



# Ses Fontanelles Shipwreck (Mallorca, Balearic Islands): An Exceptional Late Roman Vessel and Its Cargo

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## Abstract

This article summarises the results of the underwater rescue excavation of the shipwreck of Ses Fontanelles (Mallorca, Balearic Islands). The excavation documented the remains of a vessel, 12 m long and 5 m beam, loaded with two tiers of amphorae, which had set sail from the south-eastern Iberian Peninsula. The cargo includes numerous amphorae which were still sealed and bearing *tituli picti*, allowing for the analysis of their content. There is little doubt that the shipwreck of Ses Fontanelles is a key site for our understanding of third–fourth-century trade in the Western Mediterranean.

**Keywords** Shipwreck · Balearic Islands · Underwater archaeology · *Tituli picti* · Naval architecture · Late Antiquity

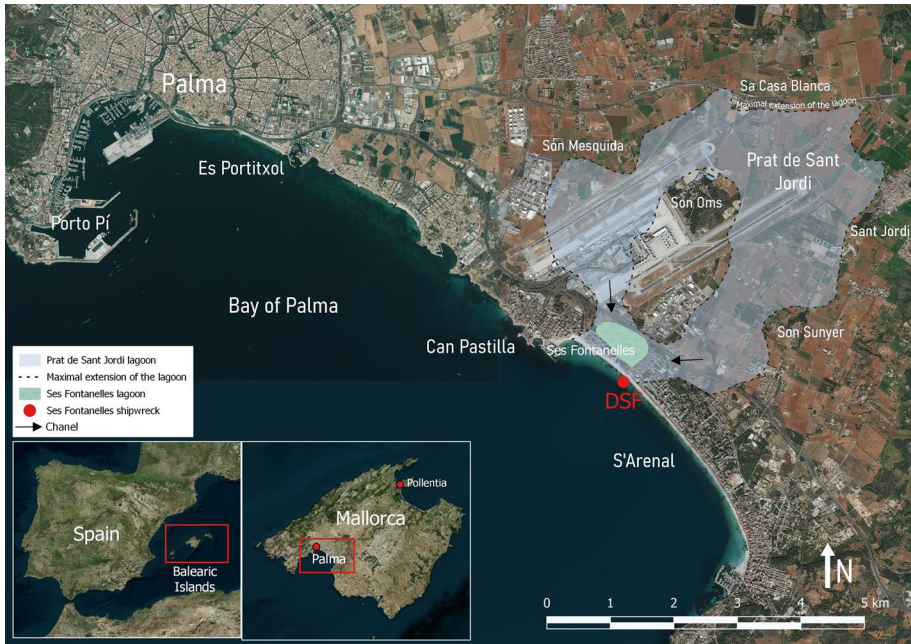
## Introduction

The shipwreck of Ses Fontanelles was accidentally discovered in one of the most touristic beaches of Mallorca, located in the area of Can Pastilla in the bay of Palma, in Mallorca (Fig. 1), in July 2019. The site had been left exposed by a strong winter gale. The wreck took place near the mouth of the *acequia* of Prat de Sant Jordi which was in Antiquity a major lagoon or navigable marsh connected with the sea by a canal (Muntaner 1957, p. 99; Rosselló 1989, p. 118). This idea is supported by the *Liber Maiolichinus*, which accounts for the disembarkation of the Pisan-Catalan troops that besieged the city of *Madina Mayurqa* in 1114–1115 (Alcover 1934). Geological studies have determined that the lagoon modified by a sand bar in the Early Modern Age (Goy et al. 1997, p. 130). Drainage works to desiccate stagnant water pools began in the early nineteenth century, and thenceforth the area was used for agricultural and stock-breeding purposes (Rosselló Verger 2000). Currently, the Prat de Sant Jordi is but a small patch of marshland known as Ses Fontanelles (in abbreviated form, the area is known as DSF—Derehcte Ses Fontanelles—which is the acronym that we shall be using hereafter).

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**Fig. 1** Location plan of the shipwreck of Ses Fontanelles in the Bay of Palma (Mallorca) and reconstruction of palaeo-landscape if the lagoon of Prat de San Jordi (by Goy et al. 1997)

The archaeological remains are approximately 65 m from the beach, and sit over a flat sand surface, barely 2 m below the sea surface (Fig. 1). At the time of discovery, only the necks of a few amphorae and the ship's frames, which outlined the shape of the vessel, were visible above the sand surface. Old fishermen claim that the shipwreck was originally discovered in the mid-twentieth century, and this seems to be confirmed by annotations in the unpublished maps used by looter Josep Beltrán and a few brief references published in the early 1970s (Mascaró 1968: map 33, square B8; Mascaró 1971, p. 69, Fig. 1). Fortunately, the wreck remained covered by a thick layer of sand and suffered little from looters. It is likely that changes in currents and the morphology of the coastline caused by the regeneration of nearby beaches and the construction of recreational ports in the second half of the twentieth century contributed directly to the uncovering of the archaeological remains (Coll et al. 2008).

