

## Watertight bulkheads and limber holes in Ancient Chinese Boats

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### 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、蓬萊古船、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.<sup>1</sup> 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.<sup>2</sup> 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.<sup>3</sup> According to the following research, this vessel also dates to the Tang Dynasty.<sup>4</sup>

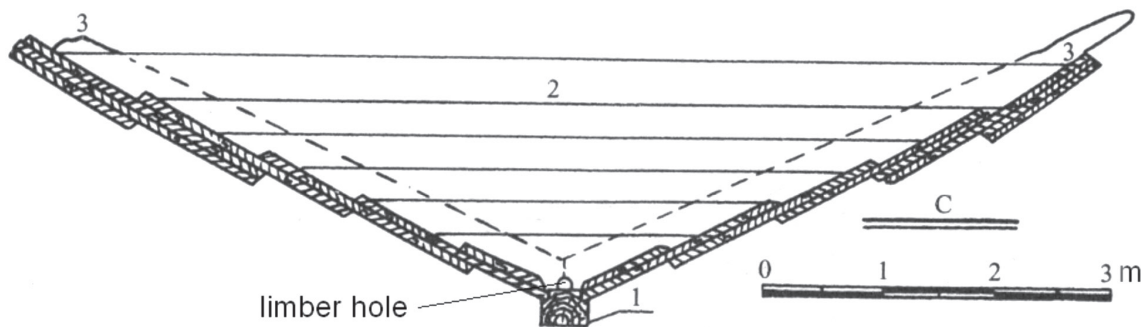


Figure 2.1 The limber hole of the Qunazhou ship in Quanzhou Bay. (Museum of Overseas Communication History 1987)

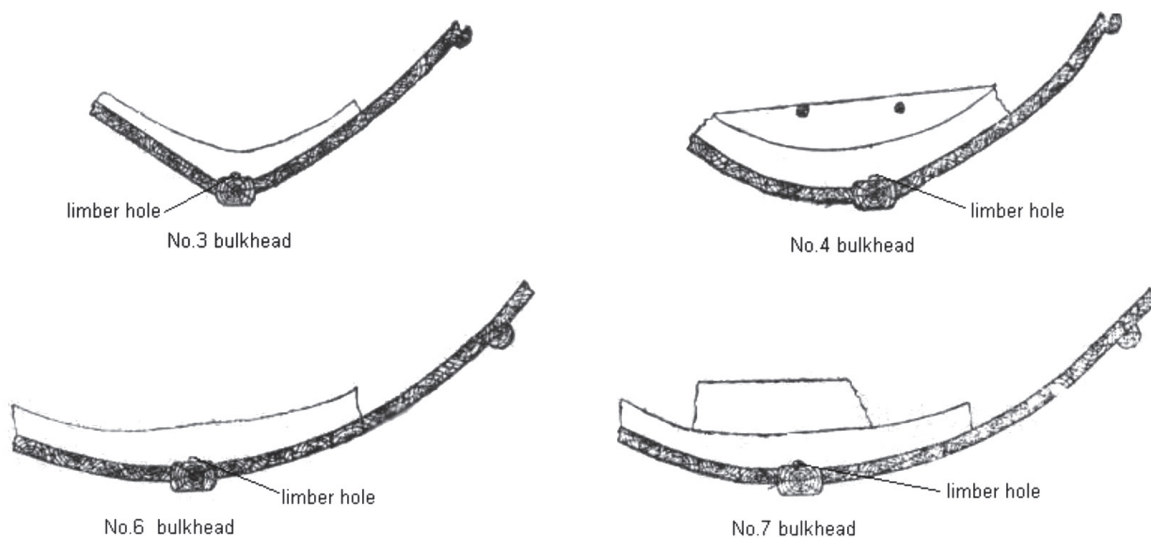


Figure 2.2 The limber hole of the Ningbo ship in Ningbo. (Reproduced from Lin 1981)

