East Asian shipbuilding traditions

and its historical evolvement

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Abstract

The archaeological study of excavated ships can contribute to knowledge and understanding of past seafaring and maritime activities. Such study includes the assessment of the hull structure and construction methods. This paper highlights technological innovations evidenced by the remnants of ships in China, Korea, and Japan. Based on data of the excavated ships from the tenth century onwards, this paper addresses the significance of the bulkhead in oceangoing ships in the light of technological innovations, diffusion, and hybridization. This contributes to further understanding of the relationship between the "Yellow Sea shipbuilding tradition," the "East China Sea shipbuilding tradition," and the "South China Sea shipbuilding tradition." The "South China Sea shipbuilding tradition" has been presented by earlier researchers as a hybrid ship building technology. This paper highlights the integration of the technologies from the Yellow Sea and East China Sea into the South China Sea tradition by tracing specific hull components, such as bulkhead(s) used for East Asian seagoing ships. The "Yellow Sea shipbuilding tradition" is exhibited by ships operating in the northern waters of East Asia. Traditionally, these ships have flat bottoms but variations are represented by the early Tang Dynasty riverine ships and Goryeo Dynasty ships, and in later periods by Ming Dynasty ships excavated in Penglai, China.

Recent archaeological inspections conducted on the Quanzhou ship, Shinan shipwreck, and ship timbers from the Takashima Underwater site established that these ships were built in the "East China Sea shipbuilding tradition". V-shaped bottoms, keel and bulkheads, and multiple-layered hull planking with iron fastenings, characterise this tradition. The ships built according to these two traditions came to be used in seaborne activities within and beyond East and Southeast Asia. The chronological linkage of three shipbuilding traditions developed in two regions will be pursued.

Introduction

The research on the hull is one of the most important themes in shipwreck archaeology as it offers us a better understanding of historical seafaring and human interaction with waters. It has been noted that the increase of the underwater archaeological expeditions in China, Korea, and Japan occurred through the last few decades, and this has resulted in facilitating accesses to the data of excavated ships in these countries. The Shipwreck ASIA project has lately demonstrated a basic data collection on the excavated hulls (Kimura 2010). The collective data allows a comparative analysis on the hull to clarify the development of East Asia shipbuilding tradition. Such an approach developed with a theoretical idea underlying technological innovations and integration of hull components. The East Asian shipbuilding tradition was explicit in previous researches in comparison with Southeast Asian shipbuilding technologies, focusing on the distinctive hull components of shipwrecks from the two adjacent regions (Green 1990; Manguin 1993). Pierre-Yves Manguin (1984; 1993) suggested that the emergence of the technological difference and similarity in these two regions are attributed to the inherence of technological hybridization observed in the historical development of shipbuilding and explained the "South

China Sea shipbuilding tradition”. Based on the appreciation of inherent nature in historical shipbuilding, this paper overviews the creation of East Asian shipbuilding traditions over centuries that were formed in the two areas: the “Yellow Sea shipbuilding tradition”, “East China Sea shipbuilding tradition”.

Context

In many colonial and Asian societies, hybridity tended to be applauded in cultural terms (under labels like association or acculturation) even while disdained in racial ones,…(Reid 2010)

One of the themes in the study of shipbuilding technologies is the identification of technological innovations in its history that tend to generate from endogenous growth as well as exogenous factors. In this context an approach to a technological hybridization observed on the hull components is important. Manguin’s studies on the early-mid 15th century Bukit Jakas site found at Bintan Island in the Riau archipelagos of Indonesia has presented an example of the hybridization of shipbuilding technology (Manguin 1993; Manguin 2010); the main structure of the hull consists of a keel and bulkheads with planks that are edged-joined with wooden dowels, while the hull planking is fastened to sturdy frames by square iron nails. The use of wooden dowels for hull planking is recognized as Southeast Asian indigenous shipbuilding tradition, yet the use of bulkheads as main transversal structure for the hull and iron fastenings are regarded as of Chinese origin. A few excavated ships in the water of the South China Sea show a similar construction method, according to a different principle from the above mentioned two distinctive shipbuilding traditions. These ship remains reveal the features of hybrid ships, identified as the “South China Sea shipbuilding tradition”.

