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New Evidence for the Steering System of the Egyptian *Baris* (Herodotus 2.96)

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A sentence of the well-known and widely debated fragment 2.96 of Herodotus' *History* (*c*.450 BC) is devoted to the steering system of a *baris*, a type of Nile cargo boat. According to Herodotus, the rudder passed through the keel of the boat. The axial rudder was known in Egypt from the 6th Dynasty (*c*.2323–2150 BC) and can be traced through representations and models till the end of the Pharaonic period and beyond; however, no archaeological evidence for this type of rudder had ever been found. The recent excavation of Ship 17 of Thonis-Heracleion, dated to the Late Period (664–332 BC), reveal numerous parallels between the construction of this boat and Herodotus' description and cast light on the steering system of the *baris*.

Key words: underwater archaeology, Egyptian shipbuilding, Late Period, axial rudder.

More than 60 shipwrecks, the majority of which date from the 6th–2nd centuries BC, were discovered during excavations by the Institut Européen d'Archéologie Sous-Marine (IEASM) in the port regions and canals of the submerged city of Thonis-Heracleion, Egypt (Goddio, 2007; Goddio, 2011; Fabre and Belov, 2012), (Fig. 1).

Ship 17 was the first vessel excavated and its construction is the subject of the author's PhD thesis, which will be examined at the University of Bordeaux at the end of 2013. During three excavation seasons (2009–2011) about 70% of the hull was uncovered (Fig. 2). The remains of the ship were well-preserved under a 0.5 m layer of sand and clay, but no traces of cargo were discovered. The radiocarbon-dates for the ship were narrowed down thanks to the ceramic material found *in situ* and, at the current stage of the research, the ship is dated to the mid 5th–mid 4th century BC.

Figure 1. Map showing the location of the site of Thonis-Heracleion in the Mediterranean.

Ship 17 and Herodotus' *baris*

The construction of the ship shows numerous parallels with the description by Herodotus (*c*.450 BC, *History*, 2.96) of a river-going cargo boat called a *baris* (Belov, in press a). A summary of the similarities between the two boats is provided below. Ship 17 is a freighter built entirely of the local species of acacia (*Acacia nilotica (L), Acacia raddiana Savi*). All constructional members of Ship 17 are coarsely worked and there is evidence for a frugal use of building materials. The joints of the planking of Ship 17 are staggered in a way that gives it the appearance of 'courses of bricks', as described by Herodotus. The planking of the boat also contains many knife-shaped planks that find parallels in the material from the Khufu I boat, from Lisht, Mersa Gawasis and Ayn Sukhna (Ward, 2000: 102; Pomey, 2012). The planking of Ship 17 is assembled transversally by remarkably long tenons that can reach 1.99 m in length and that pass through up to 11

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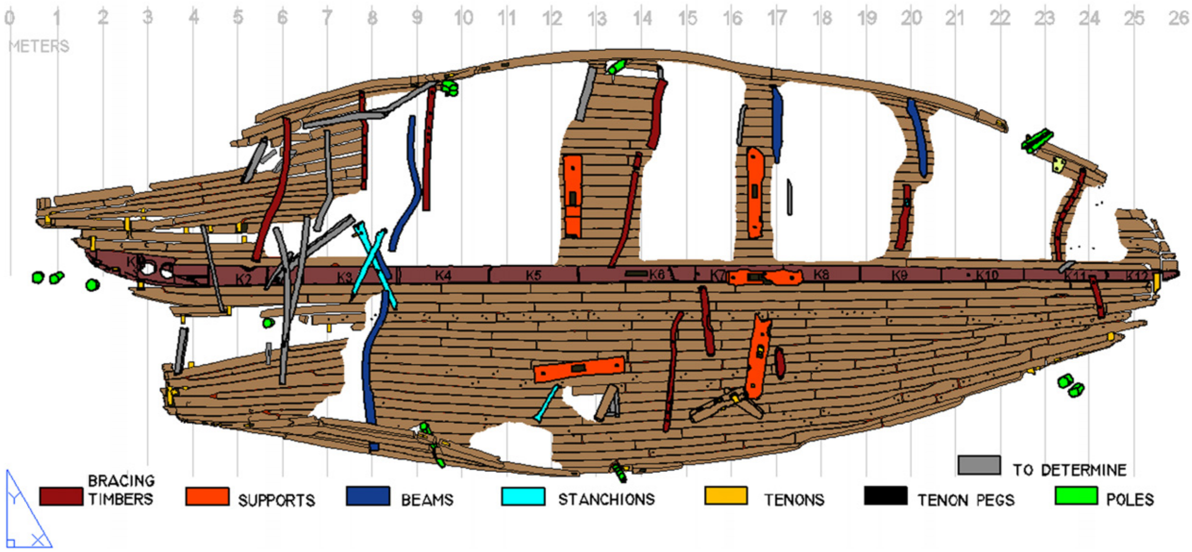

