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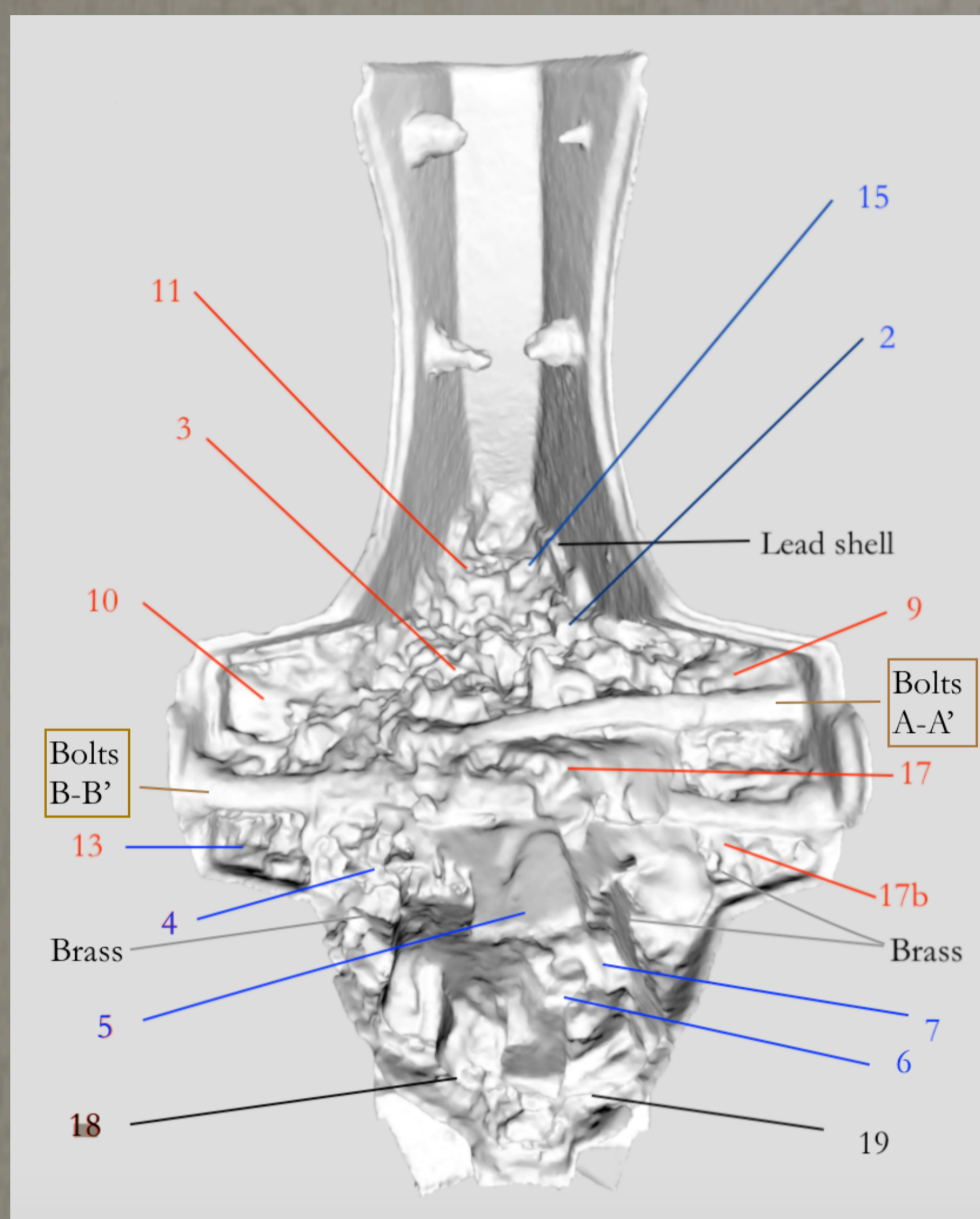
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Revisiting the Acqualadroni's Ram.

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In 2008 a naval ram, decorated with swords (*Kopis* and *Xiphoi*) was recovered by the Soprintendenza del Mare off Acqualadroni in Messina. This ram was initially attributed to the Battle of the *Naulochus* and dated to the first century BC in a preliminary study (Tusa, Buccellato 2011). In 2013, additional evidences like metal analysis of the spikes, chemical analyses on the timbers, and a new C14 algorithms OxCal dating placed the construction to the 3rd century BC (median 287-279 BC), in the context of the First Punic War (Tisseyre 2013). We propose a new possible interpretation of the internal arrangement of the timbers in the ram, characterized by the presence of one or two internal metal sheaths. Furthermore, through a study on the construction and mounting of the ram on the ship, we propose a new construction technique of the assembly.



