The archaeological contribute to the knowledge of the extra-European shipbuilding at the time of the Medieval and Modern Iberian-Atlantic tradition

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Introduction

It is believed that one of the earliest voyages made by sea was the movement of people across the various water expanses between Southeast Asia and Australia, probably around 60,000 years ago. These crossings involved a journey, even in the times of lowest sea levels, of at least 10-15 km. The movement of people into the Australian continent from Southeast Asia was followed by the arrival of the Austronesian people who largely displaced the earlier inhabitants of Southeast Asia. The Austronesian themselves then began the great migrations into the Pacific and Indian Oceans, reaching the far-off Easter Island in the Pacific Ocean and Madagascar in the Indian Ocean. These people, who explored over half of the sea surface of the Earth, would have to be the most enterprising of all the people who have sailed on the sea and represent a pinnacle of sea-going achievement. It is the surviving technology of part of this tradition that this paper addresses.

While little is known of the exact details of the development of shipbuilding in the regions east of the Mediterranean, where these great migrations occurred, it is known that the tradition goes back at least as far as that in Europe. The region, for the purposes of this discussion, is divided geographically into the following areas: the western Indian Ocean, South India including Sri Lanka, eastern Indian Ocean, Southeast Asia, east Asia and the Pacific (the latter are will not be dealt with here, nor are all the regions dealt with equally). Within these areas information regarding shipbuilding is limited to a number different types of sources: archaeological, ethnographic, iconographic, and literary. While each source has interesting information, it is often tantalisingly limited. Only a handful of shipwreck sites have been archaeologically excavated such that the information is useful. Ethnography, with the largest corpus of information reveals techniques and traditions that are remnants and vestiges of earlier traditions; while there is an enormous quantity of ethnographic evidence available, it is rapidly disappearing and it is difficult to assess its relevance to earlier periods. Iconographic evidence within the regions is also limited, rock carving being reasonably well represented, but, as with literary evidence, paintings and drawings poorly represented. Literature, relating to shipbuilding, naturally is limited to societies that had the ability and the leisure or curiosity to record such mundane matters. It is an idiosyncrasy, that as a by-product of the European encyclopaediaist movement, we have reasonably detailed literature on shipbuilding in the European region (for the sake of simplicity I take Europe to include the Mediterranean region). This philosophical approach does not seem to have occurred in the East. Not only were many of the people illiterate (just as in Europe), but also they saw no need to record in this way. Thus, for example, while there are numerous accounts of Buddhist monks travelling on ships between China and India their accounts hardly ever mention details of the ships, rather spiritual matters relating to the voyage. The Europeans, when they arrived in the East, described the Asian ships, often in some detail
and these records are one on the few sources that Western scholars have easy access to. However, this raises another issue which will be discussed: the limitation of European recording of Eastern shipbuilding traditions. It seems that as part of the Western attitude to the East, there is a continuing theme of Eurocentricity in their writings.

**The Western Indian Ocean**

In most of the Western Indian Ocean and South Asia, the characteristics of vessels often overlap. Some regions where shipbuilding has developed and modernised one sees changes in construction and style. Motorisation as everywhere else had a profound effect on shipbuilding and the economics of ship construction. Sadly, in many countries the introduction of foreign aid has resulted in the subversion of traditional wooden shipbuilding to either inappropriate technology (fibre-glass) or Western-based traditions (frames first). The region clearly has sewing as the earliest tradition and one can see this in various forms and traces from the East African Coast to Bangladesh.

**East Africa**

This region includes the East African coast where, up until recently, the *mtepe* and the *dau la mtepe* survived. These vessels were sewn boats built on the Kenyan and possibly Somali coast. The *mtepe* was described and illustrated by various writers and several models survive. Some sections of hull survive in Fort Jesus, Mombasa as part of the ceiling in one of the rooms in the fort. The *mtepe* belongs to the early dhow technology, possibly a ‘fossilised’ type, representing an earlier phase in the development of this vessel. Originally, from early illustrations and photographs, together with the remains in Fort Jesus, we know it was sewn and had diagonally driven dowels. The square sail was made of matting and the vessel had a complex stem and stern. The rudder seems to have been hung by a single rope strop and it has been suggested that the decorative ornaments seen hanging from the top of the rudder were in fact methods of balancing the rudder. A similar type of arrangement can be seen on the *battil* of the Persian Gulf.

The *mtepe* is interesting because it represents a class of Indian Ocean vessel built using dowels and sewing techniques with many of the characteristics of the modern dhow. The *Periplus Maris Erythraei* an anonymous account of trade and navigation in the Indian Ocean written around the first century AD speaks of the sewn boats of the Indian Ocean. We have evidence of sewing traditions across most of the Indian Ocean, in the Arab world (Oman), in India, the Lakshadweep, Sri Lanka, the Maldives, Vietnam and Southern China. The doweling technique used in the *mtepe*, as with the Arabian dhow, is different the technique used in Southeast Asia where the dowels are set in holes drilled in opposite faces of the edge of the plank. With the *mtepe* the dowels are driven from the outside upwards and then planed off. This has considerable implications in the construction of the vessels and indicates that a different construction sequence is used in the two systems. In Southeast Asia and the Maldives, the technique is as follows: the plank A, to be set on the strake B attached to the hull, is cut roughly to shape. A series of holes to take the dowels are drilled in B separated by a fixed distance, usually about 10 to 20 cm. Plank A is then brought up to B and the positions of the holes marked on A. Holes are then drilled in A. At this point usually a few thin dowels are placed in a number of holes in B and A is then fitted in place and marked up with
a spilling gauge, so that the joint can be cut and shaped to fit exactly. The holes are then set with the full size dowels and plank A is then hammered into place. In some cases a certain amount of twist and bend may be given to the plank in order to fit it accurately. However, this system cannot sustain sharp changes in curvature (twist), since the strength is only in the dowels unless the planks are burnt to induce the twist or curvature. This contrasts with the frames-first technique, where the frames have an intrinsic strength, which enables the shipwright to force the strakes around the shape. Even so frames first construction often utilises burning to give planks curvature before being applied to the framed hull.

Clearly, the oblique doweling technique of the mtepe and the dhow has to operate in a different way and with a different function. For the dowels to be driven upwards, the plank that they are being driven into (the top one) has to be attached in some way to the lower one. It is assumed that the dowel ‘nail’ was driven after the seams had been sewn or, in the case of an un-sewn vessel, after the strakes had been attached to the frames. Therefore we have a different technology at work. Its function in sewn boats would be to add longitudinal strength to reduce the shearing effect at the seam. We may assume then that the sewing of a seam has two functions: firstly to hold the planks together and secondly to prevent them moving longitudinally relative to each other at the seam. For that reason, lashings (bindings between holes directly opposite each other on the seam) serve to hold the planks together, but have little effect in preventing longitudinal movement. To counteract this, lashings also run diagonally between adjacent lashing holes, thus helping to reduce longitudinal shear. However, with working of a vessel, it is inevitable that these lashings will loosen. As a result the longitudinal forces will have a much greater effect because of the mechanical advantage of this type of stress on the fibres. By introducing dowels along the seam, the shear effect will be eliminated, allowing the sewing-lashing to function more efficiently to hold the seams together.
However, this issue is confused by the fact that often lashings were plugged from the outside; a small wooded spike being driven into the hole with the lashing and then the external part of the lashing was cut off. This seems a very flimsy construction method which contrasts with the Southeast Asian technique where the lashings are recessed in a groove so that the lashings are recessed below or flush with the outside of the hull, thus protecting them. Clearly, this technique is stronger than the *matepe* and Western Indian Ocean method. It is possible that this method has the function of holding the planks together during construction phase. A derivative of this method has been observed on the West Coast of India where a series of holes are drilled on either side of a plank and a rope loop is threaded through the hole. A wedge is then driven between the hull and the loop this drawing the planks together (Fig. 1).

**The Persian Gulf**

The dhow of the Western Indian Ocean and Persian Gulf is a generic name for a variety of types of vessels, which normally are thought to be large ocean-going vessels. However, within the region there are basket boats, bundle boats, small and medium sized fishing vessels and the larger trading and fishing dhows. The larger dhows are either double ended vessels like the *boom* (Fig. 3) or more often transom sterned vessels like the *ghanjah* (Fig. 2), in addition there are the fishing *bedan* (Fig. 4) that are also used in a larger form as a cargo *bedan*. In this mix of vessels are a number if smaller class of vessels not normally considered to be dhows as such, the term being non-Arab in origin. Typical of such vessels are the *battil*.

![Fig. 2 — The remains of a *ghanjah* in Muscat. Note the transom and decorated stern board (JNG).](image)
FIG. 3 – A motorised boom in Mombasa Harbour. Note the forward raking mast and the lateen yard, together with the small cargo mast forward of wheelhouse (JNG).

FIG. 4 – A Bedan at Al-Khamman showing the stern post extension where the rudder blade is hung from a rope loop and the forward stem projection (JNG).
Characteristics of vessels in this region include rudders that are controlled by ropes attached to a short spar set through the top of the rudder. In addition, rudders seem to have been suspended by rope rather than set using gudgeons and pintles. For example the modern boom has iron gudgeons and pintles but still retains a rope strop. It has been suggested that the transom stern of the ghanjah is an example of the Arabs copying the characteristics of Portuguese vessels when they arrived in the Indian Ocean at the beginning of the 16th century. This is a typical example of a cross between poor scholarship and Eurocentric thought. The fact that Chinese ships with transoms had sailed the Indian Ocean long before the Portuguese and that the first illustrated maps of the Portuguese show local vessels with transoms is largely ignored.

