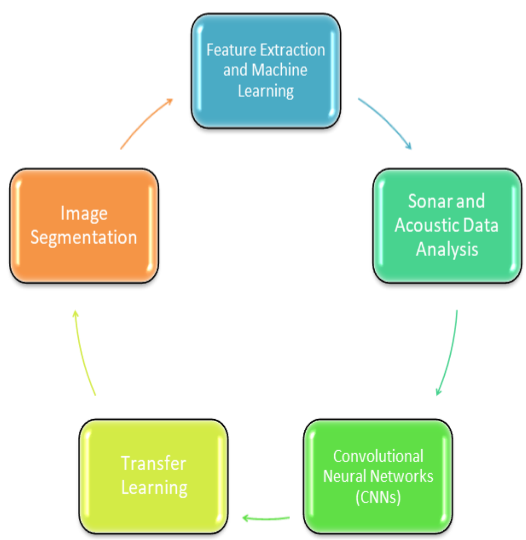
3. Transition to Future Technologies

Artificial Intelligence (AI) in Underwater Archaeological Research

Artificial Intelligence (AI) has emerged as a powerful tool in various fields, and its application in underwater archaeological research holds great promise for advancing exploration, analysis, and preservation of underwater cultural heritage. (AI) technologies assist researchers in object detection and classification, data analysis and interpretation, predictive modeling, and site mapping and reconstruction[38].

1. (AI)-assisted Object Detection and Classification

One of the critical challenges in underwater archaeological research is the identification and classification of submerged artifacts and structures **[FIGURE 4]**. (AI) algorithms are trained to recognize and differentiate objects and features from underwater imagery and sensor data[39].



[FIGURE 4]: Types of (AI) object detection and classification Techniques © Done by the researcher

[37] SECCI 2017: 16.

[38] AGARWALA 2020: 7.

[39] AGAPIOU & LYSANDROU 2023: 4.

Using deep learning techniques, (AI) algorithms analyze large volumes of underwater imagery, such as photographs and video footage, to automatically detect and classify artifacts, shipwrecks, or other submerged structures[40]. This (AI)-assisted object detection and classification enables researchers to efficiently identify and catalogue underwater cultural heritage, saving valuable time and resources[41].

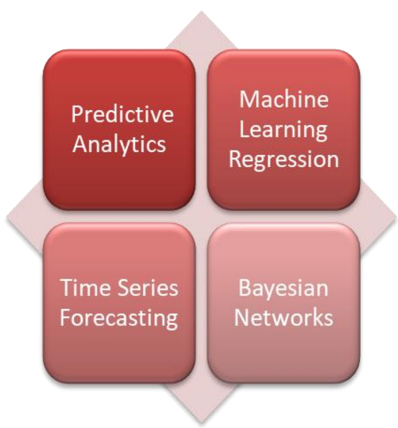
2. (AI)-based Data Analysis and Interpretation

Underwater archaeological research generates vast amounts of data, including sonar data, bathymetric data, and sensor readings. Underwater photogrammetry is the prevailing choice for documenting underwater cultural heritage (UCH)[42]. This method is characterized by its non-destructive nature and affordability, making it highly accessible. This method also generates detailed 3D models and 2D models of underwater archaeological sites and artifacts, boasting impressive levels of resolution and export to VR software[43]. (AI)-based data analysis techniques are employed to process and interpret this data, extracting meaningful patterns and insights.

(AI) algorithms identify data correlations, anomalies, and trends, helping researchers uncover hidden information and make informed interpretations. (AI) assists in identifying patterns in sediment layers, determining the age and origin of artifacts, or detecting environmental changes that impact the preservation of underwater cultural heritage sites.

3. AI-driven Predictive Modeling

(AI) plays a crucial role in predictive modeling, allowing researchers to simulate and forecast various scenarios related to underwater archaeological sites. By combining historical data, environmental factors, and (AI) algorithms, researchers develop predictive models that forecasts the degradation of artifacts, the impact of climate change, or the potential risks of human activities on underwater cultural heritage sites[44].



[FIGURE 5]: Types of (AI) modeling techniques in Underwater Cultural Heritage © Done by the researcher

[40] GAMBIN et al. 2021: 11.
[41] LUPIA et al. 2023: 8-9.
[42] KAMEL & ELSHIWY 2022: 7.
[43] CALANTROPIO et al. 2024: 2.
[44] REIMANN et al. 2018: 3.

These (AI)-driven predictive models enable researchers to make informed decisions regarding conservation strategies, site management, and future research directions **[FIGURE 5].** They provide valuable insights into the long-term preservation of underwater cultural heritage and help prioritize conservation efforts[45].

4. AI-assisted Site Mapping and Reconstruction

Accurate site mapping and reconstruction are essential for understanding underwater archaeological sites' spatial layout and context. (AI) assists in processing and analyzing sensor data, such as multi-beam sonar data or LiDAR scans, to create detailed 3D models of submerged structures and landscapes[46].

[FIGURE 6]: Reconstruction of an underwater archaeological site with 3D points. BRUNO et al. 2020: 3.

(AI) algorithms automatically process and align multiple data sources, reconstructing the original appearance of the site. AI-assisted site mapping and reconstruction provide researchers with a comprehensive understanding of underwater cultural heritage sites, facilitating further analysis and interpretation [FIGURE 6][50]. These efforts require considerable sourcing, multi-specialists from different fields, and reference data, in order to teach (AI) cultural heritage[47].

Integrating (AI) technologies in underwater archaeological research brings numerous benefits. AI-assisted object detection and classification, data analysis and interpretation, predictive modeling, and site mapping and reconstruction enhance our understanding of underwater cultural heritage's efficiency, accuracy, and depth[48]. By leveraging the power of (AI), researchers unlock new insights, streamline processes, and contribute to preserving and exploring our rich underwater heritage.

[45] KOLIOLIOU et al. 2021: 9.
[46] KAPETANOVIC et al. 2020: 9.
[47] PETRIAGGI et al. 2019: 5.
[48] BROWNE et al. 2023: 8.

III. Augmented Reality (AR) in UCH Documentation and Public Engagement

Augmented Reality (AR) revolutionizes how we document, interpret, and engage with underwater cultural heritage (UCH). By blending digital information with the real world, (AR) technologies enhance site visualization, public outreach, education, and create immersive virtual museums and exhibitions[49].

1. AR-enhanced Site Visualization and Interpretation

(AR) provides archaeologists and researchers with enhanced tools for site visualization and interpretation. By overlaying digital reconstructions, historical images, or data onto real-world underwater environment, (AR) allows more comprehensive understanding of submerged sites.

Using (AR)-enabled devices, such as smartphones or headsets, researchers view real-time overlays of virtual elements on underwater sites, aiding in the identification and interpretation of submerged structures, artifacts, and geological features. This AR-enhanced site visualization enables researchers to explore different hypothetical scenarios, test theories, and gain deeper insights into the past. By doing so, it enhances the accuracy and depth of UCH research.

2. (AR)-based Public Outreach and Education

(AR) applications enable visitors to access additional information, multimedia content, and interactive features while exploring museum exhibits or archaeological sites. For example, visitors point their smartphones or tablets at artifacts or site markers, triggering (AR) overlays that provide historical context, 3D models, and virtual reconstructions. Economic barriers are also overcome by generating open-access software and projects in the App. This AR-based public outreach creates a more engaging and educational experience, allowing people to interact with UCH dynamically and interactively.

VR-based demonstrations have been repurposed for public use, although the primary focus of virtual exhibits is the presentation and visualization of archaeological data rather than entertainment[50]. In the realm of underwater environments, there is only a handful of examples where virtual heritage demonstrations incorporate the edutainment approach to engage users. Scholars have leveraged several games in the underwater environment to enhance cultural awareness of underwater archaeology[51]. On the other hand, immersive underwater VR environments have been specifically designed to enhance users' understanding of archaeology by enabling exploration of underwater archaeological sites.

3. (AR)-enabled Virtual Museums and Exhibitions

(AR) facilitates the creation of virtual museums and exhibitions, bringing UCH to broader audiences beyond physical locations. (AR)-enabled virtual museums allow users to

[49] Kamel et al. 2022: 5.
[50] Bruno et al. 2018: 3.
[51] Bruno et al. 2020: 5.

explore and interact with digital replicas of artifacts, submerged sites, and historical contexts from the comfort of their own homes or any location with an AR-enabled device[52].

Remote access to museum resources can be achieved through a Virtual Private Network (VPN) provider that offers strong encryption, good connection speeds, and reliable server availability. By leveraging Content Delivery Networks (CDNs) or cloud-based storage, and the Internet of Underwater Things (IoUT)[53], museums can distribute (AR) content efficiently while reducing the load on their local network and underwater 5G-based networks[54].

Virtual exhibitions feature curated collections, immersive storytelling, and interactive experiences. Users navigate virtual environments, examine detailed 3D models of artifacts, and access multimedia content, allowing them to have a rich and engaging learning experience[55]. (AR)-enabled virtual museums expand access to UCH, making it more inclusive and allowing people from different locations to explore and appreciate our underwater cultural heritage[56].

Augmented Reality (AR) has significant potential in UCH documentation and public engagement. (AR)-enhanced site visualization and interpretation provide researchers with valuable tools for understanding and interpreting underwater archaeological sites. AR-based public outreach and education engage the public more effectively while fostering appreciation and understanding of UCH[57]. (AR)-enabled virtual museums and exhibitions expand access to UCH beyond physical constraints, creating opportunities for a broader audience to explore and learn about our rich underwater cultural heritage.

IV. Synergistic Potential of AI and (AR) in UCH

Integrating (AI) and (AR) has revolutionized how researchers explore and interpret underwater archaeological sites. (AI) algorithms efficiently analyze large volumes of sensor data, such as sonar scans and bathymetric maps, to identify and classify submerged structures and artifacts[58]. This (AI)-driven data analysis is then seamlessly integrated with (AR) technologies, enabling researchers to visualize and interact with the data in real-time. However, this integration requires substantial processing power, and economic and technical challenges associated with ship-based operations must be overcome[59]. The Oil and Gas sector may provide funding for these advancements due to their commercial interests in constructing oil and natural gas pipelines. Such funding would be used for underwater exploration research, particularly in surveying and mapping[60].

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[52] Bruno et al. 2019: 18.
[53] Nkenyereye et al. 2024: 1.
[54] Uga et al. 2021: 12.
[55] Calantropio et al. 2024: 2.
[56] Reimann & et Al. 2018: 10.
[57] Davidde petriaggi 2020: 4.
[58] Manglis et al. 2021: 12.
[59] Kolioliou 2021: 9.
[60] Lupia et al. 2023: 14.

1. Integration of (AI) and (AR) for Enhanced Site Exploration

Integrating Artificial Intelligence (AI) and Augmented Reality (AR) technologies in underwater archaeological sites presents promising avenue for enhancing research and exploration capabilities. (AI) can be utilized for tasks like biofouling detection, semantic segmentation for site detection, and geophysical surveys for mapping submerged cultural landscapes. (AR) provide divers with real-time visualization and interaction with underwater cultural heritage sites, improving the user experience and enabling the exploration of lost buildings and artifacts beneath the sea surface. By combining (AI) for data analysis and (AR) for immersive experiences, researchers and divers can collaborate effectively, leading to deeper understanding and appreciation of underwater archaeological sites[61].

2. (AI) and (AR)-enabled Conservation and Preservation Strategies

(AI) and (AR) play significant roles in developing conservation and preservation strategies for UCH. (AI) algorithms analyze environmental data, historical records, and site characteristics to simulate and predict the impact of various factors on underwater sites, such as climate change, sedimentation, or human activities. By integrating these (AI)-driven predictive models with (AR) technologies, researchers and conservationists can visualize and assess potential risks to UCH in real time.

(AR) overlays display information about the site's vulnerability, recommend conservation measures, or simulate long-term effects of different preservation strategies. This integrated approach of (AI) and (AR) enables more proactive and informed decision-making, ensuring the sustainable preservation of underwater cultural heritage.

3. Ethical Considerations and Challenges

The synergistic use of (AI) and (AR) in UCH research also presents ethical considerations and challenges that must be addressed. These include:

- **A.** Data Privacy: Integrating (AI) and (AR) involves collecting and analyzing large amounts of data, including sensitive information. It is crucial to ensure that appropriate data privacy and security measures are in place to protect the rights and privacy of the individuals and communities associated with UCH.
- **B.** Cultural Sensitivity: UCH is deeply tied to cultural heritage and indigenous knowledge. When applying (AI) and (AR) technologies, engaging with local communities, respecting cultural protocols, and involving stakeholders in decision-making are essential to ensure responsible and respectful use.
- **C.** Accessibility and Inclusivity: (AI) and (AR) should aim to be inclusive and accessible to diverse audiences. Consideration should be given to factors such as language barriers, technological access, and economic barriers. User-friendly interfaces should be designed to ensure that the benefits of these technologies are available to all.

[61] UGA et al. 2021: 5.

D. Accuracy and Interpretation: (AI) algorithms and (AR) visualizations are based on data interpretation and assumptions. Being transparent about these technologies' limitations, uncertainties, and biases is crucial. Researchers should strive for accuracy, validation, and peer review in their application of (AI) and (AR) in UCH3.

The synergistic potential of (AI) and (AR) in underwater cultural heritage research revolutionizes site exploration, conservation strategies, and preservation efforts. By integrating AI-driven data analysis with (AR) visualization, researchers enhance their understanding of underwater sites and make informed decisions. Ethical considerations and challenges, including data privacy, cultural sensitivity, accessibility, and accuracy, must be carefully addressed to ensure these technologies' responsible and inclusive use in UCH research.

V. FUTURE DIRECTIONS AND CHALLENGES IN (AI) AND (AR) AT UCH

As fields of Artificial Intelligence (AI) and Augmented Reality (AR) continue to evolve, several future directions and challenges need to be considered in their application to underwater cultural heritage (UCH) research.

1. Advancements in (AI) and AR Technologies

The future of (AI) and (AR) in UCH research lies in technological advancements. AI algorithms have become more sophisticated, allowing for improved object recognition, data analysis, and predictive modeling. Enhanced machine learning techniques and deep neural networks enable more accurate and efficient processing of large volumes of underwater data.

Similarly, (AR) technologies have advanced in hardware capabilities, display resolution, and tracking accuracy. The development of wearable (AR) devices, such as smart glasses or contact lenses, provides researchers with more seamless and immersive experiences in underwater environments. Continued research and development in (AI) and (AR) drive innovation in UCH research, enabling researchers to explore new possibilities and push the boundaries of knowledge in underwater archaeology and cultural heritage preservation.

2. Technological Limitations and Solutions

Technological limitations still need to be addressed in applying (AI) and (AR) in UCH research despite advancements. These limitations include:

A. Underwater Environment Challenges: The underwater environment presents unique challenges, such as limited visibility, varying water conditions, and data acquisition difficulties. Overcoming these challenges requires the development of robust (AI) algorithms and (AR) systems that can handle and adapt to the complexities of underwater environments[62]. Overcoming challenges in the underwater environment requires robust (AI) algorithms and (AR) systems that adapt to limited visibility,

[62] REIMANN et al. 2018: 20.

varying water conditions, and the need for considerable volumes of diverse source data. Gathering and processing such data is crucial for training (AI) models to effectively operate in underwater environments[63].

B. Data Quality and Availability: High-quality data is crucial for accurate analysis and visualization in (AI) and (AR) applications. Obtaining reliable and comprehensive data in underwater settings is challenging. Efforts are being made to improve data collection techniques, enhance sensor technologies, and establish data-sharing collaborations among researchers and institutions[64].

C. Power and Processing Constraints: (AI) and (AR) technologies often require significant computational power and processing capabilities. Overcoming power and processing constraints in underwater settings, where access to power sources is limited, is an essential area of research[65]. Developing energy-efficient algorithms and optimizing hardware solutions help address this challenge.

3. Collaborative Efforts and Interdisciplinary Approaches

The future of (AI) and (AR) in UCH research relies on collaborative efforts and interdisciplinary approaches. The complex nature of UCH requires collaboration among archaeologists, computer scientists, conservators, historians, and other experts to leverage the full potential of (AI) and (AR) technologies.

Collaborative efforts involve knowledge sharing, data exchange, and joint research projects. Interdisciplinary approaches promote the development of comprehensive solutions that integrate domain-specific knowledge with (AI) and (AR) capabilities. This collaboration creates more accurate and contextually rich (AI) algorithms and (AR) applications that address the needs and challenges of UCH research.

By fostering collaboration and interdisciplinary approaches, the future of (AI) and (AR) in UCH research is characterized by innovative solutions, comprehensive insights, and sustainable preservation practices.

The future of (AI) and (AR) in UCH research is promising because of technological advancements that overcome technological limitations, and collaborative efforts. Continued research and development in (AI) and (AR) open new avenues for exploring, interpreting, and preserving underwater cultural heritage. Overcoming challenges and embracing interdisciplinary approaches is crucial for harnessing the full potential of these technologies in UCH research and ensuring the responsible and inclusive use of (AI) and (AR) in the future.

[63] CALANTROPIO & CHIABRANDO 2024: 6.
[64] PEHLIVANIDES et al. 2020: 12.
[65] MATTEI et al. 2019: 4.

VI. CONCLUSION

Integration of Artificial Intelligence (AI) and Augmented Reality (AR) technologies in underwater cultural heritage (UCH) research holds significant potential for documentation, public engagement, site exploration, conservation strategies, and preservation efforts. Synergistic use of (AI) and (AR) enhances site visualization and interpretation, facilitates public outreach and education, and enables the creation of virtual museums and exhibitions. (AI) and (AR) technologies enhance site exploration by providing researchers with tools for real-time data analysis, visualization, and interpretation of underwater archaeological sites. (AR)-based public outreach and education create immersive and interactive experiences, enabling the public to engage with UCH dynamically and educationally.

AR-enabled virtual museums and exhibitions expand access to UCH, allowing broader audiences to explore and appreciate underwater cultural heritage beyond physical constraints. Integrating (AI) and (AR) supports conservation and preservation efforts by analyzing environmental data, predicting risks, and simulating the impact of various factors on UCH sites. The future of (AI) and (AR) in UCH research lies in advancements in technology, such as (AI) algorithms, (AR) hardware, and data collection techniques. Overcoming technological limitations, including challenges in underwater environments, data quality, and power constraints, will be crucial to effectively applying (AI) and (AR) in UCH research. Collaborative efforts and interdisciplinary approaches are essential for harnessing the full potential of (AI) and (AR) in UCH. Comprehensive solutions that integrate domain-specific knowledge with (AI) and (AR) capabilities were developed by fostering collaboration among archaeologists, computer scientists, conservationists, historians, and other experts. Researchers and institutions collaborate with local communities and stakeholders to ensure responsible and inclusive use of (AI) and (AR) technologies in UCH research, By involving diverse perspectives and knowledge, the benefits of (AI) and (AR) are maximized while respecting the cultural heritage and values associated with UCH.

Integrating (AI) and (AR) in UCH research revolutionizes the field by enhancing site exploration, public engagement, conservation strategies, and preservation efforts. By embracing advancements in technology, addressing challenges, and adopting collaborative and interdisciplinary approaches, we unlock the full potential of (AI) and (AR) in underwater cultural heritage research and contribute to the sustainable preservation and appreciation of our rich underwater heritage. By focusing on application and the use of innovative technologies such as (AI) and (AR), education through 3D gaming harnesses the power of play to facilitate learning. Leveraging 3D assets can actively engage with immersive and interactive experiences, promoting more profound understanding and knowledge retention in various educational domains. This paper aimed to shed light on the transformative potential of these emerging tools in Underwater Cultural Heritage. The exploration of AI's capabilities in underwater archaeological research and the utilization of (AR) for documentation, public engagement, and conservation efforts pave the way for new possibilities in UCH; this enables us to uncover and preserve our submerged cultural heritage like never before. Further research and implementation are needed to address the ethical considerations and challenges of using (AI) and (AR) in UCH. This includes ensuring data privacy, respecting cultural sensitivities, promoting accessibility and inclusivity, and maintaining accuracy and transparency in data interpretation and visualization.

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THE ARCHAEOLOGY OF *ZYGRIS/LADAMANTIA* (MARSA BAGOUSH): ILLUMINATING ANCIENT MARITIME NETWORKS ON THE EGYPTIAN MEDITERRANEAN COAST

Article 2

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ABSTRACT

[AR] آثار زيجريس/لادامانتيا (مرسى باجوش): إلقاء الضوء علي العلاقات البحرية القديمة على الساحل المصري للبحر الأبيض المتوسط

منطقة مرسى باجوش هي عبارة عن خليج كبير يقع على ساحل البحر الأبيض المتوسط في مصر، على بعد حوالي 250 كيلومترًا غرب الإسكندرية. في العصور القديمة، كان ذلك الخليج يضم مينائي (زيجريس) و(لادامانتيا) الرومانيين. وتم ذكرهما عند الجغرافي كلوديوس بطليموس. وفي الدليل البحري الروماني المعروف باسم (*Stadiasmus Maris Magni*)، حيث وجه ذلك الدليل البحارة إلى الرسو في هذين الميناءين لأنهما آمنان، كما أن السفن يمكن أن تتزود فيهما بالمياه العذبة. ويعتبر مينائي (زيجريس) و(لادامانتيا) من بين كثير من المراسي الطبيعية الممتدة على طول ساحل البحر الأبيض المتوسط بين الإسكندرية والحدود الليبية. ومنذ عام 2015، يخضع خليج مرسى باجوش لمشروع للبحث الأثري تحت الماء يقوم به مركز الإسكندرية للآثار البحرية والتراث الثقافي المغمور بالمياه بجامعة الإسكندرية، بدعم من مؤسسة أونور فروست البريطانية. وقد كشف مشروع المسح الأثري لمرسى باجوش عن ثروة من المعلومات حول النشاط البحري على طول الساحل الشمالي الغربي لمصر في العصور القديمة. ومن بين الاكتشافات الأثرية عدة شواهد على حطام لسفن من العصور الهلينستية والرومانية والعثمانية، بالإضافة إلى أكبر مجموعة من مراسي السفن القديمة التي تم اكتشافها حتى الآن على الساحل الشمالي الغربي لمصر. من ثم، سوف يتناول هذا البحث مشروع المسح الأثري لمرسى باجوش، وأهم النتائج التي تم التوصل إليها حتى الآن.

[EN] The site of *Marsa Bagoush* is a large bay located on the Mediterranean coast of Egypt, approximately 250 kilometers west of Alexandria. In antiquity, it comprised the Roman harbours of *Zygris* and *Ladamantia*. The harbours were mentioned by *Claudius Ptolemaeus*, and in the Roman guidebook, the *Stadiasmus Maris Magni*. Sailors were advised to anchor in those two harbours because they were safe and had access to fresh water. *Zygris* and *Ladamantia* are among several natural anchorages that extend along the Mediterranean coastline between Alexandria and the Libyan borders. Since 2015, the sites of *Zygris* and *Ladamantia* have been subject to an archaeological investigation conducted by the Alexandria University Centre for Maritime Archaeology and Underwater Cultural Heritage (CMAUCH), with kind support of the UK-based Honor Frost Foundation. The Marsa Bagoush Research Project (MBRP) revealed a wealth of information on ancient maritime activities along the northwest coast of Egypt. Archaeological finds include evidence of shipwrecks from the Hellenistic, Roman, and Ottoman periods, in addition to the largest collection of ancient anchors to be found on the northwest coast of Egypt. This paper will present the project, its context, goals, methods, and latest results.

KEYWORDS: Alexandria, amphorae, anchors, maritime, Roman, shipwreck.

I. INTRODUCTION

Ships have travelled along the northern coast of Egypt at least as early as the Bronze Age. During the Hellenistic and Roman periods, in particular, Egypt witnessed a surge in maritime activities in response to the expansion of trade and transport networks[1].

As a result, several coastal villages and settlements developed at natural anchorage sites along the northwest coast of Egypt. They played significant roles in sheltering and serving boats and ships travelling along the coast. This has left a wealth of evidence in the archaeological record **[FIGURE** 1] [2].

[FIGURE 1]: Marsa Bagoush C. 250 kilometers west of Alexandria. Ancient natural anchorages of *Zygris* and *Ladamantia* © Google Earth Pro 7.3.6.9345. Accessed on 08 /11/ 2023.

Among those settlements were *Zygris* (*Marsa Bagoush)* (31°10'45.33"N, 27°40'6.01"E) and *Ladamantia (Marsa Abu Hashafa)* (31°11'14.60"N, 27°38'28.16"E), c. 250 kilometers west of Alexandria. The two sites are c. 3 kilometers apart, yet presently, the whole area is commonly known as Marsa Bagoush[3].

Zygris was mentioned by *Claudius Ptolemaeus* in the 2nd century AD. It was described as a village on the coast of the Libyan Nomos in Marmarica[4]. In the 3rd century AD, both *Zygris* and *Ladamantia* were listed in the *Stadiasmus Maris Magni* as harbours of the Egyptian coast. The document stated that «*From Leuce Acte* [5] *to Zygris 90 stadia; there is an islet; put it into the place with it on your left; there is water in the sand. From*

[1] DASZEWSKI 1990: 15-51; MAJCHEREK & EL-SHENNAWI 1992: 129-136; WHITE & WHITE 1996: 11-30.

[2] «Ancient Ports in Egypt & Libya». Https://www.ancientportsantiques.com/the-catalogue/egypt-libya/. Accessed on (15/12/2023).

[3] *Marsa* is the Arabic word for (anchorage). It is also often written (*Mersa*).

[4] BALL 1942: 104-105, 131-136.

[5] *Leuce Acte,* is the present town of Ras Al-Hekma, c. 15 kilometres east of Marsa Bagoush.

Zygris to Ladamantia 20 stadia, close by lies a rather large island: put in with this on your right. There is a harbour accessible with any wind, water is to be found»[6]. Accordingly, it is believed that both harbours had rather safe anchorages and access to fresh water.

II. ZYGRIS AND LADAMANTIA

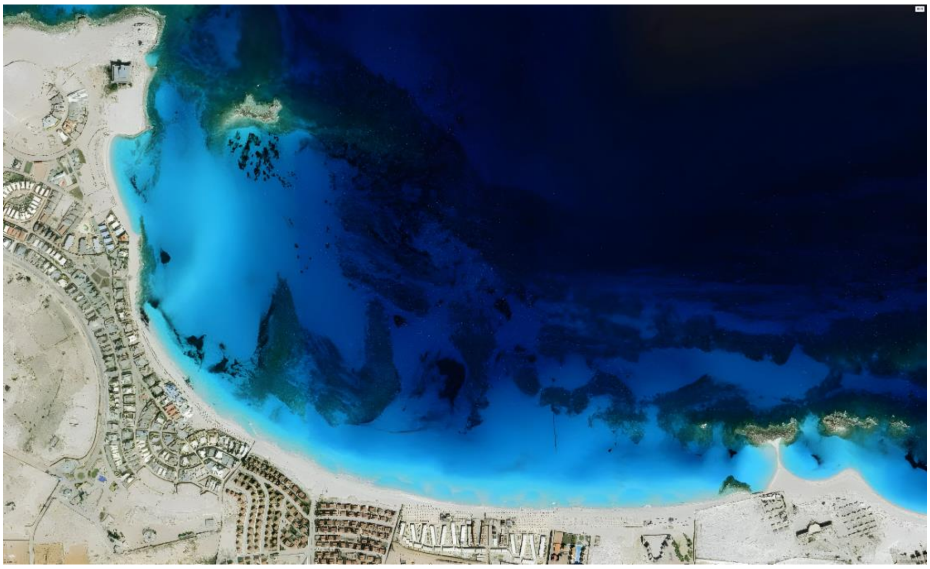
The site of *Zygris* takes the form of a relatively small bay that measures c.950 meters EW X c.320 meters NS, with a maximum depth of 8 meters. The bay covers an area of c. 0.19 square kilometers, and its coastline extends for c. 1.3 kilometers. The bay is well protected from the east and west by two rocky headlands, and from the north by a small islet and a series of submerged and protruding reefs that reduce wave action, leaving a few narrow passages through which boats could enter and exit **[FIGURE 2]**.

[FIGURE 2]: The Bay of *Zygris* was protected by two rocky headlands and a series of reefs; leaving limited clear passages for vessels to enter. Hence, getting into the bay during rough weather conditions would have been quite hazardous © Google Earth Pro 7.3.6.9345. Accessed on (08/12/2023).

However, the existence of reefs at the entrance of the bay, close to the water's surface, also presented a hazard for ships entering the bay, particularly during turbulent seas. Moreover, given that the average rate of relative sea-level rise in the Mediterranean during the past two millennia was 0.1-0.2mm/year[7], shallow reefs boarding the bay from the north would have been closer to the surface in antiquity, making the bay more difficult to enter.

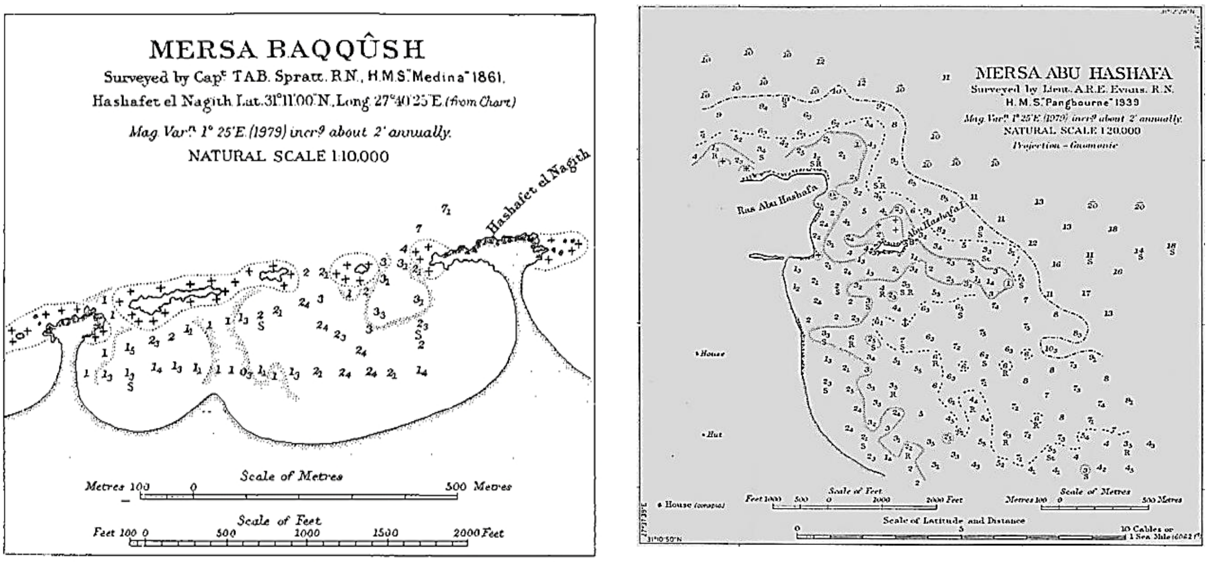
On the other hand, the bay of *Ladamantia* is much larger than *Zygris*. It extends for c. 2.7 kilometers NW-SE, with a maximum depth of c.20m. It has an area of c. 1.8 square kilometers and a coastline that extends for c. 3.8km. The bay is protected from the west by a rocky headland (*Abu Hashafa* headland), and an offshore islet (*Abu Hashafa* islet), which shelter the bay from predominant N-NW winds. The bay is mostly clear of dangerous rocks and shoals, which makes it easy and safe to access in any wind **[FIGURE 3]**.

[6] BERESFORD 2013: 193.
[7] CHURCH & GREGORY 2001: 641.



[FIGURE 3]: *Ladamantia* easily accessible, well-protected bay and clear of hazardous reefs © Google Earth Pro 7.3.6.9345. Accessed on (25/12/2023).

As part of a coastal survey of North Africa, the British Royal Navy surveyed the bay of *Zygris i*n 1861, and the bay of *Ladamantia* in 1939. These surveys produced the first hydrographic maps of both sites, which clearly show the reefs that protect both sites and them to be used as natural anchorages **[FIGURE 4]**[8].



[FIGURE 4]: Left: A hydrographic survey of Marsa Bagoush (*Zygris*) by the Royal Navy vessel HMS Medina in 1861. Right: A hydrographic survey of *Mersa Abu Hashafa* (*Ladamantia*) © The Royal Navy Vessel HSM Pangbourne in 1939.

Moreover, there is ample evidence that indicates the use of the site of Marsa Bagoush[9] as a major transit camp for the Royal Air Force during WWII[10]. The first mention of archaeological remains in Marsa Bagoush appeared in a publication in 1996, in which

[8] WHITE & WHITE 1996: 11-30.

[9] Alternative names mentioned in WWII documents include Bagush, Baqush, Ma`atin Baqqush, Maaten Bagush.

[10] SHORES et al. 2012: 171; «Back To The Desert ».Http://113squadron.com/id73.htm. Accessed on (01/12/2023); «Nº.113 Squadron (RAF): Second World War». Http://www.historyofwar.org/air/units/RAF/113_wwII.html Accessed on (15/12/2023).

the author mentions discovering, in the early sixties, several amphorae underwater. Some amphorae were intact and exposed, while others were greatly adhered to the rocks. The author believed that the amphorae belonged to an ancient shipwreck from Graeco-Roman times[11].

In 1996, the Institute of Nautical Archaeology-Egypt conducted a limited survey of Marsa Bagoush, where a few intact Early Roman amphorae were located. However, no further investigation was carried out at the site until 2015, when the CMAUCH started an underwater archaeological survey of *Zygris* and subsequently extended it to *Ladamantia*.

III. Objectives and Methodology

Archaeological evidence for maritime activities along the Egyptian Mediterranean coastline is scarce. Except for Alexandria, archaeological investigation of harbours and anchorages on the northwest coast of Egypt is quite limited. Hence, the primary goal of the MBRP is to assess the extent and nature of ancient maritime activities along this stretch of the Egyptian coastline. This is done by conducting a systematic underwater survey of the site, which includes locating, recording, mapping, and dating submerged archaeological remains.

Accordingly, between 2015 and 2017, the bay of *Zygris* was thoroughly investigated. Satellite imagery of the site was utilized to create a base-map on which the location and distribution of archaeological material would be defined. Hence, diving teams conducted a systematic visual survey of the seabed. Once archaeological material was identified, it was tagged and photographed. In areas with significant material concentration, a 10-meter by 10-meter grid was established on the seabed, marked at its corners with SMBs (Surface Marker Buoys), and precisely located using GPS readings from the surface. Subsequently, the contents of the grid were documented using photogrammetry. The survey aimed to identify and document diagnostic archaeological material. Moreover, ceramic samples were collected and raised for documentation, and dating preposes and then redeposited underwater.

Since 2018, the bay of *Ladamantia* has been under investigation. A high resolution georeferenced satellite image of the area was used to define the site's main features. The image was added into a GIS platform and used to create a base map of the site. A virtual grid of 100-meter x100-meters squares was created to cover the entire survey site. The grid is the reference on which survey work is conducted. Consequently, diving teams visually surveyed each square after defining its exact location and limits using a GPS. The survey was carried out using a 50-meter search line held by 4–5 divers with overlapping visibility. Each team was equipped with a DSLR camera, measuring tapes, tags, scale bars, SMBs, and a GPS device. The GPS device was attached to a buoy floating on the surface and connected to a rope held by one of the divers.

Moreover, at the beginning of each dive, the GPS live tracking function was activated with an interval log every 30 seconds throughout the dive; hence, the GPS records the entire track of the dive. When archaeological material was located, the

[11] Abdel Aleem 1996: 140.

diving team pauses the survey and moves towards the object for tagging, measuring, and photographing. This process normally takes 5-10 minutes, depending on the type and extent of the archaeological material. During that time, the GPS device makes several records at the same point, determining its location. Once this process is accomplished, the survey is resumed.

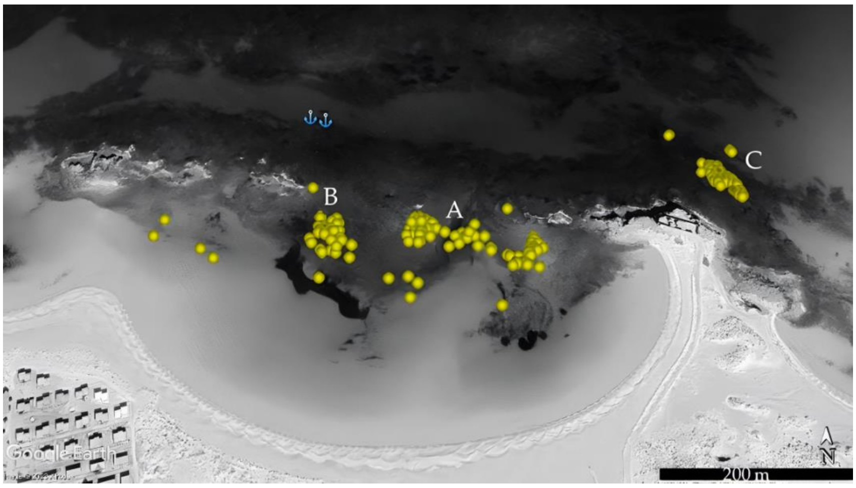
Utilizing such a method in surveying and recording archaeological materials proved to be the most effective given logistical and budgetary limitations. For specific areas and archaeological finds, photogrammetry was utilized. This was used for producing 3D documentation of the finds, developing a digital elevation model (DEM), and producing georeferenced orthoimages of the area.

The orthoimages were then exported to GIS software, which enabled the positioning of the surveyed area on the base map. This setup facilitated an understanding of the distribution of archaeological material and the spatial correlation between them[12].

IV. RESULTS OF THE SURVEY

A. Zygris

In *Zygris*, the underwater survey revealed that the bulk of archaeological material is located on the north side of the bay, adjacent to the series of reefs. The survey resulted in the discovery of three different ceramic assemblages [**FIGURE 5**].



[FIGURE 5]: Three distinctive assemblages of archaeological material [A, B & C] found at the bay of *Zygris* © Google Earth Pro 7.3.6.9345. Accessed on (02/01/2024).

Two of them (A-B) are located at the southern edge of the reefs, which delimit the bay from the north, at a depth of c.1 meter - 4 meters. The third assemblage (C) is located outside the bay, to the northeast of the eastern headland, at a depth of c. 8 meters – 10 meters. These assemblages consist mainly of concreted broken amphorae, in addition to fragments of glass, wood, and other materials.

1. Assemblage (A) covers an area of c. 5000 square meters, extending for c.180 meters in a NW-SE orientation. It consists mainly of concreted sherds of two particular types of Egyptian amphorae: the Egyptian Amphora type 3 (AE3) and the Egyptian Amphora type 4 (AE4) [**FIGURE 6**].

[12] SALAMA & KHALIL 2022: 953-958.

[FIGURE 6]: The remains of AE3 and AE4 amphorae represent the bulk of material in assemblage (A) at *Zygris* © CMAUCH

The AE3, known as the Biconical Amphora, developed as the first Roman wine amphora produced exclusively in Egypt from the late 1st century BC until the 3rd century AD **[FIGURE 7]**. This type has several variations; however, it is generally up to 140 centimeters long, with two small looped handles, a long neck, and a broad ribbed body ending in a solid spike[13].

[FIGURE 7]: Left: Illustration of the Egyptian Amphora type 3 (AE3). Right: Diagnostic neck sherds of AE3 amphorae from *Zygris* © CMAUCH

[13] Le Centre Alexandrin d'Étude des Amphores.

The AE3 is known to have been manufactured intensively in the Mareotic region west of Alexandria[14]. However, AE3 was also produced at sites on the northwest coast of Egypt[15], as well as in the Nile Valley, where evidence for its production is abundant in El-Faiyum and Hermopolis Magna[16].

The AE3 started to appear throughout the Mediterranean from the 1st century AD onward. Several individual samples were identified in the eastern and western Mediterranean, such as on the Amalfi coast, in Puteoli, and the Athenian agora[17]. Moreover, a number of AE3 found were associated with shipwrecks, specifically. For example, among the scattered amphorae that were visible around the deep-water Roman shipwreck of the 1st century AD found near Skerki Bank, three AE3 amphorae were recovered[18].

Also, about 30 Egyptian amphorae of Mareotic production, currently in the Museum of Istres, were recovered from a wreck in the Golfe de Foss in France[19]. However, in addition to AE3 amphorae, this collection contains a number of Egyptian Amphora type 4 (AE4). The Egyptian Amphora type 4 (AE4) is the second type that forms assemblage (A) in *Zygris* **[FIGURE 8]**.

[FIGURE 8]: Left: Egyptian Amphora type 4 (AE3) © CEAlex.
Right: Diagnostic sherds of AE4 amphorae from *Zygris* © CMAUCH

It is believed that the AE4 was an imitation of the western Mediterranean Dressel 2-4 amphorae, which are among the most common western Mediterranean wine amphorae of the early Roman Empire. They appeared in the Aegean by the end of the 1st century BC, and from there, their manufacture spread in different regions,

[14] EMPEREUR & PICON 1998: 75-88.
[15] DASZEWSKI 1990: 15-51.
[16] TOMBER & WILLIAMS 2000: 41-54.
[17] LAWALL 2003: 157-191.
[18] MCCANN & OLESON 2004: 183-194.
[19] EMPEREUR 1993: 39-47.

particularly in the western Mediterranean, such as Italy, Spain, and France where they were produced until the end of the 2nd century AD[20]. However, in Egypt, their manufacture extended until the 3rd century AD[21].

The Mareotic region, west of Alexandria produced large quantities of AE4, mostly along with AE3, which together formed the bulk of amphorae produced in the region. No other production centres for the AE4 were discovered in Egypt, which suggests that its production has been, by and large, concentrated in the Mareotic region.

The AE4 amphorae of the Mareotic origin were exported to the western and eastern Mediterranean as early as the 1st century AD. Several examples were found in Italy, France, Greece, Tunisia, and Turkey[22]. In addition to the ceramics, assemblage (A) also included a few wooded fragments, and several roof tiles [**FIGURE 9**].

[FIGURE 9]: Left: A fragment of ancient ship timber from assemblage (A) © CMAUCH
Right: Ceramic roof tiles from assemblage (A) © CMAUCH.

The location, extent, and nature of this assemblage indicate that they are the remains of an Early Roman shipwreck. The vessel was likely carrying a cargo of Egyptian AE3 and AE4 amphorae and sailing westwards. Possibly the vessel tried to enter the bay of *Zygris* during rough seas, but it ended up hitting the reef, scattering its cargo on the sea floor at the southern base of the reef. Because of the shallow depth in this area (0m-4m) and its violent waves, especially during winter, the ship's timber likely would not have survived intact. Consequently, the amphorae broke into clusters of sherds.

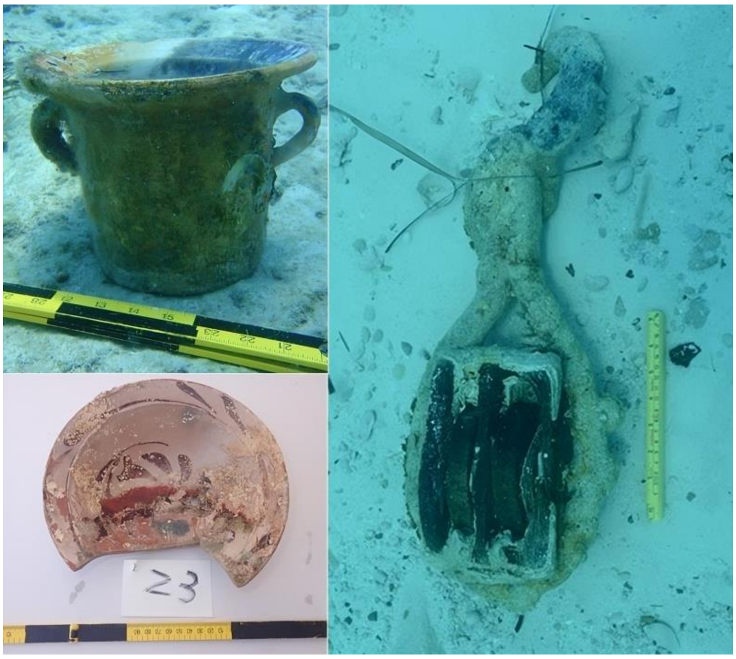
In that context, it is worth mentioning that in 1996, INA-Egypt retrieved an intact AE3 amphora from the bay of *Zygris* which was lying in the middle of the bay on a sandy seabed at a depth of c.8 meters. This might mean it is possible to find more remains beneath the sand in the deeper part of *Zygris* bay.

[20] PEACOCK & WILLIAMS 1991: 105-106.
[21] SENOL 2003: 191-211.
[22] TOMBER & WILLIAMS 2000: 46-52.

2. Assemblage (B) is located c. 100 meters west of assemblage (A), at a depth of 5m-8m. It covers an area of c.2500 square kilometers, extending for c. 60 meters in a N-S orientation. This assemblage is a composite deposit that contains mixed-up materials from different periods. The earliest ceramic sherd discovered within this assemblage belongs to a Knidian *Zenon* amphora that dates to the 3rd century BC [**FIGURE 10**][23].

[FIGURE 10]: Left: A *Zenon* amphora from Knidos dating to the period from 234 - 220 BC © CMAUCH. Right: The maker's stamp on the *Zenon* amphora from assemblage (B) © CMAUCH.

However, it was possible to identify many Hellenistic, Early Roman and Late Roman amphora sherds, in addition to coarse ware, roof tiles, a couple of large flat-based amphora, Ottoman glazed ceramic sherds, an Ottoman chamber pot, porcelain sherds, several wooden and iron fragments, and a double wooden block and tackle pulley **[FIGURE 11]**.



[FIGURE 11]: Upper left an Ottoman chamber pot, lower left an Ottoman glazed ceramic plate, and right a double wooden block and tackle pulley from assemblage (B) in *Zygris* © CMAUCH.

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[23] CANKARDES-SENOL 2015: 168-192.

Archaeological material in this area can be seen starting from a depth of c. 5 meters, at a distance of c.60 meters south of the reefs and extending southwards to deeper water in the middle of the bay. The archaeological material is mostly trapped between the rocks on the seabed. Therefore, it is likely that the material belongs to several ships that have sunk during successive periods. Nevertheless, the bulk of archaeological remains seem to date to the early modern period.

It is worth mentioning, however, that outside the bay, to the north of the reefs c. 150 meters to the NW of the ceramic assemblage (B), two, 2-meter-long, iron, four-armed grapnel anchors, were discovered **[FIGURE 12]**. One of them was on a sandy stretch of the seabed, and the other was caught in the rocky bottom. The location of the anchors suggests that they were cast on the same ship before its wreckage. It seems that N-NW gale was too powerful, so the anchors did not hold, or the ropes snapped, and the ship hit the reef.

[FIGURE 12]: The two grapnel anchors outside the Zygris bay, to the NW of assemblage (B). © CMAUCH

Based on the above, at least two shipwreck sites were identified within the bay of Zygris, an Early Roman wreck, and an Ottoman 17th – 18th century wreck. It is important to note the possibility of site contamination from archaeological material originating from several other wrecks.

3. Assemblage (C) in *Zygris* was discovered outside the bay at a depth of 8 meters -12 meters, c.70 meters NE of the eastern rocky headland. The assemblage covers an area of c.750 square kilometers extending for c.60 meters in a NW-SE orientation. This assemblage consists mostly of concreted amphora sherds. However, diagnostic sherds indicate the existence of Egyptian Amphorae type 2 (AE2), which dates to the 2nd BC. Furthermore, in 1996, INA-Egypt retrieved, from the same area, an intact amphora that was described as a Knidian amphora from the 2nd BC. Accordingly, it is evident that assemblage (C) belongs to a Hellenistic shipwreck.

