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Preliminary Analysis of the Hull of the Roman Ship from Grado, Gorizia, Italy

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The hull of the Roman wreck at Grado has been partially preserved under the cargo of amphoras. The right side presents a rare evidence of a section of the waterway. The ship has been assembled by mortise-and-tenon technique following a shell-first conception. All the frames, except one, are of pine while planking is either of pine and elm. Some strakes, of *larix*, are a repair made by patch-tenons; a wale shows an other kind of repair. Various signs left by the shipwright are on the hull. In the stern area, a box of wooden elements had to protect a 'hydraulic system'.

Key words: Grado, Roman, shipwreck, hull, ship-construction, mortise and tenon.

The wreck, which rested at a depth of 15 m, 6 miles off Grado, was discovered in 1986. The first underwater excavation on the site took place during the summer of 1987, the last one in 1999 (Colocci *et al.*, 1999 and references; Beltrame and Gaddi, in press).[1] The main part of the cargo consisted of at least 600 amphoras of various kinds, which contained fish sauces; some of them were re-used oil amphoras. In the bow, there was also a wooden barrel filled with fragments of glass vases. The total weight of the cargo could have been some 23–25 tons. This kind of cargo allows us to date the wreck back to the middle of the 2nd century AD (Auriemma, 2000 and references).

A quite large section of the hull, 13.1 m long and 6.1 m wide, is preserved (Dell'Amico, 1997; Dell'Amico, 2001). At the extremities, there are parts of the stem and stern posts; on the starboard side, the central part is preserved up to the height of the deck, while the other side is in worse condition. On the sides, the activity of *Teredo navalis* and the penetration of *Posidonia oceanica* have been quite intense.

The hull—longitudinal elements

The keel of the ship is 9.5 m long. It has a trapezoidal section without rabbets and is connected to the garboards by mortises and tenons. There are evident traces of teredo on the bottom. On the sides of the keel there are square cavities, probably made to host side fastenings and possibly used to hold the keel rigid to the ways (Fig. 1). The stem and stern posts are not complete; they have rabbets where they were joined to the garboard, both by tenons and nails (Figs 2 and 3), and were connected to the keel by '*trait de Jupiter*' joints (complex keyed hook scarfs). On the bottom of the sternpost-joint there are two nails (Fig. 4); as on the Madrague de Giens wreck (Rival, 1991: 165) and on ship no. 1 of Fiumicino. They were probably used to strengthen this part of the junction.

The keelson is 7.5 m long (Fig. 5). It has some cavities to host a pair of stanchions, the mast-step and some mast-fastenings. As on many other wrecks dating from the 1st to the 6th century (Rival, 1991: 252 and n. 12), it has a T-shape which

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Figure 1. Scarf on a side of the keel. (C. Beltrame and D. Gaddi)

lets it sit over two beams (or 'small keelsons'), about 6.5 m long, without any nails. These beams are worked to stay on the frames. Nails, one with a flower-shaped head, held the small keelsons on to these frames. Each 'small keelson' has insertions in order to host two small wooden elements necessary to chock the keelson. On the bottom, this last one has five insertions (Fig. 6). In two of these, there are small wooden elements to stop movements along the axis of the ship where the mast stopped other movements.

The presence of five insertions and only two wooden elements lets us suppose, either that the keelson had been moved from another ship, or that it could be moved along the axis of the vessel to change its position. This latter hypothesis, which would demonstrate a very modern use of

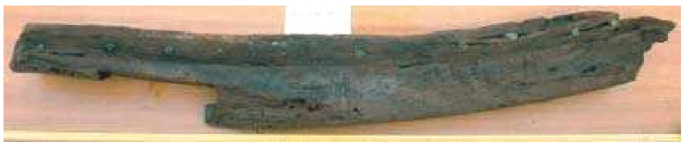

Figure 2. Stempost. (C. Beltrame and D. Gaddi)

Figure 3. Rabbet and nails on the stempost. (C. Beltrame and D. Gaddi)

Figure 4. *Trait de Jupiter* joint of the sternpost reinforced by iron nails. (C. Beltrame and D. Gaddi)