Since the 16th century when European expansion to East Asia and Southeast Asia began the technological hybridization on the ship structure probably became more apparent than during the previous periods. This is evident in iconographical and historical resources. A drawing of a Japanese ship known as an *Araki bune* sailing to Vietnam depicts a hybrid feature in its rig and hull from European, Chinese, and Japanese traditions (Figure 1). The Europeans during colonization periods recognised the involvement of hybrid ships in Southeast Asian waters, though they used the Spanish term *mestizo*, instead of the English term *hybrid*. The fact that the Europeans applied the term *mestizo* to describe ships that had mixed features in their construction is recorded in the historical Japanese text titled *Zoho Kai Tsushoko* (Studies on the Intercourse and Trade with the Chinese and Foreigners) written in 1708 by Nishikawa, Joken (Ishii 1995: 72-76). A Siam ship depicted on the Japanese scroll painting is further evidence of the existence of the *mestizo* ship in Thailand around the 18th century (Figure 2).

Figure 1. Historical painting depicting the Red Seal Ship known as *Araki bune* sailing to Vietnam. *Courtesy of Museum of Maritime Science*

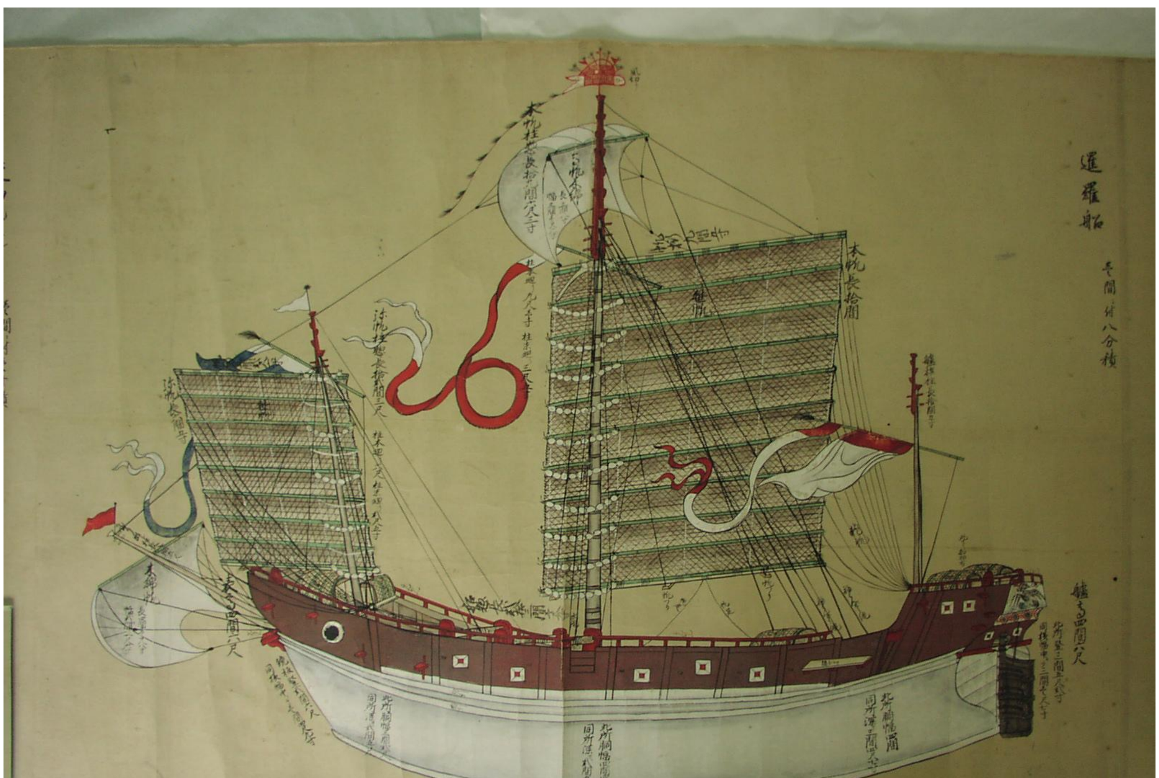

Figure 2. Siam ship from the Japanese scroll painting (Tosen no Zu) depicted probably around the 18th century. At a glance its configuration is similar with the other seven Chinese ships drawn on the same scroll yet the rigs and stern structure of the Siam ship are different from them. *Photo by author, Courtesy of Matsura Historical Museum*

Structural features defined as being of the South China Sea shipbuilding tradition in archaeological sources are correspondent with iconographical and historical records. What all this evidence indicates is the existence of a technological cluster consisting of hull components and associated construction methods from different origins. Individual technologies that are composed of the cluster are further examined to clarify their role in a long-term formation of a shipbuilding tradition. The excavated hybrid ships, for instance, use bulkheads in their interior structure and the bulkhead is located as one of the most important components as it has consistently been used in the structure of the East Asian oceangoing ships over centuries. The shipbuilding traditions in East Asia are dated to an earlier period than the appearance of the South China Sea shipbuilding tradition. This needs to be further pursued to locate the point of integration of technologies in the history of shipbuilding development.

