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Notes

An Archaic Anchor Arm from Liman Tepe/Klazomenai, Turkey

Underwater excavation at Liman Tepe (ancient Klazomenai), Turkey, in 2003–2008 exposed the remains of a wooden anchor arm in an ancient anchorage. The work was part of a joint project of Ankara University and the University of Haifa, directed by Hayat Erkanal and Michal Artzy respectively, the primary aim of which was to investigate submarine walls adjacent to the tell thought to be part of the Early Bronze Age fortifications. Liman Tepe is located about 40 km west of Izmir, Turkey, on the northern side of the Urla-Çeşme Peninsula in the municipality of Urla. The anchor arm was found in an excavation trench called 'Area A3', embedded within the ancient *Posidonia oceanica* matte in an anchorage of the Archaic Ionian city (Fig. 1). The arm fragment is dated to the late 7th or early 6th centuries BC by the surface ceramics and those found within the ancient seafloor into which the arm was set (Votruba *et al.*, forthcoming, for detailed discussion of the find's context and dating). This report describes and discusses the characteristics of the anchor arm itself.

When the anchor broke, the fracture commenced at the crown just above the embedded part of the arm. As the shank was pulled forward the split followed the grain of the shoulder/arm tearing off a tapering portion of the arm's upper surface all the way to just inside the tooth. Consequently, the upper surface of the arm appears stripped, grainy and uneven (Figs 2 and 3). This is in contrast to the excavated side and the lower portion that preserves its original, smoothed, convex shape. The area of the inner tooth left vacant is now filled by iron concretion. Teredo damage is visible on the upper portion, demonstrating that the upper end was exposed above the seafloor following the break. The orientation of the arm when found, the nature of the break, and the teredo damage suggest that the anchor arm broke away from the shank while set firmly in the seabed, probably holding a ship (Votruba *et al.*, forthcoming). The dense *Posidonia oceanica* matte that the arm penetrated both protected it from erosion and seems to have created anaerobic conditions that allowed the wood to be preserved.

Description

The Liman Tepe Area A3 (LT-A3) anchor arm was partially excavated to expose its upper face and north-eastern side so that the plan and profile could be recorded, while allowing for *in situ* preservation (Figs 2 and 3). The preserved portion measures 0.97 m long. The tip is fitted with a metal tooth, now encrusted and superficially corroded, 0.19 m long. A sample was chiselled from the upper edge of the tooth and analysed, revealing that the metal, preserved up to 13 mm thick beneath the corrosion, is iron. The wood of the anchor was identified as *Quercus cerris* (Turkey oak). The arm tapers from 0.12 m in diameter at the widest point to 0.09 m where the wood enters the metal tooth. The wood grain curves noticeably at the fractured end of the anchor with the curved edge of the shoulder following the grain. The term 'shoulder' here is equivalent to Rosloff's 'crotch of the hook' (1991: 223). Longitudinal tool marks, possibly made with an adze, are visible on the preserved original surfaces. An engraved Sardonyx gem, a type of onyx found on Sardinia, from the Museum of Calgari, dated stylistically to *c.*500 BC, shows an ancient shipwright shaping a wooden anchor arm with just such a tool (Fig. 4) (Furtwängler 1900: 72–3; cf. DeVries 1972: 49).

Reconstruction and *comparanda*

Although the remains are fragmentary, it is possible to propose a reasoned hypothetical reconstruction of the anchor based on the limited evidence of early anchors available for comparison. Excavation of a shipwreck dated to *c.*400 BC at Ma'agan Mikhael, Israel, yielded a complete one-arm wooden anchor with a lead-filled wooden stock (Rosloff, 1991, 2003) (Figs 5 and 6). The shank and arm of the Ma'agan Mikhael anchor comprise a single oak crotch timber, 0.08 m thick (Rosloff, 1991: 223). The arm tapers from the shoulder to a pointed end that is enveloped by a copper tooth. The shape of the LT-A3 arm fragment is similar to the arm of the Ma'agan Mikhael example, but round in section, while the latter is rectangular with chamfered edges.