Many of the vessels have vestiges of sewing particularly where the hood-ends are sewn to the stem and the through-beams penetrate the exterior of the hull as in, for example, the battil (Figs. 5 and 6).

Many of the vessels of the Gulf are also represented on the coasts of Pakistan and western India. Understandably, the trade links with these areas are long standing and it would be interesting to attempt to dissect the different ship traditions.
South India including Sri Lanka

Maldives

The Maldives is one of the most interesting areas in the Indian Ocean for the study of shipbuilding. It is known that the Maldivians originated from South Asia, possibly in pre-Buddhist times. As such the ships that they would have used would reflect the available technology from that region, possibly a single outrigger, dugout log with raised wash strakes, similar to the oruwa of Sri Lanka. However, today the remaining vessels, basically referred to as Dhoni, reflect a clear Southeast Asian tradition; multi-planked hull, edge-joined with dowels and a sleek sophisticated appearance (Figs. 10-15). One must immediately speculate how this tradition came about. The Maldives are a series of coral atolls consisting of about 1200 islands lying between latitudes 8°N and 2°S. The main vegetation is coconut and the products are fish, cowry shell and by-products of the coconut tree. Coconut was until recently the main shipbuilding timber of the islands and, in the generally accepted sense, is not a good timber for building ships and this is reflected in the present day adoption of imported tropical hardwood for shipbuilding.

The construction of the dhoni is completely shell-first (Figs. 9-14), originally, with the coconut timber, the strakes were made with a series of paired carved lugs that were then used to locate a complex frame and beam system (Figs. 9-11) remarkably similar to the vessels from the Philippines, the Pacific and Scandinavia. While there is strong evidence through the Austronesian people of a connection between Southeast Asia and the Pacific, there is, of course, no connection with Scandinavia. The vessels have a ‘wine-glass’ cross-section with graceful and elegant lines (Figs. 10-12). It is perhaps surprising that such vessels have developed in an area
FIG. 7 — A large *oru* in operation in Galle harbour. Note the large wash strake above the dug out log (PEB).

FIG. 8 — A *madel parawa* on the beach at Galle showing the sewn construction and the split chine dugout construction (JNG).

FIG. 9 — A partially completed modern *dhoni* showing the lugs for the mast step as the only remaining trace of this tradition (JNG).
where the elements required for shipbuilding are so limited, when we compare, some 500 nautical miles away, the yatra dhoni, madel paruwa and oruwa of Sri Lanka (Figs. 7, 8 and 16), ‘primitive’ and technologically simple to produce, in a country that abounds with forests and high quality timber.

The historical references to Maldivian shipbuilding are diverse. The earliest dateable reference is Alberuni (1030 AD) who noted that coir was used to fasten the planks of their ships. Likewise, Ibn Batuta, who visited the Maldives in 1343-4 and 1346 AD, noted that coir was used to fasten the planks of boats in the Maldives, India and Yemen and that ‘...for the Indian Sea is full of rocks, and if a ship joined with iron bolts strikes a rock, it is broken up; but when it is fastened with this cord it has elasticity and does not break.’

Ma Huan who visited the Maldives in 1413 and 1421 was the first to refer to wooden pegs or dowels:

...They never use nails; they merely bore the holes, and always use their [coir] ropes to bind [the planks] together, employing wooden pegs in addition; afterwards, they smear the seams with indigenous pitch; no water can leak in.

Similarly, Correa described Maldivian craft taken in 1503 on the Indian coast near Culicut:
..They were made of coconut-tree timber assembled with wooden pegs, without any [iron nails] and the sails...
Barbosa elaborates on the fact that the Maldivians:
...Build many great ships of palm trunks, sewn together with thread, for they have no other timber,
Witsen (1671) wrote that the planks were made of coconut wood and fastened with wooden nails and sewn together with coir.
There is reference to dowels being used on Maldivian vessels in 1854. Henry Coleman Folkard (1854, p. 259) notes:
FIG. 13 – Vestigial lashing on the stem of a dhoni, also showing the stem extension socket (JNG).

FIG. 14 – Shell-first construction of a Maldivian dhoni (JNG).
FIG. 15 — A racing dhoni showing the unusual turned supports linking the thwart beams (JNG).

FIG. 16 — Model of a Yatra Dhoni located in the Galle Maritime Museum. This type of vessel is known to have traded in the Eastern Indian Ocean and the Maldives (PEB).
Fig. 17 – *lipa lipa* in the National Museum, Manila showing the frameless construction and carved lugs (PC).
The vessels used by the Maldive islanders are of very ancient appearance, and have many peculiarities, no other vessels being built of the same material: they are constructed chiefly of cocoa-nut wood, there being no other in the islands suitable for the purposes of naval architecture. The planking is pegged together with hard wooden pegs: the large boats are particularly strong.

It seems that there was a gradual transition from sewing to doweling, so that today, the only vestige of sewing is the semi-decorative bow (Fig.10-13). There appears to be no recollection of any of the present day shipbuilders of a sewing tradition, in spite of the fact that the Maldivian word to build a ship is ‘to bind or sew’. The transition from sewing to doweling can be seen in an earlier stage in Oman (see above), where sewing is still used on the stem and stern post and where the through-beams penetrate the outside of the hull, elsewhere the hull is fastened with diagonal dowels.

In addition, we need to seek parallels for the lugs and thwart beams in Maldivian boats. It could be that the lugs are a modification of the lugs found in the lashed-lug construction found in Southeast Asia (see the Butuan Boats below). Single lugs of this general type are found in the Solo region of the Philippines, and locating lugs have been noted on a Bajau *lippa* in Tawi Tawi in the Sulu Archipelago, Philippines (Fig. 17).

**Sri Lanka**

In contrast to the Maldives, some 500 nautical miles to the east, Sri Lanka today presents a quite strikingly different shipbuilding tradition. The vessels can be divided into a number of general groups: rafts, dugouts and sewn boats. Outriggers, which are also being found on both coasts of India, are a typical feature of the region.

In Sri Lanka there exists a number of unique sewn vessels the *madel oruwa* (Figs. 7-18), *madel paruwa* (Fig. 8) and the *yatra dhoni*, or *maha oru* (Fig. 16), meaning ‘big outrigger canoe’. The former two vessels, which are still widely used for beach seine fishing, have been described in extensively by Kapitán and Kentley and Gunaratne respectively. No example of the *yatra* now exists, the last example having been wrecked in the Maldives in the 1930s. Indian-built *dhoni* still sail in the region (see Fig. 19). However, a model of this type was recently examined and documented in the Maritime Museum in Galle, Sri Lanka by Vosmer. This model had originally been in the Kumarakanda Vihara at the port of Dodanduva. It is said to have been built by a boat-builder, and to be over 100 years old. Hornell stated that the *yatra* ranged up to about 30 m in length, but normally about 15—18 m, carrying 25—75 tons of cargo, usually averaging about 50 tons. Mookerji mentions *yatra dhonis* being about 18 m in length with a beam of about 5 m. They are sewn craft, planked from domba (*Callophyllum inophyllum*), at least 50 mm thick. In recent times the *yatra dhoni* was used as a coastal trader and for voyages to India and the Maldives.

The model had been built by a boat-builder and exhibited the hallmarks of his care. For example, it was noted that the four hooked scarf joints in the keel—stem and sternpost structure were made exactly as they would have been on the real vessel with tiny locking wedges. Other elements were also executed with attention to detail: the frame fastenings were roved on the inside, the sewing together of the planks was detailed, and the general finish of the components were of high quality. In view of this attention to detail, it was thought that the accuracy of the model, both in scale and detail would make a fairly reliable source for documentation.

The hull is double-ended, with slack bilges but full midsections. The forward sections are only just slightly finer than the aft sections, displaying a subtle hollow entry at the bow.
FIG. 18 – The oru showing the extremely narrow ‘slot’ created by the built-up wash strake. This type of vessel is ideally suited for net fishing but quite unsuitable for any other form of transport (PEB).

FIG. 19 – A Dhoni from Trivandrum.
FIG. 20 — Vessel from the Persian Gulf showing built-up wash strakes and stem resembling Borobudur boat carving.

FIG. 21 — Carving of Asian vessel on temple at Borobudur. Note two forward raking masts with saiods resembling a lete lete, outrigger and strange stem arrangement.
The forefoot is extended forward by a gripe attached to the keel-stem and there is also a skeg aft to which the rudder is fitted. Both these devices would be aids to lateral stability, helping to reduce leeway and balancing the helm while sailing. It should be noted that at least one drawing of a yatra does not show these additions.

The carvel-planked hull comprises wide planks sewn together (up to the level of the deck) along their edges. The bulk of the sewing is on the outside of the hull, a practice common to Sri Lanka but unusual in sewn craft of the Arabian Gulf and India. Planking is fastened to the frames with nails roved on the inside. The frame timbers are large but relatively few for any vessel. The total sectional area of all the frames, however, is more than adequate for strength. With the exception of the pairs of bollard timbers near bow and stern, the frames are continuous, all crossing the keel and running from sheer to sheer.

The beams are also large in section, few in number (seven) and protrude through the sides of the hull. It is presumed that the edge of the planking is slotted into them in order to lock them into place, though this cannot be discerned on the model.

