

Some remarks on Romano–Celtic boat construction and Bronze Age wood technology



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The study of similarities and differences in wood technology applied to boat construction of the Bronze Age and Romano–Celtic period was prompted by the following facts: the discovery of Dover's Bronze Age boat (completing those found at North Ferriby and the more recent one at Brigg), the scarcity of data relative to Iron Age boats (absent especially on the Continent), the homogeneity and large number of Romano–Celtic vessels, the construction of *Altaripa* (a replica of the Bevaix 1970/CH lighter) and, lastly, by the increasing amount of research published on concepts and building techniques.

Romano–Celtic boats can, at present, be defined as follows:

- discarding of direct bindings of planks. The lashing or sewing was not replaced by other types of fastenings such as the mortise-tenon-peg system or by riveting. It was certainly the fundamental factor of Celtic traditional boat construction;
- heavy oak bottom-planks, flush-laid;
- strong frame attached to the hull by countless large-size nails, often turned or hooked;
- mast-step located well forward of amidships.

Two sub-groups have been identified, the first found chiefly on inland waters and the second currently consisting mainly of four seagoing vessels from either side of the Channel.

The fragmentary 1st-century AD boat from Lyon-Tolozan (1989/F) will not be taken into account in this paper. Its bottom planks were joined directly by means of mortise-and-tenon joints but not with pegs, and by tangent nailing. The use of cloth and tar for waterproofing is indicative of a strong Mediterranean influence (Becker & Rieth, 1995).

Flat-bottomed construction and polygonal craft

The first group consists of craft discovered mostly in the Rhine basin. They are flat-bottomed boats and lighters with one-log transition-planks made watertight by a considerable amount of caulking, usually moss, fixed by thousands of flat-topped nails. A number of well-preserved examples of such boats have been published more or less extensively: Bevaix (1970/CH), Drunten (1973/NL), Kapel Avezaath (1967/NL), Pommeroeul (lighters 1 and 2, 1975/B), Woerden (1978/NL), Xanten (1991 and 1993/D), Yverdon-les-Bains (1-1971 and 2-1984/CH) and Zwammerdam (2-1972, 4-1973, 6-1974/NL) (De Boe & Hubert, 1977; Lehmann, 1978; Haalebos, 1986; Weerd, 1988; Arnold, 1992a, b; Obladen-Kauder, 1995).

The base in these examples was not made up of a central element (heavy plank, strake, keel, cup-like member) but of a flat bottom. In general, the latter could be fixed to a large cradle (Arnold, 1992a: 81;

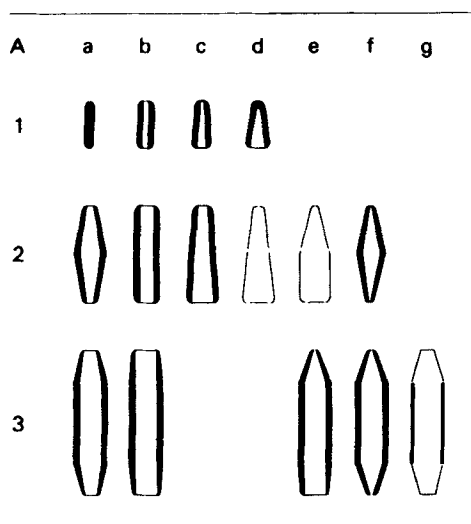


Figure 1. Typology of polygonal craft (Arnold, 1992b: 74).

1992b: 94–96). Work would start by fitting the bottom planks or the one-log transition-planks (or possibly even by assembling the sides). Whichever building method was selected, the flat bottom served as the basic entity of the construction. This is termed *bottom-based construction* (Arnold, 1991). It determined the shape and the size of the boat, the sides being of lesser importance. The frame played no role, the construction being *shell-orientated*.^[1]

Longitudinal strengthening was not provided by a central plank, as the keel, but by one-log transition-planks. They were shaped by reduction, that is by working away an important amount of wood from a log, or half a log, in the way logboats were carved. In both cases, restrictions inherent to the raw material were the same. Thus the basic shapes of the boat were reduced to a simple polygon: rectangle, hexagon, octagon (A1a, A2a, A3a), which could be further modified into a trapeze, triangle, rectangle, pentagon, bi-point (b, c, d, e, f). They are known as *polygonal craft* (Fig. 1).

