Archaeology & History in Lebanon Issue fourteen : Autumn 2001, p. 24-36.

Cedar for Ships

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Frequent mention of the procurement of cedar (*Cedrus libani*) logs from Lebanon in the Old Testament belies the actual range of this tree, which served as an important timber resource throughout the eastern Mediterranean. The mountains of Lebanon are only one of a number of mountain ranges where cedar is found in the Mediterranean. These mountain ranges run parallel to the coast, beginning in the north with the great Taurus range in Turkey, which rises to heights above 3500 m and towers over the Lycian, Pamphylian, and Cilician coasts. The Mediterranean coastal strip then turns south at the Bay of Iskenderun, where the shorter Amanus range (ca. 2200 m) hugs the coast as far as the mouth of the River Orontes. In Syria, the range continues south parallel to the coast with the Jabal an Nuşayrīyah Mountains (ca. 1500 m). After a second brief gap in the terrain, the last mountain range on this coast, the Lebanon (ca. 3000 m), reaches southward for another hundred kilometers along the coast. Cedars are generally found at elevations between 1000-2000 m, and all of these mountain ranges support cedars (*Cedrus libani*), especially on their seaward slopes. Two additional cedar species, *Cedrus brevifolia* and *Cedrus atlantica*, occur on the Troodos mountains of Cyprus and the Atlas range of northern Africa, respectively. Both are very similar in wood anatomy to Lebanese cedar.

Physical Properties of Cedar

Like pines, spruces, and firs, cedars are conifers or softwood trees characterized by a dominant stem and lateral side-branching with evergreen needles. True cedars should not be confused with most other so-called cedars, which derive their name from their similar fragrance and physical properties, such as a number of species growing in North America, including eastern and western redcedars, and incense-cedar. Mature cedars average 24 m, although 36 m long specimens are also known, and vary in diameter from 1.5-2.4 m; they may live for a thousand years[1]. Cedar is a strongly scented wood and is fairly light: well seasoned cedar weighs about 560 kg/m^3, although timber from branches may weigh as much as 768 kg/m^3 because of its higher resin content[2]. Cedar is relatively soft compared to other woods, which makes it easy to work with hand tools, including those of copper and bronze. Its light structure also allows it to be nailed easily without preboring, something that cannot be easily done with heavier woods, such as oak. Its dominant stem form produces straight timber, and its lightness, wide distri-

1 Chaney and Basbous 1978, 119.
2 Lipke 1984, 25-6.

bution, and workability explain the common use of cedar for structural lumber. Its pleasant fragrance might have been desired for religious purposes as well.

Cedar, however, is considered somewhat of an inferior wood by today's standards because it has considerable compression wood caused by branches that are stressed by snow, wind, or even their own weight. In a multi-branched conifer, these branches produce a considerable amount of compressed wood in the stem, causing undesirable results in sawn timber. The Egyptians, however, did not always saw straight planks, instead carving curved pieces of wood for building ships, thereby using compression wood to their advantage or simply avoiding it[3].

In general, cedar has only 2% radial and 4% tangential shrinkage, so distortion is minimal. The physical and mechanical attributes of cedar, therefore, are well suited for shipbuilding: it shrinks minimally, seasons without significant distortion, is easily worked with little dulling effect on tools, and is more resistant to decay in saltwater and to marine biological attack than most other woods[4].

The sparsely populated remnant cedars in Lebanese groves today are of only moderate height and carry massive, wide-spreading lateral branches. Cedars of the Taurus mountains, on the other hand, grow straight and sometimes in excess of 30 meters. Such heights and straight stems with medium-sized branches are attainable only when the trees grow close together in dense forest formations[5]. Therefore, judging the quality of shipbuilding timber obtainable from the contorted cedars growing in Lebanon alone, one cannot fully appreciate the potential of this tree for yielding shipbuilding timber. The pencil-straight cedars of the Taurus, in fact, produce timber of superb quality, straightness, and in long lengths ideally suited to build ships[6]. This also must have been the case with the cedars of Lebanon when the trees grew in densely populated forests in ancient times .

Documentary Evidence

References to the ancient use of cedar are difficult to interpret, as not only is the terminology used to refer to cedar imprecise, but the interpretation of certain ancient words as meaning cedar has not been resolved to the satisfaction of all scholars. For example, in ancient Greek, the term *kedrus* is not specific and may mean either or both cedar and juniper[8]. The case is even more vague in ancient Egyptian, for the word *ash*-wood, while translated as cedar, is thought by many others to refer to pine or fir[9].

