Preliminary analysis of timber and metal remains from *Shah Muncher* Shipwreck

By

Ng Jian Cheng Michael

Thesis submitted to Flinders University in partial fulfilment for the degree of

MASTER OF MARITIME ARCHAEOLOGY

Archaeology

College of Humanities, Arts, and Social SciencesFlinders University

August 2022

TABLE OF CONTENTS

ABSTRACT

In 1796, a Country ship, *Shah Muncher*, sank in the vicinity of Pedra Branca, a rock outcrop situated in the middle of the entrance to the Singapore straits from the South China Sea. During a geophysical and diver visual survey conducted in 2019, *Shah Muncher*'s ship remains were found. Subsequent archaeological excavations on the shipwreck between 2019 and 2021 revealed a plethora of scattered remains consisting of ceramics, glassware,organic remains, cannons, anchors, and small timber and metal fragments associated withthe ship's structure.

Country ships were constructed in India by local shipwrights, but their design and appearance exhibited European shipbuilding traditions. They were heavily involved in the maritime trade between China and India from the eighteenth- to the nineteenth-century. These ships are fitting examples to illustrate the cross-cultural connections between the theoretical aspects of ship archaeology, which include technology, tradition, economics, purpose, environment, materials, ideology and the social aspects onboard the vessel.

This research embarks on an archaeometric approach to study the timber and metal fragments from *Shah Muncher*. It aims to identify the structural features of the vessel and how they compare with archaeological remains of other Indian and British colonial-built vessels. The study informs on technology, tradition, environment, material and possible cross-cultural connections on *Shah Muncher* and reveals its connections with other contemporary British colonial-built vessels. Results from the analysis identified various similarities and differences in ship construction and techniques between *Shah Muncher* and other contemporary Indian and British colonial-built vessels. Findings from this research contributes to the understanding of British colonial shipbuilding during the eighteenth and nineteenth centuries. Furthermore, it provides valuable insights into the maritime cultural landscape within the Singapore Straits.

Keywords: Country ship, British colonial shipbuilding, Singapore Straits, timber analysis, metal analysis, eighteenth to the nineteenth century, Master's thesis.

DECLARATION

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed..

Date.. **18 AUGUST 2022**

ACKNOWLEDGEMENTS

This thesis is a product of blood, sweat, tears and a tremendous amount of caffeine.It was completed because of the support I received. Support from people around me and the organisations to which I belong. This section is dedicated to these people and organisations for helping me to see my thesis through.

Firstly, I would like to express my appreciation to ISEAS – Yusof Ishak Institute and the Tun Dato Sir Cheng Lock Tan Trust Fund. Thank you for the scholarship and opportunities I received, which helped me grow as an archaeologist and an academic. In addition, I would like to thank Dr. Terence Chong for his support and Dr. Michael Flecker for his guidance and input.

To my supervisor, Wendy van Duivenvoorde, thank you very much for your guidance, teaching, and encouragement throughout my education in the Maritime Archaeology Program at Flinders University. I genuinely appreciate the advice and patience you gave me despite my numerous issues and complications. Nonetheless, I always enjoyed our consultation times, and working with you is always a pleasure. You inspire me to be a better maritime archaeologist.

A shout out to my friends from the PB dive team. I would like to thank you all for working with me on the project. Without your help, I would not be able to use the artefactsfor this research. A special thanks to Jason Khoo and Kyna Khoo. Thank you for helping mewith documenting the artefacts for this research.

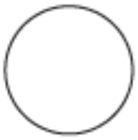
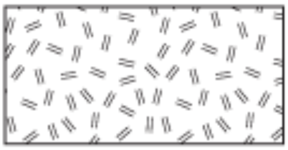
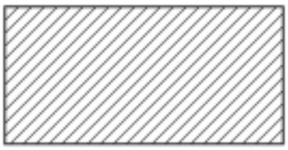
Thank you to my friends currently in Adelaide, Thailand, South Korea and Japan. The emotional and physical support I received from you helped me get through my days working on my thesis and my studies. I spent 80% of my time in Adelaide, cooped up in my room, but the rest of the time I spent with you all illuminated my life when I was most down.

To my friends back at home. Thank you for all the supportive messages and chats. Those little messages and chats may not amount to anything, but they mean a great deal to me. As I am neck-deep in my studies, I am physically missing many of our gatherings. Thank you for your patience, but I will be back to join you since the gathering restrictions are lifted.

Thank you, mum and dad. I am genuinely thankful for your unwavering support since I embarked on a journey to be a glorified garbage collector. Thank you very much for supporting my dream. The encouragement, the care, the nourishments, and the help I received were instrumental to my well-being. I am eternally grateful to you both.

To my wife, Wenny, I am genuinely thankful for your support and encouragement. Thank you for believing in me and being there for me every step of my thesis journey. You are my sunshine.

TIMBER DRAWING LEGEND

	Empty round hole
	Empty square hole
	Treenail
	Round metal fastener
	Square metal fastener
	Metal sheathing layer 1
	Metal sheathing layer 2 or Encrustations
	Shading to accentuate depth perception

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

1.1 Background

In 2015, a shipwreck was found around Pedra Branca. Archaeological surveys and excavations took place between 2016 to 2019 on what is now known as the Temasek shipwreck. The shipwreck was the first site found along the Singapore Straits that dates to the fourteenth century. The recovered artefacts from the site contained largely ceramics, small quantities of glass beads and metal artefacts related to the fourteenth century. Most of these ceramics are consistent with those found at fourteenth-century terrestrial sites in Singapore (Miksic 2013; Flecker 2022b:47). These cargo items indicate the associations between fourteenth-century Singapore, the shipwreck and long-distance socio-economic value chains from China and Asia-Pacific to the west (Figure 1). The implications are local and global. According to a preliminary analysis, the wreck's cargo consisted of Chinese ceramics similar to other contemporary wrecks in Southeast Asia. These shipwrecks include the Sinan wreck in Korea; Jade Dragon wreck in East Malaysia; Turiang wreck in West Malaysia; Dalian Island wreck in Fujian, China; Bin Chau wreck from central Vietnam; Shiyu 2 wreck at the Paracel islands, near Hainan Island, China; Red Sea wreck in the Red Sea; Nilaveli wreck near Trincomalee, Sri Lanka; and the Samar wreck found in the Philippines (Flecker 2022b:55–58). These shipwrecks carried ceramic cargo typical of the fourteenth century, but the quantity and variety of blue-and-white Chinese ceramics were much lesser than the Temasek shipwreck (Flecker 2022b:55–58). These ceramics are unique from a maritime trade perspective, as pre-Ming blue-and-white wares dating to the Yuan dynasty are rare. It intimates a technological, production and socio-economic exchange system not well understood to date.

Figure 1: Fourteenth-century blue and white hookah bottle found at the Temasek Wreck. Artefact found in- situ (Left) and artefact after conservation treatment (Right) (M. Ng, 2022).

In 2019, the local authorities approved a project to ascertain the possibilities of other underwater archaeological sites around the Temasek shipwreck area (Flecker 2022a). After a series of geophysical and diver visual surveys, the team found another shipwreck near a modern wreck (Figure 2 and 3). The surveys at the site revealed artefacts such as ceramics and two admiralty anchors. Archival research and analysis of artefacts from the site suggest that the wreck was *Shah Muncher*, a Country ship which sank in 1796 (Flecker 2022a). Further excavations in 2020 and 2021 revealed large quantities of ceramics, semi-precious stones, zinc ingots, timber fragments, two additional anchors, 24 cannons, and other remains, yielding essential data about the shipwreck.

Shah Muncher gives essential insights into the continuing maritime trade and seafaring culture along the Singapore Straits before Singapore was established as a British trading post in 1819. Country ships, like *Shah Muncher*, were vessels built in India using locally sourced materials but exhibited European ship designs (Bulley 2013; Flecker 2022a). They played a vital role in maritime trade between China and India. These ships were privately owned merchant vessels that operated under license from the East India Company. They were allowed to trade from China to Southeast Asia, Australia, India, the Persian Gulf, the Red Sea, and Africa's east coast, but they were prohibited from venturing west of the Cape of Good Hope to avoid challenging the East India Company's trade monopoly between China and Europe.

Figure 2: Magnetometer survey in search of shipwrecks around the vicinity of Pedra Branca (M. Ng, 2019).

Figure 3: The modern shipwreck, MV *Woodburn*, found around the vicinity of *Shah Muncher* wreck site during the diver visual survey (M. Ng, 2019).

1.2 Research Design

1.2.1 Research Question

This paper's primary research question is as follows:

How do the ship remains of the Bombay-built *Shah Muncher* compared to those archaeological remains of other Indian-built ships, and what comparisons can be drawn with existing studies on British colonial-built vessels?

1.2.2 Research Aims

The research aims to identify the structural features of the eighteenth-century Country ship, *Shah Muncher*. In addition, the research aims to achieve the following objectives by analysing the timber and metal remains from the site.

- The structural features of *Shah Muncher* that can be identified from the ship's timber and metal remains.
- Highlighting possible differences between Bombay-built Country ships and other Indian-built ships.
- Highlighting possible differences between Bombay-built Country ships and other eighteenth- to nineteenth-century British colonial vessels.

Ultimately, this study contributes to the current understanding of the eighteenth-century British colonial and Indian shipbuilding features, revealing more about the people involved in this vital maritime industry.

1.2.3 Methodology

This research relies on analysing the ex-situ timber and metal remains to identify the construction features of *Shah Muncher*. A sizeable quantity of organic materials and metal remains was observed during the excavation, but most of these remains have lost most of their contextual information due to the discontinuous nature of the site. In addition, the site was no longer accessible after June 2021. Therefore, only a portion of these remains were retrieved. These remains were selected based on the presence of diagnostic features and if they contained distinctive characteristics.

Firstly, the remains were catalogued before research could be conducted. The catalogue ensures that all the artefacts retrieved from the site are adequately accounted for throughout the research process. Once the catalogue is completed, the author proceeds to select the artefacts for this research. Finally, the artefacts were documented before and after samples were extracted for species or compositional analysis.

The timber remains were studied individually. Each timber was recorded in detail to include tool marks, assembly and construction marks, the size and shape of the timber remains, and identification of the species and function. Similarly, the metal remains were examined empirically, looking into the metal's composition, size and shape, and any assembly and construction marks. To ensure proper methods and approaches were used during the research, the author consulted several kinds of literature that analysed timber and metal remains (Bennett 2021; Creasman 2010; Historic England 2010; Viduka and Ness 2004; Lev-Yadun 2007).

The data obtained from these analyses were compared with existing literature on Indian-built ships or other contemporary sources and research on shipbuilding. Information from *Shah Muncher* was compared with timber and metal analysis data from *Edwin Fox, Endeavour, HMS Buffalo, Quedagh Merchant* and *Sydney Cove.* Other comparative information sources include studies examining a specific type of remains, for example, Staniforth's (1985) paper on the use of copper sheathing.

1.2.4 Permissions and Consultations

The National Heritage Board (NHB), Singapore, a government statutory board, approved and financed the *Shah Muncher* archaeological projects. They appointed ISEAS–Yusof Ishak Institute, Archaeology Unit, as the legal custodians for all the archaeological materials and information on *Shah Muncher*. Permissions were obtained from ISEAS–Yusof Ishak Institute and NHB to access the artefacts and use them for further analysis due to the site's sensitive nature.

1.3 Site Description

Pedra Branca is a rock outcrop located 24 nautical miles east of Singapore (Figure 4). In 1851, a lighthouse was constructed at the site to forewarn ships of its surrounding hazards. *Shah Muncher* wreck site is located 300 metres east of Pedra Branca (Figure 5). In its immediate vicinity was a modern wreck MV *Woodburn*, which sank in November 1963. Remains of *Shah Muncher* were identified at two locations (Figure 6). Most of the remains were concentrated at the primary site near the modern wreck. Two Admiralty anchors, possibly associated with the wreck, lay 100 metres south-south-west of the primary site and were 30 metres apart. Four pintles were also discovered clustered around Anchor #1.

Figure 4: Location of Pedra Branca in relation to Singapore (Wikicommons).

Figure removed due to copyright restriction.

Figure 5: Location of *Shah Muncher* (wreck 2) relative to Pedra Branca (Flecker 2022a).

Figure removed due to copyright restriction.

Figure 6: Site map showing the distribution of artefacts associated with *Shah Muncher* (ISEAS–Yusof Ishak Institute, 2022).

The primary site consists of two artefact distribution areas (Figure 7). The first area was a sediment-filled basin surrounded by rocks. The depth of the sediment-filled basin was 11 metres. This basin covered an area of 50 metres by 25 metres at its widest and was segmented into the grids C5 to C14. During the excavation of grids C5 to C14, no stratigraphy was observed in the sediment-filled basin. Artefacts were generally found within one metre of sedimentary context above the bedrock. Grids C13 and C14 consisted of a rocky slope with adjacent large boulders. The rocky slope extends to around ten metres before it levels off to flat terrain with a depth of six to seven metres. The second area is denoted by grids E6 to E12 (Figure 9) and D7 to D12. E6 to E8 and D7 to D8 was the rocky slope area. The entire second area measured approximately 30 metres by 30 metres and consisted mainly of rocks and boulders with pockets of sediments. The ditto remaining anchors and the 24 cannons were observed scattered across the second area (Figure 8). A gudgeon, some copper sheaths and timber remains were also observed at the intersection of C14, E8 and E9 grids. Some stratigraphy was observed in this area during the excavation. Artefacts were concentrated in the deep holes and gullies between the rocks and boulders (Figure 10). In these deep holes and gullies, the first layer was sheet corals which covered over a layer of zinc ingots. The next layer consisted of large stone rubble, which may be the ballast used on the ship. Beneath this rubble were the ceramic, glass, organic and metal remains.

Figure removed due to copyright restriction.

Figure 7: The primary site consists of the two main artefact distribution areas: the sediment-filled basin (C5 – C14) and the cannon flats (E6 – E12, D7 – D12) (Flecker 2022a).

According to the preliminary report (Flecker 2022a), the second area, also known as the 'Cannon Flats', was the possible final resting place of the ship when it sank in 1796. The 'Cannon Flats' was not flat at the time of the sinking. Instead, the terrain was possibly modified as the ship started to disintegrate. Cargo and dunnage were first dispersed, followed by ceramic artefacts. The zinc ingots were thought to have been stacked in the midship area. They eventually collapsed and dispersed with the ballast stones due to the strong currents and surges.

Figure removed due to copyright restriction.

Figure 8: Distribution of the 24 cannons and 2 anchors at the 'Cannon Flats'. A possible projection of *Shah Muncher*'s position when it sank (Flecker 2022a).

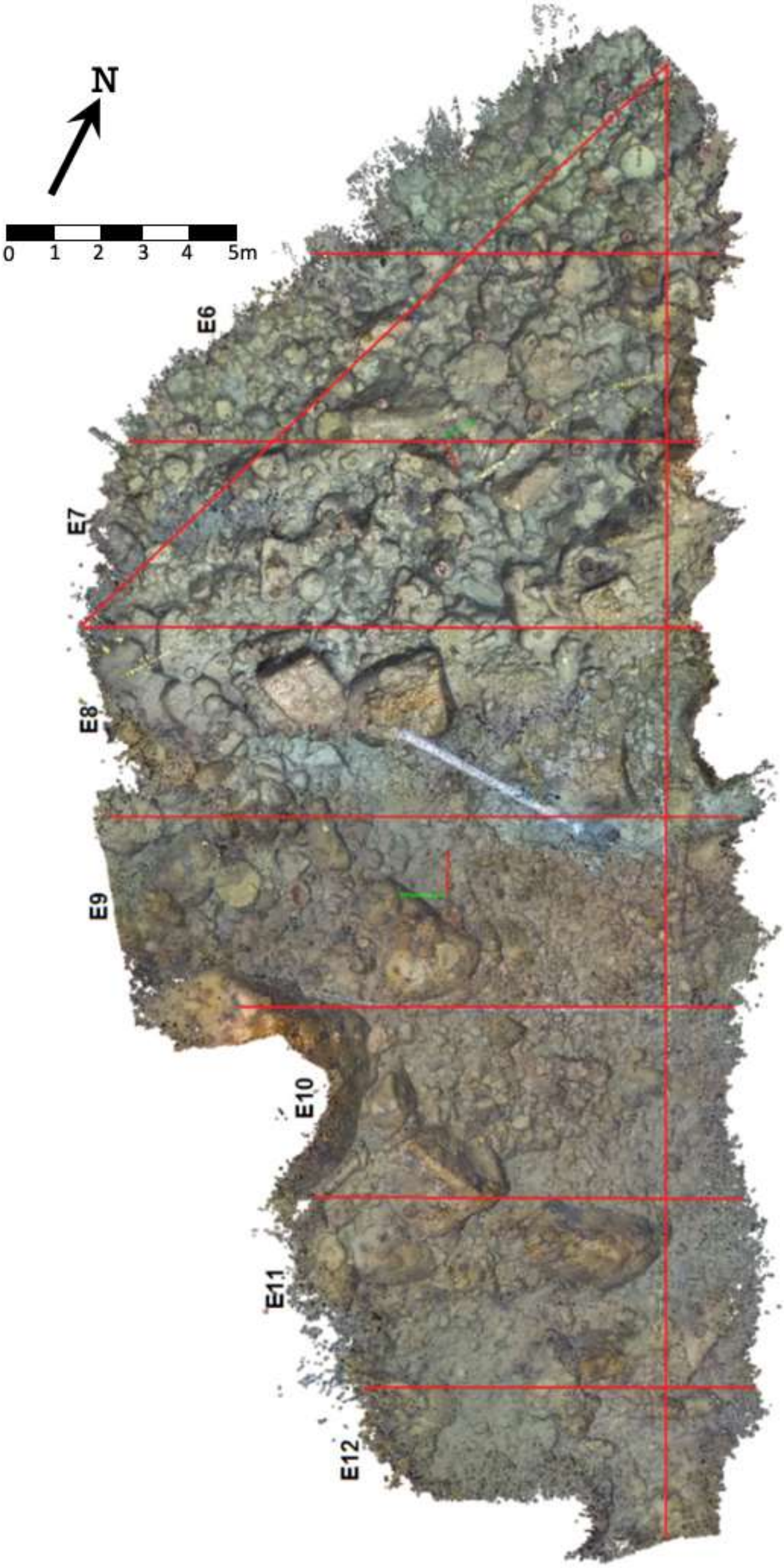


Figure 9: Photogrammetry of the E-grids at the 'Cannon Flats', illustrating the site's terrain (M. Ng, 2022).

Excavation at the site concluded in June 2021. The artefacts retrieved from the site were stored and are undergoing a conservation process at a secured facility in Singapore. A total of 4 anchors and 24 cannons were observed at the site; however, only 9 cannons and 4 anchors were successfully relocated to another underwater site to undergo ex-situ preservation.

Figure removed due to copyright restriction.

Figure 10: Divers working at the 'Cannon Flats'. It shows an example of the gullies with a large concentration of artefacts (M. Flecker, 2022).

1.4 Significance

Preliminary analysis of the artefacts and information obtained from the *Shah Muncher* wreck revealed many parallels, such as cargo and hull construction, with other Country ships and have enormous potential to contribute to the understanding of eighteenth-century maritime trade and shipbuilding practices. For example, a significant artefact type on *Shah Muncher* was its Chinese ceramic cargo. Chinese ceramics were commonly found on other contemporary shipwrecks. These ceramics were produced in China and played a significant role in the global maritime trade during the eighteenth century.

Apart from ceramics, substantial organic and metal remains, such as timber planks, timbers, rattan, bamboo, metal sheaths and fastenings (Flecker 2022a), were found at the wreck site. Unfortunately, these remains were found without much archaeological context due to the discontinuous nature of the site and constant water movements in that area (Flecker 2022a). Some of these remains may be associated with the structure of *Shah Muncher*. There might also be a possibility that these remains are associated with the ship's furniture or stowage features prevalent on eighteenth-century British colonial ships. As there was no contextual information on the ship's design and structure, further analysis of these materials will be essential to understand the shipwreck. There are contemporary shipwreck data and archival resources which can provide an inkling of the ship's design; however, it could only provide an incomplete understanding of the construction of *Shah Muncher*. Therefore, all details obtained should be examined empirically to provide valuable datasets for future thematic studies on eighteenth-century British colonial ship construction.

The study of ship construction is vital in understanding the technology, environment, and industry, which played an essential role in maintaining the trade. In addition, it can help identify the nuances in building methods, revealing changes in technology, its effect on the associated environment and the social context relating to its construction (Rönnby 2013). Despite the available information on British colonial ship construction, there are still gaps in our understanding of this aspect of nautical archaeology. The current information could only provide descriptions and data sufficient to understand certain aspects. Initial examinations, such as the study by Strachan (1986) highlighted this gap and identified possible differences in the construction of eighteenth- to nineteenth-century British colonial ships constructed in Britain, India and Southeast Asia. Building on this research gap, Kurt Bennett's (2021) PhD thesis commenced a thematic approach to understanding eighteenth- to nineteenth-century British colonial shipwright artistry. This research is crucial as Bennett studies the construction of eighteenth- to nineteenth-century British ships to uncover valuable information on cultural transmission and examine the behaviours of shipwrights operating in India compared to Britain. The ships examined in Bennett's case study compared India-built ships with British-built vessels. This research can be further expanded with the addition of new data, such as examining Country ships built in Bombay. The data that is described in this thesis will contribute to this existing research on British Colonial Ships.

The discovery of two shipwrecks within Singapore waters in the last decade is significant locally and internationally. They provide critically important information concerning the maritime trade that transpired along the Singapore Straits in pre-modern times. Both wrecks are a testament to the dangerous waters around the islet of Pedra Branca. The islet was a landmark and a maritime hazard when ships relied on sail and wind for propulsion and simple compasses, current, landmarks and stars for navigation. The presence of *Shah Muncher* at Pedra Branca showed that Country ships would utilise this trade route to ship goods and cargos to their final destination. This research plays a small part in understanding the maritime landscape observed along the Singapore Straits. The predominant narrative on the historic nature of the Singapore Straits has focused primarily on its associations with the Maritime Silk Road, which connects the east to the west through trade and exchange. Current research studies on the Maritime Silk Road include trade and exchange of goods, and a handful of research was dedicated to understanding more about the vessels that sailed along the route. The vessels examined in these narratives present information on Chinese, Southeast Asian and possibly Arab ship construction. No attempts have examined colonial ships that played a vital and possibly infamous role along the Maritime Silk Road from the eighteenth to nineteenth century.

Excavations of the *Shah Muncher* wreck were only completed in June 2021. Much is still unknown about the wreck as analysis of its materials and archaeological records are still ongoing. It is crucial to continue the study and provide professional reporting, discussion, and debate because the shipwreck may be the only eighteenth-century Bombay-built Country shipwreck ever surveyed and excavated archaeologically to date.

1.5 Chapter Outlines

1.5.1 Chapter 2 Historical Review

The chapter first provides a historical background on the significance of Pedra Branca and the maritime trade that transpires around that area during the eighteenth century. It will also provide contextual background on Country trade, which played a significant role in maritime trade and seafaring between Europe and Asia during the eighteenth to nineteenth century. In addition, a brief timeline of *Shah Muncher's* lifespan is highlighted. Lastly, an examination of historical and archaeological studies relating to eighteenth- to nineteenth-century Country shipbuilding is presented.

1.5.2 Chapter 3 Literature Review

Theoretical approaches to ship archaeology and cultural aspects of shipbuilding are explored in this chapter. *Shah Muncher* was a ship which embodied British shipbuilding traditions but was constructed in India by Indian shipwrights. The possible cultural interactions between both traditions shed light on the technology changes and transfers between different cultures while examining shipwreck materials. Furthermore, as *Shah Muncher* wreck is a discontinuous site, there is a need to evaluate the methods and theories for the study of such sites. Therefore, the theoretical frameworks explored in this chapter need to encompass the above aspects of shipwreck study to formulate a suitable direction for this research to achieve its aims and research question.

1.5.3 Chapter 4 Methods

Chapter four describes the methods used for this research endeavour. Information will be collected quantitatively through the physical analysis of the timber and metal remains. The types of analysis include visual inspection and measurements of the artefacts and their identifiable features. Scanning Electron Microscopy (SEM) analysis was employed to investigate the composition of the metal, and timber species analysis was conducted on the timber materials. This information is cross-referenced with existing studies and records relating to eighteenth- to nineteenth-century British colonial shipbuilding. Relevant information on ship construction can then be compared with the results obtained from the physical analysis of the timber and metal remains of *Shah Muncher*.

1.5.4 Chapter 5 Results

Chapter five presents the results obtained from two sources. The first source of information comes from analysing other ships and shipwreck data. Timber and metal-related data are obtained from archaeological research and reports on *Endeavour, Edwin Fox,* HMS *Buffalo, Quedagh Merchant* and *Sydney Cove.* The second source of information comes from examining the timber and metal remains of *Shah Muncher*. The results include the dimensions, characteristics, species, and elemental composition of the selected timber and metal remains.

1.5.5 Chapter 6 Discussions

Chapter six discusses the results from analysing the timber and metal remains and compares them with existing archival research, archaeological data and material analyses of other eighteenth- to nineteenth-century ships. The timber and metal remains found at the site had limited contextual information due to the discontinuous nature of the site. Therefore, through the comparison, possible functions of the timber and metal remains could be deduced. Similarities and differences between the results obtained from *Shah Muncher* and other eighteenth- to nineteenth-century ships were highlighted to show possible cultural transmissions and technology exchanges between British and Indian shipbuilding.

1.5.6 Chapter 7 Conclusion

Chapter seven highlights the limitations encountered during the research. It offers possible future directions which can improve the understanding of the structural features of *Shah Muncher*. Consequently, future research on the materials found on *Shah Muncher* can further the knowledge of the interaction of shipbuilding traditions between India and Britain during the eighteenth to nineteenth century—in addition increasing our understanding of the maritime cultural landscape of Singapore Straits.

1.6 Conclusion

In conclusion, this research attempts to identify the possible structural features obtained through analysing some of the timber and metal remains found at the *Shah Muncher* site. The analysis relied on visual examinations, measurements, material and species analysis. The results obtained were compared with the existing archival research materials and archaeological data of eighteenth- to nineteenth-century British and Indian shipbuilding and identify the functions of these remains. The theoretical framework employed in this research provides a direction to examine these materials for cultural and technology exchange elements between India and Britain. This research will contribute to the existing eighteenth- to nineteenth-century nautical archaeology narratives.

CHAPTER TWO: HISTORICAL REVIEW

2.1 Introduction

This chapter first provides a historical background of the wreck's location and its immediate environment, the maritime trade in the period it sailed and sank, and the ship itself. Subsequently, literature and other studies pertaining to eighteenth- and nineteenth-century Country ships and shipbuilding will be reviewed.

2.2 Historical Background of Site

2.2.1 Pedra Branca and the Singapore Straits

Shah Muncher sank within the 400 metres of Pedra Branca, a rock outcrop situated at the eastern entrance of the Singapore Straits. Historically Pedra Branca has been identified as a navigational landmark and a hazard by past seafarers as detailed in Chinese, Malay, and European records (Burnell and Tiele 1885a:119; Jayakumar and Koh 2009:6–8; Vernon Cornelius 2013). During the eighteenth and nineteenth centuries, surveyors identified the rocks as one of the many navigational hazards lying within the Singapore Straits from the South China Sea entrance. There were records mentioning shipwrecks or ships stranding on shoals, rocks, and reefs in that area from the early to the mid-nineteenth century (Horsburgh 1811:189; Buckley 1902:510). In 1811, James Horsburgh, a cartographer, provided sailing directions for seafarers who intended to sail through the Singapore Straits. Instructions from his sailing guide identified Pedra Branca as one of the hazards. The recent discovery of the Temasek and *Shah Muncher* shipwrecks confirms the rock's lethality along this waterway (Flecker 2022a, 2022b).

Singapore Straits is one of the busiest waterways globally, and Singapore serves as a vital entrepot along this route. Historically, the Straits was a crucial waterway, continuously serving its purpose as a conduit for exchanging goods, ideas, and people over the centuries. Present maritime borders separate the various nation-states along the Straits of Melaka and Singapore; however, these two straits were not divided in the past. On the contrary, they were an interconnected network and a platform providing maritime polities in the region access to the world around them and beyond; and vice versa (Borschberg 2012:193). Singapore was mentioned in the maps and accounts made by European seafarers during the eighteenth century. Kwa (2004a:96) highlighted the existence of sea charts, dated 1799 and 1806, describing the Singapore Straits. These charts, however, did not clearly define the Singapore Straits. According to Borschberg (2017), the Singapore Straits before 1819 were composed of four waterways that passed around Singapore's island. European historical sources viewed the straits as an extension of the Straits of Melaka or a composition of four sailing routes which extend from the South China Sea to the Straits of Melaka. These sailing routes pass through the various small islands situated south of the main island of Singapore (Borschberg 2012:194).

Some of these charts were published around the time *Shah Muncher* sank. One of the first records identifying *Shah Muncher*'s sinking was based on shipping records in the area describing the hazards to forewarn fellow seafarers (Horsburgh 1811:189). These records were only available decades after the incident. The history of Singapore and the Singapore Straits examined by contemporary scholars provides a suitable setting to associate the shipwreck in the broader regional context, such as the Maritime Silk Road.

2.2.2 Singapore and the Maritime Silk Road

The term Maritime Silk Road is a relatively recent concept. It was an extension of Ferdinand Freiherr von Richthofen, a late-nineteenth to early-twentieth-century German Geographer, interpretations of the overland trade routes which connected Han China with the Mediterranean world during third century AD, also known as the Silk Road. He acknowledges that these ancient networks were not labelled the same manner as contemporary scholars proposed. Ancient people who utilise these networks provided travel accounts based on their personal experiences and, at times, including their exchanges with other fellow travellers. The latest iteration of the Maritime Silk Road has focused on the role Southeast Asia plays in this trade route (Kwa 2016). Unlike the previous two iterations, current notions of the Maritime Silk Road seek to examine the connections between the South China Sea and the Indian Ocean (Kwa 2016). It does not merely focus on the commodities traded, but it identifies the connections between different maritime polities within this route. Kwa (2016:11–16) elaborated on how the notion has been reconstructed beyond past interpretations and encompasses the examination of maritime connections between the Persian Gulf, Red Sea,Indian Ocean and South China sea at various periods.

The notion of the latest iteration starts with the Austronesian connections, which appeared before 500 BC to 200 BC, examining the Austronesian speaking people's migration, trade and exchange throughout the region (Kwa 2016). Subsequently, between AD 200 and AD 300, trade and exchange within the region intensified with emerging chiefdoms in Southeast Asia and the enlargement of the trade network around the Indian subcontinent. Between the fourth century AD and the tenth century AD, the spread of Buddhism further connected the different regions along the overland and maritime trade routes (Kwa et al. 2019:22–23). This period overlaps with the appearance of Arab seafarers and traders in the Indian Ocean from the seventh to the seventeenth century. An increase in Asian sea trade was observed from the tenth to the thirteenth century. The rising Arab and Tamil trade activity; and China's political upheavals also contributed to the magnification of maritime commerce. The fourteenth century witnessed various calamities, which caused a standstill in trade activity. These calamities included several environmental crises, climate changes and a pandemic that spread through Asia and Europe (Kwa 2016). The period from 1450 to 1680 marked the age of commerce, including the voyages undertaken by Zheng He, a representative of Ming Dynasty China. During this period, there was an increase in trade activity in the South China Sea, Melaka Straits, Indian Ocean, and the Persian Gulf as the pandemic receded. This period also marks the beginning of European presence within the Indian Ocean and the South China Sea. From the eighteenth century onwards, the dynamics of the Maritime Silk Road changed due to the increasing presence of Europeans. Throughout history, despite occasions of raids from South India and soft power projections by the Chinese, the sea passages in the Indian Ocean and the South China Sea remain primarily free of assertions and control. With the increased European activity in the region, these passages lost their 'free' status as they became embroiled in the geopolitical rivalry between the various European nations (Kwa 2016).

Singapore’s associations with the Maritime Silk Road can be traced from the fourteenth century. Historical records from Arab, Chinese, Malay, Javanese, Vietnamese, and European sources have indicated the presence of an entrepot located south of the island, near the Singapore River (Kwa 2004a; Kwa et al. 2019:25–33; Miksic 2013:145–208). Archaeological excavations conducted in 1984 further reinforced this fact with the presence of a sizeable quantity of Chinese ceramics datable to the Yuan Dynasty found at Fort Canning Hill (Miksic 2013). Subsequent archaeological endeavours reveal more materials to suggest the activities which may have taken place on the island since the fourteenth century and continue to improve our understanding of the role it plays in the global and regional trade throughout the island’s 700 years history (Low 2004; Miksic 2013;Kwa et al. 2019:34–43).

The fortunes of this entrepot did not endure throughout the years due to regional geopolitical events that led to the reduction in trade activities, as mentioned in the above sections (Kwa et al. 2019). Between the end of the fourteenth century to 1819, there were occasions when Singapore regained some form of importance, but it did not manage to reach the same level of importance and role as it did during the fourteenth century (Kwa et al. 2019:50–227). Information on Singapore during the eighteenth century was relatively scarce, especially prior to the arrival of the British in 1819 (Kwa 2004a: 103; Kwa et al. 2019:179). At that time, Singapore was under the dominion of the Johor Sultanate. The Johor Sultanate, with its capital at Johor Lama, located along the Johor River, was the political and commercial centre (Miksic 2013: 405–432; Kwa et al. 2019:146–179).

Archaeological sites in Singapore, substantiated by the data obtained from shipwrecks located in the immediate peripheries of the island and subsequent European records about the island, reinforce the association between Singapore and the Maritime Silk Road via the Singapore Straits (Kwa 2012; Borschberg 2017). Although detailed information on the role Singapore may have played along the trade route during the eighteenth century is lacking, shipwrecks found in its adjacent waters provide the relevance between Singapore and the waterways connecting the South China Sea to the Melaka Straits. The current archaeological data obtained from *Shah Muncher* has yet to connect the island of Singapore and the ship directly. By considering the route the ship intended to take, its purpose during eighteenth-century maritime trade and the location where it sank, the information obtained from the analysis of archaeological data from *Shah Muncher* can contribute to the past narrative of Singapore’s surroundings. Consequently, it potentially furthers the understanding of an important trade route still in use today.

2.3 East India Company and Country Trade

British East India trade started in 1601 (Davis 2012:247). In 1607, a trading station was set up in Surat, India, and by 1686, trading stations had been set up in Madras (1639), Bombay (1662) and Calcutta (1686). China tea trade peaked towards the end of the seventeenth century (Davis 2012:248). During the first half of the seventeenth century, smaller ships varying in size from 400 tonnes to 600 tonnes were used to carry the more valuable cargoes such as silk and cotton to and from the Bay of Bengal. It was noted that large ships tended to wear out quicker than smaller ships, and it was challenging to fill up the large ships (Davis 2012:251). In 1687, the East India Company shifted their headquarters from Surat to Bombay. Since then, East Indiamen, which sailed from England for India and China, rarely engaged in coastal trade. Coastal trade along the Indian coast essentially involved the Indians, Armenians and Portuguese residing in Surat, but Country ships and their owners would soon join in this enterprise. Independent merchants owned Country ships and operated under a license from the East India Company. The license comes with restrictions. Country ships were only allowed to conduct trade around India, Southeast Asia, China, Australia, the Persian Gulf, the Red Sea, and Africa's East coast. They were prohibited from travelling west of the Cape of Good Hope to compete with the Company's monopoly over the trade route leading to Europe.

Trade between Europe and the East Indies changed during the eighteenth century. Prior to the eighteenth century, British trade focused on the luxury items such as spices. There was a shift towards bulk commodities such as cotton, silk, porcelain, and tea during the eighteenth century (Barua 2011; Herivel 2020:90). It was noted that English Country traders were heavily involved in the trade and negotiations with rulers in the Malay world and were constantly searching for suitable locations within the region to set up a trading outpost. The Malay world refers to the Malay-speaking communities in Malaysia, Indonesia, Singapore, Brunei, and parts of Southern Thailand. The East India Company had set their eyes on the area because of its strategic importance to its trade with China; specifically, the area around the southern tip of the Malay peninsula. One of the key events right before the sinking of *Shah Muncher* was the establishment of Penang by the East India Company in 1786 (Herivel 2020:84–203). Country traders were free merchant mariners who cooperated with the East

India Company. Often, they were listed as free mariners by the Company. It is almost impossible to tabulate the total number of these individuals as there are still gaps inthis area of research (Miller 2011:25).

During the eighteenth century, Sultans ruled over their fiefdom within the Malay world with the help of nobles who pledged allegiance to them. (Miller 2011:25). At the same time, increasing numbers of English Country traders came into the Malay Archipelago during the latter half of the eighteenth century to conduct trade. Often, they establish relationships with locals to acquire provisions for the sea voyage, and simultaneously, through their voyages, they helped survey and chart the area (Kwa et al. 2019:146–179; Miller 2011:40–41). Dutch records attributed the surge in trade along the Straits of Melaka to the rise of Johor and Kedah polities between 1620 to the 1790s, (Fernando 2015:124). By the late-eighteenth century, Country traders dominated the maritime trade around India, Southeast Asia, China, Australia, the Persian Gulf, the Red Sea, and Africa's East coast. By the end of the 1770s, the Country fleet was twice as large as other European rivals' fleets operating in India (Bulley2013:4). Besides trading, Country ships were, at times, also called upon by the East India Company to act as mail carriers and troop transports. These ships would be retrofitted as warships in certain instances, such as HMS *Trincomalee*, which is now restored as a museum ship and held in the National Museum of the Royal Navy in England (Bulley 2013:3; Wyn and Mudie 2015).

Country ship records were often scant as they were private enterprises. They were only briefly mentioned in East India Company records; however, the limited information on Country ships does not accurately indicate their role in the East India Company. Country ships and traders were pivotal in maintaining the finances of the East India Company. Until the early-nineteenth century, the Company relied on the money brought in by Country ships because they could not pay for the large quantities of tea from their profits. Indiamen, travelling from England,were unable to bring enough English goods that appealed to the Chinese market while they were required to make large tea purchases, thus causing them to suffer a deficit (Bulley 2013:1). Therefore, Country ships helped plug the gap by contributing a portion of their earnings from selling Indian goods and barter trading with Southeast Asia and China.

Ships from Bombay would use the southwest monsoon winds between April and October to make their way to China. Ships will use the northeast monsoon on their return journey, which commences in February or March (Bulley 2013:2). Maritime trade from China may be lucrative, but it also presents dangers such as the early onset of monsoon, typhoons, unfamiliar waters, and threats from piracy (Bulley 2013:3).

Historical research on Country ships has mainly examined the nature of Country trade and recounted the merchants and the crew associated with these ships but not on the ships' cargo and design (Jaffer 2015; Machado 2014). As *Shah Muncher* was constructed in Bombay and part of China and India's maritime trade, it is classified as a Bombay Country ship. Anne Bulley (2013) wrote a comprehensive history of Bombay Country ships. Her research provided details on the trade activities around these ships, their purpose, owners, mariners, and ship construction. Country ships were registered in Bombay, Calcutta, and Madras. The ships' officers were predominantly English or Scottish, while the crew was composed mainly of men of Indian, Malay, and Chinese ethnicity (Miller and Smith 2020:596–597). There were only a few Europeans on board these ships, and they often filled the role of captain of the ship or surgeon. Sometimes women travelled on board the ships. They were either the European wives or local concubines of the ship's captains. (Miller and Smith 2020:596–597). The South Asian sailors, also known as Lascars, formed the backbone of the Country ship trade. Their involvements were detailed in a book by Jaffer (2015), which also included accounts of mutiny on board these vessels. After 1820, there were reports of an increasing number of Indian captains. At times, the role of quartermasters and gunners would be filled by Indian Portuguese (Bulley 2013:4). Country ships were owned by individuals or through partnerships. The ship owners were predominantly English merchants, but there were occasions when the English merchants would partner with local Indian traders. Many owners or part-owners were Parsis, an Indian ethnoreligious group adhering to Zoroastrianism, and by 1792, it was reported they owned a total of twenty Bombay registered ships (Bulley 2013:6). Towards the latter period, Bombay residents were also allowed to own ships (Bulley 2013:4–5).

The Parsis both built and owned Country ships. The first Parsis shipwright was Lowjee Wadia, who was engaged by the British in 1672. He and his descendants were instrumental in the construction of Country ships. Some of the carpenters involved in the construction also hailed from Surat. (Bulley 2013:6). Travellers to Surat who witnessed the construction of Country ships remarked on the quality of Country ships built in Bombay (Bulley 2013:27). They were said to be one of the best ships during that age and were comparable to British-built ships, because they had a longer serviceable lifespan.

2.4 Shah Muncher

The identity of *Shah Muncher* was ascertained through desk-based analysis. Flecker (2022a) investigated the records of contemporary ships which sank in the area from the eighteenth to the nineteenth century. According to the preliminary report by Flecker (2022a:10–15), the loss of *Shah Muncher* at Pedra Branca was the most plausible identity of the shipwreck because the other shipwrecks located around the vicinity were recorded to have sunk near the island of Bintan. Furthermore, the ship's cargo, coupled with its copper hull sheathing, and the admiralty anchors found at the site, indicated an eighteenth- to nineteenth-century European-type vessel. The final manifest of *Shah Muncher,* obtained from the East India Company archives in the British Library, coincides with the type of finds found on site.

According to various records (Anon 1806:465; Phipps 1840:168; Anon 1840:609), *Shah Muncher* was constructed in Bombay in 1789. The ship's owner was identified to be Sorabjee Muncherjee. He and his family members played an active role in the Country trade. Sorabjee Muncherjee's uncle, Herhee Jeevanjee, was pivotal in his role in establishing the Bombay Country trade in 1755. By 1789, the family owned four ships (Ranganathan 2019:20). Records indicated that *Shah Muncher* was a large ship with a burthen between 1040 and 1042 tons (Anon 1806: 465; Phipps 1840:168; Anon 1840:609). Using the Builder's Old Measure, which is an equation to calculate the cargo capacity of a ship basedon the vessel's length and width; and the Royal Navy's stipulated length of the shank of a ship's anchor in the eighteenth century, *Shah Muncher* would roughly be 45 metres in length and 12 metres in beam (Flecker 2022a:19); however, according to Flecker, this measurement has yet to be confirmed from the archaeological remains and to date there were no documented overall dimensions of the ship's remains from the site. The proposed measurements of the ship essentially remain an educated guess relying on the existing archival records.

Captain John Anson Smith commanded *Shah Muncher* from its very first voyage until he abandoned the ship at Pedra Branca in 1796. He made six voyages with the ship to China between 1790 to 1795, obtaining a variety of cargo for its voyage back to Bombay (Flecker 2022a:19–22). Notably, in 1795 *Shah Muncher* was recorded to be involved in a brief skirmish close to the coast of Aceh. *Shah Muncher* and another Bombay Country ship, *Anna*, retook a ship from the French in August 1795 (Langdon 2019:113). After this episode,*Shah Muncher* continued her voyage to Whampoa, China.

Shah Muncher was recorded to have left the Whampoa anchorage on 21 November 1795. It was en route to Bombay from China when it was recorded lost at Pedra Branca on 8 January 1796 (Anon 1806:465). According to Captain Walter Caulfield Lennon's (1881:74) records, the ship was recorded to have broken into pieces upon its collision with a rock near the vicinity of Pedra Branca, and the crew managed to get on their boats before the ship sank and made their way to Malacca.

Flecker (2022a:16) provided a possible description of the site formation process. *Shah Muncher* would likely be travelling from China using the prevailing northeast winds. Swells generated off the Philippines roll during the prevailing northeast monsoon could likely cause the ship to lose its steering ability, leading to its collision on the rocks near Pedra Branca. Once the ship was stuck on the rocks and immobilised, the waves would damage the exposed hull. Swells from the South China Sea would strike the ship constantly. As the ship sank in six to seven metres of water, a portion of the ship would be left exposed above the surface and the elements.

This identification was based on extensive archival research on related maritime and ownership records. The ceramic artefacts found at the site dated to the eighteenth century further substantiated the dating of the wreck. The currently available information on *Shah Muncher* relies on data from other contemporary shipwrecks and historical records; however, much is still unknown about the ship. Based on existing literature, it is possible to note that *Shah Muncher* is the only eighteenth-century Bombay-built Country shipwreck found to date. Thus, validating the importance of research on *Shah Muncher*, which can help further understand the role Country ships played during eighteenth-century maritime trade and shipbuilding practices.

2.5 Eighteenth- To Nineteenth-Century Country Shipbuilding

Davis (2012) highlighted several observations on eighteenth-century British ships and ship builders which could provide some clues to the construction of *Shah Muncher*. For example, by the eighteenth century, British shipbuilders have constructed ships which require small crews relative to the cargo they carry (Davis 2012:55). Technical factors did not entirely determine the size of the ships but also factored in the market possibilities. This is because large ships had a higher risk of under-lading and were slower to reach full lading than small ships (Davis 2012:69).

Miller and Smith (2020:603) described the accommodation features on a Country ship. These features form a part of the ship construction, and it was mentioned that the large Country ships ranging in size between 700 to 1000 tonnes had better living quarters than smaller ships and were organised similarly to similar-sized East Indiamen. The living quarters for the women on board the Country ship would often be located within the great cabin under the poop deck. According to *The General East India Guide* of 1825 (Gilchrist 1825:20–21; Miller and Smith 2020:603), the great cabin was 'a slip taken off across the stern of a ship' containing the roundhouse with its row of glass windows on the stern part, the stateroom, which was before the roundhouse on the starboard side, and a similar space on the port side which together with the stateroom, was known as the Cuddy. In his letter to his daughters, Peter Cherry (Cotton 1949:70) remarked that the Indiaman of no less than 800 tons had a room big enough to accommodate some of the furniture back home. Frances Barkley compared her quarters aboard the *Imperial Eagle* with other ships. She felt that her quarters on the *Imperial Eagle* were comfortable but sparsely furnished (Miller and Smith 2020:604).

The above observations offered a glimpse into the ship's construction based on the passenger's first-hand accounts and the available records of eighteenth- and nineteenth-century British colonial ships. It also highlighted a potential research gap to uncover more about the ship's interior structure and provide a source of comparison for future studies looking into furniture onboard eighteenth- and nineteenth-century British colonial ships.

Country ships were European-style ships constructed with primarily locally sourced materials and workforce around the Indian sub-continent. Although their construction was based on a European design, records mentioned Indian shipbuilding techniques such as joining planks by rabbeting, dowelling, and sheathing were incorporated into these ships (Nash 2002). Overall, these accounts have praised the quality of these ships' construction. The reputation accorded to Bombay Country ships can be attributed to the shipbuilders' fine artistry and the usage of local teak in Bombay (Bulley 2013). Further studies could be conducted on how European and Indian shipbuilding practices may have influenced each other. Strachan (1986) highlighted this research gap, which indicated examples of cross-cultural exchanges when Europeans introduced European shipbuilding practices to the Indian sub-continent. He also provided evidence showing the difference between Bombay and Calcutta-built ships between 1790 to 1815.

Bennett’s (2021) PhD thesis is one of the only studies on the fabric of East India ship design from an archaeological evidence base. He focusses on three ships, *Endeavour,* HMS *Buffalo* and *Edwin Fox,* and studied how British colonial ship structures and designs can help provide information on ship manufacture during the eighteenth and nineteenth centuries. HMS *Buffalo* and *Edwin Fox* were built in Salkia (previously known as Sulkea), near Calcutta, India. Bennett applied cross-temporal and cultural transmissions of knowledge and technologies in his thesis. Two notable Country shipwrecks, *Diana* and *Sydney Cove*, provided vital archaeological information on cargo carried by Country ships and further insights into their construction during the eighteenth century. The closest wreck in terms of geographical proximity to *Shah Muncher* is *Diana*—a Country ship built in Chittagong that sank off the coast of Malacca on 6 March 1817. The assortment of artefacts found at the shipwreck included Chinese ceramics, glass bottles, jars, zinc ingots, glass beads, cannons, and cannonballs. Some organic remains such as tea and plum could also be found, still stored in the jars (Ball 1995). These finds offered clues to the type of cargo transported during the same period as *Shah Muncher*. Unfortunately, no ship remains were reported at the site. Thus, it was impossible to discern the ship construction of *Diana*. *Sydney Cove* was the other Country ship that allowed comparative analysis with *Shah Muncher* as they were constructed in the same period. *Sydney Cove* was built in Calcutta and sank on 9 February 1797, north of Tasmania, Australia. It was relocated in 1977. Multiple excavations from the 1970s to 1980s uncovered structural features, fastenings, riggings, anchors, and armaments. The cargo consisted of cask and bottled alcohol, leatherwear, tobacco, salted meats, indigo dye, and

Chinese export porcelain (Nash 1992; Nash 2002; Staniforth et al. 1998). Research on *Sydney Cove* also included an analysis of its rudder (Lester 1982).

