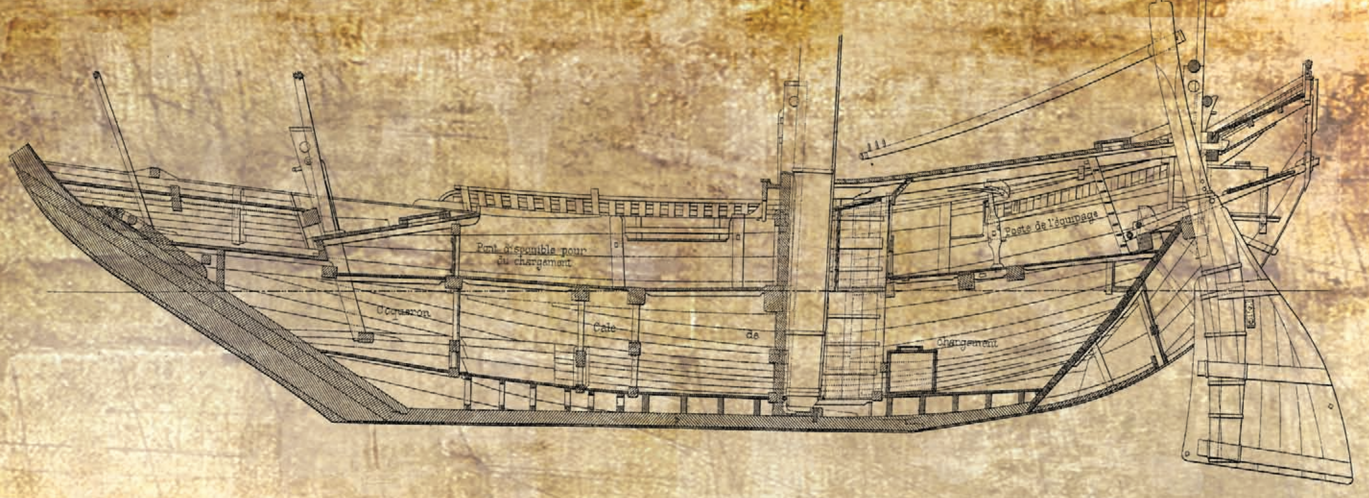
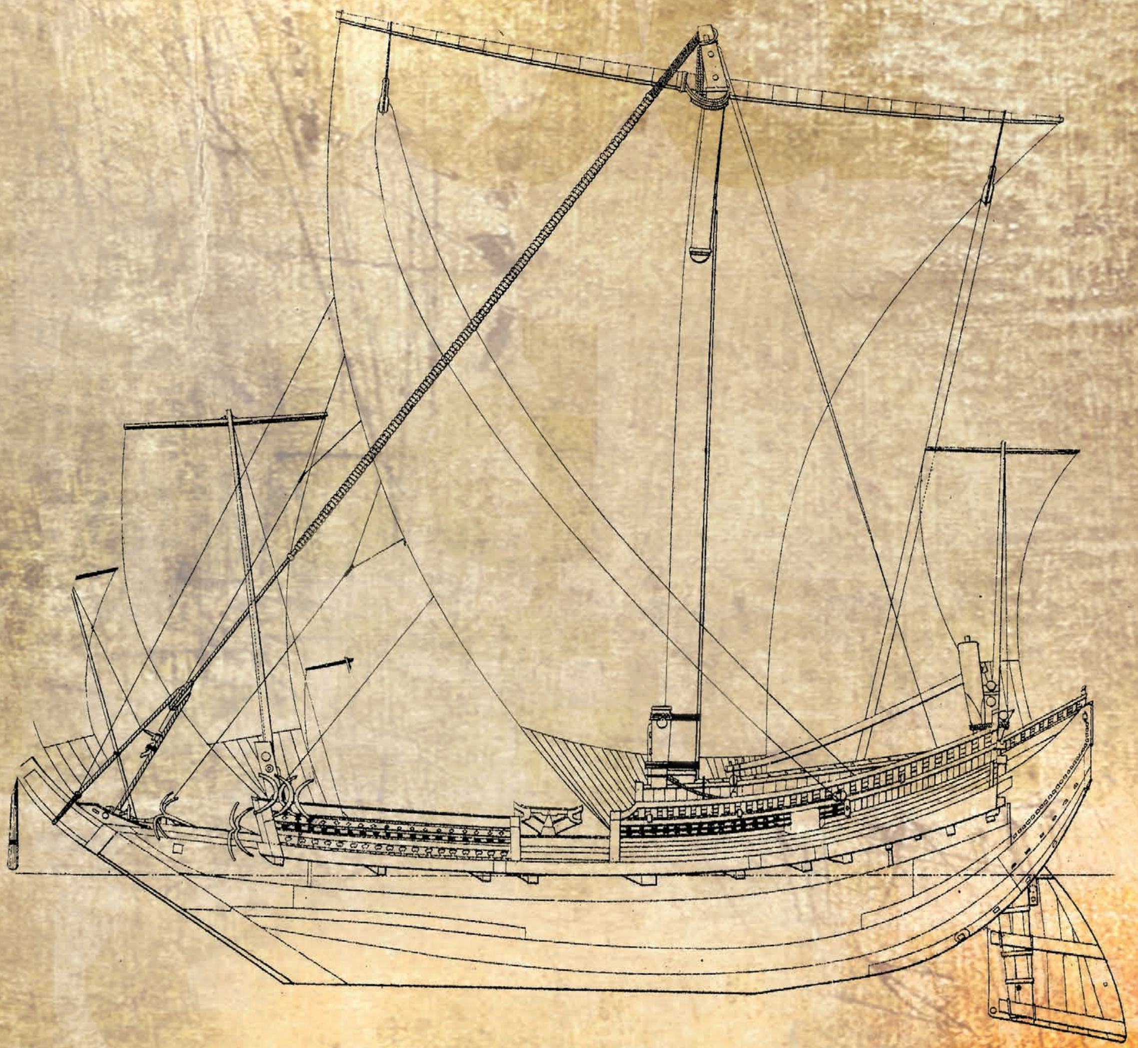


Shipwreck ASIA:
Thematic Studies in East Asian Maritime Archaeology

Edited by Jun Kimura | 2010



SHIPWRECK ASIA

Shipwreck ASIA:

Thematic Studies in East Asian Maritime Archaeology

Edited by Jun Kimura | 2010

SHIPWRECK ASIA

Published by Maritime Archaeology Program
Flinders University
Adelaide, South Australia 5001
www.shipwreckasia.org

ISBN
978–0–646–54826–5

Suggest citation
Kimura, J, ed. (2010). Shipwreck ASIA: Thematic Studies in East Asian Maritime Archaeology, Adelaide, Maritime Archaeology Program.

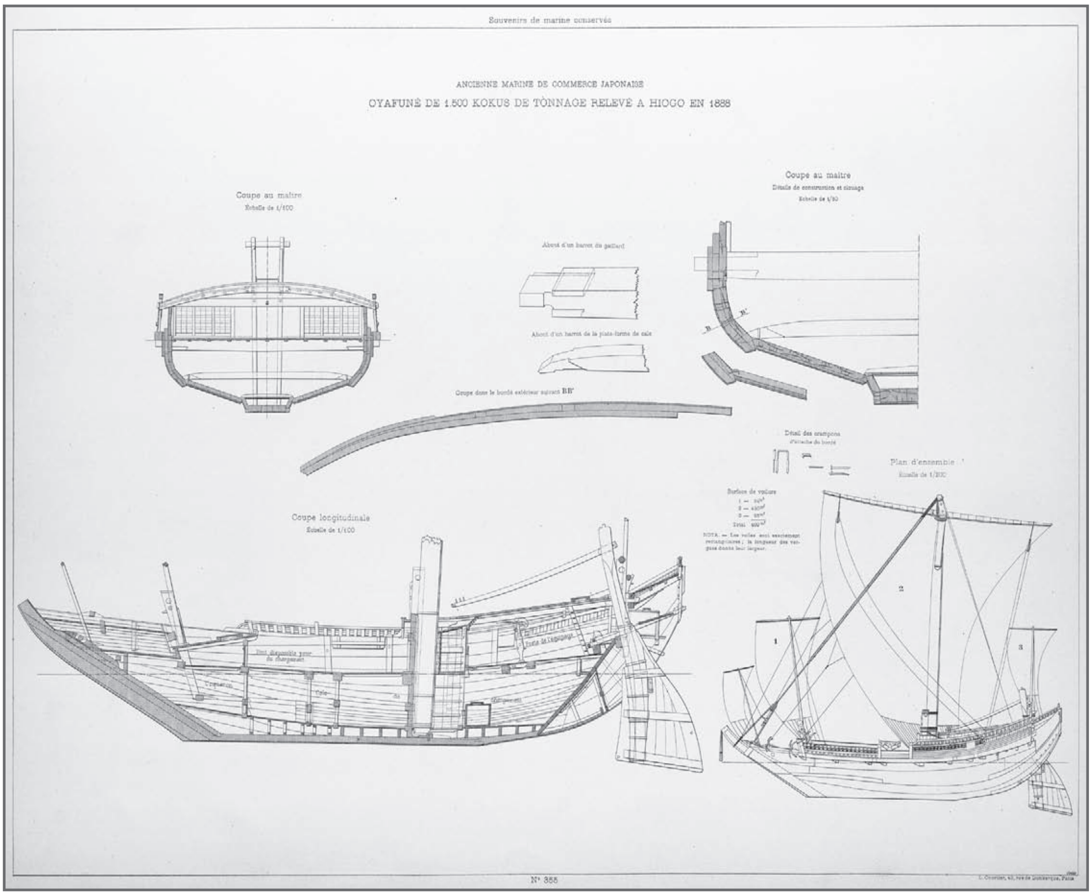
Funded by the Toyota Foundation

トヨタ財団
The Toyota Foundation

Dedicated to

Worrawit Hassapak

in memory of his achievements with
the Thai Underwater Archaeology Division



Cover image

François-Edmond Pâris, Souvenirs de Marine (Courtesy of Cushing Library, Texas A&M University)

Table of Contents

Foreword

Shipwreck ASIA project

"Each State Party shall take all practicable measures to disseminate information, including where feasible through appropriate international databases, about underwater cultural heritage excavated or recovered contrary to this Convention or otherwise in violation of international law." [1]

The Shipwreck ASIA project is conducted through the Maritime Archaeology Program (MAP) at Flinders University in South Australia and working to establish a regional database of shipwrecks and ship remains in Asia. This project is supported by the Toyota Foundation as part of the Research Grant Program *Cultural Creation in Maritime East Asia*. According to its mission statement, Shipwreck ASIA (www.shipwreckasia.org) is a regional shipwreck and ship remains database designed to promote international study of maritime cultural heritage in Asia. The database collects archaeological data for ships originating from East Asia. Data have been submitted by regional authorities and researchers in maritime archaeology, nautical archaeology, naval history and associated disciplines. Shipwreck information and site data include numerical and textual data, images, video and supporting documents.

The database has been designed to include Southeast Asian as well as East Asian constructed vessels. This is because East Asian built ships have been located in Southeast Asia through archival or archaeological research. Project researchers contacted individuals from both regions for database data. Project participants and partner institutions in this project include leading regional and international organisations and universities in primary and associated academic fields.

Asian Research Institute of Underwater Archaeology
—*Japan*

Department of Naval Architecture & Ocean Engineering, Seoul National University
—*Korea*

Department of Maratime Archaeology, Western Australian Museum
—*Australia*

Institute of Nautical Archaeology, Texas A&M University
—*The United States*

Ministry of Marine Affairs and Fisheries
—*Indonesia*

National Museum of the Philippines
—*Philippines*

National Research Institute of Marine Cultural Heritage
—*Korea*

Quanzhou Maritime Museum
—*China*

Shipbuilding History Research Centre, Wuhan University of Technology
—*China*

Underwater Archaeology Division, Fine Arts Department, the Ministry of Culture
—*Thailand*

Underwater Archaeological Research Centre, National Museum of China
—*China*

Thematic projects

Shipwreck ASIA supports thematic studies related to the central database: 'specific ship structure', 'maritime infrastructure','traditional construction methods' and ship construction material'. Thematic studies include research and publication from China, the UK, Japan, the USA, Korea and Australia. Results of this research as presented in this publication are briefly outlined below:

1) Historical development of shipbuilding technologies in East Asia

Part of the collective data through the Shipwreck ASIA project highlighting mainly excavated ships in China is presented. This study aims at adding basic information to archaeologically identified ships in East Asia. List of the identified ship remains in China is provided in chronological order from the Tang Dynasty to the Qing Dynasty with a focus on structural characteristics. The data is meant to be used for future research. Here, some inquiries may arise for future discussion, for example, when the bulkhead structure was recognized as a representative aspect of Chinese shipbuilding tradition, and when and how it started to be used in Southeast Asian regions.

Jun Kimura
(Maritime Archaeology Program, Flinders University)

2) Watertight bulkheads and limber holes in ancient Chinese boats

Chinese shipbuilding technology has developed distinctive and representative characteristics. Excavated shipwrecks from the Jin, Tang and Song Dynasties in China exhibit bulkheads for their transverse structures. In Chinese shipbuilding tradition, bulkheads produced watertight compartments. Bulkheads presenting excavated ships have limber holes that allow bilge water to flow within the bottom of ship. The limber holes are important feature, yet their details have not been clarified. Chinese researchers will discuss this as it relates to history, ethnography and naval architecture.

Dr. Cai Wei, Dr. Li Cheng, Professor Xi Longfei
(Ship History Research Centre, Wuhan University of Technology)

3) Two Ming Dynasty shipyards in Nanjing and their infrastructure

Historical landscapes of maritime culture can be documented by archaeological remains not only of ships but also of maritime infrastructure, which consists of ports, anchorages, shipyards, warehouses, ferry crossings, coastal forts, and derelict places. These sites tend to be associated with maritime trade, diplomacy, and the shipbuilding industry. Little attention has been paid in the past to maritime infrastructure in the Asian region, especially in relation to shipwreck or shipbuilding sites. Here, two shipyards that flourished in Ming dynasty Nanjing are compared, one documented by archaeological evidence and the other by textual evidence. They were in slightly different locations, had different purposes, and different historical trajectories, yet they shed light on each other, and together help to form a picture of Ming maritime infrastructure.

Dr. Sally K. Church
(Faculty of Asian and Middle Eastern Studies, University of Cambridge)

4) Study on the iron nails recovered from the plank of the Shinan shipwreck

An agreement with the National Research Institute of Marine Cultural Heritage allowed for a section of an iron nail to be sampled from a Shinan shipwreck's hull plank. The sample was sent to the Division for Archaeological Consultant at Kyusu Techno Research Inc for metallurgical analysis. Results of this analysis and a perspective on manufacturing processes of iron nails for ship construction in the medieval periods will be presented.

Lee Chul Han
(National Research Institute of Marine Cultural Heritage)

Masami Osawa
(Kyusu Techno Research Inc)

Jun Kimura
(Maritime Archaeology Program, Flinders University)

5) Goryeo Dynasty shipwrecks in Korea

The National Research Institute of Marine Cultural Heritage (National Maritime Museum) in Korea is one of the largest Institutes in East Asia specialising in shipwreck survey and research. This will be a summary report of archaeologically identified Korean ships in the country. Also, endemic features of Korean shipbuilding construction methods are clarified by looking at the structure of the excavated ships. The purpose of this study is to provide intensive information about Goryeo Dynasty's ship as an example of Korean maritime archaeological researches.

Randall Sasaki
(Institute of Nautical Archaeology)

Lee Chul Han
(National Research Institute of Marine Cultural Heritage)

6) Identification of wood samples from Quanzhou ship and Samed Nagam ship

Wood species identifications on shipwreck timber provide insights into vessel origin and shipbuilding industries. Previous studies of the Quanzhou ship have identified wood species used in hull construction. However, microphotographs to identify wood anatomical features from this research are not available. By cooperating with the Quanzhou Maritime Museum (Museum of Overseas Communication History), wood species identifications for the hull of the Quanzhou ship have been re-examined by the Forestry and Forest Products Research Institute. The Institute also conducted wood species identifications on the timber specimens from the Samed Nagam ship from Thailand.

Shuichi Noshiro and Hisashi Abe
(Forestry and Forest Products Research Institute)

7) A Report on a keel excavated at Nishihama, Nagasaki, Japan

Nagasaki was the only port opened to overseas merchants (Dutch and Chinese) during the national isolation period in the seventeenth and nineteenth centuries in Japan. In 1966, a large timber was found in Nagasaki city and was considered to be a part of keel from an overseas trader. However, the timber has not been examined in detail. An initial analysis of this timber is provided by a member of the Asia Research Institute of Underwater Archaeology.

Kazuma Kashiwagi
(Asia Research Institute of Underwater Archaeology)

Notes

[1] (UNESCO Convention on the Protection of Underwater Cultural Heritage, Article 19 — Cooperation and information-sharing, Paragraph 4)

Dr. Mark Staniforth
Maritime Archaeology Program, Flinders University

1

Historical development of shipbuilding technologies in East Asia

Jun Kimura

Abstract

Since 2008, the Maritime Archaeology Program at Flinders University has been collecting data on ship remains in East Asia in support of the Shipwreck ASIA project. This paper presents a summary of the collected data. Ship remains identified in Korea, China and the broader region are identified and discussed. Underwater archaeology conducted in Korea in the past two decades sheds new light into the discussion of possible historical interaction of the Korean and Japanese shipbuilding technology. The overall regional development of shipbuilding technologies is also discussed.

要約

2008年よりフリンダース大学海事考古学ではShipwreck ASIAプロジェクトを発足させ東アジアでこれまで発掘された船舶のデータ収集に取り組んできた。本稿では収集されたデータの概略を提示する。過去20年韓国では在来船の考古学的発見が相次いでいる。これは特に韓国と日本の造船技術に交流があった可能性があることを議論するうえで重要な意味を持つ。中国でこれまで発掘された船舶の概略を提示する。本稿は特に幅広い視野での地域的な造船技術の発展を外観することに焦点を当てている。

Introduction

This is a summary report of excavated ships in East Asia. This study also examines principles (philosophy) of shipbuilding technology that could have existed in the region. The examination derives from the implementation of inclusive data collection on excavated ships and ship remains in this region. The data collection is supported by the “Shipwreck Asia” project funded by the Toyota Foundation Research Grant Program “Cultural Creation in Maritime East Asia” 2008 through 2010. The data obtained is used to understand ships, as ships have been a means of facilitating cultural interaction throughout history. To support this idea, shipbuilding technologies behind activities of the ships will be discussed. The discussion focuses on hull components used in Korean, Japanese, and Chinese ships. The collective data of ship remains in China will also be presented in this report. The hull component study on excavated ships provides an insight into the historical development of East Asian shipbuilding technologies in relation to Southeast Asia. Maritime arteries of East and Southeast Asia have been evolving throughout centuries, and this could lead to technological hybridization of shipbuilding technologies between the two regions. A regional development theory of ship structure and construction methods will be demonstrated in this report.

Korea and Japan

Korean researchers made inroads into identifying shipwrecks since the late 1970s. Identified shipwrecks and ship remains in Korea include one overseas trader and a few indigenous ships dating to the Goryeo Dynasty (Table 1).

Country	**Korea**									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Wando ship	Offshore of Wando inland in Jeolla Province	Late 11th century	Goryeo Dynasty	High	Chemical Conservation	1983	No	Yes	Yes	Coastal trader
Sibidongpado ship	Offshore of Sibidongpado, Okdo-myeon, Gunsan, Jellabuk Province	12th century	Goryeo Dynasty	Medium	Chemical Conservation	2003	No	Yes	Yes	Coastal trader
Biando (Biungdo) underwater site	Biando Island, Gunsan, Jellabuk Province	12th century	Goryeo Dynasty	N/A (No hull remains)	N/A	2002–2003	No	Yes	Yes	Coastal trader?
Yamido underwater site	Yami Island, Okdo-myeon, Gunsan, Jellabuk Province	12th century	Goryeo Dynasty	N/A (No hull remains)	N/A	2006	No	Yes	Yes	Coastal trader?
Taean ship (Goryeo Celadon Treasure ship)	Offshore of Daeseom Island in the Taean Peninsula	12th century	Goryeo Dynasty	Low	Chemical Conservation	2007	No	Yes	Yes	Coastal trader
Daebudo ship	Intertidal zone of Daebu Island, Ansan City in Gyeonggi Province	Late 12-early 13th century	Goryeo Dynasty	Low	Chemical Conservation	2008	No	Yes	Yes	Coastal trader
Wonsando underwater site	Wonsan Island, Boryeong city, Chungnam	Early 13th century	Goryeo Dynasty	N/A (No hull remains)	N/A	2004–2005	No	Yes	Yes	Coastal trader?
Shinan ship	4 kilometres offshore from Imjado Island, Shinan-gun, Jeollanam Province archipelago	Early 14th century	Yuan Dynasty	High	Chemical Conservation	1975	No	Yes	Yes	Oceangoing trader
Anjwa ship	Agumsan-ri, Anjwa-myeon, Sinan-Gun, Jellanamdo 24 km SW of Mokpo	14th century	Goryeo Dynasty	High	Chemical Conservation	2005	No	Yes	Yes	Coastal trader
Doripo underwater site		Late 14th century	Goryeo Dynasty	N/A (No hull remains)	N/A	1995–1996	No	Yes	Yes	Coastal trader
Talido (Daliso) ship	Intertidal part of the shore of Talido (or Dalido) island in Mokpo	14th century	Goryeo Dynasty	Low	Chemical Conservation	1995	No	Yes	Yes	Coastal trader

Table 1.

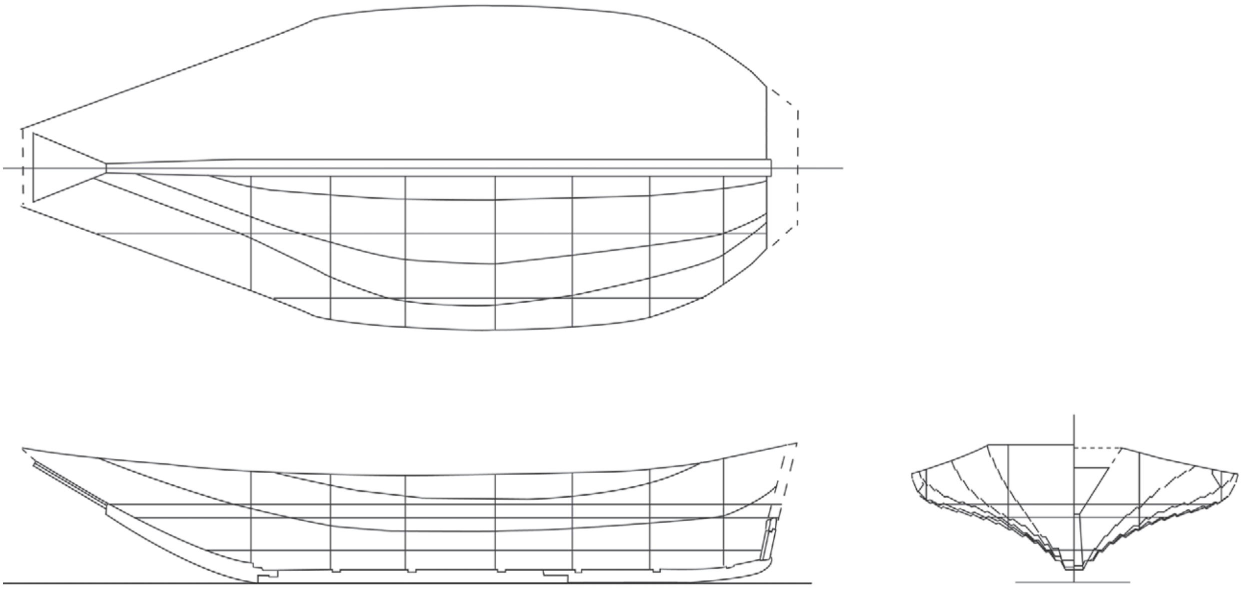


Figure 1.1 Ship line plan of the late 14th trader Shinan shipwreck. (Drawn by Jun Kimura)

Shinan shipwreck (新安沈没船)

The Shinan shipwreck is a ship that originated in China and had sunk in Korean waters. It was discovered in the waters of the archipelago in the Shinan-gun, Jeollanam Province. The ship is dated to the first quarter of the 14th century of the Yuan Dynasty period based on artefacts analysis. The Shinan ship was a private trader involved in overseas trading during the Yuan Dynasty. It was not a ship employed by governmental delegates that had been involved in the seaborne tribute trading during the previous periods. The historical study suggests that the ship can be classified as an East China Sea trader of the category entitled, "Temple-shrine chartered ship" (寺社造営料船). The ship carried commodities ordered from China by a temple in Kyoto and appeared to have departed from Ningbo.

The hull has been reviewed in a few English resources.[1] According to an archaeological report, 479 structural hull timbers were recovered. After PEG conservation, the hull was reconstructed in the gallery of the National Research Institute of Marine Cultural Heritage (National Maritime Museum) in Mokpo city. The remains of the hull measure 28.4 m in length and 6.6 m in breadth. It has a keel consisting of three timbers. The keel has been hogged.[2] A ship line plan indicates that the hog of the keel is not deliberate (Figure 1.1). The hull planking had originally been double layered by sheathing planks, but sheathing planks have not been restored into the reconstructed hull. The hull planking is fastened by iron nails in a rabbeted clinker construction. The planking in the bow, forward of the first bulkhead, however, shows gradual changes from clinker to carvel. The keel consists of three parts. The transverse structure consists of bulkheads fixed by wooden brackets and frames. This shipwreck is one of the most important resources for examining the structure of medieval ocean-going ships.

Goryeo Dynasty's shipwrecks and their feasible impact on Japanese shipbuilding technologies

Details of the Goryeo Dynasty's shipwrecks discovered in the Korean waters are examined in the other report (See Sasaki and Lee's article in this report). From the identified ship remains that have been dated to the periods during the end of the eleventh to the end of the fourteenth centuries, it is known that Korean traditional construction methods show coherent consistencies. These are: flat hull bottom constructed by baulks (keel-less structure), hull planking that uses wooden nails, and beams for transverse structure. Embryonic periods of the development of the Korean shipbuilding tradition might date back to before the 10th century when Silla merchants around unified Silla (668–935) reigned the southern portion of the Korean peninsula. While details of the ships that they used have not been clarified, their prominent maritime activities are known throughout East Asian maritime history. The 11th century Goryeo Dynasty's Wando ship, which is a shipwreck dating to the earliest period in East Asia, shows completion on the basis of the Korean shipbuilding technology. The construction methods used in the Wando ship are coherently identified

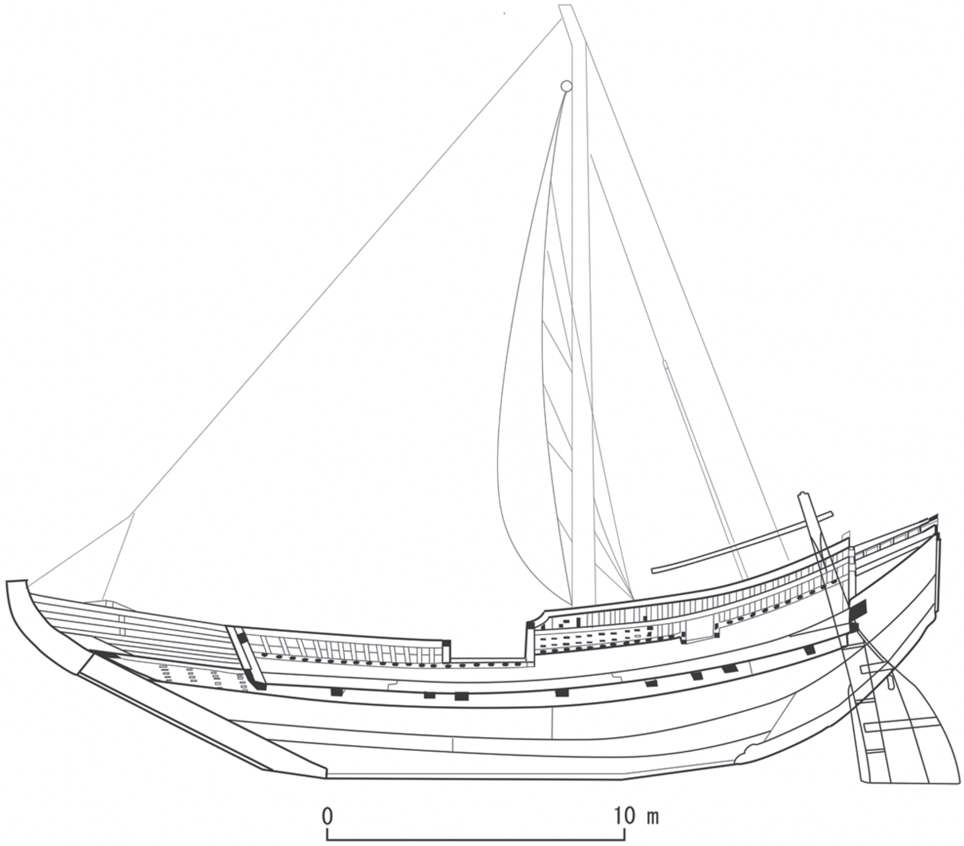


Figure 1.2 An image of the early 19th century Bezaisen. (Drawn by Jun Kimura)

in the excavated ships during the Goryeo Dynasty and even some features beyond this period (Figure 1.2).

The historical development of Japanese ships has not been archaeologically evidenced. The development has been understood only according to a linear development theory, based on many discovered dugout canoes with their evolution to planked-up dugout canoes. Further development of the planked-up dugout canoes linked to the advent of the Japanese native watercraft has been coherently presented.[3] In relation to this idea little consideration and examination have been given to the influence from outside of Japan. Due to the lack of direct evidence, technological interactions between Korean and Japanese shipbuilding traditions are hardly induced. Perhaps, the sixteenth's historical Chinese text, *"Chou Hai Tu Bian"* (Illustrated Seaboard Strategy 籌海図編), may provide an insight into what the Japanese ship's structure was around the period. It says:

> *"Japanese ships differ from Chinese ships. They consists of large baulks tightened together, by not using iron nails but iron clamps (strips), and their seams are caulked neither by hemp, by fibre, or by tang oil but by short water-weed, which requires much hard labour and many resources. …the bottoms of the Japanese ships are flat, which do not sufficiently cut into the wave."* [4]

A few queries arise from the above descriptions as to whether the flat bottom hull consisting of baulks had any similarity with the structure of the Goryeo Dynasty's Korean ships. Discussion of the feasible interactions only relying on insufficient evidence is speculative. The text mentions the use of iron to fasten the hull planks in Japanese ships. However, iron has not been used as fastening material in the Koran shipbuilding industries. As such, in order to further understand the mutual influence and historical development of shipbuilding between Japan and Korea, more evidence will be required.

The advent of Japanese construction methods of wooden ships at some stage in its naval history has been partly based on speculation. As such, the development of Japanese shipbuilding has not been fully understood. However, configuration of the Japanese costal traders that appeared during the 17th and 18th centuries show a distinctive hull structure from the other coastal traders in East Asia. A Japanese coastal trader known as the Bezaisen is regarded as a representative of the traditional type of Japanese ships. They were used throughout the Edo Period (1600–1868) and brought heyday of domestic maritime transportation during the period. The ships are no longer seen along the Japanese coasts, and their configuration and structure can be appreciated mostly by referring to iconographic resources, such as drawings on wooden plaques called Ema, small scale models placed in local shrines by

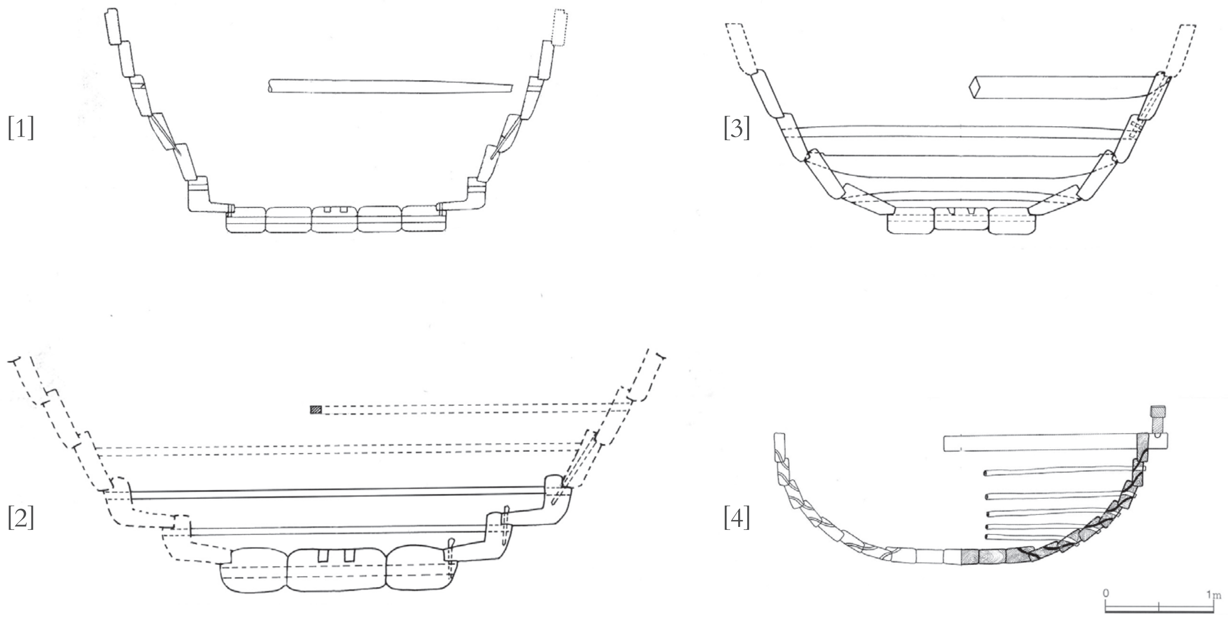


Figure 1.3 [1] Cross-sections of the Wando ship (the late 11th century), [2] Sibidongbado ship (the end 11th – the early 12th century), and [3] Talido ship (13-14th century). [4] Korean fishing boat (20th century). (Reproduced from the National Maritime Museum of Korea. (2005). Gunsan Sibidongpado Haejeo Yujeok (The Underwater Excavation of the sea off Sibidongpado, Gunsan 群山十二東波島海底遺蹟). National Maritime Museum, Mokpo.)

shipwrights for dedication, and historical documents including plans, specifications, and texts (Figure 1.3). However, how the structure and constructional methods had developed has not received thorough examination. Only limited data on archaeological ship remains has been collected in Japan and this includes a rudder post remain from the Bezaisen (Table 2).

China

A dataset of excavated ships in China is presented based on published resources. Of the data, 25 ship remains and wreck sites are introduced chronologically following their Dynastical periods from the Tang Dynasty to the Qing Dynasty (Table 3).

Tang Dynasty (618–907)
1. Rugao ship (如皋舟)

According to Chinese resources,[5] the Rugao ship was discovered at Puxi in Ruguo city, Jiangsu Province during reclamation in 1973. The well-preserved hull measures 17.32 m in length and 2.58 m in width. The remaining part consists of bottom planks, bulkheads, and some strakes from the sides of the hull (Figure 1.4). The bottom forms a flat shape suitable for river transportation. Its bluff bow and aft parts are slightly narrower than the midship. The Chinese researchers' reports indicate that the basic joinery of the bottom timbers appears to be of a mortise and tenon type, yet the details are unclear. The mortise and tenon joint is also indicative of having been used for the joint of the bulkheads and hull planking. The drawing shows ten bulkheads dividing the vessel into eleven holds. The fifth, sixth and seventh bulkheads are very close together and create two very small holds. The length of the bulkheads around the midship's beam of the vessel is approximately 2.80 m athwartship and measures approximately 0.95 m athwartship in the bow and stern parts. Chinese researchers have mentioned that there are doorways through the sixth to the eighth holds, yet these bulkheads produce watertight compartments. The Chinese researchers' reports imply that these holds could have been used as a living space in the absence of decks. Yet it could have been roofed by a bamboo sheet. The hull planking is clinker-built. The thickness of the planks is 40–70 mm and its bottom planks are 80–120 mm thick. The length of iron nails is 165 mm, and the section of the nail head measures 15 mm. Iron nails are used to fasten the hull planking and the driven pattern shows a 60 mm interval. The seams are caulked and sealed by putty. To determine the date of the Rugao ship, recovered ceramics which compose of mostly discovered artefacts from the Yue kiln are used and they are dated to the Tang Dynasty. Associated other artefacts also allow the Rugao ship to be dated to the Tang Dynasty. Chinese researchers conclude that the ship used was around the period of the reign of Gaozong (649–683) who was the third Emperor of the Dynasty.

Country	Japan									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Kurakizaki Underwater Site	Uken-son, Oshima-gun, Kagoshima Prefecture	12-13th century	Southern Song Dynasty?	N/A (No hull remains)	N/A	1994	No	Yes	Yes	Oceangoing trader?
Takashima Underwater Site	Takashima-town, Matsuura-city, Nagasaki Prefecture. 200 m off the coast. Approximately 20–30 m deep underwater	13th century	Southern part of Korean Peninsula and East China Sea. Yuan Dynasty	Low	Chemical Conservation	1981	No	Yes	Yes	Oceangoing military services
Nishihama tpwn's Keel	Nishihama tpwn, Nagasaki city	Late 15-early 16th century	China?	Low	Non-treatment	1966	No	Yes	No	Oceangoing trader?

Table 2.

Country	China									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Rugao ship	Puxixiang, Ruguo district, Nantong city, Jiangsu	618–907	Tang Dynasty	High	Non-treatment	1973	No	Yes	Yes	River transportation
Shiqiao ship	Shiqiao, Yangzhou city, Shiqiao	618–907	Tang Dynasty	High	Non-treatment	1960	No	Yes	Yes	River transportation
Hebao Island wreck site		618–907	Tang Dynasty?		Non-treatment	1985	No	Yes	Yes	River transportation
Liuzi ship No.1	Liuzi, Suixi district, Huaibei city, Anhui	618–907	Tang Dynasty	High	N/A	1999	No	Yes	Yes	River transportation
Liuzi ship No.4		618–907	Tang Dynasty	High	N/A	1999	No	Yes	Yes	River transportation
Dazhi ship	Dazhi city, Nanhui, Shanghai city	960–1279	Song Dynasty	Medium	N/A	1978	No	Yes	Yes	River transportation
Yuanmengkou ship	Duanmengkou-cun, Dongtantou-xiang, Jinghai district, Tianjing Province	960–1279	Song Dynasty	High	N/A	1978	No	Yes	Yes	River/Coastal transportation
Fengbinyang Bay shipwreck	Fengbinyang Bay shipwreck, Jiading, Shanghai city	960–1279	Song Dynasty	High	N/A	1978	No	Yes	Yes	River/Coastal transportation
Ningbo Ship	Ningbo city, Zhejiang	N/A	Song (or Yuan Dynasty)	High	Non-treatment	1978	No	Yes	Yes	Coastal trader
Nanghai No.1	Guandon, Yangjian city	960–1279	Song Dynasty	High	Others	1989	No	Yes	Yes	Oceangoing trader

Table 3.

Site	Discovered Location	Dating	Origin	Status of Hull remains	Preservation Status	Year Discovered	Salvaged	Surveyed	Excavated	Purpose
Yilu Ship	Heyilu, Ningbo city, Zhejiang	960–1127	Northern Song	High		2003	No	Yes	Yes	River Transportation
Quanzhou ship	Hozhu, Quanzhou city, Fujiang	1270–80	Song Dynasty	High	Chemical Conservation	1973	No	Yes	Yes	Coastal trader
Fashi Ship	Fashi, Quanzhou city, Fujiang	960–1279	Song Dynasty	High	In situ preservation	1982	No	Yes	Yes	Coastal trader
Bai Jiao 1 wreck site	Bai Jiao, Dinghai Bay, Fujiang	12–14th century	Southern Song (or Yuan Dynasty)	Low	N/A	1989	No	Yes	Yes	Coastal trader?
Bai Jiao 2 wreck site	Bai Jiao, Dinghai Bay, Fujiang	N/A	Southern Song (or Yuan Dynasty)?	N/A (No hull remains)	N/A	1990	No	Yes	Yes	Coastal trader?
Yamen battle shipwreck	Yamen, Xinhui. Guangdong Province	13th century?	Song (or Yuan Dynasty)	Low	N/A	1991	No			Battle ship?
Huaguang Reef No.1 shipwreck	Paracel Islands	N/A	Song Dynasty	Medium	Chemical Conservation	1996	No	Yes	Yes	Oceangoing trader
Sandaogang wreck site	Suizhong, Huludao city, Liaokning Province	13-14th cenutry?	Yuan Dynasty	N/A (No hull remains)		1991	No	Yes		Oceangoing trader?
Liaoshan Ming Dynasty battle ship	Songjin River, Heihumiao, Liangshan, Shandong Province	14th century	Ming Qing Dynasty	High	N/A	1958	No	Yes	Yes	Riverine ship
Xiangshan ship	Qibu, Xiangshan district, Ningbo city	14th century	Ming Dynasty	High		1994	No	Yes	Yes	Trader or a battle ship
Penglai ship No.1	Penglai city, Shangdon	14th century	Yuan Dynasty	High	Chemical Conservation	1984	No	Yes	Yes	Patrol ship?
Penglai ship No.2	Penglai city, Shangdon	15-16th century?	Ming Dynasty	High	Chemical Conservation	2005	No	Yes	Yes	Patrol ship?
Penglai ship No.3	Penglai city, Shangdon	15-16th century?	Ming Dynasty	High	Chemical Conservation	2005	No	Yes	Yes	Patrol ship?
Penglai ship No.4	Penglai city, Shangdon	15-16th century?	Ming Dynasty	High	Chemical Conservation	2005	No	Yes	Yes	Patrol ship?
Baolian Harbour shipwreck	Baoling Harbour, Wenchang, Hainan Province	N/A	Qing Dynasty	N/A (No hull remains)		1987	No	Yes	Yes	Trader?
Donggu Ming zheng wreck site	offshore of Dongshan, Fujian Province	N/A	Ming Dynasty or the early Qing Dynasty	N/A (No hull remains)	N/A	2000	No	Yes	Yes	Trader?
Jinjing Shenhu Bay wreck site	Shenfu Bay, Fujian Province	N/A	Ming and Qing Dynasty	N/A (No hull remains)	N/A	N/A	No	Yes	Yes	Trader?
Wanjiao No.1 wreck site	Wuzhou reefs offshore of Yutou, Pingtan, Fujiang Province	17-18th century	Qing Dynasty	N/A (No hull remains)	N/A	2005	No	Yes	Yes	Trader?

Table 3 *(continued)*.

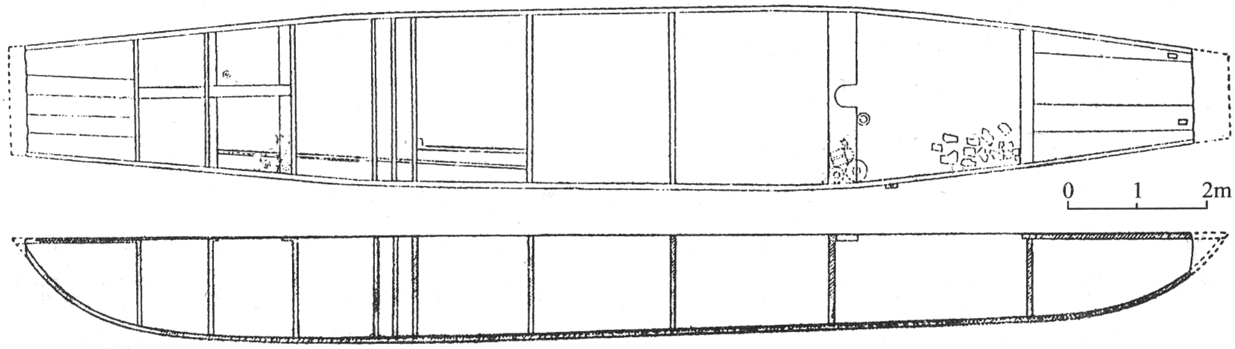


Figure 1.4 Rugao ship. (Wang 2000)

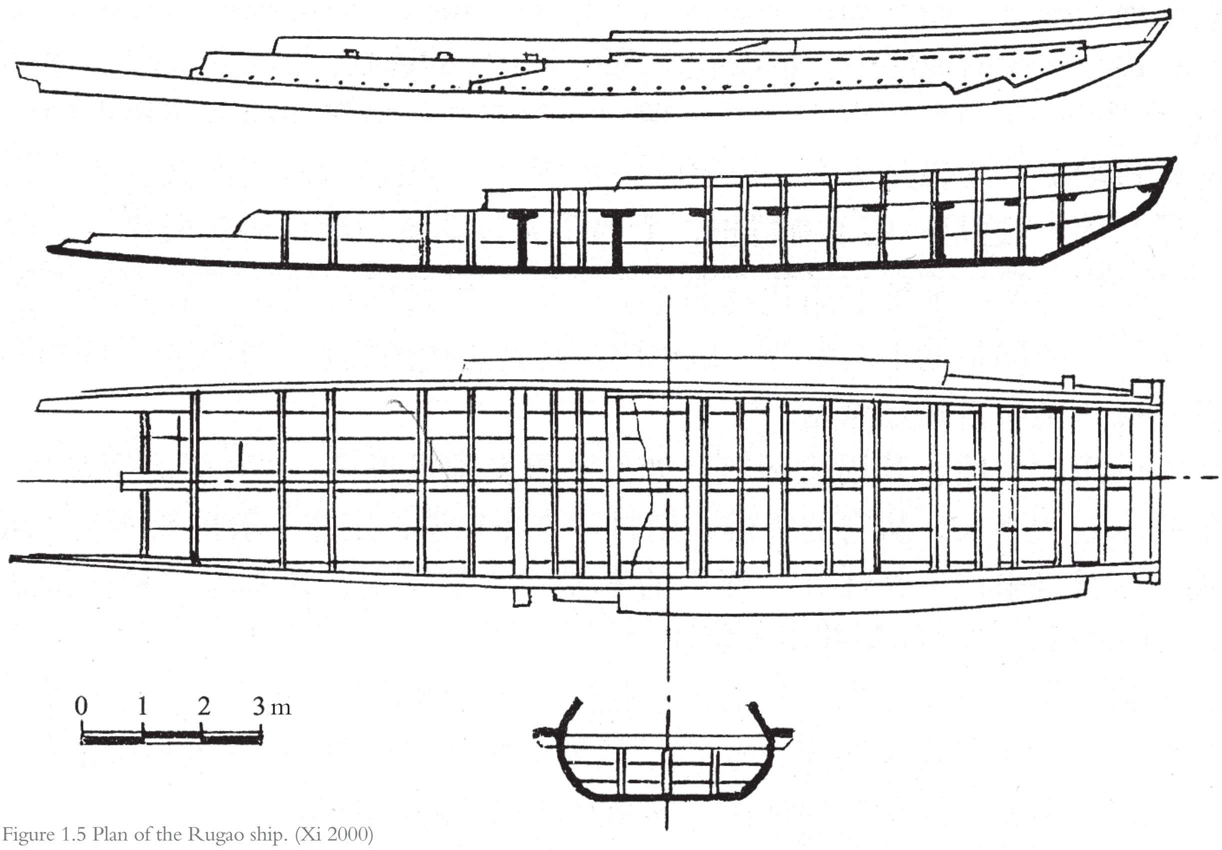


Figure 1.5 Plan of the Rugao ship. (Xi 2000)

2. Shiqiao ship (施桥舟)

During the river development at Shiqiao in Yangchan, Jiangsu Province in 1960, one wooden ship was found with a few dugout canoes. According to Xi Longfei,[6] its stern part was missing, and the remaining part of the hull measures 18.4 m in length, 2.4 m in width, and 1.3 m in depth (Figure 1.5). The transverse structure consists of the combination of beams and bulkheads (the exact number of holds divided by the bulkheads is unclear). Mortise and tenon joints and iron nails appear to have been used for hull planking. The dimension of the nails used is 170 mm in length, and its head is 20 mm. These nails are driven into the hull planks with an interval of approximately 250 mm. The nails are used for the construction of the bottom and sides. The exact date of the ship is disputable. Initially, the date was attributed to the Song Dynasty

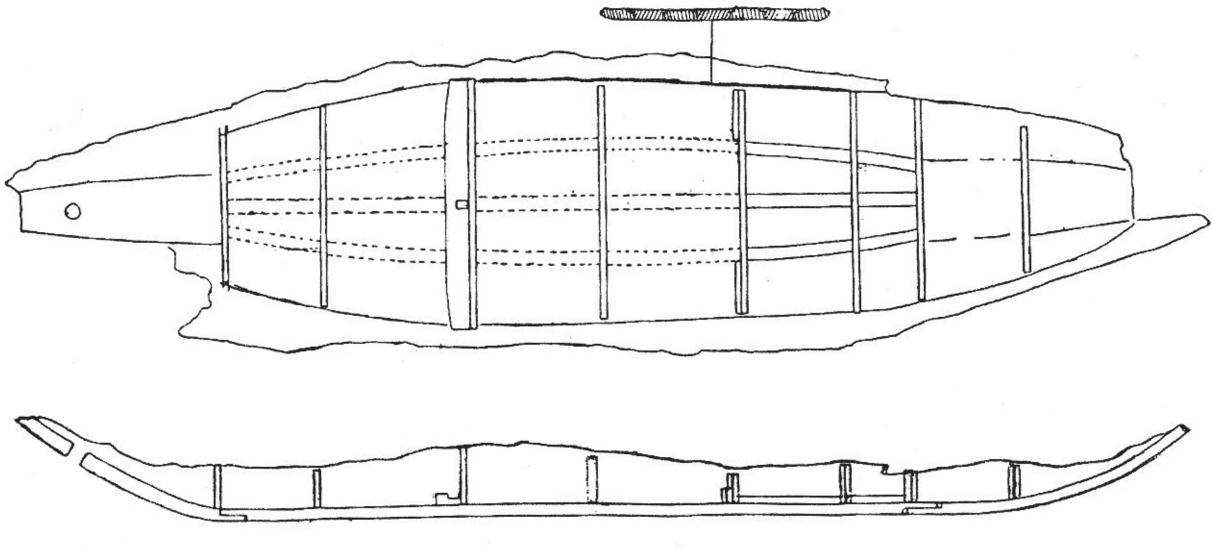


Figure 1.6 Plan of the Dazhi boat. (Ji 1987)

based on artefact analysis, but later researchers agreed that it dates back to the Tang Dynasty. The depth of the ship is not high and the structure indicates that the ship was originally used for river transportation.