After the find became known, the Servei de Patrimoni del Consell de Mallorca launched a rescue excavation with the aim of recording the site. Owing to the shallowness of the archaeological sequence, the site was not only threatened by looting, but also by its proximity to one of the island's most popular beaches. The multidisciplinary excavation team consisted of eight specialists, and included underwater archaeologists, conservators, specialists in ancient shipbuilding and documentalists [1].

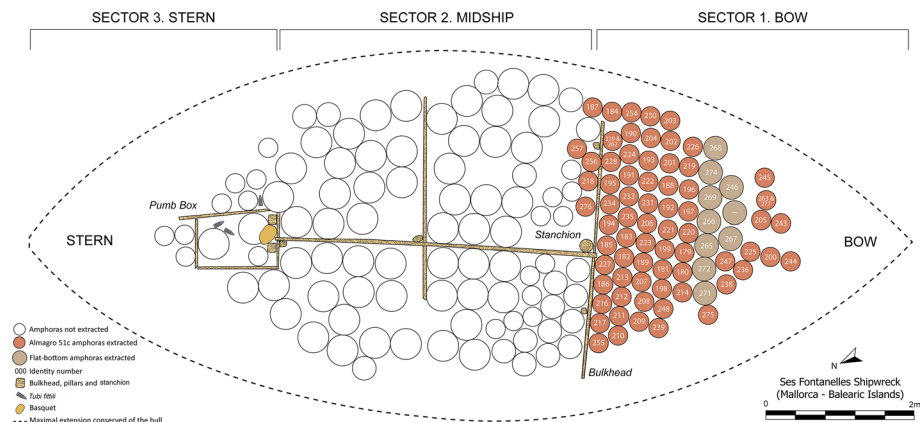
## Methodology

The rescue excavation took place in July and August 2019. As a first step, Navy divers installed the bottom of an auxiliary platform and enclosed a 900 m<sup>2</sup> work area with buoys to stop beachgoers from entering the excavation area. The proximity of the shoreline, and the shallowness of the water allowed works to proceed with a relatively simple infrastructure. Three intensive work shifts were established. However, underwater excavations in shallow waters present technical challenges different from those that affect sites in deeper waters. The site of Ses Fontanelles is affected by a land-bound summer wind regime resulting from thermal variation in the central hours of the day. This wind, known in the Balearics as *embat*, can be fairly intense (between 4 and 9 m/s). The *embat* caused considerable perturbations in the surf area, stirring the bottom sediment and blurring visibility for the divers. The surf also threatened the stability of the work platform upon which the water pumps were installed, so excavation works were largely limited to the early hours of the morning.

The archaeological remains cover an area approximately 12 m long by 5 m wide (60 m<sup>2</sup>). An open area approach was adopted, so that the shipwreck could be recorded by photogrammetric techniques. The site was divided into three sectors, following the transversal hold's bulkheads (Fig. 2):

- Sector 1. Bow (from frame 100 to frame 114)
- Sector 2: Central area (from frame 114 to frame 128)
- Sector 3: Stern (from frame 128 to frame 137)

The excavation area was further subdivided by a 2 × 2 m metal grid. The shipwreck was fenced off with a sandbag barrier to prevent current-borne dirt from entering the excavation area. Sediments were removed with three water dredges connected to water pumps installed upon the floating platform built over the site (Fig. 3). Layers were removed one by one (Nieto et al. 1989, p. 39–40) following stratigraphic criteria (Fig. 4). Below the surface detritus, a finer sand layer, which contained many fragments from the ship cargo's top tier, was attested (Layer 1). Beneath, the hold, containing an in situ layer of perfectly stowed amphorae, was found (Layer 2). The removal of Layer 2 revealed the ship's hull.



**Fig. 2** Preliminary reconstruction of the arrangement of the cargo inside the ship

**Fig. 3** View of the excavation near the bow (Sector 1) with the perfectly stowed cargo (J. Rodríguez)



**Fig. 4** Photograph taken during the excavation (J. Rodríguez)



As the excavation progressed, the enormous scientific interest of the finds became apparent. The well-preserved remains included two tiers of amphorae stowed in the ship's hold. However, the full excavation of a site with these characteristics was not feasible with the means available at that time. In addition, half-way into the excavation season, a strong gale from the south-east completely covered the site in sand, forcing us to restart the excavation process. Accordingly, the technicians of the Consell de Mallorca gave priority to the removal of surface material, which was more exposed to looting, while opening a sounding near the bow (Sector 1) to gain a better understanding of the general characteristics of the cargo and collect data with which to plan further excavations in the future.

At the end of the excavation season, the material recovered was deposited at the *Museu de Mallorca* to begin the process of desalting and conservation. In addition to elements from the cargo, vegetal matter samples were collected for identification, including samples from the hull and the packing elements in the stowage area. These samples were kept in sea water and thin-sectioned in the laboratory. The wood anatomy was examined under a transmitted/reflected light optical microscopy against clear and dark backgrounds (Olympus BX60). Wood taxonomy was examined with reference to wood anatomy atlases (Schweingruber 1990) and research group ArqueoUIB's reference collection.