Other noteworthy Country ships included *Quedagh Merchant* and HMS *Trincomalee*. *Quedagh Merchant* was associated with Captain Willian Kidd, a renowned pirate who operated in the Caribbean. As a privateer, he was assigned to the Indian Oceanto curb piracy activities. In 1698, Captain Willian Kidd captured *Quedagh Merchant* (Frederick and Beeker 2016). According to Kidd's account, the ship was constructed in Surat, India and commissioned by a group of Armenian merchants. In 1699, Kidd abandoned the vessel along the coast of the current day Dominican Republic. There is a high likelihood that *Quedagh Merchant* may be a Country ship, but further research is required. The ship's construction predates *Shah Muncher,* and if it was built in India, the information from this wreck could still shed light on the construction of Bombay Country ships despite the difference in the date of construction. HMS *Trincomalee* is another possible source of information on Bombay Country ship. The frigate is one of the surviving examples of a Country ship. Built in Bombay in 1817, it served in the Royal Navy on numerous occasions (Wyn and Mudie 2015). The ship is fully restored and serves as a museum ship. Although it postdates the construction of *Shah Muncher* and much fabric is not original, there might still be elements of shipbuilding that endure after decades.

Overall, the Country ships' current literature highlights its importance in the region's maritime trade, the people involved, ship construction features, and some insights that could be gleaned on the shipbuilding industry that helped facilitate this trade. Although historical accounts offer essential insights into the social history of the Country ships, they lack information on their construction. Bulley (2013) addressed some construction aspects of the Country ships but focuses mainly on social and economic perspectives. Information on the materials and their relevant financial cost was mentioned, but there were only some details on the ship's design characteristics. Ball (1995) focused on his excavation accounts and highlighted the artefacts excavated from the site. Unfortunately, few interpretations of these artefacts and no ship timber remains were described in detail.

In contrast, the artefacts' information shed light on the type of cargo transported along these trade routes. Scant information can be used to get a better understanding of the cargoes that Country ships carried. Publications on *Sydney Cove*, for example, offer specific details of the ship itself, its cargo, and crew. Mike Nash (1992, 2002) discusses the vessel's remains methodically, and his analysis of its timber remains provides valuable information related to the ship's construction. Further information on Country ship construction in Bombay and Calcutta can be gleaned from research conducted on the *Quedagh Merchant*, HMS *Trincomalee,* HMS *Buffalo* and *Edwin Fox*. The study of maritime trade has often focused on the cargo it carries. Ceramic shipments on both *Diana* and *Sydney Cove* were studied to a certain extent to reveal more about the Chinese ceramic export trade.

There seems to be an emphasis on ceramic artefacts because they do not deteriorate as quickly as other materials found in a submarine environment. Nonetheless, these shipwrecks could also offer the necessary source of comparison to assist in structural or material identification. In addition, other contemporary shipwreck research, such as Bennett's (2021) research on *Endeavour*, could offer valuable sources on ship construction and material data during that period. As the premise of this research focuses its examination on the metal and timber remains found on *Shah Muncher*, literature on these material analyses would be vital. Copper alloy, one of the metals used for ship construction, was used for sheathing ships during the eighteenth and nineteenth centuries (Staniforth 1985). It forms a part of the ship's surface to protect it from deterioration causedby marine organisms. In addition, copper alloy was also used extensively to manufacture timber ship fasteners. Therefore, related studies on copper tacks and sheaths on ships during the eighteenth and nineteenth centuries would be inherently helpful, such as Staniforth's (1985) study on the introduction and use of copper sheathing and McCarthy's (2005) book on ship fastenings. Timber was the predominant material used in constructing these during that period. Therefore, the timber species analysis and examining any man-made features would be essential for the research. Additional information on types of timber used for Country ship construction can be gathered from Phipps' (1840) papers on shipbuilding in India.

The *Shah Muncher* site can be considered a discontinuous site as the ship and its associated remains are scattered over a large area. Although it is difficult to identify general ship construction or design features, information obtained from *Shah Muncher* presents an opportunity to compare with other Country ships. Through comparison, a better understanding of Country ships can be achieved. Furthermore, it can contribute to the existing Country ship narratives and shed more light on their involvement in the region's maritime trade during the eighteenth century. Thus, filling a much-needed data and analytical gap. It is not just historical questions that need to be addressed but also cultural history and identity that need attention.

CHAPTER THREE: LITERATURE REVIEW

3.1 Introduction

The research's primary focus is the examination of the timber and metal remains of the shipwreck. Unfortunately, few hull remains were found at the wreck site, and most of the archaeological remains were scattered over an area measuring roughly 130m by 70m. This section details the theoretical approach to examining these scattered timber and metal remains as material culture from the ship. The approach hopes to adhere to Hocker's (2004:2) views on the type of conceptual approach. He argues that the conceptual approaches dealing with boatbuilders need to not only highlight the technical aspects but account for the differences in construction methods across culture and time, and include the decision-making process in deciding the shape, material, and structure of a watercraft.

3.2 Ship Archaeology Approaches

This study attempts to understand the technical features of *Shah Muncher* through the analysis of the timber and metal remains. Understanding a ship's technical features stems from the notion of a ship's technical and functional characteristics as a basis for study derived from Muckelroy's definition (1978:216). He stated that a ship is a complex machinethat floats and moves autonomously or is controlled. It consists of both architectural and technical systems. Muckelroy (1978:216) identifies three main aspects of a ship in which it was involved in its regular activity. First, a ship is a machine designed to harness a power source to serve as a means of transport. Secondly, the ship is an element within a military or economic system, providing its fundamental reason for existence. Lastly, the ship is a closed community with hierarchy, customs, and conventions. The study of *Shah Muncher*'s timber remains would fall under the framework of a ship as a machine. The framework outlines the need to understand the original ship's design and construction, which depended on an appreciation of the methods by which these requirements have been satisfied (Muckelroy 1978:217). This framework also falls under the discipline of nautical archaeology. A general point highlighted by Muckelroy (1978:217) stated that archaeological remains could show the hull as built and allows more direct evidence than any number of plans or drawings. Archaeology can identify these features because these systems would exist in a fragmentary state at a shipwreck site. Despite the potential information archaeologists could get from fragmentary archaeological remains, there would still be a certain amount of bias as some parts of the ship would not survive, and it will be left to the interpretation of the archaeologists.

Gawronski made further expansion on Muckelroy's three aspects of a ship. Gawronski uses his research on an eighteenth-century United Dutch Company (VOC) ship, Amsterdam (Gawronski 1991:83) and visualises it within the 'object-aimed' approach. Gawronski presented the ship as a multifunctional tool capable of performing various undertakings across five areas. According to him, three of the five areas interpret a ship as a sailing machine performing a military or economic role. The social aspect of the ship is covered in the other two areas, which investigated the 'village' concerning the personnel onboard the vessel and the closed social unit of nautical life, which examines the relationship between the VOC and the structures within nautical society. His views on the study of a ship were essentially a further breakdown of Muckelroy's three aspects into additional components, which include VOC’s influence on the ship. Despite the further breakdown and addition of details, the framework does not encompass all the possible aspects a ship might be considered from. Furthermore, it is restricted to the studies on VOC-related ships as it was an explicit area highlighted.

Adams (2013:90) proposes that when ships are objects of study, there would be a need to account for their effects on contemporary society and the maritime obligations they fulfil. Likewise, ships represent the combined social and environmental elements: ideology, technology, tradition, economics, purpose, environment, and materials. According to Adams (2013:91), these elements or constraints are interconnected, and the degree of associations between them depends on type, function, and social context (Figure 11).

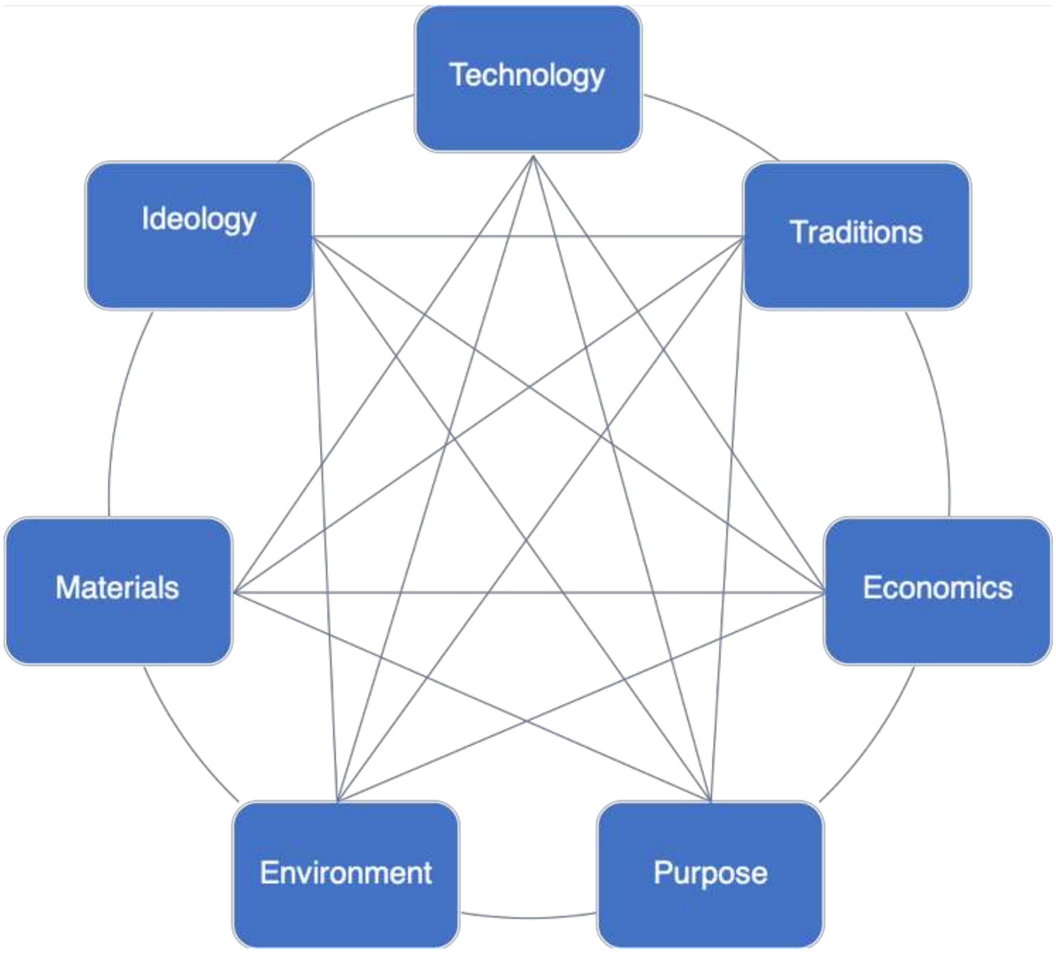


Figure 11: Diagram illustrating the interrelated constraints on form, structural characteristics, appearance and use of watercraft (after Adams 2013: 91).

Table 1: Definitions of the interrelated constraints of watercraft (after Adams 2013: 91).

Interrelated Constraints of Watercraft	Definition
Purpose	Intended function(s) of the vessel. Direct association to the society's maritime needs in terms of communication, trade, subsistence, or industry such as fishing, military, or leisure.
Technology	Development, application, and control of processes through which raw materials are acquired, converted, refined, worked, and fashioned to create new materials or things. Includes the production of tools to assist in these processes
Tradition	Craft tradition within which the vessel is constructed. It will embody a system of ideas about boats and ships and how they should be designed and constructed.
Materials	Natural or manufactured materials are available for construction and use. As observed under technology, availability will strongly influence the vessels that can be built.
Economy	Resources in labour and/or wealth are required to produce the vessel.
Environment	The intended operating environment of the vessel.
Ideology	The conceptual and ideological context governs what ships are understood and how they are used. This includes the ideas of those who need ships for various purposes and those who need ships for various purposes.

Adams argues that each watercraft potentially embodies these features that inspired its creation and its associations to the society which utilised them. His perspective allows a deeper and more complete understanding of watercraft compared to Muckelroy's notions on the study of ships as machines and Gawronski's theoretical framework for the study of *Amsterdam*.

Shipbuilding and seafaring activities are components of the social practice of the society, and the related material culture is critical in the efforts to inquire how these societies used watercraft to carry out their maritime undertaking. Therefore, technological aspects of watercraft need to be interpreted within its social context (Adams 2013:34). A similar approach will be adopted for the research conducted on *Shah Muncher*'s timber and metal remains. While the research may gravitate primarily towards a technological aspect, studying these remains could establish direct correlations with the other six aspects of Adam's diagram.

3.3 Cultural Aspects within Shipbuilding Studies

The above scholars have highlighted the theories and philosophy that drive the studyof ship archaeology. Various topics and themes can be derived from these theoretical frameworks in how ships can be studied. Although ship construction and traditions are often associated with the existing level of technology, they are also a cultural representation of the native environment in which they were built. Ship scholars view shipbuilding traditions as a continued application of a certain level of technology. The continued usage of a specific technology results from conservatism within a particular culture. These phenomena are often coupled with other cultural or social factors which encourage continued usage (Hocker 2004:8). Any technological changes are motivated by contemporary social and cultural dynamics and subsequently translated to the material culture derived from these scenarios.

The existing theoretical framework on ship archaeology would need to embrace cross-cultural elements to fully understand the social behaviours behind the construction ofthese ships. For example*, Shah Muncher,* like other Country ships, were built in India but exhibited a European design. As a result, they exhibit British colonial shipbuilding techniques, but local Indian shipbuilding traditions were incorporated concurrently. Such cultural interaction instances can be explained using an appropriate cultural theoretical framework. One theory that could be used for this research is the Cultural transmission theory.

Cultural transmission theory is a conceptual framework which could address the similarities and changes in artefacts over time and space. It examines the changes in artefacts beyond typological studies. In addition, it alludes to changes in artefacts due to possible nongenetic modes of information exchange (Eerkens and Lipo 2007:240). Culture plays a significant role in dictating human behaviour and relating it to the research on material culture is one of the main objectives of Cultural transmission theory in archaeological studies. Artefact studies and the features observed could trace how information was exchanged in the artefact's manufacturing process (Eerkens and Lipo 2007:261). This framework provides an appropriate avenue to explain how information is shared between individuals, groups of individuals or across populations (Eerkens and Lipo 2007:253). Furthermore, it allows multiple angles to examine the various information exchange pathways within cultural variability studies.

Cultural transmission theory was addressed in Bennett's PhD thesis (Bennett 2021:19–22). His choice for this framework stems from a focal point on British colonial shipbuilding traditions. It is crucial to understand this perspective as the ships he explored in his thesis have shed light on the British shipwrights and their interactions with Indian shipbuilding traditions during the eighteenth to nineteenth centuries. Nevertheless, further application of this theory in a similar context could examine the shipbuilding traditions from the standpoint of Indian shipwrights in contrast to existing understandings of British colonial shipbuilding. Furthermore, it offers an opportunity to study ship construction in terms of the relationship between the ship designers and the shipwrights. In the case of Country ships, the ship designers or the creators of the ships' plans were European. Inadvertently, the ships demonstrate a European design. While it exhibits a European design, these ships were built by largely local Indian shipwrights who applied their knowledge to construct these vessels. Hence, the experiences of the local Indian shipbuilders would need to be acknowledged and their craftsmanship identified. Cultural transmission theory can be incorporated into Adam's diagram, which depicts the connections of various aspects of a watercraft. By combining both approaches, these connections could be accentuated to allow a fuller appreciation of colonial shipbuilding in a broader cultural context.

There is a need to include the social and cultural aspects during the study of shipbuilding traditions. Archaeological evidence can highlight these technological differences within the social and cultural context in addition to historical sources (Rönnby 2013:9). Hocker (2004:3) stated that the artefacts could only be interpreted reliably by analysing them in their parent culture and accounting for the worldviews of the makers and users of the objects. Imperceptible properties of culture cannot be overlooked, although it is impossible to account for all of them. Ships, for instance, should be viewed as a circumstance of their particular time and space; and an answer to the problems faced by ship owners and shipbuilders. Ultimately, conceptual approaches to shipbuilding studies should not be determined by one notable feature but over a collection of different techniques and characteristics (Hocker 2004:8).

3.4 Archaeology of a Discontinuous Site

Before any research can be conducted on shipwrecks, it is essential to identify the traits of a shipwreck site as it would inadvertently affect the way the site is assessed (Muckelroy 1978:157). The analytical approaches would be dependent on the nature of the seabed remains. *Shah Muncher* wreck site can be identified as a discontinuous maritime archaeological site due to its scattered remains. Muckelroy (1978:196) outlined two main features of a discontinuous site. Firstly, the seabed remains undergo a considerable degreeof reordering and the absence of any defining structure to consider the remains. Both features were observed at the *Shah Muncher* wreck site. Although the scattered remains of *Shah Muncher* cover a large area, the existence of two main artefact concentrations and the consistent conditions of the preserved remains suggest that the scattered remains are related to a single nucleus, indicating the remains of *Shah Muncher*. Like the *Kennermerland* wreck site, *Shah Muncher*'s remains distribution suggests that the vessel broke up, and its associated remains were assimilated into the seabed. The scattered remains lack the relevant contextual information as the timbers were found totally separate from each other. As mentioned by Muckelroy (1979:196), the closest analogy on land to a discontinuous wreck site would be a midden site.

Muckelroy (1978:200–214) proposed to use a series of statistical procedures to describe and summarise the extensive data to reveal any patterns which could be used for further archaeological interpretation. These procedures include an array of grids indicating the presence and quantity of the shipwreck remains. Subsequently, mathematical statistics were applied to reveal any functional patterns. While using statistical procedures to identify valuable patterns for archaeological interpretation can provide certain clues about the shipwreck, analysis of the timber and metal remains, if any, could provide direct evidence of the ship's structure or construction. Muckelroy's matrix helps to study discontinuous sites by condensing a large amount of data for further archaeological interpretation, but it would not be able to provide direct evidence to areas such as ship construction compared to direct analysis of the timber and metal remains. Muckelroy did mention that this approachmay not provide significant results, however, the matrix could include an analysis of specific remains. The analysis could provide valuable inputs when combined with data from other remains. Therefore, a particularistic approach to the study of the ship remains is justified for this research.

3.5 Particularistic Approaches to the Study of Shipbuilding

The scattered remains of *Shah Muncher* are indicative of its discontinuous nature. Thus, to extract the technological, social, and cultural aspects from the timber and metal remains, a particularistic approach is adopted for this research. This section shall provide the justifications for choosing this approach.

Particularism is a feature of empirical observation and data collection. It is a process all archaeological field projects undergo, From the initial formulation of general and specific research questions to addressing the questions and interpretations of the site in the broader social and environmental context (Adams 2013:50–51; Watsons 1983).

Particularistic studies form the basis of most archaeological research. Hocker (2004:2) argues that during the study of the ship remains, the recordings of the unassuming features like the dimensions of planks and nails, tool marks, colour and texture of stains on the wood are meaningful representations of the people who were associated with these vessels. He also brought up the debate on the use of classification and typologies within maritime archaeological studies. He highlighted that both methods depend on the details obtained from the physical characteristics and grouping of artefacts that share common diagnostic traits. One of the prevalent types of archaeological analysis is the observation of changes in a specific artefact to identify the object's function within its cultural context. Pomey (2011) stated that studies conducted on shipwrecks intend to reconstruct the original state of the ship within the confines of the existing historical context.It is to identify the ship's technical and functional features in its environment. Thus, only through examining the general characteristics of the wreck and the dimensions and proportions of this fragmentary evidence can we identify the architectural and technical system on a ship (Pomey 2011:11). Lawrence (1998) stresses the need for contextual studies in the form of empirical inquiries on material culture. It provides information absent from other sources through analyses of the artefacts and their relevant context and comparison with other sites.

Opponents of the particularistic approach agree on three shortfalls of the approach. Firstly, they feel that it is too narrow to tackle the general questions of the past. Secondly, the conclusions derived from the archaeological findings attempt to connect distinct occurrences within the source materials. This mode of analysis is viewed as a form of intuition and is subjective. Lastly, under this approach, it is assumed that patterns only arise due to cultural-historical tradition. Therefore, for the above reasons, the approach should be evaluated via a scientific analytical approach tested on a general level (Gould 2011:20–21; Hocker 2013:72).

Despite this, Gould did mention that he was not entirely opposed to the historical particular approach and acknowledges that not all maritime archaeologists have an impetus to work on broad social-scientific themes. Notwithstanding, he cautioned that historical particular explanations would need to be examined against the general themes to provide suitable conclusions about the human past (Gould 2011:20–21). Gould does acknowledge that the particularistic approach does have its role in maritime archaeological research; however, he feels that it should not be the conclusion to the study of the ship remains.

On the other hand, Hocker (2013:72–84) argues that the pursuit of conceptual ideals behind ship design and construction would also not achieve the fullest potential of the archaeological source materials. Examination of individual ships and scrutiny of the small details on the ship remains are equally essential. Hocker observed peculiar features on the Swedish ship, *Vasa,* to illustrate the importance of examining individual ship remains as it focuses more on the shipbuilders rather than the ship designers. He believes that only by combining both general and particularistic approaches would there be a more comprehensive view of a ship's construction in terms of its technological aspects within the social and cultural context.

Bass supported the need for historical particularism as a basis for maritime archaeological research. He stated that for theories to be formulated, they must be built upon the existing data derived from a historical particularistic approach (Bass 1983). Richards (2006:44) noted the importance of the historical particularism approach. He acknowledged that the growth of thematic studies in Australia depended on the basis established by historical particularism.

These archaeological theoretical approaches apply directly to the study of *Shah Muncher*'s timber and metal remains. Apart from the preliminary archaeological report published, little is known about the ship's technical aspect. Therefore, it is preliminary to use the data from *Shah Muncher* for general thematic nautical-related studies. The importance of general thematic studies should not be overlooked but emphasising a general thematic approach at such an initial stage may not offer an in-depth understanding of the ship’s technical features and peculiarities. Adopting Hocker's views on the matter, equal emphasis on both particularistic and general approaches might further understand *Shah Muncher*'s place within the social and cultural context it was built. Thus, this research provides the baseline data and observations that could eventually be used in future related studies utilising an array of theoretical frameworks.

CHAPTER FOUR: METHODS

4.1 Introduction

This chapter sets out the methods used for this research, in particular those pertaining to archaeometric data from *Shah Muncher* timber and metal artefacts. It details the recording techniques used and the choice and the rationale for specific sample sets.

4.2 Methodological Approaches

The methodological approaches and standards for this research are based on existing nautical archaeological studies. These approaches and standards ensure a systematic and standardised set of data obtained from various studies on ship constructionthat would be useful to identify the disarticulated timbers from the *Shah Muncher* site.

J. Richard Steffy and Frederick Van Doorninck first applied techniques specifically developed for ship studies based on scattered and scant archaeological remains (Van Doorninck, Jr. 1982; Steffy 1994:6). A notable recent study on scattered and scant archaeological remains includes Wendy Van Duivenvoorde's research on the fifth-century BC shipwreck at Tektas¸ Burnu, Turkey. Despite the scanty hull remains found at the site,she managed to analyse the small fragments of wood and metal fasteners using archaeometry to provide additional information on fifth-century shipbuilding methods. (Van Duivenvoorde 2014:12)

Standardisation of archaeological data allows complex and confident reconstructions based on scant archaeological remains. It also allows future research to easily correlate with the existing datasets (Castro et al. 2018:63). Castro et al. (2018) recommended further improvements on this notion to avoid partial scholarships that provide overly simplistic and convenient answers to the research questions posed. Castro et al. (2018) expanded the database that J. Richard Steffy created to allow scholars to conductnautical archaeology related studies using quantitative and qualitative data. The authors' approaches resonate with the theoretical framework of this paper. It stresses the need to understand ships as artefacts and further the research on ship construction to provide sufficient data to explore other related maritime archaeology topics such as cultural transmission and technology transfers.

The database would encapsulate the materials found at the site, but a timber catalogue is a fundamental requirement for any shipwreck site if timber is found at the site. It requires proper documentation through pictures, sketches, and measurements, to include each timber's contextual information and any diagnostic features such as condition, dimensions, joinery, fastening, marks, coatings, and conversion. The methodological approach for this research would attempt to adhere to the parameters of recording proposed by Castro et al. (2018) to investigate the disarticulated timbers retrieved from the *Shah Muncher* site.

Timber fragment recording practices and protocols were also consulted during the data collection process. It should be noted that there were timber and metal remains scattered throughout the *Shah Muncher* site. These timber and metal remains lost much of their contextual information as the site was located in shallow waters and exposed to constant swells. The only contextual information about these materials consists of the grid obtained and the date on which it was extracted. As the team was not granted further access to the site after June 2021, it was impossible to remove all the timber and metal remains, and only a few in-situ measurements of the timber and metal remains were obtained during the project.

The collection of the timber fragments conforms to the assessment criteria of wood artefacts for archaeological record according to Historic England's (2019:11) publication *Waterlogged Wood: Guidelines on the recording, sampling, conservation, and curation of waterlogged wood.* Due to the lack of contextual information and absence of in-situ structural remains of the ship, there was no functional information on these timbers and metal remains, thus prompting the need for this area of research to be carried out. Thus, timber and metal remains that exhibited possible functional and technological characteristics were collected for future research. These functional and technological features include joints and fittings and evidence of tool marks and signatures.

Shah Muncher was an eighteenth-century ship. It would have been built primarily with timber, and metal would be used for fastenings and sheathing of its hull. As this is the first attempt to date to analyse the ship remains of a Bombay-built vessels, archaeological data from other similar-sized ships from the same shipyards is non-existent. Therefore, construction data from other shipwrecks or ship can provide additional data to establish a baseline comparison with the artefacts found on *Shah Muncher*. The data was effectively compiled and arranged as a timber catalogue to aid in the identification of the functions of the disarticulated timber and metal remains. The archeometallurgical data incorporated intothe timber catalogue reflects the symbiotic relationship between wood and metal artefacts found on a shipwreck site of this period. Archeometallurgical studies have been conducted on historical shipwrecks. They have yielded potential information to help identify theartefact's function and use, technological application, site formation processes, deteriorationdynamics, provenance, and dating (Ciarlo and Argüeso 2019).

4.3 Methods

4.3.1 Sources for Comparative Research

Shipwreck and ship construction data are essential aspects of this research. They would be obtained through other research papers, including shipwreck reports, analyses of shipwreck materials or archival sources providing details of ship construction and materials. The selection criteria of these sources are based on any of the following conditions:

1. Eighteenth- to nineteenth-century construction
2. British ship design
3. Built in India
4. Availability of data for comparative analysis (such as measurements, timber species and metal compositional analysis)

Ships constructed in India were the primary source of material for the comparative analysis. HMS *Buffalo* (built in 1813), *Edwin Fox* (built in 1853) and *Sydney Cove* (built in 1790s) were ships built in the Bay of Bengal region of India during the late eighteenth to the early nineteenth centuries. *Quedagh Merchant* (built before 1699) was identified to be constructed in Bombay almost 100 years before the construction of *Shah Muncher*. These four ships fulfil most of the conditions; however, there are limitations to their information. HMS *Buffalo, Edwin Fox,* and *Sydney Cove* were built in the Bay of Bengal region and constructed much later than *Shah Muncher* except for *Sydney Cove*. *Quedagh Merchant* was constructed in Bombay but much earlier than *Shah Muncher*. In addition, these ships were different in size from *Shah Muncher*. (Bennett 2021; Hanselmann 2016; Nash 2002; Lester 1982). HMS *Trincomalee* (built in 1817) was constructed in Bombay much later. It was relatively the same size as *Shah Muncher*, and information on its construction and material could be found in Wyn and Mudie (2015)'s book on the ship and an online 3D model by Wessex Archaeology. The information may be scant, but the pictures highlighting various aspects of the ship would be useful in the cross-comparison. Nonetheless, the research conducted on these ships could still offer relevant comparative information to identify the functions of the timber fragments found on *Shah Muncher*.

Shipwreck information from other contemporary British-built ships would also be another source of information which could highlight construction details, such as *Endeavour* (1771), which was built in London, ten years before *Shah Muncher* was constructed. Further information on shipbuilding materials could also be gathered from studies on the timber used in Indian shipbuilding and metal used for sheathing and tack during the late-eighteenth to the early-nineteenth century. Studies have highlighted that teak was one of the critical materials used in shipbuilding in India (Tripati et al. 2005; Tripati et al. 2016). Thus far, ships constructed in India, such as HMS *Buffalo, Edwin Fox, Sydney Cove* and *Quedagh Merchant*, uses teak as the main timber material for ship construction. Archival research on records, such as Phipps' (1840) *A Collection of Papers Relevant to Ship Building in India*, *etc.*, would also grant possible insights into the construction materialsand methods used on ships built in India.

Two critically important books used by nautical archaeologists in their study of ship construction were referenced. Steffy's 1994 book on wooden shipbuilding covers a section on eighteenth-century shipbuilding and provides relatable examples to this research. Similarly, Desmond (1919) provided similar information relating to wooden shipbuilding. In addition, it offers information on scantling and fastening dimensions of British ships of that period that could aid structural analysis.

Various researchers covered the usage of copper and its prevalence in eighteenth and nineteenth centuries shipbuilding. Staniforth (1985) provided an introduction and use ofcopper sheathing throughout history and highlighted the usage of Muntz metal, which was a critical turning point in copper alloy usage on ships during the early-nineteenth century. Further research on copper alloy was carried out to investigate the extensiveness of copper alloy used for sheathing globally (Bingeman 2018; Bingeman et al. 2000; Ciarlo 2013). In addition, site-specific analyses on copper alloys could provide material composition data that could also be used for comparison, such as the analysis done on the copper alloy artefacts from HMAV *Bounty* (Viduka and Ness 2004). Then, McCarthy's book on ship fastenings provides the necessary references and guide to the understanding of copper alloy fastenings and sheaths used on ships during the eighteenth and nineteenth centuries.

4.3.2 Timber and Metal Artefact Recording

As mentioned above, very few in-situ measurements were collected for the timber and metal remains existing at the site. Therefore, the post-excavation recording would be a critical process to ensure further research for these artefacts. Wood record sheets prepared by Historic England (2019) and the recording procedures stated by Steffy (1994:191–250) were referenced and used to record the features systematically. Written descriptions and sketches would be used to record these features. The wood record sheet from Historic England's (2019:14) manual was referenced. The features recorded would include the size and shape, damages and breakages observable during the post-excavation process,surface condition and features, and details of fittings. Depending on the condition of the timber, three to six sides of the timber would be recorded. They would be labelled and indicated on the accompanying photographs, illustrations, and written descriptions. This recording framework would also be applied to the metal remains to be studied for this research. The framework conforms to the standards detailed by Steffy (1994:191–250) for ship recording, reporting, presentation of catalogues and field data, and finally, interpretation.

4.3.3 Illustrations and Photography

A Sony A7II camera with a 24–70mm lens was used during the photography of the timber and metal samples. Photographs were taken with a black cloth or a cleaned area of the facility's grey flooring to achieve a neutral background for the artefact photography. A ring light was used to provide the appropriate lighting to cancel out shadows (Figure 12). The lighting used was neutral white, and the white balance on the camera was set to auto to ensure colour accuracy in the photos. Black and white photographic scales with different lengths were used. It consists of 1m scales with 10cm increments; 50cm scales with 10cm increments; 30cm scales with 5cm increments and 8cm scales with 1cm increments. Photographs of the timber and metal remains were then processed using Adobe Illustrator. The timber photographs were used to trace the remains and create detailed sketches with written descriptions.

Figure 12: Setting up the photography area (M. Ng, 2022).

4.4 Timber Artefact Analysis

During the excavation season between 2020 to 2021, timber artefacts obtained from the site were transported to the ISEAS–Yusof Ishak Institute for temporary storage. These artefacts were soaked in a container of tap water to prevent further deterioration. Upon conclusion of the fieldwork in June 2021, the timber artefacts were transported to a more permanent storage and conservation facility. A long-term conservation strategy was required to prevent further timber deterioration and ensure continued research in the future. The advice was sought from Ian Mcleod, a conservation specialist who previously worked for theWestern Australian Museum. The timber artefacts were briefly rinsed off the dirt and sediments, and they were placed into a conservation box with a solution comprising 10% Polyethylene glycol 400 (PEG 400) and 5% biocide. PEG 400 is used for the preservation of timber. As waterlogged wood will experience a loss of cellulose due to prolonged exposure in a water body, PEG 400 would be able to replace this lost cellulose to halt the deterioration of the timber, and it allows the timber to be placed in dry storage. Biocide was used to prevent algae growth (Grattan and Clarke 1987:165; Robinson 1998:30; Hamilton 1999:307 – 308; Kim et al. 2013:36–37).

Before any examination and analysis are conducted on the timber artefacts, there is a need to inventory the timber samples properly. The timber samples' inventory was created on the first two weeks of November in 2021. Each piece of timber artefact was issued with a Unique Identification Number (UIN: PB2_XXXX), and records of the timber artefact were input into an inventory list on Microsoft Excel. The inventory list includes photographs of the timber artefact, accompanied by rough dimensions, contextual information, and a brief description. A total of 170 timber artefacts ranging in length from 2cm to 150cm were recorded on the inventory list.

Physical analysis and extraction of timber samples for wood species identification were conducted between November and December. This process was carried out at the storage and conservation facility. The timber was first removed from the conservation boxes and laid on a black cloth. A sketch of the timber was drawn, and more precise measurementsof the timber were taken using a ruler and digital Vernier calipers. The sketch noted the diagnostic features observed on the timber with its corresponding measurements. The diagnostic features and measurements will include the positions of the tack holes and theirrelevant dimensions, and the presence of metal or other materials on the timber. Recordings were done on each side of the timber. After the physical recording was done, photographs were taken for each side of a timber sample with a photographic scale. As the timber samples were still undergoing impregnation of PEG 400 and remained susceptible to damage due to prolonged dry exposure, a spray bottle was used to keep the timber samples moist throughout the recording and photography process. As moist timber creates a reflection during photography, the surface of the timber was patted down with a kitchen towel to remove any reflection that may obscure the diagnostic features on the timber. Once the photographs for that timber profile were completed, the timber was sprayed with water to keep it moist. This process is repeated for each timber remains. The information recorded from the timber was combined with the photographs using Adobe Illustrator. The images of the timbers were traced on Adobe Illustrator to accentuate the diagnostic features and indicate the measurements.

Figure 13: Measuring the timber artefacts by Jason Khoo (Left) and retrieval of timber samples by Kyna Khoo (Right) (M. Ng, 2022).

Figure 14: Timber sample prepared for analysis (M. Ng, 2022).

A total of 25 timber fragments were obtained for wood identification. A timber chisel, mallet and a handsaw were used to extract the samples (Figure 13). Each sample measures approximately $2cm^3$ to provide enough material to be examined under a microscope (Figure 14). These samples were extracted from an area on the timber which does not exhibit any diagnostic feature. Samples would preferably be taken from the side of the timber, which shows a broken edge. These considerations were made to reduce the damage or dramatically modifythe samples. Once the $2cm^3$ samples were extracted, it was placed in a small plastic container filled with the solution from the conservation box. As there is no laboratory in Singapore capable of conducting wood identification, the samples were sent to the laboratory at Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia (Ministry of Environment and Forestry of the Republic of Indonesia). The timber specialist would sand the samples using sandpaper to expose the wood cell structure. The exposed cell structure would then be examined under the microscope.

4.5 Metal Artefact Analysis

Fasteners and sheathings were among the metal artefacts obtained during the excavation season between 2020 to 2021. These metal remains were stored in a different environment. Some were immersed in a 1% Sodium Sesquicarbonate solution to remove corrosive agents when the metal remains were stored in an aqueous state (Kim et al. 2013:76). Some remains were left to dry out, and some were embedded in the timber artefacts. Proper conservation procedures for these artefacts were carried out with the recommendations proposed by Ian Mcleod. Like the timber artefacts, none of the metal artefacts has been inventoried as they were in various stages of the conservation process after the excavation concluded. Therefore, only the metal remains left to dry out were inventoried for the research. Each piece of the metal artefact was issued with a UIN, and records of the artefact were input into an inventory list on Microsoft Excel. The inventory list includes photographs of the metal artefact, accompanied by rough dimensions, contextual information, and brief descriptions. A total of 40 metal remains were inventoried. The metal artefacts inventory was carried out concurrently with the recording of the timber artefacts during the first two weeks of November 2021.

The metal artefacts for the research were obtained from two sources. One source comes from the metal remains that were embedded in the timber. Furthermore, the other sources come from the metal remains, which were left to dry out. Photographs and measurements of these samples were obtained. The measurements include the dimensions of these samples and identification of any diagnostic features such as markings or fastening holes.

Five metal samples were eventually selected for elemental analysis at Adelaide Microscopy, South Australia. These samples comprise of tacks and sheaths found at the site. The analyses were done by Wendy Van Duivenvoorde using an FEI Quanta 450 FEG Environmental Scanning Electron Microscope. It uses a High-Resolution Field Emission Scanning Electron to image and analyse the surface topography, collect backscattered electron images, and characterise and determine a sample's elemental composition through x-ray detection with an SDD EDS detector.

Figure 15: Metal sample preparation done by Wendy Van Duivenvoorde (M. Ng, 2022).

The metal samples were first cut samples into <1cm^3 pieces (Figure 15) and embedded into a Struers MultiFast phenolic hot mounting resin. Resin was added onto the mounting resin before using a Struers CitoPress-10 hot mounting machine to set them. To attain a clean, uncorroded surface for analyses, a Struers TegraPol-11 diamond polisher was used to polish the samples (Figure 16).

Figure 16: Samples were polished using the Struers TegraPol-11 diamond polisher (Left) before they were analysed using a FEI Quanta 450 SDD EDS detector (Right) (M. Ng, 2022).

Once the samples were prepared, they were analysed using a FEI Quanta 450 with SDD EDS detector (Figure 17). The detector uses a semi-quantitative analytical method of elemental composition by spot or area testing. This is a localized testing method therefore the results may not represent the composition of an entire sample. This problem can be negated by testing three areas per sheathing and strap sample. Tack samples only require one spectrum as their cross-sectional shape easily offers a spot for testing. Setting on the Scanning Electron Microscope is set to high-vacuum, Kilovoltage: kV 20, Element Normalized, SEC table: default, standardless. The amount of time allotted for the sample analysis was automated as the Quanta 450 is the fastest SEM-EDS collector in Australia.

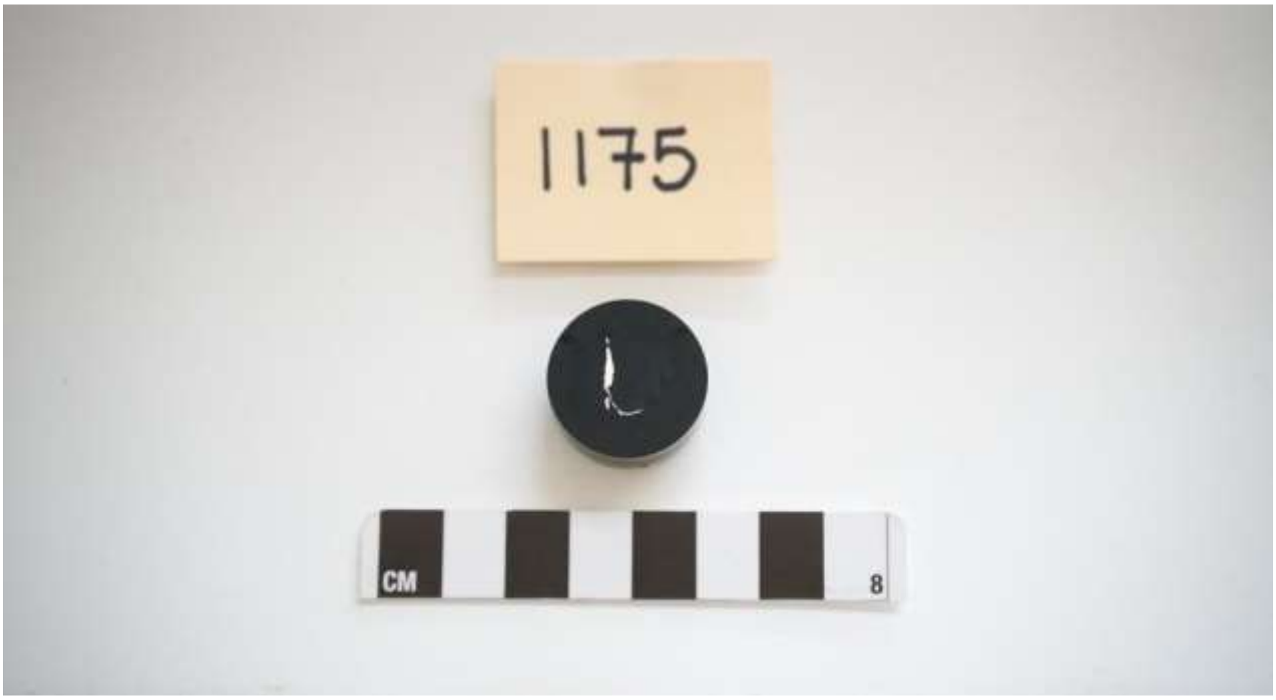


Figure 17: Metal sample prepared for analysis (M. Ng, 2022).

4.6 Conclusion

In conclusion, the chapter presented the methodological approaches, methods and the subsequent actions taken during the data collection process. The methodological approaches provide the direction to be taken during the data collection by ensuring the information gathered was relevant to the research questions and the theoretical framework of this thesis. The listed methods were derived from general guidelines and practices, ensuring systematic and accurate data collection. It is also essential to follow these existing guidelines and practices as the information gathered would be easily translatable compared with other sources, which is critical for this research paper. The methods used for this research are straightforward, and adequate for the data required.

CHAPTER FIVE: RESULTS

5.1 Introduction

This chapter covers two main sections. The first section consolidates the information obtained from *Endeavour,* HMS *Buffalo, Edwin Fox, Quedagh Merchant,* and *Sydney Cove*. The timber and metal information obtained from these shipwrecks and the existing ship shall provide the basis for comparison with the data obtained from *Shah Muncher.* The second section provides the data from analysing the wood and metal remains found at the *Shah Muncher* site. A total of 32 wood samples were examined for this research. These samples were examined for manufactured features such as notches, grooves, joinery and fastening holes. In addition, some of them were sent to the laboratory for wood species identification. The emphasis would be placed on several critical timber measurements to allow a direct comparison between the results obtained from archaeological data. They include wood species, timber dimensions (specifically the thickness), fastening holes and extant fastenings, and other diagnostic features (joinery and carpentry). Five metal samples were selected for analysis. The source of four metal samples was from the timbers that were analysed. The other sample is a loose item found at the site to be used for intra-site comparison.

5.2 Results from Desktop Review

This section summarises the information obtained from the various eighteenth- to nineteenth-century shipwrecks and related data, which would be used to compare the timbers' functions on *Shah Muncher*.

5.2.1 *Endeavour* – Structural Timbers

Table 2: Wood species identified in *Endeavour*'s structural timbers (Bennett 2021:130–192).

Ship Part	Wood Species	Common Name	Remarks
False keel	*Ulmus spp.?*	Elm	Elm
Futtock	*Quercus spp.?*	Oak	Oak
Garboard strake	*Ulmus spp.?*	Elm	Elm
Keel	*Ulmus spp.?; Quercus spp.?*	Elm; Oak	Mainly Elm with one instance of Oak
Outer plank	*Ulmus spp.?; Quercus spp.?; Pinus spp.?*	Elm; Oak; Pine	Mainly Elm with one instance of Oak and one instance of Pine
Plank	*Ulmus spp.?; Tectona grandis*	Elm; Teak	Elm and Teak

Endeavour was a 777 tons ship constructed in London in 1771 (Bennett 2021:8). Data collected from the ship included measurements and species identification of the structural timbers. The structural timbers species were identified as the majority oak or elm. Only one plank was identified as teak. Table 2 summarises the wood species identification of *Endeavour's* structural timbers.

Table 3: *Endeavour*'s structural timbers recorded dimensions (Bennett 2021:130–192).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
False keel	3163	305	138	-
Futtock	1188 – 2025	192 – 295	132 – 199	-
Garboard strake	2945	291	-	114
Keel	1381 – 3385	183 – 374	98 – 369	-
Outer plank	676 – 2656	137 – 320	-	63 – 105
Plank	1065 – 1548	160 – 308	-	63 – 105
Plank fragment	283	84	-	65

Table 3 summarises the recorded dimensions of *Endeavour's* structural timbers. Different types of fastenings were observed on the structural timbers. The false keel exhibited the presence of metal nails, bolts, and staples. The metal was identified as iron. The bolts were round and were 33mm and 50mm diameters. One of the bolts has a round washer with a diameter of 61mm. The nails and staples create a square hole with dimensions of 10mm by 11mm. Sheathing tack holes were also observed on the timbers, but the measurements were not indicated. Keel timbers exhibited the presence of metal bolts, fasteners, and wood treenails. A round keel bolt measured 800mm in length and had a diameter of 33mm. The metal fasteners were round and had a diameter of 31mm to 33mm. The material of these fasteners and bolts was identified to be either iron or ferrous metal. Extant wooden treenails found on the keel timbers were round and diameter between 41mm to 43mm. Round holes created by bolts measured 35mm in diameter, while those created by fasteners measured 38mm. Sheathing tacks were also observed on one of the keel timbers, which have a dimension of 5mm by 7mm. Futtocks of *Endeavour* exhibited essentially wooden treenails. They were round and had a diameter of 38mm.

One extant round fastener with a diameter of 25mm was found on the keel, but the material was unknown. The garboard strake, outer planks and planks all exhibited a combination of treenails, sheathing tacks and metal fasteners. The wooden treenails were round and ranged between 38mm to 41mm. Some treenails were observed to have a flat wedge driven into the treenail. The metal fasteners were primarily identified as copper alloy, but one fastener was identified as ferrous, while the material of the other fastener was not determined. These fasteners have a round head and square shank with a diameter of 18mm to 26mm. Holes made by sheathing tacks have dimensions between 2mm by 2mm to 6mm by 8mm. The ceiling plank has round dowels with a diameter of 15mm and possible iron square fasteners with a diameter of 45mm.

Loose metal sheathing tacks from *Endeavo*ur have a length of 27mm to 32mm with a round head diameter of 11mm to 12mm. The round copper alloy keel bolts have a diameter of 32.5mm and 1580mm long. The round copper alloy fasteners have a diameter of 40mm and 315mm long. The loose treenails have a length between 82mm and 211mm, with a diameter between 36.5mm and 42mm.

Structural timber fragments from *Endeavour* do exhibit some joinery features. The keel timber fragments were observed to have angled rabbets. Possible scarf joints were observed on a keel and futtock. Some planks exhibited possible butt joints. A graving piece,131mm in length and 20mm in depth, was found on an outer plank.

5.2.2 *Endeavour* – Anti-fouling Timbers

Table 4: Wood species identified in *Endeavour*'s anti-fouling timbers (Bennett 2021:130–192).

Ship Part	Wood Species	Common Name
Sacrificial sheathing	*Tectona grandis*	Teak

Table 5: *Endeavour*'s anti-fouling timbers' recorded dimensions (Bennett 2021:130–192).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
Sacrificial sheathing	201 – 3285	21 – 280	-	21 – 31

Tables 4 and 5 summarise the wood species identification and recorded dimensions of *Endeavour's* anti-fouling timbers. Sheathing tacks were observed on the sacrificial sheathing. The sheathing tacks were made of copper alloy. The length of the tacks is between 27mm to 34 mm. They have a square shank and round head with a diameter between 11mm to 12mm. Sheathing tack holes have a dimension between 2mm by 2mm to 6.5mm by 5mm. The spacing between the tacks was 35mm to 39mm vertically and 28mm to 125mm horizontally. The metal sheathing found on these sacrificial sheathing has a thickness between 0.5mm to 0.9mm. The metal sheet overlaps by 33mm to 40mm on two of the sacrificial sheathing. Tables 6 and 7 summarise the elemental composition results of *Endeavour*'s hull sheathings and sheathing tack.