The origin of this craft is to be found in the logboat, as Ellmers (1975) and other

ethnologists (Itkonen, 1941, in Finland; Rudolph, 1966, in Pomerania; Beaudouin, 1970, on the Adour) prior to him have suggested. The first principle consisted of *splitting a logboat* on the centreline. Large planks were then inserted between the two parts and when necessary, more carvel- or clinker-laid planks could be fixed on the sides. The 10 m-long Yverdon-les-Bains 2 boat is a good example of this technique although both valves were carved out of a single large oak log (Fig. 2).

During the salvage of the Gallo-Roman barge of Bevaix, its planks were sawn transversally which made a detailed study of its shaping phases possible. Basically, the transformation of the raw material was governed by the *principle of reduction*, as on logboats. The introduction of the saw allowed a more advantageous use of the raw material. The largest possible planks were selected. Evidence of this is sapwood often found on both edges. The logs were not slabbed, a method which would have reduced the thickness to saw by a third while diminishing the carpenters' efforts and at the same time yielded quality planks, almost free of sapwood. At this stage, the carpenters were still using methods close to earlier times: they did not necessarily saw following a straight line but preferred to follow a curve that ultimately corresponded to the shape of the required plank (plank F of Bevaix; Arnold, 1992a: 60).

The largest possible planks, although they regularly showed a weakness at the pith or close to it, were supplemented by inserting long and narrow joint-planks (Arnold, 1992a: 34 piece L), and using them in the longest possible way. For example plank B of Bevaix was extended by using a branch from the crown. This method of selection calls to mind the planks used on Bronze Age boats discovered in England. The basic principle here lay in the splitting of a log in two and reducing both parts subsequently into two

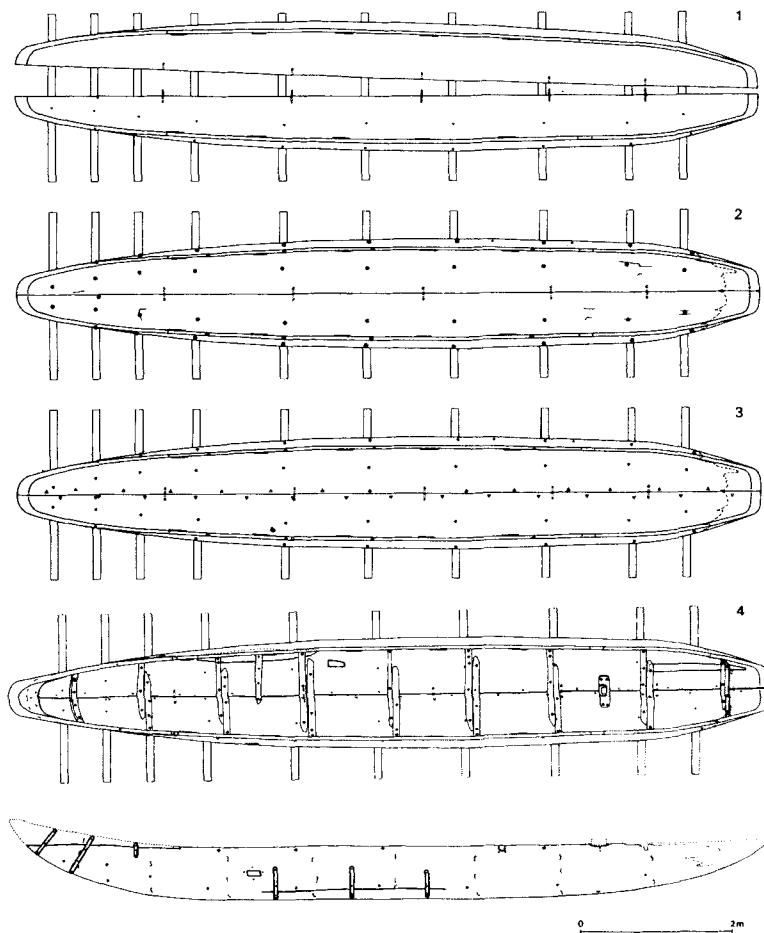


Figure 2. Constructing the Yverdon-les-Bains 2 craft 1984/CH with a cradle (Arnold, 1992b: 27). Scale 1:100.

planks with several cleats, or by using a whole log for one plank of that type.^[2] And it is the use of very large pieces of timber, rather archaic in character, which gives the Blackfriars hull a faceted appearance, where P2 and S2 were probably also used as joint-planks (Marsden, 1994: figs 25, 55). A similar function can be attributed to the narrow parts 3a+3b+3c+3d and 3e+3f+3g of the medieval lighter Orlac1986/F (Chapelot & Rieth, 1995: fig. 44).