Figure 2. General plan of the Ship 17 of Thonis-Heracleion. (Drawing by Patrice Sandrin/Alexander Belov © Franck Goddio/Hilti Foundation)

strakes. These tenons correspond to the '*long and close-set stakes'* in Herodotus' narrative (γόμφος). The general meaning of the term is 'fastening' and it has been also translated as 'stake', 'pin', 'dowel' or 'peg' (Vinson, 1998). The use of the word 'tenon' is used here for lack of a better term for this type of construction. In fact the tenons in question act as internal frames or, to draw a parallel with a living body, as ribs. Traces of vegetal material in the form of strands driven between the seams of the planks can be seen distinctly in both the longitudinal and transversal joints on the inner surface of the planking.

Another parallel with the text includes the preserved through-beams. Herodotus also mentions the *baris*' keel, and Ship 17 has a keel that is twice as thick as the planking and projects inside the hull. In this respect, it resembles the keel of the Bronze-Age shipwreck of Uluburun (1300 BC) (Pulak, 1988; Pulak, 2002). Judging by the preserved mast-step notch, the mast of Ship 17 was located in the midship area and was probably supported by a beam.

Only two mismatches between the text of Herodotus and the evidence of Ship 17 have been noted. First, the average length of the planks of the latter is 1.92 m and that is almost twice as long as in the description of Herodotus (about 1.04 m). Second, Herodotus says that there were no frames in the construction of the *baris*, while Ship 17 has 10 half-frames, or rather bracing timbers, preserved. These bracing timbers were not connected to the keel and were installed in specific areas which the shipbuilder judged to require reinforcement. Both of these discrepancies can be explained by the larger size of Ship 17 in comparison with those in the description. In fact, at the end of the paragraph Herodotus states that there were larger *barides*. With its reconstructed length of 27 m and a displacement of about 100 metric tonnes, Ship 17 obviously belonged to a larger class of Nilotic freighters. It seems logical to suppose that longer planks of acacia as well as reinforcing timbers were used to build a larger hull.

The construction of Ship 17 also shows many common features with the Mataria boat dated to 2450 ± 50 BP (Haldane, 1996: 441; Ward 2000: 129–135). A freighter built of the local sycomore (*Ficus sycomorus*), the Mataria boat demonstrates a similar plan of planking and staggered joints between the planks. The planking was probably assembled with very long tenons (Ward, 2000: 133), some of them pegged, and it is possible that, as in the construction of Ship 17, a half-lap joint was employed for joining planks of the same strake.

Axial rudders in Ancient Egypt

The first representations of the axial rudder in Egypt are dated to the end of the 5th (*c.*2465–2325 BC) (Jones, 1995: 39–40) or to the 6th Dynasty (*c.*2325–2155 BC).The best-known reliefs of the 6th Dynasty are those of Deir el-Gebrâwi from Saqqara (Davies, 1901–1902; Boreux, 1925: 402). The axial rudder and the alternative arrangement consisting of a pair of quarter-rudders that can be seen on these reliefs continued to co-exist during all subsequent Egyptian history; seemingly, it was the preferred steering system for the Nilotic freighters and passenger or travelling ships (Boreux, 1925: 397) (Fig. 3).

