

ABSTRACT

I History of research

The uncovering and salvage of the Late Roman ships found in Mainz took place between November 1981 and February 1982 under the supervision of the Archaeological Preservation of Monuments and Historic Buildings of Rhineland-Palatinate responsible for such matters. The remains of five planked vessels were measured photogrammetrically *in situ*, Wreck 3 and dislocated relics were also recorded in a field plan. Under the coordination of O. Höckmann as project leader, from the middle of 1983 on, the successive dismantling of the ships' hulls that were kept in wet storage and other parts followed. The material, including loose objects, was then documented, with written and photographic records of the technical-constructional findings and samples taken for the purpose of chemical, dendro-archaeological and metallurgical analyses. The parts were drawn on film, and an inventory was also taken. The investigations which continued until spring 1989 were accompanied by a number of preliminary reports and treatises which were devoted to marine-technical, functional and historical questions, in part also submitting proposals for reconstruction.

After the establishment of the Research Department of Ancient Navigation at the Roman-Germanic Central Museum Mainz, the transfer of the ships to the Museum of Ancient Navigation took place in September 1992. Impregnated in the latter's workshops with a melamine resin derivative and dried by means of a microwave treatment, the reassembly of wrecks MAINZ 1 to 5 followed, lasting beyond the opening at the end of November 1994. Between 1993 and 1997, two full-scale replicas were constructed there, representing the oared crew boat of type Mainz A as well as the more voluminous of type Mainz B. Taking account of the state of evaluation at that time, O. Höckmann and B. Pferdehirt presented reconstruction drawings, the author also line plans. During the preparation of the wrecks for display at the museum, from the middle of 1993 to spring 1996, the author carried out a visual inspection of the whole inventory for the purpose of comparison with the existing find files, he took care of the cataloguing of the data as well as the complete refilming and measurement of the wrecks, and arranged for further sample taking, analyses and graphic records.

II Dating and material science

The determination of age by means of dendrochronological dating goes back to the analyses by E. Hollstein (†) in the early eighties as well as to the further processing and new dating by M. Neyses-Eiden (both Rheinisches Landesmuseum Trier). According to two coin finds, MAINZ 1 was in service until at least ca. 400 A.D., the date of her construction being 385 A.D.; a presumed repair took place in 394 A.D. at the earliest. MAINZ 2, built around 310 A.D., as well as the vessel MAINZ 3, probably built in the second half of the 3rd century, are dated considerably earlier. Wreck 4 did not offer any means for determining her age, but MAINZ 5 was completed in 390 A.D., or soon after. The felling of the ship timbers numbered as »S8« is estimated to have been in the second quarter of the 5th century. For remains of a dugout, an even more recent dating is not to be ruled out.

Constructed mainly of oak, other kinds of hardwood also come into consideration for the loose rowlocks assigned to MAINZ 2 and S8, as well as for small fittings and a frame element in wreck 1. A non-identifiable

ceiling from wreck 4 was determined as being common beech. The remains of ceiling planks in MAINZ 3 are made of coniferous wood. The substance preserved as an in part multilayer protective coating on the shell of wrecks 1 to 4 proved to be wood-tar pitch contaminated with potash. Phloems of undetermined species were used for the luting of the vessels MAINZ 1, 3, 4 and 5, in one case moss as a repair measure on MAINZ 2. The iron of nails analysed at random contained constituents indicating the working of bog iron ores.

III Examination and evaluation of the ship finds

Wreck 1

It consists of a still 8.3 m long after body of a sharp-ended vessel with the fragmentary remnants of a stern post and box gunwale and the remains of the steering device, installations for rowing and crew accommodation. Lifted *en bloc*, it is the best preserved vessel concerning extent and state.

The up to 25 cm wide, maximally 6.5 cm thick plank keel was nailed fourfold to the scarfed stern post. Forwards began an approximately centric, V-shaped groove running fore and aft to distribute the bilge water. Linear marks usually positioned below the floor frames with a relatively uniform spacing – on an average of 32 cm (Tab. 3) – indicate measurement in accordance with a duodecimal system.

