

## Missing Links in the History of Boat Building Technology of India

**S.R. Rao.**

Adivisor, Marine Archaeology centre,  
NIO Goa.

### Abstract

*As a sea-faring people the Harappans not only built a dock and warehouse but also boats, some terracotta models of which are available. It is said that a Sumerian boat was built on Malabar coast in 2040 B.C. Some technical details of the size and shape of boats of early medieval period are available in Yuktikalpataru but the essential details of laying keel, building hull etc., are missing. The pictorial representations of boats in Indian murals and Borobodur reliefs do provide some clue to planking, rigger etc. but the method of construction is yet to be traced. Actual remains of two ships of Sri Vijaya's time give further clues. Hornell describes shapes, size and parts of modern Indian boats. The paper tries to provide a few missing links in the history of boat building technology, but many more are yet to be traced.*

India was the "Proud Mistress of the Eastern Seas" for nearly 4200 years from 2500 B.C. to 1700 A.D. until the European powers monopolized Indian shipping and the East India Company prevented construction of large ships as they were effective competitors to the English ships of the 18th century. India with 6000 km coastline and nearly 200 ports of various sizes had many boat-building centres. The credit for constructing the first tidal dock of the world in 2300 B.C. at Lothal goes to the Harappans. The Late Harappans and the mariners of the Epic Age had a boat building industry in the island of Bet Dwarka, also known as Sankhodhara or antardvipa of the *Mahabharata*. Two rock-cut slipways have been discovered here by the Marine Archaeology Centre of the National Institute of Oceanography. A new type of anchor, triangular in plan and having 3 holes, in preference to the Harappan single-holed spheroid or triangular anchor, was introduced in the latter half of the 2nd millennium B.C. to meet the needs of anchoring in different sea beds.

The Indian ships did not hug the coast as is borne out by the long distance overseas trade with Egypt, Sumer, Bahrain, Oman and other Arabian countries. Harappan trade mechanisms such as seals and weights reached as far away as Ur, Brak and Arpachiya in Sumer (Iraq) and Hissar and Suse in Elam (Iran) in the 3rd millennium B.C. Such far flung trade on the high seas needed durable ships. Unfortunately there is no written record giving details of the boat building technique. The earliest archaeological evidences for boats are the terracotta models from Lothal, a seal each from Harappa and Mohenjodaro depicting ships and a terracotta amulet from Dales's excavation of Mohenjodaro. But for a reed boat depicted in the Mohenjodaro amulet, other models suggest vessels made of wood. One of the Lothal models has a sharp keel, pointed prow, a hole for a mast and another for supporting the oar. In 1986 the Marine Archaeology Centre remodelled a 100 year old boat *Ramban* resembling the Lothal boat and added a rectangular sail after removing the engine.

It could sail easily upto 6 knots in the Gulf of Kutch (P1. I).

Although the *Rgveda* speaks of a hundred-oared galley of the Asvins who came to the rescue of Bhujyu's ship which had sunk in the open sea, no details are available. The only archaeological evidence is a potsherd from Lothal painted with a motif of a multi-oared galley (P1. II). but here again planking and other details cannot be inferred. Perhaps the galleys of Asvin's were similar to the Egyptian galleys. It may be recalled here that the brisk trade between India and Egypt is indicated by the presence of chessmen of Lothal type in the Tomb of Queen Hatchepsout and the occurrence of terracotta models of gorilla and mummy in Lothal.

### Sanchi Boat

The boat in the Sanchi sculpture depicting the ascetic Kasyapa trying to save the Buddha, has the shape of a paddled boat used on rivers (Nalini Rao 1988). Although the long hull is comparable to that of a log canoe it has a raised bow to prevent breaking of waves over the front.