The 7th-century-BC shipwreck partially excavated off the beach at Mazarrón, Spain (Mazarrón-2), provides another comparable anchor (Negueruela *et al.*, 2004: 476; Negueruela Martínez, 2014: 243). The anchor assembly displays a hint of encrustation that is likely a metal tooth, visible at the point where the excavation apparently ceased (Fig. 7) (Negueruela *et al.*, 2004: 478, fig. 24). A crotch-timber shank-arm construction is presumed, based on photographs of the anchor and description as '*madera curva*' (Negueruela

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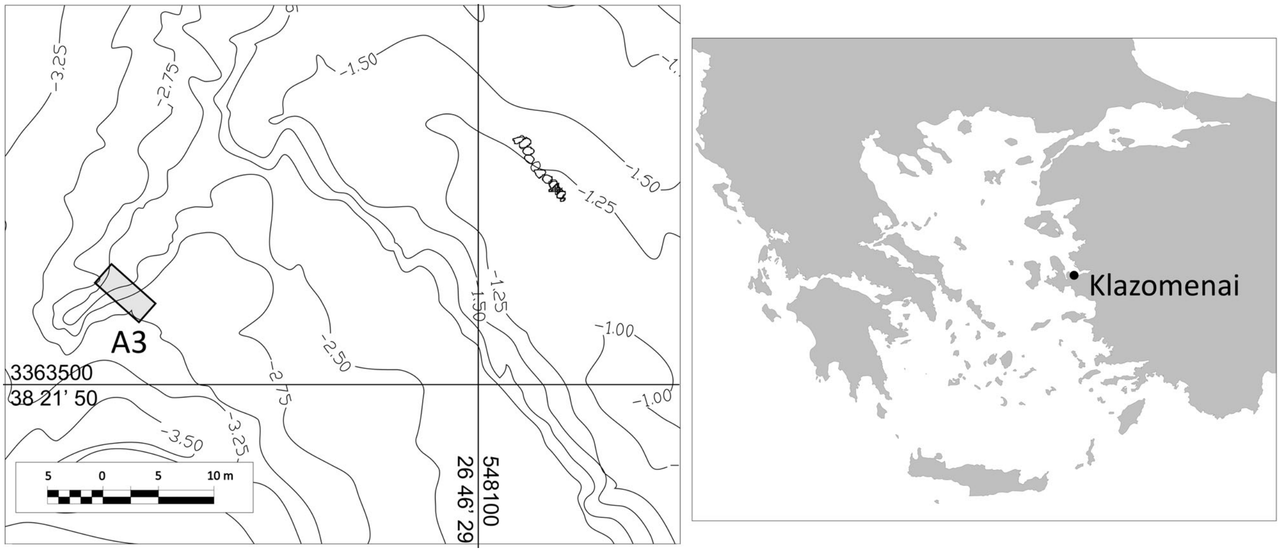

Figure 1. Regional and bathymetric maps showing the location of the submerged site and Area A3. (Y. Salmon and G. Votruba)

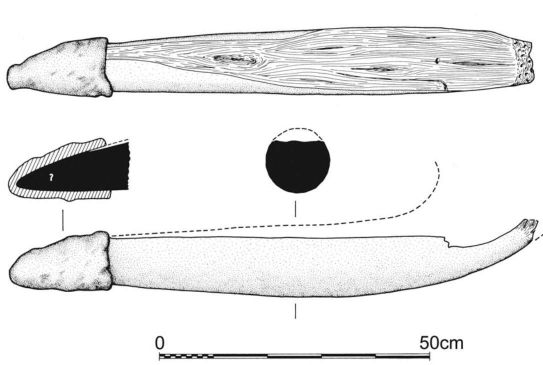

Figure 2. Drawing of the anchor arm based on its two exposed sides. (D. Faulmann and G. Votruba)

et al., 2004: 478, figs. 23 and 24). The term 'shank-arm' is employed here to refer to crooked, whole timber pieces used for both the shank and arm of early wooden stock-anchors. In one-armed anchors only one shank-arm timber would be employed. For two-armed anchors, two such timbers would be attached back-to-back—more precisely in this case '(half-shank)-arm' timbers (Kapitän, 1982; Rosloff, 1991: 224).