The planking, with an all-over external coating, is 2.5-3 cm thick, the garboard strakes up to 3.5 cm. Its plank diagram is symmetrical in appearance with two stealers (P2 and P4) in each case. A butt joint is contrasted with repairs carried out in the shipyard as well as other more recent repairs. One to two iron nails are used in the assembly of planking and ribs in each case. Traces of more than 60 treenails localised in the hull (Tab. 5a-c) appear in part as series arranged athwartships (Fig. 4).

The framing system is composed mainly of floor timbers and futtocks almost always overlapping astern; the former have limber holes. In addition, there was probably one pair of half frames in the stem and one pair of side frames in the stern. Aligned to the linear marks on the keel, the spacings of the transverse ribs ranging from 20-40 cm are extremely diversified (Tab. 6-7), but regular in some groups (A3*; A6*; A9*; A15*), predisposing oaring installations spaced at approx. 96-99 cm distance, of which remains still exist.

The ship's port side, complete up to the gunwale, is faced with five ceiling planks nailed to the frame backs, below and above the round bilge, three light narrow longitudinal beams, above them a solid wide scarboard and an inwale right at the top. The sheer strake is faced up to about halfway by a sturdy wooden fender guard. The gunwale of this multilayered construction is topped with a gunwale capping made of longer flat segments and shorter half-round sections. The former have one slit-like opening each, the latter one rectangular peg hole each, one of which contains the remains of a tholepin.

Preserved in sections or just indirectly indicated, MAINZ 1 indicates the equipment and provision of an effectively operating oar propulsion system: originally, there were thwarts mortised regularly in the thwart clamp and underpinned on the centreline by vertical stanchions placed at every third floor timber, which for their part were braced by at least three-part longitudinal stiffeners. Recesses cut into those boards correspond in their position to structures of the narrow ceiling planks. Accordingly, a boarded floor laid on cross-beams is to be reckoned on between the pillaring construction and the ship's side. Above it, there are presumably foot stretchers existing in module form, the traverses of which were attached to the second and third stays of the ribbing and two narrow beam clamps in each case. The diagram of the distribution of the propulsion fittings proves to be approximately constant with 94-97 cm long sections (Tab. 9-10). Broken-off pins arranged in pairs to the thwarts on the lower edge of the scarboard go back to fittings

relating to the crew. A solid transverse beam, once penetrating both topsides astern of the propulsion section, with more than 40cm long projecting ends, served as the bearing support for the lateral steering oar usual for ancient seagoing ships.

The result of the reconstruction of the hull lines on the basis of algorithms is a rather fragile inland waterway vessel of unknown individual length with a minimum depth of scarcely 0.8m and a breadth of some 2.6m.

Wreck 2 (ex S7)

The still ca. 10.6m long port-half of a sharp-ended after body, with its stem post and gunwale preserved to some extent as well as with remains of the steering device, was cut diagonally by a sheet pile wall. The accessible section of the wreck was raised in part as one structural section, in part recovered sawn manually into narrow strips athwartship.

A curved stem post was scarfed to the at least 18cm wide and 6cm thick plank keel and fixed with three iron nails. In front of it begins the V-shaped groove at the middle of the keel, known from MAINZ 1, to distribute the bilge water. In the area of the mounted frames, linear markings sawn athwartships also occur with a spacing of about 47 cm (**Tab. 13**).

The thickness of the hull plating, coated all-over externally, fluctuates between less than 2 cm at the ship's side and more than 3cm at the floor. Of the nine strakes of the preserved side of the hull, P3 and P5 were designed as stealers. In addition to simple plank butt joints, the more ambitious scarfed joints used in boat building occur. Luting material pressed into the plank seams was fixed outboard by delicate nails. The shell contains a large number of sheared-off treenails and plugged drill holes (**Tab. 14a-b**), a principle of arrangement (**Fig. 15**) which suggests the temporary use of constructive aids for the provisional attachment of the planking, also in order to determine the ship's form.

The frames of different types only fitted subsequently into the shell are typical of a system known only for MAINZ 2. Thus the combination of floors and futtocks attested for the stern section and a pair of side frames are followed by two series with pairs of half frames overlapping in the floor area, interrupted in each case by a thicker dimensioned, presumably segmented massive rib. Half frame fragments repeatedly show joins in the form of diagonally overlapping plain scarfs. Up to three limber holes cut into the outsides of the frames in each case ensured the distribution of the bilge water.

