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Notes on the Mediterranean and Red Sea Ships and Ship Construction From Sahure to Hatshepsut

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Abstract

A comparison of depictions of Sahure's Mediterranean and Red Sea ships suggests that the latter were smaller and lighter. Details from these reliefs with a comparison of structural features from the Khufu I vessel suggest that both types of Sahure's ships were designed to be broken down and rebuilt. Moreover, Sahure's small ships may have been designed specifically for the Red Sea, but iconographic, textual, and archaeological evidence allow for the possibility that as early as the Middle Kingdom but no later than the reign of Hatshepsut (c. 1479–1458 BCE) Mediterranean and Punt ships were the same possibly due to changes in ship construction.

Introduction[1]

A relief depicting two Punt ships from the causeway of Sahure (*c.* 2487–2475 BCE) was recently published in *Abusir XVI: Sahure—The Pyramid Causeway: History and Decoration Program in the Old Kingdom*.[2] In my review of the book, I stated that the ships of Sahure's returning Punt expedition were identical to those of his Mediterranean fleet;[3] however, upon further reflection, I realized that this statement is incorrect. I present here a comparison of the features of the two types of vessels in Sahure's reliefs, as well as other comparative iconographic and archaeological material, and propose reasons for their differences.

The word "ship" has a number of different meanings, depending on type of vessel, the period, or social context. I define a ship in this manuscript as a sailed, seagoing vessel and will use "boat" to refer to vessels constructed for use on the Nile.

Basic Assumption

This study is based on the assumption that the boats and ships portrayed by artists in reliefs for royalty and high-ranking individuals from the Fourth through the Sixth Dynasties and from the reign of Hatshepsut are accurate representations. This has been a standard, if unstated, assumption in most publications that discuss structural features depicted on the ships of both Sahure's[4] and Hatshepsut's reliefs.[5] Concerning Sahure's twelve Mediterranean ships, Cheryl Ward has observed that they have "fine details of rigging, hull construction, cargo, and passengers."[6] It has been argued that details of the fish, plants, and people depicted in Hatshepsut's Punt reliefs are so accurate that an artist or artists must have voyaged to Punt. If so, depictions of ships should likewise be accurate, possibly being the product of eyewitnesses.[7] Ward describes the depictions of Hatshepsut's ten Punt ships at Deir el-Bahri as showing "consistency in dimensions for steering oar blades, beam ends, oar looms, beam spacing, and crutch height [when compared] with finds [of actual ship remains] from Gawasis."[8] Finally, her full-scale interpretation of a Punt ship, which underwent a successful sea trial, has structural features drawn from these reliefs.[9]

Among Nilotic working boats, only Hatshepsut's obelisk carrier has undergone the same degree of examination as these ships; the main point of contention regarding this vessel has been its length rather than its structural features.[10] It has been the tacit assumption of both Lionel Casson and Bjorn Landström, in their analyses of other working boat imagery, that Nile river craft reflect a degree of accuracy similar to that of the Punt ships.[11]

Egyptian artists depict structural details on ships and boats that are consistent with a vessel's function and known contemporary building techniques.[12] For example, the recently discovered reliefs of Sahure's royal sailboats are nearly identical to the Khufu I vessel, including the small lashing covers at bow and stern used to secure hood-ends that support the papyriform decorations.[13]

Most Egyptians lived near the Nile and probably saw various types of boats every day: the most common conveyance for travel was by boat.[14] A naval yard for the repair and construction of ships

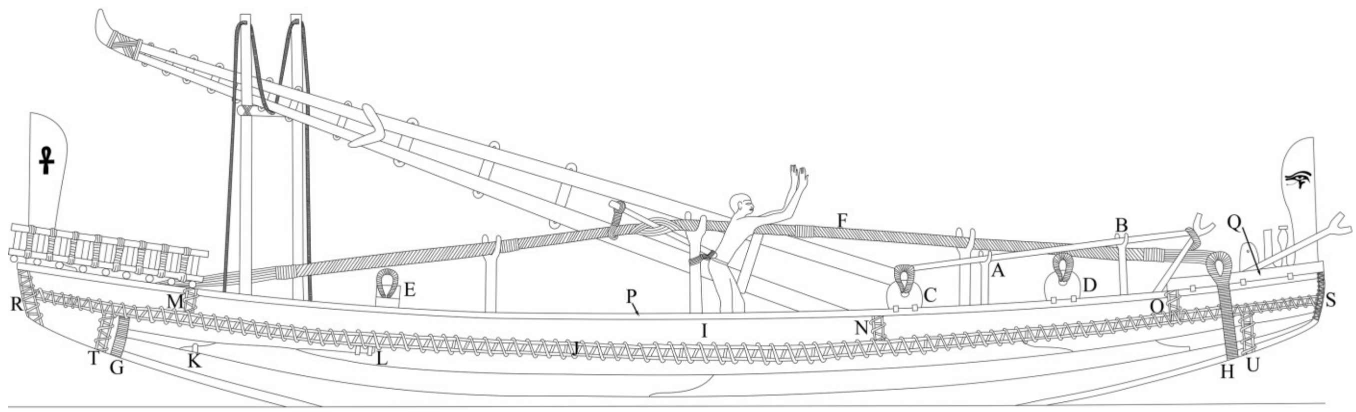

Figure 1: Reconstruction of a Mediterranean ship (after Borchardt, *Das Grabdenkmal des Königs Sahu-re* II [1913], pls 11–12 and photographs from the University of Chicago, Oriental Institute, B 567–571)

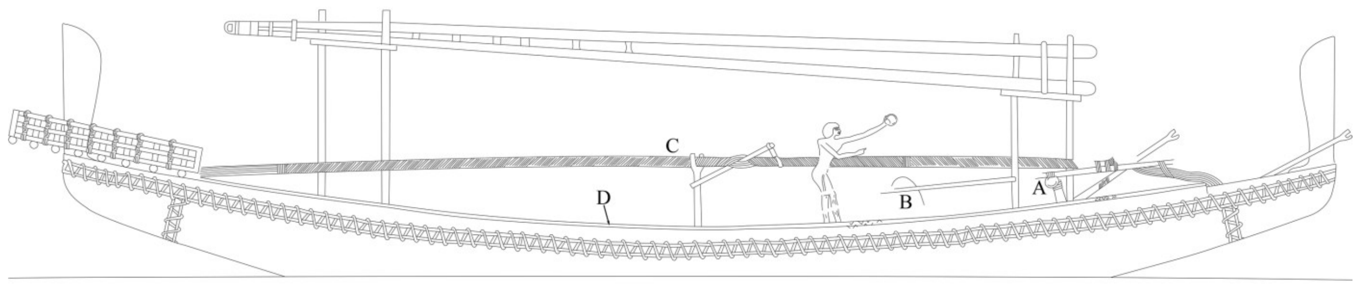

Figure 2: Reconstruction of a Punt ship (after El Awady, *Abusir XVI*: *Sahure—The Pyramid Causeway*: *History and Decoration Program in the Old Kingdom* [2009], pl. 5)

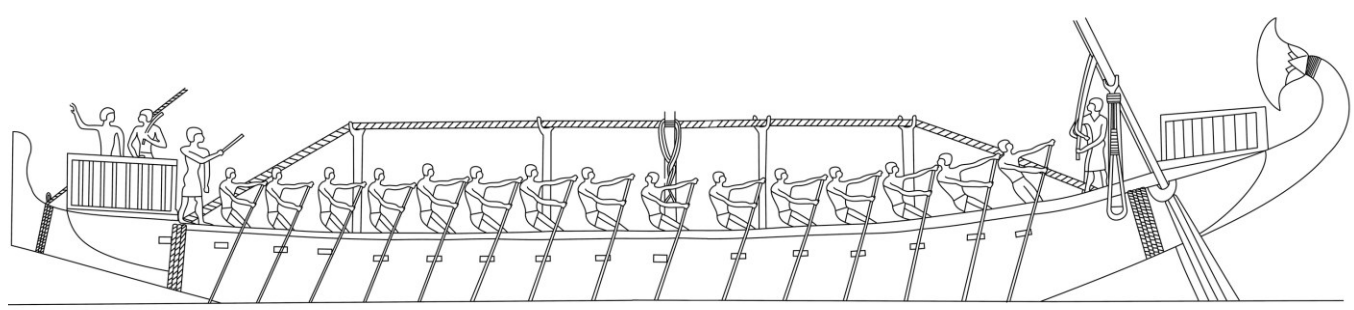

Figure 3: Hatshepsut's Punt ship (after Naville, *The Temple of Deir el Bahri* III [1898], pl. 73)

was located near Memphis.[15] Furthermore, as discussed below, it appears that Egyptians sailed Mediterranean and Red Sea ships on the Nile to celebrate a successful voyage. Ships sailing on the Nile appear to have been a common sight. For these reasons, the depictions of all vessels discussed below can be fairly assumed to be reasonably accurate representations of contemporary vessels. However, it must not be forgotten that they are artistic representations created for religious purposes within the confines of an artistic canon, not scaled ship drawings for use by shipwrights.

Conditions of the Reliefs and Reconstructions

All depictions of Sahure's Mediterranean and Punt ships are incomplete. Even the best preserved depiction of a Mediterranean ship lacks many details. Fragmentary depictions of twelve Mediterranean ships survive; two of these retain many features, visible in the published epigraphic drawings.[16] The large number of samples is important because details can be lost due to wear: it should be remembered that paint, which has commonly worn away, would have provided corrections and additional details to the carved relief. Furthermore, while Egyptian artists have been known to omit details, there is no recognized evidence that they added details that did not exist.[17]

Being able to compare structural details from photographs and epigraphic drawings of such a large number of depictions allows for a more accurate reconstruction of the representation of a Mediterranean ship (Figure 1). To create my composite reconstruction I worked from the assumption that any structural detail that appeared on one ship would have been standard on all. I have also reversed the orientation of the Mediterranean ship to facilitate comparison with the Punt vessel.

Only two depictions of Sahure's Red Sea ships survive, but one is in excellent condition except for the top of the mast, the aft end of the hogging truss, and the stern fence, which were either missing or in poor condition. These features survived on the second ship, so I traced and added them to my rendition of the first (Figure 2).[18] I omitted the oars and rudders of Sahure's ships to make it easier to see structural details and for the same reason omitted all passengers and crew except for one individual amidships. The only features that I added were obvious ones, such as hatching patterns for cables and sections of lines and cables that had been partially hidden by people or objects. Where any uncertainty exists, I left a blank space.

Finally, the drawing of Hatshepsut's ship was traced from a large and detailed drawing published in Edouard Naville's publication of Deir el Bahri (Figure 3).[19] To avoid confusion, my tracing removes overlapping vessels.

Length and Depth of the Vessels

The original depictions of both types of Sahure's ships are slightly longer than a meter. Mediterranean ships are stated to be 106 cm long, while the best preserved Punt ship is smaller, 102.4 cm from bow to aft end of stern fence.[20] A difference of 3.6 cm in such large reliefs is probably not significant. For this reason, I scaled both vessels to the same length from the forward edge of the bow to the aft end of the stern fence to facilitate comparison of their features. After doing this, I overlaid the drawings. This revealed that the Punt ship's hull is shallower by two plank widths amidships and is also shorter (Figure 4).