Table 6: *Endeavour* metal samples analysed (Bennett 2021:130–192).

Mueum sample number	Analysis sample number	Description

Table 7: *Endeavour*'s sheathing and tacks elemental composition results (Bennett 2021:130–192).

	Wt %							Atomic %						
Description	**C**	**Fe**	**Cu**	**Zn**	**Sn**	**Pb**	**Total**	**C**	**Fe**	**Cu**	**Zn**	**Sn**	**Pb**	**Total**
END4: spectrum 1	12.76	-	87.24	-	-	-	100	43.62	-	56.38	-	-	-	100
END4: spectrum 2	13.47	-	86.53	-	-	-	100	45.16	-	54.84	-	-	-	100
END4: spectrum 3	12.25	-	87.75	-	-	-	100	42.48	-	57.52	-	-	-	100
END29: spectrum 1	9.37	-	90.63	-	-	-	100	35.36	-	64.64	-	-	-	100
END29: spectrum 2	9.9	-	90.1	-	-	-	100	36.77	-	63.23	-	-	-	100
END29: spectrum 3	12.59	-	87.41	-	-	-	100	43.24	-	56.76	-	-	-	100
END30: spectrum 1	15.53	-	84.47	-	-	-	100	49.3	-	50.7	-	-	-	100
END30: spectrum 2	14.97	-	85.03	-	-	-	100	48.22	-	51.78	-	-	-	100
END30: spectrum 3	13.96	-	86.04	-	-	-	100	46.19	-	53.81	-	-	-	100
END36: spectrum 1	9.89	1.07	75.19	8.17	4.06	1.61	100	37.55	0.88	53.96	5.7	1.56	0.35	100
END37: spectrum 1	8.97	-	79.56	2.59	2.68	2.68	100	35.5	-	59.52	1.88	2.48	0.61	100

5.2.3 HMS *Buffalo* – Structural Timbers

Table 8: Wood species identified in HMS *Buffalo*'s structural timbers (Bennett 2021:193–218).

Ship Part	Wood Species	Common Name
False keel	*Tectona grandis*	Teak
Futtock	*Quercus spp.?*	Oak
Knee	*Shorea robusta*	Sal
Outer plank	*Tectona grandis*	Teak

Table 9: HMS *Buffalo*'s structural timbers' dimensions (Bennett 2021:193–218).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
False keel	2040	345	90	-
Futtock	860	155	212	-
Knee	930	90	85	-
Outer plank	677	165	-	46

HMS *Buffalo* was a 589 tons ship constructed in Sulkea, India, in 1853. Three types of wood were identified from the structural timbers of HMS *Buffalo*. The false keel and the outer planks were identified as teak, while the futtock and the knee were oak and sal, respectively. Tables 8 and 9 summarise the wood species identification and recorded dimensions of HMS *Buffalo's* structural timbers. Fastenings were observed on the four structural timbers. The false keel has square holes formed due to metal staple fasteners and sheathing tacks exhibiting a round head with a diameter of 11mm. The futtock only has round treenails which have a diameter of 25mm. The knee was found to have round ferrous fasteners with a diameter of 15mm. The outer plank has round treenails with a diameter of 17mm and sheathing tacks which appeared to be square. The false keel also exhibited a half-lapped scarf joint.

5.2.4 HMS *Buffalo* – Anti-fouling Timbers

Table 10: Wood species identified in HMS *Buffalo*'s anti-fouling timbers (Bennett 2021:193–218).

Ship Part	Wood Species	Common Name	Remarks
Sacrificial sheathing	*Cedrus spp.?; Pinus spp.?*	Cedar; Pine	Mainly Cedar with one instance if Pine

Table 11: HMS *Buffalo*'s anti-fouling timbers' recorded dimensions (Bennett 2021:193–218).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
Sacrificial sheathing	570 – 3613	123 – 240	-	19 – 28

Tables 10 and 11 summarise the wood species identification and recorded dimensions of HMS *Buffalo's* anti-fouling timbers. Sheathing tacks and holes formed by the tacks can also be found on these sheathing. The copper alloy sheathing tacks have a round head diameter between 11mm to 12mm, and a square shank. The length of these tacks ranges from 23mm to 32mm. The square holes created by these tacks have the dimension of 7mm by 6mm. Six out of eight of the sacrificial sheathing were observed to have iron fasteners and holes. These fasteners were square shanks, and the dimensions ranged from 4mm by 4mm to 6mm by 7mm. The holes created by these fasteners range from 4mm by 4mm to 15mm by 16mm. Tack spacing on the sacrificial sheathing was between 28mm to 34mm. The thickness of the copper alloy sheathing on the sacrificial sheathing is 0.5mm. The copper alloy sheathings overlap with each other between 27mm to 42mm. The copper alloysheathing on the false keel also has sheets overlapping by 25mm to 30mm. Tables 12 and13 summarise the elemental composition results of HMS *Buffalo*'s hull sheathings.

Table 12: HMS *Buffalo* Hull sheathing Analysis (Bennett 2021:193–218; Van Duivenvoorde 2022a).

Museum sample number	Analysis sample number	Description
BUF001_M1	BUF_1M1_CS	HMS *Buffalo*'s hull sheathing
BUF002_M1	BUF_2M1_CS	HMS *Buffalo*'s hull sheathing
BUF003_M1	BUF_3M1_CS	HMS *Buffalo*'s hull sheathing

Table 13: HMS *Buffalo* sheathing elemental composition results (Bennett 2021:193–218; Van Duivenvoorde 2022a).

	Wt %				Atomic %		
Description	**C**	**Cu**	**Total**		**C**	**Cu**	**Total**
BUF_1M1: spectrum 1	16.15	83.85	100		50.46	49.54	100
BUF_1M1: spectrum 2	14.07	85.93	100		46.41	53.59	100
BUF_1M1: spectrum 3	17.54	82.46	100		52.95	47.05	100
BUF_2M1: spectrum 1	18.23	81.77	100		54.12	45.88	100
BUF_2M1: spectrum 2	19.67	80.33	100		56.44	43.56	100
BUF_2M1: spectrum 3	16.89	83.11	100		51.81	48.19	100
BUF_3M1: spectrum 1	18.78	81.22	100		55.03	44.97	100
BUF_3M1: spectrum 2	17.66	82.34	100		53.15	46.85	100
BUF_3M1: spectrum 3	19.53	80.47	100		56.22	43.78	100

5.2.5 *Edwin Fox* – Structural Timbers

Table 14: Wood species identified in *Edwin Fox*'s structural timbers (Bennett 2021:219–251).

Ship Part	Wood Species	Common Name
Floor timber	*Shorea robusta*	Sal
Frame (possible #2 futtock)	*Shorea robusta*	Sal
Keel	*Tectona grandis*	Teak
Keelson	*Tectona grandis*	Teak
Main mast	*Cedrus deodara*	Himalayan cedar
Outermost timber planking directly beneath metal sheathing	*Ulmus spp.?*	Elm
Plank (Thick strake)	*Tectona grandis*	Teak
Plank	*Tectona grandis*	Teak
Rider keelson	*Cedrus deodara*	Himalayan cedar

Table 15: *Edwin Fox*'s structural timbers' dimensions (Bennett 2021:219–251).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
False Keel	4360	342	-	115
Floors	-	290	540	-
Garboard Strake Port	-	380	62	-
Garboard Strake	-	380	65	-
Keel	15930	345	440	-

Edwin Fox was an 835 tons ship constructed in Salkea, India, in 1853. The structural timbers on *Edwin Fox* include four timber species. Most of the tested samples were teak, including the keel, keelson, and planks. The rider keelson and the main mast were identified as Himalayan cedar, while the floor timber and frames were identified as sal. An outer timber planking directly beneath the metal sheathing, was identified as elm. Tables 14 and 15 summarised the wood species identification and recorded dimensions of *Edwin Fox's* structural timbers. The structural timbers were complete, as the ship is currently displayed in New Zealand in its entirety.

Copper alloy fasteners of two different sizes were observed on the false keel. The smaller round fastener has a head diameter of 25mm, while the larger round fastener has a head diameter of 37.5mm. The larger fastener also exhibited a washer with a diameter of 63mm. The false keel has evidence of a box joint located at its forward end. There were two layers of hull planking, and layer two hull planking had both copper bolts and treenails with triangle wedges. The copper bolts are round and have a diameter of 25mm, while the treenails have a diameter of 33mm. Ceiling planking below the lower deck has treenails, iron bolts, iron dumps and copper alloy bolts. Some of the treenails have a straight wedge driven into them. The treenails have a diameter between 25mm to 37mm. The round iron bolts have a diameter between 35mm to 50mm, and some have washers. The iron dumps have a diameter of 25mm. A graving piece, 230mm in length and 95mm wide, can be found on one of the ceiling planks on the port side of the rider keelson. Copper hull sheathing has tacks 35mm to 45mm in length. The round head diameter was 12mm. Measurements taken at the tip of the sheathing tack were 2mm by 2mm, and the diameter below the head of the tack measured 4.5mm in diameter. A copper hull sheathing panel was measured. It has a length of 1210mm, 353mm in width and 1mm thick. The sheets overlap with one another. The horizontal overlap was 25mm, while the vertical overlap was between 28mm to 38mm. Each panel has around 96 sheathing tacks on its edges. Other tacks fill up the centre of the sheet. The tacks were arranged in a three tacks high and ten tacks long configuration. Tables 16 to 20 summarise the elemental composition results of *Edwin Fox*’s hull sheathings, keel bolt and sheathing tack.

Table 16: Selection of *Edwin Fox*'s hull sheathing and sheathing tack for analysis (Bennett 2021:219–251; Van Duivenvoorde 2022b).

Museum sample number	Analysis sample number	Description
EFX_CS1	CS001	*Edwin Fox* hull sheathing, portside bow.
EFX_CS2	CS002	*Edwin Fox* hull sheathing, portside midships.
EFX_CS-008	CS008	*Edwin Fox* bolt used in keel at the bow.
EFX_CS-009	CS009.1	*Edwin Fox* rudder sheathing tack, starboard.
EFX_CS-009	CS009.2	*Edwin Fox* rudder sheathing tack, starboard.

Table 17: *Edwin Fox* hull sheathing elemental composition results (Bennett 2021:219–251; Van Duivenvoorde 2022b).

	Wt%				Atomic %		
Description	Cu	Zn	Total		Cu	Zn	Total
CS001:	64.46	35.54	100		65.11	34.89	100
CS001:	64.47	35.53	100		65.12	34.88	100
CS001:	64.27	35.73	100		64.92	35.08	100
CS002:	65.03	34.94	100		65.70	34.30	100
CS002:	66.59	33.41	100		67.22	32.78	100
CS002:	65.81	34.19	100		66.44	33.56	100

Table 18: *Edwin Fox* elemental composition of white spots in the Muntz metal sheathing (Bennett 2021:219 – 251; Van Duivenvoorde 2022b).

	Wt%					Atomic %			
Description	Cu	Zn	Pb	Total		Cu	Zn	Pb	Total
CS002: spectrum 4	5.46	4.02	90.52	100		14.69	10.53	74.77	100

Table 19: *Edwin Fox* elemental composition of the sheathing tacks (Bennett 2021:219–251; Van Duivenvoorde 2022b).

	Wt%					Atomic %			
Description	Cu	Zn	Sn	Total		Cu	Zn	Sn	Total
CS009.1: spectrum 1	72.63	25.77	1.59	100		73.72	25.43	0.86	100
CS009.2: spectrum 1	74.36	23.89	1.77	100		75.47	23.56	0.95	100

Table 20: *Edwin Fox* elemental composition of bolt (Bennett 2021:219–251; Van Duivenvoorde 2022b).

	Wt%						Atomic %				
Description	Cu	Zn	Sn	Pb	Total		Cu	Zn	Sn	Pb	Total
CS008: spectrum 1	76.80	13.40	2.39	7.42	100		73.93	25.50	0.87	0.20	100
CS008: spectrum 2	79.09	13.47	2.97	4.47	100		83.12	13.76	1.67	1.44	100
CS008: spectrum 3	77.08	13.21	3.55	6.16	100		82.26	13.70	2.02	2.01	100

5.2.6 *Quedagh Merchant* – Structural Timbers

Table 21: Wood species identified in *Quedagh Merchant*'s structural timbers (Hanselmann 2016).

Ship Part	Wood Species	Common Name
Keel	*Tectona grandis*	Teak
Keel (South)	*Tectona grandis*	Teak
Keel (North)	*Tectona grandis*	Teak

Table 22: *Quedagh Merchant*'s structural timbers' dimensions (Hanselmann 2016).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
Keel	4130	370	-	80
Keel (South)	2130	-	370	-
Keel (North)	2000	-	-	-
Strakes	-	200 - 250	-	50
Futtocks	860 - 1300	-	230 - 360	-

Quedagh Merchant was reported to be a 400 tons ship constructed in Surat, India. In 1699, it was abandoned off the southeastern coast of Hispaniola (the current Dominican Republic). The wood species of *Quedagh Merchant*'s keel timber was identified as teak. The dimensions of the structural timbers were measured in-situ. Tables 21 and 22 summarised the wood species identification and recorded dimensions of *Quedagh Merchant's* structural timbers. Round holes were observed on these timbers, with a diameter of 15mm to 20mm. The spacing of the holes on the north and south keel fragment was 400mm and 100mm to 600mm. Iron spikes with square shanks were found on the strakes at the wreck site. According to Hanselmann (2016), these iron fastenings were usedfor edge-to-edge plank joinery or rabbeting. The fastenings would be hammered through a square notch in the upper planks, thus connecting both planks. The planks seem to exhibit a coating of limestone with the appearance of fine-grained cement, and these planks were observed to possess rabbeted seams.

5.2.7 *Sydney Cove* – Structural Timbers

Table 23: Wood species identified in *Sydney Cove*'s structural timbers (Strachan 1986; Nash 2002).

Ship Part	Wood Species	Common Name
Hull Frames	*Tectona Grandis / Dalbergia Sisoo / Dalbergia Latifolia*	Teak / Sisoo / Indian Rosewood
Bow Frames	*?Swietenia SP.*	?Mahogany-Like Hardwood
Frames (Bow)	*Entandrophragma (Possibly Candollei)*	-
Frames	*Dalbergia Sissoo*	-
Keelson	*?Swietenia SP.*	?Mahogany-Like Hardwood
Keelson (Bow)	*Entandrophragma (Possibly Candollei)*	-
Keelson	*Dalbergia Sissoo*	-
Plank	*Tectona Grandis*	Teak
Rigging - Sheaves	*Lignum Vitae*	-
Rudder	*Tectona Grandis / Dalbergia Sisoo*	Teak + Sisoo
Starboard (Bow) Planking	*Tectona Grandis*	Teak
Mainmast Step (Midships)	*Sissoo (Not Dalbergia)*	-
Mizzenmast Step (Trench 3)	*Unidentified But Resemble Sissoo*	-

Sydney Cove was a 250 tons ship constructed in Calcutta and sank in 1797, on Preservation Island, off the coast of Tasmania. Tables 23 and 24 summarised the wood species identification and recorded dimensions of *Sydney Cove's* structural timbers.

Table 24: *Sydney Cove*'s structural timbers' dimensions (Strachan 1986; Nash 2002).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
False Keel	-	-	-	70
Floor Frames	210	210	-	-
Keel	2600	240	-	
Keelson	-	240	-	210
Keelson (Bow)	15600	240	-	-
Keelson (Trench 2)	-	240	-	160
Plank	-	180-220	-	70
Rider Keelson	-	240	-	250
Rider Keelson (Bow)	13700	240	-	-
Rider Keelson (Trench 2/3)	1910	255	-	200
Starboard (Bow) Planking	-	-	-	70
Starboard Planking	120-220	-	-	-
Plank	295-590	40-280	-	15-50
Floor Futtock	980-2160	200-220	-	-
Adjoining Floor Futtock 1	1960-4400	160/180-160/200	-	-
Mainmast Step (Midships)	2140	370	-	220-560
Step/Tenoned Heel (Midships)	260	190	-	-
Mizzenmast Step (Trench 3)	1145	3650	-	330
Step/Tenoned Heel (Mizzenmast)	170	170		
Adjoining Knee	1230.7	184.6	-	169.2-553.8

Iron spikes were observed on the planks found on the *Sydney Cove* wreck. These spikes have a square shaft and chiseled point. These planks were fastened to each frame by two of these iron spikes. No treenails or timber fastening was observed (Nash 2002:46).Iron bolts were observed on keelson and rider keelson. Loose copper alloy bolts and spikes found at the site have lengths between 146.7mm to 156.7mm. These copper alloy bolts and spikes have a round head, measuring between 26.7mm to 36.7mm in diameter. The shanks were rounded right beneath the head and square towards the tip. The rounded portions have a diameter of 13.3mm to 16.7mm, while the dimensions of the square part of the shank range from 10mm by 10mm to 13.3mm by 13.3mm.

Loose Iron bolts were found on the starboard, adjacent to the bow, towards the end of the keelson. Some of the bolts were spotted with either square or round shanks. Iron bolts with square shanks were 290mm long and 15mm in diameter. The bolts with round shanks have a diameter of 9mm. Similar bolts with round shanks, 130mm long and 20mm in diameter, were also attached to copper sheathing near anchor 2. The bolt, observed to have a square shaft with a round head, was 110mm long and 12mm in diameter. Another similar bolt, 110mm long and 12mm in diameter, were found near anchor 2. Scarf jointing was found on the planking and frames, while mortise and tenon joineries were observed on the keelson rider (Strachan 1986:28).

5.2.8 *Sydney Cove* – Anti-fouling Timbers

Table 25: *Sydney Cove*'s anti-fouling timbers' dimensions (Strachan 1986; Nash 2002).

Ship Part	Length (mm)	Width (mm)	Sided (mm)	Thickness (mm)
Sacrificial Sheathing	1205	500	-	13 – 20
Sacrificial Sheathing w/ Copper	340-1750	80-185	-	13 – 25

Table 25 summarises the recorded dimensions of *Sydney Cove's* anti-fouling timbers. According to Nash (2002:47), the outer planking was first covered by a sacrificial planking 13mm to 15mm thick. This sacrificial planking extends to the false keel. There were traces of lime and resin coating on these planks. A woollen felt was laid between the copper sheath and the sacrificial planking before they were fastened using copper alloy tacks. A single sheet of copper recovered from the site was 1205mm long and 500mm wide, requiring around 130 tacks to fasten securely to the sacrificial planking. The composition of the copper sheathing was 95% copper. Loose copper alloy sheathing tacks have lengths between 23.3mm to 66.7mm. The tack's rounded head was between 6.7mm to 13mm. The tacks were found to have 70% copper with other metals such as lead, tin, and zinc (Nash 2002:47).

5.3 *Shah Muncher* Timber Analysis Results

5.3.1 Overall Results

A total of 170 timber and wood artefact were inventoried (Figure 18). The inventory is incompleteas other timber and wood artefacts have not been accounted for because of the ongoing conservation process. Some of the timber artefacts were identified as the pulleys (Figure 19) and runners (Figure 20), which were part of umbrellas. These umbrellas were identified as cargo under the ship's manifest; however, most timber and wood artefacts were unidentifiable. The chart below illustrates the quantities of each type of timber and wood artefacts relative to the overall quantity.

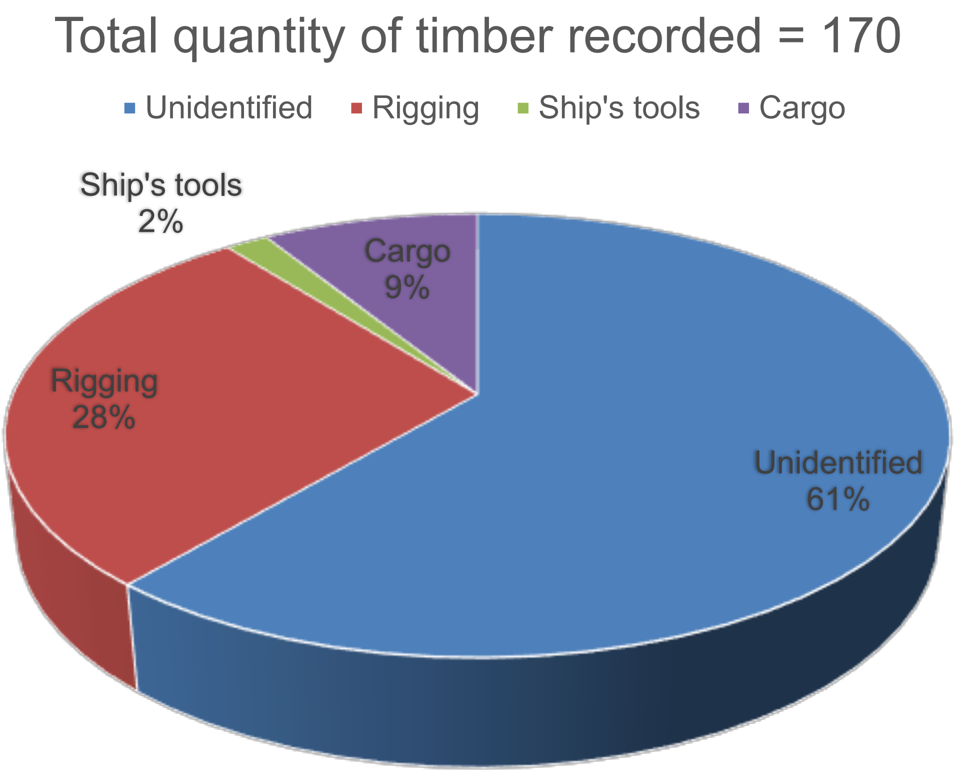


Figure 18: A breakdown of the total number of *Shah Muncher*'s timber remains inventoried.

Figure 19: Pulley block and a wooden splicer found at the site (M. Ng, 2022).

Figure 20: A wooden runner portion of an umbrella found at the site. Umbrellas were indicated in *Shah Muncher*'s final cargo manifest before it sank (M. Ng, 2022).

Among the 104 pieces of timber artefacts, 32 were examined for this research. Due to limited time and resources, only 32 pieces were selected. These 32 pieces were chosen because they exhibited the most explicit diagnostic features for study. The results obtained from the analysis of these 32 timber samples will be presented in this section. To systematically present the data, the timber artefacts will be first categorised based on the preserved thickness of the timber. Then, the tables summarise the wood species, dimensions and measurements related to the diagnostic features found on the timber. Finally, brief descriptions of the timber are provided to illustrate these diagnostic features. The drawings, outlines, and the timber record form of all the timbers can be found in Appendix 1. The timber species identification report can be found in Appendix 2. Table 26 shows the grids where the timbers were obtained, and Figure 21 shows a site map indicating the grids where the timber and metal artefacts were recovered.

Table 26: The grids where the timbers were retrieved.

Grid No.	Artefact No.
D8	PB2_1045
D9	PB2_905, PB2_906, PB2_945, PB2_953, PB2_956, PB2_971, PB2_972, PB2_974, PB2_983, PB2_985, PB2_1048, PB2_1056, PB2_1067
D10	PB2_901, PB2_903, PB2_1019, PB2_1040, PB2_1050
D11	PB2_900, PB2_975, PB2_980, PB2_1017, PB2_1038
D12	PB2_904, PB2_1018
E8	PB2_1069
E9	PB2_949, PB2_950, PB2_963, PB2_964, PB2_965

Figure removed due to copyright restriction.

Figure 21: Site map indicating the grids where the timber and metal artefacts were recovered (after Flecker 2022a).

5.3.2 Timbers thicker than 40mm

Tables 27 and 28 summarise the wood species, dimensions, and fastening hole measurements on timber thicker than 40mm.

Table 27: Timber thicker than 40mm.

Artefact No.	Wood Species	Common Name	Preserved Length (mm)	Preserved Width (mm)	Thickness (mm)
PB2_985	*Tectona Grandis*	Teak	550	70	60
PB2_975	*Nil*	Nil	620	160	75
PB2_904	*Tectona Grandis*	Teak	680	130	80
PB2_905 PB2_906	*Tectona Grandis*	Teak	802 (905)	341 (905)	81 (905)
PB2_949	*Tectona Grandis*	Teak	597	150	115
PB2_950	*Tectona Grandis*	Teak	625	174	130
PB2_964	*Tectona Grandis*	Teak	615	216	144
PB2_963	*Tectona Grandis*	Teak	530	155	150
PB2_965	*?Tectona Grandis*	?Teak	645	314	161
PB2_945	*Tectona Grandis*	Teak	603	231	190

Table 28: Dimensions and descriptions of fastening holes on timber thicker than 40mm.

Artefact No.	Shank/Hole Dimensions (mm)	Head/Hole Dimensions (mm)	Hole Spacing (Vertical) (mm)	Hole Spacing (Horizontal) (mm)	Fastener Hole Description
PB2_985	4 X 4	Diameter: 12.7	-	-	Square + Round
PB2_975	8 X 8, 10 X 10, 12 X 13	Diameter: 19, 27	-	-	Square + Round
PB2_904	Diameter: 19	-	-	140	Round
	4 X 4	-	-	-	Square
PB2_905 PB2_906	Diameter: 30	-	-	-	Round
	6 X 6	Diameter: 31	-	-	Square
PB2_949	22 X 21.6	Diameter:38.7	-	-	Square + Round
PB2_950	19.1 X 18, 19.1 X 18.2, 19.2 X 18.8	Diameter: 49.5, 40.5, 48.5	31	293	Square + Round
	5.7 X 5.7, 4.3 X 4.2, 4.2 X 4.2	-	-	-	Square
PB2_964	17 X17, 20 X 20, 14 X 14, 21 X 21	Diameter: 51, 57, 50, 50	-	-	Square + Round
PB2_963	23 X 21, 23 X 20, 19 X 19,	Diameter: 45, 61	-	347	Square + Round
	11 X 11	-	-	-	Square
PB2_965	25 X 25	Diameter: 50	-	-	Square + Round
	25 X 25, 19 X 19, 19 X 19, 21 X 21, 19 X 19	-	10, 11	300	Square
PB2_945	33 X 32, 26 X 29	-	-	-	Square

5.3.2.1 *Hull Planks*

Timbers PB2_949, PB2_950, PB2_963, PB2_964, and PB2_965 are related to the ship structure and could be identified as part of the hull planks on the *Shah Muncher*. Wood species analysis was conducted on PB2_949, PB2_950, PB2_963, and PB2_965. The results from the analysis identify them to be made from teak. PB2_964 was not analysed as it is associated with PB2_963. These timbers exhibited large fastening holes on both surfaces. Square holes within a circular impression characterise the first large fastening hole. These square holes were observed to exit on the other surface of the timbers retaining a squarish shape and similar dimensions. The number of fastening holes on each timber varies and depends on its surface. The horizontal spacing between these holes ranges from 293mm to 300mm on PB2_950, PB2_963 and PB2_965. On PB2_950 and PB2_965, the vertical spacing between the holes ranges from 10mm to 31mm. Smaller fastening holes can be observed on PB2_950 and PB2_963, most likely formed by sheathing tacks. PB2_950 has three such holes, while PB2_963 has only one small fastening hole. PB2_964 has an extant tack. The tack has a round head and a diameter of 9mm. On PB2_963 and PB2_964 (Figure 22), a rabbet recess was identified on one of its surfaces. This rabbet recess is situated on the timber's longitudinal edge, and both timbers were found to fit together. On both timbers' rabbet recess, a small square hole was observed, and they are aligned to each other when both timbers are fitted together. The observation of the rabbet recess was first pointed out by Michael Flecker (pers. comm. 2022).

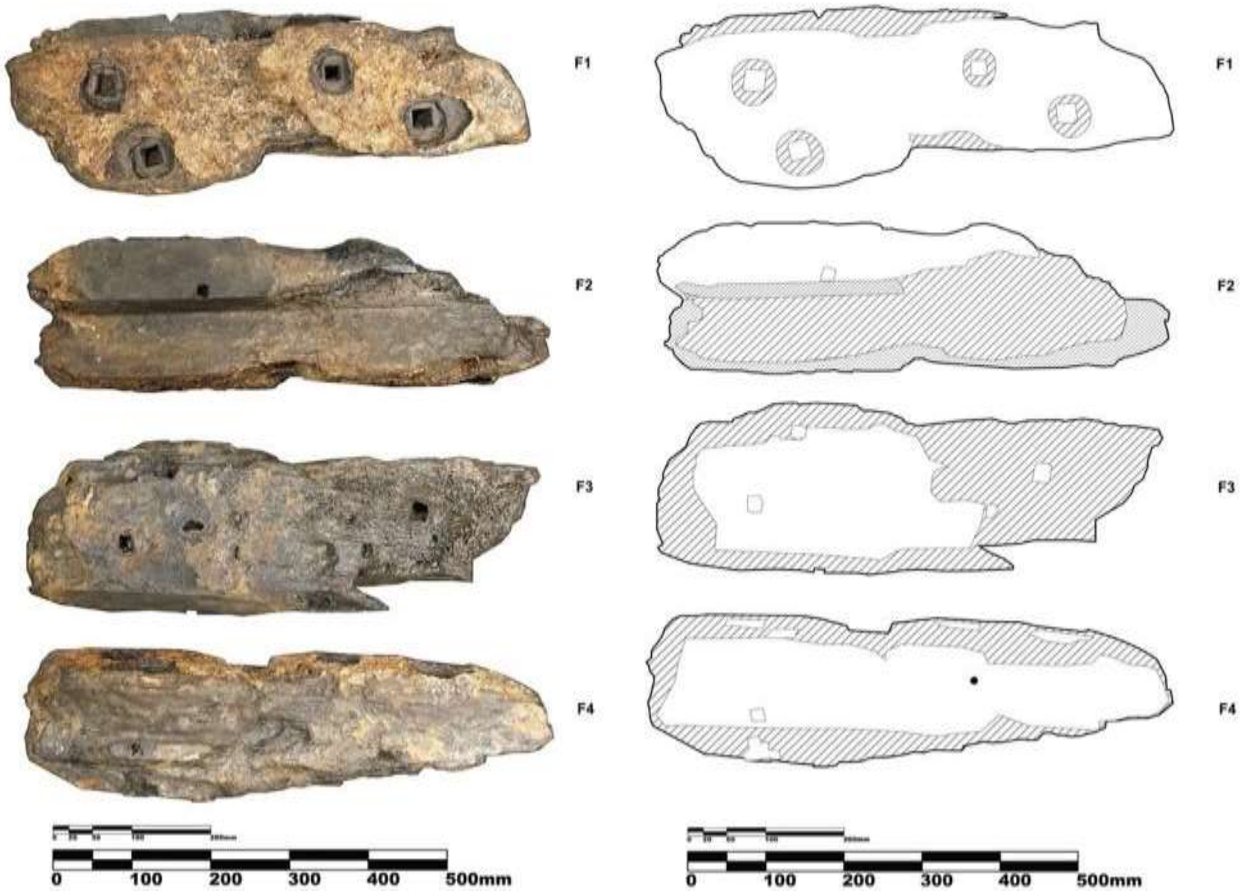


Figure 22: PB2_964 - Hull planking exhibiting the fastening holes and a rabbet recess (M. Ng, 2022).

5.3.2.2 *Structural Timbers*

Wood species analysis conducted on timbers PB2_904, PB2_905, PB2_906, PB2_945 and PB2_985 identified them as teak. They are likely to be associated with the ship structure or furniture; however, there were insufficient diagnostic data from the timbers to identify their specific functions. PB2_904 exhibits a straight flat profile with no apparent signs of carpentry or joinery. Two round holes can be identified on the two sides of the timber at the midsection.Extant treenails can be found in both holes.

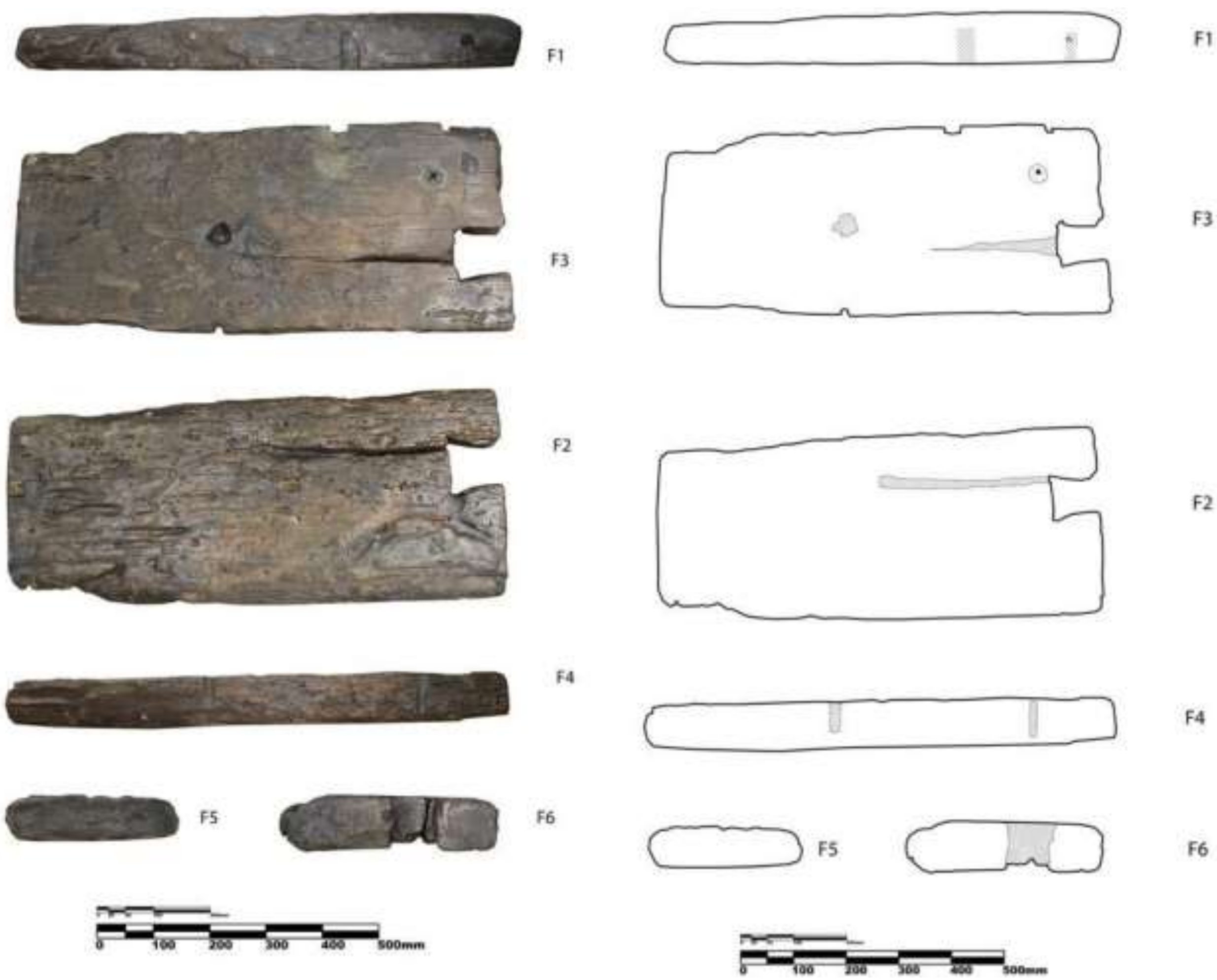


Figure 23: PB2_905 - Structural timber with a box or dovetail joint (M. Ng, 2022).

PB2_905 (Figure 23) and PB2_906 came from the same timber. PB2_906 has a distinct broken edge and a small square hole. The timber was cut to fit into the conservation tank. PB2_905 exhibited joinery and carpentry features. The ends of the plank have a box joint which is situated slightly off centre between the edges. One of the edges of the plank has two notches, while the other edge exhibited one notch. The notches have a width of 16mm to 27mm, 50mm to 81mm long and 10 to 15mm deep. A smaller square hole surrounded by around shape encrustation can also be found on its surface profile.

PB2_945 is a thick piece of timber with tacks and a square-shaped depression (Figure 24). It is degraded on all sides with signs of breakage and marine borers. Encrustations with ceramic sherds can be found on its surface. There is also a square depression which seems to have a squarish metal extant. The hole seemed to extend through the timber, exhibiting a similar squarish metal extant. Encrustation can also be observed on one of its surfaces. The edge of PB2_945 has encrustations, an extant round head tack with a diameter of 12mm and a knot.

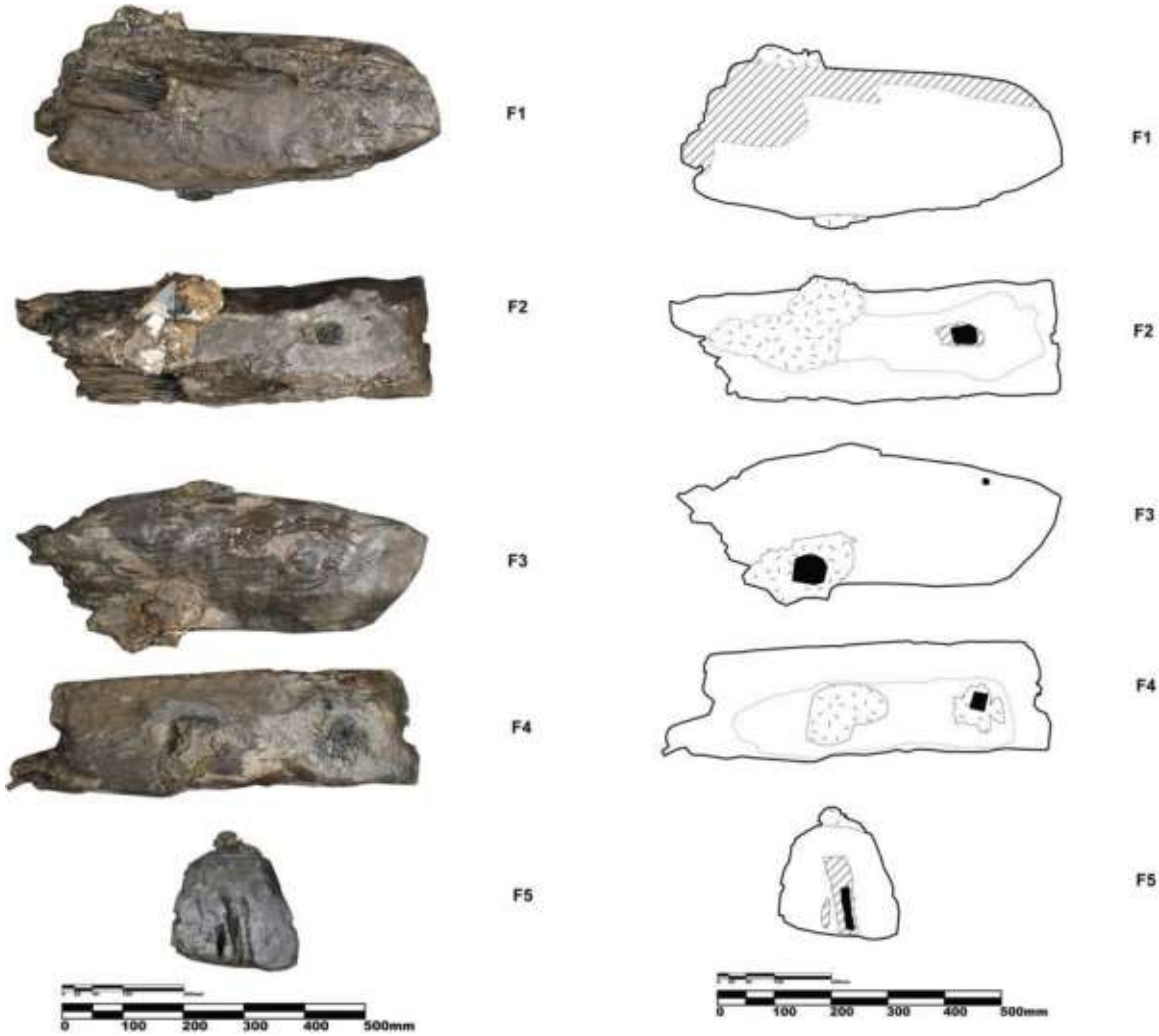


Figure 24: PB2_945 - Unidentified structural timber with extant square fastening (M. Ng, 2022).

PB2_985 is likely a teak plank. The timber is thicker at one end and narrows from the midpoint. There are no apparent signs of carpentry or joinery. The only noticeable feature is a single square hole. The hole consists of a square hole in the middle of a circular depression.

5.3.2.3 *Graving Piece*

Timber PB2_975 is identified as a graving piece (Figure 25). The shape of the timber is trapezoidal with seven sides. One side of the timber has a raised portion which exhibits a trapezoidal shape angled similarly to the overall timber borders. The raised portion is 418mm long, 116mm wide and 33mm to 45mm thick. Three square holes can be found on the timber. Two holes are located near both ends of the timber, and one hole is situated in the middle. No wood species analysis was done for this timber. On the other side of the timber, three holes are also observed. The three holes consist of a square hole in the middle of a circular depression.

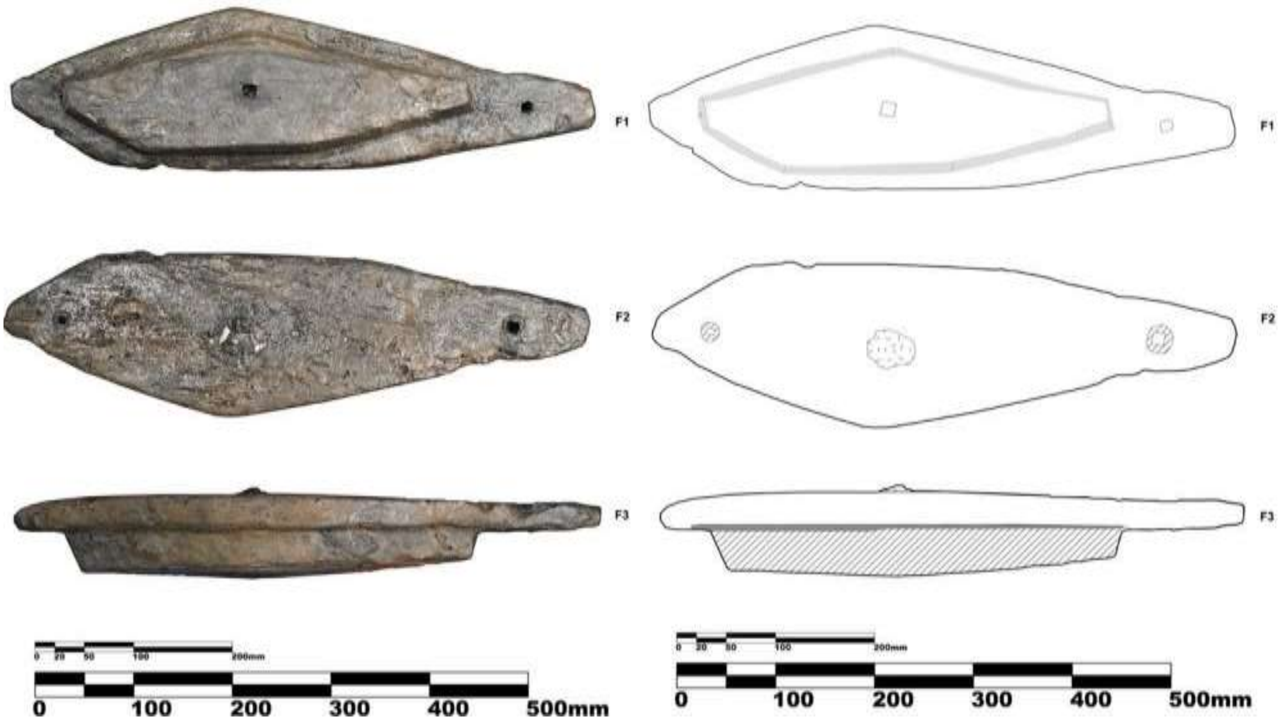


Figure 25: PB2_975 - Graving piece with a raised platform (M. Ng, 2022).

5.3.3 Timbers thinner than 40mm

Tables 29 and 30 summarise the wood species, dimensions, and fastening hole measurements on timber thinner than 40mm.

Table 29: Timber thinner than 40mm.

Artefact No.	Wood Species	Common Name	Preserved Length (mm)	Preserved Width (mm)	Thickness (mm)
PB2_1050	*Tectona Grandis*	Teak	524	56	20
PB2_1056	*Tectona Grandis*	Teak	168	81	20
PB2_1045	*Tectona Grandis*	Teak	507	77.5	23
PB2_1018	*Pinus sp.*	Pine	340	110	25
PB2_1019	*Nil*	Nil	138	58	25
PB2_1048	*Tectona Grandis*	Teak	490	73	25
PB2_953	*Tectona Grandis*	Teak	560	116	25.3
PB2_1069	*Nil*	Nil	182	25	26
PB2_901 PB2_903	*Tectona Grandis*	Teak	810	185	26.7
PB2_1038	*Pinus sp.*	Pine	157	12	27
PB2_971	*Cassia sp.*	Cassia	880	175	28
PB2_900	*Nil*	Nil	585	125	30
PB2_1067	*Lignum Vitae*	Guayacan	92.5	34	31
PB2_1017	*Nil*	Nil	370	73	33
PB2_1040	*Nil*	Nil	195	85	40
PB2_980	*Tectona Grandis*	Teak	290	143.3	26.1 (29.4 with metal)
PB2_972 PB2_974	*Tectona Grandis*	Teak	775	295	27 (28 with metal)
PB2_983	*Tectona Grandis*	Teak	473	119	29 (32 with metal)
PB2_956	*Nil*	Nil	280	183	20 (29.3 with metal

Table 30: Dimensions and descriptions of fastening holes on timber thinner than 40mm.

Artefact No.	Shank/Hole Dimensions (mm)	Head/Hole Dimensions (mm)	Hole Spacing (Vertical) (mm)	Hole Spacing (Horizontal) (mm)	Fastener Hole Description
PB2_1050	4 X 4	Diameter: 7	-	280	Square +
PB2_1056	3 X 3	-	-	-	Square
PB2_1045	5 X 6, 5 X 7, 4 X 9, 6 X 6	Diameter: 11	34	155, 188	Square + Round
PB2_1019	7 X 7, 7 X 7	Diameter: 8, 8	-	76	Square + Round
PB2_1048	-	Diameter: 11	-	-	Square + Round
PB2_953	6.1 X 6.1	-	26.4	77.6, 47.2, 36.8, 37, 35.1, 35, 25, 32.4	Square + Round
PB2_1069	DIA: 8	-	-	-	Square
PB2_901/ PB2_903	5 X 5, 6 X 6	-	89.6	215, 300, 340	Square
PB2_1038	Diameter: 15	Diameter: 20	-	-	Round
PB2_971	-	Diameter: 9–11	30.8, 58.9	33, 42, 44, 55, 55, 55, 55,170, 120, 130	Square + Round
PB2_900	21 X 28, 17 X 18	Diameter: 33, 42	-	84	Square + Round
PB2_900	3 X 5	-	-	-	Square
PB2_1017	8 X 4	Diameter: 30, 40, 60	-	128, 153	Round
PB2_1017	8 X 5, 6 X 7	-	-	-	Square
PB2_1040	-	Diameter: 4, 8	-	-	Round
PB2_1040	9 X 9, 9 X 9	-	-	84	Square
PB2_980	3 X 3, 4 X 4	Diameter: 9–11	39	21.6, 33.7, 43.9, 43, 43, 43, 139	Square + Round
PB2_972/ PB2_974	6 X 6	Diameter: 9–11	F1: 55, 40, 58	F2: 90, 115, 120, 118, 134, 119, 105, 12, 113, 154, 131	Square + Round
PB2_983	4 X 4	Diameter: 13	-	132.7, 120	Round
PB2_956	7 X 7	Diameter: 11	31.2, 33.4	56.9, 58.2, 29.2, 35, 37.9	Square + Round

5.3.3.1 *Sacrificial Timbers*

Timbers PB2_953 (Figure 26), PB2_956 (Figure 27), PB2_971, PB2_972, PB2_974, PB2_980 and PB2_983 are examples of sacrificial sheathing used on *Shah Muncher*. These sacrificial sheathings are characterised by thin sacrificial timber, copper sheathing and multiple sheathing tacks. PB2_972 and PB2_974 came from the same timber but were broken to fit into the conservation tank. Except for PB2_971 and PB2_956, these timbers were identified as made from teak. PB2_971 was identified as *Cassia sp*., while the wood species of PB2_956 was indiscernible. Timbers PB2_953, PB2_956, PB2_971, PB2_972, PB2_974, PB2_980 and PB2_983 have metal sheathing tacks. Two layers of metal sheathing were spotted overlapping each other on PB2_953, PB2_971, PB2_974 and PB2_980. These metal sheathings are fastened to the wood using sheathing tacks. Most of the timbers have extant tacks with similar dimensions. The number of sheathing tacks on these timbers varies from 3 to 30. These tacks have a round head and square shank which tapers at its ends. The conditions of these extant tacks vary, and some of the tacks were without their head. There seemed to be a pattern in the spacing between the tacks on timbers PB2_953, PB2_971, PB2_980 and PB2_983. There is visual horizontal and vertical alignment to their placements; however, each sacrificial timber's horizontal and vertical spacings vary widely. Other noticeable traits were observed on PB2_956 and PB2_974. The metal sheathing on PB2_956 is heavily encrusted, and a ceramic piece was found concreted on the encrustation. On one of PB2_974's surfaces, there were traces of greyish white stains.