Items of interest that were discovered in association with the ceramic assemblage (C) are two millstones, which comprise the upper and lower parts of a grain mill **[FIGURE 13]**. The upper millstone measures 38 centimeters in diameter and has a dove-tail-shaped slot, which would have been used for attaching the mill's wooden handle. The lower millstone measures 32 centimeters.

[FIGURE 13]: The upper and lower stones of a grain mill which were found within assemblage (C). Note the dove-tail-shaped slot in the upper millstone which would have been used for attaching a wooden handle © CMAUCH

4. Water in the Sand

As stated earlier, the *Stadiasmus Maris Magni* account of *Zygris* included an obscure reference to «water in the sand», a statement whose meaning was unclear. Therefore, during MBRP a pedestrian survey was conducted in the vicinity of *Zygris* Bay. At approximately 250 meters south of the coastline, a 2-meter-wide shaft leading to an underground cistern complex was identified. Subsequent investigation revealed 12 similar shafts, leading to a network of interconnected rock-cut cisterns at a depth of c. 4 meters, in addition to several deeper wells **[FIGURE 14]**.

[FIGURE 14]: The location of the underground rock-cut cisterns and wells that were found to the south of *Zygris* bay © Google Earth Pro 7.3.6.9345. Accessed on (23/11/2023).

Preliminary analysis suggests the complex comprises of at least three distinct cisterns, each featuring rock-cut interconnected tunnels **[FIGURE 15]**. In antiquity, these cisterns would have been used for storing rainfall runoff and groundwater. However, no evidence of red plaster (*opus signinum*), a common waterproofing material employed in Roman cisterns, and other water-exposed structures, was observed within the accessible tunnels. Therefore, it is suggested that the cisterns could date to the Hellenistic or early Roman periods.

The existence of this underground water system clearly explains the above-mentioned statements, «there is water in the sand». Moreover, given the evident challenges of accessing the bay, it is likely that the extensive cistern complex at *Zygris* served as a primary attraction for vessels to the harbour.

[FIGURE 15]: Above: The entrance to one of the cisterns in *Zygris*. Below: An underground rock-cut tunnel from the cisterns in *Zygris* © CMAUCH

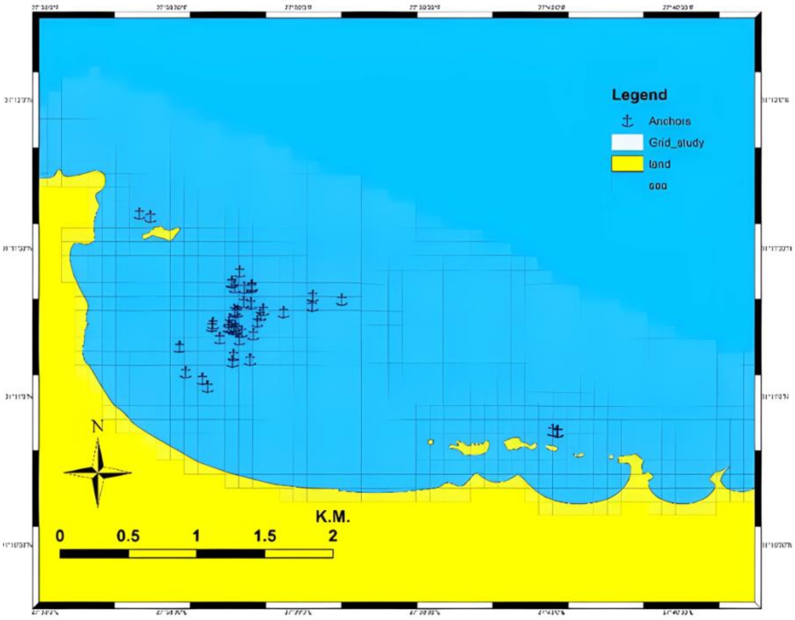
It is worth mentioning that, at present, several of the tunnels still retain water, which is used by the locals for irrigation purposes. However, additional research is necessary to fully understand the structure, dating, and development of this remarkable underground water system.

B. Ladamantia

As mentioned earlier, the bay of *Ladamantia* is different from *Zygris*. Its size, depth, and the absence of dangerous reefs made it easier to access and relatively safer to use by ancient vessels. The survey conducted in *Ladamantia* resulted in the discovery of a few intact amphorae of different types. Five Roman amphorae were recorded, raised, and transferred to a conservation laboratory in Alexandria. Those were AE3 (late 1st BC - 3rd AD), AE4 (1st - 3rd AD), LR4 (4th – 6th AD), Spatheian (4th – 5th AD), and Agora K109 (3rd – 4th AD) **[FIGURE 16]**. Moreover, several clusters of undiagnostic concreted sherds were found within the bay.

[FIGURE 16]: A Spatheion Amphora from North Africa, 4th – 5th AD, was one of the few intact amphorae found in *Ladamantiana* © CMAUCH

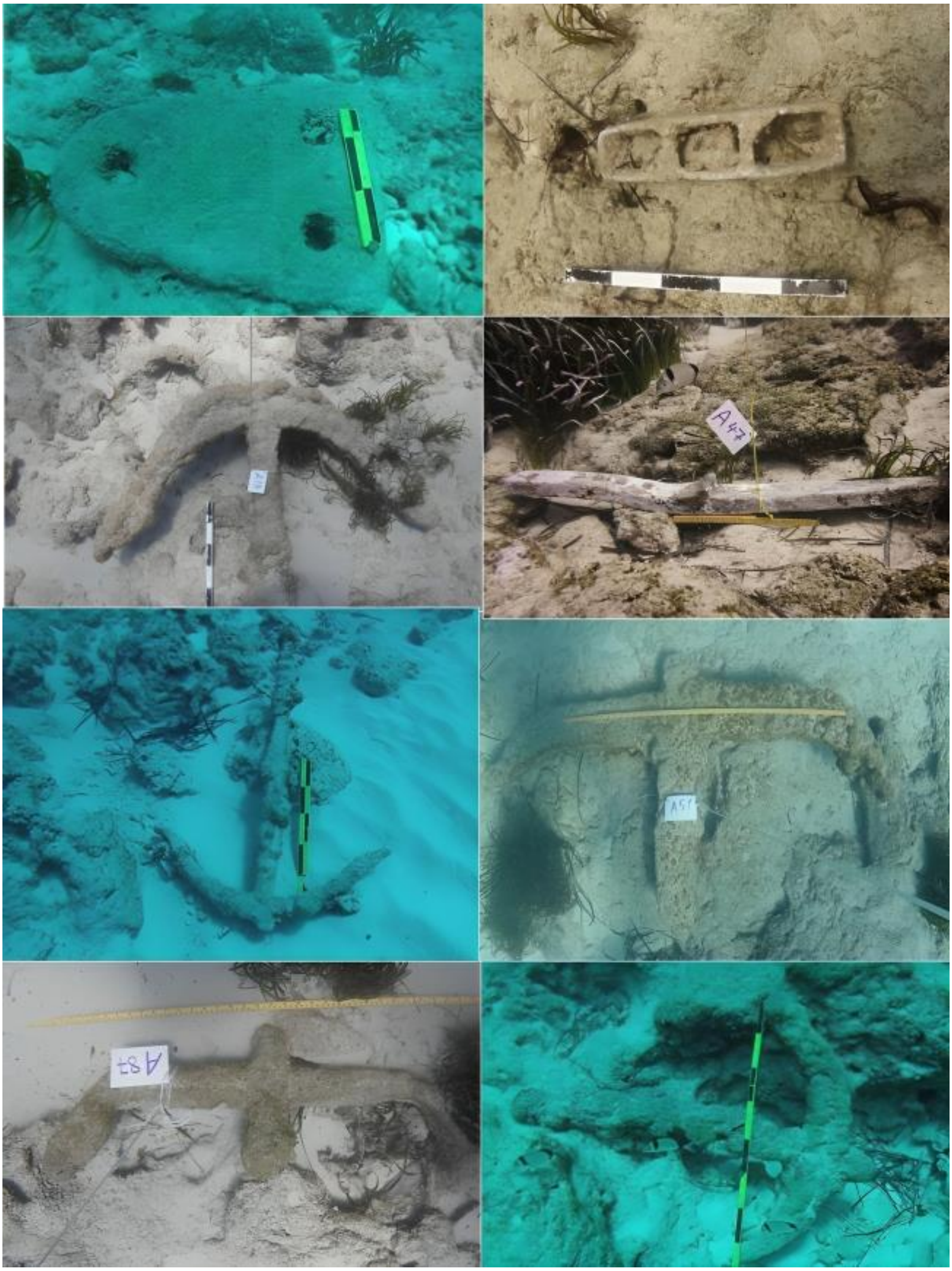
However, the most significant find in *Ladamantia* is a group of 54 ancient anchors and anchor parts of different types, dates, and materials. This collection is spread over an area of c. 60,000 square meters on the leeward side of the headland, and the offshore islet that bounds the bay from the west. This is the area most protected from the prevailing northwestern wind; hence, it would have been the preferable spot for ancient vessels to anchor. It is noticeable that the anchors were found at a depth between 8 -15 meters and at a distance of c. 800 meters from the current shoreline **[FIGURE 17]**.



[FIGURE 17]: The location of the ancient anchors found in Ladamantia © CMAUCH

The collection of anchors recorded so far includes 1 stone anchor, 5 lead collars, 6 lead stocks, 12 iron shanks, 7 iron arms, and 24 iron anchors. These are average-size anchors, the largest of which has a shank that measures 220 centimeters and a sliding stock that measures 200 centimeters. The types of anchors discovered indicate that they mostly date from the Hellenistic to the Late Roman period, with a few examples that could predate that, including a lead anchor-stock core, which probably dates to the early 5th century BC[24] **[FIGURE 18].** All the anchors were found without any corresponding wreck sites, which raises different possibilities about how they detached from their vessels. During rough weather conditions, anchor ropes might not withstand the strain of ship movements on the surface, hence, they could have been severed, rendering the anchors useless. Alternatively, in situations where anchors became entangled on underwater reefs, the ropes may have been deliberately cut to avoid jeopardizing the ships' safety. However, two isolated iron anchors were identified beyond the main cluster, situated at a depth of 7m between the headland and the islet northwest of the bay **[FIGURE 19]**.

[24] TRETHEWEY 2001: 109-l 14.



[FIGURE 18]: The bay of *Ladamantia* has different types of ancient anchors including stone anchors, lead-stock anchors, and iron anchors © CMAUCH

[FIGURE 19]: One of two admiralty pattern iron anchors found between the headland and the islet northwest of the *Ladamantia* bay © CMAUCH

These anchors, featuring an admiralty pattern, were found with scattered metal debris, suggesting the presence of a shipwreck site. Notably, one anchor retains a portion of its attached chain. These anchors can be tentatively dated to the late 19th or early 20th centuries[25]. The discovery of these isolated anchors serves as a compelling indicator that the *Ladamantia* harbour remained in active use for a significantly longer period than previously recognized, extending well into the modern era and spanning over two millennia.

Further underscoring the continued activity at *Ladamantia* beyond antiquity, the survey yielded another noteworthy discovery: an inscription on the *Abu Hashafa* islet carved in eleven English letters. The inscription identified as a misspelling of «HMS Pangbourne», a Royal Navy minesweeper launched in Renfrew, Scotland, in 1918[26]. Notably, the initial "H" has eroded, a "U" is missing after the «O», and the «E» is written backwards **[FIGURE 20]**.

[FIGURE 20]: The inscription found on the Abu Hashafa islet. It bears the name of the «HMS Pangbourne». However, the initial «H» has eroded, a «U» is missing after the «O», and the «E» is written backwards © CMAUCH

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[25] CURRYER 1999: 73-95.

[26] «HMS Pangbourne (J 37)». Https://uboat.net/allies/warships/ship/6507.html. Accessed on (28/12/2023);
«H.M.S. Pangbourne 1918». Http://www.dreadnoughtproject.org/tfs/index.php/H.M.S._Pangbourne_(1918). Accessed on (28/12/2023).

Historical records place the HMS Pangbourne in the Mediterranean during the 1930s. In 1939, it conducted a hydrographic survey *of Marsa Abu Hashafa* (*Ladamantia*)[27]. This inscription suggests that the HMS Pangbourne anchored at the bay, and one of its sailors likely carved the ship's name onto the islet's rocks. This finding not only offers tantalizing evidence of the *Ladamantia* harbour's continued use in the 20th century but also underscores the potential for further historical insights embedded within the surrounding landscape.

The underwater survey of *Ladamantia* is ongoing. Until present, less than 25% of the bay has been thoroughly explored. Therefore, it is expected that surveying the rest of the area will reveal more information about maritime activities along this stretch of coastline.

V. CONCLUSION

The archaeological survey of *Zygris* and *Ladamantia* has significantly reshaped our understanding of maritime activities along the northwest coast of Egypt. This research reveals the presence of previously undocumented anchorage sites dating back to the Hellenistic and Roman periods, providing valuable insights into ancient trade networks and communication routes.

The discovery of shipwreck sites, anchors, and other archaeological material sheds light on the types of vessels that frequented these harbours, the cargoes they transported, and the challenges they faced while navigating the region's coastline. The continued use of Ladamantia throughout history, demonstrated by the presence of both ancient and modern anchors, showcases the enduring importance of this natural harbour as a maritime haven.

The findings from Zygris and Ladamantia contribute to a growing body of knowledge about maritime history in the Mediterranean, offering valuable insights into cultural exchange, technological advancements, and economic interactions between different regions. This exceptional discovery sheds light on the scale and intensity of maritime activities that once thrived along this stretch of coastline. It also underscores the pivotal role played by coastal settlements and natural anchorages in facilitating maritime networks and fostering economic prosperity, particularly during the Hellenistic and Roman eras. The ongoing Marsa Bagoush Research Project holds immense potential for future discoveries. Further investigation could reveal additional evidence of ancient maritime practices and the development of this coastal region.

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[27] WHITE & WHITE 1996: 11-30.

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Maritime and Underwater Cultural Heritage
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UNDERWATER CULTURAL HERITAGE IN ALGERIA THE VESTIGES OF THE FIRST WORLD WAR AS AN EXAMPLE

Article 3

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UNDERWATER CULTURAL HERITAGE IN ALGERIA
THE VESTIGES OF THE FIRST WORLD WAR AS AN EXAMPLE

ABSTRACT

[AR] **التراث الثقافي المغمور بالمياه في الجزائر: آثار الحرب العالمية الأولى نموذجا**

تزخر سواحل الجزائر ببقايا مخلفات الحرب العالمية الأولى، التي تعتبر وفقًا لاتفاقية اليونسكو تراثًا ثقافيًا مغمورًا يجب حمايته واستغلاله. ومع ذلك، فإن الجزائر تفتقر إلى قائمة بمواقعها الأثرية المغمورة خلال تلك الفترة، إضافة إلى قلة الدراسات والأبحاث في هذا المجال. وعليه، يهدف هذا البحث إلى معالجة هذه الفجوة من خلال توثيق وتحديد بعض مواقع السفن والغواصات الحربية الغارقة قبالة السواحل الجزائرية. وذلك بالاعتماد على السجلات والمحفوظات البحرية في الموقع الرسمي للبحرية الفرنسية في «بريست »، بالإضافة إلى الاستعانة ببعض المراجع التي تناولت الحروب البحرية العسكرية في البحر الأبيض المتوسط. كما يهدف هذا البحث إلى تقديم رؤى جديدة حول تاريخ الجزائر البحري خلال الحرب العالمية الأولى وإثراء فهمنا لأهمية موقع الجزائر الإستراتيجية. كما سيقترح توصيات لحماية واستغلال التراث البحري المغمور في تعزيز التنمية السياحية في الجزائر.

[EN] The Algerian coasts are full of material remains of the First World War, considered according to the UNESCO convention as underwater cultural heritage to be protected and exploited. However, Algeria lacks an inventory of its submerged sites during this period, in addition to the lack of studies and research in this area. Therefore, this research aims to fill this gap by documenting and locating some sites of sunken military ships and submarines off the Algerian coast. It will be based on the archives and documents of the website of the French Navy of Brest, as well as certain references dealing with military naval wars in the Mediterranean. It also aims to shed light on the maritime history of Algeria during World War I and to enrich our understanding of the strategic importance of Algeria's geographical position. it will also propose recommendations for the protection and enhancement of this underwater heritage to promote the development of tourism in Algeria.

KEYWORDS: Algeria, world war I, protection of submerged heritage, sunken ship artifacts, tourism development, Underwater Cultural heritage.

I.INTRODUCTION

Underwater cultural heritage is considered one of the material treasures of the past and one of the most important sources for understanding ancient civilizations and human history.

UNESCO emphasizes that the importance of submerged cultural heritage lies in the fact that it is considered an integral part of the vocabulary of human cultural heritage, an extremely important element in shaping the history of certain peoples and nations, and a mirror reflecting historical or modern relations between peoples.

Since 2001, this heritage has come within the scope of the UNESCO Convention relating to the protection of underwater cultural heritage, which was approved and defined as: «all traces of human existence presenting a cultural character, historical or archaeological which, for at least 100 years, have been submerged, partially or totally, periodically or permanently, under the oceans as well as in lakes and rivers»[1].

The seas are full of remains from past wars, particularly from the First and Second World Wars. The seabed is home to the remains of many ships, planes and submarines that sunk during these events, as well as their equipment and weapons. Although decades have passed since their sinking, but many still retain their original shape underwater. These wrecks have submerged historical archives through which the details of the conflicts can be explored and studied.

The Algerian coastline, which extends from El Kala in the east to Marsa Ben Mahīdī in the west over a distance of 1,622 kilometers, contains numerous submerged archaeological sites dating from different historical periods, notably Phoenician, Roman and Ottoman. But also, several from the conflicts of the 20th century, mainly between 1914 and 1948[2]. These coasts have been the scene of many military events, during which many ships and submarines have sunk, taking with them weapons, military equipment as well as various wrecks of war **[FIGURE 1].**

Https://www.naval-history.net/WW2CampaignsRNMed3.htm. Accessed on (01/04/2024)

[1] United Nations Educational, Scientific and Cultural Organization, «the 2001 UNESCO Convention on the Protection of Underwater Cultural Heritage» 2001. Http://www.unesco.org/new/en/ culture/themes/ underwater-cultural-heritage/2001- convention/official-text// Accessed on (10/11/2023).

[2] REPUBLIQUE ALGERIENNE 2015: 16.

Today, these wrecks could form a submerged museum along the Algerian coast. The study of these submerged marine remains is of capital importance for understanding the history of the region, by establishing links between the different events. This also contributes to the preservation of the cultural and historical heritage of the area and offers scientists and researchers the opportunity to discover new secrets buried under the sea.

However, maritime historical research in Algeria suffers from a lack of studies and research on sunken warships, particularly during the First World War. Until now, research efforts have focused on the historical and political aspects of these military conflicts, without adequately addressing the maritime aspects.

Algeria, like many other countries in the world, does not yet have a list of its underwater archaeological sites. Some sites may be known to some divers, but serious scientific exploration and research have been very rare[3]. Through this research, we will attempt to fill this gap by lifting the veil on the toll of the wrecks of warships sunk during the First World War and by locating the location of certain ships and submarines sunk, relying on official documents from the Brest naval archives[4].

In addition to supporting some references dealing with the naval history of World War I, the results of this research will provide valuable information and new details on the history of the military navy off the coast of Algeria. This research will also enrich our knowledge of this decisive period and help us understand the importance of the Algerian coasts during World War I. The article will also propose recommendations for the protection of underwater heritage and explore ways to promote it from a tourism development perspective.This research aims to provide answers to the following questions: Which are World War I wrecks along the Algerian coast and how can we preserve these underwater sites and exploit them to promote the tourism sector in Algeria?

II.THE MEDITERRANEAN SEA, THEATER OF WORLD WAR I

The Mediterranean Sea was the scene of the most important events of the First World War due to its geostrategic location, located between three continents - Europe, Asia and Africa - the Mediterranean connects several seas and oceans via the Strait of Gibraltar and the Suez Canal. The Mediterranean Sea is a vast inland sea that covers a total area of approximately three million square kilometers and lies between latitudes 46° and longitudes 5.50° west and 36° east.

The Mediterranean Sea therefore communicates with the oceans through the Strait of Gibraltar and the Suez Canal, while the Bosphorus and Dardanelles straits, which control the movement of ships between the oceans, connect the Mediterranean to the enclosed Black Sea via the sea. of Marmara. The length of the Mediterranean Sea is 3,800 km and its greatest width is 800 km between the Gulf of Genoa and Tunisia. Its total area is approximately 3 million km^2. This position makes it a region of great commercial

[3] KHELLAF 2016: 05-15.

[4] «La Première Guerre mondiale (1914-1918) Un conflit mondial et mécanique, chemins de mémoire», https://www.cheminsdememoire.gouv.fr/fr/la-premiere-guerre-mondiale-1914-1918-0, Accessed on (08/10/2023).

and military importance[5]. This central positioning made it the preferred area of confrontation for the Allied navies and the Central Powers. The British, French and Italian navies on the one hand, thus confronted the German, Austro-Hungarian and Ottoman navies on the other hand within this vast semi-enclosed sea[6].

The historian «Yves Robin» emphasized that World War I represented a major turning point in the practice of naval warfare. This conflict witnessed the transition from the traditional navy of the 19th century to a more modern navy[7].

In the early part of the war, control of the seas was achieved primarily through the use of modern naval battleships, known as «dreadnoughts». Submarines were initially used as coast guard vessels, particularly stationed in front of seaports. Britain quickly deployed its submarines to the North Sea to assist in the naval blockade of Germany. German U-boats also patrolled the English Channel and the North Sea searching for Entente warships, hoping to help rebalance the existing naval force[8].

On February 4, 1915, Germany declared for the first time all-out submarine warfare to cut off Allied supplies from colonies and neutral countries. However, incidents occurred during this campaign, the most famous of which was the sinking of the liner *Lusitania*, during which around a hundred Americans perished. Faced with protests, Germany was forced to suspend its campaign on September 18, 1915. It restarted in 1917. In 1917, Germany initiated comprehensive and unrestricted submarine warfare, resulting in the sinking of hundreds of merchant ships belonging to the Allies, along with their valuable cargo[9].

As it is well known, submarines played a major role during World War I, having evolved from a defensive tool for protecting ports and coasts to a powerful weapon of attack. Indeed, German submarines caused enormous losses of lives and merchant ships for the Allies. As a result, the United States of America entered the war on the side of the Allies[10].

The battle against the submarines continued until the end of World War I, contributing to Germany's defeat due to its inability to cut the Allied maritime supply lines. The war ended with the Allies sinking more German U-boats and building more ships than were sunk.[11]

World War I also saw the beginnings of military aviation, where aircraft were used in naval battles for reconnaissance and bombing purposes in a limited manner at first. As technology evolved during the war, aircraft missions diversified to include aerial warfare, with the emergence of fighters to intercept enemy aircraft. The use of

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[5] DEDEYAN 2023: «La Méditerranée, espace et enjeu d'affrontements ». Https://www.charles-de-gaulle.org/blog/2023/05/08/la-mediterranee-espace-et-enjeu-daffrontements/ Accessed on (30/6/2023).

[6] Ministère des armées 2024: 6

[7] ROUBIN 2014: 7.

[8] MENAPACE 2017: «Guerre sous-marine à outrance». BNF, https://gallica.bnf.fr/blog/01022017/guerre-sous-marine-outrance?mode=desktop Accessed on (01/03/2024).

[9] HINZELIN 1916: 26.

[10] CHACK 1970 :38.

[11] KARAU 2014: 1-3.

bombers for attacks on troops and military positions has also increased, as did the use of aircraft against submarines[12]

During the period of conflict, the coasts of western North Africa, including the coasts of Algeria, played a central role in hosting the most important naval battles, as its waters, witnessed the sinking of many ships, submarines and warplanes of different types.These remains still lie in the waters of the Algerian coast, testifying to the intensity of the bloody battles and wars that the region witnessed. They are now part of the historical heritage of this era and allow divers to discover certain details of these wars through them.

In the next few pages, we will present some of the most important naval events that took place on the Algerian coast, including the naval battles that resulted in the sinking of many ships and submarines.

III. The Algerian Coasts during the First World War: Scene of Violent Naval Battles

The Algerian coast enjoys an important strategic geographical location due to its proximity to the southern European coasts, which gave it great importance in naval operations during World War I. France exploited this position by establishing several naval bases along the Algerian coastline[13].

These bases included facilities for the French submarine fleet, in addition to bases for warships like destroyers and cruisers. They were provided with all the necessary infrastructure and facilities, such as docks and warehouses. The main ports like Béjaïa, Algiers and Cherchell, were also mobilized for the deployment of troops and the transport of supplies, equipment and ammunition to the combat fronts.

At the end of 1915 and given the strategic importance of the city of Algiers for the defense of French North Africa, which was then the main military lock in the region and a nerve center for radio communications and intelligence, it was proposed to immediately provide Algiers with a significant fixed and mobile defense, including light cruisers, high-speed destroyers, torpedo boats and submarines. It was planned to add a gunpowder factory, and an arms, shells, and ammunition factory. The port of Algiers was to benefit from centralized defense and response against light ships and submarines in the western Mediterranean basin, concentrating all specialist equipment. Some types of defenses were also recommended in «Oran, Arzew, Ténès, Bougie, Philippeville and Bone», with the following objectives:

- Protect important coastal sites such as towns, ports, or radio stations.
- Impede the movement of German submarines and prevent them from operating on the surface in certain areas.
- Provide sea surveillance and intelligence for naval patrol forces.
- Protect coastal routes and create safe areas for ships and fishermen.

[12] Kerisel & Kerise 2001: 15–26.
[13] Pellegrinetti 2021: 130-139.

France relied on these naval bases as a starting point for many of its naval operations during the war, (there were no such convoys in the area during WWI, only in WWII) The decision was also taken to create a naval aviation center near the power station of the port of Algiers on November 10, 1916. The Grégoire company was entrusted with carrying out the work and the initial center was expanded in April 1917.

From then on, the North African air patrols in the Mediterranean were based on Oran Center (and affiliated centers in Nemour and Mostaganem), Arzou Center (Cherchal Center), Algiers Center (Tennis Centers and Bejaia), Jijel Center, Bouna Center (Collo Center).

The subcenters were equipped with warehouses and stands for seaplanes to operate and their main tasks were: surveillance of maritime routes, escort of convoys, reconnaissance, search for mines and attack on submarines. However, the number of aircraft operating at each center was limited.

In 1917, the parliamentary session held on April 17 drew the attention of the Minister of the Navy to the interest of installing a cannon on the Algerian coast between Pointe Rouge and Cape Magrana. The objective was to block secluded places in the area from a German submarine which visited them regularly.

The establishment of a number of coastal defense positions prevented at least one ship from being sunk and repelled several German U-boat incursions. On June 24, 1918, the French Minister of the Navy published a program aimed at improving the coastal armament of the six ports of Corus and Algiers. He set as his first priority the immediate replacement of small-caliber guns with 155 mm and 120 mm guns, as well as the replacement of field gun bases with ship bases offering better guidance and rapid-fire capabilities[14]. During the war period 1914-1918, the Algerian coast witnessed several naval military operations and clashes took place in the region, the most significant of which are:

- **The Shelling of Bône and Philippeville in 1914**

This event of August 4, 1914, marks the start of the hostilities of the First World War on Algerian soil. The German cruisers *Goeben* and *Breslau*, refuelled in Messina the day before, set sail on the night of August 3 for the Algerian coast to carry out actions there, well before the official declaration of war[15].

Very early in the morning of August 4, the watchman of the port of Bône saw the *Breslau* approaching at a slow speed and without lights. At 4:08 a.m., he opened fire on the city, causing the first French casualty of the conflict in the person of André Gaglione. Shortly after, it was the «*Goeben*'s» turn to bombard Philippeville. Off the coast of Bône', the merchant ship «Saint Thomas» came under attack and was sunk with 11 German shells, which injured 4 sailors. Around a hundred projectiles fell on the station, houses, and other buildings, resulting in five additional injuries. These surprise attacks by German cruisers constitute the first deadly episode of the Great War on Algerian soil[16].

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[14] Saffroy 2015: 101-194a.

[15] Kopp 1931: 20-22.

[16] «Le bombardement de Bone et de Philippeville en 1914». Https://cdha.fr/les-bombardements-de-bone-et-philippeville-en-1914 . Accessed on (23/05/2023).

▪ **Algiers Clash on May 8, 1918**

On May 8, 1918, another naval clash took place off the coast of Algiers between the Entente forces and German submarines. An American auxiliary cruiser and a British destroyer conducting an anti-submarine patrol spotted the German submarine UB-70. Where she was chased and eventually sunk.

Initially, the outcome of the combat was uncertain, as surface ships were unsure if they had sunk their submerged opponent. However, they were later credited with sinking the submarine UB-70, the first success of such a submarine hunting operation off the coast of Algiers. This engagement on May 8, 1918, known as the «Battle of Algiers», illustrates the fighting by Allied naval forces in the Mediterranean to expel enemy submarines from their operational areas off the coast of North Africa.

IV. MEMORY OF CONFLICTS AT THE HEART OF THE MEDITERRANEAN: THE REMAINS OF THE SHIPWRECKS OF 14-18 OFFSHORE ALGERIA

The Algerian coast holds enormous historical shipwrecks and archaeological sites associated with the First World War. Records indicate that approximately 200 ships were sunk due to German U-boat attacks during this period.

These submerged remains are silent testimonies to the conflict that the region has witnessed. It also highlights the importance of Algeria's strategic location and the extent of naval military activity at that time.

The National Archaeological Map listing the maritime heritage submerged during World War I suffers from a significant lack of referencing of submerged sites, which illustrates the urgent need for research work and a systematic inventory of wrecks dating from this period.

Through our research on certain official documents available from the naval archives in Brest, and relying on some documentation dealing with the naval military conflict in the Mediterranean during World War I[17], we will attempt to present a list of warships and merchant ships that sunk off the Algerian coast during this historical period:

▪ **September 9, 1915: The Steamers *Aude* and *Mostaganem* were Sunk by the Submarine U-39 off the Coast of Oran**

On September 7, 1914, the German submarine U-39 crossed the Strait of Gibraltar. On the morning of the 9th, at 1:30 p.m., he was 85 nautical miles northeast of Oran, facing the French steamers *Aude* and *Mostaganem*. After firing a warning shot with its gun the submarine stopped the two ships and evacuated their crews to the lifeboats. Then, he sunk both ships[18].

▪ **November 4, 1915: The Ship *Calvados* was Sunk off the Coast of Algiers**

On November 4, 1915, off the coast of Algiers, the troop transport *Calvados*, which left Marseille to reach Oran, was sunk by the U-38 of Lieutenant Max Valentiner. The Senegalese battalion was transporting lost bodies and property. This tragedy caused

[17] SAFFROY 2015: 101-194b.

[18] Entreprises-coloniales Française 2023.

strong emotion which led the Minister of the Navy to suspend all transport between France and Algeria.

- **November 5, 1915, the Steamer *Sidi Ferruche* Sunk off the Algerian Coast**

On November 5, the steamer '*Sidi Ferruch* was also sunk by gunfire from the German submarine U-38 (Max Valentiner), 42 miles from Algiers. There were no casualties, and the boats were recovered a short time later[19].

- **August 31, 1915, the Steamer *Bacchus* Sunk off the town of Cherchell, on the West Coast of Algeria[20]**

On August 31, 1915, the steamer *Bacchus* (3,583 tons) was sunk by cannon fire by a submarine, 67 miles north of Cherchell.

At the end of February 1916, the German submarine U-38, commanded by Lieutenant Valentiner, carried out a patrol off the coast of Algeria. Between February 27 and March 1, U-38 sunk three ships near Algeria, as part of its operations to attack 10 ships in that region. This was one of the manifestations of intense German military activity in the Mediterranean during January and February 1916.

- **April 3, 1916, Two British Cargo Ships Sunk off the Coast of Bône - Annaba - Eastern Algeria.**

In April and May 1916 attacks continued in the western Mediterranean basin, where the density of traffic represented prime bait for the enemy. U-34, after leaving Pola in the Adriatic, on March 27, the submarine sunk two English cargo ships off Bône on April 3.

- **April 5, 1916, the Ship SS *Chantala* Sunk off shore.**

On April 5, 1916, the ship *Chantala* sunk off the coast of Algiers in the evening by the U-34.

- **May 1916: Several Ships Sunk off the Coast of Oran.**

After the German submarine U-34 sunk the ship SS *Chantala* off the coast of Algiers and sunk two British cargo ships off the coast of Annaba-Bouna in eastern Algeria, the submarine headed to the west coast of Algeria, and sunk several other ships off the coast of Oran and Barcelona.

- **July 1916: 18 Steamboats Sunk along the Algerian-Tunisian Coast.**

From July 12, after ten days of cruising along the coasts of Algeria-Tunisia, -the Plane, the U-39 destroyed 18 steamers with its gun[21].

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19 B.N.F GALLICA: 2023.

20 B.N.F GALLICA 2023.

21 B.N.F GALLICA A 2023.

- **November 16, 1917, the French Cargo Ship SS *Kabylie* Sunk off the Coast of Béjaïa - North-Eastern Algeria.**[22]

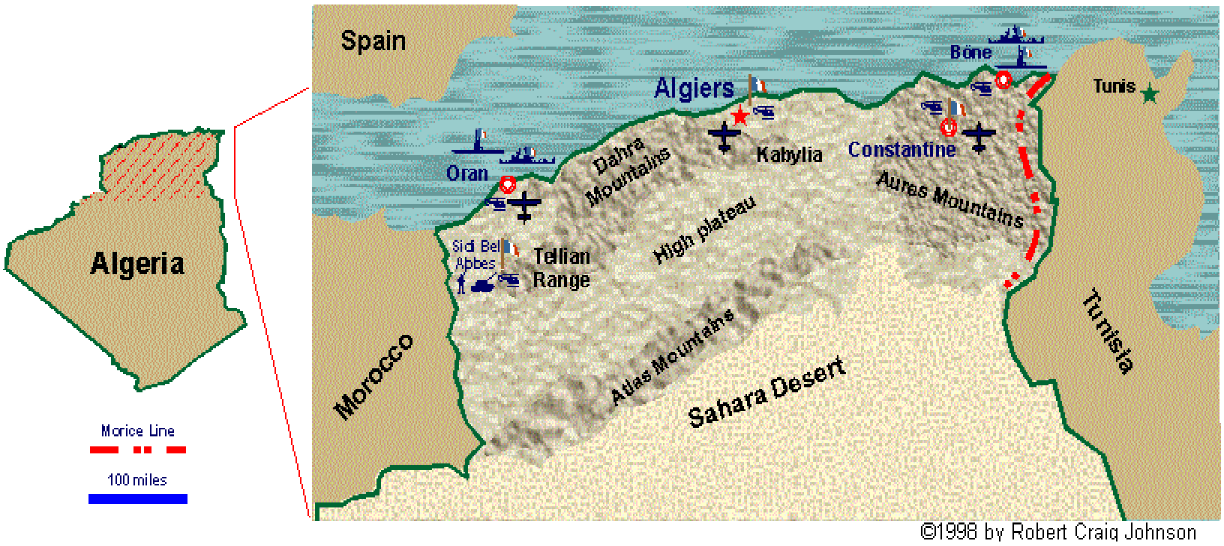
On November 16, 1917, the French cargo ship SS *Kabylie* was sunk by the German submarine U-35 off the coast of Béjaïa. All 22 crew members perished in the sinking[23].

- **June 19, 1918, the UK Auxiliary Cruiser Himalaya Sunk off the Coast of Algiers.**

The auxiliary cruiser *Himalaya* was in turn torpedoed by U-38 and sunk off the coast of Algeria on June 19, 1918. This list represents only a few examples, and it is very likely that the wrecks of many other warships and merchant ships are scattered at the bottom of the Algerian Mediterranean. This highlights the necessity for further research to explore these wrecks.

V. Underwater Heritage in Algeria between Reality and Challenges

Algeria is considered one of the countries rich in its diverse cultural heritage, in addition to its richness in many underwater sites, which are included on the UNESCO World Heritage List. The first research to discover underwater heritage was carried out in Algeria in 2005, when it made it possible to discover the site of the sinking of the Sphinx (a ship belonging to the French Royal Navy, stranded at Cape Mativo, east of 'Algiers), also the site of the sinking of another ship - undated - and of a ship, a small one containing ten sharpening stones each weighing around 800 kg and probably intended for oil mills. Both sites are located in La Marsa, near Algiers.



Http://worldatwar.net/chandelle/v3/v3n1/frcoin.html. Accessed on 01/04/2024

Convinced of the extreme importance of preserving this heritage, Algeria, like other countries, seeks to ensure the protection necessary for the preservation of its submerged marine cultural heritage, through several legal and institutional means. Algeria has promulgated Law Nº.04-98 relating to the protection of this heritage, in

[22] B.N.F Gallica A 2023.
[23] B.N.F Gallica A 2023.

addition to ratifying the 2001 UNESCO Convention, which establishes international principles for its protection[24].

The protection of this heritage has also been supported by legislative measures. The Algerian Republic has announced that the command of the Algerian naval forces is the sole recipient of information relating to the discovery or intervention in underwater cultural heritage located in the exclusive economic zone, or on the continental shelf of another State Party.

Threats to underwater cultural heritage are relatively recent. The aquatic environment has ensured total protection of underwater cultural heritage against human or natural activities. However, with the development of underwater technology after the end of World War II, it became easy to access and exploit these antiquities illegally.

According to Aznar Gomez, the threats to underwater cultural heritage can be grouped into two main categories: «accidental» threats and «non-accidental» threats. The first group mainly includes potential impacts on fishing, public or private works, industrial activities, the laying of pipelines or geological research[25].

However, the most serious threats to underwater cultural heritage are those that can be described as «non-accidental» threats, which come from treasure hunting and organized looting of archaeological objects at the bottom of the sea. These harmful activities are practiced due to the enormous economic benefits they can generate. Unfortunately, such activities damaging to underwater cultural heritage are still encouraged in some places[26].

The submerged marine heritage of the Algerian coast faces similar threats, making the process of protecting this underwater heritage a major challenge. This is due to the significant technical, technological and financial requirements needed for preservation and protection work involving the detection of archaeological sites under the sea. Achieving, this protection also requires the availability of specialized human skills in this domain.

The promotion of this heritage faces numerous challenges, the most important of which are:

- The lack of funding for exploration operations, the lack of specialized expertise in the field of archaeological diving and the absence of laws and legislation regulating this field.
- Lack of awareness of the importance of this heritage and interest on the part of official organizations and society.
- Absence of a strategy for the protection and management of submerged marine heritage in Algeria.
- Limited scientific research: In this area it is limited, hindering our complete understanding of the history of the region and its impact on successive civilizations.

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[24] Ministère chargé de l'environnement -PAP RAC/ PAM, 2015. Stratégie nationale de gestion intégrée des zones côtières en Algérie. (Appui PAM-MedPartnership. UNESCO 2015: 94.

[25] CAMARA & NEGRI 2016: 139-205.

[26] CAMARA & NEGRI 2016: 139-205.

- Gaps in maritime heritage legislation[27].

Submerged Marine Heritage in Algeria Faces Numerous Threats, Such as:

- Illegal looting: it is considered one of the most serious threats to this heritage, as some divers without licenses loot archaeological sites and sell antiquities on the black market.
- Pollution: Marine pollution poses a major threat to the safety of submerged marine heritage, as it can lead to erosion and damage to archaeological sites.
- Climate change: such as sea level rise, threatens certain archaeological sites.

To Protect this Heritage, the Algerian Government Must Work to:

- Creating a map that includes the documented submerged archaeological sites along the coast of Algeria.
- Adopt laws and legislation to protect shipwrecks from looting and theft.
- Increase funding, allocating more financial resources to carry out the necessary studies and surveys.
- Raise awareness among official organizations and society of the importance of submerged marine heritage.
- Encourage and support scientific research in this area.
- Train executives and experts specialized in the field of archaeological diving.
- Strengthen international cooperation in order to exchange experiences with leading countries in the field of exploitation of submerged marine heritage.

To Achieve the Exploitation of Underwater Cultural Heritage to Promote the Development of Tourism in Algeria, the State Must:

- Allocating Tourist Diving Areas near Submerged Monuments.
- Create marine museums.
- Organize boat/vessel tours to the submerged heritage sites.
- Produce documentaries and broadcasts on archaeological sites to contribute to their promotion.
- Use virtual reality technologies to reconstruct websites and present them to visitors.

In order to implement sustainable tourism development based on the exploitation of submerged heritage, the government must:

- Establish strict regulations to supervise tourist activities and preserve the sites (number of dives per day, minimum approach distance, authorized equipment, etc.).
- Raise awareness among tourism professionals and visitors of the fragility of the underwater environment and the need to protect it.
- Diversify the tourist offer around underwater heritage (museum visits, documentaries, virtual reality) to relieve congestion on the sites.
- Involve local populations in tourism projects so that they benefit economically and are guarantors of long-term protection.

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[27] DAHIM 2023: 514-537.

- Promote gentle modes of travel on the water (kayak, sailboat, etc.) and limit the anchoring of large boats on the sites.
- Implement a tax on underwater tourism activities to finance the maintenance and restoration of sites.
- Regularly monitor the ecological state of sites and adapt the tourist offer if necessary to preserve biodiversity.
- Promote fishing and navigation that respects marine ecosystems near tourist sites.

VI. CONCLUSION

The submerged remains of World War I along the Algerian coast represent a considerable historical and scientific treasure. Documenting and identifying these sites can provide new information about Algeria's maritime history during World War I and contribute to promoting sustainable tourism as well as local economic development. However, it is important to note that Algeria does not currently have a documented list of its submerged archaeological sites dating from this period.

To achieve sustainable exploration, protection and use, cooperation, coordination and investment in research, development and infrastructure are necessary. The government and relevant institutions should commit to supporting future research and studies in this area while promoting international cooperation in the exchange of knowledge and experiences.

This is why we undertook this work, to highlight the scale of this submerged heritage by attempting to document and identify some of the warships and submarines submerged off the Algerian coast. This involves consulting naval files and archives on the official website of the French Navy in Brest, as well as utilizing relevant references that deal with naval warfare in the Mediterranean. Additionally, this research provides new information on Algeria's maritime history during World War I and enriches our understanding of the strategic importance of Algeria's geographic location.

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Maritime and Underwater Cultural Heritage in the Arab Region 9/2

Harbour and Coastal Archaeology in Syria A Review of the Past and the Recent Archaeological and Geoarchaeological Surveys

Article 4

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Harbour and Coastal Archaeology in Syria
A Review of the Past and the Recent Archaeological and Geoarchaeological Surveys

Abstract

[AR] الآثار الساحلية والمرافئ في سوريا: مراجعة للمسوحات الأثرية والجيو أثرية الماضية والحديثة

تتميز الآثار الساحلية السورية بإرث تاريخي غني يعود تاريخه إلى العصر البرونزي، والذي يتمثل في مدن الميناء البارزة مثل أوغاريت (رأس شمرا حاليًا)، وأرواد، وعمريت، وجبلة، وتبة الحمام. لعبت هذه المدن الساحلية أدوارًا محورية في ربط الحضارات القديمة في المنطقة بعالم البحر الأبيض المتوسط الأوسع، وشهدت أنشطة بحرية نابضة بالحياة تشمل التجارة والملاحة البحرية وبناء السفن. على الرغم من محدودية الأبحاث الأثرية البحرية على طول الساحل السوري منذ الستينيات، والتي تفاقمت بسبب الاضطرابات الشديدة منذ عام 2011، فقد شهدت السنوات الأخيرة جهودًا جديرة بالثناء للقيام بمهام أثرية تحت الماء. تركز هذه المساعي، على الرغم من التحديات العديدة، على توثيق التراث الثقافي الساحلي وتحت الماء في سوريا. وبالاعتماد على أحدث الأعمال الميدانية الأثرية. تسلط هذه الدراسة الضوء على الاكتشافات المهمة في شعاب أرواد الواقعة على الامتداد الجنوبي للساحل السوري مقابل مدينة طرطوس الحديثة. وقد وفر التوثيق المنهجي للبقايا الأثرية المرتبطة بميناء أرواد والتحصينات الساحلية فهمًا شاملاً للتطور المعماري للمدينة القديمة. وهذا يساهم بشكل كبير في المعرفة الأوسع فيما يتعلق بتقنيات البناء السائدة في منطقة البحر الأبيض المتوسط. علاوة على ذلك، فإن التسجيل الأثري للبقايا القديمة المغمورة وجدران التحصينات الساحلية قد أسفر عن رؤى جديدة حول التغيرات البيئية. هذه التغيرات، المرتبطة ارتباطًا وثيقًا بالتقلبات النسبية لمستوى سطح البحر والنشاط التكتوني، تقدم منظورًا جديدًا للعوامل المؤثرة على تطور الجزيرة، مما يشير إلى أن الجزيرة شهدت هبوطًا أدى إلى غمر البقايا الأثرية. في جوهره، يثري هذا البحث فهمنا للماضي البحري في سوريا، في ظل التحديات المعاصرة، ويسلط الضوء على كل من التطور المكانية والبيئية في سياق البحر الأبيض المتوسط.

[EN] Syrian harbour and coastal archaeology have a rich historical legacy dating back to the Bronze Age, exemplified by prominent harbour cities such as Ugarit (modern-day Ras Shamra), Arwad, Amrit, Jableh and Tabbat al-Hammam. These harbour cities played essential roles in connecting the region's ancient civilizations with the broader Mediterranean world, witnessing diverse maritime activities encompassing trade, seafaring, and shipbuilding. Despite limited maritime archaeological research along the Syrian coastline since the 1960s and severe disruptions since 2011, recent years have witnessed commendable efforts to undertake underwater archaeological missions. These endeavours, despite several challenges, focus on documenting Syria's coastal and underwater cultural heritage. Drawing upon the latest archaeological missions, this study highlights significant discoveries at Arwad reef, situated on the southern stretch of the Syrian coastline opposite the modern city of Tartous. Systematic documentation of archaeological remains associated with Arwad's harbour and coastal fortifications has provided a holistic understanding of the ancient city's architectural development. This contributes substantially to broader knowledge regarding construction techniques prevalent in the Mediterranean region. Moreover, the archaeological recording of submerged ancient remains and submerged coastal fortification walls has yielded new insights into environmental changes in the region. These changes, intimately linked with relative sea level fluctuations and tectonic activity, offer a new perspective on factors influencing the island's development, suggesting that the island has experienced subsidence resulting in the submergence of the archaeological remains. In essence, this research enriches our comprehension of Syria's maritime past, even amid contemporary challenges, shedding light on both spatial evolution and environmental dynamics in the Mediterranean context.

Keywords: Arwad island, coastal fortification, construction techniques, harbour and coastal archaeology, harbour infrastructure, Syrian coastline, relative sea level change.

I. INTRODUCTION

Syria has a relatively short coastline in the eastern Mediterranean, which stretches for about 200 km between Turkey from the north and Lebanon from the south. Geographical features are characterised by sandy beaches, alternating with rocky headlands and low cliffs. The coast is surrounded from the east by a coastal mountain range (Mount Lattakia), reaching up to 1500 meters above the present msl**.** The Syrian coastline has a rich history with evidence of various civilizations such as Phoenicians, Greeks, Romans, and Byzantines that have flourished along the coast over thousands of years. These cultures have left their marks on Syrian maritime history including important Bronze Age harbours, well-known coastal settlements, Classical to Medieval period harbours and finally potentially well-preserved shipwrecks of all periods. Ancient epigraphic and literary sources described maritime trade and military activities that were hosted from at least the Bronze Age onwards. Ugarit Kingdom at Ras Shamra in the north and the Phoenician harbours of Arwad, Amrit and Tabbat al-Hammam in the south, could be among the earliest examples of the development of ports and harbours on the Syrian coastline[1].