A large outrigger is fitted on the port and windward side of the vessel, (according to the set of the sails); this is similar to the boat from Borobudur (Fig. 20-21). The use of an outrigger is curious on a vessel that appears to possess a rather stable hull rig configuration. Hydrostatic analysis of this hull form by Vosmer showed it to be a reasonably seaworthy vessel even without the outrigger. It appears that the port side was intended to be always to windward and therefore for trading voyages it would need to utilise the monsoons. Alternatively, the sea breeze could be worked during the day to move northward along the western coast, while the southward journey could use the land breeze at night. Voyages to the Maldives could be accomplished in similar fashion, by using the monsoon winds at appropriate seasons.

The vessel is rigged as a ketch with square-headed lug sails and a jib set on a short bowsprit, a rig common to the region of the Indian subcontinent. The arrangement of the halyards was such that they prevent the mizzen yard from passing around the forward side of the mast. It must therefore be concluded that the mizzen sail on the yatra was never tacked, but went aback against the mast when occasionally on a starboard tack. It has been suggested that the yatra is a derivative of the types of vessels illustrated on the Borobudur ship carvings.

The oruwa (Fig. 7) is an outrigger dugout canoe with unusually large wash strakes (Fig. 26). Essentially, the oru consists of a large log, dugout in the centre leaving a long narrow slot in the top. Above the slot is constructed a high-sided box running the length of the slot and attached to the log by sewing. The resulting slot is only just narrow enough for a person to stand (see Fig. 26). Across the top of the slot are set two outrigger beams with another small log attached to act as a counterbalance outrigger. Occasionally, these vessels can be seen using sails, but usually they are paddled or rowed, usually with a group of rowers and a person using a steering oar.

The madel paruwa (Fig. 8) is a chined strake sewn vessel used for beach sein net fishing. These ungainly-looking vessels consist of a log that is split longitudinally and set on either side of the vessel as a chine strake. Between the chines are a series of strakes sewn together to act at the bottom and sloping sections of the bow and stern. There are two or more transverse thwart beams, which project from the sides of the vessel which are used to drag the vessel up the beach. The chine strakes are constructed so that when the vessel beaches it stands on the wooden chine strakes thus protecting the sewing of the bottom of the vessel form beach abrasion.
Eastern Indian Ocean

The eastern Indian Ocean has some differences in ship construction. Greenhill has discussed the vessels of Bangladesh including the unusual reverse-clinker construction and Kentley and McGrail have also reported on the beach-fishing boats of this region. Fastenings include sewing and also iron ‘staples’.

East Asia

The origins of the Chinese ‘junk’ are still today not well understood. Hornell suggested that the concept for these vessels originated from bamboo raft construction, which can still be found today in parts of South China, Vietnam (Fig. 22) and Taiwan. Other authors have suggested that the building of these vessels originated from a concept of replicating the septa of the bamboo: others disagree. This lack of understanding is partially due to the fact that East Asian vessels have never been systematically studied. In Asia there is a lack of both written evidence and archaeological information. While many authors have described the ‘junk’ of the modern period, such studies have lacked the breadth of comparable work in Europe. European studies have relied on extensive archaeological excavation work and, where appropriate, on archival and iconographical studies. It is interesting to note that many hundreds of examples of archaeological ship excavations exist within the European context, whereas there are few examples of proper archaeological excavations of sites within the Asian region.

**Fig. 22** — A bamboo raft-boat from Thanh Hoa province in northern Vietnam. These vessels normally have three masts. In the background on the beach can be seen basket boats (NB).
Within the East Asian region vessels fall into a number of categories: the large flat-bottomed vessels of the North China Seas and the inland waterways; the keeled vessels with a distinct V-shape from the Southern part of China; the ‘dragon’ boats of the South and Southeast China Seas region; the sewn vessels of South China including Hainan and parts of Vietnam; bamboo raft-type vessels of South China and Southeast Asia; and basket boats. In Korea there is a different tradition of shipbuilding with possibly connections with North China and Japan. Japan too has a distinct tradition, with vessels which resemble those of China, but it is unclear if the connections are with North China, or the Ruykuy Islands and hence Taiwan and Southeast Asia. In Southeast Asia, one can find vessels bearing no relationship to the Chinese shipbuilding traditions, and others with a mixture of Southeast Asian and Chinese traditions.

Much of the problem in resolving the origins of these vessels is that there is very little surviving information about shipbuilding in either Chinese or Southeast Asian literature. Our first evidence occurs sporadically from the Tang dynasty in Chinese literature and paintings. The arrival of foreigners in China does little to clarify the picture, they either wrote little, and the Europeans, in particular, misunderstood much of what they saw and often dismissed it as inferior. Marco Polo stands out as one of the best, early chroniclers of Chinese ships and what he says about ships — as with other things — can often be verified.

Today, with emerging archaeological studies in East and Southeast Asia, it is possible to overview the current and past thinking of the origins and development of Chinese ‘junks’. Needham’s encyclopaedic work: *Science and Civilisation of China* is a monumental study of great importance and significance and can be used a starting point for the analysis of Chinese shipbuilding. While some authors have written about Chinese ships, few have dealt with the issue in such a broad context. Although there are some authors who criticise Needham for his Sinocentric bias, the study is of great scholarly importance. At the time that Needham wrote, within the specific areas of shipbuilding there was little archaeological information. Much of what is available was just beginning to emerge and had this information been available his conclusions may have been different. Needham was doubtless correct when he noted that it was regrettable that:

...Chinese naval architecture never found...its systemising scholar! At any rate one would not be far wrong in believing that the shipwrights of the Ming were probably the most accomplished artisans of any age in civilisation who were at the same time illiterate and unable to record their skill.

However, his writing seems confused on two issues: firstly, the significance of ocean-going vessels in China and secondly, and more obviously, the question of the existence in China of ships with a keel in the traditional European sense. Needham used the flat-bottomed Jiangsu or Pechili freighter as an example of a typical Chinese ‘junk’. He qualified this generalisation by stating that ‘Geographical factors have had considerable influence in differentiating the craft found along the coasts of China’. Some Chinese writers had noted the differences between the vessels of north and south China. A scholar of the 17th and 18th century Xie Zhan-Ren commenting on a passage in the Ri Zhi Lu (Daily Additions of Knowledge) of Gen Yan-Wu, itself finished in +1673, wrote as follows:

...The sea-going vessels of the Jiang-nan are named ‘sand-ships’ (sha chuan) for as their bottoms are flat and broad they can sail over shoals and moor near sandbanks, frequenting sandy (or muddy) creeks and havens without getting stuck...But the sea-going vessels of Fujian and Guangdong have round bottoms and high decks. At the base of their hulls there are large beams of wood in three sections called ‘dragon-
spines’ (*long gu*). If (these ships) should encounter shallow sandy (water) the dragon spine may get stuck in the sand, and if the wind and tide are not favourable there may be danger in pulling it out. But sailing to the South Seas (Nan-Yang) where there are many islands and rocks in the water, ships with dragon-spines can turn more easily to avoid them.

Here Needham suggests that this is:

"A reference to the better sailing qualities of ships with deep hulls and centreboards. With this passage in mind we may look again at Fig. 939 [Needham], where the *long gu* is the central strengthening member of the hull of the Fujian and Guangdong sea-going junk, with round bottom and high decks. Such timber is called a *long gu* by Chinese shipwrights, *but it should not be regarded as a keel in the European sense* [author’s italics]...for it is not the main longitudinal component of the vessel, this function devolving rather on the three or more enormous hardwood wales which are built into the hull at or below the waterline.

It is unclear from this passage if Needham has confused the strengthening wales with the true keel. He attributes *long gu* of flat-bottomed vessels (which are a type of wale or chine wale), with the true keel of deep-hulled vessels. The passage in the *Ri Zhi Lu* clearly indicated this error, since it refers to the *long gu* getting stuck in the sand — obviously wales cannot get stuck in the sand. Later, Needham states: ‘But Chinese ships, as we have said, were not always flat-bottomed; though lacking any true keel...’ Needham quotes Xu Jing who states in the *Gao Li Tu Jing* (Illustrated Record of an Embassy to Korea) dated to 1124, that ‘the upper parts of the vessel are bottom of the ship (deck) is level and horizontal, while the lower parts sheer obliquely like the blade of a knife...for since the bottom of the vessel is not flat.’ Needham infers that this shape could be found in modern times in certain types of fishing vessels and smaller naval junks of the Qing dynasty and all sea-going junks of the south of China.

Needham also refers to the *Tien Gong Wu* (Exploitation of the Works of Nature) by Song Ying Xing in 1637. Here a description of a canal grain-carrying vessel is given and then his description of the shipyards:

"...The construction of the boat begins with the bottom. The strakes of the hull are built up on both sides from the bottom to a height (equivalent to that of the future) deck. Bulkheads are set at intervals to divide the vessel (into separate compartments), [we may interpret this statement as an indication that the vessels were built shell-first] and (the holds have) sheer vertical sides which are called *qiang*. The horizontal bars (*heng mu*) which grasp the mast’s foot below this are called ‘ground dragons’ (*di long*), and these are connected by components called ‘lion-tamers’ (*fu shi*), while underneath them lies another called a ‘lion-grasper’ (*na shi*). Under the ‘lion-tamers’ are the ‘closure pieces’ (*feng tou mu*) otherwise known as triple tie-bars (*lian san fang*)..."

Song Ying Xing mentions that the ocean-going vessels from Fujian and Guangdong have bulwarks of half bamboo for protection against the waves; examples of this can be seen in the illustrations of the Mongol invasion of Japan (see below).