Song Dynasty (960–1279)
3. Dazhi boat (大治舟)

According to a short archaeological report, seven ship remains were discovered in 1978 during the dredging of the Dazhi River, Nanhui district in Shanghai city. The Cultural Properties Administration Board in Shanghai city conducted the excavation and has reported the discovery of one Song Dynasty's ship (Figure 1.6). Although the upper part of the hull is missing, the bottom was well preserved when discovered. The remaining part measures 16.2 m in length and 3.86 m in width. The cross section of the hull bottom is flat. It seems that the bottom consists of seven strakes. The strakes appear to comprise three planks longitudially, each joined by lap joints. Three internal runs of planks double the bottom planking, though they only partly remain. Eight bulkheads divide the hull into nine holds. The spacing of the bulkheads varies: 2.90 m, 1.26 m, 1.90 m, 1.70 m, 1.84 m, 1.42 m, 0.78 m, 1.30 m, and 1.61 m. There is no report of limber holes. Iron nails were used to fasten the hull planking to the bulkheads and putty made from lime and oil was used to seal the iron nail heads. A notable feature is a hole with a diameter of 0.2 m through the median plank in the bow (if the bow is correctly identified on the basis of the position of a mast step). It is said that this is what is called "Mao chayan" (Hole to drive anchor through 錨揷眼).[8] This would be a type of anchor that has been reported as "stick-in-the-mud" anchor in Worcester's study. It is a pole used by Chinese river boats as an anchor, driven through the bottom of the hull into the bed of the river.[9] There is one mast step attached to the third bulkhead having one recess to hold a mast. From the first hold, 24 copper coins with the inscription of Taibin Tongbao (太平通寶), which represents the reign of the second emperor of the Northern Song Dynasty (960–1127), were discovered. In the hold, a silver hairpin was also discovered. Based on the discovered coins and one ceramic glazed bowl, the ship is dated to have originated during the Song Dynasty. It is said that the use of this ship probably was for short distance coastal transportation and, for some reason, it had been abandoned.[10]

4. Yuanmengkou ship (元蒙口船)

According to Xi Longfei, there are ship remains from the Song Dynasty that were discovered at Yuanmengkou, at Dongtantou of Jinghai district in Tianjing Province in 1978.[11] The remains of the ship are 14.62 m in length, 4.05 m in width, and 1.23 m in depth. Except for the upper part of its port side, the hull is relatively well preserved. The displacement of the original ship has been estimated to be approximately 38 tonnes.[12] The shipwreck shows a flat bottom and a rectangular section shape throughout its length (Figure 1.7). It is effectively a box with a scow-bow. The structure of the bottom has not been clearly reported, but it seems that a large piece of flat timber was longitudinally placed in the centre of the hull, and there were large chine planks as well. Between these large planks, planks were longitudinally placed. The cross section drawing indicates a flush edge joint in

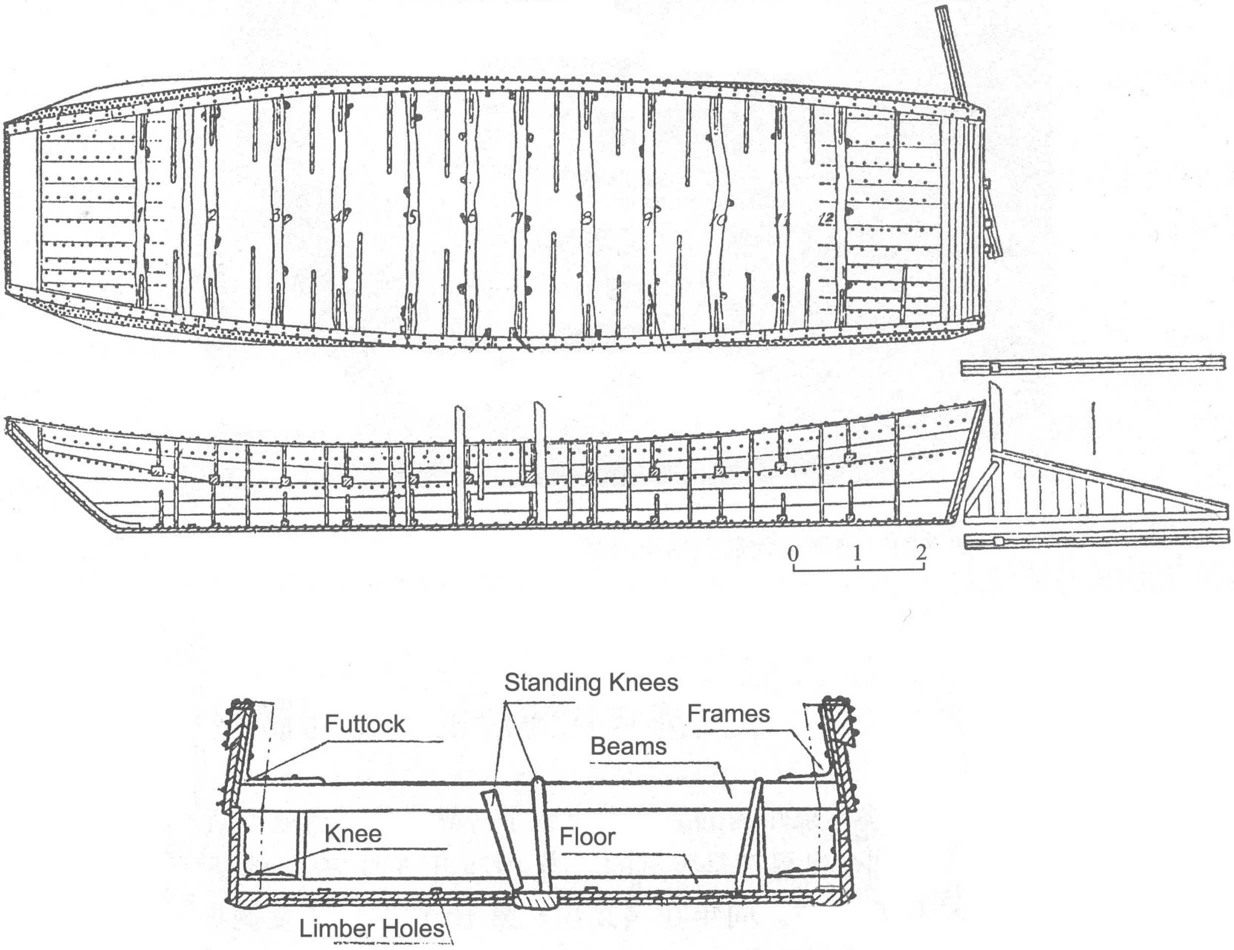


Figure 1.7 Yuanmengkou ship. (Reproduced from Xi 2000)

both the bottom and topside planking. However, the topside planking shows a double layer. The drawing shows floors (bottom frames), futtocks or knees at the chines, beams, and standing knees supporting the plank above the beams. In addition, there are twenty half frames between the beams. There are limber holes in the floors or bottom frames. The strength of the hull is further enhanced by top timbers on the fifth beam to the eighth beam around the midship. Chinese researches have pointed out that the most significant discovery is a wooden rudder regarded as the oldest example of a balanced rudder.[13] The rudder blade forms a scalene triangle measuring 3.9 m along the bottom. The height of the rudder post is 2.19 m. The ship could be dated to the Northern Song Dynasty. The date has been initially determined by identifying a copper coin Zhenghe Tongbo (政和通寳) recovered from the ship which gives an idea of an absolute date of 1111, and sedimentation analysis suggests that the ship may have been abandoned before the flood prevention works were conducted in 1117. With regard to the date, however, the uniqueness of the structure using half frames with an absence of bulkheads makes the hull appear more modern than the 12th century.

5. Fengbinyang Bay ship (封滨杨湾沉船)

In 1978, a local commune of Fengbinyang discovered ship remains among the sediments of Fengbinyang Bay adjacent to Jiading district in Shanghai city. The remaining part of the hull measures 6.23 m in length. Although the forward part of the ship is mostly missing, it is in relatively good condition (Figure 1.8). The hull is slightly tapered from the midship toward the bow in the plan, yet it forms a square transom bow that has a platform at the deck level. There are seven bulkheads comprising eight compartments, and a mast step is placed on the forward side of the fourth bulkhead. Iron brackets, known as Guaju (挂锔), are used to fasten hull planking to the bulkheads.[14] Some butts of hull planks show a half-lap joint. The cross-section shape shows a flat bottom made of two strakes, double chines, and some tumblehome of the topsides above the second chine. One of the notable

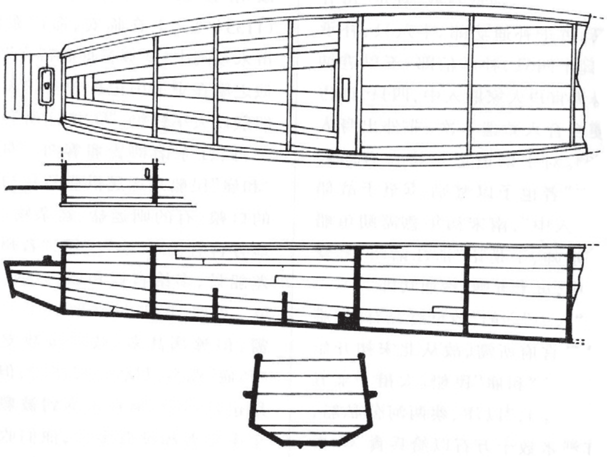


Figure 1.8 Fengbinyang Bay ship. (Wang 2000)

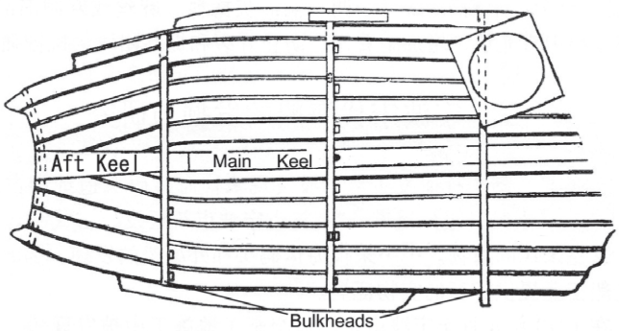


Figure 1.9 Fashi ship. (Reproduced from Xi, Yang, *et al.* 2004)

features of the ship is two longitudinals beneath the bottom planks. The two longitudinals have a semicircle section and they run along the hull as small bilge keels or bilge runners. It has been pointed out that these are more likely to provide further longitudinal strength to the hull, and they appear to be small runners to protect the bottom planking during launching and beaching.[15] From the inside of the hull, bricks and yellow glazed ceramics, which are probably from the Jizhou kiln in the Jiangxi region, were discovered. These artefacts have been used to determine the date of the ship to the late 13th century. Furthermore, the discovery of an iron pan and sword has also indicated its link to this period.

6. Fashi ship (法石船)

A shipwreck was found at Fashi vicinity of Quanzhou Bay in 1982. A portion of the hull was located under a building, so only a partial excavation was implemented.[16] An exposed part of the hull was reburied for *in situ* preservation. A portion around midship toward the stern was revealed during the excavation. The hull has a keel, and three bulkheads have been identified. The exposed keel consists of a part of the main (midship's) keel and the aft keel. Bilge water could run along the bilge through limbers in the bulkheads. The Fashi ship evidences the use of wooden brackets (or pegs) to fasten bulkheads to hull planking. The length of one wooden bracket measures 720 mm and its cross-section is 60 x 60 mm at the hull planking and tapers to 20 x 30 mm at the inboard end. They are driven from outer surfaces of some of the hull planks and attached onto the forward sides of the bulkheads. This is a similar fastening method to that noted above in the Fengbinyang Bay ship, also observed on the Quanzhou ship, and it is more or less identical to the use of wooden brackets in the Shinan shipwreck. Iron nails are used to fasten the bulkheads' planks. A portion of the recovered hull including a bulkhead plank is under chemical treatment in the Quanzhou Ancient Ship Gallery of the Museum of Overseas Communications History) (Figure 1.9).

7. Heyilu ship (和义路船)

During a rescue excavation in 2003 conducted by the Cultural Relic Preservation Administration Center of Ningbo and Archaeological Research Institute of Ningbo at the south side of the site of HeyimenWengcheng (Turret of Heyi gate), the remains of a watercraft were found.[17] Although the stern of the hull is missing, the remaining part is relatively well-preserved and measures 9.2 m in length and 2.8 m in width (Figure 1.10). The bow of the ship is fairly sharp and the cross-section of the lower hull is a fairly sharp V-shape. The forward keel and main keel remain, and the cross section of the main keel around midship is rectangular and measures 0.3 x 0.1 m, yet toward the bow it changes to a triangular shape to fit to the forward keel. Nine bulkheads remain and sturdy frames are attached to them. The bulkheads appear to be irregularly distributed. Each bulkhead remain consists of three to four planks fastened by iron clamps. There are limber holes in the bottom planks of the bulkheads. Seven strakes remain at the portside and starboard side in the mid part of the hull. Hull planks measuring 0.4–0.6 m are edge-joined by skewed iron nails. A mast step has not been found, and according to a figure of the reconstructed ship in the report, its propulsion appears to have relied on a yuhlo.[18] Based on ceramics recovered from the inside of the hull, the ship has been dated to the Southern Song Dynasty and it could have been used for short distance transportation in the harbour or coastal areas.

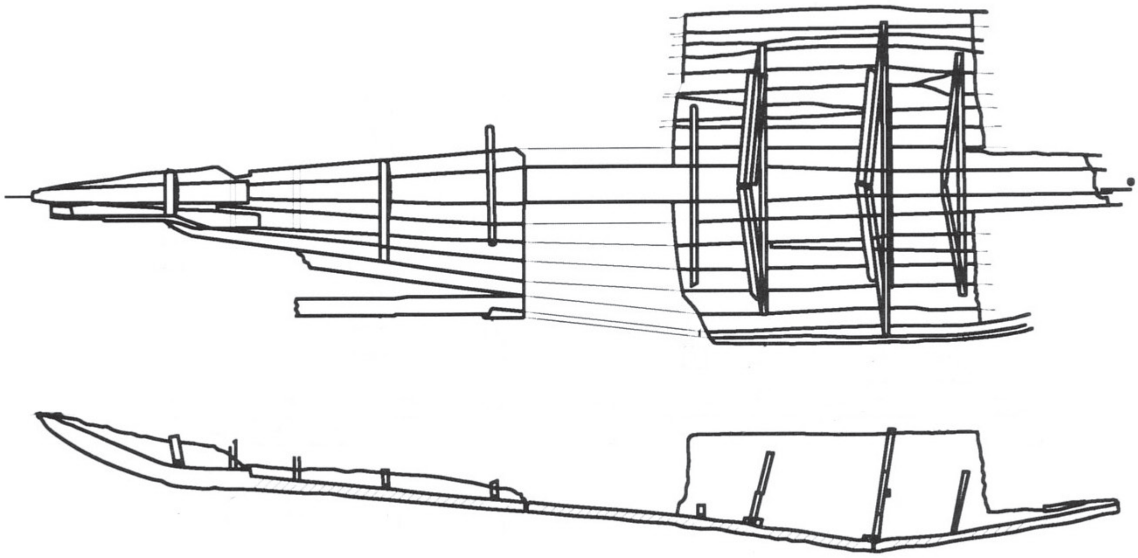


Figure 1.10 Heyilu ship. (Reproduced from Gong, C., Ding, Y., *et al*. 2008)

8. Quanzhou ship (泉州船)

The remains of the hull known as the "Quanzhou ship" or "Quanzhou ancient ship" (Quanzhou Guchuan 泉州古船) has been studied over three decades as one of the most important archaeological remains of oceangoing ships ever discovered in East Asia. A comprehensive report, the collaboration of many Chinese researchers, was published by the Museum of Overseas Communications History which is the custodian of the ship remains.[19] The Quanzhou ship has been reviewed and assessed in a few English resources.[20] The ship is currently displayed at the Quanzhou Ancient Ship Gallery in Kaiyuanshi (開元寺) at Quanzhou city in Fujian province. The overall length of the hull remains is 24.2 m and the breadth is 9.15 m.[21] The main structure of the hull is composed of a keel, bulkheads, and sturdy planking. The keel of the Quanzhou ship is composed of three parts. Twelve bulkheads produce thirteen holds on the hull. Upper planks of most bulkheads are missing. The bulkheads are fastened to the hull planking by metal bracket and large frames. The hull planking forms clinker-like steps and consists of multiple layers, double changing to triple layers around the turn of the bilge. Those outer layers function as sheathing to protect the main planking from teredo. The outer layers also contribute to the strength of the plank-shell. The date of the ship has been estimated by discovered copper coins that range from the Tang Dynasty to the Song Dynasty. The era 1265–1274 of the minting of the coins was determined as the latest date after which the ship sunk or was abandoned.

9. Ningbo ship (寧波船)

The Ningbo ship's archaeological remains were discovered at the vicinity of the Fenghua River (奉化江) at Dongmenkou in Ningbo city.[22] After revealing the hull, deterioration occurred quickly and, unfortunately, the hull was not properly preserved. The remains of the hull measure 9.3 m in length and 4.4 m in width, and they consist of the forward section of the hull bottom including the forward keel, the main keel, bulkheads, and hull planking (Figure 1.11). The length of the remaining main keel is 7.34 m long, 0.26 m wide and 0.18 m deep. The middle member of the main keel shows the greatest length measuring 5.10 m and both ends are stepped for the scarfs. On its aft scarf, a piece of the timber regarded as a part of the aft member of the main keel or an aft keel remains. Since this is hardly determined, the number of the original members that consists of the main keel is not ascertained. The forward member of the main keel is approximately 2 m long and its forward end is scarfed to join the forward keel. The forward keel angles upwards at 35 degrees. The remaining part of the forward keel measures 1.55 m long and has a triangular cross section with the widest part measuring 0.18 m with a depth of 0.20 m. It has been mentioned that there are twelve coins and associated small holes in the scarf joint between the main keel and the forward keel, associated to the shipwrights' tradition.[23] Seven bulkheads remain on the main keel. The thickness of the bulkhead planks is 70–100 mm on average. The bulkheads are nailed to the frames that are, in turn, nailed to the hull.[24] A supporting timber or stiffener is vertically installed against the aft side of the fifth

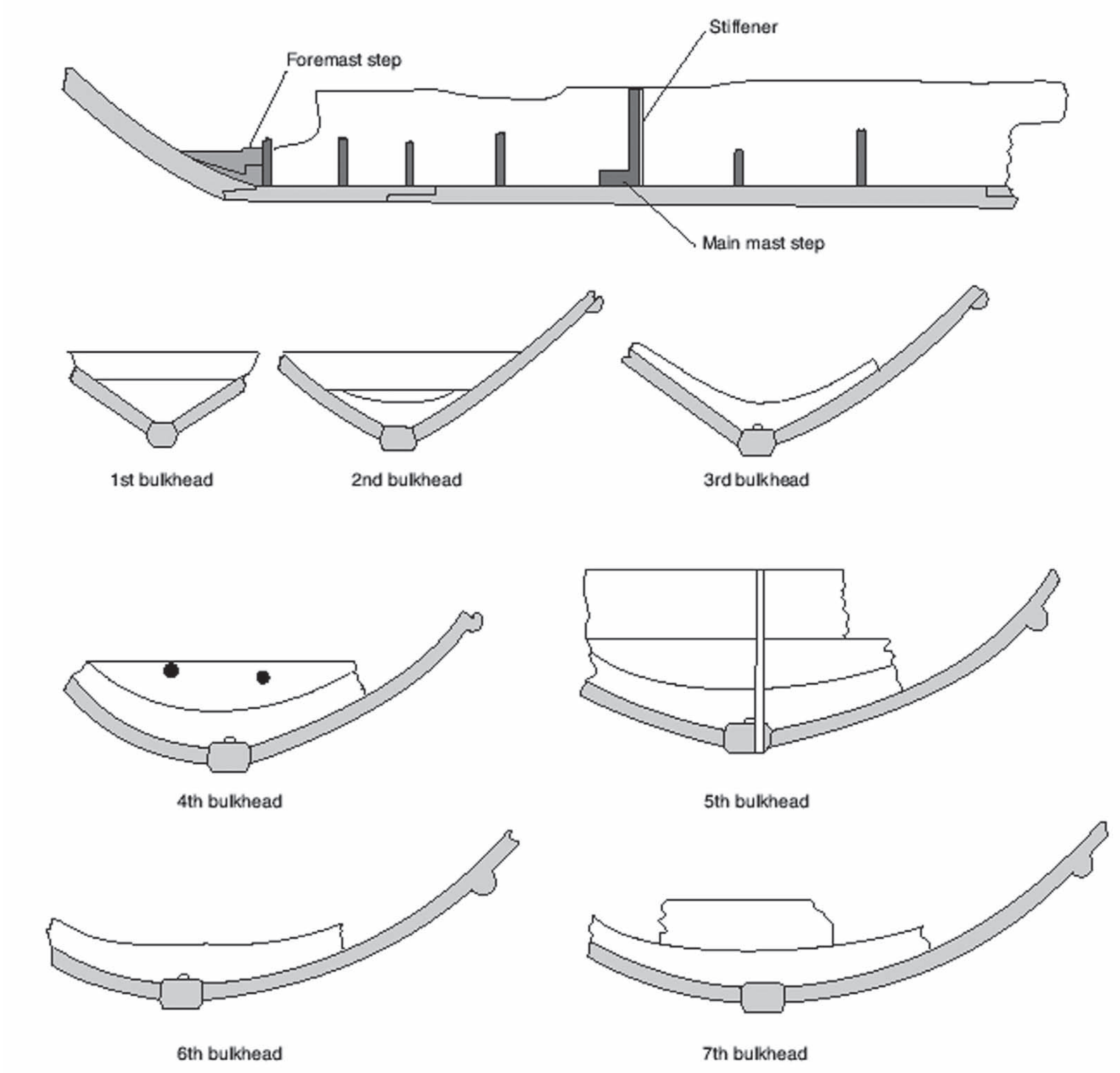


Figure 1.11 Ningbo ship. (Green 1997)

bulkhead, and this timber is fixed into a recess on the keel. As this arrangement only appears to be on the fifth bulkhead which is the position of a mast step, the timber is presumably for reinforcing the bulkhead against the loads imposed by the mast. The spacing of the bulkheads varies, and the smallest hold is the second hold measuring 0.62 m, and this is compared to the space of the fifth hold measuring 2.05 m, which is the largest space. A forward mast step is placed on the forward side of the first bulkhead and it measures 0.84 m athwartship, 0.21 m wide and 0.14 m thick. A main mast step is placed in the forward side of the fifth bulkhead and measures 1.04 m athwartships, 0.25 m wide and 0.18 m thick. Both mast steps have recesses to receive tabernacle cheeks. The cross section drawings show a gentle turn to the bilge starting at the garboards with a moderate dead rise. In the bow the cross-section shows sharp V-shape. The hull planking is carvel-built, and according to the drawing, it is single layered. The length of the remaining plank measures 3–8 m with a width of 210–420 mm and a thickness of 60–80 mm. Iron nails having a rectangular section with a side of 10–15 mm are used for the hull planking and these nails have been skew driven with an interval of 0.10–0.25 m. The seams of the strakes are filled with putty. On the outer surface around the seventh and eighth strakes in the starboard side, a longitudinal timber having a semi-circular profile is fixed by iron nails. It is 7.10 m long and runs along the hull. This has been explained to function as a bilge strake to contribute to stability and strength.[25] It seems that a part of the rudder stock remains.

10. Bai Jiao shipwreck No.1 wreck site (定海I号沉船)

The site is known as the Dinghai wreck site or the Bai Jiao 1 wreck site.[26] The site is located at 3.5 km northeast of Dinghai village on the south of Huangqi Peninsula and north of the Min and Ao rivers' mouths in Fujian Province. It was well known by the locals that from the waters around the Dinghai, a large number of various types of ceramics including bowls, jars, pots, and dishes had been recovered. These ceramics have been dated to different periods ranging from the Tang to Qing Dynasties, and the artefacts probably originate from different sources such as river sedimentation, abandoned cargos, and wreck events. The wreck site was specifically found during shell dredging operations and was inspected in 1989 to assess whether potentially it was suitable as a training site for the China-Australian cooperative programme. In 1990, provisional surveys and test excavations were conducted on the concentration of the ceramics in the site. The majority of the recovered ceramics are black glazed bowls, so-called ten moku or tainmu tea bowls. In 1995, the full excavation was implemented in the extended area adjacent to the 1990 excavation area. During the 1995 excavation, two large metal concretions regarded as originally comprised of iron billets or bars, the concentration of bowls, and some large timbers were identified. The timber lies beneath the concretions and its exposed part measures 1.4 m with a section of 0.28 x 0.30 m, and iron nails and metal concretions were observed on its surface. This timber baulk was not removed during the excavation. However, a small sample of the timber with a tree nail and nail hole was recovered, and some bamboo ropes as well. Due to the evidence of the use of iron nails and tree nails, the sample is regarded as part of the hull of the shipwreck. The species has been identified to pitch pine or yew by Australian researchers. The use of the treenails and wood used for the hull raises suspicions as to whether the ship originated from China. The date of the ship is estimated by a number of black glazed bowls that could have comprised the main cargo of the ship.

11. Nanhai No.1 shipwreck (南海I号沉船)

The Nanhai (South China Sea) No.1 shipwreck is the most known shipwreck attracting people's interest, not only because of its historical significance but also because of its state of preservation of the hull and cargo. The details of this shipwreck, however, are barely available and only in limited resources.[27] The shipwreck was accidentally discovered in 1987 by the Guangzhou Salvage Bureau under the Ministry of Communications and a British salvage company, while they were searching for Dutch East India Company's shipwrecks offshore near the Shangchuan and Xiachuan islands. The significance of the site was recognized after some precious artefacts were recovered, and immediately after that the site was protected. In 1989, the shipwreck site was initially inspected by an international team consisting of the National Museum of Chinese History and an avocational organisation for underwater archaeological survey from Japan. Since 2001, a Chinese team from the Underwater Archaeology Research Center of the National Museum commenced a series of surveys and partial excavations. As a result of the exploration that continued until 2004, a challenging approach was adopted in a way that would raise the ship remains with surrounding sediment for the sake of presenting underwater archaeological excavation work on the shipwreck within a caisson inside a museum. In 2007, a large caisson was placed onto the Nanhai No.1 shipwreck and was recovered containing the shipwreck and its physical seabed context. It was moved to the newly built museum in Hailing Island in Yangjiang city, Guangdong. Almost two decades after the discovery, the entire shipwreck still remaining in the sediments was placed on land. Chinese researchers continue to remove the sediment and expose the hull in the following years in the museum. According to the result of the partial excavation and remote sensing survey that was previously conducted, the estimated size of the burial shipwreck in the caisson measures 30 m long, 7 m wide and 4 m in depth. At this stage, further information about the shipwreck's hull is not available. A number of recovered ceramics originating from Jingdezhen, Jiangxi, Longquan, Zhejiang, Dehua, and Cizao, indicates that the ship was a trader. Many copper coins were also recovered and mainly dated to the Northern Song Dynasty (960–1127). Among them, two coins inscribed as Jianyan Tongbao (建炎通寶) and Shaoxing Yuanbao (紹興元寶) date the wreck to the Southern Song Dynasty (1127–1279). Relevant academic reports have not yet been published, and only partial information about the recovered artefacts is available at this stage.[28]

12. Huaguang Reef No.1 shipwreck (華光礁I号沉船)

A Chinese underwater archaeology team has conducted underwater archaeological surveys and excavations in the Paracel Islands (Xisha Islands) through the late 1990s. During the seasonal work, thirteen sites dating from the Five Dynasties (907–960) up to the 20th century were identified. They include one well-preserved shipwreck site. The remaining part of the hull was found at the southern-central reef known as a Discovery Reef or Huaguang Reef among the Islands. The shipwreck is named the Huaguang Reef shipwreck No.1. The date of the discovery was 1996, and immediately after locating the hull, the site was disturbed by looters. Through 1998 and 1999, the Chinese team conducted surveys and test excavations. During the operation a total of over 850 pieces of ceramics, ship timbers, and other artefacts was recovered. In 2007, a full excavation commenced, and

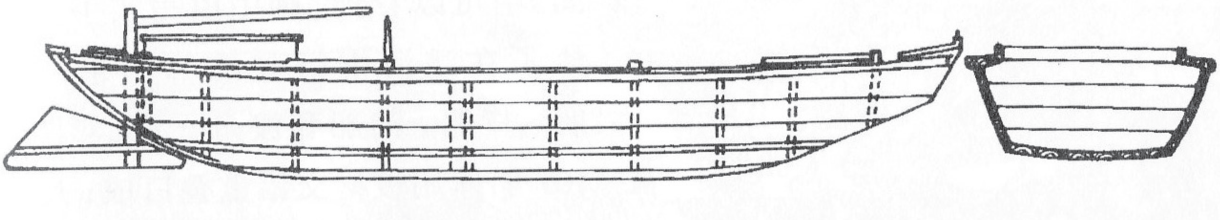


Figure 1.12 Nankai River ship. (Wang 2000)

the preservation status of the hull and the area of the site was assessed. The number of artefacts recovered from this operation is more than 6,000 items, which were more mostly ceramics, including some intact artefacts. During the second season's excavation of the year, a total of 511 ship timbers were recovered. The recovered ship timbers were brought into a museum in the Hainan Island in Guangdong Province for preservation and analysis. Although the detailed information about this shipwreck is not available for researchers outside of the country at this stage, the brief explanation of the site was provided in the international conferences in 2009 by a Chinese government officer.[29] According to Yang Zelin from the Institute of Cultural Relics and Archaeology of Fujiang Museum, the remaining hull measures approximately 17 m in length and 7.54 m in width. The preservation state of the hull is very good. Three members of the keel remain. Hull planking shows five layers in some parts. The first and second inner planks were thicker than the other outer planks. Iron nails were used for the hull planking, while the details have not been reported yet. There are ten bulkheads. The seams of the bulkheads' planks show rabbeted joints. There were limber holes in the bulkheads. It has been pointed out that the manner of joining the bulkheads to the hull planks was similar to that of the Shinan shipwreck in the use of the wooden brackets and frames.[30] The shipwreck was dated to the Song Dynasty. Some blue and white porcelain pieces were found in the hull, and some ceramics were discovered beneath the shipwreck. A large metal concretion was in the middle of the hull. This shipwreck is as significant as the Quanzhou ship and the Nanhai No.1 shipwreck in terms of comparative analyses of the hull. The official site report is expected to be available in the near future.

Yuan Dynasty (1271–1368)
13. Nankai River ship (南开河船)

In 1975, six river boats were discovered at the ancient channel of the Zhang River vicinity of Nankai village in Ci district, Hebei Province. It has been reported that of the six remains, the No.5 ship shows the most well-preserved state, measuring 16.6 m in length and about 3 m in width (Figure 1.12).[31] The hull is nearly flat-bottomed with a slight curve in the cross-section of the bottom, hard chine, flared topsides, and has eleven bulkheads. The hull planking is edged-joined, and the cross section of the hull has side decks and a low coaming. It is said that iron nails are the main fastening method. An axial balanced rudder was found on the hull. The date of the ship was determined to the Yuan Dynasty period based on an inscription on the stern of the No.4 ship remain implying the reign period of the Toghun Temur of the Yuan Dynasty (1320–70). The inscription includes the term Liang chuan (粮船), indicative of its use as a cargo ship, and for riverine transportation from the structure. The date of the ship is arguable since the hull remains look modern.

14. Sandaogang Yuan Dynasty wreck site (三道岗元代沉船)

A shipwreck was found by a local fisherman in the place called Shandaogang in the Bohai Sea, southwest of Suizhong district in Liaoning Province. From 1991 to 1997, members of the Underwater Archaeological Research Centre of the National Museum conducted remote sensing surveys and underwater archaeological excavation. Although a ship's cargo has been identified, little information is available about the hull of the shipwreck. According to an official site report, there are no remains of the wooden hulls because of the action of marine borers.[32] The area of the distributed artefacts suggests that the dimension of the original ship could be 20–22 m long and 8.5–9 m wide. Despite the loss of the hull, it seems that radiocarbon dating was conducted on a sample of the ship's timber. Its result shows 740 ± 80 BP.[33] The report focuses on the ship's cargo including a large number of porcelain remains, mostly from the Cizhou kiln. They are white and black glazed porcelains with various motifs and their types vary, such as jars, basins, bowls, dishes, lids, and vases.

15. Penglai ship No.1 (蓬莱古船Ⅰ号)

Penglai ship No.1 is the earliest discovered ship of the four ship remains known as Penglai ancient ships. They were found outside of the Penglai Castle at Yantai city in Shandon Province. In 1984, during dredging at Dengzhou harbour, one ship remain was discovered. The shipwreck has been documented in various resources (See Cai, Li, and Xi's article in this report).[34] The remaining part of the hull measures 28.6 m long and 5.6 m wide. There is a narrow flat bottom and then a gentle turn to the bilge. It appears that the cross-section shape above that turn of the bilge is very flared. The well-preserved lower hull includes a keel and thirteen bulkheads. The keel consists of three members that are joined by hooked scarf joints. The lengths of the keel members are: 3.6 m (forward keel), 17.06 m (main keel), 5.58 m (the aft keel). The main keel shows slight hogging. There are recesses for placing mirrors or coins in the keel joints. The keel scarfs are reinforced by hog pieces fitted on the top of the keel. The most well-preserved bulkheads No.3 and No.5 consist of four planks and are 0.16 m thick on the average. A part of the upper surface of the three lower planks is rabbeted to form a tongue and groove joint, and the upper most bulkhead planks have four holes that could be used to place longitudinal timbers through the hull. Each bulkhead plank is joined by four sets of mortises and tenons, and iron clamps appear to fasten the lower and upper bulkhead planks. There are two limber holes in each bulkhead, about half a metre from the keel on either side. The bulkheads located forward show that half-frames are attached to their aft side and iron brackets are used for their fixing; bulkheads hull planking is also attached to their forward side. The reverse arrangement is practised on the bulkheads located aft of midship: they have half-frames on the forward side and iron brackets on the aft side. Ten strakes remain on the port side and eleven strakes remain in the starboard side. The dimension of the hull planks is from 3.7 to 18.5 m in length, 0.20 to 0.44 m in width, and 0.12 to 0.28 m in thickness. Garboard strakes show the greatest thickness; indeed they are baulks rather than planks. The hull planking is edge-joined by two different types of square iron nails including large edge driven nails and bent skewed nails. The hull planks are joined to make up strakes with hooked scarf joints having mortise and tenon ends. Propulsion of the ship is evidenced by two mast steps remaining on the hull. A forward mast step having two recesses with a size of 0.20 x 0.20 m to receive tabernacle cheeks is located on the forward side of Bulkhead No.2, measuring 1.6 m long athwartships. A main mast step having two recesses with a size of 0.26 x 0.26 m is located on the forward side of Bulkhead No.7, measuring 2.88 m thwartships. A transom consisting of three timbers has a rudder stock hole (rudder trunk) with a diameter of 0.30 m. Discovered artefacts from the ship include five iron grapnels, a wooden anchor, three stone anchors, ropes, 489 Chinese ceramics, a few Korean ceramics, and Japanese coins. From the discovered ceramics and the study of sedimentation where the hull was discovered, it has been concluded that the ship was built around the end of the Yuan Dynasty and was used into the early Ming Dynasty.[35] Considering the historical background of the Penglai Castle and a few weaponry artefacts discovered inside the hull, Chinese researchers speculate that the ship could have been used as a battle ship, referring to a ship mentioned as "Daoyu Zhanzhao" (Sword-fish battle ship 刀鱼战棹), and in the Qing Dynasty's historical text, "Penglai Xianzhi" (History of Penglai).

Ming Dynasty

16. Liangshan Ming Dynasty ship (梁山明代船)

In 1958, a well-preserved ship was discovered near a channel of Songjin River at Heihumiao district in Liangshan, Shandong Province. The ship has been reviewed in a few resources.[36] The ship remains are said to be of the most intact condition among ship remains ever discovered in China.[37] The intact condition allowed scholars to reconstruct the original configuration of the hull. It is 21.9 m long, 3.49 m wide at deck level, 1.24 m deep with a draught of 0.75 m, and with a displacement of 31.96 tonnages. The hull has a flat bottom and bulkheads. Nine planks compose the bottom of the hull. Three planks at the centre have a thickness of 165 mm while the other planks have a thickness of 80 mm. Twelve bulkheads divide the hull. Bulkhead No.8 is the largest and consists of five planks. The bulkheads have two limber holes each located next to either side of the three centre bottom planks. The use of half frames has been indicated, yet they have not been confirmed in the original position.[38] Hull planking is comprised of eight strakes and an extra wale (or fender) is attached. The planking up to the deck level is flush constructed. There are side decks surmounted by a coaming which is supported by the bulkheads — the bulkheads are built right up the height of the top of the coaming. Butts of the hull planks appear to be of a hooked scarf joined: the same technique as the Penglai ship. Iron skewed nails are used for hull planking and the joints of bulkhead planks. A forward mast step is located at the front of the Bulkhead No.3 and a main step is located at the front of the Bulkhead No.7. When the ship was discovered, a number of artefacts were also recovered, including weapons, harnesses, metal wares, ceramics and an iron grapnel. The time period of this ship was determined from some artefacts, such as copper coins and the date inscribed on the bronze gun and the anchor associated with the reign of Hongwu (1368–1398). It has been pointed out that the appearance of armed river crafts occurred in the early Ming Dynasty.[39] The overall configuration and structure of this ship bear remarkable similarities with watercrafts for riverine use during the 20th century in China.

17. Xiangshan Ming Dynasty shipwreck (象山明代沉船)

In 1994, the remains of a Ming Dynasty ship were found in the silt area of an ancient harbour around Qibu village in Xiangshan, Zhejiang Province. From 1995, the Archaeological Research Institute of Ningbo conducted an excavation of the ship (Figure 1.13).

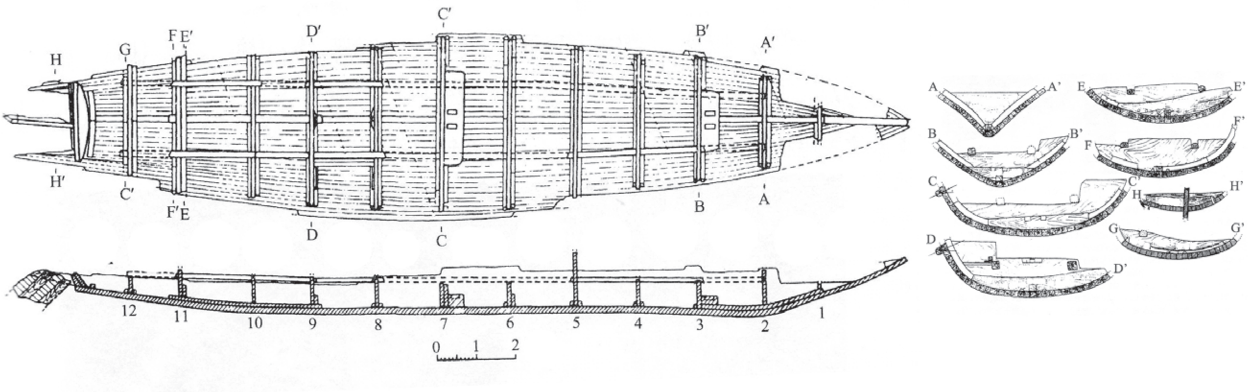


Figure 1.13 Plan of Xiangshan Ming Dynasty shipwreck. (Reproduced from Xi, Yang, *et al*. 2004)

The remaining part of the hull measures 23.7 m in length and 4.9 m in width and includes a keel and bulkheads.[40] The cross section shows a rounded bottom with sharper sections in the bow. The details of the keel have not been reported, yet it seems that the keel consists of three timbers. On each posited join in the keel, there is a hog piece like those observed on the Penglai ship. Twelve bulkheads divide the hull and two or three broad bulkhead planks remain in each bulkhead. Some of the second bulkhead planks have two square holes with a size of 0.18–0.20 m x 0.14–0.20 m to place two timbers longitudinally running through the hull. The bulkhead planks in the bottom have two limber holes. There are frames attached to the bulkheads. The distribution of the frames has not been clearly explained but it seems from the drawings that most bulkheads have frames on both the forward side and the aft side. The frames attached to the bulkheads seem to have been fastened to the hull planking by iron nails. A large number of hull planks remain, counting a total of 17 strakes per side through the mid-body of the hull. The dimension of the planks is 140–160 mm in thickness and 80–200 mm in width. They are baulks rather than planks. The hull planking is edge-joined and fastened by iron nails, though the details of iron nails and the pattern of fastening are unclear. The seams of the hull planking were caulked with hemp and are secured by a putty of tang oil and lime. The hull planking extends beyond the aft transom where a part of the rudder remains. A forward mast step remains on the forward side of Bulkhead No.2 and a main mast step remains on the forward side of Bulkhead No.7. From the bottom of the hull, besides bricks and roofing and ridge tiles, a few ballast stones were found. The date of the ship was determined from discovered ceramics including a porcelain bottle with a small mouth dating to the Yuan Dynasty period and a few celadon from the Longquan kiln dating to the early Ming Dynasty. The purpose of the use of the ship has not been identified. It was either a local cargo ship used by private merchants or a battle ship employed by the government. It is said that the ship is in most respects similar to Penglai ship No.1.[41]

18. Penglai ship No.2 (蓬莱古船II号)

The remaining part of the hull of the Penglai ship No.2 measures 21.5 m (or 22.5 m) long and 5.2 m wide. Although the stern is missing, the bottom of the hull is relatively well-preserved and the remaining part includes a keel, some bulkheads and eleven strakes in each side (Figure 1.14). Details of the hull including the dimensions of the remaining planks are available in the archaeological report with other detailed information about the hull.[42] The cross section of the bottom hull shows some hollow around the bow, and these changes to a rounded shape through the mid-body. The keel shows slight hogging. The keel is comprised of three members: 4.78 m (forward keel), 16.20 m (main keel). These are joined by hooked scarf joints with mortise and tenon. In the joints, there seems to be a hole for the placement of a mirror or coins evidencing the practice of the shipwright's belief. Iron straps and iron nails are used to fasten the forward and main keel. A hog piece is fitted on top of each joint and large iron nails are driven from them down through the keel. The sides of the main keel are rabbeted and thick planks (garboard planks) are fitted using a mortise and tenon joint. Although the ship originally has had thirteen bulkheads, only six bulkheads remain. There are limber holes from the Bulkhead No.3 to No.7, yet Bulkhead No.2 and No.8 do not have limber holes due to mast steps located at their forward faces. The lower and upper part of each bulkhead plank is fashioned for a tongued and groove joint and they are joined with mortises and tenons (loose tenons). Skewed iron nails are also driven into the seams of the bulkhead planks. Frames are used to fix the bulkheads and hull planking together, fastened by iron nails. Using iron brackets to fasten the hull planking to bulkheads is evidenced on the Bulkheads No.2, No.3 and No.7, although these brackets are mostly degraded. Only corroded iron remains in the recesses of the surface of the bulkhead planks into which the brackets have been slotted. The joint pattern of the hull planking shows the same method with the Penglai ship No.1 and uses

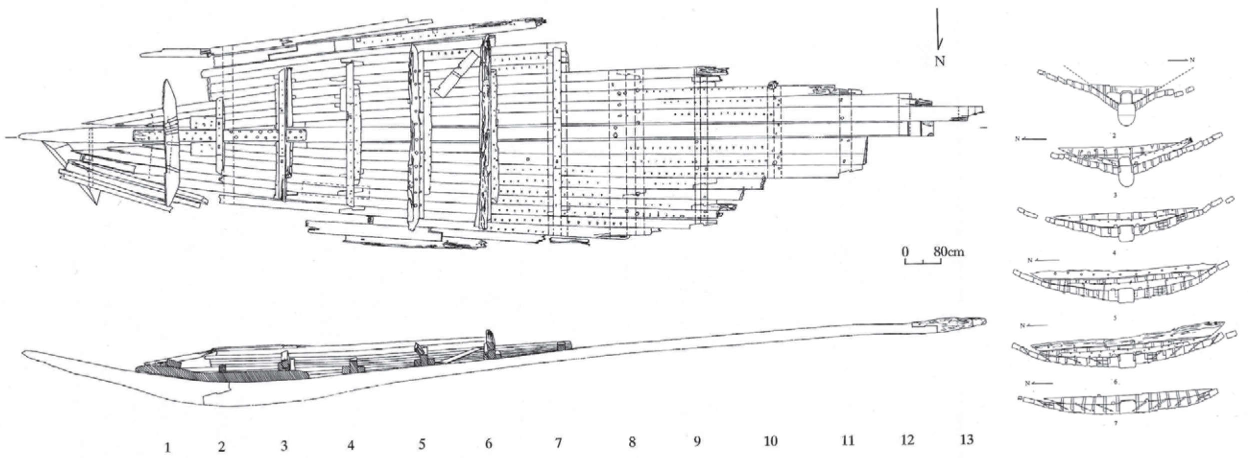


Figure 1.14 Plan of Penglai ship No.2. (Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum., *et al.* 2006)

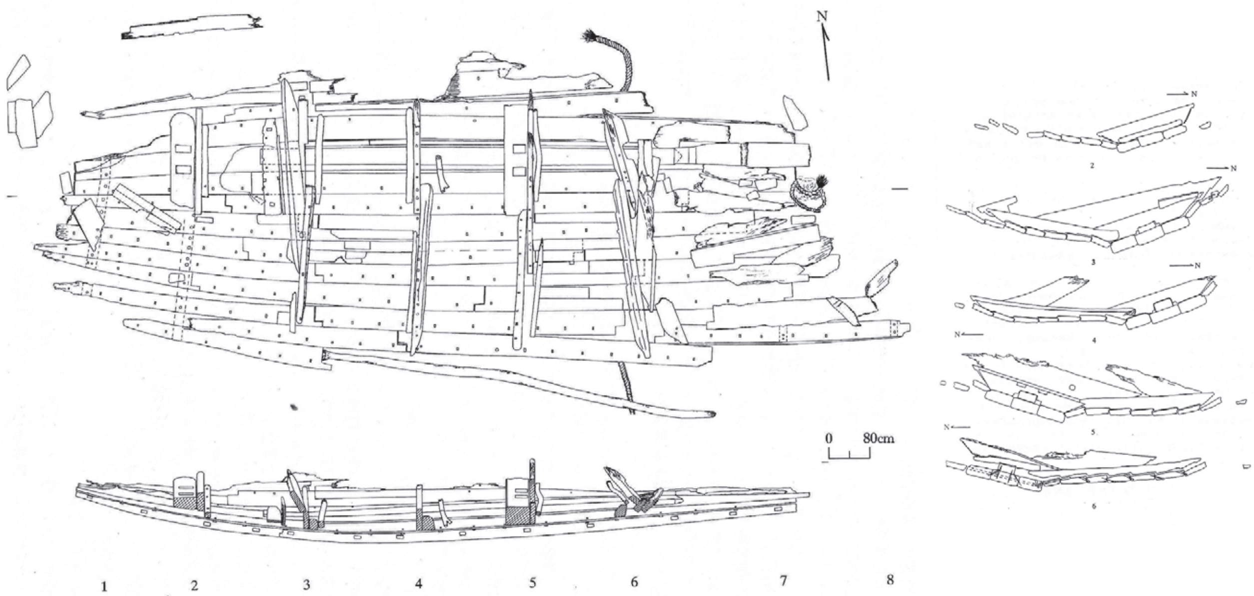


Figure 1.15 Plan of Penglai ship No.3. (Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum., *et al.* 2006)

large edge driven nails and bent skewed nails. The mast steps are fixed to the hull planking by iron nails. The length athwartships of the forward mast step is 1.9 m with two square recesses measuring 160 x 225 mm. The main mast step is missing. The Penglai ships No.1 and No.2 have been evaluated as the same type of ships.