Coastal and maritime archaeological research in Syria is still very limited, because there is a lack of systematic archaeological documentation and underwater archaeological fieldwork. Moreover, few geological and geoarchaeological research has been conducted on the Syrian coast which is also creating a gap when it comes to the interpretation of submerged archaeological sites. However, in recent years, despite the challenges, several surveys and archaeological fieldworks were performed on the Syrian coastline. The submerged reef of Arwad in the southern part of the Syrian coastline was the main target of underwater research during the last five years.

The archaeological coastal sites located along the reef are so steeped in history, already heavily occupied since the Bronze Age and possess diverse archaeological remains. Nowadays, these sites are facing severe threats such as coastal erosion, relative sea-level rise, and environmental changes caused by climate change and anthropogenic impacts. Therefore, these surveys have aimed for detailed archaeological documentation of the harbour sites and the development of strategies for future preservation and research.

II. OBJECTIVES

One of the main objectives of this paper is to establish a foundational understanding of the existing knowledge in harbour and coastal archaeological research on the Syrian coastline, both in terms of historical investigations and recent underwater archaeological surveys. Secondly, the paper aims to consolidate and illustrate the results of the only two underwater archaeological missions carried out on the southern part of the Syrian coastline since 1960s[2]. The first mission was started in 2019 by a Syrian-Russian archaeological team. The second was conducted in 2021-2022 and was used in the framework of my PhD thesis at Aix-Marseille University, which aimed

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[1] El-Amarna letters (EA 98, EA 101, EA 104, EA 105 & EA 149). The epigraphic documents at Ras Shamra. ARNAUD 1992: 180-182, PSEUDO-SCYLAX (2015): Journey, § 104, mid. 4th c. BC. STRABO (1924): Geography 16.2, 20 BC – 23 AD. Https://topostext.org/texts Accessed on (01/10/2023).

[2] Honor frost has performed the first systematic underwater archaeological fieldwork in 1964-1966.

mainly at the systematic archaeological documentation of the harbour sites along Arwad Reef, focusing on the harbour structures and their geomorphological environment.

It is important to note that the accessibility to the recent Syrian-Russian archaeological mission surveys is very limited, especially the survey at the archaeological site of Amrit. Therefore, this paper will mainly focus on the documentation results of the archaeological surveys conducted at Arwad Island. Finally, by presenting the outcomes of these missions, the paper aims to contribute to the overall understanding of Syrian maritime and underwater archaeology building upon the pioneering work of Honor Frost.

III. A Review of the Previous Harbour and Coastal Archaeological Research on the Syrian Coast

Early Travellers and Exploration Campaigns

Back in the late 17th century, many travellers and geographers started their explorations on the eastern Mediterranean coastline. Their campaigns resulted in valuable descriptions, illustrations and freehand sketches of the archaeological remains of the harbour sites along the coast. In 1697, H. Maundrell described the main ancient harbour sites such as Lattakia, Arwad island and Amrit[3]. Later, in 1743 Pococke focused on the general features of the coastal cities from Tartous to Tripoli including Tartous (Antaradus), Amrit (Marathus) and the island of Arwad and its harbour and coastal fortification[4]. Ernest Renan's archaeological studies in 1864 were confined to the documentation of the southern part of the Syrian coast[5]. Gretille J. Chester, a member of the Royal Archaeological Institute, has published an article titled «*Notes on Ruad (Aradus) and Adjacent Places in Northern Syria*». He described the topography of the island and the general features of the coastal fortification[6]. Finally, in 1896 René Dussaud travelled along the Syrian coastline and produced some topographic notes and archaeological records during the first half of the 19th century[7].

Archaeological Surveys and Excavations

During the first half of the twentieth century, archaeological surveys accompanied by photographic documentation revealed valuable archaeological documentation of ancient harbour and coastal sites. In 1916, Savignac identified the remains of ancient monuments on Arwad during a short stay on the island. He recorded some archaeological features of the harbour and the coastal fortification[8]. Later, in the 1920's Sauvaget mentioned some ancient harbour remains in Lattakia[9]. In 1940 an archaeological excavation was initiated at the archaeological site of Tabbat al-Hammam

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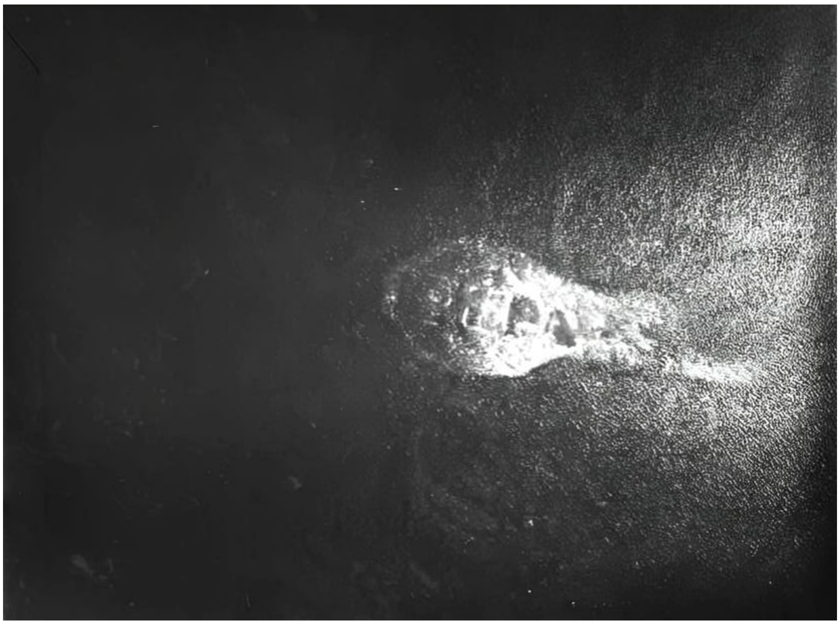
[3] MAUNDRELL 1749: 19-22.
[4] POCOCKE 1743: 202-204.
[5] RENAN 1864: 20-42.
[6] CHESTER 1875: 218-227.
[7] DUSSAUD 1927: 116-146.
[8] SAVIGNAC 1916: 567-577.
[9] SAUVAGET et al. 1934: 87.

by Robert J. Braidwood[10]. At the same time, between 1918 and 1945, aerial photographs were taken by the French Army and by R. Poidebard[11] **[FIGURE 1]**. Furthermore, ancient harbour remains in Lattakia, Tel Tweini, Tel Sukas and Paltos were mentioned between the 1950's-1960's, by members of the Danish Carlsberg expedition in Syria.[12]



[FIGURE 1]: Syria, Tartous governorate, Jableh region, the Maraclea tower, vertical aerial view 29-05-1935. French Institute of the Middle East (IFPO), French Army, (HAL open science. Https://hal.science/hal-02479410. Accessed on (22/11/2022).

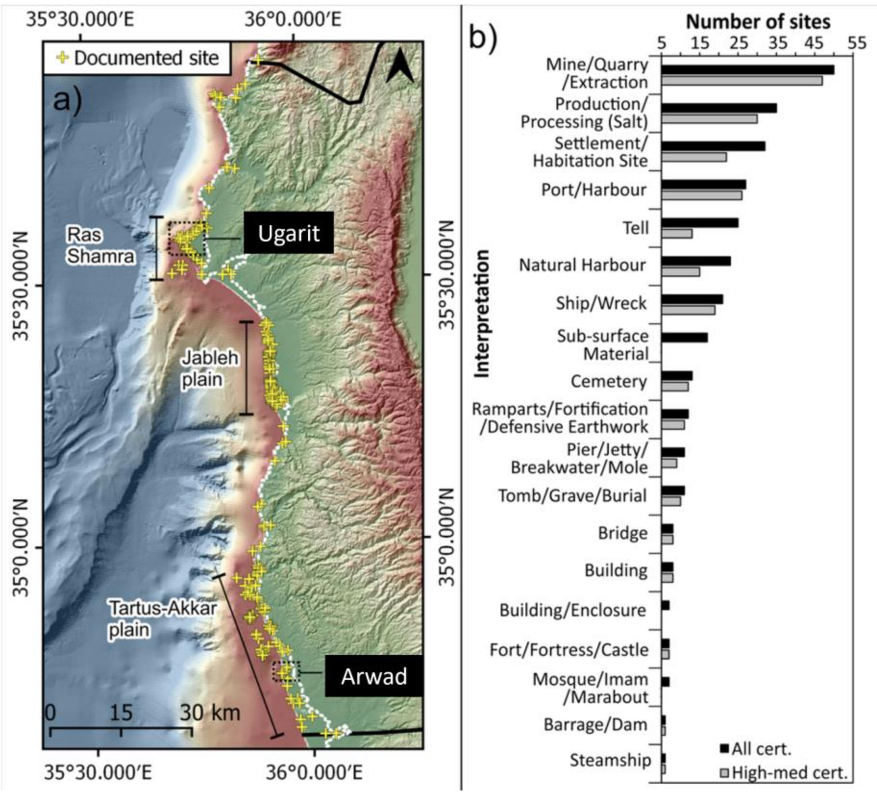
In the 1960s, Honor Frost was the first archaeologist to perform systematic underwater archaeological fieldwork in Syria introducing underwater archaeology. On the Syrian coast, she focused on the Phoenician harbours of Arwad, Amrit, Machroud and Tabbat al-Hammam[13]. Concerning other harbour installations, Courbin referred to harbour remains during excavation campaigns at al-Bassit in the 1970's[14]. Later, in 1978, the Tartous Department of Antiquities followed up the work of archaeological excavations on the archaeological site of Amrit; these works are still ongoing, aiming at the research of the area of the temple and the surrounding archaeological remains. In 1992 rescue excavations focused on the archaeological remains of the harbour of Amrit. These excavations revealed the harbour installations dating from the Hellenistic period.

One excavation was performed at the extension of the installations revealing several warehouses and a long quay[15]. Hussein Hijazi, a Syrian Navy officer, published the results of his extensive fieldwork in 1992, conducted over twenty years on the Syrian coastline, in his book *Ancient Ports, Harbours and Anchorages Along the Syrian Coast*. This book was the first systematic attempt at mapping and recording the ports,

[10] BRAIDWOOD 1940: 204-208.
[11] POIDEBARD & CAYEUX 1939: PL.XXVII; POIDEBARD et al. 1951: PL.XV.
[12] RIIS 1960: 111–132; 1965: 75–82; 2004: 15-16; OLDENBURG et al. 1981: 116.
[13] FROST 1964: 67-74; FROST 1966: 13-28; FROST 1970: 63-71; FROST 1995: 8-13.
[14] COURBIN 1986: 176.
[15] AL-MAQDISSI 1993: 448.

harbours, shipwrecks, and settlements on the Syrian coastline based on detailed field observations and architectural descriptions[16].

In 2008 N. Carayon focused his research on the identification of the geomorphological setting of the harbour sites and their infrastructures in the framework of his PhD research «*Les ports Pheniciens et Puniques geomorphologie et infrastuctures*»[17]. Recently, a comprehensive study «*the Syrian Benchmarking Report 2018*» initiated by the Honor Frost Foundation was the first concise desk-based approach to systematically gather, correlate and analyse all identified and potential sites and settlements on the Syrian coastline[18]. Finally, a comprehensive assessment that reviews past coastal environmental changes affecting the Syrian coastline was conducted in the framework of EAMENA and MarEA[19] **[FIGURE 2]**.



[FIGURE 2]: Spatial distribution of all identified and potential sites and settlements on the Syrian coastline. WESTLEY et al. 2022: 361.

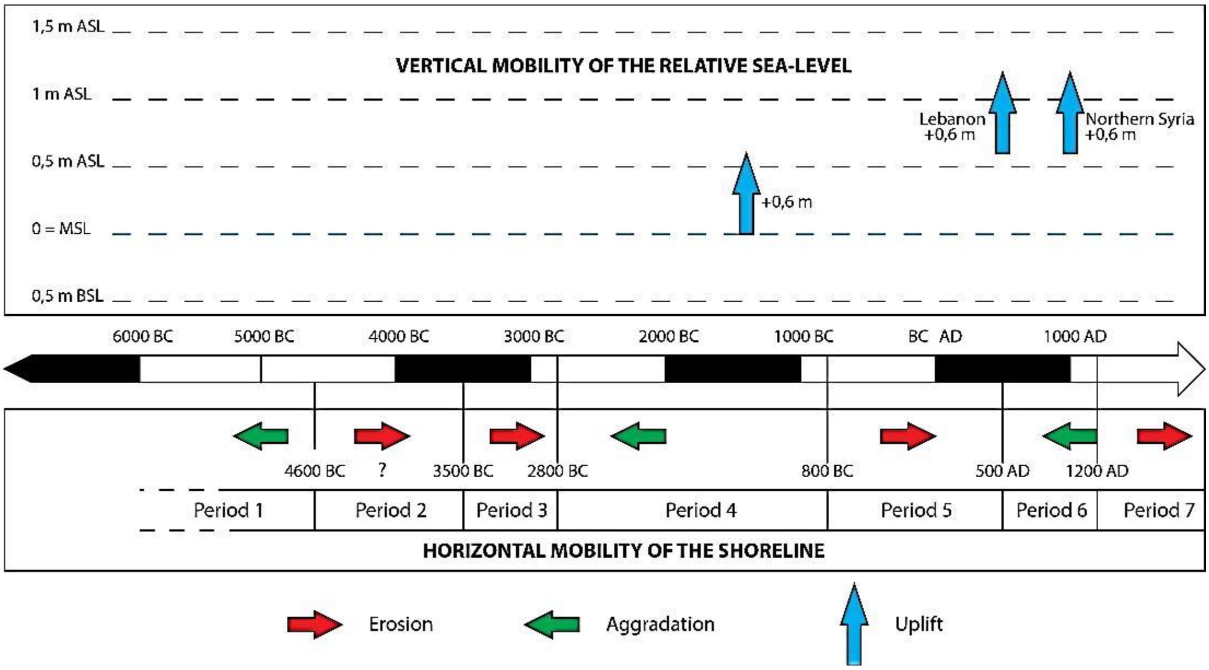
A Review of Previous Maritime Geoarchaeological Research in Syria

Understanding the main factors influencing coastal morphology is essential for comprehending the evolution of the harbour sites, where terrestrial and marine forces converge. The identification of the geomorphological settings requires a thorough understanding of the geological characteristics and topographical features of the coastal zone. Concurrently, tectonics and changes in sea level, whether natural or anthropogenic, linked to global climate change, contribute significantly to the harbour's

[16] HIJAZI 1992: 39-81.
[17] CARAYON 2008: 236-249.
[18] WESTLEY et al. 2018: 41-52.
[19] WESTLEY et al. 2022: 353–373.

coastal evolution. Sea level studies are also integral to harbour and coastal archaeology, providing a foundation for archaeological interpretations.

Relative sea-level change research has been relatively limited on the Syrian coastline[20]. Regional disparities were illustrated by these geomorphological and palaeo-environmental studies due to complex tectonic uplift and subsidence, in addition to horizontal movements controlled by sea level change, fluvial sedimentation, littoral drift and anthropic pressure. Nevertheless, two uplifted coastlines have been identified and dated on the Syrian coastline. The first occurred around c. 1400 BC and the second around c. 1000 AD in North Syria[21] **[FIGURE 3]**.



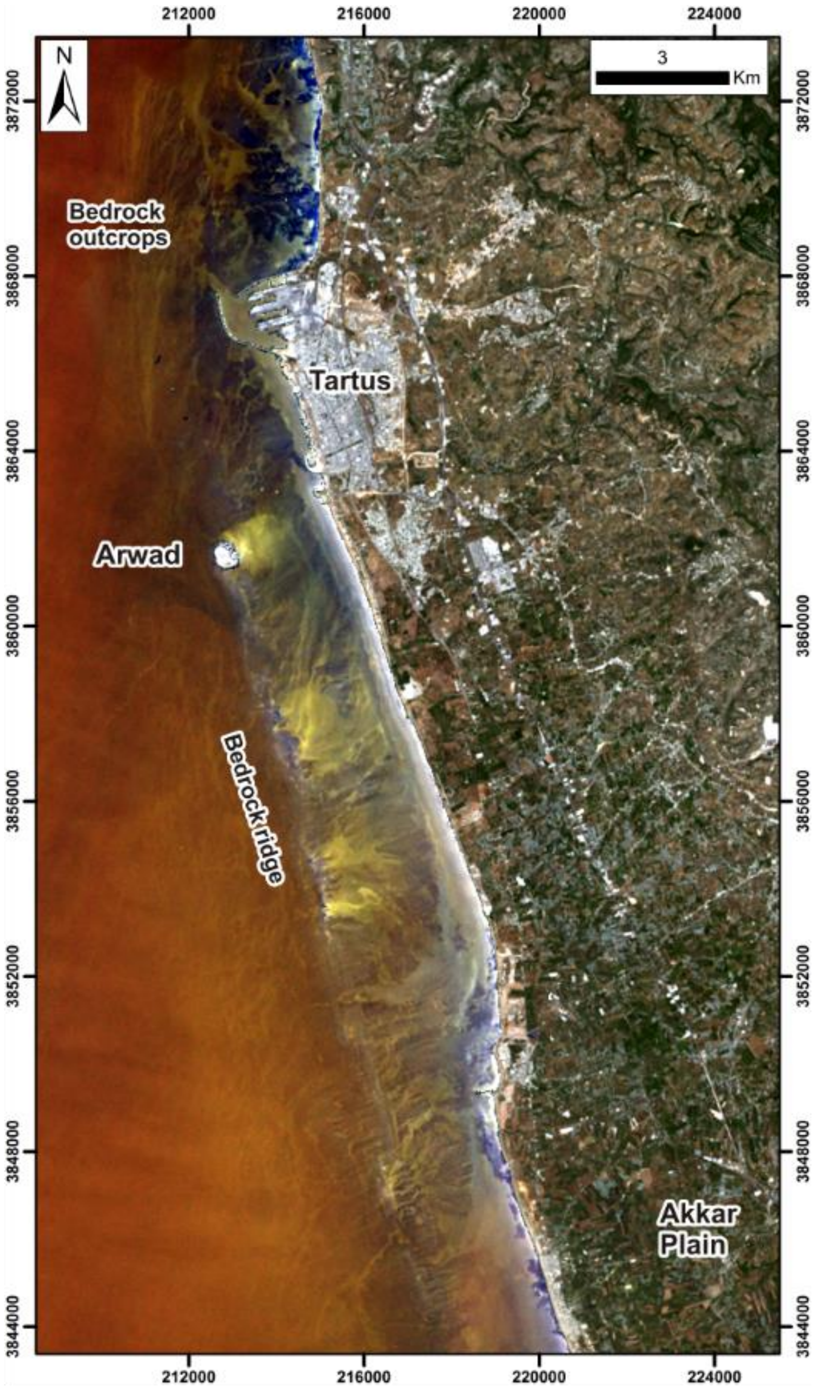
[FIGURE 3]: Relative sea level changes and principal phases of horizontal mobility along the Syrian coast during the Holocene. SANLAVILLE et al. 1997: 360; WESTLEY et al. 2022: FIG.7.

Recent Archaeological Surveys on Arwad Reef

After over 50 years, two underwater archaeological missions were carried out on Arwad reef where the Phoenician harbour sites of Arwad, Amrit and Tabbat Al-Hammam are located. The Syrian coast opposite Tartous is characterized by an underwater mountain range that forms a rocky seabed parallel to Tartous shoreline. This reef extends for about 15 kilometres towards the south starting from Arwad island which is its northern extremity. Arwad island and the other four islets (Al-Abbas, Abu-ᶜAli, Abu al-Faris and Machroud from north to south) are the only parts of this submerged bedrock ridge that have emerged. Machroud island lies about 8.5 km to the south and it is the last emerged islet of this reef **[FIGURE 4]**.

[20] DALONGEVILLE et al. 1993: 47; SANLAVILLE et al. 1997: 386-387; MARRINER et al. 2012: 46.

[21] SANLAVILLE 1997: 386-387; MARRINER et al. 2012: 46.



[FIGURE 4]: Shallow-water seabed geomorphology (<-20 to -30m) off Tartus.
WESTLEY et al. 2018: 10.

Historically, Arwad island served as a major trade harbour, connecting the ancient Near East with the Mediterranean world. As a result of its strategic location at the crossroads of major trade routes on the Levantine coast, it witnessed extensive maritime activities, including trade, seafaring, and shipbuilding. In the Late Bronze Age, Arwad was a connecting harbour between the Egyptian, Hittites, and Mesopotamian civilizations. Arwad was mentioned in several epigraphic and textual ancient sources, such as in the El-Amarna letters of the 14th c. BC and the epigraphic documents at Ras Shamra, where Arwad has been described as one of the main harbour cities in the maritime trade route linking Ugarit and Egypt[22]. During the Iron Age, Arwad was an

[22] ARNAUD 1992: 192.

integral part of the successive Empires that ruled in the Middle East: Assyrian, Neo-Babylonian, Persian, Greek, and Roman[23]. Moreover, at the battle of Salamis in 480 BC, warships from Arwad were also part of the Persian navy that faced the Athenians.[24] Finally, in the late Iron Age, it was suggested that the territory of Arwad on the mainland extended north until Al-Mina near the estuary of the Orontes River[25].

The Syrian-Russian Archaeological Mission [2019-2021]

In late 2019, an archaeological mission was initiated under a collaborative agreement between the Directorate General of Antiquities and Museums (DGAM), the Syrian Ministry of Culture and the Russian University of Sevastopol. The research was carried out within the framework of the project of the development program of Sevastopol State University.

The main objectives of the mission are the monitoring and documentation of underwater archaeological remains including ancient shipwrecks along Arwad reef by using a mobile hydroacoustic sonar system (Side Scan Sonar). The activities included a three-dimensional laser survey and a photogrammetric survey of part of the submerged reef of Arwad island in addition to the fallen ashlar blocks of the fortification walls underwater. Moreover, areas around the small islands adjacent to Arwad island from the southern side were also surveyed. A geo-radar survey was conducted on part of the beach of the archaeological site of Amrit. Based on the 2019 survey data, a total of 119 promising targets and objects of archaeological interest were identified around Arwad island and offshore near the archaeological site of Amrit **[FIGURE 5]**. Noteworthy, findings include the detection of three shipwrecks, with one presumed to be of modern date. Additionally, Medieval port installations were identified in close proximity to the modern port of Tartous. Finally, the underwater destruction zone of the Arwad ancient fortification was identified as a focal point of interest[26].

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[23] ANET 1969: 276-284; DIODORUS, (1933) 16.40: 41-42, https://topostext.org/texts. Accessed on (01/10/2023); QUINTE-CURCE (1861) :vol.4, 1, HTTP://BCS.FLTR.UCL.AC.BE/CURTIUSIV. Accessed on (01/10/2023).

[24] HERODOTUS, § 7.98, 430 BC. (1890), https://topostext.org/texts. Accessed on (01/10/2023).

[25] REY-COQUAIS 1974: 149-152; RIIS 2004: 66-88.

[26] LEBEDINSKI et al. 2020: 68-81.

[FIGURE 5]: Overview map of surveyed areas of the submerged reef of Arwad by the Syrian-Russian mission. LEBEDINSKI et al. 2020: FIG.2: 74.

Later in 2020 and 2021 the archaeological surveys were carried out by a team of divers, coupled with ROV surveys. Several archaeological targets were documented underwater near Arwad island and the tower of Maraclea (i.e. a structure measuring 16 m by16 m at a depth of -0.5 to -1.5 meters below present sea level **[FIGURE 1]**. Finally, on the south-eastern side of the island, at a depth of -4 to -5 meters below present sea level, a fortification wall was recorded. The wall has been traced for over 80 meters and is constructed with huge ashlar blocks **[FIGURE 6]**, which have different sizes ranging from 3.4 to 1.5 meters[27].

[27] LEBEDINSKI et al. 2022: 68-81.

[FIGURE 6]: A submerged fortification wall at the south-east corner of Arwad island.
LEBEDINSKI et al. 2022: FIG.5: 60.

Back to Arwad in the Footsteps of Honor Frost 2021-2022 Surveys

A systematic archaeological documentation of the southern part of the Syrian coastline from Arwad island to Tabbat Al-Hammam took place for my PhD thesis at Aix-Marseille University 2020-2024. The PhD research concerns the maritime archaeological and geo-archaeological study of the Phoenician harbour sites (Arwad, Amrit - ancient *Marathous* and Tabbat Al-Hammam). The first coastal and underwater archaeological fieldwork was performed in May 2021 focusing on Arwad island, while the second fieldwork covered the ancient harbour site of Amrit in December 2022.

Objectives and Methodology of Documentation

The first survey at Arwad indicates that the island has a wealth of archaeological remains along its coastline in the south, west and north, presenting different construction techniques and different phases of construction. Moreover, the eastern side of the island creates a protected harbour basin from the west, south-west and north-west prevailing winds. The main objectives of the survey are to undertake a systematic documentation of all archaeological and geoarchaeological features, to perform a coastal change assessment of Arwad's harbour landscape, and to identify the construction techniques of the harbour structures and the coastal fortifications.

Methodologically, the archaeological fieldwork on Arwad island involved a combination of surveying, mapping and documentation techniques:

A. Architectural and 3D topographical documentation with total station provided by the archaeological department of Tartous of the Syrian Ministry of Culture. The topographic data was collected in a local coordinate system established on the present biological mean sea-level recorded by observing vermetids bioconstructions at Arwad ± 10 cm.

B. 3D photogrammetric documentation through high-resolution georeferenced aerial drone survey and on-land recording was done on the archaeological remains. Additionally, Digital Elevation Models (DEMOs) of the archaeological structures have been created and linked with the present biological mean sea-level recoded on the island.

C. Desk-based evaluation and data integration of published and non-published archaeological sources.

D. Aerial remote sensing analysis to record the coastal changes on the island during the last 100 years. Data used in this analysis: a) low-attitude aerial mapping performed in the field which provided very high-resolution (~2cm), b) recent high-resolution satellite imagery (<1 m) hosted on Google Earth (2009–2020), c) high-resolution (~3m) declassified Corona spy satellite imagery (1968–70) hosted by the open access Corona Atlas (http://corona.cast.uark.edu/)

E. Finally, we proceeded to the creation of a subsequent GIS database to facilitate the analysis and visualization of the documentation results and to enhance the management of maritime cultural heritage resources on Arwad reef by integrating diverse interdisciplinary datasets.

Documentation Results

The geomorphological environment, in which the harbour of Arwad island was established, comprises a sheltered anchorage created by an offshore emerged reef. This practice is also attested at several harbour sites along the Eastern Mediterranean coastline such as Ras Ibn Hani, Tripoli, Sidon, Tyre, Jaffa, Tel Dor, as these reefs offer partial protection against prevailing wind[28]. The systematic archaeological documentation has covered most of the coastal archaeological remains located on the south and south-west coast of the island in addition to several preserved parts of the coastal fortification wall. Submerged remains in shallow water up to – 1 meter below present sea level were recorded as well during the topographical survey and the aerial photogrammetric mapping **[FIGURE 7]**. Moreover, a detailed analysis of Arwad harbour structures was performed and the results of this analysis will be published in the Mediterranean Harbour Cities I Conference Proceedings[29].

[FIGURE 7]: Arwad island. Overview map showing the results of the archaeological documentation, integrated with archaeological observations of Frost 1964-1966 © Done by the researcher

[28] POIDEBARD & CAYEUX 1939: 37.

[29] ANBAR forthcoming.

Construction Techniques of the Ancient Structures

The study of the construction techniques of the archaeological structures was one of the objectives of the study. Indeed, the construction patterns observed in the ancient structures on Arwad island exhibit distinctive characteristics:

- **A.** The structures comprise walls constructed with sandstone ashlar blocks (cuboid).
- **B.** The majority of walls follow a connected pattern at vertical angles, forming a crossed network. Exceptions are noted at the south-east and south-west corners of the island. The network is composed of long (east-west) lines parallel to the south coastal fortification wall and shorter (north-south) lines vertical to the coastal fortification wall. Some of the vertical walls are interconnected with the fortification wall.
- **C.** The dimensions of the ashlar blocks are standardised, with lengths ranging between 100-120cm, widths between 40-60cm, and heights between 20-35cm.
- **D.** All documented walls are observed at elevations ranging from -1m to +1m in relation to the present biological mean sea-level.
- **E.** Typically, only one or two courses of ashlar blocks are visible in the structures, although in some instances, three courses were observed.
- **F.** Given the location within the Low Elevation Coastal Zone (LECZ < 1m), the walls are subjected to substantial abrasion caused by coastal erosion.

Consequently, there is a lack of clear evidence of tool traces or binding material between the ashlar blocks, further emphasizing the impact of coastal erosion on the preservation of these structures. Two primary ashlar block positioning techniques were identified in the observed construction patterns:

- Walls Constructed with Single Row Alignment: These walls are built using either one row of headers (width: 100-120cm) or one row of stretchers (width: 40-60cm). Most of these walls are situated above the present biological mean sea-level.
- Walls Constructed with Headers Against Stretchers: In this technique, headers are positioned on one face of the wall, while stretchers are placed on the opposite face. Headers are commonly set on the outer side of the wall, and in some instances, headers alternate with a row of stretchers.

These distinct ashlar block positioning methods contribute to the overall diversity in construction styles observed in the ancient structures on Arwad island, reflecting variations in architectural practices and design **[FIGURE 8]**.

Finally, quarries positioned on the western side of the island, situated on the inner side of the double rock-cut fortification walls, are identified as potential sources of construction materials. These quarries are believed to have been the main source supply of the requisite materials for the construction of the ancient structures on Arwad island. This hypothesis is based on the matching measurements between non-extracted blocks still preserved at the quarries and those used in the construction of the ancient walls.

Construction Techniques of the Coastal Fortification

The fortification wall exhibits a diverse array of construction techniques across different sectors of the island. In the south and east, the wall is entirely composed of constructed massive ashlar blocks[30], in both positioning headers and stretchers demonstrating a continuous construction technique **[FIGURE 9]**. Conversely, on the western side of the island, two fortification walls extend for over 400 meters and are intricately carved into the natural bedrock. Remarkably, the northern side combines both principles, featuring a fusion of the rock-cut wall serving as a foundation for the construction of the elevation of the fortification **[FIGURE 10]**.

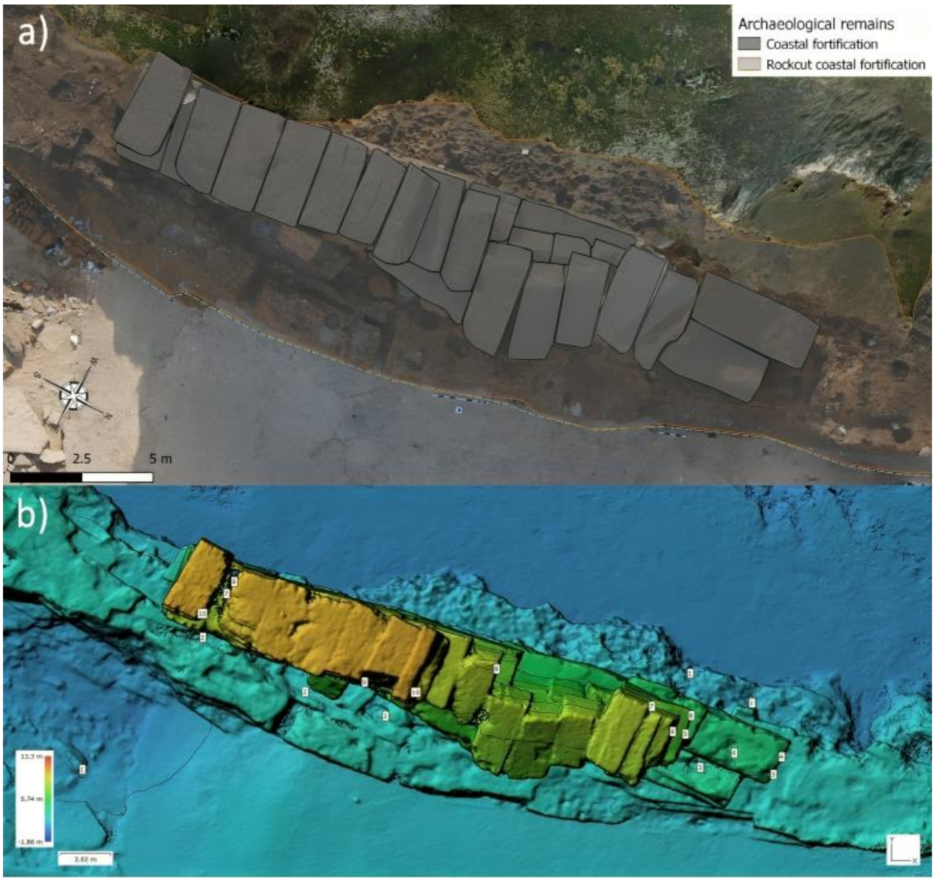
[FIGURE 8]: Aerial view of the southern side of Arwad island showing the submerged archaeological remains and the submerged coastal fortification wall © Taken by the researcher

Moreover, on the southern and eastern extremities of the island, the foundation of the fortification exhibits a construction technique characterized by the use of ashlar blocks. These blocks are arranged in a header positioning.[31]. Notably, on the eastern side of the island, topographical recording through the total station revealed the presence of three distinct courses of these headers. The lower part of the lowermost course is situated at an elevation of -1 meter below the present biological mean sea level. This multifaceted approach to fortification construction represents the strategic considerations and adaptive engineering solutions employed in response to the varied topographical conditions encountered on the island.

Finally, at the southeast corner of the island, a secondary fortification wall has been systematically documented, with a total length of 90 meters **[FIGURES 6 & 8]**. It is positioned approximately 14 meters to the south of the initial fortification wall. Remarkably, this secondary wall is submerged at an approximate depth of -4 to -5 meters below the present biological mean sea level. The construction of this submerged fortification wall entails the use of massive ashlar blocks, placed in a header positioning, comprising two discernible courses.

[30] Length: 2.5 to 5 m; Width: 1 to 2 m; Height: 1.5 to 2.5 m.

[31] Dimensions ranging from 2 to 2.6 meters in length; 0.4 to 0.6 meters in width; 0.25 to 0.35 in height.



[FIGURE 9]: A. 3D photogrammetric recording of a fortification wall on the northwest side of Arwad island. B. A digital elevation model of the same wall shows a total height of over 10 meters above the present biological mean sea level © Done by the researcher

IV. DISCUSSION

Construction Phases

Indeed, the eastern Mediterranean region, including archaeological sites along the Syrian coastline, bears witness to the widespread use of ashlar construction techniques. This construction method was prominent in the creation of durable architectural structures and showcased a high level of craftsmanship and engineering expertise. Notably, various sites dating to different periods have provided valuable insights into the application of these techniques. Some prominent examples include Ugarit (Ras Shamra) during the Late Bronze Age[32], Tabbat al-Hammam in the Early Iron Age[33], as well as Amrit[34], Tel Sukas[35], and Tel Kazel[36] in the latter half of the first millennium BC.

Arwad island has witnessed continuous occupation from at least the Late Bronze Age to the present day, necessitating the establishment of chronological sequences for its various construction phases. While the analysis of the documentation results is ongoing, preliminary observations regarding the layout of the archaeological remains indicate a coherence in construction timelines **[FIGURE 7]**. Initial assessments suggest that the majority of the structures on the island appear to belong to a singular

[32] BOUNNI 1979: 230.
[33] BRAIDWOOD 1940: 208.
[34] DUNAND et al. 1955: 193-196.
[35] RIIS 1970: PL.4.
[36] DUNAND et al. 1964: PL.4.

construction phase. The observed matching patterns in wall construction and connectivity across various structures strongly suggest the notion that these architectural elements share a common chronological origin. Acknowledging the complexity of Arwad island's history, it is important to note that the presence of restoration phases, particularly evident in the coastal fortifications, cannot be dismissed. Contrary to the prevailing patterns indicating a singular construction phase, the presence of structures featuring rubble walls suggests the existence of subsequent construction phases. On the other hand, the non-alignment of certain structures with the general site planning implies intentional deviations or adaptations, possibly reflecting shifts in architectural styles, functional changes, or cultural influences over time.

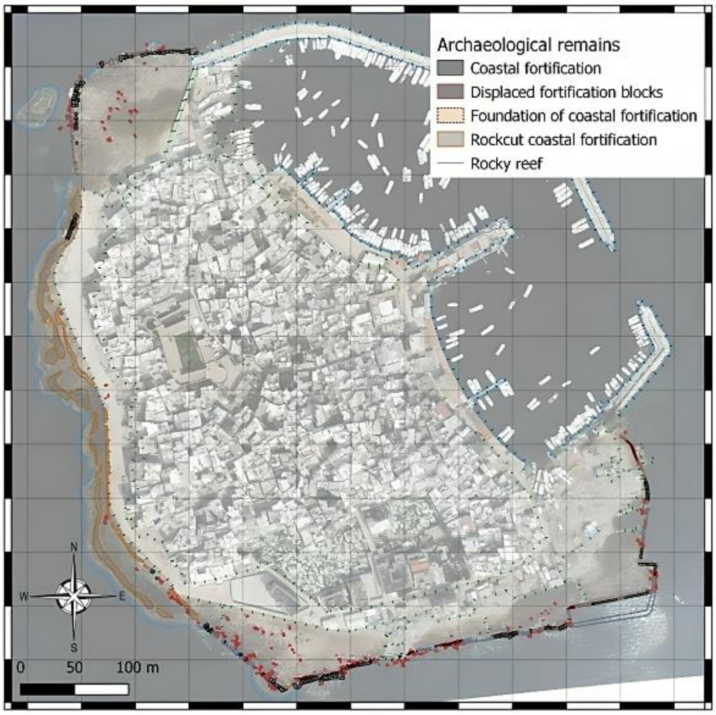
These observations highlight the importance of further underwater and coastal investigations through systematic archaeological excavations, to refine our understanding of the historical development and evolution of the architectural landscape of Arwad island.

Relative Sea-Level Change

Incorporating the study of relative sea-level change into archaeological analysis enriches our comprehension of the complex interactions between human activities and the maritime environment. Arwad reef region has not yet received any analytical paleoenvironmental studies. Only two prograding shorelines with distinct characteristics were observed along the coast opposite the reef: a) beach rock shells at Tabbat al-Hammam and continental shells at Amrit (1st half of the second millennium BC), b) the second shoreline related to the al-Abrash River, dated between 165 AD and 186 AD[37]. The ongoing archaeological investigations on Arwad island have demonstrated the need for a comprehensive systematic study of relative sea-level change on the reef of Arwad.

Basically, submerged structures on the southern side of the island and the submerged foundation of the eastern fortification wall have been identified at a depth of approximately -1 meter below the present biological mean sea level **[FIGURE 8]**. Moreover, a fortification wall in the southeast corner of the island is situated at depths ranging from -4 to -5 meters **[FIGURE 6]**. These submerged ancient structures provide contradictory evidence for the establishment of relative sea-level changes, suggesting that the island has experienced a subsidence most likely caused by regional tectonic activities; this resulted in the southern landmass of the island sinking. Another factor to be considered is the sea level rise on the global level. Over the last 4,500 years, there has been a rise of 1.5 meters in sea levels[38]. This global trend may have contributed to the submergence of archaeological remains, especially since the island of Arwad is situated in a place where the elevation zone is particularly vulnerable to rising sea levels.

[37] DALONGEVILLE et al. 1993: 51-52
[38] STWEART & MORHANGE 2009: 389.



[FIGURE 10]: Overview map of Arwad island coastal fortification based on 2021 archaeological documentation © Done by the researcher

V. CONCLUSIONS

The development of the maritime façade of the Syrian coastline is quite remarkable, especially in the second half of the twentieth century. The establishment of coastal installations including industries, trade and tourism installations have contributed to the expansion and modernization of port facilities and waterfront areas, which have negative consequences on historical and cultural heritage sites, particularly ancient harbours and coastal areas. Several ancient harbours such as Arwad, Tartous, Jableh and Lattakia have lost all or some of their features due to the expansion of the modern ports. Certainly, the absence of underwater archaeological investigations along the Syrian coastline during this era of rapid development is a matter of notable concern. Addressing this gap becomes imperative to ensure the preservation and proper management of maritime cultural heritage resources, fostering a more extensive appreciation of the historical and archaeological richness that the Syrian coastline holds.

Nevertheless, the recent underwater archaeological research on the Syrian coastline marks an initial step toward establishing a systematic framework for future studies aimed at advancing maritime and underwater cultural heritage in Syria. Future endeavours should play an essential role in several key aspects, starting with setting up a cultural heritage management plan identifying archaeological sites with significant archaeological potential and cultural importance, or those facing preservation challenges. Moreover, sustained efforts for international collaborations will significantly encourage capacity building and the training of specialists in underwater archaeology, conservation, and related fields. Furthermore, interdisciplinary collaboration in applying near-shore and off-shore innovative technologies will be essential in advancing research on coastline evolution and relative sea-level change research.

Finally, concerning the international legal framework, the UN has recognised the importance and vulnerability of the coastal zones. To preserve and manage sustainably the extended coastal and submerged cultural environment of Arwad, also taking into account the accelerating effects of climate change, several Sustainable Development Goals (SDGs) outlined by the United Nations[39] should be considered: SDG 14 (*Life Below Water*), focuses on the conservation and the sustainable use of marine resources, as well as the protection of coastal ecosystems including coastal and underwater cultural heritage sites for maintaining their resilience in the face of climate change induced threats. More specifically, addressing these issues SDG 13 (*Climate Action*) focuses on the need to take urgent action to combat climate change and its impacts, including sea-level rise, coastal erosion, and extreme weather events that particularly threaten the cultural heritage site of Arwad island. Moreover, like many ancient coastal cities, Arwad's archaeological remains are located in direct relationship with the urban area and, thus, are directly affected by urban development and associated infrastructure. Therefore, it is important to consider SDG 11 (*Sustainable Cities and Communities*), which emphasizes the importance of making cities and human settlements inclusive, safe, resilient, and sustainable through the preservation and promotion of cultural heritage in coastal regions and by raising awareness among the local population and stakeholders. Combined with SDG 15 (*Life on Land*), which addresses the importance of preserving cultural heritage, including terrestrial archaeological sites and landscapes that are often located in coastal areas, local communities can promote inclusive coastal management strategies. These can be inspired by international guidelines, such as the *Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM),* signed in 2008, which aims to protect coastal zones and help stakeholders deal with emerging coastal environmental challenges.

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[39] https://sdgs.un.org/goals. Accessed on (01/04/2023)

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BEYOND THE PAINTED SURFACE ANALYZING OLD KINGDOM'S STEERING DEVICES BY DELVING INTO THE ICONOGRAPHY OF NOBLES' TOMBS

Article 5

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BEYOND THE PAINTED SURFACE ANALYZING OLD KINGDOM'S STEERING DEVICES BY DELVING INTO THE ICONOGRAPHY OF NOBLES' TOMBS

ABSTRACT

[AR] **ما وراء الجدران المصورة : دراسة تحليلية لأدوات توجيه قوارب الدولة القديمة من خلال مناظر مقابر النبلاء**

تقدم المقابر المصرية القديمة المزينة بالنقوش والمناظر نافذة آسرة على المعتقدات والبراعة التكنولوجية لهذه الحضارة القديمة. نقشت هذه المناظر لتلبية احتياجات المتوفى في الحياة الآخرة، وخاصة الصور البحريةالتي تسلط الضوء على التراث البحري لمصر القديمة. تتناول هذه الورقة البحثية دراسة أجهزة التوجيه الموجودة على مراكب النقل الخشبية التي تظهر في مناظر مقابر النبلاء من عصر الدولة القديمة. فهي تفحص بدقة الترتيبات والمواضع والأعداد والتحسينات الفنية لأجهزة التوجيه. في عصر الدولة القديمة، كان للقوارب دورًا محوريًا في السياقات الدينية والجنائزية والاقتصادية والاجتماعية، مما أدى إلى تطوير أنواع مختلفة من القوارب ذات هياكل ومعدات متميزة. تطورت أجهزة التوجيه بمرور الوقت، واعتمدت في البداية على مجاديف التوجيه اليدوية المعلقة على الجانبين الخلفيين للقوارب. تم التعامل مع هذه المجاديف بالحبال أو الحلقات الجلدية المدعومة على محاور، عن طريق تدويرها على محورها أو رفعها على جانب القارب. ومع تقدم الدولة القديمة، شهدت مجاديف التوجيه تحسينات، بما في ذلك إضافة قطعة عرضية قصيرة لتحسين التحكم. حدث تحول ملحوظ في نهاية العصر، حيث تم تركيب مجاذيف التوجيه على أعمدة الدفة، مما أدى إلى تقديم محور ثابت لمزيد من التحكم في الملاحة. لا توضح هذه المناظر البحرية الجوانب الفنية لأجهزة التوجيه فحسب، بل تغذي أيضًا المناقشات العلمية حول تصويرها. يُظهر التنوع في أنواع القوارب وآليات التوجيه والانتقال من الحركة الجانبية إلى الدوران المحوري الفهم الدقيق للديناميكيات البحرية خلال عصر الدولة القديمة. في جوهرها، تعد المناظر البحرية الموجودة داخل مقابر نبلاء الدولة القديمة بمثابة سجل مرئي لتطور أجهزة التوجيه في القوارب المصرية القديمة. لا تسلط هذه الصور الضوء على التقدم التكنولوجي فحسب، بل تعرض أيضًا لمحة عن الاعتبارات الثقافية والعملية التي شكلت الإرث البحري لمصر القديمة.

[EN] Ancient Egyptian tombs adorned with reliefs and scenes provided a captivating window into the beliefs and technological prowess of this ancient civilization. Decorated to cater to the needs of the deceased in the afterlife, these scenes, especially nautical depictions, illuminated the maritime legacy of ancient Egypt. This paper delves into the study of steering devices on wooden transport boats, as portrayed in scenes on nobles' tombs during the Old Kingdom. It meticulously examines the arrangements, positions, numbers, and technical improvements of steering devices. In the Old Kingdom, boats played a pivotal role in religious, funerary, economic, and social contexts, leading to the development of various boat types with distinct hulls and equipment. Steering devices evolved, initially relying on hand-held steering oars suspended over the quarters. These oars, worked with rope or leather grommets or supported in pivots, were manipulated by turning them on their axis or levering them against the boat's side. As the Old Kingdom progressed, steering oars experienced enhancements, including the addition of short cross pieces for improved control. A notable shift occurred towards the end of the era, with steering oars mounted on rudder posts, introducing a fixed axis for more controlled navigation. The scenes not only illustrated the technical aspects of steering devices but also fueled scholarly debates on their portrayal. The diversity in boat types, steering mechanisms, and the transition from lateral movement to axial rotation showcased the nuanced understanding of maritime dynamics during the Old Kingdom. The scenes in the nobles' tombs served as a visual chronicle of the development of steering devices in ancient Egyptian boats. These depictions not only highlighted technological advancements but also offered a glimpse into the cultural and practical considerations that shaped the maritime legacy of ancient Egypt.

KEYWORDS: Grommets, iconography, Old Kingdom, rudder post, steering oar, transport boats, tiller.

I. INTRODUCTION

The reliefs and scenes found in ancient Egyptian tombs have been instrumental in providing extensive insights into the beliefs and technology of the time. Tombs were adorned with depictions of daily life activities, reflecting the belief that these scenes would fulfill the needs of the deceased in the afterlife. Nautical scenes, showcasing activities like boat construction, sailing, cargo handling, fishing, and funerary processions, hold particular significance, offering valuable glimpses into the ancient Egyptian maritime heritage.

This research paper aims to explore the steering devices used on transport boats depicted in numerous scenes found in the tombs of nobles during the Old Kingdom. By documenting the various types and forms of steering devices and tracing their evolution, the study seeks to unravel the intricate details of these maritime technologies. Wooden transport boats played a pivotal role in facilitating the movement of cargo and people across different directions – from east to west, south to north, and vice versa. The navigation activities served diverse purposes, including religious, funerary, economic, and social.

