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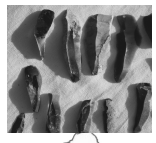

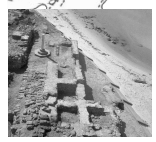

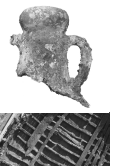

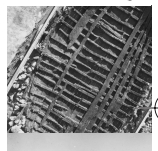

The wrecks and artifacts discovered in the excavations indicate that the harbor began gathering silt at its western end soon after the mole was constructed to form the harbor basin. In time, as the silting progressed eastward and sth

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Titelmotiv

Large rectangular mortises along the upper edge of the wale and mortise-and-tenon assemblage without peg between the wale and the previous strake.

Aus: Marie-Pierre Jézégou - Patrick Andersch Goodfellow - Jonathan Letuppe - Corinne Sanchez,
Underwater Construction and Maintenance, Abb. 7.

Vorwort

Bei der Öffnung der Sendung wird man bei aufmerksamer Betrachtung dieses Heftes bemerkt haben, dass sich der Untertitel verändert hat. Statt "Zeitschrift für Unterwasserarchäologie" lautet er jetzt "Zeitschrift für maritime und limnische Archäologie und Kulturgeschichte". Das hat gute Gründe. Allzu oft wird - auch in archäologischen Fachkreisen - Unterwasserarchäologie immer noch lediglich als Hilfstechnik zur Dokumentation und Bergung unter Wasser geratener Objekte angesehen. Blättert man aber die wachsende Zahl ausländischer Zeitschriften und Periodika durch, zeigt sich sogleich, dass das internationale Verständnis sich erheblich erweitert hat, auch wenn in den Titeln der Publikationen wie auch in den Namen der herausgebenden Institutionen manchmal noch engere Begriffe wie "underwater archaeology", "archeologia subacquea" usw. vorkommen. Tatsächlich erstreckt sich heutzutage deren Arbeitsgebiet trotz notwendiger Schwerpunktbildungen prinzipiell über alle Perioden der menschlichen Entwicklung, durch alle Kulturen und über sämtliche Regionen der Erde. Dabei bilden Wasserfahrzeuge aller Art, ihre Bauweise und nautischen Eigenschaften, ihre Ladung und der durch Schiffahrt bewirkte Kulturaustausch zwar besonders wichtige Arbeitsbereiche, aber auch alle Wasserbauten wie Häfen, Befestigungen, Küstenschutz, Brücken, Seezeichen, ans Wasser gebundene Siedlungen sowie Einrichtungen für Fischfang und Jagd zu Wasser gehören dazu, d.h. alles was dem Leben des Menschen auf oder an Meeren, Seen und Flüssen dient und seiner Kultur ein besonderes Gepräge gibt. Dieses schließt die künstlerische Verarbeitung nautischer oder maritimer Themen ebenso ein wie Sitten und Gebräuche, weltliche und religiöse Vorstellungen und Begehungen, Mythen und Legenden, Arbeits- und Verhaltensweisen gewässernaher Bevölkerungen, also ethnographische, anthropologische und soziologische Aspekte und Fragestellungen - nicht anders, als in den herkömmlichen archäologischen Fächern auch!

Einem ebenso breiten Verständnis des Begriffs "Unterwasserarchäologie" ist diese Zeitschrift seit dem ersten Heft verpflichtet. Die Erfahrung hat aber inzwischen gelehrt, dass eine solche Einstellung auch nach außen deutlich gemacht werden muss. Mit "maritim" und "limnisch" soll auf Meer und Binnengewässer hingewiesen werden, "Archäologie" bleibt als zentraler Begriff erhalten, erfährt aber durch "Kulturgeschichte" eine wesentliche Erweiterung im oben beschriebenen umfassenden Sinne und unterstreicht, dass die Arbeit keinesfalls mit dem Auftauchen des Forschers aus dem Wasser beendet ist oder sich gar von nicht archäologisch geschulten Tauchern erledigen lasse.