The shipwreck was left protected against gales and sea microorganisms by a polyethylene cover and a layer of sandbags laid out horizontally. A visit undertaken in October 2020 confirmed that the site remains totally sealed by a 1 m-thick sandbank.

## The Commercial Cargo and Its Position Inside the Vessel

### Synthesis of the Material

The first excavation season in the shipwreck of Ses Fontanelles yielded a comprehensive perspective on the vessel's archaeological context, largely constituted by amphorae, although some items for the use of the crew were also identified.

The vessel carried a heterogeneous cargo of products contained in amphorae. At least four types of amphorae were characterised: several variants of the Almagro 51c type, various types of flat-bottomed amphorae, a new type labelled as Ses Fontanelles I (which could be regarded as an imitation of the Dressel 23 type) and a few specimens of the Keay XIX type.

The possible possessions of the crew include several fragments of cooking wares with outfolding rims, which still preserved remains of soot on their exterior surfaces, and several large fragments of *tegulae*, probably used for cooking (Nieto et al. 1989: 215–217, Fig. 153.6). There was also a circular bronze dish, approximately 15 cm in diameter, with a flat bottom and infolding rim, like those found in the Cabrera III shipwreck (Bost et al. 1992). It is worth noting that most of these items were found in the portside stern of the ship (Sector 3), between frame 129 and 130, suggesting that the kitchen and pantry of the ship could have been located in this area, probably in an upper level. On the other hand, a weaved esparto unidentified item, approximately 30 cm long and 26 cm wide, was found over the ship's bilge pump well; it was not extracted due to its bad state of preservation. Near the textile find, numerous greyish mineral fragments were found, currently under analysis (Fig. 5). It is not yet known whether this was part of the cargo or something for the use of the crew.

Carpological remains and four bronze fishhooks were found among the stowed amphorae; the fishhooks had a U-shaped harpooned head, a straight shaft and presented no

**Fig. 5** Woven textile item over the pump box (J. Rodríguez)



element to fix the line. The largest was 5.2 cm long and 3 cm wide, while the rest were approximately 3 cm long and 1.7 cm wide; all of them were, therefore, mid-sized hooks suitable for the capture of small and middle fish species from the ship (Bernal-Casasola 2010: 92, Fig. 4, Type AI). Finally, the finds also included a partially broken and heavily sand-eroded shell of *Charonia lampas*, located outside the portside beam. Seamen used these seashells or *buccinum* to make sounds by blowing through a hole in the appendix (Nieto et al. 1989: 214, Fig. 153.3). In any case, the specimen found in Ses Fontanelles presents no deliberate hole in the *apex*, which suggests that it may have had a different use.

## The Commercial Cargo

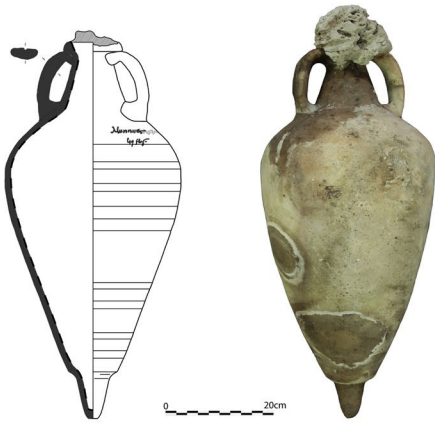
The typological study of the amphorae found during the first excavation season (Bernal-Casasola and Cau 2020), which is being prepared for publication, led to the characterisation of 249 diagnostic pieces forming four formal groups (Fig. 6). The vessel was mostly loaded with *garum* amphorae (Almagro 51c), some olive oil amphorae (Ses Fontanelles I/ Dressel 23) and a smaller number of flat-bottomed amphorae used to store wine/vinegar, or a grape by-product used as an olive preserve (wine reduced by heat, which was known in Antiquity as *defrutum* or *sapa*). The amphorae were tightly stowed, packed mostly with vine shoots (*Vitis vinifera*) but also other non-woody plants such as common reed (Poaceae cf. *Phragmites*) (Figs. 7, 12 and 13). Despite this, some ceramic fragments present sub-circular marks of abrasion caused by the contact of the amphorae in the ship's hull. This suggests that the amphorae suffered substantially during the voyage, but none appears to have broken, and/or due to post-depositional processes.

From a typological perspective, the most numerous group is that formed by the Almagro 51c type, used to contain fish sauces and produced in *Baetica* (Bernal-Casasola 2001), southern *Lusitania*, the mouths of the Tagus and Sado rivers (Vaz Pinto et al. 2016) and, to a lesser extent, in the south-east of the Iberian Peninsula (Berrocal 2012). The second line of their *tituli picti* (which refers to the content of the amphorae) is in all cases *Liq Fls*, which can be interpreted as *Liquaminis Flos* (flower of *liquamen*), one of the famous Roman fermented fish sauces (Fig. 7) (Curtis 1991; Étienne and Mayet 2002). The in-detail analysis of the painted inscriptions has been published elsewhere (Soler et al. 2021).