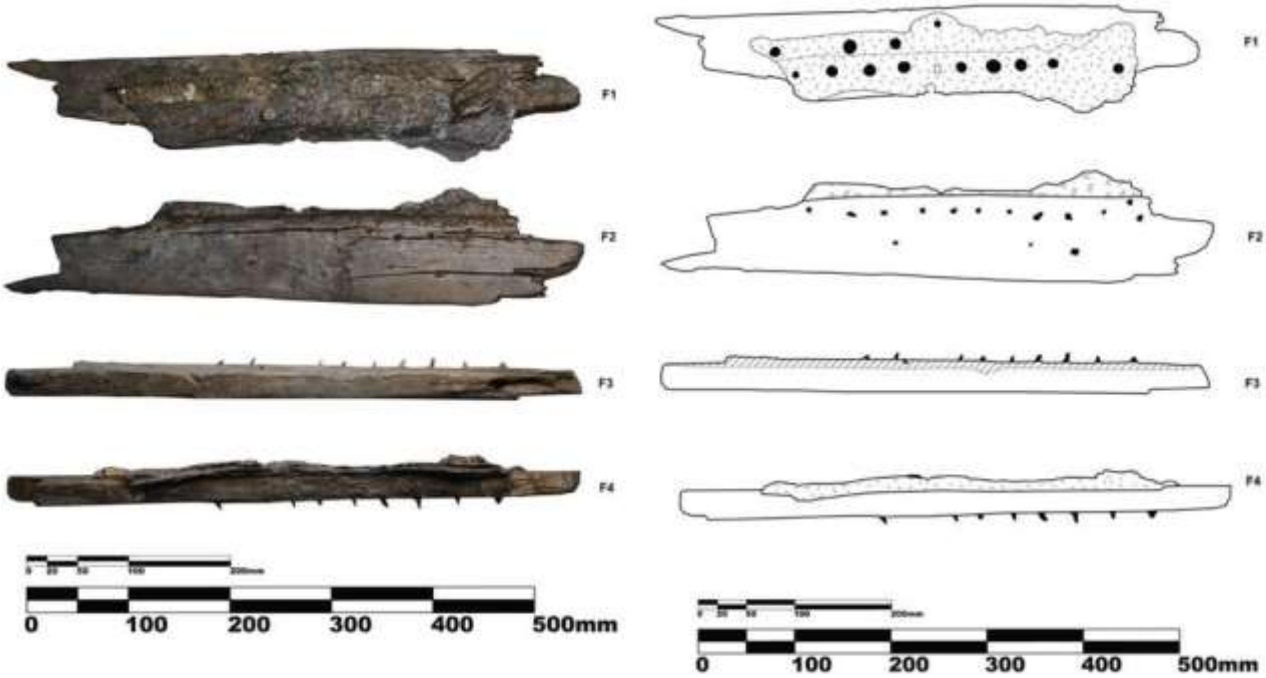


Figure 26: PB2_953 - Sacrificial timber with extant sheathing and tacks (M. Ng, 2022).

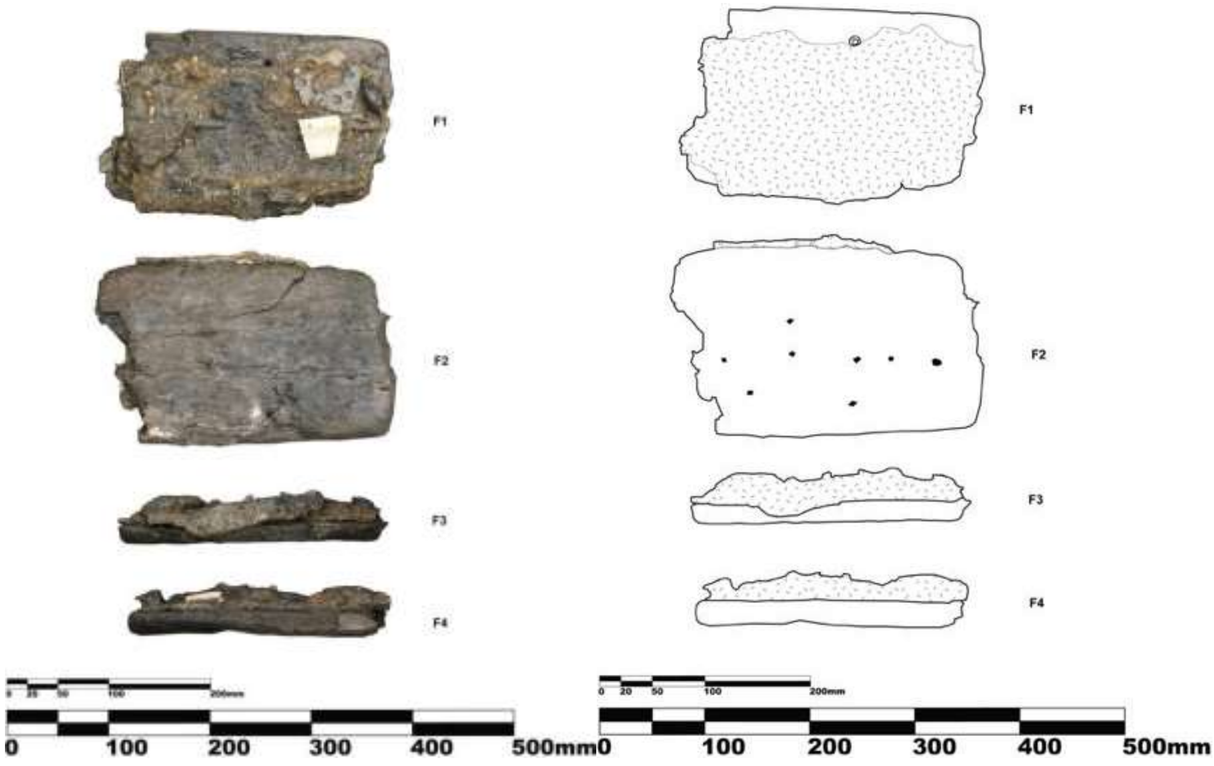


Figure 27: PB2_956 - Sacrificial timber with extant sheathing, encrustations and tacks (M. Ng, 2022).

5.3.3.2 *Thin Plank Fragments*

PB2_901, PB2_903, PB2_1045 (Figure 28), PB2_1048, PB2_1050, and PB2_1056 are teak plank fragments related to the ship structure or the furniture within the ship. All of them exhibit tacks or tack holes, but the number of tacks on each timber was much lesser than those found on *Shah Muncher*'s sacrificial timber. There was also no sheathing found on them or indications of sheathing remnants. PB2_901 and PB2_903 came from the same timber, but it was broken to fit into the conservation tank. Six square holes were observed on its surface and exits on the other surface as round holes. The spacing between the tacks exhibits a pattern as there is a horizontal and vertical alignment to their placements. Between one to three extant tanks can be observed on PB2_1045 and PB2_1048. PB2_1045 has a square hole with a circular impression on one of its surfaces (Figure 29). On PB2_1048's edges, nine notches approximately 4mm wide and spaced 20mm apart were observed. There are visible traces of metal encrustation observed on one of the surfaces of PB2_1050. The timber has a knot on the opposite face and faint impressions of notches on one of its edges. PB2_1056 is a possible teak plank fragment (Figure 30). It has one extant round head tack on one of the ends of the timber.

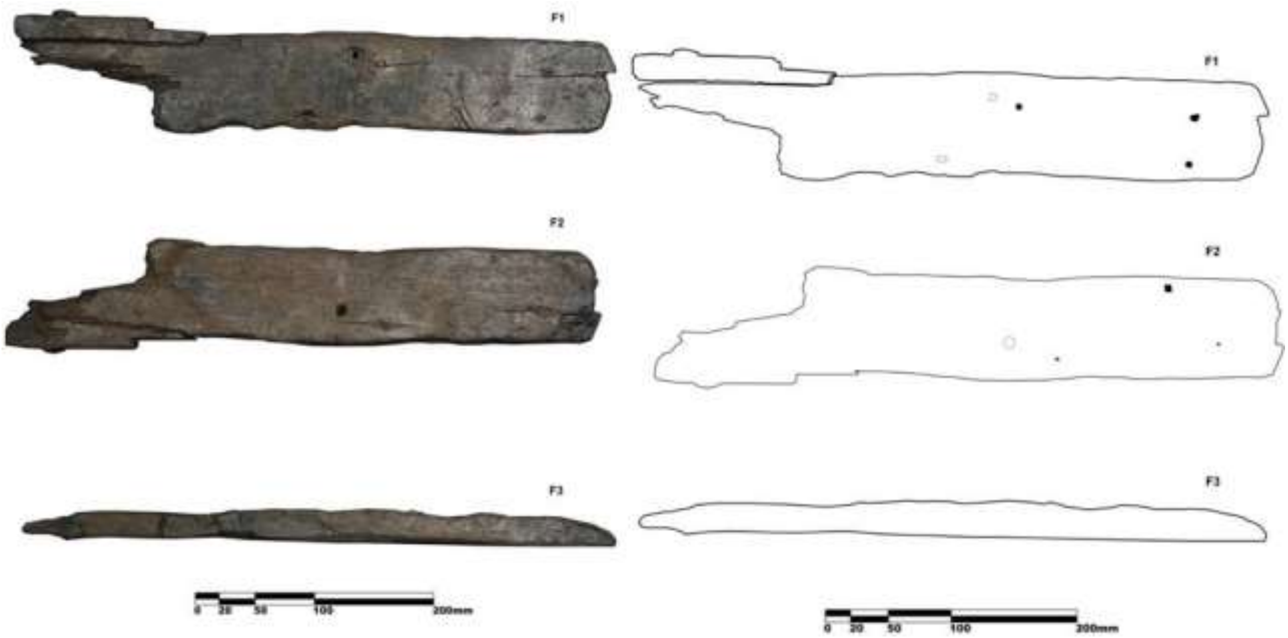


Figure 28: PB2_1045 Plank fragment with extant tacks and tack holes (M. Ng, 2022).

Figure 29: Close up image of an extant tack and a fastening hole. The fastening hole consists of a square hole within a circular impression (M. Ng, 2022).

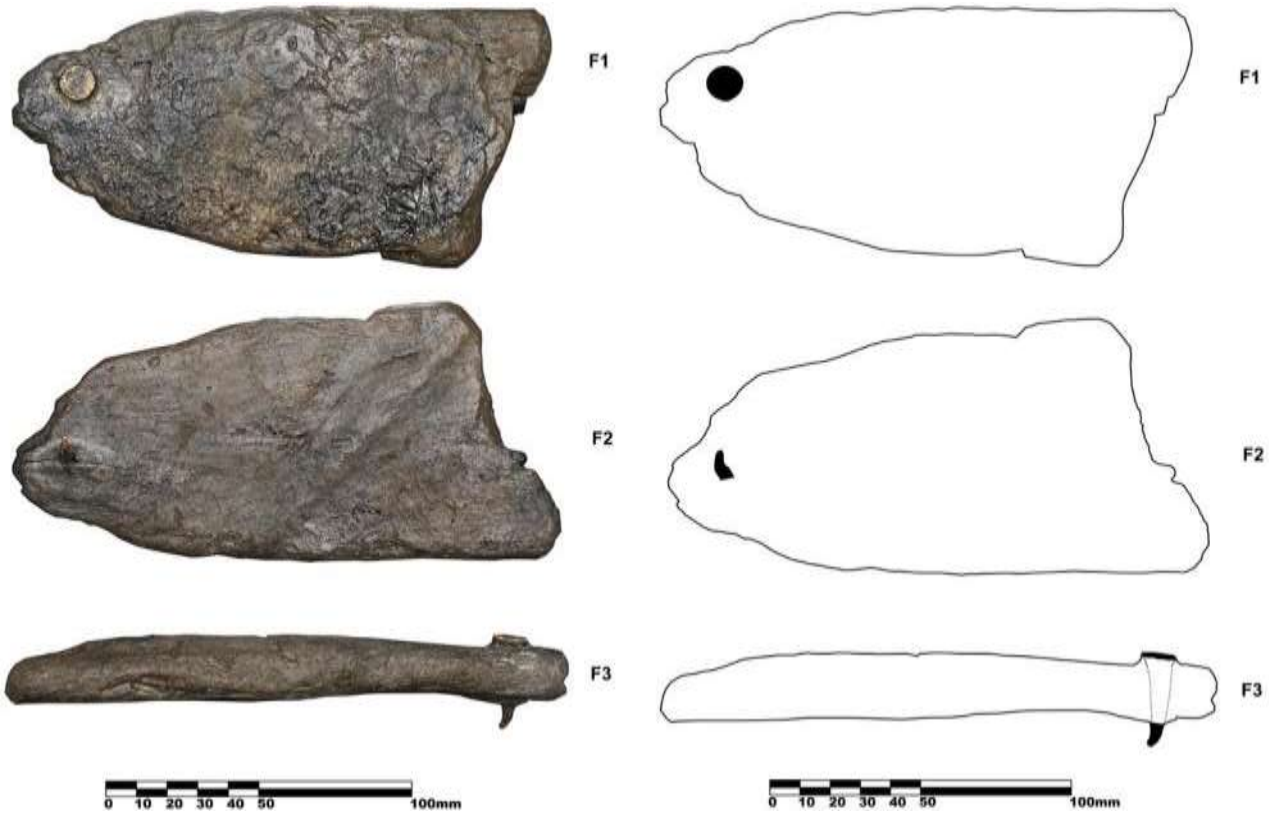


Figure 30: PB2_1056 - Thin plank fragment with extant tack. The tack was analysed for its elemental composition (M. Ng, 2022).

5.3.3.3 *Graving Pieces*

PB2_900, PB2_1017, PB2_1019 (Figure 31) and PB2_1040 have a trapezoidal shape and presence of fastening. These timbers are identified as graving pieces. They were not tested for their species because they were designated for future museum displays; thus, no approval was given to obtain a sample for said analysis. PB2_900 has a trapezoidal shape with two holes that extends through the timber. Two holes are observed on the timber extending from surface to another. The holes on one surface have a square hole in the middle of a circular depression. The holes on another surface are square. A smaller square hole was observed on both surfaces. On one of the surfaces, the smaller square hole seemed to have some form of encrustations around its edge. On PB2_1017, three circular encrustations are found on timber's surface. On the other surface, there are three small square holes related to the circular encrustation. The holes seemed to be aligned horizontally. PB2_1040 exhibits a raised portion in the middle of the timber. The raised portion is also trapezoidal, 84mm long, 70mm wide and has a height between 26mm to 32mm. There is also a round hole on one of its edges and 2 round holes on the surface. The other surface has two square holes related to the 2 round holes. On PB2_1019, two holes were found to extend through the timber. On the timber's surface are the two square holes within a circular depression. On the opposite surface, the holes are square.

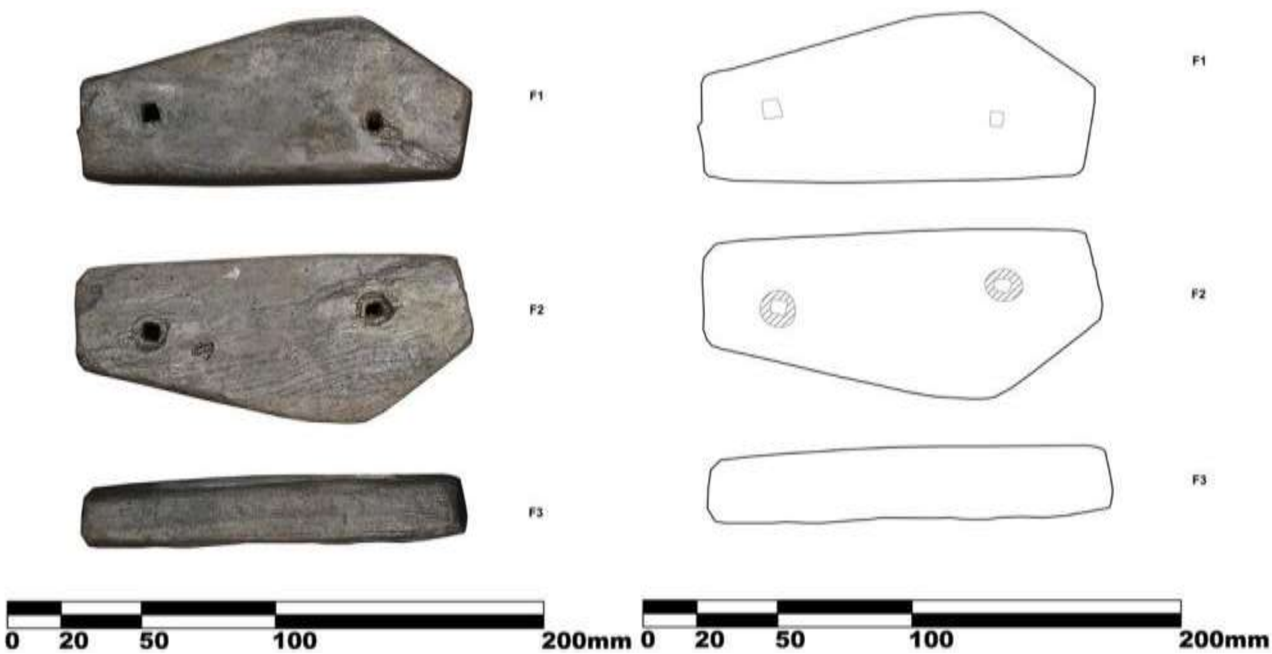


Figure 31: PB2_1019 – One of two small graving pieces (M. Ng, 2022).

5.3.3.4 *Rigging timber*

PB2_1067 is identified as part of a rigging sheave (Figure 32). Wood species analysis identified that the timber was made from *Lignum vitae*, and there is a noticeable concave groove in the middle of the timber fragment.

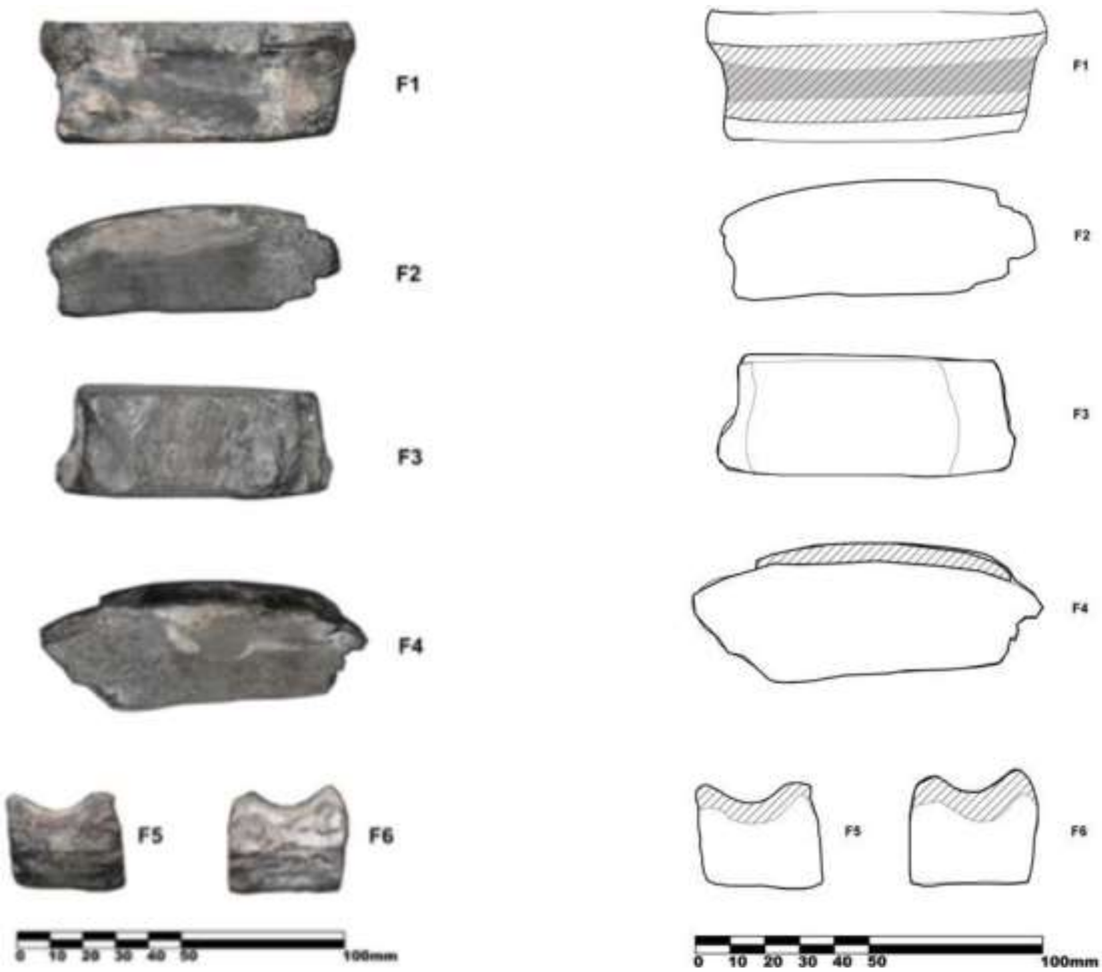


Figure 32: PB_1067 – Pulley block sheave fragment (M. Ng, 2022).

5.3.3.5 *Unknown timbers*

It was impossible to identify any functions on timbers PB2_1018, PB2_1038 and PB2_1069 as there were insufficient diagnostic data. PB2_1018 and PB2_1038 were identified as *Pinus sp.*, commonly known as pine. PB2_1018 seemed to have been shaped as it is flat on its surface and slightly curved on another. It is unsure how these timbers could relate to the ship structure as there are very few diagnostic features. A hole in PB2_1038 could be formed from a knot or a tack. One of its surfaces is curved, while the other shows a flat surface. PB2_1069's condition is fair as all sides seemed worn down and broken. A round hole and an extant headless tack were found on one of its surfaces. Both holes are found on adjacent profiles. The wood species of PB2_1069 was indiscernible.

5.4 *Shah Muncher* Metal Analysis Results

Table 31: Dimensions and descriptions of extant tacks on timbers.

Artefact No.	Extant Dimensions (mm)	Fastener Hole Description
PB2_1056	Diameter: 10.4	Round Head, Square Shank
PB2_1045	Diameter: 6, 5, 5.6	Round Head, Square Shank
PB2_1048	Diameter: 11	Round Head, Square Shank
PB2_953	Diameter: 12.1, 13.8, 11.4, 8, 11.8, 13, 12.6, 6.4, 11, 7.9, 11,14.1, 9.2, 13, 11.2	Round Head, Square Shank
PB2_1069	4 X 4	Square Shank
PB2_971	Diameter: 12	Round Head, Square Shank
PB2_980	Diameter: 11.1, 13, 11.4, 10, 10, 10, 12, 11	Round Head, Square Shank
PB2_972/ PB2_974	Diameter: 11, 12, 11.3	Round Head, Square Shank
PB2_983	Diameter: 10.5, 14.4, 13	Round Head

Table 31 provides a summary of the extant tacks found on the timber. Most of the extant tacks still retain the tack head, which is round, and all have square shank. The diameter of the roundheads of the tack ranges from 6mm to 14.4mm. Most tacks have diameters between 10mm to 12mm.Tacks without the heads have dimensions between 4mm by 4mm to 5mm by 5.6mm. The average length of the tacks found on PB2_972 and PB2_974 is 70mm. Tables 32 to 34 provide a summary of the tacks and metal sheaths that were sent for elemental compositional analysis. PB2_983 (Figure 33), PB2_1056 (Figure 34), PB2_1069, and PB2_971 (Figure 35) are metal samples obtained from the timbers, while PB2_1175 (Figure 36) was a loose sheath. The analysed results of the collected samples are presented in tables 35 to 37. The full metal compositional analysis report can be found in Appendix 3.

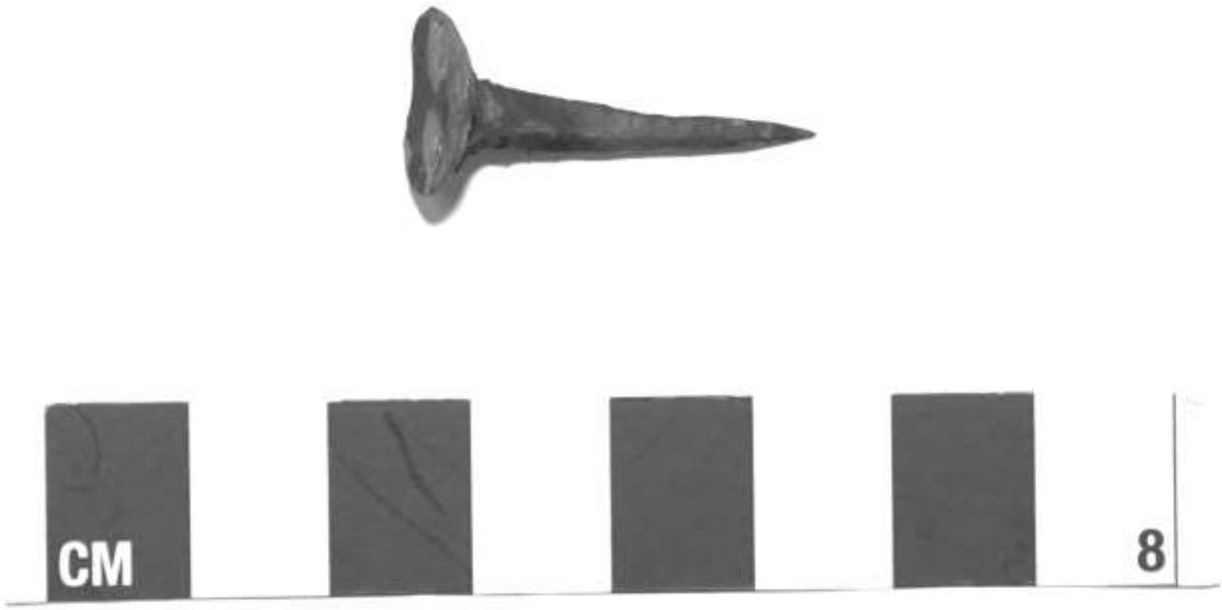


Figure 33: Extant tack from PB2_983 (M. Ng, 2022).

Table 32: Description of metal sheathing and tacks samples sent for elemental analysis

Artefact No.	Description
PB2_983	Sheathing tack from timber sample 983
PB2_1056	Sheathing tack from timber sample 1056
PB2_1069	Sheathing tack from timber sample 1069
PB2_971	Metal sheathing from timber sample 971
PB2_1175	Metal sheathing

Figure 34: Extant tack from PB2_1056 (M. Ng, 2022).

Table 33: Dimensions of the metal tacks samples from *Shah Muncher* sent for elemental analysis

Artefact No.	Length (mm)	Tack Diameter (mm)	Thickness Top(mm)	Thickness Mid(mm)	Thickness Tip(mm)	Remarks
PB2_983	27.6	13	4	2.5	0.4	Bent, Square, Sharp Tip
PB2_1056	31.6	10.3	4.2	3.8	1.2	Bent, Corroded, Square, Sharp Tip
PB2_1069	11.15	-	4.05	3.1	1.3	No Tack Head, Square, Broken Tip

Table 34: Dimensions of metal sheathing and strap samples sent for elemental analysis

Artefact No.	Length (mm)	Width (mm)	Thickness (mm)
PB2_971	-	-	0.4
PB2_1175	150	90	0.5

Figure 35: Section of PB2_971 sheathing where sample was retrieved (M. Ng, 2022).

Table 35: Elemental composition of ship's hull sheathing from *Shah Muncher*.

	Wt%			Atomic %	
Description	**Cu**	**Total**		**Cu**	**Total**
Sample 0971: spectrum 1	100.00	100		100.00	100
Sample 0971: spectrum 2	100.00	100		100.00	100
Sample 0971: spectrum 3	100.00	100		100.00	100
Sample 1175: spectrum 1	100.00	100		100.00	100
Sample 1175: spectrum 2	100.00	100		100.00	100
Sample 1175: spectrum 3	100.00	100		100.00	100

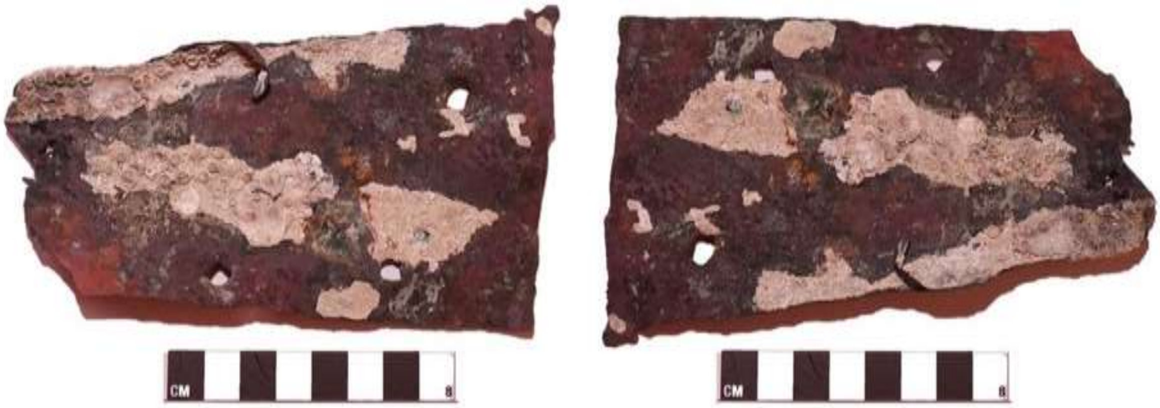


Figure 36: Front and back view of PB2_1175 sheathing (M. Ng, 2022)

Table 36: Elemental composition of ship's hull sheathing from *Shah Muncher*.

	Wt%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0971: spectrum 1	0.06	0.00	98.26	0.00	0.83	0.16	0.19	0.00	0.51	0.00	100
Sample 0971: spectrum 2	0.00	0.00	98.66	0.07	0.56	0.22	0.02	0.19	0.29	0.00	100
Sample 0971: spectrum 3	0.04	0.00	98.54	0.40	0.88	0.01	0.00	0.00	0.00	0.14	100
	Atomic%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0971: spectrum 1	0.07	0.00	98.87	0.00	0.71	0.10	0.10	0.00	0.16	0.00	100
Sample 0971: spectrum 2	0.00	0.00	99.13	0.07	0.48	0.13	0.01	0.10	0.09	0.00	100
Sample 0971: spectrum 3	0.04	0.00	98.78	0.39	0.75	0.00	0.00	0.00	0.00	0.04	100
	Wt%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 1175: spectrum 1	0.18	0.03	98.10	0.00	0.11	0.23	0.06	0.00	1.29	0.01	100
Sample 1175: spectrum 2	0.04	0.01	97.96	0.00	0.21	0.31	0.00	0.00	1.34	0.14	100
Sample 1175: spectrum 3	0.00	0.25	99.19	0.00	0.00	0.14	0.00	0.00	0.43	0.00	100
	Atomic%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 1175: spectrum 1	0.21	0.04	99.09	0.00	0.10	0.14	0.03	0.00	0.40	0.00	100
Sample 1175: spectrum 2	0.04	0.01	99.13	0.00	0.18	0.18	0.00	0.00	0.42	0.04	100
Sample 1175: spectrum 3	0.00	0.23	98.16	0.00	0.00	0.23	0.00	0.00	1.38	0.00	100

Table 37: Elemental composition of ship's sheathing tacks from *Shah Muncher*.

	Wt%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0983: spectrum 1	0.17	0.19	86.44	5.05	0.52	0.06	7.46	0.00	0.12	0.00	100
Sample 1056: spectrum 1	0.08	0.07	64.69	32.81	0.04	0.03	0.00	0.00	2.28	0.00	100
Sample 1069: spectrum 1	0.89	0.10	64.97	28.38	0.64	0.08	0.29	0.38	4.27	0.00	100
	Atomic%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0983: spectrum 1	0.20	0.21	89.81	5.10	0.46	0.03	4.15	0.00	0.04	0.00	100
Sample 1056: spectrum 1	0.09	0.08	66.35	32.71	0.03	0.02	0.00	0.00	0.72	0.00	100
Sample 1069: spectrum 1	1.06	0.11	67.72	28.76	0.57	0.05	0.16	0.21	1.36	0.00	100

5.5 Summary

Consolidating the information on the timbers from the various shipwrecks and an existing ship provides a suitable set of information to compare with similar data obtained from *Shah Muncher* timbers. Timbers used in ship construction can be distinguished by their features, characteristics, and contextual information. These features and characteristics include wood species, timber dimensions, fastening holes and extant fastenings, and diagnostic features such as joinery and carpentry. Thus far, wood species, descriptions of the fastening holes and extant tacks found on other ships offer the most compelling data to identify the functions of *Shah Muncher* timbers. In addition, it sheds light on several of *Shah Muncher*'s construction and anti-fouling features.

CHAPTER SIX: DISCUSSIONS

6.1 Introduction

This chapter discusses the results which were obtained from the *Shah Muncher* site and other ship data. The chapter is divided into three main sections which relate to *Shah Muncher.* Firstly, it identifies the structural features of the disarticulated timbers from *Shah Muncher*. Relying on comparisons with other ship data for identification. The ship data which were used for the comparative analysis include fastenings, sheathing, joinery, timberspecies and features. The section would also highlight the differences between *Shah Muncher* and the other ship data. The second section highlights the anti-fouling features of *Shah Muncher*. Similarly, using comparable features such as fastenings, sheathing, joinery, timber species and features to justify the identification and illuminate differences between the various ships. The third section highlights the graving pieces found on *Shah Muncher*. The fourth and last section highlight other features which were related to the shipwreck.

6.2 Structural Features

Diagnostic ship's hull timbers identified among *Shah Muncher* archaeological remains. It was possible to identify structural timbers by comparing the fastening holes, thickness of the timber and the timber species identified with the data obtained from *Endeavour,* HMS *Buffalo*, *Edwin Fox, Sydney Cove* and *Quedagh Merchant*.

6.2.1 Fastening comparisons and highlights

The first key evidence to suggest that the timbers PB2_949, PB2_950, PB2_959, PB2_963, PB2_964, and PB2_965 are related to the ship structure were the holes found on the timbers. These timbers exhibited square holes and some of these square holes were found to be in the middle of a circular impression. The square holes were roughly measured 17mm by 17mm to 25mm by 25mm in section. The dimensions of the circular fasteners measured between 38.7mm to 61mm in diameter. The large difference in the circular dimensions could be attributed to the deterioration of the timber. The size of these holes and their shape suggest a spike would have been used on these timbers. Spikes found on these ships has a round head and a square shank. Historical records mentioned that the bolts on Bombay country ships are mostly square, and the bolt heads were smoothened with a composition. This description coincides with the holes found on *Shah Muncher* structural timbers (Bulley 2000:27). Evidence of similar fastenings can be found on *Endeavour,* HMS *Buffalo*, and *Sydney Cove.* They exhibited similar shapes albeit different in size.

Figure 37: Close up of the hole made by a spike with round head or with washer on PB2_963 (M. Ng, 2022).

Other types of fastening which could create a circular impression would be bolts that comes with clench rings, dumps, or welts. These types of fastenings could be found on *Endeavour*. Clench rings were often used together with round bolts which create a round hole upon fastening to the timber. Based on the shape and description of the fastening holes found on *Shah Muncher*, it is unlikely that the holes on *Shah Muncher* timbers were made by round bolts. The ship's hull planking has circular impression that surrounds the square holes on one surface and the opposite face exhibits only a square hole (see PB2_949, PB2_950, PB2_963, PB2_964, PB2_965 in Appendix 1). This represents that the timber face where the circular impression is located should be where the spike was driven into the plank. Therefore, that side of the plank would be the outward facing side. PB2_963 (Figure 37) and PB2_964 also exhibited a square hole, 14mm by 14mm, located at the corner of the rabbet recess which could be made by a square fastener.

Spikes, as described by McCarthy (2005:72), are large square sectioned, tapering nails. One of the uses of spikes highlighted would be to fasten deck planks to deck beams. They would be countersunk into an approximately 50mm by 50mm hole. The holes were created using a dowelling auger. They often exhibit cylindrical shape but there are occasions whereby they were found to be square, or diamond shaped. For example, square shaped spikes were used on deck planks of *Jhelum*, a 428-ton ship built in Liverpool in 1849 (McCarthy 2005:73).

The type of material used for these fastenings could not be obtained from the examination of the timber fastenings because there were no extant remains. There were some encrustations around the holes, but no analysis was conducted on them due to time constraint. Iron and copper alloy were often identified as the two main types of material used for making fasteners. Iron nails were found on the outer planks and the sacrificial timbers of both *Endeavour* and HMS *Buffalo*. The irons nails serve as holding nails while copper nails were driven through the timber on both vessels (Bennett 2021:280). Iron nails were understood to be less expensive than using copper nails. Teak's oily nature helps to prevent the corrosion of iron. Thus, it would often be the preferred metal fastener used by Indian shipwrights (Strachan 1986:32). Copper alloy fasteners, which were either a dump or spike are only found on *Edwin Fox*. They were positioned alongside treenails with triangular wedges. *Sydney Cove* has both copper alloy spikes and iron bolts. These spikes have a rounded head with flat undersides, projecting a circular shaft which tapers to a square cross section (Strachan 1986:31). The rounded portions have a diameter of 13.3mm to 16.7mm while the dimensions of the square part of the shank ranges from 10mm by 10mm to 13.3mm by 13.3mm. Two of the iron bolts have a square shank with a diameter between 12mm to 15mm. An iron spike, suspected to have belonged to the ship, was recorded near the site.It has flushed rounded head, a square shank which tapers down to the tip. The reason for the difference in dimensions between the abovementioned four ships and *Shah Muncher* is uncertain and intriguing. It could be due to the size of the ship but referring to Lloyds's tables on the size of the fastenings as a guide (Desmond 1919:23), ships between 150 to 1050 tonnes would generally have diameter between 19.05mm to 22.225mm for planking fastenings. Other features which were identified that were unique include the placement of the of the fastenings on some of *Shah Muncher* timbers. On PB2_950, PB2_963 and PB2_964, it was observed that each end of the plank had a pair of holes which were very close to each other. Each pair of holes exhibited a diagonal alignment, and separated horizontally from the other pair of hole at a distance of 300mm to 350mm. The spacing distance is also similar to 965. This fastening placement would require further research.

No treenails were observed on PB2_949, PB2_950, PB2_963, PB2_964, and PB2_965. This is different from the planks observed on *Endeavour,* HMS *Buffalo*, and *Edwin Fox*. Treenails were found on the ceiling planking, outer hull planking and futtock timbers on these three ships. According to Ball, based on historical records, Country ships did not use treenails as the effects of the tropical climate may affect their integrity. He also mentioned that *Diana* was only fastened with iron bolts (Ball 1995:83). There were also no treenails observed on *Sydney Cove*. Echoing Bennett (2021:278)'s remarks, it is a perplexing observation as there are contradictions between the archaeological data and historical records on the use of treenails on Indian-built ships.

6.2.2 Sheathing comparisons and highlights

There are presence of sheathing tacks or holes made by similar type of tacks. Each timber only reflected one or two of these holes and there was no presence of sheathing on these structural timbers. It is unsure what are the purpose of these small square holes. The outer planks of *Endeavour,* HMS *Buffalo* and the *Edwin Fox* exhibited multiple sheathing tacks whereas none was observed from *Shah Muncher*'s structural timbers (Bennett 2021:283). As there are encrustations on the wood, it is difficult to discern if there are any sheathing holes or sheathing tacks on them.

6.2.3 Joinery comparisons and highlights

Timbers PB2_963 and PB2_964 (Figure 38) exhibited similar joinery which enables both timbers to be connected. Both timbers exhibited a right-angle rabbet recess on one of its longitudinalsides, and it includes a square hole located at the recess which aligns both timbers. Such joinery construction could be edge to edge rabbeting. This suggests that both timbers can be identified as a hull planking. Edge to edge rabbet or scarf joint planking have been identified as a key construction feature in Bombay Country ships (Figure 39) (Stravorinus 1798:20–21). According to Bulley (2000:26–27) the planks were joined in their bottoms and sides using rabbet work.

These rabbeted planks could be found as high as the second or third plank above the bands. The rabbet joint or seam was poured with boiling hot dammer, a kind of pitch, with a covering of fine, clean cotton wool. Ships were never caulked. Bolts were square and bolt heads were smoothen using a composition. These descriptions were obtained from various first-hand accounts during the eighteenth and nineteenth centuries (Stravorinus 1798:20, 22; Phipps 1840:23, 24; Wadia 1957:189). Similar joinery can also be found in *Quedagh Merchant*. In addition to the similar joinery, an iron fastening was used for the edge-to-edge plank joinery (Hanselmann 2016:98). This fastening could be related to the square hole located at the rabbet recess of PB2_963 and PB2_964. This type of joinery was not observed on *Endeavour*, HMS *Buffalo*, *Edwin Fox,* and *Sydney Cove*. The joinery method could be a key characteristic of Bombay-built ships.

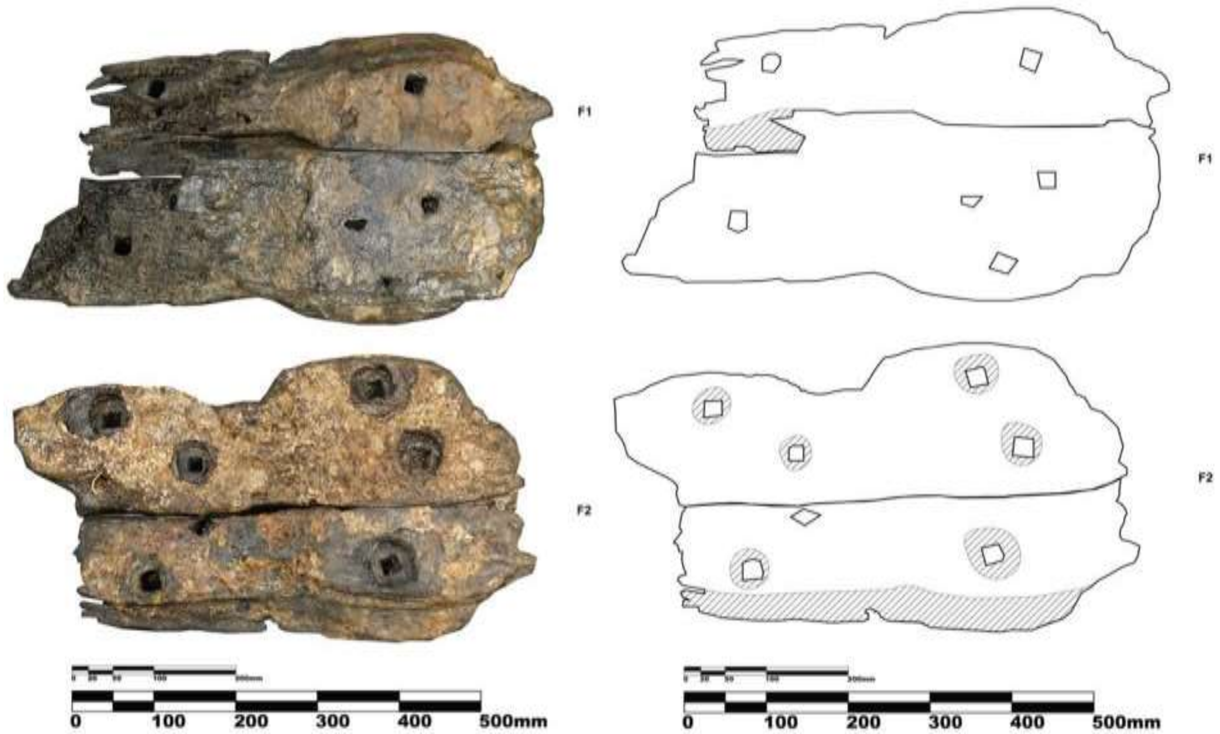


Figure 38: PB2_963 and PB2_964 fitted together (M. Ng, 2022).

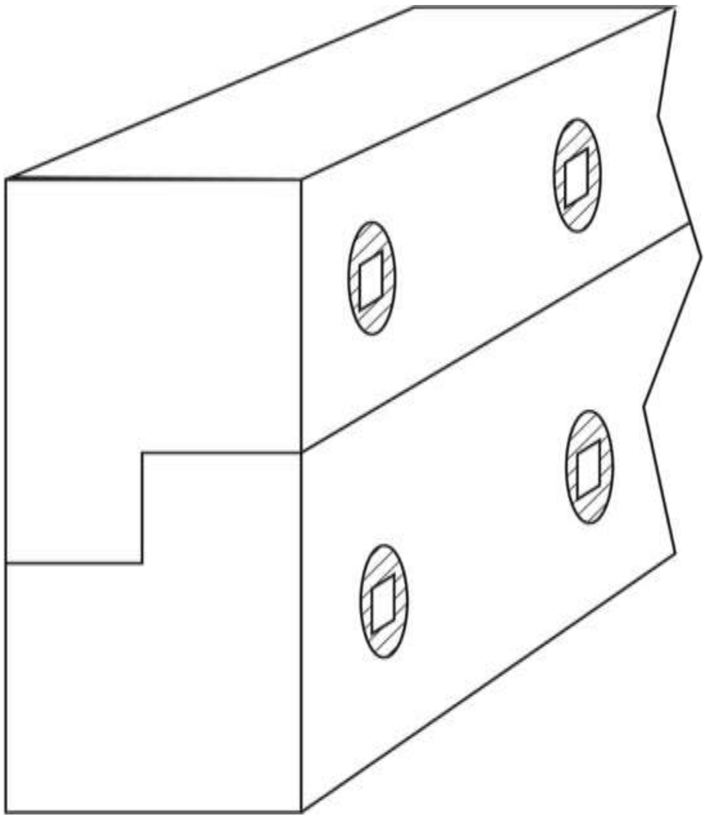


Figure 39: Schematic image of the rabbet joinery between PB2_963 and PB2_964 (M. Ng, 2022).

6.2.4 Timber comparisons and highlights

The wood species identified on PB2_949, PB2_950, PB2_963 and PB2_965 were identified as teak. The thickness of these timber was between 110mm to 161mm. Indian-built ships were reported to be constructed from teak wood. Teak is regarded as a superiortimber for ship construction. It was understood to be just as good as oak as the primary ship's timber. Teak experiences little shrinkage therefore there was not a need for caulking,and it did not splinter. In *Observations on the Expediency of Shipbuilding*, William Taylor Money provided examples of the qualities and the long-wearing properties of teak from his experiences on *Milford*, a Bombay built ship in service till around 1829 with a burthen of 625 tons (Money 1811:64–65). Iron bolts fixed in teak do not corrode as easily as oak due to theoil secreted from teak. (Bulley 2000:27–29). The other two Bombay built ships mentioned in this research were *Quedagh Merchant* and HMS *Trincomalee*, which were built with teak in Bombay or Surat. On the other hand, HMS *Buffalo*, *Edwin Fox,* and *Sydney Cove*, constructed around the Bengal region relied on teak which were sourced from Pegu (Bago), in modern day Myanmar and Chittagong in Bangladesh (Bulley 2000:29). Shipyards in Bombay had access to teak supplies north and south of the island. Records indicated that crooked timber suitable for constructing knees of the ships were obtained from the forests of Ghir in Kathiawar, while straight timbers were acquired from the forests in Gujarat, Konkan, Canara, and Travancore. During the early-nineteenth century, teak supplies dwindled due to diminishing forests, and only Travancore was able to supply timber (Bulley 2000:29). Other sources of teak for ship construction in Bombay came from Malabar area (Bulley 2000:89–100). Ship parts which were made of teak from Malabar area were mentioned in records and they included ship timbers, floor timbers, lower and futtocks, keel and keelson, stem, and stern, orlop deck beams, upper ditto, forecastle ditto, poop, bow and after timbers and lastly ship planks (Bulley 2000:96).