Whether *ash*-wood meant cedar or not, it does not change the fact that the ancient Egyptians had obtained large amounts of coniferous timbers from Lebanon since at least Dynasty 2, and probably

3 Ward 2000: 21
4 Steffy 1994, 256.
5 Meiggs 1982, 55-6.
6 During the summers of 1984-85, we purchased several dozen cubic meters of cedar logs for use in constructing our camp for the excavation of the Late Bronze Age shipwreck at Uluburun. These straight logs had been cut to standard commercial sizes of four- and six-meter lengths to facilitate their transportation, and were of superb quality for use in shipbuilding. We admired the splendor of these tall magnificent trees on our frequent forays to the dense cedar forests nearby on the Lycian slopes of the Taurus range. When asked, a local boatbuilder in Bodrum, Turkey remarked that he used pine to plank his boats only because of the expense and unavailability of cedar.
7 *contra* Nibbi 1994, 37-8.
8 Meiggs 1982, 410.
9 Nibbi 1994, 44; Meiggs 1982, 55, 405-9; for additional references see Ward 2000: 21 n. 67.

much earlier. Throughout history, Egyptian kings, especially during Dynasties 12 and 18, received great quantities of timber from Syria for use mostly in buildings, but also for constructing huge *ash*-wood ships[10]. Cedar has been identified in large-scale buildings, statues, furniture, tool handles, and coffins, as well as other wooden items[11]. For example, King Tutankhamen's coffins and large shrine were built with cedar planks nearly 6 cm thick[12].

New Kingdom documents from Thebes reflect the high cost of *ash*-wood used in shipbuilding: a mast of 40 cubits cost four silver *deben* (twice the cost of the most expensive bull). Good quality timber sold in 40-50 cubit lengths cost between five and ten silver *deben*, while a keel (?) timber of good quality sold for five cubits per silver *deben*, and one of second quality for seven cubits per silver *deben*; these are double the mast prices[13]. During Dynasty 21, the priest Wenamun experienced great difficulties procuring lumber for the ceremonial ship of Amun-Re. Wenamun could obtain only seven logs, after which he was compelled to produce jars of gold and silver, rolls of linen and papyrus, garments, cowhides, ropes, lentils, and fish before the Syrian prince arranged for three hundred men and three hundred oxen to cut and haul to the seashore the remaining timber needed to build Amun-Re's ship[14].

Despite its apparently exorbitant cost, the importation of cedar and its use in boat construction in Egypt seem to have continued unabated until later times. A late fifth-century B.C. letter written in Aramaic by the chancellor and scribe of the Persian satrap in Egypt, and addressed to an Egyptian bureaucrat, meticulously catalogues the supplies needed to repair a Nilotic boat. In the letter, cedar wood is referred to as both "new" and "old and broken." This may mean both new and reused timber was utilized in the repair of the boat, or it may refer simply to green and seasoned cedar[15].

Today, the densest and widest-ranging cedar forests in the Mediterranean are those found on the Taurus mountains in southern Turkey[16]. This, presumably, was also the case in antiquity, yet there are no ancient sources referring specifically to the procurement of the magnificent cedars from this region for use in shipbuilding. References to the general exploitation of timber from the Taurus for building large fleets, however, do exist, but ancient sources usually refer to the use of cedars from Lebanon in construction and shipbuilding. At least two ancient sources mention the forests of the Taurus to accommodate the building of large fleets.

It is remarkable that the forested Taurus mountains bordering Lycia and Cilicia, as well as those of the Lebanon range, were not mostly denuded at the time of Alexander the Great's conquest of these

10 Breasted 1906, 46; Meiggs 1982, 407.
11 Ward 2000, 21 n. 70.
12 Lucas 1962, 433.
13 Janssen 1975, 375-80.
14 Goedicke 1975, 94-9.
15 Wachsmann 1998, 224-5.
16 Atalay 1983, 149-50.

regions during the fourth century B.C. After Alexander's death, Ptolemy I of Egypt inherited most of Alexander's fleet. To confront this hostile navy, Antigonus set out to build his own large fleet. This, in turn, launched the greatest naval arms race in ancient history. Antigonus assembled from throughout his empire a large work force of shipwrights, as well as eight thousand lumbermen and sawyers to cut the necessary wood, and a thousand wagons to transport the Lebanese timber to the coast. He proceeded to establish a shipyard in Tripoli, Byblos, and Sidon, for the mountains of these cities boasted cedars and cypresses of great beauty and extraordinary size. Antigonus founded a fourth shipyard in Cilicia, in order to exploit the woods of the Taurus, and a fifth in Rhodes was commissioned to build ships with timber that would be brought to the island[17]. Much later, Mark Anthony assigned Pamphylia to Cleopatra, as this area, abounding in cedar wood for shipbuilding, was suitable for the building of her fleets[18].