These finds are analogous to anchors on 4th-century BC coins from Apollonia Pontica in the display of a conspicuously robust shoulder (Fig. 8). Keeping the shoulder as wide as possible must have been a deliberate design feature meant to maximize strength, where most of the stress was concentrated. Indeed, the LT-A3 anchor broke at this very location.

The authors further propose that the engraved gem from Sardinia, *c.*500 BC, provides additional evidence for back-to-back shank-arm construction. The anchor under construction displays a central line towards the head and lower shank (Fig. 4). In this case, the seam continuing through the crown is invisible for several possible reasons, besides 'artistic license'. A straight line that extends from arm to arm across the throat (indicated by an asterisk on the drawing) could mark the edge of a temporary binding of the two parts. This would have helped the shipwright to shape the two parts symmetrically. The stock aperture is missing since the head has not been fully formed.

It is apparent that the crotch-timber shank-arm anchor tradition was widely employed considering that the evidence of Archaic and Classical date, both physical and iconographic, is widespread (Spain, Sardinia, Black Sea, and Israel). This construction differs from that of Hellenistic and Roman traditions where separate arm pieces were attached to the shank timber, typically with scarfs and mortise-and-tenon joints, such as the well-preserved Lake Nemi (Ucelli, 1950: 242–7), Port-la-Nautique (Bouscaras, 1993), Ein Gedi (Hadas *et al.*, 2005: 301–4), Chrétienne C (Joncheray *et al.*, 1972, Joncheray, 1975: 101–6), and Les Laurons (Ximénès and Moerman, 1988) examples. Therefore, from a chronological standpoint, it is most likely that the LT-A3 anchor's shank and arm were made in the crotch-timber tradition.

The slight curvature along the grain at the shoulder also corresponds to this tradition. Careful examination of the Ma'agan Mikhael shoulder shows that it consists of an elongated knot and naturally curving grain portion cut from a crotch timber (Figs 5 and 6). The location of the curving grains matches the LT-A3 anchor's shoulder portion. This is in contrast to examples with separate arm and shank pieces, in which only straight grains are apparent. Employing straight-grained timbers, the scarf can be more easily shaped with the necessary precision. For single-timber