Historical records on which part of the ship was constructed with teak helps to narrow down the possible functions of *Shah Muncher*'s structural timbers, however, the lack of contextual information and additional diagnostic features makes it difficult to pinpoint the specific functions of them. The thickness of these structural timbers, ranging between 110mm to 161mm, are intriguing. Differences in thickness were observed when the results were compared with *Endeavour*, which built around the time of *Shah Muncher* and closest to its size among the comparable ship data. Assuming the timbers were in fact hull planking evidenced from its rabbet joinery, they were much thicker than *Endeavour*'s planking. When *Shah Muncher*'s timbers were compared with Lloyd's scantling dimension table, the thickness of the plank fits quite closely to the dimensions of wales for ships with a tonnage of 1050 (Desmond 1919:20–22). Wales are thick planking located at the side of a ship to stiffen the outer hull (Steffy 1994:281). As mentioned above, there were no signs of sheathing observed at the point of this research. Wales is located above the waterline, thus, it does suggest that these structural timbers, situated above the waterline, could be wale planking. Differences in the thickness of hull planking on eighteenth- to nineteenth-century colonial ships were highlighted in Bennett's research. It was not until the early to mid-nineteenth centuries when the hull planking thickness was reduced as shipwrights start to appreciate the value of teak (Bennett 2021:275). Therefore, it is still premature to suggest that the structural timbers are wales because the scantling dimensions on the list serves only as a guideline, and it should not be used as definitive source of information. Further examination of the artefacts and additional ship data from other sources would be required.

Timbers PB2_904, PB2_905 and PB2_906 were identified as teak, which pertains to the structure of the ship, however, there was insufficient data from the timbers and the other case studies to identify their functions. Nonetheless, these timbers still exhibited interesting traits which could be explained through future research endeavour.

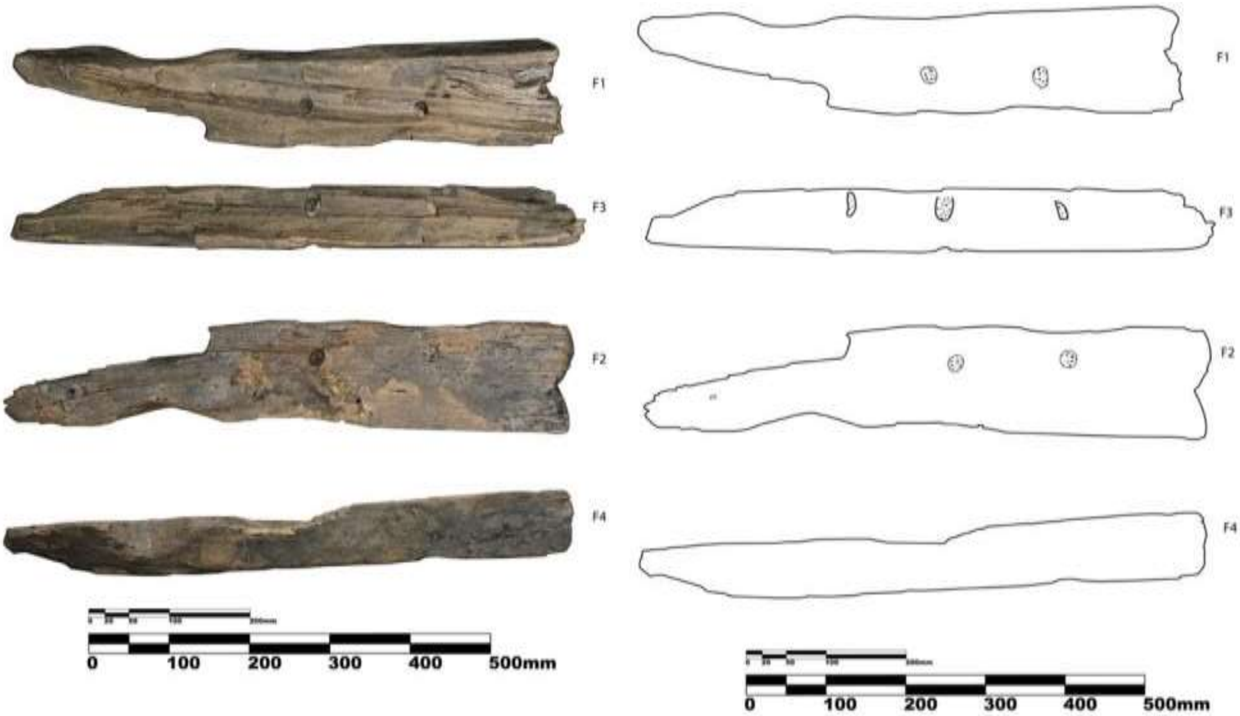


Figure 40: PB2_904 with two extant treenails (M. Ng, 2022).

Figure 41: Close up of the treenail on PB2_904 (M. Ng, 2022).

PB2_904 is a thick piece of timber with treenails (Figure 40). The treenails found on PB2_904 (Figure 41) were found to be smaller in diameter (19mm) as compared to those found on *Endeavour,* HMS *Buffalo,* and *Edwin Fox*. Treenails were used to connect the outer planks to the ships' framings as evident by the presence of treenails on *Endeavour* and HMS *Buffalo* (Bennett 2021:277). On *Edwin Fox*, they were found on ceiling planking and the second outer layer of hull planking, but these features could be a later addition. It is likely the treenails on PB2_904 are related to these construction features but there are insufficient diagnostic features to specify its functions. It is also likely that they are treenail pegs which, according to Bennett (2021:278), have different functions as treenails. These pegs have no wedges and have small diameters between 15mm to 25mm in diameter. They could be used to fill the holes left by ferrous fasteners which have rusted out or it could be a guiding aid for shipwrights when they fasten the planking with larger treenails or metal bolts (Bennett 2021:279).

PB2_905 and PB2_906 exhibited a box or dovetail joint. Box joints were also found on false keel sections on both *Endeavour* and HMS *Buffalo* (Bennett 2021:268), however, the false keels on both ships were coppered unlike PB2_905 and PB2_906. Thus, with the current data at hand, functions of both timbers remain uncertain, therefore posing more questions on the type of joinery and fastenings which could be found on *Shah Muncher* or other Bombay Country ships.

In summary, the timbers PB2_949, PB2_950, PB2_959, PB2_963, PB2_964 were identified as teak which is a main type of timber used for the construction of ships built in India during the eighteenth and nineteenth centuries. These timbers are likely structural elements of the ship, but it is unsure what type of fastening material was used on them. It is possible to postulate the hole on these structural timbers would be made by iron or copper spikes. The joinery suggests that these structural timbers could be associated to hull planking and if there were absence of copper sheathing, it would suggest that these timbers would be situated above the waterline,and considering the thickness of the planks, these planking could be wales. The differences observed between *Shah Muncher* and the other four case studies were evident. The uncertain nature of timbers PB2_904, PB2_905 and PB2_906 also raises more questions on the construction of *Shah* Muncher. Consequently, it creates an impetus to further the research to understand their functions.

6.3 Anti-Fouling Features

Timbers PB2_953, PB2_956, PB2_971, PB2_972, PB2_974, PB2_980 and PB2_983 are examples of sacrificial sheathing used on *Shah Muncher*. These timbers demonstrated similar features with other sacrificial sheathing found on *Endeavour,* HMS *Buffalo*, *Edwin Fox*, and *Sydney Cove*. Sacrificial sheathing found on these ships were found to comprise of, copper sheathing, copper alloy sheathing tacks and sacrificial timber.

6.3.1 Sheathing comparisons and highlights

Shah Muncher's sheathing was identified to be of pure copper. As there are no complete sheathing obtained from the *Shah Muncher's* site, only the thickness of the sheathing was compared. The following table (Table 38) provides a comparison of the metal composition and thickness between *Shah Muncher*'s sheathing and *Endeavour,* HMS *Buffalo*, *Edwin Fox*, and *Sydney Cove*.

Table 38: Hull sheathing metal composition and thickness.

	Shah Muncher	***Endeavour***	**HMS *Buffalo***	***Edwin Fox***	***Sydney Cove***
Composition	97.98–99.19% Cu	*85.03–90.63 % Cu: 9.37–15.53% C*	80.34–85.93% Cu: 14.07–19.66% C	63.52–66.22% Cu: 33.63–35.75% Zn: trace elements of Pb	95.00% Cu
Thickness	0.4–0.5mm	0.9mm	1mm	1.1mm	-

The copper content on *Shah Muncher* suggests that the sheathing is pure copper,but it was also noticeably higher than the other ship data. The pure copper sheathing on *Shah Muncher* shares similarity with *Endeavour,* HMS *Buffalo,* and *Sydney Cove* but vastly different from *Edwin Fox*, as it is confirmed that the latter was sheathed in Muntz metal based on the presence of a sheathing stamp and the metal composition analysis (Bennett 2021:294). Sheathing on *Endeavour,* HMS *Buffalo* and *Sydney Cove* were also pure copper based on their composition which were similar to *Shah Muncher*'s copper sheathing.

The copper sheathing on *Shah Muncher* shares even closer similarities with HMS *Sirius*, a similar time period vessel. HMS *Sirius* was a British-built ship that sunk in 1790 near Norfolk Island, Australia. The copper content of HMS *Sirius*'s sheathing is 99.4% (Macleod 1994:218).

Endeavour, HMS *Buffalo,* and *Edwin Fox* have similar sheathing thickness, but were much thicker than those found on *Shah Muncher. Diana* also exhibited copper sheets with 1mm thickness (Ball 1995:83). Although, no measurements of sheathing thickness of *Sydney Cove* were taken, it was mentioned that the sheathing was thin and ductile (Strachan 1986:34). It is possible *Sydney Cove*'s sheathing may exhibit similar thickness with *Shah Muncher*, however, this would require access to the sheathing from *Sydney Cove*. Thus far, the copper sheathings found on *Shah Muncher* wreck do not have any evidence of stamp marks unlike HMS *Buffalo* and *Edwin Fox* (Bennett 2021: 213, 237). In addition, there are no available historical records which could inform on the repairs and refits *Shah Muncher* underwent during its lifespan. Therefore, it is still unknown if the sheathing was installed during its conception or during its repairs and refits.Copper sheathing on Indian-built ships did not occur until the early 1780s (Bulley 2000:26–27). It was seen as an effective anti-fouling technique to protect the ship's hull from deterioration; however, many attempts were made to search for the best composition to ensure the effectiveness of the technique. The similarities and differences in the composition and thickness of the copper sheathing mentioned above serve as an example to highlight the changes in the composition of the copper sheath before an era where Muntz metal was widely used. Hays (1863:91–94) conducted a discussion during the eighteenth century to underline a problem about good and bad copper used for sheathing. With modern analysis, these good and bad copper were identified (Bingeman et al. 2018). The analysis suggests that good copper contained small quantities of impurities which allows a consistent rate of deterioration allowing the desired anti-fouling effects. Bad copper includes pure copper which eroded within two years or copper with too many inclusions such as iron, which does not deteriorate therefore unable to achieve the desired anti-fouling effects. Quantitative information obtained from these shipwrecks could better inform on the quality of the copper sheath used for ships during the late-eighteenth to nineteenth century and identify which category they belong to. Furthermore, helping to understand the wastage of copper sheathing during that period (Bingeman et al. 2000:222–223).

Sheathing holes and tacks are another key evidence found on PB2_953, PB2_956, PB2_971, PB2_972, PB2_974, PB2_980 and PB2_983 which suggests that the timber is a sacrificial timber. There seemed to be some regularity in the arrangement of the tacks on these timbers and the loose copper sheathing PB2_1175. They were aligned on a horizontal and vertical axis like a square patterning (Staniforth 1985:30), however, the spacing between the sheathing tacks and holes were different. *Endeavour*'s tacks exhibited varying distance between the tacks, suggesting that the holes were manually punched. On the other hand, the tacks found on *Edwin Fox*, were uniformly punched which suggest that the process was more machine-based as opposed to the labour-intensive process adopted on the construction of *Endeavour* (Bennett 2021:296). Therefore, it is likely that *Shah Muncher*'s sacrificial timbers were also tacked via a labour-intensive process similar to *Endeavour.*

6.3.2 Fastening comparisons and highlights

The fastenings found on the timbers are sheathing tacks which secures the copper sheathing onto the sacrificial timber. The dimensions of these tacks were like the tacks found on the sacrificial sheathing found on the other ship data. The extant tacks have a round head diameter between 6.4mm to 13mm. PB2_983, PB2_1056 and PB2_1069 were tacks obtained from timber samples and they have a length between 11.15mm to 31.6mm. Diameter of the thickness beneath the tack heads of PB2_983, PB2_1056 and PB2_1069 were measured and they were around 4mm. Shanks without their head have a square dimension of 4mm by 4mm to 5mm by 5.6mm. The shank dimensions were compared with the square holes found on other timbers examined in this study. These timbers exhibited hole dimensions between 3mm by 3mm to 9mm by 9mm, which coincide with the dimensions of the extant tack shanks. It could conclusively suggest the type of tacks or fasteners used on timbers with minimal diagnostic features. Similarities were also observed when these data is compared with other ship data. Both *Endeavour and* HMS *Buffalo* have tacks measuring less than 34mm, square shank, and with a head diameter of less than 13mm. Sheathing tacks found on *Sydney Cove* also shared similarities with the tacks found on *Shah Muncher*. The loose tacks have a length between 23.3mm to 66.7mm and their round heads have a diameter between 6.7mm to 13mm. According to Bennett (2021:284), the tacks found on *Endeavour* were probably manufactured using the wire cut process. This process was the most common practice for tack production during the late-eighteenth century (McCarthy 2005:175). Thus, as *Shah Muncher* would have been constructed during the late-eighteenth century, it is likely that its tack would also be manufactured using the wire cut process.

Table 39: Sheathing tack comparison.

	Shah Muncher	***Endeavour***	***Edwin Fox***	***Sydney Cove***
Composition	(PB2_983) 86.44–89.81% Cu: 4.15–7.46% Sn: 5.05 – 5.10% Zn: (PB2_1056/PB2_1069) 64.69–67.72% Cu: 28.76 – 32.81% Zn	79.1–79.6% Cu: 8.97–9.89% C 2.5–8.17% Zn	72.63–74.36% Cu: 23.89– 25.77% Zn: 1.59– 1.77% Sn:	70% Cu with other metals such as lead, tin and zinc

The tacks from *Shah Muncher* which were sent for elemental composition analysis revealed distinct results. Firstly, the tacks were identified to be made up of copper alloy. PB_983 has 80% copper and 5% zinc while PB2_1056 and PB2_1069 exhibited much lower copper content (64.69–67.72%) and higher zinc content (28.76 – 32.81%). It is common to find other elements such as zinc, tin and lead in sheathing tacks manufactured during the late-eighteenth to nineteenth century (Bennett 2021). This addition hardens the tacks so that it could be harder than the sheathing. PB2_983 has an elemental composition like sheathing tacks found on HMS *Sirius*. The sheathing tack found on HMS *Sirius* exhibited 91.1% copper and 7.69% tin (Macleod 1994:268). Both PB2_1056 and PB_1069 exhibits Muntz metal signature. It is likely that the timber and the sheathing tack could be from other ships which collided in the area as Muntz metal was adopted after 1832. Thus, more investigation is required to examine the materials from *Shah Muncher* or further research onsheathing tacks may provide a possible explanation for this observation. The results from *Shah Muncher* tacks were vastly different from the results obtained from other ship data as well (Table 39). The sheathing tacks did not exhibit any Muntz metal signature. Even *Edwin Fox*, which was sheathed in Muntz metal did not exhibit tacks with Muntz metal signature.

6.3.3 Joinery comparisons and highlights

Shah Muncher's sacrificial timbers did not exhibit any forms of joinery as the ends and edges of the timbers were degraded and broken. While *Endeavour* has possible scarf joints and HMS *Buffalo* has possible butt joint features on their sacrificial timbers. This difference in joinery could be representative of the area where it was re-sheathed. It is likely that *Endeavour* could have undergone re-sheathing in Bombay, and the practice of scarf timbers could be a representation of the re-sheathing practice in that region. As *Shah Muncher* was constructed in Bombay, it may exhibit similar joinery as *Endeavour*, however,this would require additional data and future research.

6.3.4 Timber comparison and highlights

The sacrificial timbers on *Shah Muncher* are between 13mm to 25mm thick and were identified as teak through wood species analysis, except for PB2_971, which was identified as *Cassia sp*.. The thickness of the sacrificial timbers was like those observed on *Endeavour,* HMS *Buffalo,* and *Sydney Cove*. The thickness of the timber used for the sacrificial timber on the Indian-built country ships, HMS *Buffalo,* and *Sydney Cove*, were between 13mm to 28mm which were comparable to the sacrificial timber on *Shah Muncher* 20mm to 29mm. Sacrificial sheathing on the London-built *Endeavour* ranged between 24mm to 31mm.

The sacrificial timber on HMS *Buffalo* was identified as cedar and pine while *Endeavour's* sacrificial timber was teak. Comparing between the Indian-built ships, it seemed that the sacrificial timber used were different. This may allude to a difference in shipbuilding practice between Bengal-built Country ships as opposed to Bombay-built Country Ships. On the contrary, the difference in the timber used could also be alluded to access to teak supplies. HMS *Buffalo* was constructed much later than *Shah Muncher*, therefore, the supply of teak from its regional sources would have changed, thus prompting shipbuilders to use a specific type of wood that were practical based on the existing environmental and economic situation. The source of the sacrificial timber used on HMS *Buffalo* was unknown as there were no refitting records of when the cedar or pine was used. It is likely that the cedar was used when it was re-sheathed as the average lifespan of copper sheath during the early-nineteenth century was three to four years (Marquardt 2003:139; Bennett 2021:273). *Endeavour* was constructed during the same period as *Shah Muncher*. Although it was constructed in London, teak and pine was used as its sacrificial timber in addition to some of its structural features. Pine was probably used when the ship was berthing at Britain,while the teak was probably used when it stopped at Surat/Bombay during one its many voyages. This suggests that the choice of timber for sheathing in Bombay during the late- eighteenth century was teak which is consistent with the wood species identified on *Shah Muncher* hull remains.

On PB2_974 (Figure 42), traces of greyish white stains were observed on one of its surfaces. The surface does not have any sheathing presence and the tips of the tacks can be discerned. The stains were insufficient for further analysis. The colour of the stains suggests a possibility that the sacrificial timber could be lined with *chunam* before it was fastened to the hull of the ship. Historical records do indicate that a layer of *chunam* or lime, mixed withhair, was applied all over the sheathing of teak plank. Blankets boiled in dammer of tar and cover all of the copper sheathing (Bulley 2000:27). The above observation did not indicate that the *chunam* was applied to the space between the hull plank and the sacrificial timber,however, this observation could provide evidence that *chunam* was also used in that context.Similar observations were found on *Quedagh Merchant*, where the planks exhibited a coating of limestone with the appearance of fine-grained cement.

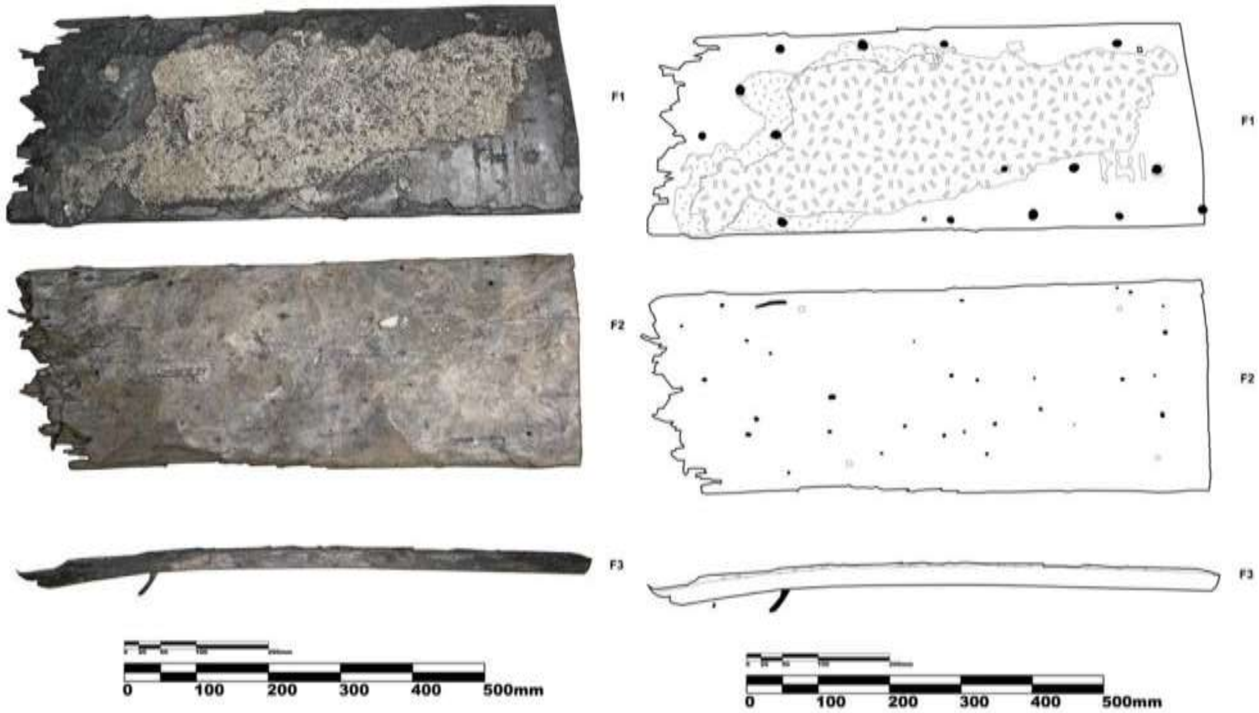


Figure 42: PB2_974 exhibiting a possible *chunam* coating, sheathing and tacks (M. Ng, 2022)

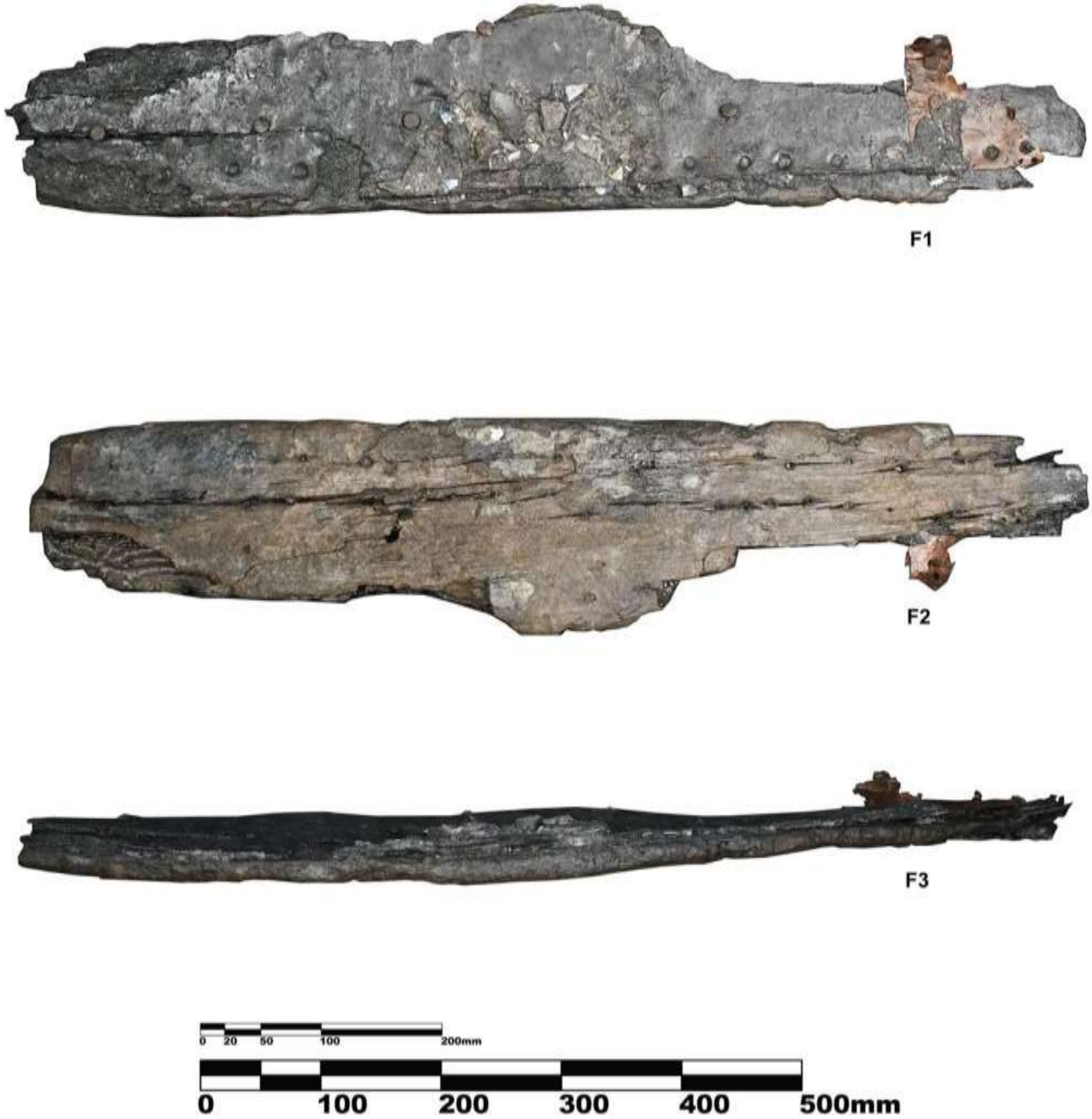


Figure 43: PB2_971 (M. Ng, 2022)

The findings obtained from the sheathing plank PB2_971 are interesting. It exhibited features of sacrificial planking such as the presence of copper sheathing and copper alloy tacks, but the wood species, cassia, is an atypical wood for such feature. Based on archaeological and historical ship data obtained from this research, Country ships relied on teak, cedar, or pine as sacrificial timber. This suggests that sheathing plank was added when the ship was repaired at an unknown location during its life (Figure 43)

Using sacrificial timber on ships was practiced by Indian and European shipwrights (Strachan 1986:35; Phipps 1840:195; Bingeman et al. 2000:219). It was a method to prevent decay of the hull by marine organism and include the addition of a thinner layer of planking to the outer hull planking to facilitate ease of repairs. Ships are known to have been re-sheathed multiple times throughout their working lives (Strachan 1986:35; Coates 1911:10; Bennett 2021:291). Currently, it is unknown if *Shah Muncher* was re-sheathed and whether it was re-sheathed more than once, but it is likely to have had such repair at least once or perhaps even twice in its six years of service as re-sheathing with wood and copper alloys was recommended every two to three years (Bennett 2021: 273; Strachan 1986:35). Despite these recommendations, there were indications that practices were not adhered to as it would raise the cost for the ship owners (Van Duivenvoorde et al. 2023).

6.4 Graving Pieces

PB2_900, PB2_975, PB2_1017, PB2_1019 and PB2_1040 are graving pieces.These pieces share similarities with the graving pieces found on *Endeavour* and *Edwin Fox.* As defined by Steffy (1994:272), graving piece is defined as a wooden patch or insert, placed into a damaged or rotted plank. Graving pieces exhibit trapezoidal shapes with some fastenings according to Steffy's graphic depiction. The identified graving piece on *Endeavour's* outer plank has a length of 131mm and 20mm in depth, while *Edwin Fox* exhibits a piece 230mm and 95mm wide in one of its ceiling planks. Both graving pieces do not exhibit any fastenings and their entire shape cannot be determined as they were still lodged into the original piece of timber. On the other hand, suspected graving pieces could be observed on the deck planking on HMS *Trincomalee*. From the 3D model of the vessel, it was possible to find possible graving pieces with fastenings on the upper and lower deck planks (Figures 44 and 45).

Figure removed due to copyright restriction.

Figure 44: HMS *Trincomalee* graving piece inserted into a deck plank. This graving piece is found in the officers' mess, at the lower decks of HMS *Trincomalee* (The National Museum of the Royal Navy: HMS *Trincomale*e, 2017)

Figure removed due to copyright restriction.

Figure 45: Another graving piece found in the officers' mess, at the lower decks of HMS *Trincomalee* (The National Museum of the Royal Navy: HMS *Trincomale*e, 2017)

It is certain that PB2_900, PB2_975, PB2_1017, PB2_1019 and PB2_1040 are graving pieces although there is no contextual information which could highlight its functions and identification of these timber pieces. These graving pieces exhibited characteristics which are different from those found on *Endeavour* and *Edwin Fox* but like HMS *Trincomalee*. Firstly, the suspected *Shah Muncher* graving pieces all exhibited fastening holes which were absent from those found on *Endeavour* and *Edwin Fox*. In addition, there were differences in the size of the fastening holes among the five timbers. PB2_900 has fastening holes which were between 17mm by 18mm to 21mm by 28mm. It also has a smaller tack hole measuring 3mm by 5mm. The circular impression found on one of the surfaces on PB2_900 could suggest that the fastener has a round head and was driven into that surface. The other timbers have square holes which were smaller, between 4mm by 8mm to 12mm by 13mm. It is possible that PB2_900 is placed in a location which requires larger fasteners as compared to the other suspected graving pieces. The size of the fastener holes found on PB2_900 is similar to those found on *Shah Muncher*'s structural timbers like PB2_949, PB2_950, PB2_963, PB2_964 and PB2_965.

PB2_900, PB2_1017 and PB2_1019 exhibited flushed surfaces. PB2_975 and PB2_1040 exhibited a raised portion. The purpose of the raised portion is unknown however, the holes characteristics could provide some clues with regards to its placement on timber. On PB2_975, the circular impression surrounding a square hole was only found on the flushed surface of the timber. This denotes that the round head fastener was driven into the flushed surface, thus the raised portion will be directly in contact with the timber it was meant to be fastened to. This observation could not be further investigated with the data at hand as the graving pieces on *Endeavour* and *Edwin Fox* only reflected a flushed exposed surface and no information was available on the opposite surface.

There are currently no available records which provided information on its construction, repairs and refitting throughout *Shah Muncher*'s lifespan and insufficient data to further understand these graving pieces. It does present possible future research on the graving pieces that could be found on *Shah Muncher* as compared to other eighteenth- to nineteenth-century British colonial ships. Investigations could be conducted to identify if fastening graving pieces and the raised portion represents a distinct repair technique representative of the place where it was repaired.

6.5 Other Features

PB2_1067 is identified as *Lignum vitae* and together with the groove it exhibits, the timber is part of a rigging sheave. The use of *Lignum vitae* for rigging sheave was prevalent on most ships during the eighteenth and nineteenth centuries. This wood would have been imported from America. (Strachan 1986:45; Ball 1995:83).

Initial assessment and hypothesis of timbers PB2_901 and PB2_903 suggests it could be related to dunnage for cargo. The tack features and the absence of sheathing were like those found on *Griffin*. Light China boards and matts were used as dunnage for the cargo (Bulley 2000:28). Examples of these light China boards could be found on board *Griffin*, an East Indiaman which sank in the Philippines in 1761. These China boards were identified to be milled from *Cunninghamia sp*, which is a type of cypress tree native to China (Goddio and Guyot de Saint Michel 1999:77). As these timbers were identified teak, they are not likely to be dunnage but could be more related to the ship's structure or furniture. Further research will be required to identify their true functions.

PB2_945 is a thick piece of timber with tacks and a square shaped impression. Within the impression, some metal encrustations could be discerned. A similar impression with encrustation was also observed on the other surface. It has a square extant fastening which will require further compositional analysis.

PB2_1018 and PB2_1038 were identified as *Pinus sp.*, commonly known as Pine. Itis unsure how these timbers could be related to the ship structure as there are very little diagnostic features. PB2_1038 was identified to have a circular hole probably made from a nail. The appearance of these wood species is interesting. Pines have been used in ship construction. An outer plank from *Endeavour* and a sacrificial timber from HMS *Buffalo* was identified as pine. The early-eighteenth-century pirate ship, *Queen Anne's Revenge,* which was captained by Edward Teach, exhibited the use of pine as a sheathing timber (Newsome and Miller 2009). Pine was also used as sheathing on the seventeenth-century ship *Batavia*. They were fastened to the exterior of the ship's hull with iron sheathing, filling, and nails (Van Duivenvoorde 2012). It was also highlighted in East Asian shipbuilding. The Turiang shipwreck, a Chinese ship dated to 1370 which sank in the Malaysian waters, also exhibited bulkhead timbers which were made from pine (Sjostrand and Barnes 2001:76).

PB2_985, PB2_1045, PB2_1048, and PB2_1050 are teak planks which could be related to the ship structure or the furniture within the ship. All of them exhibit tacks or tack holes which suggests it could be fasten to something. There was no sheathing found on them and no indications of sheathing remnants like those found on *Shah Muncher*'s sacrificial timber. PB2_1056 is a possible teak plank fragment as it still has extant sheathingtack. It was not possible to identify the wood species of PB2_1069, however the extant sheathing tack has similar elemental composition with PB2_1056 tack. It is still unsure what function it plays but the tacks exhibit Muntz metal signature. Although, both tacks have Muntz metal signature, it should not be confirmation that they were Muntz metal as copper tack composition were not fixed at that time and further research needs to be conducted to examine these tacks against other shipwreck sites. Another possible explanation would be that both these planks may be from other ships which may have collided at the site, leaving timber fragments at the *Shah Muncher*'s site. Nonetheless, more research is required to ascertain if PB2_1056 and PB2_1069 were associated with *Shah Muncher* and this would require further analysis of copper tacks used during that period.

6.6 Conclusion

In conclusion, by comparing data of similar traits and features between *Shah Muncher* and the other ship data, it was possible identify some possible functions of the timbers. The timbers studied in this research exhibited strong correlation to *Shah Muncher*'s ship construction simultaneously revealing differences with the other ships. These differences could be examined in future research.

CHAPTER SEVEN: CONCLUSION

7.1 Introduction

This thesis aimed to identify the structural features observed on *Shah Muncher* and highlight similarities and differences between Bombay-built Country ships and other eighteenth- to nineteenth-century British colonial ships. These structural features were examined through the analyses of the ship's hull remains. The thesis included visual examinations, timber species and metal analysis. This study set out to answer the following primary research question:

> How do the ship remains of the Bombay-built *Shah Muncher* compared to those archaeological remains of other Indian-built ships, and what comparisons can be drawn with existing studies on British colonial-built vessels?

Through comparative analyses of the ship data from *Shah Muncher* and other related case studies, it is possible to identify specific features or functions of the disarticulated timbers found at the site. Secondly, with the data at hand, common eighteenth- to nineteenth-century British colonial shipbuilding features were identified and the differences in ship construction were highlighted. These differences may be a circumstance of cultural transmission between Indian and British shipbuilding traditions during that period.

This chapter first summarises the findings from this study, and then proceeds to highlight the limitations of this research. It proposes future research studies which could broaden the understanding of eighteenth- to nineteenth-century shipbuilding practices, and local Indian shipbuilding traditions. In addition, it would also feature the relationship of *Shah Muncher* to its surrounding environment.

7.2 Summary of Findings

The timber artefacts obtained from the site offered insights into the ship construction, anti-fouling, and repairs of *Shah Muncher*. Teak was the principal wood species used to construct the vessel, evident from the structural timbers identified in this research. Spikes, a prevalent type of fastenings used to secure structural components within a vessel,were used. No extant fastenings were found on the timber. Thus, the material of the spikes is currently unknown. Based on past research from other ship data, these fastenings could be made from iron or copper alloy. Some of the features on the timber cannot be confirmed, such as the placements of the fastening holes, absence of treenails and the plank's thickness. It is unsure why they exhibit such characteristics which were not observedin the other case studies. The lack of sheathing and multiple sheathing holes might suggest that these timbers were located above the waterline. The rabbet joinery observed on two ofthe timbers fit the descriptions of longstanding shipbuilding traditions in Bombay. While it ispossible to identify the structural components, there were not enough data to ascertain which structural part it belongs.

Anti-fouling elements on *Shah Muncher* were identified from the timber artefact assemblage. It sheds more light on this crucial feature which protects ships from marine organism infestation. Elemental analysis of the copper sheathing found on *Shah Muncher* shares similarities with some case studies. Pure copper was used for sheathing, but after 1832, Muntz metal was adopted as observed from the sheathing from *Edwin Fox*. Differences between the ships sheathed with pure copper could be detected. The sheathing found on *Shah Muncher* is much thinner than those reported in *Endeavour* and HMS *Buffalo*, but it matches the descriptions of *Sydney Cove*'s sheathing.

Nevertheless, without concrete measurements from *Sydney Cove*'s sheathing, it will still be premature to suggest its similarities with the sheathing found on *Shah Muncher*. The species of the sacrificial timbers were identified as teak except for one timber, *Cassia sp.* A variety of wood was used as sacrificial timber. Thus far, Country ships constructed in the Bengal region exhibited cedar and teak. The use of *Cassia sp.* as sacrificial timber has not been found yet. As *Shah Muncher* is currently the only Bombay country ship examined archaeologically, there are no other direct comparisons. A possible *chunam* layer can also be found on one of the sacrificial timbers, which fits the historical descriptions of Bombay Country ship construction. The sheathing tacks sent for elemental analysis differed slightly from those found on the other shipwrecks. One of the tacks was found to have closeto 90% copper content, around 10 – 20% higher than the other comparable ship data. Two tacks exhibited approximately 65% copper content and about 30% zinc, like the Muntz metal signature. Possibly, the tacks belong to another ship's timber fragment that could have collided in the area and contaminated the site. Nevertheless, the timbers and the tacks likely belonged to *Shah Muncher* as they were found in-situ amongst other *Shah Muncher* artefacts such as ceramics and flora cargo. No joinery could be found on *Shah Muncher*'s sacrificial timbers, unlike *Endeavour* and HMS *Buffalo*, which exhibited scarf and butt joints.

Graving pieces were observed from the timber assemblage from *Shah Muncher*. The timbers were positively identified as graving pieces as they share stylistic similarities with graving pieces found on *Endeavour*, *Edwin Fox,* and HMS *Trincomalee*. The graving pieces found on *Shah Muncher* exhibited two different types of fastening holes. The fastening hole on PB2_900 suggests that the timber could be affixed to a structural timber as its fastening hole has similar dimensions to *Shah Muncher*'s other structural timber. The other graving pieces exhibited fastening holes like sheathing tacks. Fastening holes were not observed on the graving pieces of *Endeavour* and *Edwin Fox*. In contrast, fastening could be detected on the deck planking of HMS *Trincomalee*.

Other timbers identified included a rigging sheave made from *Lignum Vitae*, a North American hardwood commonly used for rigging sheaves. There were two timber fragments which were identified as *Pinus sp*. or pine. It was unsure how the fragments were related to *Shah Muncher*, but it has been used as sheathing timbers on seventeenth- to eighteenth-century European ships or as bulkhead timbers on Chinese ships. PB2_901 and PB2_903 were made of teak, which helped rule out their possible functions as stowage packing material. Packing boxes used for stowing artefacts were made of light China boards. Examples of these light China boards were found on the *Griffin*, and they were identified as made of *Cunninghamia Sp.*, a type of cypress tree native to China.

Despite the current lack of information to ascertain the purpose and reason behind some of these features, it does highlight the unknown structural characteristics of Bombay Country ships. It adds another spectrum to our understanding of eighteenth- to nineteenth-century British colonial and Country shipbuilding. In addition, while much of the ship's structure may be based on a European design, there were elements of Indian shipbuilding traditions that could relate to other shipwrecks constructed in India during different periods.

It is also important to continue researching cultural transmission between Indian and European shipbuilding.

7.3 Limitations

Challenges were faced during the research and could be attributed to three main factors. Firstly, the timbers obtained from the site were disarticulated. They were often found amid other artefacts. Therefore, there were no in-situ structural remains or context to derive possible conclusions to the identity of these timber remains.

Most of the timber remains were also primarily deteriorated. They were either deteriorated by marine organism infestations, broken, or weathered due to the constant water activity in the area. All the timber remains obtained from the site did not exceed 150cm. Lastly, the inventoried timbers, including those included in this research, have been impregnated with Polyethylene Glycol 400 (PEG 400). The use of PEG 400 ensures continued preservation of these timbers; however, it was not possible to conduct any furthercellular analysis (Hamilton 1998:29). Therefore, limiting the scope of this research to woodspecies analysis and physical examination.

A fraction of timber remains has yet to be inventoried as the process is still ongoing. Thus, this research only utilises timbers which have been catalogued. Further analysis would need to be conducted on timber remains, which have not been inventoried. In addition, some of these timber remains may not have undergone the PEG 400 treatment. Therefore, DNA or strontium analysis can likely be conducted on these remaining timbers, which could resolve some possible questions about *Shah Muncher*.

7.4 Future Research

The online 3D model of HMS *Trincomalee* was helpful with the identification of the graving pieces found on *Shah Muncher*. While it was helpful to a certain extent, it also highlights that further studies and detailed recording of the HMS Trincomalee could reveal more information on the timber remains of *Shah Muncher* and Bombay Country ships. The 3D model provides an excellent representation of the vessel but lacks details. These details include construction, such as the dimensions of the scantlings, fastenings, and the ship lines. As the last remaining Bombay Country ship floating, it is essential to conduct a complete survey of the ship as reference material for future studies.

Detection of ferrous materials on *Shah Muncher* timbers can also be done to narrow down the type of fastening. From the data obtained from this research, it was possible to identify that spikes were used for fastenings, though it is unsure if they were made of copper alloy or iron. Similar to Bennett's (2021) research, a magnet could be used to detect ferrous elements, which may be in the form of encrustations.

Further investigations on eighteenth- to nineteenth-century ship fasteners could further understand the different fastenings used on eighteenth- to nineteenth-century ships.Current data have examined the elemental composition of fasteners ranging from ship fasteners to sheathing tacks. In addition, some ship reports provided the dimensions of these fasteners and tacks to allow comparison with other ships' fastenings. These valuable data offer further insights into the manufacture of these fastenings. Still, more data on elemental composition, shape and dimensions are required, especially for ships constructed before Muntz metal was prevalently used. The stamps on the Muntz metal provide some form of provenance, but copper alloy used before the 1830s could only be derived from an increasing corpus of fastening information.

Future study on the use of treenails on Country ships could also reveal differences in shipbuilding practices between Britain and India. Treenails were found on *Endeavour*, HMS *Buffalo*, and *Edwin Fox* but not on *Sydney Cove*. Historical mentions stated that Indian shipwrights did not fancy the use of treenails to fasten ships' structures due to their susceptibility to damage in tropical climates. Data from Bennett (2021)'s research reported otherwise, and no treenails were found on *Shah Muncher*'s structural timbers. There seemed to be contradictions between the archaeological data and historical records on the use of treenails on Indian-built ships. It does pose a question on the usage of treenails and how it might inform eighteenth- and nineteenth-century Country ship construction.

Shipwrights would use graving pieces to replace timber sections which they suspected could threaten the integrity of the ship structure on *Endeavour*, *Edwin Fox,* and *Shah Muncher*. While they were stylistically similar, there remain overt differences such as the presence of fasteners, the type of fastener used, and the raised portion found on some of *Shah Muncher*'s graving pieces. Therefore, further investigations will be required to determine if they were a trademark of the local shipwright. In addition, no timber species analysis has been conducted on *Shah Muncher*'s graving pieces; thus, it would be pertinent to identify the species and how it is related to the vessel's construction.

Rabbeting recesses found on two of *Shah Muncher*'s structural timbers gave further credence to the observations made on Bombay country ship constructions. It shares similar characteristics to *Quedagh Merchant* structural features, built almost 100 years before *Shah Muncher*. This type of edge-to-edge plank joinery is unique to ships constructed in Bombay and could be the key characteristic unique to Bombay Country ships. This technique highlights the cultural transmission in shipbuilding practices in Bombay, whereby local shipwrights will apply indigenous techniques while constructing a European-style vessel. This technique should be investigated further as other research has been done on ship construction in a similar region which exhibited similar rabbet, scarf joint, and edge to edge plank joinery.

Other historical accounts have mentioned how the planks were rabbeted on their edges to be fitted together. Before the planks were joined, cotton and lime putty were used to seal the seams (Wilson 1909:31; Burningham 2007:96). Examples of similar joints were observed in ethnographic boat studies around Goa. An examination of the fastenings found in Goan crafts included a copper fastened ship-lap halved seam resembling the rabbet recess on *Shah Muncher* (Fenwick 2015:393). Sewn-plank boats of Goa also exhibited planks joined edge to edge with an 's' groove, which is somewhat like an angled rabbet recess (Zeeshan et al. 2012:152). These examples of edge-to-edge plank joinery may be a characteristic of West Indian shipbuilding practice. A traveller's account in 1786 mentioned that the Indian shipbuilders inherited their skills from those who had built the ships for the Gujarati fleet in the seventeenth century (Bulley 2000:27). It would be interesting to reveal any possible relationship between the rabbet recess joinery reported in these research. Other potential archaeological sites that could benefit the research on shipbuilding in India include shipyards around Bombay and identifying the sources of raw materials for shipconstruction.

This research reveals the potential information Country ships has on India shipbuilding and technology. Country ship research is currently at its burgeoning stages andthere are many areas yet to be examined. Furthermore, there are other Country ships which have yet to be fully investigated or located. For example, six Country ships, reported to be constructed on the east coast of India, have been recorded to have sunk in Queensland, Australia between 1801 and 1826 (May 1986:19). Further investigations of these ships couldoffer additional comparative data to compare with the India-built vessels from the west coast of India.

7.4.1 Situating *Shah Muncher* in a Maritime Cultural Landscape

It was possible to understand Singapore's role as an essential entrepot since the early-fourteenth century using a combination of historical and archaeological data (Kwa 2012; Miksic 2013). Scholars researching Singapore's past have maintained the island's connection to the Maritime Silk Road. The island's past was often intertwined with its locationalong the Singapore Straits. Their importance was further highlighted by shipwrecks, the Temasek wreck, *Shah Muncher,* and *Diana*. These shipwrecks are a testament to the importance of this area to the Maritime Silk Road. The emerging notions of the Maritime Silk Road provided a precipice to examine connections rather than concentrate on a specific polity or commodity and associating these connections to the significant global events in each period. It opens a plethora of possibilities to understand more about the human activity that transpires along this trade route. Kwa (2016)'s notion of the Maritime Silk Road focused on the macro implications of global geopolitical trends and trade. It emphasises the trade and exchange that occurred during the various periods, effectively highlighting the importance of the road in a global context.

A maritime cultural landscape can be defined as the human utilisation of maritime space by boat: settlement, fishing, hunting, shipping, and, in historical times, its attendant subcultures, such as pilotage and lighthouse and seamark maintenance (Westerdahl 1992:5). Westerdahl (2011:13–14) provided further iterations to the original definitions of maritime cultural landscapes via seven types of landscapes. It includes the economic landscape, the landscape of transport and communications, power landscape, outer resource landscape, inner resource landscape, cognitive landscape and recreative landscape.

It is possible to associate the study of the Maritime Silk Road as a component of a maritime cultural landscape. When the maritime cultural landscape concept is applied to the Maritime Silk Road, parallels can be observed. Notions within the Maritime Silk Road can broadly fall under a combination of landscapes of transport and communications, and power landscape. The landscape of transportation and communications refers to routes, seamarks, pilotage, harbours, roads, portages, and navigational markers, such as transit lines and the associated place names. On the other hand, power landscape refers to the mansions of great chieftains as administrative and central places, including a landscape of defence, territorial, or allegiance. In addition, it includes the social landscape of class structures, settlement patterns, boathouses, blockages, and other fortifications (Westerdahl 2011:13). The notions explored in the Maritime Silk Road fit into these two categories of landscape asit identifies the trade, exchange, and communication between the different polities. Most importantly, it is a route littered with multiple transit lines, harbours, and seamarks, accompanied by various social and political landscapes in varying times.