Wang Gungwu suggests that there were no large Chinese-built vessels involved in the Nanhai trade in the Tang, although it is known that large Chinese vessels sailed to Korea and Japan. However, Wang Gungwu states that:

"On all these routes [from Guangdong south and then east] sailed Chinese and K’un-lun [Vietnamese or Southeast Asian] as well as Arab, Persian, Ceylonese and Indian ships. Only past the Nicobar Islands, and especially past Malabar it is doubtful whether Chinese and K’un-lun were ever found at this time [800 AD]."
However, by the 15th century according to Ch’oe Pu:
...From Su-chou, Hang-chou, Fukien, Kwangtung, and other places in our country, sea-going smugglers go to Champa and the Islamic countries to buy red sandalwood, black pepper and foreign perfumes.

The illustrations of Chinese vessels are limited in number. One of the earliest illustrations of Chinese ships is on a stele in the Wan Fu Su temple at Chengdu dating to the Liu Chao Period (Six Dynasties — 3rd to 6th centuries AD). Slightly later are some ships shown on the frescos in the Dunhuang cave temples in Gansu Province, dating to the 7th century. Both are mentioned and illustrated by Needham who suggests that these vessels have steering oars rather than axial rudders. While the illustrations are rather unclear, the largest ship in the Dunhuang cave-temple frescos has square ends, a square sail and what looks like poles or oars at both ends of the vessel. Audemard illustrates a large range of vessels with axial rudders and strange steering sweeps set at the stern in pairs or singly projecting from the transom above the rudder. These are different from the sweeps, possibly yuloh that are set at the side of the vessels. Audemard’s illustrations come from an 18th century description of warships entitled Tu Shu Ji Cheng (Imperially Commissioned Compendium of Literature and Illustrations, Ancient and Modern). It is, therefore, possible that the Dunhuang illustration, like the Audemard illustrations, show a combination of stern sweeps and an axial rudder.

The Wan Fu Su Temple stele has a well-defined square sail, a large stern structure and a square bow, in this illustration it is uncertain if a rudder depicted. Needham suggested that these illustrations of vessels might be of Indian rather than Chinese, particularly because of their Buddhist origins.

The carving on the Bayon temple at Angkor Thom, Cambodia, dated to 1185 shows, among other vessels, a large two-masted ship with forestays, mat and batten sails, multiple sheets and no mast shrouds. The vessel is thought to be Chinese since it has many characteristics typical of a Chinese ship, and is relatively untypical within the illustration where other, obvious Southeast Asian vessels appear. There appears to be two flagpoles with forestays: a jack staff (at the bow) and an ensign staff or at the stern. The jack staff flag has multiple points (typically Chinese). At the top of the fore and main masts there seems to be a small square mat sail (?), flag or crows-nest. The ensign flagpole has a matting flag. At the bow a sailor is operating the anchor windlass and lifting a crown stocked anchor. Sitting on the deck in pairs are six people, apparently not engaged in any nautical activity (possibly merchants). Aft of them are two sailors working the fore and main sheets. Aft again are three people standing apparently looking forward and involved in the activity of sailing. The head of one person shows just above the gunwale at the line of the sternpost and is presumably the helmsman. The stem post is slightly concave and thicker at the top. There seem to be eight strakes; the stern top three strakes extend to form a counter over the sternpost. The sternpost is much narrower than the stem extending from the counter down two strakes where it combines into an extended rudder which projects below the keel. The carving is unclear and some writers have suggested that it represents a quarter rudder rather than an axial rudder but this is unconvincing. Possibly the confusion is the result of the stonemason unfamiliarity with ships below the waterline.

Large river vessels of the Song Dynasty are illustrated in the famous scroll by Zhang Zeduan entitled Qing Ming Shang Ho Tu (Going up the river the capital (Kaifeng) at the Spring Festival) and painted with meticulous care sometime around 1126. It shows three separate groups of vessels, the down-stream group has six vessels, the middle group shows a large vessel, bows-on, negotiating, with difficulty, the passage under a bridge and the
upstream group shows two vessels tied up to the river bank. The largest vessel is about 15 metres long. The vessels all have no noticeable sternpost and the axial, semi-balanced rudders appear to be fixed on a hinge system on the transom with chains so that they can be raised and lowered. There are three different types of vessels:

1. Vessels with the hull planking sweeping up, in a uniform manner, to a small, high, vertical transom, reminiscent of the Dutch fluits of the early 17th century.
2. Vessels with a small counter overhanging a small low transom and with a noticeable chine indicating a flat bottomed vessel.
3. Vessels with a large low transom and a considerable overhanging counter. The planking is uniform with no chine.

While these vessels are obviously river-craft, their construction is of great interest because of the detail of the illustration, indicating how the Chinese shipbuilders had developed construction methods.

The *Moko Shurai Ekotoba* or Illustrations and Narrative of the Mongol Invasion of Japan (Fig. 23), produced in 1292 and preserved in the Imperial Household Museum illustrates the Second Mongolian invasion of Japan in 1281 (the first was in 1274). The scroll illustrates the adventures of the nobleman Takezaki Suenaga and it has been suggested that he was responsible for illustrating part of the scroll. The central part of the maritime scenes from the scroll shows two large Chinese or Mongolian vessels retreating to the left. From the right (in the direction of reading and chronology) come the Japanese in small vessels to attack the Chinese fleet. At the left come some vessels to counter this attack and some in retreat. The scroll has been damaged and possibly repaired, but it is lively, and suggests an active engagement between a small lightly armed Japanese force against a larger and more unwieldy Chinese force.

Another important source from the period of the Quanzhou ship is Marco Polo who resided in China between 1275 and 1292. He wrote on Chinese river shipping and also on sea-going vessels of Guangdong and Fujian. As with all translations one needs to approach the works with caution. For example, there are interesting variations in the translation of *The Travels of Marco Polo*. The version translated by Latham gives the following account at the beginning of Chapter Six: From China to India:

![Fig. 23 — Depiction of a Chinese/Mongol vessel from the *Moko Shurai Ekotoba* showing a Japanese raiding party attacking the vessel. This ship would be very similar to the Quanzhou ship.](image-url)
...To begin with, we shall tell you first of the ships in which merchants trading with India make their voyages.
This then I would have you know, is how they are made. They are built of a wood called spruce or fir. They have one deck; and above this deck, in most ships, are at least sixty cabins, each of which can comfortably accommodate one merchant. They have one steering oar and four masts.

Needham gives an alternative and unreferenced translation that will be quoted here in full. Note the differences between the two versions:
...We shall begin first of all to tell about the great ships in which the merchants go and come into India through the Indian Sea. Now you may know that those ships are made in such a way, as I shall describe unto you.
I tell you that are mostly built of the wood that is called fir or pine.
They have one floor, which with us is called a deck, one for each, and on this deck there are commonly in all the greater number quite 60 little rooms or cabins, and in some, more, and in some, fewer, according as the ships are larger or smaller, where, in each, a merchant can stay comfortably.
They have one good sweep or helm, which in the vulgar tongue is called a rudder [the earliest recording of the word rudder seems to be around the early 14th century, this may imply that Marco Polo was unfamiliar with the term rudder and an axial rudder in particular, since at that time quarter rudders in the Mediterranean were the norm]. And four masts and four sails and they often add to them two masts more, which are raised and put away every time they wish, with two sails, according to the state of the weather.
Some ships, namely those which are larger, have besides quite 13 holds, that is, divisions, on the inside, made with strong planks fitted together, so that if by accident that the ship is staved in any place, namely that it either strikes on a rock, or a whale-fish striking against it in search of food staves it in. And then the water entering through the hole runs to the bilge, which never remains occupied with things. And then the sailors find out where the ship is staved and then the hold which answers to the break is emptied into the others, for the water cannot pass from one hold to another, so strongly are they shut in; and they repair the ship there and put back the goods which were taken out.
They are indeed nailed in such a way; for they are all lined, that is, that they have two boards above the other.
And the boards of the ship, inside and outside, are thus fitted together, that is, they are in the common speech of our sailors, caulked both outside and inside, and they are all well nailed inside and outside with iron pins. They are not pitched with pitch, because they have none of it in those regions, but they oil them in such a way as I shall tell you, because they have another thing that seems better than pitch. For I tell you that they take lime and hemp chopped up small and they pound it all together, I tell you that becomes sticky and holds like birdlime. And with this thing they smear their ships and this is worth quite as much as pitch.
Moreover I tell you again that when the great ships wish to be decorated [?], that is to be repaired, and it has made a great voyage or has sailed a whole year or more and needs repair, they repair it in such a way. For they nail yet another board over the aforesaid original two all round the ship without removing the former at all, and then there are three of them over the whole ship everywhere, one nailed above the other, and then when it is nailed they also caulk and oil it with the aforesaid mixture and this is the repair which they do. And at the end of the second year at the second repair they nail yet another board
leaving the other boards so that there are four. And this way they go each year from
repair to repair until the number of six boards, the one nailed on the other. And when
they have six boards the one upon the other nailed then the ship is condemned and they
sail no more in her on too high seas but in near journeys and good weather and they do
not overload them until it seems to them that they are of no more value and that can
make no more use of them. Then they are dismantled and broken up.

Much of what Marco Polo says here can be related to the Quanzhou ship; however, the
statements about the watertight bulkheads are of considerable interest and present an
apparent conflict with the archaeological record. Marco Polo is the origin of the theory that
Chinese ships had bulkhead compartments that were completely watertight. Later writers,
up to and including Needham followed this suggestion. However, every Asian vessel with
bulkheads that has been excavated by archaeologists shows evidence that the bulkheads,
although sealed with luting, had limbers to allow water to flow between the compartments.
Additionally, in all the wreck sites there has been no evidence of stoppers or bungs in the
limbers, indicating at the time of sinking the limbers were open. This issue is discussed in
more detail below. The statement about the multiple planking is also of great interest, since
it provides historical evidence for a technique that would be hard to understand from the
archaeological evidence alone.