19. Penglai ship No.3 (蓬莱古船III号)

Ship remains were identified just next to the Penglai ship No.2. However, the two ships are distinguishable in their structure. The remaining part of the hull measures 17.1 m long and 6.2 m wide and includes bottom planks, bulkheads, and hull planks, though the stern is missing (Figure 1.15). Details of the hull including dimensions of the remaining planks are available in the archaeological report with other detailed information about the hull.[43] The structure of the bottom hull and hull planking shows remarkable similarities with Korean shipwrecks discovered in Korean waters (see the section below). The hull has a flat bottom consisting of three strakes. The planks of the strakes are joined together by transverse wooden bars or dowels. Thirteen bars are used in the extant portion of the ship's bottom. Wooden nails seem to be driven from the centre bottom planks to the sided planks in a few places. The structure of the bottom planks and their fastening methods are similar to those observed on the Korean origin shipwrecks. However, an extra plank placed on top of the centre bottom plank and its fastening method using edge driven iron nails have not been found on the Goryeo Period's Korean ships. Three strakes remain in the portside

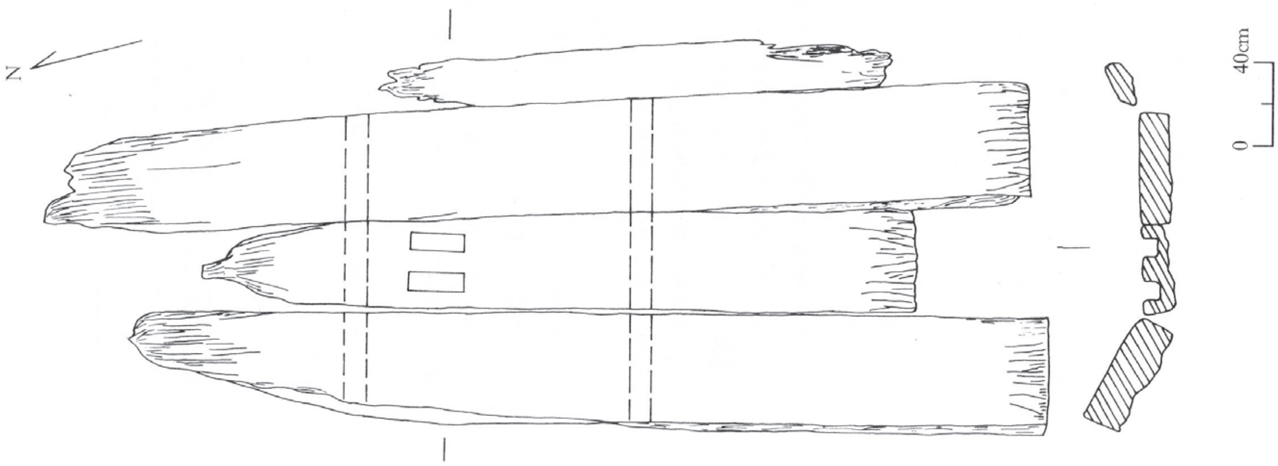


Figure 1.16 Plan of Penglai ship No.4. (Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum., *et al.* 2006)

and nine strakes remain in the starboard side. The first strakes are fitted into rabbets on the upper edge of the side bottom planks and appear to be fastened with mortises and tenons (or dowels). The hull planking is a form of clinker-built with rabbeted seams. Skewed wooden nails are driven from the outer surface of the upper planks into the lower plank through the rabbeted seams. Butts of the hull planking are held together by lap-joints. Also, iron nails are used to fasten the hull planking. Bulkheads, which are not used in the Korean shipbuilding tradition, are the main structures for the transversal strength of this ship. Five bulkheads remain and they are regarded as the second to sixth bulkheads. One to five remain. More than eight bulkheads have been originally used. The bulkheads' bottom planks have a recess in their bottom that fits to the extra plank onto the centre bottom plank and also creates limbers. Bent skewed iron nails are used to fasten bulkhead planks as well as to fix the hull planking and bulkheads together. Frames are attached onto some of the bulkheads and the bent skewed iron nails are used to fasten the hull planking to the frames. Intensive use of iron nails is unusual in the traditional Korean shipbuilding. The use of different types of the wooden bars, mortises and tenons, nails and iron nails is emphasized in a comparable study on the Penglai Ship No.2 and No.3.[44] The forward and main mast steps that have two recesses are identified at the second and fifth bulkheads. The ship was discovered in almost the same elevation as the Penglai Ship No.2, indicative of the contemporary use of the two ships.

20. Penglai ship No.4 (蓬莱古船IV号)

A few ship timbers were discovered about twelve metres away from the No.2 and No.3 ships. Only four timbers remain, yet they clearly show identical features with the Penglai ship No.3 (Figure 1.16). According to an archaeological report, of the four timbers, three are the bottom planks forming a flat bottom.[45] The dimension of the remains of the centre bottom plank is 3.46 m long, 0.20–0.44 m wide, and 0.16–0.20 m thick. It has two recesses that could receive tabernacle heels directly, instead of using a mast step. This arrangement is well-evidenced on the discovered shipwrecks of the traditional Korean coastal ships as discussed below. Two bottom planks are positioned, one on each side of the centre bottom plank. The dimension of the remaining part of the two planks measures 4.8 m in length, 0.26–0.52 m in width, and 0.10–0.22 m in thickness. The upper edges of their outer parts appear to be recessed to place strakes. The three bottom planks are fixed by two wooden bars. One timber regarded as a part of the hull planking was found and another large timber measuring 9.24 m long was found away from the four timbers and also regarded as a hull plank. It is disputable if the Penglai ship No.4 had hybrid features like the No.3's bulkhead structure, and the use of both iron and wooden fastenings. Besides many distinctive structural features between the ship remains adopting Chinese traditions (Penglai ship No.1 and No.2) and the ship remains adopting Korean traditions (Penglai ships No.3 and No.4), the assemblage of woods used for each tradition shows differences. The Penglai ship No.1 and No.2 use more different types of wood in the hull structure. In contrast, the kinds of wood used for the main structure of the Penglai ships No.3 show less diversity, and most parts of the hull use pine.

Qing Dynasty

21. Baolian Harbour shipwreck (or known as Hainan Wenchang shipwreck) (宝陵港沉船)

The Agency for Cultural Affairs in Hainan Province discovered one old shipwreck in the waters of Baoling Harbour in Wenchang in 1987. While an Underwater Archaeology Team from the National Museum was conducting a survey on the shipwreck in 1990, it identified a remain of the shipwreck that has been substantially covered by sediment. Large concretions were found on the sites and contained some metal remains consisting of iron pans and copper drums. Also, miscellaneous artefacts, such as some ceramics, a copper candle stick, silver ingots, and copper coins were found inside the concretions. It is said that remnants of hull planking were identified under the concretions, yet the details have not been made available.

22. Shantou Guangao shipwreck (or known as Nangao No.1 shipwreck) (汕头广澳沉船)

In 1995, members of the National Museum of Chinese History conducted an underwater survey in Guangao Harbour in Shangtou city, Guandon Province and found one shipwreck. On the seabed, its keel and frames were exposed, yet most parts of the hull have still been covered by sediments. During the inspection, copper alloy seals were found and their inscriptions indicate that the ship probably dates back to the 17th century.

23. DongguMingzheng wreck site (冬古明郑沉船)

The site was identified by a local museum in Dongshan district in Fujian Province in 2000. As result of underwater survey, four bronze guns, two iron muskets, a set of bullets and gun powders, and ten pieces of ceramics and some ship timbers were recovered. The discovered ceramics are blue and white porcelains from the Zhangzhou kiln, likely to be dated to the end of Ming Dynasty or the early Qing Dynasty

24. JinjingShenhu Bay wreck site (晋江深沪湾沉船)

A municipal museum in Jinjiang in Fujian Province inspected the shallow waters of Shenfu Bay and found the wreck site. Discovered artefacts include a large bronze cannon that has been caste in Wenzhou, an iron gun, fragments of copper alloy drums, and a few other metal objects, such as a spoon, a sword handle, and ingots. From the inscription on the discovered white porcelain, the date of the site was determined to have been at the end of the Ming Dynasty or the Qing Dynasty.

25.Wanjiao No.1 wreck site (碗礁I号沉船)

The site was discovered at the Wanjiao reef which is a part of Wuzhou reefs offshore of Yutou at Pingtan district in Fuzhou city in 2005. Immediately after the discovery the site was looted, such that an underwater archaeological excavation was conducted and directed by the Underwater Archaeology Research Center of the National Museum cooperative with regional government agencies. As a result of the excavation, 17,000 ceramics, which mostly consist of the blue and white porcelains from the Jingdezhen kiln dating to the mid-period of the reign of Kangxi Emperor (1661–1722), were recovered and also an ink stone and copper coins were found. Despite the discovery of this great number of artefacts, the site has been substantially destructed by looters since it was shallowly buried in the seabed in a depth of 13–15 m. Many artefacts as well as the hull went missing. An archaeological report lists the major types of ceramics from the site, yet no information about the hull is available.[46]

Bulkhead structure in the excavated ships in Southeast Asia

The use of bulkheads has been recognized as a lasting characteristic of the Chinese shipbuilding tradition. In developing the data of ship remains in China, bulkheads are identified as early as in the Tang Dynasty's riverine ships. During the Song Dynasty, it is presumed that Chinese merchants made inroads into trade with Southeast Asian regions on their own initiative. This suggests an idea of examining the possible influence of Chinese shipbuilding in Southeast Asia. It has been known from previous studies that some identified shipwrecks from Southeast Asia have some similarities in the hull structure and construction methods with Chinese ships.[47] Since the 1980s, underwater archaeological excavations have been implemented in some countries of Southeast Asia. Many of the discovered ships in the Philippines, Thailand, and Indonesia indicate an influence from the Chinese shipbuilding tradition, represented in the use of bulkheads. An inventory of those ship remains in several Southeast Asian countries is developed in the Shipwreck ASIA project through cooperating with local experts (Table 4, 5 & 6). In the Philippines, some underwater sites are dated to the Song Dynasty period, yet the hull remains are not identified. In Indonesia, a site known as the Pulau Buaya wreck is identified to the Song Dynasty. While various artefacts recovered from the site assembled cargo dating to the Song Dynasty's ships, whether they have originated from Chinese built ships has not been clarified. It is well known that Chinese commodities have been distributed by seaborn trading since the Tang Dynasty. A question remains as to the time period that Chinese merchants started to use their own built ships.

Conclusion

Data presented in this paper resulted from a database approach implemented in the "Shipwreck Asia" project. In general, a database is understood as a useful instrument

Country	Philippines									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Butuan (Balangays) No.1	Butuan, Agusan Valley, Mindanao	320?	Philippines	Low	Chemical Conservation	1976	No	No	Yes	Coastal transportation?
Butuan No.2	Butuan, Agusan Valley, Mindanao	1250?	Philippines	Medium	Chemical Conservation	1986?	No	No	Yes	Coastal transportation?
Butuan No.5	Butuan, Agusan Valley, Mindanao	1215?	Philippines	Low	Chemical Conservation	1986	No	No	Yes	Coastal transportation?
Breaker Reef wreck	Breaker Reef, Palawan	N/A	Song Dynasty?	N/A (No hull remains)	N/A	1991	Yes	No	Yes	Trader?
Investigator Shoal wreck	Investigator Shoal, Palawan	N/A	Yuang Dynasty	N/A (No hull remains)	N/A	1990	Yes	No	Yes	Trader?
Lena Shoal wreck	Lena Shoal, Busuanga, Palawan	N/A	Ming Dynasty	High	Non-treatment	1997	Yes	No	Yes	Trader
Marinduque wreck (junk)	Gaspar Island, Gasan, Marinduque	N/A	Ming Dynasty? or Siam origin?	Low	Non-treatment	1980	Yes	No	Yes	Trader
Pandanan wreck	Pandanan Island, Palawan	15th century	South China Sea/Vietnamese?	N/A (No hull remains)	N/A	1993	Yes	Yes	Yes	Trader
Puerto Galera wreck	Puerto Galera, Mindoro	N/A	South China Sea?	N/A (No hull remains)	N/A	1983	Yes	No	Yes	Trader
Santa Cruz wreck	Sta, Cruz, Zambales	Late 15th century	South China Sea	High	Non-treatment	2001	Yes	No	Yes	Trader
San Isidro wreck	San Isidro, Zambales	16th century	Southeast Asia?	Low	Non-treatment	1996	Yes	No	Yes	Trader

Table 4.

Country	Thailand									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Ko Rang Kwien Shipwreck	About 800 m north from Rang Kwien island, West of Bang Sarea Bay	14-early 15th century	N/A	Low	Non-treatment	1978	N/A	Yes	Yes	Oceangoing Trade
Bang sak shipwreck	1.6 km from Thabtawan beach, Phang Nga	Radio carbon date of 760±220 B.P	N/A	Low	Non-treatment	2008	N/A	Yes	No	N/A
Ko Si Chang 1	Ko Sichang, Chonburi	Late 16th century	N/A	Low	Non-treatment	1982	N/A	Yes	Yes	Oceangoing Trade
Ko Si Chang 2	Ko Sichang, Chonburi	14–15th century	S.E.A	Low	Non-treatment	1982	N/A	Yes	Yes	Oceangoing Trade
Ko Si Chang 3	Ko Sichang, Chonburi	Mid 16th century	Siamese?	Low	Non-treatment	1985	N/A	Yes	Yes	Coastal trade
Ko Khram or Sattahip Shipwreck	Near ko Kram Island which faces Sattahip Bay, Chonburi	1450–1475	N/A	Low	Non-treatment	1974	N/A	Yes	Yes	Oceangoing Trade
Klang Aow 2	At the middle in the gulf of Thailand, 62 Miles from Sattahip Chonburi	16th century	N/A		Non-treatment	2004	N/A	Yes	No	N/A
Hin Bush wreck site	N/A Rayong province?	16th century	N/A	Low	Non-treatment		N/A	Yes	Yes	Oceangoing Trade
Ko Kra	14 km from Ko Kra, 94 km from Pak Panang	16th century	N/A		Non-treatment	2005	N/A	Yes	No	Oceangoing Trade
Ko Tao	N/A	16th century	N/A	Low	Non-treatment	2009	N/A	Yes	No	
Klang Aow 1 Shipwreck	At the middle in the gulf of Thailand, 55 miles from Sattahip Chonburi	1500–1530	N/A	Low	Non-treatment	1991	N/A	Yes	No	Oceangoing Trade
Ko Kradat Shipwreck	1 km north of the northern end of the island in Trad	1522–1566	S.E.A	N/A (No hull remains)	Non-treatment	1977	N/A	Yes	Yes	Oceangoing Trade
Ko Rin wreck site	N/A	1558–1757	N/A	N/A (No hull remains)	N/A	1988	N/A	Yes	No	N/A
Ko Samae San Shipwreck	N/A	1658–1857	N/A	N/A	N/A	1985	N/A	Yes	No	Jettison
Ko Samui Shipwreck	In the waters between Samui island and Tan island	1658–1857	N/A	Low	Non-treatment	1984	N/A	Yes	Yes	Oceangoing Trade
Prachuap Khiri Khan wreck site	N/A	1558–1757	N/A	Low	N/A	1987	N/A	Yes	No	N/A
Pattaya Shipwreck	In the waters between Pattaya beach and Lan island	1558–1657	N/A	Low	Non-treatment	1977	N/A	Yes	Yes	Oceangoing Trade
Rayong wreck site	N/A	1657–1757	N/A	N/A	N/A	1977	N/A	Yes	No	N/A
Nakhon si Tammarat	N/A	450 B.P/carbon 14	N/A	N/A	N/A	1978	N/A	Yes	No	N/A
Bangkachai I	Bangkachai Bay	N/A	N/A	N/A (No hull remains)	Non-treatment	1989	N/A	Yes	No	N/A
Bangkachai II	In the waters 2 km away from the seashore, Bangkachai Bay	Early 17th century	Siamese?	Low	Non-treatment	1992	N/A	Yes	Yes	Oceangoing Trade
Samed Ngam	At the riverbank around the mouth of Hanthabiuri river, Tambon Samedngam Aumper Muang, Chanthaburi province	18th-19th century	Fujian junk?	Low	Covered the ship by roof and soak it in fresh water at Local site museum.	1982	N/A	Yes	Yes	Oceangoing Trade

Table 5.

Country	Indonesia									
Site	**Discovered Location**	**Dating**	**Origin**	**Status of Hull remains**	**Preservation Status**	**Year Discovered**	**Salvaged**	**Surveyed**	**Excavated**	**Purpose**
Cirebon Wreck	Nothern Java Sea	973	Five Dynasty Period, Arab or India origin?	Low	Non-treatment	2003	Yes	Yes	No	Cargo for Trade
Belitung shipwreck	"Offshore Belitung Island"	9th century?	Arab or India origin?	High	Non-treatment	1998	Yes	Yes	No	Trader
Intan Shipwreck	N/A	10th century?	Arab or India origin?	High	Non-treatment	1997?	Yes	Yes	No	Trader
Java Sea Shipwreck	N/A	13th century?	Indonesian origin?	Low	Non-treatment		Yes	Yes	Yes	Indonesian trader
Pulau Buaya Wreck	Pulau Buaya – Kepulauan Riau	1300s	Song Dynasty	N/A (No hull remains)	Others	1989	Yes	Yes	No	Cargo for Trade
Belanakan Shipwreck	Belanakan waters, Subang, West Java	14th century	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bukit Jakes Shipwreck	Bintan Island	1400–1460	Ming Dynasty	High	In situ preservation	1981?	No	Yes	Yes	Trader
Teluk Sumpat Wreck	Bintan Island	1700s	Yuan and Ming Dynasties	N/A (No hull remains)	Non-treatment	2005	Yes	Yes	Yes	

Table 6.

to store and share the information and contributes to the development of a regional cooperation in both archaeological research and underwater cultural heritage management. As represented by the states of Korea, China, and Thailand, some achievements in maritime and underwater archaeology in Asia occurred in the last two decades. Of maritime archaeological study, however, shipwreck and ship remains themselves have been lagging behind, compared to the international study regarding their cargo and trading commodities. Considering the past achievements in each state, it becomes more meaningful to analyse archaeological remains of Asian ships inclusively by taking a comparative approach. The collective data in the project is expected to be used as an inventory. Further details of each identified ship remains in the project are expected to be pursued by individuals with their own research themes.

Notes

1 Keith, D. H. (1980). 'A fourteenth-century shipwreck at Sinan-gun', *Archaeology*. 33 (2): 33–43; Keith, D. H. and Buys, C. J. (1981). 'New light on medieval Chinese seagoing ship construction', *The International Journal of Nautical Archaeology*. 10 (20): 119–132; Green, J. (1983a). 'The Shinan excavation, Korea: an interim report on the hull structure', *The International Journal of Nautical Archaeology*. 12 (4): 293–301; Green, J. and Kim, Z. G. (1989). 'The Shinan and Wando sites, Korea: further information', *The International Journal of Nautical Archaeology*. 18 (2): 33–41; Lee, C. E. (1991). 'A study on the structural and fluid characteristics of a rabbeted clinker type ship (The sunken ship salvaged off Shinan)' in Shanghai Society of Naval Architecture & Marine Engineering, Marine History Researchers' Association of CSNAME (eds.), *Proceedings of International Sailing Ships History Conference Shanghai*, Shanghai.

2 Green 1983a; Lee 1991.

3 Ishii, K. (1957). *Nihon no Fune (Ships in Japan* 日本の船). Tokyo, Sogensha; Farris, W. W. (2009). 'Shipbuilding and nautical technology in Japanese maritime history: origins to 1600', *The Mariner's Mirror* 95 (3): 260–283.

4 Own translation in *Chou hai tu bian* (584: 67–68) reproduced by Taiwan Shangwu Yin shuguan.

5 Wang, G. (2000). *Zhongguo Guchuan Tupu (Catalogue of Ancient Chinese Ships* 中国古船图谱). Beijing, Sanlian Shudian; Xi, L. (2000). *Zhongguo Zaochuanshi (History of Chinese shipbuilding* 中国造船史). Hubei, Hubei Education Publisher; Xi, L., Yang, X. and Tang, X. (eds.). (2004). *Zhongguo Kexue Jishushi: Jiaotong Juan (The History of Science and Technology in China: Transportation* 中国科学技术史:交通卷). Beijing, Science Press.

6 Xi, 2000.

7 Ji, S. (1987). 'Brief report on the ancient boat from the Dazhi River, Nahui Country, Shanghai', *The Bulletin of the Shanghai Museum* 4: 175–178.

8 Ji 1987: 177.

9 Worcester, G. R. G. (1971). *The Junks and Sampans of the Yangtze*. Annapolis, United States Naval Institute.

10 Ji 1987: 177.

11 Xi, 2000: 152–157; Xi, L., (ed.). (2008). *Chuan Wenhua (Ship culture* 船文化). Beijing, China Communication Press.

12 Xi, Yang, *et al*. 2004: 112.

13 Xi, Yang, *et al*. 2004: 114.

14 Wang 2000: 120–121.

15 Wang 2000: 121.

16 Green, J. (1997). 'Archaeological evidence East Asian vessels' in J. Green (ed.), *Maritime Archaeology in the People's Republic of China*. Fremantle, Western Australia Maritime Museum; Xi, Yang, *et al*. 2004: 124–125.

17 Gong, C., Ding, Y., Chu, X. and Xi, L. (2008). 'Zhejiang Ningbo Heyilu Chutu Guchuan Fuyuan Yanjiu (Study on the reconstruction of the ancient ship from Zhejiang Ningbo Heyilu 浙江宁波和义路出土古船复原研究)', *Ningbo Wenwu Kaogu Yonjiu Wenshi in Ningbo*. 2: 183–194.

18 Gong, Ding, *et al*. 2008: 187.

19 Museum of Overseas Communication History. (1987). *Quanzhouwan Song Dai Haichuan Fajue yu Yanjiu (Excavation and Research of the Song Dynasty Ship Found on the Quanzhou Bay* 泉州湾宋代海船発掘与研究). Beijing, Ocean Press.

20 Merwin, D. (1977). 'Selections from Wen-wu on the excavation of a Sung Dynasty seagoing vessel in Chuan-chou', *Chinese Sociology and Anthropology*. IX (3): 3–106; Keith and Buy 1981; Green, J. (1983b). 'The Song Dynasty shipwreck at Quanzhou, Fujian Province, People's Republic of China', *The International Journal of Nautical Archaeology* 12 (3): 253–261; Burningham, N. and Green, J. (1997). 'Description of the Quanzhou Ship', in J. Green (ed.), *Maritime Archaeology in the People's Republic of China*. Fremantle, Western Australia Maritime Museum; Green, J., Burningham, N. and Museum of Overseas Communication History. (1998). 'The ship from Quanzhou, Fujian Province, People's Repulic of China', *The International Journal of Nautical Archaeology* 27 (4): 277–301; McGrail, S. (2002). *Boats of the world from the Stone Age to Medieval times*. Oxford, Oxford University Press.

21 Merwin 1977: 11; Museum of Overseas Communication History 1987: 16.

[22] Lin, S., Du, G. and Green, J. (1991). 'Waterfront excavation at Dongmenkou, Ningbo, Zhe Jiang Province, PRC', *The International Journal of Nautical Archaeology*. 20 (4): 299–311.

[23] Green 1997: 20.

[24] Green 1997: 20.

[25] Wang 2000: 144.

[26] Kenderdine, S. (1995). 'BaiJian 1 — the excavation of a Song Dynasty shipwreck in the Dinghai area, Fujian Province, China, 1995', *The International Journal of Nautical Archaeology*. 24 (4): 247–266; Kenderdine, S. (1997). 'The Bai Jiao excavations', in J. Green (ed.), *Maritime Archaeology in the People's Republic of China*. Fremantle, Western Australia Maritime Museum.

[27] Zhang, W. (2006a). 'The Application of the Basic Principles and Methods of the Underwater Archaeology in China', in National Maritime Museum of Korea (ed.), *Shinan Underwater Relics and 14th Century Asian Marine Trades: International Symposium in Celebration of the 30th Anniversary of the Shinan Wreck Excavation,* Mokpo.

[28] Zhang 2006a: 432.

[29] Zhang, W. (2006b). 'Preface', in Underwater Archaeology Research Center of the National Museum of China and Cultural Heritage Administration Office of Hainan Province (ed.), *Xisha Shuixia Kaogu (1998–1999) (Underwater Archaeology in Xisha Islands* 西沙水下考古). Beijing, Science Press; Conference paper 'An introduction to the hull of Huaguang Reef one shipwreck site of the Song Dynasty in Xisha Islands' delegated by ZelinYang, presented at Of Ships and Men, the Sino-French Workshop, Ningbo, EFEO in 2009.

[30] ZelinYang indicated that the bulkhead planks' fastening method of the Huaguang Reef No.1 shipwreck is similar with that of the Shinan shipwreck that used wooden brackets (or stiffeners).

[31] Wang 2000: 121.

[32] Zhang, W., (ed.). (2001). *Suizhong Sandaogang Yuan Dai Chenchuan (Yuan Dynasty shipwreck in Suizhong Sandaogang* 绥中三道岗元代沉船). Science Press, Beijing.

[33] Zhang 2006a: 431.

[34] Xi, L., (ed.). (1989). *Penglai Gunchuan Yu Dengzhou Gugang (Ancient Penglai ship and Ancient Dengzhou port* 蓬莱古船与登州古港). Dalian Haiyun Xueyuan Chuban she, Dalian; Xi, L. and Y. Xin (1991). 'Preliminary research on the historical period and restoration design of the ancient ship unearthed in Penglai', in Shanghai Society of Naval Architecture & Marine Engineering, Marine History Researchers' Association of CSNAME (eds.), *Proceedings of International Sailing Ships History Conference Shanghai,* Shanghai; McGrail 2002: 371–373.

[35] Zou, Y. and Yuan, X. (1989). 'A study of date and use of ancient Penglai ship.Penglai Guchuan Yu DengzhouGugang (Ancient Penglai Ship and Ancient Dengzhou Port)', in L. Xi (ed.), *Penglai Gunchuan Yu Dengzhou Gugang (Ancient Penglai ship and Ancient Dengzhou port).* Dalian Haiyun Xueyuan Chuban she.

[36] He, G. (1991).'Measurement and research of the ancient Ming ship unearthed in Liangshan', in Shanghai Society of Naval Architecture & Marine Engineering, Marine History Researchers' Association of CSNAME (eds.), *Proceedings of International Sailing Ships History Conference Shanghai,* Shanghai; McGrail 2002: 373–374. Xi, Yang, *et al*. 2004: 191–195.

[37] Xi, Yang, *et al*. 2004: 192.

[38] Xi, Yang, *et al*. 2004: 192.

[39] Xi, Yang, *et al*. 2004: 192.

[40] Xi, Yang, *et al*. 2004: 195–198.

[41] Xi, Yang, *et al*. 2004: 199–200.

[42] Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum and Cultural Relics Bureau of Penglai City. (2006). *Ancient Ships from Penglai*. Wenwu Press, Beijing.

[43] Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum., *et al*. 2006: 35–44.

[44] Yuan, X. (2006). 'The excavation and accomplishment of the shipwreck on Penglai area', in National Maritime Museum of Korea (ed.), *Shinan Underwater Relics and 14th Century Asian Marine Trades: International Symposium in Celebration of the 30th Anniversary of the Shinan Wreck Excavation,* Mokpo.

[45] Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum., *et al*. 2006: 44–46.

[46] Underwater Archaeology Team of Wanjiao No.1 (ed.). (2006). *Donghai Pingtan Wanjiao Yihao Chusui Ciqi (Porcelain from the Wanjiao Yihao Chusui No.1 site* 东海平潭碗礁一号出水瓷器) Beijing, Science Press.

[47] Green, J., and Harper, R., and Intakosi, V. (1987) *The Maritime Archaeology of Shipwrecks and Ceramics in Southeast Asia, the Maritime Connection / Jeremy Green and Rosemary Harper. The Ko Si Chang Three Shipwreck Excavation 1986 / Jeremy Green, Rosemary Harper and Vidya Intakosi.* Victoria, The Australian Institute for Maritime Archaeology.

2

Watertight bulkheads and limber holes in Ancient Chinese Boats

Cai Wei

Li Cheng

Xi Longfei

Abstract

The first watertight bulkheads in ship of the world appeared in the Yixi Era of the Jin Dynasty (Eastern Jin Dynasty) of China, and the watertight bulkheads had being widely used by the Tang Dynasty. Limber holes were found in many ancient Chinese ships, such as the Song Dynasty ship found in Quanzhou Bay, the Song Dynasty ship found in Ningbo, the ships discovered in Penglai, the Liangshan ship, and the South Korea's Shinan ship. According to the analysis, the role of the limber hole is to exclude water while washing cabins.

要旨

世界の造船史において水密隔壁が最初にあらわれるのは中国晋朝義熙年間である。そして唐代には水密隔壁は幅広く使用されるようになった。汚水孔は多くの古代中国船、例えば泉州湾の宋代船、宋代寧波船、蓬莱古船、梁山船、韓国新安船などにみられる。本研究によれば、これら汚水孔の役割は船室を洗った際に水を流すためのものである。

Introduction

The first watertight bulkheads in ship construction appeared in the 6th year of the Yixi Era of the Eastern Jin Dynasty (410). By the Tang Dynasty, watertight bulkheads were widely used. Limber holes were found in many ancient Chinese ships, such as the Song Dynasty's Quanzhou ship in Quanzhou Bay, the Song Dynasty's Ningbo ship in Ningbo, the Penglai ship, the Liangshan ship, and the Shinan shipwreck. According to this analysis, the role of the limber hole is to exclude water while washing cabins.

The initial appearance of watertight bulkheads

It can now be deduced that the first watertight bulkheads appeared around 410. It is believed that Lu Xun, the leader of the peasant rebel army at the time, was the inventor of watertight bulkheads.[1] They quickly gained popularity and were widely used throughout the Tang Dynasty.

In June 1973, the Tang Dynasty's Rugao ship was found in Rugao County of Jiangsu Province.[2] Remains indicate that the estimated overall hull length was 17.32 m long, divided into nine cabins from stem to stern. According to researchers, the ship was in operation and sunk sometime after 649. In March of 1960, another ancient ship with a residual hull length of 18.4 m was found in Shiqiao of Jiangsu Province. This hull was divided into five cabins by watertight bulkheads.[3] According to the following research, this vessel also dates to the Tang Dynasty.[4]

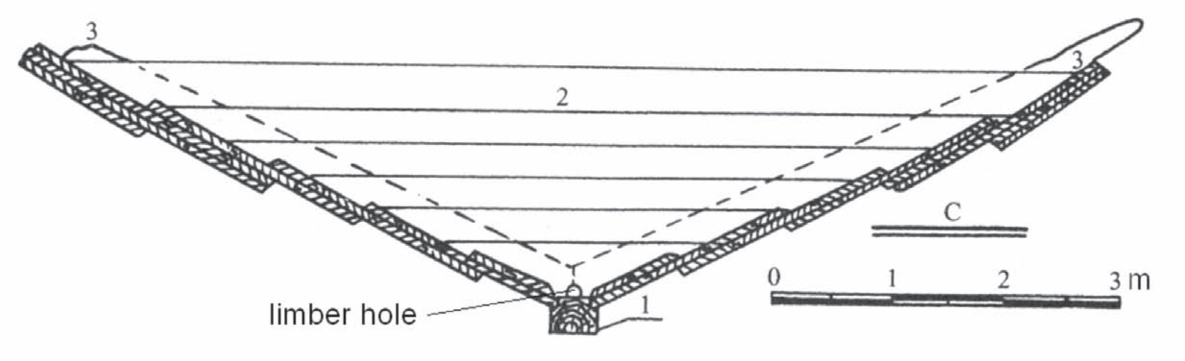


Figure 2.1 The limber hole of the Qunazhou ship in Quanzhou Bay. (Museum of Overseas Communication History 1987)

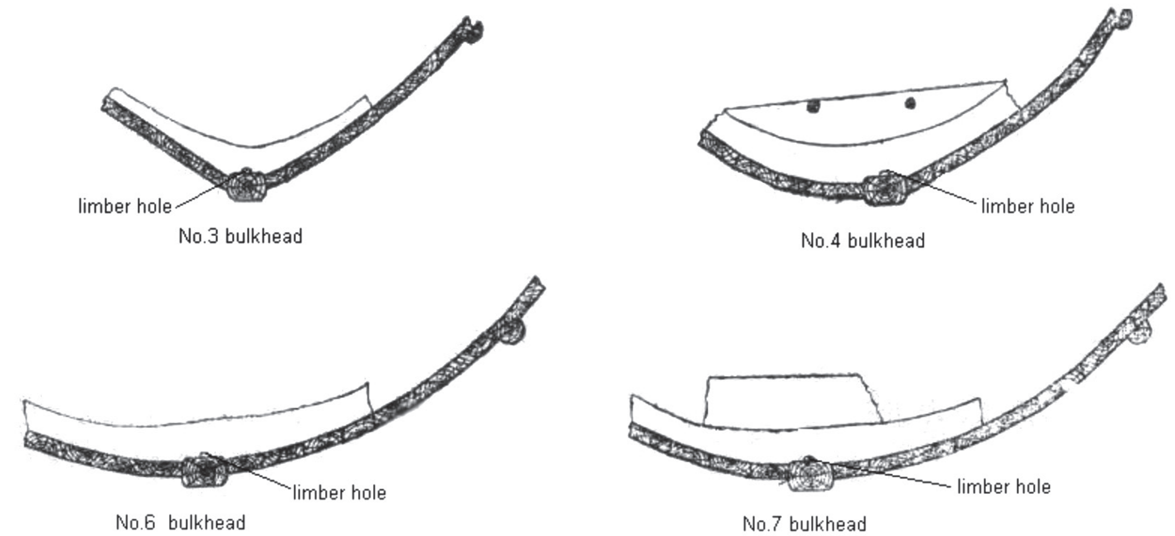


Figure 2.2 The limber hole of the Ningbo ship in Ningbo. (Reproduced from Lin 1981)

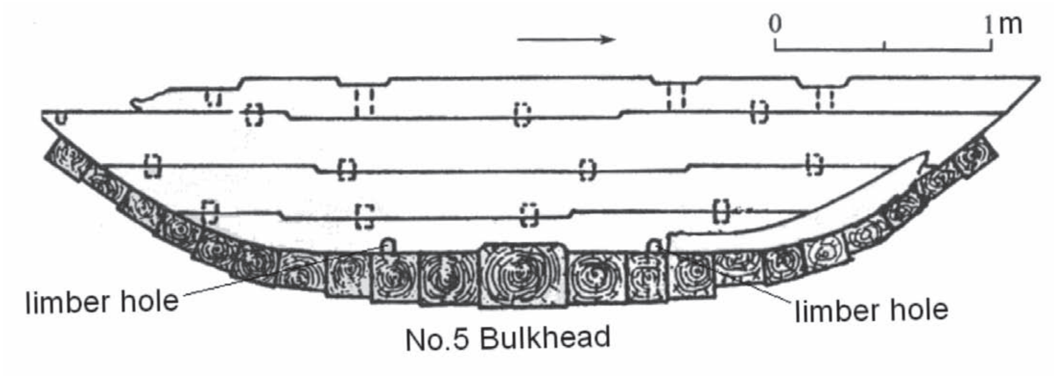


Figure 2.3 The limber holes in No.5 bulkhead of the Penglai ship. (Xi 1989)

Watertight bulkheads with limber holes

The Quanzhou ship in Quanzhou Bay was discovered in 1974. The surviving portion of the hull is divided into 13 cabins by 12 watertight bulkheads. At the bottom of each bulkhead, there are placed openings called limber holes. This is the first archaeological evidence for limber holes in Chinese shipbuilding (See Figure 2.1). [5]

In August of 1978 to April of 1979, during the construction of Ningbo Transportation and Post Office Building, a terminal site and an ancient sailing boat of Northern Song Dynasty, known as the Ningbo ship were located and excavated. The bulkheads of this ship also exhibit limber holes (See Figure 2.2).[6]

Figure 2.4 The limber holes of the Penglai ship. (Produced by authors)

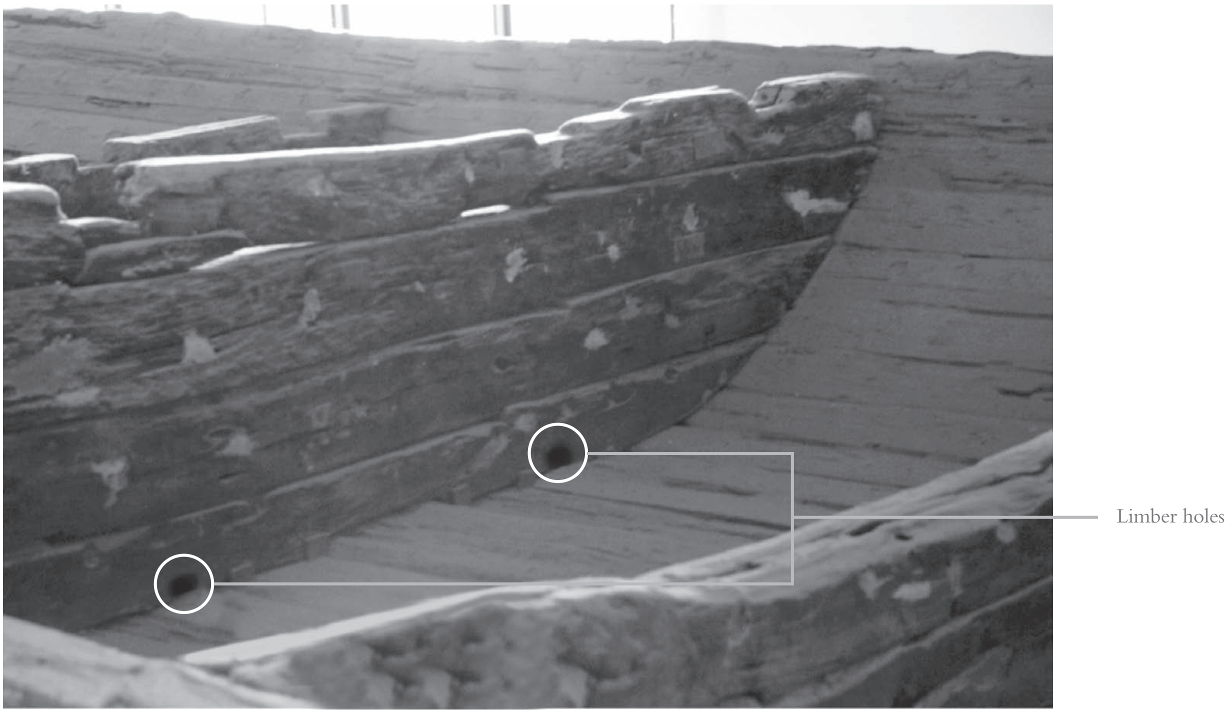


Figure 2.5 The limber holes of the Penglai ship. (Produced by authors)

In June 1984, another ancient ship was unearthed in the southwest of small sea of Penglai waterside city during dredging operations. In August of 2006, during the International Symposium on Penglai Ancient Ship organized by Wuhan University of Technology, Marine History Researchers' Association of CSNAME, and the Penglai Cultural Bureau, overseas scholars discussed the construction of ancient ships without limber holes and deduced that the Penglai ship was a Korean vessel. This was a result of structural analysis, shipbuilding methodology and material culture analyses. The estimated age of the ship is the end of Yuan Dynasty/beginning of the Ming Dynasty. The hull is divided into 14 cabins by 13 watertight bulkheads, and the No.5 bulkhead is relatively complete (Figures 2.3 through 2.5).[7] The difference between the Penglai ship and the previous two ships is that there are two holes on each bulkhead, respectively, located on the left and right side. The main keel of the ship is protruding inward; therefore the median plane is not the lowest point.

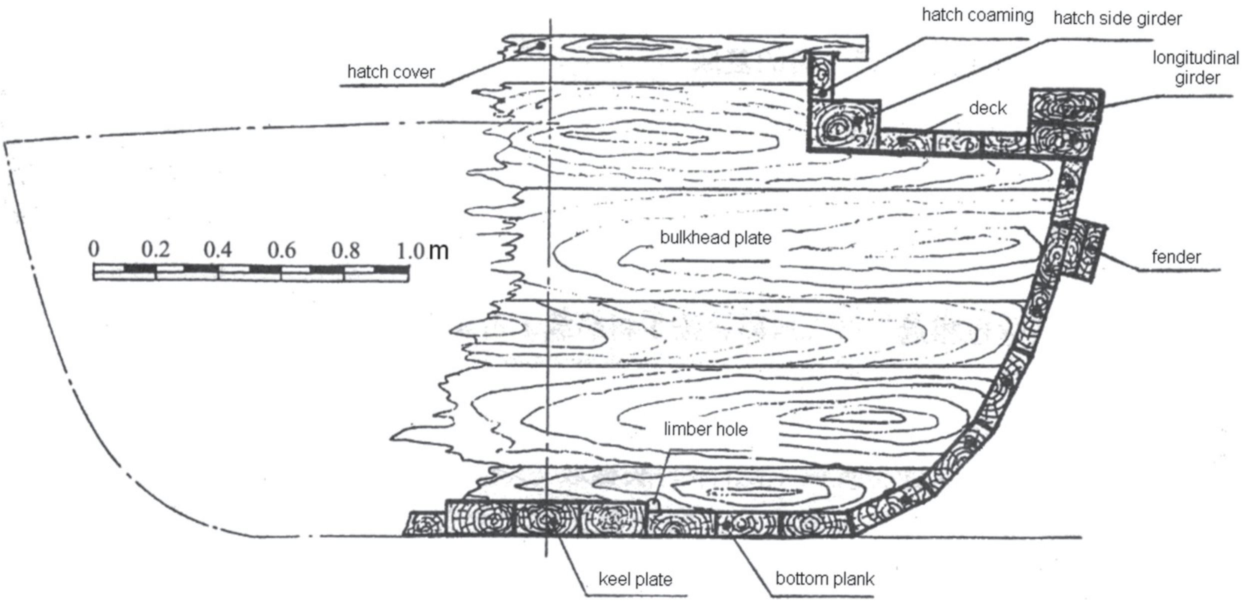


Figure 2.6 The No.8 watertight bulkhead of the Liangshan ship and the limber hole. (Xi, Yang, *et al*. 2004)

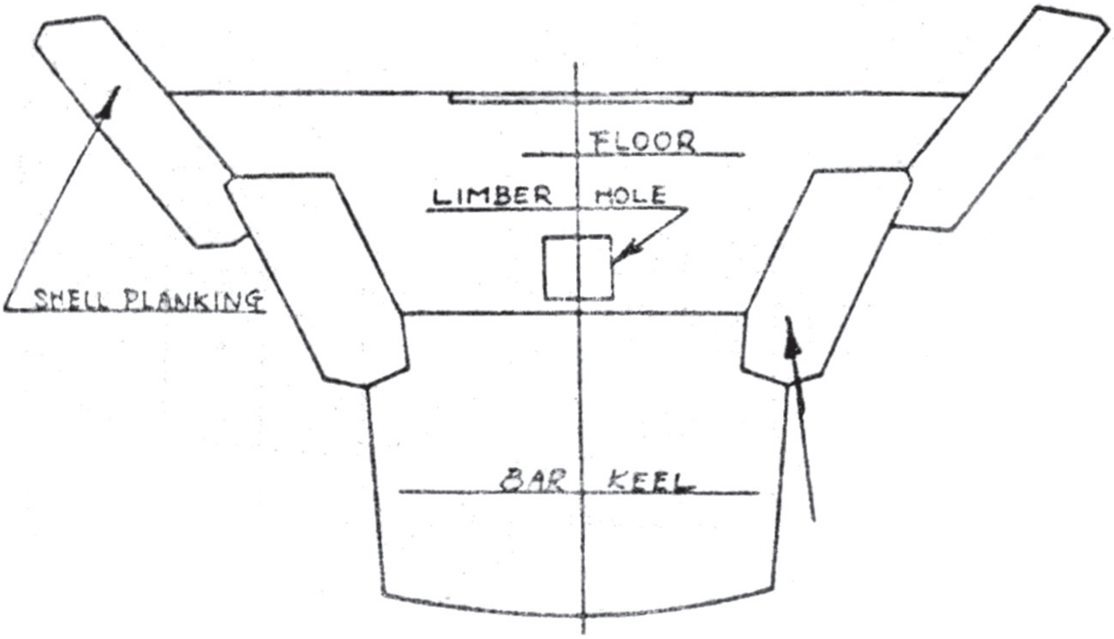


Figure 2.7 The square hole on the bulkhead of the Shinan shipwreck. (Lee 1991)

All of the above-mentioned oceangoing ships have limber holes, but it is necessary to examine riverine vessels to see if they exhibit the same construction attributes. The Liangshan ship (which is dated to the late Yuan Dynasty/early Ming Dynasty) of Shandong province was excavated in 1956. This vessel has three intrusive keel plates, and next to the keel plate are limber holes on both sides.[8] See Figure 2.6.