### The Bharhut Ship

There are two scenes in the Bharhut medallions. One of them depicts Vasugupta (whose name is inscribed) who calls for help from the Buddha. The bulging shape and curved deck of the ship make it a sea-going trading vessel. The flag fluttering from stern to bow suggests that the ship was driven by a tail wind. The technique of building known as swallow-tailed planking is what is suggested in the Bharhut and Sanchi ships. Another feature of construction is the use of wooden dowels instead of cord for sewing the planks (Schlingloff 1988). These sculptural representations give a clue to the building of the outer hull. The hulls of Arabic and later Indian ships were built by fastening together the planks with cords. In the absence of any textual

reference to the use of iron nails for securing planks to the ribs in India-built ships, it must be understood that no iron nails were used on account of the myth that magnetic rocks attract such ships and cause damage. The ships depicted on the Andhra coins of the 2nd century A.D. are two-masted and their bow and stern are curved upward. Steering oars are seen on the star board and port sides. The masts are held by cables (stays) on fore and aft. On one ship the furled sails are shown at the mast head.

It may be noted here that hemispherical stone bases with hole for holding the flag post have been found in the sea beds of Dwarka and Somnath (Rao S.R. 1991).

### Aurangabad Ship

A ship depicted in the Aurangabad cave has 3 masts, the foremast being larger than the muzzen (Schlingloff 1988, 201) as in the case of the ships of Borobodur. An oarlock on the starboard secures the oar to the upper edge of the boat. The ship seems to be sailing through a storm as suggested by the furled sails and the flag blowing in a head-wind.

### Technical Parameters of Boat-Building

In any discussion on the technique of boat-building the following parameters should be taken into account.

1. General shape of the hull
2. Multiple sheathing of the hull
3. Type of stern and stem (bow)
4. Method of fastening the planks and frames
5. The presence or absence of watertight bulkheads
6. The type of steering gear
7. The length, breadth and height of the vessel.

If we are to study how much the modern boat-building technology owes to the

traditional craftsmanship, it is not enough if we study the ancient texts such as the *Yuktikalpataru* and *Tilakamanjari*. The technical details available from the representation of vessels of the early historical period in the murals and bas reliefs should be taken note of and studied with particular reference to the seven parameters mentioned above. Fortunately a fairly deep study of Ajanta and Borobudur ships has been made by Prof. Dieter de Schlingloff of Munich University. He has published details of Ajanta boats in his monograph *Ajanta*. I had the opportunity to discuss with him some of the technical details of Ajanta boats during his visit to the caves as I was then in charge of Ajanta. I would like to mention the technical details referred to by him.

The artist of Ajanta has drawn the troop-carrying ship of *Simhala Avadana Jataka* in the conventional way and not in the realistic manner. He had to follow the size scheme of animals which are shown in bulging empty hulls shaped like those of trading vessels of Vasugupta (Schlingloff 1988, 120 ff). However the ribs on which planks were fixed are shown on the inner face. There is one rowing oar and a steering oar. A beast's head with claws and tusks looks like a monster. In Cave 1 the artist has shown Kalyanakarin's boat having a crescent-shaped hull with a high bow and stern and a curved bottom. The planks are also seen. The ship has a pavilion in the middle. In the ships of later Indian miniatures there are two or three storeyed pavilions. Three masts with sails loosely attached to the yards are visible. The steersman in the stern is standing on a ladder wielding in water a single steering oar on starboard side of the ship. The oars are pivoted on their own axis to both sides of the stern. "When the helmsman moved the tiller it rotated the blade of the oar in flowing water and the current created pressure on the blade causing the ship to turn" (Schlingloff op. cit.). It must however be

remembered that this type of steering mechanism is useful in deep flowing waters and not in still water. The Ajanta artist was intelligent enough to draw another type namely a single steering oar attached on the starboard side so that it can both be rotated and moved.

Another interesting type of ship is shown in the murals of Ajanta in Cave 2. This vessel resting in water has a 'sheer' in the line of the deck, that is low in the middle and curved up slightly at the stern and bow which improved navigability. The planks are mounted on the stern and bow to give protection against swamping. The hull of the ship is not curved much. The structures on the deck are clear. There is a flag pole with a flag at the stern. Pots containing drinking water are seen in the open pavilion. The cabin in the middle of the vessel is also an open pavilion.