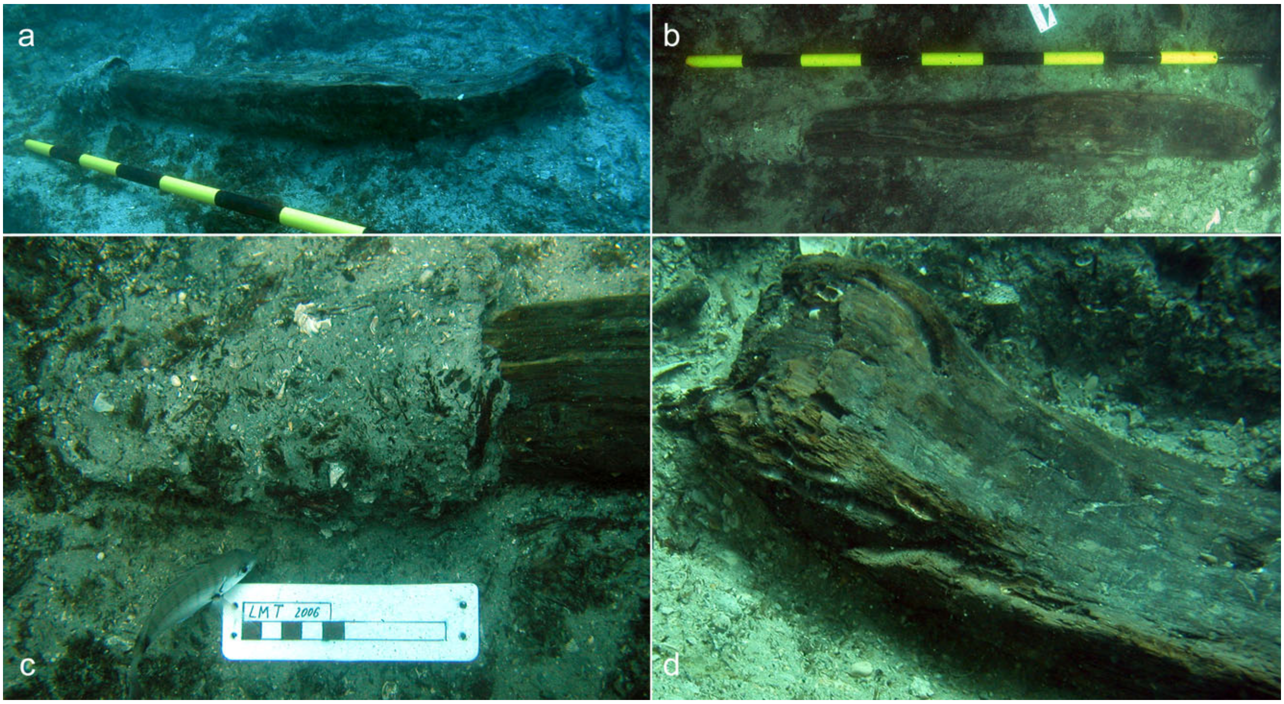

Figure 3. *a)* The north-eastern face of the anchor arm, with traces of longitudinal, adze-like working marks; *b)* plan view of the anchor arm; *c)* the iron tooth of the anchor arm covered with corrosion concretion; *d)* detail showing the natural curvature of the wood and Teredo boring damage on the upper portion of the anchor arm. (G. Votruba)

shoulders, however, curving grains would have been preferred for their ability to absorb and transfer stress in different directions, and, in most cases, protect the arm and shank from splitting apart.

The identified wood type, oak (*Quercus cerris*), corresponds with other early wood stock-anchor examples in the Mediterranean. The Ma'agan Mikhael stock and shank-arm timbers have, both, been identified as *Quercus coccifera* or *calliprinos/ilex* (Rosloff, 2003: 144; Werker, 2003: 242; Liphschitz, 2004: table 1). The *c.*300 BC Kyrenia shipwreck anchor was identified as *Quercus coccifera* (van Duivenvoorde, 2012: 400). Oak was chosen among the readily accessible timbers for its relatively greater hardness and durability compared to pine, as well as for having more negative buoyancy. The various oak species listed by Halperin and Bible (1994: table E.1) indicate an average specific gravity of 0.69 for oak (range 0.68–0.73), and, 0.44 for pine (range 0.36–0.55). There is a direct relationship between wood density and hardness. So far, pine has only been identified from a few anchors of later date, when the arms were attached separately with scarfs and mortise-and-tenon joints and, therefore, were more readily repairable and replaceable; for example, Chrétienne C, Laurons C, and Laurons D (Ximénès and Moerman, 1988: 88 and n. 38), and within a lead-stock find housed in the Berlin Museum (Moll, 1929: 267). The LT-A3 anchor is made of *Quercus cerris*, a wood commonly found around Izmir and throughout much of the north-central portion of the Mediterranean region (Coode and Cullen, 1965: map 86, Rival, 1991: map 8) and, therefore, provides limited provenance information.