The development of the axial rudder continued in the First Intermediate Period (*c.*2180–2040) and in the Middle Kingdom (*c.*2040–1730). Hundreds of models of travelling boats dated to the Middle Kingdom were equipped with an axial rudder (Fig. 4). The rudder-stock passed through a cleft at the stern of the

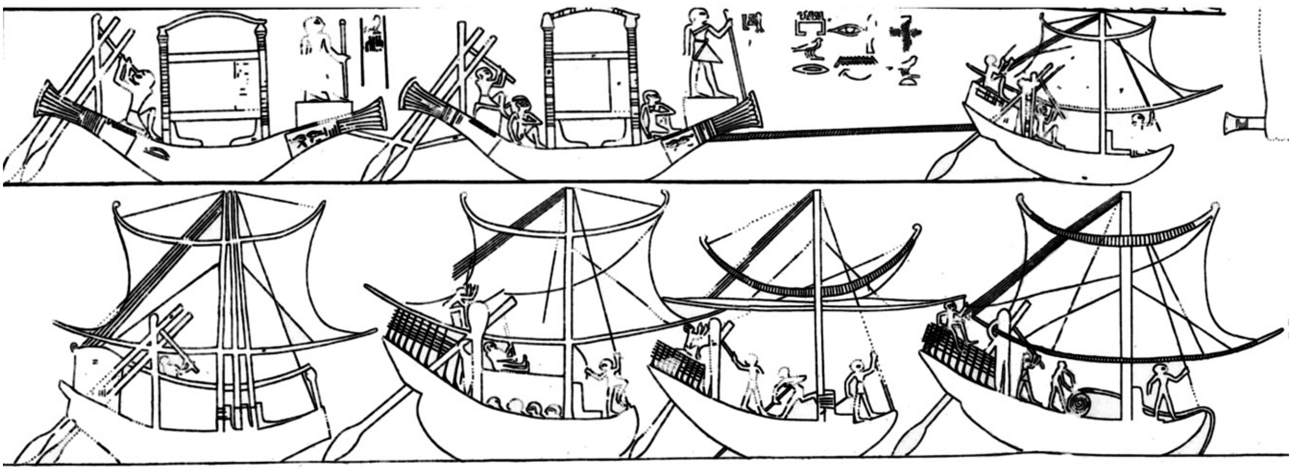

Figure 3. Boats from the reliefs of Deir el-Gebrâwi, 6th Dynasty (*c.*2325–2155 BC). (Davies, N. de G., 1901–1902:)

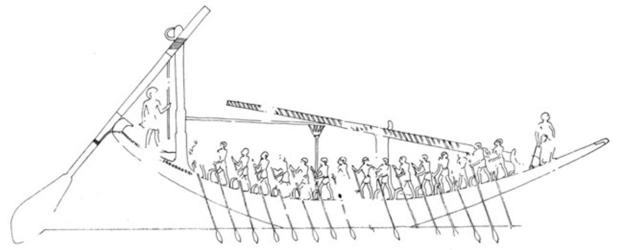

Figure 4. Typical steering arrangement of a Nile boat in the Middle Kingdom. Fragment of the relief from the tomb of Antefoker, 12th Dynasty (1971–1926 BC). (N. de G. Davies, 1920: pl.18)

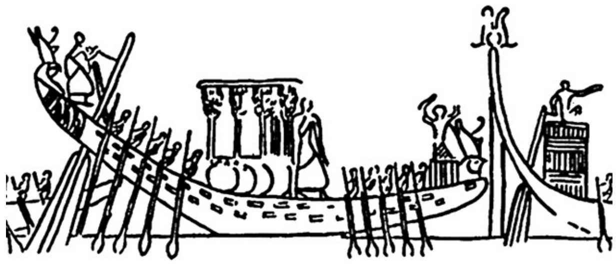

Figure 5. Fragment of the stele of king Piankhi (Piy) from the temple of Mut at Karnak, 25th Dynasty (715–664 BC). (Benson and Gourlay, 1899: 254, pl.20)

boat and was secured to a more massive stanchion than in earlier periods. In comparison with the Old Kingdom, the surface of the rudder was also considerably enlarged. In the New Kingdom (*c.*1560–1085) the cleft at the stern became more pronounced and often, in order to make it visible on the drawing, the artists turned it towards the spectator (Doyle, 1998: 56). The upper extremity of the rudder-stock was sometimes crowned with a massive rectangular piece that probably served as a counter-balance to facilitate lifting the rudder from the water (Landström, 1970: 134).