This paper proposes to build upon the current emerging notions of the Maritime Silk Road by incorporating the study of the maritime cultural landscape to observe the micro connections and perhaps a closer examination of the social activities which existed along this maritime trade route. It views the entire straits as a maritime cultural landscape rather than segregating the landscape based on current geopolitical boundaries. Hence, the Singapore Straits is a micro maritime cultural landscape within the more enormous MaritimeSilk Road scope. Through this perspective, a foundation can be established to situate the research conducted on *Shah Muncher* appropriately within the region's existing past maritime narrative. The narrative will include its association with Singapore's maritime cultural landscape, the maritime trade during that period and the vessel - *Shah Muncher*.

Maritime cultural landscapes of smaller regional areas have been explored. Such instances provide the precedence to apply the concept of maritime cultural landscape onto Singapore Straits. Areas where the concept were applied include Thunder Bay, Ontario, and Hare Harbour on the Quebec Lower North Shore (LNS) in the north-eastern Gulf of St. Lawrence. Thunder Bay is situated along Lake Ontario. Apart from the presence of the shipwrecks, there were other cultural features left behind by Native Americans and subsequently the French and British Explorers. A multitude of maritime activities which include fishing, lumbering, and commerce took place at the bay. Furthermore, maritime infrastructures were also built to keep up with the commercial activity of the area (Lusardi 2011). Archaeological information obtained around Hare harbour provided evidence of early Europeans and Inuit interactions, which culminates to mutual economic collaborations between both groups. The diverse activity spun from this interaction highlights the location importance as a "gateway" region to the New World (Fitzhugh et al. 2011). Both locations are perfect examples to illustrate how the maritime cultural landscape could be applied to asmall regional area teeming with maritime activity. The concept allows the possibility to combine terrestrial and maritime archaeology by including multiple geographical, historical, archaeological, and cultural perspectives to reveal a much more comprehensive outlook of a maritime settlement and its adjacent activities.

Approaching the maritime cultural landscape of the Maritime Silk Road in a more localised manner helps illuminate the ships and boats which played a significant role in transporting goods, ideas, and people. It can also be specific to an area such as the Singapore Straits. Seafarers of the past were aware of the Straits and deliberately sailed past to reach their destination. Shipwrecks along the straits can provide more information on sailing experiences through different periods. For example, the shipwrecks near the easternentrance are testament to the dangers faced by seafarers. Pedra Branca is located on the eastern entrance to the Singapore Straits. Historically, the rock is a navigation landmark anda hazard for shipping. Therefore, the shipwrecks reported around the vicinity of the rock form part of the maritime cultural landscape around the area. Thus, based on this premise, the study of *Shah Muncher* will fall under the analysis of the maritime cultural landscape of transport and communications within the Singapore Straits.

The premise in this section is still unrefined and would require further iterations and improvements to merge both notions succinctly. Nevertheless, it hopes to promote further exploration of other aspects that make up the Singapore Straits maritime cultural landscape. Further research can be undertaken to understand the economic, outer resource, inner resource, cognitive and recreative landscapes of this region.

7.5 Conclusion

Information obtained from *Shah Muncher* presents an opportunity to further the understanding of Country ships built in India and the eighteenth- to nineteenth-century shipbuilding practices. The similarities helped to reinforce specific techniques, but the differences highlight the need to embark on further research in this field of study. The cross-cultural elements highlighted in this research also create a suitable backdrop to examine this shipwreck from the perspective of the local Indian shipwrights. These shipwrights were constructing a European style vessel, but elements of Indian shipbuilding can be detected. Thus, it highlights Indian shipbuilding practices and how they evolve and eventually adapt to their new assignments. *Shah Muncher* is not just related to where it was constructed. Asit sank along the Singapore Straits, it is a testament to the maritime cultural landscape of this significant route within a large Maritime Silk Road context. Therefore, *Shah Muncher*, like other shipwrecks, should not be only regarded as a mere time capsule but as a vessel which embodies elements that transcend space, culture, and people.

REFERENCES

Adams, J. R. 2013. *A Maritime Archaeology of Ships: Innovation and Social Change in Late Medieval and Early Modern Europe*. Havertown: Oxbow Books.

Anon. 1806. *The Naval Chronicle, for 1806, containing a General and Biographical History of the royal Navy of the United Kingdom; with a Variety of Original Papers on Nautical Subjects*, *etc. Vol. 15*. London: Printed and Published by Joyce Gold.

Anon. 1840. *Report from the Select Committee on East India Produce*. London: House of Commons.

Ball, D. 1995. *The* Diana *Adventure*. Kuala Lumpur: Malaysian Historical Salvors.

Barua, P. 2011. Maritime trade, seapower, and the Anglo-Mysore wars, 1767–1799. *Historian* 73(1):26–27.

Bass, G. F. 1983. A Plea for Historical Particularism in Nautical Archaeology. In *Shipwreck Anthropology*, edited by R. Gould, 91–104. Albuquerque: University of New Mexico.

Bennett, K. 2021. Shipwright artistry: cultural transmission of British colonial ship design and construction during the eighteenth and nineteenth centuries. PhD thesis, History and Archaeology, College of Humanities, Arts and Social Sciences, Flinders University, Bedford Park.

Bingeman, J. M. 2018. Copper and Muntz metal sheathing: a global update. *International Journal of Nautical Archaeology* (47)2:460–471. DOI: 10.1111/1095-9270.12299.

Bingeman, J. M., J. P. Bethell, P. Goodwin and A. T. Mack. 2000. Copper and other sheathing in the Royal Navy. *International Journal of Nautical Archaeology* (29)2:218–229. DOI: 10.1111/j.1095-9270.2000.tb01453.x.

Borschberg, P. 2012. The Singapore Straits in the Later Middle Ages and Early Modern Period (c. 13th to 17th Centuries): facts, fancy and historiographical challenges. *Journal of Asian history* 46(2):193–224.

Borschberg, P. 2017. Singapore and its Straits, c.1500–1800. *Indonesia and the Malay World* 45(133):373–390. DOI: 10.1080/13639811.2017.1340493.

Buckley, C. 1902. *An Anecdotal History of Singapore: (with portraits and illustrations) from the foundation of the settlements under the Honourable the East India Company, on 6 February 1819, to the transfer to the Colonial Office as part of the colonial possessions of the Crown on 1 April, 1867*, *Vol. 2*. Singapore: Fraser & Neave Limited.

Bulley, A. 2013. *The Bombay Country Ships, 1790–1833*. New York: Routledge.

Burnell, A. and P. Tiele, eds. 1885. *The Voyage of John Huyghen van Linschoten to the East Indies*, *from the Old English Translation of 1598. Vol. 1*. London: Hakluyt Society.

Burningham, N. 2007. *Baghla, Ghanja* and *Kotia*: Distinguishing the *Baghla* from the Suri *Ghanja* and the Indian *Kotia*. *The International Journal of Nautical Archaeology* 36(1):91–111.

Castro, F., C. Bendig, M. Bérubé, R. Borrero, N. Budsberg, C. Dostal, A. Monteiro, C. Smith, R. Torres, and K. Yamafune. 2018. Recording, publishing, and reconstructing wooden shipwrecks. *Journal of Maritime Archaeology* 2018(13):55–66.https://doi.org/10.1007/s11457-017-9185-8.

Ciarlo, N. 2013. Naval metals from mid 18th- to early 19th-century European shipwrecks: a first analytical approach. *Historical Metallurgy* 47(2): 146–152.

Ciarlo, N.C. and A. Argüeso. 2019. Archaeometric and Archeometallurgical on historical shipwrecks: Research experiences in Argentina. *Journal of Maritime Archaeology* 2019(14):127–150. https://doi.org/10.1007/s11457-018-9203-5.

Coates, W. H. 1911. *Old Country Trade*. London: Imray, Laurie, Norie & Wilson Ltd.

Cotton, E. 1949. *East Indiamen: The East India Company's Maritime Service*. London: Batchworth Press.

Creasman, P. P. 2010. Extracting cultural information from ship timber. PhD thesis, Department of Anthropology, Texas A&M University, College Station.

Davis, R. 2012. *The Rise of the English Shipping Industry in the Seventeenth andEighteenth Centuries*. Newfoundland: International Maritime Economic History Association.

Desmond, C. 1919. *Wooden Ship-Building*. New York: Vestal Press Ltd.

Eerkens, J.W. and C.P. Lipo. 2007. Cultural transmission theory and the archaeological record: providing context to understanding variation and temporal changes in material culture. *Journal of Archaeological Research* 15(3):239–274.

Fenwick, V. 2015. A cognitive approach to extant boat structure in Goa, India. *The International Journal of Nautical Archaeology* 44(2):388–409.

Fernando, M.R. 2015. Continuity and Change in Maritime Trade in the Straits of Melaka in the Seventeenth and Eighteenth Centuries. In *Trade, Circulation and Flow in the Indian Ocean World*, edited by M. Pearson, 109–128. New York: Palgrave Macmillan US.

Fitzhugh, W.W., A. Herzog, S. Perdikaris, and B. McLeod. 2011. Ship to Shore: Inuit, Early Europeans, and Maritime Landscapes. In *The archaeology of maritime landscapes*, edited by B. Ford, 99–128. New York: Springer.

Flecker, M. 2022a. The wreck of the *Shah Muncher* (1796) Singapore: preliminary report. *Temasek Working Paper Series 3*. Singapore: ISEAS – Yusof Ishak Institute. Retrieved 17 June 2022 from < https://www.iseas.edu.sg/wp-content/uploads/2022/01/Flecker_TWPS03-_Final-FINAL-revised-28Jan2022.pdf>

Flecker, M. 2022b. The Temasek wreck (mid-14th century) Singapore*:* preliminary report. *Temasek Working Paper Series 4*. Singapore: ISEAS – Yusof Ishak Institute. Retrieved 17 June 2022 from <https://www.iseas.edu.sg/wp-content/uploads/2022/03/Flecker_TWPS04_Final_r.pdf>

Frederick H.H. and C.D. Beeker. 2016. The wreck of the *Quedagh Merchant*. In *Pieces of Eight: More Archaeology of Piracy*, edited by C.R. Ewen and R.K. Skowronek, 10–131. Florida: University Press of Florida.

Gawronski, J. 1991. The Archaeological and Historical Research of the Dutch East Indiaman Amsterdam (1749). In *Carvel Construction Technique, Oxbow Monograph 12*, edited by R. Reinders and K. Paul, 81–84. Oxford: Oxbow Books.

Gilchrist, J.B. 1825. *The General East India Guide and Vade Mecum*. London. Retrieved 28 May 2022 from <http://www.columbia.edu/itc/mealac/pritchett/00generallinks/gilchrist/index.html>

Goddio, F. and E. J. Guyot de Saint Michel. 1999. *Griffin: on the route of an Indiaman*. London: Periplus.

Gould, R. 2011. *Archaeology and the Social History of Ships*. Cambridge: Cambridge University Press.

Grattan, D.W. and R. W. Clarke. 1987. Conservation of waterlogged wood. In *Conservation of Marine Archaeological Objects*, edited by C. Pearson, 164 – 167. London: Butterworths.

Hamilton, D.L. 1999. Conservation of Cultural Materials from Underwater Sites. *Archives and Museum Informatics* 13:291–323. https://doi.org/10.1023/A:1012420510516.

Hanselmann, F.H. 2016. The wreck of the *Quedagh Merchant*: analysis, interpretation and management of Captain Kidd's lost ship. PhD thesis, Department of Anthropology, Indiana University, Indiana.

Hay, W.J. 1863. On copper and other sheathing for the Navy. *Proceedings of the Institution of Naval Architects* 4:79–98.

Herivel, J-M. 2020. 'A Perfect Malay': James Scott, East Indies Country Trader. PhD thesis, College of Indigenous Futures, Arts and Society, Charles Darwin University, Darwin.

Horsburgh, J. 1811. *Directions for sailing to and from the East Indies, China, New Holland, Cape of Good Hope, and the interjacent ports, etc*. *Vol. 2.* Cambridge: Cambridge University Press.

Hocker, F. M. 2004. Chapter One: Shipbuilding: Philosophy, Practice and Research. In *The philosophy of shipbuilding: conceptual approaches to the study of wooden ships*, edited C. A. Ward and F. M. Hocker, 1–12. College Station: Texas A&M University Press.

Hocker, F. M. 2013. In details remembered: Interpreting the human component in shipbuilding. In *Interpreting Shipwrecks: Maritime Archaeological Approaches Södertörn Academic Studies 56*, edited by J. Adams and J. Rönnby, 72–

84. Southampton: Highfield Press.

Historic England. 2010. *Waterlogged wood: guidelines on the recording, sampling, conservation and curation of waterlogged wood*. Retrieved 29 March 2021.

<https://historicengland.org.uk/images-books/publications/waterlogged-wood/waterlogged-wood/>.

Jaffer, A. 2015. *Lascars and Indian Ocean Seafaring, 1780–1860*. Suffolk: The Boydell Press.

Jayakumar, S. and T. Koh. 2009. *Pedra Branca: The Road to the World Court*. Singapore: NUS Press.

Kim H., S. Yang, M. Cha, Y. Yoon, G. Lee, S. Lim and S.Kim. 2013. Conservation manual of maritime archaeological objects in Korea. South Korea: National Research Institute of Maritime Cultural Heritage.

Kochhar, R. 2016. Shipbuilding in India: Wadia shipbuilders. In *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by H. Selin, 1–5. Dordrecht: Springer. https://doi.org/10.1007/978-94-007-7747-7_8927.

Kwa, C.G. 2004a. Sailing past Singapore. In *Early Singapore, 1300s–1819: evidence in maps, text and artefacts*, edited by J.N. Miksic, C.M.G. Low and Singapore History Museum, 95–105. Singapore: Singapore History Museum.

Kwa C.G. 2012. Locating Singapore on the Maritime Silk Road: Evidence from Maritime Archaeology, Ninth to Early Nineteenth Centuries. *Nalanda-Sriwijaya Centre Working Paper No.10.* Singapore: ISEAS – Yusof Ishak Institute.

Kwa C.G. 2016. The Maritime Silk Road: History of an Idea. *Nalanda-Sriwijaya Centre Working Paper No.23.* Singapore: ISEAS – Yusof Ishak Institute.

Kwa, C.G., D. Heng, P. Borschberg and T.Y. Tan. 2019. *Seven Hundred Years: A History of Singapore.* Singapore: National Library Board, Singapore.

Langdon, M. 2019. The journals of William Scott, 1794–1805. *Journal of the Malaysian Branch of the Royal Asiatic Society* 92(2):99–135.

Lawrence, S. 1998. The role of material culture in Australasian Archaeology. *Australasian Journal Historical Archaeology* 16(1998):8–15.

Lennon, W. C. 1881. Journal of a voyage through the Straits of Malacca on an expedition to the Molucca Islands under the Command of Admiral Rainier, etc. *Journal of the Straits Branch of the Royal Asiatic Society* 7:51–74.

Lester, S. 1982. The rudder of the *Sydney Cove* (1797): reassembly, construction and assessment of importance. *The Bulletin of the Australian Institute for Maritime Archaeology* 6(2):19–31.

Lev-Yadun, S. 2007. Wood remains from archaeological excavations: a review with a Near Eastern Perspective. *Israel Journal of Earth Sciences* 56:139–162.

Low, C.M.G. 2004. Singapore from the 14th to the 19th century. In *Early Singapore, 1300s–1819: Evidence in Maps, Text and Artefacts*, edited by J.N. Miksic, C.M.G. Low and Singapore History Museum, 14–40. Singapore: Singapore History Museum.

Lusardi, W. R. 2011. Rock, Paper, Shipwreck! The Maritime Cultural Landscape of Thunder Bay. In *The archaeology of maritime landscapes*, edited by B. Ford, 81–98. New York: Springer.

Machado, P. 2014. *Ocean of Trade: South Asian Merchants, Africa and the Indian Ocean c.1750–1850*. Cambridge: Cambridge University Press.

Macleod, I. 1994. Conservation of corroded metals - A study of ships' fastenings from the wreck of HMS *Sirius*. *Ancient and Historic Metals Conservation and Scientific Research*:265–278.

May, S.R. 1986. The potential resource of India-built vessels wrecked in Queensland. *Bulletin of the Australian Institute for Maritime Archaeology* 12(2):17–21.

Marquardt, K.H. 2003. *The Global Schooner: Origins, Development, Design and Construction 1695–1845*. Annapolis: Naval Institute Press.

McCarthy, M. 2005. *Ships' Fastenings from Sewn Boat to Steamship*. College Station: Texas A & M University Press.

Miksic, J. N. 2013. *Singapore and the Silk Road of the Sea, 1300–1800*. Singapore: NUS Press.

Miller, W.G. 2011. English Country Traders and Their Relations with Malay Rulers in the Late Eighteenth Century. *Journal of the Malaysian Branch of the Royal Asiatic Society* 84(1(300):23–45.

Miller, W.G. and A.G. Smith. 2020. European wives and local concubines: women on board English Country trader vessels in the Malay Archipelago and beyond, from the 1770s to the 1830s, with some reference to life on board other contemporary sailing vessels. *International Journal of Maritime History* 32(3):596–615.

Money, W. T. 1811. *Expediency of ship-building at Bombay*. London: Longman, Hurst, Rees, Orme, & Browne.

Muckelroy, K.1978. *Maritime Archaeology*. Cambridge, New York: Cambridge University Press.

Nash, M. 1992. The *Sydney Cove* historic shipwreck (1797). *Australian Sea Heritage* 32:11–13.

Nash, M. 2002. The *Sydney Cove* shipwreck project. *The International Journal of Nautical Archaeology* 31(1):39–59.

Newsome, L. A. and R. B. Miller. 2009. Wood species analysis of ship timbers and wooden items recovered from Shipwreck 31CR314, *Queen Anne's Revenge* site. In *Queen Anne's Revenge* shipwreck project, research report and bulletin series QAR-R-09-01.

Pomey, P. 2011. Defining a Ship: Architecture, Function, and Human Space. In *The Oxford Handbook of Maritime Archaeology* 1st ed., edited by B. Ford, D.L. Hamilton, and A. Catsambis, 1–22. Oxford: Oxford University Press.

Phipps, J. 1840. *A Collection of Papers Relevant to Ship Building in India*, *etc.* Calcutta: Printed by Scott and Co.

Ranganathan, M. 2019. Mohammad Ali Rogay: Life and Times of a Bombay Country Trader. In *Bombay Before Mumbai: Essays in Honour of Jim Masselos*, edited by P. Kidambi, M. Kamat, and R. Dwyer, 15–33. New York: Oxford University Press.

Richards, N. 2006. Thematic studies in Australian maritime archaeology. In *Maritime Archaeology: Australian Approaches*, edited by M. Staniforth and M. Nash, 41–54. New York: Springer US.

Robinson, W. S. 1998. *First aid for underwater finds*. London: Archetype Books and the Nautical Archaeology Society in association with the National Maritime Museum.

Rönnby, J. 2013. The archaeological interpretation of shipwrecks. In *Interpreting Shipwrecks: Maritime Archaeological Approaches Södertörn Academic Studies 56*, edited by J. Adams and J. Rönnby, 9–24. Southampton: Highfield Press.

Sjostrand, S. and C. Barnes. 2001. The 'Turiang': a fourteenth-century Chinese shipwreck upsetting Southeast Asian ceramic history. *Journal of the Malaysian Branch of the Royal Asiatic Society*. 74 (1 (280):71–109.

Staniforth, M. 1985. The introduction and use of copper sheathing—A history. *The Bulletin of the Australian Institute for Maritime Archaeology* 9(1/2):21–48.

Staniforth, M., and M. Nash. 1998. *Chinese Export Porcelain from the Wreck of the* Sydney Cove *(1797)*. Special publication of the Australian Institute for Maritime Archaeology. Adelaide: Brolga Press.

Steffy, J.R. 1994. *Wooden Shipbuilding and the Interpretation of Shipwrecks*. College Station: Texas A&M University Press.

Strachan, S.M. 1986. Indian and Southeast Asian shipbuilding for the European market: a survey 1790–1815. *The Bulletin of the Australian Institute for Maritime Archaeology* 10(2):13–16.

Stavorinus, John S. 1798. *Voyages to the East-Indies, Vol. III*. London: G. G. and J. Robinson/Pater-Noster-Row.

The National Museum of the Royal Navy: HMS *Trincomale*e. 2017. 3D model of HMS *Trincomalee* hosted on Matterport. United Kingdom: National Museum of the Royal Navy and California: Matterport. Retrieved 1 July 2022 from < https://matterport.com/discover/space/4frhx6zLinZ>.

Tripati, S., M. Sujatha, R. Vijendra Rao and K. Satyanarayana Rao. 2005. Use of timber in shipbuilding industry: Identification and analysis of timber from shipwrecks off Goa coast, India. *Current Science* (89)6:1022–1027.

Tripati, S., S. R. Shukla, S. Shashikala and A. Sardar. 2016. Role of teak and other hardwoods in shipbuilding as evidenced from literature and shipwrecks. *Current Science* (111)7:1262–1268.

Van Doorninck, Jr., F.H. 1982. III: The hull remains. In *Yassı Ada: Volume 1: A Seventh-Century Byzantine Shipwreck*, edited by G.F. Bass and F.H. van Doorninck, Jr., 32-64. College Station: Texas A&M University.

Van Duivenvoorde, W. 2012. Chapter 34: Use of Pine Sheathing on Dutch East India Company Ships. In *Between Continents: Proceedings of the twelfth International Symposium on Boat and Ship Archaeology, Istanbul 2009*, ISBSA 12, edited by N. Günsenin, 241–251. Istanbul: Ege Yayinlari.

Van Duivenvoorde, W. 2014. The 5th-Century BC Shipwreck at Tektas Burnu, Turkey: evidence for the ship's hull from nail concretions. *International Journal of Nautical Archaeology* 43(1):10–26. DOI: 10.1111/1095-9270.12035

Van Duivenvoorde, W. 2022a. Report on the results of the semi-quantitative elemental analysis of the *Buffalo* ship metal samples. Unpublished report prepared for Flinders University.

Van Duivenvoorde, W. 2022b. Report on the results of the semi-quantitative elemental analysis of the *Edwin Fox* ship metal samples. Unpublished report prepared for Flinders University.

Van Duivenvoorde, W., L. Davison, M.E. Polzer, M. de Ruyter, K. Bennett, D. Nutley and P. Waterson. 2023, in press. Wrecked all over the place: the identification of disarticulated context-free ship remains from the Gold Coast in Queensland, Australia. *Historical Archaeology* 57(1). Thematic issue ‘Contextualizing Maritime Archaeology in Australia’, edited by M. de Ruyter and W. van Duivenvoorde.

Vernon Cornelius, T. 2013. *Pedra Branca*. National Library Board, Singapore. Retrieved 26 May 2022 from <https://eresources.nlb.gov.sg/infopedia/articles/SIP_722_2005-01-20.html>.

Viduka, A. and S. Ness. 2004. Analysis of some copper-alloy items from HMAV *Bounty* wrecked at Pitcairn Island in 1790. In *Metal 04*, edited by J. Ashton and D. Hallam,160–172. Canberra: National Museum of Australia.

Westerdahl, Christer. 1992. The maritime cultural landscape. *International Journal of Nautical Archaeology* 21(1): 5–14.

Westerdahl, C. 2011. The Maritime Cultural Landscape. In *The Oxford Handbook ofMaritime Archaeology* 1st ed., edited by B. Ford, D.L. Hamilton, and A. Catsambis,1–32. Oxford: Oxford University Press.

Wadia, R. A. 1957. *Bombay Dockyard and the Wadia Master Builders*. New Delhi: Archaeological Survey of India.

Watson, P. J. 1983. Method and Theory in Shipwreck Anthropology. In *Shipwreck Anthropology*, edited by R. Gould, 23–36. Albuquerque: University of New Mexico.

Wilson, N. F. J. 1909. *The Native Craft*. Bombay Port Trust, Bombay.

Wyn, D. and M. Mudie. 2015. *HMS* Trincomalee*: 1817, Frigate*. Great Britain: Seaforth Publishing.

Zeeshan A. S., S. Tripati and V. Shinde. 2012. A study of the sewn-plank boats of Goa, India. *The International Journal of Nautical Archaeology* 41(1):148–157

APPENDIX 1: TIMBER ARTEFACTS CATALOGUE

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D11-B117-900
DATE:	**CATALOGUER:**		**FUNCTION:**
16 Nov 2021	Michael Ng		Graving Piece
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good as all sides are complete. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	585		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	125		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	30		*Uncertain* ☒

JOINERY:

Nil.

FASTENINGS:

No extant fastening.

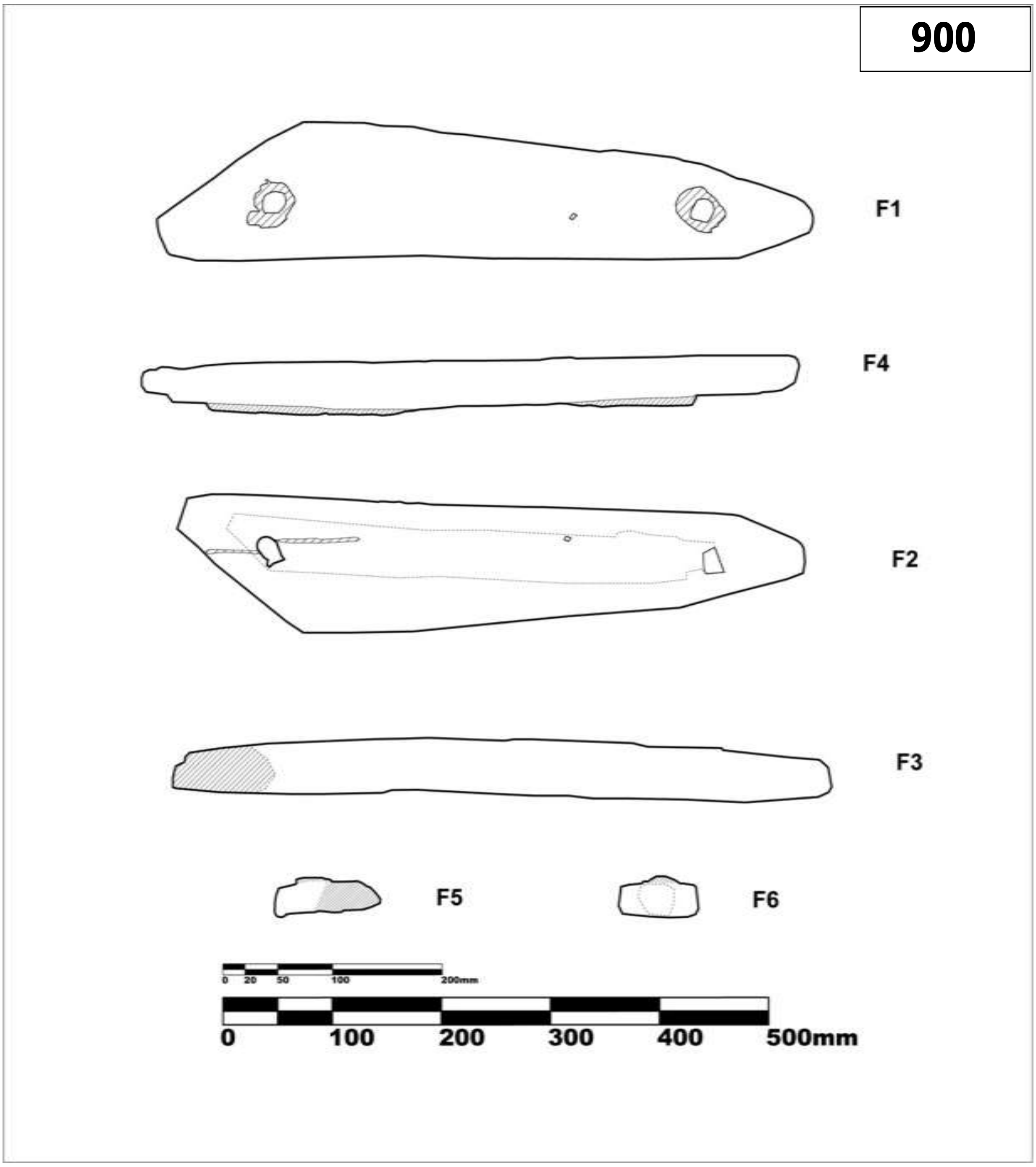
MARKS AND COATINGS:

3 fastening holes
2 types of fastening hole.
21mm x 28mm, Diameter 33mm; 17mm x 18mm, Diameter 42mm – Square hole, circular impression.
3mm x 5mm – Square hole
Horizontal spacing between large holes = 84mm

COMMENTS:

The timber has a trapezoidal shape have two holes which extends through the timber. There are two holes observed on the timber which extends from Face 1 to Face 2. The holes on Face 1 have a square hole in the middle of a circular depression. Holes on Face 2 are square. A smaller square hole was observed on both Face 1 and Face 2. On Face 1, the smaller square hole seemed to have some form of encrustations acircular its edge.


900
F1
F4
F2
F3
F5
F6
0 20 50 100 200mm
0 100 200 300 400 500mm


900
F1
F4
F2
F3
F5
F6
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**		**REGISTRATION NO:** PB2-D10-B116-901 PB2-D10-B116-903
DATE:	**CATALOGUER:**	**FUNCTION:**
16 Nov 2021	Michael Ng	Plank

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
The timber condition is fair as all sides and surfaces seemed to be worn down and there is one broken end. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	810 (901) 325(903)		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	185 (901) 80(903)		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	26.7 (901) 25(903)		*Uncertain* ☒

JOINERY:

Nil.

FASTENINGS:

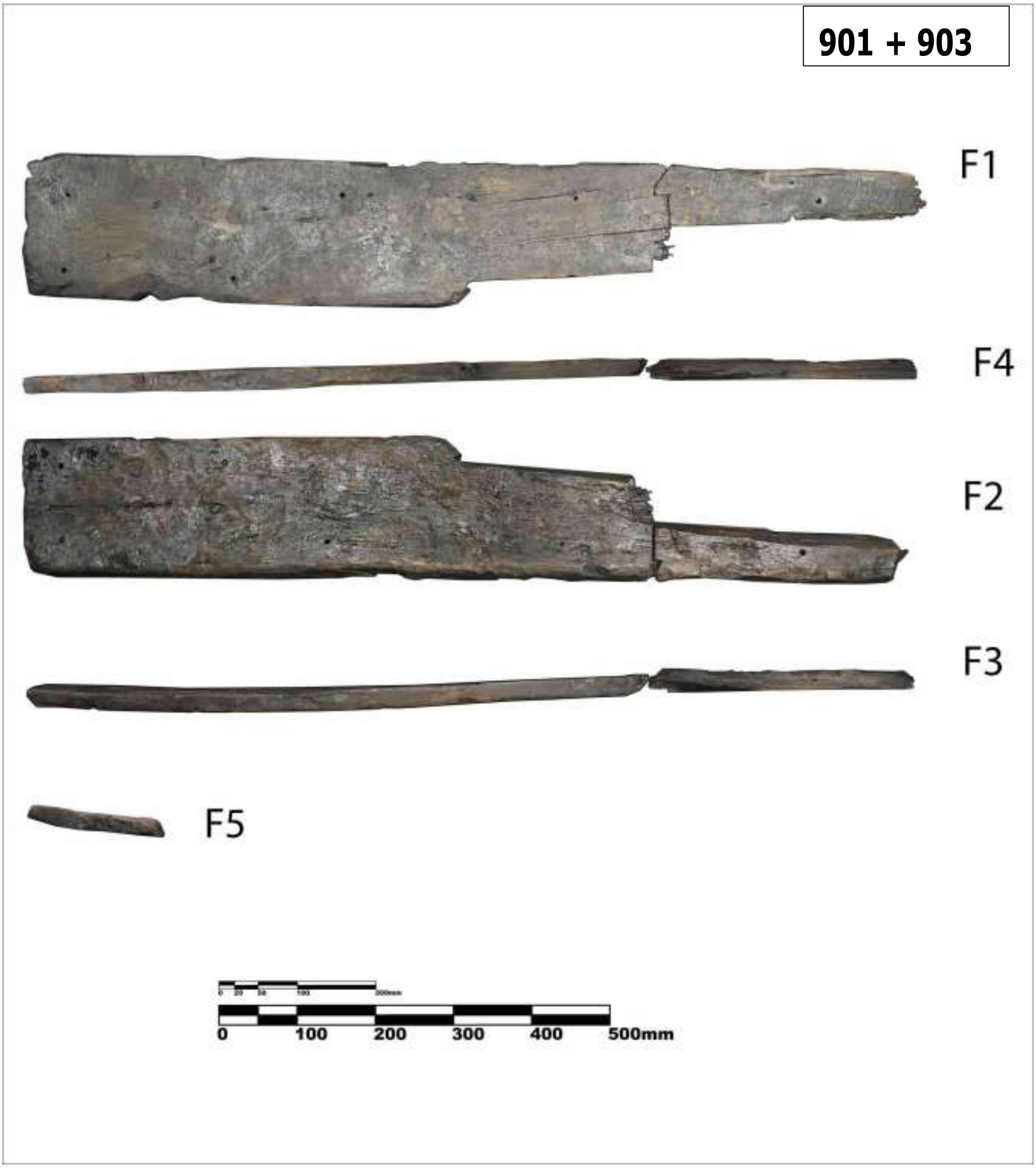
No extant fastening.

MARKS AND COATINGS:

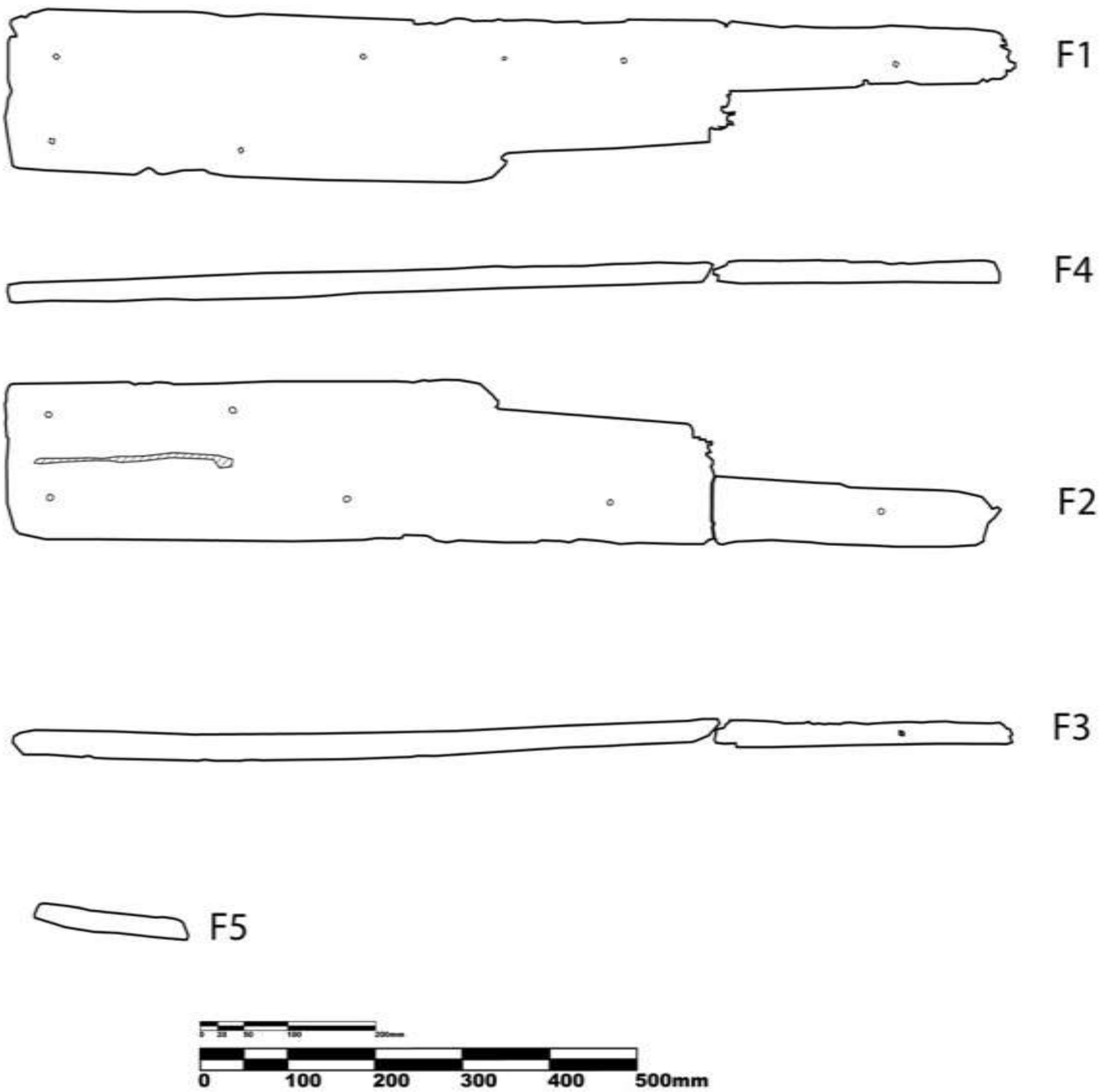
1 type of fastening hole.
5mm x 5mm – Square hole
6mm x 6mm – Square hole
Vertical spacing between square hole = 89.6mm
Horizontal spacing between square hole = 215mm, 300mm, 340mm

COMMENTS:

901 and 903 came from the same timber but it was broken to fit into the conservation tank. Six square holes were observed on Face 1 and the holes exit on Face 2. The holes on Face 2 are circular. There seemed to be a pattern in the spacing between the tacks as there is a horizontal and vertical alignment to their placements. 1 square fastening hole on 903.


901 + 903
F1
F4
F2
F3
F5
0
100
200
300
400
500mm

901 + 903



SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-D12-B134-904
DATE:	**CATALOGUER:**		**FUNCTION:**
16 Nov 2021	Michael Ng		?Structural timber
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
The timber condition is fair as all sides and surfaces seemed to be worn down and broken. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	680		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	130		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	80		*Uncertain* ☒

JOINERY:

Nil.

FASTENINGS:

2 extant fastening. Both treenails. Diameter 19mm.
Horizontal spacing between treenails = 140mm.

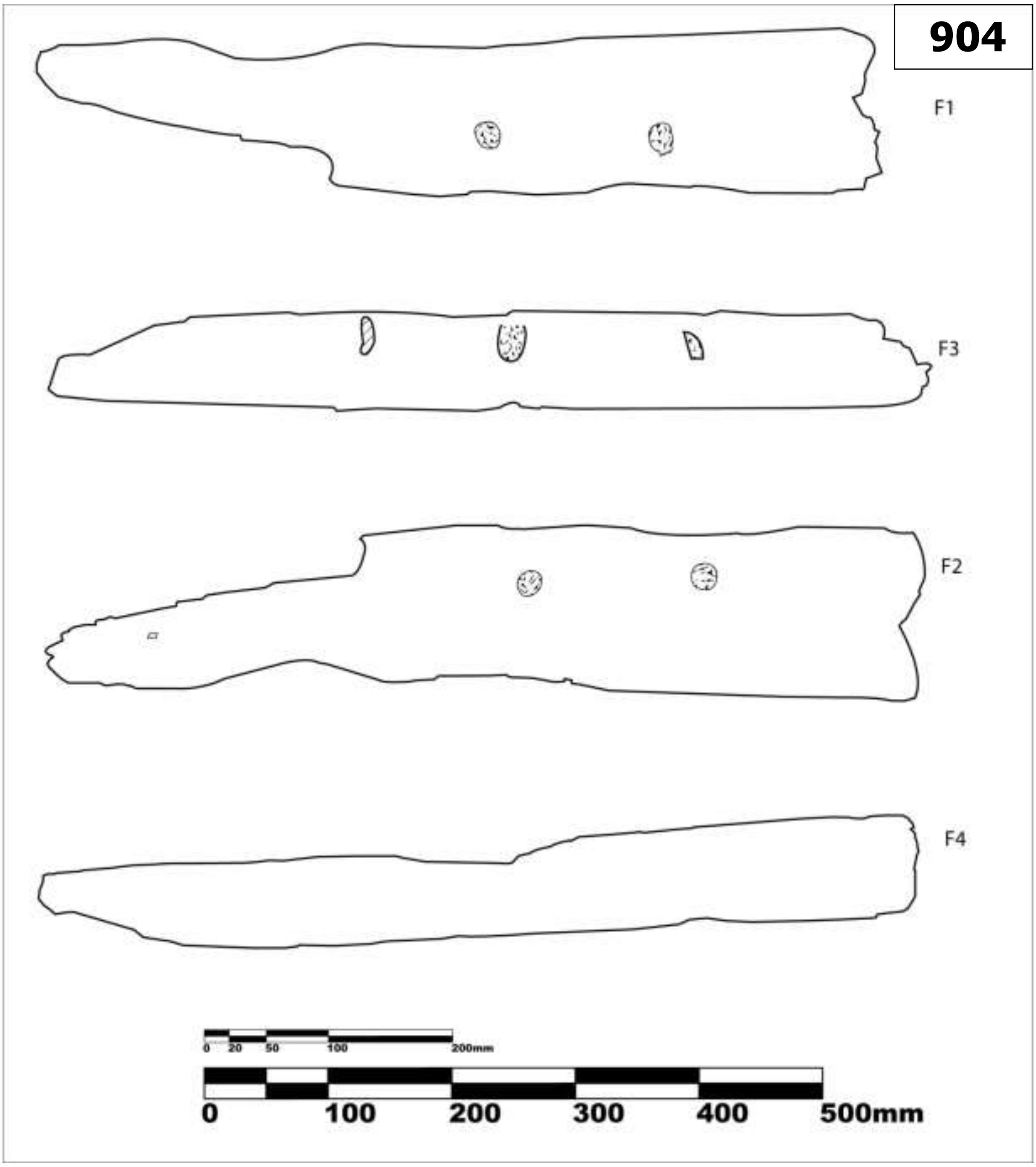
MARKS AND COATINGS:

4mm x 4mm – Square fastening hole

COMMENTS:

Timber exhibits broken edges on most of its profiles. Only one profile showed a straight flat profile. There are no obvious signs of carpentry or joinery. Two circular holes can be identified on the two sides of the timber, at the mid-section. Extant treenails can be found in both holes.

904


904
F1
F3
F2
F4
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B118-905 PB2-D9-B118-906
DATE:	**CATALOGUER:**		**FUNCTION:**
16 Nov 2021	Michael Ng		?Structural timber
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
The timber conditions were good with minimal signs of marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	802 (905) 500(906)			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	341 (905) 300(906)			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	81 (905) 78(906)			*Uncertain*	☒

JOINERY:

Box joint on 905.
Notch dimension = notch opening 7cm, depth of notch 8.5cm, thickness 8cm.

FASTENINGS:

2 extant fastening. Both treenails. Diameter 19mm.
Horizontal spacing between treenails = 140mm.

MARKS AND COATINGS:

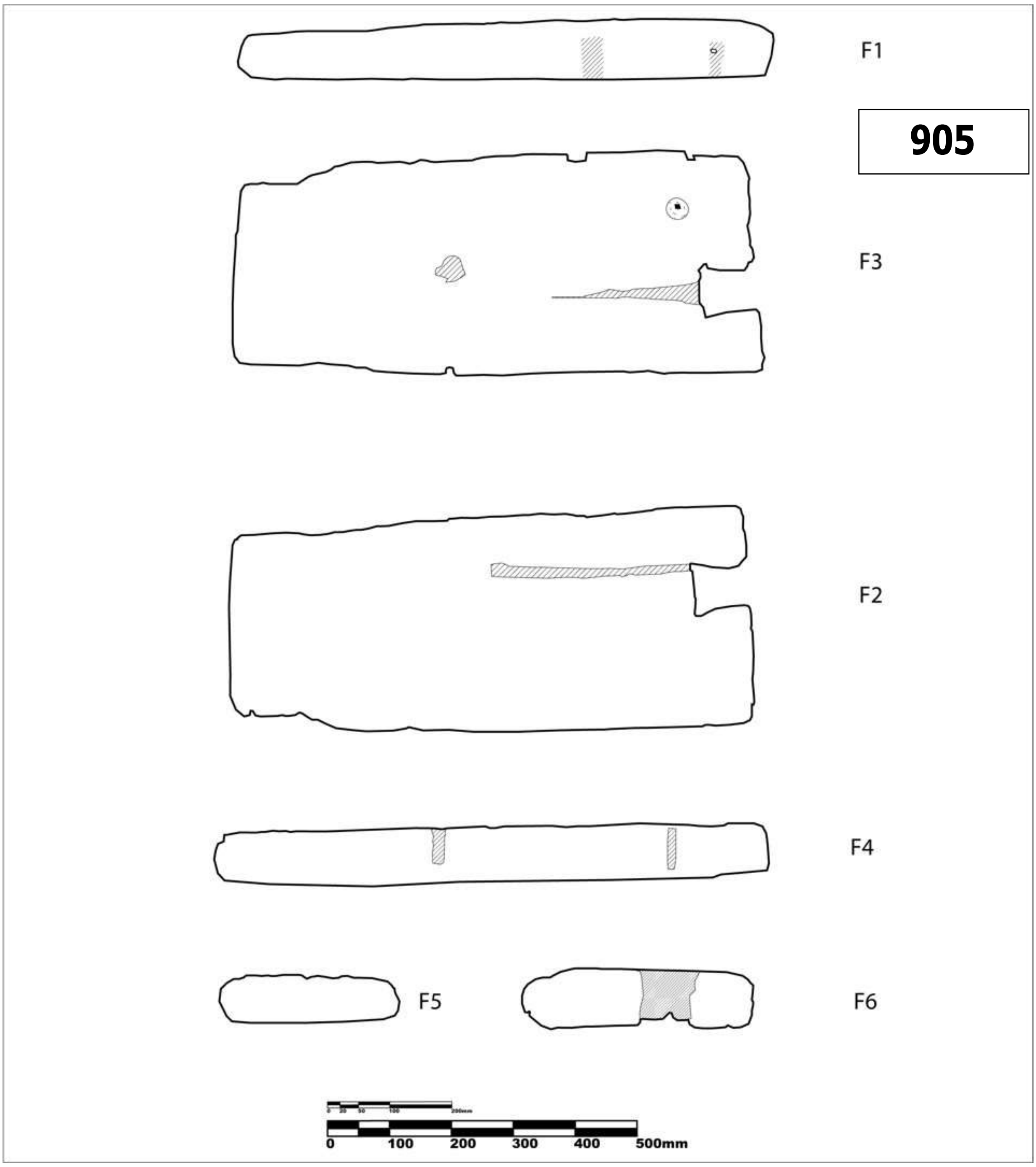
6mm x 6mm – Square fastening hole

COMMENTS:

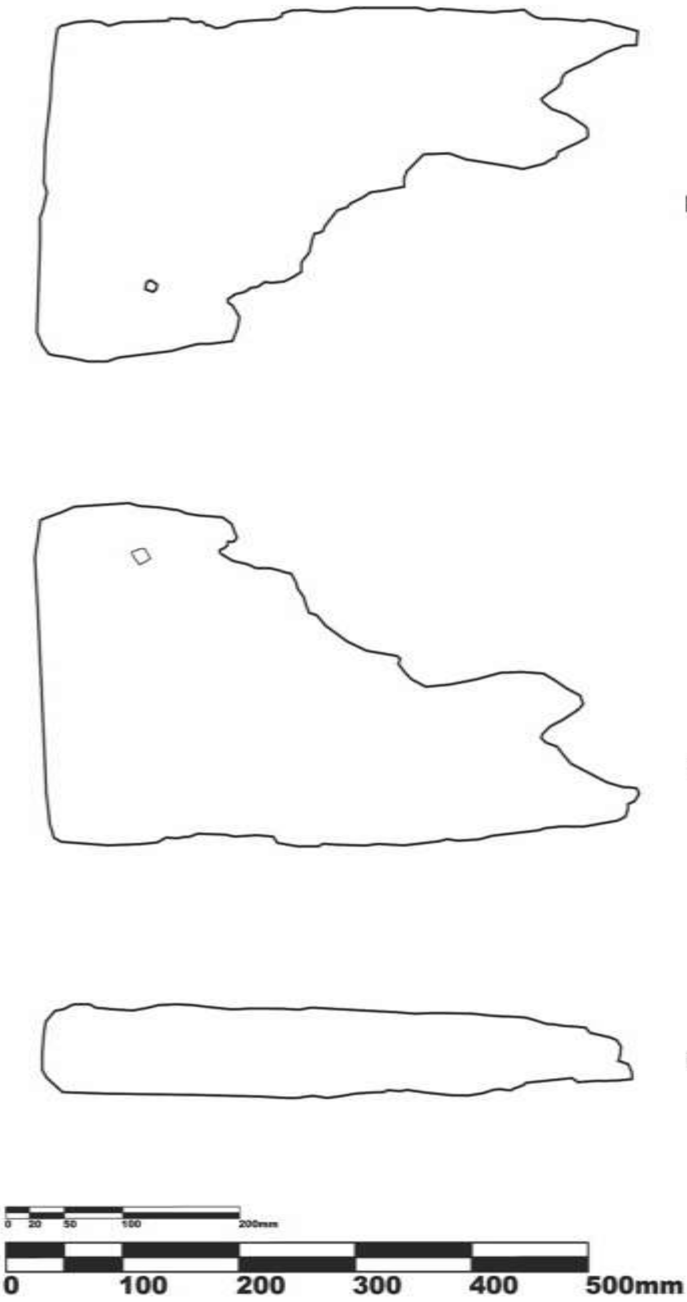
Sample 905 and 906 came from the same timber. Sample 906 has a distinct broken edge and a small square hole. The timber was cut to fit into the conservation tank. Sample 905 exhibited joinery and carpentry features. The ends of the plank has a box joint which is situated slightly off centre between the edges. One of the edges (Face 4) of the plank has two notches while the other edge (Face 1) exhibited one notch. The notches on Face 1 has a width of 27mm, 50mm long and 15mm deep. The notch on Face 4 has a width 16mm, 81mm long and a depth of 10mm. A smaller square hole surcirculared by a circular shape encrustation can also be found on Face 1. A timber sample was extracted from 906 to be analysed for its wood species.