Ibn Battutah, who was in China in 1347, was a less detailed observer than Marco Polo.
He noted that:

...We stopped in the port of Cālicūt, in which there were at the time thirteen Chinese
vessels, and disembarked... On the Sea of China travelling is done in Chinese ships
only, so we shall describe their arrangements.

The Chinese vessels are of three kinds; large ships called chunks [in other translations
jonouq, in Needham chuan], middle sized ones called zaws (dhows) [elsewhere zaw, cao or
sao] and the small ones kakams. The large ships have anything from twelve down to three
sails, which are made of bamboo rods plaited into mats. They are never lowered, but turned
according to the direction of the wind; at anchor they are left floating in the wind. A ship car-
ries a complement of a thousand men, six hundred of who are sailors and four hundred
men-at-arms, including archers, men with shields and arbalests, who throw naphtha. Three
smaller ones, the “half”, the “third” and the “quarter”, accompany each large vessel. These
vessels are built in the towns of Zaytūn and Sin-Kalān. The vessel has four decks and con-
tains rooms, cabins, and saloons for merchants; a cabin has chambers and a lavatory, and
can be locked by its occupant... This is the manner after which they are made; two (parallel)
walls of very thick wooden (planking) are raised and across the space between them are
placed very thick planks (the bulkheads) secured longitudinally and transversely by means
of large nails, each three ells in length. When these walls have thus been built the lower deck
is fitted in and the ship is launched before the upper works are finished (Ibn Battūta).

Both Marco Polo and Ibn Battutah refer to the large size of the vessels and the large
crews. However, the interesting issue is the reference by Marco Polo to a number of features
of Chinese ships that can be related to both the Quanzhou Ship and other Asian built vessels.

A Japanese scroll of the early Qing shows eleven Chinese ships and one Dutch ship.
The scroll (Tosen no zu) and its associated scroll showing foreign ships’ tools (Gaikoku Ŝengu
Zukan) are housed in the Matsura Historical Museum with a copy belonging to the
National Gallery of Victoria. It has been approximately dated by Oba to between 1718 and
1727. These illustrations are well drawn, given a scale, most of the major dimensions of the
vessels and a description of their features. Oba suggests that the scroll was produced to help
the customs officials identify foreign vessels and assist in the control of smuggling.
Over the last 25 years a number of excavations have been carried out in the Asian and Southeast Asian region on vessels that have relevance to the discussion. The vessels are: (Chinese) the Quanzhou Ship, Dongmenkou, Fa Shi, Shandong, Shinan, Ko Si Chang Two, Con Dao; (Southeast Asian, see below) Pattaya, Ko Si Chang One and Three, Ko Khram, Rang Kwien, Phu Quoc and Bukit Jakas.

The Quanzhou Ship

This ship was discovered in 1973 and excavated in 1974. The site has been reported previously in a series of four reports in the Chinese archaeological journal *Wen Wu*. The ship was discovered whilst dredging a canal at Houzhou, about 10 km from Quanzhou. The excavation took place between 7 June and 31 August 1974. The ship was then dismantled and transported to Quanzhou, where it was rebuilt under a temporary shelter in the grounds of the Museum (Figs. 24 and 25). Between 1977 and 1979 a building was constructed which included the ship, a display area and administrative quarters. The surviving portion of the hull is approximately 24m in length and 9m wide. There is a straight keel some 13m in length and this is extended in the stern by a piece that angles upwards 27°; the garboard strake runs parallel to this extension all the way aft to the transom. In the bow, an extension of the keel angles upwards 35°. The forward extension could be regarded as a strongly raked stem since the lower planking does not run parallel to it, but terminates on it. However, there is reason to suspect that a transom surmounted it, so we will refer to it as the forward keel extension. There are knees reinforcing the scarf joins of the extensions to the keel. These knees are fairly light, sawn from small pieces of timber and left half-round in section.
They would appear to have been used to position the keel extensions during assembly rather than as an important part of the ship’s main longitudinal structure.

The midsection of the hull shows considerable dead rise and there is distinct hollow in the dead rise close to the keel. The turn of the bilge is gentle: only the lower part of the turn of the bilge survives and the exact sectional shape at this point cannot be determined since it is not confirmed by the remains of any bulkheads, but the appearance as that the full beam of the hull must have been substantially greater than the 9m of the surviving portion. There is only a slight increase in dead rise, and no increase in the hollow, towards the stern. Towards the bow, both dead rise and hollow increase markedly. The hollow is greatest in the vicinity of the junction of the keel and forward keel extension. This is an unusual characteristic; it would give the hull greater lateral resistance forward than aft and suggests that a large and deep rudder was used to counter the ‘grip’ of the bow.

The planks of the main (inner) planking layer are fitted together with rabbeted carvel joints and rabbeted clinker joints at the seams. The planks of the main planking are skew nailed together through the seams. The skew nails have been driven down from the upper plank to the lower from the outside of the hull; during this process the rabbeted seams would hold the planks in alignment.

The garboards were skew nailed to the keel with nails at about 160mm apart. They are fairly massive planks and rise near vertically from the keel through the midbody of the hull, so that, together with the keel they form a narrow, channel-sectioned structure, on to which the plank shell of the hull is built. It is possible to see this structure as a development from a vestigial dugout canoe/keel.

The main planking is fastened to the bulkheads by L-shaped metal brackets. The brackets are recessed into the bulkheads, and the feet of the brackets are recessed into the outer face of the main planking. Most brackets are aligned within about 7-8° of normal (90° to the plank that
they fasten, when viewed in transverse section; but a few are as much as 10° from normal. This suggests that the ends were bent over in situ, since if they were pre-bent all brackets could be expected to be bent at the same angle (about 90° and to lie more or less precisely normal. Like the pattern of plank butts, the positioning of the brackets is symmetrical port and starboard (except for an extra bracket in strake ten at bulkhead eight on the starboard side). The strakes immediately below the clinker steps (strakes 5, 8 & 11) have only one or two brackets connecting them to the bulkheads throughout their length. Whereas the strakes immediately above the steps (strakes 6 and 9: too little remains of strake twelve to constitute a useful sample) have the greatest number of brackets — thus these strakes clamp in place those immediately below them.

The slits where the brackets pass through the planking show that the brackets were only about 5—7 mm in thickness, but in a few cases they were recessed as much as 12mm into the bulkhead. The slits were not always perfectly positioned in relation to the face of the bulkhead with which they were required to align.

There are fairing strips on the inside of the hull at each clinker step, presumably to prevent water and grunge from lying in the step. It was previously reported that these fairing strips run under the bulkheads, but that is not the case except where the bulkheads have been reconstructed. The fairing strips are short lengths cut to fit between bulkheads. They appear to have been lightly fastened with only one or two nails on each length. It is not clear whether they went under the frame timbers which lie against each of the bulkheads on the side facing midships.

The bulkheads are constructed from planks about 80 mm thick, skew nailed together. The skew nails were driven downwards and were inserted from both forward and aft faces of the bulkheads. Unlike the plank shell skew nails, they are very irregularly spaced. The few scarfs in the planks that make up the bulkheads are complex and carefully made. The planks have been planed, or smoothed in some other way, but in some cases this has been done in a rather cursory way and marks remain showing that the planks were sawn.

On the side of each bulkhead closest to midships there are half frames. The half frames are on the aft side of bulkheads 1-6 and the forward side of bulkheads 7-11. There are no half frames at bulkhead twelve. The brackets that secure the bulkheads to the planking are on the opposite side of each bulkhead: there are no brackets on bulkhead twelve. It may be that bulkhead twelve is not correctly fitted; it does not conform to the sectional shape of the hull on the starboard side.

The stern transom appears to be composed of three layers plus a layer of thin sheathing on the outside. The inner layers are fitted inside the main planking; presumably the ends of the strakes are fastened to this inner transom. The outer layer is aft of the end of the main planking but inside the outer planking layer. The outer planking layer is extended aft of the transom to form a kind of false counter. The outer layer of the transom has a slot cut in it for the rudder stock and is made of baulks of timber only slightly thicker than the diameter of the rudder slot, thus the slot almost cuts them in half and the strength of the transom relies on the inner layer(s). The uppermost of the extant outer transom baulks appears to have its ends cut square, so it did not extend right out to the sheathing planking at its upper face. This suggests that the outer transom did not continue above this height though there would need to have been baulks forming brackets to hold the rudder stock higher in the transom, as there are on traditional vessels of the region today (Fig. 25).

There are no bulkheads forward of the junction of the keel with its forward extension. This suggests that the complete hull did not extend a great deal forward of the forward extremity of the currently extant hull, which contributes to the argument for a transom in the bow. Forward of the first bulkhead, there is a kind of apron or deadwood which lies on top of the keel extension. It is made up two large timbers and smaller filler pieces. The forward mast step lies on top of the aft end of this apron.
The Fa Shi Ship

The Fa Shi ship, which was discovered in 1982 near Quanzhou, is not well documented. This vessel was partially excavated; the remains were located partially under a building. It is generally described as Song Dynasty. The excavation is briefly reported in Xu Yingfan and shows bulkheads and wooden pegs or stiffeners similar to the Shinan Ship. The stiffeners are unusual as they appear to be angled.