Langjährigen SKYLLIS-Lesern ist das alles vertraut. Neue Abonnenten, die immer herzlich willkommen sind, können sich gleich in diesem Heft von der thematischen Breite der Beiträge überzeugen, von denen die ersten zehn aus der Jubiläumstagung "In Poseidons Reich XX" hervorgegangen sind, die die DEGUWA im Jahre 2015 dank der Gastfreundschaft und Unterstützung des Germanischen Nationalmuseums in dessen Räumen abhalten konnten.

Der Bogen ist zeitlich von der Eiszeit bis in die frühe Neuzeit gespannt. Garry Momber und Sara Rich folgen den unter Wasser geratenen Spuren des Menschen während seiner Landnahme im damals trockenen Nordseegebiet und Laura Sanna berichtet über neue Forschungen in der größten, schon lange für ihre prähistorischen Funde verschiedener Epochen bekannten Karsthöhle der ligurischen Küste. Alexander Fantalkin und Oren Tal führen uns in die nahöstliche Eisenzeit und legt dar, wie es die Assyrer als typische Landmacht verstanden, das Mittelmeer und die darin mündenden Flüsse logistisch zu nutzen. Marta Bajtler eröffnet uns erstmals Einblicke in die Unterwasser-Forschungen Montenegros an dessen kurzer Adria-Küste und macht einige hellenistische Amphoren- und andere Keramikfunde eines neueren Surveys bekannt. Wasserfahrzeuge kann man nicht nur zum Befahren von Gewässern benutzen, sondern damit auch einen Dammbruch schließen. Das wußten aber auch schon die alten Römer, wie Marie-Pierre Jézégou mit ihrem Team an einem spätantiken Fund aus den Sumpfgebieten von Narbonne demonstriert. Mit Shelley Wachsmanns Beitrag gelangen wir abermals in den Orient: wir begleiten ihn auf der Suche nach dem einstigen Hafen von Jaffa. Massimo Capulli führt anhand einer kleinen Insel die Beziehung zwischen Mensch und Lagunen-Umwelt bei Venedig vor. Gleich zwei Beiträge, nämlich die von Ana Crespo-Solana sowie von Koldo Trápaga Monchet und António Rocha Santos, beschäftigen sich mit der staatlichen Sorge um Schiffbauholz auf der Iberischen Halbinsel in der frühen Neuzeit. Vesna Zmaić Kralj schließlich macht dem Tagungsort Nürnberg ein besonderes Geschenk, indem sie eine bedeutende Fundgruppe von Kostbarkeiten nürnbergischen Kunsthandwerks des beginnenden 17. Jhs. aus einem leider schon weitgehend geplünderten Wrack vor der kroatischen Küste bekanntmacht. Soweit die aus der Tagung in Nürnberg hervorgegangenen Beiträge - weitere folgen im nächsten Heft.

Die drei letzten Artikel sind unabhängig von DEGUWA-Tagungen eingesandt worden. Vladimir R. Chepelev schildert uns - gewissermaßen als Fortsetzung seiner früheren Berichte - das Schicksal weiterer Zaren-Boote, diesmal vom Alten und Neuen Ladoga-Kanal. Buche und Esche als Schiffbauhölzer sind schließlich die Gegenstände zweier Beiträge von Nili Liphschitz, die sich ebenfalls einer ganzen Serie ähnlicher Studien anschließen. So hofft die Redaktion, den Leserinnen und Lesern abermals eine recht bunte Palette an Themen bieten zu können.

Die Redaktion
Juni 2016

Underwater Construction and Maintenance

A wreck from Late Antiquity used to repair a breach in the bank of the Narbonne harbor channel

Marie-Pierre Jézégou – Patrick Andersch Goodfellow
Jonathan Letuppe – Corinne Sanchez

Abstract *– The archaeological excavations undertaken in Narbonne marshes revealed an almost two kilometer long harbor channel created in the 2nd half of the 1st century AD, that was extended and maintained without interruption until Late Antiquity. During one of these repairs, the wreck of a harbor barge damaged by an unspecified climatic event that ruptured one of the banks of the canal, was used to fill in a breach.*
This boat can be considered as having only been used within the harbor channel. This restricted area of navigation was confirmed by both the frequency and the low quality of repairs and by the occasional reuse of recuperated items for the ceiling plates and the frames.
The study of this wreck is crucial to improve our knowledge of harbor boats. While the development of underwater archaeology in the last 50 years has given us a good knowledge of deep-sea and coastal ships, the flat-bottomed boats used to offload seagoing vessels are less well known.