Kalyanakarin's crescent-shaped ship is said to resemble a ship of Jonah on a Roman fresco in the Calixtus Catacomb of 2nd century A.D. But two thousand years earlier the ship drawn on a Mohenjo-daro seal (Pl. III) and graffitti on Daimabad potsherd are both of the crescentic type. Kalyanakarin's ship had an indigenous origin, and was better suited for heading into the rolling sea. It was not easily tossed on to a wave crest subjecting it to break. An important feature which distinguished Indian ships from Roman ships of 5th-6th century A.D. is that the former had 2 or 3 masts whereas the latter had only one. In fact Ajanta ships had 3 masts and the ship on Satavahana coins had 2 masts. There were a few Indian ships with a single mast only.

### **Ships of Borobudur**

Evolution in the boat building technique of India from the days of Ajanta murals to the period of Borobudur is clearly discernible. Perhaps the change in shape, planking etc., was necessitated by the

nature of long voyage in the rough seas of the Bay of Bengal and further south. Four out of seven boats carved in the Borobudur panel in Java have two sails each and the rest have one mast only. One of the single masted ships has no sheer in the middle of the deck. Horizontal timbers projecting from the hull supported the upper deck. Almost all the vessels in the Borobudur panel have double steering oars and a foresail. What is interesting is that a large ship has its lower part built with triple planks to withstand battering. A couple of ships have 2 or more cabins and are multiribbed. The provision of outriggers of half or one third length of the ship ensured safety of the vessel. The high rectangular sails seen in junks were developed by the Chinese 400 years after the Indian sailors used them as shown in the Ajanta ships. Indian sails made of cloth were superior to the Chinese sails made of mats and cross bars. Later on, Indian sails appear to have influenced the Chinese sails.

It is not necessary here to go into details of ship-building techniques mentioned in the *Yuktikalpataru* of Bhoja (11th century A.D.) and *Tilakamanjari* as much of it has already been published by R.K. Mookerjee and further elaborated by Lallanji Gopal (1985). These particulars coupled with the details given by Hornell about Arab boats will be useful in tracing the boat-building technique in vogue today.

The classification of ships is done according to size in *Yuktikalpataru*. Two classes of ships namely the ordinary and special are recognized. The seagoing vessels come under the special class with 2 subdivisions namely the *dirgha* and *unnata*. In the former subdivision ten types noted for great length are mentioned. The *unnata* subdivision has five types noted for their height. It is said that the measurements given by the text are theoretical. The largest river vessel would measure 180' x 90' x 90'

and the largest seagoing vessel would measure 264 x 33 x 26'. Ships of this length would be too long and their beam too narrow. But R.K. Mookerjee justifies their length. Nicole Conti who saw many India-built ships says that some of them were larger than those of Europe. A ship of Surat stopped off Aden by Henry Middleton in 1612 was found by Captain John Series to measure 153' x 42' x 31'. It may be recalled that the ships depicted in Borobudur are also longish. It must have been quite easy to build ships of 150' length. The *Yuktikalpataru* might have slightly exaggerated the length for ideal merchant ships. So far as Indian shipping with Arabian and Persian Gulf countries is concerned, Abu Zaid says that Indian merchants visited Siraj in large numbers and had very friendly relations with the Muslim merchants of that place. Indian merchants like Jagadu had Indian agents of Hormuz and maintained regular trade with Persia transporting goods in their own ships. Obviously the India merchantmen must have been large enough to carry textiles and other goods.