Anchor stocks from the Aegean and central Mediterranean of similar date are generally made of stone (cf. Gianfrotta, 1977; Haldane, 1986). However, the Mazarrón-2 anchor reportedly has a lead-filled wooden stock (Negueruela Martínez, 2014: 243), although this has not been demonstrated as yet. On the published photographs, the surface of the stock has a lighter hue and a finer texture than the shank-arm timbers, and the edges are unusually sharp for wood, and distinct from the well-rounded or chamfered edges of the shank-arm timbers (Moity *et al.,* 2003: 43; Negueruela *et al.*, 2004: 476, fig. 24). It also appears to lack the characteristic apertures on the lower edge where the lead would have been poured, as seen with the Ma'agan Mikhael anchor stock, and a stock find from the Carmel Coast (Galili, 1994: 24–5). So far, the earliest demonstrated evidence of a stock with lead cores derives from the 5th-century-BC shipwrecks at Kyra Panaghia and Tektaş Burnu (Kazianes, 1996 and Trethewey, 2001). Incidentally, a fractured stone stock was found in a later-built harbour at Klazomenai, dating from a slightly later stratigraphic facies than the arm in discussion here (Votruba and Erkanal, forthcoming).

It is not possible, however, to ascertain if the LT-A3 anchor was one-armed, with the stock necessarily offset towards the arm, as seen in the Ma'agan Mikhael

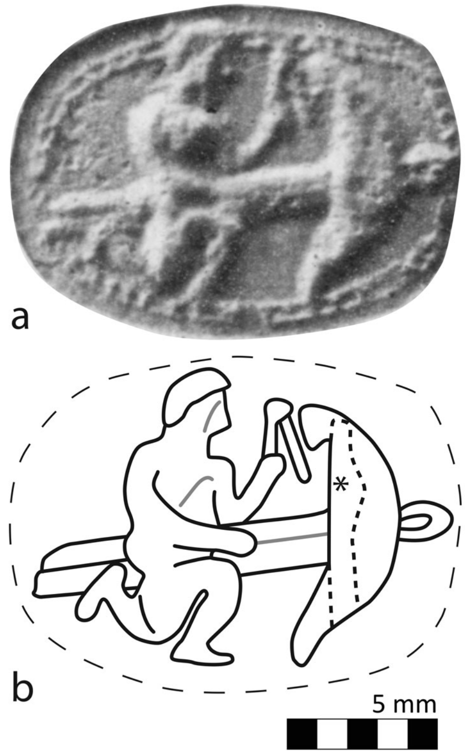

Figure 4. Gem engraving from Sardinia dating to *c.*500 BC, depicting a shipwright shaping an anchor with an adze. *a)* the original casting (Furtwängler, 1900: pl. 15 no. 61); *b)* drawing. (G. Votruba)

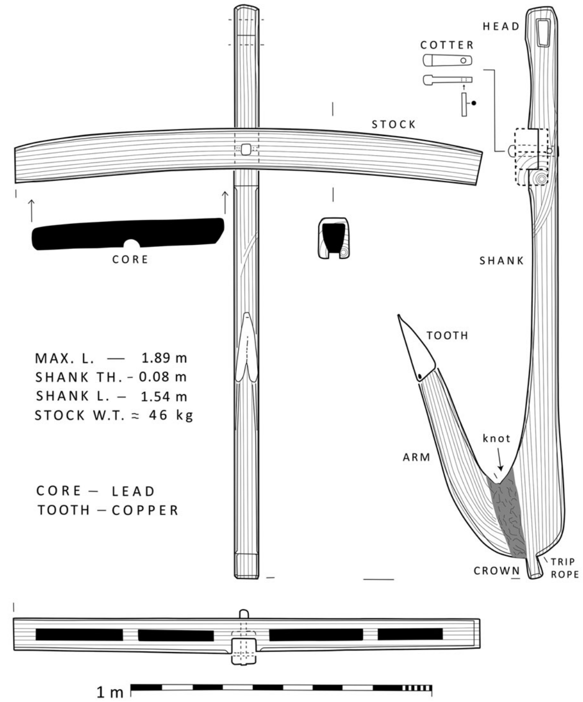

Figure 5. Drawing of the Ma'agan Mikhael anchor (after Rosloff, 1991: fig. 2), with the addition of the observed patterns of the wood grains. (G. Votruba)

anchor, or two-armed, with the stock fitted centrally between the two shank-arm timbers, fastened back-to-back (Kapitän, 1982; Galili and Rosen, 2006). The Mazarrón-2 anchor is an example of the latter type and demonstrates that the timbers could be attached by mortise-and-tenon joints (Fig. 7).