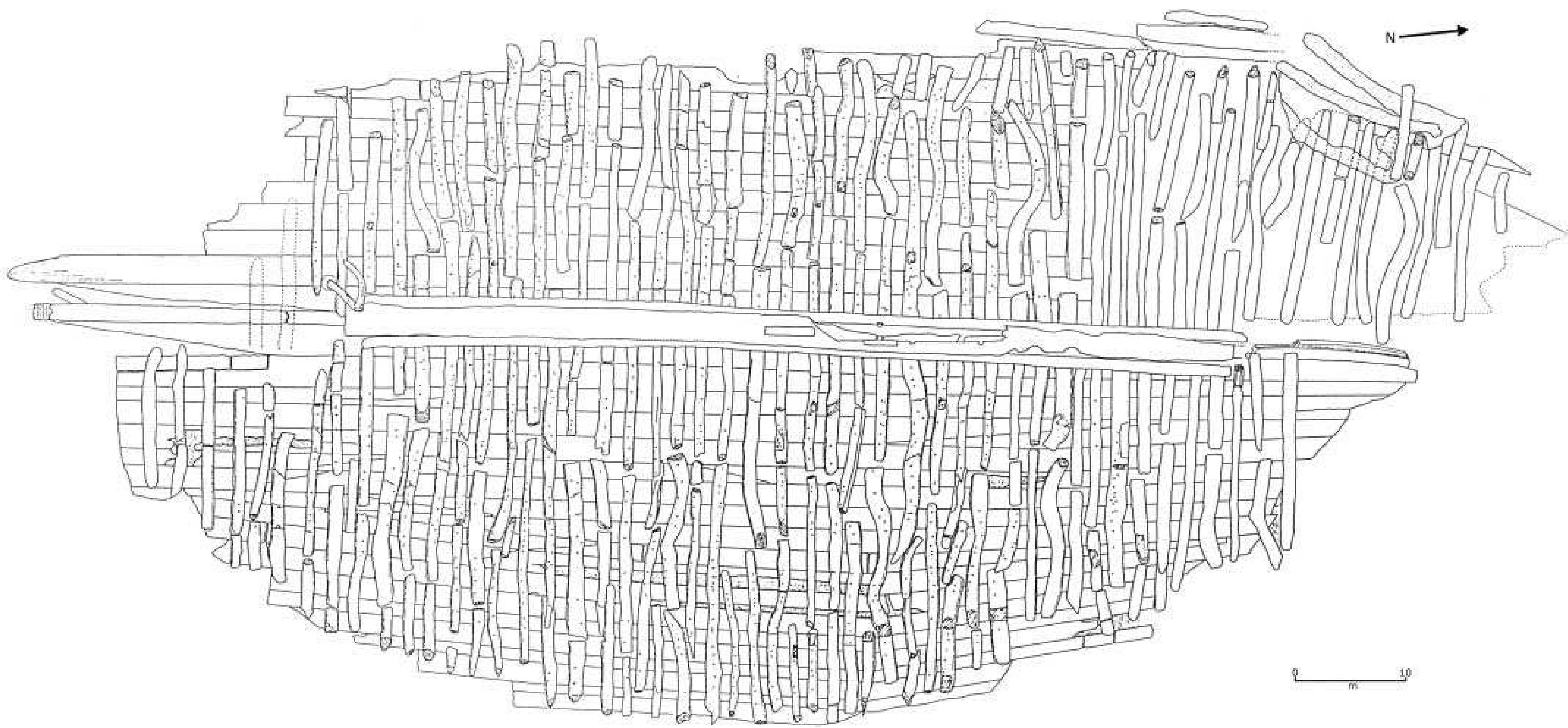

Figure 5. Plan of the hull without inner planking. (Soprintendenza per i Beni Archeologici del Friuli-Venezia Giulia)

Figure 6. Insertions under the keelson. (C. Beltrame and D. Gaddi)

Figure 7. Nails along the edge of the garboard. (C. Beltrame and D. Gaddi)

the sail, will have to be confirmed during the re-building phase of the hull.