Examining the diversity in hulls and equipment provides a means to trace the overall development of the Old Kingdom's boats, shedding light on the evolution of their steering devices. Through a comprehensive analysis of these scenes, the paper aims to enrich a deeper understanding of the ancient Egyptian nautical legacy and its significance in various aspects of life during the Old Kingdom.

The rudder stands as the universal instrument that connects boats of the past and present, serving as an indispensable component. This singular device plays a pivotal role in enabling operational navigation and control, without which the very essence of steering a ship would be unattainable[1]. Gilmer[2] suggests that it should be called a steering device because «rudder» is a recent appellation. The steering device of a ship or boat is typically manipulated from within the vessel to alter its angle or direction. This is achieved by using one or more steering oars, the number of which may vary based on the size and design of the craft. These steering oars allow the navigator or helmsman to exert control over the vessel's course, facilitating effective maneuvering on the water[3].

In ancient Egypt, a common and widely adopted steering mechanism for boats was the use of steering oars. This practice became a standard feature on boats across various regions throughout antiquity. These steering oars were typically mounted on each quarter of the boat, allowing for effectively controlling the vessel's direction [4] **[FIGURE 1]**.

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[1] MOTT 1997: 3.
[2] GILMER 1999: 185.
[3] CASSON 1995: 18.
[4] ROBERT & EMEIL 1996: 39.

[FIGURE 1]: Old Kingdom's steering device, Giza tomb of *Kaemankh*, sixth dynasty. JUNKER 1940: PL.V.

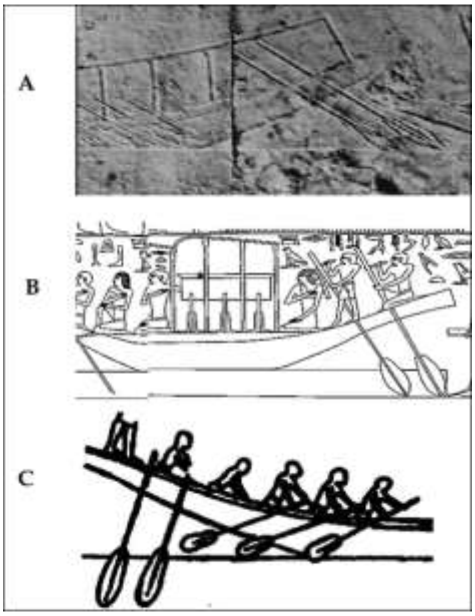
II. STEERING DEVICES' ARRANGEMENTS

The steering devices employed on transport boats in the Old Kingdom were composed of various elements carefully crafted to ensure effective control and navigation of the vessel. The key elements of the steering devices used aboard transport boats include:

1. A steering oar is an oar affixed to the planking or a crosspiece of a boat, allowing it to pivot against the hull. This type of oar is independent and can be leveraged to influence the boat's direction. It consists of:

A. Loom or stock: The loom refers to the section of an oar situated inward from the pivot point. It might be constructed as a built-up structure rather than a single solid piece, and the stock could find support from a crosspiece[5].

B. Blades: The blades on steering oars were notably larger than those on rowing oars. They took three shapes: lancet, where the edges of the blade seamlessly integrated into the loom, lancet with squared shoulders, and globular **[FIGURE 2]**[6]**.**

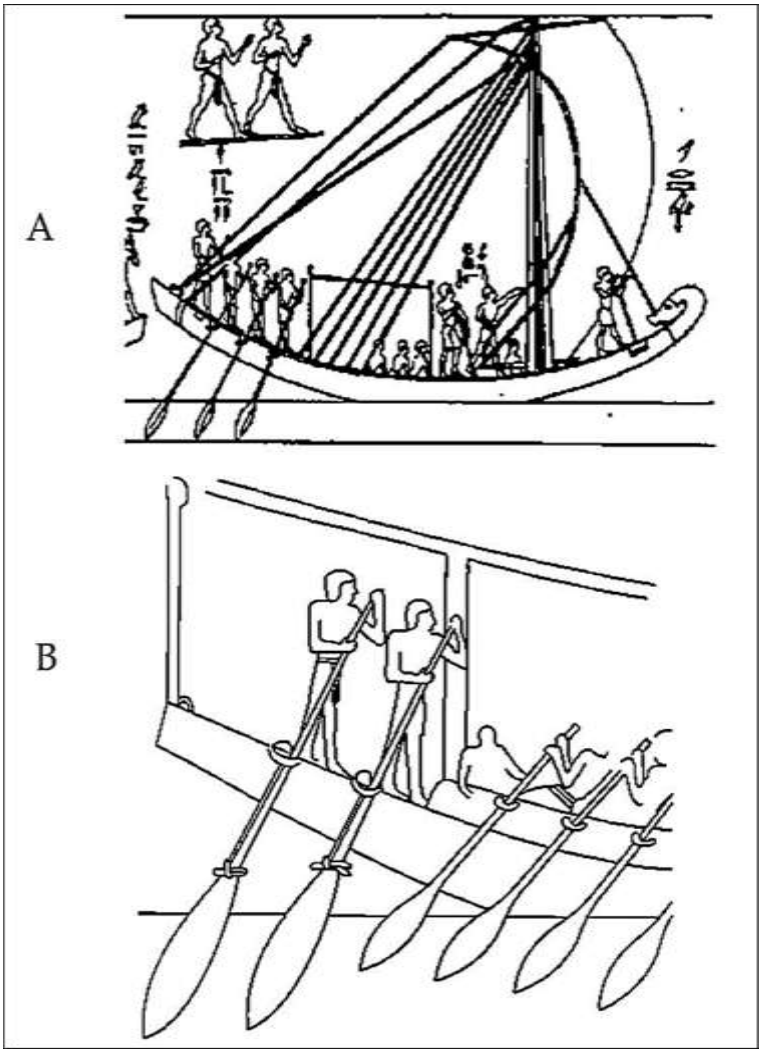


[FIGURE 2]: A. Lancet blade with the edges of the blade merging into the loom. STEINDORFF 1913: PL.21; B. Lancet blade with squared shoulders. SIMPSON 1976: FIG.24; C. Globular blade. BOREUX 1925: 343.

[5] DOYLE 1998: 85; MCGRAIL 2004: 468; STEPHENS 2012: 64.

[6] FABRE 2005: 119; STEPHENS 2012: 64.

2. Grommets or Lanyards: Starting from the fourth dynasty, depictions of steering oars revealed the use of rope slings **[FIGURE 3],** serving to provide support and function as relieving tackle (rudder pendants). These ropes played a dual role, preventing the steering oar from swinging excessively and serving as hoists to modify the blade depth in shallow waters. They were threaded through openings in the blade or looped around the stock[7].



[FIGURE 3]: Steering device's grommets. A .Giza, Mastaba of *Sech-em-nefer*, fourth dynasty. BOREUX 1925: 386; B.Saqqara, Mastaba of *Ty*, fifth dynasty. MARK 2012: 85.

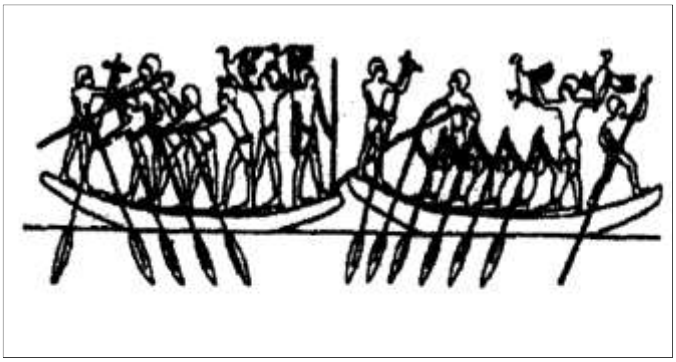
3. Tiller: A short, straight pin inserted through the loom of the steering oar for ease of turning on its axis **[FIGURE 4]**; tillers took their appearance during the fifth dynasty[8].

4. Rudder post: A vertical post, often referred to as a stanchion **[FIGURE 5]** and termed by Edgerton as a "steering post"; its main purpose was to offer support to the upper section of the rudder loom. This feature allowed the use of rudders with longer looms, enhancing helm control. Additionally, it led to a more efficient steering process, requiring fewer helmsmen. During the sixth dynasty, it became a customary practice to secure the loom of the steering oar to a stanchion by lashing[9].

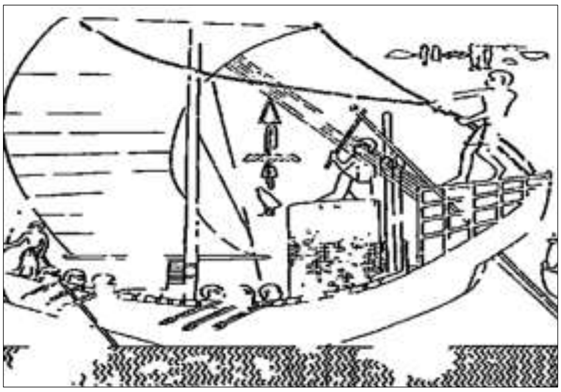
[7] DOYLE 1998: 85.

[8] CASSON 1995: 18; DOYLE 1998: 103; EDGERTON 1927: 257; MCGRAIL 2004: 33.

[9] EDGERTON 1927: 260; DOYLE 1998: 103; GILMER 1999: 178; STEPHENS 2012: 66.



[FIGURE 4]: The Old Kingdom's tillers.Saqqara, Mastaba of *Ptahhotep*. fifth dynasty. WILSON 1944: PL.XIII



[FIGURE 5]: Rudder post. El Hawawish, Tomb of *Tti-ikhr*, sixth dynasty. STEPHENS 2012: 87.

III. STEERING DEVICES' POSITION

The placement of steering devices has been a subject of debate among scholars, who disagreed on whether draftsmen depicted all steering devices or only those on the visible side of the vessel. For instance, GRASER (1869), REISNER (1913), BOREUX (1925), EDGERTON (1927), LEHMANN (1978), and THURNEYSSEN (1980) argued that draftsmen illustrated only half of them, suggesting that an equal, unillustrated complement operated on the other side. However, ASSMANN (1913), DOYLE (1998), and STEPHENS (2012) found this viewpoint improbable.

Reisner proposed that the rudders were likely leveraged against the stern side. In this scenario, steersmen on one side would pull the shaft inward, causing the blade to extend outward, turning the boat in that direction. On the opposite side, steersmen would either allow their rudders to float or pull them up out of the water. The construction of the broad overhanging stern seemed to be specifically designed to enhance steering through this method[10]. Edgerton, possessing a thorough understanding of navigation, shared a similar viewpoint with Reisner on this matter. Although he appeared to suggest that only the steering oars depicted were present in each case, his overall stance aligned closely with Reisner's perspective[11]. Assmann held a similar belief but speculated that the steering oar was rotated on its axis, resembling practices observed in later periods[12]. Boreux proposed that the early form of dual steering involved the helmsman (or helmsmen) physically shifting from one side of the

[10] REISNER 1913: VIII.

[11] EDGERTON 1927: 256.

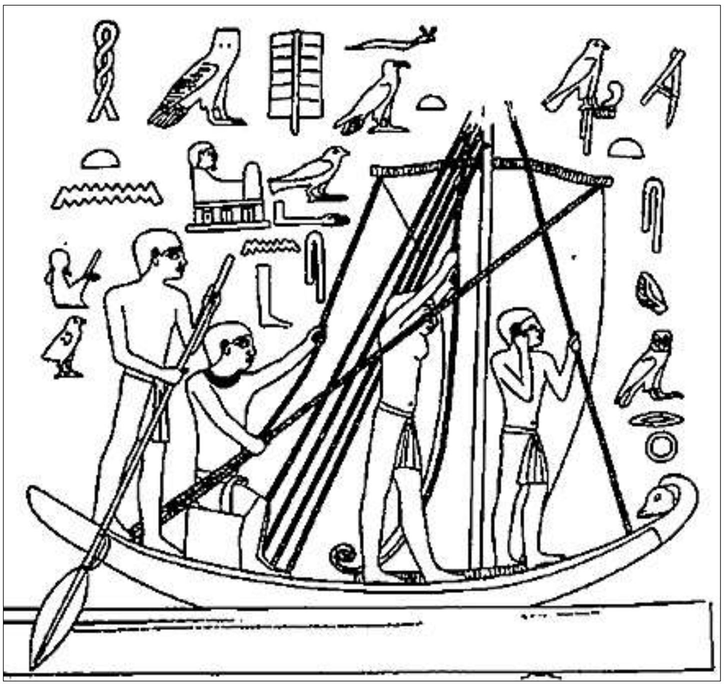
[12] ASSMANN 1913: 143.

vessel to the other[13]. Edgerton believed that the sizable passenger boats from the Old Kingdom likely had twice the number of steering oars depicted. He held the belief that the exact method of utilizing these early steering oars remained unclear, considering the possibility that both methods might be employed. Additionally, he affirmed that starting from the sixth dynasty, the steering oar could only be turned on its axis. Rouge observed that Egyptian steering devices were larger than typical ones and were managed at the stern by multiple helmsmen. He proposed that the differences in size could be attributed to artistic convention and theorized that they were positioned on both sides. Rouge speculated that, following the addition of the tiller and the rudder post, the steering oars functioned through the rotation of the blade on its axis, with the two points on which it rested preventing any lateral motion[14]. Lehmann theorized that the steering oar was secured in two locations, with the loom serving as the axis[15].

Thurneyssen firmly asserted that there was a rudder on each side of the ship, and they were maneuvered laterally rather than axially. He also noted that the oars had symmetrical blades, requiring minimal effort to turn them on the axis. Thurneyssen cited the example of the Mastaba of *Akhethetep* from the fifth dynasty in the Louvre, which depicted a boat on the right with two or three helmsmen standing, each handling an oar without any visible pivots at the deck level. However, the low relief clearly illustrated a rope descending from the gunwale to the top of the blade. In this scenario, helmsmen could effortlessly maintain their oars' position and move them in various directions. The depiction showed the left hand holding the top of the loom (with its back clearly visible), while the right hand grasped the loom close to the blade[16]. Jones proposed that the steering oars were suspended over the quarters and could be maneuvered by rotating them on their axis or leveraging them against the boat's side. In the latter case, the boat would turn in the direction of the outward thrust of the blade[17]. Finally, Abd el-Maguid substantiated this perspective, drawing support from studies of the Khufu Boat and various illustrated evidence[18].

Doyle proposed that, except for larger vessels, there was little necessity for steering oars to be installed on both sides. This conclusion was drawn from the observation that numerous Old Kingdom reliefs seldom depicted helmsmen with all steering oars positioned over the far side **[FIGURE 1]**. Moreover, some boats and rafts appeared too small to accommodate more than a single helmsman[19] [**FIGURE 6].**

[13] BOREUX 1925: 387-403.
[14] ROUGE 1981: 58.
[15] LEHMANN 1978: 95.
[16] THURNEYSSEN 1980: 3.
[17] JONES 1990: 38.
[18] ABD EL-MAGUID 2009: 34.
[19] DOYLE 1998: 92.



[FIGURE 6]: A small boat carries a single helmsman. Giza tomb of *Snb*, fourth dynasty. JUNKER 1941: FIG.14b.

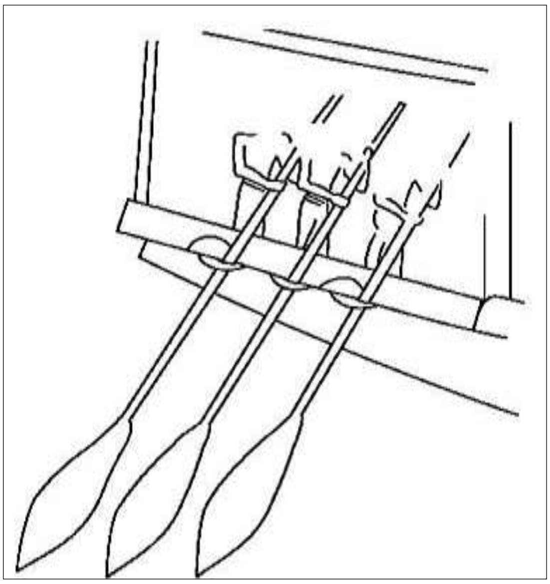
Gilmer posited that the larger Egyptian vessels navigating the Nile necessitated more than a single helmsman. In this context, the helmsman naturally depended on the lateral movement of the steering oar blades. This was attributed to the boats having a relatively short waterline and long overhangs[20]. Stephens proposed that helmsmen would reposition themselves on the side of the vessel based on the direction in which it was turning. When turning to port, they would align along the port stem quarter, and when turning to starboard, they would align along the starboard quarter. This arrangement, according to Stephens, allowed each helmsman to mimic the stance and actions of the person in front of him when all the rudders were placed on the same side of the craft. This disposition maximized the pressure exerted by the rudders, ensuring uniform bracing and angling of all the rudders. It also provided an additional advantage by utilizing the pressure of the water against the rudders to force the looms of the rudders against the side of the hull, enhancing the firmness of the steering[21]. Mark identified the steering devices of the Old Kingdom as quarter rudders, describing them in pairs. He proposed that these steering devices could function as primitive fulcrums, enabling a steersman to push a steering oar away from the hull as well as forward and aft. Additionally, Mark suggested that a loom line could serve as a fixed point or axis, allowing a steersman to turn these steering oars partially. This versatile steering device might facilitate the use of steering oars in all three directions[22].

[20] GILMER 1999: 186.
[21] STEPHENS 2012: 66.
[22] MARK 2012: 90.

IV. STEERING DEVICES' DEVELOPMENT

The most basic approach to navigating a paddle or oar-propelled vessel involves directly using the paddle or oar. However, the evolution of steering mechanisms during the Old Kingdom highlighted the convenience and advancements achieved by incorporating a dedicated steering device at the stern of the craft[23].

In the Old Kingdom, boats were navigated using one or more hand-held steering oars suspended over the quarters. The oars' looms were manipulated through rope or leather grommets, or they were supported within semicircular grooves carved into the ends of a cross-beam inset into the deck just forward of them **[FIGURES 3, 6-7].**



[FIGURE 7]: Steering device pivots; Saqqara, Mastaba of *Ty*, fifth dynasty. MARK 2012: 89.

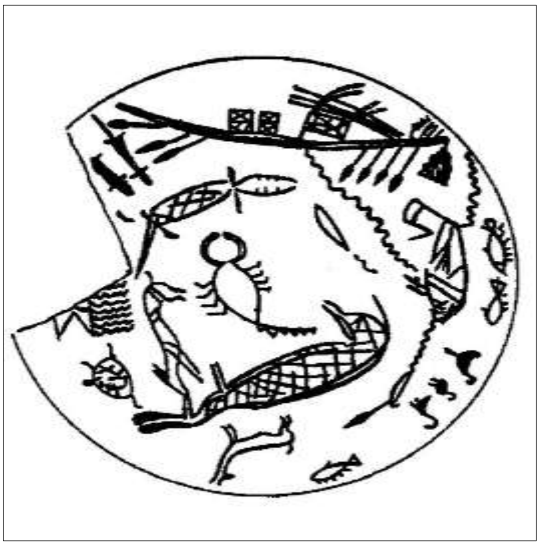
These steering oars could be operated by either turning them on their axis or levering them against the boat's side, causing the boat to turn following the outward thrust of the blade. Toward the end of the Old Kingdom, short cross pieces were added near the butt-ends of the steering oars to enhance the steersman's control. Eventually, a notable development had the steering oar mounted on a vertical stanchion[24].

Technical enhancements in steering devices, introduced to enhance boat performance during the Old Kingdom, are elaborated in:

1. Steering oar

In the Old Kingdom, vessels propelled by oars or paddles primarily relied on the crew's adherence to the captain or pilot's instructions, with the rudder(s) playing a stabilizing role. This steering arrangement offered limited control, suggesting that the Egyptian sailors were not substantially aided by their rudimentary rudder[25]. The use of steering oars persisted from the Predynastic period **[FIGURE 8]** through the Old Kingdom, representing a relatively primitive method of vessel control[26].

[23] ROUGE 1981: 57.
[24] JONES 1990: 38-39.
[25] STEPHENS 2012: 69.
[26] DOYLE 1998: 89.

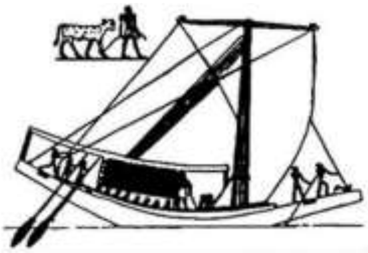


[FIGURE 8]: Boat depicted on a bowl; Naqada II. MCGRAIL 2004: 17.

The true steering oar with rotational capability is recognized as the oldest and most versatile form of steering. However, it is acknowledged as one of the most physically demanding for the helmsmen[27]. In Old Kingdom boat scenes, depictions ranged from one to five steering oars, with two being the typical number on passenger boats. On cargo boats, the usual representation was one steering oar, though occasionally two were depicted [28] [**FIGURE 9**].

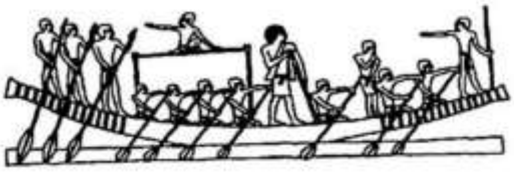
As a natural progression, the subsequent developmental phase aimed to alleviate helmsmen from strenuous tasks and enhance the steering force by increasing the number of steering oars. While this evolution was not particularly inventive in terms of the steering mechanism itself, it effectively addressed the challenges posed by the demanding nature of steering tasks[29].

A



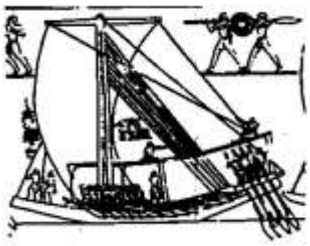
Two steering oars. Giza, Tomb of *Kaemankh* fifth dynasty. JUNKER 1940: PL.3

B



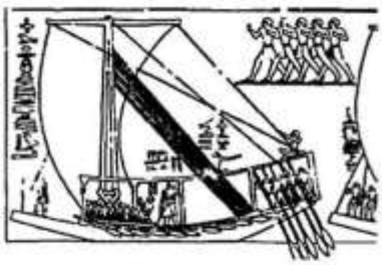
Three steering oars. Giza, Tomb of *Kanenisu*t fifth dynasty. JUNKER 1940: 156

C



Four steering oars. Saqqara, Mastaba of *Ty*. fith dynasty. DOYLE 1998: 17.

D



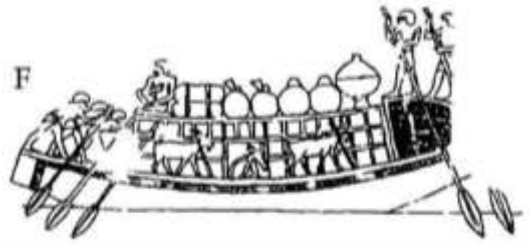
Five steering oars. Saqqara, Mastaba of *Ty*.fith dynasty. DOYLE 1998: 17.

[27] GILMER 1999: 185.

[28] EDGERTON 1927: 255.

[29] GILMER 1999: 185; DOYLE 1998: 96.

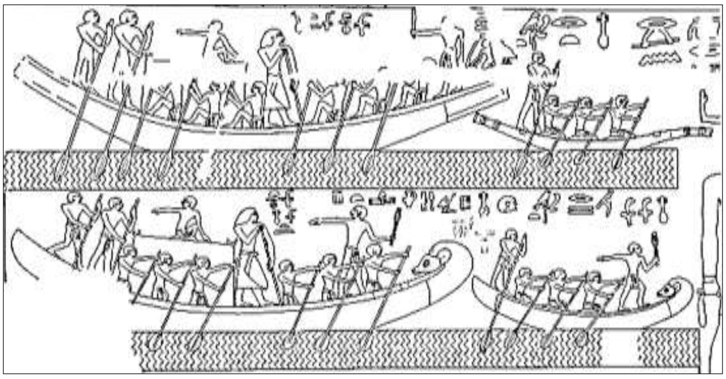
Cargo boat with one steering oar. Dahshur, fifth dynasty. LANDSTROM 1970: 60.



Cargo boat with two steering oars. Abusir, Tomb of *Ptahshepses*. fifth dynasty. DOYLE 1998:12.

[FIGURE 9]: Different Old Kingdom's steering devices.

During the fourth dynasty, some steersmen seemed to be steering with freely held steering oars[30] **[FIGURES 2/C & 10]**, a practice that Mark found physically impossible[31]. Iconographic evidence provided little indication that the steering oars were firmly attached, if at all, to the vessel's hull, allowing for considerable freedom of movement. In numerous instances, helmsmen were depicted with their left arms wrapped around the upper length of the oar, suggesting a form of loose and flexible control[32] **[FIGURES 2/C & 10].**



[FIGURE 10]: Helmsmen show their left arms wrapped around the loom. Giza tomb of *Nesutnefer*, fifth dynasty. KANAWATI 2002: PL.54.

Boreux expressed skepticism about how helmsmen, using steering oars, could influence the vessel's course solely through the "strength of the wrist" without any additional support. He believed that this seemingly inconvenient steering gear would limit the duration of voyages, implying potential inefficiency in prolonged navigation using such a mechanism[33].

In the fifth dynasty, the pivots for steering were depicted as horizontal half circles, with one per rudder, securely attached to the hull. These pivots could be situated at the junction between the deck line and the bulwark or at deck level. The steering oar preventer ropes extended from the connection point of the loom and blade, securing them to the grommet[34] **[FIGURE 3/B & 7]** on the quarter. The angle is relatively

[30] MCGRAIL 2001: 33.
[31] MARK 2012: 89.
[32] GILMER 1999: 185,187.
[33] BOREUX 1925: 388.
[34] STEPHENS 2012: 69.

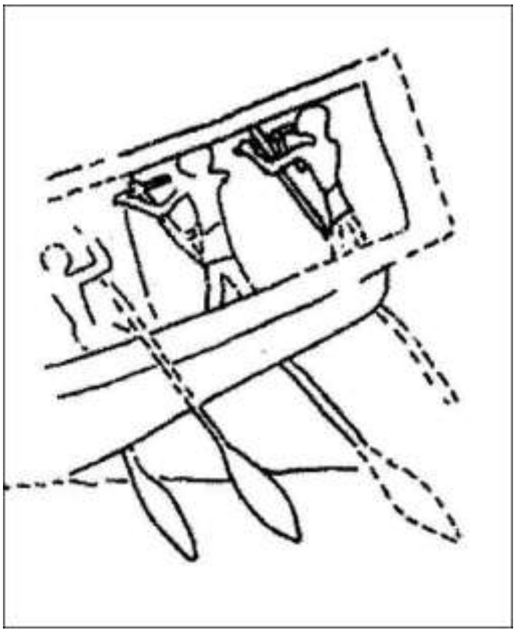
steep by today's standards[35]. Additionally, Stephens proposed that, apart from steering by adjusting the oar's angle to the fore and aft lines, this securement method had a dual benefit: it provided greater stability to the rudder, preventing its loss if the helmsman were to lose grip, and also facilitated the steering task by shifting the weight of the rudder from the helmsman's hands to the hull itself[36].

Certain scenes depicted the grommet and preventer rope arrangement used to secure the rudder, showcasing the rudders positioned against the forward edge of protruding beams. This configuration was illustrated on the Mastaba of *Akhethetep* from the fifth dynasty in the Louvre Museum and *Ty*'s tomb in Saqqara **[FIGURE 3/B]**. This suggests that such a form of steerage would impart increased firmness to the rudders. When positioned aft of the beam, the rudders would naturally tend to trail a little astern, with the amount of trail being regulated by the preventer rope. While in motion, the water pressure against the looms would push them against the beam, creating a more robust pivotal point for turning the rudder[37]. McGrail proposed that the sailors might utilize a push stroke to maneuver the boat in this setup[38]. Gilmer suggested that the oars in use were transitioned to axial rotation for steering, offering a significantly easier and more efficient method. The oar, in this evolution, essentially became a primitive rudder, turning about its axis. Gilmer added that for a sailing craft, this type of steering and helmsman was both the most natural and desirable approach[39].

2. Steering oars with tiller

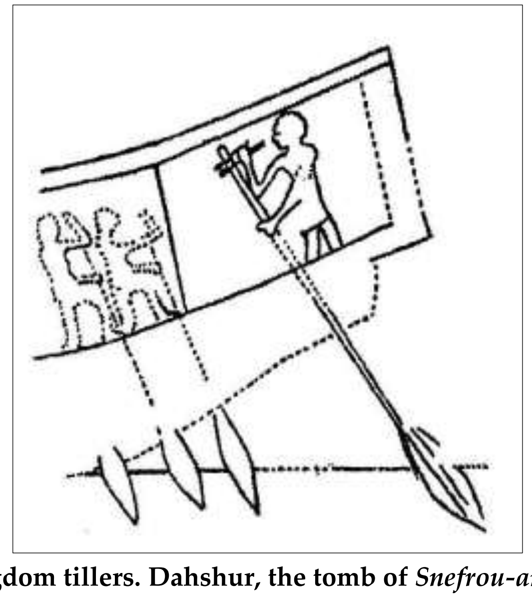
The ancient Egyptians along the Nile evidently acknowledged the necessity for increased power in their steering systems, as they began incorporating a third and even a fourth or more helmsmen. Eventually, they recognized the significant advantage offered by the tiller[40], which substantially eased the helmsman's task[41]. The introduction of the tiller marked its appearance during the fifth dynasty. This device was relatively short and extended from the loom at nearly a right angle, projecting in either one or both directions. Among the earliest tombs depicting the tiller were those of *Ptahhotep and Akhethetep* in Saqqara **[FIGURE 4]** and the tomb of *Snefrou-ani-mertf* in Dahshur[42] **[FIGURE 11]**.

[35] MCGRAIL 2001: 34.
[36] STEPHENS 2012: 69.
[37] STEPHENS 2012: 70.
[38] MCGRAIL 2004: 34.
[39] GILMER 1999: 187.
[40] GILMER 1999: 186.
[41] CASSON 1995: 18.
[42] EDGERTON 1927: 257- 259; CASSON 1995: 18; DOYLE 1998: 103; MCGRAIL 2004: 33.



[FIGURE 11]: Old Kingdom tillers. Dahshur, the tomb of *Sneferu-ani-mertef*. fifth dynasty Helmsmen operating steering oars with tillers. EDGERTON 1927: 260.

The introduction of the tiller would provide enhanced control over the steering oar, reducing the physical effort required. With the lower hand serving as a fulcrum, the upper hand could manipulate the steering oar via the tiller **[FIGURES 4 & 12]**. Despite this advancement, Stephens argued that, since the helmsman still needed to force the blade into the water and support the weight of the steering oar, it may not represent a substantial improvement after all[43].

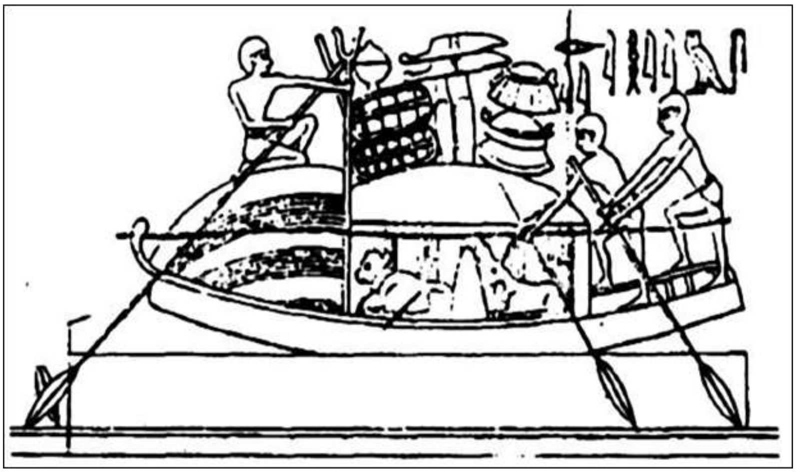


[FIGURE 12]: Old Kingdom tillers. Dahshur, the tomb of *Snefrou-ani-mertf*, fifth dynasty. DE MORGAN 1894-1895: PL.21.

With the introduction of the tiller, helmsmen might adopt a more seated position rather than standing, a departure from previous practices. A standing helmsman at the quarters would hold the tiller with the far hand and the loom of the steering oar with the near hand or both hands. In the case of a seated helmsman, the tiller would be held

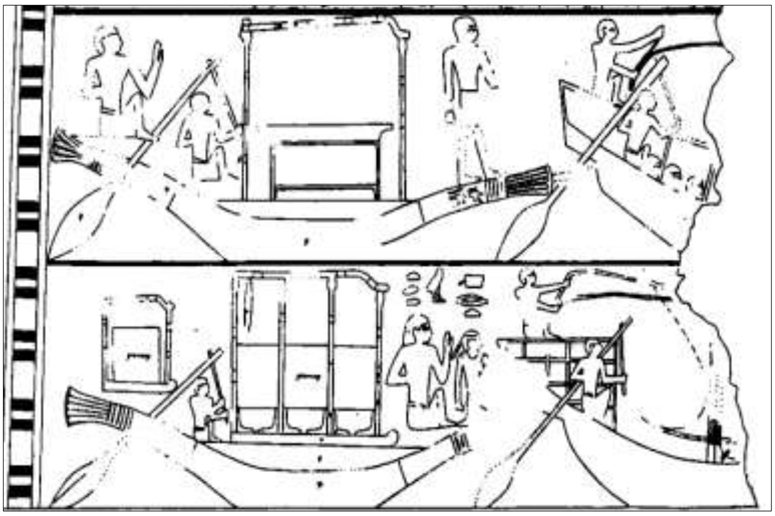
[43] STEPHENS 2012: 69.

with one or both hands **[FIGURES 11-12]**. However, an occasional error by a draftsman resulted in the depiction of a helmsman grasping not the tiller but the mast crutch[44] **[FIGURE 13]**.



[FIGURE 13]: Rudder post. Saqqara, the Tomb of *Ptahhotep*. fifth dynasty. DOYLE 1998:185.

In the sixth dynasty, there was a trend for the tiller to become longer and to hang vertically from the loom[45]. Despite its vertical appearance, the helmsman's use of both hands implies that it extended horizontally **[FIGURE 14]**, aligning athwart the ship and parallel to the deck. The manner in which it was held resembled the grip one might have on the handlebars of a bicycle[46].



[FIGURE 14]: Horizontal tiller. Deir El-Gebrawi, the tomb of *Aba*, sixth dynasty. DAVIES 1902: PL.X.

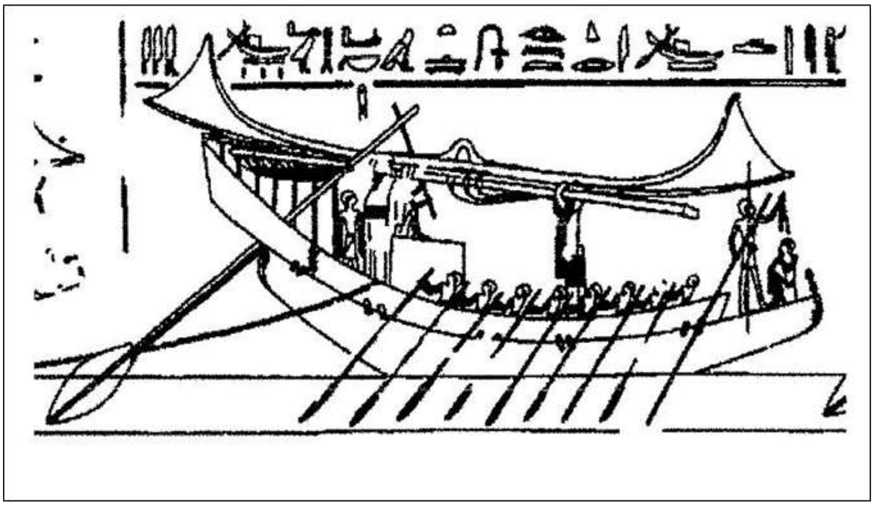
3. Axial rudders in the Old Kingdom

Towards the end of the Old Kingdom, a notable shift occurred, and the single steering oar with a tiller, pivoted on the stern and against a vertical stanchion, became increasingly prevalent. The introduction of the tiller brought forth another innovation: the stern-mounted steering oar **[FIGURE 15].**

44 DOYLE 1998: 103.

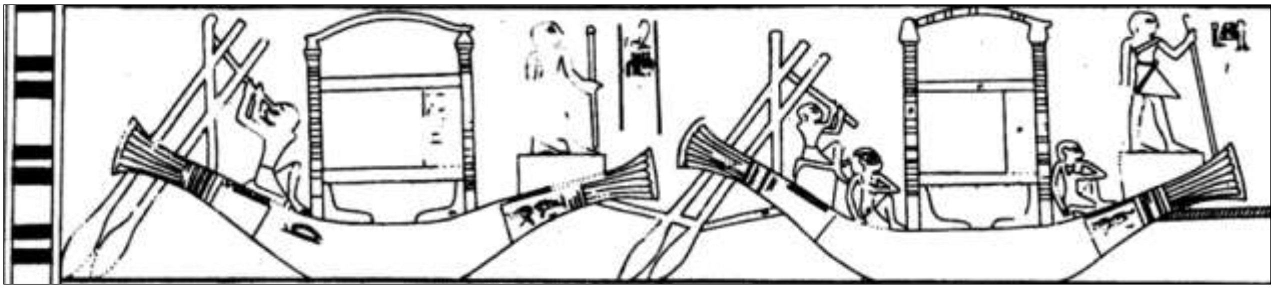
45 EDGERTON 1927: 262.

46 DOYLE 1998: 103.



[FIGURE 15]: The stern-mounted steering oar; Meir, the Tomb of *Pepi-anch Heni-kem*, sixth dynasty. BLACKMAN 1914: PL.XLII.

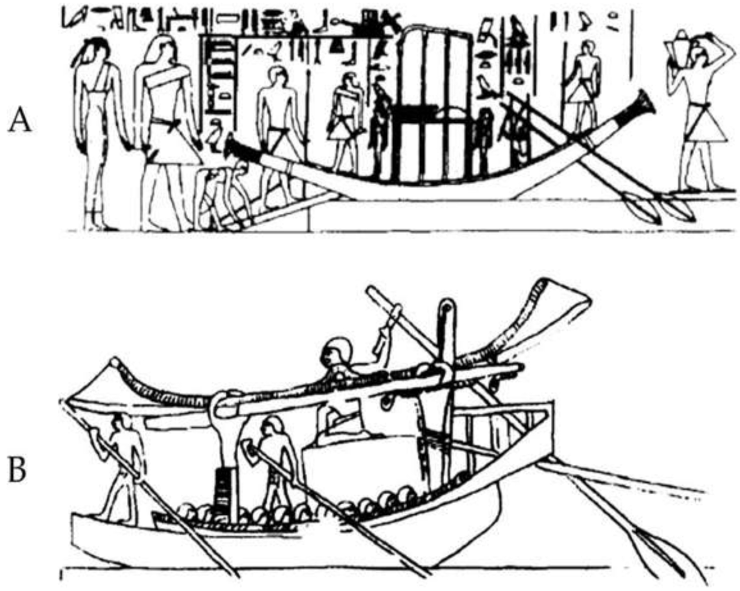
Steering oars might be affixed to curved or straight timbers projecting up from each corner of the flat stern. The most well-known depictions of the axial rudder are found in the tombs of Deir El-Gebrawi from the sixth dynasty. From the sixth dynasty onward, the steering oar could only be turned on its axis [47] **[FIGURE 16].**



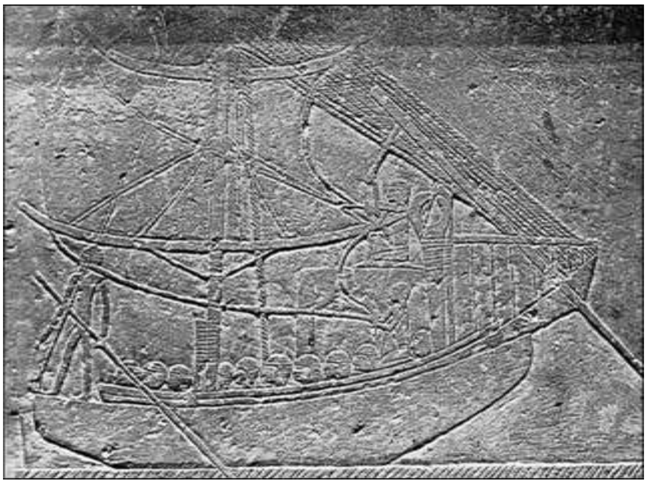
[FIGURE 16]: Steering device stanchions; Deir El Gebrawi, Tomb of *Zau*, sixth dynasty. DAVIES 1902: PL. VII.

Draftsmen illustrated various methods of fastening rudders to stanchions. In the scene from the tomb of *Pepi-anch Heni-kem* in Meir, lashings were depicted holding the loom to the stanchion. Alternatively, in scenes like the one at the tomb of *Ipy* in Saqqara, the loom seemed to pass through a loop of rope reefed through an eye in the stanchion. In this case, the loom did not appear to be secured by the stanchion but was merely supported by it **[FIGURE 17].** Draftsmen might portray two stanchions, as seen in *Pepi-anch Heni-kem*'s tomb, or only one, as in *Ipy*'s tomb. If this was the case, it signified an intermediate step between the steering oar with a tiller and the development of the rudder. Like steering oars, rudders could be mounted either over the stern, as seen in *Ipy*'s tomb, or at the quarters, as depicted in the tomb of *Pepi-anch Heni-kem*. In certain instances, crosspieces were likely employed, although they might not be visible in two-dimensional representations **[FIGURE 15].** Tillers were typically long and extended forward of the stanchion, in front of which the helmsman would sit[48]; this arrangement allowed a helmsman to manage two rudders simultaneously or handle the tiller and braces concurrently **[FIGURES 17/a-18].**

[47] EDGERTON 1972: 262; DOYLE 1998: 103; BELOV 2014: 3.
[48] DOYLE 1998: 103,110.

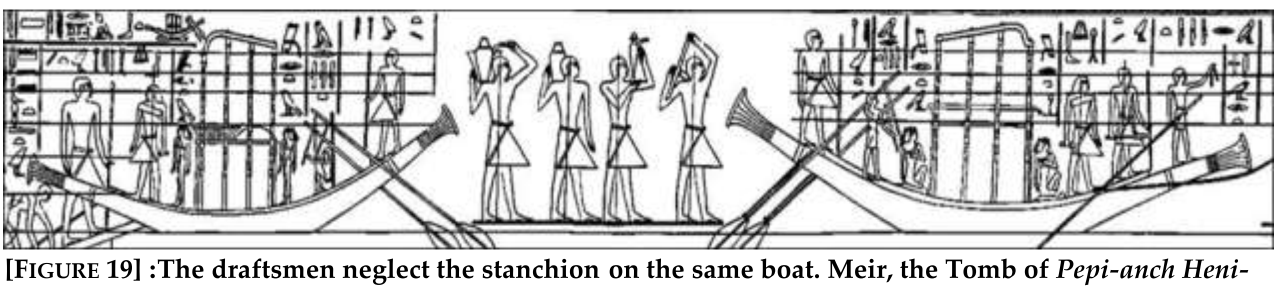


[FIGURE 17]: Different stanchions. A.Meir, the Tomb of *Pepi-anch Heni-kem*. sixth dynasty. BLACKMAN 1914: PL. XLIII; B. Saqqara, Tomb of *Ipy*. sixth dynasty, VANDIER 1969.2: PL.XXXIX, FIG.301.



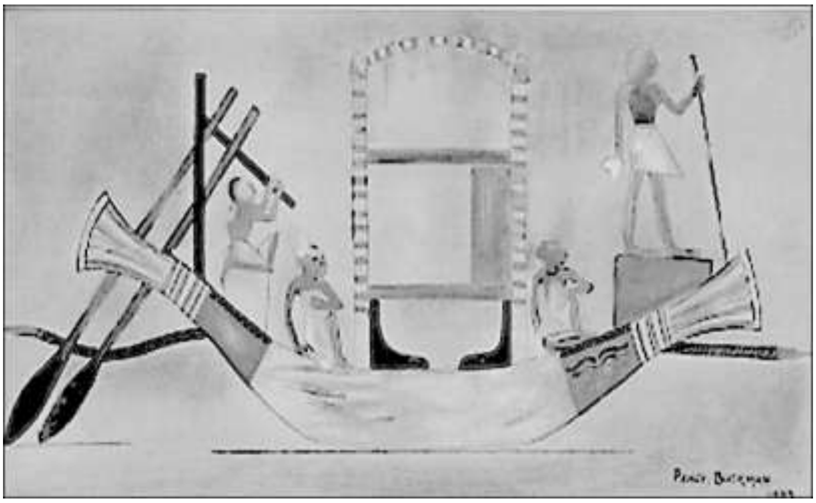
[FIGURE 18]: The helmsman handles the tiller and braces. Saqqara, the Tomb of *Ipi*, sixth dynasty. DOYLE 2006: 16.

Draftsmen occasionally omitted the stanchion, even when portraying the same boat. For instance, in the tomb of *Pepi-anch Heni-kem* in Meir, stanchions were illustrated aboard the boat in one depiction and then neglected in another portrayal of the same boat **[FIGURE 19]**.



[FIGURE 19] :The draftsmen neglect the stanchion on the same boat. Meir, the Tomb of *Pepi-anch Heni-kem*. sixth dynasty. WENZEL 2007: 359.

In some scenes, draftsmen neglected to connect the rudder with the stanchion; the loom might be angled to avoid any contact with the stanchion **[FIGURE 13]**. Alternatively, both rudders might appear on one side of the vessel, and a single tiller might be sufficient for two rudders, as observed in the tomb of *Zau* in Deir El-Gebrawi from the sixth dynasty **[FIGURE 20]**. It is essential to interpret these images not as factual representations but as early examples in the depictions of rudders.



[FIGURE 20]: A single tiller suffice for two rudders. Deir El-Gebrawi, the Tomb of *Zau*, sixth dynasty. DAVIES 1902I: PL.VII.

V. CONCLUSION

In conclusion, the steering devices employed in the Old Kingdom's boats could be categorized into two main types: the steering oar and the rudder. Both devices were utilized at either the quarters or the stern of the vessel. The steering oar, characterized by a larger blade than that of a rowing oar, was mounted solely to the planking or a crosspiece, allowing it to be freely levered against the hull. This technology persisted from the Predynastic period to the Old Kingdom. The rudder, featuring an oar with a tiller mounted to a stanchion, emerged by the late fifth dynasty.

The disappearance of grommets in scenes before this period does not necessarily indicate their absence in reality, as the strength of helmsmen's wrists alone would not have been sufficient for steering.

The tiller was invented during the fifth dynasty after the reign of *Sahure* and before *Djedkare*, suggesting a transition from lateral to axial steering. By the end of the fifth dynasty, the grommet was replaced by a stanchion (rudder post), potentially evolving from the stanchion used to support dismounted masts and yards. The researcher suggests that both axial and lateral steering methods were used consecutively, not simultaneously, with the lateral method preceding the axial. The evolution of steering devices aligns with Mott's notion that the replacement of one technology by another is a complex and multifaceted process[49]. Furthermore, there might not be a need for double steering in smaller or lighter boats, but larger transport boats in the Old Kingdom often featured double the number of displayed steering oars.

Finally, the iconographic representations of the Old Kingdom's transport boats served as invaluable sources of information, offering insights into the technological advancements of Ancient Egyptian shipwrights. These depictions, showcasing the oldest presentations of planked boats known to date, provided rich documentation of a diverse fleet adapted to the unique challenges of the Nilotic environment. The fleet's gradual development over centuries reflected its ability to navigate and thrive in the specific conditions of the Nile, showcasing distinctive traditions of construction and navigation.