Some South Korea Scholars' bewilderment as to the limber holes on watertight bulkheads

Excavations at the Shinan shipwreck lasted from 1976 to 1984. This vessel is considered a Chinese seagoing cargo ship of the Yuan Dynasty. The hull is divided into right cabins by seven watertight bulkheads. As shown in Figure 2.7, in the top of the keel, there is a square hole at the lowest point of the bulkhead.[9]

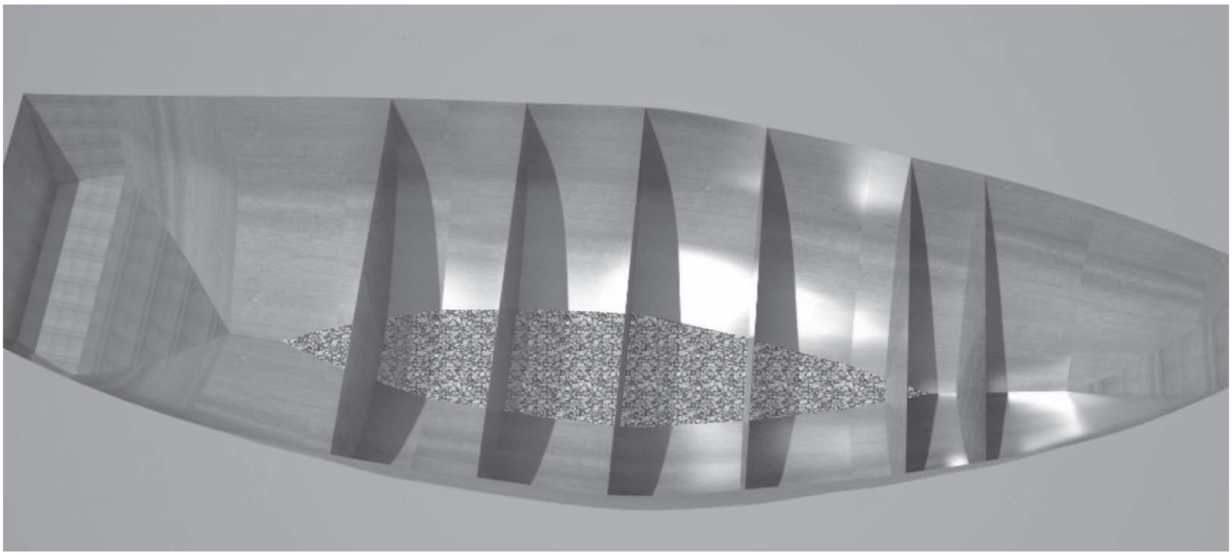


Figure 2.8 The illustration of a 3D-model of a ship floating on even keel. (Produced by authors)

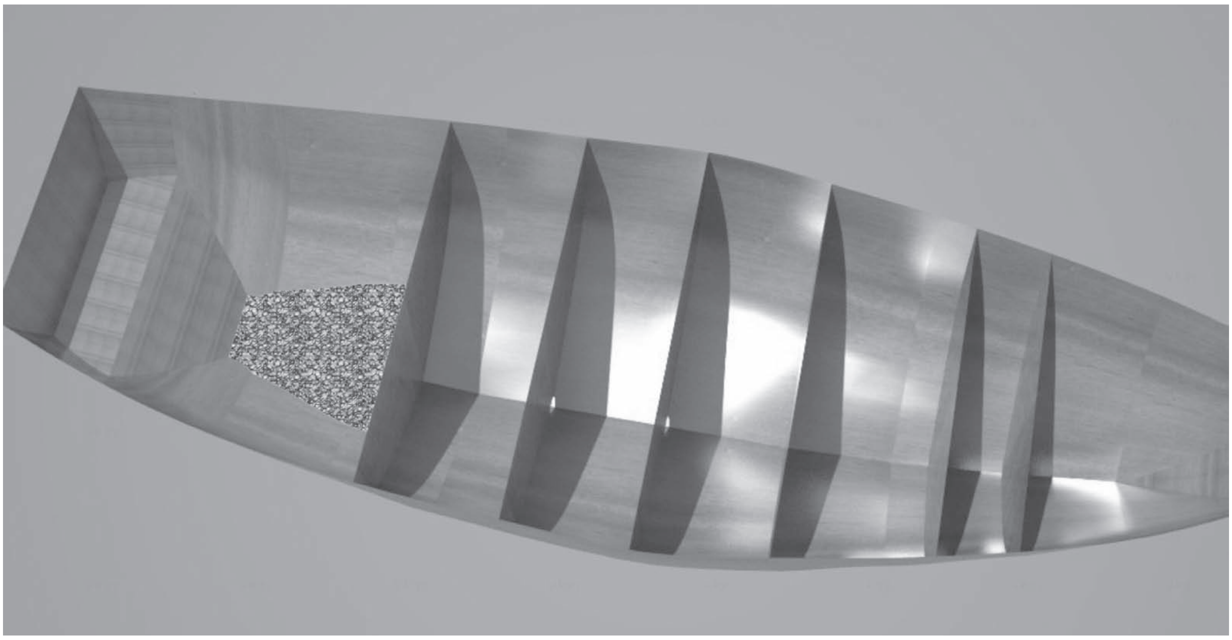


Figure 2.9 The illustration of a 3D-model of a ship trimming by stern, water concentrated on the stern cabin through limber holes. (Produced by authors)

Bulkheads are not present in traditional Korean ship construction, as beams are used to ensure the ship's transverse strength. Therefore, some South Korean researchers were bewildered to the purpose of the square holes located at the lowest point of the bulkhead. Lee Chang Euk, a South Korean scholar, postulated, "this transverse bulkhead is not entirely watertight, and this is a strong challenge to the Needham's theory on that the Chinese ancient ships usually have a number of watertight bulkheads".[10]

The role of the limber hole

As long as limber holes are sealed with cork, the bulkhead is completely watertight. Although corks or other organic plugs have not being found in excavated sites, Chinese junks used in the 1970s in China utilised plugs and corks to block the limber holes. So it may be inferred that this was the case in ancient times. Limber holes were located at the lowest point at the bulkhead, and were used to conveniently extrude water while washing cabins. Without limber holes, the ponded water in each cabin would need to be removed as a separate process, which could be time-consuming. After of the introduction of limber holes, all gray water flowed to a tank at the stern automatically while keeping slight trim by the stern (See Figures 8 and 9). In this way, the work of washing cabins would be much more convenient. Mr Wei Wenxi, a well-known model ship builder and captain of a Chinese junk in the 1970s, explained that they used small pumps to extrude the collected water in stern tanks through limber holes, although most of the work was conducted by manpower.[11]

Conclusion

First invented in 410, limber holes have been located on the Quanzhou ship, the Ningbo ship, the Penglai ship, the Liangshan ship, and the Shinan shipwreck. Archaeological, archival and ethnographic evidence presented herein present the researchers analysis regarding the role of the limber hole to exclude water while washing cabins. This would have greatly decreased the need to manually extrude water from the cabins. Limber holes may have been sealed with cork or some other organic material at other times.

Notes

1 Xi, L., Yang, X. and Tang, X. (eds.). (2004). *Zhongguo Kexue Jishushi: Jiaotong Juan (The History of Science and Technology in China: Transportation*中国科学技术史:交通卷). Beijing, Science Press: 58.

2 Nanjing Museum (1974). 'The wood ship of Tang Dynasty of China in Rugao', *Historical Relic*. 5: 88.

3 Heritage Task Force of Jiangsu Province. (1961). 'An ancient wood ship found in Shiqiao of Yangzhou', *Historical Relic*. 6: 54.

4 Zhu, J. (1986). *A Famous Port of Maritime Silk Road: Yangzhou*. Beijing: 50.

5 Museum of Overseas Communication History. (1987). *Quanzhouwan Song Dai Haichuan Fajue yu Yanjiu (Excavation and Research of the Song Dynasty Ship Found on the Quanzhou Bay* 泉州湾宋代海船発掘与研究). Beijing, Ocean Press: 17.

6 Lin, S. (1981). 'The excavation report of the Dongmenkou Terminal Site of Ningbo', *The Journal of Cultural Relics and Archeology of Zhejiang Province*. Beijing, Cultural Relics Publishing House: 111.

7 Xi, L., (ed.). (1989). Penglai Gunchuan Yu Dengzhou Gugang (Ancient Penglai ship and Ancient Dengzhou port 蓬莱古船与登州古港). Dalian, Dalian Haiyun Xueyuan Chuban she: 30.

8 Xi, Yang, *et al*. 2004: 193.

9 Lee, C. E. (1991). 'A study on the structural and fluid characteristics of a rabbeted clinker type ship (The sunken ship salvaged Off Shinan)', in Shanghai Society of Naval Architecture & Marine Engineering, Marine History Researchers' Association of CSNAME (eds.), *Proceedings of International Sailing Ships History Conference Shanghai*, Shanghai: 165.

10 Lee 1991: 119.

11 Personal communication, Mr Wei Wenxi, 2009.

3

Two Ming Dynasty shipyards in Nanjing and their infrastructure

Sally K. Church

Abstract

This paper draws a clear distinction between two shipyards in the northwestern corner of Nanjing: the Treasure Shipyard and the Longjiang Shipyard. The former was the site where the Treasure Ships used on Zheng He's maritime expeditions (1405–1433) were built. The latter was founded at the beginning of the Hongwu period (1368–1398) in the Ming dynasty (1368–1644) to provide ships of a military nature to protect the capital (Nanjing, until 1421) and also to defend some of China's waters and shores against pirates. These two shipyards were in slightly different locations, and had different purposes and different historical trajectories. Our knowledge about them also comes from two different types of sources, one archaeological and the other textual. The two types of evidence complement each other well, and here they are used to survey what is known about the two shipyards and to bring them together into a more comprehensive picture of early Ming shipyards than has been attempted in the past.

要旨

本論文は南京の北西端に位置する二つの造船所（寶船廠・龍江寶船廠）を明らかに異なるものとする。前者は鄭和西洋下り（1405－1433）に使用された寶船を建造した造船所であった。後者は明朝洪武帝在位年間（1368－1644）の初めに、首都（1421年まで南京）防衛のための、また中国海域・沿岸域の海賊を取り締まるための軍船を供給するために建てられた造船所であった。これら二つの造船所は僅かに異って位置し、目的や歴史的歩みにおいて異なっていた。これらについては考古学的な資料と文献資料の両者により知識を得ることができる。これら資料は互いに十分に補完し合うものであり、ここでは二つの造船所についての知見を調査するために、これまでより明初の造船所について包括的な理解にむけての整理のために使用される。

Introduction

From 1405 to 1433, the eunuch admiral Zheng He (鄭和) commanded a series of maritime expeditions to India, Africa and the Arabian Peninsula. Approximately 120 years later, in the 1540s–1550s, China's coasts were being attacked by pirates. Each of these events gave rise to a sudden wave of shipbuilding by the Chinese government. The first led to the creation of the Treasure Shipyard in the early 15th century, and the second to the revitalisation of the Longjiang Shipyard in the mid 16th century. Both of these shipyards were in Nanjing (南京), which lies on the bend of the Yangzi River about 259 km (161 miles) west of present-day Shanghai.

At the time of Zheng He, Nanjing was the capital of the Chinese empire. This status, combined with its strategic location on the Yangzi, made it a logical place from which to launch the maritime expeditions. By the 16th century, the capital had been transferred to Beijing (北京), but the need for ships was still great along China's southeast coast, and Nanjing was one of the shipbuilding centres in the region that was revitalised during this period.

A visitor to Nanjing today, who wishes to see the site where Zheng He's *Treasure Ships* were built, will be taken to an area in the northwestern corner of the city called *Zhongbao cun* (Zhongbao village 中保村) on the eastern shore of the Yangzi before it bends eastward toward Shanghai and the sea. The visitor will notice that the official name of the site is marked as Longjiang Treasure Shipyard (*Longjiang baochuan chang* 龍江寶船廠) on a stone plaque at the entrance to the shipyard. Unfortunately, this is a misnomer, which conflates two separate establishments, the Treasure Shipyard and the Longjiang Shipyard, thus blurring the historical distinction between them. The two shipyards were in different locations, had different purposes, and different historical trajectories, and they produced different types of ship.

Moreover, our evidence about them is of two different types. For the Treasure Shipyard, most of the evidence is archaeological in nature, thanks to the recent excavations of the site and the publication of a detailed archaeological report by the Nanjing Municipal Museum (*Nanjing shi bowu guan* 南京市博物館), entitled *Ming Dynasty Baochuanchang Shipyard in Nanjing*.[1] For the Longjiang Shipyard, on the other hand, our evidence is largely textual, in the form of the *Longjiang Shipyard Treatise* of 1553. There is little archaeological evidence for the Longjiang Shipyard, and there is not likely to be in the future because so much urban development has taken place.

This study combines the archaeological evidence from the Treasure Shipyard and the textual evidence from the Longjiang Shipyard into a single investigation of the infrastructure of shipyards in the Ming period (1368–1644). It first introduces the two shipyards, highlighting their different locations, purposes, and histories, and clarifying the relationship between them. Then each is examined separately in the light of its sources. It is hoped that bringing them together into a single discussion can help to create a fuller picture of shipyard infrastructure in the Ming Dynasty than has been possible before.

I. The Two Shipyards

It is well known that the Longjiang and Treasure shipyards were both situated in northwestern Nanjing near the Yangzi River. As indicated above, however, not everyone is aware that these were two separate shipyards. Moreover the precise location of the Longjiang Shipyard is difficult to pinpoint. By contrast, the Treasure Shipyard is easily locatable because of its striking physical remains, which are still visible today. They lie at 32.0634 N and 118.7287 E,

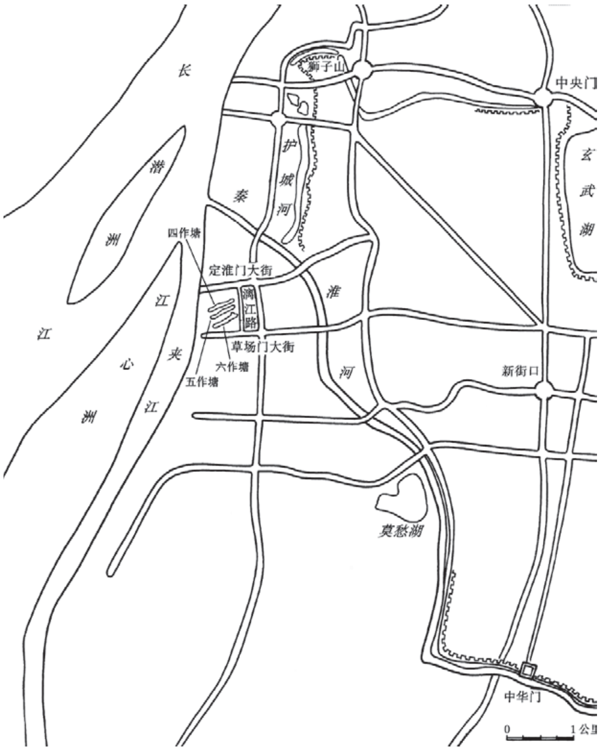


Figure 3.1 Modern map. (Courtesy of Nanjing Municipal Museum)

between Dinghuaimen boulevard (*Dinghuaimen dajie* 定淮門大街) to the north and Caochangmen boulevard (*Caochangmen dajie* 草場門大街) to the south (See Figure 3.1). To the west is the Yangzi River, and to the east is South Sanchahe street (*Sancha he nan jie* 三叉河南街), whose name changes to Lijiang road (*Lijiang lu* 灕江路) where it runs south of Dinghuaimen boulevard.[2]

We know from a map made in 1944[3] that the Treasure Shipyard previously extended northward all the way to the Qinhuai River (See Figure 3.2). It is estimated to have been 2.1 km from north to south. There has been an enormous amount of construction in Nanjing, particularly since the 1970s, and the land has become the site of many high-rise residential buildings. The top half of the shipyard has now been turned into apartment complexes, and the remains of shipyard site today extend only 225 m from north to south and 605 m from east to west.[4] The archaeological report estimates from the 1944 map that it once contained at least 13 basins. Hans Lothar Scheuring, author of a PhD dissertation on the Longjiang Shipyard, says that when he visited the Treasure Shipyard in the 1980s six basins were extant and a seventh had recently been filled in for the construction of residential buildings.[5]

The remains of the Treasure Shipyard that are now extant consist of three elongated basins, parallel to each other and stretching from northeast to southwest. Their southwestern ends are approximately 350 m from the river. In the past they were probably closer to

Figure 3.2 1944 map. (Courtesy of Nanjing Municipal Museum)

the river, as the bank area has been substantially filled in and fortified against flooding during modern times.[6] At the time, there would have been gates joining the western end of the basins to the river via a channel, called *Jia jiang* (夾江), which skirts present-day Jiangxin island (*Jiangxin zhou* 江心洲, literally, "island at the heart of the Yangzi") and leads to the main part of the Yangzi. These gates would have allowed the completed ships to pass out of the dockyard into the Yangzi River on their journey toward Shanghai and the sea. The gates no longer exist and the exit from the basins to the river is blocked by dikes along the riverbank to guard against flooding. A modern road (*Jiangdong men beilu* 江東門北路) also runs in a north-south direction between the basins and the river.

The three remaining basins, which have conventionally been numbered basins 4, 5, and 6, are all approximately the same size. The basin to be examined here is No.6, the one that is furthest south. It was excavated intensely from 2003 to 2004, when it was entirely drained of water. All the finds were collected and analysed at that time. Although there are a few pieces of textual evidence concerning the Treasure Shipyard,[7] the archaeological finds from this excavation constitute by far the largest quantity of evidence about it. These have been published in the archaeological report mentioned above.

By contrast, the site of the Longjiang Shipyard cannot easily be located today. Instead of archaeological evidence, we have only textual evidence, in the form of the *Longjiang Shipyard Treatise* (*Longjiang chuanchang zhi* 龍江船廠志), written in 1553 by the shipyard's director, Li Zhaoxiang (李昭祥, fl. 1537–1553). This work contains a vast amount of information about the Longjiang Shipyard and its infrastructure. Based on the two site plans given in Chapter 4 of the *Treatise*, as well as the verbal descriptions it contains, one can see that it was bordered on the east by the city moat and city wall, and west by the Yangzi. It is south of Lulong outlook (*Lulong guan* 盧龍觀), or Lulong mountain (*Lulong shan* 盧龍山), and Yifeng gate (儀鳳門), and north of the Qinhuai river where it flows into the Yangzi.[8]

The two sites not only had different locations, but also different purposes and historical trajectories. The Longjiang Shipyard was founded at the beginning of the Ming period for the purpose of building relatively small ships for inland transport and military defence. It was in operation from approximately 1368 to well into the 16th century and beyond. The Treasure Shipyard, on the other hand, was built specifically for the construction of the "Treasure Ships" for Zheng He's maritime expeditions, and functioned only between 1403 and 1433.

The historical context for the founding of the Longjiang Shipyard is crucial to understanding its importance. The Ming founder Zhu Yuanzhang (朱元璋) (Emperor Hongwu 洪武, r. 1368–1398) had just wrested power from the Mongols, who had ruled China for the previous century during the dynasty they proclaimed as the Yuan (元), 1279–1368. His effort to restore the empire to Chinese rule had involved a struggle for supremacy among Chinese rivals, and some of these battles had taken place on water. The Emperor thus recognised the need for naval strength both to acquire power and to hold onto it. During the first few years of the dynasty, the area around Nanjing and the Yangzi River was relatively secure, but the situation of the empire as a whole was not stable. Large parts of the country were still in Mongol hands. The memory of foreign conquest was fresh, and the desire to insure against its recurrence was strong. In addition to establishing military guards (*weisuo* 衛所) in strategic locations throughout the empire, Hongwu also attempted to build up the Ming's naval forces and it was to this end that the Longjiang Shipyard was founded, to provide ships for military use, and to guard the waterways around the capital. A further motivation for shipbuilding at the time was to secure China's shores against pirates, because the southeast coast had become a target for pirate raids during the latter part of the Yuan period.[9] As a result of this policy to build up naval defences, four hundred families from China's southeast coast were moved to the Longjiang Shipyard to begin work, and ships were turned out in large quantities.[10]

It was not until over 30 years later that orders were issued by the third emperor, Zhu Di (朱棣) (Emperor Yongle 永樂, r. 1403–1424), for a different type of ship to be built. This was the huge ocean-going ship to be constructed in large numbers to sail overseas on the maritime expeditions of Zheng He. The *Ming shi* (明史) says that 62 of these ships were built for the first voyage, and other numbers are given elsewhere.[11] It is thought that most of the Treasure Ships used on Zheng He's maritime expeditions were built in the Treasure Shipyard, although some may have been built in Fujian province at Changle (長樂).

After 1433, when no further expeditions were sent out, ships were no longer produced at the Treasure Shipyard and it was allowed to go to ruin. The Longjiang Shipyard, on the other hand, continued to produce ships well into the 16th century. Although it went through periods of decline and revitalisation, a major effort was made in the mid 1550s to bring the Longjiang Shipyard back into efficient and productive operation. The appointment of Li Zhaoxiang as its director was a step in this direction. In fact, one reason why he wrote this *Treatise* was to record the situation as he found it in order to identify the problems and eventually eliminate them. The composition of this *Treatise* was thus the first step in the overhaul of the shipyard's operations.

II. The Treasure Shipyard and the Archaeological Evidence

As noted above, the Treasure Shipyard was founded in 1403 to build the ships that would be used on Zheng He's maritime expeditions. Because these ships were said to be going overseas to "collect treasures" (*qu bao* 取寶), the ships were called "Treasure Ships" (*baochuan* 寶船), and the shipyard was called Treasure Shipyard (*baochuan chang* 寶船廠, literally, "the yard for constructing Treasure Ships"). Other types and sizes of ship were probably also built at the yard as well, for use on the expeditions. These ships sailed along the Yangzi River eastward to *Taicang* (太倉), a large, deep-water port near present-day Shanghai, where the fleet for the expeditions assembled before sailing out to sea.

The Excavation

Between August 2003 and September 2004, the Nanjing Municipal Museum carried out a thorough excavation of Basin 6. The basin is 421 m (1,381 ft) long and 41 m (134 ft) wide. Before the excavation, it was full of water and mud to a depth of 3.5 m (11.5 ft). During the excavation, it had to be completely drained of water and flushed out gently with clean water to remove most of the mud. Thirty-four built-in structures were discovered along the centre-line of the basin's floor; these had to be excavated and the finds analysed. The loose items found in the basin, totalling roughly 1500, were cleaned, catalogued, labelled and properly stored. Because the site had to be prepared for its Grand Opening in July 2005, which was one event in the celebrations for the 600th anniversary of Zheng He's expeditions, the Nanjing Municipal Museum was under considerable pressure to make the site presentable to the public quickly, as well as to build a museum on site for displaying the finds. All these tasks were accomplished within the year. The photo of Basin 6, taken from the archaeological report of the excavation that was published in 2006,[12] looks westward toward the Yangzi River, which is just visible in the background. It shows the basin completely drained of water, while basins 4 and 5, visible on the right (north) side of the photo, are still full (See Figure 3.3).

Structures on the Basin's Floor

The 34 discrete structures embedded in the floor of the basin are rectangular or oval in shape, and lie perpendicular to the basin's longitudinal axis. The structures are irregularly spaced along the length of the basin, and are all between 10 and 14 m (33–46 ft). They consist of a series of upright wooden posts driven into the bottom of the basin, with lengths of wood

Figure 3.3 Basin 6 after excavation. (Courtesy of Nanjing Municipal Museum)

lying on top of them. These lengths of wood are either arranged neatly as if part of the structure or scattered haphazardly nearby (See Figure 3.4).

The authors of the report seem to suggest that these structures were frames on which the ships rested while under construction. However, there is no proof that they were used in this way, and it would go counter to the way in which ships are usually built: first on dry land and then lowered into the water. Another theory is that the basins may have been pumped dry during the construction period and then flooded to allow the ships to exit the shipyard. This theory also has its difficulties, not least because pumping the basin dry was sufficiently difficult during the excavation, with modern equipment. One wonders whether it was even possible during the 15th century. Moreover, all the ships would have had to have been finished and ready to exit the shipyard at once, which would have required a massive amount of coordination.

This being said, the authors of the archaeological report seem to assume that these structures were indeed frames on which the ships were built. If so, it becomes a question of how the ships would have been arranged in the basin, whether each of the 34 frames supported a single ship, or whether they were clustered together in larger units. If each of the frames were for a single ship, the ships would have been quite small. Although the total length of the basin is 421 m, the portion containing structures is only about 300 m long. If the structures had been evenly distributed among the 34 frames, which they were not, the ships could not have been longer than 8.57 m.

This size contrasts sharply with the size of the gigantic treasure ships described in some of the Chinese sources, which were supposedly 44 by 18 *zhang* (丈). These dimensions work out to approximately 137 m (450 ft) long and 56 m (183 ft) wide. If they had been this size, Basin 6 would certainly have been long enough. In fact, three ships of this size could have fit along the 421 m length. However, the basin would not have been wide enough to accommodate even one of these ships. The width of the basin was only 41 m (134.48 ft), while the beam of the ships was supposedly 56 m (183.68 ft). One might attempt

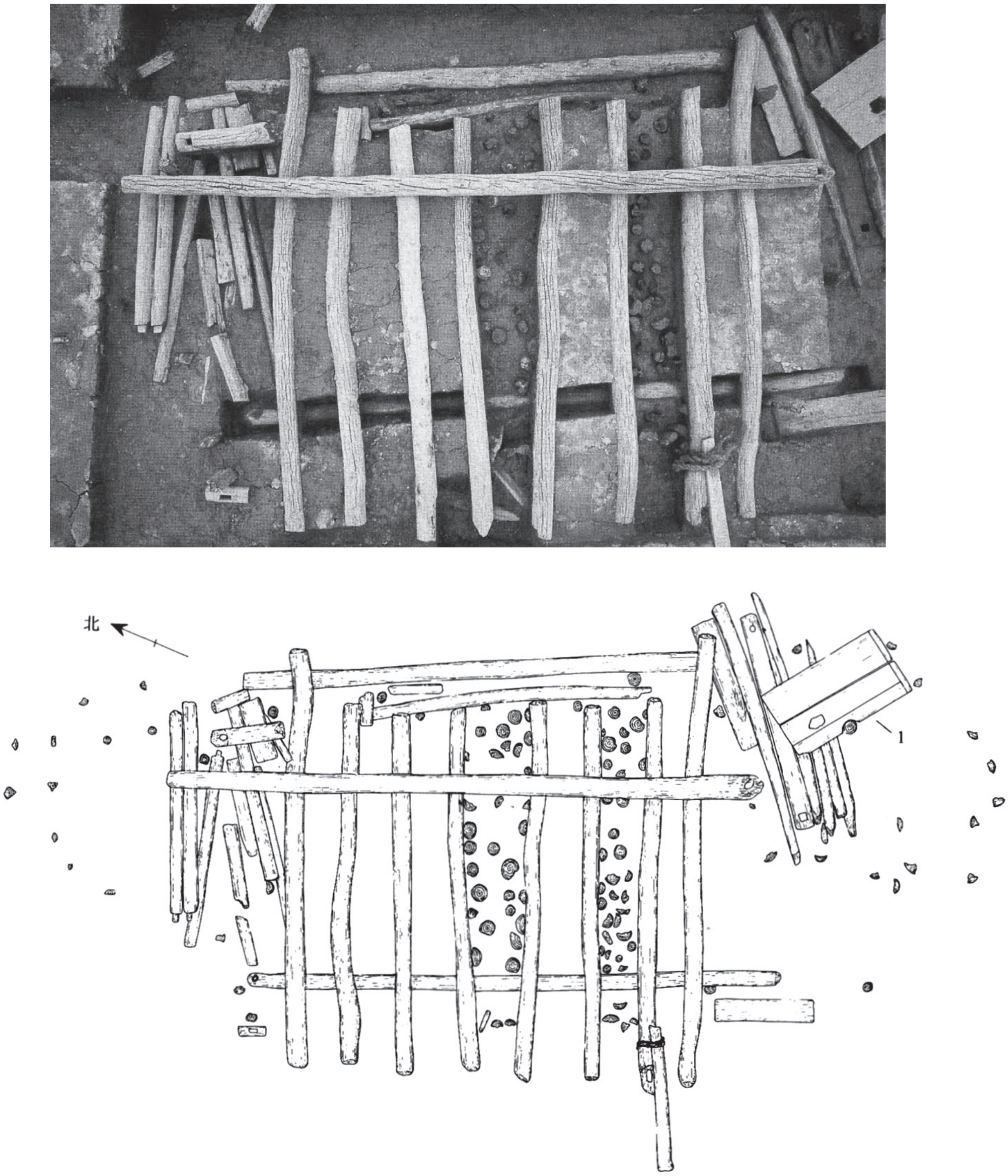


Figure 3.4 Drawing and photo of one of the structures. (Courtesy of Nanjing Municipal Museum)

to argue that the ships could have been wider than the frames supporting them, or than the basin itself, but one has to remember that the frames themselves within the basin were not 41 m wide. Instead they were 10 m wide. Moreover, it appears that the width of the basin rules out this size of Treasure Ship. An examination of ships under construction in shipyards suggest that the ships are not usually much wider than the frames that support them.[13] The depth of the basin, which is about 4 m (13.12 ft), could also not have accommodated a ship of sufficient depth for this size.

Some of the structures appear to be clustered together in groups, while others have larger gaps between them. It is possible that each of these clusters corresponds to the length of a ship.[14] The westernmost cluster seems to include structures 1–10, which extend for 70 m (225 ft); the next cluster may include structures 11–17, which cover about 50 m (165 ft); the third

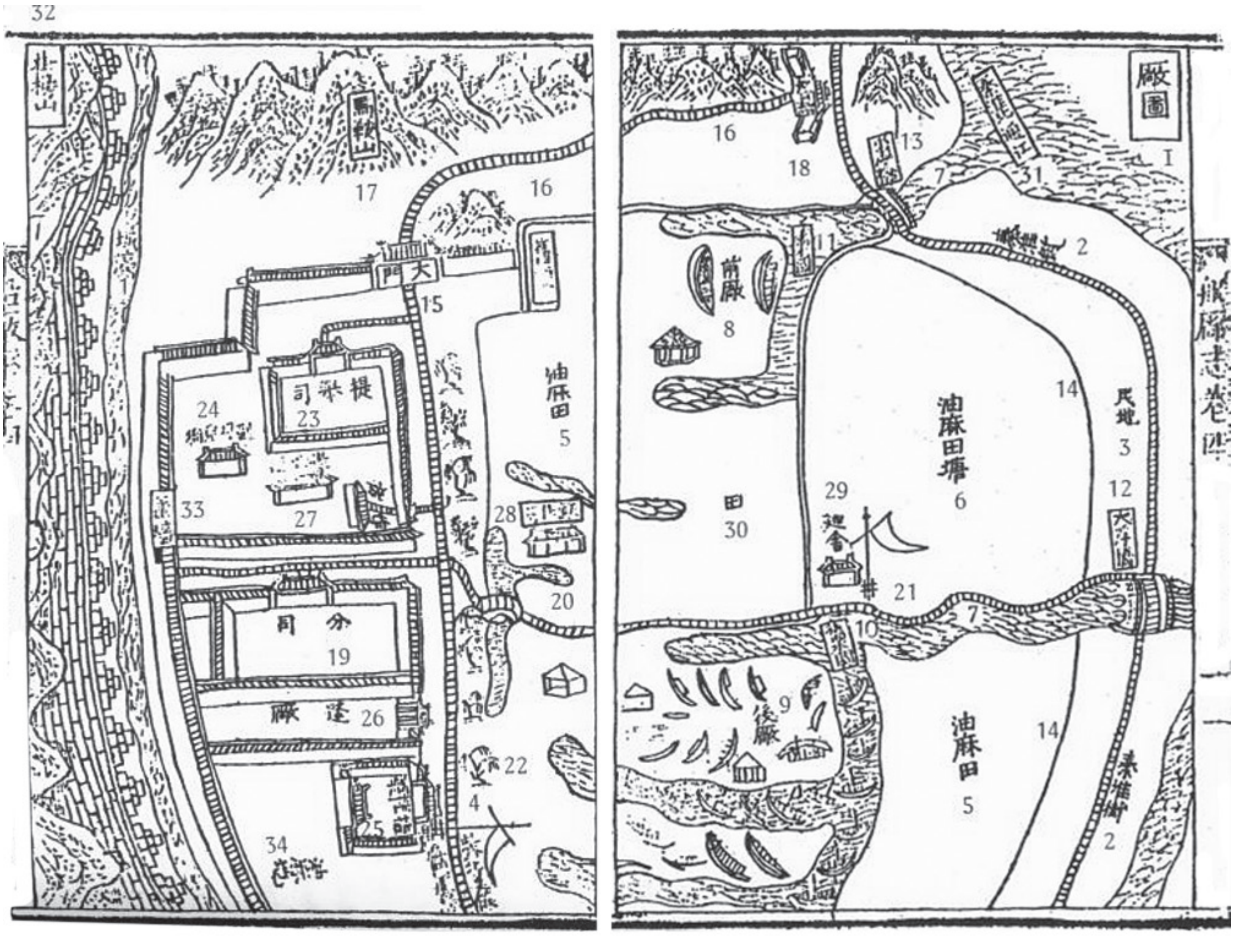


Figure 3.5 Site Map of Longjiang Shipyard. (Courtesy of Nanjing Municipal Museum)

cluster may include structures 18–24 or 18–25), which would measure 50 m (165 ft); and the final cluster may extend from structures 25 to 34 and cover 50 m (165 ft). Allowing for an overhang of the bow and stern, as well as some space between the ships, the basin might then have been divided into 3 or 4 separate sections each 50–68 m (165–225 ft) long. This way of looking at the site would tally with the view that the largest ships were probably less than 75 m (250 ft) long. They may of course have been even smaller. The site map in the *Longjiang Shipyard Treatise* shows ships lying neither lengthwise nor completely crosswise the waterway, but at an angle. The site map, however, is not a technical drawing, and although it is suggestive of what might have been going on in the Treasure Shipyard, one cannot be certain (See Figure 3.5).

The western end of the basin, nearest the river, has a higher concentration of finds and more complete structures than the eastern end, suggesting that more ships were built in the western end than the eastern end. The western end may have been the preferred end for shipbuilding because it was nearest the exit to the Yangzi River. It is probable that during the height of productivity the entire basin was used, whereas during more lax times ships were built or repaired primarily at the western end.

The Artefacts

As mentioned above, approximately 1,500 artefacts were discovered in Basin 6. These include only the loose items. In addition to these, a total of 1,615 pieces were embedded in the bottom of the basin. Of the loose artefacts, 1,000 were made of wood, 600 of iron, and 355 of pottery. These items seem to derive primarily from the infrastructure of the yard rather than from the ships themselves, although there were some ship parts among the finds. The discussion of the finds below follows roughly the same order as they are presented in the archaeological report, which groups them according to the material of which they are made, rather than the purpose of the objects. This is because the site was full of water when the excavation began, and had to be drained and hosed down to remove the mud. Thus many of the finds were disturbed or swept away with the water, and could not be restored to their original position. For this reason, and because no complete ships were found, it was sometimes difficult for the archaeologists to determine the function of the pieces. Therefore, the authors of the report did not try to group them by function. Instead, the authors first classified the objects according to the material they were made of, and then into type, shape, and size. Only in cases where their use was clear were items of similar use grouped together.

Wood

In its discussion of the over 1,000 loose wooden objects found in the basin, the archaeological report divides them into three main categories. The first is tools and implements. These include hammers, T-shaped supports, wooden knives, earth pounders, wooden rulers, wooden paddles, and the like. The second consists of remains from what the report calls "shipbuilding infrastructure" (*zaochuan sheshi goujian* 造船設施構件), which is explained as: "items that are related to the engineering aspect of the shipyard" (*he zaochuan gongcheng youguan* 和造船工程有關).[15] This is a narrower sense of the term "infrastructure" than is being used in this paper; in some senses all the items found at the shipyard can be seen as belonging to the infrastructure, except for the ship parts themselves. The report includes such items as wooden posts and piles (posts driven vertically into the ground), logs, a single water-wheel base (*shuiche longgu* 水車龍骨), and the like, in this category. The third category consists of ship parts, including rudderposts, parts of masts, railings, door frames, carved decorations, and so forth.

In the category called "implements" (*yongju* 用具), the first class of items to be discussed is the T-shaped supports, of which 12 were found.[16] These were hardly the largest or most numerous finds, but they appear to be important because they had an unusual and unexpected shape. They are grouped with tools, probably because their T-shaped tops resemble some of the hammers, but they are much longer than hammers and they may have been supports on which the ships rested while being worked. The T-shaped tops may have protected the hulls of the ships from being punctured by the sharp ends of supporting posts. The other wooden implements found in the basin were: 16 hammers, 67 hammerheads and support-post heads, one earth pounder, one wooden pestle, nine knives, two wooden rulers, three paddles, two flat pieces of wood whose use is unknown, one footboard, two work-benches, 18 oars, and 85 handles for pottery and other vessels.[17]

Of particular interest are the two wooden foot-rulers, both 313 mm long, discovered in the basin.[18] Although it is not absolutely certain when these rulers fell into the basin, if they date from the time of Zheng He, they may represent the size of the foot used for building the Treasure Ships. These rulers therefore constitute the most solid evidence we have so far concerning the size of the shipbuilding foot in Zheng He's day.[19]

Figure 3.6 Water Wheel Base. (Courtesy of Nanjing Municipal Museum)

Under the category of "Shipbuilding Infrastructure", the first type of wooden find to be discussed is wooden posts or piles. Those that were integral parts of the 34 structures embedded along the bottom of the basin were left in place during the excavation and were not analysed individually in the report. The posts examined in the report, which were removed from their original context, were the most numerous objects in the entire excavation, totalling 645 pieces. Of these, 96 are hardly worked at all by human hands. The largest number of posts, totalling 382, are rounded and pointed at the bottom. Finally, 167 were originally ship parts and only later reused as posts. Some have nail holes and traces of paint.[20]

The second type of find in this category is the whole, round, virgin log (*yuanmu* 原木), i.e. a log that has not been cut or split longitudinally. The logs of this type are almost in their original state, only minimally adapted for use by having their bark stripped off and branches removed. Their trunks are left in tact, and they are crude and unfinished. Marks of knives and axes are visible on some of them. Sixty-six of these types were found in the shipyard. According to the authors of the archaeological report, these are major components and tended to be used in relatively complex structures.[21] Some have mortise or tenon elements on them, and some are inscribed with writing. Their use is unknown. They may have formed the long sections of the T-shaped supports, or they may have functioned as piles or parts of ships. The authors include the water-wheel base (See Figure 3.6) in this category.[22]

Several different types of information are inscribed in writing on wooden and other objects. Sometimes it is a person's name, as is the case of one of the rulers and some of the pottery. At other times the inscribed text consists solely of numbers. Wood was a valuable commodity that was difficult and costly to obtain. These could therefore have been inventory numbers, symptomatic of the careful control that was kept over wood supplies to prevent them from being wasted or pilfered. Some of these inscriptions include the size of the piece of wood, for example "three feet" (*san chi* 三尺).[23] In other cases the characters indicate where on the ship the object was to be fitted.[24] One wooden object is inscribed with

Figure 3.7 Windlass. (Courtesy of Nanjing Municipal Museum)

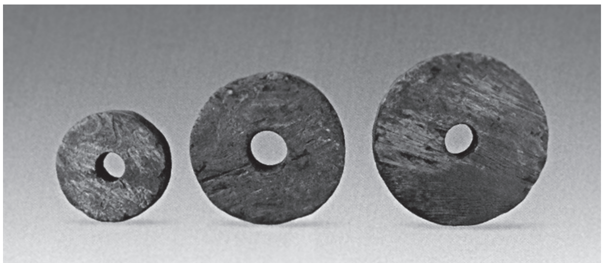


Figure 3.8 Wooden disks. (Courtesy of Nanjing Municipal Museum)

the word *guan* (official 官), indicating that it was "for official use only".[25] It should be remembered that because the workers lived on or near the site, it would have been important to distinguish materials that were for official use from those that could be used privately. According to the *Longjiang Shipyard Treatise*, pilfering of supplies by the workers was an administrative problem in the shipyard.

The third category consists of ship parts. There are 55 items in this category. These are worked with considerable technical skill, and some are quite finely made. They are smooth, finished, and regularly-shaped, often having nail holes, wider holes, or grooves in them. Some have decorative motifs carved on them. In this category the authors have included two rudderposts and one portion of a rudderpost, 56 planks, eight round disks of various sizes with holes in the middle, three windlasses, and one door frame.

The rudderposts are perhaps the most striking of these items because of their size. The two complete rudderposts are both over 10 m (32 ft) long and made of teak. They supplement the one that was found in 1957 in the same shipyard, which measured 11.07 m (36.32 ft) in length. The fact that three complete rudderposts were found here, all of roughly the same size, strongly suggests that this was the type of rudderpost used on the Treasure Ships.

These rudderposts have been used in the debate about the size of the Treasure Ships. Zhou Shide (周世德) published an article in 1962 about the 11.07 m rudderpost, arguing that it proved that the Treasure Ships were 137 m (450 ft) long.[26] However, Zhou's results are highly suspect. He used a formula for calculating the proportion of rudderblade area to ship size, but unfortunately, this formula was one designed for modern steel, propeller-driven ships, not for wooden ships. One cannot expect such a formula to work for modern wooden ships, let alone 15th century Chinese ships. Moreover, none of the rudderblades survive; we have only the three rudderposts. In order to obtain the rudderblade area, Zhou Shide measured the length of one side, which is possible because the distance between the two slots on the rudderpost for the insertion of the rudderblade can be measured, and then estimated the length of the other three sides.

If the rudderblade were rectangular, he would have been correct about the two vertical sides, providing they were parallel, but without the rudderblade itself one cannot know the correct shape or length of the horizontal side. Therefore the area cannot be known, and is of no use in any formula. Moreover, the shape of the rudder illustrated in his article is appropriate for a flat-bottomed *shachuan* (沙船), not for an oceangoing *fuchuan* (福船), which is the type to which most scholars now agree the Treasure Ships belonged.

Although the length of these rudderposts inspires awe, the stern mounted rudder, which is the most likely type to have been used,[27] requires a long rudderpost to extend upward from the water-level through the ship to the deck, where it is operated by means of a tiller. Thus a large proportion of the rudderpost is out of the water. One example of a modern junk with an 11 m long rudderpost, made in the traditional *Lümeimao* (Green Eyebrow 綠眉毛) style, is only 31 m long.[28]

The 56 planks found in the basin are finely made, with nail holes at regular intervals. Some have red, blue, or black paint on them. Inscriptions are written on them to show where on the ship they fit. The archaeological report divides them into two types: single planks, of which there are 44, and planks joined together, of which there are 12. The longest single plank is 5.36 m long, and the longest joined one is 2.63 m long. Many of them contain traces of caulking material covering nail openings and in the seams, where more than one is joined.

One precious wooden find is the windlass pictured here, showing indentations from a rope that was wrapped around it. (See Figure 3.7) It is 594 mm long. The authors of the report speculate that one or more of the wooden disks that were found (See Figure 3.8) may have fitted on the ends of this windlass or one like it.[29] However, it seems doubtful that the pieces at the ends of a windlass would be circular; they would need the stability that such a round disk could not provide to perform their function. The largest of these disks is 581 mm in diameter and the smallest is 164 mm.

The finds at the shipyard show wooden pieces joined in mortise and tenon fashion, or with ends or slots that suggest this type of joinery. We can reasonably assume that this was the method of joinery used at the time of the Treasure Ships, although we cannot say that other methods were not used. As will be shown below, a large number of iron staples were found which may also have helped to join pieces of wood together. The majority of these staples were quite small.

As part of their study, the authors of the archaeological report had 236 of the wooden pieces found in the shipyard analysed to determine their species. The breakdown of these species is shown in the following table. Most were found to be *Cunninghamia lanceolata*, with small numbers of pieces from a few other species.[30]

Species	Pieces Found
Cunninghamia lanceolata	188
Tectona grandis	26
Erythrophleum fordii	13
Castanopsis sp.	4
Pinis sp.	2
Diospyrus sp.	1
Shorea sp.	1
Cotylelobium sp.	1
Total	**236**

Five pieces of wood found at the site have been carbon-dated, and the dates seem to range from 1320 to 1490. The results of this and all the tests done on the materials are presented in Appendix 2 of the report.

Iron

Iron objects were the second most common find at the Treasure Shipyard, after wood. Approximately 600 iron artefacts were found, most of which were tools and implements used in shipbuilding. Some agricultural implements and items for daily use were also found. The most numerous finds were iron staples, of which 292 were unearthed. The archaeological report divides these staples into categories according to size, with the largest 250 mm long. Only two fragments of this type were found. Most of the staples (258) were between 154 mm and 181 mm long; 29 were slightly larger and 3 slightly smaller. These staples may have been used to hold pieces of wood together during construction; it is unlikely that they would have been able to hold a ship together (See Figure 3.9).

The report says that 258 iron nails were found. It divides them into types according to the shape of the heads: straight, bent, flat, round, hammer-shaped, and looped. Some also had no heads at all, and these were called date-pit (*zao he* 棗核) shaped. The most numerous were the straight- and bent-head nails, numbering 135 and 101 respectively. Because of their length, one unique bundle of six nails should perhaps be called pins; they had never been used and were still wrapped together with cord. These were between 552 mm and 587 mm long (See Figure 3.10).

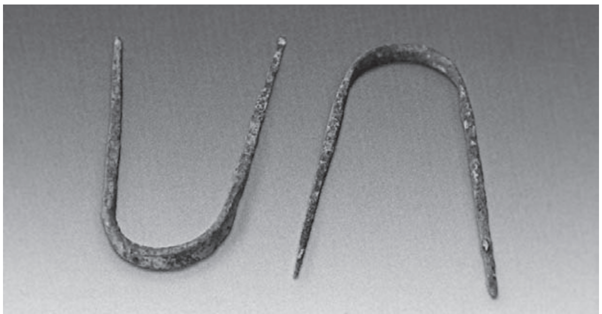


Figure 3.9 Staples. (Courtesy of Nanjing Municipal Museum)

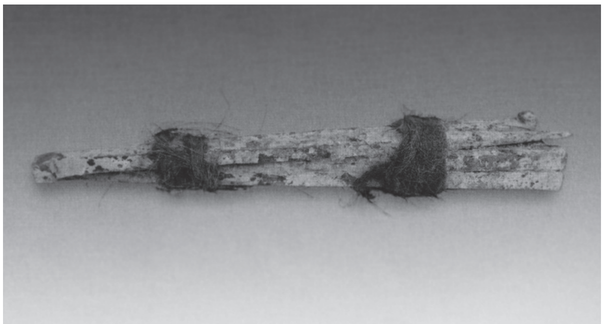


Figure 3.10 Nail Bundle. (Courtesy of Nanjing Municipal Museum)

The report divides the iron tools into those used for shipbuilding and those for agricultural work or daily life. Thirty-three items were classified as shipbuilding tools. These included three axe-heads, ten bores, seven knives, four awls, four chisels, one pick, one drill, and two saws. Tools like these would have been indispensable for shipbuilding. An additional find was a sharp iron tip that would have fitted on the end of a wooden pole. It is not clear what its use was, but appears to be a kind of spear. Five agricultural implements were found, including two sickles, two hoes, and a shovel. In addition, there were eight iron rings, four hooks, three reinforcement strips, two hoops, one butt end of a spear (*zun* 鐏), and one scoop.[31] There were other miscellaneous objects whose use was not clear to the authors of the report, including a fork-shaped object, five U-shaped objects, one L-shaped object, and an object with a chain attached (See Figure 3.11). As with all the items found in the basin, some may have dropped into the basin at a later time, after the era of Treasure-ship construction. Therefore we cannot say conclusively that they all date from the time of the maritime expeditions.

Given the combination of objects used for shipbuilding and those used for agriculture and daily life that were found in the shipyard, the question arises whether the workers lived on or off site.

Figure 3.11 Object with chain. (Courtesy of Nanjing Municipal Museum)

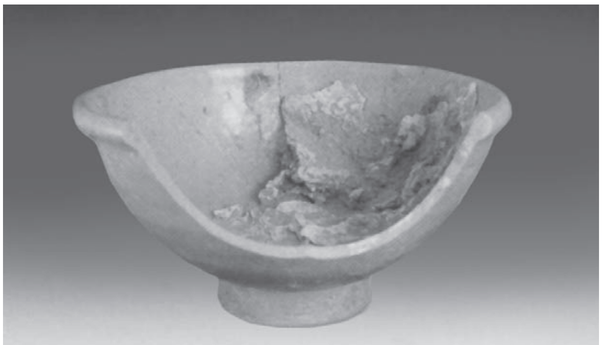


Figure 3.12 Porcelain. (Courtesy of Nanjing Municipal Museum)

The agricultural implements may have been used by the workers for growing their own food, or for tending non-food crops, such as hemp plants and *tong* oil trees, which yielded products that could be used in shipbuilding (hemp and *tong* oil, or *tongyou* 桐油). In the case of the Longjiang Shipyard, according to the site maps, some of the land was for producing hemp and oil for shipbuilding. Other plots, called simply "people's land" (*mindi* 民地), were probably used to grow fruits and vegetables.

Ceramics

A total of 355 ceramic items were found at the shipyard. Of these, 303 were porcelain, including small numbers with green, yellow, white, or brown glazes. The largest number (199) was of *qing* (青) porcelain, with 17 of *qinghua* (青花) and 9 of *qingbai* (青白). There were 68 *qing* bowls, four plates, one rice bowl, two glasses, two small plates, and one bowl on a tall pedestal (See Figure 3.12). One of the porcelain items was a weight used to sink a net (*wang zhui* 網墜).