The iron tooth of the anchor is the earliest example identified to date of a tradition that would continue into the Roman Period. Iron teeth were found on the 5th-century BC Tektaş Burnu and *c.*300 BC Kyrenia shipwrecks (van Duivenvoorde, 2012: 398, 406); the 3rd-century-BC Tour Fondue shipwreck (Joncheray, 1989: 143, Dangréaux, 2012: pls. 9 and 13); the 2nd-century-BC Chrétienne C (Joncheray, 1975: 104–107) and Jeaune-Garde B (Carrazé, 1974: 153) shipwrecks; and the 1st-century AD Lake Nemi (Speziale, 1931: 312 and 319, Ucelli, 1950: 242), Caesarea Maritima (Raban *et al.*, 1990: 244–245), Port-la-Nautique (Bouscaras, 1993: 4–5) and the Balise de Rabiou shipwreck (Joncheray and Joncheray, 2009: 85). However, several Classical examples of anchor teeth were cupreous. The *c.*400 BC Porticello and Ma'agan Mikhael shipwrecks' anchors were made of bronze and copper respectively (Eiseman and Ridgway, 1987: 19–21, Rosloff, 1991: 223, 2003: 144). A bronze tooth, dated to the 4th–2nd centuries BC, was also found at Heracleion-Thonis on the Egyptian Delta (Fabre, 2006: 220, 338). Pindar, writing in the 5th century BC, makes a likely reference to a bronze tooth with the phrase 'ἄγκυραν … χαλκόγενυν' (Pythian Odes IV, 24), meaning 'bronze-tipped anchor'. Presumably the durability of iron would have been preferable to bronze for this purpose; however iron would have to be pre-forged, whereas bronze could be shaped upon the anchor. Other complex factors include the price of the metals and resistance to corrosion. Ultimately, the criteria guiding the choice of bronze or iron teeth in pre-Roman times remain to be elucidated.

Since the LT-A3 tooth is obscured by corrosive concretion, details such as form and means of fastening remain uncertain. Other archaeological examples of teeth were attached to the arm-ends with nail-like fasteners fixed at various angles. The Ma'agan Mikhael anchor tooth was secured with three small iron nails placed around its base (Rosloff, 1991: 223, 2003: 144). The well-preserved bronze tooth from Heracleion-Thonis has fastener holes of various sizes (Fabre, 2006: 220), which correspond to tacks. Tacks were used to fix the teeth to the Porticello anchors (Eiseman and Ridgway, 1987: figs. 2–20 and 2–21). A single square-sectioned iron tack projecting through the lower portion of the Kyrenia iron tooth was recorded (van Duivenvoorde, 2012: 398 and fig. 6). A similarly placed tack is visible on a find from 4th century BC Chyton (Votruba and Erkanal, forthcoming, fig. 2)