On the right (on a 3D base), indicative sketch of the distribution of wood species in the Acqualadroni ram according to the core sampling. The numbers correspond to the core sample taken.
 - RED arrows: *Pinus nigra* Arn. (Black Pine) or similar taxonomic species *Pinus laricio* Poirlet for samples n°. 9, 10, 11, 19.
 - BLUE: *Pinus halepensis* Mill. or *Pinus L.* samples n°. 4, 5, 12, core 15 portion 4 belong to the second group.
 - Black: samples polluted by metals.

Arrangement of the internal wooden elements

In the upper part of the ram, there is a separation between at least two elements (samples: 11-3/15-2). We also noted that two elements are inserted inside the inner metal casing, as the latter continues upwards the ram wall. The mass of timber 11 encases the upper spikes (or bolts) A-A' (which passes through it); Below 11, still inside the inner metal plate 1, four other elements belonging to a different subspecies of pine (Sample 4,5,6,7) are observed, showing an additional vertical separation below the level of the spike A-A'.

Sample 17 supports such interpretation, i.e. additional vertical differentiation of the wood species; for sample 17, used for the *wiggle matching*, we noticed at least 25 growth rings on its upper part, with a width between the rings increasing from right to left over about 13 cm. (i.e. 19 mm. average distance between the rings). The visible sided dimension of the block is about 31 cm. The timber was fashioned from a halved log, placed with its growth rings towards the outside (25 rings for 13 cm, visible 31 cm, or 59.6 rings assumed).

Outside the metal mass, on the left side, the wood species are equally vertically divided (samples 10/13), whereas this is not the case on the right side (samples 9/17b). However, the existence of a constructive symmetry, as in Athlit ram, can be assumed. Thus, probably at least two vertical timbers were used for each side;

The presence of at least two pegs (7x 2 cm. long in oak - sample 8) on the right side of area 17b indicates the existence of several other missing elements. The connection between the two timber parts was made with a dissymmetrical Jupiter's shaft joint, with four wooden pegs covered by the brass of the metal jacket, which separates them from the upper central block.

At least two cylindrical pegs were visible (length 6.2 x 1.7 cm.). The symmetry of construction, and the trace of two other specular pegs on the side of the samples 4 and 5, suggest at least four other elements in this part of the ram were fastened using the mortise and tenon technique.

Direct/modified investment casting

The lost-wax casting technique is still the most probable for a ram of this size (300 kg). As for the Athlit's ram (465 kg), for the Acqualadroni's ram neither autoptic examination nor radiographic analysis have led to the identification of a division into two shells, or a central weld line.

The trace of spacers external to the hull, arranged in a T-shape on the surface of the upper wing of the ram and under the empennage, suggests the existence of a direct shaping, usually used for casting.

Similarly to the Athlit's ram, the casting was probably carried out in a single, and therefore effectively direct, mould. Even if primary mould could have been shaped in part on the timbers, undoubtedly the ram was cast separately and then mounted on the ship.

Therefore, this technique is a variation in the operational sequence of casting proposed by A. Oron, with a primary shaping for the lead, which could be done indifferently with both direct and indirect techniques. We cannot check whether the inside of the decorations are flat, a characteristic of the direct investment wax process. It is possible that these traces are hidden behind the lead coating. Thus, we do not know if the side swords and the decoration were applied successively, as the empennage/tail piece could have been, as a "positive" addition to the replica of the ram.

This mixed or double technique is not uncommon in ancient statuary. For the insertion of metal in the timbers, the sphyrelaton technique, according to the rationality of direct/modified casting, could be a viable solution: a metallic sheathing hammered to a central core of certain statues, in order to ensure the solidity of the core. For large statuary, this technique allowed the mechanical welding of internal plates. A similar technique could have been applied to the Acqualadroni ram, although slightly modified but still related to the final casting process found in statuary. This technique, seen as a form of archaism in monumental statuary, is here associated with the technique of indirect casting of bronze statuary, applied in an undoubtedly innovative way on the ram, shows a workshop that mixed several approaches.

Conclusions:

The analysis can be summarised in a few points:

- The analysis of the wood species has revealed a much more complex arrangement of the rostral timbers, closer to the structure of the Athlit ram.

