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For nearly twenty years the Phanagorian expedition of the Institute of Archaeology of the Russian Academy of Sciences in Moscow has been focusing its research on the land and coastal area of the Greek city of Phanagoria. Located on the Kerch Strait separating the Black Sea and the Sea of Azov, the city was founded during the 6th c. BC by greek colonists and was occupied until the Middle Ages.

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From 2012 onwards, the underwater team lead by our colleague Sergey Olkhovskiy, who unfortunately could not join us today, has used different methods of survey on the maritime area next to the ancient city. It allowed the localisation of part of the city’s port infrastructure composed by two large berthing facilities: the eastern pier built in the 5th-4th century BCE and the western pier of a latter unknown date. It is in 2012, during the excavation of the massive stone embankment near the eastern pier that the remains of the ship were found (Labelled S on the slide).

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After removing the seabed deposits covering the entire ship’s structure, the ballast and a few objects used on board were found.

The layer of small stones and fragments of tiles that covered the bottom of the shipwreck were interpreted as a ballast while A Megarian bowl, a jug, some cooking wares and two Colchian amphorae were probably belonging to the onboard equipment.

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Two years later, the ballast was removed in order to document and study the hull remains. During the removing of a stone mound not far from the NE end of the ship, a bronze casing decorated with a five-rayed star and a crescent was found. This finding permitted to identify the bow of the ship and to associate the ship with the Kingdom of Pontus during which the star and crescent is well attested in coins minted especially during the reign of Mithridates VI (120-63 BCE). The stratigraphic context and the findings place the wrecking event around the first half of the 1st century BCE.

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In 2019, Sergey invited Giulia and myself to participate to the fieldwork in order to complete the documentation and study of the ship. The site was reopened, cleaned and documented, samples for xylological analyses were collected and the ceiling and some other components were removed from the seabed.

The wreck consists in a remarkably well-preserved hull 15.82 m long and 2.40 m wide.

The ship was keel-based and built shell-first in the typical Mediterranean fashion with planks regularly assembled by a network of pegged tenons. The frame system, alternating floor-timbers and half-frames, was regularly reinforced by paired floor-timbers, and fastened to the planking by the means of clenched nails passing through treenails. The structure was strengthened by keelson made of two components apart of the mast-step.

The remains reveal a nice carpentry and a careful choice of types of wood in relationship with the function of the ship’s components.

As the ship rested on its port flank, this side was best preserved almost until the caprail. The transverse section at the main frame depicts a flat garboard with a round turn of the bilge.

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The stem, even if not preserved, was characterized by a concave profile as proved by the shape of the bronze casing. A few other elements of the ship were discovered detached from the main part of the wreck, add a considerable amount of information to the understanding of the ship’s original shape at the stem: thus the bronze casing but also two identical timbers, as well as a V-shaped floor-timber from the stem.

Regarding the bronze casing: the piece is 0.9 m long, 0.44 m high and weighs 15 kg. Two nails, whose holes are visible on the slightly curved arm, or cowl, fixed the “ram” to the stem-post. A single nail secured the straight arm to the keel

As said before, the bronze casing is finely decorated: all its edges have mouldings and a crescent accompanied by a five-rayed star is represented on both of its lateral faces.

Regarding the two similar oak timbers found dislocated not far from the bronze casing, they are 1.35 m long, and 55 mm thick. Both timbers are very similar in shape: a long and flat piece with one straight extremity, another slightly curved. Once the two timbers are put side-by-side, they form a sort of V-shaped structure and the various nails match perfectly the holes on the opposite timber.

It is suggested that this V-shaped structure was nailed to the outer part of the planking at the bow and capped the stem post. In this configuration, this structure could be identified with a *proembolion* such as depicted in the slide on the right corner.

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Given the quantity and quality of the remains, we quickly considered the opportunity of trying to reconstruct the original shape of the hull.

CLICK

On the one hand, it was felt that the port side was sufficiently well preserved in extension to allow such a search.

CLICK

However, the longitudinal profile of the wreck, with a significant hog, led us to question the appropriate method for assessing deformations and perceiving the amount of the necessary redress to find the original shapes.

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We decide to follow a method which consist in mixing 3D printed parts and manually formed pieces: the idea is to build a model shell first, assembling the planks by mortise and tenon, using parts extracted from the 3D model of the remains. This type of hybrid approach is not completely new in nautical archaeology (one thinks in particular of the example of the reconstruction by the Norvegian Maritime Museum of the Sorenga 7 shipwreck) but it is, based on our knowledge, unprecedented for a ship of the ancient Mediterranean.

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To begin, we simply modelled all the elements of the wreck from the photogrammetry: keel, separated planks with theirs pegs for the tenons, the frames with their nails and treenails, as well as the ceiling and the keelson. Whether these elements are obtained by redrawing them in Rhino3D or by reworking the mesh directly from the photogrammetry, in a software like Geomagic, the goal is the same: to obtain a final 3D model of the remains identical to the original photogrammetry.

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This provides a complete model of the remains with all the distinctive parts of the wreck.

