

ANCIENT EGYPTIAN HULL CONSTRUCTION

Representations, written descriptions, and even graves attest to some of the features of ancient Egyptian watercraft, but the physical remains of Egyptian watercraft themselves provide us the best opportunity to evaluate hull construction. Eight ancient vessels are available for study: the two Cheops hulls of the Fourth Dynasty-built, disassembled, and buried in stone pits beside the great pyramid at Giza¹, timbers at Lisht from what were probably freight boats of the early Twelfth Dynasty (c. 1950 B.C.)², four ceremonial vessels of Senwosret I of about 1840 B.C. buried near a Dahshur pyramid³, and the remains of a 2,500 year-old boat from Mataria, a Cairo suburb.

The Cheops Hulls

Features of the sewn planked boats of the IVth Dynasty pharaoh Cheops, have been described in several works that are based upon a study of the hull excavated in 1954 and reconstructed over nearly two decades. This 43-meter-long vessel was constructed of edge-joined planks 7 to 23 meters long and 12 to 15 cm. thick. Rail-to-rail lashing secured planks, seam battens, and frames before stanchions were placed to support the longitudinal spine which was notched, to receive deck beams. Sixteen frames, eight full length and eight three-quarter length, are notched over seam battens and are lashed to the hull through a mortise at each end of the frame. No dimensions are given for the frames in any of the publications available, but drawings show that they are slightly less than 10 cm thick and span about 4.25 m at midships. Frames seem designed to maintain hull shape rather than to serve as structural support.

Deck structures include a large cabin and a frame around it, probably to support reed mats. Construction techniques of the cabin differ from those used on the hull in that some joints make use of pegged mortise-and-tenon fastenings and other fixtures that pass through the thickness of the plank. Builders of the hull avoided these types of fastenings with the exception of the fender area which was then protected with additional pieces of wood.

The second Cheops vessel remains in a stone pit just beyond the museum that housed the first hull. Investigated by nondestructive exploration techniques in a 1987 joint National Geographic Society and Egyptian Antiquities Organization effort, the second boat is not as well preserved as the first. Many of its features

are similar to those of the first boat, but larger and more numerous copper fastenings are visible on Cheops II. The uppermost layer of the wood in the pit holds elements of the cabin structures and steering oars in addition to other timbers not yet identified.

In a preliminary report on these timbers, Paul Lipke and I suggested that the cabin was about 20% smaller than that of the first vessel, which prompted us to wonder about the overall length of Cheops II. With the application of a computer program written to provide more accurate measuring techniques, it is clear that there are only a few centimeters difference between the two cabins, and thus the hulls are probably the same size as well.

The study of photographs and video tapes resulting from this visual exploration of the still-sealed pit form part of my continuing study of ancient Egyptian hulls.

The Lisht Timbers

Excavations by the Egyptian Expedition of the Metropolitan Museum of Art (MMA) from 1914-37 revealed more than 50 timbers buried beneath courts, ramps, and roadways surrounding the pyramid of Senwosret I, pharaoh of Egypt about 1950 B.C. During the recent re-excavation of the site by Metropolitan Museum of Art egyptologist Dieter Arnold, 20 additional timbers were located, recorded, and reburied on site. I have identified these timbers as pieces of a disassembled vessel, or vessels, and compared the construction techniques used to create them with those used by the builders of other ancient Egyptian hulls. The catalogue of material also includes a three-part frame and two model boats, one of which is built of planks.

In most cases, three sides of the timbers are mortised, and every example had the uncut side of the timber facing up, indicating careful placement of the timbers. Although adjacent timbers seem to fit together, fastening patterns show that they do not.

Timbers range in length from 1.5 m to 2.6 m and are, on average, 16 cm to 20 cm wide, but may be as wide as 40 cm or as narrow as 12 cm. Thickness ranges between 12 and 15 cm, providing a sturdy, squat appearance to the timbers. Major knots were avoided in timber selection, but economical use of the wood is apparent in the presence of major knots (more than 30 cm diameter) in the ends of many of the timbers. Identification of wood samples suggests that most of the timbers are *Tamarix* species, a locally available wood that provides short lengths that can be quite knotty.