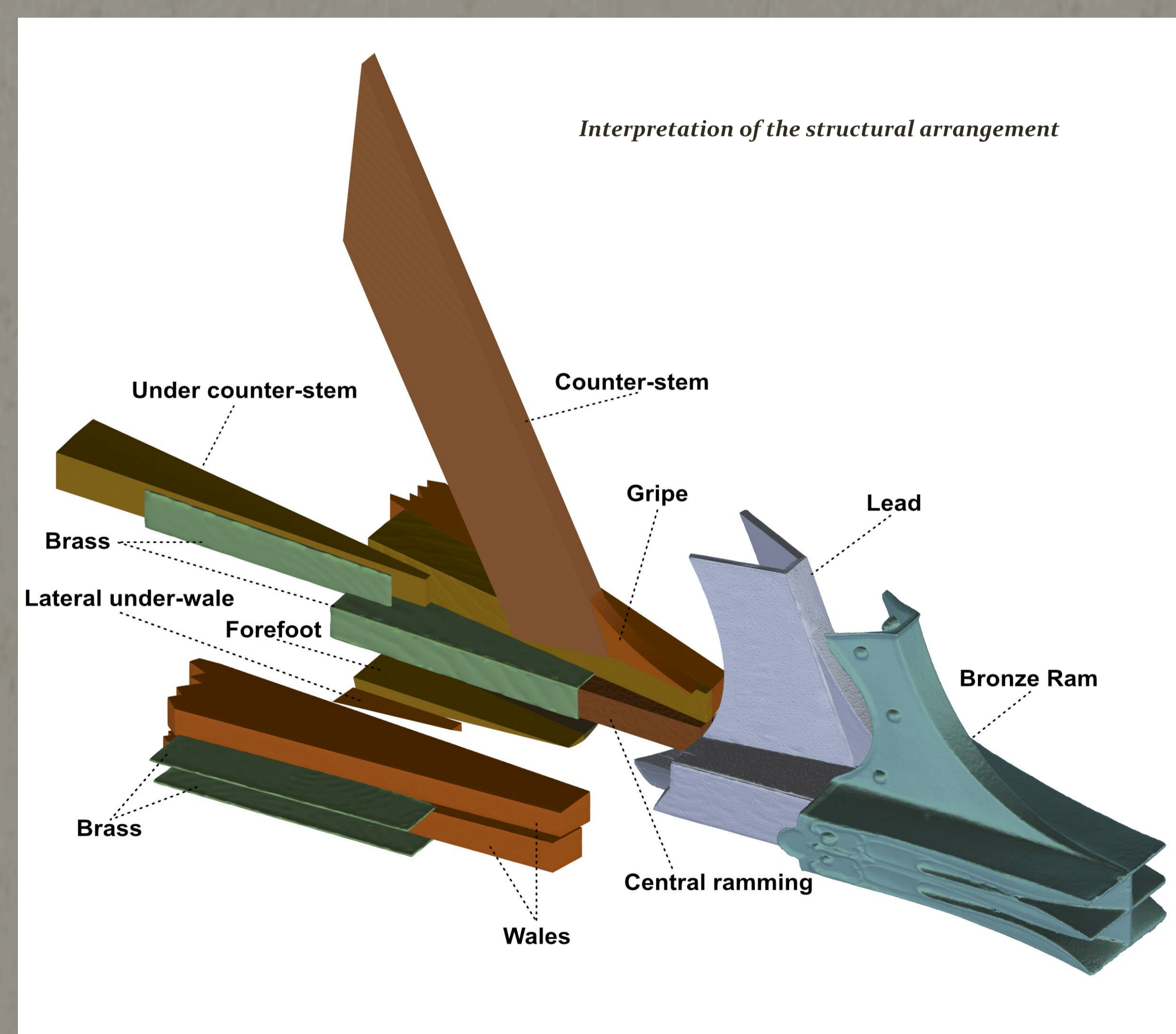
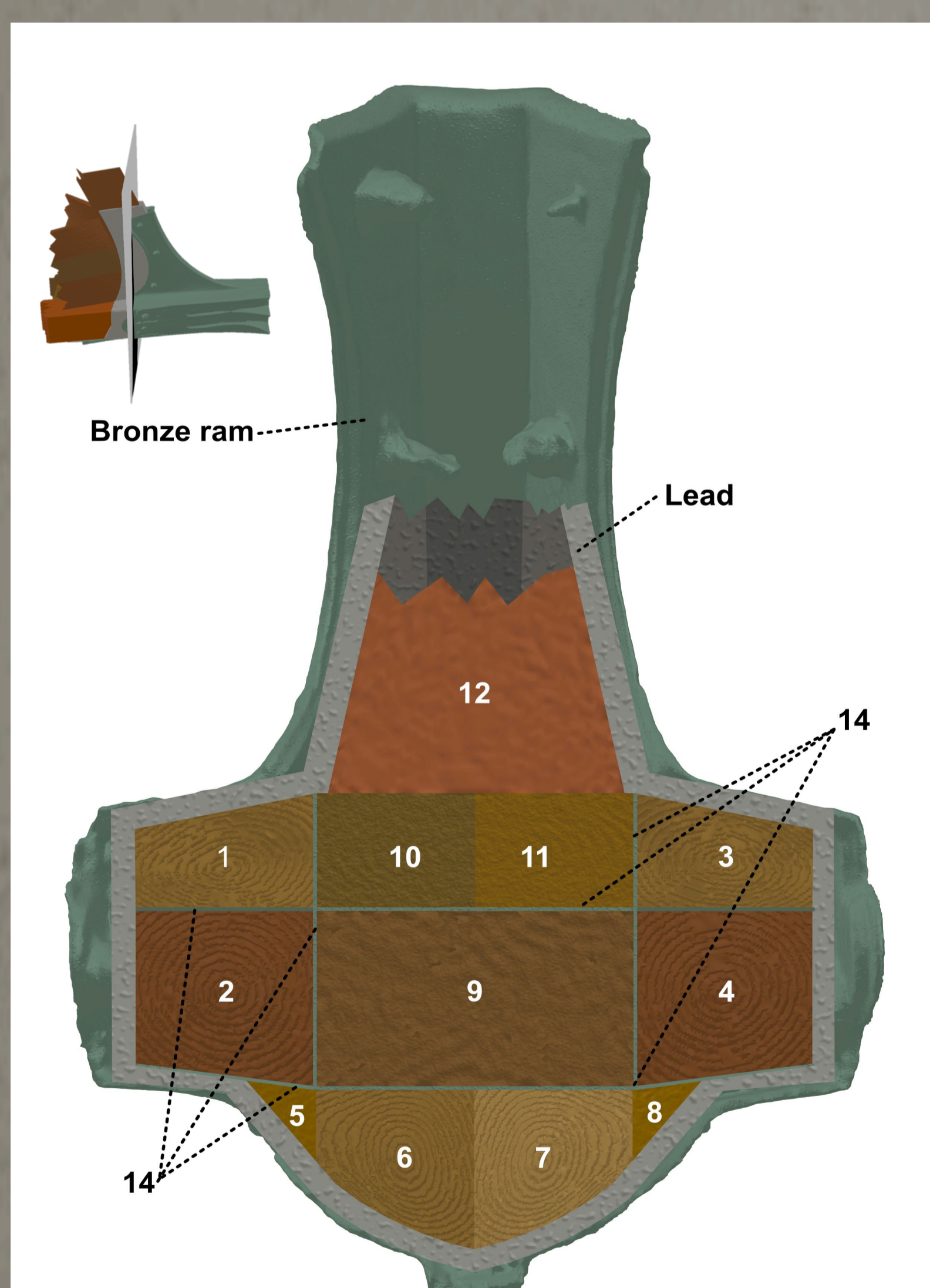
- The presence of the internal metal plates and the lead covering demonstrate complexity behind the fastening of the ram to the bow.