The Ningbo Ship, Dongmenkou

The archaeological excavation of the Song ship at Dongmenkou, Ningbo has been described by Lin Shimin. The site consisted of the fore part of the vessel, including seven bulkheads (the stern-part was missing). The keel was made up of at least three parts and attached to it was a stem angled at about 35° to the horizontal (the term stem will be used here but it could be described as a forward keel extension or a strongly raked stem).

When it was uncovered the ship was approximately horizontal in position, the timbers were greyish yellow in colour and its shape and components could be clearly seen. Unfortunately after being exposed to the sun, the timbers shrank and the components of the ship were distorted out of shape and broke making it impossible to preserve them.

The remaining part of the ship was 9.30 m long and 1.14 m high. Taking the keel as the central line, half of ship’s breadth is 2.16 m, the upper structure having rotted away. The remaining stem, bilge, planking, garboard and keel were well preserved. The marks of the bulkhead and an inlaid repair consisting of a round wooden plug on a plank were very clear. The steps of the fore and main masts were carefully made. A supporting timber or stiffener was installed behind the bulkhead under the main mast step to strengthen the planking and the mast. The remains of part of the rudder were found at the stern of the ship. This ship was probably a three masted sea-going vessel with a sharp bow, ‘V’-shaped bottom and a square stern.

The remaining part of the pine wood keel was 7.34 m long, 0.26 m wide and 0.18 m thick, the aft part being broken. Judging from the joints the keel, it is made up of three parts with the third one turning slightly upwards. The length of the first part is 1.98 m (not including the mortise and tenon joint at the stem post), the second part is 5.10 m long and the mortise and tenon joint with the first part is 45 cm; the remaining third part is about 3.45 m according to these, the total length of the main keel would be over 10.5 m.

The stem was made of China fir, triangular in cross-section with the widest place 18 cm, the thickness 20 cm, the remaining length 1.55 m and there was evidence that the planking was rabbeted to the stem. In the scarf joint between the keel and the stem were two small rectangular holes, 3 cm long, 2.5 cm wide and 4 cm deep separated by 3 cm containing six coins in each hole. These holes are called Holes of Longevity (baosongkong). The 12 coins are of the early Northern Song and are Hing De Yuan Bao, Tian Sheng Yuan Bao, Huang Song Tong Bao. The scarf was jointed with a mortise and tenon to the keel and was fastened by nails of 1-1.5 cm in diameter, 15-17 cm in length, which were arranged in plum flower pattern.

The hull planking was made of China fir, pine or camphor. The planks were 6-8 cm thick; the widest was 42 cm, the narrowest 21 cm. The remaining large planks were 3-8 m long. The planks were joined scarf jointed with the oblique side up to 1.55 m long and the scarf usually spans one or two frames. Tongue and groove joints were used when butt joining the planks. The tongue was 2-4 cm high and nailed up with rectangular iron nails. The
planking was skew nailed with rectangular iron nails, 1.5 x 1 cm in cross-section, 12-20 cm long. The interval between two nails was 10–25 cm, but at the bow, the interval is closer, only 10 cm. The seams were filled with mixture of tung oil, lime and hemp.

All the frames were made of camphor wood in regular shape and generally 16–25 cm wide, 7–10 cm thick (at bottom) becoming narrow at the top. At the bottom of the ship, each frame has a 3 x 4 cm semicircular limber hole level with the keel.

The remaining part of the ship has six compartments, of which the fifth is the largest, being 2.05 m long with a maximum half beam 2.16 m. The smallest is the second compartment, 0.62 m long, the smallest half beam 1.64 m. The fourth one 1.16 m long, largest half beam 1.64 m; the sixth 1.14 m long, largest half beam 2 m. Most of the bulkheads are made of pine, some are of cypress. The bulkhead aft of the main mast at the fourth hold is 7-10 cm thick, 70 cm high. Only one bulkhead of 7-10 cm thick, 28-30 cm high remained. The bulkheads were nailed to the frames which were in turn nailed to the hull.

The bulkhead at the middle of the rear of the 4th compartment which had the mid-mast fixed to it, had a concave mortise of 4-5 cm wide, 0.5 cm deep, in which square supporting timber or stiffener was fixed. This timber was fixed into the mortise on the keel to strengthen the bulkhead and support the mast.

At the stem before the first bulkhead there is the mast step for the foremast, 84 cm long, 21 cm wide and 14 cm thick. Two holes for the tabernacle of the mast were 14 x 7 cm in size, 5 cm in depth with 13 cm interval were opened in the middle of the step. The step is made out of a complete piece of camphor wood.

The mid-mast had a relatively large mast step at the back part of the fourth compartment from the fore part of the ship. This was made out of several kinds of wood; the step was 105 cm long, 25 cm wide and 18 cm thick. There were two holes for mast tabernacle which were 15 x 8 cm in size, 5 cm in depth were opened in the middle of the step. Because the stern of the ship was broken, there was no evidence for the existence an aft mast step, however, given the proportions of the vessel and the location of the existing mast steps it is likely that there was at least one other mast, possibly stepped on the deck.

No complete components of the rudder were found. A remaining piece of timber, found at stern of the ship, was 186 cm long, 42 cm wide and 18 cm thick with a hole of 26 cm in diameter in the middle and is thought to be part of the rudder.

At the outer side of the joint between the seventh and eighth strakes, a semi-circular bilge strake or whale was attached, 710 cm long, 14 cm wide and 9 cm thick. Both ends were broken, the whale tapered towards the bow (10 x 4 cm). The whale was made of cypress wood and was nailed to the hull by two rows nails with 4-50 cm intervals. Clearly its position was not that of a rubbing strake, but possibly a feature to assist with stability and strength.

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The Jinan Ship, Shandong

This vessel was discovered in 1956 in the province of Shandong and is now preserved in the Shandong Provincial Museum at Jinan. A very brief report in English has been published by Needham. The vessel is about 20 m long by 3.5 m wide, transom-ended with 13 compartments. The vessel is flat bottomed and has a sharp chine, thus typical of the river and North China Seas design. The ship dates from the 14th century: an anchor was dated 1372 and a bronze gun 1377. It is thought to have been a government river patrol boat.
The Shinan Ship

The Shinan ship has been widely described, mainly for its exotic cargo of Chinese and Korean ceramics. Relatively little has been published about the hull structure which is both interesting and important to the understanding of Chinese-built. The vessel has been dated to about 1323 from artefacts and coins. The remains of the ship include the keel, about 14 strakes of the starboard side and six strakes of the port side of the ship, part of the transom bow and a small section of the stern transom.

The hull of the ship is rabbeted clinker construction with evidence of sheathing. In the fore part of the vessel the rabbeted clinker changes to rabbeted carvel allowing a flush joint on the transom bow. The strakes are butt-jointed. In most cases the butt joint is a lap joint, but on the garboard strake and on at least one other place the joint is a tongue and groove joint. On the internal face of the butt joints there are butt plates which sit over the top of the joints and clamp them together. In some cases these butt plates are set under a frame, indicating that the frames were put in place after the completion of the planking. The strakes are rabbeted clinker construction, with the rabbet cut out of the uppermost plank, on the lower inside edge.

Frames and stiffeners support the seven bulkheads. Bulkheads forward of the mast step are supported on the aft side with frames and on the forward side by stiffeners — aft of the mast step the reverse is true. The stiffeners, which are pointed wooden pegs, penetrate each strake from the outside of the hull planking through the middle of the plank and are not rebated into the bulkhead. Thus the stiffeners locate the opposite side of the bulkhead to the frames and are attached to the face of the bulkhead.

There is a fore and a main mast step, a structure that is possibly part of the decking of the ship and evidence for a water tank of some sort forward of the main mast. The Mokpo Conservation and Restoration Centre have built a research model at a scale of 1:5 based on measurements made of the hull timbers. This model raises a number of complex and interesting problems, however, the model has some limitations. Firstly, because of the poor visibility on the wreck site, it was not always possible to establish the exact orientation of the pieces, thus in some cases their relationship is uncertain. Additionally, the plans of the timbers were made from individual measurements made on the timbers, but not direct 1:1 tracings. In spite of these drawbacks, the model is of great interest, and of course is just one step in the development of a complete understanding of the structure.

One of the major problems that has not yet been resolved is that the keel has a distinct hog, the Centre is 220 mm higher than the fore and aft ends, over the length of the keel. It is not certain at present if this is a feature that was incorporated in the construction of the ship, or is a result of forces on the hull structure after the sinking. It is expected that further work on the research model will resolve this problem. The scarf joints in the keel have a similar arrangement to the Quanzhou ship but with coins and a mirror placed on the sloping horizontal face of the joint rather than the vertical faces, as in the Quanzhou ship.

The arrangement of the mast step and the composite three-part mast is unusual. It is possible that the orientation of the mast in the plan is wrong. It will be noticed that the main mast does not make contact with the bulkhead. The foremast, however, is arranged to lie against the bulkhead and the bulkhead, it seems, has been especially angled so that is aligned with the rake of the mast. There is also a pin to fix the base of the masts.

The way that the transom bow is attached to the keel is not absolutely certain. However, it is double planked. A single cant frame was recovered. It is unusual because it has a series of semi-circular holes cut from the upper surface through to the side face of the frame. The purpose of these holes is unclear.
The arrangement of the upper part of the side of the ship is also uncertain. It is thought that the structure that projects into the body of the ship is a deck of sorts. However, it has also been suggested that this may have been a coaming. Thus, it is not certain if the timbers that are associated with this were separated from the main part of the hull or not. The bulwark associated with this has circular holes 150 mm cut in them. It is also not clear what these holes were for. They may have been scuppers or possibly holes for oars. Until the position of the bulwark on the section of the hull is known more precisely, the function of the holes is uncertain.