Towards the end of the New Kingdom representations of boats become rare; however, those dated to the reign of Ramses III (20th Dynasty, *c.*1194–1163 BC) confirm that the axial rudder was still used for steering the boats of the Nile (Jones, 1995: 58–59). This pharaoh's warships, depicted on the walls of his funerary temple in Medinet Habu, were probably also equipped with axial rudders (Landström, 1970: 112–113). Iconographic evidence for the Third Intermediate Period (*c.*1069–664 BC) and for the Late Period (664–332 BC) is extremely scarce. The most important iconographic document dated to this time is the stele of king Piankhi (Piy) from the temple of Mut at Karnak (25th Dynasty, 715–664 BC. A date in the 26th Dynasty has been proposed by Kitchen, 1972), (Fig. 5).

Representations in the temples of the Ptolemaic Period (331–30 BC) depict traditional Egyptian river-going boats steered by an axial rudder. Even taking into consideration the religious character of these reliefs that conform to ancient iconographic traditions, it seems, however, reasonable to suggest that local craft still possessed many indigenous constructional features, including the axial rudder.

Evidence for an axial rudder on Ship 17

The aftermost segment of the keel of Ship 17 is cut of a single piece of acacia wood and has the following dimensions: length 3.05 m; width 0.56 m; thickness varying from 0.10–0.21 m. The detail is generally well preserved, except the eroded starboard stern extremity. In addition there are two transversal and two longitudinal cracks owing to post-depositional deformation of the hull (Fig. 6).

In plan, segment K1 consists of a rectangular part 1.66 x 0.56 m and a trapezoidal part which tapers to a width of only 0.15 m to the stern. Two circular openings with respective diameters of 0.33 and 0.39 m can be seen in the centre of segment K1. The openings were carefully cut with a small chisel and go through the entire thickness of the keel. The first opening is damaged but the detached pieces of wood were found in their initial position. The shortest distance between the edges of the openings measures only 50 mm. Both openings are almost vertical, both having an angle of 92° in reference to the horizontal axis of segment K1 (anticlockwise inclination in sheer view). In profile segment K1 is characterized by a greater thickness of the rectangular central part which corresponds to the position of the openings (Fig. 7). Segment K1 is assembled to the neighbouring segment K2 by means of the same simple mortise-and-tenon joint that is used for the assemblage of all the other parts of the keel (see Fig. 7). Six tenons pass through segment K1 and secure it to the strakes of both boards (Fig. 8). One can note that these tenons pass through the keel exclusively in places where they do not obstruct the openings. The unpreserved tenon between the openings was most probably trimmed to leave the apertures free.

Figure 6. Aftermost segment K1 of the keel of Ship 17 of Thonis-Heracleion featuring two circular openings. (Photo by Christoph Gerigk © Franck Goddio/Hilti Foundation)

Discussion

The keel segment K1 is characterized by its position at the preserved aft extremity of Ship 17 and by a width that is larger than that of all the other segments of the keel. Thus, the width of the keel segment K12 at the preserved bow extremity of the ship is only 214 mm and the average width of all segments of the keel is 348 mm. The trapezoidal form of K1 and the converging lines of the planking attest that the two openings were situated at the aft extremity of the ship. However, it is evident that K1 is not preserved completely as the

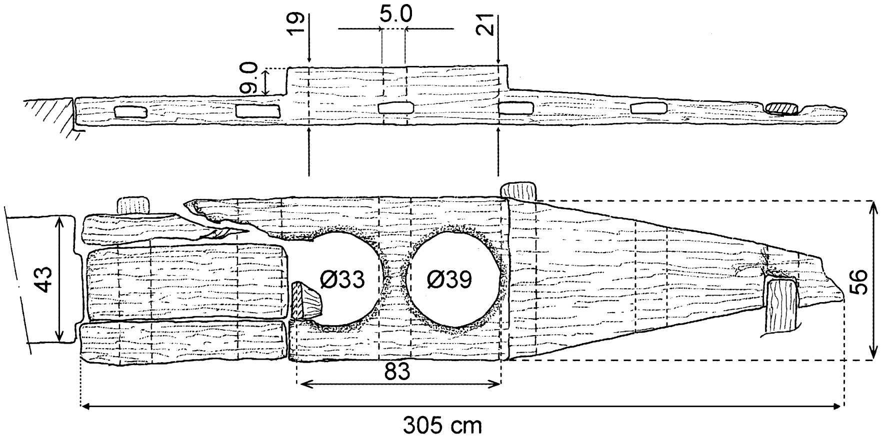

Figure 7. Plan and profile of the segment K1 featuring two circular openings. (Drawing by Patrice Sandrin © Franck Goddio/Hilti Foundation)