[49] MOTT 1997: 154.

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THE ORIGIN OF USING DOVETAIL JOINTS IN ANCIENT EGYPTIAN BOATS AND SHIPS

Article 6

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The Origin of Using Dovetail Joints in Ancient Egyptian Boats and Ships

Abstract

[Ar] **أصالة استخدام مفصلات ذيل الحمامة في السفن المصرية القديمة**

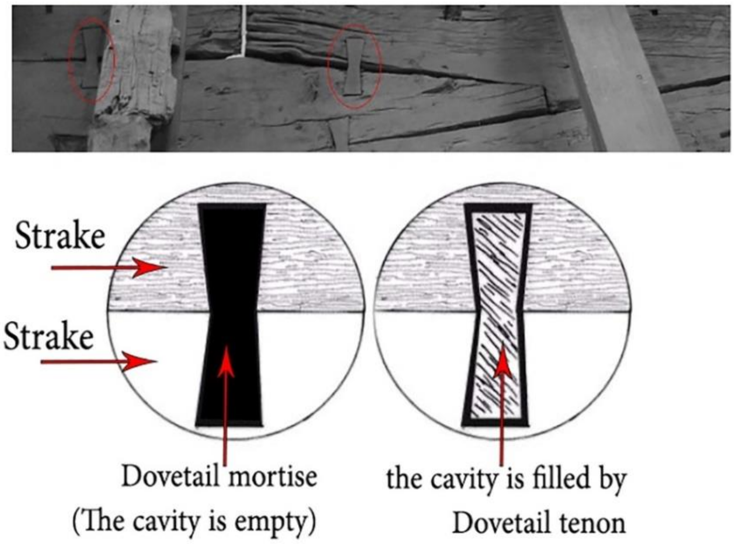
شهدت الحضارة الفرعونية تنوعًا في صناعة السفن طبقاً للوسط المائي الذي أبحرت فيه السفينة سواء نهر النيل أو البحرين الأحمر والمتوسط، بالإضافة إلى المسطحات المائية مثل البحيرات والقنوات. كان لبناة السفن خصائص خاصة في طرق ربط وتجميع ألواح المراكب، إحداها تُسمى ذيل الحمامة. على الرغم من ظهور طريقة ذيل الحمامة في الاثاث والتوابيت المصرية القديمة في العصور المبكرة، إلا أنها ظهرت لأول مرة في صناعة السفن فى الدولة الوسطى فى سفن دهشور، والتي كثر الجدل بين العلماء حول ماهية استخدام تقنية مفصلات ذيل الحمامة بالدُسرة أم بالخياطة في تلك السفن، حيث اختلفت أراء العلماء حول أصلية استخدام هذه التقنية؛ بعضهم يعتقد إن ذيل الحمامة استُخدم مع الخياطة وأن ما يوجد في الوقت الحاضر من دسُر ما هو إلا تجديد أَضيف بعد اكتشاف السفن في أوائل القرن الماضي عوضاً عن الخياطة، والبعض الأخر يعتقد أنه استُخدم مع الدسُر منذ القدم. مع مطلع القرن الحادي والعشرون، اكتشف علماء الآثار البحرية ألواح سفن تعود إلى فترة الدولة الوسطى في كهوف مرسى وادي جواسيس على ساحل البحر الأحمر، وعلى أحد هذه الألواح ظهرت نقر مفصلات ذيل الحمامة. تناقش هذه الورقة البحثية ماهية طريقة ذيل الحمامة في ربط ألواح السفن وأهميتها، وتستعرض اختلافات آراء العلماء حول استخدامها مع الخياطة أم الدسُرة، وتقديم ملاحظة الباحث التي تؤكد وتُحسم الجدل حول استخدام تلك المفصل مع الخياطة ام الدسُرة في سفن دهشور اعتماداً على مقارنتها بما ظهر في ألواح السفن من مرسى وادي جواسيس.

[En] Ancient Egyptian civilization experienced a variety of ships designed for different bodies of water, including the Mediterranean, the Red Sea, and the Nile River, as well as lakes and canals. Shipbuilders used special fastening methods to assemble their ships, such as the use of dovetail joints. While the dovetail technique was applied in ancient Egyptian furniture and coffins, it was first observed in the Egyptian shipbuilding of Dahshur boats in the Middle Kingdom. The antiquity of dovetail joints with ligatures or tenons in Dahshur boats has long been debated by archaeologists. Thus, different theories have been presented on the originality of using dovetail mortise with ligatures or tenons. Some authors believed that it was originally used with ligatures, but tenons were modified after the boats' discovery in the early 20th century, while others argued that it was used with tenons from ancient times. In the early 21st century, archaeologists discovered the dovetail technique in ship timber at Mersa / Wadi Gawasis on the Red Sea, dating back to the Middle Kingdom. This paper aims to explore the significance of the dovetail technique in ancient Egyptian shipbuilding, as well as the various theories on its use with tenons or ligatures. It presents the author's analysis and observation to resolve the controversy about its use in Dahshur boats, based on a comparison with the ship timbers of Wadi Gawasis.

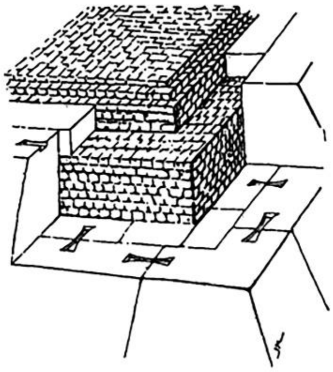
KEYWORDS: Assemblage, dovetail, tenon, shipbuilding, boats, ships, maritime archaeology, Middle Kingdom.

I. INTRODUCTION

First, what is the significance of the dovetail? It is a method of fastening used to assemble the hull planks to provide transverse reinforcement. This technique is embedded within the inner surfaces of the planks and consists of two components: the dovetail mortise and the dovetail tenon. The latter is a solid wooden piece, composed of two trapezoidal shapes meeting at their summits and positioned within the cavity of the former, which is divided into two sections at the seams of the planks **[FIGURE 1]**. The complete joint is used to secure the connection between each pair of planks from their internal surface[1]. The dimensions of the dovetail tenon are equal to those of the two parts of the dovetail mortise. Although the dovetail technique was observed in ancient Egyptian furniture and coffins in the fourth dynasty and was employed to join the blocks of the pyramid of Senwosret III[2] **[FIGURE 2]**, it initially appeared in the Egyptian shipbuilding of Dahshur boats in the Middle Kingdom[3].



[FIGURE 1]: Dovetail mortise and tenon joints © Drawing and photo used with the permission of P. Creasman. CREASMAN 2005: 13. Modified by the author.



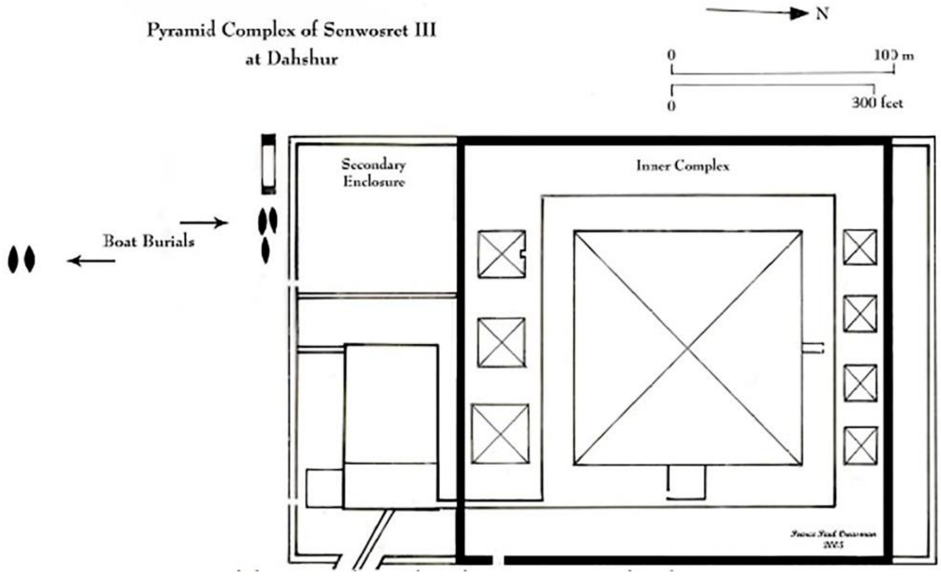
[FIGURE 2]: The pyramid blocks were connected by dovetail mortise and tenon © Drawing by De Morgan. DE MORGAN 1895:48, FIG.108.

[1] MCGRAIL 2004: 38; CREASMAN 2010:116.
[2] HALDANE 1984:100-101; DE MORGAN 1895: 48, FIG.108.
[3] WARD 2000: 93; CREASMAN 2005: 11.

II. ARCHAEOLOGICAL EVIDENCE

1. Dahshur Boats

Dahshur boats were discovered by Jaques De Morgan on the southeastern side of the southern wall of the funeral complex of the pyramid of Senwosret III in Dahshur **[FIGURE 3]**. They were dated back to 1850 BC[4]. Four assembled boats were found and divided into two groups, with a distance of one hundred meters. Two of these boats were initially kept in the Egyptian Museum in Cairo. However, they were relocated to the Sharm El-Sheikh Museum in 2020. The remaining two boats can be found in the Chicago Museum and the Carnegie Museum in the United States. Regrettably, the location of the fifth boat at the site remains unknown. All the boats are of similar size, featuring a rounded shape and constructed using arched brick-shaped planks. This design allowed the even distribution of stress across the hulls, and they were specifically designed to be Nilotic boats[5].



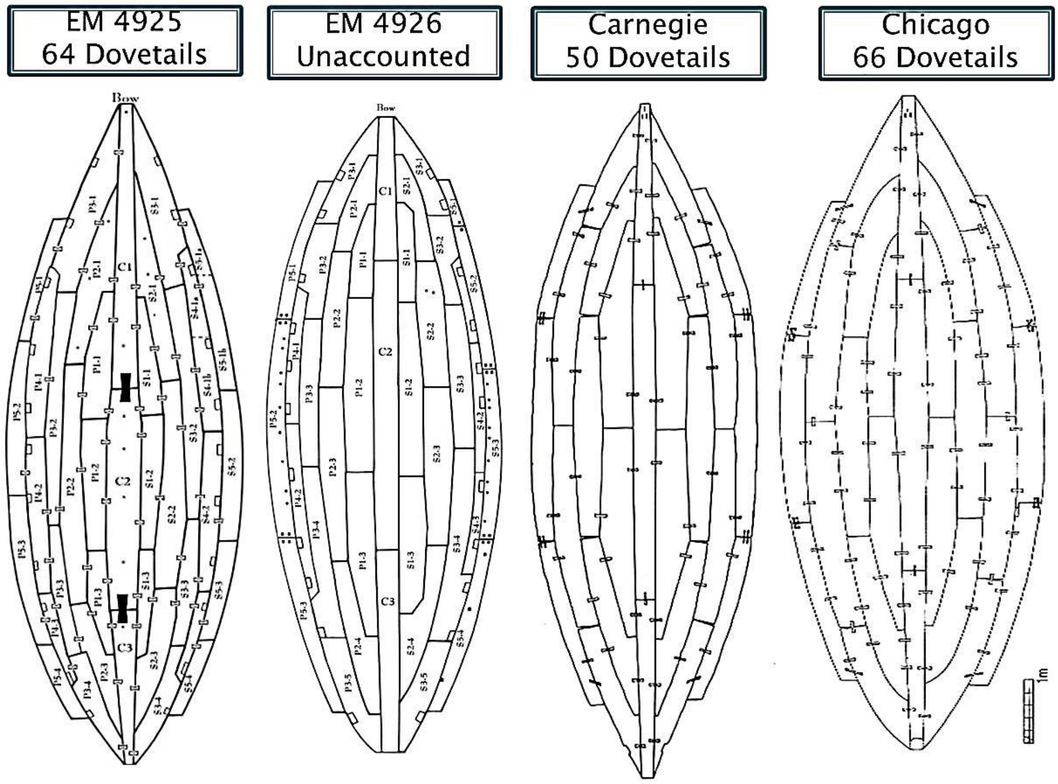
[FIGURE 3]: A plan shows the pyramid complex and the discovered boats in Dahshur © Drawing by Creasman. Drawing used with the permission of P. Creasman. CREASMAN 2005: 10.

2. Assemblage of the Dahshur Boats

The hull planks were firmly fastened using deep mortise and tenon joints, as the primary method of fastening in the Dahshur boat. These joints were arranged in transverse rows as internal frames, with every two joints placed in pairs at 5-15 cm from each other, while the distance between each pair was 25-60 cm[6]. Lashing methods were used in specific areas, such as between the ends of the bulwark strakes and the sheer strakes. Additional lashing was utilized to bind the extremities of the bow and stern strakes[7]. Dovetail joints were a common feature in Dahshur boats, with dovetail tenons measuring 13-17 cm long, 5 cm wide at the widest point, 3 cm at the narrowest point, and 2 cm deep. These joints were distributed at 70-100 cm from each other, with each

[4] HALDANE 1984: 3; WARD 2000: 84; ABD EL-MAGUID 2009: 59.
[5] MCGRAIL 2004: 37-38; CREASMAN 2010: 120-121,123.
[6] HALDANE 1984: 23-24; WARD 2000: 90, 92, 97; BELOV 2019: 107.
[7] CREASMAN 2010: 121.

half dovetail mortise measuring 8.5 cm long at the middle of the ship and 6.5 cm long towards the extremities of the boat. Additionally, bitumen was used by shipbuilders to fill the joints and seams to prevent any leakage[8]. The number of dovetail joints varied across the four boats: EM 4925 had 64 joints, EM 4926 had an unknown number, the Carnegie boat had 50 joints, and the Chicago boat had 66 dovetail joints[9] **[FIGURE 4]**.



[FIGURE 4]: Distribution and number of dovetail joints in each boat; Chicago and Carnegie boats. © Drawing by Ward. Drawings used with the permission of Cheryl Ward. HALDANE 1984: 14-49; EM 4925 and EM 4926 boats © Drawing by Creasman. Drawings used with the permission of P. Creasman. CRESMAN 2005: 48, 91; assembled and modified by the author.

The originality of the dovetail tenon has been a subject of inquiry for a considerable period. Some scholars believe that the dovetail tenons are not original and were added as modern modifications after the excavation of the boats. In opposition, others argue that they are an original technique developed in shipbuilding during the Middle Kingdom.

3. Different Opinions on Dovetail Joints

De Morgan[10], the discoverer of the boats, did not mention dovetails or lashing in his reports but reported the concealed mortise-and-tenon joinery between hull planks. Forthingham[11] pointed out that the boats needed repairs before being moved to the museum, and the hull planks were fixed with dovetail dowels and wooden treenails. Moreover, Reisner[12] observed that the Dahshur hulls were assembled using mortise and

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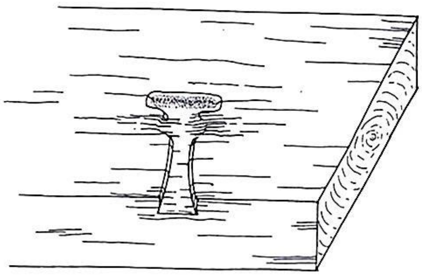
9 HALDANE 1984: 56-57, 100; Creasman 2005: 63; ABD EL-MAGUID 2009: 65; CREASMAN 2010: 123.

10 DE MORGAM 1895: 82.

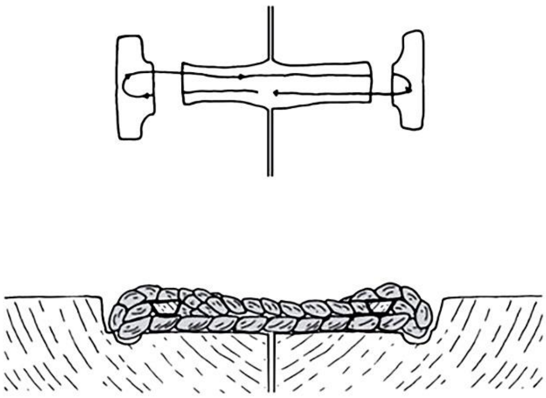
11 FORTHINGHAM 1895: 72.

12 REISNER 1913: XXIII.

tenon and tied planking. Although he could not confirm the use of dovetail with tenon or lashing, he believed that most dovetail tenons in these boats are modern. Clarke[13], on the other hand, described the state of the ship in the Egyptian Museum and stated that they were in bad condition, and it is difficult to distinguish between the old and new repairs in the boats because they were repaired after the discovery. Ward[14] believed that dovetails were used with ligatures in the original case, and those dovetail tenons were a recent modification, following the discovery of the boats in the last century. She noticed the shallowness of the dovetail mortises and interpreted the erosion in the edges caused by ligatures. She found the oval shapes of a few mortises **[FIGURE 5]**, well cut and located in the Carnegie hull, and these mortises were the bases of the ligature channels that escaped modification **[FIGURE 6]**. She presented proof that all the dovetails in all the hulls were modern and the assemblies were located in the same places as the ligature points in the Lisht planks **[FIGURE 7]**.



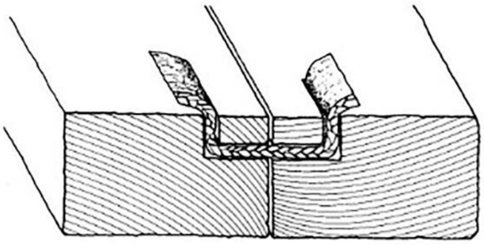
[FIGURE 5]: The oval shape of the Carnegie boat motivated Ward to think that they were used with a ligature © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 94, FIG. 43.



[FIGURE 6]: Ward's theory regarding the utilization of lashing as opposed to dovetail tenons for the assemblage of the Dahshur boats © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 95, FIG.44.

[13] CLARKE 1920: 7.

[14] HALDANE 1984: 101; WARD 2000: 93-94.

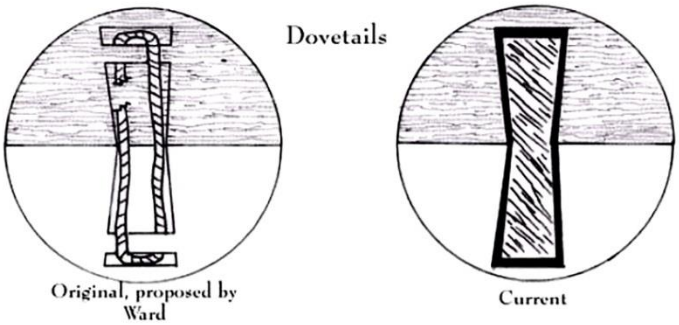


[FIGURE 7]: Lashing by single stitching or a single point in the Lisht timbers © Drawing by Ward. Drawing used with the permission of Cheryl Ward. WARD 2000: 118, FIG.63a.

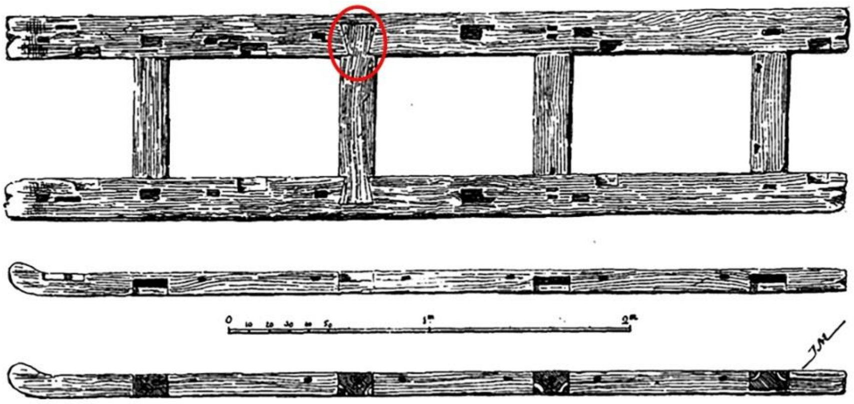
Steffy[15] thought that shipbuilders did not use lashings for edge joinery below the waterline in Dahshur boats, and the lack of frames seemed strange. However, the construction provided enough structural integrity for travel on the Nile. The tenons and mortises provided substantial bottom support, but secure dovetail fastenings or lashings still seemed necessary internally to prevent the planks from separating. McGrail[16] agreed with Ward and believed that the arrangement of the large tenons into mortises in all strakes, even if they were unpegged, could have ensured the hull.

Creasman[17] presented an alternative perspective, arguing that the fastening method was original, with dovetail tenons filling their respective mortises and conforming to the same Egyptian measurements (digit and palm) used in mortise and tenon joints. The dovetail tenons were approximately two palms long, 3 digits at the widest edge, and 2 at the narrow edges. The Cairo boats exhibited jagged edges resulting from ancient chisels, with no evidence of smooth edges caused by lashing straps. In contrast to the evidence found by Ward in the Carnegie boat **[FIGURE 8]**, there was a lack of proof regarding the presence of ropes or animal skin. Upon comparing the dovetail in the ships' timber of Wadi Gawasis, Creasman observed that it exhibited an opposing position on each side of the board, similar to the discovery of numerous half-dovetail tenons. This finding suggested a clear association between these tenons and the ship components[18]. Additionally, Creasman noted the existence of dovetail mortise and tenon joints in all four boats, despite variations in their numbers, suggesting their originality[19]. The discovery of three sledges with the boats, each containing at least one dovetail mortise tenon joint **[FIGURE 9]**, denoted the shipbuilders' familiarity with this fastening method. Creasman speculated that this technique might have been imported from countries conquered by the kings of the 12th dynasty, or it could have been a rapidly abandoned evolution, which explained its rare use in ship construction.

[15] STEFFY 1994: 35-36.
[16] MCGRAIL 2004: 38.
[17] CREASMAN 2005: 119-124.
[18] CREASMAN 2010: 117.
[19] ABD EL-MAGUID 2009: 68.



[FIGURE 8]: Comparison between Creasman's theory on using dovetail tenon and Ward's theory on using lashing © Drawing by Creasman. Drawing used with the permission of P. Creasman. CREASMAN 2005: 13, FIG.9.



[FIGURE 9]: A sledge was discovered with the Dahshur boats, probably used to carry the boat, bearing a dovetail tenon, see the red circle © Drawing by De Morgan. DE MORGAN 1895: 83, FIG.204.

In contrast, Abd el-Maguid[20] argued that De Morgan, the discoverer of the boats, did not mention or refer to the dovetail joints in his report. He only acknowledged the presence of mortise and tenon joints. Furthermore, Abd el-Maguid commented on Forthingham's note, which was published four months after the discovery, and did not consider it as evidence of the use of dovetail joints. He proposed that during the interim period, the boats might undergo some repairs, as Clarke realized that these ships were repaired after their discovery, due to their transfer to the museum. Abd el-Maguid supported Ward's theory because she had the opportunity to closely examine the hull planks of the Carnegie boat in the United States. In his opinion, after the discovery, the ligatures were replaced with tenons. However, the discovery of the Wadi Gawasis segment, which was analysed for the first time, revealed two opposite dovetail mortises on the inner face, suggesting that dovetail joints were likely used only between the first strake and the central strake. This was due to the hydrodynamics of the boat, which would cause the dovetails to break in the remaining strakes, necessitating the use of lashings instead of tenons[21].

After presenting these contradicting viewpoints, a question arises as to whether the dovetail tenons observed in the Dahshur boats were ancient or a recent modification. Additionally, the significance of Wadi Gawasis ship timber in the context of shipbuilding will be considered.

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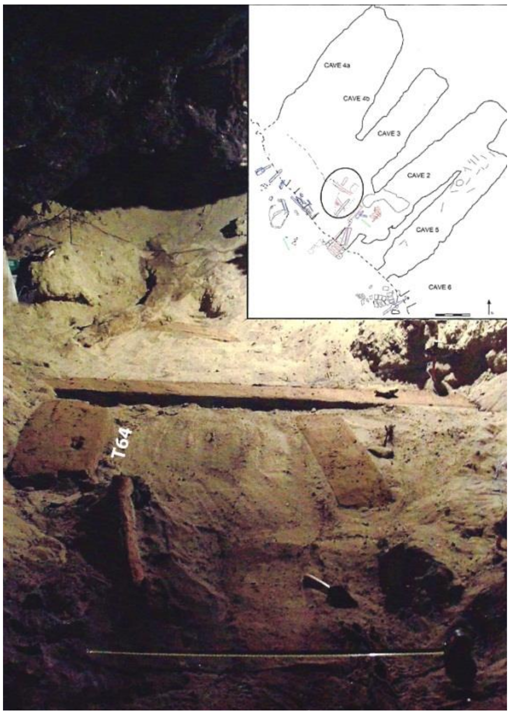
[20] ABD EL-MAGUID 2009: 66-69.

[21] ABD EL-MAGUID, M. (Alexandria Library), interview by author. 17/05/2018.

4. T64 Hull Plank Segment

T64 segment was discovered in Cave 3 at Mersa/Wadi Gawasis, dating back to the Middle Kingdom, based on the information provided by a wooden box discovered in SU25 (strategic unit 25) in WG32 (Wadi Gawasis 32) near Cave 6. The box had an inscription referring to Amenemhet IV, the ruler of Egypt from 1786 to 1778 BC. In addition, the pottery and ceramics found in the caves referred to the Middle kingdom[22]. Furthermore, it exhibited noticeable resemblances to the boat construction techniques employed in the Middle Kingdom like those observed in Dahshur boats and Lisht timbers[23]. Mersa/Wadi Gawasis and its caves were constructed to facilitate state expeditions from Koptos to Punt. The ships were built at a shipyard along the Nile in Koptos, dismantled for transportation across the Eastern Desert, and then reassembled at the Red Sea harbors for their voyages **[FIGURE 10]**. T64 shed light on an ancient Egyptian technique for fastening ships, which could be compared to the method used in the construction of Dahshur boats. T64 referred to a section of plank that archaeologists have identified as being part of a ship's hull planks. It belonged to the first strake that was fastened to the keel[24]. It contained valuable information about the fastening methods employed, including pegged and unpegged deep and double mortise-and-tenon joints. Additionally, there was evidence of a ligature for copper strips and two opposite dovetail mortises on the inner face of the plank like in Dahshur boats[25] **[FIGURES 11-12]**.



[FIGURE 10]: T64 segment is lying along the length of Cave 3, with the permission of K. Bard & Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. ZAZZARO & CALCAGNO 2012: 77.

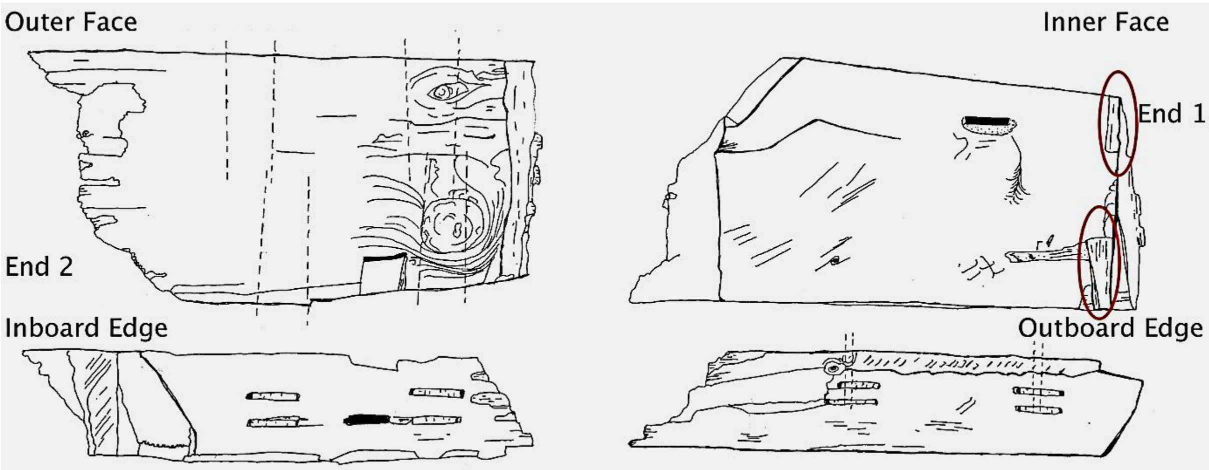
[22] MAHFOUZ & PIRELLI 2007: 47; PERLINGIERI 2007: 27-28; WARD et al. 2010: 389; FATTOVICH & BARD 2012: 23; MADY 2020: 2.

[23] WARD 2007: 137.

[24] Its dimensions are: 106 cm long; 50.5 cm wide; 22.5 cm thick.

[25] WARD & ZAZZARO 2010: 27-31,33-36,38,40; WARD et al. 2010: 387-388; MADY 2020: 2.

[FIGURE 11]: T64 segment shows two opposite dovetail mortises in the inner face of the plank, see the red circle. With the permission of K. BARD and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. ZAZZARO & CALCAGNO 2012: 79.



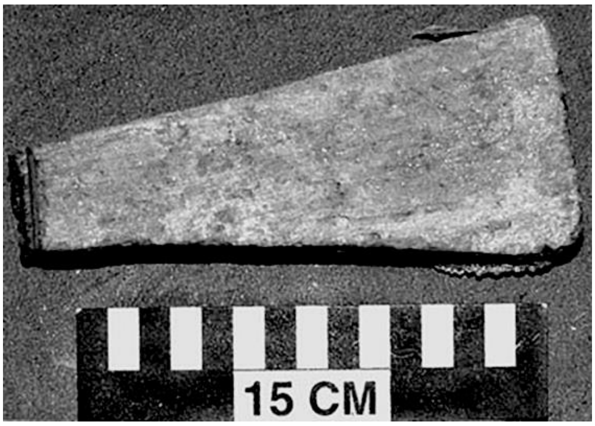
[FIGURE 12]: An illustration shows some fastening methods and the dovetail mortises, see the red circle ©Drawing by Ward. Drawing used with the permission of Cheryl Ward and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO; WARD et al. 2010: 388, FIG.1.

These dovetail mortises are the primary focus of this research. As noted by Creasman and Abd el-Maguid, there are similarities in the position of the dovetails when compared to Dahshur boats. This T64 segment served as the second piece of evidence of dovetail joints in shipbuilding in the Middle Kingdom. Ward and Zazzaro[26] compared the beams in Dahshur boats and those in Wadi Gawasis. They discovered similarities in the square holes found at each end of the beams. Furthermore, they observed that the beams in Wadi Gawasis were larger, indicating that they belonged to larger vessels. The author compared the dovetail mortise and tenon in Dahshur boats and the T64 segment.

[26] WARD & ZAZZARO 2010: 32,35.

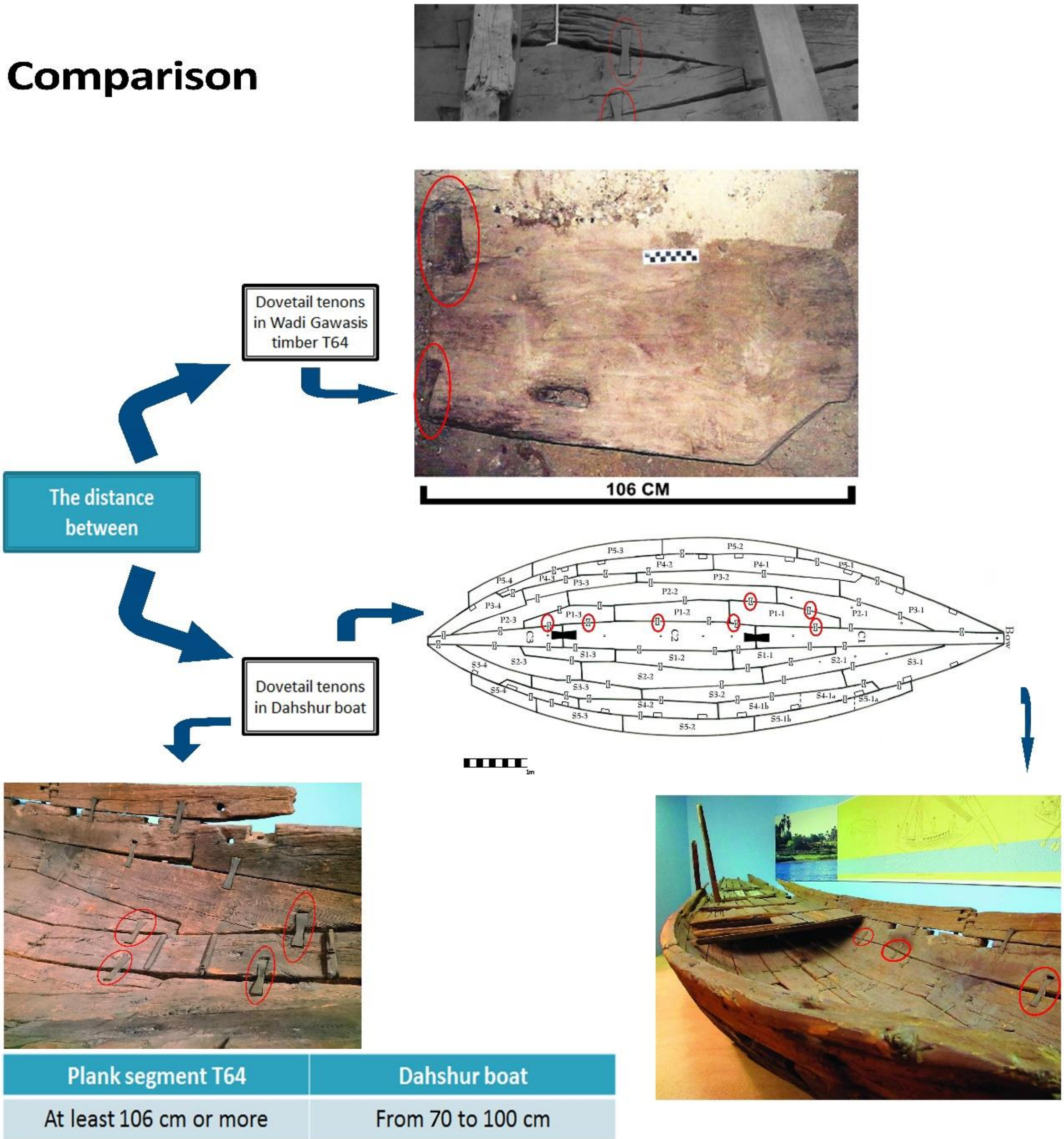
III. COMPARISON

The T64 segment occupied a position within the first strake of the ship, either forward or aft[27] with dimensions, as the author noted above. When compared to the Dahshur boat, the planks in the forward and aft sections of the first strake ranged from 160 cm to 186 cm long, with a minimum width of 7 to 12 cm and a maximum width of 24 to 30 cm. The thickness at the outboard edges was 9 cm and at the inboard edges, it was 9.5 cm[28]. The half dovetail mortise measured 14.5 cm long, leading to an estimated full length of 28-30 cm. It had a width of 3.4 - 6.5 cm and a depth of 3.8 cm. In contrast, the half dovetail mortise in the Dahshur boat had an estimated length of 7.5 cm from a full length of 13 - 16.5 cm. Its width at the narrow midpoints was 1.5 - 2 cm, while at its widest point, it measured 4 - 5 cm. The depth was 2 cm[29]. A total of 15 half-dovetail tenons were found near Cave 3, one of which corresponded to those in the T64 segment and measured 15 cm long[30] **[FIGURE 13]**. The dovetails in the Dahshur strakes were spaced approximately 70 cm apart at the extremities of the hull and 80 - 100 cm apart in the middle, these dimensions elucidated that the T64 segment might belong to a ship bigger than the Dahshur boat twice as Ward reached the same result when compared between the beams of Wadi Gawasis and Dahshur. According to Creasman's observation of the similar opposite dovetails in T64 and Dahshur boats supported the hypothesis that dovetail tenons were an original fastening method and not a later modification. Another observation by the author, reinforcing this possibility was the presence of only two opposite dovetails at the end of T64, with no others along the remaining 106 cm segment **[FIGURE 14]**. This finding indicated that the distance between those dovetails and the other dovetails in the missing part of the plank must be 106 cm or more, compared to the distances between dovetails in Dahshur boats, ranging 70-100 cm apart[31]. It reflected the desire of the shipbuilders to use the dovetails in the large distances between each other.



[FIGURE 13]: A half dovetail tenon which corresponds to the measurement of dovetail mortise in T64; © With the permission OF K.BARD and Courtesy of the joint expedition at Mersa/Wadi Gawasis of the University of Naples «L'Orientale», Boston University & ISMEO. WARD & ZAZZARO 2010: 38.

[27] WARD et al. 2010: 387-389.
[28] CREASMAN 2005: 49.
[29] HALDANE 1984: 57; STEFFY 1994: 33; CREASMAN 2005: 63,105.
[30] CREASMAN 2005: 122; CALCAGNO & ZAZZARO 2007: 31-33; WARD & ZAZZARO, 2010: 37-38; WARD et al. 2010: 387; ZAZZARO & CALCAGNO 2012: 70.
[31] HALDANE 1984: 26; Creasman 2005: 105.



Plank segment T64	Dahshur boat
At least 106 cm or more	From 70 to 100 cm

[FIGURE 14]: Cresman's observation in addition to the author's observation about the use of dovetail Tenons in both Dahshur boats and T64 in the wide distances © photos and drawing used with the permission of P. Creasman. CREASMAN 2005: 13; PETERS et al. 2017: 100 © a photo of T64 used with the permission of K. Bard. ZAZZARO & CALCAGNO 2012:79. Figures were assembled and modified by the author.

IV. CONCLUSION

After analyzing the position of T64 in the first strake, it is confirmed that dovetail mortise and tenon were used not only between the keel and the first strake but also connected between the first and second strakes like in the case of Dahshur boats. Shipbuilders desired to use dovetails in a large space between each other, as the author noted above, reflecting two points that probably interpreted the large spaces; the first point was that dovetails probably played a secondary role in securing the hulls, which were already secured by deep mortise and tenon from the internal edges; the second point was that even though the dovetail had the same importance in securing like mortise and tenon joints, they were probably spaced so far from mortise and tenon joints to avoid the weakness of the planks caused by digging a large part from the plank thickness. After presenting different perspectives and opinions and drawing comparisons and analyses between the available pieces of evidence, along with the author's observation, it could be confirmed that dovetail tenons were used on Dahshur boats as an original fastening method and not a modern modification in the last century after the excavation.

ACKNOWLEDGMENT

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Maritime and Underwater Cultural Heritage
in the Arab Region 9/2

AUTOBIOGRAPHY OF WENI (2)
SOME REMARKS ON THE EXPEDITION OF HATNUB

Article 7

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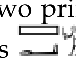
AUTOBIOGRAPHY OF WENI (2) SOME REMARKS ON THE EXPEDITION OF HATNUB

ABSTRACT

[AR] **سيرة وني الذاتية (2) بعض الملاحظات على بعثة حتنوب**

تجري الدراسة الحالية فحصًا دقيقًا لجزء من المساعي الملاحية المسجلة في السيرة الذاتية لويني خلال عهد الملك مرنرع، وتبين تفاصيله بشكل دقيق؛ إذ سجل وني في سيرته الذاتية قيامه برحلة نهرية نجح فيها في بناء مركب ذي خصائص محددة - نوعًا ومادّة وأبعادًا - لنقل مائدة قرابين من حتنوب إلى سقارة خلال مدة محددة. وعلى الرغم من بساطة مفردات وني، وخلوها من التعقيد، إلا أنها لا تزال عصية على الفهم بشكل واضح - رغم تعدد ترجمات النقش وتنوعها - لاعتماد وني على أسلوب بلاغي ذي مسحة شديدة الإيجاز. الأمر الذي حال كثيرًا دون إماطة اللثام عن عدد كبير من التفاصيل اللغوية والملاحية من ناحية أخرى. ويكمن مفتاح فك رموز هذا النقش في خطوتين أساسيتين: أولًا، تحديد معاني المصطلحات المتعلقة ببناء المركب مثل  و ، وتبيان دلالاتهما اللغوية والسياقية بشكل دقيق. ثانيًا، مقارنة هذين المصطلحين بالأفعال الأخرى المستخدمة لأغراض مماثلة في أنشطة وني الملاحية في سيرته الذاتية. ثالثًا، تفسير أسباب استخدام وني لهذا الأسلوب في وصف بعثته النهرية. ويهدف هذا النهج إلى التحقق من صحة فترات بناء المركب والملاحة، بالإضافة إلى تمييز الأهمية الحقيقية للإطار الزمني المكون من السبعة عشرة يومًا، والجوانب الملاحية الأخرى ذات الصلة. ومما لا شك فيه أن التكامل بين دراسات الآثار المصرية وعلم الآثار البحرية كفيل بإلقاء الضوء على هذه الاستفسارات.

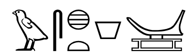
[EN] The current study undertakes a closer examination of a segment of the nautical endeavors chronicled in Weni's autobiography, which pertains to an expedition involving the construction of a barge with specific characteristics in terms of type, wood, and dimensions for the transportation of an offering table from Hatnub to Saqqara within a determined period. Despite the apparent simplicity of the vocabulary used in this inscription, it poses several challenges due to adopting the literal meanings, thereby impacting the translation and comprehension of the inscription. The key to deciphering this inscription takes two primary steps: Firstly, delineating the meanings of terms related to boatbuilding in the inscription, such as  and , and understanding their precise and contextual significance; secondly, comparing these verbs with others employed for similar purposes elsewhere in Weni's autobiography. This approach aims to validate the durations for the barge construction and navigation and discern the true significance of the seventeen-day timeframe and other pertinent nautical aspects. Undoubtedly, the integration of studies in Egyptian archaeology and nautical archaeology promises to shed light on these inquiries.

KEYWORDS: Autobiography, barge, boatbuilding, boatyard, caulking, expedition, nautical, navigation, Weni.

I. INTRODUCTION

Weni's autobiography is inscribed on a monolithic limestone slab, originally part of a wall in the single-room tomb chapel in the Northern Necropolis in Abydos[1]. The inscription comprises fifty-one vertical columns, and it is preceded by a horizontal line containing a prayer for offerings[2]. It is currently housed in the Egyptian Museum in Tahrir[3].

Weni held various positions during the reign of three consecutive kings of the 6th dynasty (Teti, Pepi I, and Merenre)[4] and was entrusted with numerous tasks, all of which he fulfilled, according to his narration, to the fullest[5]. Among these tasks were five nautical expeditions. In the fourth expedition, conducted during the reign of King Merenre (as detailed in lines 42 to 45), Weni was commissioned to journey to Hatnub to quarry and transport an offering table to Saqqara aboard a barge made of acacia wood[6].

In a previous article, we explored common themes across the five expeditions, including the use of acacia as the primary local wood for boat construction, particularly for the working boats; the type of barge referred to as  with dimensions of (60 x 30 cubits), conforming to Egyptian boat sizes and nautical archaeology standards. We noted that while the length was typical and feasible, the length-to-width ratio (2:1) was somewhat unusual, though the name of the barge, meaning «wide», may elucidate its exceptional width. Additionally, we observed Weni's concise and brisk narrative style, characterized by a preference for brevity and a tendency to avoid detailed explanations. This linguistic approach mirrors the constraints faced by artists in the Old Kingdom's tomb scenes, suggesting shared religious and practical conventions between autobiographies and depictions[7].

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[1] A group of blocks inscribed with a copy of the autobiography of Weni was found in Saqqara in 2012. The terms of the autobiography, which describe the hierarchical rise of Weni and several episodes of his life, are too similar in the two versions. However, the two texts are not identical. We find passages added or omitted in each of the texts but they don't concern the expedition under question. COLLOMBERT 2015: 145-157.

[2] LICHTHEIM 1973: 18. Compare MARIETTE 1864: 286; TRESSON 1919: III; EL-KHADRAGY 2002: 61-62; RICHARDS 2002: 82; KLOTH 2002: 11.

[3] Inv.CGC 1435. Width: 2.70 ms; Height: 1.10 ms; nearly half a meter thickness. For the dimensions of the slab, see: MARIETTE 1864: 286; MARIETTE 1880a: 84, Nº.522; MASPERO 1890-1900: 25; BREASTED 1906: 134, Nº.a; TRESSON 1919: III; BORCHARDT 1937: 115-119 [1435], and PLS.29-30; PIACENTINI 1987: 3, N°.1; EL-KHADRAGY 2002: 61; RICHARDS 2002: 39, 78, 82; KLOTH 2001: 11. BROVARSKI mentioned that the slab may be originally wider than 2.70 m. He stated that at the right end of the slab is a single column of sunken hieroglyphs facing left; followed by five other columns, all facing right. It is impossible to ascertain how many columns occupied the lost section of the slab to the right. BROVARSKI 1994: 115, Nº.122.

[4] BREASTED 1906: 134 § 291; PORTER & MOSS 1937: 72; ROCCATI 1986: 852; KLOTH 2001: 11.

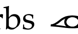
[5] RICHARDS 2002: 39, 78.

[6] For Weni's activity in Hatnub quarries, see: PETRIE 1894: PL.XLII; ANTHES 1964: 14, TAF.5, Inschrift VI; SHAW 1986: 194; GRIMAL 2005: 112; SHAW 2005: 435; STRUDWICK 2005: 147; GOURDON & ENMARCH 2017: 237.

[7] AL-SHARKAWY & ABD EL-MAGUID: Forthcoming.

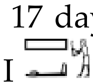
Our discussion now turns to the location of the barge's construction site in the Hatnub quarries and the duration of its construction and navigation. Numerous scholars believe that the barge was constructed in a seventeen-day timeframe. Yet, this hypothesis fails to address the feasibility of completing such a vessel in such a short period.

II. METHODOLOGY

Drawing on their respective scientific backgrounds, the two authors collaborate to ascertain whether Weni constructed the acacia barge in 17 days, as translated by most scholars, or if there is an alternative interpretation. Their investigation also encompasses the duration of navigation and other nautical aspects. Adopting an analytical descriptive approach, the authors begin by translating the relevant paragraph and scrutinizing the two verbs employed therein:  and . They consider Weni's other nautical activities documented in his autobiography, if necessary, to interpret or compare certain terms, such as the verbs  and . Subsequently, they analyze the boatbuilding processes and procedures deduced from texts, iconography, or excavated materials to assess the feasibility of constructing a barge of such dimensions in this short period.

III. THE INSCRIPTION

hꜣb w(ꞽ) ḥm[=f] [43] *r Ḥwt-nbw r ꞽn.t ḥtp ꜥꜣ n(y) šs.t Ḥwt-nbw s:hꜣꞽ=k(w) n=f ḥtp pn n hrw 17 wḥꜣ(.w) m Ḥwt-nbw rd.y nꜥꞽ=f m-ḫdꞽ(=ꞽ) m <w>sḫ.t t[n]* (44) *šꜥ=k(w) n=f wsḫ.t m šnḏ n(y).t mḥ 60 m ꜣw=s mḥ 30 m wsḫ=s sp.t n 17 hrw m ꜣbd 3 šmw sṯ n wn[.t]* (45) *mw ḥr ṯs.w mnꞽ(=ꞽ) r (mr) ḫꜥ(ꞽ)-nfr-Mr(ꞽ)-n-Rꜥ m ḥtp ḫpr.n m-ꜥ(=ꞽ) m-ḳd ḫft ḥw wḏ.n ḥm n nb (=ꞽ)* [8]

«[His] majesty sent me[43] to Hatnub to bring a great offering table of alabaster of Hatnub[9]. I brought this offering table down for him in 17 days. After it was quarried[10] in Hatnub, I had it go downstream in this *wsḫ.t*-barge; (44) I  ? for it (the offering table) a *wsḫ.t*-barge of acacia wood of 60 cubits in length and 30 cubits in width  ? in 17 days in the third

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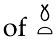
[8] Text: SETHE 1903: 107, 16-108, 10. See also for example: DE ROUGÉ 1866: 139-140; MARIETTE 1880b: PL.45 [43-46]; MASPERO 1890-1900: PL.XVIII [43-46]; BRUGSCH 1891: 1476-1477 [42-45]; TRESSON 1919: 7 [43-46]; HOFMANN 2002: 228 [43-46].