- The analysis of the traces from the casting process confirm a mixed method of manufacture, which belong to the ancient statuary but was also adapted to such a specific task (A. Oron 2006).

- Furthermore, it must be noted that the main characteristic of the two rams of Athlit and Acqualadroni, their lateral "ears" called "trough ears", is certainly a marker. The spikes at the level of these trough ears on the Acqualadroni ram are an essential element for fixing the bronze ram to the ship's bearing structure. Such elements are also seen on the very recent Egadi 12 "punic" ram (241 B.C. - 100 kg). For the Athlit ram, given the much heavier construction, the system of double internal plates and spikes could have been simply not suitable: spikes when exceed a given length are more keen to deformations.

- The structure of Acqualadroni ram would reflect a different construction technique, perhaps because of its size. Many wooden parts of Athlit ram can compensate for its size, and one can only wonder what would have been the internal fastening system of the giants Nicopolis rams, supporting W.M. Murray's theories.

- The convergence, parallelism and alteration of techniques must be considered. As in Athlit and no doubt elsewhere, the shipbuilders of warships had to surround themselves with the best specialists of their time. Founders and shipbuilders had to work in the shipyards: it is possible that some techniques could have been tested, with more or less success. The rams of Athlit and Acqualadroni, surely a few years apart, and very close in their lines, are however different in their internal structures. The development of the attachment of rams to the prows, like that of shipbuilding, probably does not follow a straight path, with legacies rich in complex technical diversity.



Timbers/location	Number of piece	Estimated dimensions (cm.)
Lateral wale (n°1,2,3,4)	4 (2 for side)	14, 2x 10,8
Under bow (n°10-11)	2	15 x ?
« central ramming/keel » (n°9)	1	30,9 x 20
« false keel/ forefoot » (n°6-7)	2	20 x 11
Lateral under-wale pocket (n°5-8)	2	?
Brass (n°14)		

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