Stern Fence

Stern fences are approximately the same length and height for both ship types. In each case they consist of nine slats, each with a corresponding circular object below it. Between each slat is lashing with similar spacing. On the Mediterranean ship, only one slat and its associated circle extend abaft the hull, while over a third of the fence on the Punt ship does so (*cf*. Figures 1–2, 4).

It has been proposed that this fence was a ladder,[21] but a shallower hull should require and thus be outfitted with a shorter ladder. Furthermore, what purpose would the circular elements serve on a ladder, and why would the Punt "ladder" have an additional longitudinal element in the middle? Instead, the circles appear to represent spheres or knobs used as thole-pins for quarter rudders.[22] On one of Sahure's Mediterranean ships, deployed rudders are clearly depicted attached to these spheres with grommets (lines that secure rudders to thole pins while still allowing them to rotate).[23]

If this is so, it may explain the extra longitudinal element on the Punt ship's fence. The hull of the Mediterranean ship would support the weight and absorb most of the stress of a deployed rudder. On a Punt ship, however, the fence extending beyond the stern would have to carry the weight and absorb the stress from the rudders mounted on it, thus requiring additional reinforcement. This outboard extension would have allowed the shorter hull of a Punt ship to accommodate the same number of helmsmen as a Mediterranean ship. This would seem to indicate a desire to minimize the length and weight of the hull of a Punt ship.

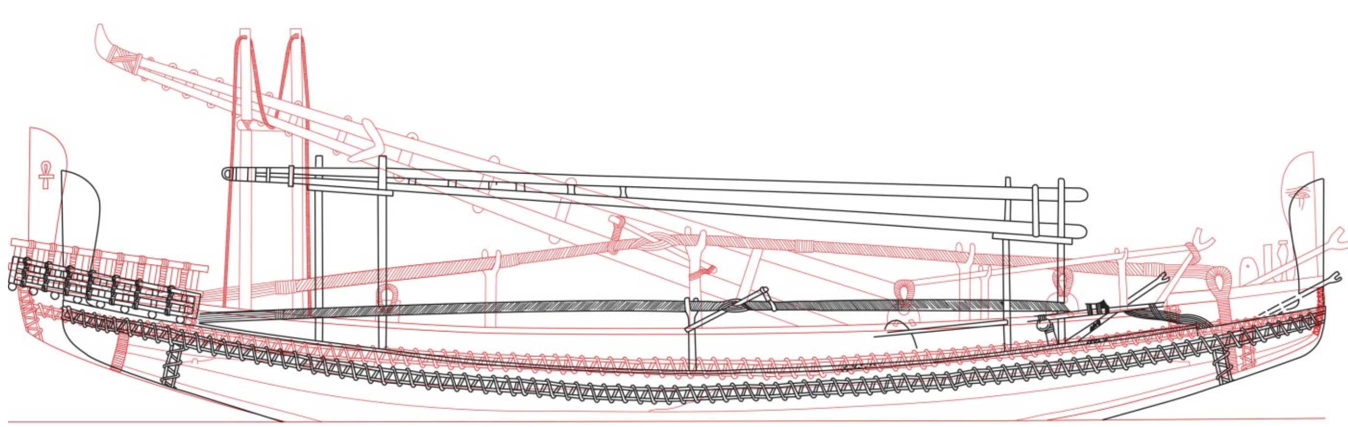

Figure 4: Sauhre's Punt ship in black overlaid on his Mediterranean ship in red

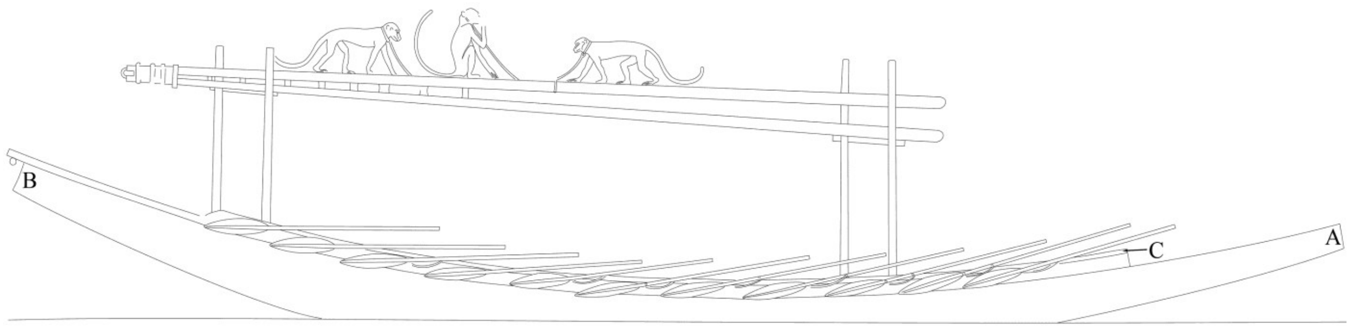

Figure 5: River boat (after El Awady, *Abusir XVI*: *Sahure—The Pyramid Causeway*: *History and Decoration Program in the Old Kingdom* [2009], pl. 5)

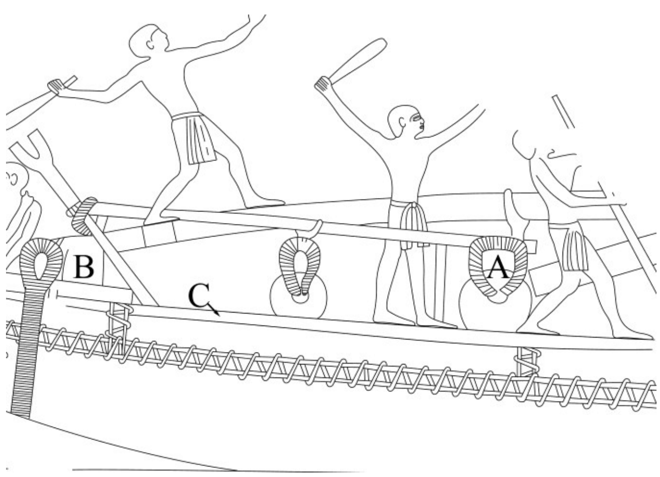

Figure 6: Forward section with crew on a Mediterranean ship (after Borchardt, *Das Grabdenkmal des Königs Sahu-re* II [1913], pl. 11)

Masts

Another indicator of the smaller size of Punt ships is the type of bipod mast (*cf*. Figures 1–2). The mast on the Punt ship is the same type depicted on Nile boats (*cf*. Figures 2, 5). It was so light that both ends could be stowed on raised supports or gallows without making a vessel top-heavy. In contrast, the mast of the Mediterranean ship is only tilted out of place, so that just the top is stowed in a gallows; a hole is cut near the top of each gallows post to take a cable to help raise and lower the mast (Figure 1),[24] mechanical aid evidently unneeded for the Punt ship's.

The greater weight of the Mediterranean mast is also indicated by its construction. Not only do its timbers appear to be heavier but it also has more cross braces, extending through both legs, and each brace has holes to take shrouds (lines used to support a mast). In contrast, for Punt ships and Nile boats the cross braces on masts do not extend through the legs and shrouds are fastened by other means. The mast on Mediterranean ships has a longer, curved top reinforced with numerous lashings to resist greater stresses, while the top of the mast on Punt ships is smaller and, like the masts of Nile boats, lacks evidence of additional fastening. Finally, the mast on Mediterranean ships has a U-shaped support lashed to both legs, a feature lacking on the Punt ship masts. All data are consistent with Mediterranean ships carrying heavier mast and sail than did their Punt counterparts.

Masts outfitted on Nile boats were designed to take advantage of the relatively constant north winds. In contrast, on the Red Sea a sail had to withstand "notorious" winds, gales, and sand storms, which sometimes struck while sailing in brown seas that hid reefs from view. These conditions have been described as "treacherous."[25] To outfit a ship with such a light mast and rig that was designed for use on the Nile then sail it on a long voyage in such waters, which furthermore lacked harbors where major repairs could be made, are indications Egyptian shipwrights were willing to take risks to minimize weight.

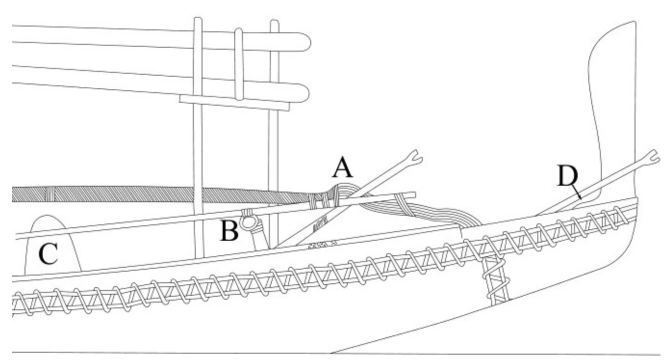

Figure 7: Reconstruction of the bow of Sahure's Punt ship (after El Awady, *Abusir XVI*: *Sahure—The Pyramid Causeway*: *History and Decoration Program in the Old Kingdom* [2009], pl. 5)

It should be noted that Tarek El Awady proposed that the vessel depicted in Figure 5 is a small Punt ship, while the ship in Figure 2 is a large Punt ship; since both had just returned from Punt, he also believes they are sailing on the Red Sea.[26] The vessel in Figure 5 lacks any structural characteristics of a ship, regardless of size: instead, all details are consistent with standard Nile boats of the Fourth and Fifth Dynasties.[27] Furthermore, everyone

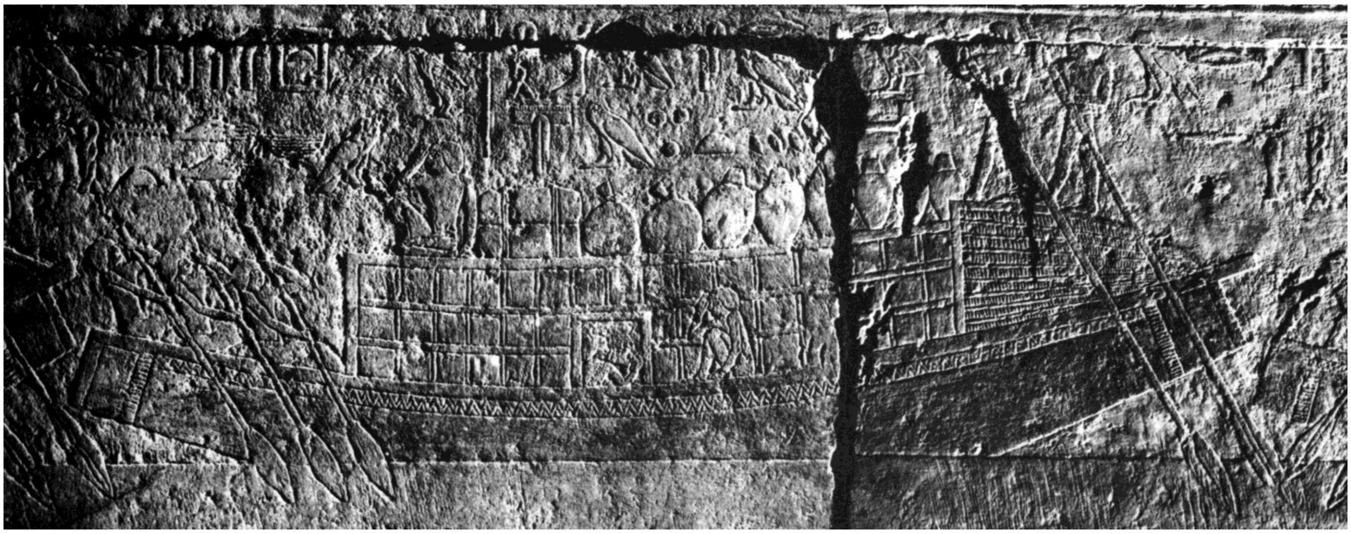

Figure 8: Nile cargo boat with external hull lashings (from Miroslav Verner, *Abusir*: *The Mastaba of Ptahshepses* [Prague: Charles University, 1977], pl. 10, pg. 187. With kind permission of the Czech Institute of Egyptology)