Southeast Asia

Of all the regions discussed in this paper, Southeast Asia has the most diverse shipbuilding traditions. Within the region one can find bamboo raft, sewn boats, basket boats, lash lug, edge-joined with dowels, out riggers double and single, quarter rudders, axial rudders and a whole variety of sail types.

Butuan Boats, Philippines

The Butuan Boats represent an important part of the understanding of Southeast Asian shipbuilding technology. These vessels have a lashed lugs construction which has parallels in other parts of Southeast Asia, particularly in archaeological finds in Malaysia and Sumatra. The technique is still found in the Moluccan and Solar Archipelago and the Solomon Islands and also has parallels in Europe.

Nine boat-sites have been discovered around Bancasi, Libertad, in the Butuan area of Mindanao; three have been excavated: Butuan 1, now on display in Libertad City, Mindanao; Butuan 2, now on display in the National Museum, Manila; and Butuan 5, in the Butuan Region X Museum, Mindanao (Fig. 26).
The remains of Butuan 1 comprise a keel, a wing stem, two strakes on one side, one strake on the other and some fragments. The dowels are counter-pegged at every alternate dowel, except at the wing stem where they pegged at every dowel. The strakes are broad at the centre and the overall length of the remains is about 13 m. The keel plank is interesting because, except at the narrow end, it has lugs in sets (transversely) in threes, the outer two have been drilled to take the lashings, the middle one apparently to act as a support. All the other strakes have single lugs. There are three lashing holes on nearly all of the lugs, two of the holes are equidistant from the ends of the lug, the third hole (possibly having been drilled later) is spaced at an equal distance to the separation of the symmetrically placed holes.

Butuan 2 is the best preserved of the three vessels. The remains consist of a keel and two strakes on one side and five strakes on the other. The remains suggest there were at least fourteen sets of lugs cut into each strake and the keel and set in rows across the vessel. The lugs were rectangular (40 mm x 300 mm x 30 mm on the keel and about 115 mm x 300 mm on the strakes) except for the keel lugs which were double. Each lug had two pairs of lashing holes and in many cases the original fibre could still be seen in the holes. There were some small remains of a frame or frames, but badly degraded. The dowels were set about 129 mm apart without locking pins. A complex scarf joint system was noted at one end of the ship that ended in a complex stem or stern post (at this time it is still uncertain which was the bow and which was the stern of these vessels). At the other end, the strakes taper to a fine point. The lugs on the strakes were aligned across the hull, although there was a lot of variation in the size of the lugs and their separation. It was noted that the dowelling pattern for all the strakes showed that the dowels were arranged in a pattern of six, possibly reflecting that a template was used to mark the holes.

The remaining timbers of Butuan 5 are fairly degraded, with only a few of the planks in good condition. Those frames that remain are generally in better condition than the planking. The vessel was probably about 13 m in length, though the longest remaining portion, the keel, is about only 11.5 m. There are remains of eight planks on one side of the vessel and seven on the other. The planks vary in thickness from 30–45 mm. The maximum thickness at the lugs is 80 mm, but is usually about 60–75 mm. The planking is edge-joined with dowels of approximately 12 mm diameter, spaced about 200 mm apart. The dowels extend more than half way through the width of the plank. The relative position of dowels on opposite sides of the plank strakes is staggered slightly. The dowels on each side of the lugs are counter-pegged with hardwood locking pins, square in section and slightly tapered. In the midships part of the boat, where there is a large space between lugs, every third dowel is pegged. On plank number 8, the lugs are different from the others, being carved in a triangular cross sectional shape. Unlike the other lugs, these triangular section lugs have no lashing holes. This was the last, or highest, strake remaining on the site, but the presence of dowels on the upper edge indicates this was not the highest strake. Most lugs show slight compression of the timber at the frame lashing positions. In some lugs, a slightly raised ridge running across the lug about midway between the lashing holes was noted. Remains of another unusual plank, thought to be number 7, were also noted. This strake has a continuous raised portion, similar to the keel, but off centre, and lugs pierced with lashing holes. The strake also has a series of notches cut in it between the lugs, perhaps to hold beams or uprights. The continuous raised portion certainly could have functioned as a whale, but may have been a beam shelf. The keel is a narrow plank with a raised lug running its full length. This carinate or ridged keel is different from keel planks found on the other excavated Butuan boats, numbers 1 and 2. Presumably this continuous raised lug not only serves as a frame lashing structure, but also — and primarily — increases the stiffness of the keel and decreases any tendency for the vessel to hog.
**The Ko Si Chang 2 Ship**

It is interesting that this is one of the only sites in the Gulf of Thailand that is likely to be of non-Southeast Asian construction. The vessel has planking that is skew nailed from the inside, with traces of *cham* putty in the heads of the nail holes. The skew nailing suggests a Chinese or East Asian origin, although skew nailing from the inside has not been recorded to date. It is double planked (plank thickness 120 mm and 40 mm) but there is little surviving detail of the bulkheads and keel since the hull structure was extensively damaged. There are remains of two bulkheads, the evidence of at least six others, together with traces of a keel. The planks have short hooked, diagonal scarfs located under the bulkheads. This site is dated to 1290±60.

**Con Dao**

Flecker described the excavation of a late 17th century Asiatic vessel at Con Dao, Vietnam. The vessel had seven compartments of varying dimensions made up of two wide, one narrow, two wide, one narrow and two wide (minimum width 1.34 m maximum 2.52 m). The bulkhead planking was skew nailed and had small rectangular limbers. Between each bulkhead there were two, three or four frames which consist of first futtock, scarfed and clamped at the keelson, then the second futtock, which is not laterally fastened to the first futtock, and the same with the third futtock. The hull planking is double (inside 60 mm outer 40 mm) and the inner is edge-joined with skew nails. The outer seems to be nailed directly onto the inner. There is ceiling planking and a keelson. Flecker concludes that the vessel was a lorchā (a vessel with both Asian and European components), dated to about 1690 and possibly Chinese owned. Flecker notes that there are longitudinal bulkheads between bulkheads 2 and 3 and 5 and 6 (both narrow compartments). The main cargo of floor tiles was located in large compartments 4–5, 6–7, and 7–8 and while the site plan is unclear, the details suggests that at least compartment 6–7 had a clear space in the central part of the hold thus providing access to the bilge. Since the vessel broke along the garboard strake, it is uncertain if each compartment had this arrangement since the tiles have spilled out across the site. The mast-step, just forward of bulkhead 6, had a very heavy and complex support and bracing structure, although no measurements of the tabernacles or their separation is available.

**Pattaya**

The Pattaya wreck site was investigated in 1982. This was one of the first sites in the Gulf of Thailand to be excavated where substantial hull structure was uncovered. Only the bow-half of the site was excavated.

The ship had triple planking, the inner layer 70 mm and the outer two 40 mm thick. At least one strake had a trapezoidal cross-section, it may well have been the garboard, the sharp angles resulting from the hollow dead-rise adjacent to the keel. There were at least six bulkheads between the mast step and the forward part of the vessel. Bulkheads varied in separation, ranging from 1.40 to 1.60 m. Frames on the side facing the centre of the vessel supported the bulkheads. Both the bulkheads and the bulkhead frames had two large limbers cut into their base. There was luting covering the joints and face between the bulkhead and...
bulkhead frame. This was hard resinous putty. The modern Thai fishing vessels use material almost identical in consistency and smell, called chum.

The keel had a block sitting on top of it 3.6 m long 200 mm wide by 150 mm thick running from the first bulkhead through to the fourth where it was rebated into the bulkhead and bulkhead frame. It is thought that this was a type of clamp covering and supporting the scarf joint in the keel.

One of the aspects of this excavation not appreciated at the time was evidence as to how the cargo was arranged on the ship. Between bulkheads three and five on the starboard side of the vessel was a very large concretion which was confined to a line 300 mm off the centre line of the vessel. There was also evidence of bamboo dunnage protruding from the concretion. It is likely therefore that the concretion was confined by a partition to the starboard side of the vessel and that because the iron cargo remained largely confined by this after the vessel sank. This may reflect the internal arrangement that otherwise would not be seen and may explain the problem concerning the function of the watertight bulkheads and the limbers. It is unclear why one would go to such lengths to seal the bulkheads while having large limbers on the bilge. Marco Polo’s statement that the compartments were watertight has been taken in the past to mean that the compartments were sealed. However, every vessel with bulkheads has been found to have open limbers. Some rational explanation is required to explain the presence of sealed bulkheads with open limber holes. If the cargo completely filled the compartment, how then does this work?

It is possible, from the evidence of the Pattaya shipwreck, that in some cases there was a space in the centre of the compartment, about 600 mm wide which was kept clear. Presumably there was some form of longitudinal partition to confine the cargo space. This would then provide a narrow, but clear access to the limbers at the bottom of the bulkheads and thus explain the anomaly of the watertight luting of the internal seams of the bulkhead and the presence of limbers, which in all wreck sites have never been found blocked up with bungs. One possibility is that in the event of the vessel springing a serious leak, the crew could gain access to the limbers and block them so that the leak could be confined to the hold affected. In normal circumstances, the limbers were free to allow the movement of bilge water to the lowest point where it could be bailed or pumped out. If there were no limbers then the bilge water would collect in each compartment, necessitating a bilge pump to be located or used in each compartment. However, this was not always the case, as in Ko Si Chang Three (below) where a large concretion of iron and storage jars was located over the keel area in one compartment, thus blocking the access to the limbers within that compartment. Possibly, depending on the nature of the cargo and loading arrangements, access (in these cases) was provided on alternate sides of the bulkheads. Other explanations, although less likely, are that the compartments may have held liquid such as water (although the evidence from the Shinan ship was that there was a separate water tank within the bulkhead) or that the compartments were never intended to be water tight, as such, simply the luting was to prevent rot.