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Beginning with the planking, the idea is to obtain the developed plan of the planking flattened out. To do this we used the **UnrollSurface** command of Rhinoceros on the surfaces representing the inner face of the planking. The position of the tenon pegs, the position of the frames and the position of the treenails are also labelled on this inner face and reported on the developed plan. These elements will be used later on during the construction of the model to check the correct alignment of all the elements.

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It is necessary to stress that this technique can only be applied to developable surfaces: a plank that owes its curvature partly to carving cannot be developed. In the same way, if the planks are torn, the result is a non-developable surface that prevent to use this method.

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Once this plan is generated, it is printed at a scale of 1/10 and then glued on a wooden cardboard from which each independent plank will be cut.

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For the frames, we used 3D printing, taking care to have well design the holes corresponding to the assembly elements (treenails and nails) to the planking. It is necessary to note that all the elements of the frame have been printed and that, apart from few elements, all have been put in place in the model.

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However, it can be stressed that the possibility of having frames deformed in the transversal direction is quite possible as demonstrated by previous studies like on the Newport ship. For the Phanagoria research model, we estimated that transverse shape of port side was quite undisturbed. Anyway, to compensate for possible transversal deformations we could also rely upon the slight plasticity of the printed elements (obtained with SLS, selective laser sintering).

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Before beginning the reassembly of the pieces and the construction of the model, we had to find a technical solution, that would allow a certain degree of freedom in terms of longitudinal curvature and height of each section.

CLICK

This in order to find the best solution in which all the elements fit correctly.

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This is how the construction site, you see here, was designed and built: it allows to adjust the height at the level of three sections CLICK

 as well as the height of the bow CLICK

 and the curvature of the stern. CLICK

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The first planks were then mortised and tenoned and the bow was temporarily held in place with a clamp.

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The assembly of the first five strakes, up to the turn of the bilge, posed no particular problems other than being extremely time consuming for the drilling of the mortises.

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At this point in the construction, the insertion of the bottom frames allowed both the shape to be fixed and the degree of rocker of the keel to be specified. Indeed, it is known that increasing the keel rocker will flatten the central part of the boat. While decreasing the keel rocker will close-in the midship section. The height of the bow is then defined by looking for the best match between the shape of the bottom frames and the keel rocker.

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The construction continued with the assembly of the successive planks and the insertion of the futtocks. On the picture on the right you can see from the outside of the planking the metal nails corresponding to nails on the ship and the small metallic pins corresponding to the pegs of the tenons.

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At this point, we inserted on the starboard side the symmetrical futtocks of the port side in order to not unbalance the hull.

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When we reached almost the level of the caprail, it seemed to us that the hull tended to have a more and more rigid, self-supporting shape, and that we could therefore fix the height of the bow and the rocker of the keel which was given to us by the whole structure.

Towards the stem, the planking and the keel, which had been deliberately left longer than necessary, were thus cut to the correct length.

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From then on, it was possible to verify the good adaptation on the hull of the bronze casing, the proembolion as well as the V-shape frame on the inside. This validating the shape of the bow obtained.

Due to the lack of preserved transverse elements in this section, we have to add a series of transversal reinforcements to fix the shape obtained.

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The completed model was then scanned in 3D to record the shapes in order to make a 3D model of the resulting shape.

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At this point it can be established that the original dimensions of the Phanagoria ship can be estimated with a certain degree of certitude around 19,3 m in length and 2,7 m width at the main section. The length-to-breadth ratio is 1/7, which is much higher than the ratios observed on maritime Greco-Roman commercial vessels generally established between 1/3 and ¼.

This ratio is typical of oared long-ship

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The number of rowers is estimated between 20 and 22, two rowers per bench. This assumes that the ship housed ten or eleven transversal beams used as rowing thwarts and supported by stanchions fitted in recesses carved in the keelson. The mortises still conserved on the keelson are spaced one meter apart and this distance corresponds almost exactly to the distance between oars (*interscalmium*) put in evidence in the ancient texts and archaeological records

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A working hypothesis arose from the comparison between the longitudinal profile of the ship of Phanagoria and a graffito engraved in a wall of the house of Dionysus in Delos island, and dated between 88 and 69 BCE when the house was abandoned after the sacks perpetrated by the troops of Mithridates. The graffito, a ship propelled by 50 oars on each side, was identified by Capitain D. Carlini with a *hekatontore*. The shape of the bow with its prominent cutwater, the blunt-faced ram and the *proembolion*, is similar to the one that we reconstructed for the Phanagoria ship even if the dimensions and the function of the two ships are not comparable.

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Given the shape and structure of the hull, the presence of both the bronze blunt-faced casing and the *proembolion*, we can identify the Phanagoria wreck as the remains of a light sailing and rowing military ship, which must have proven to be very fast and manoeuvrable. Given its limited size, it doesn’t fit into the category of the larger ships of the line. Instead, it must have been employed in minor war activities as a scoot, or as a patrol ship. Its simple casing is completely different from the three-finned rams discovered off the shore of Athlit or in the Egadi Archipelago and we do not think it was intended to deliver a pounding blow to the enemy ships, but was rather placed at the stem to reinforce the cutwater.

Considering that the phanagoria ship is an exceptional and unique example of ancient military ship the obvious next step is to complete the reconstruction of the ship in order to calculate its displacement and study its overall performances under rowing and sailing.