Inhalt *– Die Ausgrabungen in den Sümpfen von Narbonne haben einen fast 2 km langen Hafenkanal aus der 2. Hälfte des 1. Jhs. n. Chr. ergeben, der ununterbrochen bis in die späte Antike ausgebaut und unterhalten worden ist. Im Rahmen einer dieser Reparaturen wurde das Wrack eines durch ein unbekanntes Wetterereignis, das den Bruch eines Kanalufers verursacht hatte, zerstörten Hafenkahns zur Füllung der Bresche benutzt.*
Dieser Kahn ist als ausschließlich im Kanal verwendet zu betrachten. Solch eng begrenzter Gebrauch ist durch die Häufigkeit und geringe Qualität von Reparaturen und gelegentliche Wiederverwendung von Bauteilen für die Innenbeplankung und die Spanten belegt.
Das Studium dieses Kahnes ist wichtig für die Kenntnis von Hafenbooten. Während die Entwicklung der Unterwasserarchäologie in den letzten 50 Jahren uns gute Kenntnisse von Hochsee- und Küstenschiffen geliefert hat, sind tatsächlich die Flachbodenprähme für die Entladung von Seeschiffen noch wenig bekannt.

Introduction

Archaeological excavations carried out in the Narbonne marshes since 2006[1] have uncovered a harbor channel nearly 2 km long first created in the second half of the 1st century AD and extended and maintained without interruption until Late Antiquity (Sanchez – Jézégou 2015). The two parallel banks, 15 to 17 m wide, which channeled the Aude river as it emptied into the lagoon the Romans called Rubresus were also improved for human activity. Between them flowed the channel 50 m across.

During Late Antiquity, an undetermined climatic event damaged the left bank, requiring immediate repair. A wreck damaged during this same event was used as a caisson and filled with material to enable reconstruction of the dike on top of it. The boat is completely encapsulated within the dike and serves as a foundation for its raising (**Fig. 1**).

Fig. 1: The wreck used to fill in a breach.

The wreck called Mandirac 1 has been dated by its cargo, comprising mainly Lusitanian and North African amphoras, Almagro 50 and 51 and Keay 25.2 (African III C) from the end of the 4th or beginning of the 5th century (Sanchez – Jézégou 2015). There were also several Dressel 23 amphoras from Betic. This wreck can be added to the 50 or so wrecks from the long

Fig. 2: The wreck without amphoras.

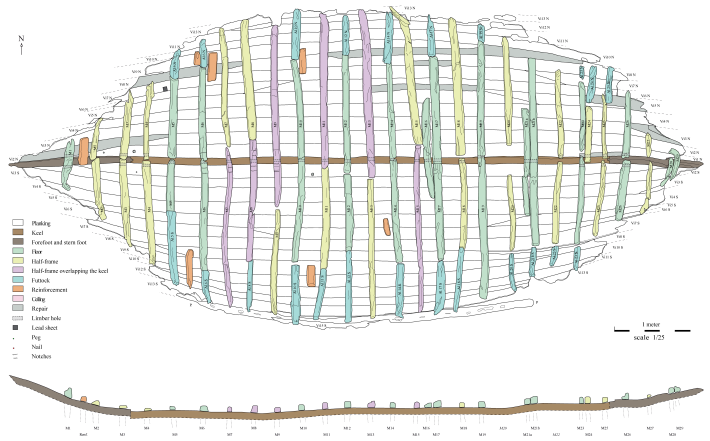

Fig. 3: The wreck after removal of the ceiling-planking.

transition period (mid-2th to 11th centuries) marking the shift from shell-first to frame-first construction (Pomey et al. 2012, 236-237. 286-289). In the first system, the strakes represent the major structural element and determine the shape of the hull. In the second, the frames take over these roles. This transition is not chronologically linear, since there are 5th and 6th-century wrecks with more advanced features than some from the 7th to 9th centuries. Nor is it geographically continuous. Similar evidence can be found in both the western and eastern Mediterranean beginning in the 6th and 7th centuries, depending on the historic-geographical context (*ibid.*). Nor is it linked to one or another type of vessel.