Early Bengali literature gives description of construction of ships. Although the parts of the vessel such as *dara* (helm), or *patwal*, *malumkastha* (deck), *tala* (hold), *mathakastha* (prow), *Chhaighar* (shed), *Putatan* (deck), *dandakarwal* (oar), *banaskarwal* or *dhwaji* (bamboo pole), *fas* (chord), *nangar* (anchor), *pal* (sail) and *dara* (Keel), are noted, there is no description of the actual technique of building the ship. The *Varnaratnakara* mentions parts of a ship and varieties of ships.

### Training

Training sailors has been mentioned in the *Jatakamala* according to which at Sopara a pilot could handle ships only after he had learnt the *Niryamakasutra*. The library of the Old College in Fort St. George, Madras possessed a manuscript on *navasastram* (*Kappalsastram*) which is said to be a late astrological text dealing with

some directions about the material used in the construction of vessels and their dimension. There are a few manuscripts in the Keladi Museum dealing with navigation and trade.

### Ships of Sri Vijaya

Pierre-Vyas Manguin of Ecole Francaise d-Extreme-Orient presented a paper in 1991 at the SPAFA Workshop on the ships of Sri Vijaya and of 1st millennium A.D. in South-East Asia. It is of special interest to researchers on Indian ship-building technique because the archaeological sites with ship remains which have been dated will give a true picture of ship-building in India almost 1500-2000 years ago. Many of the technical details given in early medieval Indian texts and depicted in Ajanta and Borobudur ships conform to the details available from actual wrecks studied by Evans in 1926 (Evans 1927) and Booth (Booth 1984). What is more interesting is that Manguin has brought to light the cohabitation of three techniques in the construction of the hull of the Pontian shipwreck (Manguin 1991, 4, Fig. 1). It may not be redundant to quote him here:

**Pontian Wreck:** The Pontian wreck was found and excavated by Evans in 1926 (Evans 1927). The remains after falling into oblivion were found back by C.A. Gibson O Hill who described and offered a very hypothetical reconstruction of the hull (Gibson-Hill 1952). They again went into oblivion until they were exhibited in the newly opened museum Abu Baker at Pekan (Pahang). A sample had meanwhile been taken from its timbers and a 14C dating yielded a  $293 \pm 60$  A.D. result (BM 958, 1984, 203). The ceramics found in the wreck by Evans have been found by Malleret to be similar to those in his own excavations at Oc-eo which gives them a broad 1st to 6th century A.D. dating (Malleret 1959, 63II, 118 & Pl. LXXIII)". Manguin adds "one of the essential pieces of evidence that may

be gathered from this shipwreck is the cohabitation of three techniques namely (1) the sewing of the planks, (2) edge-dowelling of the planks and (3) frames (and thwarts) lashed to carved-out lugs. The Butnan boat preserved at the site museum is dated by 14C method to  $320 \pm 110$  A.D. (Scott 1982). Fig. 2 showing fastening of the planks and of the Pontian (A) Butnan (B) shipwrecks drawn by Manguin may throw some light on the Borobudur fastening".

It is said that in Sri Vijayan times the large merchant ships were of the flexible sewn-plank type and for lashed-lug fastening techniques they switched to rigid frame dowelled and later nailed techniques. The illustrations in the Mohenjo-daro ship seals, Bharhut ship motif, Ajanta sea voyage and shipwreck scenes, Borobudur relief of Indian ships landing at Borobudur and the early medieval sculptures depicting naval battles show a transition from the sewn plank or lashed lug fastening to dowelled and nailed rigid framed boats. How far these two ancient indigenous techniques have survived to this day after the introduction of mechanised and powerdriven ships is what should draw the attention of the researchers, and proper documentation of traditional boat-building technique at Indian boat-building centres should be done before the craftsmanship dies. Serious effort to discover actual remains of ancient ships of the Harappan, Satavahana, Gupta, Chalukyan, Kadamba, Vijayanagar, Bijapur, Maratha and Mughal ships should be made by marine archaeologists in India, but what a pity, that for saving this extremely important underwater cultural heritage of India neither the Archaeological Survey of India nor the Science and Technology Departments of the Central and State Governments are showing any interest to provide at least a pittance of a few lakhs of rupees to the Marine Archaeology Centre for undertaking research. The U.G.C. is equally indifferent.