Archaeological Evidence

The archaeological record has produced few actual examples of Bronze Age ships, making it difficult to assess the use of cedar in ancient shipbuilding. Evidence for the use of cedar in Egyptian boatbuilding is derived from the well-preserved remains of funerary vessels from Old and Middle Kingdom Egypt, specifically the royal funerary boats of Khufu and Senwosret III. The sparse remains of the hulls of the ships that wrecked at Uluburun and Cape Gelidonya on the southern coast of Turkey provide invaluable insight into the exploitation of cedar in seagoing ship construction during the Bronze Age.

Khufu's Royal Boats

No one could fully comprehend the magnificence and elegance of Old Kingdom Egyptian hull construction until the discovery of two disassembled 4,600-year-old vessels sealed in pits beside Khufu's great pyramid at Giza. Their discovery has revolutionized the study of ancient Egyptian shipbuilding. When the first of the entombed boats was excavated, a strong odor of cedar was apparent[19]. After the vessel was reassembled from its 651 major components, it produced a massive boat 42.3 m long and 5.7 m wide[20]. Various woods were used in the construction of the Khufu I ship, but all 30 planks comprising the hull were carved from cedar into planks 7-23 m long and 12-15 cm thick. A large collapsible deckhouse was also constructed from prefabricated cedar panels. In fact, 95% of the ship is made of cedar, including at least one of its oars[21]. The entire boat was held together with unpegged mortise-and-tenon joints and transverse lashings of halfa grass, which not only joined the planks together, but also held other timbers such as frames and clamps in place[22].

17 Diodorus Siculus, *Library* 19.58.2-5; Meiggs 1982, 134.
18 Strabo, *Geography* 14.5.1; Meiggs 1982, 84.
19 Lipke 1984, 2.
20 Ward 2000, 47.
21 Lipke 1984, 25.
22 Lipke 1984, 64-9, 74-5; Ward 2000, 49-54; Steffy 1994, 25-7.

A second, unexcavated boat pit adjacent to the first was visually examined for the first time in 1987. A specially designed camera lowered into the pit revealed a second dismantled boat similar to Khufu I, although less well preserved[23]. Samples later taken from the boat confirmed that the wood used was cedar. Although the pit's hermetic seal had been broken at some point and the conditions in the pit were conducive to the complete deterioration of wood, the naturally high concentration of fungicidal chemicals in the cedar had apparently slowed the rate of decay[24].

The Dashur Boats

In 1894, five or six wooden boats were excavated from the Middle Kingdom pyramid of Senwosret III (ca. 1878-1859 B.C.) at Dashur. Excavation reports mention the discovery of three boats, each just under 10 m long, beside a large brick chamber, and three others nearby[25]. The whereabouts of only four of these boats are now known. Two are displayed in the Egyptian Museum in Cairo, and one in each of the Field Museum of Natural History in Chicago and the Carnegie Museum of Natural History in Pittsburgh.

The latter two boats were built completely of imported cedar (*Cedrus* cf. *libani*), still fragrant, with at least some tenons of tamarisk (*Tamarisk* sp.)[26]. While the results of scientific wood species identification are not yet available for the two boats in the Egyptian Museum, it is almost certain that they were also built of cedar. The construction of all four Dashur boats is quite similar. In each boat, the central strake is composed of three butt-joined planks varying from 2.25-4.55 m in length and 9-12 cm in thickness. There are three strakes to either side of the central strake, with a bulwark strake above each sheer strake. In the Carnegie and Field Museum boats, there are a total of nine planks per side, while the boats in the Cairo Museum differ slightly from this configuration. Hull planks vary between 1.17-3.87 m in length and 6-13.8 cm in thickness. As with the Khufu boat, the strakes and other timbers were fastened with unpegged mortise-and-tenon joints, which contribute significantly to the strength of the hull[27]. Additionally, the planks and other timbers were secured to one another by transverse lashing, although much of the evidence for this was obliterated during the removal and restoration of the boats[28]. Timber conversion studies indicate that the Carnegie boat was built using wood from at least 18 cedar trees[29]. The use of at least six, and probably 10 or more, tons of cedar to build six boats would have represented a large expenditure of labor and capital during the Middle Kingdom. The burial of these craft near the pyramid of Senwosret III, therefore, enhanced the prestige and standing of their owner in the afterworld and in the ritualized world of the mortuary cult[30].

23 Ward 2000, 61-8.
24 Ward 2000, 61.
25 de Morgan 1895, 81-2, pl.1.
26 Ward 2000, 84-5, n. 11.
27 Ward 2000, 90-5; Steffy 1994, 32-6; Patch and Haldane 1990, 34-42.
28 Ward 2000, 90-4.
29 Ward 2000, 96.
30 Ward 2000, 102.
31 Meiggs 1982, 408.
32 Sayed 1980, 156-7, fig. 3, pl. 22:5; Wachsmann 1998, 215-6.
33 For the most recent overview of the Uluburun site, see Pulak 1997; 1998. The first three excavation campaigns are in Bass 1986; Pulak 1988; Bass et al. 1989.
34 For a detailed discussion and analysis of the hull remains and construction of the Uluburun ship, see Pulak 1999.
35 Peter I. Kuniholm, of the Malcolm and Carolyn Wiener Laboratory for Aegean and Near Eastern Dendrochronology at Cornell University, made the wood identification, which were subsequently confirmed by Werner Schoch at the Swiss Federal Forestry Research Institute in Zurich.
36 Bass 1989, 25.