905

906


F1
905
F3
F2
F4
F5
F6
0
100
200
300
400
500mm

906



F1

F2

F3

SHAH MUNCHER TIMBER RECORD		REGISTRATION NO: PB2-D9-B091-945	
DATE:	**CATALOGUER:**	**FUNCTION:**	
17 Nov 2021	Michael Ng	?Structural timber	
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	603		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	231		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	190		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

2 square extant fastening.
33mm x 32mm, 26mm x 29mm

MARKS AND COATINGS:

Nil

COMMENTS:

Encrustations with ceramic sherds can be found on Face 2. There is also a square depression which seem to have a squarish metal extant. The hole seemed to align with the hole on Face 4 which was observed to also have a similar squarish metal extant. Encrustation can also be observed on Face 4. Face 3 has a encrustation on its edge and an extant circular head tack with a diameter of 12mm. Face 3 also shows a knot on the timber.

945

F1

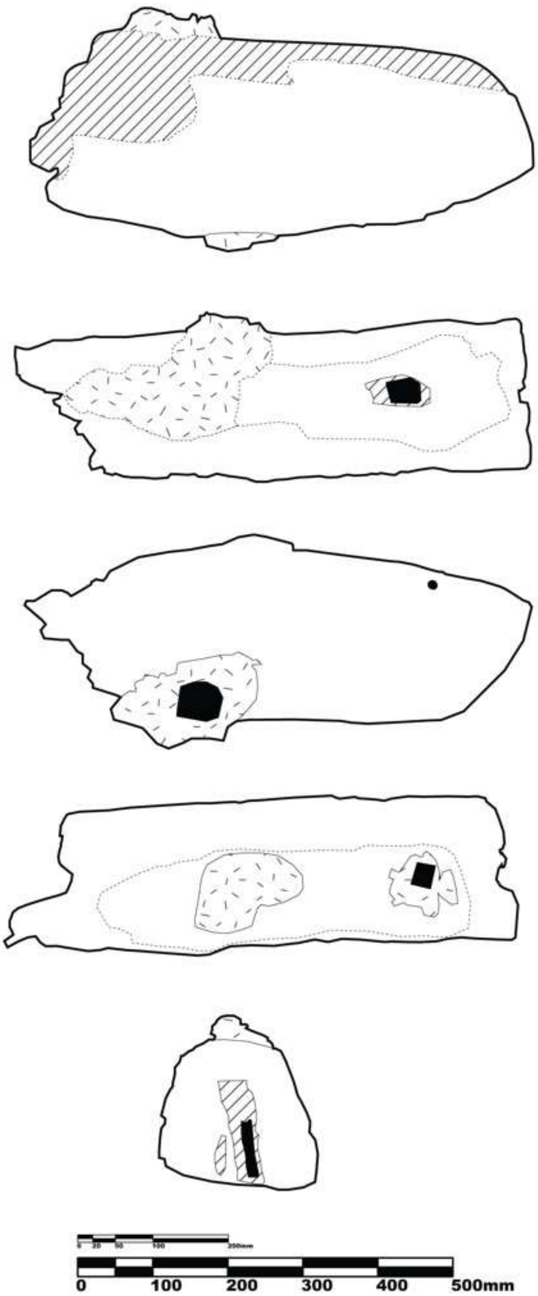
F2

F3

F4

F5

945



F1

F2

F3

F4

F5

SHAH MUNCHER TIMBER RECORD			**REGISTRATION NO:** PB2-E9-B091-949
DATE:	**CATALOGUER:**		**FUNCTION:**
17 Nov 2021	Michael Ng		?Hull Planking
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	597		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	150		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	115		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

MARKS AND COATINGS:

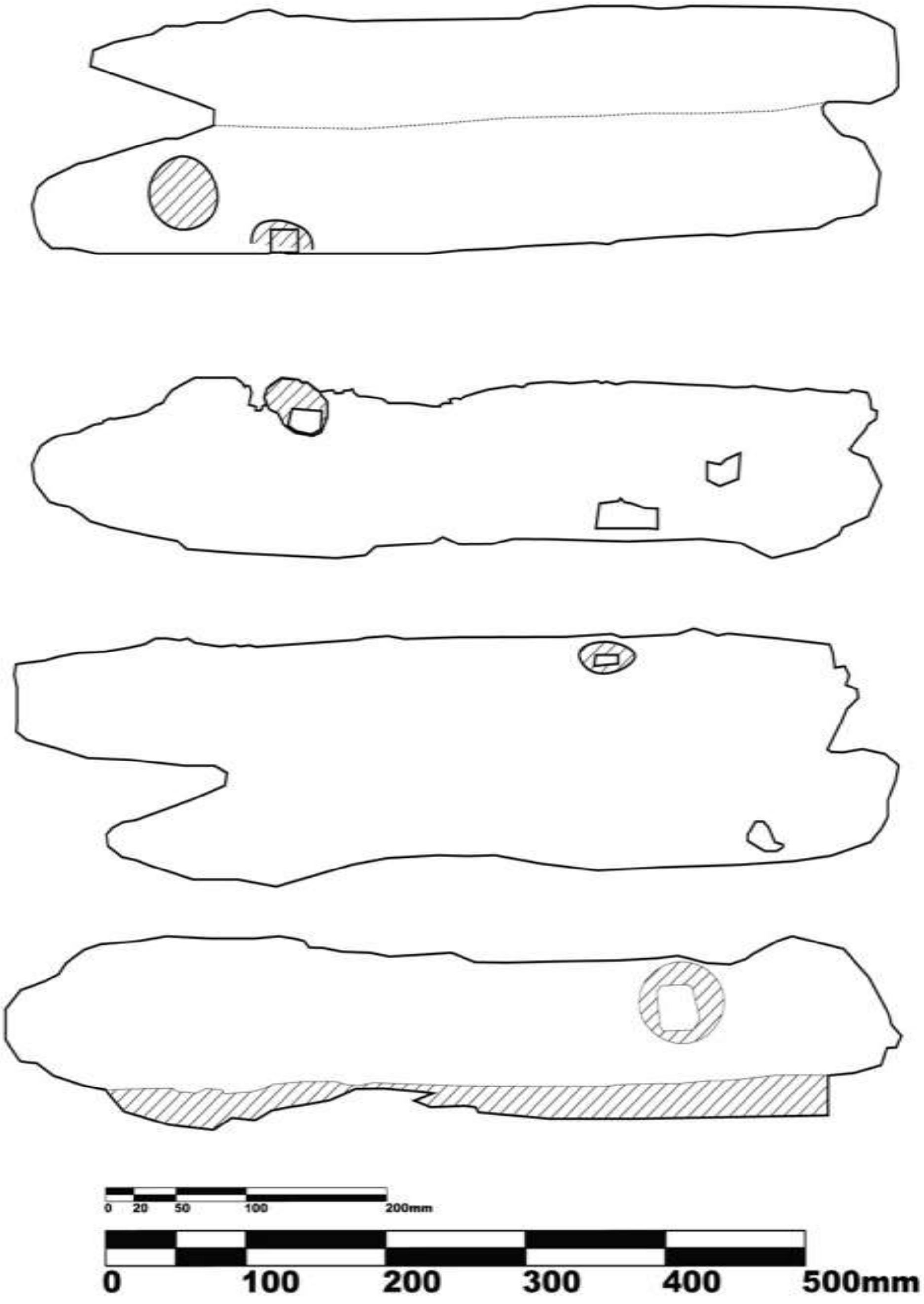
1 fastening hole. Square hole within circular impression. Square hole: 22mm x 21.6mm, Circular impression: 38.7mm Diameter

COMMENTS:

Face 1 has a two circular impression near one of the end of the timber. One of the impressions forms a complete circle on Face 1. There were encrustations observed within the circle while the other impression was a semi-circle impression with a square hole in its centre. No holes were observed on the other side of the timber (Face 2). On Face 4, a square hole with a circular depression was observed. The hole extends through the timber and exits on Face 3 maintaining a square shape. Two other holes were observed on Face 3, one of them is semi-circular while the other hole or notch is squarish. A timber sample was extracted to be analysed for its wood species.


949
F1
F2
F3
F4
0 20 50 100 200mm
0 100 200 300 400 500mm

949



SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-E9-B051-950
DATE:	**CATALOGUER:**		**FUNCTION:**
17 Nov 2021	Michael Ng		?Hull Planking
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	625			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	174			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	130			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

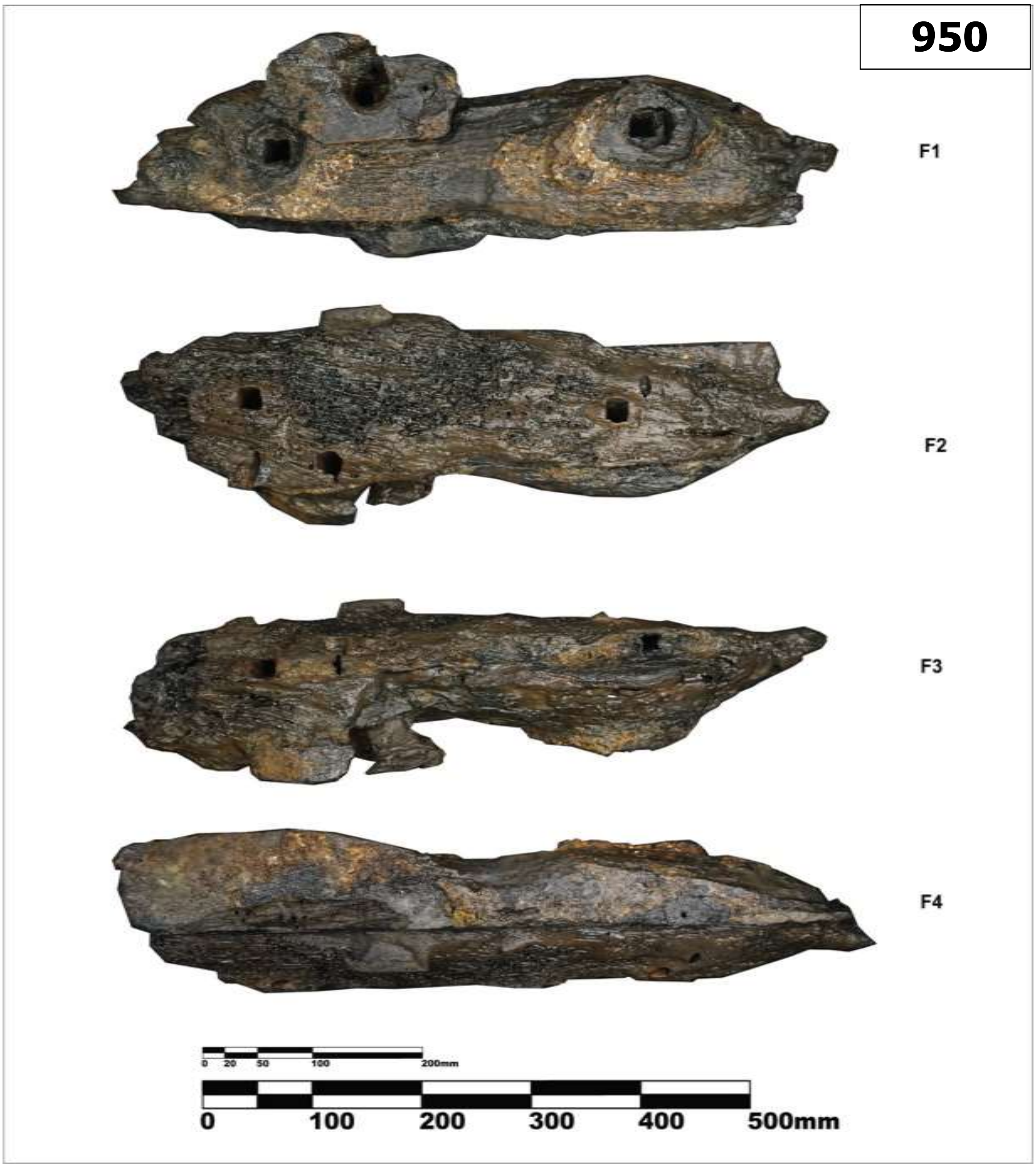
Nil

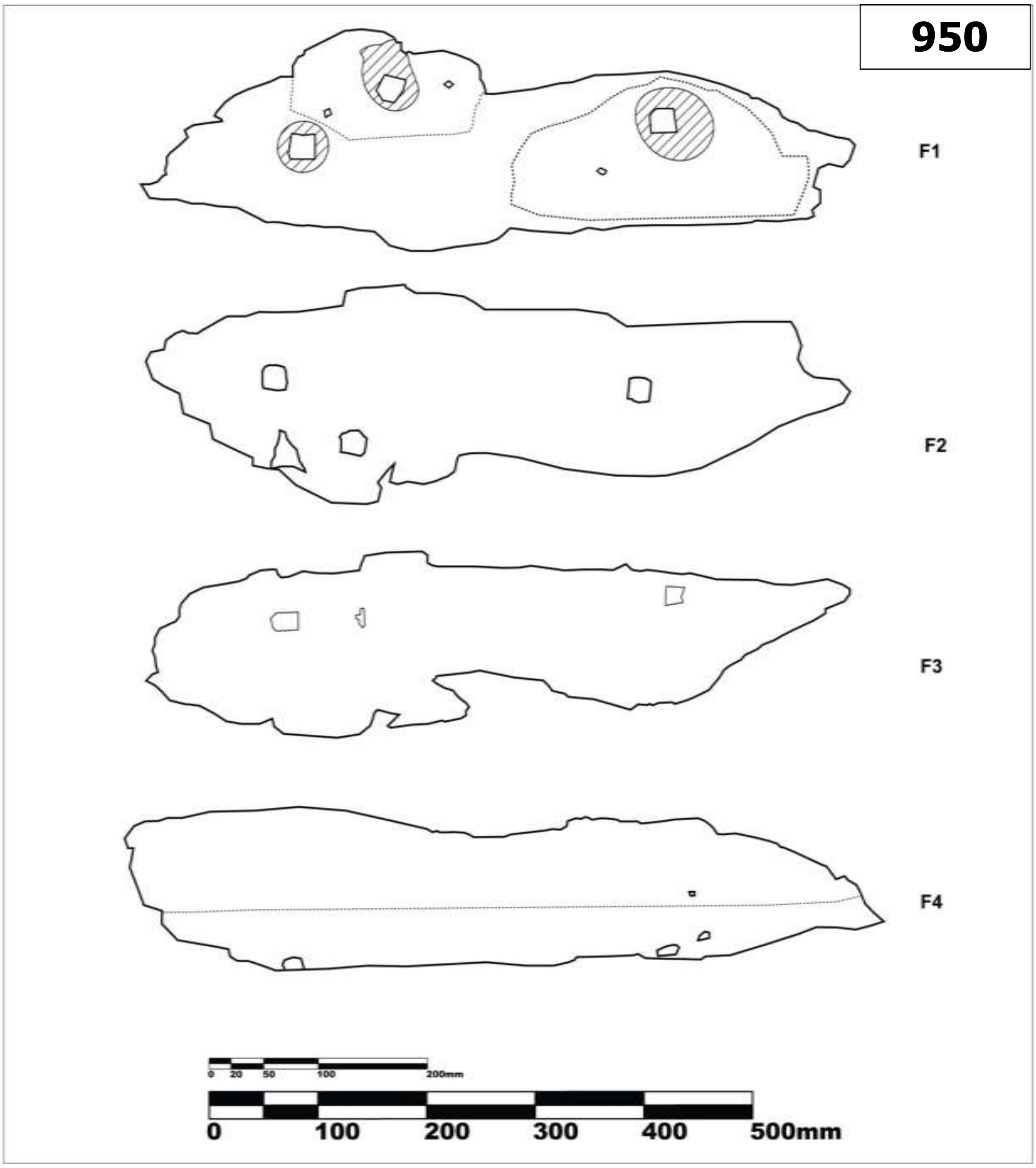
MARKS AND COATINGS:

2 types of fastening hole. Square hole within circular depression. 19.1mm x 18mm, 19.1mm x 18.2mm, 19.2mm x 18.8mm, Diameter: 49.5mm, 40.5mm, 48.5mm. Vertical Spacing: 31mm, Horizontal spacing: 293mm. Small square fastening holes: 5.7mm x 5.7mm, 4.3mm x 4.2mm, 4.2mm x 4.2mm.

COMMENTS:

Six holes were observed on Face 1. The larger holes have a square hole in the middle of a circular depression. Two of the holes were close to each other while the other hole was situated 290mm away. The other three holes were square and smaller in size. The three large holes extends through the timber and exit on Face 2 maintaining a square shape. Two other square holes 300mm apart can be found on Face 3.


950
F1
F2
F3
F4
0 20 50 100 200mm
0 100 200 300 400 500mm


950
F1
F2
F3
F4
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B067-953
DATE:	**CATALOGUER:**		**FUNCTION:**
17 Nov 2021	Michael Ng		Sacrificial Sheathing
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is fair as all sides seemed to be worn down and broken except for its surfaces and one of the edge. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	560		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	116		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	25.3		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

15 extant fastenings. Tack head diameter: 12.1mm, 13.8mm, 11.4mm, 8mm, 11.8mm, 13mm, 12.6mm, 6.4mm, 11mm, 7.9mm, 11mm,14.1mm, 9.2mm, 13mm, 11.2mm.

MARKS AND COATINGS:

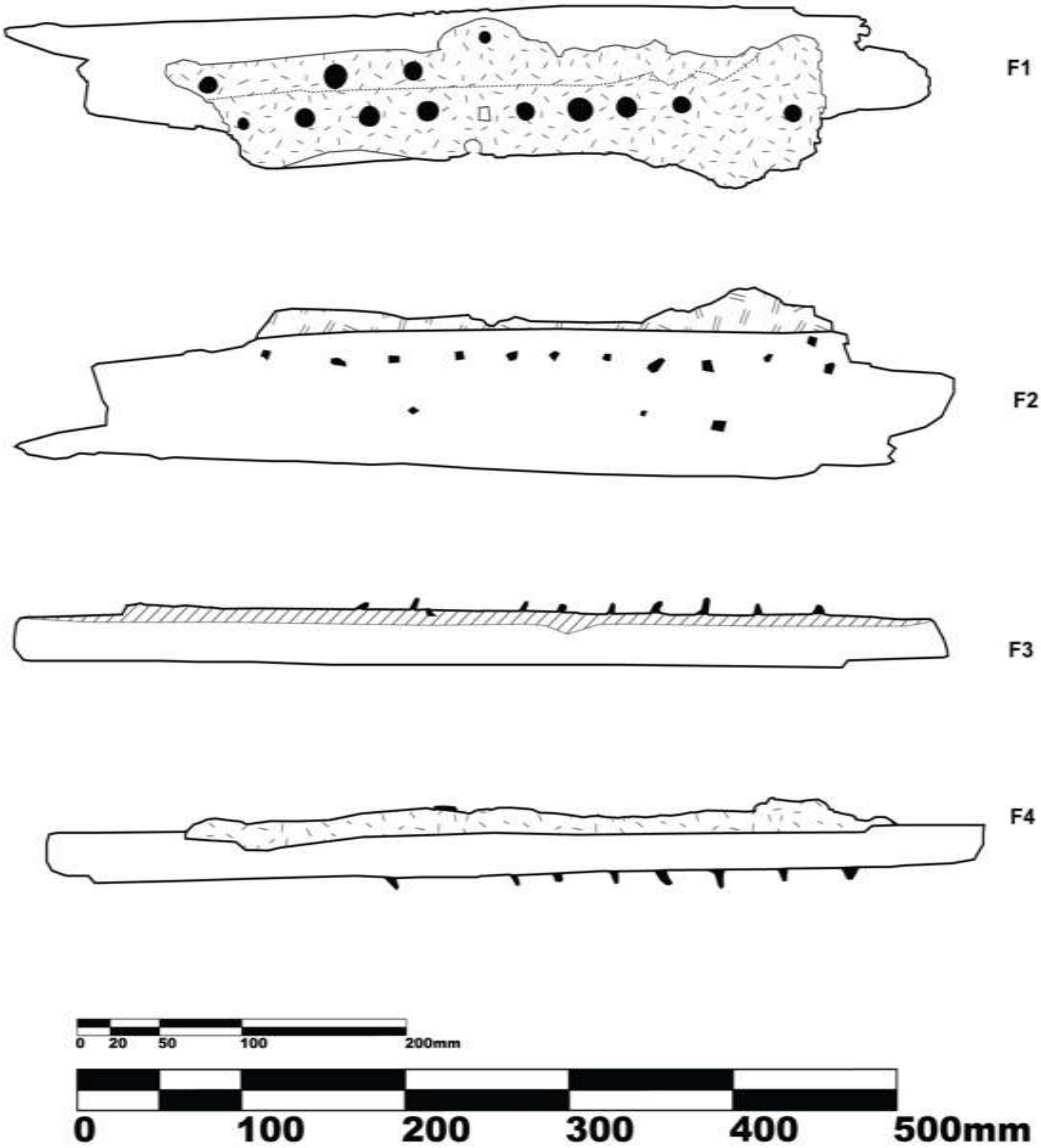
Vertical spacing: 26.4mm, Horizontal spacing: 77.6mm, 47.2mm, 36.8mm, 37mm, 35.1mm, 35mm, 25mm, 32.4mm, 28.2mm, 31mm, 70.9mm. Small square fastening hole: 6.1mm x 6.1mm.

COMMENTS:

The timber has metal sheathing and extant circular tacks. The metal sheathing seemed to exhibit two layers but it cannot be confirmed. Horizontal spacing between the tacks range between 28.2mm to 77.6mm. Vertical spacing is approximately 26.4mm.

953

953



***SHAH MUNCHER* TIMBER RECORD**		**REGISTRATION NO:** PB2-D9-B077-956
DATE:	**CATALOGUER:**	**FUNCTION:**
17 Nov 2021	Michael Ng	Sacrificial Sheathing

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber condition is fair as all sides seemed to be worn down and there are two broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	280			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	183			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	20 (29.3 with metal)			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

8 extant fastenings. Small square fastening dimension: 7mm x 7mm.

MARKS AND COATINGS:

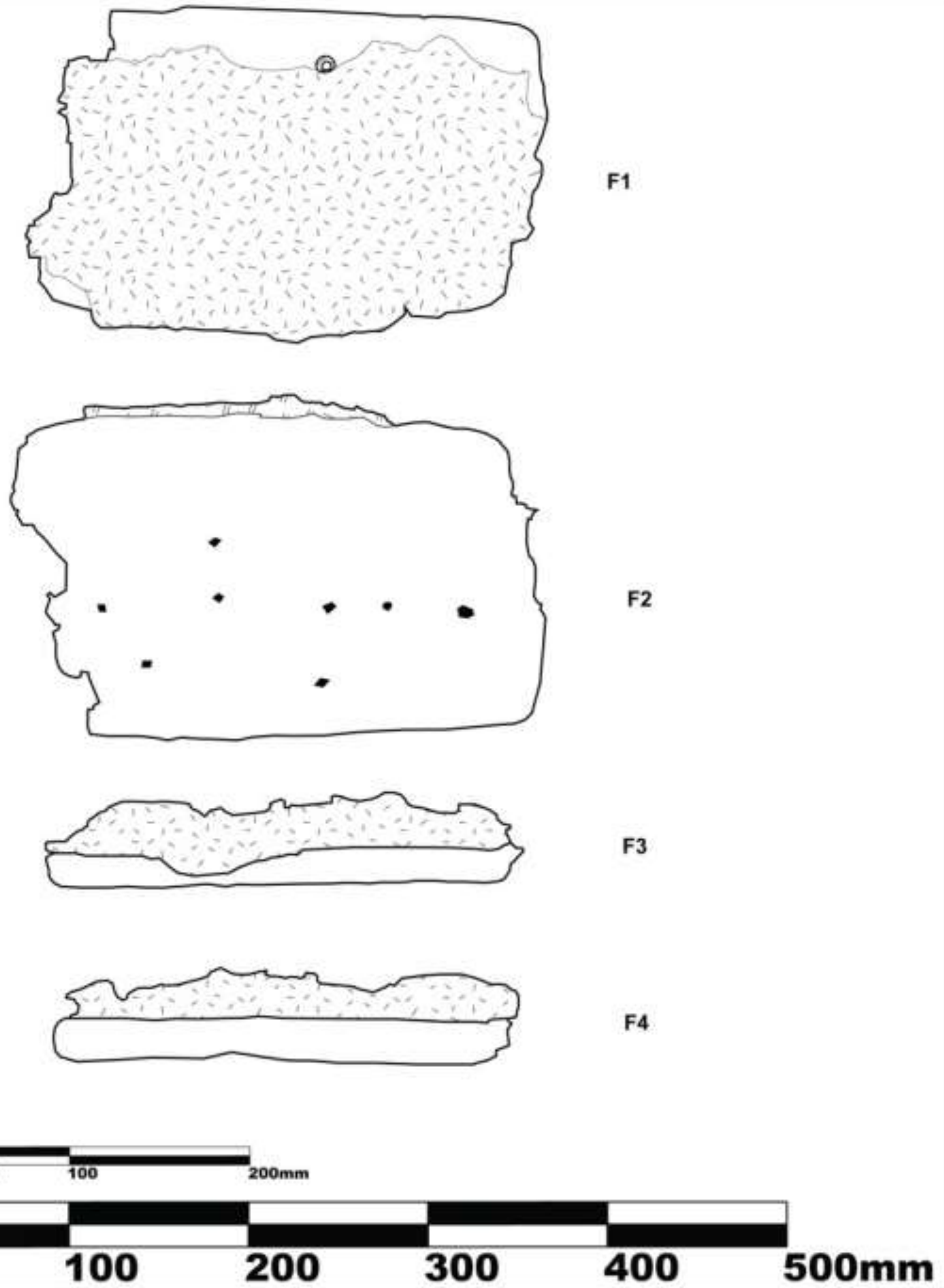
Vertical spacing: 31.2mm, 33.4mm Horizontal spacing: 56.9mm, 58.2mm, 29.2mm, 35mm, 37.9mm. Circular impression: 11mm.

COMMENTS:

There are metal sheathings on one of the timber's surface and eight headless extant tacks on the timber. The metal is heavily encrusted and a ceramic piece was found concreted on the encrustation. There seemed to be a pattern in the spacing between the tacks as there is a horizontal and vertical alignment to their placements

956

956



SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-E9-B052-963
DATE:	**CATALOGUER:**		**FUNCTION:**
18 Nov 2021	Michael Ng		Hull planking
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	530			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	155			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	150			*Uncertain*	☒

JOINERY:

The timber has a rabbet recess visible on Face 2 and 3.

FASTENINGS:

Nil

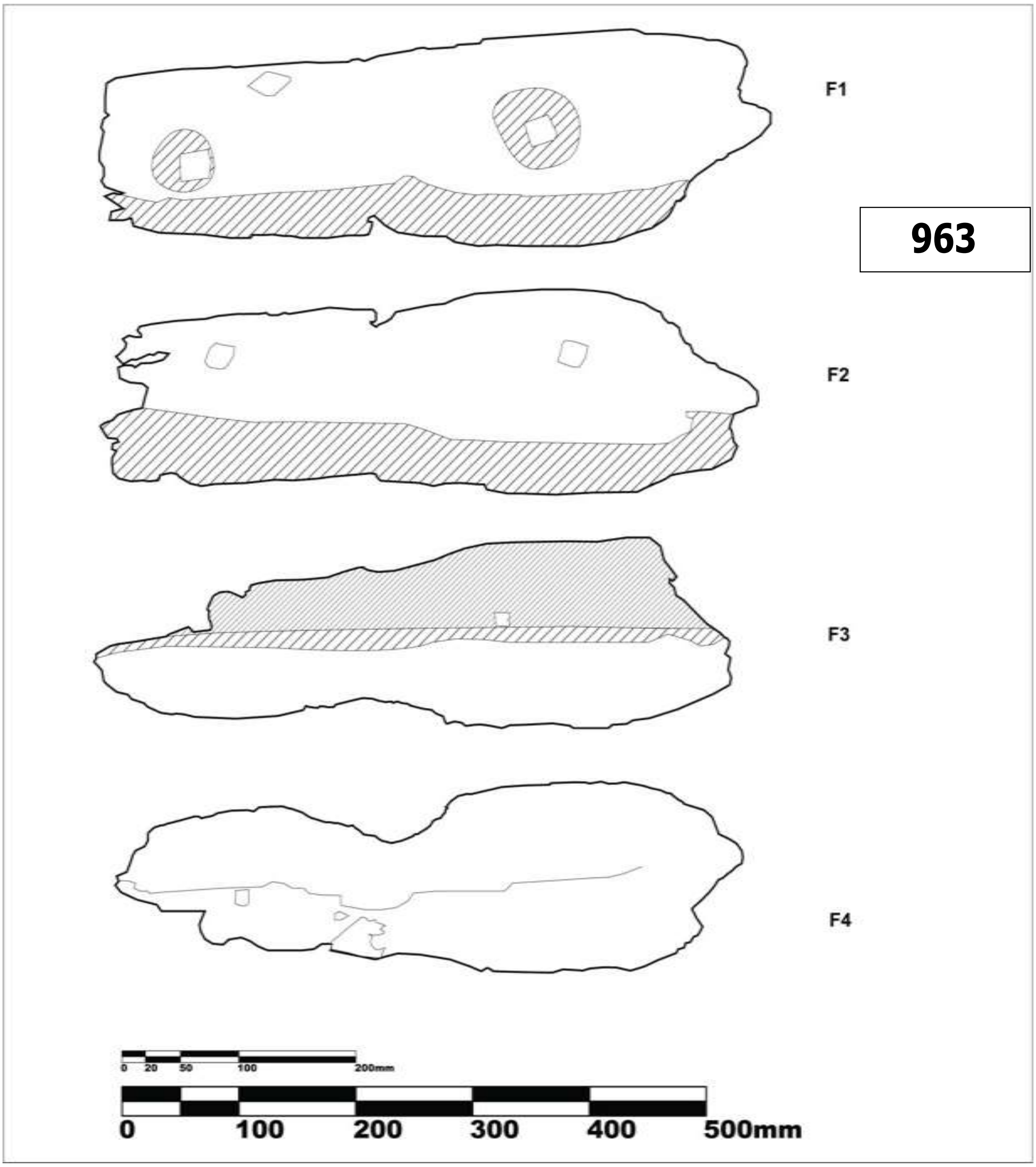
MARKS AND COATINGS:

Horizontal spacing: 347mm. Square fastening: 23mm x 21mm, 23mm x 20mm, 19mm x 19mm. Circular impression diameter: 45mm, 61mm. Small square fastening: 11mm x 11mm.

COMMENTS:

Two of the holes have a square hole in the middle of a circular depression and 350mm apart along a horizontal axis. The other hole is square and located near one of the aforementioned two holes. The two square holes with the circular impression extends through the timber and exits at Face 2 maintaining a square shape. A small square hole was observed on the rabbet recess at Face 3. Face 4 has one distinct square hole. A timber sample was extracted to be analysed for its wood species. Connects with 964.


963
F1
F2
F3
F4
0 20 50 100 200mm
0 100 200 300 400 500mm


F1
963
F2
F3
F4
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-E9-B052-964
DATE:	**CATALOGUER:**		**FUNCTION:**
18 Nov 2021	Michael Ng		Hull planking
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	615		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	216		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	144		*Uncertain* ☒

JOINERY:

The timber has a rabbet recess visible on Face 2 and 3.

FASTENINGS:

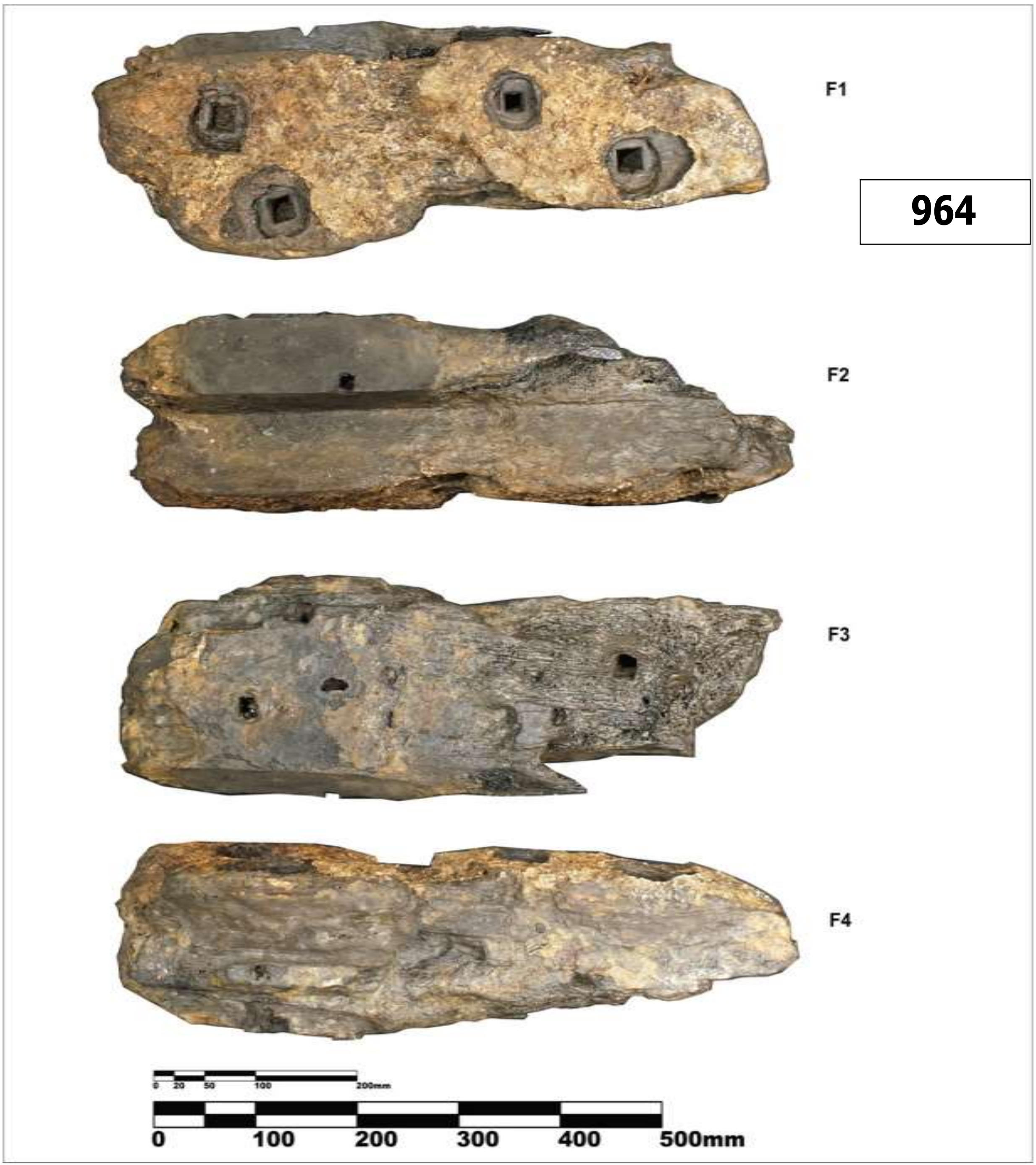
Nil

MARKS AND COATINGS:

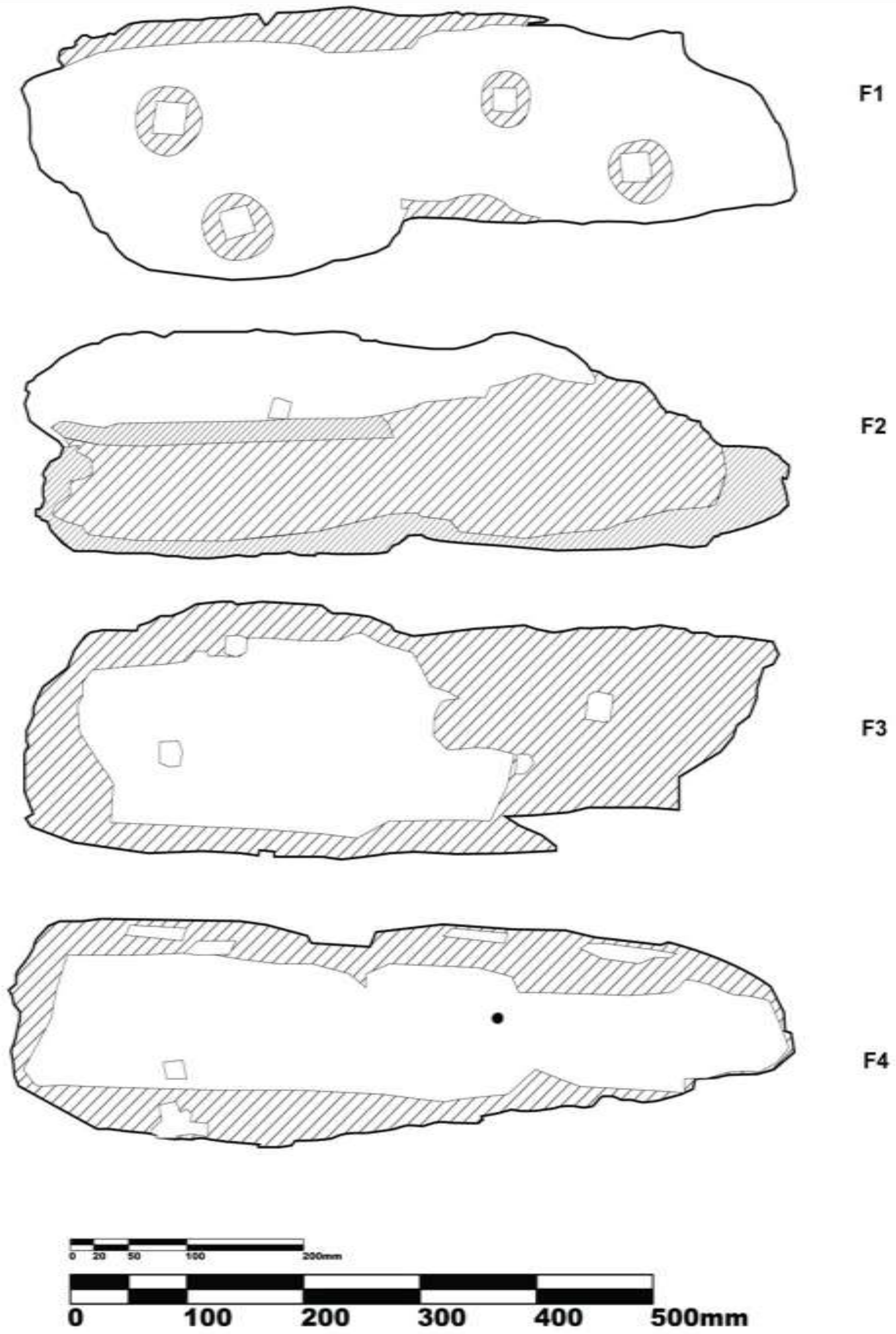
Square fastening holes: 17 x17mm, 20 x 20mm, 14 x 14mm, 21 x 21mm. Circular impression diameter: 51mm, 57mm, 50mm, 50mm.

COMMENTS:

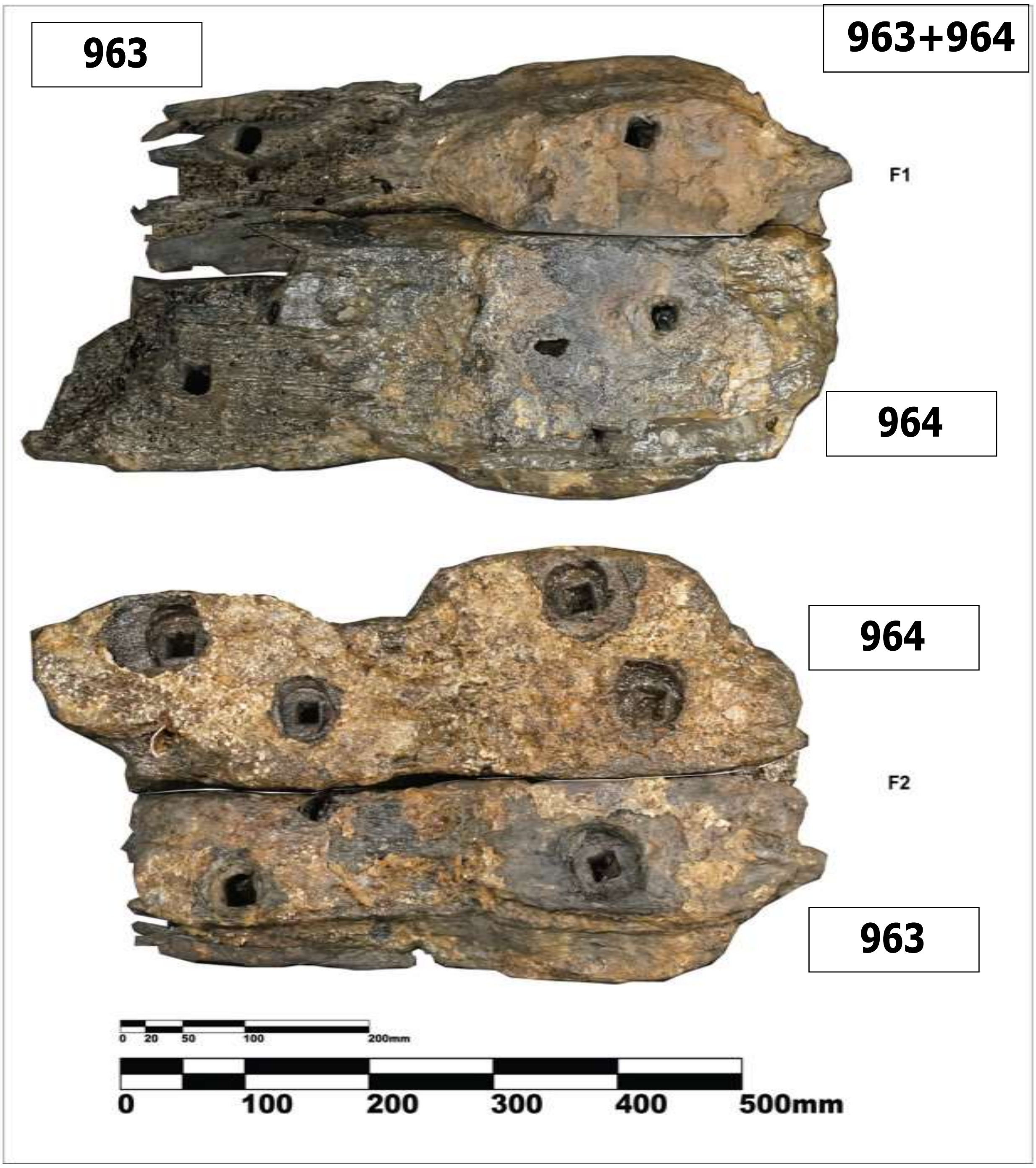
Face 1 has four holes. Two holes near each end of the timber. The holes have a square hole in the middle of a circular impression. Face 2 has a rabbet recess and a small square hole on one of the rabbet's side. Face 3 has four square holes while Face 4 has two square holes and a extant tack. The extant tack has a circular head with a diameter of 9mm.Connects with 963.