In general, the ceramics found at the shipyard were rather crudely made. They were probably produced in kilns belonging to the common people and made for daily use. Some were inscribed on the bottom with names or numbers in black ink, but these seem to have been scribbled hastily, without great care. Some pieces were used for work purposes as well as for containing food: a small number of bowls contained left-over caulking material, which was probably mixed in the bowl and then applied to the ship from the hand-held bowl. This find is consistent with the archaeological report's statement that most of the objects were for practical use, "having some relationship to the craftsmen's work and life".[32]

Some of the pottery dates from a time after the maritime expeditions, i.e. from the mid- and late-Ming and even the Qing periods. Thus it is quite clear that, because the basins were open sites, these later pieces must have been dropped in after Zheng He's expeditions were terminated in 1433.

Other Artefacts

A number of stone items were also unearthed at the site. The vast majority (70 out of 72) were stone balls (perhaps used as weapons) made from hard rock. They are grouped in the report by size. Most of the stone balls (55 out of 70) were between 84 mm and 108 mm in diameter. The largest was 148 mm in diameter, but this was the only one of its size. Six were between 113 mm and 132 mm in diameter, and another six were between 36 and 52 mm. There was an additional one of irregular shape. The other two stone items included one earth-pounding stone (*hangtou* 夯頭) and one stone with a hole and grooves in it of unknown function.[33]

A total of fourteen bricks (*zhuan* 磚) were found at the site, including three showing signs of use for knife-sharpening.[34] In addition, there were three circular eave tiles (*wadang* 瓦當), one of which was decorated with an image of a lion with its mouth open, showing its teeth (See Figure 3.13).[35]

Items made of coir (*zong* 棕) were more numerous, totalling 67. These included 64 pieces of rope, one rope mat, one shoe, and a palm-bristle brush with a wooden handle. Of the rope fragments, two were plaited and 62 were twisted using a method called "hemp-flower" (*mahua* 麻花). The longest rope found at the site was 12 m long. It was 78 mm in diameter and made with nine strands of palm. The thickest rope was 90 mm in diameter and made with twelve strands. It was 3.58 m long. The thinnest was 12 mm in diameter; it measured 1.24 m long and was made of three strands.

Four clumps of thoroughly hardened caulking material were also found. They were subjected to X-ray and infrared analysis to determine their composition, and the results are shown in Appendix 3 of the report.[36] They were found to contain calcium carbonate, montmorillonite powder, quartz, and feldspar. The largest was 296 mm x 208 mm x 172 mm. and the smallest was 212 mm x 180 mm x 144 mm.[37]

Figure 3.13 Eave Tile. (Courtesy of Nanjing Municipal Museum)

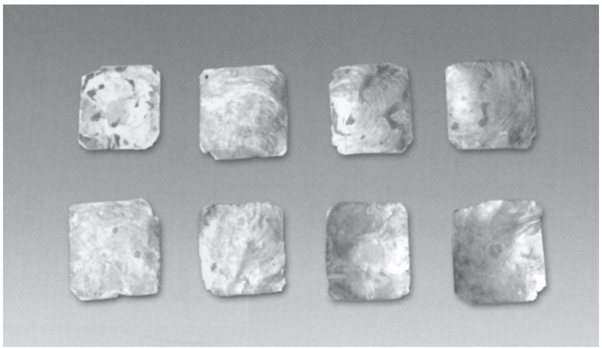


Figure 3.14 Mother of Pearl. (Courtesy of Nanjing Municipal Museum)

Eight uniform squares of mother-of-pearl were among the most beautiful objects found at the site. It is not known what they were used for; perhaps they were decorations on a belt or some other item of clothing. They are all about 1 mm thick and range from 71 to 81 mm long and from 65 to 73 mm wide (See Figure 3.14).[38]

Some Puzzling Omissions

Several items are puzzling for their absence from the shipyard finds. One is hemp, the material most commonly used for rope. Many fragments of coir were found but none of hemp. Perhaps, being a lighter material than coir, it simply did not survive. It is an essential material for making ropes, used extensively in sailing, and the *Shipyard Treatise* mentions it in all its discussion of materials. In fact, it is so important that it was one of two staple items grown on the shipyard site to save money because so much was needed. The other such staple item was *tong* oil. The quantities of these products required for each type of ship are given in Chapter 7 of the *Treatise*.

Another material conspicuous by its absence is *nanmu* (楠木). According to the *Longjiang Shipyard Treatise* this is the wood species used in greatest quantity for shipbuilding, with fir coming second. However, the archaeological report does not record a single piece of *nanmu* having been found in Basin 6. Most of the wood found there was *Cunninghamia lanceolata*.

No so-called "treasures" were found at the Treasure Shipyard, though this is not particularly surprising. Presumably if there had been any gifts from overseas left on the site — which is doubtful because they would have been delivered as presents or tribute to the emperor — they would have been kept in the treasury at the Treasure Shipyard. We know that there had been a treasury because of a passage in the *Longjiang Shipyard Treatise*, which says that by its time of writing in 1553, the "treasury for keeping valuables" (*bao ku* 寶庫) was completely overgrown with weeds. The passage reveals that two men were regularly sent from the Longjiang Shipyard to guard the grounds of the Treasure Shipyard, which were so deserted that the men spent the time gambling, for lack of anything else to do.[39] This is an eerie image of a once glorious but now vacant site. Any remaining treasures in the treasury must have been looted from the site long ago.

There were also no military weapons included in the report of the excavation. The only finds that might be considered military in nature are the round stone balls and the single *zun*, or butt end of a spear. Since the voyages were partly of a military nature, and the ships were known to have been armed, it is slightly surprising to find no more than this. Perhaps there were more at some point and these were looted as well.

III. The Longjiang Shipyard and the Textual Evidence

Chapter 4 of the *Longjiang Shipyard Treatise* is the best source of information on the infrastructure of the shipyard because it concerns the physical plant of the site. Entitled "The Construction Site" (*jianzhi zhi* 建置志), it gives the history of the site, as well as some description, and the two site maps mentioned above. The maps are particularly informative. One is an overall map of the site and the other is a close-up plan of one of the building complexes, called the Branch Office of the Ministry of Works (*gongbu fensi* 工部分司, often referred to *fensi* 分司). This was one of the main administrative offices of the shipyard. The features of the shipyard site shown in these two plans fall into four main categories: facilities used for the construction of the ships themselves, administrative offices, features of the internal geography of the shipyard, and landmarks indicating the wider geographical context of the site. I shall discuss the various features within these categories below.

Ship Construction Facilities

The shipyard contained separate workshops for activities directly involved in shipbuilding, such as sail-making, metal-working, caulking, fine carpentry, rope- and cable-making and painting. Some are indicated on the overall map, others are shown on the close-up map and still others are mentioned in the text of Chapter 4 but not shown on either of the maps. On the overall map are what look like single buildings, named "sail-making workshop" (*peng chang* 篷廠), "caulking workshop" (*nian zuofang* 艌作房), and "iron workshop" (*tie zuofang* 鐵作房). On the Branch Office map there are a "cabinet (fine-woodworking) workshop" (*xi mu zuofang* 細木作房), a "painting workshop" (*youqi zuofang* 油漆作房), and a "ceramics studio" (*jingtao zhai* 景陶齋).

The verbal descriptions of these workshops, which occur at the end of the chapter, indicate that in some cases these are not single buildings but multiple ones. Depending on how one interprets the word *jian*(間), however, these could be seen as multiple buildings or multiple rooms in single buildings. Their location and size are both mentioned in terms of numbers of *jian*. For instance, the sail-making workshop is said to have been in the northern part of the Branch Office complex, and to consist of ten buildings joined together (*fang shi lian* 房十連). An interlinear comment says that this is calculated to equal 60 rooms (*jian*). The use of the word "calculated" suggests that the word *jian* should be taken as a measure-word indicating room size; one *jian* was probably about 6 feet long.[40] This would mean that the sail factory was located in a building that was 360 feet long.

The passage also says that there were six carpentry workshops (or one, of six rooms) in the southwestern part of the Branch Office complex, four painting workshops (or one, of four rooms) in the northwestern part of the complex, three caulking workshops (or one, of three rooms) in the northern part, and four iron workshops (or one, of four rooms) beyond the road that goes northwest (*xibei lu* 西北路) of the Supervisorate Office (*tijusi* 提舉司). Also mentioned are *peng zuofang* (篷作房), probably the same as the sail-making workshops mentioned above, "rope-making workshops" (*suo zuofang* 索作房), and "cable-making workshops" (*lan zuofang* 纜作房). The last three, according to Li Zhaoxiang, were all in ruins by 1553. In addition, there was a "material checking house" (*kan liao pu she* 看料鋪舍), perhaps for inventory or some other inspection activity, at the intersection of the roads in the rear half of the shipyard.[41] This may be the same as the Material Observation Station or Patrol Office (*xunshe*) indicated on the overall plan and mentioned above.[42]

Certain fields can also be considered part of the shipbuilding infrastructure because they were essential for growing such items used in shipbuilding as *tong* oil and hemp for caulking and rope-making. There were fields for these products (oil and hemp fields or *you ma tian* 油麻田), and ponds or pools for them (*you ma tian tang* 油麻田塘), as well as storage areas for these products (*youma di* 油麻地). Stands of bamboo had been planted within the shipyard, and may have fulfilled some of the ships' requirements for bamboo, which were extensive.[43]

Administrative Offices

Being an official himself, Li Zhaoxiang was preoccupied with the administrative operation of the shipyard. There were many sites within the shipyard that had an administrative function, particularly the buildings and office complexes. These captured his attention and were included on the site maps. They included the Branch Office of the Ministry of Works (*fensi*), the offices of the Supervisorate (*tijusi*) and Vice Supervisorate (*fu tijusi* 副), the Navy Coordination Command Station (*banggong zhihui ting* 幫工指揮廳),[44] the Material Observation Station (*xun she* 巡舍, also called the Patrol Office), the Main Administrative Office (*shuiheng bieshu* 水衡別署), the Control Office for Supervision of Craftsmen (*jiandu* 監督) and the Control Office for Supervision of Officials (*sheng shi* 省試). Li's interest in administration is also shown in the inclusion of the separate close-up plan of the Branch Office, where Li must have had his office. Various other offices and halls are shown on the maps, as well as a library (*wenshu fang* 文書房).[45] The number and variety of different military and civilian offices show how many official institutions were involved in the operation of the shipyard and the complexity of its governance.

The Internal Geography of the Shipyard

Apart from the administrative buildings and complexes, and the buildings and other spaces used directly for shipbuilding, a number of other features are shown on the maps, which are part of the internal geography of the shipyard. These include roads, bridges, gates, walls, fences, canals and waterways, wells, additional fields, gardens, and a temple. The maps show an approach road (not labelled),[46] a Ring Road (*xungeng lu* 巡更路) around the shipyard, large and small pontoon bridges (*fuqiao* 浮橋), the Main Gate (大門 *da men*), the Ceremonial Gate (*yi men* 儀門), the Approach Control Station (*Longjiang chang* 龍江廠),[47] a Side Gate on the Ring Road,[48] the outer wall surrounding the shipyard (*wei qiang* 圍牆),[49] the northern and southern branch canals (*shui ci* 水次), and the northern and southern water gates (*bei/nanmian* *shuiguan* 北/南面水關). These canals and water gates may suggest what the gates in the Treasure Shipyard leading to the Yangzi River were like.

Other features marked on the maps include a well (*jing* 井) on the overall map, the pools or ponds for soldiers and civilians (*jun min tang di* 軍民塘地, abbreviated as *mindi* 民地), and something called "old land" (*jiu di* 舊地), about which nothing is known.[50] There were also some fields (*tian* 田), which must have been for general farm use, in contrast to the dedicated oil and hemp fields mentioned above. The close-up map also shows the east garden (*dongpu* 東圃) and the west garden (*xiyuan* 西園), which were perhaps for fruits and vegetables. There are also some areas where willows and bamboo were planted. The willow trees may have been purely for coolness in summer and to prevent erosion; they may also have provided material for basket-weaving. Waterways were necessary for transporting materials as well as completed ships, and roads were also needed for conveying people and materials, as well as for communication with the rest of the city. Finally, the close-up map also shows a Temple to the Soil God (*tudi ci* 土地祠). Mentioned in the text but not shown on the map are a fence (*mu zha* 木柵) and a pond in front of the Branch Office. The front and rear halves of the shipyard are also indicated on the overall plan. Each of these areas had its own waterway leading to the river, and its own water gate.[51]

Landmarks Indicating the Wider Geographical Context

Several features on the map are included for the purpose of orienting the viewer and setting the shipyard in the wider context of the city. These features have been used to locate the shipyard. They include the city wall (not labelled on the map, but shown clearly on the left-hand side of the overall map), the city moat (*chenghao* 城濠) between the edge of the shipyard and the city wall on the northeast side, Qinhuai street (*Qinhuai jie* 秦淮街), labelled "the road leading to Yifeng gate and Lulong mountain (盧龍山)", and two outlying hills, Ma'an shan (馬鞍山) and Guabang shan (掛榜山).

It is important to note that, as mentioned above, the map as pictured in the *Treatise* is oriented to face south or southeast. Therefore the city wall, which is actually on the northeastern side of the shipyard, is shown on the left-hand side of the map. The place where the Qinhuai River meets the Yangzi (*Qinhuai tong jiang* 秦淮通江) is also marked on the overall plan. The position of this conjunction on the map strongly suggests that the shipyard was north of the Qinhuai, near the point where it joins the Yangzi River.

Omissions from the Treatise

Several items are conspicuous for their absence from the *Treatise*. No specific location for processing or storing wood is shown on the map. This appears to be a serious anomaly, as cutting and working with large pieces of wood were essential to the operations of the shipyard. (The cabinet-maker's workshop was woodworking on a different scale.) In the other chapters of the *Treatise*, there are copious references to wood and woodworking (*mu zuo* 木作); in fact wood seems to have been the most important material in the shipyard, heading the list of items required for shipbuilding in Chapter 5 as well as the more detailed quantities of materials used for the ships in Chapter 7. Woodworking is also listed as the first set of tasks in the calculations of work units required for shipbuilding in Chapter 7. Perhaps it was left off the map because it was so obvious and ubiquitous, or perhaps woodworking was done out-of-doors and not confined to any particular building. There is only one oblique reference to the storage of wood in an unused sail-making workshop (*peng zuofang*):

> *The sail-making workshop was located north of the Branch Office. In past years it was where the sails (**feng peng** 風蓬) were made for the ocean-going ships.*[52] *It consisted of ten buildings joined together. It was used to store shipbuilding materials (**liao** 料). Today it is all in ruins. Only the walls still exist. Old planks from broken-up ships are piled up in the centre, and since there is no roof over it, the planks have become rotten over time. This building was probably constructed to house the work of the shipyard that could not be completed.*[53]

One therefore suspects that this long, narrow building may have been a place to store wood for shipbuilding.

There is also a striking absence of any reference to large engineering equipment — tools, dereks or cranes, ladders, and so forth. Perhaps as a scholar-official, and not an engineer himself, the author simply did not pay attention to such equipment. However, as he writes in such detail about other somewhat technical matters, this omission is still surprising. It is possible that there was no such heavy equipment, and that there was only scaffolding on which the workers climbed to reach higher areas of the ships.

The fact that there were at one time storage facilities for treasures brought back from overseas supports the view that the Treasure Shipyard was located on a different site from the Longjiang Shipyard, as does the passage quoted above about the soldiers sent to guard the Treasure Shipyard.

Timeline of Events in the Development of the Longjiang Shipyard

The timeline given below, is compiled from the information given in Chapter 4 concerning the history of the site, as well as information from Chapter 3, "Officials and Other Employees" (*guan si zhi* 官司志), on the personnel who were employed there.

ca. 1368 The Longjiang Shipyard was built in the northwestern part of the capital city of Nanjing. This was an area with many rivers, therefore ships were very important. This is why the Supervisorate was established. There were two officials plus a clerk in charge. Later, the shipyard became subordinate to the Water Ministry (*shuibu* 水部).

pre 1465 The burning of documents.[54]

ca. 1465 The Branch office of the Ministry of Works was first built; it was located in the east and faced west, and there was a pool or pond in front of it.

1491 Wang Huan (王環) built a fence encircling the two halves of the shipyard to make the perimeter secure. Water gates were built to allow easy access in and out, and make it convenient for the guards.

1519 Bureau Secretary Wang Wei (王煒) had three rear halls built, with left and right wings, as dormitories for workers; Head of the Supervisorate Guo Yanshi (郭彥實) had the building complex refurbished.

1528 Bureau Secretary Fang Peng (方鵬) built a Ceremonial Gate and three *paifang* (memorial gateways 牌坊), labelled "Branch Office" for the middle one, "Supervision of Grounds" (*jianmu* 監牧) for another, and "Supervision of Construction" (*duzao* 督造) for a third.

1536 Wang Li (王利) built the Branch Office for the Ministry of Works at the intersection of the roads in the northwest. A new road, paved with bricks, was 360 *zhang* long.

1537 Head of the Supervisorate Liu Zizhen (劉子貞) rebuilt the Ceremonial Gate and dormitories at the rear of the Hall.

1538 Zhang Han (張瀚), Bureau Secretary, built the drum towers (*genglou* 更樓) at the left and right corners of the gate.

1543 Head of the Supervisorate Zou Heng (鄒亨) set up a stele praising his predecessor.

1547 Qiu Yan (裘衍), Bureau Secretary, built Xikan Hall (*Xikan tang* 希侃堂) north of the Ceremonial Gate, and the Grain Hall (*Guting* 穀亭) on the left side of that hall. The Xikan Hall was built as a summerhouse. Head of the Supervisorate Zou Qiong (鄒瓊) built a house with three small rooms on the site of the old Officers' Drawing Room (幕廳). Behind the office was a site for storing oil and hemp. There were eight storehouses on each side, left and right, but the storehouses were in ruins by 1553.

1549 All the buildings were burned down except for the Xikan Hall. The latter's name was changed to Jingtao studio (*Jingtao zhai* 景陶齋).

1551 When Li Zhaoxiang took over in 1551, the Branch Office was overgrown with weeds because there had been a fire and it had burned down.

1552 Li Zhaoxiang rebuilt the Branch Office, modifying it to face south; Head of the Supervisorate Gong Ji (龔佶) rebuilt the eight storehouses. Behind the storage site were the rooms of the Head and Assistant Head. In Li's day they were all abandoned, and only their outer structure remained.

1552 There was a fire in the old buildings where the painting workshops had been, as well as in the Branch Office. These were rebuilt in the same year.

IV. Conclusion

The two types of evidence relating to the shipyards, textual and archaeological, seem to complement each other to a large extent. Some of the textual evidence relating to the Longjiang Shipyard fills in the gaps created by the lack of documentary evidence for the Treasure Shipyard. The land between the waterways shown in the site maps of the *Treatise* seems to have been divided into fields for growing food and other products, as well as workshops, administrative buildings, gates, a well, roads, and so forth. These various facilities suggest the type of infrastructure that may also have been present in the Treasure Shipyard. The land between the basins in the Treasure Shipyard may have been used as work-space for shipbuilding, or as agricultural land for the cultivation of plant products for use in the shipyard, such as *tong* oil and hemp, or for growing fruits and vegetables for the workers and officials to eat. There may have been small ponds for stocking fish. There were probably also offices for the supervisors and inspectors who conducted the administrative operation of the shipyard, as well as workshops for the various activities involved in shipbuilding.

The land could also have been used for residences for the workers and/or officials. The *Treatise* mentions dormitories being built for the workers, though it also mentions that at least one group of workers lived off-site in a residential area nearby. Perhaps there was a combination of the two — some living on site and some off site.

Although the water gates leading from the Treasure Shipyard to the Yangzi River do not survive, those pictured on the plans of the Longjiang Shipyard suggest what they might have been like. The images of the ships lying in the waterways in the *Treatise* are also suggestive; if the Treasure Ships were much smaller they could have been arranged that way, some lengthwise along the basin and some crosswise. If the Treasure Ships were of the gigantic size mentioned above, or even half that size, they would have been too large to fit any way but lengthwise. It is hoped that further excavation at the Treasure Shipyard may yield more evidence of its infrastructure.

Some of the archaeological evidence also helps to flesh out the textual description and maps of the Longjiang Shipyard. The iron workshops may have produced pieces of iron like those found in the Treasure Shipyard, and the ceramic workshops may also have turned out items similar to those found at the site. The clumps of caulking material found there give tangible reality to the caulking workshop referred to in the *Treatise*, as does the porcelain bowl found still to contain caulking material in it. The latter shows the use of ceramic bowls for work purposes. The ceramic objects may have been produced in a workshop like the Jingtao studio in the *Treatise*. The joinery methods, the writing on wood and ceramics, and decorations are all highly suggestive of what may have been used in the Longjiang Shipyard. In fact, the evidence of each shipyard is evocative of the other.

Neither archaeological nor written sources are totally reliable or complete. Both provide only partial evidence. However, they both suggest certain minimum characteristics of the infrastructure of shipyards in the early Ming period can thus be perceived. Shipyards required proximity to a river bank or large body of water so the completed ships can be removed; they require a means to move the ships from the dockyard into the nearby waterways; water in which to build and manoeuvre ships, irrigate fields, provide drinking water and perhaps fishing stocks, and which provides a means of communication within the shipyard and with the outside world, for delivery of supplies, and for other uses during shipbuilding work; roads for the delivery of supplies; land on which to work, for the various tasks necessary for shipbuilding; land on which to store items for future use; land for administration buildings that supervise the workers, supplies, and products; and land for growing crops for food. With both types of sources present for the two shipyards of this geographical area and time period, a significant amount of information about their infrastructure is now available.

Notes

This research was undertaken with the assistance of funding from the Golden Web Foundation. I would like to thank Richard Barker for his advice on numerous points, and Shunyi Tan for his help with the Chinese text of the *Longjiang Shipyard Treatise*. Any errors that remain are my own. Shunyi Tan and I are currently preparing a critical edition of the *Treatise* in English.

1 Nanjing Municipal Museum. (2006). *Baochuan chang yizhi: Nanjing Ming Baochuan chang liu zuotang kaogu baogao* (*Ming Dynasty Baochuanchang Shipyard in Nanjing* 寶船廠遺址: 南京明寶船廠六作塘考古報告). Wenwu, Beijing. I have published reviews of the shipyard excavation report in *Archipel* 74. (2007): 261-265, and in the *International Journal of Nautical Archaeology,* Vol. 37, No.1. (March 2008): 198-200. I am grateful to the Museum for letting me publish the illustrations for this report.

2 Li Zhaoxiang. (1553). *Longjiang Shipyard Treatise*, Chapter 4: 97. References to this work are from the modern edition edited by Wang Lianggong 王亮功. (1999). Treatise of the Longjiang Shipyard (*Longjiang chuanchang zhi* 龍江船廠志). Nanjing, Jiangsu guji chubanshe. See also the facsimile edition, Xuanlantang congshu xuji 玄覽堂叢書續集, vol. 117.

3 Nanjing Municipal Museum 2006: Colour Photo 1.

4 Nanjing Municipal Museum 2006: 1-3.

5 Hans Lothar Scheuring. (1987). *Die Drachenfluß-Werft von Nanking: Das Lung-chiang ch'uan-ch'ang chih, eine Ming-zeitliche Quelle zur Geschichte des chinesischen Schiffbaus*, Heidelberger Schriften zur Ostasienkunde, Band 9. Frankfurt/Main, Haag und Herchen: 114-115. When Scheuring was there in the 1980s, the extant basins were numbered from north to south as follows: 7, 3, 2, 1, 4, 5, and 6: 114, and map: 116. He refers to an article by Hong Changzhuo 洪長倬 entitled "Baochuan chang yizhi ji baochuan chidu wenti" 寶船廠遺址及寶船尺度問題, in Jinian weida hanghaijia Zheng He Xia Xiyang 580 zhounian choubei weiyuanhui 紀念偉大航海家鄭和下西洋五百八十周年籌備委員會, *Zheng He Xia Xiyang lunwenji* 鄭和下西洋論文集. (1985). Vol. 2. Nanjing, Nanjing University: 37-49.

6 Nanjing Municipal Museum 2006: 1-3.

7 The textual evidence consists of a few scattered sentences here and there and one image on a map.

These include Gu Qiyuan's 顧起元 *Kezuo zhuiyu* 客座贅語 (1618), and the "Mao Kun Map", folio 1. The name of this map was coined by J. V. G. Mills because the map was found in the *Wubei zhi* 武備志, published by Mao Yuanyi 茅元儀 (1594-1641), who was Mao Kun's 茅坤 (1511-1601) grandson. The map dates from 1621, but it is thought probably to have been derived from a map from around the time of the voyages. See J. V. G. Mills. (ed. & trans.). (1970). *Ying-yai sheng-lan. The Overall Survey of the Ocean's Shores [1433]*, Hakluyt Society Extra Series 42. Cambridge, England, Cambridge University Press.

8 Scheuring, 1987. *Die Drachenfluß-Werft:* 104-124. Scheuring summarises the controversy surrounding the shipyard's location, concluding that it was north of the Qinhuai river, near its conjunction with the Yangzi. He pointed out that the plans have to be turned 200 degrees for north to be at the top, although 180 degrees seems to be sufficient.

9 Kwan-Wai So. (1975). *Japanese Piracy in Ming China during the 16th Century*. Lansing, Michigan, Michigan State University Press: 2-3.

10 Li Zhaoxiang 1553. Chapter 3: 92. For a discussion of the policy of the period, see Lo Jung-pang. (1958). "The Decline of the Early Ming Navy." *Oriens Extremus* 5.2.

11 For references to these numbers, see Sally K. Church (2005). "Zheng He: An Investigation into the Plausibility of 450-ft Treasure Ships." *Monumenta Serica*, Vol. LIII: 1-42.

12 The complete reference for the report is given in the first footnote to this paper.

13 For example, see Peter H. Spectre, and D. Larkin (1991). *Wooden Ship: The Art, History and Revival of Wooden Boatbuilding*. Boston: Houghton Mifflin; Ole Crumlin-Pedersen. (1997). *Viking-Age Ships and Shipbuilding in Hedeby/Haithabu and Schleswig*. Schleswig & Roskilde: The National Museum of Denmark & the Viking Ship Museum.

14 Sally K. Church (2008). "The Ming Treasure Shipyard Archaeological Report" in S. Langley & V. Mastone (eds.). *ACUA Underwater Proceedings 2008*, Advisory Council on Underwater Archaeology. Columbus, Ohio: PAST Foundation: 30-38.

15 Nanjing Municipal Museum 2006: 78.

16 Nanjing Municipal Museum 2006: 54-57.

17 Nanjing Municipal Museum 2006: 57-78. This makes a total of 219 items. In examining the report, I often find that the totals of the individual items often do not exactly match the totals given of the larger categories, although the discrepancy is not usually large. The difficulty of counting small fragments of materials can explain this discrepancy.

18 Nanjing Municipal Museum 2006: 66-67.

19 Sally K. Church (forthcoming). "How Long is a Foot: The Size of the Ships used on China's 15th-century Maritime Expeditions." Proceedings of the Asia-Europe Workshop on Medieval Wooden Ships in Portugal, April 2008.

20 Nanjing Municipal Museum 2006: 78-95.

21 Nanjing Municipal Museum 2006: 95.

22 Nanjing Municipal Museum 2006: 111, Fig. 58; Black & White photos 19-1, 19-2.

23 Nanjing Municipal Museum 2006: 63, Fig. 38, BZ6: 30.

24 Nanjing Municipal Museum 2006: 121, Rubbing 6, BZ6: 250, 207.

25 Nanjing Municipal Museum 2006 Colour Plate 21 [XII], BZ6: 30.

26 Zhou Shide 周世德. (1962). "Cong Baochuanchang duogan de jianding tuilun Zheng He baochuan" 從寶船廠舵杆的鑑定推論鄭和寶船. *Wenwu* 文物 No.3: 35-40.

27 It seems correct to assume that a stern mounted rudder was used, partly because of tradition, and partly because the illustrations associated with the voyages indicate this type of rudder system. See those that accompany *Taishang shuo Tianfei jiuku lingying jing* 太上說天妃救苦靈應經, a religious text dating from 1420, the "ocean-going ship" (*haichuan* 海船) pictured in Chapter 2 of the *Longjiang Shipyard Treatise*, and the four "stellar diagrams" that occur at the end of the "Mao Kun map". While these are not technical drawings, they give an indication that the ships used this type of rudder. See Jin Qiupeng 金秋鵬. (2000). "Qijin faxian zuizao de Zheng He xia Xiyang chuandui tuxiang ziliao — Tianfeijing juanshou chatu" (The Earliest Hitherto Discovered Illustration of Zheng He Going to the South Seas in the Sutra on the Celestial Spouse 迄今發現最早的鄭和下西洋船隊圖像資料 – 《天妃經》卷首插圖). *Zhongguo keji shiliao* 中國科技史料 21(1): 61-64. See also Mao Yuanyi 茅元儀. (1989). *Wubei zhi* 武備志, 51 vols. (facsimile of the 1621 edition), j. 240, in *Zhongguo bingshu jicheng* 中國兵書集成. Beijing: Jiefangjun chubanshe. Vols: 27-36. The map is in vol. 36: 10388-10431 of this collection. It is also found independently in Xiang Da 向達. (1961). *Zheng He hanghai tu* 鄭和航海圖. Beijing: Zhonghua shuju.

28 Thomas Hoppe. (2008) "Mainland China: Revival of the Junk." http://thomashoppe.net/work/junks/luemeimao.php, accessed 27 November 2010.

[29] Nanjing Municipal Museum 2006: 129-130.

[30] Nanjing Municipal Museum 2006: 239-251.

[31] Nanjing Municipal Museum 2006: 169-174.

[32] Nanjing Municipal Museum 2006: 190.

[33] Nanjing Municipal Museum 2006: 205-208.

[34] Nanjing Municipal Museum 2006: 208-209.

[35] Nanjing Municipal Museum 2006: 210,

[36] Nanjing Municipal Museum 2006: 256-257.

[37] Nanjing Municipal Museum 2006: 217.

[38] Nanjing Municipal Museum 2006: 216, Fig., 109.

[39] Li Zhaoxiang 1553: Chapter 3: 93.

[40] This is a tentative estimate of the length based on one definition of *jian* found in Morohashi's dictionary, where it says that one *jian* in Japan was 6 feet long. Morohashi Tetsuji 諸橋轍次. (1960). *Dai Kanwa jiten*大漢和辭典. Tokyo: Taishukan.

[41] The shipyard had previously been divided into front and rear halves (*qian/hou chang* 前/後廠).

[42] Scheuring 1987. *Die Drachenfluß-Werft*. Karte II, No.29: 92.

[43] Chapter 7 provides lists of all the materials required for shipbuilding and their amounts for each type of ship. Bamboo is one of these, in several varieties.

[44] This is said to have been in the northeastern corner of the yard. It faced west, and the front and rear each had 3 rooms, with wings on the left and right. If one follows Mark Elvin, it would be called the "Command Office of the Military Tithing Soldiers". See Mark Elvin. (1969). *The Ming Tribute Grain System*. Hoshi Ayao 星斌夫 (trans). *Chugoku shakai keizaishi goi* 中國社會經濟史語彙. Michigan Abstracts of Chinese and Japanese Works on Chinese History, No.1, Center for Chinese Studies, University of Michigan. Michigan, Ann Arbor.

[45] For instance, there are the Main Hall (*zheng ting* 正廳), the River Hall (*chuan tang* 川堂), and the Rear Hall (*hou tang* 後堂), as well as the Liyin tang 吏隱堂 in the close-up map of the Branch Office.

[46] This is listed in Scheuring's work as No.16 on the overall map. See Scheuring 1987. *Die Drachenfluß-Werft*. Karte II: 92.

[47] This name is very difficult to read in all the editions I have examined. I am following Scheuring here, but unfortunately he does not give the Chinese characters. It is No.18 on Scheuring's overall map, Scheuring 1987. *Die Drachenfluß-Werft*. Karte II: 92.

[48] I am following Scheuring here in calling it the Side Gate, because I'm unable to decipher the Chinese on the map in any of the editions I have examined. It is at No.16 on the close-up map. Scheuring 1987. *Die Drachenfluß-Werft*. Karte III: 93.

[49] This outer wall is marked only on one side of the overall map, Karte II, No.33, on the side nearest the moat and the city wall. Scheuring 1987. *Die Drachenfluß-Werft*: 92.

[50] This site on the map is not listed by Scheuring.

[51] One can tell that each had its own waterway and water gate from the map.

[52] It is not entirely clear whether the text is referring to Zheng He's ships or to ocean-going grain transports, as the latter were also discontinued after the Grand Canal opened in 1411, when grain ceased to be transported by sea and was transported solely inland, via canal. Lo Jung-pang, "Decline of the Ming Navy": 160.

[53] Li Zhaoxiang 1553: Chapter 4: 106.

[54] It is an interesting question whether this burning of documents, dated before 1465, was the same destruction of documents attributed to Liu Daxia 劉大夏, which supposedly took place in the Chenghua period (1465-1487). It seems to be a different occasion. J. J. L. Duyvendak translates the account of the documents' demise that appears in Yan Congjian's 嚴從簡 *Shuyu zhouzi lu* 殊域周咨錄 of 1574, rpt. Zhongwai jiaotong shiji congkan series. (1993). Vol. 13 (Beijing: Zhonghua shuju): 307-308. See Duyvendak. (1938). "The True Dates of the Chinese Maritime Expeditions in the Early Fifteenth Century", *T'oung Pao* 34: 341-412, esp. 395-396. The historian Gu Yingtai 谷應泰 (1620-1690) in *Mingshi jishi benmo* 明史紀事本末 (1658; rpt. Beijing Zhonghua shuju, 1977): 362, gives the date of the destruction of documents that related to the Annam campaign as 1480, and it is often claimed that Liu Daxia burned those relating to Zheng He's maritime expeditions at the same time. However, we have no hard evidence for this destruction other than Yan Congjian's discussion. Some scholars think that the only documents destroyed were those relating to the Annam campaigns. See Lo Jung-pang, "Policy Formulation and Decision-Making on Issues Respecting Peace and War", in Charles O. Hucker. (1969). *Chinese Government in Ming Times: Seven Studies*. New York: 41-72, esp. 62-63, n. 79. Tang Zhiba 唐志拔 suggests that the fire in the archives may have been the same one recorded in the *Ming Shilu* 明史錄 of 14 Jan 1482, which took place in the Nanjing Ministry of Works. See Tang Zhiba 唐志拔, "Zheng He baochuan chidu zhi wo jian" 鄭和寶船尺度之我見, in *Zheng He yanjiu* 鄭和研究 47 (2001) 2: 26-32, esp. 27-28, reprinted in *Chuanshi yanjiu* 17 (2002): 21-27.

4

Iron nails recovered from the plank of the Shinan shipwreck

Lee Chul Han

Masami Osawa

Jun Kimura

Abstract

This is a short report on iron nails used for the Yuan Dynasty Shinan shipwreck in Korea. The Shinan shipwreck is the fourteenth century's oceangoing merchant ship that originated from China. Since its discovery in the late 1970s, a number of studies have been conducted on the hull and cargo artefacts. This report is the result of a first attempt to assess the nails from the hull plank highlighting the quality of iron used for the nails.

要旨

本論は韓国新安沈没船に使用されている鉄釘の研究の概要報告である。新安沈没船は中国を起源の14世紀の交易船である。1970年代の同船の発見以来船体と積荷についての多くの研究が進められてきた。しかしながら船釘についてはこれまで研究されていない。本報告では船体外板の釘について使用されている鉄に焦点を当てた研究に関するものである。

Introduction

Study on iron nails of the Shinan shipwreck, a Yuan Dynasty's trader sunk in Korean waters, has not previously been conducted. This is because all nail remains in the hull were presumed to have been fully degraded. Under agreement with the staff of the National Research Institute of Marine Cultural Heritage, an attempt to identify magnetite remains of iron nails was made as a part of the Shipwreck ASIA thematic studies. The goal of the study is to assess the quality of the iron used for the nails of the shipwrecks. A timber specimen that contains nail remains from the plank of the Shinan shipwreck was provided for metallurgical study. Due to the substantial degradation of the nails, the results of the metallurgical study is not sufficient to examine the quality of the iron. Based on the result this report still provides some perspective regarding the manufacturing processes of the original nails by referring to the previous study of identified iron nails during the same period as the Shinan shipwreck.

State of iron nails remaining in the Shinan shipwreck

Magnetitic remains were barely identified in a part of the hull plank of the shipwreck by magnets. It was necessary to determine further whether this is a sign to contain iron remains and whether it would be used for metallurgical study. X-ray and CT-scan analyses to

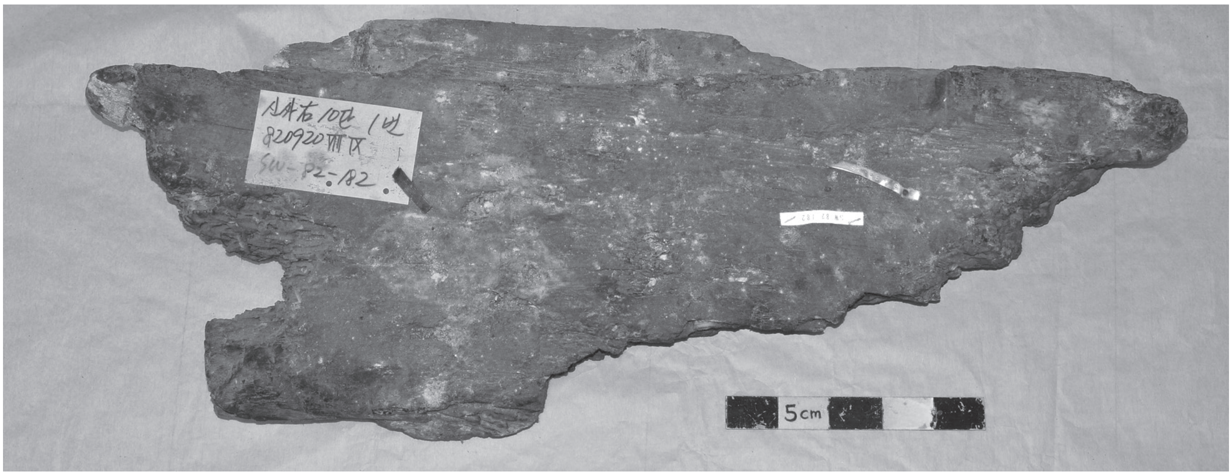


Figure 4.1 Hull plank (SW-82-182) from the Shinan shipwreck. (Photo by Jun Kimura)

Figure 4.2 Rabbeted seam of the SW-82-182, and a scale is placed on the inner surface of the hull plank. (Photo by Jun Kimura)

determine the quality of iron remains were conducted on the hull plank (SW-82-182). X-ray and CT-scan analyses are non-destructive approaches to reveal the nails' position and driven patterns that cannot be visible from outside.

SW-82-182 is a portion of a hull plank from the Shinan shipwreck (Figure 4.1). Due to deterioration, the only remaining original dimension is the thickness of the plank (105 mm). Present dimensions are a maximum width of 395 mm and a maximum length of 1.02 m. The original placement of SW-82-182 is yet to be determined clearly. The rabbet, however, appears to be cut at only one seam that likely joins to the edge of the lower plank (Figure 4.2). Most parts of the hull planking of the Shinan shipwreck are rabbeted clinker construction, except for the planking in the bow, forward of the first bulkhead shows gradual changes from clinker to carvel. The feature identified with the plank (the rabbet cuts at only one seam) must have been used in the clinker-built part. It appears that a few corroded nails are driven from outside of the rabbeted seam. The pattern indicates that the plank was located at the portside.

The x-ray and CT-scan images show that broken remains of four nail shafts are diagonally driven at the rabbeted seam (Figures 4.3 and 4.4). The interval of the four nail shafts shows slight irregularity. Two spaces between three of the nails measure 250 mm. The other two nails were very narrowly spaced at about 80 mm. Nail length ranges from 95 to 145 mm.

Figure 4.3 X-ray image of the SW-82-182 showing the two iron nails that have square cross-sections. (Courtesy of the National Research Centre of Marine Cultural Heritage)

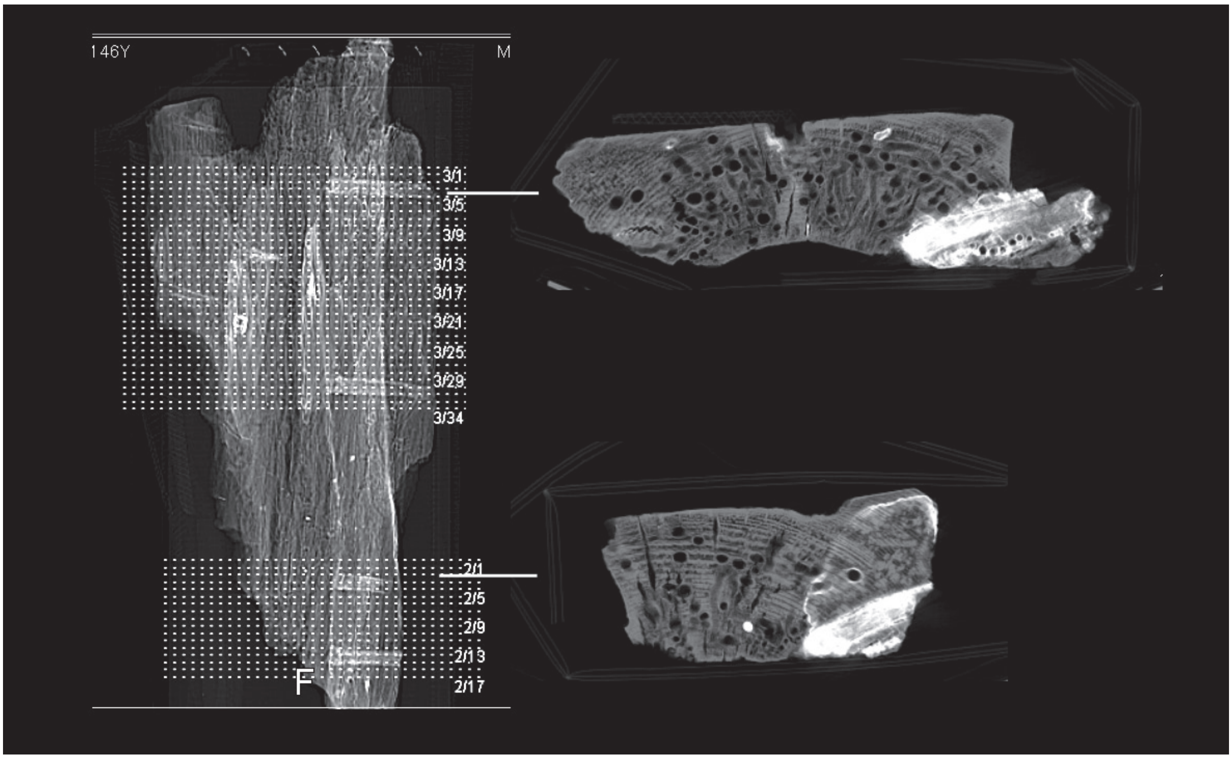


Figure 4.4 CT-scan image of the SW-82-182 and images of the cross-sections where the iron nails are driven. (Courtesy of the National Research Centre of Marine Cultural Heritage)

Figure 4.5 A cut piece from the SW-82-182 for metallographic analysis. (Photo by Jun Kimura)

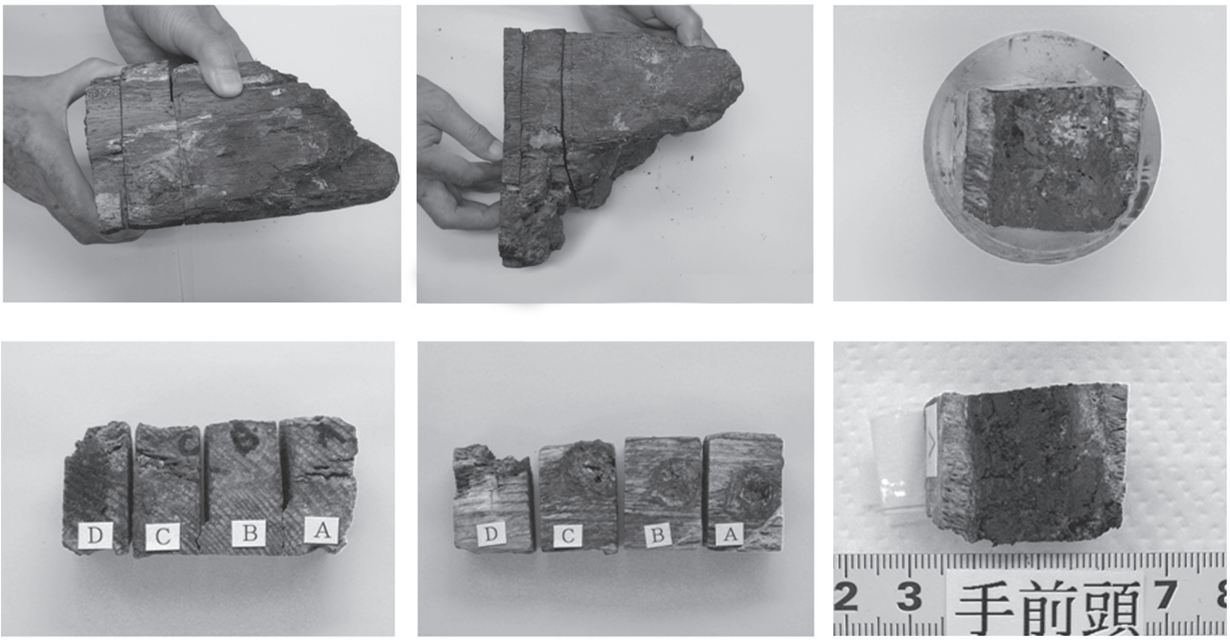


Figure 4.6 Specimens containing a nail remain from the cut piece. (Courtesy of the Kyushu Techno Research Inc)

The nail shaft is slightly skewed and tapered (as seen in the CT-scan image Figure 4.4). The configuration of the nail shaft remaining at this seam evidences that original nails were skewed nails. From the remains of the nail shafts at both the upper and the lower seams, the original length could reach 250 mm but is less likely to have exceeded 300 mm. The cross-section of these nails measures a square 20 mm on each side and the section of one of the nails is exposed on the broken part of the lateral of the plank.

From the analyses, the quality of the iron remains seems to be different. The x-ray and CT-scan images present a fully-corroded iron remain that is shown as a black hollow image with a only thin magnetite layer that indicates the presence of the original surface. Some nail remains show white blur images, which suggest possible mineral remains or slugs inside the nail. With regard to the white blur images, it is difficult to determine the detailed corrosion status by just looking at the x-ray and CT scan images.

