ISIS@MACH ITALIA

Science and Technology Facilities Council
ISIS Neutron and Muon Source

Experiment Proposal

Experiment number GP2024014

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Experiment title	SEM-EDS analysis of nails from different antique shipwrecks in the Mediterranean
MRF Instrument	**SEM with correlative AFM**
Access Route	Direct Access
Science Areas	Cultural Heritage
Sponsored Grant	None
Grant Title	-
Start Date	-
Similar Submission?	-
Industrial Links	-

Days requested: 3
Previous GP Number: GP2023070
DOI: -
Sponsor: -
Grant Number: -
Finish Date: -

Non-Technical Abstract

Ship nails can provide important information about the construction techniques of ancient ships and, depending on their typology, alloys, and internal structure, deliver information on the ship provenance and travel routes. The study of their production and mechanical treatment allows to approach questions like if there was, all over the Mediterranean a general standardisation or not, based on a cultural exchange, or if there are culturally different and chronologically evolving technologies used to produce the nails.

Here we propose a further characterisation of several ship nails, from different findspots and cultures, using SEM-EDX. Preliminary results showed a systematic presence of tin in the Roman nail compared to the Punic one, yet also suggested that the analysis can depend largely on the region considered (head or tip) and on the spatial scale considered, mainly due to the presence of environmental layers partially shadowing the original nails (e.g., Si, Al, Ca and S).

Publications -

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E-platform: No

Instruments	
Access Route	
Science Areas	
Sponsored Grant	
Grant Title	
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Industrial Links	

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Sample record sheet

Principal contact Dr Laura Strolin, Institut Català de Arqueologia Clàssica, SPAIN
MRF Instrument **SEM with correlative AFM** **Days Requested:** 3
Special requirements:

SAMPLE

Material	Bronze nail	-	-
Formula	Cu, Sn	-	-
Forms	Solid		
Volume	10 cc		
Weight	90 g		
Container or substrate	-	-	-
Storage Requirements	-	-	-

SAMPLE ENVIROMENT

Temperature Range	300 - 300 K	-	-
Pressure Range	- 1000 mbar	-	-
Magnetic field range	- T	-	-
Standard equipment	None	-	-
Special equipment	-	-	-

SAFETY

Prep lab needed	Yes	-	-
Sample Prep Hazards	-	-	-
Special equip. reqs	-	-	-
Sensitivity to air	No	-	-
Sensitivity to vapour	No	-	-
Experiment Hazards	-	-	-
Equipment Hazards	-	-	-
Biological hazards	-	-	-
Radioactive Hazards	-	-	-
Additional Hazards	-	-	-
Additional Details	-	-	-
Sample will be	Disposed by IS	-	-

1. Background and Context

Underwater excavations regularly provide an important number of nails, usually in bronze or copper alloys, used for different purposes. The so-called treenails consisting of a nail driven through a wooden peg are used fixing the planks and the frames of the ship, whereas wooden pegs have been used to stabilize the tenons keeping the planks in place. Shorter nails have been used to protect the outside of the hull with thin lead sheets. As the analysis of one single plank from the Antikythera shipwreck is showing (fig. 1), there is an enormous number of nails used in antique ship construction (yellow and red dots). The nails are therefore not only a fundamental part of a ship but can also deliver a rich amount of information from scientific analytical methods.

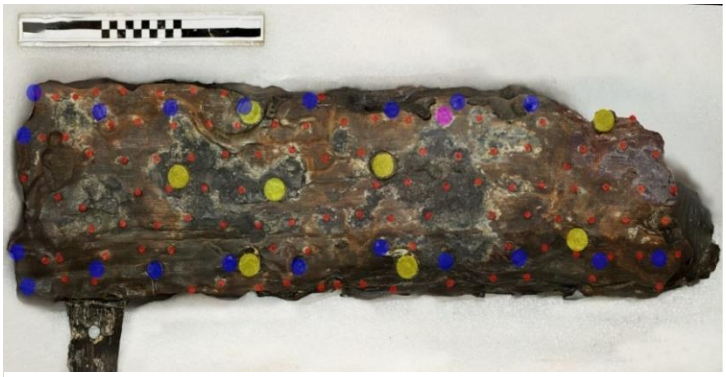

Fig. 1: Analysis of the number of different types of nails used in a single plank from the Antikythera shipwreck, 1st century BC. (yellow: treenails; red: bronze nails; blue: wooden pegs)

While ship construction was, during the antiquity, a highly specialized industry, e.g., for the Phoenicians, the Greeks, and the Romans, and producing a large series of special ship types for all kind of purposes (war ships, long distance cargo ships, etc.), it is astonishing that the nails, as fundamental as they are, have so far only found little interest. Aside of giving important information about the construction techniques, they can, by their typology, by their alloys, and by their internal structure deliver information e.g., about the provenance and, by analyzing reparations, about the routes of the ships. Moreover, investigating production techniques and mechanical treatment of the nails, will help understanding if there were standard technologies shared in the whole Mediterranean - thanks to cultural exchange - and how they evolved through time.

2. Proposed experiment

We propose a surface characterization of several ship nails, coming from different findspots, and belonging to different cultures and periods. In that interest, nails coming from at least three different shipwrecks will be analyzed, allowing the comparison of their metal composition, their provenance, and their mechanical treatment. For the time being, three shipwrecks have been selected as a starting point of the project. From each shipwreck, between 3 and 12 nails will be selected for analysis. The three ships are: the Marsala Punic (Phoenician) military ship (3rd century BC), the Antikythera Greek (?) cargo ship [3, 4, 5, 6] (1st century BC), and the Marausa Roman merchant ship found near Trapani. While surface characterizations were already performed on samples from the Punic ship [2], here we plan a systematic comparison of nails from the three different ships using Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy using the instrument SEM with correlative AFM, a TESCAN VEGA SEM, located at the University of Rome Tor Vergata, IM@IT Unit. This instrument is particularly suitable for analyzing this samples given it has a suitably large sample volume with linear dimensions of about 10 cm. The mapping of the elemental composition on the surface of each nail will provide information of the type of bronze alloy used, thus on its origin.