Apart from the remains of a rubbing strake mounted in front of the sheer strake, as well as a lavishly stiffened cross-beam for the lateral steering oars, the number of elements of the technical ship equipment preserved is scanty. Mainly demonstrable on the basis of the traces of contact and nails, the existence once of at least four ceiling planks or stringers becomes apparent. Of these, a longitudinal beam positioned above the floor heads could be considered as the support of a floor stretcher or a simple foot spar, another one, on account of its length, as an inwale. Connection technique indications and marks of the pressure of lost components on the floor sections of individual frames support the assessment of MAINZ 2 as a crewed boat with an individually designed oar system.

From the rudimentary water lines at our disposal, a length of scarcely less than 16m, a beam of 3m overall, as well as a positive sheer curve with a nearly 1 m to approx. 1.3m structural height.

Wreck 3 (ex S3 and S5)

The ca. 12.6m long ship relic preserved in the section has been joined by the ship's side segment of the starboard side (**Suppl. 5, 1**) previously counted as »S5«. The mixed salvage procedure was the same than for lifting MAINZ 2.

On the basis of a nearly completely preserved stern post as well as features of a lateral bearing of steering oars, the longitudinally complete central part, as well as the fore body have survived to some extent. The inner surface of the up to 30cm wide, 5cm thick keel plank is marked by a centric longitudinal groove as well as a series of shipwrights' marks. The latter are distributed with a spacing of nearly 34cm on average (**Tab. 16**), for the most part concealed below the frames. The same is true for treenails to be found in pairs or plugged bore holes whose longitudinal position in the ship corresponds in part to equivalent findings in the planking (**Tab. 17a-b**). The 2-3cm thick planking is made up of up to nine strakes; of these, P4 and presumably P8 are arranged as stealers. We find scarf joints in the form of butt joints and butt straps, repairs as inserted sections of planks or laths; cracks were caulked.

The frame system begins at the stern with a short sequence of one pair of side frames, as well as floor timbers and loose futtocks, overlapping aft in each case. Forward follows a long series, interrupted just by the mast frame, of two to three-part ribs constructed in a single row, scarfed systematically next to the keel or within the bilge. They were fixed to one another and at the same time to the hull planking by iron nails double-clenched inboard. Nailing to the keel plank took place alternately from outside and inside.

Almost nothing at all has been preserved of the inside cladding of the hull. Technical construction features, at least, point to a ceiling laid loosely on the frames at both faces of the mast, in the bilge area and on the flanks of the ship bottom. Traces of nails on both sides of the keel indicate the original presence of two longitudinal beams that could be considered as the foundation of a rising construction. For the after body, on the starboard a ceiling plank following the shearing like stands out; amidships on the port side there is a similar find, however, with a considerably lower lying gunwale.

From the reconstruction of the water lines, with an appraisal of the mast position and the silhouette of the hull that can be deduced, comes the plan of a flat-bottomed, presumably covered, double sharp-ended vessel. However, its flatter middle section probably had a light outrigger construction available for single-banked oar propulsion, as is to be deduced from a contemporary secondary source. The ship's body was maximal 1.35m high; its greatest breadth was 3.6m. The length of the vessel can be estimated to have been about 17m.

Wreck 4

The still 10.7m long section of a ship's side, with an (for the most part) intact gunwale, was lifted in two larger parts. On the basis of the structures of a lateral steering oar bearing, it is the starboard side of an after ship section.

Of the up to seven plank strakes still preserved, two are to be recognised as stealers. Structural features are limited to a scarf joint extending over two frame distances, an adapter piece as well as a beam port. The remains of treenails or plugs for the most part penetrating the shell (**Tab. 20**) reflect in part axially arranged series and are interpreted as the remains of temporarily attached constructional aids. The shear strake was faced in the upper field with a prismatically shaped, up to 16.5cm wide and about 5cm thick rubbing strake. Aft of the beam port was the stiffening element of the lost transverse beam mounted outboard.