Metallographic analysis

A specimen of the timber was cut from the hull plank (SW-82-182) for metallographic analysis and provided to the Kyushu Techno Research Inc (Figure 4.5). The specimen was further cut to expose the sections of the nail (Figure 4.6). The sections of the microscopic images were produced (Figure 4.7). The microscopically observed structure shows that iron

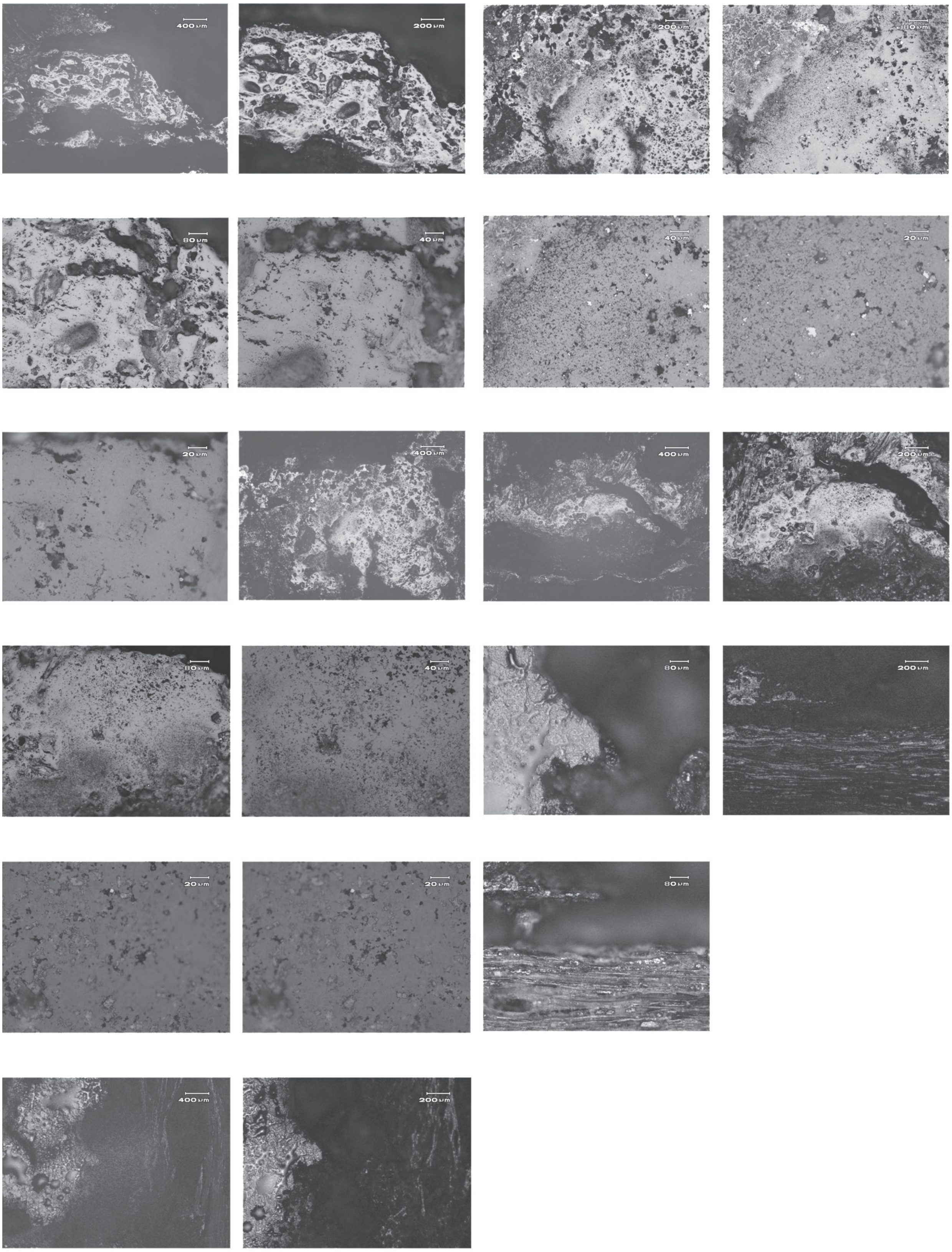


Figure 4.7 Microscopic images of the structure of the nail remain. (Courtesy of the Kyushu Techno Research Inc)

has been fully oxidised and the nail does not contain metal structures. The corrosion status of the nail is hydrated iron oxide (goethite: Fe2O3/H2O). The substantial oxidization caused the loss of the metal structure. Under this condition, it is difficult to assess the quality of the original iron.

Perspective on manufacturing processes of the iron nails

To assess nails used in the construction of the Yuan Dynasty's Shinan shipwreck, a few iron nail remains found at the Avraga Site are suggested as a comparable resource. The site is related to the Genghis Khan's mausoleum where workshops to manufacture iron materials existed. The result of archaeological excavations at the site is available and includes a study on iron material remains.[1] Identified iron manufacturing technologies may be applicable to the technologies used to produce nails of the Shinan shipwreck, as the date of the two sites is relatively close.

Manufacturing processes of nails from the Avraga Site suggest that thin rectangular ingots of cast iron were initially produced by using moulds with 10–15 mm cross-sections. The cast iron ingots might have been too brittle to be used for nails (Table 4.1). Consequently, annealing processes must have been conducted by heating them under a temperature of 900–950 degrees F for a few days during which decarbonisation of the iron occurred. As a result, the quality of the iron turned soft and pliable. The iron was then further forged for nail production. The quality of the iron product through the processes is defined as an iron casting decarbonised steel.

C	Si	Mn	P	S	Cu	Ti	V	Cr	Zr
2.80	0.89	0.05	0.339	0.53	0.45	0.02	0.01	0.04	<0.01

Table 4.1 Chemical composition of the iron ingot from the Avraga Site (mass %). (Osawa 2005a)

Iron nails of the Yuan Dynasty's ships are identified on timbers recovered from the Takashima Underwater Site, associated with the Mongolian fleet that attacked Japan in 1281. Metallographic analysis was conducted on the nails. While these nails had fully corroded, a similar perspective regarding their manufacturing procedures has been presented.[2]

Conclusion

The use of iron for ship nails is one of the lasting traditions in constructing ocean-going ships in East Asia. However, iron nails are not commonly retrieved from East Asian shipwrecks. Because of this, detailed nail studies have yet to be successfully conducted for East Asian excavated ships. Under current estimation, ships' nails around the medieval period were probably produced by casting iron ingots first and then manufacturing them into nails. The details of the quality of iron nails, however, have yet to be assessed with better preserved ship nails.

Notes

1 Osawa, M. (2005a). 'One of the forms of iron producing in the Mongol Empire Obtained from forge-related objects found at Avraga Site: Approach based on metallurgical study', *The Avraga Site: Preliminary Report of the Excavation of the Palace of Genghis Khan in Mongolia 2001–2004*. Kokugakuin University. Niigata.

2 Osawa, M. (2005b). 'Takashima Kaitei Iseki Shutudo Tetsukugi no Kinzokugakuteki Chosa (Metallurgical analysis on the iron nails from the Takashima Underwater Site 鷹島海底遺跡出土鉄釘の金属学的調査（速報）'. *Takashima Kaitei Iseki XI (Takashima Underwater Site XI)*. Nagazaki-ken Takashima-cho Board of Education. Nagasaki.

5

Goryeo Dynasty (918-1392), shipwrecks in Korea

Randall Sasaki

Chul-Han Lee

Abstract

To date, the history of Korean shipbuilding technology has not received much attention from international scholars despite the fact that a growing number of properly excavated and reported vessels are providing a rich source of information regarding historic Korean maritime culture. In this brief article, six Korean coastal vessels, Sibidongpado, Wando, Daebudo, Taean, Dalido, and Anjwa shipwrecks, all from the Goryeo Dynasty (918-1392) will be discussed with particular attention paid to hull structure. These archaeological discoveries represent ships from the golden age of Korean maritime history. The main focus is placed on describing the differences and similarities among these vessels. Evolutionary themes in Korean shipbuilding technology will also be illustrated. The basic features of historic Korean ships are the use of heavy timbers joined with wooden fasteners. These vessels were built without the use of iron nails and beams were placed in transverse direction to bolster hull strength. The gradual development and continuity of Korean shipbuilding tradition, as well as some peculiar construction features are illustrated.

要旨

韓国の造船技術の歴史は、沈没船の発掘や報告例から得られた豊富な資料が増えているにも関わらず、いまだに世界の研究者から正当な注目を受けていない 。 本文は韓国高麗時代 (918-1392) の6隻の内航船（十二東波島船、莞島船、大阜島船、泰安船、達里島船、および安佐島船）それぞれの船体構造について特に詳しく解説してある。これらの考古学資料は、韓国海洋文化の黄金時代を築いた船であると考えられている。主な焦点はこれらの沈没船の基本構造と相違点や類似点などである。本論文を執筆するに至った主な目的は、韓国で発掘された沈没船をより多くの読者に紹介することであるが、韓国伝統船の発達過程もひとつのテーマである。朝鮮半島の伝統船舶技術の基本的構造は頑丈で大きな木材を使用し、それぞれの部材を木製の留め具で結合していることである。これらの船は鉄釘を使用せずに造られ、船体は横方向に配置された梁で強化されたつくりを持つ。これらの沈没船を研究・分析することによって、韓国高麗時代において基本的な伝統造船技術が時間を経て保持・継続されていると同時に、すこしずつ進化していく過程、そして、いくつか独特の技術も稀に見ることができる。

Introduction

This article provides an overview of excavated Korean vessels. A peninsula country like Korea would have a strong seafaring tradition with the potential of becoming a regional maritime power. However, it is often assumed that Korea did not possess a culture strongly oriented towards maritime enterprise. The lack of nautical development is often ascribed to the complex sea line of Korea, which is dotted with numerous small islands surrounded by mudflats, difficult currents, and one of the world's highest tides.[1] It is argued that because of these conditions, no great ships could be developed. The traditional ships were usually described as box-like and crude. Chinese envoys sent to the country in 1124 thought the Korean ships were crude, simple, and unworthy of mentioning in details.[2]

Due to this common notion, studies of Korean shipbuilding technology are often neglected. But these are the views of people who did not understand the ingenuity of local Korean watercraft, ships best suited for a peculiar and often hazardous marine environment. The maritime archaeology of Korea has seen a rapid development in recent years, as over a dozen shipwrecks have been identified, with some extensively analyzed and fully reported. Thanks to the work of Korean archaeologists, we know much about the ships from the Goryeo Dynasty (918–1392), considered to be the golden age of maritime Korea. The recent research provides new insights into the study of this important maritime culture; despite the detailed studies conducted by Korean researchers, the valuable information has not been widely circulated to a broader audience. This brief overview is intended to illustrate the potential of further research of Korean coastal ships from the Goryeo Dynasty.

This article describes the hull of the Korean coastal vessels from the Goryeo Dynasty based on archaeological evidence. The vessels discovered outside Korea, such as the *Penglai No.3* and *No.4 ships* believed to be Korean or Korean influenced vessels as well as ship timbers discovered at Takashima Underwater Site of Japan, are not discussed in this paper.[3] Particular attention is paid to the structure of the hull itself, but only limited references are made to its cargo and other artifacts from the shipwrecks. Iconographic and textual evidence regarding the Korean vessels are not discussed. The intention of this survey is to simply introduce the hull structures of the Goryeo vessels to a wider audience, and not to propose a new theory of shipbuilding technology. The vessels described here are only a small percentage of ships that sailed the Korean coast. The continuity of tradition, however, may be altered by a discovery of another vessel. Some of the vessels are undergoing the process of conservation and only brief descriptions, drawings, and photographs are available for study. Nonetheless, it is not without merit to synthesize the archaeological evidence at hand to detect a possible pattern in the evolution of Korea's shipbuilding tradition. Only six vessels, Sibidongpado, Wando, Daebudo, Taean, Dalido, and Anjwa shipwrecks will be introduced by chronological order based on archaeological evidence (Figure 5.1 and Table 5.1). It should be noted that the date for both the Wando and Sibidongpado ships has been identified to the similar time period based on the ceramic analysis, and the exact chronological order is disputable. For this article, the Sibidongpado ship is placed earlier than the Wando ship. These vessels represent the local Korean watercraft from the Goryeo Dynasty. Despite the limited scope of this study, many readers will find new information on this often neglected topic. The hull characteristics of six vessels described below are followed by a brief discussion and summary. The reports of these vessels were obtained through the kindness of National Research Center for Maritime Cultural Heritage (National Maritime Museum of Korea at Mokpo). This project is part of the Toyota Foundation supported project Shipwreck ASIA; a field trip to Korea and some translations have been funded by the foundation. We would hope this small step in research would lead to a better understanding of the maritime tradition of Korea and that of the world, and instigate further investigation on this topic.

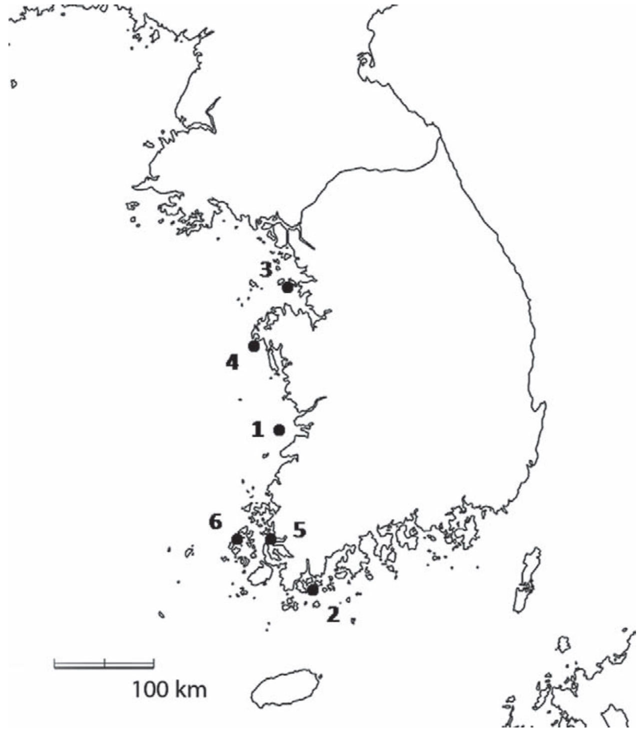


Figure 5.1 A map of Korea and location of excavated hulls. (Drawn by Randall Sasaki)

	Date (in Cent)	Bottom Structure	Survived Dimensions (m)	Estimated Length (m)	Estimated Beam (m)	Year Excavated
Sibidongpado	11–12	3 + 2L/Chine	7 x 1.8	14	5.5	2004
Wando	12	5 + 1L/Chine	6.5 x 1.65	9	3.5	1983–4
Daebudo	12–13	5	6.6 x 1.4	NA	NA	2003
Taean	12	NA	8.21 x 1.5	NA	NA	2007-on going
Dalido	13–14	3	10.5 x 2.72	12	3.6	1995
Anjwa	14	3	14.7 x 4.53	17	6.6	2005

Table 5.1a Basic Comparison of Six Hulls

	Central Bottom Plank Dimensions: W x Th (cm)	Average Bottom Plank Dimensions: W x Th (cm)	Average Side Plank Dimensions: W x Th (cm)
Sibidongpado	71 x 33	47 x 33	29 x 12.5
Wando	35 x 20	32 x 20	30–34 x 10–12
Daebudo	41 x 25	32 x 27	NA
Dalido	40–43 x 15–20	30–37 x 17–25	33–40 x 11–14
Anjwa	22–54 x 22–39	54–55 x 24–29	39–46 x 19–30

Table 5.1b Comparison of Plank Dimensions

Figure 5.2 A photo of a reconstructed traditional Korean vessel. (Photo taken by Randall Sasaki)

Archaeological Evidence

The traditional seagoing ships of the Goryeo Dynasty share common features that should be illustrated prior to describing each vessel. The most characteristic feature is the use of heavy timbers, both on bottom and side planks, to construct a hull. The bottom of the vessel is made flat, and the side planks are blocky in appearance, giving the distinguishing box-like shape of the Korean vessels (Figure 5.2).

The hull derives most of its strength from these heavy timbers along with beams (가룡). The use of these beams is one of the most prominent characteristics of Korean vessels. The entire hull is built with strongly built timber and the use of curved timbers as frames did not develop in Korea. Bulkheads, a common feature of Chinese vessels, are not used on ships built in Korea. Another native feature is that Korean shipwrights did not utilize iron nails; traditional Korean vessels were flat

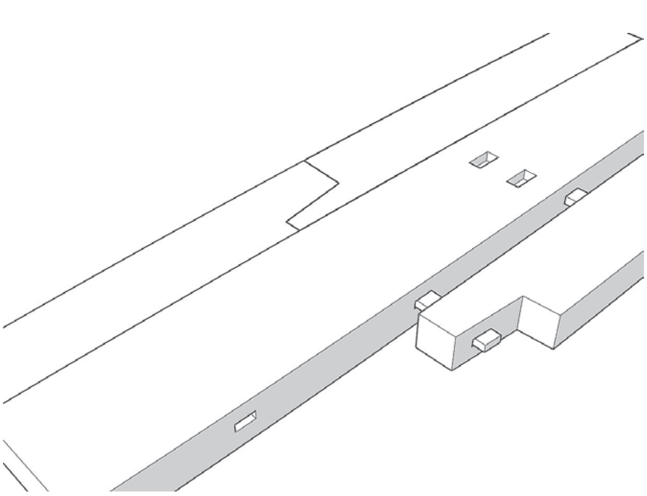


Figure 5.3 A simple model of bottom plank structure showing *jangsaks*. (Drawn by Randall Sasaki)

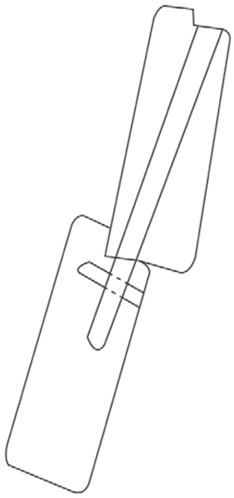


Figure 5.4 A simple drawing showing *pisak* and plank configurations. (Drawn by Randall Sasaki)

bottomed boats, consisting of three or five bottom planks, connected with *jangsaks* (장삭). A *jangsak* is a large and long tenon, fitted to the mortises cut through the width of the bottom planks. It not only joins the bottom planks together but serves also as an internal frame (Figure 5.3). Side planks of the Korean watercraft almost always have a rabbet cut at the upper outer edge where the next plank is placed above. The planks are joined with *pisaks* (피삭), a type of mortise and tenon joinery unique to Korean shipwrights. Usually, a mortise is cut through the width of a plank above and into the middle of the plank below. To hold two planks together, a *pisak* is secured with a peg placed only along the plank located directly below (Figure 5.4).

Another feature that all of these vessels share is the presence of two rectangular slots used to hold the heel of the mast located on a bottom plank. Bow and stern structures were found on several vessels, but more archaeological samples are required before making any conclusive statements regarding the structure at the extremities of the hull. However, it is known from the study of traditional boats and iconographies that the Korean vessel had both bow and stern transoms. The six vessels starting from the oldest are described below. In the description, overall information about the vessel is provided first, and the characteristics of the hull is described from the bottom timbers, side planks, beams, and other structures.

The Sibidongpado ship[4]

The Sibidongpado ship was excavated in 2004, and is believed to date back to the end of the 11th century to the early 12th century based on the style of celadon on board. The vessel was found near Gunsan city in Jeollabuk-do. Fourteen pieces of the hull, a stone anchor, more than 8,000 celadon wares, and a handful of personal and shipboard items were found. The presence of dunnage and packing materials gave archaeologists and historians a unique opportunity to study the seafaring practice of the time. The main structure of the hull consists of three bottom planks, joined with *jangsaks*, two L-shaped chine strakes on each side of the hull, and shell planking; the hull is kept in shape with several beams (Figure 5.5 and Figure 5.6). A possible bow section (bow transom-like structure) was found apart from the main hull section. Mast slots were discovered on the center bottom plank. Only three beams were found from the wreck, and one degraded hull plank. One interesting find is part of a windlass possibly for pulling the anchors. The surviving hull section measures approximately 7 m in length and 1.8 m in width. Korean researchers estimated the hull to be 14 m in length and 5.5 m in breath while the depth of the ship was about 2.5 m. It must be stressed that this is a rough estimate since only a small portion of the hull survived.

The bottom section of the hull consists of three strakes, and the total width is about 1.79 m. All three strakes are joined by *jangsaks*. The hull is curved upwards towards one end, considered to be the bow. The center strake consists of two planks, joined with a square tongue and groove joint (Figure 5.7). The total length of the central bottom strake is 6.86 m (2.20 m and 4.66 m) and the width and thickness appear to remain constant at 0.71–0.73 m and 0.33 m respectively. The cross-section is rectangular in shape, and both top (inside) and bottom (outside) surfaces are made flat. The port side bottom strake consists of two planks joined with a step joint. The total length of the strake is 7.07 m (4.89 m and 2.18 m). The

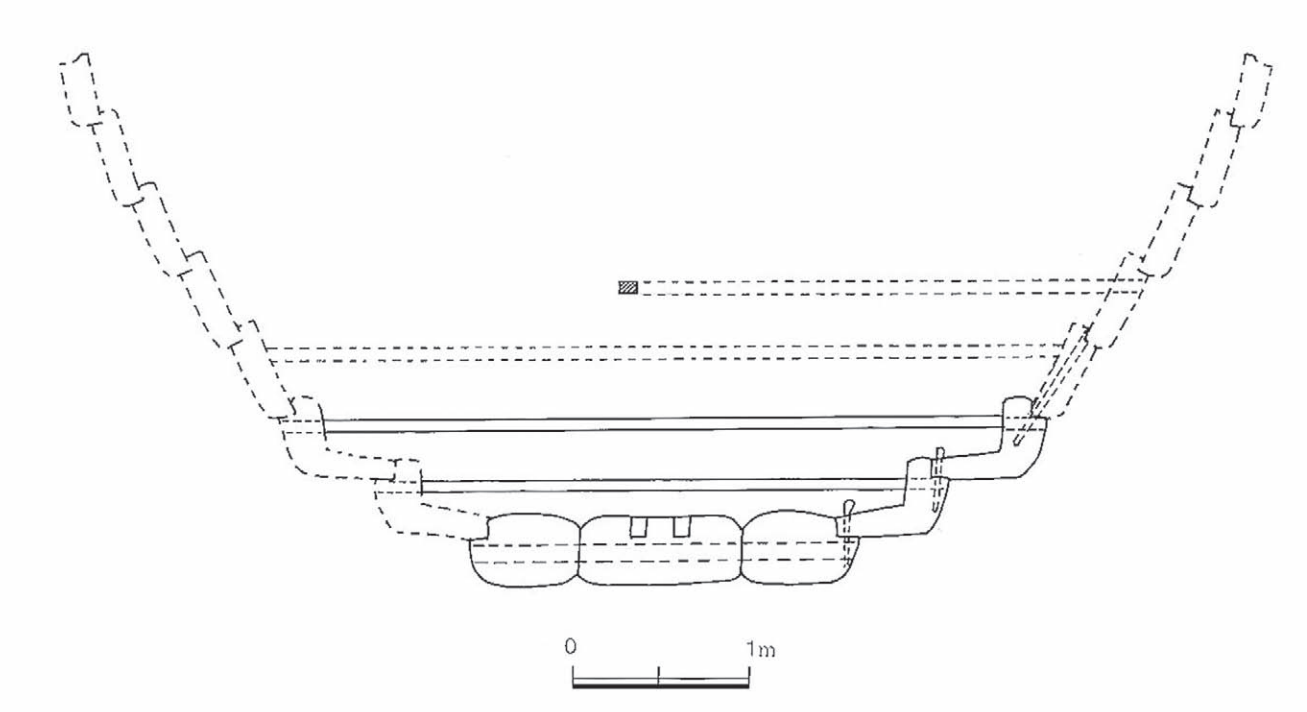


Figure 5.5 A possible reconstruction drawing of Sibidongpado ship. (Courtesy of the National Research Centre of Marine Cultural Heritage)

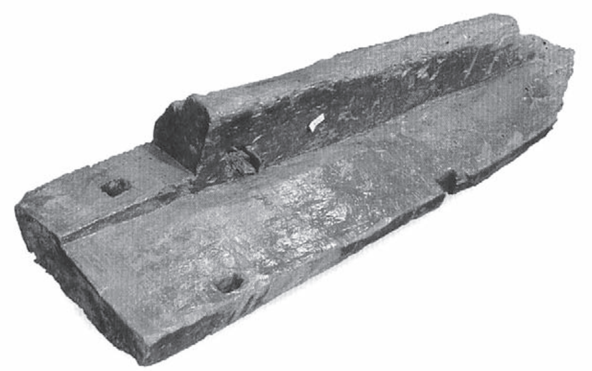


Figure 5.6 A photo of L-shaped chine strake. (Courtesy of the National Research Centre of Marine Cultural Heritage)

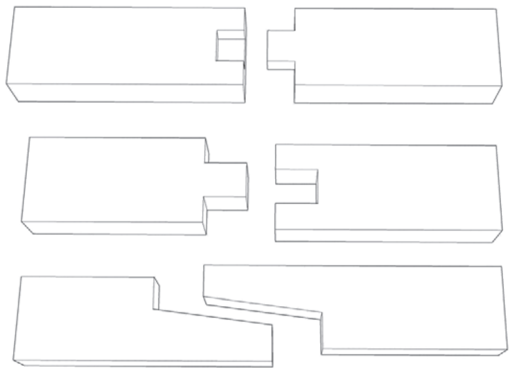


Figure 5.7 Example of some of the joinery found in Korean vessel. Top: complex tongue and groove joint, Middle: square tongue and groove joint, Bottom: step joint. (Drawn by Randall Sasaki)

width of the strake is about 0.47 m and the thickness is a constant 0.33 m, which is the same as the central plank as well as the starboard bottom strake. The starboard bottom strake also consists of two planks joined with a step joint positioned symmetrical to the portside joint; the step joints are located 1 m aft of the mast slots located most likely at the midship. The starboard strake is 6.16 m in length (4.88 m and 1.28 m). The maximum width is about 0.53 m and becomes narrower, about 0.43 m, towards the bow with a gentle curve. Both port and starboard strakes have a rectangular cross-section, but the bottom surfaces are made rounded, leaving the natural shape of the timber outside while upper (inner) surfaces are made flat. Rabbets are made at the outer upper edge of the strakes where L-shaped chine strakes are attached. A total of six *jangsaks* are used to connect all three bottom strakes together. Flat rectangular mortises of about 90 mm and 70 mm are cut out, and a *jangsak* is fitted into each mortise. These are set 1–1.1 m apart. One *jangsak* goes through the step joint position while no *jangsak* is placed at square tongue and groove joint on the center strake.

One of the most important characteristics of the Sibidongpado ship is the use of double chine strakes. This vessel uses two overlapping L-shaped chine strakes for transition from the bottom strake to the side strake at the turn of the bilge. The bottom chine strake consists of two planks joined by an overlapping step joint. Looking at a cross-section, the plank is 0.50–0.58 m wide and approximately 0.30 m high. The shape is not uniform, but the flat area of the “L” is about 0.2–0.3 m, and the Long side of the “L” rises to about 0.2 m. The upper section of the outer edge has a rabbet where another L-shaped chine strake is connected. The upper chine strake did not survive well, but the size appears to be slightly larger than the one below, about 0.6 m in width and 0.45 m in height. *Pisaks* are used for connecting the bottom planks with the chine planks, and to the planks above as well. The sizes of the *pisak* vary according to the size of the plank, but they are usually between 280–400 mm in length, 60–80 mm in width, and 25–30 mm in thickness. A total of twelve *pisaks* were found. The *pisak* is secured with a wooden pin or a peg, only at the lower plank; this is the standard method of joining planks found in all of the traditional vessels discovered. The presence of pegs for the connection between the bottom planks and the first L-shaped chine planks is not mentioned in the available report. The location of these *pisaks* appears to be random, perhaps set 0.6–0.8 m apart. However, extra *pisaks* are used along the plank scarfs to secure the joints. A total of four *pisaks* are used to secure the overlapping step joint found on the lower chine strake.

Only one heavily degraded outer plank was found at the site. It is 1.38 m in length, 0.29 m in width, and 0.125 m in thickness. It has one *pisak* going through the width of the plank. The mortise for the *pisaks* located at the upper chine strake are set diagonally, compared to the *pisaks* that connect the bottom planks as well as the chine planks which are set vertical. Beams were used extensively on traditional Korean vessels, and three of them were found from the Sibidongpado shipwreck. Two of the beams were found at the lower chine strake with another found at the upper chine strake. It is not possible to reconstruct the layout of the beams due to the degraded nature of the find. The beams are about 85 mm by 70 mm, and were laid flat. However, it appears that less number of beams were used compared to the later vessels.

The mast slots appear to be a standard feature on all excavated Korean vessels, with slight variations in size and depth. The slots of the Sibidongpado ship are 90 mm wide, 285 mm long, and 90 mm deep. These slots are made on the surface of the center bottom plank. No feature or additional elements was found around the slots. Planks around the mast slots were slightly burnt, indicating that this area may have been used for cooking on board. Another important find from the Sibidongpado ship is the bow transom section, found 3 m away from the main hull. The remaining bow section consists of three planks placed vertically and it measures 1.65 m x 1.10 m, with a thickness of 0.11 m. Each plank is about 0.35–0.38 m in width. The bow becomes narrower towards the bottom of the hull, making a trapezoidal shape. A groove or notch is made in a step-like fashion where

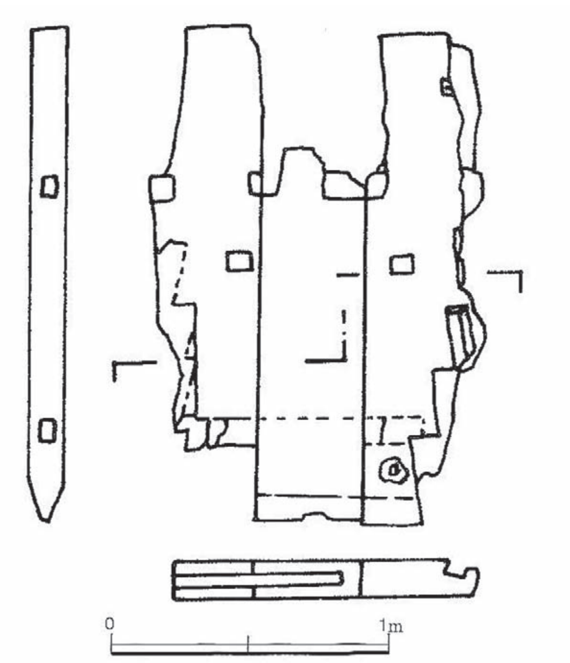


Figure 5.8 A drawing of the bow transom. (Courtesy of the National Research Centre of Marine Cultural Heritage)

the transom meets the planks. The hull planks are made to fit snuggly with the bow transom (Figure 5.8). Korean researchers have suggested that another layer of planks may have been placed over these transom timbers. The last feature of the Sibidongpado ship that must be mentioned is the presence of a windlass stand 1.97 m long, 0.195 m wide and 0.115 m thick. The hole at the top where the centerpiece of the windlass was fitted goes through this timber.

The Wando Ship[5]

The Wando ship was excavated in 1983–4, and it is the first local Korean vessel to be fully excavated underwater. Together with the Shinan ship excavation, this Wando ship's excavation is recognized as the beginning of underwater archaeology in Korea. Based on the cargo remains, the Wando ship dates to the late 11th century. The vessel was discovered in Wando-gun, Jeollabuk-do. Close to 30,000 artifacts, mainly of celadon porcelain, were uncovered from the site. It is one of the best preserved vessels discovered, providing a unique opportunity to compare the remains with traditional boats, and later, with other excavated vessels. The main structure of the hull consists of five flat bottom strakes, single line of L-shaped chine strake, and side strakes. As with other Korean boats, the transverse strength of the hull derives from several through beams. Planks are joined with *pisaks* as seen in the Sibidongpado ship. The mid-ship section of the hull is well preserved, but no bow or stern sections

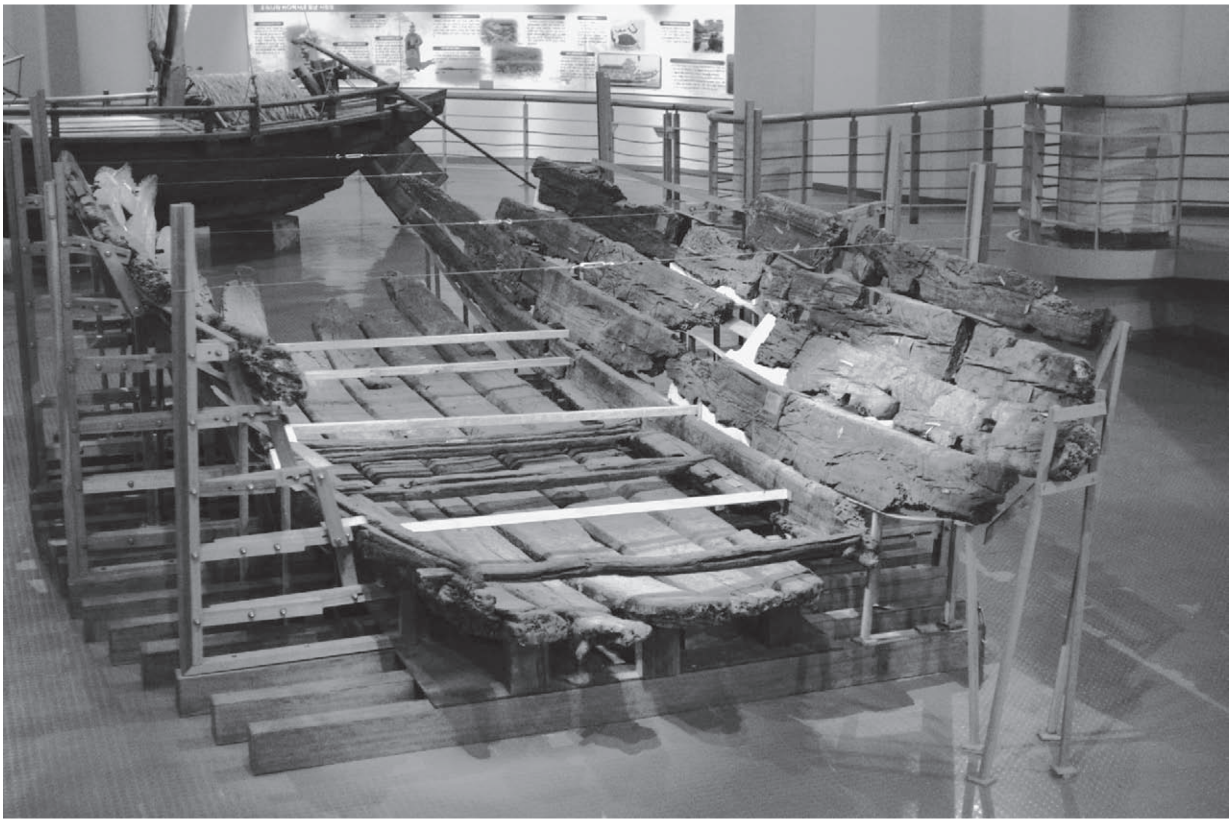


Figure 5.9 A photo of the Wando ship on display. (Photo taken by Randall Sasaki)

were discovered. Mast slots are located on the center bottom plank. Several wooden fragments of internal structures were found but the purposes are unknown. The survived hull section measures approximately 6.5 m in length and the bottom of the hull is 1.65 m in width. The Korean researchers estimate the hull to be 9 m in length and 3.5 m in breath while the depth of the ship as about 2.5 m (Figure 5.9).

The bottom section of the hull consists of five strakes, with each strake shaped close to square in cross-section. The positions of the scarfs are made symmetrical. The central strake consists of three planks, joined by square tongue and groove joints; the total length is 6.30 m (with the plank at the middle having a length of 3.93 m). The width is 0.35 m and the thickness is about 0.20 m; the strake becomes slightly narrower and flatter at both ends, where the hull has a gentle curve upwards, but the hull is damaged and lost. The central plank also hosts two rectangular mast slots near midship. The strakes next to the central bottom strake consist of two planks each joined with a step joint. The step joints are located towards the bow, between the midship and the square tongue and groove joint of the central plank, making the forward planks much shorter (forward planks are less than 2 m in length and the aft plank 3.5 m or longer). The step joint extends no longer than 0.5 m. The widths of the planks are 0.32 m and 0.2 m thick with slight variations. The two outer-most strakes consist of three planks joined by step joints. These step joints are located along the same line of the tongue and groove joints of the central plank. Thus the middle plank is nearly 4 m in length. The width of the strakes is 0.33 m and slightly tapers at both ends, giving the appearance of a curve towards the center of the boat. Planks are about 0.2 m in thickness. The rabbet for laying the L-shape chine-strake is made at the edge of the strake with a depth of 30 mm and a width of 60 mm. Some locations show the mortises used to fasten the L-shaped strake. All five strakes are joined by *jangsaks* piercing through the planks. An average dimension of a *jangsak* is 80 x 50 mm, laid flat. Additional wedges are inserted into mortises after *jangsaks* are fitted securely to fasten the planks in place. It appears the central three strakes might have served as a unit and the outer-most strakes were added later. A total of six *jangsaks* connect all three bottom strakes together. These *jangsaks* are not pegged and are set at the interval of 0.1–0.11 m apart from each other, avoiding the square tongue and groove joints and the mast slot; however one *jangsak* is pierced through the middle of the step joints of the two outer strakes. The outer-most strakes are joined to this central structure with *jangsaks*, but the mortises are chiseled only into the middle of the planks and do not reach the central strake. These *jangsaks* are pegged and placed in

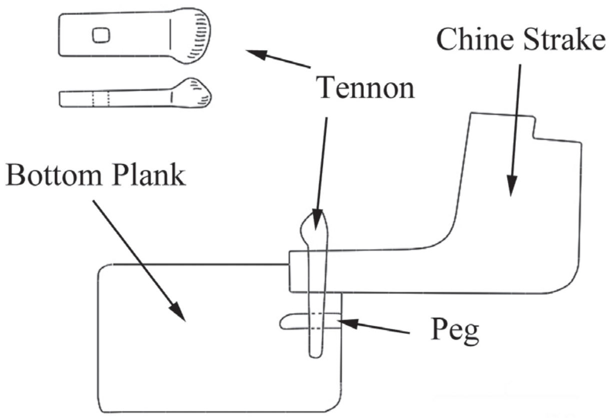


Figure 5.10 A drawing showing a joining configuration of bottom plank and the L-shaped chine strake. (Drawn by Randall Sasaki)

between the *jangsaks* of the central structure. It must be noted that *jangsaks* are placed in positions to go through all step joints.

The Wando ship uses L-shaped chine strakes for the transition between the bottom strakes and side strakes. The L-shaped chine strake consists of two planks joined by an overlapping step joint. This scarf is located parallel to a position slightly forward of the aft tongue and groove joint of the central bottom strake. Looking at cross-section at midship, the plank is 0.38 m wide and approximately 0.28 m high. The shape of the plank is archived by carving out the L-shape from a log and is not uniform. The strakes become narrower at both ends and curves upward and inward. The flat part of the "L" is about 0.2 m, and rises about 0.2 m, making the bottom section thin. The upper section of the outer edge has a rabbet where upper strake is joined. The bottom plank and the chine Strake are joined using *pisaks* placed at the flat section of the "L", making the upper third of the *pisaks* exposed inside the hull. The upper end of the *pisaks* are left unfinished, giving the appearance of a bulge that is left outside which locks the *pisaks* in place along with the square 20 x 20 mm peg, inserted at the bottom end and from the side of the bottom plank. The *pisaks* are about 180 mm in length and 60 x 20 mm in dimension. The *pisaks* are inserted approximately 0.90–1.1 m apart from each other (Figure 5.10).

Four starboard strakes and five portside strakes survived. Most of the planks are uniform in shape and size, approximately 0.3–0.34 m in width and 0.1–0.12 m in thickness. Some strakes, especially the lowest strakes, appear to become narrower towards the ends. Unfortunately, it is not possible to know if the Wando ship used a drop strake or stealer to adjust to the narrowing at prow, or how the bow and stern transoms were made. Although some parts of the strakes are damaged, it appears that all strakes consist of three planks with step joints, which the upper lips always project aft. The locations of the step joints are offset of each other in what appears to be an alternative pattern. The rabbet is cut along the outer upper edge of the plank to join another strake above. The rabbets are about 30–50 mm in width and 30 mm in depth. To secure the planks above and below, the Wando ship employs *pisaks*. The size of the *pisaks* varies according to the width of a plank, maximum of 450 mm in length, 80 mm in width, and 30 mm in thickness. As with the Sibidongpado ship, mortises are made completely through the width of the upper planks and stop at the middle of the lower planks where pegs are placed. No peg is inserted on an upper plank; however, small wedges are inserted to secure the movement of *pisaks*. The location of these *pisaks* appear to be random; however, a close examination reveals a certain pattern. The *pisaks* are placed forward and aft of the aforementioned set joints, as close as 0.2 m or about 0.5 m from the joint. Another *pisak* is inserted through each joint itself but not going through the plank above or below and is not pegged. These three *pisaks* fasten the scarf tightly together. Additional *pisaks* may be placed 0.6–0.8 m apart.

Several beams were utilized on the Wando Ship, but the details are not fully reported. The beams have a natural appearance around the center while both edges are shaped rectangular and are also made narrower to fit the square openings made into the planks. Several wooden pieces of what appears to be an internal structure of unknown function were also found. The mast slots are made on the central bottom plank as seen in all other excavated Korean vessels. The two rectangular holes are 50 mm wide, 160 mm long, and 50 mm deep. No feature or additional element was found around the slots. The wood species analysis revealed some hull components were made from species only grown in the southern half of Korea and all of the wood was available in Korea. This indicates that the Wando ship was made in southern Korea. Bottom planks are made of coniferous tree (*Torreya nucifera*) native to Japan and Cheju Island and the remaining bottom planks along with some hull planks are made of pine tree (*Pinus densiflora*). Some planks, beams, and pegs are of oak (*Quercus spp*). It is interesting to note that while *pisaks* are made of softwood (*Pinus densiflora*), *jangsaks* are made of hardwood (*Quercus acutissima*).

The Daebudo Ship[6]

The Daebudo ship was discovered in 2003 in a tidal flat near Ansan city of Gyeonggi-do. The excavation was conducted in 2006. Only a few porcelain shards and a small section of a hull, three bottom strakes and a garboard, were found. Based on the construction style and artifacts, the Daebudo ship is dated to the 12th century or possibly the early 13th century. The vessel originally had five bottom strakes and it appears that the L-shaped chine strake was not used. The transverse strength of the hull is achieved by the beams, as can be deduced from the mortise left on the garboard. The bottom planks are joined by *jangsaks* and the garboard to bottom planks by *pisaks*. The Daebudo ship is another example of the continuation of the traditional Korean vessels, and can be placed in between the Wando ship and the Dalido ship. The surviving hull section measures 6.62 m in length and 1.4 m in width. The estimate size of the hull has not been reported, as the hull components discovered were limited.

The central bottom strake and two strakes that are attached to one side, believed to be a starboard side, are all that is left of the Daebudo ship. The central bottom strake is badly damaged and only one plank survived. The plank curves upwards gently at both ends and becomes slightly narrower and thinner towards the end. The total length is 4.89 m, 0.41 m in width, and 0.25 m in thickness. Both the bottom and inner (top) surfaces are made flat; the planks are well made compared to the Sibidongpado ship. The first starboard side bottom strake consists of two planks joined with butt scarf. No additional joinery is made to secure this joint. The aft section is 1.43 m long, has a maximum width of 0.325 m, and a thickness of 0.27 m. The plank appears to be only slightly narrower at the end. The bottom surface is left rounded but the inner surface is made flat. The forward section is 4.4 m in length, 0.38 m in width, and 0.265 m in thickness. The cross section is a well fashioned rectangular shape compared the end piece just described above. The second strake, which is the outer-most bottom strake, also consists of two planks. These two planks are attached by a step joint. The outer edge has a rabbet cut with a width of 70–80 mm and a depth of 45 mm. The aft section is 2.46 m in length, 0.29 m in width, and 0.25 m in thickness. The cross-section is more rounded than square, but the inner surface is made flat. The longer front section is 4.54 m in length, 0.32 m in width, and 0.28 m in thickness. The cross-section also appears rounded compared to the shape of the first bottom strake. In general, all planks show changing cross-section shapes. The *jangsaks* are used for connecting the planks. The mortises are made through the width of the central plank and the first strake. The unpegged *jangsaks* of 120–130 mm in width and 60–70 mm in thickness are placed just forward and aft of the joint and additional *jangsaks* set approximately 1.10–1.50 m apart when there is no joint. It is assumed that three strakes, the surviving central strake and one next strake as well as one lost strake, consisted of the base. These three strakes are connected using *jangsaks* with no pegs as seen in the Sibidongpado and Wando ships. The outer-most bottom strake is connected using pegged *jangsaks*. The central bottom plank has mast slots, which measure 250 mm in length, 70 mm in width and depth.

The first side hull strake is badly damaged, but it appears that this is not an L-shaped chine strake found on earlier vessels. The total surviving length is 5.70 m, the width is approximately 0.33 m and the thickness is 0.15–0.22 m. The *pisaks* are used for connecting the bottom strake to the first strake, and are placed about 0.8 m apart. One important note to make regarding the Daebudo ship is that the pegs are placed from the side surface of the bottom planks, which is the same method employed on the Wando ship. Mortise for the beams are about 100 mm x 40 mm. All bottom and side planks are made of pine wood while *jangsaks* and *pisaks* are made of oak (*Quercus*).

The Taean Ship[7]

The recently discovered and excavated Taean Ship is one of the most unique traditional Korean vessels found. More than 20,000 celadon wares dated to the 12th century have been found, along with many shipboard items and wooden tags used for cargo registry. The Taean ship was discovered in Taean-gun, Chungcheongnam-do; excavation and research projects were directed by the National Research Institute of Maritime Cultural Heritage. The rough sea of Taean is one of the major waterways to reach the capital of the Goryeo Dynasty, Gaegyoeng. The 12th century is considered to be the height of maritime activity in Asia, when many foreign traders and government officials visited Korea. It should also be noted that the types of celadon discovered were the kinds deeply appreciated by the Song Dynasty envoy in 1124. Despite the fact that only four strakes were found, these discovered planks exhibit characteristics not known to other traditional Korean vessels. In addition, part of a windlass, possible anchor stones, and cables were found. A total of six planks were found, measuring 8.21 m in length and 1.5 m in width. The strakes have a gentle curve at both ends following the line of the hull. The size of the hull is uncertain, but it is estimated to be one of the largest Korean traditional vessels.

The best way to illustrate the hull remains of the Taean ship is to describe characteristics of each strake beginning from the bottom, perhaps the garboard strake, and then observing the different joining methods employed between the strakes. The possible garboard strake consists of two planks joined by a step joint with a peg-less *pisak* going through the width. One end is broken and the other end has remains of a step joint where another plank had been added. The surviving planks are 4.555 m and 2.715 m in length. The cross section is thick and the exterior surface is made with a gentle roundness while the interior surface is made flat. The maximum width is 0.435 m and the minimum 0.35 m; the thickness ranges from 0.12–0.16 m. The strake appears to become narrower and thinner towards one end. In addition, the cross-section of the thinner and narrower edge appears to be fashioned straight for both the exterior and interior. In other words, the cross section changes from rectangular at the extremities to having a more rounded exterior surface near the midship. The second strake consists of one long plank of 8.21 m in length, 0.52 m in width, and 0.07 m in thickness. One edge is broken but the opposite edge shows the step joint configuration. The third strake also consists of one long plank, 8.17 m in length, 0.32–0.36 m in width, and 0.07 m in thickness. As with the second strake, one side is broken and the opposite end shows the step joint. Both strakes have a well-made straight rectangular shape at cross-section with no rounded surface. *Pisaks* are placed at the step joints, which do not go through the entire width of the plank. Two planks survived from the fourth strake, which is connected with a step joint. One end is broken and another end has a step joint. While the thicknesses of both planks are about 0.1 m, the width varies from 0.20–0.26 m. The planks are 4.28 m and 3.19 m in length. The cross-section shape of the strake is not a clean rectangular shape like the second and third strakes. The bottom surface is rounded and the upper surface is slanted down towards the outer surface. The step joint connecting the surviving planks are with *pisaks* going through the entire width and are pegged at the bottom.

Several methods of connection between the strakes can be found in the Taean ship. First, the connection between the first strake and the possible bottom plank uses traditional *pisaks* of 0.13 x 0.1 m in dimensions. The *pisaks* are placed forward and aft of the step joints, approximately 1.1–1.5 m apart from each *pisak*. This basic method is commonly found in most traditional Korean vessels. The connection between the possible garboard and the second strake uses a different method. A mortise is made near the edge of the upper plank, set diagonally to the plank at the bottom, going through the interior surface of the lower plank. Smaller 40 x 20 mm *pisaks* are placed and the pegs (20 x 10 mm) are placed from the upper-edge of the bottom plank to secure the *pisak*. The *pisaks* are set about every 0.45 m. The rabbet is cut on the upper surface of the outer edge of the lower plank. The connection between the second and third strakes use an identical technique just mentioned; however

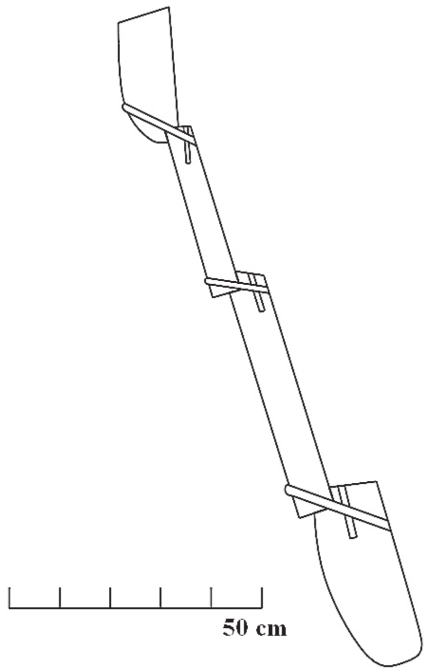


Figure 5.11 A cross-section diagram of the Taean ship's plank arrangement. (Reproduced by Randall Sasaki from Munhwajaechung Guklip Haeyang Munhwajae Yeonguso 2009)

the *pisaks* are slightly smaller. The third and fourth strakes were connected much the same way, using diagonally set *pisaks*. However, the rabbet is made on the inner edge of the upper strake (fourth strake), and the lower plank (third strake) has no rabbet making this third plank the only plank from a Korean vessel with no rabbet cut. The last connection, which can be found on the upper surface of the fourth strake, exhibits two joining methods. The diagonal *pisaks* are used much the same way as the connection between the third and fourth planks, but with wider interval. Another method, which is the traditional long *pisaks* placed vertically from the strake above, is also used. The intervals of the *pisaks* are set at 1.1–1.5 m. Such a complex hull construction method described here has not been seen on other excavated vessels (Figure 5.11).