In this context, the bottom planks of the Zwammerdam 2 and 6, very regular in form on the published plans (Weerd,

1988), may indicate that they had been slabbed prior to sawing.

The building of *Altaripa* (Arnold, forthcoming), based on the Bevaix lighter, has enabled us to better understand the archaic features of this boat. The entire work rests on logs, whole or split lengthways in two. In the first instance, there are four one-log transition-planks; in the second, four spoon-planks which prolong the side planks right to the top, as on Yverdon-les-Bains 1; (Arnold, 1992b: fig. p.16). Planks A and D can also be grouped with the latter, as can planks B, E, and even F, on the Gallo-Roman model (Arnold, 1992a:

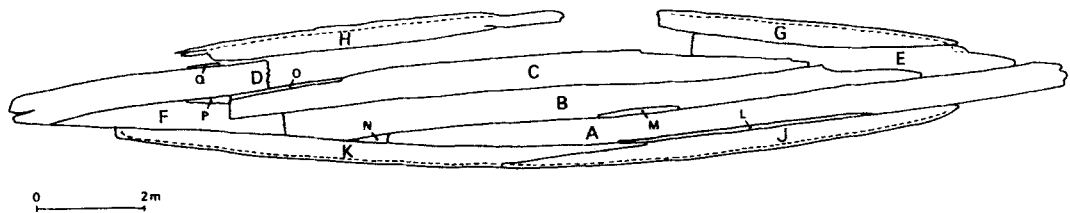


Figure 3. Planking of the Bevaix 1970/CH lighter (Arnold, 1992a: 34).

34, 58–60) (Fig. 3). Sawing was certainly a method intensively used to produce planks and rough knees. Yet the basic concept is identical to that which is to be found on the Bronze Age boats discovered in England, in other words, half a log from which the biggest possible plank is carved by reduction. The use of its maximum width was sought, as well as its greatest length, at times, with the retention of a major branch (Arnold, 1992a: 59 plank B).

Central planks and ships

The second group is made up of four vessels from Blackfriars 1962/GB, St Peter Port 1982/Guernsey, Bruges 1899/B and Barland's Farm 1993/GB (Marsden, 1967, 1976, 1994; Rule & Monaghan, 1993; Nayling *et al.*, 1994). The first two only will be examined here as their hulls have been thoroughly studied. Their centreline extended from stem- to sternpost and was made up of two especially thick planks (keel-planks) at Blackfriars and three at St Peter Port. Tracing back building techniques implies that these are known or at least identified. A number of diverging hypotheses have been made, based on the study of these two wrecks (Rule & Monaghan, 1993: 26–28, fig. 14; Marsden, 1994: 77–79, fig. 70). An objective analysis of the relation between the planking and the framework is difficult to make. First, during the excavation of Blackfriars, the first of its kind and none the less a model in the '60s, not much attention was given to detail. Further, at St Peter Port, the only parts preserved are the three central planks

and the floor-timbers. Additionally, the base of the sternpost is very well preserved.

In the case of the St Peter Port ship, the authors suggest that all the floor-timbers were nailed once the three central planks had been brought together edge to edge (Rule & Monaghan, 1993: fig. 14/8–10). This does not seem possible as it would have been difficult to adjust the seams carefully while the remaining planks were being placed. This remark could be corroborated by analysing traces left by this activity (Rule & Monaghan, 1993: pl. 15) over a sufficient length. These traces should not display irregularities resulting from the need to avoid existing frames. This observation is of course valid for Barland's Farm or any future discovery. It also seems unreasonable to use up just the space that was needed when adjusting the stem- and sternposts to the central planks, a particularly difficult task. The luting material on both ships (pine resin mixed with strands from hazel twigs for the former and with oak shavings for the latter) was applied to the edges of each plank when placed into position.