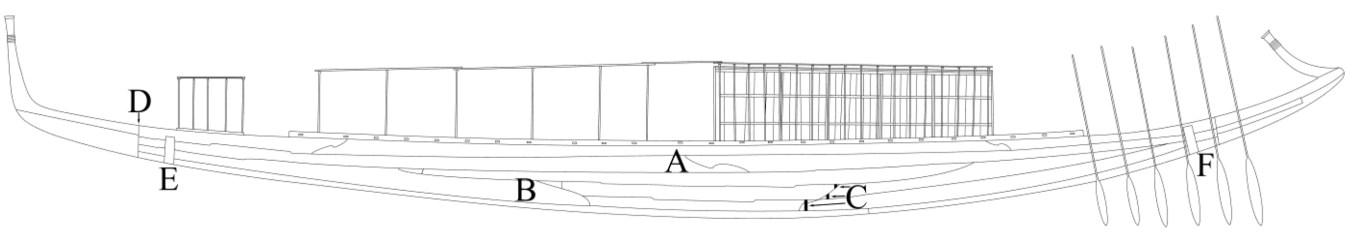

Figure 9: Profile drawing of the Khufu I vessel (not to scale, after an unpublished photograph from the Paul Lipke Collection and photograph 31 from the vessel section of the Paul Lipke Collection)

aboard both Punt ships are bowing to the king, who is standing above them tending to a tree from Punt.[28] Thus, this scene is consistent with a formal celebration taking place on the Nile. A similar celebration of a returning fleet is depicted of six Mediterranean ships with crews and passengers bowing to Sahure.[29] This celebration must have taken place on the Nile.

Forked Poles and Objects with Looped Cables

Forward of both masts are two poles. On Mediterranean ships, both are lashed together near the forward ends, and the shorter one is forked. The longest pole rests in two forked stanchions (Figure 1 A, B), and below it are two structures consisting of a curved body pierced by a hole through which runs a looped cable. Both objects (Figure 1 C, D) appear to have been mounted on and fastened to a caprail (Figure 1 P). The forwardmost loop (D) does not appear to be attached to anything, while the aft loop (C) is wider and flatter. The pole terminates either at this aft loop or slightly aft of it (*cf*. Figures 1 C; 6 A), suggesting the pole was lashed here. Also mounted on the caprail near the stern is a rectangular object with a looped cable (Figure 1 E). A similar structure may have been located at the bow directly below the lashing that ties the two poles together, but the only depiction of it, if it existed, is badly damaged (Figure 6 B).

The Punt ship has similar devices, which appear in my reconstruction (*cf*. Figures 2, 7). The forked pole has a similar orientation but is lashed between the hogging truss and a second pole (Figures 2, 7 A). The aft end of the second pole is lashed to a circular loop at the end of a heavy cable (Figures 2 A; 7 B). Heavy cables may also have been laced through this loop and tied off to one leg of a mast when it was stepped. Because the loop is located at about the same place as the forward curved object with a loop on the Mediterranean ship, it could also have had the same function (Figures 1 D; 2 A, 4).

Whether this second pole had a fork at the forward end is unknown because it is blocked from view. Aft of this pole on the Punt ship is a third pole running outboard of a curved object (Figure 2 B, 7 C). The shape and location of the curved object is consistent with it having the same function as the aft curved object with a loop seen on Mediterranean ships, but on the Punt ship depiction of the lashings did not survive (Figures 1 C; 2 B; 4; 7 C). The purpose of this third pole is not clear. Considering the similarities of all these structures to those on the Mediterranean ship and the orientation of this object, this "third" pole is probably part of the Punt ship's long (unforked) pole (Figure 7).

Despite a number of proposed explanations for these devices on the Mediterranean ship, their purpose remains unclear. The only agreement is that they facilitated the raising and lowering of a mast.[30] All elements on the Punt ship appear to have been fixed in place; presumably the same was true for the corresponding elements on the Mediterranean ship. The only hypothesis consistent with this observation is that lines tied to the mast were run through the fork in the pole and then pulled aft. This redirection of effort (akin to a sheaveless block) would allow more men to participate in the mast-raising, after which lines would be tied to the looped objects on the caprail.[31]

Regardless of the specifics of operation, the Punt ship has fewer wooden elements, relying instead on more lashings and cables. This suggests a smaller and lighter ship.

Hogging Trusses

Each ship has a long, heavy cable extending nearly the length of each vessel (Figures 1 F; 2 C). This cable, known as a hogging truss, is a primary structural element that gave longitudinal strength to what is typically described as a weakly constructed hull.[32] Tension was regulated by twisting the rod near the middle of a cable. If this cable parted, structural failure of the hull would probably follow quite rapidly. It is therefore significant that Egyptian shipwrights lashed the previously discussed forked pole on Punt ships to it (Figure 7 A). Every use of this forked pole—regardless of its function—would pull against and chafe this cable; over time this could fray and weaken a truss. In contrast, these two elements are separate on Mediterranean ships (Figure 1). Use of a hogging truss to secure the forked post in this manner may have been another calculated risk taken by shipwrights, conveying the idea of the critical importance of keeping weight to a minimum on Punt ships. Notably, a hogging truss on a Punt ship required only one stanchion to support it, as opposed to three on a Mediterranean ship.[33]

Heavy cables wrap around the exterior of a Mediterranean ship's bow and stern (*cf*. Figures 1 G, H, 2). Large loops at the end of this bow cable may have taken a lateral timber to which a hogging truss was tied.[34] In contrast, the corresponding stern cable appears to pass through a slot cut between the bulwark (side planking above a main deck) (Figure 1 I) and sheerstrake (a continuous run of planking from bow to stern below a main deck) (Figure 1 I).[35] This stern cable must have been tied off inside the hull, possibly to a crossbeam. This configuration was necessary because the presence of large external loops at the stern would interfere with the operation and placement of quarter rudders. These cables may also have reinforced a hull at the extremities. Similar cables are depicted on a Nile boat from the mastaba of Ptahshepses (Figure 8), which dates to the reign of Nyuserre (*c*. 2445–2421).[36] This work boat is outfitted with such bow and stern cables but lacks a hogging truss.

The Punt ship's lack of these external cables suggests that its hogging truss was tied directly to crossbeams. Their absence also may be evidence that the hull did not need additional reinforcement, perhaps because it was smaller and lighter than that of the Mediterranean ship.

Exterior Transverse Lashings Securing Scarfs

Exterior lashings depicted on Sahure's ships have been cited as unique, and a number of theories have been proposed to explain them.[37] To better understand their various functions, it is necessary to study the Khufu I vessel. J. R. Steffy proposed that structural elements found within the Khufu I vessel reflect "what must have been standard maritime technology in ancient Egypt,"[38] and indeed features appearing on Sahure's Mediterranean ships are consistent with structural elements found on the Khufu I vessel.[39] These propositions, along with new data from Sahure's Punt ships relief, substantiate some interpretations and allow for new ones.

Much of the hull strength in the Khufu I vessel comes from the use of cedar planks that are long, wide, and thick. Excluding the decorative ends and associated support timbers, the hull is 34.5 m long,[40] with hull planks ranging in length from 7 to 23 m.[41] The ends of these planks are joined with long, curving scarfs that, although wasteful of wood, produce stronger joints (Figure 9). One of Sahure's ships is depicted with hull planking that is very long and features scarfs similar to those on the Khufu I vessel. Hull planks on the Khufu I vessel are edge-joined with mortise-and-tenon joints (Figure 10 A) and secured with transverse lashings (Figure 10 B).[42] At the ends of some long scarfs that are very narrow, lashings protrude through the hull to reinforce them (Figures 9 C, 10 C).[43] Notches were cut into the exterior surface of these planks so that the lashings would lay flush with the hull (Figure 10 C).[44] With some external lashings being well below the waterline on the Khufu I vessel (Figure 9 C, 10 C), Egyptian boatwrights must have perfected a technique of effectively sealing a hull. On Sahure's ships, the ends of some scarfs have rectangles drawn across them (Figure 1 K, L). These are consistent to the appearance of the external transverse lashings used on the Khufu I vessel,[45] but these external lashings appear to be *above* the waterline.

The only advantage to using this lashing system is that it allowed a vessel to be broken down and rebuilt rather easily. These observations support the contention that Sahure's ships were built using the same techniques as the Khufu I vessel.[46]

Highest Vertical Lashings, Bulwarks, and Caprails

On Sahure's ships, a bulwark was added to hull planking (Figures 1 I, 2),[47] probably secured with the same fastening system used for the hull planking on the Khufu I vessel. A bulwark would add some longitudinal strength to a hull, but this does not appear to have been its primary function.