The shapes and decorative features of these Old and Middle Kingdom boats suggest that they were funerary boats probably intended to be towed by other vessels on the calm waters of the Nile. Their construction reflects their ceremonial importance as well as probably demonstrating technological continuity and change from earlier vessels. Durability is a prime practical concern for shipwrights, and the Egyptians may have preferred cedar in the construction of their funerary craft because they appreciated its fragrance and resistance to rot, characteristics that they may have coveted for religious reasons[31].

Egyptian Seagoing Ships

While these boats provide insight on the construction of inland watercraft in ancient Egypt, no Egyptian seagoing ships have survived to indicate how they were built and what woods were used in their construction. Unlike Nilotic craft, such ships would have had to withstand the rigors of sea voyages, including waves, storms, and other dangers. Available evidence is limited to information from Egyptian documents dealing with the construction and repair of ships at royal dockyards, and wall paintings depicting ship construction and seafaring voyages. While important, much of this information relates to Nilotic boats rather than to seagoing vessels. Archaeological evidence for the use of cedar in Egyptian seagoing ships is limited to a possible fragment of hull planking discovered along with other plank fragments and ropes at the Red Sea port of Wadi Gawasis[32]. This port served as a staging point for ships traveling to Punt during the Middle Kingdom. The cedar fragment in question is 38 cm long, 14 cm wide and 12 cm thick, and has three rectangular mortises along one edge. Unfortunately, the piece is of limited size and its mortises are too shallow to be conclusively attributed to a particular use.

The Uluburun Shipwreck

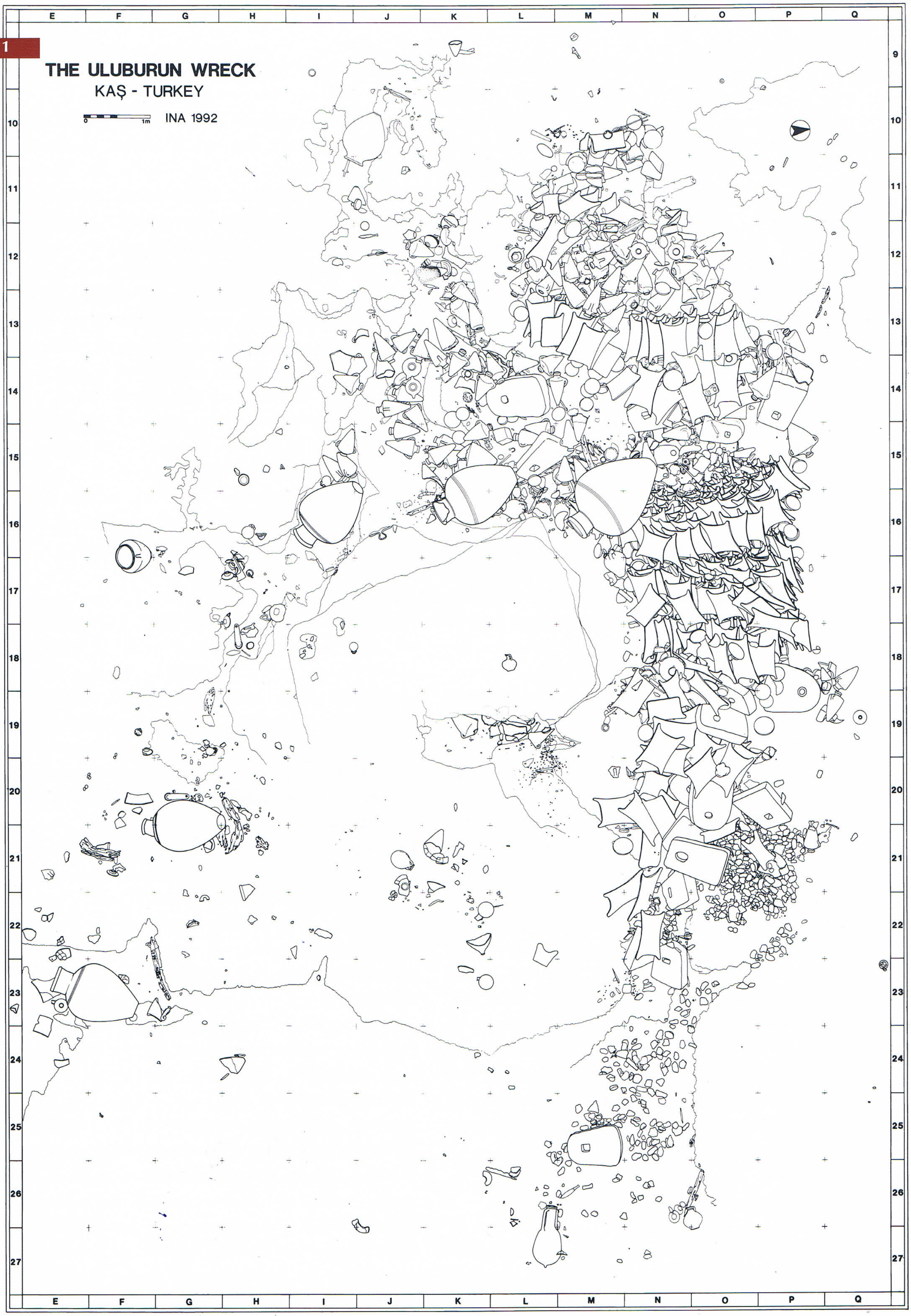
There is, however, conclusive evidence for the use of cedar in the construction of seagoing ships on the Syro-Canaanite coast. The most important evidence is provided by the Late Bronze Age ship that sank off Uluburun, in southern Turkey during the end of the 14th century B.C[33].