[9] BREASTED and LANDSTRÖM read  *rwd.t* «enduring or hard stone», and «hard stone» respectively. See: BREASTED 1906: 149, N°.d; LANDSTRÖM 1970: 62. For the reading and true meaning of  *šs* «alabaster», see: ERMAN & GRAPOW (eds.): *Wb* 1971: vol.4, 540, 10-12.

[10] BREASTED mentioned that «the word *wḥꜣ* is used for cutting grain, papyrus, plucking grapes, separating blocks from the quarry, etc. It is used (in pseudo-participle) exactly as here, in the Hammamat inscription of the official Sesostris (LEPSIUS 1849: 11, 138, e): *twt … wḥꜣ m rnp.t tn*, «a statue … quarried in this year»; and often in the quarry inscriptions». See: BREASTED 1906: 149, N°.e.

month of *šmw* when there was no (45) water on the sandbanks. It landed at the Pyramid «Merenre-appears-in-splendor» in safety. It came about through me entirely in accordance with the royal ordinance commanded by my Lord»[11].

IV. LINGUISTIC ANALYSIS

The initial inspection of the inscription reveals that Weni did not furnish any explicit details regarding the construction phases of the barge. He contented himself with employing only two terms. Weni's linguistic pattern suggests that the construction process consisted of merely two stages. Unfortunately, these two terms proved insufficient for delineating the complete building phases of the barge. Adding to the ambiguity of the inscription is Weni's description of constructing other boats used to transport the massive granite blocks for King Merenre's Pyramid in Saqqara, as detailed in his 5th expedition. In this instance, he also utilized only two expressions: «his majesty sent (me) to excavate ... and to build  (*ir.t*) three *wsḫ.t*-barges …» and «to draw  (*sṯꜣ*) the timber for them»[12]. In the forthcoming pages, we delve into the interpretation of these four terms from a linguistic perspective.

1. ,  and their Literal and Contextual Significance

Weni employed two terms,  and , to encapsulate the entire process of barge construction. Both terms denote several meanings, some of which may not directly relate to boatbuilding compared to the broader group of terms found in inscriptions and depictions of Egyptian nautical activities in boat construction. Therefore, examining these two terms is crucial for grasping their literal and contextual significance, which in turn is essential for accurately interpreting the inscription.

A. 

In the Egyptian language, «*šꜥ*« signifies actions, such as «cut off», «cut up», «knock down», «divide into pieces by cutting», and « diminish»[13]. This term finds its primary association with the Pyramid Texts. Within these texts, «*šꜥ*» was employed to convey threats, intimidation, slaughter, and dismemberment[14]. Additionally, it was linked to cutting barley in a few instances[15]or simply cutting something[16]. However, «*šꜥ*» did not

[11] Translations: MARIETTE 1864: 287; ERMAN 1882: 24-25, 29; MASPERO 1888: 9; GRIFFITH 1894: 17-18; BREASTED 1906: 149 § 323; BOREUX 1925: 128-130; CLARKE & ENGELBACH 1930: 34; STRACMANS 1935: 514; GARDINER 1961: 97; LANDSTRÖM 1970: 62; LICHTHEIM 1973: 21; OSING 1977: 173-174; ROCCATI 1982: 196-197 § 187; GRIMAL 2005: 167; WARD 2000: 9; HOFMANN 2002: 228, 232; KLOTH 2002: 183, 202; SIMPSON 2003: 406; STRUDWICK 2005: 356; SERVAJEAN 2018: 208; ESPOSITO 2019: 40-41.

[12] SETHE 1903: 108, 13-109, 7.

[13] TRESSON 1919: 41; GARDINER 1976: 594; MEEKS 1980: [77.4097]; FAULKNER 1986: 262; LESKO 1987: 136; HANNIG 1995: 805 (1-2); WILSON 1997: 992; HANNIG 2003: 1282 (1-2); DICKSON 2006: 152; HANNIG 2006: 2425-2426 (1-2); HANNIG 2012: 156, 561; JEGOROVIĆ 2017: 320.

[14] SETHE 1960: §§ 442, 653, 673, 1212, 1337, 1339, 1545; FAULKNER 1969: 89, 123, 127, 193, 210, 211, 235.

[15] KANAWATI 2012: 50-51, PL.37, 44, 84.

[16] HASSAN 1941: 190, FIG.153.

feature prominently in depictions of boatbuilding, nor was it commonly associated with cutting timber or trees[17] for boatbuilding. Two inscriptions dating back to the Late Old Kingdom utilized «*šʿ*» in boat building, one belonging to Weni and the other to the tomb of Ni-Ankh-khnum and Khnum-hotep in Saqqara.

This last scene depicts two men positioned on opposite sides of a tree, rhythmically wielding their axes to cut through its trunk. The legend describes this act as: *šʿ ẖt in sḳd* «The tree was cut down by the boat maker»[18]. Following this scene, three subsequent scenes in the lower register depict the progression of boat construction. Among the scenes, additional legends provide further insight into the advancement of the work, such as: [*šd*].*t* [*m*] *dšr šꜣbt* «building a *dšr*-barge(?), (*i.e.*) a *šꜣbt*-boat« and *nḏr sẖt in mḏḥ* «carpentering the *sẖt*-boat by the carpenter»[19] **[FIGURE 1]**.

[FIGURE 1]: Saqqara, the tomb of Ni-Ankh-khnum and Khnum-hotep, 5th dynasty. MOUSSA & ALTENMÜLLER 1977: ABB.8.

The term «*šʿ*» denotes various meanings in the Coffin Texts[20], including «cut off», «make an incision into the body (possibly referring to surgical operations during birth)», and «be cut». In these texts, there are references to «cutting the papyrus stems» as part of constructing a papyrus boat for the deceased's journey to heaven[21]. From the Second Intermediate Period onwards, «*šʿ*» was used in the sense of «cut off»[22], with references to «cut down trees» and «cut branches from ebony trees». The first is in the Gebel Barkal stela of Tuthmosis III, where it describes punishment aimed at depriving enemies of these trees[23], and the second is in the accounts of Hatshepsut's Punt expedition[24].

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17 FAULKNER 1986: 262; HANNIG 1995: 805 (5); HANNIG 2003: 1283 (5); HANNIG 2006: 2426 (3); HANNIG 2012: 504; JEGOROVIĆ 2017: 320.

18 The authors provided several translations for *sḳd*: «sailor», «rower of a boat», «boat builder», and «woodcutter». MOUSSA & ALTENMÜLLER 1977: 74 [Sz.9.1.2], TAF.21, ABB. 8.

19 MOUSSA & ALTENMÜLLER 1977: 74-75, [Sz.9.2.1], [Sz.9.2.2], [Sz. 9.2.3], ABB.8.

20 VAN DER MOLEN 2000: 604.

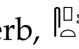
21 De BUCK 1947: 97g, 113 *n-p*; FAULKNER 1973: 158, 161.

22 BUDGE 1898: 391 [9]; GARDINER 1955: (P. Ram. IX = pBM EA 10762), 12, PL.XLA I, I; RATIÉ 1968: Tb 169, line 560; ALLEN 1974: 151; FAULKNER 1985: 149; MUNRO 1994: TAF.124 (Tb 99 B line 233); LAPP 1997: PL. 57 (Tb 153 A line 9); QUIRKE 2013: 378.

23 DE BUCK 1948: 57 [14-15].

24 NAVILLE 1898: PL.LXX; SETHE 1961: 326, 17-327, 1.

According to this historical record, the term «*šꜥ*» was rarely used in boatbuilding scenes and inscriptions. While scenes depicting the transportation of felled tree logs existed, «*šꜥ*» was not specifically associated with these depictions. This absence of «*šꜥ*» from scenes depicting tree felling was consistent across various necropoleis, spanning from the Old and Middle Kingdoms, including sites, e.g., Giza[25], Saqqara[26], Lisht[27], Beni Hasan[28], El-Hammamiya, Meir[29], and el-Moalla[30]. Surprisingly, even during the New Kingdom, «*šꜥ*» was absent from such scenes, regardless of their context[31]. This scarcity suggests that «*šꜥ*» was more closely related to other topics, such as daily life or religious practices, rather than boatbuilding.

To summarize, «*šꜥ*» in Weni's inscription means «cut» as an authentic meaning. Thus, the expression *šꜥ.k*(*i*) *n=f wsḫ.t m šnd* must be translated «*I had cut for it a wsḫ.t-barge of acacia wood*». Hence, we dismiss the translation of the verb «*šꜥ*» to mean «build a boat»[32], «made»[33], or similar meanings. The former is negated by the presence of another verb, , which is likely involved in the construction process in the same paragraph. The latter translation is contradicted by the usage of the verb  «*ir*» in the same context in the autobiography. However, the authors acknowledges translations, such as «hew ship»[34] and «to carpenter»[35], because they closely align with the direct meaning of the verb.

B. 

This term was more frequently associated with boatbuilding operations in the Old Kingdom. It usually means «to bind together a papyrus float or skiff» with ropes[36]. This meaning is clearly mentioned in the Pyramid Text § 1206 as follows:  *sp=sn sḫn.wy n*(*y.wy*) *Rꜥ šm Rꜥ im*(*=sny*) *ir ꜣḫ.t=f* «They bind together for Re the two reed-floats on which Re goes to his horizon»[37]. It is also attested in the Pyramid Text § 1209 as follows: 

bꜣ=ti ḫꜥ=ti m-ḫnt smḥ=k pw ni mḥ 770 sp(*w*)*.n n=k nṯr.w P ꜥrḳ*(*w*)*.n n=k nṯr.w iꜣb.t sḏꜣi.n=k N pn ḥnꜥ=k m šnꜥ.w smḥ=k* «You having a soul are appearing in the front of your *smḥ*-boat of 770

[25] Hassan 1943: 115, Fig. 60.
[26] Moussa & Altenmuller 1971: Pl.20.
[27] Deglin 2011: 89-90.
[28] Newberry 1893: Pl.XXIX.
[29] Deglin 2011: 89-90.
[30] Vandier 1950: Pl.29.
[31] For example: Davies 1927a: Pls.18-19, 21; Davies 1927b: Pl.XXX; Davies 1963: Pl.2; Gale et al. 2000: 353.
[32] Jones 1988: 226 [102].
[33] Strudwick 2005: 356.
[34] Breasted 1906: 149 §323; Faulkner 1986: 262; Dickson 2006: 152; Jegorović 2017: 320.
[35] Erman & Grapow (eds.): *Wb* 1971: vol.4, 416, 4; Hannig 1995: 805 (3); Hannig 2003: 1282 (3); Hannig 2012: 504, 716; Hannig 2000: 1573 (3); Kloth 2002: 183.
[36] Erman & Grapow (eds.): *Wb* 1971: vol.4, 96, 13-14; Jones 1988: 222 [76].
[37] Erman 1893: 79; Sethe 1960: 1206 *c-d*; Faulkner 1969: 192; Servajean 2018: 201.

cubits, which the gods of Pe bound together for you, which the eastern gods built for you. Take this King with you in the cabin of your *smḥ*-boat»[38]. This term also appeared as / and / in other versions of these two spells.

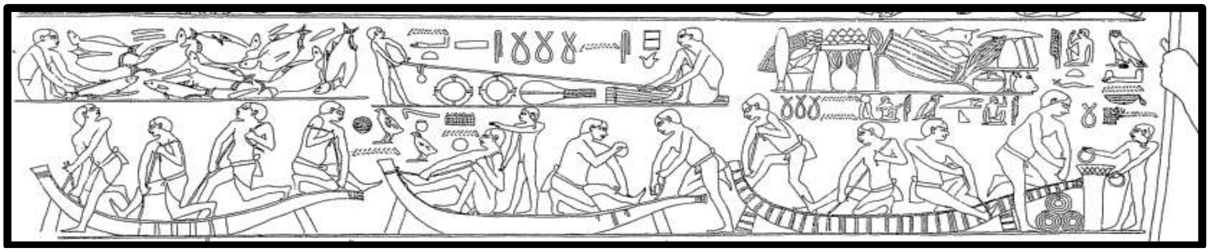
Following this principle, I emerges as a commonly encountered legend in scenes depicting boat building during the Old Kingdom. It appears with regularity, either independently or alongside other legends describing various boatbuilding operations. This usage is documented in the tombs of Rahotep, **[FIGURE** 2][39], Nefermat and Atet in Meidum[40], Urarna II in Sheikh Saïd [FIGURE 3][41], as well as Akhet-hotep-her[42], Ptah-hotep, and Akhet-hotep in Saqqara **[FIGURES 4-5]**[43], and another Akhet-hotep in the same necropolis[44]. The term is also depicted in scenes of boatbuilding in the Sun Temple of King Neuser Ra[45] **[FIGURE 6]**. Another scene, found on a limestone block from Saqqara, portrays the binding of a papyrus boat[46] **[FIGURE 7]**. It also appears in the tomb of Khunes at Zaouiyet el-Meitîn **[FIGURE 8]**[47].

This term was written: , , , , , , , and in these scenes. In other scenes, the artists depicted the operation of binding boat parts without explicitly labeling it with -legend[48]. In other instances, they included coils of papyrus ropes in the scenes[49] **[FIGURE 9]**. Additionally, there are examples where artists combined both coils and -legend together[50] **[FIGURES 3 & 8]**.

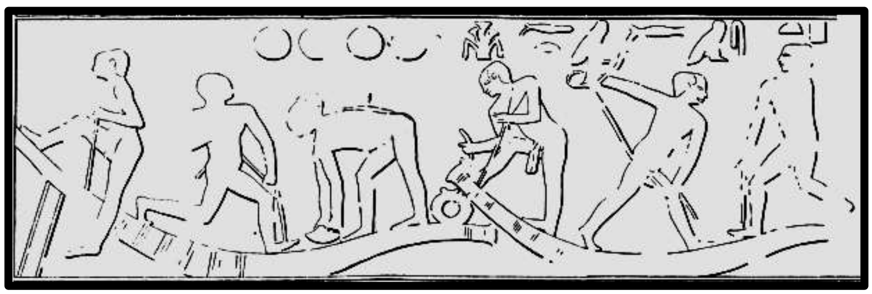
[FIGURE 2]: Meidum, the tomb of Rahotep, 4th dynasty. PETRIE 1892: PL.XI.

[38] SETHE 1960: 1209 *a-c*; FAULKNER 1969: 192; SERVAJEAN 2018: 203.
[39] PETRIE 1892: 23, PL.XI.
[40] PETRIE 1892: 26, PL.XXIII; BOREUX 1925: 177.
[41] DAVIES 1901a: 24, PL.XII; BOREUX 1925: 180-181.
[42] HOLWERDA, BOESER & HOLWERDA 1908: PL.14; BOREUX 1925: 178.
[43] GRIFFITH 1898: 28, PL.XXXII; DAVIES 1900: 10, PL.XXI, XXV-XXVI; DAVIES 1901b: 15-16, PL.XIII.
[44] SERVAJEAN 2018: 206.
[45] EDEL & WENIG 1974: PL.11.
[46] BORCHARDT 1964: 141 [1697], PL.90.
[47] LEPSIUS 1849: 106 a; BOREUX 1925: 181.
[48] See the tomb of Nebemakht (N°.86) at Giza. LEPSIUS 1849: 12 *b*; BOREUX 1925: 177-178.
[49] See the tomb of Inty at Deshaseh. PETRIE 1898: 7, PL.V; BOREUX 1925: 180.
[50] See the tomb of Urarna II (N°.25) in Sheikh Saïd. DAVIES 1901a: 24, PL.XII; BOREUX 1925: 180-181. See also the tomb of Khunes in Zaouiyet el-Meitîn. LEPSIUS 1849: 106 *a*; BOREUX 1925: 181.

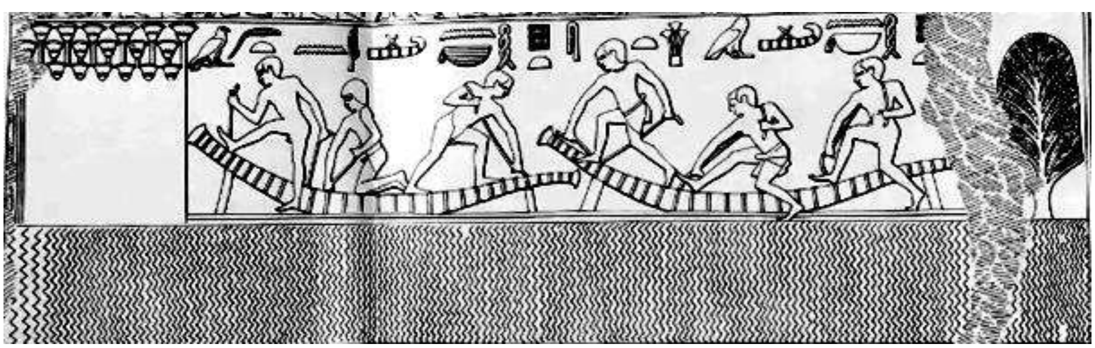
[FIGURE 3]: Sheikh Saïd, the tomb of Urarna II, 5th dynasty. DAVIES 1901a: PL.XII.



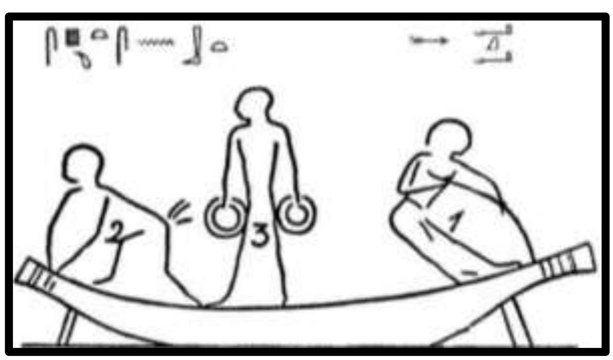
[FIGURE 4]: Saqqara, the tomb of Ptah-hotep and Akhet-hotep, 5th dynasty. GRIFFITH 1898: PL.XXXIII.



[FIGURE 5]: Saqqara, the tomb of Ptah-hotep and Akhet-hotep, 5th dynasty. DAVIES 1901b: PL.XIII.

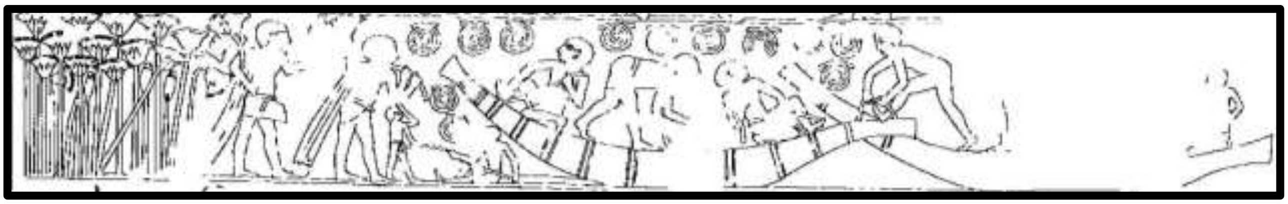


[FIGURE 6]: Abu Gorab, the Sun Temple of King Neuser Ra, 5th dynasty. EDEL & WENIG 1974: PL.11.



[FIGURE 7]: Saqqara, a limestone block, 5th dynasty. BORCHARDT 1964: 141.

[FIGURE 8]: Zaouiyet el-Meitîn, the tomb of Khunes, 6th dynasty. LEPSIUS 1849: 106a.



[FIGURE 9]: Deshaseh, the tomb of Inty, 5th dynasty. PETRIE 1898: PL.V.

Coffin Texts also confirm the previous meaning of as a verb in the sense of «frap»[51], or «bind tightly»[52], such as spell 195, as follows:

N pn šꜥ ḏyt nꜥ smꜥ.w sp smḥ iy.n N tn šꜥ N pn (ḏ.t) nꜥ N pn smꜥ sp N pn smḥ N pn nsw nt.yw im «O this N, cut the papyrus stems, twist the lacings (?) and frap the hull. This N has come, this N has cut (the papyrus-stems), this N has twisted the lacings (?), this N has frapped the hull, this N is the king of those who are yonder»[53]. Besides, the form , this term was also written: , , /, , , , , , , , , and in other spells[54].

In the same vein, the Middle Kingdom funerary scenes continued the pattern of depicting boatbuilding operations. An example of such a scene could be found in the tomb chapel of Senbi's son Ukh-hotep in Meir. In this scene, the boatwrights were depicted continuing their work on the boat, ensuring that the ropes binding the bundles of papyrus reeds together were tightly attached, as indicated by the -legend[55] **[FIGURE 10]**.

[51] To frap means to bind tightly in nautical terminology. LAYTON 1994: 148.

[52] VAN DER MOLEN 2000: 489.

[53] DE BUCK 1947: 113 *n-p*; FAULKNER 1973: 161. SERVAJEAN 2018: 202.

[54] DE BUCK 1947: 97g; 199 *i-k*; V 178 g-e; 212 *b*; 213 a.

[55] BLACKMAN 1915: 14, PL.IV, XXVI, 2.

[FIGURE 10]: Meir, tomb-chapel of Senbi's son Ukh-hotep, Middle Kingdom. BLACKMAN 1915: PL.IV

The usage of was not restricted to binding together or frapping papyrus boats; it was also employed in the construction of wooden boats[56]. This is evidenced by the presence of this term as a legend in many scenes depicting wooden boatbuilding, such as the wooden boatbuilding scene in the tomb of Rahotep. This scene led many scholars to mistakenly identify the boats as being made of papyrus due to the depiction of a worker pulling a rope inserted into the hull, which could suggest carpentry lashing or sewing. The inclusion of woodworking tools in these scenes, along with the presence of the legend «*mnḫ*«, further confirms the wooden construction of these boats[57] **[FIGURE** 2]. Moreover, the overall boatbuilding operations were expressed in a few terms in the tomb of Zaʿu at Deir el Gebrâwi, accompanied by a damaged scene, as follows: [58] *nḏr mnḫ dḳʿ wsr sp.t* (*in*) *ḥm.t n*(*y*)*.t pr ḏt tn* «striking, working with the chisel, shaping (?) a paddle, assembling (the boat) (by) craftsmen of the funerary estate»[59] **[FIGURE 11].**

[FIGURE 11]: Deir el Gebrâwi, the tomb of Zaʿu, 6th dynasty. DAVIES, CRUM & BOULANGER: 1902: PL.X

To clarify the meaning of and its application to binding operations in wooden boats, Pepi-nakht provided explicit insight into his tomb's inscription in Aswan. This official recounted his journey to the Red Sea coast, following the orders of Pepi II. His mission was to retrieve the body of An-Ankhet and his companions, who had been slain by Bedouins while «assembling a boat» on the sea coast. This account underscores the

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56 ERMAN & GRAPOW (eds.): *Wb* 1971: vol.4, 96, 13-14; JONES 1988: 222 [76].

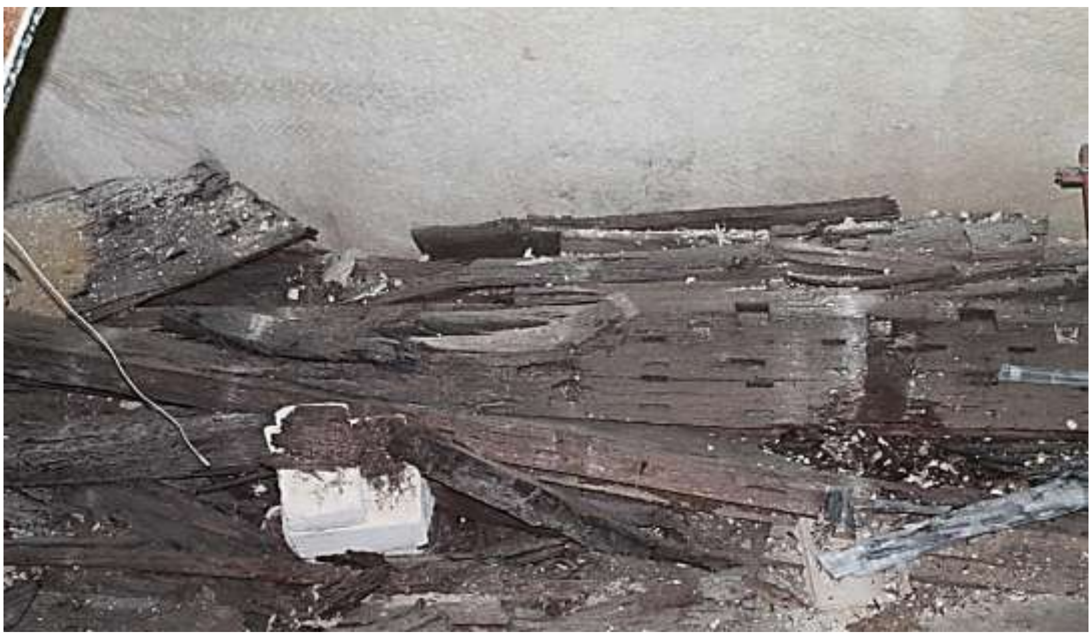
57 ROGERS 1996: 5.

58 DAVIES, CRUM & BOULENGER 1902: PL.X.

59 SERVAJEAN 2018: 209.

association of binding operations with boat construction, even in the context of wooden boats intended for voyages to destinations such as Punt[60].

Evidently, An-Ankhet did not construct his boat on the coast of the Red Sea; rather, he assembled the parts of the boat, which were disassembled and transported from the Nile across the desert. This tradition finds validation in the inscription of Antefoker from the 12th dynasty found in Mersa Gawasis. It confirms the ancient Egyptian custom of reassembling boats dismantled after being constructed on the Nile bank, then transported through desert wadis to the Red Sea coast[61]. Archaeological findings in locations such as Mersa Gawasis[62], Wadi al-Jarf[63], and Ain Sokhna confirm this practice[64]. This common practice of dismantling boats served various purposes, including funerary practices, as evidenced by the deposition of boats in pits like those found at Khufu I and II. Additionally, it served the practical need for wood reuse[65] **[FIGURE 12]**.



[FIGURE 12]: Giza, Khufu's boat pit 2, disassembled hull planks © Photo taken by Mohamed Abd El-Maguid

[60] Text: SETHE 1903: 134, 13-17. For translation, see: BREASTED 1906: 163 § 360; BOREUX 1925: 134-135; KITCHEN 1971: 192; ROCCATI 1982: 208–211; LICHTHEIM 1988: 16; STRUDWICK 2005: 335; TALLET 2009: 712-713; CREASMAN & DOYLE 2010: 14; TALLET 2013a: 191; BARD & FATTOVICH 2018: 192; SERVAJEAN 2018: 207; ESPOSITO 2019: 49.

[61] SAYED 1977: 169-173; SAYED 1978: 70-71; LECLANT 1978: 70; SAYED 1983: 29-30; FAROUT 1994: 144; TALLET 2009: 704; MAHFOUZ 2011: 54-56; ABD EL-RAZIQ et al. 2012: 6; TALLET 2013b: 76; FAROUT 2016: 22-23; BARD & FATTOVICH 2018: 193-195.

[62] BARD & FATTOVICH 2007: 250-251.

[63] TALLET 2012a: 152; BECKTELL 2014: 4, 9-10.

[64] TALLET 2009: 703-704; TALLET 2010: 18-19; ABD EL-RAZIQ et al. 2012: 5, 9-10; TALLET 2012a: 150; TALLET 2012b: 35; POMEY 2012: 35-52.

[65] ABD EL-MAGUID 2015: 15.

The term appeared in boatbuilding scenes and inscriptions with various determinatives. The majority of these signs corroborate the meaning of binding and assembling, further emphasizing the role of in the construction process, such as (forearm with hand holding stick = SL D40), (leg = SL D56), , , (boats on water = SL P1/20), (coil of rope = SL V1), and (a circle representing rope tie).

However, there are other determinatives whose relationship to the process of binding and assembling is difficult to explain. A sign somewhat resembles a piece of flesh /. Another one represents a pustule or gland (SL Aa2). A third one represents the same sign with liquid issuing from it (SL Aa3). The egg (SL H9) is the fourth one. The last one is the confusing sign with its diverse forms: , , , , which may represent the sign (lump of clay or dung = SL N32) or a vessel with two handles(?), or a form of Aa2, or anything else. These later determinatives aroused the interest of several scholars. Their efforts resulted in some interpretations that completely changed the meaning of this term, rendering a different function.

For Montet, could not represent anything other than a certain quantity of the sticky product spread on the joints. He interpreted - which appeared with the determinatives , , - in the sense of «caulking». But he was convinced that the rope played a role in the -action and that it was used to caulk papyrus barques according to the legend in the tomb of Ptah-hotep[66].

Boreux believed that the most common determinative of appeared to be a form of the sign that appeared particularly in medical papyri as an ideogram. On the one hand, it denoted the meanings of «put a poultice» and «mummified». It served as a determinative following words expressing ideas about sebum, secretions, and unpleasant-smelling substances. He believed that the sign indicated the same meaning and pointed out the appearance of this sign in the Pyramid Texts as a determinative to the word «waste» and its connection to the traditional depiction of clay and natural fertilizer in Griffith's opinion. Boreux's interpretation changed the significance of . He conceded that it might adopt the broader interpretation of «to construct a boat», yet he contended that the original sense was not «to tie» but rather «to seal» with resin, bitumen, or possibly a combination of both, after thorough assembly and binding, to prevent water leakage. Therefore, he believed that the use of the verb , in maritime language, meant «caulking a boat«, either with regolith, as Griffith suggested, or dissolved bitumen, which, in his opinion, corresponded to the determinative of the word[67].

Vandier, in turn, described this determinative as an object whose contours were particularly and deliberately imprecise. He wanted to make it either a stylized reproduction of a certain quantity of the sticky product used to caulk the boat or a simple

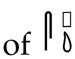
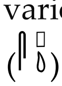
[66] MONTET 1925: 342-344.

[67] BOREUX 1925: 185-186.

rope, more or less clumsily represented. He acknowledged that the verb could have the meaning proposed by Boreux and Montet, such as «caulking». However, he argued that if the verb had such a narrow meaning, the Egyptians would not have used it so frequently to describe scenes in which workers were involved in tying ligatures. Therefore, Breasted's interpretation of the verb «*sp*» as having a broader meaning, encompassing boatbuilding, appeared more appropriate. According to Vandier, the first meaning would have been «to bind», and the verb would only have been used for the construction of wooden boats by analogy. On the other hand, he drew our attention to the fact that the construction of the boat also required caulking, explaining the regular presence of the curious determinative following the verb «*sp*».[68]

Servin established a connection between the different forms of the determinative of the verb «*sp*» and an ovoid mass object equipped with two handles. This object was depicted in the hand of a worker striking the upper face of a boat in Akhet-hotep's tomb. The use of this mass object was rare in Egyptian art; it was depicted in a three-quarter perspective to emphasize the need for the stems to be struck obliquely in order to even out the layers. The artist transgressed the conventions to highlight this crucial detail.[69]

The verb, therefore, represents, in the first analysis, the operation of finishing the boat. This verb is generally accompanied by two determinatives: in the first  , one recognizes the mass used in the tomb of Akhet-hotep to compact the sheaves; the second O, the roll of rope, relates to the tightening of ligatures. In the tomb of Akhet-hotep, in the application of an almost general rule, the determinative  already represented in the drawing is omitted from the legend.[70]

Consequently, Servin had reservations about the interpretation of  in the sense of «caulking», claiming that this process would weigh down the papyrus boat and affect its buoyancy. Upon analyzing the inscriptions featuring the word  in various boatbuilding scenes found in the Old Kingdom's tombs, he highlighted the verb's () association with *smḥ* papyrus boat. Additionally, he noted its occurrence alongside the determinative of the two side handles  or , symbolizing the papyrus coil. He indicated that the same verb appeared with the determinative  in the aforementioned Pyramid Texts 1206 and 1209, linked to the process of binding Ra's boats.[71]

The analysis of these texts affirms, according to Servin, that at the time of building the tomb of Akhet-hotep, the term «*sp*» indicated a phase of construction of papyrus boats. The hull was formed by compacting the reeds (which made up the boat), using an ovoid mass fitted with two handles, and tightening the ligatures by force. This operation was intended to transform the papyrus hull into a homogeneous mass. But at the end of the Old Kingdom, artists refashioned their theme, and the wooden boat construction replaced that

[68] VANDIER 1969: 554-555.

[69] SERVIN 1948: 61-62.

[70] SERVIN 1948: 62.

[71] SERVIN 1948: 82-83.

of papyrus. Therefore, «*sp*» and its determinative disappeared from the inscriptions. However, it appeared in Weni's inscription with the meaning «to assemble the various parts of the (wooden) boat» and in the tomb-chapel of Senbi's son Ukh-hotep from the Middle Kingdom. The artist of Ukh-hotep's tomb copied the theme and the inscription from the tomb of Akhet-hotep[72].

Finally, Servin concluded that in ancient Egyptian boatbuilding, «*sp.t*» is found in its verbal form (var.) and in its nominal form . The first, «*sp.t*» is the feminine infinitive of the verb *sp*(*i*): «to pack and bind (the papyrus boat)» then, by extension of meaning, «to bind«, by all useful means, or, in fact, «to build». The compound word , which characterizes certain fixing elements of the Egyptian boat, derives directly from the idea of connection or joining contained in the root *spi*. The second, , , …, *sp.t* designates a kind of resin (?) that was originally used in manufacturing or coating ropes used to bind the boat. These two phonetically identical words were distinguished by their determinatives: , with or without its handles for the verbal form and , , and fortuitously for the nominal form[73].

Servajean noted that the determinative of evolved from the form of the 4th dynasty to of the 5th dynasty. He also mentioned that the shape and arrangement of remained almost the same, with some minor differences, since the 6th dynasty, with the exception of and and the reappearance of the sign . He added that, in the Middle Kingdom's Coffin Texts, was definitively replaced by that of the pustule . Using Griffith's interpretation in the explanation of the sign : «a conventional figure, apparently for mud, dung», that refers to the word *sin* «clay», determined by the same sign. Servajean confirmed that , in the word *mḥsḥs*, was mentioned in the Mastaba of Ty and represented bovine droppings[74].

According to Servajean, the Egyptians possibly used a mixture of clay and bovine droppings not to caulk the hull in the strict sense but to seal cracks or weak points in the hull through which water could infiltrate. Consequently, he rejected the interpretation of «caulking» in its strict semantic field, believing that it refers to a systematic filling or sealing of the hull's parts. For papyrus boats, this assembly was made using a single operation: «attach» the elements of the hull to each other. For wooden hulls, it involves two distinct operations: «binding» the elements of the hull (determinative) and waterproofing (determinative). Regarding the term , it does not imply a systematic operation but is performed only once, if necessary, on the weak points of the hull under construction. Thus, when referring to this operation, terms such as «caulking» or «to caulk», which denote a

[72] SERVIN 1948: 83-84.

[73] SERVIN 1948: 88.

[74] SERVAJEAN 2018: 217-219.

specific and easily identifiable action, should be avoided. He preferred using «waterproofing» or «clogging» for nouns and «waterproof» or «to clog» for verbs[75].

The determinative of the verb «*sp*» is confusing and puzzling. While we acknowledge the earnestness of prior attempts to elucidate its significance, it remains challenging to endorse the notion that all its forms denote a singular concept or to streamline them into a solitary form, particularly given the notable disparities among them as follows: , , , , , , , , , , , and . In addition, the clear difference between all these forms on the one side and in the tomb of Akhet-hotep on the other side makes the comparison somewhat questionable. Since there is repetition of the old form across the different periods, we cannot trace the development of the sign in such a continuous manner that it can be said that the form of the 5th dynasty arose from the form of the 4th dynasty.

The second problem revolves around the reason for altering the form of the same tool in boatbuilding scenes, particularly when other tools depicted in the same scenes have not undergone significant or noticeable changes. It is noteworthy that appeared alongside the sign . In the legend in Saqqara's 5th dynasty pyramid of King Unas, a scene in the causeway depicts two workers polishing utensils of gold and stone with small round or oval-shaped blocks[76]. Interestingly, the artist depicted the two tools together, proving the tools were not interchangeable and had differing purposes.

Irrespective of caulking or any other procedure, the challenge lies in discerning the nature of the mass and determining whether all these determinatives denote a unified concept, evolved forms over time, or if the process varied with each instance, employing different tools. The scene of the two-handled mass , in the tomb of Akhet-hotep, represents an exceptional case because we have not found a similar scene to confirm the use of this mass in packing the sheaves.

Another question to arise is why the process depicted in Akhet-hotep's scene is not repeated elsewhere. While scenes of boat building often depict workers holding various tools such as adzes, axes, chisels, saws, drills, awls, hammers, mallets, and plumb bobs, no similar scenes showcase workers with a tool resembling the determinative of the term «*sp*». This suggests that the tool depicted in the hands of one of the workers in Akhet-hotep's scene is likely just a simple hammer.

One last question: why have the two determinatives and been disregarded? It is noted that the scribe used «*sp*» in different forms in a number of versions of spell 403 of the Coffin Texts: , , , . He used the form , among others, as a version of the same verb in spells 195 and 407. In addition, the form / appeared in spell 219, where the last sign represented either part of a bird or a human finger. The multiplicity and diversity of these determinatives confirm we are not facing a process different from binding and assembling the parts of the boat , , with ropes /

[75] SERVAJEAN 2018: 221-222.

[76] HASSAN 1938: 520, PL. XCVI; SCHEEL 1989: 39, FIG.42.

by hands  and  legs, using a different set of tools referred to in the previous determinatives. For the determinative of «*sp*» as a form of  or  as Boreux and Servajean believed, respectively, this is contradicted by the diversity and difference in the forms of determinatives, as previously mentioned, regardless of their function or role, as we discuss later.

In conclusion, all previous scenes and legends support the true meaning of «*sp*» as «to tie», «to bring together the different parts of the boat's hull using ties»[77], «bind»[78], «assemble»[79], «lash together»[80], and «strap together»[81]. This usage is akin to the colloquial Egyptian word «sabbat», which refers to delicate baskets made from reeds or soft materials. These materials undergo cleaning, drying, cutting, braiding, and shaping to form the final product. Therefore, we can translate the verb «*sp*» literally as «to frap», «to bind», or «to tie» for papyrus boats, and as «to assemble» or «to join» for wooden boats. As a result, the translation «to build»[82] or «to construct»[83]should be ruled out, contrary to the translations proposed by many scholars[84].

2. Other Verbs Related to Boatbuilding in Weni's Autobiography

Indeed, Weni possessed a distinct narrative style when recounting his autobiography. When detailing King Merenre's directive to construct three barges and four tow-boats from Nubian acacia wood during his 5th expedition to the 1st Cataract, Weni employed a comparable approach. Utilizing a succinct yet evocative abbreviation, Weni crafted concise and expressive sentences devoid of unnecessary length, digression, or redundancy. His narrative unfolded with sequential phrases, exemplifying his ability to convey complete thoughts effectively, as follows:

(*1*) *h3b* <*wi*> *hm=f r š3d mr 5 m Šmꜥ.w r ir.t wsẖ.t 3 s3ṯ 4 m šnd n W3w3.t* «His majesty sent (me) to excavate five canals in Upper Egypt and to build three *wsẖ.t*-boats and four *s3ṯ*-boats of acacia wood of Wawat».

(*2*) *sṯ ḥḳ3.w ẖ3s.wt n*(*y*)*.w ꞽrṯt W3w3.t ꞽ3m Mḏ3.t ḥr sṯ*(*3*) *ẖ.t* (*i*)*r=s*(*n*) «Then the foreign chiefs of Irtjet, Wawat, Yam, and Medja drew the timber for them«.

(*3*) *iw ir.n=i mr-ḳd n rnp.t wꜥt* «I did it all in one year».

(*4*) *mḥ.w 3tp.w m m3ṯ ꜥ3 wr.t r* (*mr*) *ẖꜥ*(*i*)*-nfr-Mr*(*i*)*-n-Rꜥ* «Floated, they were loaded with very large granite blocks for the Pyramid «Mernere-appears-in-splendor»[85].

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[77] TRESSON 1919: 38.

[78] JONES 1988: 222 [76].

[79] LICHTHEIM 1973: 21; STRUDWICK 2005: 356.

[80] OSING 1977: 174; KLOTH 2002: 183.

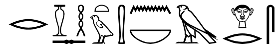
[81] HOFMANN 2002: 232.

[82] GRIFFITH 1894: 17; DAVIES, CRUM & BOULENGER 1902: 11; BREASTED 1906: 149 § 323; NEWBERRY 1942: 65; LANDSTRÖM 1970: 62; WARD 2000: 9.

[83] BOREUX 1925: 129; CLARKE & ENGELBACH 1930: 34; MEEKS 1981: 319 [78.3454]; JONES 1988: 222 [76].

[84] MASPERO went too far as he translated it «embark». MASPERO 1888: 9.

[85] Text: SETHE 1903: 108, 13-109, 7. Compare: MARIETTE 1880b: 84, PL.45 (46-49); ERMAN 1882: 25-26; BRUGSCH 1891: 1477 [1-6]; TRESSON 1919: 7 [47-49]. Translations: ERMAN 1882: 25-26; MASPERO 1888: 9-10; GRIFFITH

Strikingly, Weni only used the conventional terms always mentioned in ancient Egyptian texts: «*ir*» and «*sṯ3*», but in his own style. When his contemporary Sabni - overseer of foreigners and keeper of secrets of the doorway of Upper Egypt[86] - used «*ir*» in a similar context, he used it directly, without resorting to any rhetorical method, as follows:   *iw h3b.n* <*wi*> *ḥm n nb*(=*i*) *r ir.t wsḫ.ty* (*ꜥ3.ty*) *m W3w3.t r s:ḫdi tḫn.wy ꜥ3*(*.wy*) *r Iwn.w* ...... *iw ir.n*(=*i*) *wsḫ.ty* (*ip*)*tn r ḥz.t w*(*i*) *ḥm n nb*(=*i*) *ḥr*=*s* «The majesty of (my) lord sent (me) to build two great barges in Wawat, in order to convey two great obelisks to On. … I made the two barges so that the majesty of my lord rewarded me for it»[87]. Similar to Sabni, Djadjay of the very end of the Old Kingdom[88], Thethi[89], and Henu[90] of the 11th dynasty also used (*ir*) in a similar way.

Regarding , whether pronounced as «*sṯi*» meaning «to supply the wood for boatbuilding»[91], or «*sṯ3*» denoting «drag«, «pull«, «tow», and «pull a boat»[92], it represents just one phase out of a long chain of operations that boatbuilding undergoes. Consequently, it cannot be translated in any logical context to mean «build» or «construct», particularly boats, since Weni linked this term to the wood itself and not the boat, which underscores this interpretation. It is evident that the intended meaning of this term is pulling or dragging, as it can be applied to various activities, such as moving statues, transporting the deceased to the cemetery, conveying funerary furniture, pulling sledges, ships, papyrus, wine, wood, and cattle[93].

While Weni's autobiography stands out for its stylistic eloquence compared to his contemporaries and non-contemporaries, the term  alone is not sufficient to fully describe the construction of any boat. Even if we accept translations, such as «fell (the

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1894: 18; BREASTED 1906: 149-150 § 324; BOREUX 1925: 130; STRACMANS 1935: 514; GARDINER 1961: 97; LICHTHEIM 1973: 21-22; ROCCATI 1982: 197 § 188; WARD 2000: 9; KLOTH 2002: 181-182; SIMPSON 2003: 407; GRIMAL 2005: 167; STRUDWICK 2005: 356-357; ESPOSITO 2019: 40.

[86] *S3bni* possesses ownership of tomb N°.35a situated in Qubbet el-Hawa at Aswan, dating back to the conclusion of Pepi II's reign. This particular *S3bni* is distinct from the more renowned expedition leader sharing the same name. There's a possibility that this individual could be Pepynakht Heqaib's son, given the proximity of this chapel to Pepynakht's, with inscriptions adorning the sides of the entrance. STRUDWICK 2005: 339-340 (N°.244).

[87] ROCCATI 1982: Nr.45, 214-215; HABACHI 1984: 40-41, FIG.16; LICHTHEIM 1988: 9, Nr. 4, 17-18; KLOTH 2002: 31 (Dok. 67), 182; STRUDWICK 2005: 339.

[88] An inscription on a door jamb (?) found in debris west of tomb 104 of *Dmḏ*, at Hamra Dom (al-Qasr wa es-Saiyad), on the eastern bank of the Nile, at the mountain of al-tariff, Qena. KLOTH 2002: 39 (Dok. 85), 182; STRUDWICK 2005: 350.

[89] An inscription on a stela (BM 614). BLACKMAN 1931: 56-57, PL.VIII (Line 11); SCHENKEL 1965: 150; KLOTH 2002: 182, N°.675.

[90] Inscription N°.114 in Wadi Hammamet. COUYAT & MONTET 1912: 83 [14-15].

[91] ERMAN & GRAPOW (eds.): *Wb* 1971: vol.4, 365, 10.

[92] ERMAN & GRAPOW (eds.): *Wb* 1971: vol.4, 351-353; FAULKNER 1986: 255; JONES 1988: 225 (97).

[93] HASSAN 1943: 175-177, FIG.122; MOUSSA & ALTENMÜLLER 1977: 62 [Sz.6.4.], TAF.16; BROVARSKI 2001: 44-54, FIG.38; KATERINA 2012: 8-75.

wood)» by Maspero, Griffith, and Ward[94] «cut« by Lichtheim and Strudwick[95], «furnished (the timber) » by Kloth[96], these translations fall short in capturing the complexity of boatbuilding. The intended meaning of boatbuilding seems to be somewhat elusive and not adequately conveyed by the term  alone.

But why did Weni resort to using this precise term? Why did he ignore the verb *ỉr*, or other terms, such as *ꜣꜥ*, *ꜣꜥw* (verb used for 'constructing' a boat), *ỉr dpt* (build, construct boat), *ỉzp* (hew wood with ax, build boat), *mḏḥ* (hew, build boat), *nḏr* (hew wood 'for boatbuilding'), *ḥwsi* (build 'boat'), *zmꜣ* (make ready a boat), *šd dšr*, and *šd m ḏsr* (to build a boat)[97], and others? The exact reason for Weni's choice remains unknown; perhaps it reflects his personal stylistic preference. Nevertheless, we must acknowledge and consider the translations of this term, encompassing meanings such as «cut», «draw», «fall», «furnish», and potentially even «build». The interpretation of these meanings hinges on the specific context within the text.

V. Nautical Analysis

Following the linguistic analysis of the text, several issues have surfaced that require further clarification or validation. Others must be either confirmed or refuted to achieve a comprehensive understanding. This process is essential for extracting all available information when assessing from a nautical perspective. We shall commence by presenting the boatbuilding process, and sequences deduced from excavated materials, accompanied by relevant texts and iconographies. Subsequently, we delve into discussions regarding the construction location, methods, timeframe, and navigation period.

1. Boatbuilding Process in Ancient Egypt: Insights from Direct and Indirect Evidence

The process commences with the felling of trees in the forests, followed by the removal of stems and branches using an ax. Subsequently, a pull saw is employed to fashion boards, which are then carved into planks using adzes. Boatbuilding in Egypt is characterized by the carving of planks to achieve the desired shape, as the hull planks of Egyptian ships and boats are notably thicker compared to other shipbuilding traditions, which rely on thinner planks bendable by force, fire, or steam. Upon completing the shaping of each plank, one or more craftsmen commence mortise cutting on each side of the plank using a chisel and hammer.

The boat construction initiates by laying a central strake and inserting the tenons into the mortises opened at its sides. Subsequently, planks are alternatively added on both sides, along with the tenons[98], until the hull mounting process is complete. Following the

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[94] Maspero 1888: 10; Griffith 1894: 18; Ward 2000: 9.