At deck level, hull planks on the Khufu I vessel are joined with crossbeams that are fitted into small notches and lashed in place (Figures 10 D, 11). Crossbeams are reinforced with three heavy

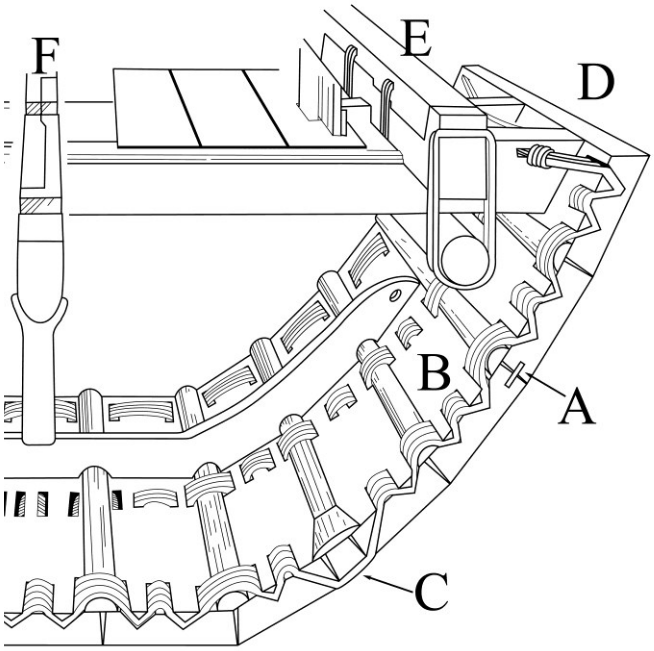

Figure 10: Half-breadth view amidships of the Khufu I vessel (not to scale, after Lipke, *The Royal Ship* [1984], figs 48, 56 and from the Paul Lipke Collection Interior photographs 7 and 12 by Sherri Moore, vessel photograph 31 by Paul Lipke, and Drawings 39–41 by Hag Ahmed Youssef Moustafa)

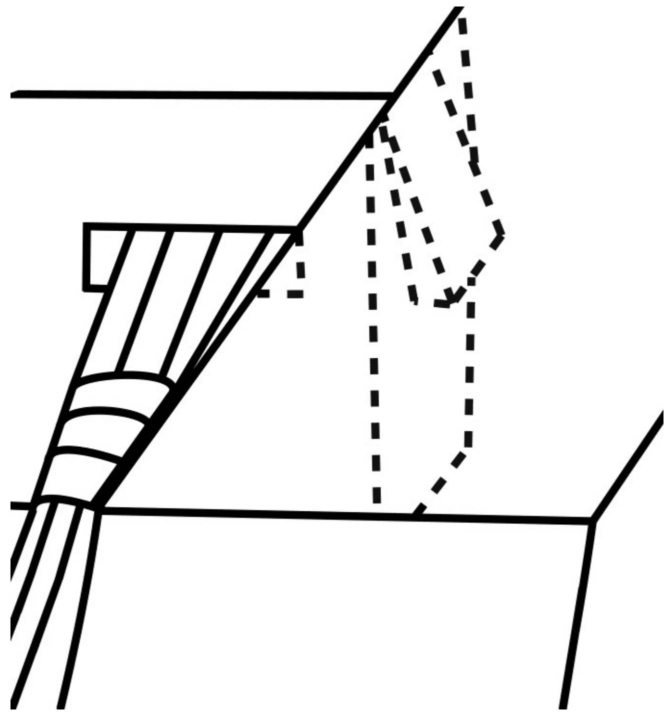

Figure 11: Sketch of notched crossbeam on the Khufu I boat (not to scale, after Lipke [1984], fig. 11).

longitudinal girders that are *c.* 26 m long,[48] or about 75% of the length of the hull. Two are side-girders (Figure 10 E) and one is a central-girder (Figure 10 F). All are notched to fit crossbeams,[49] and each consists of two pieces joined with hook scarfs. However, the hook scarf joining the side-girders is a horizontal hook scarf (that is, cut from side to side) (Figure 10 E), while the central-girder has a vertical hook scarf (cut from top to bottom) (Figure 10 F). The former was designed to resist longitudinal forces; the latter, lateral forces.[50] Thus, some of the greatest stresses on this hull were concentrated at deck level: crossbeams and longitudinal girders were primary structural timbers in this type of construction.[51] Because these stresses would be considerably greater at sea, these elements would require more and larger fasteners to secure and reinforce them in a ship hull.[52] The central-girder may have extended the length of a ship.[53]

Side-girders are such important structural elements that if they were replaced with bulwarks, then the same type of scarfs and lashings used to join and secure side-girders would be required to join and secure planks of a bulwark (Figures 1 K, L; 10 E; *cf.* the scarfs that join the hull planking in the Khufu boat, Figure 9 A, B).[54] However, no evidence exists for long, rolling scarfs on the bulwark (Figure 1 M, N, O). The builders probably instead employed a weaker butt joint, which consists of one straight cut (see Figure 9 D).[55] Butt joints were then lashed together (Figures 1 M, N, O). The parallel lines of these lashings pierced the planks: once the parallel lines were laced through holes, tightened, and then lashed, an external diagonal line, which did not pierce the planks, was wrapped around them and tightened. This allowed greater tension to be applied to the parallel lines. Where details in the relief survive, the diagonal lines are clearly shown to wrap around the parallel ones.[56]

Neither scarfs nor lashings appear on bulwarks of Punt ships, probably because either these ships were so small that a bulwark could be fashioned from a single timber or butt joints could be secured with standard internal lashings, such as those used on the Khufu I vessel (Figures 1, 2). This again is consistent with a smaller and lighter ship.

Given the evidence of their relative structural weakness, bulwarks more likely structurally complemented rather than replaced side-girders. If ships had been outfitted with bulwarks strong enough to replace side-girders, such bulwarks would have also replaced side-girders on Nile boats, especially considering the amount of deck space lost when using side-girders (Figure 10). The primary function of a bulwark on Sahure's ships was, rather, to raise the height of a hull and to help keep out seawater.

Furthermore, what appears to be a caprail is fitted on bulwarks on both ship types (Figures 1 P, 2 D, 6 C). A caprail is typically a relatively narrow timber covering the tops of frames, the upper edge of a bulwark, or both. On Sahure's Mediterranean ships, however, caprails are very wide and appear to span the space between side-girder and bulwark. The space between sheerstrake and side-girder on the Khufu I vessel is *c.* 40 cm wide.[57] By covering this space, it kept out seawater while adding work space. This caprail is so wide that sailors on Sahure's Mediterranean ships typically rowed and signaled while standing on it instead of on deck (Figure 6). In contrast, rowers depicted on Sahure's Nile boats[58] and on Hatshepsut's New Kingdom Punt ships (Figure 4), for example, stand on deck when rowing. Furthermore, if Sahure's Mediterranean ships were outfitted with a standard caprail, it would have been fitted on top of the additional bulwark plank at the bow. Instead, this caprail sits below the bow plank (Figures 1 Q, 6 B).

Finally, if this caprail indicates the length of the side-girder, then on Mediterranean ships side-girders extended the length of a vessel, while on Punt ships they extended only between bow and stern decks. This would be similar to the arrangement of the Khufu I vessel, suggesting these ships were smaller and lighter than their Mediterranean counterparts.

Longitudinal Hull Lashings

Both ship types have, running from bow to stern (Figures 1 J, 2), longitudinal hull lashings identical to the vertical lashings on bulwarks. Thus, they were probably mounted in the same way. Such lashings added longitudinal support,[59] but if this was their sole function, one heavy cable (*cf.* the hogging truss) would have been more effective. As previously mentioned, crossbeams were primary structural elements, and these three lines appear to be at the same level as crossbeams along the length of a hull.[60] According to Casson, they "probably served to keep the planking there from starting under the pressure exerted by the deck beams."[61] Images of Fourth and Fifth Dynasty Nilotic work boats prior to the reign of Unas support this interpretation. Work boats that appear to be carrying the heaviest cargoes on deck are outfitted with this same configuration of lines at the same location on a hull (Figure 8). These three lines were probably used to tie crossbeams more securely to the hull planking.

Vertical Lashings at Bow and Stern and Blade-Shaped Objects

At the extremities of Mediterranean—but not Red Sea—hulls are vertical lashings (Figure 1 R, S). Typically, ends of strakes (rows of hull planks) are fastened to vertical timbers called a stem (at the forward end) and a stern post, producing a stronger and more rigid structure. It does not appear that Egyptian boatwrights used such posts by Khufu's time[62] or that shipwrights had developed them by the reign of Sahure, because, as Landström pointed out, the large, blade-shaped elements at the bow and stern are set inside the hull planking and must have another function.[63] It appears that these external lashings and probably mortise-and-tenon joints were the primary fasteners tying hull planking together on Mediterranean ships. If this was so, the iconography of Punt ship suggests that it required only internal lashings with its mortise-and-tenon joints, perhaps because its lighter hull did not require external ones.

On Mediterranean ships these blade-shaped objects (henceforth referred to as "blades") are decorated with an *udjat* sign at the bow and an *ankh* sign at the stern; the former also appears on Sahure's royal sailboat.[64] During the Old Kingdom these blades were outfitted on ships and Nile stone carriers,[65] the hulls under the most stress. There also appears to be a correlation between loads carried and the number of blades. Stone carriers with a cargo of one sarcophagus and lid, as well as the previously discussed ships, are outfitted with one at bow and stern.[66] Unas's stone carrier, which has a cargo of two stone columns, is outfitted with three blades at bow and stern,[67] suggesting that these blades were structural timbers.

The blade at the bow of Sahure's Punt ship has a wide base (Figures 2, 7 D). Since all other blades on Mediterranean and Punt ships have the same shape and the bases are hidden by structural features, all probably had the same type of base. Only three interpretations of its actual configuration are possible. The first is a standing knee, a naturally curving, L-shaped timber (Figure 12 A). This seems unlikely because the shorter horizontal arm is too short to support the long and wide vertical arm that rises above the hull planking, and there is too little hull planking to secure it, let alone contribute to the structural integrity of a hull. Furthermore, a central-girder would have to support the full weight of a blade of this configuration, which would either weaken a hull or require a larger girder.

Instead, shipwrights may have taken a log with a protruding branch and crafted the outboard face to fit the curvature of a hull, while the branch would be shaped as a base (Figure 12 B). A timber

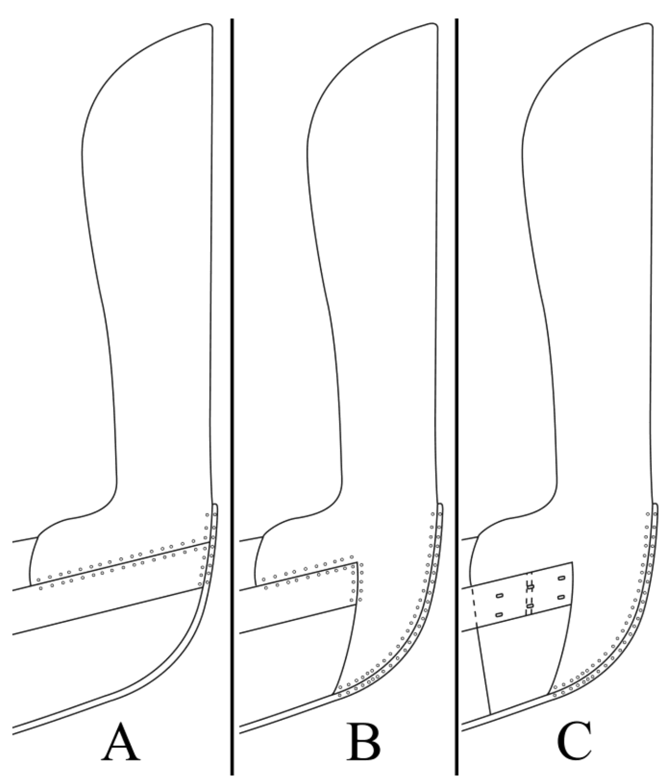

Figure 12: Three proposed blade configurations for Sahure's Punt ship

of this form would reinforce hull planking and tie planking to a central-girder.