The primary cargo of the Uluburun ship consisted of approximately ten tons of copper ingots and a ton of tin ingots (fig. 1). Other raw materials included glass ingots, ebony logs, hippopotamus and elephant ivory, ostrich eggshells, nearly a ton of terebinth resin carried in Canaanite jars, and various foodstuffs. Manufactured goods included ten large storage jars, some of which contained Cypriot export wares, pomegranates, and probably oil. Metal and faience vessels, ivory containers, a jeweler's hoard of gold and silver, and tools and weapons of bronze were also found. Study of the cargo and personal effects of those on board suggests that the ship was a Canaanite or Cypriot vessel sailing from the Syro-Palestinian coast or Cyprus to the Aegean. The finds further suggest that there were at least two Mycenaeans of rank traveling on the ship, probably as envoys.

The distribution of artifacts on the site suggests a length of about 15 m for the ship. The ship carried 24 stone anchors weighing 3.3 tons. Since it is not known how much of the ship's original cargo of perishable goods, such as ebony logs, disappeared, any estimates regarding dimensions and capacity of the ship are speculative. However, based on the weight of the recovered cargo, stone anchors, and ballast, its total capacity must have been in excess of 20 tons.

In addition to its extraordinary cargo, another unique aspect of this Late Bronze Age shipwreck is the preserved parts of its hull[34]. Unfortunately, due to the steep, rocky nature of the seabed at Uluburun, the preserved remains of the hull are extremely sparse and fragmentary (fig. 2). Small sections of hull were preserved under the rows of copper ingots, which protected the wood by discouraging marine borers and other wood devouring organisms. However, the largest preserved portion of the hull was located under some stone anchors in the only relatively flat and sandy area of the site. Results of wood analyses revealed that the keel and planking were built of cedar (*Cedrus* sp.)[35], instead of fir (*Abies* sp.), as previously published[36]. This identification is not surprising in light of the many Bronze Age references that mention cedar as the preferred timber for building ships.