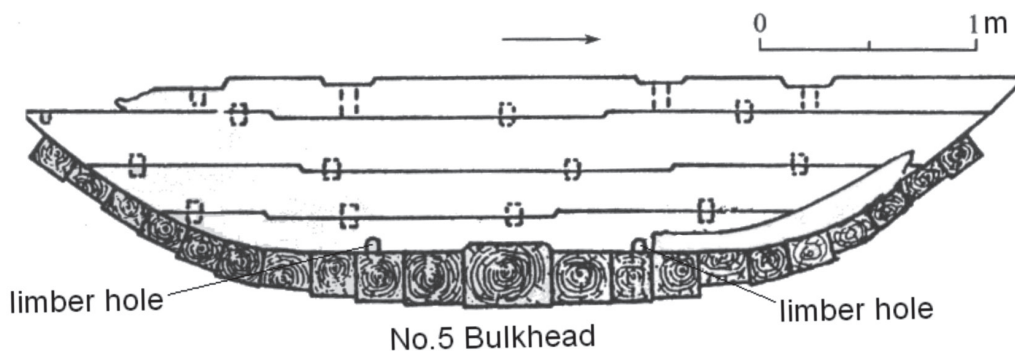


Figure 2.3 The limber holes in No.5 bulkhead of the Penglai ship. (Xi 1989)

### 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).<sup>5</sup>

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).<sup>6</sup>



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

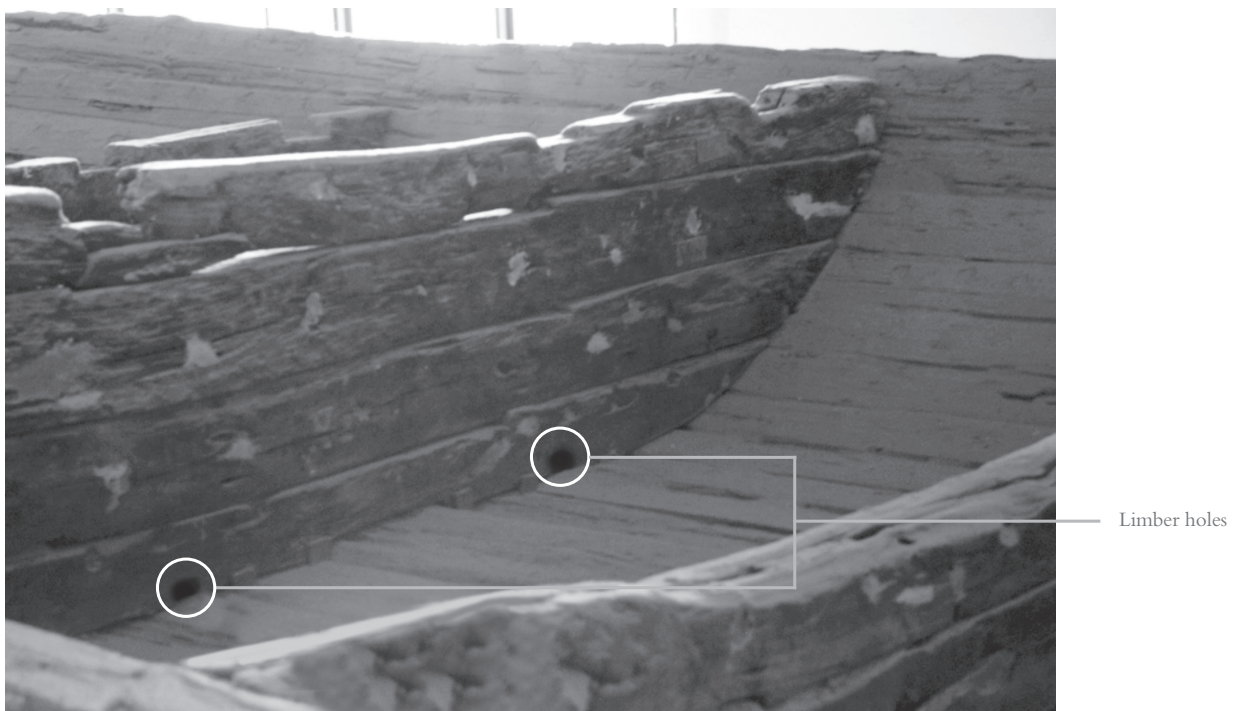


Figure 2.5 The limber holes of the Penglai ship. (Produced by authors)

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).<sup>7</sup> 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.