Chronology of technological hybridization in East Asian shipbuilding

The data of excavated ships in East Asia is presented in chronological order. These data focus on the remains of coastal and oceangoing ships with substantial structure rather than primitive watercraft. The examination on the hull and construction methods in this section intends to lead to three distinctive traditions which have been linked with Manguin's studies the idea of technological hybridizations.

In the Yellow Sea's area

In China, the use of bulkhead traces is identified in excavated ships dating to the tenth century during the Tang Dynasty (618-907 A.D.) (Kimura 2010; Xi, *et al*. 2004). Bulkheads initially appeared in the structure of riverine ships before their adaption to oceangoing ships. The bulkheads, which have been perceived as representative of Chinese shipbuilding tradition, were originally used for a flat bottom hull with no keel suitable for riverine ships. Two Tang Dynasty ships have been discovered inland of the Jiangsu Province. Such flat bottom ships, however, could have been used for sail out to sea. The province faces the Yellow Sea which is known for its shallow waters where people could probably embark using flat bottom ships which were originally designed as riverine ships. The Jiangsu Province and southerly adjacent Zhejiang Province had ports for ships conducting distant voyages before the tenth century. Many ships were involved in early maritime activities between the Chinese continent and Japan during the Tang Dynasty as evidenced by the delegation of envoys, including envoy ships (Reischauer 1940). To date, there are no ships that have been identified that are known to have been specifically designed for seafaring and dated to that period, therefore we can only deduce that the structure of those ships that people used to sail into the East China Sea were opposed to the structure and construction methods identified in the riverine ships. For example, in much later periods the Sha-chuan (sand ships) represented a Hangzhou Bay trader, or ship from Nanjing. These are still perceived as ships used for riverine and oceangoing purposes in the Yellow Sea and northern East China Sea (Oba 1974). Early stage shipbuilding of oceangoing vessels in the northern coasts of China can be regarded as more similar to technology in-use for the construction of riverine boats at the same time.