1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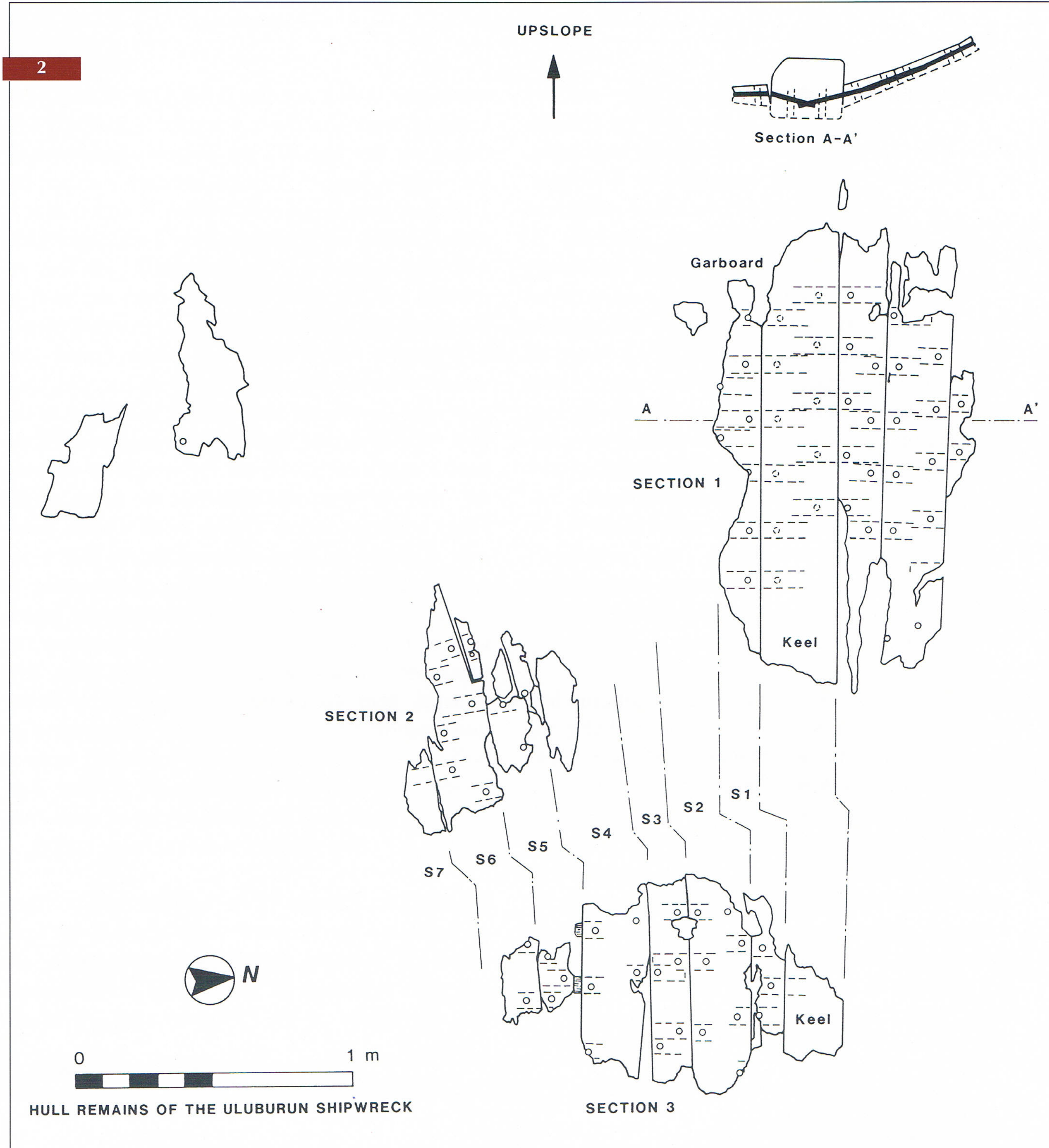

1. Plan of the Uluburun shipwreck site. Stern of the ship is to the top of the site plan. Each grid square measures 1 x 1m.

2. Preserved sections of the Uluburun hull. The large hull section with preserved section of keel is to the top. The smaller section below, also includes a small section of poorly preserved keel of reduced width. Dashed lines on planking and keel represent mortises.

Several fragmentary oar or sweep blades and the remains of bulwark fencing were tentatively identified at Uluburun. A row of five round stakes, the best preserved example of which is 1.7 m long and nearly 7 cm in diameter, was excavated several meters to the north of the hull remains on the starboard side of the ship. Lying on top of, and generally perpendicular to the stakes, were closely-spaced parallel withies. While no evidence survives to suggest that the withies were fastened to the stakes, this assemblage almost certainly represents the type of wickerwork weather fencing visible on all the Syrian ships depicted in nearly contemporary Egyptian tomb paintings[37], and it also evokes the wicker fencing assembled by Odysseus to keep the waves out of the boat he built to leave Calypso's island[38].

The largest preserved section of the Uluburun hull measures 1.0 x 1.8 m in area and includes the planking and portions of the keel. These remains comprise a 1.7 m-long section of the ship's keel, port garboard (the first planking strake adjoining the keel) and second strake, both of which are preserved over their complete widths, as well as fragments of the third strake. Only a fragment of the starboard garboard survived. The garboards taper in thickness from about 10 cm at the edge adjoining the keel to about 6.0-6.5 cm on the opposite edge, where they adjoin the second strake. The remaining strakes are also 6.0-6.5 cm in thickness. Unusual aspects of the hull are the lack of any evidence for framing and the overall appearance of the ship's keel. Unlike modern keels, the Uluburun keel is not only wider (28 cm) than it is high (22 cm), but it projects only 2 cm beneath the outboard surface of the garboards, whereas its inboard surface is 10 cm higher than the level of the planking (fig.3). Still, unlike the central planks of Egyptian ships, this is a robust timber that would serve as the ship's spine and would have provided significant longitudinal stiffening to the hull. Moreover, the slight bottom projection of the keel would have supported the weight of the vessel when beached and absorbed the brunt of the shock when grounded. Unlike modern keels, however, it would not have counteracted the ship's leeward drift while beating or sailing close hauled. It appears, therefore, that in the rudimentary proto-keel of the Uluburun ship we are witnessing the emergence of a true keel. Not only does this unusual keel configuration allow for a better understanding of the development of ancient shipbuilding concepts, it also helps reveal the technological and sailing limitations of Bronze Age seagoing ships and the implications of such constraints for contemporary maritime trade routes.