Ko Si Chang One

This excavation uncovered part of the hull of a Southeast Asian-type vessel. A single compartment flanked by two bulkheads was uncovered. The construction of the vessel was very difficult to interpret, partially because of the limited extent of the excavation, but also because the site was deep and the visibility was very poor. The inner planking was 45 mm thick, edge-joined with dowels at 190 mm intervals. There was evidence of several stiffeners
or pegs protruding through the planking and these were thought to support the frames (although this may be a misinterpretation and could have supported the bulkheads). There was evidence for more than one layer of planking, since the inner planking was found to have resin luting indicating it was attached to another layer of planking. Evidence for the second layer found on the sites suggested that this was 300 mm thick.

On top of the planking in a rather irregular manner were a series of ‘cover boards’ made of a pale wood, softer than the hull planking. These boards were attached to the inner planking, and were about 25 mm thick with a 25 mm bevel on the sides. It is possible that these boards were intended either to protect the inner planking from wear from the cargo or to seal the joints, possibly they indicate that the vessel was old or had been repaired. In addition to the bevelled boards, there were some boards that were unbevelled and placed over the bevelled ones. These boards were rebated in the frames, which is rather unusual and cannot at present be adequately explained.

It appears that there was a series of light frames 125 mm thick, three of which were identified in the excavation trench. These frames consisted of a floor, scarfed at each end to fit the next futtock. The frames lay slightly asymmetrically across the keel. The frame was rebated on one side of the keel to allow an unbevelled board set on top of the cover boards to pass under the frame. On the other side a bevelled cover board that was set on top of the ‘normal’ cover boards has a short 20 mm rebate into the body of the frame. Both rebates were set symmetrically on either side of the keel, but their function and significance is not clear.

The bulkhead arrangement is also complex, since the bottom of the bulkhead appears to be floor and the bulkhead plank butts against the first futtocks, but utilises the thickness of the floor for the bottom of the bulkhead. The poor visibility on the site made the interpretation of these features very difficult. In addition to the cover boards there were a series of dunnage boards that were set on top of the frames and clearly were a method of keeping the particular cargo in the particular compartment that was excavated off the planking. Why there was a need for both cover boards and dunnage planks is uncertain. The site is dated to 1570±90.

**Ko Si Chang Three**

This site, which was completely excavated in 1986, was carefully documented, although the hull structure was not dismantled. The planks, 80 mm thick, were edge-joined with dowels at intervals of 75 to 85 mm. There was a second, outer layer of planking 30 mm thick. The planks were joined with scarfs that were distributed with almost no discernible pattern. In most cases the scarfs lay under the bulkheads. It was suggested that the vessel might have been old as there was evidence that some of the strakes had been repaired. The vessel had at least 10, possibly a total of 16 bulkheads that were arranged in a rather unusual manner. Assuming that the mast step was set on the side of the bulkhead facing the fore part of the vessel, with the frame on the aft side. Then the bulkheads aft of this all had the frames on the forward side of the bulkhead. At the bulkhead forward the mast step this situation was the same. Forward of this the frames were on the aft side of the bulkhead. There is evidence for some form of longitudinal bracing between the bulkhead frames both fore and aft of the mast step. This is arrangement and may be related to some form of complex bracing of the mast step and the fact that the side of the bulkhead that the frames are set are not symmetrical about the mast step. In order to brace the mast
step and the frame on the other side of the mast step bulkhead, the frames fore and aft must face the mast step bulkhead. Hence the arrangement described above.

The keel had three blocks (similar to the block on the Pattaya ship) the two larger are thought to be clamps covering scarfs on the keel. Interestingly, the evidence of an iron cargo in one compartment with storage jars placed on top of this cargo, suggests that this vessel, unlike Pattaya, did not have a clear access to the keel area. The site is dated 1440±60 and 1540±120.

The Ko Khram Ship

The Ko Khram site was found near the island of Ko Khram near Sattahib, on the SE coast of the Gulf of Thailand; it was inspected and a limited excavation then took place between. Despite attracting considerable interest because of the quantities of Thai ceramics on board, very little has been published on the hull structure. The little evidence extant on this site indicates a V-shaped lower hull, edge-joined with dowels. The ship is variously dated 1520±140, 1680±270 and 1380±50.

Bukit Jakas

Manguin and Nurhadi discussed a Southeast Asian vessel found in the Riau Archipelago at Bukit Jakas, Pulau Bintan, Indonesia. This vessel was edge joined with dowels (250 mm intervals) and had a keel length of about 25 m; planks are about 100 mm thick with a maximum width of 370 mm. The vessel had 17 bulkheads and the remains of (possibly) a fore mast step. The step had two rectangular holes for the tabernacles (100 x 150 mm by 100 mm deep). The separation of the holes was about 250 mm. The site is tentatively dated to 1445±80.

Phu Quoc Ship

Blake and Flecker describe a site near Phu Quoc Island. The vessel is clearly of Southeast Asian construction, about 25 m long, with 15 bulkheads. At either end of the vessel there was a single, more substantial frame without bulkheads. The bulkheads are constructed from planks edge joined with dowels. The bulkhead timber *Pterocarpus* sp. is Southeast Asian in origin and in the case of *Pterocarpus macrocarpus* highly regarded as a boat-building timber (*P. macrocarpus* (*chengal*) is the favourite boat-building timber on the East coast of Malaysia). The bulkheads had two limbers on either side of the keel and single limber hole level with the frame. The function of the latter is obscure since there is no indication of ceiling planking it is unusual since it is triangular or five sided (pointed at top). The bulkheads are located with frames on one side and stiffeners (similar to Shinan and Fa Shi) on the other, but the arrangement is reversed with the stiffeners on the midships-facing side. The planking has three layers (inner 80–90 mm, 48 mm middle and 32 mm outer); the main (inner) layer is edge-dowelled with a regular spacing of 180 mm. The middle and inner layer are teak (*Tectona grandis*). The planks are joined with short stepped scarfs located under bulkheads in all cases. In the two compartments excavated (between bulkheads 2–3 and 12–13), the former has evidence on bulkhead 2 (side towards centre) of 5 stiffeners (40 x 60 mm section) penetrating the inner
planking and rebated into the face of the bulkhead. The Blake and Flecker conclude that this vessel closely resembles the Pattaya wreck both in construction and dating. The site is not accurately dated, but is thought to be 14th century.

**Rang Kwien**

This vessel is about 15 m long and was excavated by the Fine Arts Department and discussed in Atkinson. The vessel is unusual as it has a keel with a hollowed out section on the top. There is evidence for stiffeners, bulkheads and frames. The 1983 excavation report is brief and it is unclear if the vessel is edge-joined with dowels, the 1989 inspection by Green also does not mention the presence of dowels.

**Conclusions**

The regions discussed above have complex boat-building traditions. While one can see regional variations, it is often difficult to interpret the significance. Generally there seems to be two very broad classes of wooden vessels in existence today, the cargo carrier and the fishing vessel. Most cargo vessels are now motorised and use sail as an auxiliary form of power, although there are anomalies. For example, in Indonesia, the government imposes harbour duty on all motorised vessels. As a result the Madura salt carrying vessels are all un-motorised. Fishing vessels, on the other hand, are more likely to be sail only, particularly for coastal fishing where it is possible to utilise the morning land breeze and the afternoon sea breeze to visit the fishing grounds on a daily basis.

The general evidence throughout the region is that vessels were primarily built shell-first and that frames-first seems to be a later development. One cannot be absolutely certain that this is always the case and there may be exceptions. It is also possible that the sewing tradition was the primary vector in boat building that implies shell first construction. Where the sewing tradition was replaced with other forms of fastening, the shell-first tradition continued. Hence in Southeast Asia it is possible that sewing was replaced by edge joining with dowels, as can be seen in the Butuan Boats where the lashing remains with raised lugs to support the frames and with individual lashing holes where the lashing is needed to hold the planks together. In Chinese shipbuilding the issues are more complex, bulkhead system is unique to China and while there is evidence that there has been a transition from frames-first to shell first, the frames first is, in many cases, crude (Fig. 27).

Throughout the region there are fare flung similarities, hence the basket boats of Vietnam (Fig. 28) closely resemble the basket boats of the Tigris and Euphrates. McGrail reported that in Tamil Nadu, shipbuilders were using the Ibero-Atlantic dovetail mortises to fasten the adjacent frames together. Many of the styles and techniques of building in the region have parallels in Europe, particularly, several authors have noted that the lugs of the Butuan Boats and the Maldivian dhoni are similar to the Viking shipbuilding. The transverse thwart beams of Maldivian boats can be found in the Pacifica and in Scandinavian parallels. It is obvious that in such cases the Austronesian connection is the link, but also clearly, from Scandinavia, it is unlikely that there has been a transfer of technology, rather that there are only a limited number of solutions to boat building and both the Vikings and the Austronesians had a sophisticated maritime focus to their culture and society.
FIG. 27 — Chinese ship construction at Chong Wu, Fujian Province. Note the rudimentary frames-first method of construction (PC).

FIG. 28 — Basket boat in use in Phu Quock, Vietnam (MF).
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