The ancient woodworkers used at least two types of fastenings in these timbers: mortise-and-tenon joints and lashing. Mortises commonly measure 9-10 cm wide, 12 cm deep and 1.5 cm thick. In addition, there are partial mortises, 5 cm wide and 5 cm deep, cut into timber ends. Mortises are often paired in plank edges, and spacing of the joints is fairly consistent.

Tenons remain in some of the 4,000-year-old mortises, and measure 10.5-11.5 cm long, 6.5 cm wide at base to 4.5 cm wide at the beveled tip, and about 1.5 cm wide. These were often wedged in place with small squared pegs placed on either side of the tenon in the mortise. All tenons remaining in the timbers are broken off at plank edges, and some bear saw marks and breakage scars suggesting that planks were sawn apart from the inside, then pulled off the hull from the outside.

Straps of a plaited webbing also bound timbers together, and about half of the lashing mortises retain the webbing. Most timbers had at least four L-shaped lashing fastenings about 8.5 cm wide, 5 cm deep, and slightly more than 1 cm thick. All of the fastenings exited on plank edges of the inner planking surface, never to the outer surface.

Although it is tempting to say that all the timbers are from the same vessel, none of them actually fit together although if shape alone is used as the criterion for a match, a planking pattern similar to that seen in other Egyptian hulls can be created. Almost every scarf in the planks that I have seen was cut at an angle of about 120 degrees, and consistency in mortise sizing and patterning also supports the idea that the timbers came from a single hull. The features are similar enough to those seen in the Cheops and Dahshur boats, however, to suggest that the source of the consistency may be the shipbuilding tradition of the ancient Egyptians rather than that of a single Middle Kingdom shipwright.

The Frame

In 1914, excavators discovered a frame with a group of other timbers on the west side of the pyramid complex. Although the frame's present location is unknown, drawings and photographs provide detailed information about its structure. The frame is built of three timbers: two upper timbers about 1 m long fastened to a 2.4-meter-long curved floor timber by mortise-and-tenon joints and webbed lashing.

The top timbers are about 15 cm molded (thick) and 20 cm sided (wide) near the inboard ends. The outboard ends are notched and continue the curve shown

by the floor timber for 40 cm on one side and about 25 cm on the other. The inboard ends of the timbers are separated by about 50 cm; this opening corresponds to a 1 cm deep notch on the inner face of the floor timber.

An illustrated section of the floor timber suggests that it is about 12 cm molded and 22 cm sided. It has 12 slightly triangular notches on its outer face that measure, on average, 5 cm wide at the base and 10 cm deep. There are also three circular holes 8 cm deep and 6 cm in diameter in the outer face. One is located directly in the center of the frame; the other two are about 80 cm away on either side of the central hole.

The three timbers making up the frame were fastened together with a complex system of mortise-and-tenon joints, lashing, and mortises of unknown function which pass through the thickness of the timbers. Lashing mortises, and mortise-and-tenon joints are present on both upper and lower surfaces of the top timbers. Although fastenings in the lower surfaces correspond to those in the upper face of the curved floor timber, there are no indications as to the function of fastenings on the top of the assembled frame. They may have served to attach the frame to deck beams or other reinforcing lateral hull members.

The three-part construction of the frame from Lisht is unique. Frames from the Cheops I vessel are cut from single timbers, notched slightly for battens, but with no top timbers and lashing fastenings only at frame ends. The 50-centimeter-wide notch on the Lisht frame's upper face suggests that a heavy timber rested upon it—whether longitudinal stringer, maststep, keelson, or a longitudinal brace like those visible at the prow of many Middle Kingdom boat models cannot yet be determined. The three holes in the frame's lower face suggest perhaps treenail-type fastenings of the hull to the frame, but there is no physical evidence to support this position.