The frame system is made up of two-row, staggered cross-ribs, floor frames with overlapping futtocks forward and aft; of the latter, individual ones were scarfed in two parts. Clad inboard with very wide ceiling planks, the elements of the equipment of an oared vessel are to be seen indirectly here (**Fig. 38-39**): the narrow, but particularly massive longitudinal beam of up to 5.5cm thickness, running parallel to the ship's side, is to be seen as a gunwale; the up to 35cm wide, thinner planks below reveal themselves to be scarboards and beam clamps by their constructive details and their pattern of arrangement. The former is determined by around 23cm long slots to admit banks of oars. Their principle of distribution, with spacings from around 85-92cm (**Tab. 22**) makes a comparatively uniform impression. Markedly narrower recesses in the adjoining beam clamp II below refer to this (**Tab. 22**); however, the rests have been shifted at least 60cm aft from the centre of a thwart's notch and ca. 30cm in the vertical plane. Beam clamp I mounted near to the round bilge does, it is true, also have recesses; however, their arrangement with distances of in most cases 1-1.5m, gives a vague and confused impression (**Tab. 22**). If it is possible to think here most likely of a partial covering on account of the lateral support for transverse beams, the structures in beam clamp II and the scarboard, correlating spatially with one another, bear witness to the erstwhile presence of technical operating fittings, not only rowing banks, but also foot stretchers and foot spars (**Fig. 40**).

From the often less than 0.9 m spacing between the elements results an astonishingly limited oarsman's space, even less than the literary standard (**Tab. 23**). The type with a rounded headpiece, block-like base and laterally wedged thole-pin attested in other complexes (Wreck 2 and »S8«) would have been suitable as tholes. Technical clues on Wreck 4 do not preclude this.

The remains of the vessel offer hardly any possibilities for a dimensional and formal reconstruction. If a larger crewed boat with a nearly horizontal gunwale is indicated here, not least through the matching rowing equipment, moderately sized ship's sides and a hull height of about 1.3m are to be deduced from the graphic-trigonometric evaluation of the bevels (the slots, recesses etc.).

Wreck 5 (ex S9)

During the uncovering of the still extensively preserved wreck of 16.2m length, only one 8.6m long part was lifted *en bloc*. The underwater hull of a flat-bottomed rowing vessel, rotted just above the round bilge, is the only one of the Mainz ship finds to show any remains of a bow construction and is also different with respect to its extensive traces of technical installations.

The unusually massive keel, with a maximum width of 21cm and thickness of some 10cm, merges forwards into a scarfed bow construction. The inside of the keel is structured by a central V-shaped groove. Below the mounted frames, grooves sawn athwartships are to be found; in the position of the mast frame, there is a drawing-like marking (**Fig. 21**, right). Its relative location reflects the orientation to a standard section of 36cm (**Tab. 25**). A few wood pins closing drill holes in the keel are hardly keeping with the documented traces in the planking in a considerably larger number (**Tab. 26**).

Five plank strakes in each case have been preserved from the hull shell on both sides of the keel; P3 is to be identified as a stealer on the starboard and port sides. The thickness normally fluctuates between 2-3cm. Multiple attested joints are dispersed over simple plank joints and more lavish butt straps. Treenail findings go back in part to the temporary fixing of neighbouring planks to auxiliary constructions employed by the shipyard. Nevertheless, there is a lack of appropriate indications of the use of larger templates, moulds or comparable objects. However, treenails served to a greater extent as a primary frame-plank connection, supplemented secondly by iron nails, with their shanks penetrating or just missing the plugged

pins. The luting pressed in during the course of the planking is accompanied in sections by retaining nails hammered in from outboard.

The frame system is reduced to floor timbers with a pair of futtocks arranged fore or aft in each case; the heavy mast frame was supplemented by four side pieces. Apart from the material used for some crotches in the area of the bow, the floor timbers and the futtocks following the contour of a relatively sharp round bilge were sawn from boards, despite a high risk of breakage. In this connection, seasoned material was demonstrably used at times, even though infested by wood worm. The best parallel in comparison to the frame with an 8.5×8.5cm large, up to 6cm deep mast step is the element in the clearly older barge in Bevaix.

Vertical stanchions were nailed in pairs to the fore or after edges of certain floor timbers, as can be deduced either from rotted stumps or indirectly from traces of nails. Braced among themselves with one to two longitudinal stiffeners, the installation divides the hull into three longitudinal sections. The fragmentary remnant of the construction is repeatedly crossed above the lower longitudinal ribbing by board-like cross-beams, the ends of which lie on narrow beam clamps mounted at the beginning of the bilge or resting in recesses there (**Tab. 27**). Remains of a floor boarding indicate a deck limited to the lateral longitudinal sections.