The author does not agree with Marsden (1994: 79, fig. 70/1–2) either when he suggests that once the two central planks had been positioned a midship floor-timber was fixed, as well as two others close to the ends of the ship at the point where the stem- and sternposts join the heavy bottom planks. It seems much more logical to consider a primary phase where the central planks were laid down, followed by the adjusting of the endposts held temporarily

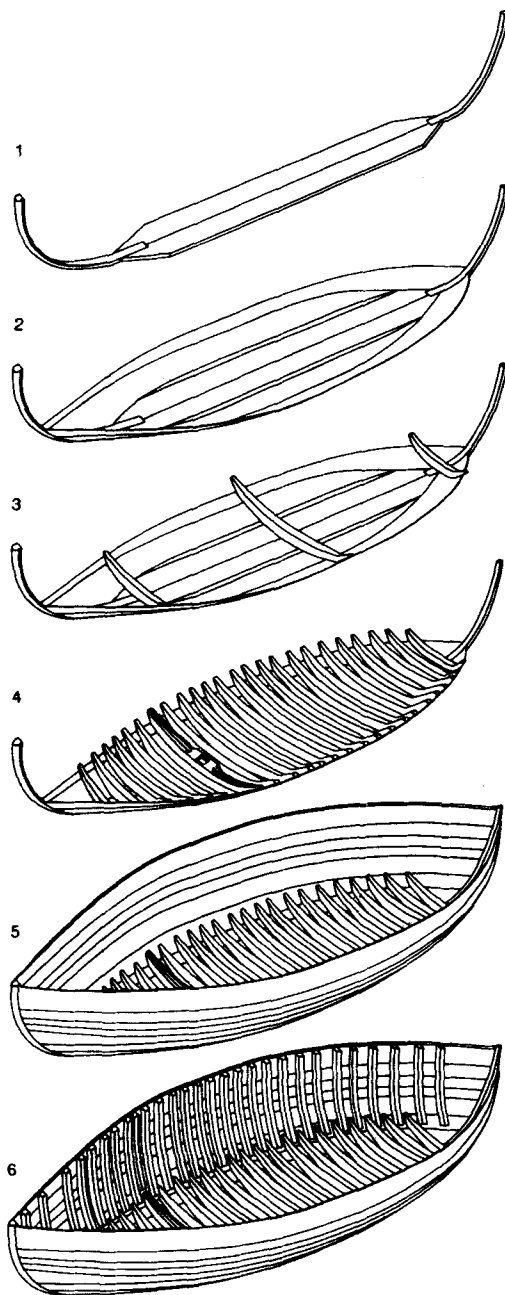


Figure 4. Reconstructed stages in building the Blackfriars ship 1 1962/GB (3 and 4, Marsden, 1994: fig. 70/2–3).

by supports (Fig. 4/1). The shape of the St Peter Port boat centreline was at this stage determined, as were the location

points for the mast-step and the floor timbers also.

Currently, it seems possible that the bottom was built on a large cradle since there is a sparing use of planks of very large size (Fig. 4/2). The central bottom planks could have been indirectly fixed to the cradle and, for example, sandwiched by means of battens nailed to it. The difference in thickness between the central planks and the adjoining ones could thus be explained. The inclination of the outer bottom planks would have been controlled or adjusted by a set of large wedges. The resin found in the luting material, applied while the planks were being positioned, would also have given support. This process might have been completed by temporarily nailing a few small boards on the seams, but without new discoveries only conjectures can be made.

The basic problem remains: did one, two, three or more floor-timbers, fastened to the central bottom planks, hold the structure together as work on the bottom progressed or, on the contrary, were the bottom planks all fitted before the floor-timbers were built up with the help of a cradle, or by one or more inner moulds? The first technique would be frame-orientated, as suggested by McGrail (1997).

The second, a shell-orientated type, is presented here. None the less, Marsden's stage 2 appears to be a necessary step (Fig. 4/3). At this stage what is created is a bottom which forms an entity structurally *different* from the sides.

The fixing of the sides need not have taken place only after the side frames were positioned, as Marsden suggests for Blackfriars (1994: fig. 70/4). It seems rather problematic to attach a side frame at one end only on a single ordinary plank as a lot of tension is borne at that point. More probably, the preliminary assembly of the side planking was made using the shell-first technique (Fig. 4/5).