The preserved part of the vessel measures 9.40 m long, 3.80 m wide and 0.8 m high along the starboard side. Nearly all the architectural remains uncovered are in contact with one another, with the exception of two boards, probably ceiling planking, found athwart ships in the space between frames 7 and 8. The remains consist of the keel with its forefoot to the west and stern foot to the east, 28 strakes amidships, 13 to starboard and 15 to port (including one low wale), 30 frames (some reinforced) and 14 ceiling planking fragments (9 starboard, 5 port), including 11 fixed and 3 loose (**Fig. 2**).

The midships of the wreck tilts up to 30 degrees to the south, its port side. In addition, while this side of the wreck is preserved higher up, it has slumped just proximal to and, especially, at the level of the turn of the bilge which begins at strakes 7N and 7S. The wreck lies flat longitudinally. Elevation differences in the hull are due mainly to the forefoot and stern foot. The Mandirac 1 wreck has a long bow, but it is difficult to draw any conclusions as to the shape of the stern. In the center, the bottom is flat, with rounded bilges. The transverse sections are finer forward than aft.

In 2014, structural elements – starboard ceiling and frames – were excavated and partially removed[2]. Transverse sections for each frame at 1:10 enable us to recreate the buttock lines and the hull shapes. A complete topographic relief plan was backed up by orthophotography. There was also photogrammetric recording at each stage of the disassembly. Each piece removed was recorded photogrammetrically, drawn at full scale and recorded digitally. Samples were taken for xylology and dendrochronology studies.

1. The axial assemblage

Three elements comprise the axial assemblage: the keel, its stern foot and forefoot (**Fig. 3**). They are joined by scarfs which may tentatively be identified as keyed hook scarfs, pending disassembly. The keel measures 6.3 m long. Its width varies from 8 to 9 cm.

Fig. 4: An engraved mark on the northern face of the stern foot.

The forefoot width varies from 7 cm at its preserved terminus to 9 cm where it joins the keel. The stern foot measures a uniform 8 cm across and extends beyond the preserved end of the garboards. It is 11 cm high at its endpoint. The profile of the rabbets along the faces of these two pieces will be studied after removal of the garboards. Near the eastern end of the stern foot, there is a 6 cm-deep step on which we identified the trace of an iron nail, offset to starboard. This cut continues for 33 cm, to the preserved end of the foot to the east. Beyond this, there is the start of a second rabbet to starboard.

Since its eastern end has disappeared, it is impossible to determine how the stern foot was attached to the sternpost. However, there is room for a possible deadwood

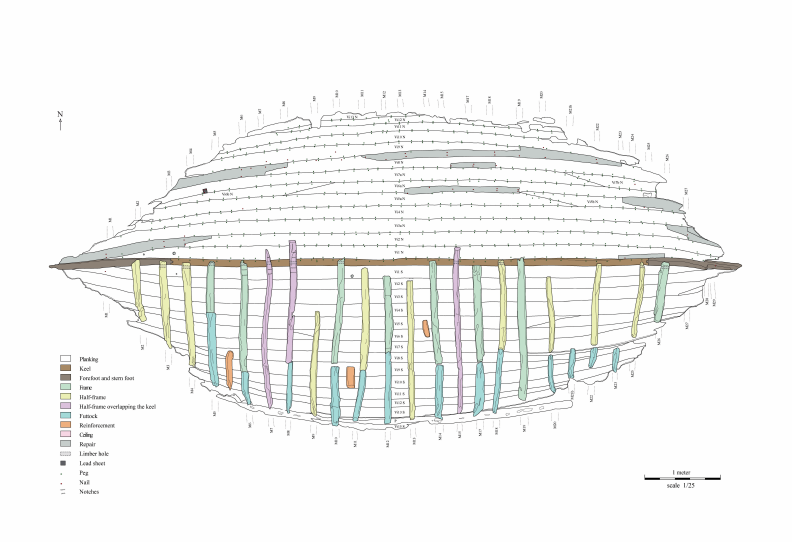

Fig. 5: The wreck after removal of both the ceiling-planking and the starboard frames.