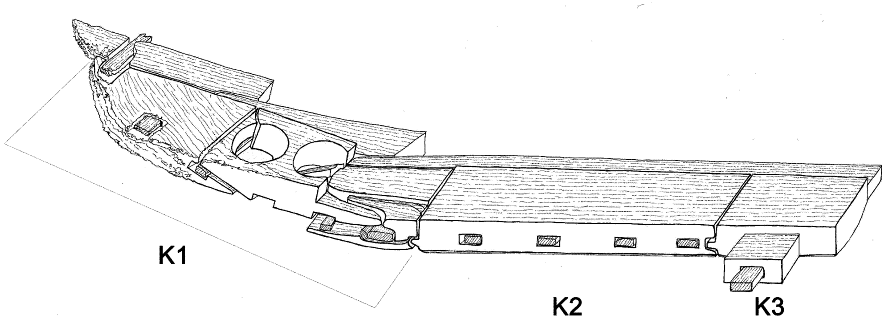

Figure 8. Axonometric view of the stern segments K1, K2 and K3 of the keel of ship 17. (Drawing by Patrice Sandrin © Franck Goddio/Hilti Foundation)

strakes of the port side surpass it by 1.08 m. It is also possible that there existed an additional piece in continuation of K1. Two openings cut in K1 with almost the same diameter and at the same angle are situated close to each other. Therefore we can suggest that these two openings had an identical function. The part of K1 where the openings were cut has a deeper, box-like appearance. The fact that the numerous tenons of the planking assemblage leave the openings free is of great importance. Another important observation is that there are no traces of the use of ropes on the interior surface of the openings. Therefore the possible function as hawse-holes for mooring (*cf* '*oeilletons d'ammarage*' on the reliefs of Unas: Goyon, 1971: 25) or as hawse-holes for haulage (as described by Herodotus, 2.96) does not stand up. This role would necessarily have left visible traces in the wood—even in a wood as hard as acacia. In addition the existence of a (double?) hawse at the stern of the boat and the absence of a similar feature at the prow would be surprising. As for a haulage-related function, a cable was commonly attached to the mast of the boat for this purpose (Casson, 1965: 31–39).

Therefore the most plausible interpretation for the openings is as shafts for an axial rudder. No remains of the rudder itself were found, but this is not surprising considering the context of the ships of Heracleion (Robinson, in press). Ship 17 belongs to a ship graveyard or to an artificial island, and boats studied so far have neither cargos aboard nor any rigging. Evidently the rudder would be one of the first elements to be dismantled before abandoning the ship.

Returning to the narrative of Herodotus we learn that the *baris* had '. . . one rudder, passing through a hole in the boat's keel.' (*History*, 2.96). This short phrase is informative and quite unambiguous. The verb διαβύνομαι is mono-semantic and means 'to go through' while τρόπις is a standard Greek term for 'keel'. However, some of the earlier translators made the rudder pass not through the keel but through 'the hull' and this completely changed the sense of the phrase. A rudder of that kind existed in the Old Kingdom and its stock passed through the steering platform without touching the keel or the keel-plank. The absence of archaeological evidence encouraged the development of other hypotheses as well. According to one, the rudder in Herodotus' description would have passed through a cleft at the stern (Graser, 1869). Nevertheless, it must be admitted that the majority of scholars have accepted the information provided by Herodotus *ad verbum* (in particular Boreux, 1925: 248; Edgerton, 1926–1927; Landström, 1970: 26; Vinson, 1998; Basch, 1999).