The keel-less ship was not the only prevalent type in riverine ships. In early East Asian shipbuilding technology (i.e. during the Goryeo Dynasty 918-1392 A.D.) we have an example with the Wando ships, which consist of flat bottom hulls (Green and Kim 1989). These ships were discovered offshore along the west coasts of the Korean Peninsula. The fundamental structure identified on the Wando ships is perceived to be a long-term technology that used beams not bulkheads (Sasaki and Lee 2010). The shipbuilding technology developed in the Korean Peninsula, represented by baulks for longitudinal structures and athwart beams for transverse structures, resulted in the construction of ships with sufficient seaworthiness to sail in East Asian waters, especially, in the shallow waters of the Yellow Sea. This could have facilitated the dominant role of merchants who originated from the Korean Peninsula in maritime trade between the Korean Peninsula and Japan.

The advent and evolution of the flat bottom ships, represented by the early northern Chinese ships for riverine use and the Goryeo Dynasty's coastal traders, is identified as an ancestral form of seagoing ships. Consequently, the definition of the "Yellow Sea shipbuilding tradition" encompasses the shipbuilding technologies that are identified in two distinctive shipbuilding technologies from northern China and the Korean Peninsula. Technological interactions and mutual influences that might have occurred in shipbuilding between these two regions are still speculative. There were many distinctive features in the construction methods and structural elements between the two traditions. Differences in the usage of distinctive fastenings and different materials for them, for example, represent less similarity, which lead to a perspective that two major traditions are distinctively identified in early East Asian shipbuilding tradition.

In the East China Sea's area

In middle and southern China the details of early shipbuilding tradition before the 10th century has not been clarified. Contemporary historical records of Chinese Buddhist pilgrim w indicate the use of Southeast Asian indigenous ships to cross the South China Sea (Hall 1985; Wang 1958). Before the 10th century some cities from southward of Hangzhou Bay (around Ningbo) to southern China (Guangzhou), which face the East China Sea and South China Sea, were the focal area of trade by foreign merchants from Persia and Arabia. It is unclear the influence of the shipbuilding traditions from outside of East Asia on existent shipbuilding industries in the middle and southern Chinese coasts. The next phase of substantial technological development is suggested to have occurred during the Song Dynasty (960-1279 A.D.), particularly southward around Hangzhou Bay and coasts around the Taiwan Straits. This may be represented as the advent of constructing oceangoing ships in the "East China Sea shipbuilding tradition". It is recognized as an innovation that bulkhead structure and construction methods evolved to a keel. However, uncertainty exists as to how the keel was introduced into, or evolved from, existent hull components.

The Quanzhou ship from China (dated to the second half of the 12th century) and the Shinan ship from Korea (dated to the first quarter of the 14th century) are archaeologically excavated ships that will here be considered in detail to address the structural characteristics of East China Sea shipbuilding tradition (Figure 3). They represent a standardization of the structure of these periods' oceangoing ships (Figure 4). This is interpreted as one stage of the completion of technological integration or clustering of hull components. The keel and hull planking synergistically contribute to longitudinal strength. The keel is composed of three members and thick garboards are fixed. The hull planking that extends from the garboards form a steep deadrise angle. The hull planking is edge-fastened by skew nailing with rabbeted seams. The system of multiple layered hull planks has also been standardised for the purpose of the inner planks' protection, and possibly to the shell hull planking itself for longitudinal strength. The bulkheads function in providing transverse strength. Large half frames are attached to secure the bulkheads' planks, fixing them into the hull planking with brackets. A comparative study will develop in the future with the progress of research on the other ship remains that have recently been excavated in Chinese waters, including the Nanhai No.1 and Huaguang Reef No.1 shipwrecks (Kimura 2010).