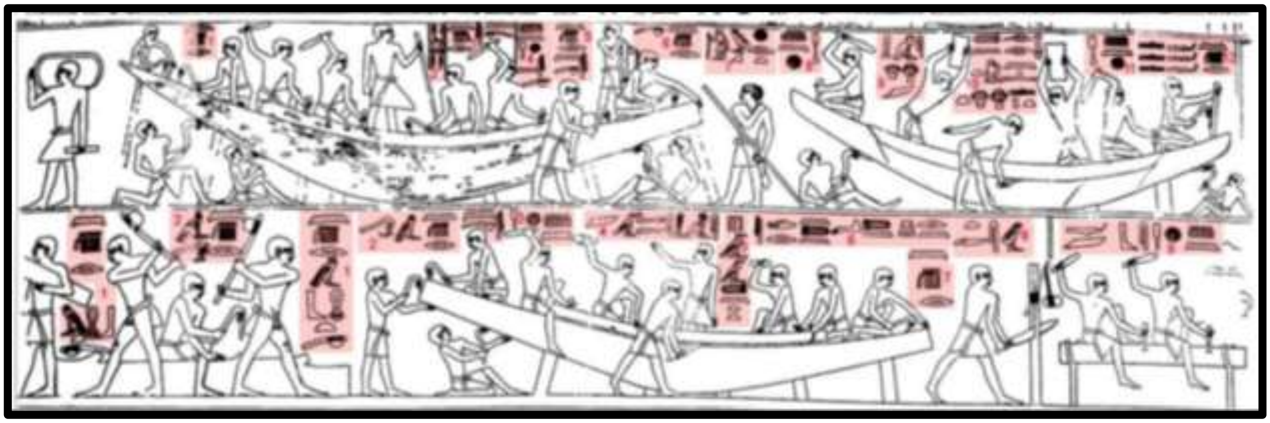
[95] Lichtheim 1973: 22; Strudwick 2005: 357.

[96] Kloth 2002: 181.

[97] Jones 1988: 208 [1], 210 [8] & [10], 215-216 [39] & [42], 218 [57], 222 [77], 228 [115].

[98] The tenons play an important role in fixing the planks in place and in maintaining the general shape of the ship before placing the beams and sewing the hull.

planking, transversal beams, integral to the ship's deck and serving as the primary transverse strengthening element, are incorporated by the builder. Except for stone-carrying ships that had complex ribs or frames to strengthen the inner structure of the ship, the inclusion of stiffening ribs in other boats is at the discretion of the builder. The construction concludes with the chief craftsman reviewing the ship's dimensions, quality, and accuracy of work, ensuring final finishing touches are made, including adzing and smoothing the surface before painting the ship[99] **[FIGURE 13]**.



[FIGURE 13]: Saqqara, 5th dynasty. The mastaba of Ty p.5 (osirisnet.net) Accessed on (23/01/ 2024)

In the Old Kingdom, the boatbuilding process typically concluded with the transverse sewing of its planks together, contrasting with the later Mediterranean building traditions where sewing was done longitudinally. This practice was inherited from the manufacturing method of papyrus boats. However, it remains unclear at which stage the sewing channels, which open into the sides and inner faces of the planks, are cut. Were they created simultaneously with the opening of the mortises or after the completion of the ship's mounting? In the latter scenario, the hull is disassembled to create the channels, after which the planks are reassembled, with ropes inserted inside the channels[100].

Numerous insights were gleaned from the construction and navigation experiment of a replica vessel named «Min of the Desert»[101], which emulates Egyptian seagoing ships and approximates construction technology from the early second millennium BC. Although the reconstruction is theoretical due to the absence of extant ships to replicate, the full-scale replica draws upon all available scientific evidence, including physical remains and representations such as the Punt relief. Measuring 20 meters in length and five meters in width, the construction of the replica spanned eight months. The construction involved the labor of five workers, averaging ten hours per day, and excluded the initial phases of tree felling, trunk trimming, and log preparation[102].

[99] The painted wall of the tomb of the official Ty from the 5th dynasty bears the most detailed scene of the process of building boats and gives the best example of these building sequences.

[100] For more information on the characteristics of ancient boatbuilding. ABD EL-MAGUID 2009: 307-310.

[101] ABD EL-MAGUID documented and supervised the construction of this *replica* during the year 2008.

[102] WARD 2012: 223; WARD et al. 2012: 287-292.

It became evident that sewing channels could not be cut until after the planks were shaped and the ship's walls were mounted because the process of matching the planks is complex, requiring meticulous alignment to eliminate gaps between the strakes. If a mismatch occurs, the upper plank is removed, and its side is smoothed until it fits properly, potentially altering the shape and position of previously cut sewing slots. Consequently, cutting the channels can only occur after the boat has been fully mounted and its quality ensured. The sewing process occurs at the conclusion, as the builder passes ropes through the channels from one side of the ship to the other. Certainly, the insertion of tenons for pre-assembly, ensuring the planks remain in place, occurs with the addition of each plank.

2. Boatyard

In his nautical activities, Weni briefly spoke about the types of boats, their dimensions, timber, tonnage, and the itineraries of his five expeditions. However, not a single mention was made about the boatyards. Importantly, no mention was made of the boatyard that hosted the construction of Hatnub. In the midst of these difficulties, one notices several important indications, shedding light on this issue. In his inscription, Weni alluded that: «[His] majesty sent me to Hatnub to bring a great offering table … I had cut for it a *wsḫ.t*-barge of acacia wood … Assembled in 17 days …«. In fact, this description necessarily implies - without dispute - that Hatnub was the scene of all the operations: «the destination», «cutting off the offering table«, «falling trees», «boatbuilding», and «the point of departure». There is some evidence supporting this implication.

Firstly, acacia trees spread in the area. Hatnub, like other ancient Egyptian towns and cities scattered along the banks of the valley and in the Delta, was overgrown with acacia trees[103]. Acacia was one of the local wood trees that had already been recorded in quantities in Middle and Upper Egypt as early as the Old Kingdom[104]. In Egypt, acacia trees grew in the Nile Valley, in some desert wadis, and in the oases of the western desert[105]. Hence, Weni would not exert much effort to obtain the wood necessary to build his boat.

Secondly, Hatnub is a region of the Eastern Desert, spreading over several square kilometers, the core of which is 16.4 km southeast of Amarna (Kom el-Nana). Thus, Hatnub contains relatively well-preserved traces of a network of ancient roads connecting the quarries with the Nile Valley[106]. Archaeological research suggests that the northwestern end of the ancient stone road, linking Hatnub with the Nile Valley, terminates in some form of harbor adjacent to the modern villages of Hagg Qandil and Hawata[107]. Today, the remains of this harbor would be buried beneath modern cultivation[108]. Undoubtedly, the

[103] DIXON 1974: 205.
[104] KILLEN 1994: 7.
[105] GALE, GASSON, HEPPER & KILLEN 2000: 335; DEGLIN 2011: 85-87, FIGS.1-2; BARD & FATTOVICH 2018: 95-96.
[106] Enmarch & Gourdon, Quarry epigraphy at Hatnub. Https:// livrepository.liverpool .ac.uk /3093960/1/Hatnub%20 Graffiti %20 article .pd. Accessed on (03/02/ 2024).
[107] SHAW 2013: 521-523.
[108] SHAW 2005: 435-436.

entirety of this facility linked the alabaster quarries of Hatnub to the Nile River, facilitating extensive transportation and mobility for stonecutters, lumberjacks, carpenters, or others who were assigned to carry out the mission of cutting the offering table and building the boat.

Thirdly, the construction of a boat would require a spacious place with water, equipment, living quarters, and logistics services. These conditions applied to Hatnub. In addition to the water of the Nile, around the quarries, and along the main road, there are also extensive remains of cairns, dry-stone huts, and windbreaks used by the ancient population working there[109].

This theory is also supported by several pieces of evidence. The first indication of the connection between boatbuilding and quarries comes from a graffito dating back to the reign of King Teti, the first ruler of the 6th dynasty. This graffito mentioned the 15th nome of Upper Egypt as the location for boatbuilding, alongside quarries. It stated, «60 men were making [boats (?)] in the 15th nome of Upper Egypt«[110]. Additionally, a graffito at Hatnub from the reign of Pepi II, successor to Merenre, further supported this connection. The graffito mentioned boats named «*ḥʿw*» and described the construction of a barge, indicating the involvement of boatbuilding activities in the quarries themselves[111].

The intense activity of extracting alabaster from Hatnub during the 6th dynasty is undeniable. The current Hatnub Mission cataloged 23 epigraphic features, along with another 13 possible compositions dating back to the same period[112]. Given this activity, it is reasonable to assume the presence of a dedicated boatbuilding area at Hatnub. This area likely lies close to the harbor or the *Rꜣ-mw*, as revealed by King Merenre's inscriptions (DS 17, 19). According to Gourdon, this could correspond to the pier from which blocks extracted from the «P Quarry» were loaded onto the Nile for transportation[113]. The presence of a boatyard adjacent to the harbor or pier would provide workers with optimal conditions to successfully complete their tasks.

3. Caulking

It became imperative to examine the potential use of caulking in this boat after a group of scholars, as stated above, took turns interpreting «*sp*» with caulking because of its different determinatives. We previously rejected this interpretation from a linguistic perspective, and we reiterate our rejection from the standpoint of ancient boatbuilding traditions. Before delving into the reasons for our rejection, it is prudent to offer the reader a definition of caulking from maritime dictionaries: «Term of wooden construction: the

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109 ENMARCH & GOURDON, *Quarry epigraphy at Hatnub*. Https://livrepository.liverpool .ac.uk/3093960 /1/Hatnub%20 Graffiti%20 article.pdf. (Accessed on 03/02/ 2024).

110 ANTHES 1964: 18-19, TAF.9, Gr.1; STRUDWICK 2005: 145.

111 ANTHES 1964: 20-21, TAF.10, Gr.4; STRUDWICK 2005: 148.

112 ENMARCH & GOURDON, *Quarry epigraphy at Hatnub*. Https://livrepository.liverpool.ac.uk/3093960/1/ Hatnub %20Graffiti%20article.pdf. Accessed on (03/02/ 2024).

113 GOURDON, *Les inscriptions rupestres de Hatnub*. File:///C:/Users/dell/Downloads/Hatnoub_inscriptions_ IFAO_University_ of. pdf. Accessed on (03/02/ 2024).

action of filling by force, with oakum then covered with pitch, the seams of the planking and the strakes of a deck in order to make them watertight»[114]. This definition underscores two key points: Firstly, caulking applies specifically to wooden boats and secondly, it involves a forceful action that necessitates tools for its execution. Regarding the first point, papyrus boats were not concerned with caulking. As for the second point, neither caulking mallets nor caulking chisels were depicted in related scenes or mentioned in their legends. Furthermore, caulking did not appear in boatbuilding techniques until the early 5th century AD; no caulking material was discovered between the seams of ships, found in the Mediterranean and its surroundings, constructed via the «shell-first» method[115]. Driving the caulking material could potentially damage the mortise and tenon network crucial for the boat's strength[116]. The same cautionary method applied to sewing material.

[FIGURE 14] - Caulking process © Photo taken by Mohamed Abd El-Maguid

It is understandable that these scholars could make that mistake, given the lack of awareness about the «shell-first» building technique before the discovery and study of the Kyrenia ship approximately half a century ago. Vandier attempted to link the activity depicted in the Rahotep relief with Herodotus' phrase translation, «They caulk the interior joints with papyrus», assuming that bundles of papyrus were stuffed inside the boat and sewn[117]. However, Haldane and Shelmerdine challenged this assumption, as well as the

[114] DICTIONNAIRE GRUSS DE MARINE 1978: 64.
[115] ABD EL-MAGUID 2009: 275.
[116] BASCH 1986: 187-198.
[117] VANDIER 1969: 666.

common translation of the text, both from lexicographical and archaeological perspectives, and correctly translated it as «They bind in the seams from within with papyrus»[118].

Therefore, the verb «*sp*» does not directly imply caulking, but there is a possibility that it refers to a process of water tightening or waterproofing, acknowledging that no hull is entirely impervious to water leakage. Water tightening can be achieved by inserting papyrus stalks between the planks before lashing them together. These stalks not only expand to prevent water infiltration but also aid in securely tightening the lashing ropes[119]. Evidence uncovered by Ward revealed imprints left in the coating beneath the GB 10 hull in Abydos, as well as long plant fibers lodged between the strakes, likely bundles of reeds or grass used to watertight the hull. Traces of wooden laths, similar to those found in the Khufu boat, were also discovered inside the hull[120], indicating a technique known as luting[121].

Waterproofing is accomplished by saturating, tying ropes with bitumen, asphalt, tar, or resin or pouring them over areas prone to leakage, such as the seams between planks. Servin rightly dismissed the idea of pouring pitch or resin onto a papyrus boat, arguing it would add weight and affect buoyancy[122]. Moreover, papyrus boats do not require this method, as the papyrus swells shortly after launch, preventing surface leakage. In contrast, Ward observed a thin layer of black substance for wooden boats in areas with knots, scarves, and the edges of mortises in El-Licht boat fragments[123]. Additionally, Creasman noted traces of old tar or pitch on the tenons of Dahshur boats displayed in the Egyptian Museum[124]. Abd El-Maguid distinguished the same substance on some fragments from Wadi Gawasis. These were archaeological evidence from the Middle Kingdom, but we have textual evidence from the New Kingdom on the application of asphalt in boatbuilding. The reference originates from the Egyptian-Hittite correspondence found in the Bogazkoy archives. The correspondence involves a letter sent by Ramses II to Hattousil III regarding the construction of a ship replicating another sent by Ramses. In this communication, the pharaoh suggests applying asphalt, *i.e.*, mineral pitch, both inside and outside the ship to ensure the hull is waterproof and prevent ships from sinking[125].

In short, this verb was employed to describe a construction phase for both papyrus and wooden boats. While this phase might not involve caulking, it likely pertained to water tightening or waterproofing. However, it seemed improbable that this process was considered one of the two main construction processes by Weni. In any scenario, this process could be completed in just two days rather than requiring seventeen days.

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118 HALDANE & SHELMERDINE 1990: 535-539.
119 LAURES 1989: 266-267.
120 WARD 2003: 21.
121 STEFFY 1994: 275.
122 SERVIN 1948: 82.
123 HALDANE 1988: 146.
124 CREASMAN 2005: 62.
125 POMEY 2006: 239-241.

4. Construction Duration

Upon examining the text linguistically, Weni's description lacked details regarding the boat's construction phases. He simply utilized two terms to encompass the entire process. However, these two terms are insufficient for delineating the stages of constructing the hull.

As previously discussed, the verb «*šꜥ*» did not present translation issues, unlike the verb «*sp*», but it did introduce confusion in interpretation. We must ponder the meaning behind «I cut for it a barge». Did Weni refer to cutting the acacia trees, or was he including all cutting operations? As previously outlined, the boat construction process involved various cutting activities during hull mounting. In the former case, «*šꜥ*» would indicate tree cutting, with «*sp*» comprising the remaining building processes. In the latter case, «*šꜥ*» would encompass all cutting activities, while «*sp*« would specifically denote hull assembly.

We face two main groups of scholars; one translates «*sp*» with «to assemble»[126], and the other translates it- erroneously- with «to build»[127]. One wonders how they missed the impossibility of building such a barge in only 17 days. From his perspective, Landström suggested that the time frame for building a barge might not be exceptionally short, considering the extensive experience of the builders. However, he speculated that «the timber can very well have lain ready, hewn into planks and perhaps in traditional standard shapes, waiting for Weni's arrival»[128]. If this theory holds true, a question arises: Were these planks sourced from a nearby location or retrieved from a warehouse at Hatnub's boatyard? The latter option aligns with a well-known tradition mentioned in papyri from the New Kingdom, where boat parts were ordered from one boatyard's warehouse to another[129]. In either case, this hypothesis divided the operation into two stages: one occurring before Weni's arrival and the other after his arrival, with the latter undoubtedly corresponding to the assembly phase.

As previously demonstrated, the experiment involved the construction of a boat, less complex and approximately one-third the size of Weni's barge, because it was not designed to transport heavy cargoes like stones and required eight months of construction (excluding the stages preceding the shaping of the planks). Given this timeframe and the nature of boat construction, it is improbable that simply increasing the number of workers would have significantly reduced the duration, as it is unfeasible to install two planks in the hull simultaneously.

Ultimately, we propose that the most plausible interpretation is that Weni used the verb «*šꜥ*» to encompass the entire process of wood preparation, particularly considering that most phases involve cutting actions, whether conducted before or after his arrival. In

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126 ERMAN 1882: 24-25, 29; BREASTED 1906: 149, №. g; TRESSON 1919: 38; STRACMANS 1935: 514; LICHTHEIM 1973: 21; OSING 1977: 173-174; JONES 1988: 222 [76]; HOFMANN 2002: 228, 232; KLOTH 2002: 183; SIMPSON 2003: 406; STRUDWICK 2005: 356; SERVAJEAN 2018: 207-208.

127 GRIFFITH 1894:17; BOREUX 1925: 129-130; CLARKE & ENGELBACH 1930: 34; NEWBERRY 1942: 65; GARDINER 1961: 97; MEEKS 1981: 319 [78.3454]; ROCCATI 1982: 196-197 §187; GRIMAL 2005: 167; WARD 2000: 9.

128 LANDSTRÖM 1970: 62.

129 GLANVILLE 1931: 105-21; GLANVILLE 1932: 7-41.

this scenario, «*sp*» would denote the final mounting of the hull, which includes its assembly, primarily with ligatures, in accordance with the tradition during the Old Kingdom. For a barge of this dimension, the 17 days as a timeframe for this phase is within the realm of reason.

5. Navigation Duration

The reference to seventeen days not only serves to determine the duration of the ship's assembly but also underscores Weni's capability to deliver the ship to its destination within this timeframe.

To assess the validity of this timeframe, we must examine the average speed of Egyptian boats and the typical number of navigation hours per day. Considering the distance between the Nile in front of the Hatnub quarries and Memphis, which is approximately 180 miles[130] or 156.5 nautical miles, we can estimate the feasibility of completing the journey within 17 days.

Egyptian antiquities do not provide direct evidence to accurately determine the speed of boats, whether on the Nile or at sea. Instead, the texts mention the duration of a journey, as recorded in Weni's autobiography or the records of Wenis' causeway[131]. These durations include various factors such as sailing and stopping times, favorable and adverse wind conditions, navigation with or against the current, and traversing both hazardous and non-hazardous waters.

In his assessment of the Punt expedition in the Red Sea journey, Kitchen proposed an average speed of 3 knots. With an estimated the sailing day of 8 to 9 hours, Kitchen approximated a minimum distance of 25 nautical miles traveled per day[132].

The experience of navigating «Min of the Desert» in the Red Sea, between Safaga and Marsa Alam, provides some valuable insights. In 2009, an amateur rowing team, primarily consisting of women, achieved a steady speed of 2.5 knots while rowing upwind. However, this exercise was of short duration (10 to 15 minutes) and not sustained for hours. While sailing in the prevailing winds of the Red Sea, the average speed reached 7 knots[133]. Nevertheless, daily navigation periods did not exceed 5 hours to ensure the capacity of anchoring in safe spots or shelters.

Of course, ancient sailors did not measure navigation in terms of speed but rather by the distance traveled. Navigation on rivers allowed for easier tracking of distance covered compared to navigation on the open seas. As a result, sailors typically measured distances during sailing days. A standard day of navigation, known as a 17-hour day (diurnal navigation), was used for relatively short voyages, while a full 24-hour day was employed for longer journeys spanning multiple nights. According to Herodotus' estimation, a day's

[130] FISCHER 1975: 34.
[131] FISCHER 1975: 34-35.
[132] KITCHEN 1971: 196.
[133] WARD 2012: 224; WARD et al. 2012: 290-291.

navigation in a straight line, with favorable winds, equated to a distance of 700 stades[134], which is approximately 70 nautical miles.

The voyage to Memphis typically took place in «the third month of the «*šmw*«, coinciding with the river's lowest level, as described by Weni: «when there was no water on the sandbanks». This month corresponds to January for Krauss[135] or May for De Jong[136] in the current calendar[137]. We completely excluded that the navigation was carried out on a full-day basis, as it required light to monitor the course of the river, emerging islands, and sandbanks. We also ruled out that Weni used the full diurnal time because the duration of sunshine in Egypt in that period averaged 13 hours at maximum. Moreover, he might be forced to stop at stations for various reasons, whether protocol or practical. The number and duration of stopovers and the weather conditions encountered could reduce the daily navigation hours. We estimated that the navigation time would not have exceeded 10 hours in any case, with an average of around eight hours per day. This accounts for departure and docking maneuvers, meal breaks, navigating difficult areas, and preparing the ship for different methods of propulsion[138].

Considering all the figures provided, one might wonder why Weni took pride in the duration it took him to transport the table to its designated location. This is especially pertinent when contrasting it with the account of delivering columns from the granite quarries in Aswan to King Wenis' funerary complex in just seven days. In this instance, the distance between Aswan and King Wenis' funerary complex was three times greater than that between Hatnub and Memphis[139]. According to Somaglino, even during periods of low water, the duration of seventeen days for transportation appeared to be quite lengthy and not something a dignitary would typically boast about. She suggested that these seventeen days likely included multiple stages of the transportation process, such as moving the blocks from the quarries to the river, navigating downstream, and finally placing the blocks at the burial site[140]. But, we do not follow this suggestion.

Essentially, Kitchen's speed estimates and the outcomes of the «Min of the Desert» experiment cannot be directly applied because they pertain to boats under sail, which is not suitable for upwind navigation. However, we can utilize the resulting speed from the rowing experiment with two conditions in mind. Firstly, adjustments are necessary to accommodate a professional crew, warranting an increase in the speed rate. Secondly, that rowing was conducted in short bursts rather than continuously for eight hours a day. As assumed in our estimation and Kitchen's, the speed to ensure sustainability throughout the

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134 POMEY 1997: 33.

135 KRAUSS 2006: 370.

136 DE JONG 2006: 438.

137 SOMAGLINO believes that this statement is exaggerated, since this date falls approximately during January, at a time when the waters were not yet at their lowest level. SOMAGLINO 2014: 128.

138 On the difficulties of navigating the Nil. COOPER 2011: 189–210.

139 FISCHER 1975: 34.

140 SOMAGLINO 2014: 144.

day must be reduced. If we adopt an average speed of 2 knots, the journey would only take 10 days.

Traveling in low water against the wind must have been particularly difficult, and the enormous dimensions of the barge aggravate the problem. The stats of Willoks[141] in 1904 gave an average velocity during the water short supply of 0.85 m/s[142]. Utilizing this speed, equivalent to 1.652 knots, and the eight hours/day navigation brings us to a 12-day voyage. Regrettably, journeying downstream presents its own set of challenges. Without a vessel maintaining a favorable velocity compared to the water, steering becomes practically impossible. Specifically, a barge left to drift aimlessly on the water would quickly veer sideways to the current, leading to unpredictable and hazardous movements. The crew has to sail the boat slower than the current so it does not become ungovernable. Herodotus described what the ancient Egyptians did to slow and steer their boats when navigating downstream. Their method involved adding a small raft in front and an anchor at the rear, working in tandem to correct its course[143]. As a result, the average speed would decrease to approximately 1 knot, leading to the completion of the voyage in 17 days.

VI. CONCLUSION

The king commanded the noble Weni to journey to the quarries of Hatnub and retrieve an offering table for placement in his funerary complex. Weni departed from Memphis to Hatnub, located south of Minya, to fulfill his lord's directives. Upon arrival, he instructed the quarrying of the sacrificial table from the alabaster quarries while simultaneously commissioning the construction of a sizable barge, from wsx.t type, suitable to transport the required table. Exploiting the abundance of acacia trees in central and southern Egypt, he procured wood for his vessel and proceeded with its construction. In his narrative, Weni employed only two verbs to delineate the shipbuilding process: one (*šꜥ*) for all tasks related to timber cutting, from felling trees to fashioning mortises for the tenons and channels for the sewing in the planks, and another (*sp*) for assembling the hull planks. It was this phase that lasted 17 days. The vessel embarked from a pier, likely adjacent to the boatyard, during the dry season when the Nile's water levels were at their lowest.

Through a meticulous analysis of the inscription and a comparison with other relevant terms in Weni's autobiography, the study highlighted the importance of understanding the literal and contextual significance of boatbuilding terminology for accurate interpretation. This scrutiny revealed that Weni's narration was characterized by a wonderful style and a special presentation of sentences beyond the known meanings of some traditional verbs in the Egyptian language, leaving the reader to visualize those implied meanings. This feature is not limited to our two verbs but also includes two others: *ỉr* and *sṯi*/*sṯꜣ*, specific words and implied meanings.

Weni used all these verbs rhetorically. He chose not to document his instructions to the workers regarding the construction of the boats, nor did he depict the various stages of labor and the strenuous effort he exerted to demonstrate his loyalty and dedication to serving the king, as was customary in such texts. Suddenly, we are confronted with boats floating on the Nile, indicating

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141 WEHAUSEN et al. 1988: 304.

142 COOPER has adopted a velocity of 1.1 knots following Philips, yet we opt to maintain Willoks' statistics. This decision is based on his pre-1902 study origins, unaffected by the construction of the Aswan Low Dam, in contrast to Philips, who published his figures in 1924. COOPER 2011: 189-210.

143 WEHAUSEN et al. 1988: 304-305.

that Weni traversed all stages of construction, from selecting the forest for felling acacia trees to transportation, timber cutting, preparation, shaping, carving, building, assembling, and beyond.

Undoubtedly, this dominant method in the inscription falls within the framework of rhetoric by deletion—a common linguistic phenomenon across human languages. Deletion involves selectively choosing essential elements of speech while omitting surplus details, such as letters, words, sentences, or repetitive elements. It may also entail excluding elements that the listener can infer, thereby enhancing the eloquence and beauty of speech. In contrast, some of his contemporaries used the same terms directly in a similar context without resorting to rhetoric. This difference in approach highlighted individual variations in expression among ancient Egyptian writers, even when discussing common subjects.

Caulking's potential use in a boat, suggested by scholars who interpreted a term ambiguously, was discussed. We argued against this interpretation linguistically and historically, stating that caulking was not a practice in ancient boatbuilding traditions, especially for papyrus boats. Instead, we suggest the possibility of a process for water tightening or waterproofing using materials like papyrus stalks and bitumen. Evidence from archaeological findings and textual references supports this idea, indicating the use of plant fibers and substances like tar or pitch in boat construction. Thus, while the term may describe a construction phase related to water tightening or waterproofing, it is unlikely to be one of the main construction processes mentioned in Weni's text.

The text analysis revealed a lack of detail regarding the boat's construction phases, using only two aforementioned terms to describe the entire process. The interpretation of these terms, «*šꜥ*» and «*sp*», introduced confusion, with scholars divided on their meanings. Some translated «*sp*» as «to assemble», while others mistakenly translated it as «to build». The feasibility of building such a barge in only 17 days was questioned, with speculation that pre-cut timber might be prepared before Weni's arrival. The most plausible interpretation suggests that «*šꜥ*» encompasses the entire process of wood preparation, while «*sp*» denotes the final mounting (i.e., the assemblage) of the hull, which could feasibly take 17 days for a barge of this size.

According to Weni's account, the journey lasted 17 days. This duration suggests that the boat's speed slightly exceeded one knot. To assess this, the average speed of Egyptian boats and typical navigation hours per day were examined. While ancient records did not provide direct evidence of boat speeds, estimations were made based on similar expeditions and experimental data. Considering factors like wind conditions and navigation methods, it's estimated that daily navigation hours would not exceed 10, with an average of around 8 hours. Despite the challenging conditions of low water and upwind and downstream navigation, calculations suggested that the journey from Hatnub to Memphis could be completed in approximately 17 days, as stated by Weni.

The collaborative efforts of the authors, drawing on their respective scientific backgrounds in Egyptology and maritime archaeology, have been instrumental in unraveling the complexities of Weni's expedition. By combining linguistic analysis with nautical perspectives, the study bridged the gap between textual interpretations and practical maritime knowledge, offering a holistic view of ancient Egyptian seafaring activities. The integration of archaeological studies and maritime archaeology has not only enriched our understanding of Weni's expedition but has also highlighted the interdisciplinary nature of historical research, emphasizing the importance of diverse perspectives in reconstructing the past.

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EARLY MODERN HUMANS AND THE MARINE ENVIRONMENT [THE IBEROMAURUSIAN]

Article 8

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EARLY MODERN HUMANS AND THE MARINE ENVIRONMENT [THE IBEROMAURUSIAN]

ABSTRACT

[AR] **المجموعات البشرية الحديثة الأولى و البيئة البحرية (الإيبرومغربي)**

تظهر علاقة الإنسان بالبحر في العديد من الشواهد الأثرية لفترة ما قبل التاريخ في شمال إفريقيا خاصة في الجزائر، ونجد من بين أهم حضارات ما قبل التاريخ الحضارة الإيبرومغربية، يهدف هذا المقال إلى فهم سلوك المجموعات البشرية الإيبرومغربية في محيطها وعلاقاتها مع المحيط البحري، وكذلك تثمين التراث الأثري المغمور تحت مياه البحر. فقد شهدت المناطق الساحلية في شمال إفريقيا تغيرات مع مرور الوقت مما أدى إلى تغير مظهرهم، على سبيل المثال بسبب تقلبات مستوى سطح البحر، فقد غمرت المياه بعض المواقع التي أقيمت بجانب البحر قبل الهولوسان والتي يمكن أن تشهد علاقة السكان الساحليين الأوائل بالبحر مثل المغرب. يعود الوجه الثقافي الإيبرومغربي إلى العصر الحجري القديم الأعلى، يؤرخ ما بين 22000 إلى 10000 ق.ح ويمتد على سواحل بلاد المغرب من شمال تونس إلى جنوب المغرب الأقصى. يرتبط بالإنسان العاقل القريب جدًا من Cro-Magnon، فهناك منه مجموعتان: مشتى آفالو ويتمثل بالشكل الخشن، والمشتاوي الذي يمتاز بالشكل النحيف. تعد المناطق الساحلية غنية بالكتلة الحيوية وتوفر موارد غذائية وفيرة ويمكن الوصول إليها بسهولة، لهذا السبب، قد كانت بالفعل مناطق جذابة للإيبرومغربيين؛ لذلك يتركز مكان استيطانهم على الساحل حيث يستقر الإنسان غالبًا في ملاجئ تحت الصخر والمغارات، لكنهم استوطنوا أيضا في الهواء الطلق على مستوى المناطق الداخلية. توفر الوديان والحافة الساحلية للبحر الأبيض المتوسط على وجه الخصوص المواد الأولية، وتوفر الممرات والأماكن الاستراتيجية لإقامة القاطفين والصيادين خلال البلايستوسان الأعلى.

[EN] The relationship of human and marine environments appear in many archaeological testimonies of prehistoric North Africa; this is seen especially in Algeria, one of the most important civilizations we find the *Iberomaurusian*. This paper aims to understand *Iberomaurusian* humans behavior in their environment and their relationship with the marine environment, therefore promoting underwater archaeological heritage. The coastal areas of North Africa have undergone major changes over time, which changed their appearance. Some of these changes include sea level fluctuations, during which sites that were established by the sea before the Holocene. These sites, like the Maghreb, bear witness to the relationship of the first inhabitants of the coast with the sea, and were submerged. *Iberomaurusian* is a prehistoric culture that dates back to the Upper Paleolithic, between 22 to 9,5 ka cal BP. It extends on the coasts of the Maghreb from northern Tunisia to southern Morocco, and housed Homo sapiens, who were genetically very close to Cro-Magnon. There are two groups of homo sapiens: Mechta-Afalou, the robust form, and Mechtoïd, the slender form. Coastal regions are rich in biomass and offer abundant and easily accessible food resources, and they were already, for this reason, attractive areas for the *Iberomaurusian*. Habitations of the *Iberomaurusian* concentrate on the coast where humans often settled in caves and rock shelters. Coastal borders of the Mediterranean provide, in particular, raw materials, offer mobility paths, strategic places to set up hunters-gatherers of the Late Pleistocene.

KEYWORDS: Algeria, coastal borders, *Iberomaurusian*, marine environment, North Africa, subsistence.

I. INTRODUCTION

The coastal areas of North Africa have undergone major changes over time, which changed their appearance. For example, due to sea level fluctuations, settlement sites by the sea, which were established before the Holocene, were submerged like Tunisia. Moreover, the sea is an important source of nutrients. The closed Mediterranean basin does not present favorable conditions for the development of marine fauna, and according to biological and archaeological data, some fauna from prehistoric periods are identical to current fish and shells, which are contemporaneous to the *Iberomaurusian* culture. This research is aimed at investigating the relationship between the *Iberomaurusian* of North Africa and the marine environment. Our study is closely connected to maritime environments, and focuses on *Iberomaurusian* culture that often relied on coastal resources. This culture was involved in maritime activities such as fishing, collecting marine mollusks or shellfish harvesting. *Iberomaurusian* groups had navigation skills, and they fished sea bream that live in the coastal seabed. Until now, there is no clear evidence that shows that the *Iberomaurusian* of North Africa knew navigation outside of North Africa. Meanwhile in the Capsian, there is the presence of obsidian stone artifacts and striker reindeer wood. During the Neolithic period, the primary evidence that draws attention are archaeological remains, such as the remnants of printed and cardinal pottery, and the obsidian material that spread during the Neolithic period in the Tellian regions of the Maghreb. Probably, the obsidian was brought by Neolithic human groups to the Maghreb from Iberian Island (in the west) and from the islands of south Italy (in the east). The similarity in the remains distinguishes the neighboring countries of Egypt, Italy and Spain, which explains that there is a relationship among the prehistorical human groups. The essential arguments likely to prove the existence of any nautical activity in North African Prehistory comes from the marine environment. But we do have not direct evidence of preserved remains of boats or safe and well-dated iconographic representations[1].

The *Iberomaurusian* groups were hunter-gatherers. Also, they lived in diverse environments, both inland and along the coastal territories. We will, first of all, identify the different biotopes available, which were revealed by aquatic taxa from Algerian *Iberomaurusian* assemblages. It will thus be possible to determine the exploitation zones of these environments and to present examples of their exploitation. This study will be enriched by the examination of fish and mollusks remains from *Iberomaurusian* sites.

II. MATERIAL AND METHODS

Once aquatic territories are described, it is easier to estimate the type and degree of their exploitation by human communities, or in other words to outline the extent of human influence. It is obvious that the location of the sites in relation to the physical territories in question is not sufficient on its own to explain what is happening. We subsequently analyze and interpret human territories in a marine environment using GIS (Geographic Information Systems) as a tool. The approach, «Site catchment analysis», has been executed in this study, which focuses on hunter-gatherer economies and site resource bases for part of the Algerian region as a model. This approach relates

[1] ONRUBIA-PINTATO 2012: 1.

to the study of spatial connections in archaeology, and has usually been used in archaeological studies[2]. This approach was founded by the researcher Chisholm[3] and was developed by researchers Vita-Finzi and Higgs according to requirements and the special features of archaeology. They defined this theory as the study of the relationship between technology and those natural resources represented in the economic zone neighboring the site[4]. GIS has become an efficient tool to implement predictive models and simulations in archaeology including the site catchment analysis[5].

We have explored ArcGIS for spatial repartition and analysis, and applied the buffer methods into main *Iberomaurusian* sites in this study in order to analyze the distance of *Iberomaurusian* sites from the seashore (near or far from archaeological sites). For the transportation of marine resources, we relied on «least-cost analysis» to reconstruct mobility patterns and procurement strategies for mollusks resources in west Algeria.

We used the data provided by the first authors and discoverers of *Iberomaurusian* sites, particularly for the marine remains of fish, mollusks and crustaceans[6], We have included our experiences in archaeological surveys of the Algerian coastlie, like Sidi Said, which is under the direction of Y. Saoudi and N. Saoudi in 2008. Our experience in archaeological excavations such as at Rachgoun site, which is under the direction of M. Betrouni in 2017, our moving from the Rachgoun site to the sea (Madrid Beach) by foot, helped us to understand the mobility of *Iberomaurusian* humans. Further, our visiting Taforalt and its surrounding area, such as Zegzel in 2019, during the First Congress of Geological and Archaeological Heritage (CPGA1, University Mouhamed Premier Oujda), has let us to know the territory of the iberomaurusian in this region of Morocco, this visit is under the direction of A. Bouzouggar and EL H. Talebi. We use our[7] study and analysis of *Iberomaurusian* stone artefacts of Taza I, and we exploited our[8] analysis of prehistoric human settlement in the region of Tiaret Mountains too (south-Oranais). We did many archaeological surveys at Columnata and its surrounding area in order to understand prehistorical human behaviors. The recent studies are also used to understand marine malacofauna exploitation by the *Iberomaurusian* groups of the Alain rockshelter, specifically of Oran and Taza I of Jijel in the Babors region.

III. *IBEROMAURUSIAN* CULTURE

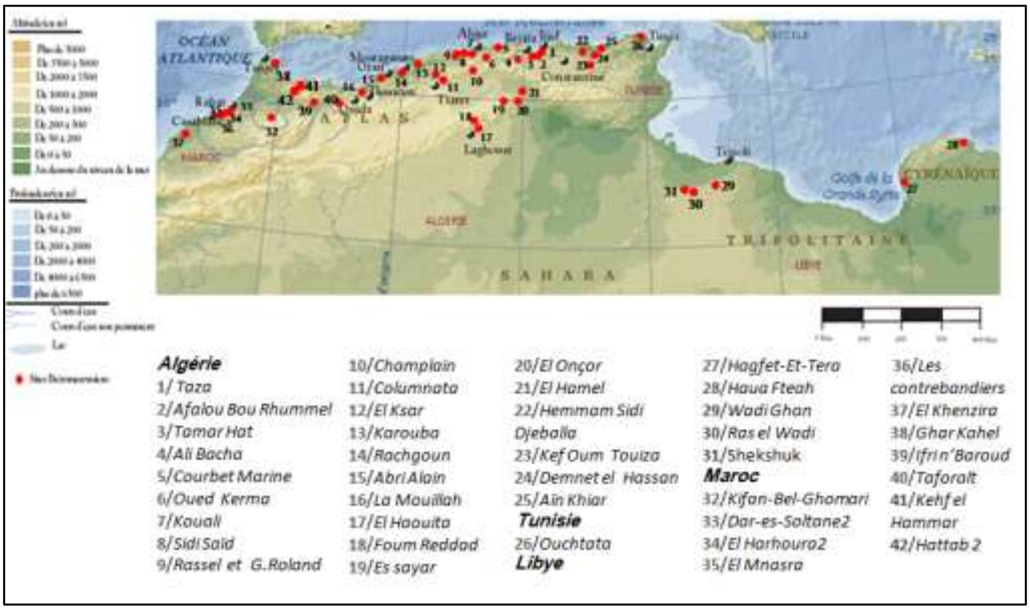
Many researchers have been interested in the *Iberomaurusian* culture, which is a prehistorical culture belonging to the epipaleolithic. This culture was first named by Paul Pallary in 1909[9] after the tools that were found in La Mouillah, a site near

[2] ROOD 1982: 28.
[3] CHISHOLM 1968: 113
[4] VITA-FINZI & HIGGS 1970: 5.
[5] SAVAGE 1991: 331
[6] Such as PALLARY, P. 1909 ; BARBIN, P. 1910 & 1912 ; CADENAT, P. 1948 ; BALOUT, L. 1958 ; CAMPS, G. 1974 ; Camps-Fabrer, E. 1975. In addition, we have included studies by recent authors: Campmas, E. et al 2016; MERZOUG, S. 2017; MERZOUG, S. et al 2022.
[7] CHABANE 2012: 281.
[8] CHABANE 2022: 925.
[9] BRAHIMI 1968: 5; TIXIER 1963: 10.

Maghnia west Algerian.[10] He attributed the Ibero name to Spain, believing that it had cultural contact and communication with the Iberian Upper Paleolithic.

The *Iberomaurusian* existed in North Africa during the Late Pleistocene, 22 and 9.5 ka cal BP.[11] This period appears towards the end of the second Heinrich event and developed throughout the Late Glacial in Northern Europe. It correlates broadly with the northern European Younger Dryas. This Upper Paleolithic culture is mostly divided into two subphases: an Early and Late *Iberomaurusian* [12]. This period developed under a relatively cold and dry climate[13].

North Africa hosts numerous *Iberomaurusian* sites **[FIGURE 1].** Notable locations in Algeria include La Mouillah, Afalou Bou Rhummel, Taza, Zemmouri El Bahri, and Tamerhat, the oldest known site in Algeria[14]. Additionally, El Ansor, dating back to 8100 BP (GIF.44.33), predates El Haouita, El Hamel, and Columnata. In Morocco, there are the following sites: Tafouralt, Harhoura, El Khenzira, and Ouchetata. There is also Hawa Fteeh in Tunisia, Hagfa Tira in Libya, and Nazlet Khater-4 in Egypt[15]. Outside of Africa, there is the site of Ksar Akil in Lebanon, which is located near Beirut, in the layer (B3). It contains shells and microlithics, dominated by backed bladelets[16].



[FIGURE 1]: Site distribution and land use of *Iberomaurusian* in the Maghreb. **CHABANE 2012: 15, FIG.1**

During this period, *Iberomaurusian* humans developed an industry characterized by distinctive bone and stone artifacts, setting them apart from previous periods. Paul Pallary defined the *Iberomaurusian* stone artifacts as microlithic backed bladelet industry[17] what spread along the coastal areas[18]. To investigate the industrial complex of

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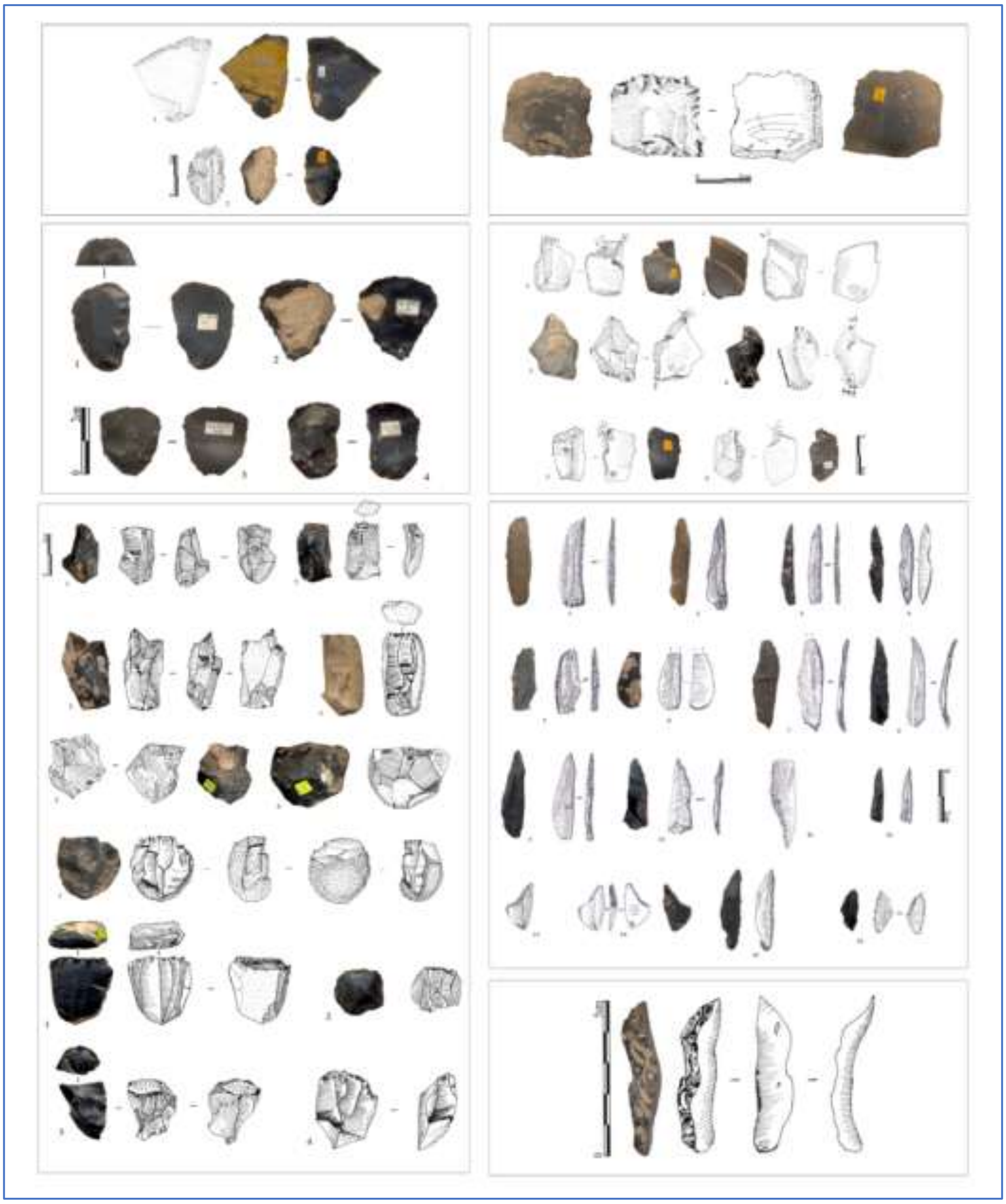
[10] CAMPS 1974: 57; BARTON et al. 2005: 59; BALLOUT 1958: 112-113; BARICHE et al. 2006: 563.
[11] CAMPMAS et al. 2016: 83.
[12] LINSTÄDTER 2008: 45.
[13] MERZOUG 2017: 190.
[14] CLOSE 1984: 11-12.
[15] VERMEERSCH et al. 1990: 444.
[16] LUBELL 2004: 86.
[17] BALLOUT 1958: 111.
[18] BARTON et al. 2005: 79.

this culture, researcher Tixier provided a specific typological list in 1963, derived from the Maghreb region. This list, which includes 112 types distributed into 11 groups, serves as the primary model for attributing types within the Epipaleolithic period, to which the *Iberomaurusian* and Capsian cultures belong. An *Iberomaurusian* stone artifact is defined by its compact size and microlithic attributes, notably featuring crescent-backed bladelets[19] alongside larger-sized pieces.

Its main products are the bladelet lithic industry[20]. Small cores allow for the production of bladelets, and are distinguished by a skewed flat striking platform such as what is seen in Taza I cave[21]. These lithic cores are usually small pyramidal shapes. **[FIGURES 2-3]**.

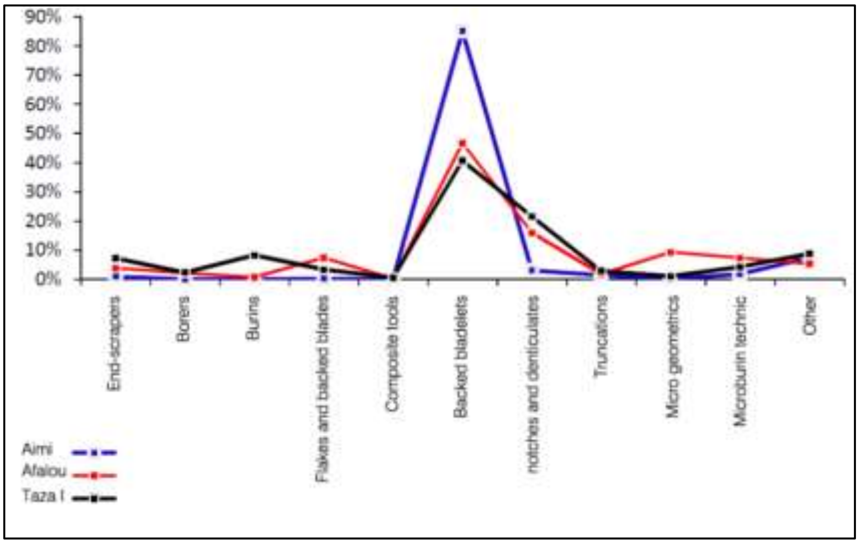


[FIGURE 2]: *Iberomaurusian* stone artifacts of Taza I site. CHABANE 2012: 15.