The garboards are more than 11 m long; they have a maximum width of 34 cm and an average thickness of 5 cm, and were connected to the keel and the stern- and stemposts by mortise-and-tenon joints. Stern- and stemposts were also jointed to the garboards by iron nails (Fig. 7). This solution, documented on many Roman ships, reinforced a very critical part of the hull where the planks had to bow. Traces of charring for bending the wood are present on the inner extremities.

On the better-preserved side there are 19 outer planks, whose average width ranges from 10 to 28 cm, and the thickness from 2.5 to 4.5 cm. They have been sawn on both radial and longitudinal axes. After they have been sawn, the *faber navalis* has worked their inner face by adze. No rule was followed in the building process and the centre of the tree is either outside or inside. In these planks, the average distance between the mortises is 7–8 cm, but this is very irregular. Various anomalies have been recorded on these joints. We have found three pegs, instead of two, to stop one tenon (Fig. 8), pegs not connected with any mortise, and mortises and tenons without pegs. In some cases these anomalies could be interpreted as the shipwright's mistakes, but we must bear in mind that the presence of pairs of pegs to fasten one tenon in a plank has also been seen on the

Figure 8. Double-pegs to stop tenons on a plank. (C. Beltrame and D. Gaddi)

Figure 9. Diagonal scarf between two planks. (C. Beltrame and D. Gaddi)

Figure 10. Vertical diagonal flat scarf in a wale. (C. Beltrame and D. Gaddi)

Figure 11. Patch-tenons and white coating on a plank. (C. Beltrame and D. Gaddi)

ships at Ma'agan Mikhael (Jabour, 2004: 199, 122), Baratti (Riccardi, 1990: 25), Port la Nautique (Falguera and Jézégou, 2002: 43) and Sant Jordi 1 (Colls, 1987: 32–5) wrecks. On this last hull, the repetitiveness of the phenomenon assures us it was not a mistake. Horizontal treenails, which have been noted between two planks, could be reinforcements.

Planks are jointed by diagonal scarfs and, in some cases, horizontal nails helped the junction of the extremities (Fig. 9). Each side of the ship has three wales. They are about 9 cm thick and have vertical diagonal flat scarfs (Fig. 10); these are also present in the so called '*pirogue*' from Pisa S. Rossore (Bruni, 2000: fig. 35). Wales and other planks are coated with a white material made from animal fat (Fig. 11); we cannot say whether it was paint or covering. In any case, as on all the other ships dated after the 1st century AD, the bottom of this vessel does not have any lead sheathing, but only a simple coating of pitch.

The hull—transverse elements

Frames are composed of very asymmetrical floor-timbers alternated with half-frames (Fig. 5). Both elements are prolonged by futtocks. In one case there is a double-futtock similar to one seen on the Dramont I wreck (Joncheray and Joncheray, 1997b: fig. 10).

The average distance between the frames is 14–17 cm. They are naturally-curved branches, which have a very irregular and sinuous shape. Some of them have been only slightly worked with an adze and they still maintain their bark. Some are half of a branch cut by a saw while others had been worked, by this same tool, on all four faces. All of the frames, on the inner and outer sides, have been levelled by an adze. Floor-timbers, half-frames and futtocks are not connected. In rare cases, there is an arrangement whereby the extremities simply touch each other. Frames are connected to the shell by wooden, bronze and iron nails inserted from the outside. The metal nails were distributed over the entire hull. This is an exception in comparison to the evidence of other Roman ships that show a concentration of nails on the bottom planks. For this reason, we cannot exclude the possibility that the nails are from repairs made after a period of use. Sometimes the treenails that connect the frames to the hull are double, as on the Chrétienne C wreck (Joncheray,