The preserved fittings go back to the concept known from MAINZ 1 of an operation-oriented accommodation for the crew, the number of which must be reckoned in two figures in view of the longitudinal dimension of the findings in Wreck 5. If the vertical stanchions are to be regarded as being the inboard underpinning of rowing banks, the arrangement of the oar crews is clear from their position in relation to one another. Despite greater divergences, a system is to be recognised on the basis of an intended longitudinal module of 89cm (**Fig. 44**). When the design was planned, the calibration of the shipwright's markings on the keel seem to have also played a part. The installation of longitudinally reinforced pillars approximating curvilinear to the contour of the hull separated the crew's foot space that was enclosed underneath from an open centre section which gave access to the bilge limber and provided storage space for bulky items.

The structure of the convex rising stem post gives the vessel a concave bow silhouette in its superstructure with an appearance typical for Mediterranean warships. Near to the ram-shaped, albeit unarmed tip, we find a destroyed nailed joint in the rear of the stem post which suggests the existence of a segment, aligned with the same centre axis, that raised the height of the bow. The rudimentarily recorded lines of the fore body do not allow that this segment could have served for the direct connection of the planking. Instead, one has to reckon with a bow of a complex design above the line of flotation which was presumably characterised by a ploughshare-like front with separate planking.

On the basis of the waterlines available for the lower part of the ship's hull, by including the stern post of MAINZ 1, as well as its maximum hull height, it is possible to justify a length reconstruction of around 17.5m. From this results a crew number of 24-26 oarsmen distributed over 13 longitudinal modules.

Dugout

Astern of MAINZ 3, the scarcely 0.8m long end of the hull of a dugout was discovered with its interior structures produced monoxylyly. The find is now only accessible through published descriptions and drawings.

Loose boat parts (ex S8)

Of the complex uncovered between the linked hull compartments of Wreck 3, a still nearly 8m long rubbing strake as well as four multiple piece oarlocks claim our interest. The latter presuppose a box gunwale for their mounting, such as Wrecks 2 and 4 offer. However, constructional links to the same remain vague. The same applies for further objects, with the exception of a futtock with a knob-like sculpted head which for stylistic reasons can also be ascribed to the vessel MAINZ 3.

IV Ship typology

As far as dimensions and ship lines are concerned, MAINZ 3 (Type B) stands out very clearly against Wrecks 1, 2, 4 and 5 that have been shown to be boat relics. Even if its technical and constructional features have not been fully determined and the characterisation succeeds in the final analysis only with the acceptance of an iconographically justified reconstruction as a decked ship with outrigger, the constructional and functional relationship is obvious. By contrast, MAINZ 1 and 5 form one unit in a typological sense, namely on account of the interchangeable elements of their equipment; in addition, they can be regarded as being of the same age. To classify both of them as crewed boats and individual representatives of the same type would probably come closest to the truth (Type A, Var. I). The fact that MAINZ 2 and 4 likewise represent large oared vessels appears quite indubitable; from a functional viewpoint, it is a variant (A-II); however, differences in shipbuilding are not to be overseen.

V Procedure of construction and technical historical assessment

The plank vessels left their yards with their surfaces for the most part in a rough sawn state. This fact and also other qualitative criteria of the execution of the constructional work and maintenance cause one to suspect a certain carelessness behind which there may have been a certain rationalising action, in part, probably also a lack of suitable resources.

A carvel type of construction, dispensing with intermediary plank connections, then luted seams, with the luting material secured by nails, the occasional use of moss, the butt plank joint as a substitute for statically more reliable scarfing and, not least the use of a voluminous frame with an integrated mast step link the Mainz vessels with the Romano-Celtic shipbuilding tradition. The same is true (with reservations) for the preferred use of oak as construction material, for frame-plank connections made by double-clenched nails inboard, the characteristic combination of floor timbers and futtocks, as well as for the plank keel. However, their technical historical importance offered the occasion to appreciate the conditions of the operational environment and to reflect their distribution against the conditions of tradition. On the other hand, the question about the cultural historical significance of boatbuilding types had to be asked, the problems of ancient metrology linked with this, together with the intellectual performance underlying the phenomenon. As is shown in principle by the evidence of the elaborate oar propulsion systems, Mediterranean-based know-how that was certainly available in shipbuilding in the northern Roman provinces is apparent here, a fact that is made more certain by the Mainz finds. The process techniques and principles, such as the use of phloem for luting, iron nail joints made through dowels or wooden plugs, the clenched nails inboard as well as the dominant frame type in Wreck 3 allow to compare parallels in Mediterranean shipbuilding which did not, admittedly, play a further role in the epoch. Consequently, one has to think of a