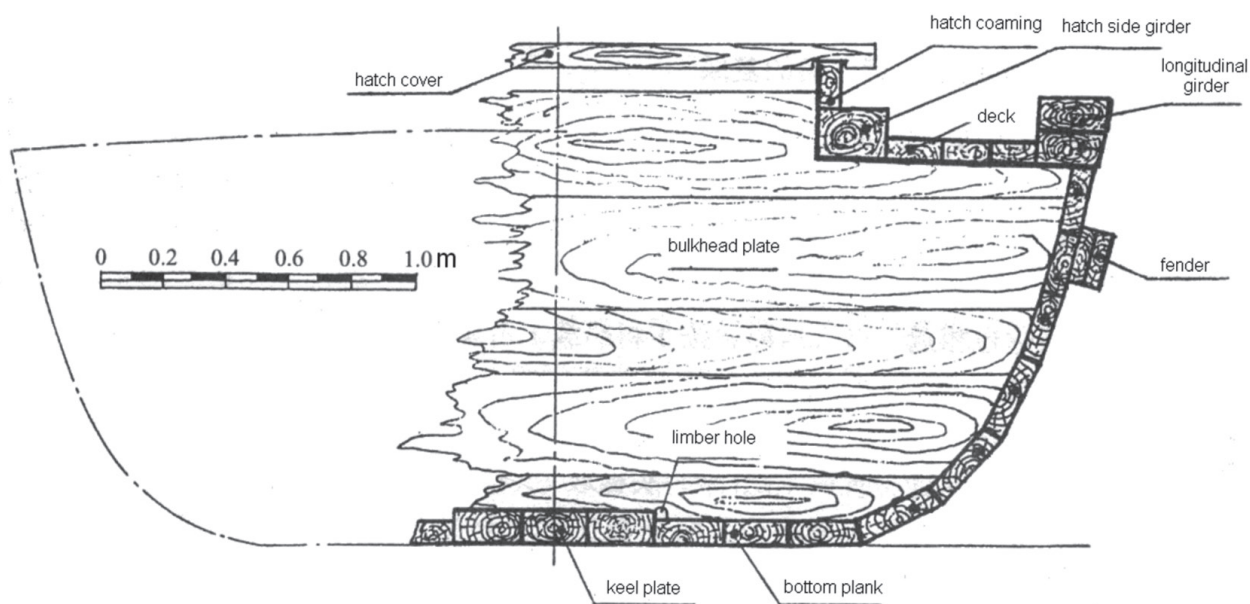


Figure 2.6 The No.8 watertight bulkhead of the Liangshan ship and the limber hole. (Xi, Yang, *et al.* 2004)