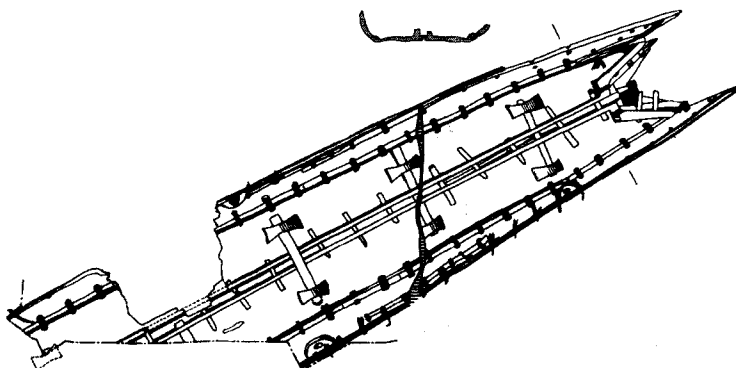


Figure 5. Dover 1992/GB: Middle Bronze Age lashed-plank boat and its members attached by direct tenon-mortise fastenings (Courtesy: Canterbury Archaeological Trust). Scale 1:100.

Thus the limit of each side plank could be marked on the side frames and the holes drilled before fixing the side frames. Once more, analysis of the shape of saw-marks on the seams could prove crucial.

These ships could be seen in the light of a tradition which began with the logboat followed by the bottom-based construction. The axial elements will later become more important ultimately influencing the shape of the hull (and gradually leading to the skeleton-first construction). This hypothesis is appealing as it is based on two architectural principles: flat-bottomed, and axial constructions, the former progressively giving way to a stronger central structure and to a more homogeneous unbroken framework from bottom to sides.

Longitudinal and transverse strengthening

The mastery of longitudinal and transverse strengthening is of fundamental importance in shipbuilding, besides the various methods of construction and waterproofing. On flat-bottomed barges, the transition-planks, at the chine, are the main strength members. Pairs of knees nailed head to foot consolidate the boat crosswise. This device is very flexible, resisting central torsion, and it is well

adapted to carry asymmetrical strains such as those created when a boat hits waves diagonally.

The two sea-going vessels analysed here differ. There is an absence of many direct fastenings joining planks, of the mortise-tenon-and-peg type characteristic of the Mediterranean region, and of iron rivets, as found on shell-first built craft in the Scandinavian region. This absence did not create a flexible, vigorous hull since it did not allow the tensions created on rough seas to run along the strakes. The very light fastening that kept the central bottom planks together with the stem- and sternposts did not give the centreline much supporting strength either. Only the floor-timbers and the way they were fixed to the planks could have played a role. A solid frame fastened by large hooked or turned nails may have solved the problems related to the bottom but those concerning the sides have not been clarified. For example, the key question of how the structure of the deck was made is not yet resolved.

Therefore, a strong homogenous and continuous frame is required, as well as a strong fastening system between the planking and the frame, for example by nailing, in the absence of direct bindings of the planks.

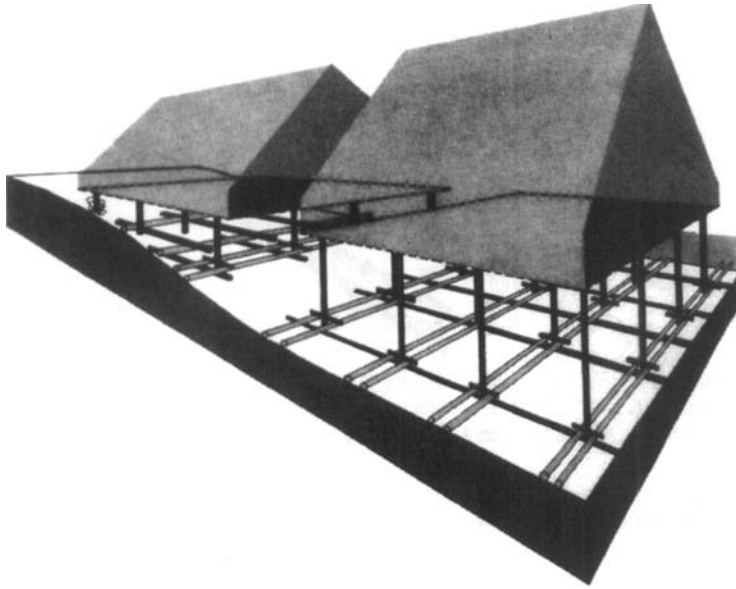


Figure 6. Device based on the use of a tenon preventing the posts from sinking into soft earth. Found in a Middle Bronze Age village of West Trentino (Perini, 1984: fig. 99).