Archaeological examination on ship construction materials, specifically ship nails and timbers, has been practiced. A sample iron nail was collected from a hull plank of the Shinan shipwreck for analysis and the result reported (Lee, *et al*. 2010). The CT scan and X-ray images of the nail revealed the configuration of the nail is skewed. Since the nail has been fully degraded its original metal structure could not be identified. A similar degradation of nails was identified in the timber remains of the Takashima underwater site in Japan. This site is known as the late 14th century naval battle site associated with the Mongol Empire (Yuan Dynasty) invasion of Japan. The nails used for the Shinan shipwreck and Takashima underwater site are possibly produced through similar manufacturing procedures based on the microscopic image of the cross-section of the nails. These nails could have been manufactured from thin bar iron ingots with a square cross-section. Those iron ingots were as-cast products that were being widely produced in the iron industries and showed a substantial growth during the Song Dynasty (Hartwell 1962; Hartwell 1966). In order to be used as ship nails, the quality of the iron of these ingots needed to be soft ended and made more pliable through the process of decarbonisation (Lee, *et al*. 2010). For these processes, annealing work was conducted in the smithy and iron workshops, which could probably be built on the shipyards.

Wood species identification has been conducted recently on specimens of ship timber from the Quanzhou ship (Noshiro and Abe 2010). Three major species were identified including *Pinus massoniana,* Lamb known as the Chinese pine; *Cunninghamia lanceolata* (Lamb.), Hook known as the Chinese fir; and *Cinnamomum camphora* (L.), Presl known as the camphor tree. The result is comparable to wood used in the hull of the Shinan shipwreck and the ship timber of the Takashima underwater site. *Pinus massoniana* is a dominant species used for most of the hull components of the Shinan shipwreck. The timber analysis data from the Takashima underwater site shows, that despite the wood taxa being diverse, *Cinnamomum camphora* and *Cunninghamia lanceolata* occupy the majority of the assemblage. From the comparative study there is a pattern in the use of specific wood types for distinctive hull components. The keel, for instance, consists of *Pinus massoniana* and *Cinnamomum camphora* which are harder than *Cunninghamia lanceolata* that were used for hull planks. C*unninghamia lanceolata* are found as sheathing planks of the Shinan shipwreck, probably due to the wood being softer and lighter and relatively easy to be cut and worked and it has relevant resistance against marine borers.