Lacking any framework in the preserved portions of the hull, the Uluburun ship appears to have relied on massive mortise-and-tenon joints for strength. Although its overall size is much smaller, the tenons of the Uluburun ship are nearly

37 Davies and Faulkner 1947, pl. 8; Davies 1963, pl. 15; Säve-Söderbergh 1957, pl. 23; Basch 1978, 102, figs. 4-6; 1987, 63-5.
38 *Odyssey* 5.256-57
39 Bass 1967, 50-2, fig. 51: Wd 2.
40 Bass 1967, 168-9.
41 Identified by Robert Blanchette, of the University of Minnesota's Department of Plant Pathology.
42 Herodotus, *Histories* 2.96.1-2.
43 Haldane and Shelmerdine 1990.
44 Ward 2000, 32.

three times as long as those on the Khufu I boat, and about 1.3 times longer than those used on the Dashur boats. These tenons are of live oak (*Quercus* sp.), measuring 30.0 x 6.2 x 15.8 cm, and are locked in place with live oak pegs averaging 2.2 cm in diameter. The mortise-and-tenon joints are not uniformly spaced as is the case in later Greco-Roman ships. Rather, they are more widely spaced but much deeper, and are arranged in pairs to form a network of internal paired frames of tenons extending continuously up the sides of the hull planking. Clearly, these unusually long oak tenons were much more than simple plank fasteners and acted as small internal frames, providing considerable stiffness and mechanical strength to the shell of outer planking. The use of such tenons may have been specifically intended to supplement the hull's lateral rigidity with an internal framework, compensating for the scarcity or absence of proper framing. Nevertheless, the use of very widely spaced frames, bulkheads or throughbeams on the ship cannot be excluded.

The Cape Gelidonya Shipwreck

A few planking fragments and a fragmentary oak tenon were all that was found during the excavation of the Cape Gelidonya shipwreck[39]. This tenon is remarkably similar in shape to those from Uluburun, featuring the same taper in both width and thickness, but it is about 20% smaller, in keeping with the smaller size estimated for this vessel. The extremely limited quantity of preserved planking and the disarticulated distribution of these timbers on the seabed makes their attribution to a specific part of the hull extremely difficult. Samples of this planking were originally identified as cypress (*Cupressus sp.*)[40], but samples submitted recently for analysis proved to be of cedar[41].

Discussion: Bronze Age Ship Construction

The ship from Uluburun and, presumably, Cape Gelidonya were assembled in the *shell-based* tradition, with their planks edge-joined to one another, in a manner similar to that found much later on Greek and Roman ships. This method of ship construction contrasts technically and philosophically with present-day *skeleton-based* construction techniques, wherein a ship's planking is shaped around and fastened to a pre-erected skeleton of frames. Based on the evidence from Uluburun, it would appear that the Syro-Canaanites were the first to use the shell-based method that employed edge-joining of the planks with mortise-and-tenon joints locked in place with wooden pegs, pushing back the use of this technique in seagoing ship construction by more than half a millennium. This is the same shell-based building concept used in the construction of the Egyptian boats discussed above, which also made use of mortise-and-tenon joints in their construction, with the difference that these joints were freestanding and not pegged. Rather, their primary functions were to align the planks during construction and to restrict longitudinal and vertical movement between planks. The planks, as well as the other timbers on these ships, were then fastened to each other with transverse lashings using vegetal ligatures.

This tradition of shipbuilding in Egypt appears to have persisted until at least the fifth century B.C., when Herodotus observed nearly identical construction methods still in use in Egypt. In his oft-cited account[42], Herodotus noted that short planks were joined to each other with long, close-set tenons; the seams were then bound from within with papyrus fibers[43]. There is no mention of locking the close-set tenons with pegs, a technique that Herodotus would have been familiar with from its use in Mediterranean boatbuilding. The Egyptians began using pegged mortise-and-tenon joints in furniture making early on, the oldest archaeological examples of such joints being from beds dating to the Naqada IIIa period at Tarkhan (ca. 3250-3050 B. C.)[44]. Curiously, as far as can be determined, they did not employ them in shipbuilding, unless their use was restricted to seagoing ships, of which there are no surviving examples. While lashed construction produced a sound assemblage of planks, pegged mortise-and-tenon joints generally made for stronger, more efficient, and more seaworthy vessels, especially in the case of larger ships.