NISTAD of CSIR gives money for theoretical study and not for actual search for ancient boats which it is expected to do.

### Ancient Technology in Modern Boat-Building:

The first serious attempt to study the typology of modern Indian boats was made by James Hornel, Director of Fisheries, Madras Government who produced a monograph on the *Origin and Ethnological Significance of Indian Boat Design* (1918). He distinguished eight coast and island regions on the basis of characteristic boat types as follows:

- (a) The North-West coast, comprising Baluchistan, Sind, Kutch and Kathiawad.
- (b) The Bombay coast southward of Mangalore.
- (c) Malabar and Travancore.
- (d) The Gulf of Mannar
- (e) Palk Bay and Strait.
- (f) The east coast northwards of Point Calimera.
- (g) The Maladive and Laccadive Islands.
- (h) The Andaman and Nicobar Islands.

He concluded that Arab influence was exclusively dominant in boat and ship design along Northwest coast. The *Great Kotia*, a sister of Red Sea and Persian Gulf *Baggala* and the *Kotia* are the aristocrats of the seas and the builders lavished their skills on them. *Baggala* is built by Arabs in their land and *Kotia* by Indians in Kutch and Kathiawad for Indians and Arabs. *Kotia* is powerful and admirably fitted for deep sea. It varies in size 50' to 80' long upto 150 tons. It is 2 masted with poop and can make long voyages. It is said to be an ocean tramp going anywhere if there is demand. Hornel describes the *Batel* a primitive coaster of *baggala* type but undecked. *Sambuk* is another prismatic 2 masted decked coaster. Boom and Dhangli are cheap older forms of a small sized *Baggala* and *Nauri* is like *dangi* with a "parrot head"

stem ornament. A boat under construction in Bet Dwarka throws much light on the traditional technique still surviving in Saurashtra.

### Bombay Coast:

The *machwas* undertake fishing and also coastal trade. The hull of Gujarat *machwas* built at Bulsar and Billimora shows a difference with Karachi *machwas* and *sambuks* in the construction of the hull. In the Arab style boats, the planking is laid edge to edge and thereafter rendered watertight by caulking. In the Gujarat *machwas* of Indian design the planks are grooved or rabbetted to fit one another closely and in the grooves are laid strands of cotton and a layer of putty (a mixture of resin and oil boiled and subsequently hamme mass). The planks are then drawn together by lashings passed through holes bored in adjoining strakes lantened by means of wedges driven in between the lashings and planks. When drawn sufficiently tight, long iron nails are driven through the planks and ribs, the projecting inner ends being beaten down to serve as clamps. This method of construction renders the repair of damaged planks a matter of difficulty, but these men look down in contempt at what they consider the crudeness of the caulked planking of Arab-style vessels. *Battelas* are of the same design but larger and used for cargo.

### Konkan Coast:

*Pattamars* are known for their great sheer fore and aft, long curved overhand of the bow and great beam in the quarters, when the stern is rounded. It is indigenous in design uninfluenced by European or Arab models. Of the two masts, the main mast is as long as the foremast. They carry a long slender jibboom rigged in or out as required. The aftermast is of great length and its sail larger than in the Arab type. It is in constant use, serving as a principal sail. *Pattamars* built on Kanarese and

Konkan coast are coasters. Fair weather craft have no permanent bulwarks or properly laid decks, temporary bulwark of matting is provided. Pattamars are used as large fishing boat at Ratnagiri etc.

Hornell compares the pattamars to the old style Ceylonese Yatra-dhoni in its bamboo-decking, presence of jibboom etc. The original square sails became Arab lateen - also an evolution from the sewn planking to bolt-secured hull. Palm-thatched Penthouse is also retained.