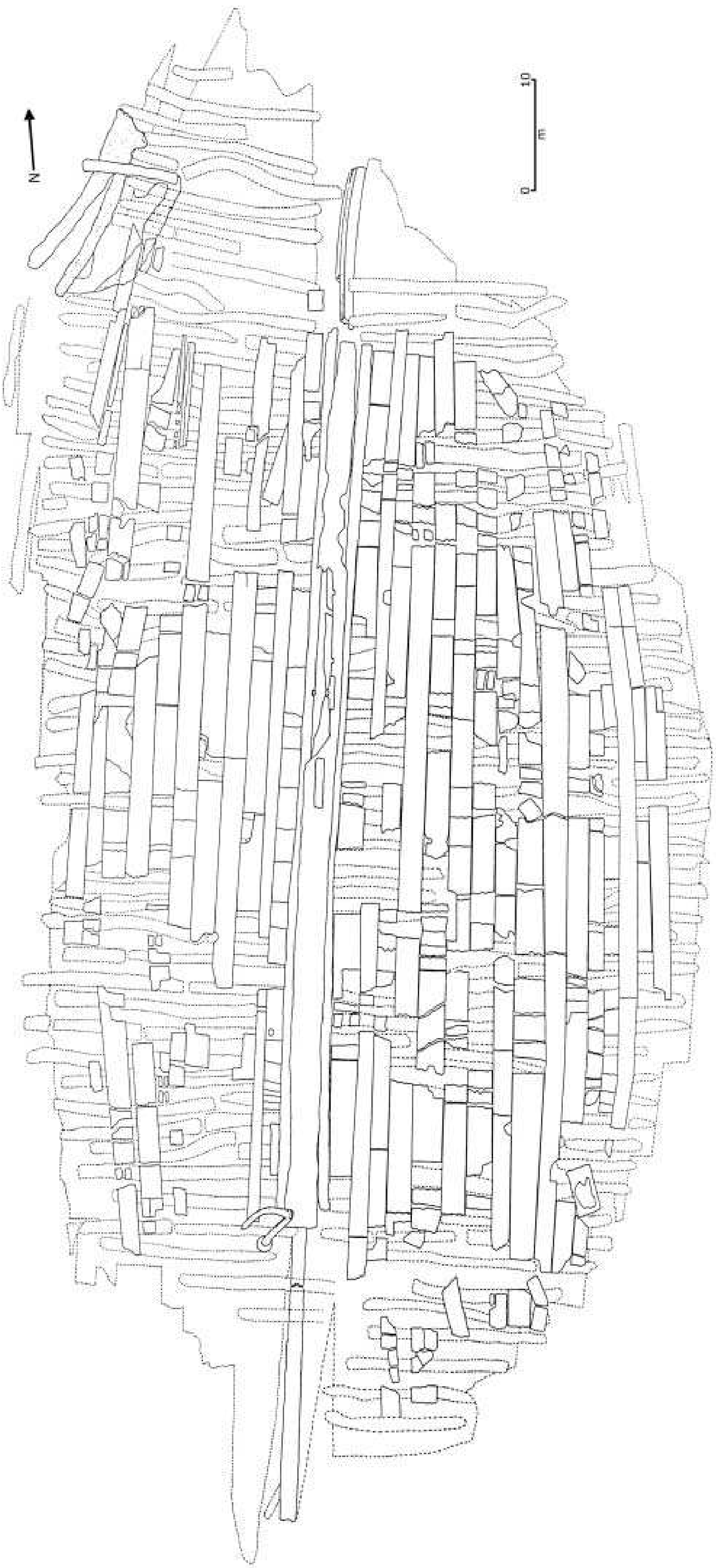

Figure 12. Plan of the hull with inner planking. (Soprintendenza per i Beni Archeologici del Friuli-Venezia Giulia)

1975: 68). The presence of metal nails on the bottom face of the frames, having no correspondence on the planking, suggests that sometimes we are dealing with re-used elements. At least two floor-timbers were connected to the keel by big nails. Frames have been worked both on the top, to host the ceiling and the small keelsons, and on the bottom to stay on the sternpost. One or two limber-holes of different sizes and shape (rectangular, triangular and trapezoidal) are on the bottom of the frames where they meet the keel.