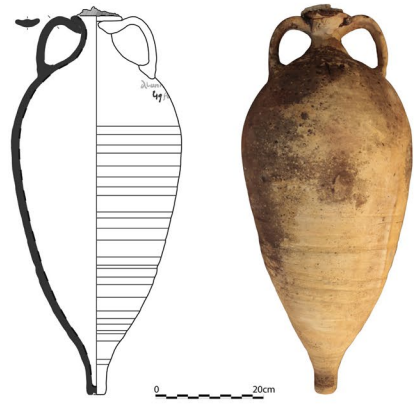
The second most numerous group is constituted by a hitherto unknown type of amphora, which has been reliably characterised thanks to the presence of a whole specimen (Fig. 6, DSF-002); when in a fragmentary state, the type is easily mistaken for olive oil amphorae from the Guadalquivir region, with which it shares the circular and sub-circular handles and the pointy bottom. Following standard practice, the type –although it can also be regarded as an imitation of the Dressel 23 type– was labelled as Ses Fontanelles I, after the site where it was first identified (Bernal-Casasola and Cau 2020). Concerning the flat-bottomed specimens, we prefer to use this general description, for they belong to a variety of types, including the Matagallares I (DSF-268, not illustrated) and other types (DSF-255, DSF-266); these amphorae are currently in the process of being characterised in detail. A “Gallic” origin can be ruled out, because of their typological proximity to well-known Hispanic types dated to the third and fourth centuries AD and found most frequently in eastern *Baetica*, where several *figlinae* have been excavated (Bernal-Casasola 2019). Owing to their shape and formal similarity with types from *Narbonensis*, they are generally associated with the transport of wine.

The amphorae repertoire also includes two specimens of the Keay XIX type. Judging by the macroscopic characteristics of the fabric, the provenance of these amphorae is totally

DSF-179



DSF-189



DSF-266



DSF-002



**Fig. 6** Amphorae: most of the cargo was constituted by Almagro 51c-type amphorae (A.- DSF-179 and B.- DSF-189); flat-bottomed amphorae (C.-DSF-266) and Ses Fontanelles I-type amphorae (D.- DSF-002)

**Fig. 7** Detail of *titulus pictus* in Almagro 51c-type amphorae (J. Rodríguez)



different from that of the other containers found in the site (Bernal-Casasola and Cau 2020), perhaps suggesting that they were not part of the cargo, but of the crew's provisions.

Exceptionally, as many as 39 of the amphorae preserved *tituli picti*, the highest number found in a Late Roman shipwreck to date; 36 specimens of the Almagro 51c type carried the same inscription; another member of the type (DSF 187) presented a different inscription, but this specimen was located on a different part of the ship (Sector 2). On the other hand, flat-bottomed amphorae DSF 265 and 266 present different inscriptions.

The detailed study of these inscriptions is the subject of another specific publication (Soler et al. 2021). At this stage it is possible to state that the most numerous group shares the same text: *Alumni et Ausonii nn* in the first line and *Liq. Fls* in the second (Fig. 7). The second line leaves little room to doubt concerning the content of the amphorae, which must be identified with *liquaminis flos*, a liquid fish sauce.

### Arrangement of the Cargo

The vessel of Ses Fontanelles was wrecked upon a sandy bottom barely 2 m below the surface. The weight of the cargo made the ship sink progressively in the sandy substratum up to the top of the hull. The post-depositional processes caused by the decomposition of the wood above the lower wale led to some of the amphorae that were leaning on the hull to fall outwards and disperse around the site. Over time, the shipwreck became completely sealed by a thick layer of sand that contributed to its preservation. However, the strong surf and sea currents occasionally uncovered the archaeological remains, leading to the looting of the topmost levels. The bottom tier of the cargo was perfectly preserved, except for some amphorae situated on the sides, the bow, and the stern. In contrast, the materials stowed in the top tier were heavily fragmented, especially the globular amphorae located near the stern (Sectors 2 and 3), which presented fragile fabrics that were further deteriorated by physical–chemical reactions induced by the marine environment (Fig. 8).

The site's magnificent state of preservation has allowed us to preliminarily reconstruct the composition and disposition of the cargo (Figs. 2 and 8). The hull was divided into





**Fig. 8** Photogrammetry of the Ses Fontanelles shipwreck (K. Yamafune)

horizontal sections by vertical bulkheads, 0.6 cm thick and 26 cm wide, which were used to organise the cargo inside the hull. To date, one longitudinal bulkhead, running along the vessel's axis and three transversal ones, at the prow, stern and amidships, have been identified (Fig. 8). The end of the boards was fitted to one another through simple incisions to give the structure extra consistency (Fig. 9). Plaited ropes were used to tie the bulkheads to the stanchions that supported the beams (Fig. 10).