'The Great Ship from Sais' depicted on the relief of King Piankhi (Fig. 5) has a central deckhouse while both extremities of the hull are decorated with the crowned falcon heads. We may note that the presence of this massive figure at the stern of the ship would not allow the use of a 'cleft system' to install a rudder. The deckhouse in the form of a shrine and the sculptures bear witness to the religious destination of this vessel (Landström, 1970: 140); however, the ship is rowed and not towed as the majority of Egyptian religious barks. The text on the relief indicates a length for the ships represented varying between 22.6 and 23.4 m. 'The Great Ship from Sais' is steered by a large axial rudder that is positioned at a very steep angle. Basch has commented on the steering system of this boat. According to him, the stock of the rudder turns inside a 'shaft' cut in the high stern of the ship (Basch, 1999: 45). He concludes that this technical configuration did not require a stanchion to support the rudder while providing maximum verticality to the stock in comparison to all previous systems. The same type of rudder was used by the Copts in the 7th century BC (Basch, 1999: 45). It can be suggested that the box-like appearance of the central part of segment K1 of Ship 17 served both to strengthen this segment and to support the stock of the rudder in a vertical position.

However, in my opinion, the iconography of Piankhi's fleet testifies instead to an additional support for the rudder. In the case of the 'The Great Ship from Sais' a small stanchion can be seen right in front of the helmsman, while the rudder of the second ship seems to rest on the deckhouse. We return to this point as it seems that the meagre thickness of segment K1 (maximum 0.21 m) is insufficient to have held the rudder in its working position. An additional support in the form of a stanchion, a deckhouse or a deck-beam must have existed to offer a second point of support.

In general terms, an axial rudder seems to be a logical choice for Nilotic work boats. It is much easier to steer with one rudder than with a pair of quarter-rudders that require a good deal of coordination. At the same time the area of the submerged surface of the blade is not so important here as in sea-going vessels because there is no leeway to cope with. There are numerous examples of an axial rudder being installed on Roman boats and all of them are river-going vessels (Basch, 1999). We should be cautious in supposing that the installation of an axial rudder was less work and less time consuming; however, taking into consideration all the stages of the technological process, it was probably not more demanding than installing a pair of quarter-rudders.

The development of the axial rudder in the New Kingdom could also have led to the solution of the shaft (Belov, in press b). In spite of the small number of representations of water-craft at the end of the New Kingdom, it can be noted that the cleft for the rudder-stock at the stern of many boats becomes more pronounced than before (for representations see Landström, 1970: fig. 353–356, 396, 405; Jones, 1995: fig. 53–54) (Fig. 9).

The deep cleft at the stern allowed for increasing the verticality of the rudder-stock while lifting it from the water remained fairly easy. At the same time it is evident that the axial steering system of the New

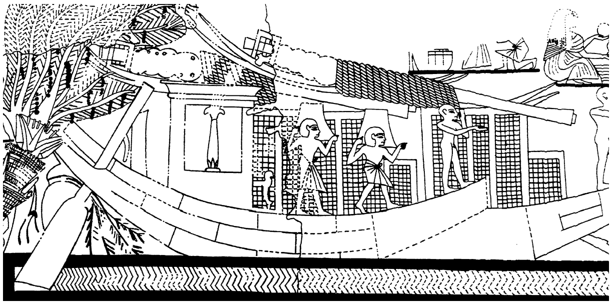

Figure 9. Representation of the boat from the tomb of Ipy from Thebes, 20th Dynasty (1186–1069 BC). (N. de G. Davies, 1927: pl.30)

Kingdom is much more compact compared to that of the Middle Kingdom where the rudder-stocks are very long indeed. Moreover, the new arrangement allowed the rudder-blade to be closer to the stern, thus increasing manoeuvrability. This kind of rudder finds a technical parallel in modern 'suspended' rudders.

The solution of the deep cleft must have worked well for relatively small craft; however, its use on larger boats seems problematic because of the falciform hull of the Egyptian boats with considerable overhangs at the extremities. Thus, the elevation of the stern stood in direct relation to the size of the boat. For larger boats it was necessary to increase the depth of the cleft in order to achieve sufficient verticality of the rudder-stock. Although technically possible within certain limits, the deep cleft, however, considerably violates the integrity of the stern. The after-parts of the planking of both boards cannot be sufficiently supported and the keel (or keel-plank) is weakened by the cleft. The choice of a shaft for the axial rudder solves this problem without much difficulty.