The study and analysis of the recorded date for the frame are particularly important since the earliest examples of frames in the Mediterranean date considerably later than the Lisht timbers. The Lisht frame is significant not only for what it can tell us about ancient Egyptian shipbuilding technology, but also for what it can suggest about the level of technology available to Bronze Age shipwrights in the region.

The Boat Models

Two boat models were discovered early in the Lisht excavations. The larger, one-piece model was taken to the Metropolitan Museum of Art for display, but the

less well-preserved model remained buried outside the mastaba of Imhotep. I visited Lisht in 1986 and was able to make a partial record of the 1.95-meter-long boat. The reason for its lack of preservation was instantly apparent: it was a plank-built model with no timbers thicker than one centimeter.

As I recorded its features, it also became apparent that the model could have served as a virtual 1:5 scale model of one of the Dahshur boats I had previously studied. Like the four known examples, the Lisht model has a central strake of three planks jointed to the three strakes on each side with mortise-and-tenon joints before rising to a gunwale. Scarphs and joins also parallel the Dahshur boats, and the model has the same number of planks in each strake as do the Dahshur boats in Pittsburgh and Chicago. It also has a similar paint scheme.

The Dahshur Boats

At least six 10-meter-long wooden boats were discovered buried near the pyramid of Senwosret III, dating to about 1850 B.C., by de Morgan in 1894. Today, two of the boats may be seen in the front hall of the Egyptian Museum of Cairo; a third is in the Field Museum of Natural History (Chicago), and a fourth is on display at the Carnegie Museum of Natural History in Pittsburgh. Wood samples from planks in the latter two have been positively identified as cedar, and ancient tenons have been identified as tamarisk.

All of the boats exhibit the same curved sheer, broad and shallow body, and narrow, tapered ends with slots for the attachment of decorative finials. The Pittsburgh and Chicago boats and the Cairo boats seem to be two "pairs" that resemble each other more than they resemble the boats in the other pair. As these boats are more well known, I will address only a few topics concerning their construction.

Hull symmetry seems to have been one of the most important factors in construction design. The planking pattern is strictly adhered to, even when smaller lengths had to be scarfed together to construct a larger shape as in the forward section of a port strake in one of the Cairo boats. The seam in the lowest strake of the Pittsburgh hull is located at a point almost exactly half the length of the second plank in the central strake, and the pattern of the dovetail fastenings is consistent throughout the hulls.

The dovetail fastenings are one of the least understood aspects of these hulls. Unique in their use in boat construction despite their frequent appearance in other types of wooden construction such as furniture, coffins, and even a sledge

possibly used to tow one or more of the boats, the dovetail fastenings are some of the most heavily reworked features of the hulls.

When the Cairo and Chicago boats were excavated in 1894, they were transported to Cairo where they were strengthened by having tenons in joints replaced, iron bands nailed around the hulls, and dovetail mortises recut and filled with modern dovetail tenons. The Pittsburgh boat, shipped in 1901, was probably reconstructed by the same crew. Modifications recorded during my study of this hull include ends sawn off of planks, mortise-and-tenon joints expanded or recut, the use of a blue pencil to mark which tenons would receive new mortises, and the use of a heavy hammer with a distinctive head to pound the planks together.

All but four of the dovetail fastenings were also recut—usually resulting in an unfinished appearance with no symmetry, delicacy of design, or apparent utility. The four ancient fastenings on the Pittsburgh boat offer a surprising contrast to the modified ones. They also include a feature seen in some of the recut mortises: what I believe to be the bottom of a mortise which may well have served as a lashing point.

Although de Morgan makes no mention of the dovetail fastenings and does not record them in a drawing of one of the boats, he does record the presence of mortise-and-tenon joints. Reisner, in *Models of Ships and Boats*, includes this statement: "The hull is constructed of mortised and ties planking", with the added note, "So far as I was able to learn, the greater part, if not all of the dove-tail joints are modern. At any rate I so understood M. Barsanti".