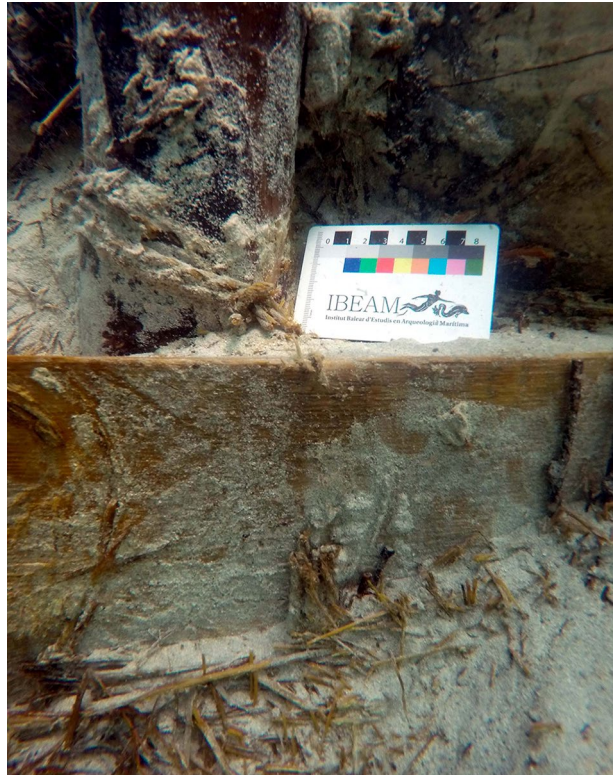
The cargo was organised in two tiers that covered the whole length and width of the ship. The amphorae were vertically arranged, slightly tilted towards port (Fig. 11). This arrangement maximised the limited space available in the hull. Globular amphorae, which were larger and heavier, occupied the centre and the stern area (sectors 2 and 3). SF I amphorae, much heavier than the Almagro 51c type, were in the top tier, towards the stern. Smaller containers were mostly found near the prow (Sector 1) and the sides (Fig. 2).

The sounding undertaken in Sector 1 provided additional information concerning the disposition and characteristics of the cargo. The top tier was largely formed by Almagro 51c-type amphorae, although a few flat-bottomed containers and two necks corresponding to Keay

**Fig. 9** Joint between longitudinal and transversal bulkhead (J. Rodríguez)



**Fig. 10** Tie anchoring the bulkhead to the prop (J. Rodríguez)



**Fig. 11** Cargo of Almagro 51c-type amphorae near the prow (Sector 1) (J. Rodríguez)



XIX-type amphorae in a secondary position were also found. Most of the amphorae found in the top tier clustered on the sides of the ship (Fig. 8). It was at first thought that this was a consequence of the displacement of the cargo during the wreck, or the result of continued looting. However, the excavation failed to find any ceramic remains in the central area of the top tier, but managed, in contrast to identify the highly deteriorated remains of esparto items in this area. This opens the possibility that the *Ses Fontanelles* vessel was transporting some organic

product of which no trace has survived. Future excavation seasons will have to confirm or discard this hypothesis. The bottom tier, however, was formed by tightly stowed amphorae; only a few specimens were found outside their original position, following post-depositional processes. The weight of the top tier had caused some of the amphorae in the central area of the bottom tier to crack or partially collapse. The top tier was almost entirely formed by Almagro 51c-type amphorae, although a small cluster of flat-bottomed containers was found near the stern, forming two rows of seven and three specimens, respectively (Fig. 8). All the amphorae situated in the bottom tier sat directly on the ceiling, regularly arranged (a minimum of 10 rows and 12 columns). The two rows near the stern bulkhead, however, were arranged forming a triangle (Fig. 2). A similar triangular arrangement can also be inferred on the sides and the remaining flat-bottomed amphorae near the stern. The free space formed by the stowing frame was used to fit the bottom of the amphorae in the top tier, although some of the flat-bottomed amphorae sat directly on top of the mouth of the amphorae in the bottom tier.

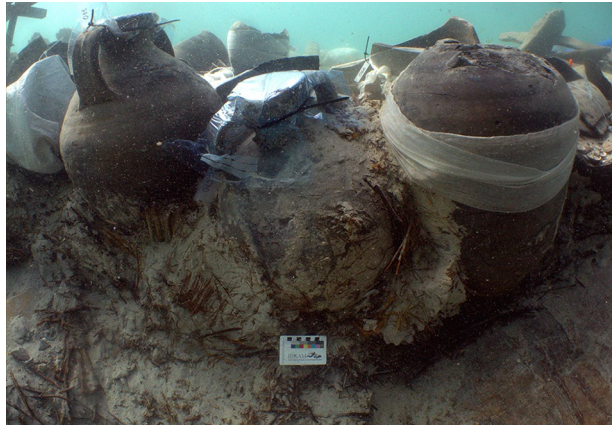
Information about the disposition of the cargo in sectors 2 and 3 is much more limited, as the excavation only removed the soil covering the top tier. In addition, the remains were much more exposed to the surf and the currents and are more deteriorated than towards the bow (Fig. 8). As such, only an approximate reconstruction of the arrangement of the cargo in these areas can be put forward. The largest and heaviest containers were situated towards the stern, also arranged in two tiers. The bottom tier was constituted by large globular amphorae that are currently being characterised typologically, as none of them was extracted. The disposition of these containers above the ceiling remains unclear, as they were covered by the fragments of the amphorae situated in the top tier. The position of a few protruding necks, however, suggests that they may have been regularly arranged in six longitudinal columns, three to port and three to starboard. The top tier was formed by smaller globular amphorae, which are difficult to ascribe typologically with any certainty due to their fragmentary state; only in some cases have the lower section of the amphorae survived whole, fitted into the stowing frame of the top tier (Fig. 13). The analysis of the fragments suggests, however, that most of these amphorae corresponded to the Ses Fontanelles I type (Bernal-Casasola and Cau 2000). It is worth emphasising that the only complete specimen of this type was found in the stern area of the wreck during a preliminary survey undertaken shortly before the excavation began. The free space on the bow, stern and sides was used to stow smaller containers, especially belonging to the Almagro 51c type and a few flat-bottomed amphorae. The top tier was regularly arranged with a minimum of eight rows, combined with the triangular arrangement noted above near the bulkheads and the sides of the hull (Fig. 2).