A third possibility is that the lower arm is instead a wide base, extending to the bottom of a hull (Figure 12 C). The outboard edge would have been crafted and secured as previously described, while the inboard edge would be thinned to take a central-girder: Shipwrights would carve a vertical hook scarf into the wide base of a blade and a corresponding scarf into the end of the central-girder, and as previously noted, the two timbers making up the central-girder on the Khufu I vessel were joined with a vertical hook scarf (Figure 10 F). This arrangement would greatly strengthen the ends of a hull lacking a stem and stern post. Either of these last two configurations (Figure 12 B, C) would produce a stronger hull. On Mediterranean ships the external vertical lashings may have extended through the hull planking and the outboard edge of this timber, adding additional support (Figure 1 R, S).

The purpose of the vertical lashings extending below longitudinal lashings on both ships (Figures 1 T, U, 2) is not clear. They are, however, identical to the previously discussed lashings and must have been mounted in the same manner. Like the other lashings, they may have been added as additional reinforcement for the hull planking. However, two other possibilities exist.

Two-dimensional iconography and models suggest that the most common boat type of the Fifth Dynasty had a flat bow and stern (Figures 5 A, B; 8) tied together with a flat transom.[68] During the Fourth and Fifth Dynasty this may have been the basic hull shape from which all other vessel types were adapted. For example, Figure 13 shows the bow timbers of the Khufu I vessel: if all timbers were cut off at A and joined with a flat transom, the resulting vessel would be similar in profile to the Nile boat in Figure 5. A transom was probably fixed in place with a combination of mortise-and-tenon joints and internal lashings, as were other structural elements on the Khufu I vessel. Port side edges of bow and stern transoms appear to be depicted on the river boat in Figure 8.

When Egyptians extended the hull of royal vessels to make them finer and to mount decorations, they omitted this transom and extended the bottom plank. On it they fitted timbers called hood-ends or backing-timbers (Figure 13 B). A hood-end on the Khufu I vessel is a timber that was as thick as but wider at the inboard end than most hull planks, but it becomes progressively narrower and thinner away from the hull. The inboard ends were notched and fitted to the bottom plank, while the top edge was crafted with a deep bevel in which was fitted the lower edge of a sheerstrake (Figure 13 B). All of these timbers were fastened together with a combination of mortise-and-tenon joints and lashings. The butt joint was under considerable stress, thus requiring additional lashings that penetrated the hull (Figure 13 B, C, D). These and lashings at the end of scarfs are the only ones that protrude outside the hull of the Khufu I vessel. The former cannot be seen because they are laced through wooden lashing covers (Figure 9 E, F).[69] These covers are in roughly the same location as the lower vertical lashings on both of Sahure's ships

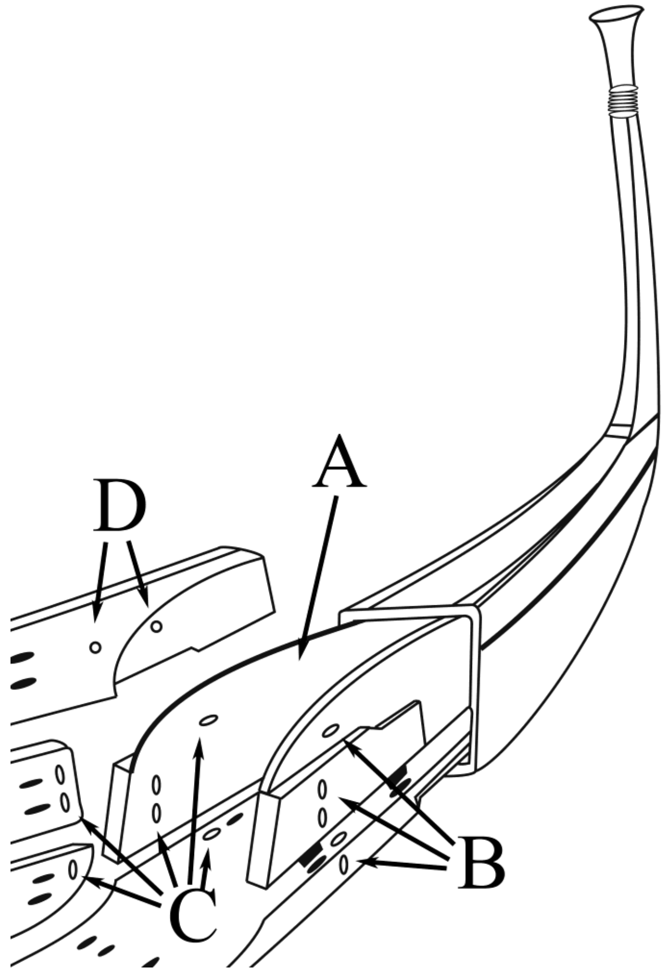

Figure 13: Bow construction of the Khufu I vessel (not to scale, after Drawing 9 by Paul Lipke and Drawings 2, 4–5 by Hag Ahmed Youssef Moustafa from the Paul Lipke Collection)

(Figures 1 T, U; 2; 9 E, F).

This interpretation is consistent with the construction of the Khufu I vessel, but it also appears to be the least structurally sound interpretation. Egyptian boatwrights designed hood-ends as a base for a decoration that had to be as light as possible on the ends of very fine vessels. These hood-ends did not structurally reinforce a hull: integrating such short timbers into the ends of ships would produce a weaker hull. Furthermore, this would be inconsistent with the depiction of hull planks on Sahure's ship. The forward hull strakes appear to extend through the vertical bow lashings to the bow of the ship (Figure 1).

A second possibility is that these lashings did not join scarfs. Since they are in roughly the same location as we would expect a flat transom on a Nile boat, they may be external lashings of a transom that was retained and converted into an internal bulkhead. Such a structure would both reinforce the hull planking at a weak location and give additional support to a central-girder.

Regardless of the correct interpretation, these exterior lashings and blades appear to have been needed to tie the ends of

Egyptian ships together in the absence of a fully developed stem and stern post.

Changes in Ship Construction

All of the features just discussed convey the impression that Punt ships during the reign of Sahure were smaller and lighter versions of Mediterranean ships and that shipwrights took calculated risks when designing and building these ships to keep weight to a minimum. This raises the question of why.

Why did the Egyptians not transport large Mediterranean ships to the Red Sea, allowing larger cargoes to be shipped from Punt? One possible reason is that perhaps, unlike Nile boats and Punt ships, Mediterranean ships were not designed to be broken down and rebuilt. [70] This seems unlikely because, as previously discussed, Mediterranean ships, like their Red Sea counterparts and the Khufu I vessel, possessed structural features that seem to have been designed to allow this very process.

Furthermore, there is the matter of the hogging truss possessed by Sahure's ships. The most common explanation for the use of this device on Egyptian ships is that it compensated for a flat bottom, no keel, and a lack of internal framing timbers.[71] This interpretation is an oversimplification, because vessels with these features can be seaworthy without a hogging truss.[72]

At least as early as Khufu's time, Egyptian shipwrights understood the structural advantages of building hulls with thick, heavy planking. On the Khufu I vessel, planking thicknesses range from 12 to 15 cm,[73] while the three bottom planks vary in widths in the range of *c.* 55–70 cm.[74] The remains of Middle Kingdom hull planks found at Mersa/Wadi Gawasis on the Red Sea have thicknesses of 6.5–22.5 cm,[75] and a contemporary site at Ayn Soukhna, also on the Red Sea, has yielded hull planks 10 cm thick and 30 cm wide from two ships estimated to be 14–15 m long.[76]

Egyptian boatwrights had developed the bulkhead at least as early as the Middle Kingdom and, as previously discussed, possibly sooner. Timbers from a vessel found at Lisht (*c.* 1950 BCE) appear to have been pieces of a bulkhead designed to secure a large longitudinal timber (Figure 14).[77] An advantage to using bulkheads to replace or supplement the large single-piece frames seen on the Khufu I vessel would be ease of transport: bulkheads could be disassembled (*cf.* Figures 10, 14).

The Middle Kingdom *Tale of the Shipwrecked Sailor* describes a Punt ship as being 120 cubits (*c.* 62 m) long and 40 cubits (*c.* 21 m) at the beam,[78] giving a length-to-breadth ratio of 3:1. This indicates a beamy, slow-sailing ship. The advantage of such a design is greater cargo capacity compared to a ship with a longer, narrower, and therefore faster, hull. If only one voyage could be completed in a sailing season, even in the fastest Egyptian ship, the most efficient strategy would be to send ships designed for larger and heavier cargoes. A ratio of 3:1 would also produce a stronger hull, suggesting that at least as early as the Middle Kingdom, Egyptian shipwrights understood the structural advantages of integrating heavy planking, and bulkheads that secured a large longitudinal timber running from bow to stern into a beamy hull.

Nonetheless, over 400 years later, during the reign of Hatshepsut, Punt ships were still outfitted with a hogging truss (Figure 3). Why did the Egyptians fail to take advantage of these evidently known structural elements to build ships without hogging trusses? Even if shipwrights did use all of these elements, a hogging truss would probably still be needed because Egyptian vessels were designed to be taken apart and rebuilt. For Punt ships this was required to transport them across the Eastern Desert to the Red Sea, but why build Nile boats and Mediterranean ships in this manner?

Wood in ancient Egypt was expensive, especially large timbers for large structures, such as ships, because Egypt lacked trees that could satisfy all its timber needs, especially those of long length.[79] Bureaucrats consequently made great efforts to recycle wood,[80] and an effective method of doing so was to design boats and ships that could be broken down and rebuilt rather easily.[81] This strategy would allow for preventive maintenance not possible on other types of traditional vessel construction. It would extend the life of

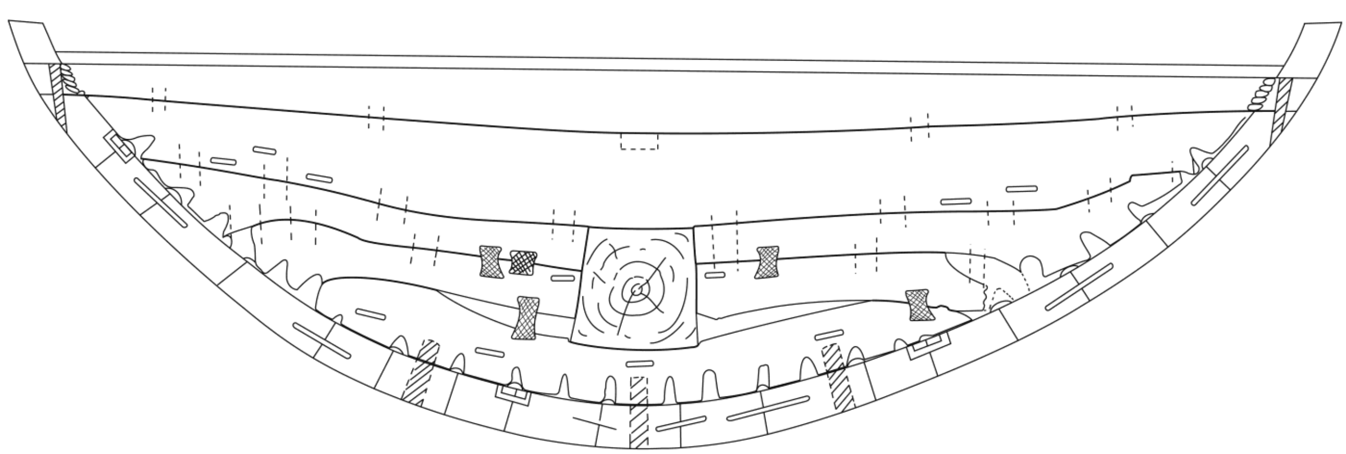

Figure 14: Lisht bulkhead (not to scale, after Ward, *Sacred and Secular: Ancient Egyptian Ships and Boats* (2000), fig. 70)