Fig. 6: Treenails used to fill holes.

piece resting against the missing sternpost. There is an engraved mark on the northern face of the stern foot near the step. It takes the form of two vertical strokes which cut across the grain of the wood. It cannot be confused with the neighboring fissures and resembles a Roman numeral "II" (**Fig. 4**)[3].

2. The planking

There is but a single layer of carvel hull planking. The garboards consist of single planks 8 m long, with a maximum width of 18.3 cm. Other than the garboards, the 33 hull planks of the Mandirac 1 wreck constitute 13 starboard strakes and 15 port strakes, including the wale. Strake elements are joined by oblique flat scarfs, which vary from 50 to 85 cm long. The scarf layout on the starboard side does not appear to be random. The scarf on strakes 5N and 7N is toward the stern between frames 21 and 19, and frames 22 and 21, respectively. Strake 6N is scarfed toward the bow between frames 10 and 8. Strake 9N is characterized by a dead joint toward the stern (the strake disappears), while strake 12N has a dead joint toward the bow (**Fig. 5**).

On the port side, the second strake consists of a single plank 9 m long. The scarfs on this side of the hull could not be drawn as accurately, but scarfs were observed on strakes 3S and 5S toward the stern, and on strakes 6S and 8S toward the bow. Strake 9S has a dead joint toward the stern, while 11S has a dead joint toward the bow.

Thus, it seems the carpenters took the trouble to alternate the planking to obtain complete strakes running from stem to stern. In addition, the scarfs are never aligned from one strake to the next along a given side of the hull. But such alignment can be observed between hull sides. For example, both the starboard and port fifth strakes are scarfed between frames 21 and 19. This placement of scarfs on the sixth strakes, found between frames 10 and 8 to starboard and frames 9 and 8 to port, approximate this pattern.

Each garboard has two treenails that are not structural. Nor do they indicate reused materials, as we observed on other hull elements. These treenails were used to fill holes where knots had been removed from the wood (**Fig. 6**).

2.1 Planking fastening

The strakes are laid edge to edge and fastened to each other and to the keel by pegged tenons in closely-spaced mortises cut into the edges of the planks. They are mainly fastened by pegged tenons in closely-spaced mortises on the starboard side, where we were able to observe nearly everything. The interval between peg centers varies from 11 to 19 cm, more often from 15 to 19 cm, over most of the wreck, especially between frames 3 and 25. The tenons are not aligned from one strake joint to the next, but are roughly staggered in a quincunx pattern.

The scarfs between planks are also fastened by tenons perpendicular to the scarf and mostly pegged.

Garboard-keel and garboard-foot fastenings

The garboards are fastened to the keel by the same pegged mortise-and-tenon system. Another method seems to have been used to attach the garboards to the forefoot and stern foot. Numerous traces of ferrous oxidation along the rabbet of the stern foot suggest the use of iron nails driven tangentially, from the exterior, through the starboard garboard. This same technique seems to have been used to fasten port strake 2S, which, better preserved to starboard, ends its course in the stern foot rabbet beyond the garboard. Such use of iron nails to fasten garboard ends and other strakes to a foot was discovered by Giulia Boetto on the Fiumicino 1 wreck (Boetto 2008, 41-42). It also can be found on the neighboring Mandirac 2 wreck, of which only a fragment is preserved. Tangential nailing between longitudinal elements is not common in Mediterranean shipbuilding but it's usual in the context of Romano-Celtic sea/river boats[4].

3. The wale

Thicker planking 4.75 m long is preserved on the port side between

Fig. 7: Large rectangular mortises along the upper edge of the wale and mortise-and-tenon assemblage without peg between the wale and the previous strake.

Fig. 8: Two or three treenails were used to fasten each strake to the frames.

Fig. 9: From frame 13 to frame 18. On some frames, the number of treenails exceeds the number of those whose imprint is visible on the planking.