#### **Konkan Coast:**

The *machwas* are large in size on Bombay coast. A typical 7-ton Bombay machwa is 47 ft. with a beam of 11 ft. and depth 3 ft. The bow is long and raking with great overhand. The rig consists of a large mainmast and small mizzen, both with considerable rake forwards; the sails are pattamar lateen, the vessel has no permanent deck. There are some large vessels of 10 to 15 tons burden with 10-12 crew men. Small vessels come under the category of *hodi*.

#### **Malabar and Travancore:**

The Malabar coast is known for dug-out and pseudo-dug-out the former being a beautiful vessel; the latter is ugly with planks. Dug-outs have no rudder, steering is effected by a big paddle on one quarter used for propulsion as well as control.

Catamarans are suitable for high surf zone, normally worked in pairs (1) 23' long 3' wide (2) 20 1/2' wide Boat. Under sail they float almost in level with water. The large pseudo-dug-out built on Tuticorin coast is of planks meant to carry stone etc.

Kilakarai (Ramnad) outrigger fishing boat type is used in Goa also. Its outrigger may be having one boom or two booms (see Borobudur outriggers).

Hornell observes that before the days of Marco Polo and Ibn Batuta there is no

technical detail of boats and ships used on the Indian coast. This is not true. The *Yuktikalpataru* gives technical description of boats regarding size, capacity and various parts of the ships. The author of the *Periplus* seems to have seen a two-masted ship with pointed end and equipped with a stout outrigger comparable to present Sinhalese Yatra-dhoni. Other ships had no outriggers, and were pointed at both ends (cf. Ajanta boat). They were steered by quarter oar on each side. Ibn Batuta (1340 A.D.) says "the ships of India and Yeman are sewn with coir thread, when they happen to strike against a rock, the thread will yield but not break, contrary to what happens when put together with iron nails. The west coast of India had large boats to carry considerable cargo and horses in the 13th century. Large ones must have been in use even from the early centuries of Christian era.

Early Andhra sea-going vessels were two-masted, square rigged vessels with raked stem and stern both sharp without bowsprit and rudder and steered by two quarter paddles. Hornell thinks that it is in such vessels that the Indians set sail to Malay Archipelago. Later when upper west coast ports sent vessels to colonise Malay Archipelago they had outriggers as in the Borobudur vessels.

We have seen descriptions of ancient and modern boats. The main question that faces the nautical archaeologist of India is how much of the ancient technology in the actual construction of boats has survived to this day. Most of the descriptions we have from *Yuktikalpataru* and other texts is about the size and type of vessel, material used and capacity. To a large extent this is true of Hornell's description of modern boats but for an occasional reference to sewing or dowelling - that too not in detail. What we urgently need is the method of laying keel, building the hull by proper attachment of ribs, planking method, the

type of dowelling and joints adopted, besides details of building the deck and cabin and size of outriggers. Actual remains of two vessels of Sri Vijaya's period which Manguin has studied in detail throw some light on the method of construction which must have been followed in India in the early historical period. Schlingloff's description of technical details of Ajanta ships is useful to a certain extent.

B.K. Apte in his monumental work *A History of the Maratha Navy and Merchantships* (1973) has given details of naval establishment, fleet, types of ships, crew and equipment. But in a 312 page volume, only 4 pages (168 to 172) are devoted to ship building. Here again how exactly the keel is laid, whether a template is made before fixing ribs to the beam, how

the skeleton is made before planking and actual planking and caulking are not mentioned in detail. However other details are extremely useful.

My colleagues in the Marine Archaeology Centre and the Department of Ancient Industry in Tamil University and other scholars who are researching to find out how much of ancient boat-building technology has survived to this day will be presenting papers which will be useful in tracing the evolution of the boat types and navigational aids. We have discovered 3 shipwrecks but they are only 200-300 years old. What is urgently needed is large scale survey of Indian coastal waters to locate and excavate shipwrecks in order to understand the sophisticated boat-building technology.

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