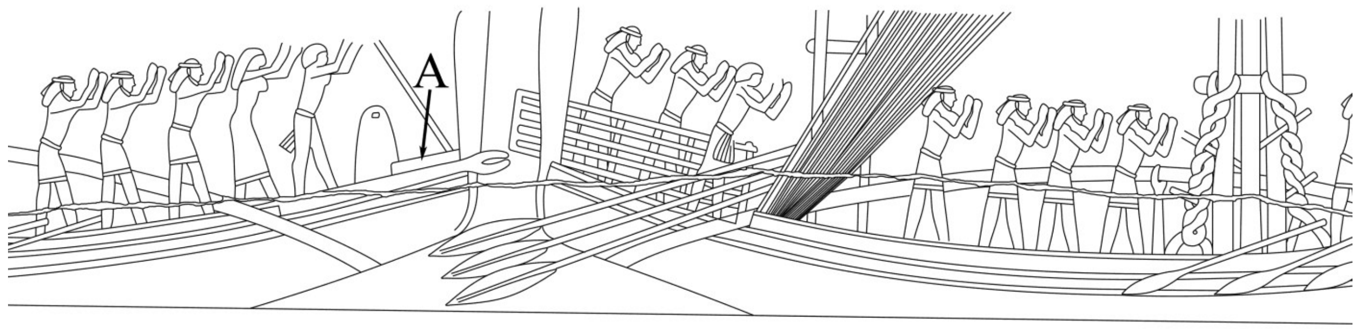

Figure 15: Section of relief depicting Unas' ships (after Hassan, *Zeitschrift für ägyptische Sprachen und Altertumskunde* 80, fig. 2)

not only Egyptian vessels but also individual timbers for later recycling.[82] A drawback to this method of construction is that the fastening system that allowed these vessels to be taken apart and rebuilt produced an inherently weaker hull that required a hogging truss to hold it together.[83] Extant data thus suggest that both Red Sea and Mediterranean ships were designed to be broken down and rebuilt.

If Mediterranean ships could be broken down during Sahure's time, why not sail them on the Red Sea? The likely answer is that the long, wide, and heavy hull planking—as well as the large, one-piece framing—of such vessels was too large and too numerous for practical transport across the desert. A comparison of hull planking and scarfs on the Khufu I vessel with depictions of both on Sahure's Mediterranean ships suggests that Egyptian shipwrights employed long planks as an aid to strengthen hulls. As previously mentioned, the Khufu I vessel without decorations is 34.5 m long, and hull planking ranges in length from 7 to 23 m. The lengths of Sahure's ships are unknown, but if a Mediterranean ship built with the same techniques was only half the length of the Khufu I vessel, *c.* 17 m,[84] hull planks would still be 3.5-11.5 m in length.

It has been proposed, however, that Sahure's Mediterranean ships were considerably larger,[85] and there may be evidence to support this. The Palermo Stone states that Sneferu built four "*dewatowe*-ships" that were 100 cubits (*c.* 52 m) long.[86] If these were seagoing vessels, then the images of Sahure's Mediterranean ships could represent 100-cubit-long *dewatowe*-ships. If so, they would require even larger timbers than did the Khufu I vessel. It should be noted that more than one interpretation exists for a *dewatowe*-ship; according to Dilwyn Jones, it is a royal craft like the Khufu I vessel.[87] Regardless which length is correct, according to Ward, most timbers for Punt ships must have been less than 4 m long because they had to be carried by men and donkeys for over 150 km.[88] If so, it may have been impractical to transport the many large timbers required to build a standard Mediterranean ship across the Eastern Desert. As a result, Egyptian shipwrights designed a smaller, lighter ship by adapting elements from both ships and Nile boats that could be carried to the Red Sea.

By the reign of Hatshepsut, however, the situation appears to have dramatically changed. A comparison of Sahure's ships with Hatshepsut's Punt ships conveys the impression that the latter were not only larger than Sahure's Punt ships but also his Mediterranean ones as well. To judge from the sailors aboard all three ships, Hatshpesut's ships appear larger, especially when the height of sailors is compared to the height of the hogging truss (*cf.* Figures 1–3). On Sahure's Punt ship the truss is above a sailor's waist, while on the Mediterranean ship it is at shoulder height. On Hatshepsut's ship this truss is well above the heads of rowers. However, care must be taken when using humans to estimate scale. For example, the man on Sahure's Mediterranean ship is 16% taller than the man on the Punt ship when both ships are scaled to the same length. Moreover, the higher-ranking individual standing near the bow on Hatshepsut's ship is larger than any of the rowers.

A more reliable indicator may be the hogging truss. As previously stated, on Sahure's Punt ships the hogging truss is supported by only one stanchion and lacks external cables around the hull to secure it, whereas the truss on his Mediterranean ships requires three stanchions and external cables. In contrast, the truss on Hatshepsut's Punt ship required four stanchions for support. All four stanchions are the same height, maintaining the maximum height of this cable over a greater percentage of a hull. The number of stanchions is important because as a truss is tightened and the ends of a ship are pulled up, increasing downward force is applied to a stanchion. Thus, as ships become larger and heavier, more stanchions are required to distribute this force more evenly throughout a hull. The truss on Hatshepusut's ship is also secured with external cables, which Sahure's Punt ship lacks (*cf.* Figures 1–3). All of this suggests that Hatshepsut's Punt ships were larger and heavier than any of Sahure's ships.

Other structural changes are evident when comparing Sahure's and Hatshepsut's ships. For example, on Hatshepsut's, longitudinal lashings have been replaced with through beams,[89] and the short vertical lashings at the ends of Sahure's ships have disappeared, probably because shipwrights now use a stem and stern post. Fixed pole masts on Hatshepsut's ships, which replaced the retractable masts on Sahure's, are expected on larger hulls. By Hatshepsut's time, Egyptian shipwrights appear to have developed techniques that not only allowed them to build larger ships with smaller elements but also to replace lashings with timbers. Weight was obviously less of a concern.

This same technology may be reflected in the earlier Lisht timbers. Ward points out that Middle Kingdom boatwrights used short lengths of timber to build large stone carriers that were able to carry hundreds of tons.[90] Furthermore, Pearce Paul Creasman and Noreen Doyle state that evidence from the Middle Kingdom suggests that for "most watercraft, timbers approaching 4 m in length would probably have been rare."[91] Thus, at least as early as the Middle Kingdom, Egyptians could build large working vessels, possibly including their ships, with shorter timbers, consistent with a need to conserve long lengths of timber.

Iconography may depict some of these structural changes as early as the reign of Unas, the last king of the Fifth Dynasty. From the end of the Fifth Dynasty through the Sixth Dynasty several changes take place to Nilotic vessels. There is a trend of replacing multiple pairs of quarter rudders mounted with grommets with either a single stern rudder or one pair of stanchion-mounted quarter rudders with tillers.[92] High, narrow sails were replaced with short, broad ones.[93] Seán McGrail rightfully describes this time as a "phase of experimentation."[94] A relief from Unas's causeway depicts two ships that have been interpreted as the same type of ship as Sahure's Mediterranean ship (Figure 15), but Unas's ships are rarely discussed because scholars believe they lack the same degree of detail and otherwise suffer due to artistic license or error.[95] However, these difficulties should not exclude them from examination, as they may still contain useful, interpretable information.

The single hogging truss stanchion on Unas's ship implies that it is closer in size to Sahure's Punt ship. Its depiction as an arc running from the bottom of the hull near the bow to the bottom of the hull near stern lacks the detail of any of Sahure's ships, though it has been suggested that it is a stylized representation of the truss on Sahure's Mediterranean vessels.[96] However, this same convention of depiction does appear on one of Sahure's boats being paddled apparently in a race,[97] raising the possibility that it is an accurate representation. Whatever its missing details, the images convey the idea of a truss secured with cables wrapped around the hull, such as discussed previously. But on Sahure's ship, only the bow is so wrapped, whereas the stern end of Unas's is as well (*cf*. Figures 1, 15). This is possible because the end of the hogging truss or cable it is tied to at the stern angles toward the middle of the ship and would not interfere with the placement and use of rudders.

It should also be noted that the stern fence on Unas's ship extends beyond the hull farther than the stern fence on Sahure's Mediterranean ship but not as far aft as the fence on Sahure's Punt ship (*cf*. Figures 1–2; 15), signaling it is smaller than the former but larger than the latter.

There is only one gallows on which to stow what appears to be a tripod mast, which is consistent with a much heavier mast than on Sahure's Punt ships. Another change is the location of the mast. It has been shifted aft, closer to amidships compared to Nile sailboats of the Fifth Dynasty.[98] Such changes would result in a configuration that could carry more weight higher up on a mast and distribute it over a wider area of a hull. Unas's ships may have been outfitted with a shorter sail. This interpretation is supported by depictions of such a type of sail on all Nile boats in the mastaba of Mereruka,[99] who was a vizier to Unas's successor, Teti.

On Unas's ship the mast is secured by shrouds tied off forward of the stern deck. At about this same location on Sahure's Mediterranean ship is the large looped cable fixed to a rectangular base (*cf*. Figures 1 E; 15); this coincidence hints that the looped cable likewise served as a place to tie off shrouds. The lack of this element on Sahure's Punt ship may indicate that shrouds were tied off as on Unas's ship, and it also suggests that the forwardmost looped cable mounted in a curved object on Sahure's Mediterranean ship was also used to tie off lines (Figures 1 D; 15). Port and starboard legs of the mast in Unas's ships are further secured with trusses. Each truss was tightened with a pole, like the hogging truss, and the lower ends appear to be laced through a ring similar to the ring depicted on Sahure's Punt ship (Figures 2 A; 7 B; 15).

Another difference is a large forked pole, which on Unas's ship is similar to but heavier than those depicted on either of Sahure's ships (Figures 1–2; 15). Furthermore, it has been moved forward and lowered, creating a lower center of gravity. It appears to be fitted into a notch in the bulwark. These changes would be consistent with added difficulties in raising and lowering a considerably heavier mast on a smaller ship while removing obstacles on deck and, most importantly, reducing wear on the hogging truss, a hazard of the arrangement seen on Sahure's Punt ship.