Repairs

The Grado ship has had a significant amount of repair. Some planks have been substituted thanks to the use of patch-tenons inserted from the outside (Fig. 11), as on the Herculaneum boat (Steffy, 1999: 398). This direction of insertion is less frequent than that from inside the ship, as can be seen on the Roman wrecks of Tour Fondue (Dangreaux, 1997), Barthélémy B (Joncheray and Joncheray, 1997a) and no. 5 of Place Jules Verne (Pomey, 1999: 323). This is probably due to the fact that normally only the inner side of the hull's remains can be analysed while the outer face is not visible till the recovery of the wreck.

Figure 13. X graffiti between parallel lines on the inside face of a plank. (C. Beltrame and D. Gaddi)

On the inner side of some of the planks, the *faber navalis* made X-shaped graffiti between parallel lines, in the space not occupied by the frames (Fig. 13). Because these signs are present on replaced planks only, they must have been reference marks for use during the replacement of the planking. The analysis of this evidence is still in progress, taking into consideration the presence of similar parallel lines on the Punic ship of Marsala (Frost, 1981: 197), the Roman wrecks no. 4, Place Jules Verne (Pomey, 1999: 322). Gervais 3 (Liou and Gassend, 1990: fig. 98), Chrétienne A (Frost, 1963: 266), Chrétienne C (Joncheray, 1975: fig. 19), Mainz (pers. comm. R. Bockius), Oberstimm (Bockius, 2002: 18–19, 21, 51), and the Yassi Ada Byzantine wreck (Van Doorninck, 1982: 59).

A repair is also present on a wale. In fact a plank has been repaired to replace a broken part with three small pieces of wood (Fig. 14). These elements have been nailed one on to the other in order to fill the space left by the working of the thick plank. This repair has no structural force but only an aesthetic value. A horizontal nail on a plank could have been used during the building of the ship to close a break. A moving knot on a plank has been stopped with two small nails to prevent a hole; in any case, the hole could not become dangerous because the plank was at a high level.

The inner planking was composed of 17 planks on each side, about 2 m long (Fig. 12). They are ceilings joined to the frames by small nails, alternated with mobile ceiling. The 2nd and 14th planks are thicker than the others.

The box of the 'hydraulic system'

In the stern area are two small planks, about 75 cm long, made of red fir (*Picea abies* Karst), one on each side of the longitudinal axis of the ship (Fig. 16). They were nailed over floor-timbers

Figure 14. A complex repair on a wale. (C. Beltrame and D. Gaddi)

Figure 15. Small planks present on each side of the longitudinal axis of the ship. (C. Beltrame and D. Gaddi)

and had rectangular mortises that could have hosted a small stanchion. Connected to these were horizontal tablets of fir (either *Picea abies* Karst or *Abies alba* Mill) which, together with floor-timbers, protected a lead tube that was inserted in the hull between the garboard and the first strake. The tube was nailed to the planks thanks to the presence of a double flange. The interpretation of this tube is still not clear, but, considering that piston pumps were already known in the Roman period and that they could be made either of metal or of wood (Schiøler, 1999), it is possible that it was part of a pump which was either recovered from the site or destroyed by post-depositional agencies. The pump could either discharge water, in a very modern way, under the bottom of the ship, or suck in water from the sea; we are more inclined to the second hypothesis (Beltrame and Gaddi, 2005: 42–6).

The 'waterway'

On the starboard side of the ship, the limited surviving evidence for the deck is represented by a trace of one plank, 75 cm long, nailed perpendicularly on the top of the last strake of the side by one iron nail (Fig. 16). Some futtocks passed through this deck-plank, which was fixed to them by other iron nails, while other futtocks stopped under this element. Two mortises show that the strakes must have been connected to another one (see also Dell'Amico, 2001: 42). These could be part of the waterway of a partly-decked ship. Although the reconstruction study of the ship is still in progress, we think that it was decked only at the extremities, because of the absence both of a sufficient number of cavities to host the necessary stanchions on the keelson, and of any evidence of deck beams.