Fig. 10: A treenail overlaps another one.

strakes 13 and 15 from frame 5 to frame 21b. Its maximum width is 13.5 cm, and its maximum thickness is 7.9 cm. It is fastened to the preceding and the following strakes. Along its upper edge, between frames 8 and 18, the wale has four large rectangular mortises about 1 m apart. These differ from the planking mortises (**Fig. 7**). They are offset from the pegged mortises, and are cut into the outer part of the edge. Some of these mortises still contain a tenon whose visible section varies from 3.5 × 2 cm to 4 × 2.5 cm. One tenon is sticking out of its mortise against frame 17. Pending further study of the wale, we can hypothesize that it might have been intended for the placement of wash strakes.

The preserved port wale (**Fig. 7**) fragment is fastened using the same mortise-and-tenon method, but without pegs connecting them either to the previous strake (13S) or to the following one (15S).

4.The frames

The vessel's framing comprises 30 elements consisting of 15 floors, 8 pairs of half-frames, an isolated half-frame and 6 half-frames overlapping the keel. The first floors at each end, M1 at the bow and M29 at the stern, are cant floors. With the exception of those at the ends, most of the floors are preserved over their entire length and are extended by futtocks. The 23 preserved futtocks include 13 to port and 10 to starboard (**Fig. 3**).

The spacing tends to be regular, usually about 32 cm. All the starboard frames were removed in order to be drawn, photographed and digitized ashore[5]. There are limber holes in the frames to allow bilge water to circulate freely at the bottom of the hold.

The floors

The floors have either a square or a rectangular section. Width varies from 7 to 12 cm, but most measure 10 cm. Height varies from 7 to 13 cm, with most at 10 cm. The floors cover the entire hull from one turn of the bilge to the other. Floor 19, the longest, runs from starboard strake 10N to port strake 13S. Most of the others cover the area between strakes 8N and 8S, demonstrating a certain attempt at symmetry and solidity between the two sides (for example, floor 14).

The futtocks

The futtocks extend the floors starting at the level of the strakes at the turn of the bilge. They are not fastened to the frames and are very dissimilar. Some are butted with beveled ends, while others are separated by several centimeters. Some are reused pieces.

Frame-planking fastening

Frames were fastened to planking by truncated conical treenails driven mostly from the exterior. Two or three treenails were used per strake, spaced 5 to 10 cm apart and aligned (**Fig. 8**). Careful examination of the frames reveals that, in some cases, the number of treenails greatly exceeds the number of those whose imprint is visible on the planking *in situ*. This is particularly evident on frames 13, 17, 18, 19 and 21b, and on the M10 starboard futtock (**Fig. 9**). On M17, we can see that a treenail overlaps another one (**Fig. 10**). This means that the second one was present in the frame before the first one was put in place and testifies to the reuse of elements removed from another structure, probably a boat.

Several floors and futtocks are replacement pieces removed from another structure, probably a vessel[6]. Examination revealed the presence of numerous treenails which do not serve as fasteners on this wreck. These useless treenails cannot be confused with those used in the original construction of this vessel, before the replacement of several strakes. As the treenails are only visible on frames and futtocks and not on the strakes, it cannot be signs of repairs as observed on Pakostane wreck (Boetto *et al.* 2012, 120).

Absence of fastening between floors and futtocks

Not a single frame is fastened to the keel, not even the floors. The futtocks are not attached to the frames.

Fig. 11: Ceiling plank number 2: location of a treenail in the space between two frames. The nail is used to fasten the ceiling plank to a frame.

Fig. 12: Notches on either side of the keel on each of the frames 6, 7, 8 and 9.

5. The internal longitudinal structure

This comprises 11 ceiling planks fastened in place and three fragments of loose ceiling. Traces of two central sister-keelsons meant to support a mast step are visible on frames 6 to 9.

Ceiling planking

Signs of reuse are visible on the ceiling, especially in the form of mortises, sometimes with tenons and pegs still in place. Most of the tenons serve no purpose because they are almost never found in alignment. There also are many unpegged tenons in the mortises. More evidence of the reuse of former strakes can be seen in the abundance of pitch on the lower surface of certain ceiling planks, which corresponds to the outer face of these pieces when they were elements of hull planking.