variety of technology transfer pointing back further into the past, the recipient of which had been pre-Roman shipbuilding in Central and north-western Europe, which for its part had handed down constructional practices within the area into the Roman epoch. The lasting nature of originally Mediterranean thought is shown, not least, by the depositing of coins on board ancient ships (**Map 1**).

The more or less clear indications on the Mainz planked vessels of the employment of a shipbuilding method that did not only make possible the construction of a hull shell without leaving a pre-erected skeleton frame inside, but that can in addition assume the pattern pre-determining the ship's form, and that represents the *conditio sine qua non* under pre-industrial conditions for serial production, is to be regarded from various viewpoints. First of all, here too, the traces point to the Mediterranean area rather than to the Gallo-Roman-British world. If, for want of a better term, there is talk of mould construction, the term also includes all conceivable boatbuilding variants; on the one hand, the holding together of a plank shell not yet braced by frames at different stages of construction, on the other hand, however, also the determining and checking of the form and dimensions of a hull. Particularly as here smaller templates, restricted to a few positions, come just as much into consideration as complete sequences of auxiliary framing defining the ship hull cross-sections, distinguishing in detail between purely craft measures and designers' attainments based on planning is difficult. Nevertheless, the procedure used, just as much as the effort involved with applying boatbuilding markings, reflect the intended uniformity, or a plan-oriented execution of the product. Hardly to be reconciled with an economic use, not least for operating reasons, only a public-sector client and an objective involving state interests are up for discussion. Against the background of the epoch and the location, nothing other than the military is possible.

VI Historical interpretation

The late-Roman oared vessels provide, so to speak, ship archaeology answers to military history questions which arise from the records for the conditions in the region around the Middle and Upper Rhine in the post-limes period. However, the varied dendrochronological signs on the wrecks and an inequivalent flow of data force us to make a differentiated evaluation. First of all, the fact has to be recorded that the Mainz garrison apparently no longer counted as part of the operating area of the *classis Germanica* that existed as an organisation until the late 3rd century. However, somewhat older epigraphic and iconographic sources do confirm shipbuilding activities by the 22nd Legion garrisoned there; late-Roman bricks signed by it use an oared vessel with a ram-like bow as a stamp motif. Just as at other scenes, too, one must reckon with amphibian special duties of bodies of troops within the army here. As the section of the river had become the frontier again after 259/260, the suspicion arises that it was not just a question of logistics and engineer troops here, but also of tactical measures.

The use of MAINZ 3 could still fall in that period for which militarily motivated operations on the river under Postumus and Bonosus were considered. In exactly the same way, however, the Constantinian period that was significant for the expansion of the Rhine frontier could also be taken into account, which would have overlapped with the operating phase of MAINZ 2. One could speculate particularly about the nature and extent of the operative use of both units.

By contrast, a well-founded explanation model becomes apparent for the type Mainz A-I from the late 4th century. The backdrop is provided by the Rhine that had been overcome by the Alamanni again and again since 233/234 A.D. Reinforced as a strongly fortified frontier under Julian Apostata and Valentinian I. and protected by frontier troops, the records for the period after 360 A.D. tell of amphibian commando operations carried out with crewed boats, as well as of a reformed concept for securing the military approaches

which is also supported by archaeological finds: small forts spread out in two sections on the enemy bank between the mouth of the Neckar and the Middle Rhine basin (**Map 4**), nothing other than fortified landing places with an outpost character (**Fig. 48**), make it clear that the imperial frontier in late antiquity was covered, it is true, by the garrisons on the left bank of the Rhine; however, the landscape of the river in its whole depth was included within their surveillance. This presupposed Roman command of the water and fast vessels suitable for the area whose primary concern was to be mobile checks of stretches that were not readily visible. The crewed boats of type A-I have to be regarded as late witnesses of that strategy which, according to the finds made in Mainz, is to be confirmed down until the second quarter of the 5th century.