I believe that this statement refers to the entire fastening, not just to replacement dovetail tenons. The Chicago and Pittsburgh hulls are almost identical in shape, construction, and dimension, but the Chicago hull has 66 dovetail fastenings, while only 50 are present in the Pittsburgh boat. One of the major differences between these two hulls is the greater separation between plank edges in the Chicago hull where, uniquely, dovetail fastenings are found across butt joins in its upper strake.

Because the dovetail fastenings visible today always include locations parallel to lashing locations on the Lisht timbers, and because of the curious depression remaining in the bottom of some of the present cuts, I believe that shallow lashing mortises may have been part of the original construction of the Dashur boats, and that the modern reconstructors interpreted them by choice or accident as dovetail fastenings similar to those in all other forms of woodworking, but never seen in another ship or boat represented by physical remains, or in tomb reliefs, models,

or other depictions.

Other features of the hulls, including ancient repairs of a plank in the Pittsburgh hull, painted black lines marking mortise placement, the high frequency of saw marks in a tradition which supposedly relied almost entirely upon the adze, and details of the beams and steering apparatus will be covered in my dissertation.

The Late Period Boat at Mataria, Cairo

In November of 1988, Dr. Shawki Nakhla of the Egyptian Museum, Cairo, invited me to look at the remains of a Late Period boat found in the Cairo suburb of Mataria. Excavations for the renovation of Cairo's sewer system in 1987 revealed the boat 12 meters below the surface. About one-third of the hull was destroyed by heavy machinery, but the conservation department of the Egyptian Museum attempted to record and preserve the remainder of the hull.

According to Dr. Nakhla, the hull rested on barren sand, suggesting that it was last beached near an old river channel. Roman artifacts are found in the layers above the boat, but archaeologists discovered no artifacts directly related to the boat. Dr. Nakhla reports that the Radiocarbon Laboratory of Gif-sur-Yvette, France, C14 dated samples of wood from the hull to 2450±50 B.P. The wood samples were identified as sycomore (*Ficus sycomorus*), a local Egyptian wood, by the laboratory. Several additional samples have been taken of planks, pegs and tenons for further identification.

Because the sewer excavations had to continue, the hull was excavated under salvage conditions. Dr. Nakhla provided a sketch plan made of the hull, but no sectional measurements were taken. A photograph of a model suggests the hull curvature. Only the planked shell remained; neither frames, deckbeams nor separate maststep were recovered. Several sections of the hull were selected for salvage and conservation. Unfortunately, many of the pieces broke apart and lost their labels during treatment. Most pieces are 35-50 centimeters long. The Department of Conservation attempted to use the sugar treatment for the first time on waterlogged wood from this vessel. Wood fragments were placed in three small tanks in a concentration of 5% sugar solution. After one week, the sugar concentration was raised to 10% for another week. The final week of conservation treatment was in a 20% sugar solution. Following this treatment, the wood was removed from the tanks and spread in a shed to air dry.

In late 1988, the treated wood seemed in stable condition, although many of the pieces were twisted along the knotty wood grain and the surface of many

fragments was highly friable or fragile. A small tub of untreated wood, mostly small plank fragments and fasteners, is characterized by wood fragments that are essentially sound, although slightly spongy, with good surface preservation remaining.

Hull Construction

The sketch plan and model of the hull illustrate a shell-built vessel about 11 m. long, 4m. wide, and 1.2 m. deep⁴. A central strake, which appears to be nearly double the width of other planks, serves as the foundation of the hull. Excavators of the hull reported that the central strake protruded one or two centimeters below the vessel's outer surface. Two large mortises in this strake may be related to mast placement, but unfortunately these fragments were not preserved.

The preserved end of the vessel has 15 strakes on one side and 16 on the other. Fourteen strakes remain on the better preserved side near what seems to be the midships area. These strakes are narrow, probably less than 20 cm.