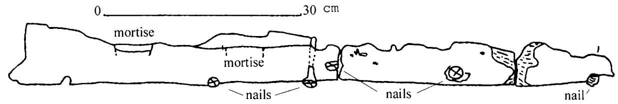

Figure 16. Section of plank, nailed on the top of the side of the ship, presumed evidence of the deck. (C. Beltrame and D. Gaddi)

Conclusions

We can draw a few important conclusions. The first is that, after the xylotomical analysis of 90 per cent of the preserved wooden elements by O. Pignatelli of Dendrodata s.a.s., Verona, we can say that the shipwright made a very logical selection of the kind of wood to be used. In this ship, the distribution of the various species of wood is very homogeneous. As at Madrague de Giens (Rival, 1991: 168), Dramont I (Joncheray and Joncheray, 1997b: 192), Siciliano (Olbia) (Riccardi, 2001: 497) and Heliopolis 1 (Joncheray, 1997: 163), the shipwright used elm (*Ulmus* sp.) for the keel. Elm was used for the garboards and the second strakes on each side too. The choice of this kind of wood on the most important part of the vessel, and where nails had to be used to connect garboards to posts, is excellent. In fact, although it is hard to saw, this wood has good mechanical properties and can receive nails without breaking.

Pine (*Pinus* sp. sec. *sylvestris*) was used on all the outer planking except for four planks. Here, as is very common, another resinous wood, larch (*Larix decidua* Mill.), was chosen, as it was on the Laurons 1 wreck (Guibal and Pomey, 1998: tab. 2). The presence of larch is a very important indication that this must have been a local ship. This tree lives over 1000 m and is very diffused throughout the Italian Alps. Vitruvius (II, 9, 53) says that it was used on the western Adriatic coast as happens later during the long period of the thalassocracy of Venice. To this observation we can add that, in this region, elm was often used especially in the construction of sewn Roman ships (Beltrame, 2002: 372–6). A less excellent wood, red and white fir (*Picea abies* Karst and *Abies alba* Mill.) was chosen for most of the less-important parts of the ship: the ceiling, where we found larch and pine too, and the box protecting the lead tube.

Both the posts and the small keelsons were of pine, while the keelson was of fir. This is one of the Roman wrecks with more evident homogeneity in the choice of wood for the frames. In fact, pine (either *Pinus pinea* L. or *Pinus halepensis* Mill.) was used for all the frames except one. For this isolated half-frame, perhaps replaced, the shipwright chose *Fagus*, a wood recognized on only two ancient wrecks, Yassi Ada 2 and Laurons 2 (Guibal and Pomey, 1998: tab. 3). The treenails of the frames are in olive (*Olea europea* L.) which is a hard wood, perfect for this purpose. Olive was used for some of the tenons, while others are of *Quercus ilex* L. For the pegs of the tenons only *Pinus sylvestris* was cut.

The analysis of the direction in which the pegs were inserted and other considerations on the construction of the ship allow us to hypothesize that the shipwright probably built, if not all, at least a good portion of the shell (by mortises and tenons) before inserting any frame. Nonetheless, the presence of at least two floor-timbers nailed to the keel means that we cannot exclude the possibility that these elements were fixed before the planks in order to guide the building of the planking (Beltrame and Bondioli, in press).

As we have seen, the ship had been repaired several times. The most important restoration was executed on the outer planking. Traces of replacement of planks are present on the left side, while clear evidence of two phases of refits is on the right one. The analysis of the patch-tenons has demonstrated that, in the first phase, the shipwright replaced one plank, while, in a second phase, he moved five planks for the replacement of at least three of them. The sequence of replacement of the planks has been reconstructed: it starts from the bottom to the top.

Finally, we are quite convinced that this vessel was built along the north-Adriatic coast and that, during its probably long life, it was towed to a local shipyard for a refit more than once.

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Note

1. The project was directed by Dr Paola Lopreato (Soprintendenza ai Beni A.A.A.A.S. del Friuli Venezia Giulia). The elements of the hull, already restored, are stored at the new Museo di archeologia subacquea of Grado. Although the authors worked together during the research, the paragraphs 'introduction', 'longitudinal' and 'transversal elements' were written by D. Gaddi, while the rest of the paper is by C. Beltrame.

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