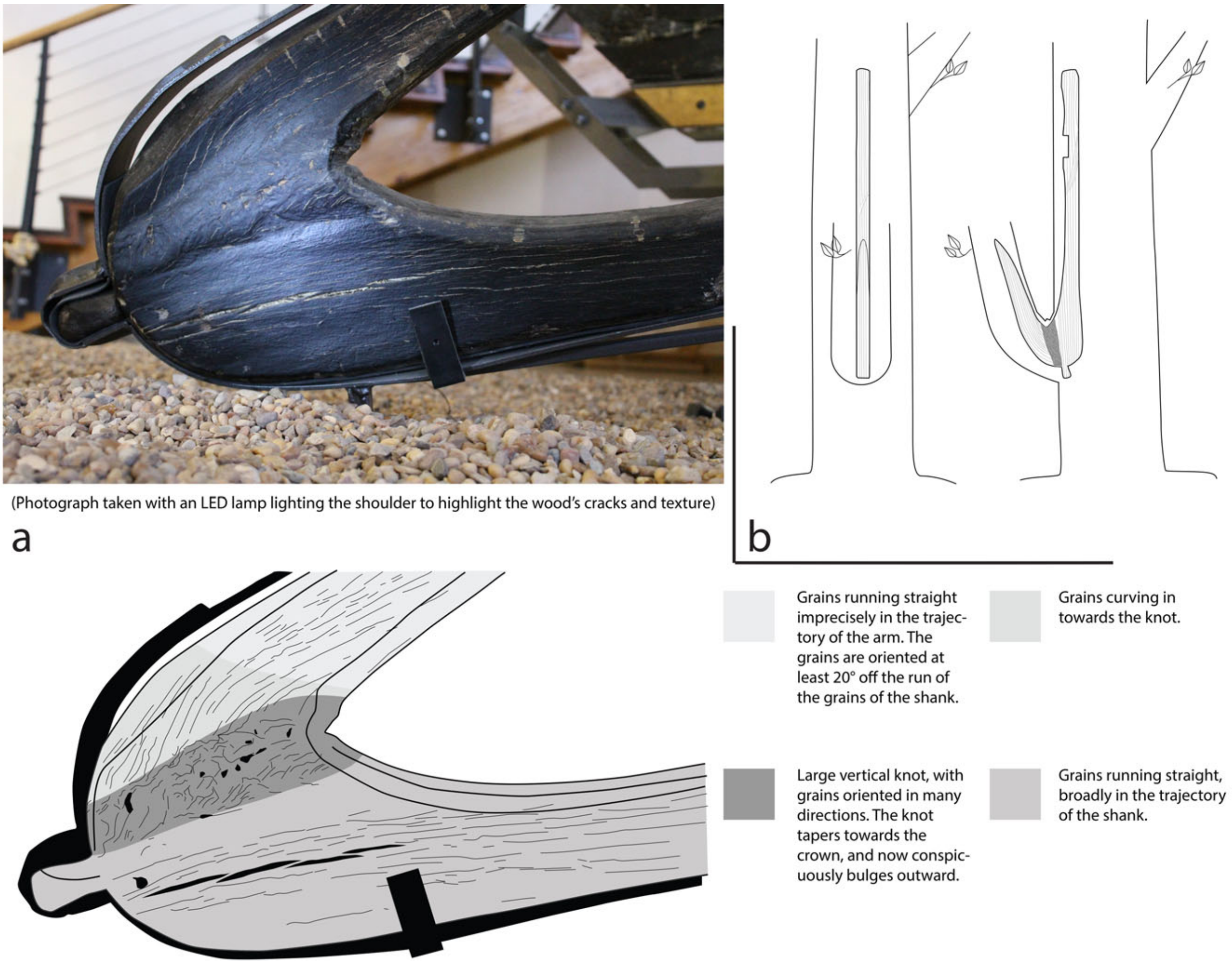

Figure 6. *a)* Details of the Ma'agan Mikhael shoulder; tracing of the wood showing the various grain patterns; *b)* possible situation of the original crotch timber cut to produce the Ma'agan Mikael anchor's shank-arm timber. (G. Votruba)

Regarding the form, where Classical anchor teeth are well preserved and clearly illustrated they display a V-shaped opening where the metal was predesigned to leave the upper portion of the wooden arm-end exposed (for example Heracleion-Thonis, Kyrenia and Porticello). The LT-A3 tooth, however, appears to lack such a gap and the tooth was a complete cone (Figs 2 and 3). These teeth, as well as the Ma'agan Mikhael anchor tooth (Rosloff, 1991: 224 fig. 2), also display a short flat nib projecting from the basal side. Such nibs served to strengthen the tooth-tip enhancing durability, and help the arm to pierce the seafloor (Kapitän, 1984: 42). The encrustation on the A3 tooth obscures whether or not it has a modest nib or a simple cone-point.