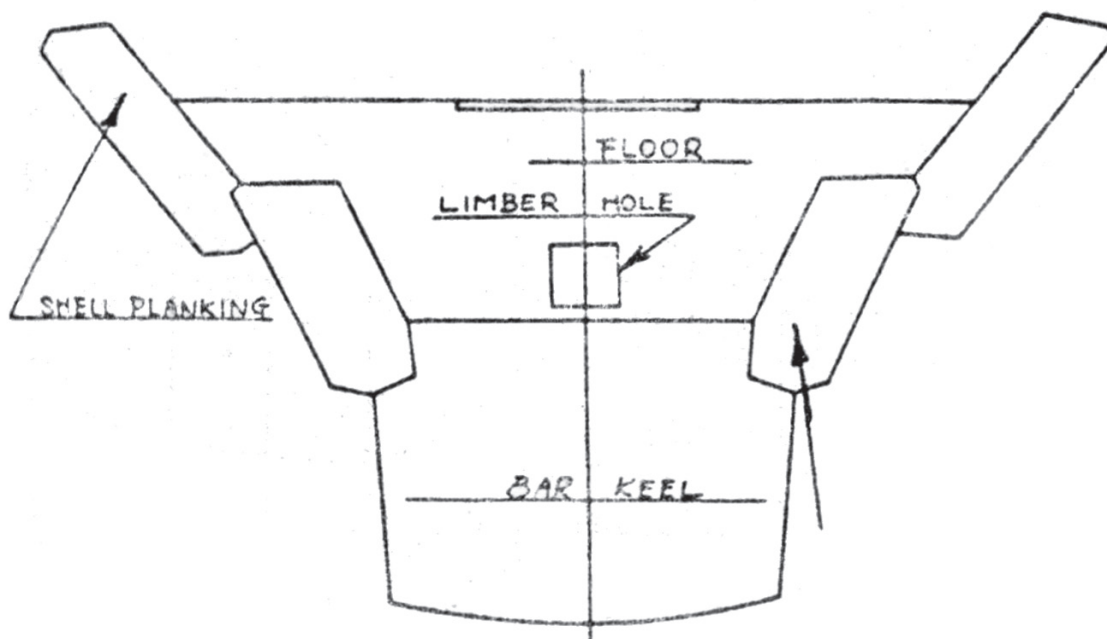


Figure 2.7 The square hole on the bulkhead of the Shinan shipwreck. (Lee 1991)

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.<sup>8</sup> 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.<sup>9</sup>

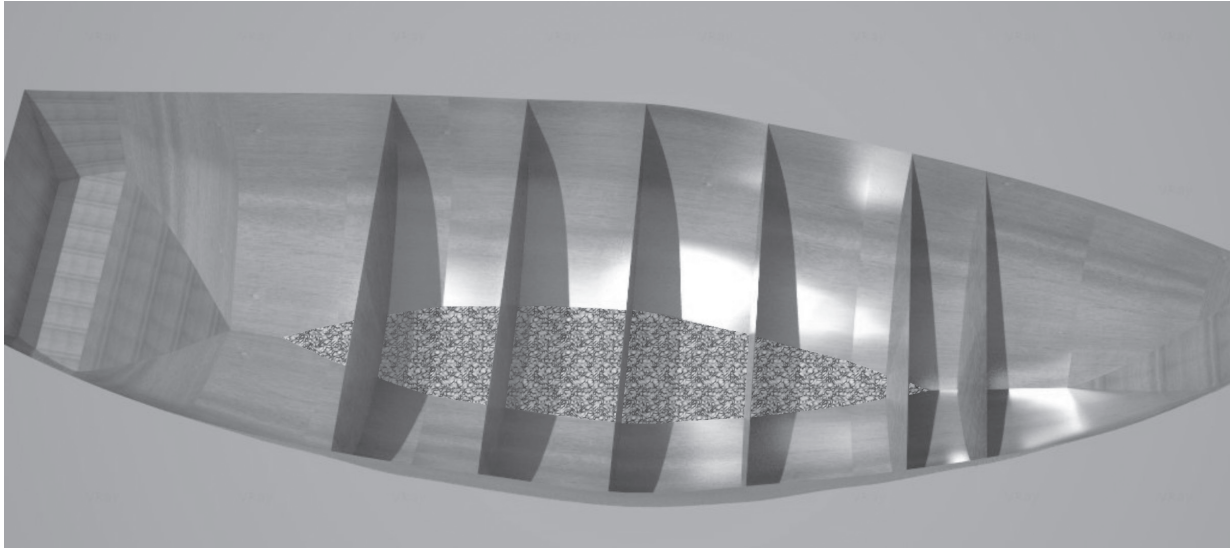


Figure 2.8 The illustration of a 3D-model of a ship floating on even keel. (Produced by authors)