Still, lifting of the rudder from the water, an important aspect in an axial arrangement (Sleeswyk, 1982), remains a problem. Ship 17 does not provide any information in this respect and it can only be stated the rudder could only be lifted in the vertical axis. A sufficient length of stock (between the top of the rudder-blade and the exterior surface of the hull) could have been left free to allow for the complete or partial lifting of the rudder in this manner.

Two shafts for the axial rudder of Ship 17 were probably provided to allow for improved steering when the ship was in ballast and when fully loaded (P. Pomey, pers. comm.). Recently, a single opening of a similar type was discovered at the stern of Ship 43 of Thonis-Heracleion, which, although smaller than Ship 17, shares many of its constructional features (Robinson, in press).

Figure 10 provides a hypothetical reconstruction of the steering arrangement of Ship 17. As mentioned above, it seems that a second point of support was necessary to hold the rudder in its working position. The stern of Ship 17 is considerably damaged and this leaves room for speculation. According to the 3D

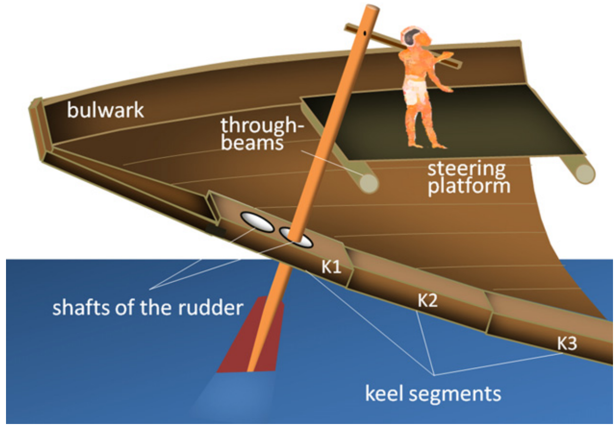

Figure 10. Hypothetical reconstruction of the steering system of Ship 17. Not to scale. (Author)

reconstruction, the after-part of Ship 17 containing the rudder shafts is characterized by a pitch of around 30°. Evidently the helmsman needed a more horizontal area such as a steering platform or the roof of a deckhouse. We cannot exclude either possibility. A small hatch or a door (0.66 x 0.46 x 0.20 m) discovered in the central part of the hull may serve as an indication of the existence of a deckhouse. In any case, either of the structures must have been based on the through-beams as shown in Figure 10. Three irregularly spaced through-beams were preserved in the construction of Ship 17 but it seems that initially there were more. No trace of a stanchion has been detected on the keel.

Ship 17 perfectly suited the navigational conditions in the region of Heracleion that included shallow waters and numerous sandbanks. The boat possessed a flat keel, a shallow draft and a steering system in complete accordance with the requirements of the fluvial environment. Some of the boats depicted on the rocks of Rod el-Air, that show parallels with the ship remains of Ayn Sukhna, also seem to be equipped with an axial rudder (Pomey, 2012a, 2012b). However, Pomey notes that these boats were probably adapted to the sea while belonging to the Nilotic construction tradition, and that the navigation to the Sinai Peninsula would not have taken more than one day. Generally speaking, an axial rudder does not seem a good choice for a sea-going vessel because of the difficulties of replacing it at sea in case of damage (Mark, 2013).

As the context of the steering-oar blades found in Mersa Gawasis strongly indicates a paired quarter-rudder system for the sea-going ships (Zazzaro, 2007: 151–153; Zazzaro, 2009: 3–8; Ward and Zazzaro, C., 2010), we can state that, not counting the models, Ship 17 of Thonis-Heracleion provides the first archaeological evidence for the axial rudder arrangement in Egypt.

Conclusions

The construction of the recently excavated Ship 17 of Thonis-Heracleion shows numerous parallels with

Herodotus' description of the Egyptian river-going *baris* (*History*, 2.96, c.450 BC). According to Herodotus the *baris* was steered with an axial rudder and the remains of this steering system have been discovered at the stern of the Ship 17. The evolution of the axial rudder at the end of the New Kingdom seems to indicate the appearance of a rudder-shaft several centuries later as evidenced by the text of Herodotus, iconography and the ships of Thonis-Heracleion.

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