The Taean ship utilizes beams for transverse strength of the hull. While no beams remain, their distribution pattern can infer from the holes that were made in the planks. The beams are placed in a row, with approximately 1.5 m intervals. Not all planks have a beam placed in a row. It appears as though beams were not placed where *pisaks* are located. The rectangular openings on the second strake are smaller, 100 x 80 mm as compared to other strakes, which have openings the size of 120–130 x 100 mm. There are two types of beams, Type A (가룡) and Type B (멍에형가룡). Type A is a typical through beam where an opening, or a mortise, is made at the center of a plank going through the thickness. Type B may be called a hooked beam where a cut is made at the upper edge of the plank and the beam is rested on top of the plank. Type A beams are found on the second and third strakes, while the hooked Type B beams are found on the first and fourth strakes.

The artifacts discovered on board the Taean ship provides new information regarding trade, and seafaring life and practice. Some planks show evidence of a charred surface on one side, which may be purposely made to prevent attack by marine organisms. A total of five timbers of what appears to be components of windlasses were found. These timbers are heavily damaged and distorted. The length of the most complete component is 0.69 m long and 0.06 m in width. The end of the shaft is made smaller to fit a mortise. Two stone anchors or anchor stocks were also discovered. A stone is roughly of rectangular shape with dimensions of 1.23 x 0.49 x 0.23 m. It weighs 115 kg. A small notch is made on a side surface where it is suggested that a rope had been lashed to hold a wooden anchor component. The second stone is made into a thin rectangular shape. It is 70.5 kg in weight, and the size is 0.9 x 0.34 x 0.14 m. The result of the species identification of the timbers conducted showed that all planks are made of pine, and *pisaks* made of either oak (*Quercus*) or a kind of Walnut tree (*Platycarya*) native to the region.

The Dalido Ship[8]

The Dalido ship, found in a tidal flat located near Mokpo-city in Jeollanam-do, was excavated in 1995 and the vessel is believed to date to the 13th or14th centuries based on the carbon 14 dating of the hull timbers. No cargo was discovered from the site, making the precise dating of the hull somewhat uncertain. The main structure of the hull consists of three bottom planks joined directly with the hull planking. The hull is kept in shape with several beams and planks joined with large mortises and tenons. The three bottom planks are nearly complete, and up to the fourth strakes were found. The aft section of the hull survived well compared to the forward section. A part of the stern transom boards was discovered while almost none of the port side planks forward of the midship survived. Several beams were also found revealing the precise pattern of the beam placement. The survived hull section measures approximately 10.5 m in length and 2.72 m in width. The Korean researchers estimate the hull to have been 12 m in length and 3.6 m in breath, while the depth of the ship to have been about 1.6 m. The Dalido ship appears to be a relatively narrow vessel with a sharp turn of the bilge.

The bottom section of the hull consists of three strakes, and the total width is slightly over 1 m. The center bottom strake consists of two planks, joined by a complex square tongue and groove joint. The upper and lower surfaces are made into a different step, creating an appearance of a step joint when viewed from the side. The upper protrusion, or a tongue of the step, is faced towards the stern. The forward plank is 3.43 m in length, 0.43 m in width, and 0.15 m in thickness. The longer plank, which has the mast slots, is 6.03 m in length, 0.4 m in width, and 0.2 m in thickness. The cross-section of the plank is rectangular. The strake rises at both ends. The strakes next to the central bottom strake consist of three planks each joined with a complex butt joint. It appears as a straight butt joint from the top surface while appearing to be a step joint when viewed from the side. Two of the bottom strakes are made in symmetry and the forward planks are approximately 2.22 m, middle planks are 5.17 m on both sides, and the aft planks are about 2.13 m. The width of each plank at the midship is 0.37 m, but it becomes narrower (0.30–0.33 m) towards the ends. Both of the strakes are 0.25 m in thickness at the midship, and they become thinner towards both ends to 0.17 m. It is important to note that the planks at the midship are made uniform and flat; only the shorter planks at both ends are made narrower, thinner, and curving upwards (approximately 15 degrees at bow and 9 degrees at stern). It must also be noted that the center bottom strake is thinner than the outer-strakes, which may seem contrary to the Western shipbuilding tradition. The rabbets to place the garboards are cut, and several mortises and pegs used to connect the garboard can be seen. All three strakes are joined by *jangsaks* pierced through the planks. A typical *jangsak* of the Dalido ship is about 120 x 40 mm, the length varies according to the width of the planks they join. A total of twelve *jangsak* mortises can be observed and these are placed slightly aft and forward of the strake joints, but are not put through the joint. At the middle of the hull, *jangsaks* are placed about 1–1.10 m apart.

The Dalido ship does not utilize the L-shaped chine strake for the transition between the bottom strakes and side strakes. The garboard strakes are the thickest of all planks, but only slightly so (0.14 m compared to 0.11 m). The width varies depending on the position within the hull; in general, strakes become narrower towards the ends. At midship, the garboard is 0.33 m, the second strake is 0.38 m, the third strake is 0.28 m, and fourth strake is 0.4 m. No plank is longer than 4 m in length, and it appears that each strake uses three planks connected with step joints seen in other excavated vessels. The locations of the step joints are offset by each other in what appears to be an alternative pattern, made nearly symmetrical on port

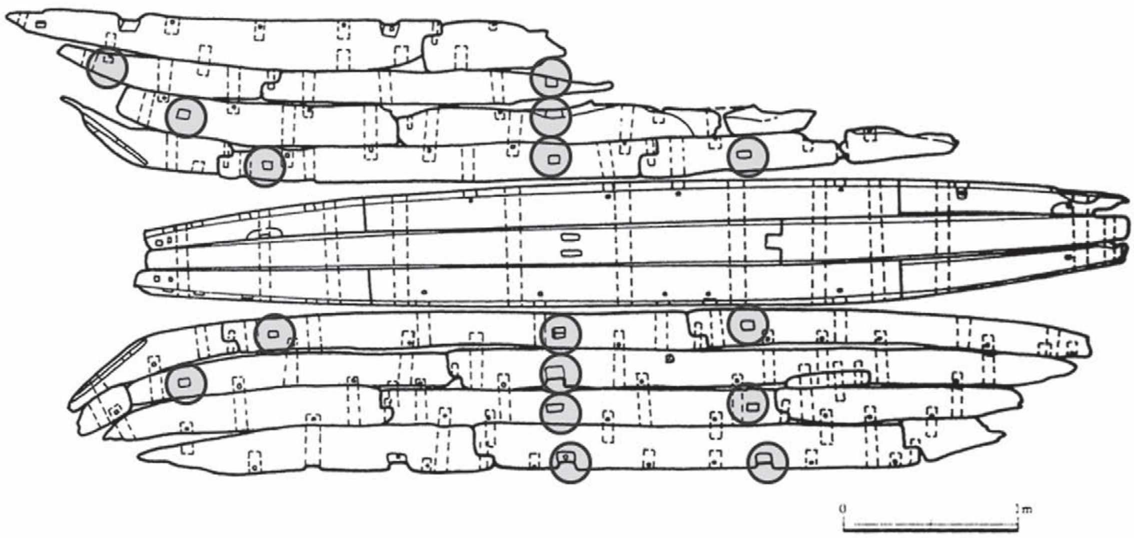


Figure 5.12 A flat view of the Dalido ship showing beam stations. (Reproduced by Randall Sasaki from Guklip Heyang Yumul Joensi Gwan 1999)

and starboard sides. Rabbets are cut at the outer edge of the upper surface to the depth of 30 mm and 30–50 mm in width. No modification is made for the lower surface of the plank, except for the garboard. The garboard strakes appear to be made slightly flat at the lower surface, giving irregular cross-section shape. The Dalido ship uses *pisaks* to secure the planks above and below, including the garboard and the bottom plank connection. For the bottom planks, the pegs are placed from the upper surface to secure the *pisaks*, fitted to the mortises made through the width of garboard strakes. This is different from the Wando or Daebudo ships where pegs were placed from the side. The sizes of the *pisaks* varied according to the size of the plank, 550-600 mm in length, with the average of 100 mm in width and 50 mm in thickness. As with the Wando ship, mortises are made completely through the thickness of an upper plank and stop at the middle of a lower plank where pegs, roughly 20 x 20 mm are placed. The *pisaks* are placed as close as 0.20 m forward and aft of the aforementioned step joints. Another *pisak* is inserted through the joint itself, but does not go through the plank above or below and is not pegged. Additional *pisaks* may be placed along the longer planks. The connecting method used between the third and fourth strakes is unique. Along with the regular *pisaks* that go through the entire length of the plank straight, another type of *pisaks* is placed from the middle of the upper plank and set diagonally. Pegs are placed from the side of the bottom plank.

Only six beams were found from the Dalido vessel, but archaeologists had the chance to study the placement pattern because of the mortises found on the planks. It is assumed that there were four rows of beams but the row closest to the bow cannot be detected. Two sets of beams are set straight in transverse direction while the set of beams closest to the stern is set at an angle parallel to the rise of the bottom plank, or the angle of the stern transom. Two basic types of beams are used on the Dalido vessels, Type A beams and Type B beams, discussed above with the Taean ship. However, the Dalido ship provides more information regarding the use of beams because some of the beams survived. Mortises of the Type A beams are 70–90 mm x 150–210 mm in dimensions, and located at the middle of planks to create through beams. The beams on these mortises naturally appear with rounded cross-sections, with edges shaped to fit the rectangular mortise made. These beams are used on the garboard and the third strakes. The Type B beams are "hooked" on the planks and the beams are made flat and rectangular in cross-section, which is about 0.14–0.17 m x 0.15–0.21 m. The notches for the Type B beam are found on the second and third strakes. A beam at the stern located on the second strake has two stanchions attached. These stanchions are fitted into the mortises cut in both the bottom planks (left and right) and the beam (Figure 5.12).

Thanks to the discovery of four degraded transom boards from the Dalido ship, the stern structure of traditional Korean vessels became clear. The width of the boards ranges from 95 to 200 mm, but all are 50 mm in thickness. Protrusions are cut out at both edges of the boards. There are also diagonal grooves or slots cut near the outer edge of the inner plank surface at the stern. The transom boards are fitted into these slots. However, these boards are only loosely fitted and there is no apparent waterproofing mechanism in place, suggesting an additional transom structure was built extending over the stern; however,

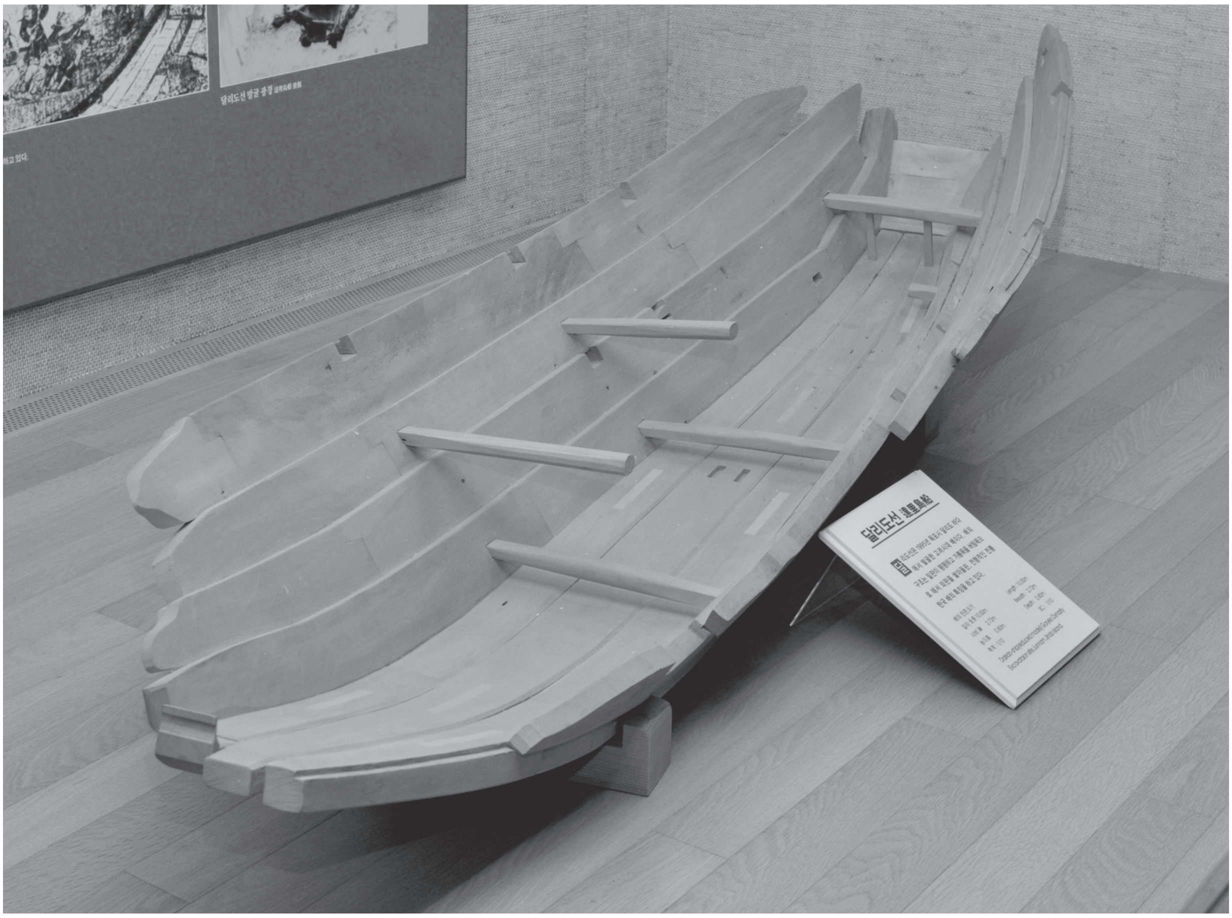


Figure 5.13 A small model of Dalido ship on display showing beams and stern board. (Photo taken by Randall Sasaki)

no remains were found. The two rectangular slots for the mast were also found on the Dalido ship. A row of beams located just aft of the mast slots most likely played an important role in supporting the mast. In fact, one of the beams had additional pieces of timber attached (Figure 5.13). Unfortunately, at this point, the exact way in which this structure functioned is not known, but it was likely a tabernacle that held the mast in place. The last feature of the Dalido ship to be mentioned is a possible repaired section of hull planking. The second plank of the starboard second strake has a small piece of timber added. Four *pisaks* are set through this small timber, and no pegs are used. The species identification of the hull revealed that side planks as well as bottom planks are made of pine (*Pinus densiflora*) while beams are made of oak (*Quercus acutissima*).

The Anjwa Ship[9]

The Anjwa ship was discovered in a mud-flat by a local resident in Shinan-gun, Jeollanam-do and excavated in 2005 by the National Maritime Museum. Based on a few cargo remains, and Carbon 14 dating of the hull itself, the Anjwa ship is dated to the late 14th century. The artifacts discovered, including a whetstone, an anchor stone, basket, and firewood, all revealed the life on-board these traditional vessels at the time. The Anjwa ship may be the latest Goryro period vessels showing a well developed tradition with various features in details. The hull consists of three bottom planks and the garboard is directly attached to the bottom planks. The cross-section of the hull shows a flat bottom with a gentle wineglass-like turn of the bilge not seen in previous Korean vessels (Figure 5.14). Beams were used to hold the hull in shape and the Anjwa ship exhibits a complex use of beams to support the hull. As with other Korean vessels, planks are joined by *jangsaks*. The entire three bottom planks, seven starboard planks, port garboard, stern transom board, and beams were found. The remains of the hull measures 14.7 m in length and 4.53 m in width. The estimated length of the ship is 17 m, width is 6.6 m, and depth is 2.3 m. Much of the hull has survived, but the short report published by the National Maritime Museum is not sufficient to fully understand this archaeological treasure. Detailed analysis and reconstruction are expected once the conservation process is complete.

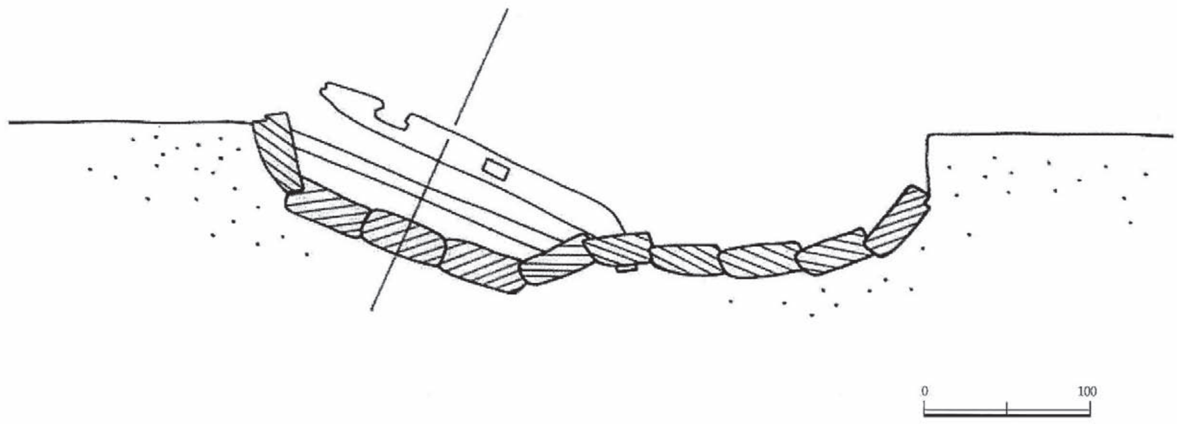


Figure 5.14 A cross-section of Anjwado ship as it lay at the site. (Courtesy of the National Research Centre of Marine Cultural Heritage)

The total length of the three bottom strakes structure is 13.33 m, and its width at the broadest point is 1.55 m. At the bow, the width becomes 0.89 m, and at stern 0.91 m. All three bottom strakes have two planks each. The forward middle plank is 3.76 m in length with changing thickness and width; the bow is made narrower and thinner. It is 0.22 m wide and 0.22 m thick at the bow, but it becomes as large as 0.54 m in width and 0.39 m in thickness. The forward section has a rounded bottom surface while the plank becomes a well shaped rectangular in cross-section towards aft. The aft middle plank is 9.88 m long, the maximum thickness is 0.24 m, and the maximum width is 0.54 m. The cross-section shape remains almost the same throughout the length of the plank, except near the stern. The width and thickness decreases, but not as dramatically as the forward middle plank. A complex tongue and groove joint, similar to the joint found on the Dalido ship, joins the two planks. Both the starboard and port bottom planks are made almost identical, so only the description of one side is provided here. The forward plank is about 4.60 m in length, 0.54 m in width, and 0.24–0.29 m in thickness. The plank becomes narrower towards the bow and the cross-section becomes more rounded. The aft plank is 9 m in length, 0.55 m wide, and 0.25 m in thickness. It becomes slightly narrower towards the stern. The forward and aft planks are joined by a complex butt joint, similar to the Dalido ship. The rabbet is cut at the outer edges, approximately 90 mm wide and 30 mm deep where the first side strake is laid. The connection between the three bottom strakes employs *jangsaks* much the same way as other excavated vessels. These *jangsaks* are placed forward and aft of the bottom plank scarfs and additional *jangsaks* placed roughly 0.9–1.1 m apart. The size of a *jangsak* is 0.13–0.20 x 0.04–0.07 m. The mortises of the central strake are made to fit the *jangsaks* almost exactly. However, the mortises of the starboard and port bottom planks are made slightly larger where additional wedges are placed to hold the *jangsaks* firmly in place. A total of fourteen *jangsaks* are used to connect the bottom planks. Both the bow and stern are raised steeply, but the curve of the stern is gentle. Grooves are cut at both ends, suggesting that stern as well as bow transom planks were inserted. A bulge is present beyond these groves, which appears to be extended out from the transoms. The bottom planks of the bow section are shaped carefully and are difficult to illustrate without more detailed information (Figure 5.15). The transom and other structures related to the hull's extremities will be discussed in detail below. The connection between the first side plank, or a garboard, and the bottom planks are achieved by using several *pisaks* placed through the garboard and into the bottom plank and pegged placed from the top surface of the bottom planks. The intervals of the mortises are 0.3–1 m, depending on the location of the plank scarfs.

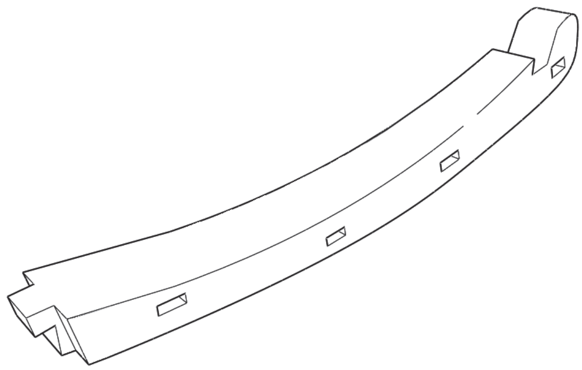


Figure 5.15 A 3D model of the Anjwa ship's central bottom plank near the bow. (Drawn by Randall Sasaki)

The Anjwa ship was listed to the starboard side when it was discovered, and thus only the garboard and small section of the second strakes of the port side survived, while much of the starboard strakes, up to the seventh strakes, survived. Each strake usually has three or four planks connected with a step joint. These scarfs are spaced across the hull so that no joints are overlapping in close proximity to avoid making a weak point; all scarfs are aligned with the upper projection towards the bow. Usually, a *pisak* is placed through these scarfs. The garboard of the Anjwa ship is unique among the Korean vessels. The plank closest to the bow is 3.22 m in length and has a width of 0.39 m. The cross-section of the plank becomes an upside down triangle, creating a broad platform facing upward. This structure is most likely made to hold the windlass that operated anchors and perhaps to support the bow as well. A mortise was cut into this surface in the dimension of 230 x 70 mm. The thickness of the plank ranges between 0.19–0.3 m, and the planks become narrower but thicker towards the bow. The rabbet is cut on the upper edge of the outer surface, 90 mm wide and 40 mm deep. *Pisaks* are used to connect the planks. The next two planks are over 4 m in length, 0.45–0.46 m wide, and 0.19 m in thickness. These two planks display standard plank features, including rabbets as well as *pisaks* placed 0.6–1.6 m apart and extra *pisaks* placed close to the scarfs. The sizes of the *pisaks* average 110 mm in width and 40 mm in thickness; however, it exhibits a variety of shapes depending on the angles of the joining plank. The plank at the stern must be described in detail. It is 2.32 m in length and 0.16 m in thickness. The plank appears "bulky" and becomes wider (0.45–0.57 m) and projects upward towards the stern. No rabbet is cut into the last quarter of the length. A diagonal groove is cut into the side of the inner hull surface where the stern transom board is fitted in. A *pisak* is placed through this groove to fix the transom board. The second strakes and above show little deviation from the standard plank joining methodology found on other excavated vessels. All planks are over 2 m to sometimes over 5 m in length. The planks at the stern are usually the shortest, often 2 m or less, except for the second strake, which is over 3 m in length. The thickness varies from strake to strake and plank to plank, but usually within 0.15–0.2 m. It appears that the planks are thickest at the bow and become thin towards the stern, while maintaining thickness along midship. The width also decreases towards the stern. For instance, the second strake is 0.5 m wide at the bow, about 0.4 m across the middle of the hull, and becomes 0.38 m at the stern. The planks at the bow appear "twisted" to accommodate the change in direction of the strake to fit the blunt but wider hull shape at the bow. On the other hand, the planks at the stern show a gentle curve inwards. The stern is narrower and has a gentle curve upward as well. The planks near the bow appear to have been burnt, and it is suggested that the planks were burnt to twist and fit the curve of the hull.

The transverse strength of the Anjwa ship, as seen in all Korean traditional vessels, derives from the beams. It appears that five rows of beams are placed in the hull. There are three mortises on the garboard, two on the second strake, three on the third strake, only one on the fourth strake, two on the fifth strake, three on the sixth strake, and one (or perhaps more) on the seventh strake. The beams were divided into two types, Type A and Type B as seen in the Dalido Ship. The smaller Type A beams (approximately 100–120 mm x 40–70 mm) are put through the planks, while the larger Type B beams (300 x 300 mm or larger) are "hooked" on the notch cut at the upper edge of the planks. Type B beams were only found on the second, sixth, and seventh strakes. The largest beam of the hull is placed just aft of the mast slots. This beam is 2.6 m in transverse length, about 300 mm in width, and has the maximum thickness of 340 mm. The bottom is made flat while the upper surface are made with a gentle bow, narrowing towards the both ends to become 300 x 300 mm square to fit the notch made at the top of the second strake. A possible mast support structure was attached to the beam, but the exact detail is not known.

The Anjwa ship provides an excellent opportunity for archaeologists to examine the bow and stern of the ship. One stern board was found attached to the stern. This board has a trapezoidal shape with the wider side at the top, and is 0.75 m across, 0.39 m in width, and 0.07 m in thickness. The transverse edges are made thin to fit the groove cut into the garboard. An additional two *pisaks* are placed from the garboard; the *pisaks* go through the garboard to the external surface where two pegs are place to lock the *pisaks* and the garboard in place. The transom is tilted 120 degrees. The V-shape groove is cut at the bottom planks that do not seem to have a strong connection. No bow transom board was found attached to the hull; however, possible bow transom boards were discovered 30 m away from the main wreck site. Three planks were found connected during the initial survey, but only two planks were found during the main excavation. The maximum length is 1.3 m, width 0.35 m, and the thickness 0.185 m. The planks are joined using *pisaks*. The boards are thick and appear strongly built compared to the stern transom. At the bow, the bottom planks have a groove of 0.1 m in depth and 0.15 m in width where the bow and transom board are fitted. The bottom strakes extend out with a bulb where additional support for the bow transom may have been constructed. The transom is tilted 110 degree, which is a steep angle compared to that of the stern transom.

The possible stem of the rudder was discovered from the shipwreck site. It is 6.55 m, and the cross-section has a changing oval shape of roughly 0.2 x 0.32 m. Two openings are present where the tiller was inserted. In addition, four mortises were found where blades were attached. A paddle blade or a possible yuloh blade was also excavated. It is 0.67 m long and 0.13 m wide. The blade is thickest at the center (40 mm) and becomes thinner (10 mm) on both sides. Several stone blocks, or possibly tiles or bricks, of various sizes and shapes were collected. These bricks were used as a cooking stove in the ship's galley. These are important artifacts for studying life on board the ship at the time. The mast slots, the standard feature of traditional vessels, can be found on the Anjwa ship as well. The slots are made on the raised surface, which is a new feature that has not been found on other excavated ships from the period. One important technological development seen on the Anjwa ship is the use of a caulking compound, a form of lime paste used between the planks as adhesive as well as for waterproofing the hull. Another significant discovery of the Anjwa ship is that markings with ink are used for building the Anjwa ship. The location of *jangsaks* is marked by ink, indicating that a preconceived plan of the vessel existed, which may have delineated the construction pattern and placement of the hull elements.

Discussion/Comparison

The Goryeo Dynasty vessels represented in this article share similar characteristics and exhibit continuity in tradition. Although some changes can be seen, the Sibidongpado boat already shows developed features as a Korean traditional vessel, which continues to the Anjwa ship and later traditional ships. There are "things that did not change" in Korean ships, which may be called a core structural concept of Korean traditional vessels. Changes, however, occurred and were prominent the disappearance of the L-shaped Chine strakes. Corresponding to this change, the cross-section of a hull began to change from the box-like hull to a vessel with a grace curvature. Strategic use of the beams and stronger hull components can also be seen. One important vessel that must be noted is the Taean ship. This ship appears to be made of a slightly modified traditional form than the rest of the vessel. In this conclusion, some characteristics shared by all vessels are discussed, as are some general developmental trends over-time, and the importance of the Taean ship.

All traditional Korean ships, perhaps except for the Taean Ship, relied on heavy plank structures for primary hull strength. These almost rectangular bottom and side planks connected using only wooden joineries created a strong hull, albeit heavy and clumsy appearance. This hull did not require much internal structures for strength because the hull itself provided rigidity. The joinery method of these ships did not change over time. The three bottom strakes consisted the base of the vessel. Even with vessels having five bottom planks, such as the Wando and Daebudo ships, the central three bottom planks acted as the foundation on which other planks were added. All traditional Korean vessels discovered so far have three bottom planks joined using "un-pegged" *jangsaks* that went through all three planks. The bottom planks that were added to the central three planks used "pegged" *jangsaks*, which may be considered almost as *pisaks*.

In a sense, the outer most bottom planks were a part of the L-shaped chine that became flat to increase the cargo capacity at the bottom. The *jangsaks* are almost always placed 0.9–1.1 m apart except when joineries were found on the adjoining central three planks, and joinery (or scarf) bolstered by placing *jangsaks* forward and aft. This bottom structure acted as the fundamental concept in the traditional Korean ships. Another unchanged feature is the side plank building method. *Pisaks* were the main technology used for joining strakes. *Pisaks* acted as an internal framing in some cases, and were made of hardwood, which expanded when wet and secured the joinery. The diagonally placed *pisaks* may be considered a slight variation in applying this method. The spacing appears to be random, but *pisaks* are placed around the scarfs. Often an un-pegged short *pisak* was placed inside the scarf, and served as reinforcement for the joinery. The use of beams is another unchanging characteristic of the traditional Korean ships. However, what may have been a simple bolstering timber quickly developed into an elaborate system of making the hull strong. Perhaps, we can also add the presence of mast slots as an omnipresent characteristic of the traditional Korean ships.

Despite the fundamental concepts of shipbuilding technology remaining unchanged, there were many changes that took place as well. Scholars have attributed the use of L-shaped chine strakes seen in Japanese and Korean vessels as the vestigial structure that developed from a log-boat tradition. It is usually assumed that the vessel developed from a dugout boat, either by adding extra strakes to increase freeboard or adding extra bottom strakes to increase the cargo capacity. The Sibidongpado ship seems to occupy a unique place in the development of ships for it may be the only example of a hull using two, or doubled, L-shaped chine strakes. With such a small section of the hull surviving, it is difficult to make a conjecture as to why two L-shaped chine strakes had to be used. The unfashionable and somewhat crudely made bottom strakes may suggest a recent development from the log-boat tradition, or perhaps it developed from a raft. The question, however, cannot be answered using currently available evidence.

The Wando ship had five bottom strakes and the two of the outer bottom strakes were attached to the central three bottom strakes using *jangsaks* with pegs. The Daebudo ship also exhibits characteristics of a possible box-like shaped vessel, but without the use of the L-shaped chine strake. It is reasonable to assume that the later vessels did not employ the L-shaped chine, but further discoveries may invalidate this statement. The loss of hard chine may have allowed the Korean shipwright to create a shape of the hull more freely. The box-like hull is indeed efficient for carrying cargo, but with the sacrifice of efficient hydrodynamic qualities. The Dalido and Anjwa ships show an almost wineglass shaped turn of the bilge; such a shape usually represents a compromise between the cargo space and the hydrodynamic properties. Combined with the rudder that can be lowered or raised, the sailing quality of such vessels in various sea conditions may have been superb compared to other vessels of the world with similar hull shape at the time.

The graceful curvature of the hull gave rise to a need to make the ship stronger by adding beams. Perhaps, it may have been the other way around; the discovery of efficient or strategic use of the beams may have opened the way for the Korean shipwright to create vessels with graceful lines. The first example of the strategic use of beams — the use of different types of beams as well as the pattern — can be first seen on the Dalido ship. The Wando ship does not seem to have had such a pattern. However, because of the lack of substantial hull remains from the earlier period, it is problematic to propose the exact pattern of evolution with confidence. The general trends toward the increase reliance on internal structure in bolstering the hull can be seen when comparing the Wando ship and the Anjwa ship. The earlier box-like vessels probably did not require much internal structure considering that the bulk of the hull itself provided the hull strength. The shapes of the planks were also adjusted as seen in the garboard of the Anjwa ship, which exhibited various cross-section shapes. The size and shapes of the *pisaks* also appear to vary on later vessels. The earlier, perhaps a simple, brick-like vessel did not require much variation in the shape of the planks and *pisaks*. With the specific shape of the plank and *pisaks*, the shipwrights who built these vessels had to determine which part fitted where and the sizes of mortises. Thus, with the Anjwa ship, we see evidence of marking using ink. The graceful curvature of the hull, however, did not only require internal bracing by beams, but also improvements in holding the seams together. The Anjwa ship is the first example of having caulking material. The changing hull design led to the decrease in holding strength of the seams, and *pisaks* were not enough to hold the seams tight.

The discovery of the Taean ship came as a surprise. This vessel may be the largest vessel discovered, but has possibly the thinnest planks among the traditional Korean vessels. The use of *pisaks* is different than other ships as well. The cargo appears to be of high quality and it may have been a royal carrier or belonged to a noticeably wealthy merchant, set apart from a local cargo carrier such as the merchants who were on board the Wando ship. The difference in hull structure suggests that there might have been different types of vessels built for different purposes. It can also be inferred that there were different shipbuilding traditions. If this was the case, however, it is difficult to explain why archaeologists were unable to find a vessel similar to the Taean ship until now. In addition, the nature of the cargo, which we have not discussed in detail in this paper, was different than other excavated vessels. If we assume that the Taean ship was specifically made for carrying highly valuable cargo, perhaps for overseas transportation, it explains well why no similar vessel was found before. Perhaps, such a vessel needed speed and manoeuvrability more than the cargo space. There are many arguments and counter arguments to be made, but not enough hull remains were found to support or disprove any of the theories that might be proposed. Further surveys may prove the existence of many types of vessels that the Koreans once had. Nonetheless, the Taean ship proved a colourful variety in the traditional Korean ships.

Conclusion

The purpose of this paper is to illustrate the characteristics of the traditional Korean ocean-going vessels based on archaeological evidence. The Goryeo Dynasty was the golden age in Korean maritime history and was an important period in development of Korean vessels. The vessels archaeologists have discovered so far date from the 11th to 14th centuries. Beginning with the Sibidongpado ship, the Wando ship, the Daebudo ship, the Dalido ship, the Taean ship, and the Anjwa ship have all been excavated and reported. This report provides detailed illustrations of hull structures of these local vessels discovered within Korea. Thus readers who wish to study Korean vessels excavated elsewhere should refer to other sources. It is unfortunate that these vessels are not well known outside Korea. It is my hope to engage scholars in the study of East Asian vessels. The detailed descriptions provided in this report may not be relevant to scholars at this point, but it may be used as a "starting point" in learning about these Asian watercrafts. Those who are interested in Korean vessels should refer to the original publications for further studies.[10] We have only illustrated the hull details and structures, and kept the description of other artifacts, such as cargo and personal items, minimal. As this is a preliminary report of the excavated vessels, interpretation of evidence is kept at minimum. Nonetheless, these vessels provide insights into rich and well-developed shipbuilding tradition of Korea. The bottom three planks acted as the fundamental basis for each vessel, and all planks were joined using wooden joineries. The box-like ship with chine strakes gradually changed to a graceful vessel with hydro-dynamic form. The changes led to the development of well-planned beam supporting hull with purposefully made planks. The Taean ship is a unique discovery, which sheds a new light onto possibly more diverse Korean shipbuilding tradition. The research on this subject is only emerging and further discovery will provide a chance for further analyses and new interpretations of the finds described herein.

Notes

1 Seth, M. (2006). *A Concise Sistory of Korea: from the Neolithic period through the Nineteenth Century*. Rowan & Littlefield Publishers, New York.

2 Pak, S. and Xu, J. (1995). *Senna Hoshi Korai Zukyo* (宣和奉高麗図経). Kokusho kanko kai, Tokyo.

3 Cultural Relics and Archaeological Institute of Shangdong Province, Yantai Municipal Museum and Cultural Relics Bureau of Penglai City. (2006). *Ancient Ships from Penglai*. Wenwu Press, Beijing; Sasaki, R. (2008). *The Origin of the Lost Fleet of the Mongol Empire*. MA thesis, Texas A&M University.

4 National Maritime Museum of Korea. (2005). *Gunsan Sibidongpado Haejeo Yujeok* (The Underwater Excavation of the sea off Sibidongpado, Gunsan 群山十二東波島海底遺蹟). National Maritime Museum, Mokpo.

5 Cultural Properties Administration, (1985). *Wando Haejeo Yumul* (Wando Underwater Relics 莞島海底遺物). Seoul, Cultural Properties Administration of Korea.

6 National Maritime Museum of Korea. (2008). *Ansan Daebudo Seon* (Ansan Daebudo Sea Site: Submarine Excavation 安山大阜船: 水中発掘調査報告). National Maritime Museum, Mokpo.

7 National Research Institute of Maritime Cultural Heritage. (2009). *Goryeo Chungja Bomulseon: Taean Daeseom Sujung Balgul Josa Bogoseo* (Taean Treasure Ship: Submarine Excavation 高麗青磁寶物船). National Research Institute of Maritime Cultural Heritage, Mokpo.

8 National Maritime Museum of Korea. (1999). *Balgul Josa Mokpo Dalido Bae* (Excavation of Dalido ship in Mokpo발굴조사 목포 달리도배), National Maritime Museum, Mokpo.

9 National Maritime Museum of Korea (2006). *Anjwa Seon Balgul Bogoseo* (The Excavation of Anjwaship, Sinan). National Maritime Museum, Mokpo.

10 This is in reference to all publications listed as primary sources for each vessel: endnotes 3–9.

6

Identification of materials of the Quanzhou ship and Samed Nagam ship

Shuichi Noshiro

Hisashi Abe

Abstract

This report is a result of wood species identifications on ship timbers from the Quanzhou and Samed Nagam ships. *Cunninghamia lanceolata* (Lamb.) Hook., *Cinnamomum camphora* (L.) J. Presl, and *Pinus* subgen. *Diploxylon* (*Sylvestris* group) are identified to the Quanzhou ship. Woods identified on the Samed Nagam are *Pinus* subgen. *Diploxylon* (*Sylvestris* group) and a diffuse-porous wood. Except for the diffuse-porous wood specimen, all the specimens shows distinct growth rings and this suggests that they originated from trees that grew in subtropical areas, including the areas of lower Yangtze River or Taiwan. In contrast, the diffuse-porous wood specimen does not have growth rings and is from a tropical area.

要旨

泉州船およびSamed Nagam船の部材の樹種を同定した。泉州船にはコウヨウザンとクスノキ，マツ属複維管束亜属（シルベストリス・グループ）が使われており，Samed Nagam船にはマツ属複維管束亜属（シルベストリス・グループ）と熱帯産の散孔材一種が使われていた。未同定の散孔材を除くといずれも成長輪界が明瞭で，揚子江下流域や台湾といった亜熱帯域に生育していた樹種である。それに対し，未同定の散孔材は成長輪界をもたず熱帯域の樹種であった。

Introduction

This report is a result of wood species identifications on ship timbers from the Quanzhou and Samed Nagam ships. *Cunninghamia lanceolata* (Lamb.) Hook., *Cinnamomum camphora* (L.) J. Presl, and *Pinus* subgen. *Diploxylon* (*Sylvestris* group) are identified to the Quanzhou ship. Woods identified on the *Samed Nagam* are of *Pinus* subgen. *Diploxylon* (*Sylvestris* group) and a diffuse-porous wood.

In 2010, six wood samples from the Quanzhou ship at Quanzhou and four wood samples of the Samed Nagam ship were submitted by a Flinders University Department of Archaeology PhD student to researchers at the Forestry and Forest Products Institute, Tsukuba, Japan for identification. The Quanzhou ship was discovered at Quanzhou in Fujiang Province, China, and is dated to 1260–70. The Samed Nagam ship was discovered at King Taksin's dock at Chanthaburi, Thailand, and is dated to the early 17th century. Among the ten samples, two coniferous and two dicotyledonous taxa were recognized (Table 6.1).

Specimen No.	Taxon	Ship	Part
BUN-544	Cunnighamia lanceolata (Lamb.) Hook	Quanzhou ship	sample 1
BUN-545	Cunnighamia lanceolata (Lamb.) Hook	Quanzhou ship	sample 2
BUN-546	Cinnamomum camphora (L.) Presl	Quanzhou ship	forward keel
BUN-547	Cinnamomum camphora (L.) Presl	Quanzhou ship	stern
BUN-548	Cinnamomum camphora (L.) Presl	Quanzhou ship	frame
BUN-549	Pinus subgen. Diploxylon (Sylvestris group)	Quanzhou ship	aft keel
BUN-550	Pinus subgen. Diploxylon (Sylvestris group)	Samed Ngam ship	keelson
BUN-551	Pinus subgen. Diploxylon (Sylvestris group)	Samed Ngam ship	strake 10 portside
BUN-552	Pinus subgen. Diploxylon (Sylvestris group)	Samed Ngam ship	bulkhead 14
BUN-553	Diffuse porous wood	Samed Ngam ship	bulkhead 14

Table 6.1 Identification of materials from Quanzhou and Samed Ngam ships.

The samples were sectioned with razor blades and mounted with Gum Chloral (a mixture of Chloral Hydrate 50 g, Arabic Gum 40 g, Glycerin 20 ml, and pure water 50 ml). Specimen numbers BUN-544 to BUN-553 were applied to the preparations. The preparations are deposited at the xylariorum of Forestry and Forest Products Research Institute (TWTw).

Here we describe the wood anatomical features of the specimens with microphotographs of representative specimens and show the basis of identification. The taxonomic treatment of identified taxa follows Wu & Raven and Wu *et al.*[1]. All samples are presented in Figure 6.1.

Cunninghamia lanceolata (Lamb.) Hook. (Taxodiaceae) (BUN-544 – BUN-545)

Cunninghamia lanceolata is a coniferous wood without resin canals and distinct growth rings. Tracheid diameter changes vary gradually from early- to latewood; volume of latewood is medium, with lumina visible in latewood tracheids. Axial parenchyma with dark brown resin; diffuse or in discontinuous tangential lines occurring usually in latewood. Rays consist only of parenchyma cells, occasionally with brown resin; cross-field pits large taxodioid, with two per cross-field.

Cunninghamia lanceolata is distributed in southern China and Taiwan and includes two varieties, var. *lanceolata* and var. *konishii*.[2] It is impossible to distinguish the two varieties from wood structure.

Pinus subgen. *Diploxylon* (*Sylvestris* group) (Pinaceae) (BUN-549 – BUN-552)

Pinus is a coniferous wood with axial and horizontal resin canals and distinct growth rings. The transition from early- to latewood is rather abrupt; latewood is voluminous, with lumina visible in latewood tracheids. Axial and horizontal resin canals are lined with thin-walled epithelial cells. Rays consist of parenchyma cells and tracheids; horizontal wall of ray tracheids dentate; cross-field pits window-like, with one to two per cross-field.

Pinus subgen. *Diploxylon* (*Sylvestris* group) includes species such as *P. massoniana* Lamb. and *P. taiwanensis*. Hayata growing in southern China and Taiwan, and *P. densiflora* Siebold et Zucc. growing in northeastern China. The identification of *Pinus* species in the *Sylvestris* group from wood structure is difficult. Two species of *Pinus* growing in southeast Asia (*P. merksii* and *P. kesiya*) differ in wood structure from the species in the *Sylvestris* group.

Cinnamomum camphora (L.) J. Presl (Lauraceae) (BUN-546 – BUN-548)

Cinnamomum camphora is a semi-ring-porous wood with distinct growth rings. The transition of vessel size from early- to latewood is gradual: earlywood vessels 150–180 μm, latewood vessels 40–70 μm in tangential diameters; solitary or in radial multiples of 2–3 vessels. Vessels and vessel multiples are rather sparse, with ample ground tissue even in earlywood and simple perforation plates. Axial parenchyma are vasicentric and diffuse, often with large, axially elongate oil cells filled with brown oil. Rays heterocellular with 1(–2) row(s) of upright cells often including oil cells; 2 cells wide.

Cinnamomum camphora grows in southern China and Taiwan. Based on the distinct ring-porosity and large oil cells, BUN-546-548 can be identified to this species.

Diffuse-porous wood (BUN-533)

This sample presents a diffuse-porous wood without growth ring boundaries; vessels solitary or in radial multiples of 2; vessels (40–) 100–200 μm in tangential

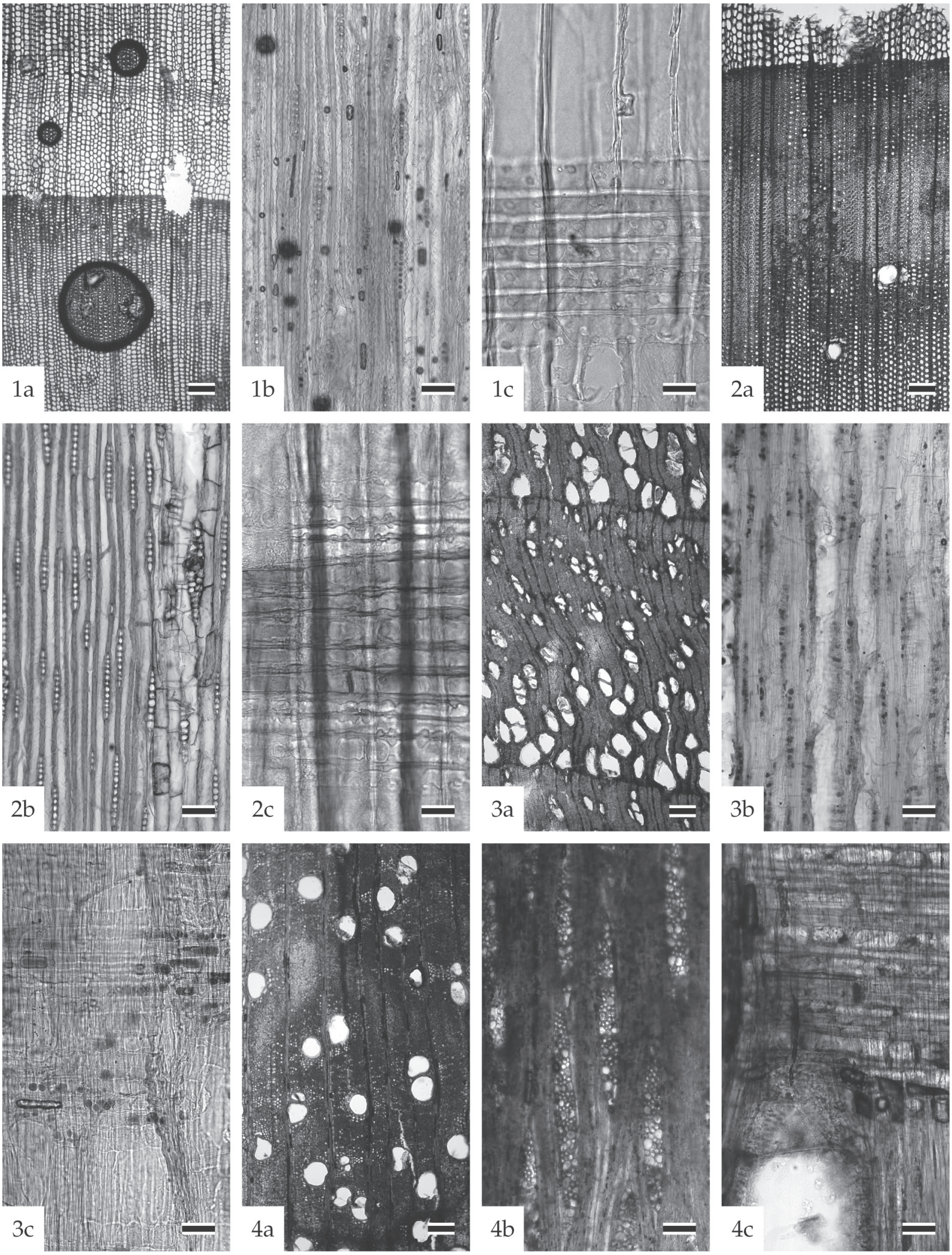


Figure 6.1 Microphotographs of materials of the Quanzhou ship and the Samed Nagam ship.
1a–1c: *Cunninghamia lanceolata* (Lamber) Hooker (BUN-544), **2a–2c:** *Pinus* subgen. *Diploxylon* (*Sylvestris* group) (BUN-552), **3a–3c:** *Cinnamomum camphora* (L.) Presl (BUN-546), **4a–4c:** Diffuse-porous wood (BUN-533). **a:** Transverse section (scale bar = 200 μm), **b:** Tangential section (scale bar = 100 μm), **c:** Radial section (scale bar = 25 μm (1c, 2c), 50 μm (3c, 4c)).

diameters, 4–5.5 vessels/mm^2. Axial parenchyma are vasicentric with diffuse-in-aggregates. Rays heterocellular consisting of a mixture of procumbent, square and upright cells, ca. 3–5 cells wide, 0.55–1 mm tall, marginal rows 1; vessel-ray pitting small with distinct borders, usually alternate, occasionally scalariform. Crystals are absent.