The bottom of the hull and the spaces between amphorae were tightly packed with vine shoots (*Vitis vinifera*) to protect the amphorae during the voyage (Fig. 12). Some of the globular amphorae in the top tier were surrounded by large bundles of yellowish common reed (Poaceae, cf. *Phragmites*) also to protect the amphorae from smashing (Fig. 13). As noted, many of the amphorae present evidence of abrasion above the body ridge, indicating where the amphorae rubbed against one another (De Juan 2018: 139, Fig. 6).

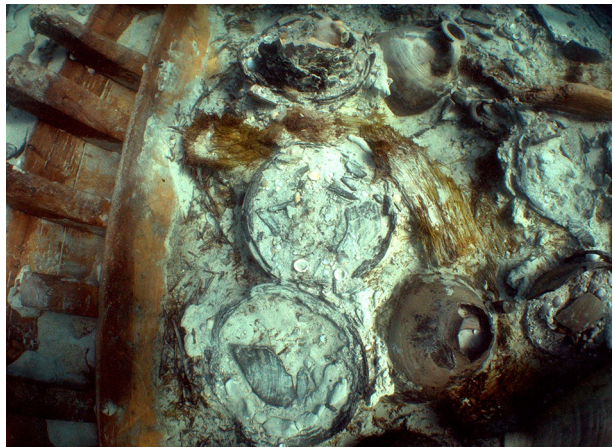
## Interim Approach to Its Shipbuilding

It is, in general, not advisable to undertake the study of a ship's architecture before the excavation is completed and all the details of the carpentry are known. However, in this particular case, it is already possible to a first insight into the shipbuilding of the Ses Fontanelles shipwreck.

**Fig. 12** Bundle of reed packed between the flat-bottomed amphorae (J. Rodríguez)



**Fig. 13** Bundle of reeds disposed around one of the globular amphorae amidships (J. Rodríguez)



As noted, the ship is in shallow waters, near the modern beach, which suggests that the ship ran aground, either accidentally or deliberately, on a sand bar. As a result, the ship is right almost level, only slightly tilted to port. It soon sank in the sand bank, and in consequence the preserved woodwork is excellent. However, time and the marine environment have degraded even the anatomy of some of the top level woods used, making them difficult, if not impossible, to identify taxonomically. The top ends of the frames, which were regularly exposed by gales to sand erosion and the action of organisms, are the most degraded elements.

The hull's underwater body (nearly 1 m height) is completely preserved, from stem to stern post and from starboard turn of bilge to port one, including lower wales. Its preserved dimensions are 12 m long and 4.86 m wide. With these approximate measurements, it presents a ratio that can be placed close to 2.5, which suggests that we are facing an archetypal merchant within Pomey's western Roman imperial architectural family (Pomey et al. 2012: 237). A first estimate of the transport tonnage, following the formula of the French navy of the eighteenth century and accepted for ships of the Roman period (Pomey and Tchernia 1978: 234) gives us an interval between 40 and 60 t. This value may be further refined in the future once the first hypothesis concerning its water lines are formulated. The most

remarkable feature of this shipwreck is the excellent state of preservation of some of the carpentry work, which allows for a detailed analysis.

### Longitudinal Carpentry

The excavation has revealed the upper strakes, situated above the turn of the bilge. The planks are 3.5 cm thick and approximately 18 cm wide. A much thicker strake (nearly 8 cm) was identified on the portside; this was interpreted as the lower wale which may be close to the flotation line. The mortises of this wale were displaced inwards to fit with the upper strake.

Some of the pegged mortise and tenons joints in the wreck upper strakes, could be measured; the mortises were 8 cm wide, 3 or 4 cm deep and 1 cm thick. The distance edge to edge was between 8 and 12 cm. The tenons were 8 cm long, 4–6 cm wide and 0.8 cm thick. Six of them could be analysed; they were crafted in olive (*Olea europaea*) and laurel (*Laurus nobilis*) wood, although in two specimens the exact species could not be determined. The tenons show all the angles slightly bevelled. The pegs, slightly conic, are 1 cm in inner diameter and 0.7 cm on the outer face; four pegs could be extracted, all of which were made in pine wood, made with faceted technique. The species and family of two of them could not be determined, while the other two were related to the Cupressaceae family. The peg holes occupied a central position in the mortises, approximately 2 cm from the plank lateral side.