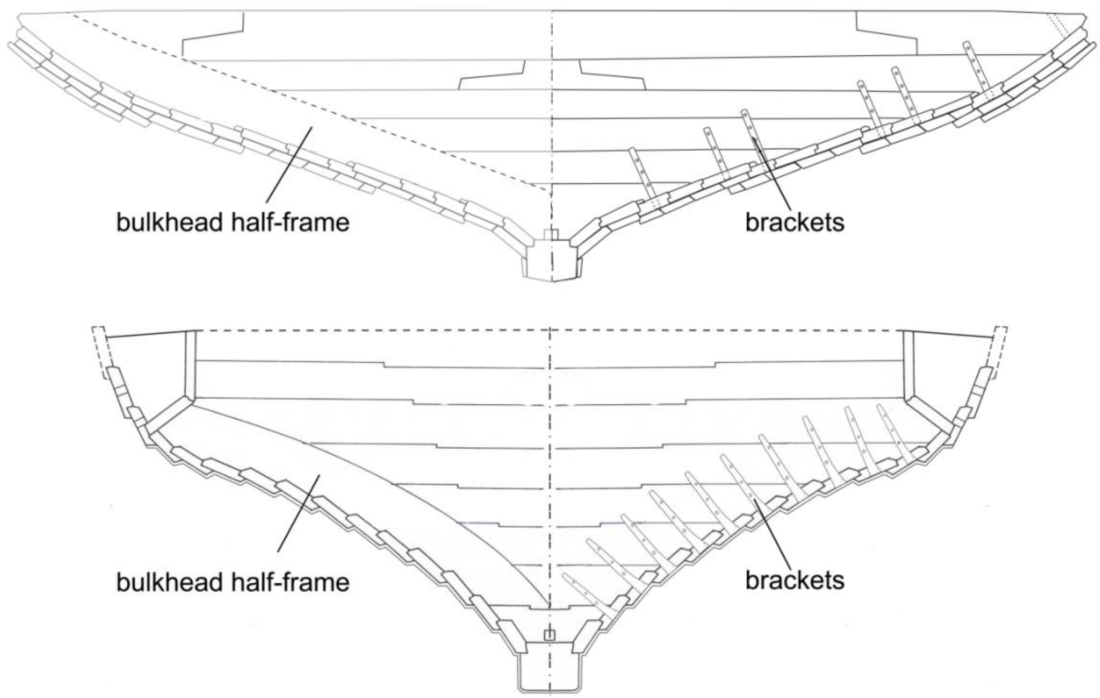

Figure 3. Cross-sections of the Quanzhou ship (above) and the Shinan shipwreck (bottom). *Produced by author, Courtesy of the Western Australian Museum and the National Research Institute*

Evidence of technological hybridization in East Asia

Excavated ships dating to the Ming Dynasty (1368-1644 A.D.) show different features from the previous periods' ocean-going traders. As an example of the distinctive structural feature, multiple layered hull planking is hardly identified on the hulls of the Ming Dynasty's ships, including the Xiangshan Ming Dynasty shipwreck from Ningbo and the ship remains discovered at Penglai (Kimura 2010; Xi, *et al*. 2004). These ships similarly have longer hulls in the length/beam ratio than the hulls identified in previous periods, such as the Quanzhou ship and the Shinan ship. The Xiangshan ship appears to have been used around the East China Sea area and the Penglai ships were used around the Yellow Sea, but the similarity of these ships is emphasized.

Of the four discovered ships in Penglai, the basic structure and construction methods of the two ships (Penglai No. 3 and No.4) are identical with the features of the Goryeo Dynasty's Korean ships (Cultural Relics and Archaeological Institute of Shandong Province, *et al*. 2006) (Figure 4). In addition, the species of the woods of these two ships are clearly distinctive from the other Penglai ships of Chinese origin. While most characteristics of the two ships are correspondent to the Korean shipbuilding tradition, their transverse components are bulkheads (traditionally used in Chinese ships) not beams (traditionally used in Korean ships). The structural features of the Penglai ships evidence hybridization between the Chinese shipbuilding technology and Korean technology; by the period of the Ming Dynasty an interaction of shipbuilding technologies between the East China Sea and the Yellow Sea could widely have occurred.