The forerunners

As there are no examples of Iron Age boats assembled by nailing, it is of interest to define a likely ancestor as well as the architectural principles referred to in this paper. The Dover 1992/GB and North Ferriby 1-1937 and 2-1940/GB boats (Wright, 1990; Parfitt & Fenwick, 1993) seem at first very differently built. The planks were lashed (or sewn) together and this gave the hull a structural coherence that recalls a clinker or mortise-tenon-and-peg construction. Crosswise strengthening was obtained by using large rods passed through a number of lined up mortised cleats left proud on the bottom planks. A similar system of cleats may have existed on the sides of the Dover boat (Fig. 5).

The rods were placed prior to the fitting of the sides; the bottom completed first formed an entity which suggests a bottom-first method of construction. The centreline was made up by a single thick plank (North Ferriby 1 and 2) or two

(Dover) and is reminiscent of the Blackfriars and St Peter Port boats, even though the Bronze Age strengthening was provided not by a massive framework but by many stitches fixing the planks.

In spite of their apparently strong aspect at the level of the cleats, the Bronze Age transversal elements were fragile and difficult to repair. These disadvantages could easily have been avoided, as is shown on the Iron Age Hjortspring (1921–1922/DK) and the later Nydam (1863/DK) boats where the elements were lashed. The former constructions are fundamentally based on the *concept of direct fastenings of tenon-mortise type*, also much in use in Bronze Age house architecture. In both fields too, tenons redistributing or controlling loads were used. For example, in the foundations of the Fiavé-Carera (Fig. 6) and the Bodman-Schachen 1 (Baden-Württemberg; Königer 1995: fig. 21) villages, a mortise was carved just at the start of the post points through which a