The LT-A3 arm fragment is somewhat larger in dimension to that of the corresponding part of the Ma'agan Mikhael anchor arm. It is therefore feasible the anchor had been employed on a similar sea-going vessel, as opposed to a provincial boat (see Winters and Kahanov, 2003).

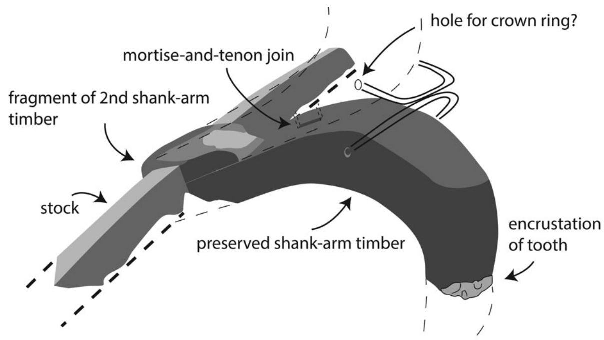

Figure 7. A tracing of a grayscale image of the Mazarrón-2 anchor in its excavated state in which the lower portions remain covered by sand. (G. Votruba, after Negueruela *et al.*, 2004: 476, fig. 24)

Other interpretations

Finally, it is necessary to address the possibility that this find could be related to some other form of nautical

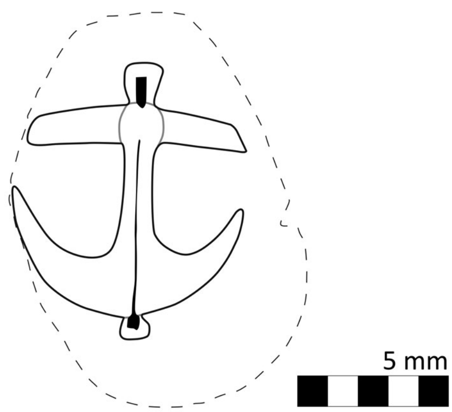

Figure 8. Tracing of the anchor details on a 350 BC coin from Apollonia Pontica. (G. Votruba, after Ben-Eli *et al.*, 1975: no. 63)

tool. One possibility is a mooring stake. Festus (538.28) has defined *tonsillae* as hewn stakes, tipped with iron, that were driven into the shore to which ships were attached. Similarly, iron-shod boat poles employed for various uses, such as temporarily stabilizing a ship and holding-off other vessels, should be considered. These have been described, for instance, by Virgil (*Aen.* 5.208–209) as *ferratasque trades*, 'iron-shod poles', and *acute cuspidor contos*, 'sharp pointed poles'. Wooden piles for harbour structures, such as those discovered in the ancient harbour of Alexandria for a possible wooden jetty should also be considered (Goddio and Darwish, 1998: 29–31). However, a boat pole is unlikely since these would have been lighter and more slender than the LT-A3 find. Moreover, the iron tip would be an unnecessary feature for piles. Finally, in neither of these cases would a naturally curving timber be functionally advantageous.

Conclusion

The LT-A3 anchor arm furthers understanding of ancient anchoring technology. Although it is not possible to determine its complete original form, it is likely a typical Mediterranean stone-stocked anchor, whether one- or two-armed. The conical iron tooth may represent an early form. Archaic and Classical shipwrights of the Mediterranean carefully selected their anchor timbers from grown crotches. The relatively large size of the anchor arm may suggest that the anchorage accommodated seagoing vessels. Finally, the testimony that a robust wooden anchor fractured while set within an anchorage context, adds to our understanding of the complications of mooring in the ancient world.

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