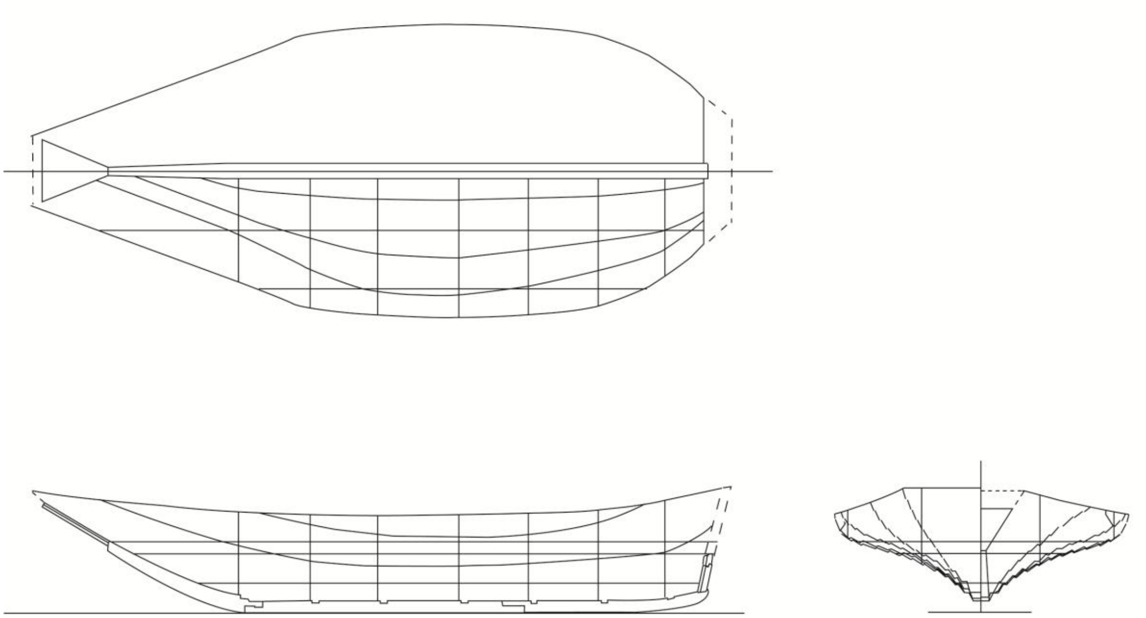

Figure 4. Ship lines of the Shinan shipwreck from Korea, involved in overseas trade between China and Japan. *Produced by author*

Shipbuilding traditions

The focus on hull components and construction methods helps in the development of a chronological sequence on East Asian shipbuilding traditions. It is suggested that the utilization of the bulkhead as a structural element in hull construction probably derived from its use in fluvial ships before the 10th century in China. Some of these ships could have been used to sail along coasts, perhaps even in early blue-water seafaring. The bulkhead came to be used in the structure of the Song Dynasty's oceangoing ships. The innovation of this is linked with keel-use. These regions in the sphere of the South China Sea historically had relationships with Southeast Asia and were probably the focus of exportation of East Asian shipbuilding traditions. Potentially, during the Yuan Dynasty to become more prominent during the Ming Dynasty, the South China Sea shipbuilding tradition gradually formed under the strong influence of technology from the middle and southern Chinese coasts.

Table 1. Structural principle of East Asian shipbuilding traditions used for oceangoing ships.

Yellow Sea shipbuilding tradition
Technologies are evidenced in the following: 1) Excavated Tang Dynasty's riverine ships before the 10th century that might have been used for seafaring, show flat bottom and uses bulkheads and iron fastenings; 2) Excavated Goryeo coastal traders of the 11th to 14th centuries that show the hull of the floor with chines and use beams for transverse components and wooden fastenings; 3) Excavated Yuan and Ming Dynasties' ships that have a keel and show round bottom, and the hull is constructed by single layered planking (baulks) and use bulkheads; 4) Excavated flat bottom keel-less ships that are constructed by Goryeo shipbuilding technologies use bulkheads and both iron and wooden fastenings.
East China Sea shipbuilding tradition
Technologies are evidenced in the following: 1) Excavated oceangoing ships of the 13th and 14th centuries that show V-bottom deadrise by the use of a keel and garboards. The transverse component composes bulkheads that are secured by half frames and brackets to the hull planking. The hull is constructed by layered planking and uses various types of iron fastenings; 2) Excavated ships dating from the Song to Ming Dynasty show a round bottom that uses a keel. The hull is constructed by single layered planking (baulks) and uses bulkheads.
South China Sea shipbuilding tradition
Technologies are evidenced in several shipwrecks, mostly dated to the 14th century and afterwards, found in Southeast Asian waters. They use a keel, showing a round bottom. The transverse components use bulkheads and, likely, half frames. The hull planking is multiple layered and the main planking (innermost planking) use wooden fastenings with compensatory uses of iron fastenings.

Conclusion

Based on the data of the hull components of the excavated ships in East Asia, this paper has outlined the formation of regional shipbuilding traditions. The concept that technological hybridizations were inherent in the regional shipbuilding history is of importance to explain the chronological development of traditions in the Yellow Sea, East China Sea, and South China Sea. This approach introduced the hypothesis that around the 13^{th} - 14^{th} centuries innovations of the "East China Sea shipbuilding tradition" in the region was an impact-factor to the advent of the "South China Sea shipbuilding tradition". Both the growth of indigenous technology and innovations from outside of the region underlay the formation of regional shipbuilding traditions and their linkage over time.

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