[19] ROCHE 1963: 5.
[20] CLOSE 1980: 154.
[21] CHABANE 2012: 277.

[FIGURE 3]: Microlithic industry, bone industry, shells and red ochre of *Iberomaurusian* culture of Taza I © Photo taken by the author

In terms of debitage, the human maker prefers the extended shape because of their elegance and lightness[22]. In addition to the bladelets, we find blades and flakes. Stone tools are exceptionally rich and diversified, and this lithic industry contains a large percentage of backed bladelets tools **[FIGURE 4]**. The most notable one of backed bladelets tools is La Mouillah point[23] and truncations tools which were made with the microburin technique. There is also an abundance of scrapers which mostly are flakes, denticulates, burins and micro geometrics that are rare[24]. The *Iberomaurusian* lithic industry characterized by the appearance of ouchtata retouche too[25]. Various raw materials are used including flint, sandstone and quartzite[26]. The *Iberomaurusian* lithic industry contains some sturdy tools such as hummer, grindinds or crushing tools, seen in the case of Dar-es-Soltan 2 site[27].



[FIGURE 4]: A graphical curve representing a comparison of the content stone artifacts of *Iberomaurusian* sites (Taza I, Afalou Bou Rhummel and Aimi). CHABANE 2012: 276, FIG.218.

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[22] GOBERT 1945: 448.
[23] TIXIER 1963: 106; STRAUS 2001: 98.
[24] SCHURMANS et al. 2006: 12.
[25] RODRIGUE 1994: 210.
[26] DERRADJI 2003: 49; LUBELL 2001: 138.
[27] NESPOULET & EL HADJRAOUI 2004: 89.

In addition, the presence of the bone industry among the *Iberomaurusian* is represented by bone tools and ornaments, which was identified by Camps-Fabrer in 1966. The bone industry contains only 27 of 54 types which are found in four groups. The first group is the cutter group, which were received in 06 types (slicers, knives and scissors). The second group include the polishers, the third group includes perceives and the forth group encompasses the ornaments, along with one type of pendant[28].

Bone tools were made with varying degrees of mastery. Some of the tools discovered at the Afalou Bou Rhummel site showed masterful technique, while other tools were prepared by burning with less precision. It seems like the Afalou human did not care about the perfection of their manufacture, as they still preserve the anatomical parts of animal bone **[FIGURE 5]**.

[FIGURE 5]: *Iberomaurusian* bone industry of Columnata site © Photo taken by the researcher

Iberomaurusian graves are available, sometimes forming cemeteries. The most famous cemetery is Columnata that presented 110 individuals. Taforalt had 183 individuals, while Afalou Bou Rhummel at least 60 individuals[29]. Furthermore Ifri n'Baroud is characterized by an individual burial[30]. Bodies are placed in a variety of positions, such as sitting cross-legged, on the back, or lying down such as in the case of H28 of at Afalou Bou Rhummel. The squatting position is also observed at the Taforalt site. Funeral rituals were associated with some buried bodies (animal remains, body adornment, stone or bone tools and pieces of red ocher). *Iberomaurusian* inhabitants practiced tooth avulsion, or the removal of the upper incisors. This ritual is applied to the two upper incisors.[31]This phenomenon was practiced whether female or male[32], teenager or child. The lower incisors were removed even if they are not used regularly[33]. The concept of practicing this ritual remains ambiguous.

[28] CAMPS 1974: 67.
[29] HACHI 2006: 430.
[30] BEN-NCER 2004: 180.
[31] CAMPS 1974: 97.
[32] NESPOULET & El HAJRAOUI 2004: 89.
[33] HADJOUIS 2002: 338

Iberomaurusian made art throughout North Africa, which is characterized by small figurines made of pottery (baked clay). The Tamar Hat cave has many of these artistic examples. At this site, a piece of baked clay, dated to 20200 BP, was found and published by Saxon in 1973. The site also yielded two spherical sandstone pebbles, which were perforated and of large size[34]. Similarly, Afalou Bou Rhummel is a site that contains the largest collection of objects made of pottery, some of which are piles of clay including spherical and sub-spherical shapes, but the majority of the clay pieces represent animal shapes and Anthropique shapes[35]. Statues of Afalou Bou Rhummel concentrated in the layer VIII and IV, dated between 14910 ± 180 BP and 13120 ± 370 BP[36].

IV. *IBEROMAURUSIAN* HUMAN

The aterian human being disappears and the Mechta Afalou human type appears in the *Iberomaurusian* record[37]. The name Mechta Afalou is derived from Mechta El Arbi, the archeological site where MERCIER & DEBRUGE (1907, 1912, 1914) found the first representative of this human gendre, and Afalou Bou Rhummel , the site where a large number of human skeletals were found and allowed for VALLOIS & BOULE to identify more Mechta Afalou[38]. This is a true homo sapiens[39], very close in shape and appearance to the cro-magnon[40], who appeared in Europe about 35000 years ago[41].

There are two groups: the Mechta Afalou, who have a rough appearance, and the Mechtoïd, who have a thin appearance or body[42]. The available evidence suggests that they were anatomically modern Homo sapiens, more than 500 individuals were found. According to Chamla, this human type contains the following physiological characteristics: A man's stature is estimated at 1.74 m and that of the woman is 1.63 m with a brain capacity estimated at 1650 cm^3. The skull has a pentagonal shape from the upper view, and is long dolichocephal, mesocephal and disproportionate to the face. The facial shape is low, short, broad and generally thrust forward with a prominent nose. The orbits are far apart and have a rectangular shape, lowered and the lower jaw is sturdy.

The skeleton is rough and the bones are thick. The forearms and feet are long comparing to the humerus and thigh. Chamla showed that the Mechta Afalou species combines four subspecies, forming the evolution connections of this species. The oldest type has the longest «hyperdolicocephal» skull, which is seen in number 38 from Afalou Bou Rhummel. The Classical is characterized by long and a medium skulls, dolichocephal and mesocephal, which we find in Afalou Bou Rhummel and Taforalt.

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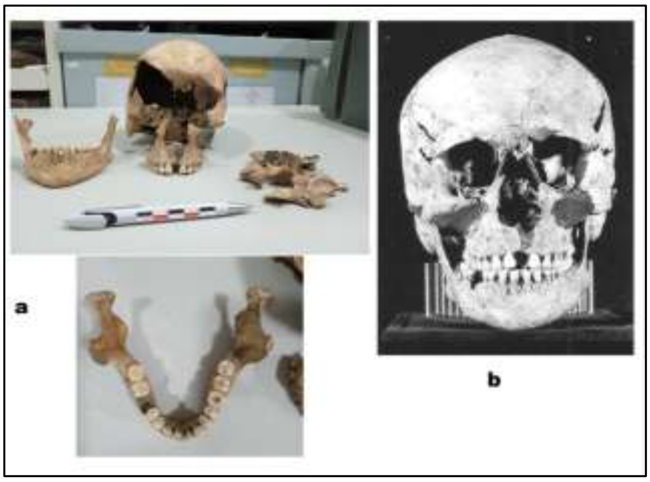
[34] CAMPS-FABRER 1960: 105.
[35] HACHI 2003: 163.
[36] HACHI 2006: 431.
[37] HADJOUIS 2003: 7; HACHI 2006: 430; AOURAGHE 2006: 241.
[38] ARAMBOUR et al.1934: 64
[39] DEBENATH 2000: 137; DERRADJI 2003: 52.
[40] IRISH 2000: 393.
[41] AOURAGH 2006: 241.
[42] LUBELL 2001: 138.

The evolved *iberomaurusian* is known as Mechtoïd and has a less robust skull and small dimensions; this kind is found in Taforalt, Afalou Bou Rhummel and Columnata. The last type has a short skull, which correlates with brachycephal, is known in north Africa; it is autochthon and characterized by its slender shape. This type evolved locally and has been identified in Afalou Bou Rhummel and Columnata **[FIGURE 6]**.



[FIGURE 6]: Human Nº.22 from the Columnata necropolis. CHAMLA 1994: 6. Modified by the researcher

V. HABITAT

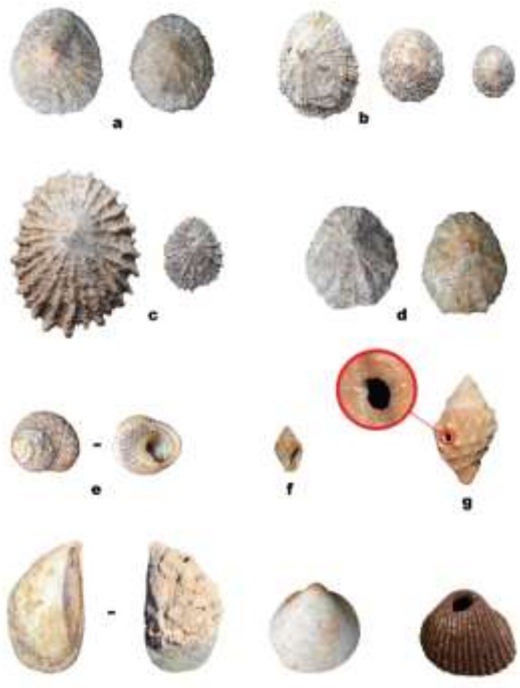
Coastal regions are rich in biomass and offer abundant and easily accessible food resources. They were already, for this reason, attractive areas for the first hominids in different parts of the world[43]. The *Iberomaurusian* almost completely occupied the coast[44], occupying caves and deep rockshelters. We also sometimes find them in exposed habitats. Mostly, they are common in sandy regions or territories which Balout spoke about «law of the sands»[45], like in fixed dunes.[46] Such sites include Rachgoun, El Khiar and Ouchtata. Or they live on stands of erosion, such as Le Musoir site, Courbet-Marine (the new noun is Zemmouri El Bahri), Demnet El Hassan and El Ksar site, cut out of alluvium where sand dominates. These habitats were built and shaped with branches and reeds, having left no visible structures in the archaeological layers[47]. The thickness of archaeological layers in certain rokshelters and caves (Tamar Hat, Taforalt, Ténès, Taza I) reveals the sustainability of the occupation, which is confirmed, in at least three cases, in Taforalt, Afalou bou Rhummel and Haua Fteah. This is a chronological sequence covering several millenaries. On the basis of the large size of the sites, the depth of the deposits and the large number of burials discovered in certain sites, it seems that the *Iberomaurusian* lived in large groups. At least a few sites functioned like base campsites[48]. There are also sites that are interpreted as seasonal fishing stations, such as cave of Taza I[49].

[43] ALVAREZ-FERNANDEZ 2015: 192.
[44] CAMPS 1974: 59.
[45] BALOUT 1955: 347.
[46] BARICHE et al. 2006: 568.
[47] Camps 1974: 91.
[48] LUBELL 2005: 210; CAMPS 1974: 92.
[49] MERZOUG et al. 2022: 101.

VI. THE RELATIONSHIP BETWEEN HUMAN *IBEROMAURUSIAN* AND THE MARINE TERRITORIES

Whenever the region and aquatic environment (continental or marine) is concerned, the examination of prehistoric navigations poses a certain number of methodological issues that must be taken into account[50]. Aquatic remains are collected and studied in archaeological sites. The evidence suggests that, during the *Iberomaurusian* period at the coastal sites, hunter-gatherers used several marine vertebrates and invertebrates. These include bones and otoliths bony fish, calcified vertebrae and teeth of cartilaginous fish like sharks (Abri Alain site)[51]. There are also mollusk shells at Taza I site and Columnata. The hard parts of crustaceans, sea urchins, and the bones of marine mammals at places such as anatidae in Abri Alain site[52] generally indicates that humans introduced these organisms into a land territory.

Iberomaurusian groupes used marine shells at Afalou Bou Rhummel and champlain at Blida[53] (Algeria), Ifri el Baroud and Ifri n'Ammar[54] (Morocco). Archaeological shells contributed both to diet and manufacture, such as making ornaments **[FIGURE 7]**. Marine mollusks give us access to the environments exploited by these *Iberomaurusian* populations and their movements and their relationship with the sea.

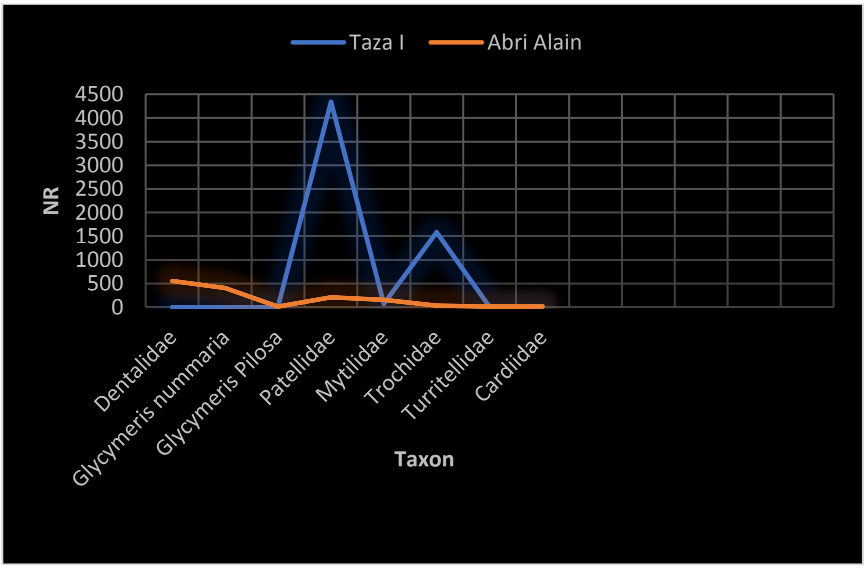


[FIGURE 7]: Mollusc shells from TAZA I. A. Cymbula safiana; B. Patella rustica; C. Patella ferruginea; D. Patella caerulea; E. Phorcus turbinatus; F. Columbella rustica; G. Stramonita haemastoma; H. Mytilus edulis; I. Glycymeris nummaria; J. Cerastoderma edule.
MERZOUG et al. 2022: 104, FIG.4

[50] ONRUBIA-PINTADO 2012: 1.
[51] CAMPMAS et al. 2016: 90.
[52] CHIBANE 2016 : 31
[53] BALOUT 1958: 121.
[54] NAMI 2011: 264.

1. Dietary Behavior of *Iberomaurusian* Humans through Aquatic Remains

The *Iberomaurusian* groups were accustomed to using the resources of the Mediterranean and Atlantic, mainly mollusks, crustaceans and fish. In complementary sites where shellfish constituted a part of the diet, the piles of shells provide us with a great deal of information about the human who occupied them. The piles of shells report sites that were only occupied in certain seasons and usually show evidence of specialized economic activity, such as fishing. «*Shells, through the richness of their colors and the brilliance of their pearl, very early on exerted a great attraction for the prehistoric human of North Africa, as elsewhere. Iberomaurusians and Capsians who mainly fed on the product of their harvest and collecting marine shells, or land snails have obviously sought among these elements of their diet a good part of their objects of ornament*»[55]. Sometimes, marine mollusks, some of which served as objects of adornment, are most common; those that were used for food, seen at the Abri Alain site, for instance, are the rarest[56]. The hunting of terrestrial animals leaves several archaeological remains, in the form of animal bones, microlithic tools and weapons, and other technologies. Fishing and related activities leave less. *Iberomaurusian* inhabitants generally had at their disposal territories and aquatic fauna quite comparable to those currently observable. However, fauna was probably exploited differentially depending on fishing and gathering techniques, the individualities of production, consumption and habits, or subsistence behaviors. We can note this in the Taza I and Abri Alain sites **[FIGURE 8]** according to studies carried out by Campmas and al. in 2016, Merzoug S. in 2017 and Merzoug S. and al. in 2022.



[FIGURE 8]: Graph curves show majorities. Taxa that identificated in Taza I and Abri Alain sites © Done by the researcher.

Shells and shells have helped to understand the activities and behaviors of *Iberomaurusian* groups. Depending on whether man sought the raw material that is the shell or the flesh of the animal, the methods of supply may have varied. The marine shellfish and shell have a privileged place in the daily life of the populations who

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[55] CAMPS-FABRER 1994: 2088.
[56] PALLARY 1934: 26.

occupied the sites (rock shelters or open-air sites), whether they are coastal or more than 100 km away from the *Iberomaurusian* coastline.

Groups stayed on the coast and hunted mammals, seabirds (anatidae)[57] and consumed the shells that eventually created the shell middens. Fish certainly constituted the bulk of the diet. We find this type of remains in most coastal sites that indicate human consumption. Among the remains are fish vertebrae or bone pieces, which are numerous at Abri Alain (Alain rockshelter)[58]. Marine taxa in the *Iberomaurusian* sites are labridea, Sparidae which revealed the presence of royal sea bream in Taza I[59]; this indicates that prehistorical humans practiced marine fishing[60]. *Iberomaurusian* flint artifacts are used for marine fishing. They have regular geometric shapes, such as a trapezoids and triangles that have refined edges, including those found in (Taza cave, La Mouillah, Abri Alain, Sidi Saïd, Rassel, Taforalt, Temara and Ghar Cahal...). The piece is attached to the end of the stick with a barb for hunting. It is probable that the *Iberomaurusian* used the bone tools for fishing: straight hooks, assegais and harpoons, the latter type is the only fragment of a harpoon with a row of bone barbs collected in level III of Taforalt[61]. The bone hooks found in *Iberomaurusian* sites are well made. Fish vertebrae are very often found at coastal sites, indicating that fish were a source of food, along with marine mollusks.

Among the sources of food for the humans in the coastal region are marine mollusks that one can pick up from the sea and ocean, and other shellfish. Through this type of activity, one can identify an aspect of food selection during the *Iberomaurusian* in the coastal areas of the Mediterranean and Atlantic. Among the species that have been consumed by *Iberomaurusian* humans are Mytilidae, Patellidae, Trochidae, which are found in a rocky biotope in the intertidal zone. They were probably collected at low tide[62], making them easy to locate and collect on emerged rocky substrates. These families are represented in the Mediterranean (Abri Alain, Taza, Tamar Hat, Afalou Bou Rhummel). Similarly, they are found on the Moroccan Atlantic coasts (Temara-Rabat) which is defined as the Middle Stone Age in North Africa[63]. Likewise for Pattelidae which are widespread in the *Iberomaurusian* sites of the Mediterranean coast[64], for example at Rassel site C. Brahimi in 1970 noted the presence of Torchidae and Patellidae which are in the Babors region, such as Afalou Bou Rhummel, Tamr Hat and Taza I cave and in the Oranais region too (Abri Alain)[65]. According to P.BARBIN in 1910, there are Cypraea lurida shells that were extracted in 1907 in La Mouillah, which was discovered in 1899 by P.PALLARY[66]. Mytilidae, Patellidae, Trochidae are found at

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[57] CAMPMAS et al. 2016: 97.
[58] CAMPS 1974: 94; CAMPMAS et al. 2016: 11.
[59] MERZOUG et al. 2022: 102.
[60] CAMPS 1998: 83.
[61] CAMPS 1974: 67.
[62] CAMPS 1974: 94; CAMPMAS et al. 2016: 91.
[63] STEELE & ALVAREZ-FERNANDEZ 2011-2012; CAMPMAS et al. 2016: 97
[64] CAMPS FABRER 1994: 02.
[65] ARAMBOURG et al. 1934; SAXON et al. 1974 ; CAMPMAS et al. 2016: 93; MERZOUG 2017: 197; MERZOUG et al. 2022: 99.
[66] BALOUT 1958: 113.

Temara in the Moroccan Atlantic (la grotte des Contrebandiers). The *Iberomaurusian* groups mainly ate Mytilidae and Patellidae, but also to a lesser extent Trochidae and Muricidae[67]. With regard to mollusks, Arambourg noticed a difference in the consumption of their strains. For example, in the upper stratigraphic level of the Afalou Bou Rhummel and Tamar Hat sites, he noticed a large spread of marine shells compared to the lower level with upper level[68].

Archaeological and ethnographic data indicate that the first species caught or collected were probably accessible at the waterline or slightly below, without requiring large technical investments: hand fishing or use of knives made of stone, bladelets or hooks sufficed. The notches on the Patellidae shells indicated that they were adapted to be tools, which would allow one to slide between the shell and the rock to detach a mollusk from the rocky substratum[69]. In this way, the collection of coastal invertibrates is attested in the *Iberomaurusian* levels of North Africa.

It is noted that the exploitation of other fishing resources by the *Iberomaurusian* inhabitants are crustaces, and Crab clips (Afalou Bou Rhummel and Taza I cave)[70]. Also, the human groups of this period exploited sea urchins at Abri Alain, Taza I[71] and Rachgoun[72]. There are some fishing resources not identified in the ancient assemblage, including (Aterian and Mousterian), Haliotis (Contrebondiers site)[73] and (Dar es Soltane site)[74]. Also, the crab claws were found in the *Iberomaurusian*, but not in the oldest assemblage, despite the robustness of these fossils. It was found in the most recent material from the Haua Fteah site too, but not in Late Pleistocene material[75].

Apparently, Invertebrates and Crustaces are not the main food of the *Iberomaurusian* groups, but were supplements to the meat they got from the animals they hunted. *Iberomaurusian* groupes have also collected marine shells or mollusks for other uses such as body adornment.

Body Adornment Marine Remains

Iberomaurusian human groupes mainly feasted on their harvest and collected marine shells and fish[76]. They also used marine shells as body adornment **[FIGURE 9]**, **[FIGURE 10]**. Many *Iberomaurusian* sites suggest that marine mollusks were used as body adornments along the Atlantic coast (Temara, Bouskoura, El Khenzira, Dar es Soltane) and the Mediterranean coast, including sites such as Rachgoun, Rassel, Tamar Hat, Afalou Bou Rhummel, Taza, and Ouchtata.

Marine shells were an important feature in the spiritual life of *Iberomaurusian* inhabitants, and were used as symbolic expression. For example at La Mouillah site, the Cypraea Lurida seemed to have been burned, and the human skeletons discovered in a

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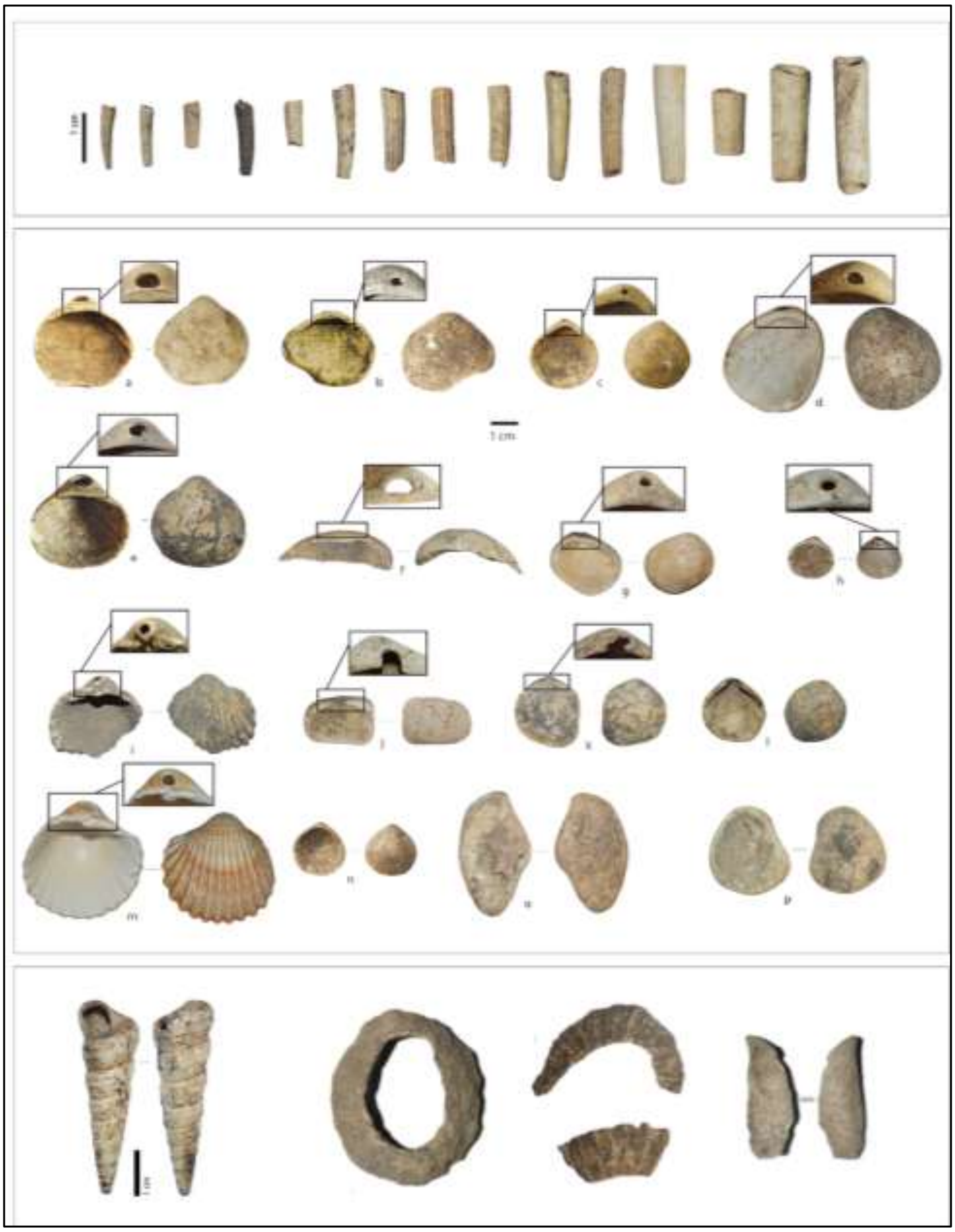
67 CAMPMAS et al. 2016: 96.
68 CAMPS 1974: 93.
69 CAMPMAS et al. 2016: 91.
70 MERZOUG et al. 2022: 109.
71 CAMPMAS et al. 2016: 91.
72 CAMPS 1974: 94.
73 STEELE & ALVAREZ-FERNANDEZ 2012: 225
74 RUHLMANN 1951: 33
75 STEELE & ALVAREZ-FERNANDEZ 2012: 225
76 CAMPS-FABRER 1994: 2088.

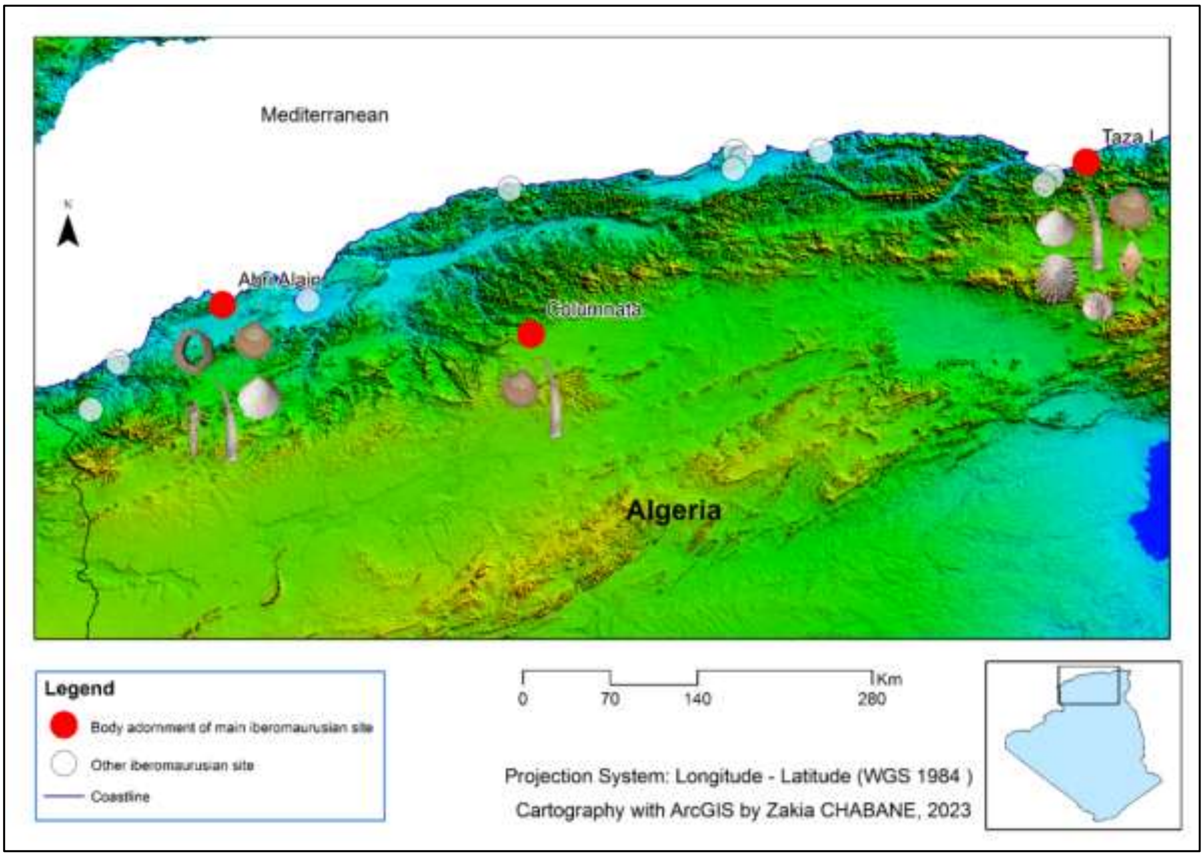
rock shelter there was found wearing a marine shell of this type as a necklace. The *Iberomaurusian* people at Abri Alain in the Oranean and Taza I in the Babors region adorned themselves with shells, primarily using tusk shells (Dentaliidae), Glycymerididae, Cardiidae, and Turritellidae, all of which are still commonly found in the Mediterranean Sea. At Taforalt, the majority of the marine shells that were used for bodily adornment were sea scallop, turrets, and dentales[77]. Among the scaphopods, tusk-shell (Dentaliidae) are very common at the *Iberomaurusian* sites in the Maghreb, and are especially common during the Neolithic era[78]. Marine and land mollusks of various types have been used by humans since the *Iberomaurusian* period at coastal sites. Even to this day, in this region, people use them to adorn their bodies.



[FIGURE 9]: Marine shells as body adornment. CAMPMAS et al. 2016: 92, 94-95. Modified by the researcher.

[77] CAMPS 1974: 94.

[78] CAMPS-FABRER 1994: 2088.

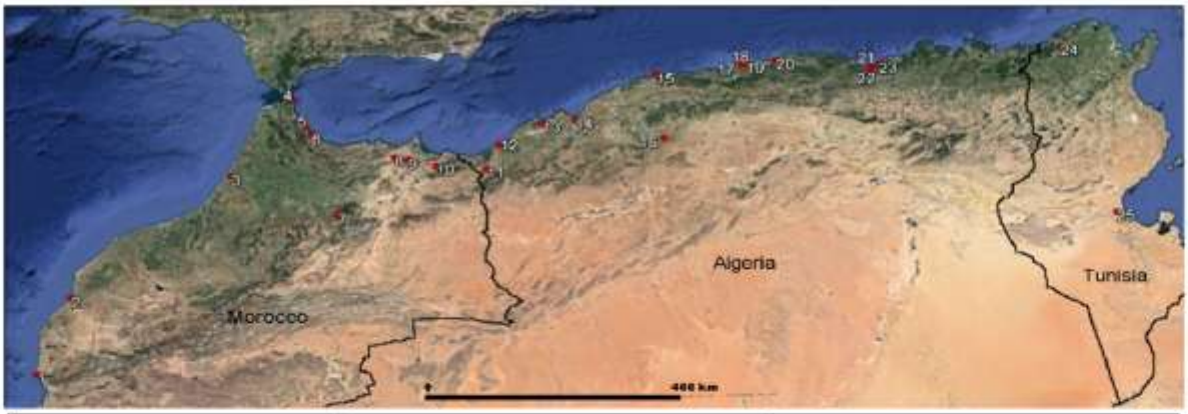


[FIGURE 10]: The majority species identified according to their uses/body adornment in the main *Iberomaurusian* sites © Done by the researcher

2. The Marine Territory of the *Iberomaurusian* Fisherman

A coastal territory is an area defined as an ecotone, or a region of transition between two terrestrial and marine biomes[79]. The *Iberomaurusian* culture spread throughout all of the coastal regions of the Maghreb, starting from the Libyan coast in the east to the Atlantic Ocean in the west. The specific regions include Libya, Tunisia, Algeria and Morocco, with the exception of the eastern Tunisian coast, because the geological formations dating back to this period are currently submerged under the Mediterranean Sea, several kilometers off the current coastline, which is particularly low[80]. This culture also extends to inland regions such as the high plateau (Hauts Plateaux) in Algeria and the middle Atlas in Morocco **[FIGURE 11]**.

[79] BAILEY & PAKINGTON 1988: 1-6.
[80] CAMPS 1974: 61-62.



N

Legend:

• Iberomaurusian site

Id	nom	Id	nom
1	Cap Ghir	14	Oued Guettera
2	El Khenzira	15	Cap Ténes
3	Témara	16	Columnata
4	Ghar Cahal	17	Rolland
5	Kef El Hemmar	18	Rassel
6	Hattab II	19	Oued Kerma
7	Kifan Bel Ghomari	20	Courbet Marine
8	Ifri El Baroud	21	Afalou Bou Rhummel
9	Ifri n'Ammar	22	Tamar Hat
10	Taforalt	23	Taza
11	La Mouillah	24	Ouchtata
12	Rechgoun	25	Oued Akarit
13	Abri Alain		

Projection System: Longitude - Latitude (WGS 1984)
Cartography using ArcGIS by Zakia CHABANE, 2023

[FIGURE 11]: Geographical localization of main coastal *Iberomaurusian* sites that represented on Satellite Image © Done by the researcher

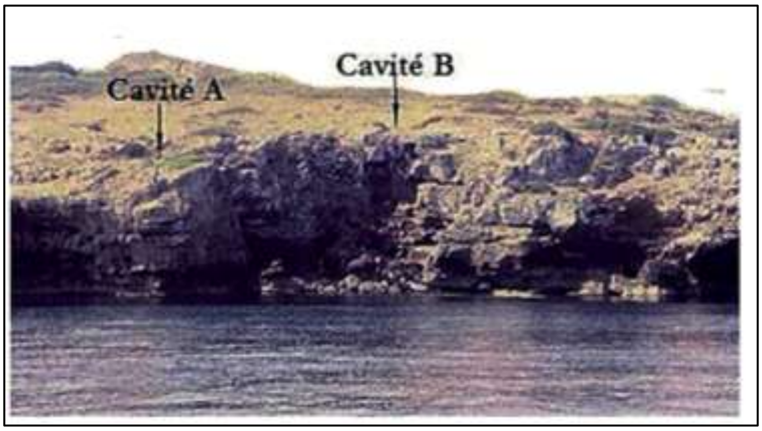
The coastal zone was an important territory during the *Iberomaurusian* period when hunting and fishing were the main activities. The proximity of the aquatic territory with the land makes it more easily accessible by humans and can contain various substrates: rocky, sandy or sludgy. Each marine organism is dependent on a type of substrate. By cross-referencing data on archaeological taxa habitats with the specific geomorphological conditions to each region, we can determine the exploited coastlines, evaluate the distances covered to procure resources, and understand how populations strategized to collect such resources.

We took as a case of study the Algerian *Iberomaurusian* sites that cover this period and which effectively demonstrated the relationship between the *Iberomaurusian* human and the marine territories. We tried to use site catchment analysis, which is used to study ancient hunter-gatherer mobility and subsistence. Researchers conducted experimental studies to test the theory of site catchment analysis, focusing particularly on how human groups move around sites of activity. They concluded that moving in an uninhabited area requires great effort. In order to procure natural resources that are necessary for living, populations needed to be able to exploit neighboring areas, especially when they reached the point of sufficiency[81]. In most of the cases studied, the distances walked was less than 10 km.

[81] CHISHOLM 1968: 131; LEE 1969: 61.

We applied the buffer methods with ArcGIS into 03 main *Iberomaurusian* sites as a model in this study (Taza I, Abri Alain and Columnata) and other sites of this period. As a result, we conclude two groups of sites, the first group is near the coastline and the second groupe is far from the coastline. Sites close to the sea for example, Sidi Saïd, in Algeria was partly submerged in the sea **[FIGURE 12]**, along with Temara, Morocco. There were also sites that were distant from the maritime territories. It seems that the *Iberomaurusian* inhabited the area along the seashore, less than 500 m away. Such areas of inhabitation include Taza I cave of Jijel (Algeria) and Kef El Hemmar (Morocco). These populations consumed the fish and marine mollusks, and collected marine shells from rocky substrates near the site. Additionally, the Abri Alain rock shelter of Oran is located in a wetland less than 5 km from the seashore. The Oranean region is considered to be one of the oldest regions where prehistoric people used maritime navigation[82]. The same distances are noted between sites and the coast in Morocco, such as Hattab II site, Cap Ghir site, El Khenzira and Temara in Moroccan Atlantic. The *Iberomaurusian* human settlement was primarily concentrated along the coastline, influenced significantly by the availability of key natural resources, particularly those related to nutrition. There is distance between the settlement location and these vital resources.

Iberomaurusian human groups who frequented habitats located near the sea were familiar the marine world, which is clear according to the archaeological remains found in the sites. It is obvious that aquatic fauna was an integral part of the diet and daily life of the *Iberomaurusian*.



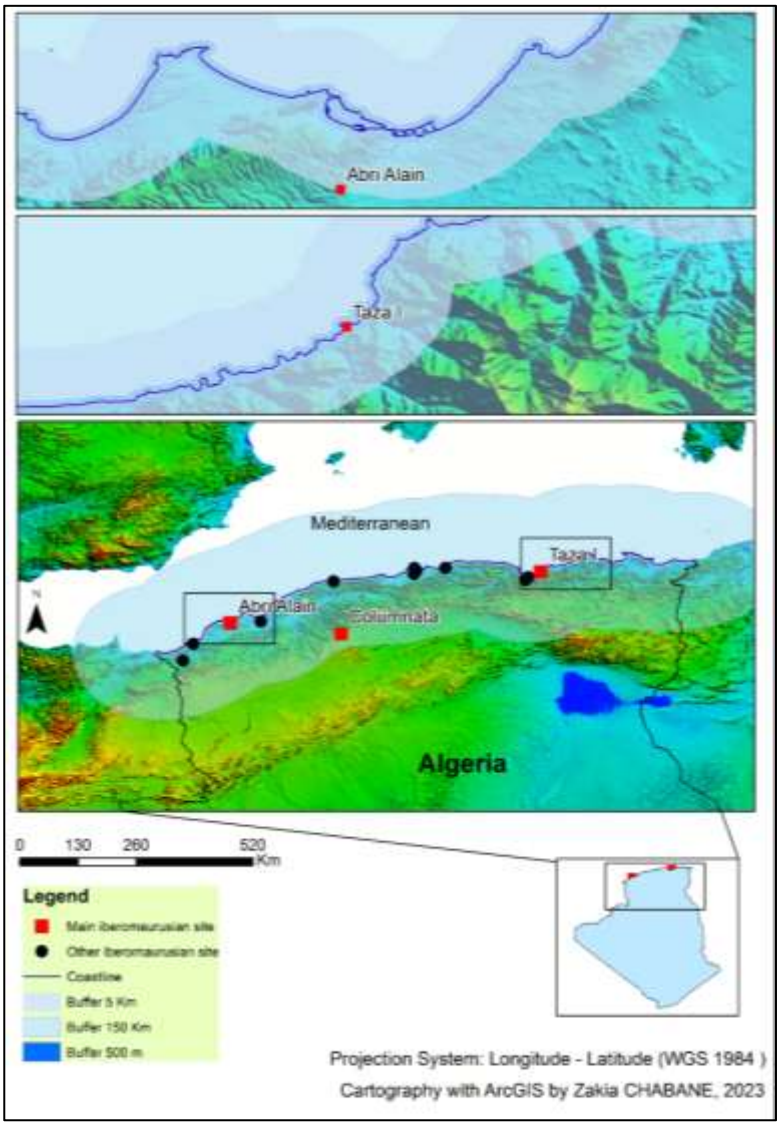
[FIGURE 12]: The aterian/ *Iberomaurusian* Sidi Saïd site. BERTROUNI 2021: FIG.8

The exploitation of marine fish and shells are evidenced in the inland territories through the remains of marine mollusks found at Columnata. Rare dentalium shells and cardium valeves that are pierced with suspension holes indicate possible interaction with inhabitants of the coastal areas[83]. The buffer shows a distance less than 150 km from the coastline **[FIGURE 13]**, which indicates that the *Iberomaurusian* exploited the maritime environment in this site. Furthermore, this population used inland fish and mollusks, whereas in the inland sites, they only transported mollusks. As we have seen, they more systematically exploited nearby territories, rivers and lakes. However,

[82] CAMPS 1974: 275.

[83] SARI 2023: 74.

southern populations, (Hauts Plateaux) also sometimes exploited coastal resources (Columnata site in Algeria and Kifan Bel Ghomari in Morocco), despite their distance. Examination of the faunal remains revealed less exploitation of these resources for consumption. On the other hand, this supply, which were mostly mollusks, seems to have served other purposes, such as the production of ornaments and utility objects. In other words, the way these remote territories exploited marine fauna was not to meet daily needs, but seems to be more selective.

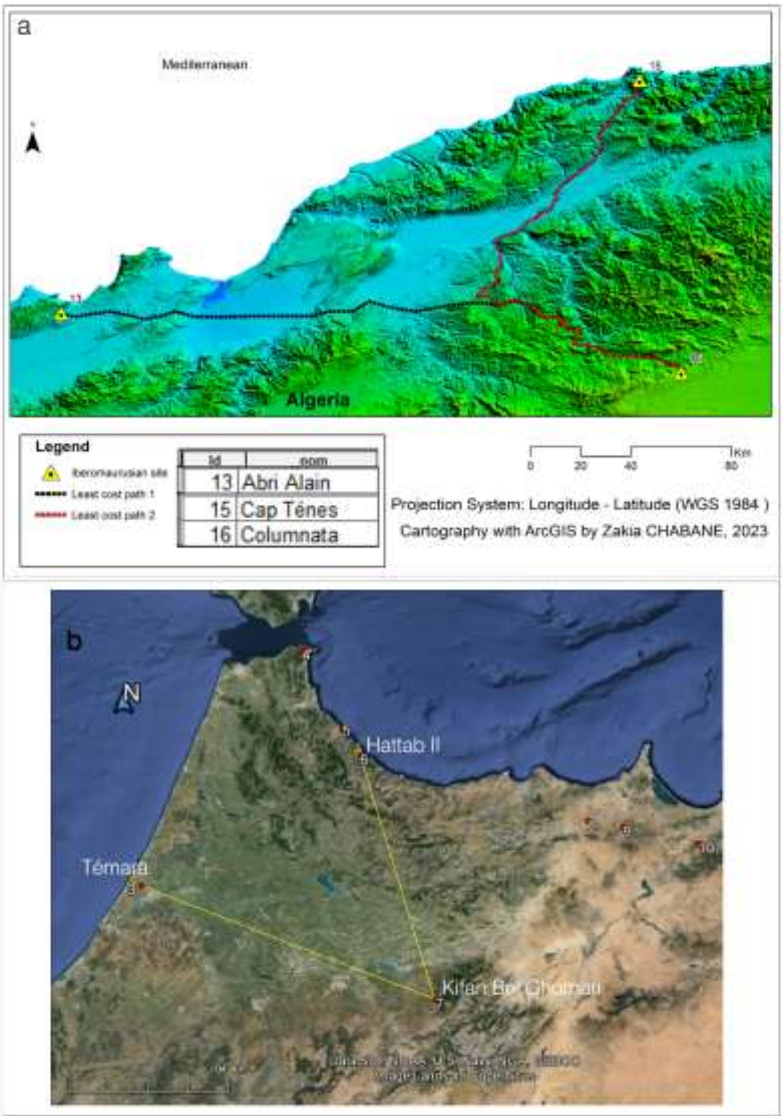


[FIGURE 13]: Application of a buffer with SRTM into main *Iberomaurusian* coastal sites and marine territories of Algeria © Done by the researcher

Probably, links between these *Iberomaurusian* sites allowed natural resources such as marine mollusks to be transported. The accessibility of sites is a determining criterion, and calculating the average of the two least-cost distances between two locations, measures the number of paths that served these human settlements[84]. This allows for the analysis of exchange networks and circulation paths between archaeological sites. As a result, we apply, in this case, «least-cost analysis», to reconstruct possible ancient paths between sites of human activity and sites catchments

[84] HERZOG 2014: 226-227.

(molluscs resources) in west Algeria. Three *Iberomaurusian* sites (Columnata, Abri Alain, and Cap Ténès) were selected as proxies to delineate the least-cost paths for the movements toward natural sources of marine fish and mollusks **[FIGURE 14/A]**. Then, the least-cost path 1 is between Abri Alain and Columnata site, with a distance of 180 km; the *Iberomaurusian* would have walked more than 36 hours to take raw material or natural resource. The least-cost path 2 is between cap Ténès site and Columnata site , or a distance of 207 km, which is the equivalent of a 41 hours walk. The distance between the coastline to Columnata is 118 km. In Morocco, from the distance between the Mediterranean coastline to Kifan Bel Ghomari, which is situated in eastern Morocco at foothills of the middle Atlas[85], is 163 km (Kifan Bel Ghomari to Hattab II). From the Atlantic to Kifan Bel Gohmari, the distance is more than 206 km (Kifan Bel Ghomari to Temara) **[FIGURE 14/b]**. The surounding area of the catchment base in Kifan Bel Ghomari site is larger than at Columnata. On average, a prehistoric human could only walk 10 km a day. To move to the sea the human needs other encampments, which means there are probably others sites in these regions.



[FIGURE 14]: The accessibility of sites and mobility © Done by the researcher

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[85] ROUBET & HACHI 2005: 1.

VII. CONCLUSION

The study of *Iberomaurusian*'s relationship with the marine world proves interesting. This study suggests that there was a critical juncture for *Iberomaurusian* humans, wherein they needed to break away from their inland territory and explore a previously unfamiliar marine environment. Food was acquired through hunting and gathering. *Iberomaurusian* humans also liked to collect shellfish, and probably fished. Archaeological remains indicate that both marine and terrestrial food resources are exploited.

The marine remains were primarily across the coastline and extended inland (more than 200 Km from the coastline), with marine shells being found at Columnata, in the Tiaret's Mountains (Algeria) and at Kifan Bel Ghomari (Morocco). Aquatic or marine resources, however, remain a small portion of the fauna exploited, even when compared to the terrestrial resources, particularly mammals. The evidence suggests that, during the *Iberomaurusian*, hunter-gatherers at the coastal sites used several marine vertebrates (fish and seabirds) and invertebrates (marine mollusks) as subsistence. However at sites far away from the Atlantic and Mediterranean coast, hunter-gatherers only carried marine mollusks such as dentaliidae.

It's plausible that the *Iberomaurusian* people occupied open-air sites instead of rock shelters, unlike the Aterian culture, and migrated closer to the coastline. This trend is evident not only in the Temara area, which is currently submerged in the Moroccan Atlantic, but also in regions of Algeria and Tunisia. Verification of this hypothesis would require the development of underwater archaeological techniques to explore submerged sites. It is necessary to do inventories, surveys, and explorations of submerged prehistoric sites, particularly of the *Iberomaurusian* sites off the coasts of North Africa. This effort allows us to understand human's behavior in their environment, and highlights the importance of underwater archaeological heritage.

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