The excavation could also detect traces of resin, probably pitch, on the hull and the mast step, although the analysis of this resin is still pending.

The 2019 excavation season managed to reveal 1.30 m of the mast step of the minor mast, probably used to steer the ship, called *artemon* and situated near the bow. This mast step might sat directly on the floor timbers and was 13 cm wide. From the mast mortise, for approximately 1 m, mast step width increases to 20 cm. The mortise where the foremast was fitted (33 × 6.4 cm) was full of resin, which was not removed (Fig. 14).

This forward mast step is joined by a scarf, the detailed study of which is still pending, with the keelson, which could not be fully excavated. The keelson was quadrangular in section and is wider amidships; it is 20 cm wide in the bow end.

**Fig. 14** Detail of the box where the foremast was fitted (J. Rodríguez)

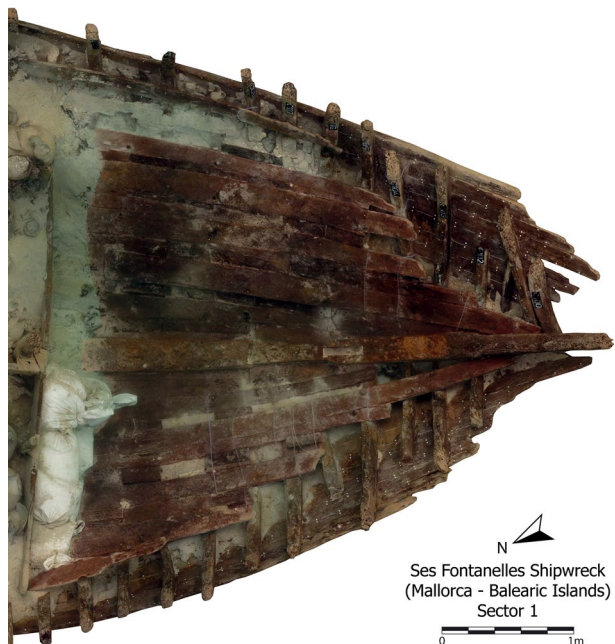


As usual in within Pomey's western Roman imperial architectural family, the main mast step appears to be fitted, embedded, upon two parallel lateral keelsons, which may reinforce the longitudinal carpentries.

The mast step that serves as a keelson stops at the bilge pump well, but no precise data about the morphology of the parallel keelsons could be extracted. The bilge pump well, is rectangular in shape (1.1 m long  $\times$  0.7 m wide) and is located between frames C-129 and C-133 (Sector 3). Four planks, oriented vertically, are preserved. This well could continue up all the way to the deck and separate the cargo from the two vertical wooden pipes inside which ran the rope of pistons that pumped water from the bilge to the deck. Inside this preserved box, where run the pistons rope, at least two globular amphorae were found, suggesting a secondary position. The remains of esparto and other badly preserved vegetal fibres, possibly ropes, could also be identified there. Four specimens of *tubi fittili*, used in Roman architecture to build vaults (Adams 1996: 360–362; Lancaster 2015), were also found inside and in the vicinity of the box. These are common finds in underwater contexts, especially from the third century AD onwards (Bound 1987: 192), although the naval function of these elements remains unclear. In most cases, for instance in the shipwrecks of Cabrera III (Bost et al. 1992), Cap Blanc (Llabrés 1976: 4, Fig. 7) and Dramont E (Santamaria 1995: 67–68), they appear in small numbers, generally towards the stern. They have been interpreted in various ways: as remains of earlier cargoes, forgotten inside the hull (Santamaria 1995), as pieces used to separate the cargo (Beltrame 2002: 96–97) and as elements used as part of the hearths in the aft cabin (Gibbins 1989: 4) which suggests they could be brazier blower nozzles.

As is common in the western Roman imperial architectural family defined by Pomey (Pomey and Rieth 2005), the ceiling is constituted by stringers (pinewood, possibly stone pine, *Pinus cf. pinea*), broad and robust planks nailed to the top face of the frames, which alternating with narrower and thinner mobile planks (Fig. 15). Some of these appear

**Fig. 15** Photogrammetry of the area near the prow (Sector 1) after the removal of the cargo (K. Yamafune)



reused, judging by evidence of sawing. It is also possible that vertical stanchions helped to stow the cargo, maybe an earlier one, according to some holes founded in the stringers. The ceiling started with rows of mobile planks, from the side keelsons. The stringers contributed to reinforce the hull longitudinally. Some of the mobile planks are joined by flat scarfs.

### Transversal Carpentry

The ship preserves 39 frames (numbered from 100 to 138) (Fig. 8). They are rectangular in Sect. (14 cm moulded × 12 cm sided). A sample was taken from frame 105, which was identified as stone pine (*Pinus cf. pinea*). The framing-pattern of half frames and floor timbers in the fore-and-aft axis is unclear, but a rhythmical classical pattern seems to operate in several areas of the bow. The frames room and spaces measurements are between 18 and 25 cm.