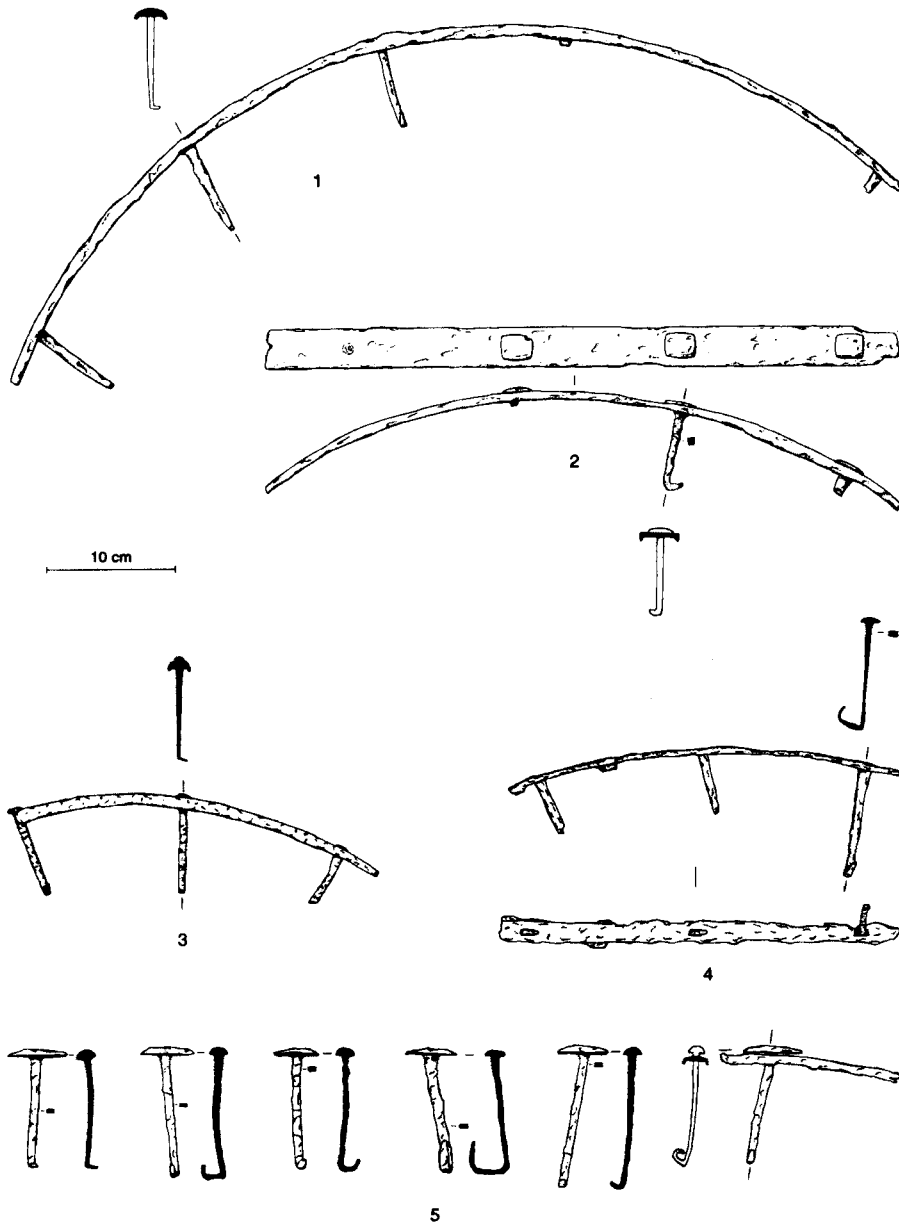


Figure 7. More than 150 wagon-graves of the Early Iron Age were discovered in Central Europe. On a number of wagons, turned iron nails were used to fix the tyres to the wheels. The following illustrations taken from the plates published by Pare (1992) are examples from Baden-Württemberg (1), Bavaria (2-4) and Austria (5): (1) Klettgau-Geisslingen; (2) Kitzingen-Repperndorf; (3) Lupburg- Gottesberg; (4) Albertshofen; (5) Wörgl.

tenon was locked. The latter then rested on a number of beams placed on the ground that prevented the construction from sinking into the soft earth.

The joint between the two centre planks of the Dover boat is a good example of this last aspect. On either side of the seam there is a rail in relief carrying a number of

mortises through which small connecting wedges (or tenons) were placed.

North of the Alps, the use of treenails and treenail-wedges (the latter used to insert the pegs firmly into a mortise or drilled hole) during the Neolithic is an established fact but it clearly does not correspond to the concept of 'serial fastenings' of the Bronze Age carpenters; a succession of stitches was no doubt sufficient to strengthen a 15–20 m long hull and carpenters did not have to search for another way of fixing the transverse elements.

The probable obsolescence of the sewing and tying techniques of planks brought about a fundamental development of the framework and the fastenings. The Roman boat of Comacchio, although found south of the Alps, is instructive in that the base of the hull is sewn and its upper part is assembled by means of mortises, tenons and pegs (Berti, 1990). The more common recourse to the drill, especially during the second Iron Age, did not generalize the use of treenails but of turned iron nails, a method that was already mastered during the Hallstatt Period, used, for example, to fix the tyres to the wheels of wagon wheels (Fig. 7).

Similarities are found between Bronze Age and Romano–Celtic craft discovered north of the Alps but since there are so few artefacts it is currently not possible to decide which resemblance, in form or technique, can be ruled out. Nevertheless, the driving cause behind the change of technical unity is to be attributed to the gradual abandonment of the stitching of

planks, a strong and systematic method of fastening. It was replaced by a true and strong framework and by an indirect and rigid method of holding the hull together (nailing). The latter replaced the direct tenon-mortise fastenings much in use during the Bronze Age but not very efficient in naval architecture. This could be seen as the heavy method. In Scandinavia, a lighter way was chosen, where iron rivets replaced lashing and sewing, the latter technique reserved for the fastening of the frames. In this last group, as sails developed and brought new physical constraints to the keel, the vessel was progressively strengthened, for example, by pegging the frames.

The Romano–Celtic craft, as it is known, seems to be derived from the original logboat and inspired by a principal followed in the flat-bottom construction, such as survived on river boats and barges.

As far as ships are concerned, the central members became increasingly significant, ultimately leading to skeleton-first and to shell-first (if direct fastening of the planks survives) constructions. Two architectural principles were thus superimposed:

- flat-bottomed construction gradually replaced by a stronger central structure and a more homogeneous distribution of the frame along the transverse axis;
- assemblage of different elements according to a skeleton-first or shell-first principle.

Acknowledgements

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Notes

[1] Or plank-orientated (McGrail, 1997); cf. likewise Pomey (1988).

[2] That the bottom planks of the Dover boat were constructed from two different trees was perhaps because no single oak of sufficient size could be found (Fenwick, pers. comm.).

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