The sketch plan suggests that strakes were added to the hull with irregular shapes common near the end. Within the main body of the hull, most joins appear to be butt joins. Some of these planks are slightly swollen near their centers in a manner reminiscent of Egyptian boat construction of the Old and Middle Kingdoms. Planks below the turn of the bilge are straighter and more regularly shaped than those above.

The most striking feature of this vessel is that, despite its similarity in hull design and planking plan to boats of Pharaonic Egypt, its fastening system represents a radical departure from those traditions. For the first time, we have an example of a hull with pegged mortise-and-tenon joints from ancient Egypt. The hulls of the Old and Middle Kingdoms seemed designed to avoid such fastenings, and may have relied instead on pegs wedged parallel to tenons within the mortises (Haldane 1988). This hull is fastened with the common technique, frequently used in Mediterranean hulls such as the *Kyrenia ship*⁵, of pegs driven perpendicularly through the tenons to lock them in place in at least some mortises. Unfortunately, the present condition of the hull remains prevents an analysis of how the use of pegs relates to the construction of the vessel.

The Department of Conservation is considering plans to build either a section or a scale model of the hull that will include some of the original fragments in the reconstruction.

Conclusions

The physical remains of ancient Egyptian hulls have much to offer the student of shipbuilding techniques. In addition to providing a solid basis for understanding what the Egyptian tradition of shipbuilding was, they offer a departure point for speculation about the interior construction and design of such debate-sparking hulls as the Punt ships or obelisk barges of Hatshepsut.

The study of Egyptian hulls also includes the study of tool marks upon them. For example, the frequent presence of the adze in depictions of boatbuilding and the testimony of hulls like these timbers from the Pittsburgh Dahshur boats suggest that the adze was the primary shaping tool of the ancient shipwrights, yet my study of the Lisht and Dahshur timbers shows that the timbers retain many marks of saw blades with teeth one to two millimeters apart. The saw has not received much attention in traditional discussions of shipbuilding, but it is clear that it played a major role.

The ancient Egyptian method of building wooden boats seems to have evolved from methods used to create papyrus hulls. As has been pointed out repeatedly, the Cheops hulls are the only ones known in the world to have a rail-to-rail lashing system rather than a sewing pattern that follows plank seams. I believe this is directly related to the technique of sewing papyrus hulls together across their width. This cross-hull technique is seen in the early depictions of boats in pots of the Amratian period, and its heritage could be seen in the design-mandated tradition of carrying loads on the decks of Nile *nuggs* rather than below.

Dendrochronological studies of the Pittsburgh Dahshur boat's planks confirmed the suggestion that some of the planks came from the same tree; further analysis of the planks will help to pinpoint the construction process in greater detail. Builders of the Dahshur boats were not overly concerned with timber wastage. The curved planks were probably cut from beams at least three times the thickness of the final piece, yet the patch on the outer surface of one plank suggests an unwillingness to forego the amount of labor invested in a single timber for the perfection of an unmarred surface.

In addition to investigating the physical properties of these hulls, I am looking at how they fit into the society and the roles played by the Cheops and Dahshur hulls in the funerary cult. I am also interested in exploring the mind of the ancient Egyptian shipwright and learning about the factors that governed the design and production of a symmetrical, cleanly finished and finely wrought hull.

The nautical traditions of ancient Egypt developed in concert with the rise of the dynastic state. Maritime and nilotic trade fed Egyptian economic growth and fostered contact between societies of the ancient Eastern Mediterranean. Because the Egyptians transformed shipping as a practical technology and commonplace activity into a primary ingredient of the ideological sphere, boats became symbols of divine power and pharaonic glory. The intersection of technology and ideology may be represented in construction patterns of these vessels, and I plan to consider these factors throughout my study of the eight ancient hulls of Egypt.

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ABBREVIATIONS

AJA: American Journal of Archaeology
MM: Mariner's Mirror