Concerning the joining technique of the frames, cone-shaped treenails are combined with blind nails. Only the top end of the treenails could be measured (1.5 cm in diameter). They were driven in from the outside of the hull, at intervals of approximately 18 cm. They are combined short iron nails (only rusty concretions remain).

Several stanchions, presumably associated with beams (not preserved), were identified. They are arranged in pairs to the side of the fore-and-aft axis; two, circular in section (approximately 8 cm in diameter) are associated to the mainmast, and another pair, quadrangular in section (approximately 12 cm wide) are situated near the stern. No other stanchions were preserved.

Another piece of transversal carpentry for which little archaeological evidence exists are the bulkheads that separated the cargo. They were constituted by vertical planks placed perpendicular to the fore-and-aft axis, dividing the hold into separated compartments. They are 26 cm wide and 6 cm thick. The remains suggest that the bulkheads were tied to the stanchions. In Ses Fontanelles, the bulkheads are not joined to the stringers.

### Preliminary Conclusions

The Ses Fontanelles shipwreck is an especially interesting site owing to its accessibility and the excellent state of preservation of the remains. The first excavation season, sponsored by the Consell Insular de Mallorca, has allowed for a preliminary characterisation of the ship's architecture and the historical contextualisation of the site.

Most anchorages in the Bay of Palma, such as the Roman harbour of Porto Pí (Cerdà 1999), are located in its north-western part. The location of the DSF near the beach is remarkable, as it is an open area with little shelter, especially exposed to third quadrant winds. In principle, therefore, the area is unsuitable as a shelter for ships, although it may offer favourable anchorage to ships exposed to northwest gales. Is it possible that the vessel sought shelter in the interior lagoon of Prat de Sant Jordi? The use of this kind of marshland was common in Antiquity, as attested by other examples in the Albufereta, in Alicante (De Juan 2008) and the Roman city of *Pollentia* (Giaime et al. 2017). However, the use of Ses Fontanelles as a harbour remains uncertain, and only systematic geomorphological, geophysical, and archaeological survey can put the matter to rest.

What caused the wreck? It cannot be ruled out that the crew was surprised by rapidly changing weather conditions while the vessel was anchored at the beach. However, when

ships run aground in shallow areas because of a gale, they tend to sit across the direction of the wind and to eventually break up, the cargo dispersing around it, as attested in other similar sites in the island, such as the Greek vessel of Cala Sant Vicenç (Nieto and Santos 2009), the Republican ship at Colònia de Sant Jordi (Cerdà 1980) and the Imperial-period vessel of Ses Llumetes (Munar et al. 2017). Ses Fontanelles, in contrast, points almost perpendicularly towards the beach, and the two tiers in which the cargo was arranged are largely undisturbed. As such, it seems unlikely that the ship ran aground due to a strong gale. What was then the cause of the wreck? It must be considered that these were sailing ships, and that it may have simply stranded, accidentally or on purpose, on a sand bank.

The Ses Fontanelles shipwreck must be interpreted as a merchant ship with a fairly mixed cargo, which included fish sauces, especially *liquamen*, as attested by the *tituli picti* found in the Almagro 51c amphorae; perhaps olive oil, in the Ses Fontanelles I type; olives and other products in brine; as well as other perishable products, which have not survived. Although archaeometric analyses are still ongoing, the first results indicate that the amphorae were similar in terms of fabric and technology (except the specimens of the Keay XIX type), which suggests that they came from a single production area. One strong possibility is that their origin was the south-east of the Iberian Peninsula (the area around Cartagena). This would open an interesting avenue of research, for the type of amphorae found in association with the shipwreck have not been found in the region's *figlinae*, and there is no evidence of them being traded internationally (Bernal-Casasola and Cau 2020).

It is likely that the Ses Fontanelles vessel used the waters surrounding *Palma* (current capital of the island of Mallorca) as shelter and victualing point, although its final destination is hard to establish with the evidence available, and it is even possible that it was the island of Mallorca itself. The absence, to date, of fine wares or coins precludes the shipwreck from being dated with greater precision. The amphorae yield a wide chronological range, but it seems reasonable to date the shipwreck sometime in the third, probably in its second half, or the fourth century.

The preliminary examination of the shipbuilding remains suggests that Ses Fontanelles shipwreck is a typical example of Pomey's western Roman imperial architectural type. The first excavation season has yielded important information and recommends that the remains be fully excavated. Especially remarkable are the ship's state of preservation (from bow to stern, to an approximate height of 1.5 m) and some details of its architecture (such as the carpentry related to the mainmast's embedded, an unprecedented find, and the presence of bulkheads in association with the transport of Baetican and African products from the third century AD onwards). It is also important to emphasise that the hull is very well preserved, as is the position of the two masts, which present us with the possibility of gaining a very precise understanding of the ship's structure, developing reconstruction hypothesis, an important step forward in the study of late Roman naval architecture.

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