On the hull, exterior lashings have disappeared and there are only three narrow sets of parallel lines. The two upper sets of lines may define an upper and a lower caprail, each with a different function. The top set is consistent with a standard caprail. It is too high to be the wide caprail on Sahure's ships, but it may have been the same type outfitted on the upper edge of side-girders on some Nile boats during Sahure's reign (Figure 5 C).[100]

The two lower sets of parallel lines have been interpreted as corresponding to the longitudinal lashings on Sahure's ships, with the diagonal lines between them being merely omitted by the artist.[101] As previously noted, Egyptian artists were known to omit some details, but here they have also placed these two sets of lines too high on the hull to correspond to the longitudinal lashings on Sahure's ships. The middle set of parallel lines on Unas's ships have the same thickness, are located at the same level, and have the same length as the wide caprail on Sahure's Mediterranean ships (*cf*. Figures 1 P; 15). The legs of the men standing on the stern deck on Unas's relief disappear below these middle parallel lines, which would be consistent with a caprail. Based on this comparison, the bulwark amidships on Unas's ships now has a height of two planks, whereas both types of Sahure's ships have only one. The additional bulwark plank was mounted atop the wide caprail, and a bow plank is also mounted above or on it, similar to Sahure's Mediterranean ship (*cf*. Figures 1 Q; 15 A). If this is so, a wide caprail was still being used but extended the full length of a ship smaller than Sahure's Mediterranean ship, but consistent with greater structural reinforcement needed for a heavier and possibly slightly larger hull than Sahure's Punt ship.

The lowest set of parallel lines are at the same height as the pair of lines that denote the upper edge of longitudinal lashings on Sahure's ships; perhaps some lashings were still required to reinforce crossbeams and possibly the seam between the sheerstrake and bulwark. These changes may have been possible because the blades appear to have been shifted outboard and protrude beyond the hull planking (Figure 15). Egyptian shipwrights may now have been securing hull planking directly to a stem and a stern post,[102] which may explain the disappearance of the vertical hull lashings seen on Sahure's ships.

All of these changes would also result in a heavier hull, as lashings were replaced with wooden elements, a difference noted between Sahure and Hatshepsut's ships. All elements depicted in this relief are consistent with such changes in ship construction. Whatever the other difficulties presented by this relief may be, its artists represented a number of logical structural details that did not exist on earlier ships.

Logistics

Logistics may also have influenced the size of ships sailing to Punt. A standard proposition is that Hatshepsut's ships, as well as ships of previous periods, returned to the Nile after a successful voyage to Punt.[103] But recent data suggest that, possibly no later than the reign of Khufu, ships were in fact not returned to the Nile. Sometime between the end of the Old Kingdom and early in the Middle Kingdom, Egyptians were using two seasonal ports on the Red Sea coast. Mersa/Wadi Gawasis was the southern port for trade with Punt, while, to the north, Ayn Soukhna was used to acquire turquoise and copper mined at Sérabit el-Khadim in the Sinai.

At Mersa/Wadi Gawasis, structures were built with coral blocks, anchors were carved from stone, and caves were cut into the cliffs.[104] At least eight caves, about twenty meters deep, survive and appear to have been used for storage.[105] Excavators found considerable wood debitage, the result of the "[a]ggressive removal of wood damaged by marine borers" from timbers belonging to ships that had completed voyages to Punt.[106] After this cleaning, timbers were stored, discarded, or recycled on site, while others may have been taken back to the Nile for recycling at shipyards or carpentry shops.[107] It should be noted that these excavations cover only the western sector of a site that was, in antiquity, much larger. The central sector was almost completely destroyed by road and railroad construction, and the eastern sector was disturbed by a military installation and a quarry.[108]

At the northern site of Ayn Soukhna, a dozen rock-cut galleries have been found. As previously noted, in two of them were discovered the charred remains of stacked ship timbers.[109] According to Ward, these planks are thinner than those at Mersa/Wadi Gawasis, consistent with a smaller ship;[110] these timbers appear to be from two different ships, each 14-15 m long.[111] According to Pierre Tallet, the evidence suggests that ships were transported from the Nile to the Red Sea at both sites, but instead of being returned to the Nile, they were stored in these galleries until the next sailing season.[112]

Once ships had completed a sailing season, they would be dismantled, each piece being closely inspected for any damage or wear.[113] Those that could be reused were stored in the galleries, while any timbers that had to be replaced were measured so shipwrights at a Nile shipyard could craft replacements before the next sailing season. Once all reusable timbers were stowed in galleries, stone masons would seal the entrances. For the next voyage, only replacement parts were brought from the Nile, and these probably consisted primarily of hull planking below the waterline. This would have reduced the number of workers needed for subsequent expeditions. Once ships had been transported to the Red Sea, an extremely large expenditure in resources and labor might be required only to replace a ship lost at sea.

Recent work at the site of Wadi el-Jarf, also on the Red Sea, has revealed another Egyptian harbor with caverns sealed with large blocks, much like those at Ayn Soukhna and Mersa/Wadi Gawasis. Evidence of supplies and ship elements were found, including a frame similar to that used on the Khufu I vessel. According to Tallet, ship timbers were stored in these caverns between voyages, which is important because this site appears to have been abandoned during the reign of Khufu.[114] That such facilities existed in the Old Kingdom suggests that this kind of storage was not a primary factor that allowed Hatshepsut to build and subsequently transport larger ships across the Eastern Desert than did Sahure.

Conclusion

The iconography from the causeway of Sahure, along with other archaeological and iconographic data, are consistent with Punt ships during the reign of Sahure being smaller and lighter than contemporary Mediterranean ships. This may have been due to the practical limitations inherent in transportation of large timbers across the Eastern Desert to build such a large ship on the Red Sea. By the reign of Hatshepsut, however, Punt ships appear to be larger even than Sahure's Mediterranean ships. This change in size may have resulted from innovations in construction that allowed larger ships to be built with smaller, more transportable timbers.

The relief from the causeway of Unas seems to preserve evidence of a number of structural changes, especially the development of stem and stern post, which would have produced stronger hulls. Developments must have continued, because by the reign of Hatshepsut through-beams were added and all evidence of external hull lashings disappears. This evolution may have allowed shipwrights to use smaller timbers in the construction of larger and heavier ships on the Red Sea coast. Considering the apparent large size of Hatshepsut's Punt ships and also that all Egyptian vessels appear to have been designed to be broken down and rebuilt to maximize the recycling of timber, by the New Kingdom there may have been no difference between Mediterranean and Red Sea ships of comparable size. This would have allowed for greater standardization and increased efficiency in the recycling of timber.[115]

Notes

1 The iconographic and archaeological evidence on ships and ship construction during this period is sparse. Iconography depicting ships consists of reliefs from the causeways of Sahure and Unas and from Hatshepsut's temple at Deir el Bahri. The condition of Sahure's and Hatshepsut's reliefs are described in the text. Only a drawing of Unas' ships has been published. Based on my personal observation, the original is worn and has lost much of its finer details. For this reason I only discuss large details. In regards to archaeological data, boat and ship construction from the Old Kingdom is limited to the Khufu I boat and a few ship fragments recently discovered at Wadi El-Jarf. From the Middle Kingdom only fragmentary remains of Red Sea ships and Nile work boats have been well-published and analyzed. Finally, only a preliminary publication of two disarticulated ships stored at Ayn Soukhna has been published, and it describes only the most basic details. Thus, our knowledge of ship construction is based on limited data. All relevant publications describing remains of ships and boats are cited below.

2 Tarek El Awady, *Abusir XVI*: *Sahure—The Pyramid Causeway*: *History and Decoration Program in the Old Kingdom* (Prague: Charles University, 2009), pl. 5.

3 Samuel Mark, "Review, *Abusir XVI: Sahure—The Pyramid Causeway: History and Decoration Program in the Old Kingdom*," *International Journal of Nautical Archaeology* 40.2 (2011): 435.

4 See for example, Ernst Assman, "Die Schiffsbilder," in Ludwig Borchardt (ed.), *Das Grabdenkmal des Königs Sahu-re* II (Leipzig: J.C. Hinrich, 1913), 133–156; R.O. Faulkner, "Egyptian Seagoing Ships," *Journal of Egyptian Archaeology* 26 (1941): 5–6; Carl V. Sølver, "Egyptian Sea-Going Ships, about 2600 B.C.," *The Mariner's Mirror* 47.1 (1961): 24–30; Bjorn Landström, *Ships of the Pharaohs* (Garden City, New York: Doubleday & Company, Inc., 1970), 64; Lionel Casson, *Ships and Seamanship in the Ancient World* (Baltimore and London: Johns Hopkins University Press, 1995), 20.

5 See for example, Carl V. Sølver, "Egyptian Shipping of about 1500 B.C.," *The Mariner's Mirror* 22.4 (1936): 430–469; Faulkner, 5–6; Casson, 20.

6 Cheryl Ward, "From River to Sea: Evidence for Egyptian Seafaring Ships," *Journal of Ancient Egyptian Interconnections* 2.3 (2010): 42.

7 Sølver 1936, 436; Shelley Wachsmann, *Seagoing Ships and Seamanship in the Bronze Age Levant* (College Station, TX: Texas A&M University Press, 1998), 19, 22.

8 Ward 2010, 46.

9 *Cf*. Edouard Naville, *The Temple of Deir el Bahri* III (London: The Egypt Exploration Fund, 1898), pls. LXXII–LXXV; Cheryl Ward, "Building Pharaoh's Ships: Cedar, Incense and Sailing the Great Green," *British Museum Studies in Ancient Egypt and Sudan* 18 (2012): fig. 9.

10 See, for example, Edouard Naville, *The Temple of Deir el Bahri* VI (London: The Egypt Exploration Fund, 1908), 2–5; G.A. Ballard, "The Transporting of the Obelisks at Karnak," *The Mariner's Mirror* 6 (1920): 264–273, 307–314; G.A. Ballard, "Queen Hatsheput's Great Lighter," *The Mariner's Mirror* 12 (1926): 221–222; Carl V. Sølver, "The Egyptian Obelisk Ships," *The Mariner's Mirror* 26 (1940): 237–256, 2 pls; G.A. Ballard, "The Great Obelisk Lighter of 1550 B.C.," *The Mariner's Mirror* 27 (1941): 290–306; Landström, 128–133; Casson, 17.

11 See respectively: Casson, 16–20; Landström, 26–139. *Cf.,* however, e.g., Noreen Doyle, "Iconography and the Interpretation of Ancient Egyptian Watercraft" (master's thesis, Texas A&M-University, 1998), http://nautarch.tamu.edu/pdf-files/Doyle-MA1998.pdf, for cautions regarding potential epigraphic and artistic error.

12 For example, see Mark 2013, 273–280.

13 Samuel Mark, "Graphical Reconstruction and Comparison of Royal Boat Iconography from the Causeway of the Egyptian King Sahure (*c*. 2487–2475 BC)," *International Journal of Nautical Archaeology* 42.2 (2013): 278–279.