3. Summary of previous characterizations.

This is a continuation proposal based on the results from the access GP2023070, for which 1 day of access at the SEM with correlative AFM was awarded. Within the limited time allocated, a systematic comparison between two nails, one from the Marausa Roman and

one from the Marsala Punic one, was performed. Fig.2 shows an example of the SEM images obtained, while Fig.3 typical results from EDX. The comparison showed a systematic presence of tin in the Roman nail compared to the Punic one, yet it also suggested that the analysis can depend largely on the region of the artifact under characterization (head or tip) as well as on the size of the image, mainly due to the presence of environmental layers partially shadowing the original nails (e.g., presence of Si, Al, Ca and S). Additional measurements are required to define 1) what is the best field of view where to maximize the counts as well as have a representative picture; and 2) to confirm a systematic difference in stoichiometries amongst nails from different civilizations.

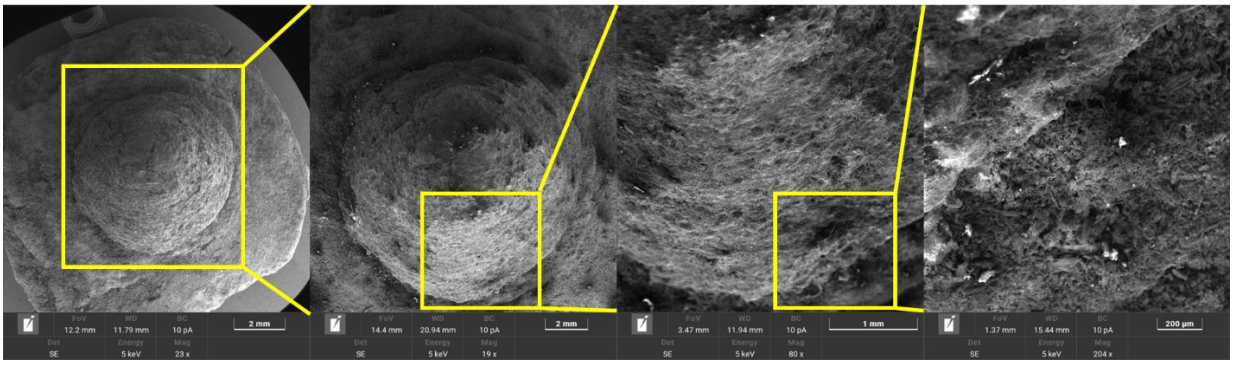

Fig. 2: SEM images of a nail from a punic ship (ref. 11016), with a subsequent zoom in yellow-framed regions. The image scale (bottom-right corner of each image) changes from 2mm (left) to 200 um) right.

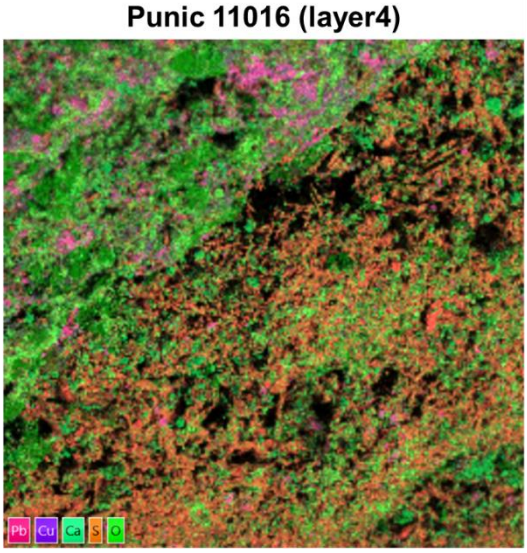

Fig. 2: EDX elemental map from the punic nail 11016, corresponding tot he right image in Fig.2. Pb, Cu, Ca, S and O are reported as magenta, violet, olive, orange and green.

4. Justification of time requested

We request 3 days of instrument time on the *SEM with correlative AFM* MRF, to complete the preliminary measurements, to be used as follows: up to 3 hours of measurements per ship nail, considering additional 4 ship nails for both the Punic and the Roman ships. This results in about 24 hours of measurements to be divided over 3 days of instrument time.

References

[1] Albertin F., Baumer L. E., Bettuzzi M., et al., *X-ray computed tomography to study archaeological clay and wood artefacts at Lilybaeum*, The European Physical Journal Plus 136, 513 (2021). https://doi.org/10.1140/epjp/s13360-021-01465-1

[2] Armetta F., Celeste Ponterio R., et al., *New Insight on Archaeological Metal Finds, Nails and Lead, Sheathings of the Punic Ship from Battle of the Egadi Islands,* Molecules 28(4), February 2023:1968. https://doi.org/10.3390/molecules28041968

[3] Kaltsas N. et al, ed., *The Antikythera Shipwreck. The ship, the treasures, the mechanism,* Athens, National Archaeological Museum 2012.

[4] Simosi A., Baumer L., E., *L'épave d'Anticythère livre peu à peu ses secrets*, Archéologia, 614, novembre 2022, 56-63.

[5] Simosi A., Baumer L., *Anticythère 2021*, Antike Kunst 65, 2022, 155-157. 163. https://www.jstor.org/stable/27164586

[6] Simosi A., Baumer L., *Anticythère 2022*, Antike Kunst 66, 2023, 119-124 (in print).