This means that strakes from another boat were reused as ceiling on this craft. Other elements confirm this. For example, the location of some of the treenails in the space between frames means they served no purpose here (**Fig. 11**). The fact that these treenails (round or polygonal) are not aligned with any frame is evidence of their prior use elsewhere.

The mast step system

The only evidence of a possible mast step was observed at the forward end of the boat on frames 6, 7, 8 and 9. It takes the form of notches on either side of the keel on each of the frames (**Fig. 12**). These grooves enabled two sister-keelsons, to be set onto frames 6 to 9. These sister-keelsons supported a very short mast step riding on a crosspiece linking the two sister-keelsons. This system is characteristic of the western Roman Imperial naval construction (Pomey 2012, 300). It was found on Port-Vendres 1 (Chevalier – Santamaria 1972, 18-21; Liou 1974, 425-426) and Pakostane (Boetto 2012, 121) which are contemporaries with the Mandirac vessel and also on earlier wrecks as Saint-Gervais 3, Laurons 2, La Bourse, La Luque B or later as Saint-Gervais 2[7].

On the Mandirac boat this assembly is very short. In fact, it spans just four frames as on Pakostane wreck. Its length was likely no more than about 1 m. It is not situated precisely at the 1/3 forward position, which was the custom on seagoing vessels from Antiquity. Nor is it located all the way forward, as would be a spritsail. The more probable interpretation is that it supported a cargo boom or was a tow post. Such masts are normally situated in the forward third of the boat for efficient towing parallel to the banks of the canal (Beaudouin 1985, 11-12; Rieth 1998 106-107). The best comparison is the wreck Fiumicino 1 where was found a small forward keelson which was a towing-post-step directly fitted onto the floor-timber (Boetto 2008, 45). This was interpreted as the result of riverine influence as on the County Hall vessel: both wrecks were of sea-river vessels (Pomey 2012, 301).

6. The repairs

Strake 6N had been partially replaced between frames 13 and 19 over a distance of 1.55 m. Strake 8N had been partially replaced between frames 15 and 18 over 0.63 m. Strakes 8N and 9N had been repaired at the same time between frames 11 and 23 over a distance of 3.40 m. Finally, strakes 2N and 8N had been repaired at the bow.

This was also true of strakes 3N and 5N at the stern. Strake 3N was repaired twice. In each case, the original plank was cut into to receive the ends of the repair planks. We also observed the use of a square sheet of lead measuring 5.5 cm on a side to fill a gap. It was attached to the inner surface of strake 7N, toward the stem, by square nails with a cross-section of 0.5 cm as is frequently observed on wrecks from Late Antiquity (Boetto 2012, 123-125) or earlier (Daveau – Boetto 2012, 135).

Repaired strakes were fastened to the frames by nails rather than treenails. At the repair points, the

Fig. 13: Repaired strakes fastened to the frames by nails.

strakes are no longer fastened to each other by pegged tenons (**Fig. 13**). The new hull planking elements replacing the defective ones had to be forced into the space created by the removal of the original pieces. They were simply nailed to the frames as it was observed on Fiumicino 1 for the port garboard (Boetto 2008, 47).

7. Interpretation

The construction of the Mandirac 1 boat perfectly embodies the tradition of a "longitudinal shell-first conception" in which the hull shape is determined by the strakes (Pomey – Rieth 2005, 30-31). The hull planking also plays the primary structural role, while the framing is of secondary importance. The use of pegged tenons in mortises to assemble the strakes constitutes a network which ensures the longitudinal cohesion of the structure. This network is dense on the Mandirac 1 wreck since the spacing is between 15 and 19 cm and very regular[8]. Our current observations indicate that this interval is comparable to that found in wrecks dated between the mid-2nd century and the beginning of the 4th century A.D., such as Saint-Gervais 3, Laurons 2, La Bourse and La Luque B. On wrecks from the 4th and 5th centuries, the spacing is around 30 cm (Pomey 2012, 297). Unpegged mortises-and-tenons joints are used only from the assembly of the wale of Mandirac 1.