Distribution of axial parenchyma and composition of rays is characteristic of diffuse-porous wood but the specimen could not conclusively be identified.

Except for one diffuse-porous wood specimen, all the specimens had distinct growth rings and were derived from trees that grew in subtropical areas with cessation of growth during winter. However, latewood tracheids of two coniferous taxa had visible lumina, and winter cessation does not seem to be as drastic as that in the temperate zone. Thus, southern China or Taiwan seems to be the primary origin of material timber for these ships. Contrarily, the diffuse-porous wood used for the Samed Nagam ship bulkhead 14 did not show any effect of winter and seems to be derived from a tropical area.

The three identified taxa, *Cunninghamia lanceolata*, *Pinus* subgen. *Diploxylon* (*Sylvestris* group) and *Cinnamomum camphora*, agree with the previous report for the Quanzhou ship, that of the Shinan wreck[3] and historical study of ships making timber of the Song period.[4] Although Chen and the National Maritime Museum of Korea attributed *Pinus* materials to *Pinus massoniana* Lamb., we avoided the species-level identification considering possible use of other species of the *Sylvestris* group growing in southern China or Taiwan. The agreement of the three taxa to those in the previous reports and the above discussion on the formation of growth rings seem to indicate that both the Quanzhou ship and the Samed Nagam ship were probably made in or around southern China, and the bulkhead of the Samed Nagam ship was added somewhere in southeastern Asia.

Notes

1 Wu, Zh. and Raven, P.H. (eds.). (1999). *Flora of China, vol. 4*. Beijing, Science Press, Beijing & St. Louis, Missouri Botanical Garden Press; Wu, Z, Raven, P.H. and Hong, D. (eds.). (2008). *Flora of China, vol.* 7. Beijing, Science Press, Beijing & St. Louis, Missouri Botanical Garden Press.

2 Chen, Z. (1987). 'Quanzhouwan Chutu Song Dai Haizhuan Mucai Jianding (Timber species identifications on the Song Dynasty's ship discovered in the Quanzhou Bay 泉州湾出土宋代海船木材鉴定)', in Museum of Overseas Communication History (ed.), *Quanzhouwan Song Dai Haichuan Fajue yu Yanjiu*. Beijing, Ocean Press.

3 Chen, 1987; National Maritime Museum of Korea. (2004). *The Conservation and Restoration Report of Shinan ship*. National Maritime Museum of Korea, Mokpo.

4 Shiba, Y. (1968). *Commercial Activities during the Sung Dynasty*. Tokyo, Kazama Shobo.

7

長崎県長崎市西濱町出土の所謂「竜骨」とされていた木材に関する調査報告

A report on a keel excavated at Nishihama, Nagasaki, Japan

Kazuma Kashiwagi

Abstract

In 1966, building construction at Nishihama-machi in Nagasaki City, Japan, uncovered a wooden artefact thought to be a portion of a 16th century's ship keel. Although no less than 40 years has passed since its excavation, this artefact has not been officially reported or published. In 2010, the author took the opportunity of recording this artefact at Dejima in Nagasaki City. Nagasaki City developed into one of the largest trading towns of the Edo Period. Therefore, it is possible that this artefact is associated with an historic vessel operational within the foreign trade system in Nagasaki: the Shuinsen "朱印船" Trade System. This research is as a part of Shipwreck ASIA Project which is at present administered by Department of Archaeology, Flinders University, Adelaide, Australia. Results of 2010 author-led research is reported below.

要旨

1966（昭和41）年、長崎県長崎市西濱町に於いて、建築物の基礎工事のために土中を掘削中、江戸時代初期頃の木造船の一部と思われる考古遺物が発見された。発見当時より中国船の竜骨材の一部分と考えられており、それは船体遺構の一部ではあるものの、偶然にも陸上から発見されたものである。発掘されてから40年以上が経過しているが、「竜骨」は長らく調査の手がつけられないままに保管され、従って学術的報告や資料紹介の機会を得ずに今日に至っている。2010年6月、筆者はこの「長崎の竜骨」に関して現地調査を実施する機会を得た。現在の長崎市は江戸期より当時の国内では最も大きな国際貿易港として栄え、「長崎の竜骨」もまたそうした貿易の中で活躍した船舶の一部である可能性が示唆される遺物である。
本調査はオーストラリアのフリンダース大学海事考古学プログラム主導によるプロジェクト「Shipwreck ASIA Project」の一環として、船舶考古資料の情報収集を目的に実施したものである。本稿はその調査に関する事後報告を含めて、「長崎の竜骨」とされてきた木材の資料紹介を行ない、海事文化遺産に関わる貴重な歴史的遺物のデータベースに加えようとするものである。

はじめに

1966（昭和41）年、長崎県長崎市西濱町にて、ビルの基礎工事中に江戸期の木造船の一部として使用されていた「竜骨」らしき木材が発見された。この所謂「竜骨」とされてきた木材は発見されてから40年以上を経過しているものの、正式な学術報告・資料紹介がされぬままに、長崎市により長く保管された状態であった。この度、オーストラリア・フリンダース大学の調査プロジェクト「Shipwreck ASIA Project」のデータ収集活動の一環として、この「竜骨」の実見を計画し、現地へ赴き木材を調査することとなった。本稿はその調査に関する報告と考察を行なうものである。

Shipwreck ASIA Project について

2009年度より2010年8月現在に至るまで、オーストラリアのフリンダース大学海事考古学プログラムにおいて「Shipwreck ASIA Project」と呼ばれる調査プロジェクトが実施されている。このプロジェクトでは公益財団法人トヨタ財団の助成の下、アジアの国々における「沈船遺跡」および「船の遺構」などといった船舶考古資料に関係するデータベースを作成している。同プロジェクトの目的として、「アジアでの海事文化遺産マネージメントとその利用方法を確立」し、そうしたことに関わる「国際的な調査・研究を促進する」ということが掲げられている。

フリンダース大学海事考古学研究室から受け取ったガイドラインや同プロジェクトの公式ホームページを見ると、東アジアでは中国・韓国、そのほかアメリカ・オーストラリア・イギリスなど欧米の海事考古学・船舶考古学・海事史に関わる代表的な研究機関や研究者に協力を仰いでデータ収集をしていることが分かる。

プロジェクトのデータ収集の対象となるものは、wreck site（沈船遺跡／遺構）およびship remains（船舶の部材と特定できる遺物）とされており、また年代・地域・船舶の種類に関しては「東アジア・東南アジア起源の中世の木造船」ということとされている。

NPO法人アジア水中考古学研究所の会員である筆者に協力依頼が来たのは日本国内のデータ収集に関する事項であるが、日本においては中世のwreck siteに相当する遺跡／遺構が現在までのところ数件のみ確認されている状態であるため、現段階ではship remainsに特化したデータ収集となっている。具体的には「鷹島海底遺跡から引き揚げられている木材」および、本稿にて報告・紹介する「長崎市西濱町出土の竜骨」ということになっている。

長崎県北松浦郡に位置する鷹島海底遺跡からは、1980年に最初の調査が開始されてから現在に至るまで、学術調査によって多くの木材片が引き揚げられている。しかしながら、実際に「船舶の部材」と特定できるものはごく僅かしか存在しておらず、その中でも確実に「船舶の部材」と断定できるものとしては木製イカリと隔壁材である。我が国においては、とりわけ近世以前の木造船などに属する船舶考古資料は極めて数が少ないというのが現状である。

調査に至る経緯

「長崎市西濱町出土の所謂『竜骨』」とされてきた木材の存在については、Shipwreck ASIA Projectの担当者からの調査依頼によって知ることとなった。初めに情報収集も含めて幾つかの事前調査を行なった。

Figure 7.1 長崎県地図

中国造船技術史を専門としている山形欣哉氏の著書の中に、この「長崎の竜骨」について言及している箇所があり、当初はこの情報のみしか手掛かりが無い状態であった[1]。氏の著書の中には「長崎市西濱町で1966年、ビルの基礎のため地下を掘っていた際に発見された中国船（後略）」という記述があり、それのみを拠り所として聞き込みを開始することとなった。

長崎市埋蔵文化財課に問い合わせてみたところ「出島の方にある可能性が高い」という回答を得、最終的に所在地として出島復元整備室に辿り着くこととなった。事前に得られた情報によれば、当初この「竜骨」は長崎市立博物館の倉庫に置かれていたものが出島に渡り、暫くの間、出島史料館に展示してあったということである。そして現在では、出島の復元整備事業が進められている敷地内の石倉の中に保管されているということが判明した。

「竜骨」は長い間、倉庫に保管されたままであったが、出島復元整備室の担当者によれば木材は当初からかなり慎重に保管されてあり、養生・梱包も丁重にされているということであった。加えて、木材自体の重量もかなりのものであることから、写真撮影および実測図作成にあたっては充分な作業が出来ない恐れがあるということであった。また、出島の方でも長らく保管してはきたものの、当該木材の実質的な学術的評価や「竜骨」としての可否に関しては曖昧なところがあったようで、今調査に伴って先方より「船の竜骨」であるのか実際に判断して欲しいという依頼を受けることとなった。こうしたことから、作業するには適さない状態であったとしても、実見の価値はありとして実際に現地へ赴くこととなった次第である。

Figure 7.2 長崎市街地図（昭文社『長崎県道路地図』2009より転載）。JR長崎駅より南に1 kmほど下ったあたりに出島町がある。

調査内容

調査は出島復元整備室の担当学芸員の協力のもと筆者が実施し、アジア水中考古学研究所の高野晋司氏の助力を得て作業を進めることとなった。現地調査は2010年6月18日の一日のみ実施した。長崎市出島町の一区画の中に、17世紀から幕末にかけて歴史上「長崎の出島」としてよく知られていた場所が存在しており、現在その復元整備事業が進められている。2010年8月現在、当該敷地内にはオランダ商館を初めとする当時の建造物が復元されており、出島の発掘調査によって発見された各種の遺物・遺品が展示されている。本調査の対象となる「長崎の竜骨」は敷地内にある石倉に保管されているものである。現地での調査としては、初めに木材の計測・作図およびデジタルカメラによる写真撮影を行ない、続いて木材サンプルの採集と詳細な観察および現状記録を行なった。後述するが、木材片は調査後に放射性炭素による年代測定と樹種同定のために化学分析機関へ回すこととなる。

Figure 7.3 出島町と西濱町　（昭文社『長崎県道路地図』2009より転載、一部加筆）。出島がオランダ船との交易港として栄えていた16世紀前葉から幕末にかけての江戸期、扇状の出島は中島川を隔てて現在の江戸町と1本の橋で繋がっているだけであった。

長崎市出島復元整備室所蔵「竜骨」の概要

出土地点には2010年現在商業施設が建っている。出土状況などを記した当時の記録類が見つからないため、出土状況についての詳細は不明である。当時の新聞記事には出土現場の写真が掲載されてはいるものの、不鮮明な部分が多い。過去に、学術報告書や刊行物でこの木材について論考している文献・資料も皆無である。出島復元整備室の話によると、同室からもこの「竜骨」について言及・紹介した出版物などは出してはいないということであり、また最近10年の間には調査研究のために訪れた研究者などもいなかったということであった。

遺物自体の現状を詳述すると、地中から引き揚げる際におそらく電動鋸のようなもので切断されたものと思われ、大きな木材と小さな木材の2つに分断されて保管されている状態となっている（Figure 7.4 and 7.5）。当初、切断した時にはいずれか片方はまだ地中に埋没したままであったということである。恐らく工事中に土を掘り起こしている時に木材が出てきたため、工事現場の作業員が掘り出し、ある程度掘り出した段階で一旦切断して引き揚げ、工事が進行していくに従いもう片方も露見しはじめたところで、残存部分を回収したものと筆者は推測している。従って、最初に回収されたのは小さい方の木材で、後に回収されたのは大きい方の木材なのではないかと考えられる。事実、大きい方の木材を見ると、ちょうど中間付近に、切断しようとして途中で切断するのを中止した痕跡が確認できる（Figure 7.6）。切断が試みられた痕が意味するのは、ここで再び木材を分断しようとはしたものの、下（或いは横）にまだ続いている可能性が高いために切断するのはやはり止めようと判断され、現場作業員が手を止めたということではなかろうか。ここでは仮に、大きな木材を「木材A」、小さな木材を「木材B」と仮称することとする。A・Bそれぞれの木材の法量については、Table 7.1に示す数値となっている。

	木材A	木材B
残存長	395.0cm	194.0cm
最大残存幅	36.0cm	37.0cm
最大残存高	39.0cm	38.0cm
木材の推定直径	50.0cm	50.0cm

Table 7.1　木材A・B法量。

残存幅と残存高については、A・Bともにほぼ近似した数値になっていることが分かる。長さに関してはA・Bをつないでみると、約5.9 m余となる。また木材AとBは、その断面の切り口がほぼ接合でき、元来1本の部材であったものが切断されたのは確実であろうと思われる。

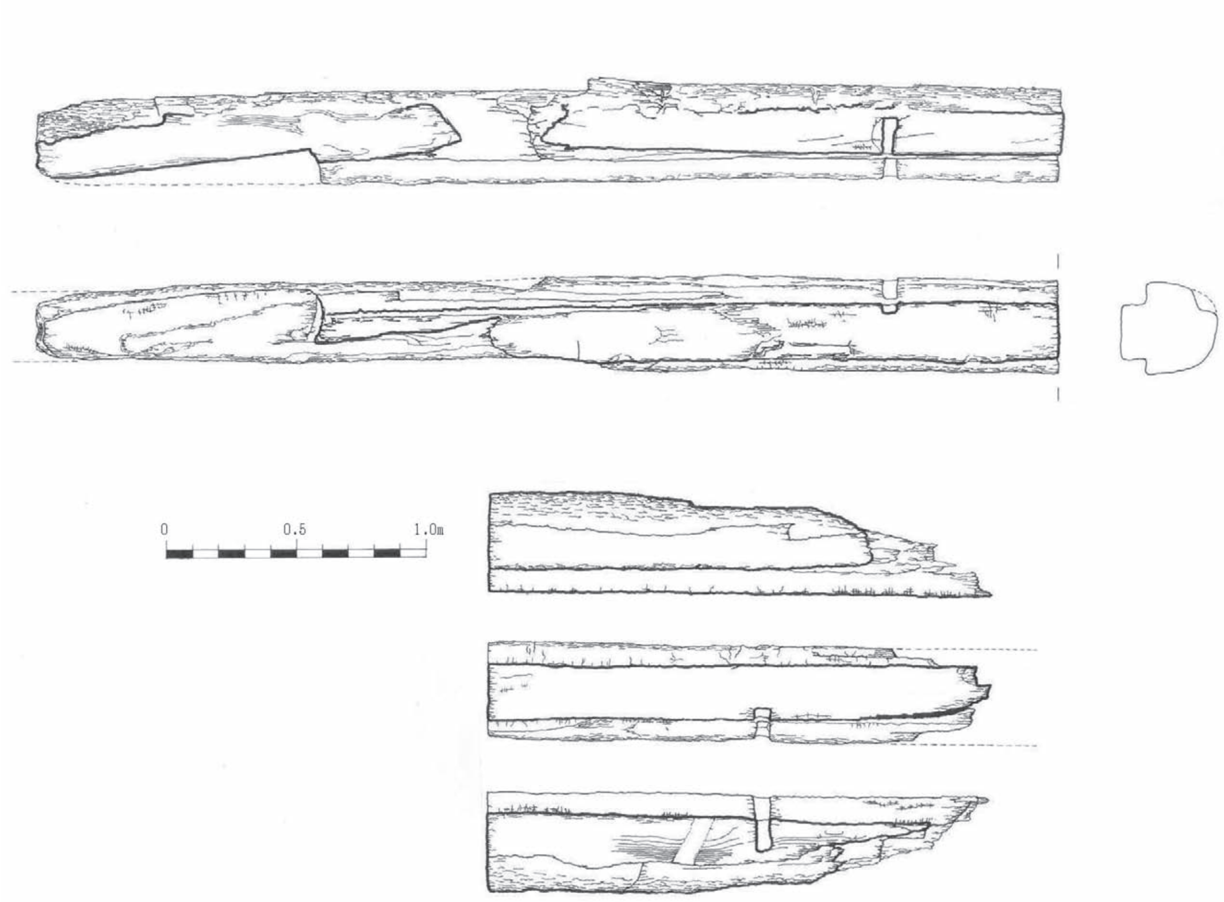


Figure 7.4 実測図（柏木）。長崎市西濱町出土の竜骨（長崎市文化観光部出島復元整備室所蔵）。

Figure 7.5 木材A (左)、木材B (右)（写真：柏木）。

Figure 7.6 鋸による切断が試みられた痕跡（木材A）(写真: 柏木）。

木材の樹種についてはマツ属であるが、日本産のマツ属の種ではないとされる[2]。また、伐採年代・使用年代・廃棄年代については後ほど言及する。

大小2つの木材には特徴的な加工痕が幾つか見られた。実測図上の断面図を観ると分かるように、A・B両方とも、左右両サイドには、前方から後方にかけて竜骨翼板を取り付けたと考えられる切り込みを持つ[3]。切り込みの部分をよく観察してみると所々に腐食した金属物か、あるいは接着剤か、木材同士の隙間を埋めるための充填剤かと思われるコンクリーション（凝固物）が附着している（Figure 7.7）。鉄製品あるいは鉄釘などの使用跡と考えられるが、釘跡・釘穴自体は残存していない。建築現場などで使用するかなり磁力の強い磁石を近づけてはみたものの、磁気反応は全く無かった。

木材Aについては、切断されていない方の先端から切断されている側を見ているとすると、向かって左手側に人工的に深く削られた痕跡が見られる。同様に木材Bの方には、AとBが繋がっている状態で考えると、向かって右手側に同じような切削痕が見られる（Figure 7.8）。これら方形状の凹みは恐らく隔壁などの上部構造を固定した補強材の使用痕であろうか。また木材Aの方には、先端上部に斜めに切り込みの痕があるのが窺われるが、これは船尾竜骨部か或いは船首竜骨部との接合部分を示唆するものであろうか（Figure 7.4参照）。また、木材A・Bともに左右両側面には鉋などで形を平坦に整えたかのような整形痕が見られる。その加工ライン上には、火熱のあとが確認される。実測図で木目が明瞭になっている箇所は、この火熱箇所である（Figure 7.9）。

木材について、過去に保存処理などは施されてきてはいないようで、工事現場から引き揚げられたあと簡単に表面を洗浄処理したままの状態で保管されている。木皮などの残存は見受けられない。全体的な様相から判断するに、木材としての劣化が顕著であり温度・湿度に留意した管理が必要となろう。

電動鋸による切断面を見ると、年輪ははっきりと観察することができる（Figure 7.10）。乾燥などによる細かなひび割れや亀裂は目に付くものの、フナクイ虫による破損・破壊は見当たらない。フナクイ虫とは異なる害虫に齧られた痕跡は若干見られる。

調査結果

法量測定および全体的な観察に基づいて、木材A・Bは「船の竜骨」と判断できると考えられる。具体的に「左右両側面にある竜骨翼板を接合するための切れ込み」および「船首または船尾の竜骨との接合部と考えられる斜めの加工痕」、木材A・Bの呈する全体的な形状・大きさが竜骨としての様相を示しているものと考えられる。

但し、木材A・Bはともに左右両側の切り込みの削り方が荒く、材の断面形状に関して言えば通常の竜骨材とは異なり四角形ではなく船底部分が半円状になっているなど、竜骨部材としては全体的に整形が粗雑である。また腐食した金属物なるものの形跡は

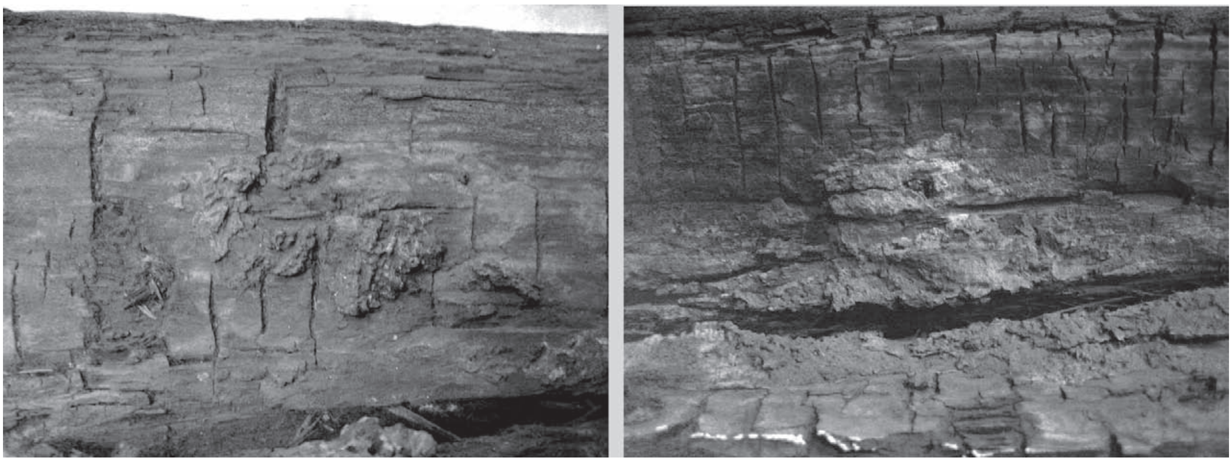


Figure 7.7 金属物の附着（木材A）(写真：柏木）。

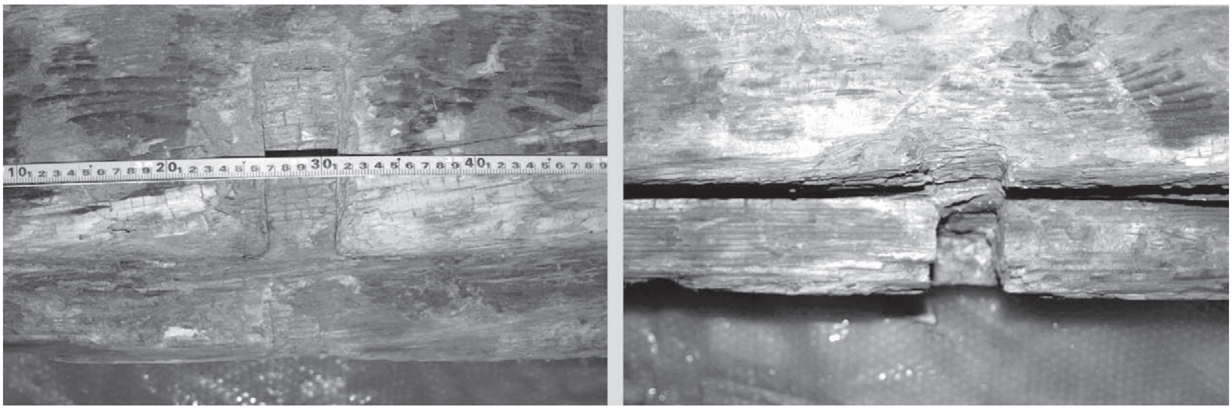


Figure 7.8 穿鑿痕（木材A）(写真：柏木）。

Figure 7.9 火熱による一部炭化箇所（写真：柏木）。

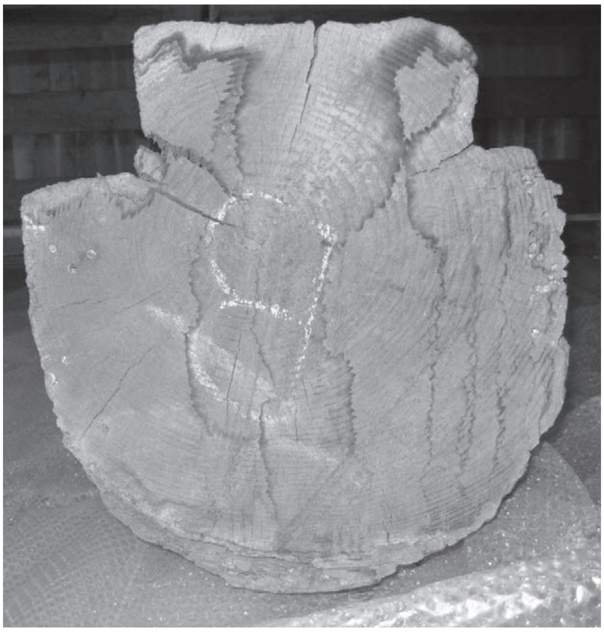


Figure 7.10 切断面と年輪（木材B）（写真：柏木）。

認められるものの釘の打ち込み痕自体が見当たらないところなどは、竜骨としては珍しいケースであると考えられる。

加えて、木材を実際に観察してみると、建築工事の時に土中から掘り出された時には左右両側面の切り込みの部分に竜骨翼板がいくらか残存していた可能性もあることが分かる。残存部分を観察しても、竜骨翼板を含めその他にもまだ部材が附着していたのではないかと推測できる遺存状況となっている。

この竜骨が地中から発見された当時、記事として取り上げている昭和41年3月5日付の長崎新聞を観ると、「地階をつくるため掘さく工事をしていたところ2月28日、地下4 m 50 cmのがた土の中に大きな木造船が横たわっているのを見つけた。出てきたのは船底と船骨の一部で、それ以外は工事区域外であるためわからないがあらわれた船の形からあと3分の1がかくれているものと思われる」となっている。

更に、同年3月7日付の西日本新聞の記事によれば、発見当時の地層の様相に関しては、路面以下3 mまでが赤土の盛土となっており、その下3 mが泥土の層、更にその下1 mは礫層になっているという。船体は泥土の層から検出している。同記事の中にも、現存する竜骨部材以外にも船体の一部が残存していたことを示す記述が見られ、「ヘサキとみられる部分はこなごなになって土といっしょに捨てられている。現在、工事現場の東南のスミに竜骨の残りの部分と側材の2本が顔を出している」と記されている。また、記事によれば、現在の長崎市街の埋め立てが始められた江戸期には、埋め立て工事の際の土木技術として、船の中に土砂を詰め込んで沈めるという方法が採られていたという。

このように、発見当時この竜骨を取り上げている新聞記事を調べると、竜骨の残り部分を含めたその他の船体については、現場が工事区域内と区域外にまたがっていたために、全てを発掘し引き揚げているわけではないことがうかがえる。発見当時、地元の文化財関係者の間では全体を掘り出し保存する動きも見られたようであるが、その実現には至らなかったようである。現在もなお現場の地中に残されたままとなっている残存部の存在が惜しまれるところではある。

考察　―和船の発達過程から観た「長崎の竜骨」の実態―

今回の調査では長崎市西濱町から出土した「竜骨」部材を確認したわけであるが、最も問題とされるのは、この竜骨が果たしてどういった船に使用された船材であったのかということである。

「フネの歴史」というのはかなり古く、日本で人類が生活を始め、その過程の中で「フネ」という道具が考案されてから近代に至るまで、「フネ」というのは構造上の観点から3種類に大別されている。刳船・準構造船・構造船がそれらに相当する。

刳船は、縄文時代・弥生時代・古墳時代の丸木舟などが河底や水田跡などからしばしば発見されるが、その名が示す通り丸太材を縦に割り内部をまるごと刳りぬいて作る舟のことを指す。刳船は形状的に４つの類型に分類されており、割竹型・箱型・鰹節型・折衷型が存在する(Figure 7.11) [4]。　船としては初期段階に相当する刳船は、準構造船・構造船と比較しても簡素で小型の造作となっているものが多い。

刳船の次の段階である準構造船というのは、刳船に若干手を加えたもので、刳船の側面に「棚板（たないた）」と呼ばれる板材を組み足して、船体の両サイドを作ったものである。換言すれば、船底は刳船のままで両舷には板材を接合し構造を持たせた造作を施している船ということになる。時代としては、古墳時代にはもう既に準構造船が使われており、室町時代頃まで使用され続けた。古墳時代の準構造船については、複雑な構造を持った舟の埴輪が出土していることから、また古墳内部の壁画に描かれている舟などから、当時の準構造船の様子を窺うことができる。

構造船と準構造船の違いは、「構造船」の場合、舷側板に加えて船底をも板材で組み立てるというところにある (Figure 7.12)。そうして造作することによって、準構造船よりも船底の船幅を広く保つことができ、結果として船体自体もこれまでの段階の船よりも規模の大きなものにすることができるようになる。刳船から準構造船へ、そして準構造船から構造船へと移行していった背景には、積載量を増やすといった目的以外にも、樹木の乱伐によって刳船を作るのに必要な丸太材が減少し、安価な板材で設計

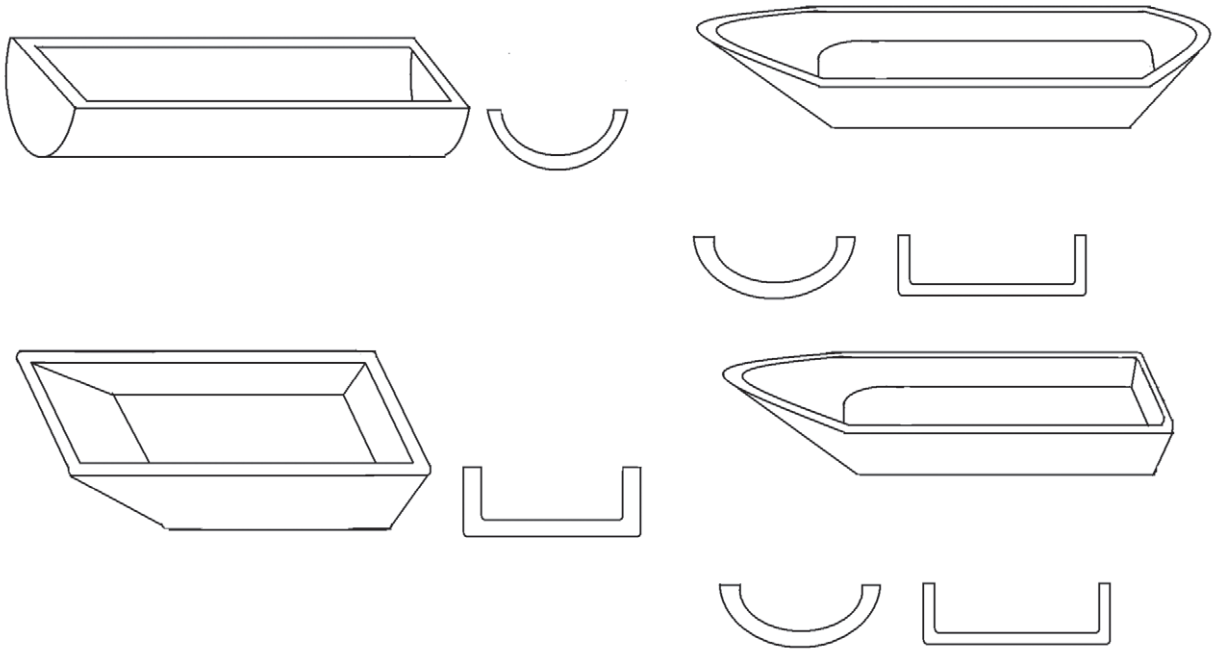


Figure 7.11 割竹型刳船（左上）、箱型刳船（左下）、鰹節型刳船（右上）、折衷型刳船（右下）（石井　1957）。

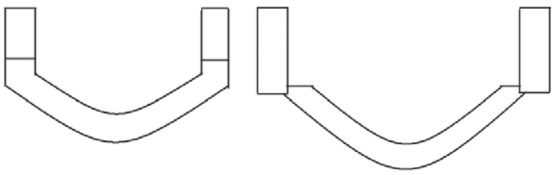


Figure 7.12 準構造船の船底と船縁。

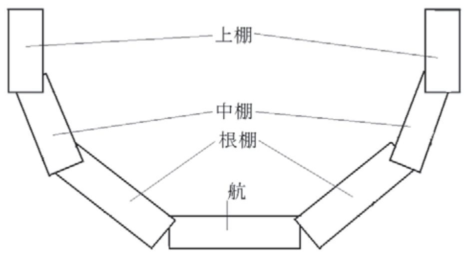


Figure 7.13 航と棚板の接合による構造船。

可能な船が考案されるようになったということがある。こうして、より複雑な機構を持った構造船が作られていく過程の中で、和船には中国を初めとする外国の船舶の造船技術が漸次取り入れられるようになってくる。「竜骨」という部材は、この「構造船」の段階になって登場してくるものである。

構造船の種類について、和船の場合は、大きく分けて日本形・中国形・西洋形という3つのタイプに分類されている。このうち、船体構造上の竜骨を持つタイプは中国形と西洋形に当たる。日本形の場合は、船底には竜骨ではなく「航(かわら)」と呼ばれる構造を持ち、竜骨材は断面がほぼ正方形の角材であるのに対して航の方は断面長方形の板材となっている。竜骨というのは船を建造する際の基軸となる部材である。まず竜骨があってその横にプランク類（板材）が取り付けられ、或いは竜骨があってその上に肋材や隔壁が組み立てられるといった具合である (Figure 7.13)。要は、船というのは「はじめに竜骨ありき」と言っても過言ではなく、竜骨は船体構造の土台となるパーツに相当する。その機能としては「船体の強度と安定性の保持」、「横滑りの防止」、「推進力の向上」などといったことが挙げられる (Figure 7.14)。

長崎市西濱町出土の竜骨が使われていた船に関して、出土地が「長崎の出島附近」という地理的条件から「長崎貿易」に関連するものであることが想起でき、可能性としてはオランダ船・中国船・朱印船交易に用いられた船などが有力なのではないかと考えられる。御朱印船というのは、貿易船として運航していた17世紀、いずれの船も出港地も帰港地も長崎と定められており、「長崎から出港して、長崎に帰ってくる」という形式になっていた。そうしたことから朱印船であった可能性も否定はできない。

筆者自身は出島附近の海難記録を直接確認してはいないが、この竜骨がかつて出島史料館に展示されていた頃の解説を見ると、「ポルトガル船やオランダ船の沈没記録がないことから、朱印船のものと考えられている」と書かれている。

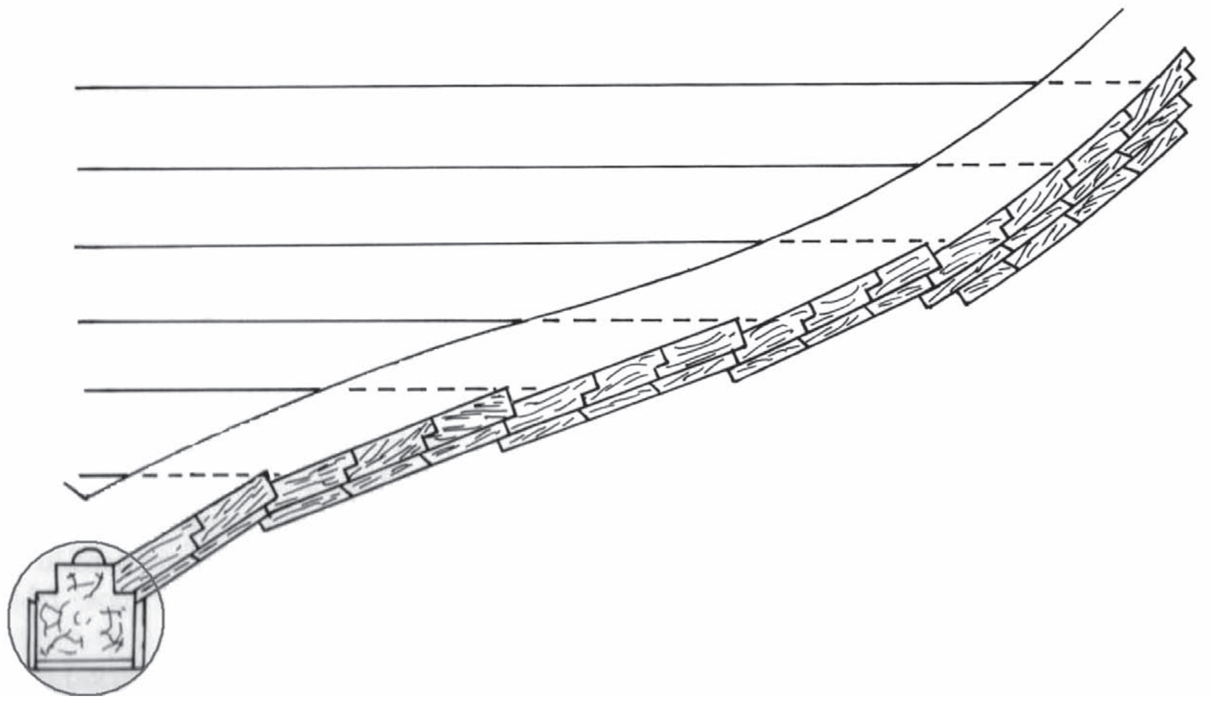


Figure 7.14 中国福建省泉州湾沈没船の竜骨と外板の構造（Steffy 1994 より転載、一部加筆）[5]

この木材の伐採年代に関して、放射性年代測定の結果C14年代が算出され、当該年代を暦年代に較正した数値が出されている。それによれば、1518AD―1634ADの暦年代範囲に入る可能性が68.2%、1492AD―1642ADの範囲に入る可能性が95.4%となっている。また、使用した木材サンプルの年輪が最外年輪には当たらない可能性もあり、暦年代範囲よりも若干新しい時期に伐採されたことも考えられることから、総合的に判断して、船が建造されたのは16世紀初頭から17世紀中頃の間である可能性の高いことで結論付けられている[6]。年代数値としては、朱印船の運航していた時期も収まっている結果が示されている。

1つの考察として、仮にこの船が「御朱印船であった」とするならば、長崎市西濱町出土の竜骨の使用年代と廃棄年代に関しては次のように仮定することができる。現在の西濱町と江戸町附近の埋め立て工事というのが寛文3（1663）年に開始されている[7]。また、朱印船貿易の行なわれていた時期については、1600–1630年代（第3次鎖国令が発令されて海外渡航が完全に禁止された年代）であったという通説を採れば、この船の使用年代と廃棄年代については、「1600年前後から使用され始め、その後、御朱印船としての時期を含めて制度が廃止されたあとも、木造船として機能するまで運航し続け、1660年代に現在の西濱町附近が埋め立てられるのに伴って廃棄処分されたものか」という風に考えられる。

この竜骨が使われていた船の廃船原因としては、木材を見ても残存部分が竜骨の全長には及ばず約6 mと短く、破損している箇所も多いことからしても、老朽化に伴って竜骨が損傷したために廃船にした可能性もあると思われる。既述したように、竜骨というものは船体の基軸となる構造であるため、竜骨部に湾曲・折損などといった損傷ができると、通常は廃棄処分されることが多かったようである。たとえ補修するとしても、それには新たに建造するのと同程度のコストと手間が必要になってしまうため、普通は竜骨が損傷した時点で廃船になっていた。

但し、この竜骨が用いられていた船を「朱印船貿易で使用されていたもの」とするには、当然のことながら問題もあり、上記の根拠からのみでは断定はできない。朱印船貿易に携わっていた船舶は特定の船型を持った船ではなく、様々なタイプの船が利用されていたことから、部材の構造的特徴からは「朱印船」であることを裏付けられるわけではないのである[8]。また、年代測定の数値を考慮すると、朱印船が通用していた時期よりも前の時代の唐船の可能性も指摘される。現時点ではその他の可能性もあることを念頭に入れつつ、課題として今後追究すべき事項であると考えている。

結論

本調査後、採集した木材サンプルの方を、年代や樹種についての詳細な分析を実施するために、株式会社パレオ・ラボおよび森林総合研究所木材特性研究領域に送って分析鑑定を依頼した。これらについては、出島復元整備室から木材サンプルの回収許可を得たうえで分析に回すこととなった次第である。考察の項にて引用したように、この竜骨に用いられた木材の伐採年代および船の建造年代は、年代測定の結果、16世紀初頭から17世紀中頃の間に入る可能

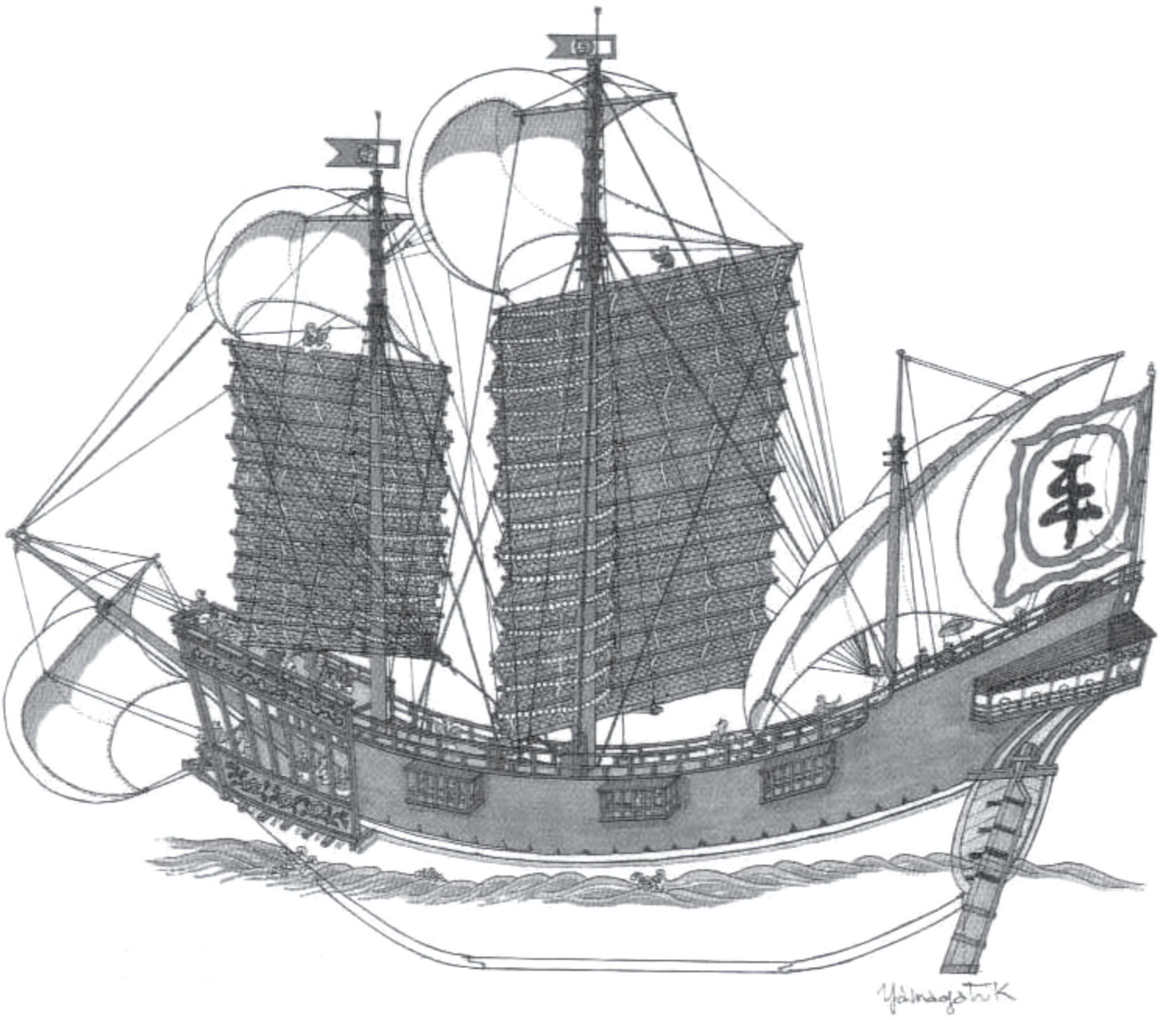


Figure 7.15 朱印船「末次平蔵船」（山形2004より転載）

性が最も高いということが示されている。日本国内における「船舶遺物」の1つとして「長崎市西濱町出土の竜骨」を観たときに言えることは、近世以前の木造船の実物資料としては国内では他に類例も存在しないことから、海事史・船舶史・造船史などの観点から遺物としての学術的な価値は高いものと評価できるということである。また、「船の部材」であるということが明確に判別できる木材資料としては、同じ長崎県の鷹島海底遺跡から検出している木製イカリ・隔壁材に加えて、この竜骨材が新たに挙げられることとなる。加えて、「竜骨」としては国内では初見ということにもなる。そうした観点から見ても「長崎の竜骨」は貴重かつ稀少なship remainsの1つであると評価できるものと考えられる。

謝辞

本調査を実施するに当たっては、竜骨を管理・保管されている出島復元整備室担当者の方には実見の快諾をして戴いた上、調査への協力も積極的にしていただくこととなった。また、アジア水中考古学研究所理事・長崎県教育庁学芸文化課の高野晋司氏には調査の仲介をして戴いたのみならず、資料提供、当日の作業での御協力をして戴くこととなった。本調査関係者の方々へ末尾ではあるが本稿をお借りして深く御礼申し上げます。

Notes

[1] 山形欣哉 2004,『歴史の海を走る 中国造船技術の航跡』図説中国文化百華第16巻（社）農山漁村文化協会　東京。

[2] 森林総合研究所能城修一氏のご教示による。

[3] 竜骨翼板：竜骨の両サイドに直接取り付けられた１枚目のプランク（板材）。

[4] 石井謙治　1957,『日本の船』創元社。

[5] Steffy, R.J. (1994). *Wooden Ship Building and The Interpretation of Shipwrecks*. Texas A&M University Press, College Station.

[6] 株式会社パレオ・ラボによる放射性炭素年代測定結果に基づく。

[7] 長崎市役所 1938,『長崎市史』清文堂出版　大阪。

[8] 永積洋子 2001,『朱印船』日本歴史叢書　吉川弘文館　東京。

Project participants list:

Name	Organisation
Green, Jeremy	Western Australian Museum
Kimura, Jun	Maritime Archaeology Program Flinders University
Dr. Staniforth, Mark	Maritime Archaeology Program Flinders University
Dr. Cai, Wei	Associate Prof./Dir., Shipbuilding History Research Centre, WHUT
Prof. Xi, Longfei	Honorary Professor, Wuhan University of Technology (WHUT)
Zhang, Wei	Underwater Archaeological Research Centre National History Museum of China
Dr. Hang S. Choi	Dept. of Naval Architecture & Ocean Engineering, Seoul National University
Lee, Chul han	National Research Institute of Marine Cultural Heritage
Hayashida, Kenzo	Asia Research Institute of Underwater Archaeology
Miyashita, Hiroaki	Asia Research Institute of Underwater Archaeology
Sasaki, Randall	Institute of Nautical Archaeology, Texas A&M University
Dr. Church, Sally	Faculty of Asian and Middle Eastern Studies, University of Cambridge

Partner organisations:

국립해양유물전시관
National Maritime Museum

INA

トヨタ財団
The Toyota Foundation

SHIPWRECK ASIA

WESTERN AUSTRALIAN museum