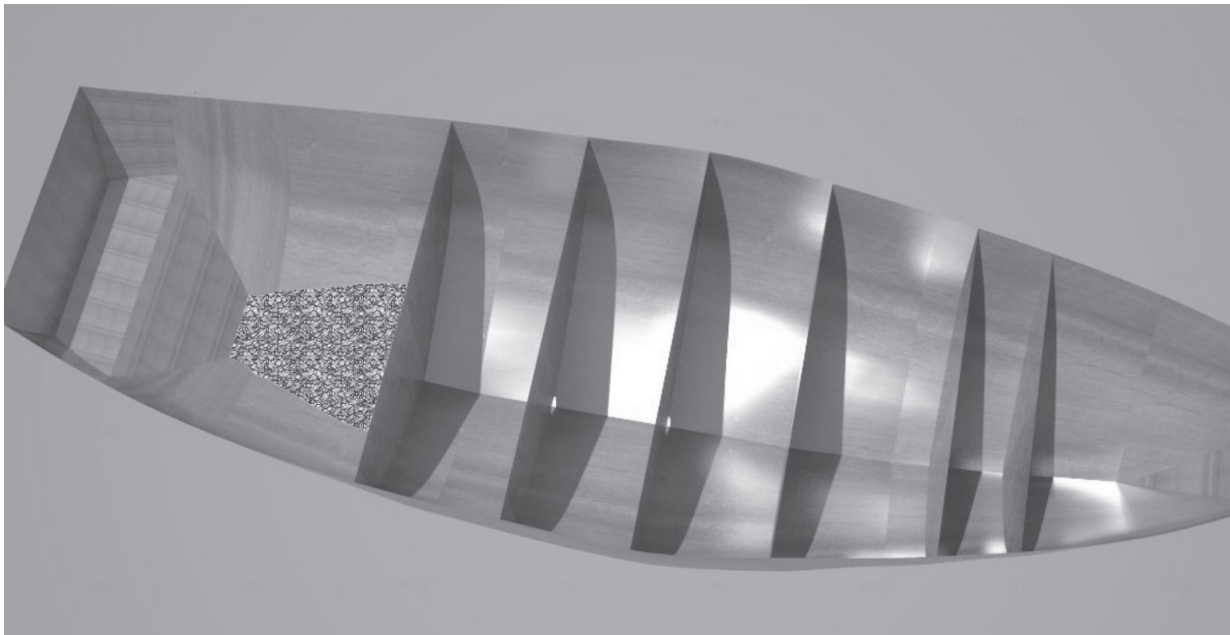


Figure 2.9 The illustration of a 3D-model of a ship trimming by stern, water concentrated on the stern cabin through limber holes. (Produced by authors)

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".<sup>10</sup>

### 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 been 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.<sup>11</sup>

## 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

- <sup>1</sup> 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.
- <sup>2</sup> Nanjing Museum (1974). 'The wood ship of Tang Dynasty of China in Rugao', *Historical Relic*. 5: 88.
- <sup>3</sup> Heritage Task Force of Jiangsu Province. (1961). 'An ancient wood ship found in Shiqiao of Yangzhou', *Historical Relic*. 6: 54.
- <sup>4</sup> Zhu, J. (1986). *A Famous Port of Maritime Silk Road: Yangzhou*. Beijing: 50.
- <sup>5</sup> 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 泉州湾宋代海船发掘与研究)*. Beijing, Ocean Press: 17.

- <sup>6</sup> 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.
- <sup>7</sup> 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.
- <sup>8</sup> Xi, Yang, *et al.* 2004: 193.
- <sup>9</sup> 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.
- <sup>10</sup> Lee 1991: 119.
- <sup>11</sup> Personal communication, Mr Wei Wenxi, 2009.