While Lebanese cedar appears to have been used in both funerary and seagoing ships in the Mediterranean during the Bronze Age, its use after that period seems to have dropped drastically. Although, dozens of shipwrecks post-dating the Bronze Age have been fully or partially excavated in the Mediterranean and its immediate hinterland, I am aware of only a single vessel, the Kinneret boat, in which the hull planking was primarily of cedar. Only one other shipwreck, the Athlit ram, has revealed even minimal use of cedar in its construction.

The Athlit Ram

In 1980, a bronze ram dating to the first half of the second century B.C. was found at Athlit, Israel[45]. A small section of the warship's bow was preserved inside the bronze ram. The size of the ram suggests that it is from a galley larger than a trireme, perhaps a "four". The preserved section of the hull consists of a portion of the keel, two bottom planks, two wales, the ramming timber, the stem, six side planks, a chock, and the nosing timber, totaling sixteen pieces in all. All but one of the timbers were sampled for wood species identification. The stem and ramming timber proved to be of cedar (*Cedrus* sp.), while the keel, wales, and planking were of pine (*Pinus* sp.), and the chock and nosing timber of elm (*Ulmus* sp.)[46]. Oak (*Quercus* sp., possibly of the live oak group) was used for the tenons and pegs[47]. Again, it is not unexpected that the keel and planks are made of softwood and the edge fastenings of oak, an apparently successful combination that was commonly used in antiquity. For the ramming timber, one might expect the use of silver fir instead of cedar, since ancient authors raved about fir's attributes[48]. But the use of cedar also seems to be an appropriate choice, for its lightness, strength, and resilient qualities are desirable in a timber designed to absorb considerable impact force. The preservation of this timber was remarkable even after several millennia in the sea, attesting to its resistance[49].

The Kinneret Boat

A small fishing boat found in the Sea of Galilee (Kinneret), broadly dated to between the first centuries B.C. and A.D., was built mostly with reused timbers representing a variety of wood species. Measuring 8.8 m long, 2.5 m wide, and 1.25 m deep, the frames of this boat were fashioned of hardwoods, mostly oak (*Quercus* sp.), but also willow (*Salix* sp.) and redbud (*Cercis siliquastrum*). Eighteen of the 19 hull planks sampled proved to be of cedar (*Cedrus* sp.), the remaining plank being fashioned of Aleppo pine (*Pinus halepensis*)[50]. The tenons and pegs, as expected, were of oak (*Quercus ithaburensis*)[51]. Cedar was also used in the forward section of the boat's three-piece keel; one of the other keel sections was made of jujube or sidder (*Ziziphus spina-christi*), a wood species rarely used in boatbuilding, while the third section has not been identified[52]. The forward-

45 Casson and Steffy 1991, 66.
46 Casson and Steffy 1991, 17.
47 Casson and Steffy 1991, 17.
48 Theophrastus, *Enquiry into Plants* 5.7.1; other references conveniently collected in Meiggs 1982, 118-9.
49 Casson and Steffy 1991, 36-7.
50 Wachsmann 1990, 31, 65-75; Steffy 1987, 325-9.
51 Wachsmann 1990, 33.
52 Wachsmann 1990, 30, 132.
53 Wachsmann 1990, 38-9, 132.
54 Theophrastus, *Enquiry into Plants* 5.7.1
55 Gore 2001, 91-3.

most keel timber, as well as some of the hull planking, proved to be reused from older boats[53]. It is evident that the Kinneret boat was built by an experienced boatwright fusing limited wood supplies with second-hand timbers. The resulting hull had a rounded stern and fine bow, and was made primarily of edge-joined cedar planks braced with mostly oaken frames.

The reason why the archaeological record has yielded so few ships built of cedar may be hinted at by Theophrastus who, in discussing ship timbers, says that fir, pine, and cedar provide the most useful timbers for shipbuilding. He states that triremes were built of fir because of its lightness, while pine was favored for the construction of merchantmen due to its resistance to decay. He also notes, however, that some triremes were built of pine due to an inadequate supply of fir, and that the people of Syria and Phoenicia used cedar because of insufficient pine resources [54]. This suggests that cedar was more common in Lebanon than pine and fir, and that it was more often used to build ships along the Syro-Phoenician coast. Therein lies a possible answer, for very few shipwrecks excavated in the eastern Mediterranean can be attributed conclusively to a home port along the Cypriot, Syrian and Phoenician coasts; those that are, such as the Uluburun and Cape Gelidonya ships, were indeed built of cedar. Further research may someday reveal whether cedar was also used to construct the two late eighth-century "Phoenician" ships recently found off Ashkelon in water 365 m deep[55].

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3. White dots on planking correspond to pegs of mortise-and-tenon joints. The unworked timber in the center is the ship's keel. Photo: Institute of Nautical Archaeology.

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The cedars of Lebanon.
Postcard of Friedrich Perlbereg's painting. End of the 19th century
(Private collection, Gaby Daher).