14 Disk wheels did not appear until either the late Fifth or early Sixth Dynasties, and even though spoked wheels were "well-known by the New Kingdom," a well-developed system of roads did not exist until Roman times. The Nile was so important for travel it has been described as a "superhighway" Pearce Paul Creasman and Noreen Doyle, "Overland Boat Transportation during the Pharaonic Period: Archaeology and Iconography," *Journal of Ancient Egyptian Interconnections* 2.3 (2010): 14, 21.

15 S.R.K. Glanville, "Records of a Royal Dockyard of the Time of Thutmosis III: Papyrus British Museum 10056," *Zeitschrift für Ägyptischen Sprache* 68 (1932): 108.

16 Ludwig Borchardt, *Das Grabdenkmal des Königs Sahu-re* II (Leipzig: J.C. Hinrichs, 1913), pls. 11–13.

17 Mark 2013, 270.

18 See El Awady, pl. 5.

19 Naville 1898, pl. LXXIII.

20 See respectively, Assman, 133; El Awady, pl. 12.

21 Assman, 139–40; El Awady, 155.

22 Samuel Mark, "A Different Configuration for the Quarter-Rudders on the Khufu I Vessel (*c.*2566 BC), and Egyptian Methods of Mounting Quarter-Rudders and Oars in the 4th and 5th Dynasties," *International Journal of Nautical Archaeology* 41.1 (2012): 89.

23 See Borchardt 1913, pl. 11, bottom register.

24 Assman, 139–40; El Awady, 145.

25 S. Searight, "Navigating a Hazardous Sea," in Janet Starkey, Paul Starkey, and Tony Wilkinson (eds), *Natural Resources and Cultural Connections of the Red Sea* (Oxford: Archaeopress, 2007), 121–122.

26 El Awady, 155–160.

27 See Georg Steindorff, *Das grab des Ti* (Leipzig: J.C. Hinrichs, 1913), pls. 21–22, 74–81; Landström, 40–45, 55.

28 See El Awady, 155–161, pl. 5.

29 Borchardt, pl. 12.

30 See Assman, 151–156; Sølver 1961, 26–27; Landström, 66.

31 See Assman, 152, 154.

32 See Assman, 140–1; Faulkner, 4; Steve Vinson, *Egyptian Boats and Ships* (Princes Risborough, Buckinghamshire, UK: Shire Publications, 1994), 37; Dilwyn Jones, *Boats* (Austin: University of Texas Press, 1994), 40; Louise Bradbury, "*Kpn*-boats, Punt Trade, and a Lost Emporium," *Journal of the American Research Center in Egypt* 33 (1996): 48; Wachsmann, 14.

33 Noreen Doyle (personal communication, 25 August 2013) points out to me that on river boats hogging trusses appear with as few as one or as many as three stanchions. The cattle boats depicted in Theban Tomb 40 each have a single stanchion (over the cattle pen); see Nina de Garis Davies, *The Tomb of Huy, Viceroy of Nubia in the Reign of Tutankhamun* (London: Egypt Exploration Society, 1926), 34 fig. 5, and Doyle 1998, 49, fig. 3-2. Up to three may be required when a boat is unsupported by water; see Noreen Doyle, "Curious Nautical Details from the Eleventh Dynasty Temple at Deir el-Bahri," in Pearce Paul Creasman (ed.), *Archaeological Excavations in the Valley of the Kings and Ancient Thebes: Papers Presented in Honor of Richard H. Wilkinson* (Tucson: University of Arizona Egyptian Expedition, 2013), 139–141. See also Creasman and Doyle, 20.

34 Landström, fig. 199.

35 Landström, fig. 199.

36 Miroslav Verner, *Abusir* I: *The Mastaba of Ptahshepses* (Prague: Charles University, 1977), 36, n. 1.

37 See Faulkner, 4–6; Sølver 1961, 26–7; Landström, 64, fig. 198.

38 J. Richard Steffy, *Wooden Shipbuilding and the Interpretation of Shipwrecks* (College Station TX: Texas A&M University Press, 1994), 28.

39 See Landström, 64, 66, fig. 199; Steffy, 28; Wachsmann, 14, 218.

40 Samuel Mark, "The Abydos BG 10 Boat and Implications for Standardisation, Innovation, and Timber Conservation in Early Dynastic Boat-Building," *Journal of Egyptian Archaeology* 98 (2012): 112.

41 Paul Lipke, *The Royal Ship of Cheops* (Greenwich: British Archaeological Reports, 1984), 104.

42 Lipke, fig. 48.

43 Samuel Mark, "New Data on Egyptian Construction Methods in the Khufu I Vessel (*c.*2566 BC) from the Paul Lipke Collection," *International Journal of Nautical Archaeology* 40.1 (2011): 23, fig. 8.

44 Cheryl Ward, *Sacred and Secular: Ancient Egyptian Ships and Boats* (Boston: Archaeological Institute of America, 2000), 53; Mark 2011, fig. 8.

45 See Wachsmann, 14, 218.

46 Landström, 64–67.

47 Landström, 66, figs 197–9.

48 Ward 2000, 54; Samuel Mark, "The Construction of the Khufu I Vessel (*c.*2566 BC): a Re-evaluation," *International Journal of Nautical Archaeology* 38.1 (2009): 147–8.

49 Lipke, fig. 48.

50 Mark 2011, 27–30.

51 Mark 2011, 27–30.

52 Steffy, 28.

53 Landström, 66, fig. 199.

54 Mark 2011, 27–30.

55 Landström, figs 197, 198.

56 See the longitudinal lashing on photographs from the Oriental Institute, University of Chicago photographs B 569, B 571. See also, Borchardt, pl. 12; Landström, 66, fig. 197.

57 Lipke, fig. 52.

58 Borchardt, pl. 14.

59 Assman, 138; Landström, 64–5.

60 See Assman, 138; Faulkner, 5; Casson, 20–1.

61 Casson, 20–21.

62 Steffy, 28.

63 Landström, 66, fig. 199.

64 Borchardt, pl. 9; Landström, fig. 174; El Awady, pl. 1.

65 Landström, 62–5. They also appear in a fragmentary Fourth or Fifth Dynasty relief of a vessel whose nature is uncertain (Landstrom, 43 fig. 116).

66 See respectively, Landström, 62, fig. 186; 66, fig. 199.

67 Landström, 62, fig. 185.

68 Landström, 41, figs 104, 108.

69 See Mark 2011, 32–35.

70 For a discussion of the overland transport of boat timbers, see Creasman and Doyle, 14–16, 24.

71 See, Assman, 140–1; Faulkner, 4; Vinson, 37; Jones, 40; Bradbury, 33, 48; Wachsmann, 14.

72 One such vessel type was the Kiangsu trader, a Chinese ship with a flat bottom that lacked a keel. The hull of this ship was built of pine planking with straight seams; a *c.* 26 m Kiangsu trader had hull planking *c.* 5 cm thick with a hardwood keel plank *c.* 35 cm wide and *c.* 10 cm thick. Hull strength was provided by 14 pine bulkheads as well as five port and starboard wales. Each wale, which is a very thick strake of hull planking, appears to have been *c.* 10 cm thick. (G.R.G. Worcester, *The Junks & Sampans of the Yangtze* [Annapolis, Maryland: Naval Institute

Press, 1971], 163–164). Most hull planks on the Egyptian vessels under discussion are larger and thicker than the wales and keel plank on a Kiangsu trader and also had joggled (and thus stronger) edges along planking seams.

73 Lipke, 104.

74 Mark 2012b, fig. 4.

75 Cheryl Ward and Chiara Zazzaro, "Evidence for Pharaonic Seagoing Ships at Mersa/Wadi Gawasis," *International Journal of Nautical Archaeology* 39.1 (2010): 30.

76 Pierre Tallet, "Ayn Sukhna and Wadi el-Jarf: Two Newly Discovered Pharaonic Harbours on the Suez Gulf," *British Museum Studies in Ancient Egypt and Sudan* 18 (2012): 150.

77 Ward 2000, 124–6.

78 Faulkner, 7.

79 Mark 2012b, 119–121.

80 For a discussion of the reuse of ship and boat timbers, see Pearce Paul Creasman, "Ship Timber and the Reuse of Wood in Ancient Egypt," *Journal of Egyptian History* 6.2, 152-76.

81 Ward 2000, 139–40.

82 Mark 2012b, 125.

83 See Steffy, 28.

84 Landström, 65.

85 Wachsmann, 18.

86 John Breasted, *Ancient Records of Egypt*, I (Chicago, 1906), 65, no. 146; 66, no. 147.

87 Jones, 62.

88 Ward and Zazzaro, 41; *cf.* Creasman and Doyle, 24.

89 Faulkner, 8.

90 Ward 2000, 142.

91 Creasman and Doyle, 24.

92 William F. Edgerton, "Egyptian Steering Gear," *The American Journal of Semitic Languages and Literatures* 43 (1927): 255–61; Doyle 1998, 103–113; Wachsmann, 15, 28; Sean McGrail, *Boats of the World* (Oxford, New York: Oxford University Press, 2001), 33–4; Mark 2012a, 84.

93 Landström, 46–7; McGrail, *Boats of the World*, 33.

94 McGrail, 33.

95 Landström, 65; Wachsmann, 15.

96 Wachsmann, 18.

97 El Awady, pl 12.

98 Steindorff, pls 77–81; El Awady, pls 2–4.

99 See John Albert Wilson and Thomas George Allen, *The Mastaba of Mereruka* II (University of Chicago Press; Chicago, 1938), pls. 140, 142–144.

100 Mark 2013, 283.

101 See respectively, Landström, 65; Wachsmann, 15.

102 Landström, 65.

103 See Naville 1898, 16; John Breasted, *Ancient Records of Egypt* II (Chicago, 1906), 103, no. 238; 109–110, nos 265–266; Wachsmann, 19.

104 Kathryn A. Bard and Rodolfo Fattovich, "Introduction," in Kathryn A. Bard and Rodolfo Fattovich (eds) *Harbor of the Pharaohs to the Land of Punt* (Napoli: Università degli Studi di Napoli "L'Orientale", 2007), 23; Kathryn A. Bard, Rodolfo Fattovich, Magaly Koch, and Abdel Moneim Mahmoud, "The Site," in Kathryn A. Bard and Rodolfo Fattovich (eds) *Harbor of the Pharaohs to the Land of Punt* (Napoli: Università degli Studi di Napoli "L'Orientale", 2007), 31.

105 Ward and Zazzaro, 44.

106 Ward and Zazzaro, 29.

107 Ward and Zazzaro, 40, Creasman 152-76.

108 Bard, Fattovich, Koch, and Mahmoud, 29.

109 Patrice Pomey, "Les bateaux d'Ayn Soukhna. Les plus vieux vestiges de navires de mer actuellement connus," *Égypte, Afrique & Orient* 64 (2012): 5–10.

110 Ward and Zazzaro, 40.

111 Tallet, 150.

112 Pierre Tallet, "The Wadi El-Jarf site: A Harbor of Khufu on the Red Sea," *Journal of Ancient Egyptian Interconnections* 5.1 (2013): 76.

113 Ward 2010, 44–6.

114 Tallet 2013, 82–83.

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