Not a single frame is fastened to either the keel or the futtocks. On wrecks earlier than the 5th century of our era, the sporadic fastening with nails or pins that we find does not necessarily mean that these frames were "active". We also must consider that this might represent frame repairs. In Graeco-Roman naval construction, floors and half-frames face-to-face on the keel were usually alternated. Beginning in the 2nd century of our era, a certain number of cargo vessels in the Roman western Mediterranean had half-frames overlapping the keel alternating with floors. All of these are flat-bottomed craft with rounded bilges (Pomey 2012, 298). The Mandirac 1 framing consists of half-frames overlapping the keel alternating with half-frames meeting on the keel and floors. The overlapping half-frames increase the transverse strength to the structure. Of the six found on Mandirac 1, three are related to the mast step, which they support.

The internal axial longitudinal elements, the mast step and keelson, are also of fundamental structural importance. From the 2nd century of our era, we begin to see in the western Mediterranean a system comprising two central sister-keelsons, connected by transverse braces to which the mast step is fitted (Pomey 2012, 300). On the Mandirac 1 wreck, there is neither keelson nor notches which might have served to attach one. In contrast, there are traces of a system using two short central sister-keelsons.

Our study of the Mandirac 1 wreck indicates that the builders sought both seaworthiness and economy of construction. The former is seen in the care taken to ensure symmetry between the vessel's sides, with frames and, in particular, floors which cover the bottom to the turn of the bilge, and strakes with dead joints at the same level to port and to starboard.

The builders also sought to avoid weakening the hull planking with numerous scarfs. Most of the strakes are of one plank. When necessary, the scarfs of adjoining strakes are never aligned. In the same way, the tenons of planking in successive strakes are not aligned, but staggered in a quincunx pattern.

The dead joints of the midships strakes are characteristic of a rounded hull. This allows for the narrowing of the upper topsides toward the hull ends, but also constitutes a significant weakness, resulting in a degree of fragility at the turn of the bilge. The numerous reused pieces and partial repairs to certain planks indicate economical, utilitarian construction. The many repairs suggest a service craft requiring successive renovation and, perhaps, a rather long working life.

The position of the mast step into the forward third of the wreck rather than at the forward third is incompatible with the use of a square sail intended for maritime shipping. It also suggests a service craft, a lighter intended for the off-loading of cargo ships in the port access channel and the transfer of cargo to the city by towing. In fact, the narrowness of this body of water would have made proceeding under sail difficult.

Conclusion

The wreck Mandirac 1 has been built with a strong arrangement of pegged mortise-and-tenon joints, according to hull-shape concept and structure, with a full shell-first construction-process.

A thorough study of this wreck is essential for our understanding of river and lagoon transport and the construction of harbor craft. While the development of nautical archaeology over the last half century has given us a good grasp of blue-water and coastal ships, "service" craft remain relatively unknown. Their discovery is usually due to large-scale urban development projects (Toulon, Antibes, Marseille, Pisa, Naples and Istanbul). The Mandirac 1 wreck seems to exhibit an ensemble of particular characteristics which merit further study to improve our understanding. These characteristics, which result from the craft's adaptation to its milieu, its function and utilization practices, remain marked by the ancient Mediterranean tradition which gave birth to the boat.

Notes

[1] Collaboration between the Languedoc-Roussillon Region, the CNRS, the Ministry of Culture (DRAC and DRASSM) and INRAP.

[2] Labex ARCHIMEDE, program «Investissement d'Avenir» ANR-11-LABX-0032-01.

[3] Engraved marks were found on other wrecks: for bibliography see Tran 2014, 165-170.

[4] For bibliography, see Boetto 2008, 41, note 24; Pomey 2012, 304-305.

[5] They were drawn at 1:1 on polyethylene film and digitized by Véronique Mathieu and Hervé Bohbot of the UMR 5140 at the CNRS.

[6] 14 of the 15 floors from this wreck were studied: six are previously-used pieces.

[7] For bibliography, see Pomey 2012, 300.

[8] Awaiting the disassembly of the planking, we cannot calculate the ratio between the space between two adjacent mortises and the width of the mortises. We can only indicate the interval between peg centers from 11 to 19 cm, more often from 15 to 19 cm.

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