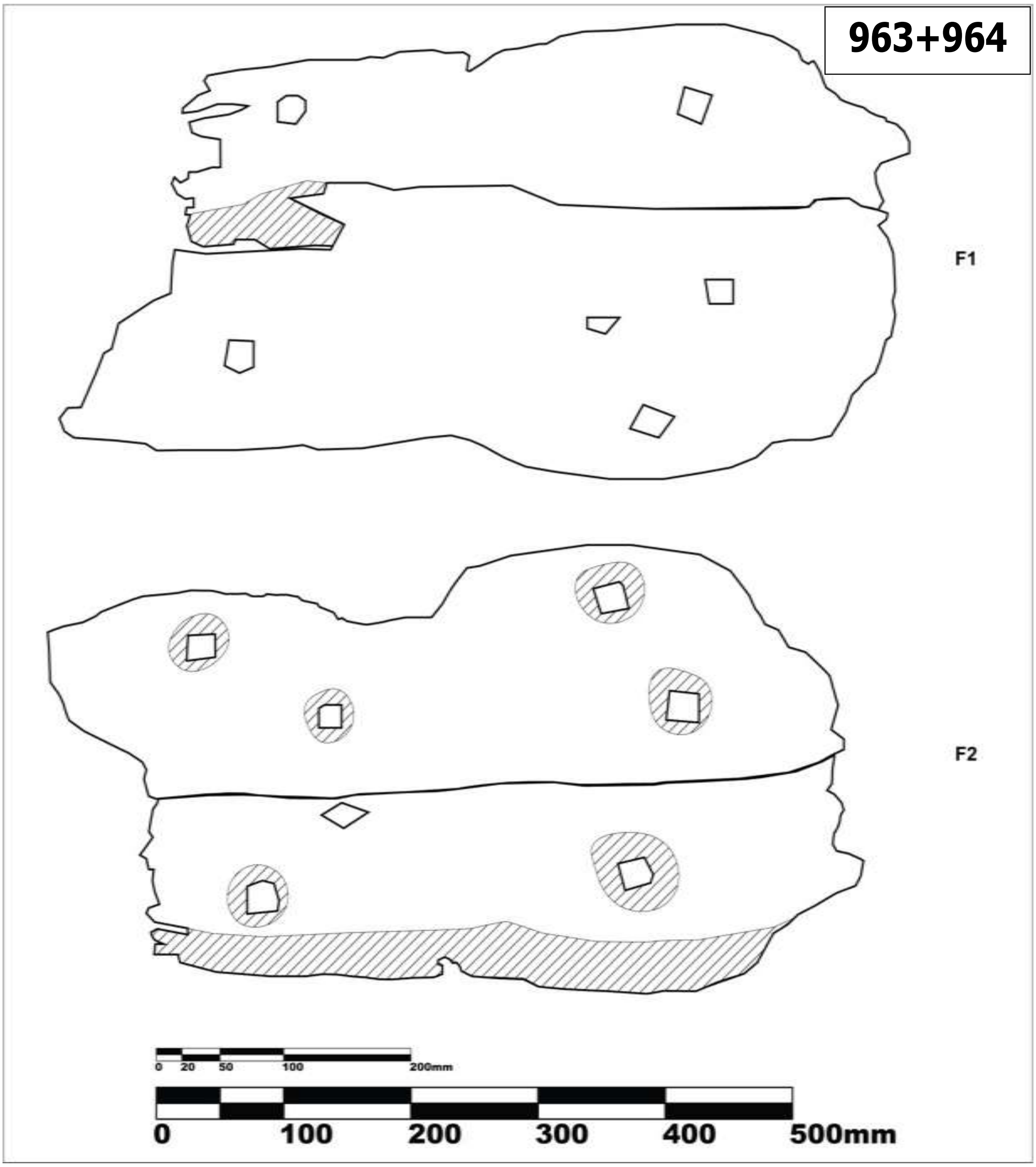


964



964


963
963+964
F1
964
964
F2
963
0 20 50 100 200mm
0 100 200 300 400 500mm


963+964
F1
F2
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-E9-B055-965
DATE:	**CATALOGUER:**		**FUNCTION:**
18 Nov 2021	Michael Ng		Hull planking
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	645		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	314		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	161		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

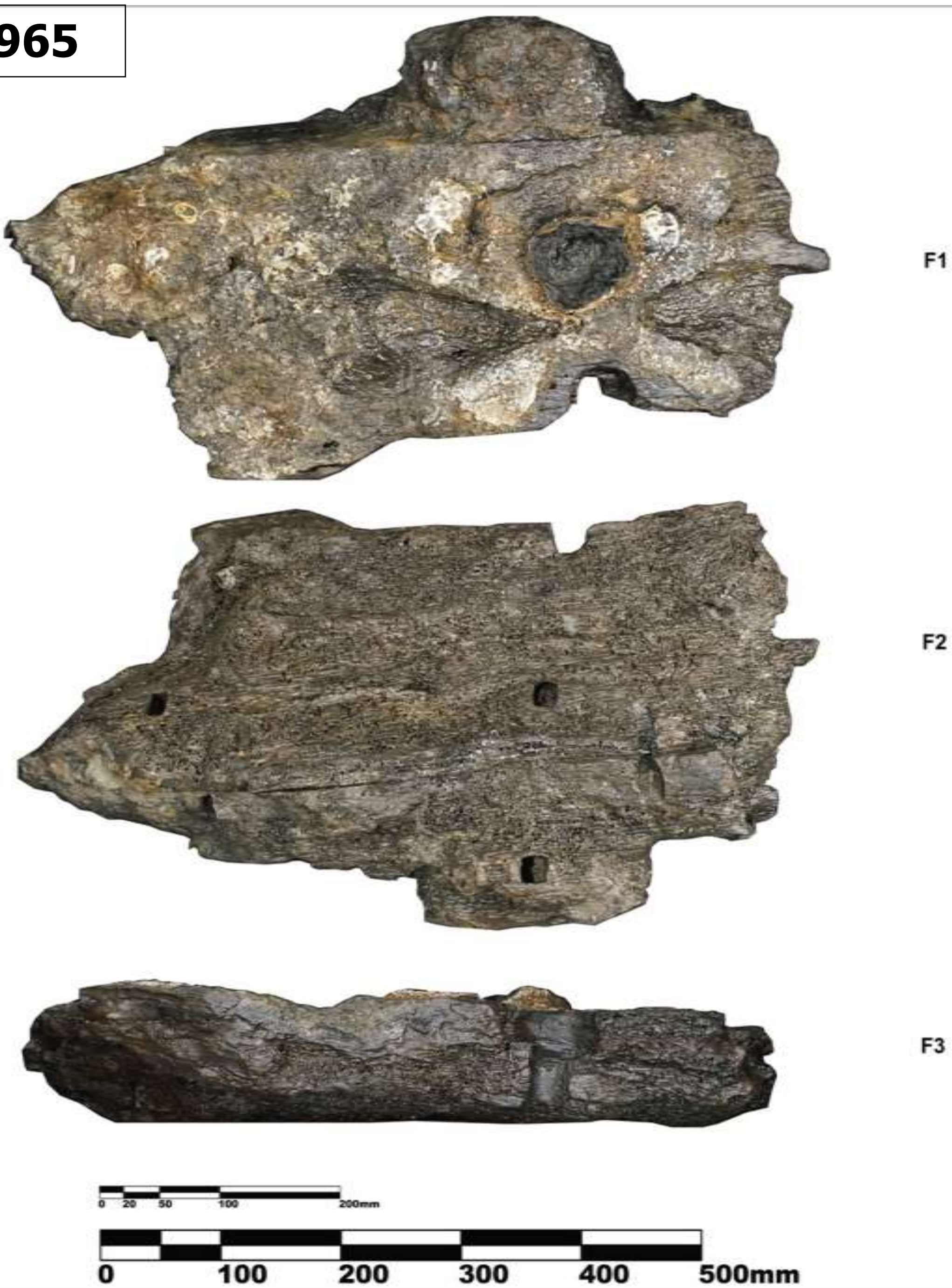
MARKS AND COATINGS:

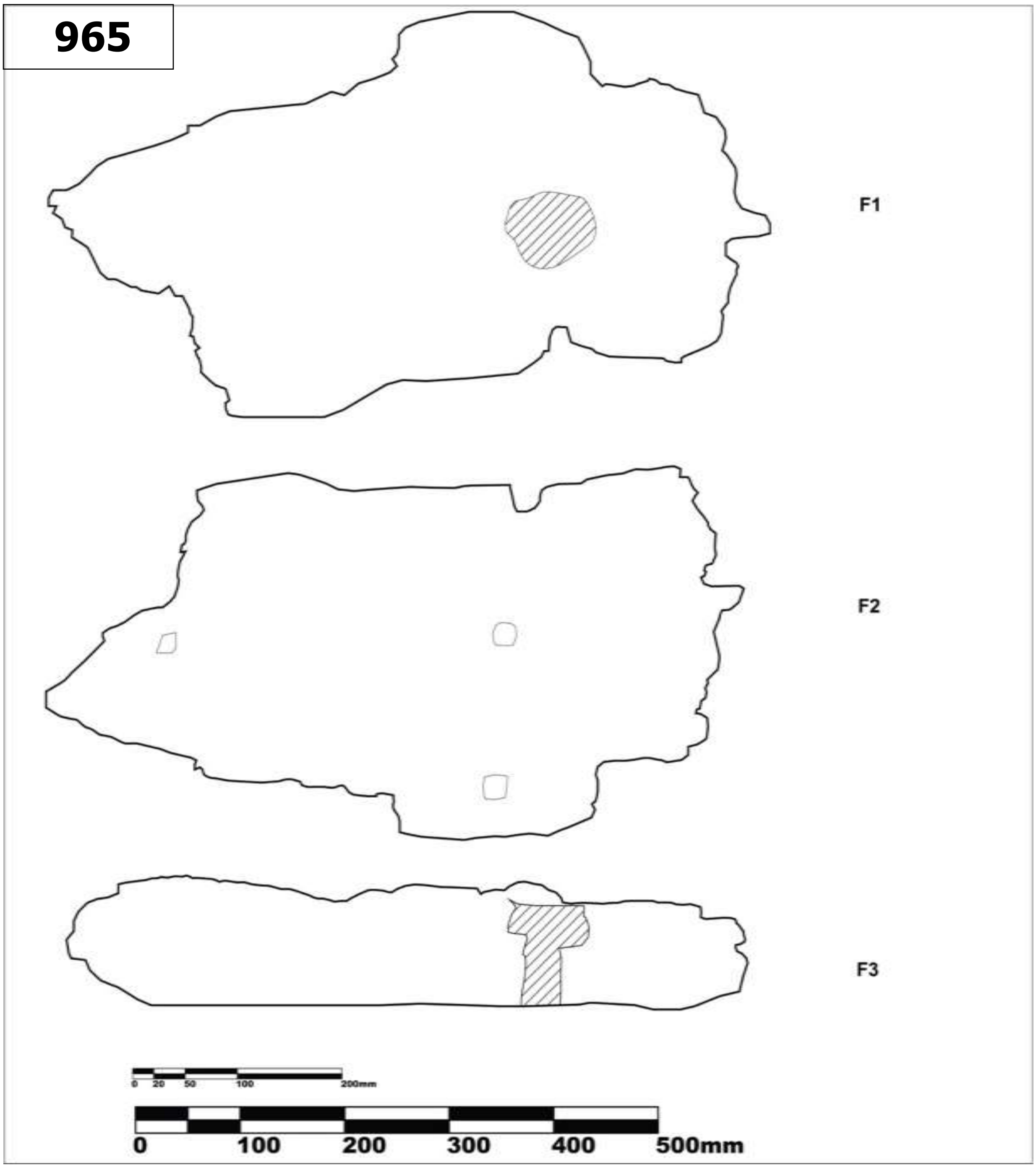
Square fastening holes: 25 x 25mm, 25 x 25mm, 19 x 19mm, 19 x 19mm, 21 x 21mm, 19 x 19mm. Circular impression diameter: 50mm. Vertical spacing: 10mm, 11mm. Horizontal spacing: 300mm.

COMMENTS:

Face 1 has one circular depression and a semi-circular hole on its edge. The circular depression seemed to be composed of some form of encrustation. The semi-circular hole has a squarish hole within it. Face 2 have four square holes. Three of the holes were aligned on a vertical axis and spaced 10mm to 11mm apart. The fourth hole is situated along a similar horizontal axis with the middle of the three holes and is 300mm apart. Face 3 provides a profile view of the semi-circular hole observed on Face 1.

965




965
F1
F2
F3
0 20 50 100 200mm
0 100 200 300 400 500mm

SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B079-971
DATE:	**CATALOGUER:**		**FUNCTION:**
18 Nov 2021	Michael Ng		Sacrificial Sheathing
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	880		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	175		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	28		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

28 extant tacks, Diameter of tack head: 9–11mm

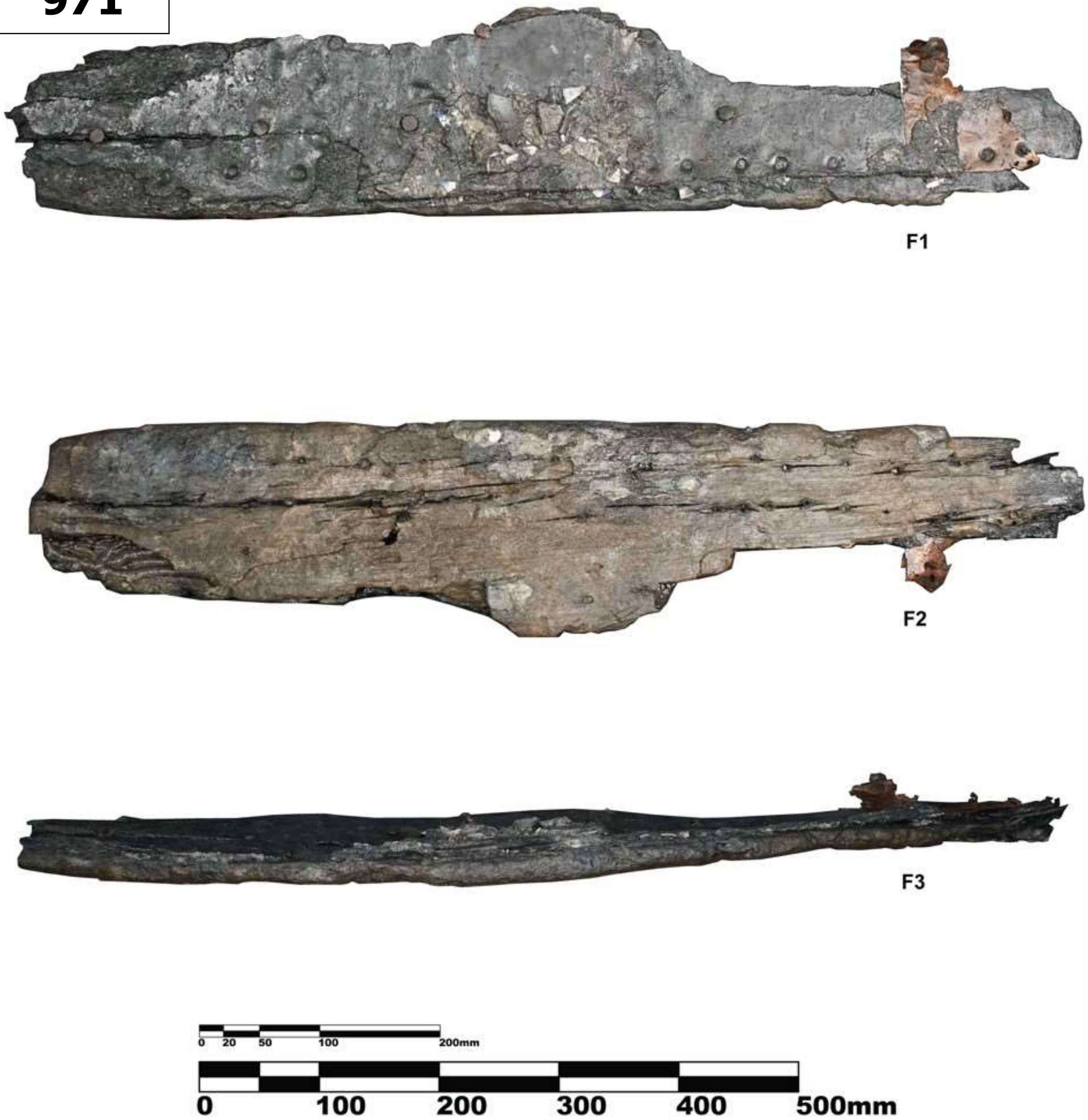
MARKS AND COATINGS:

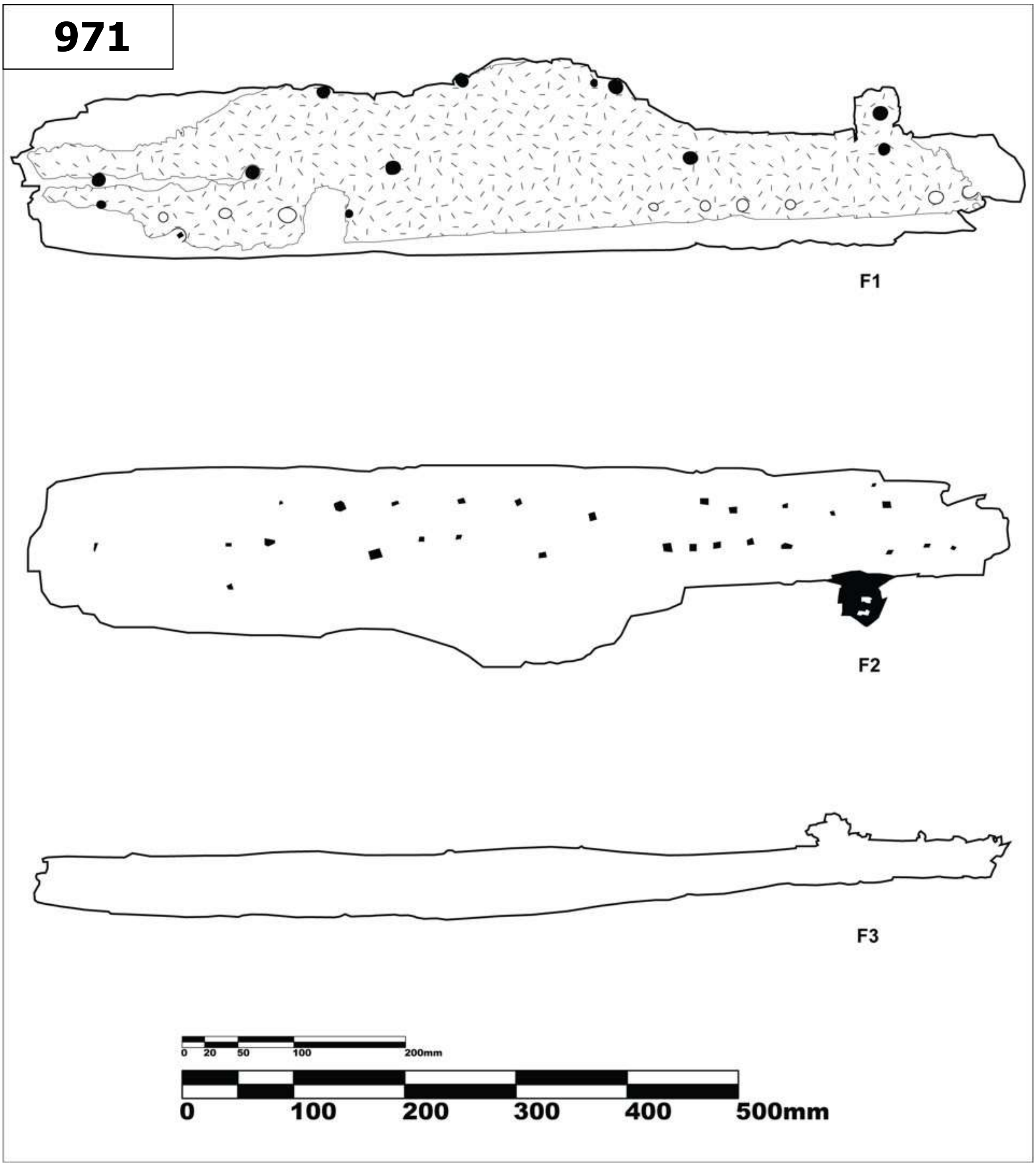
Circular impression diameter: 50mm. Vertical spacing: 10mm, 11mm. Horizontal spacing: 300mm.

COMMENTS:

There are metal sheathings, 28 extant tacks on the timber. There seemed to be two sheathing overlapping each other. The sheath directly applied on the wood is overlapped with a smaller strip of sheath which is broken. There seemed to be a pattern in the spacing between the tacks as there is a horizontal and vertical alignment to their placements.

971




971
F1
F2
F3
0 20 50 100 200mm
0 100 200 300 400 500mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B085-972 PB2-D9-B085-974
DATE:	**CATALOGUER:**		**FUNCTION:**
19 Nov 2021	Michael Ng		Sacrificial Sheathing
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	880 (974) 260 (972)			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	175 (974) 95 (972)			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	28 (974) 26 (972)			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

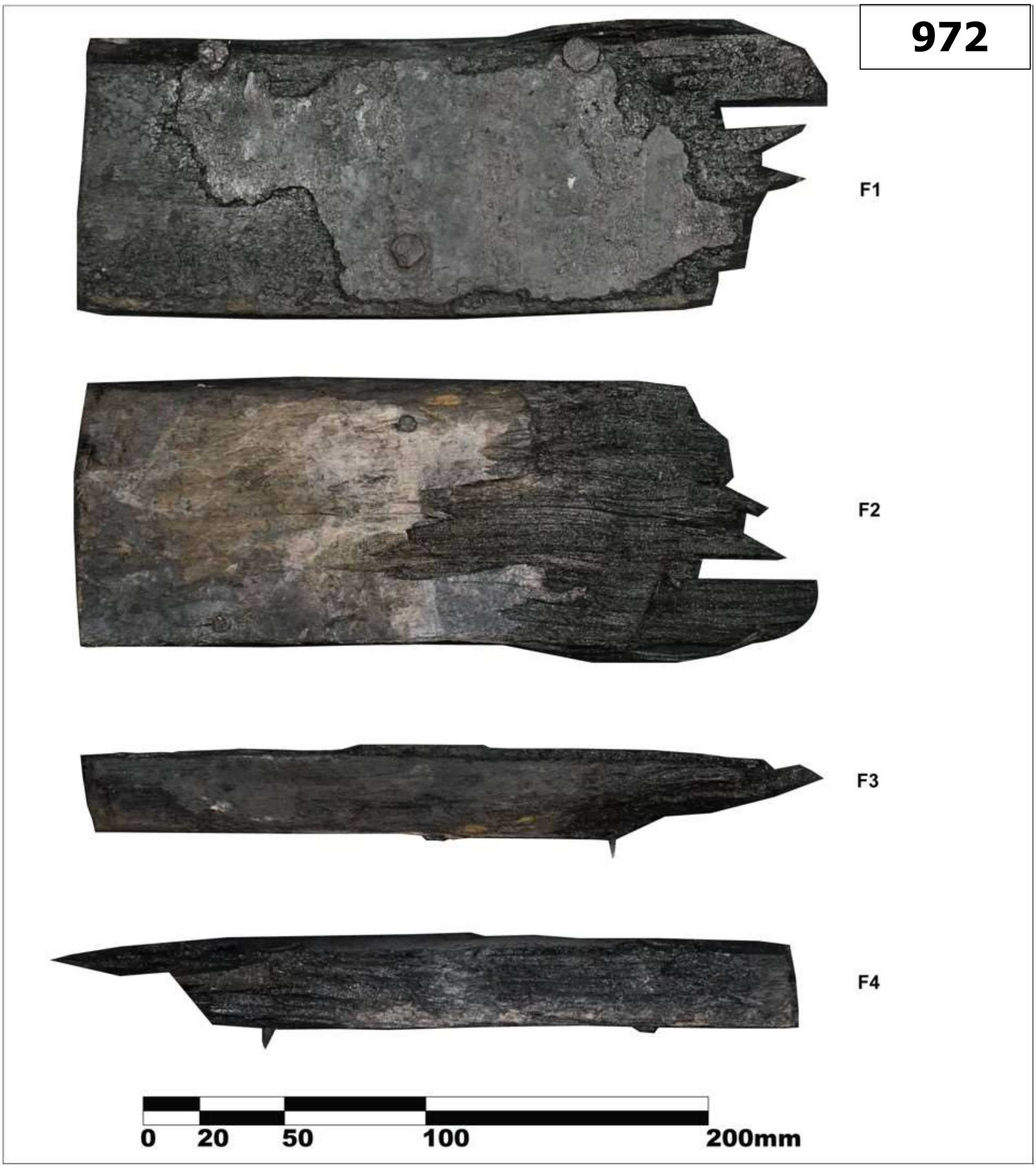
30 and 3 extant tacks were observed on 974 and 972 respectively. Tack head diameter = ~11mm, ~12mm, ~11.3mm.

MARKS AND COATINGS:

Circular impression diameter: 50mm. Vertical spacing: 55mm, 40mm, 58mm. Horizontal spacing: 90mm, 115mm, 120mm, 118mm, 134mm, 119mm, 105mm, 12mm, 113mm, 154mm, 131mm. Greyish white coating on 972 and 974. Tack hole dimension: 6 x 6mm,

COMMENTS:

972 and 974 came from the same timber but it was broken to fit into the conservation tank. There are metal sheathings on the timber's surface. The extant tacks have a circular head and square shank. The surface of 974 exhibits two possible overlapping sheathing however it could be an encrustation layer. There is no pattern to the placement of the tacks.



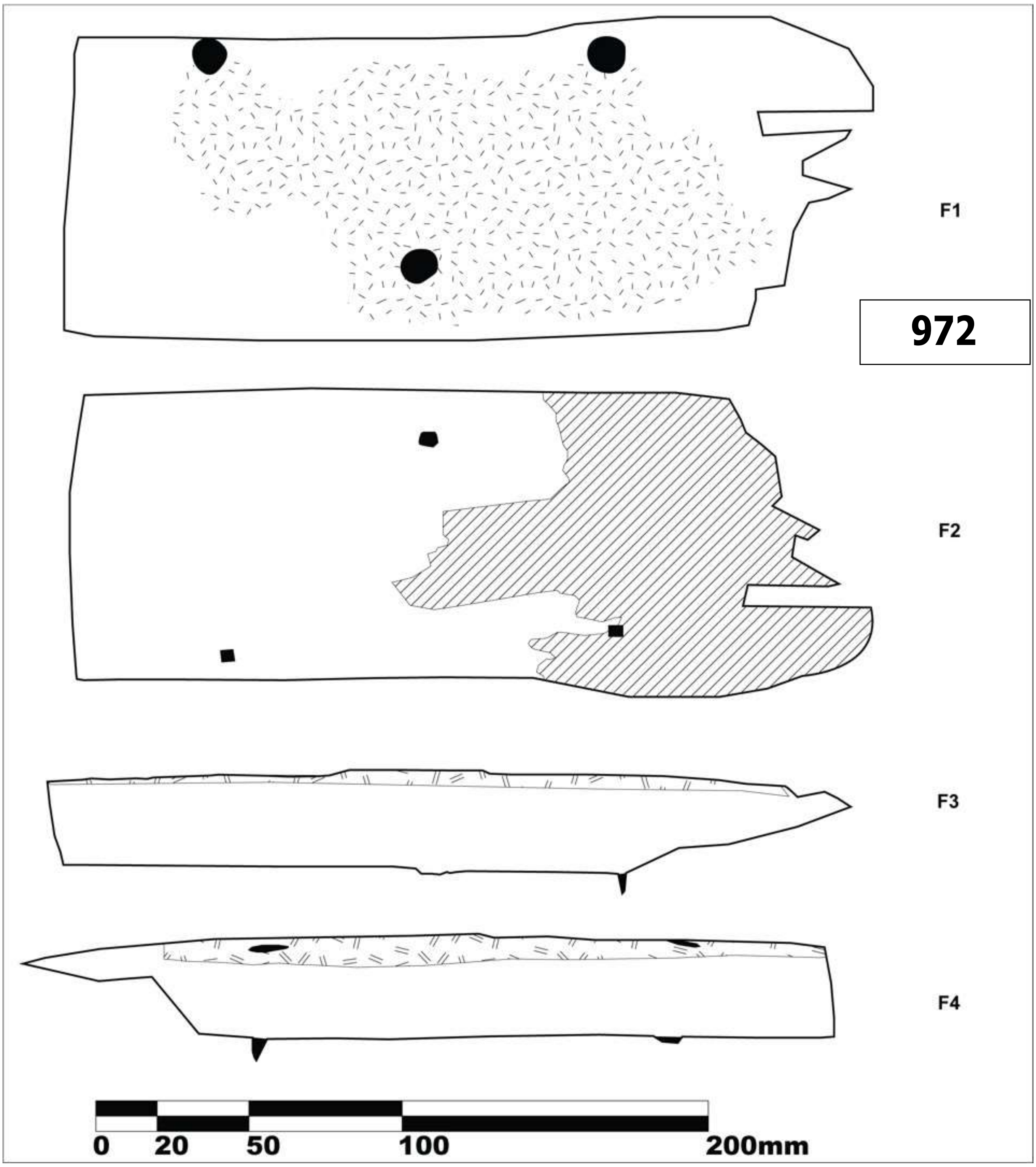
972
F1
F2
F3
F4
0
20
50
100
200mm

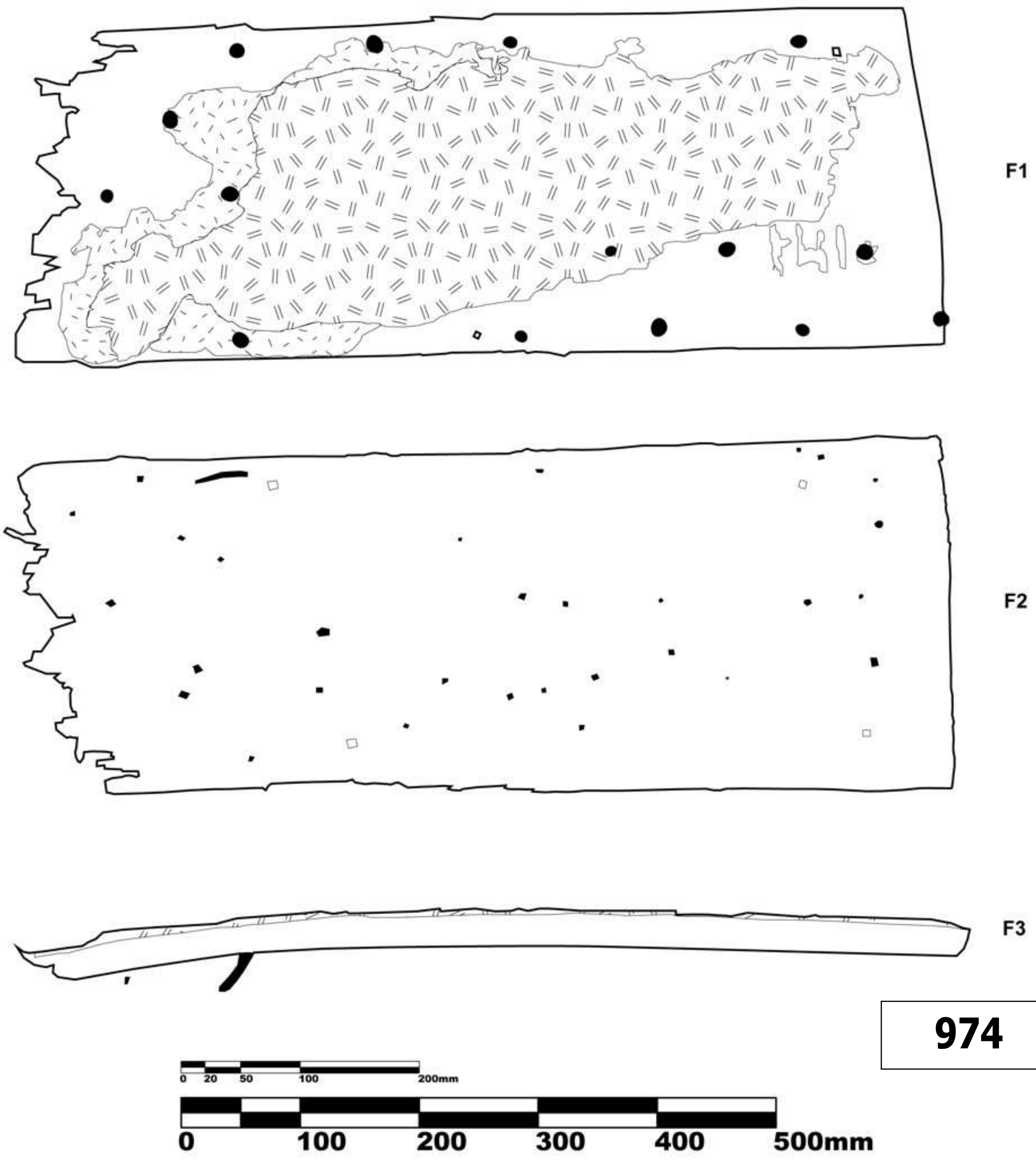
F1

F2

F3

974


F1
972
F2
F3
F4
0
20
50
100
200mm



974

SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-D11-B108-975
DATE:	**CATALOGUER:**		**FUNCTION:**
19 Nov 2021	Michael Ng		Graving piece
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is complete without any broken edges but some degradation can be observed. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	620		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	160	☐	*Tangential* ☐
	Thickness (mm):	*Bark*	*Radial* ☐
	75		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

MARKS AND COATINGS:

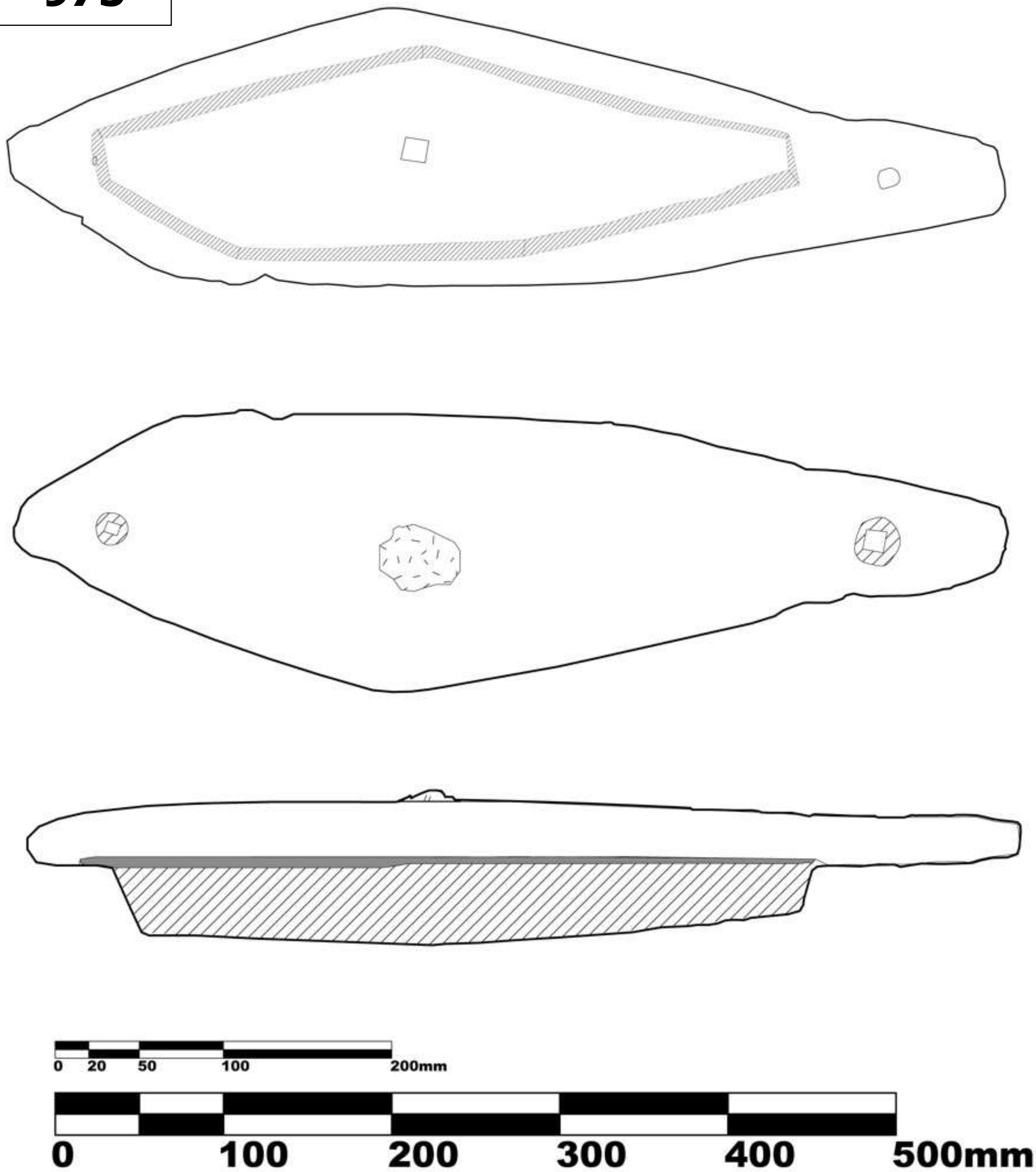
Fastening hole dimension: 8 X 8mm, 10 X 10mm, 12 X 13mm. Circular impression diameter: 19mm, 27mm.

COMMENTS:

The shape of the timber is trapezoidal with seven sides. Face 1 has a raised portion of the timber also exhibits a trapezoidal shape which is angled similarly to the overall timber borders. The raised portion is 418mm in length, 116mm wide and 33mm to 45mm thick. Three square holes can be found on the timber. Two holes are located near both ends of the timber and one hole is situated in the middle. On the other side of the timber, Face 2, three holes are also observed. The three holes consist of a square hole in the middle of a circular depression.

975

975



SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-D11-B108-980
DATE:	**CATALOGUER:**		**FUNCTION:**
19 Nov 2021	Michael Ng		Sacrificial Sheathing
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good except for two broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	290		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	143.3		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	26.1 (29.4 with metal)		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

8 extant tacks were observed. Diameter of tack head: 11.1mm, 13mm, 11.4mm, 10mm, 10mm, 10mm, 12mm, 11mm.

MARKS AND COATINGS:

Tack hole dimension: 3 x 3mm, 4 x 4mm.
Tack hole spacing =
Vertical spacing: 39mm, Horizontal spacing: 21.6mm, 33.7mm, 43.9mm, 43mm, 43mm, 43mm, 139mm

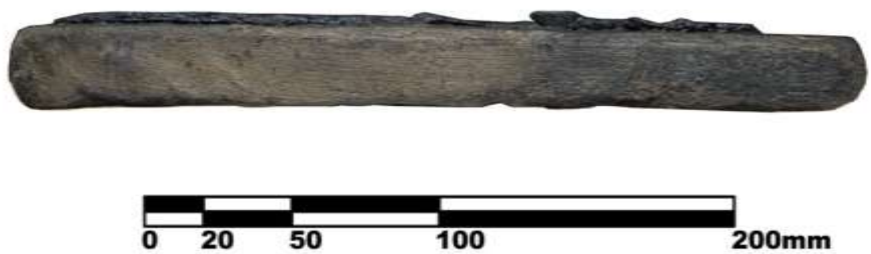
COMMENTS:

There are metal sheathings on one of the timber’s surface and nine extant tacks on the timber which have circular heads. There seemed to be two sheathing overlapping each other. The sheath directly applied on the wood is overlapped with a thinner strip of sheath. There seemed to be a pattern in the spacing between the tacks as there is a horizontal and vertical alignment to their placements.

980

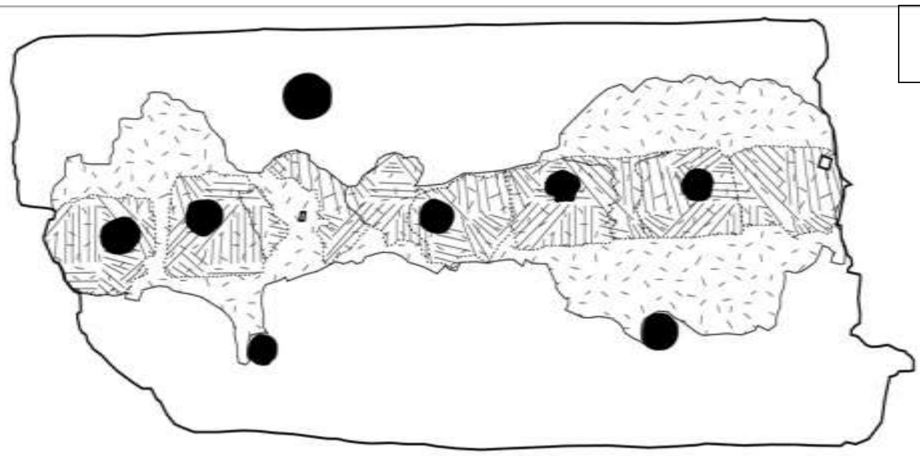
F1

F2

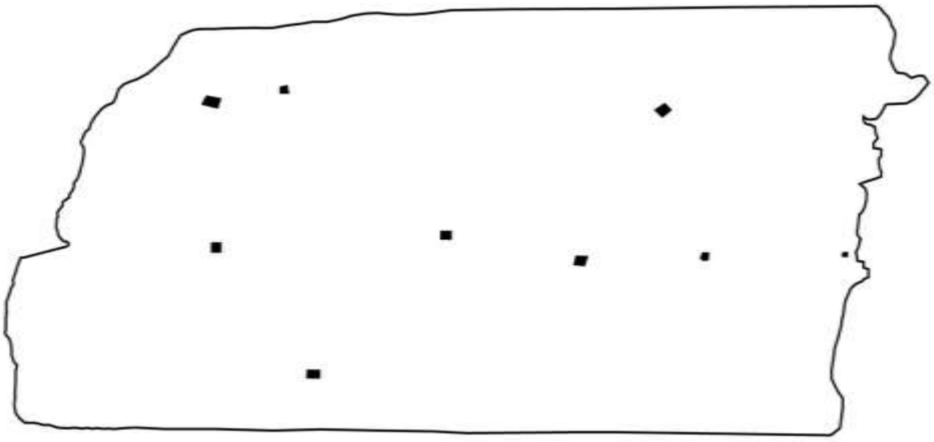


F3

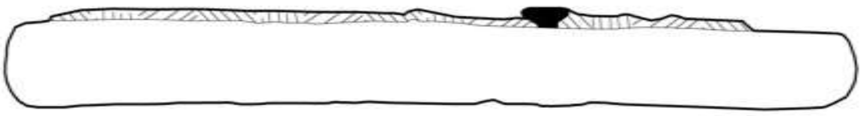
980



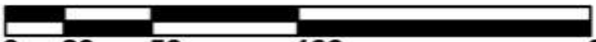
F1



F2



F3



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B085-983
DATE:	**CATALOGUER:**		**FUNCTION:**
19 Nov 2021	Michael Ng		Sacrificial Sheathing
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber is degraded on all sides with signs of breakage and marine borers. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	473		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	119		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	29 (32 with Metal)		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

3 extant tacks were observed. Fastening dimension: 4 x 4mm. Diameter of tack head: 10.5mm, 14.4mm,13mm

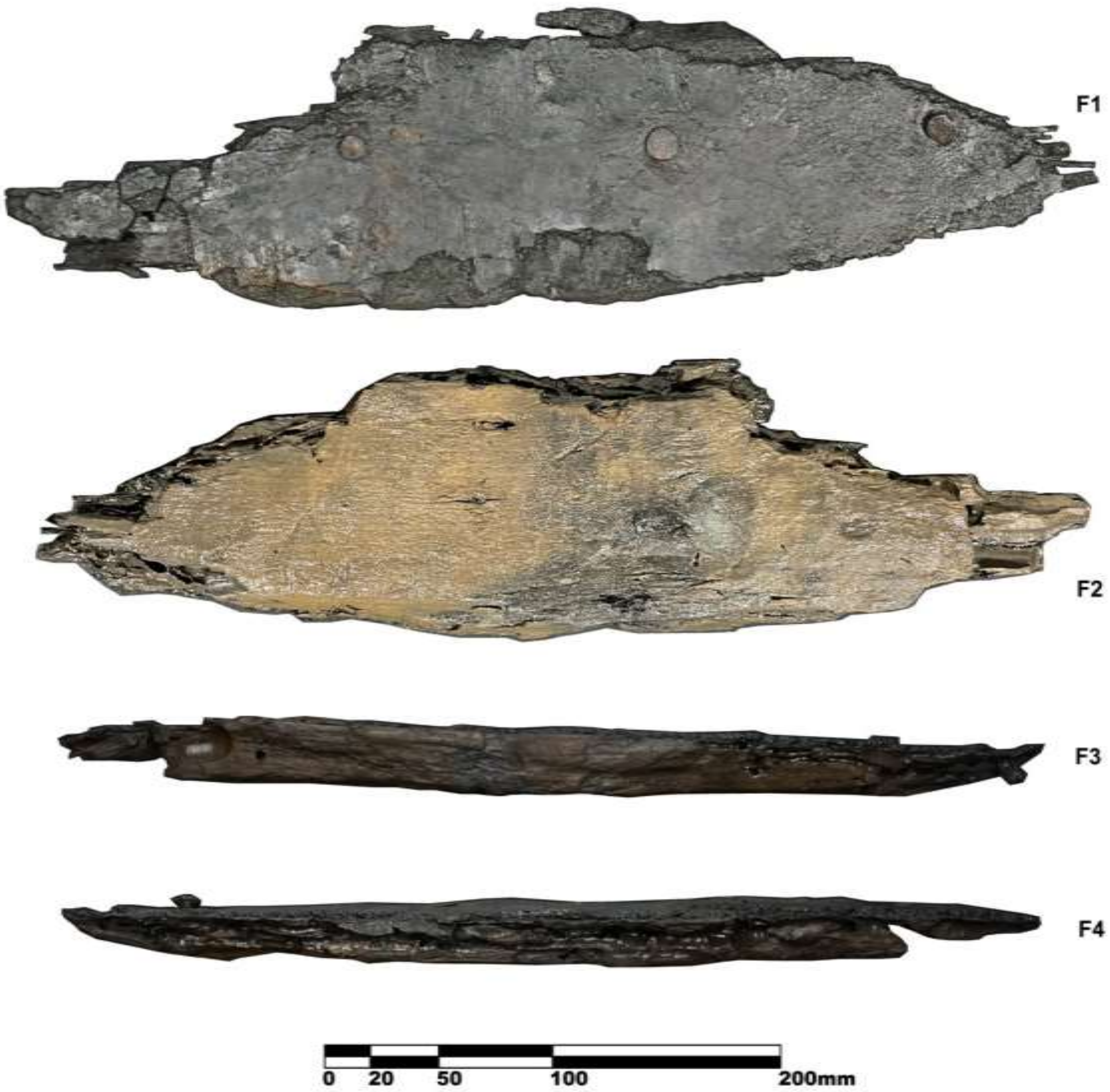
MARKS AND COATINGS:

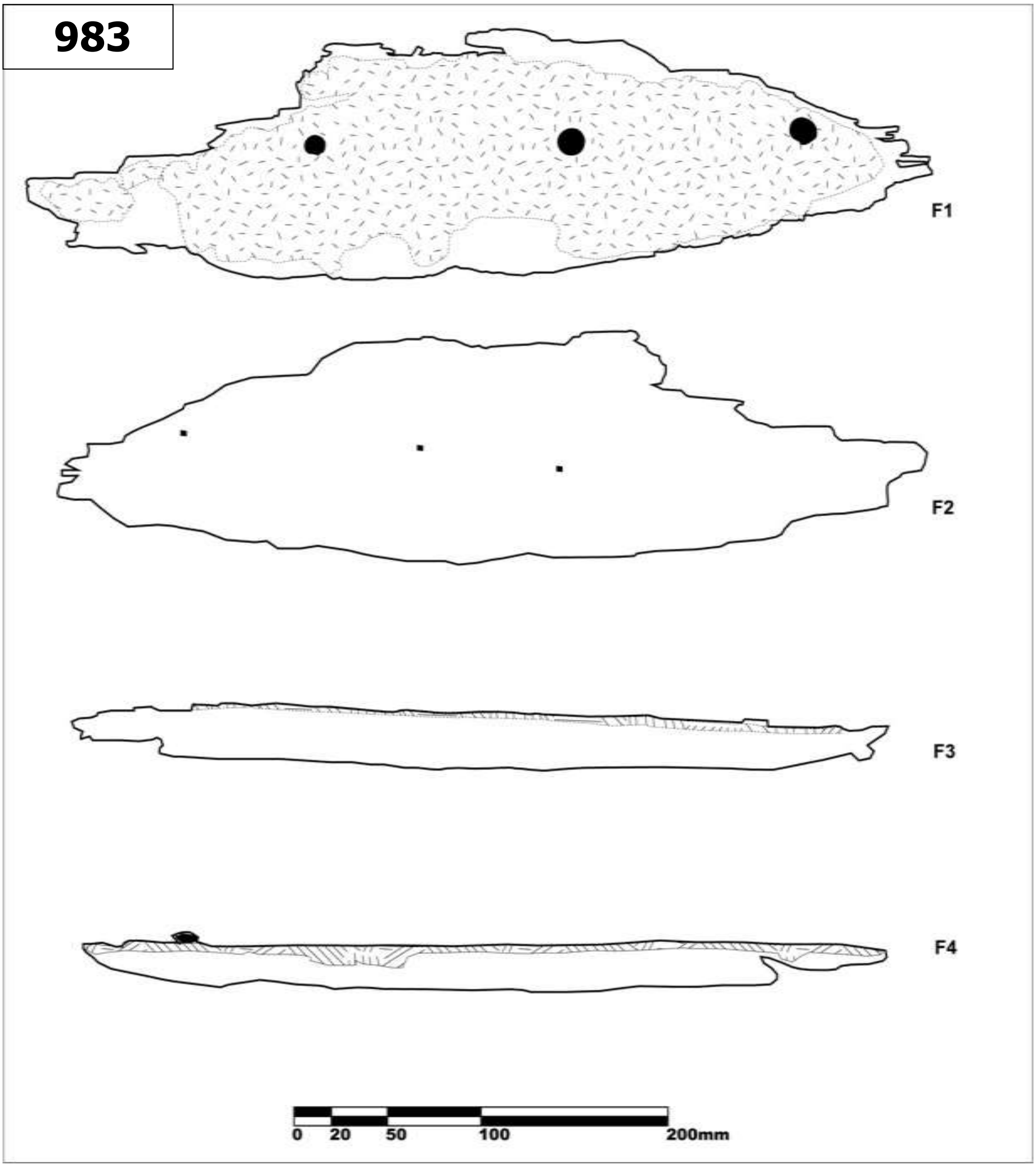
Fastening hole spacing =
Horizontal spacing: 120mm, 132.7mm

COMMENTS:

There are metal sheathings and 3 extant tacks on the timber’s surface. The tacks seemed to be evenly spaced horizontally.

983





983
F1
F2
F3
F4
0
20
50
100
200mm

***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B085-985
DATE:	**CATALOGUER:**		**FUNCTION:**
20 Nov 2021	Michael Ng		?Structural timber
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Condition of the timber is fair. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	550		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	70		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	60		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

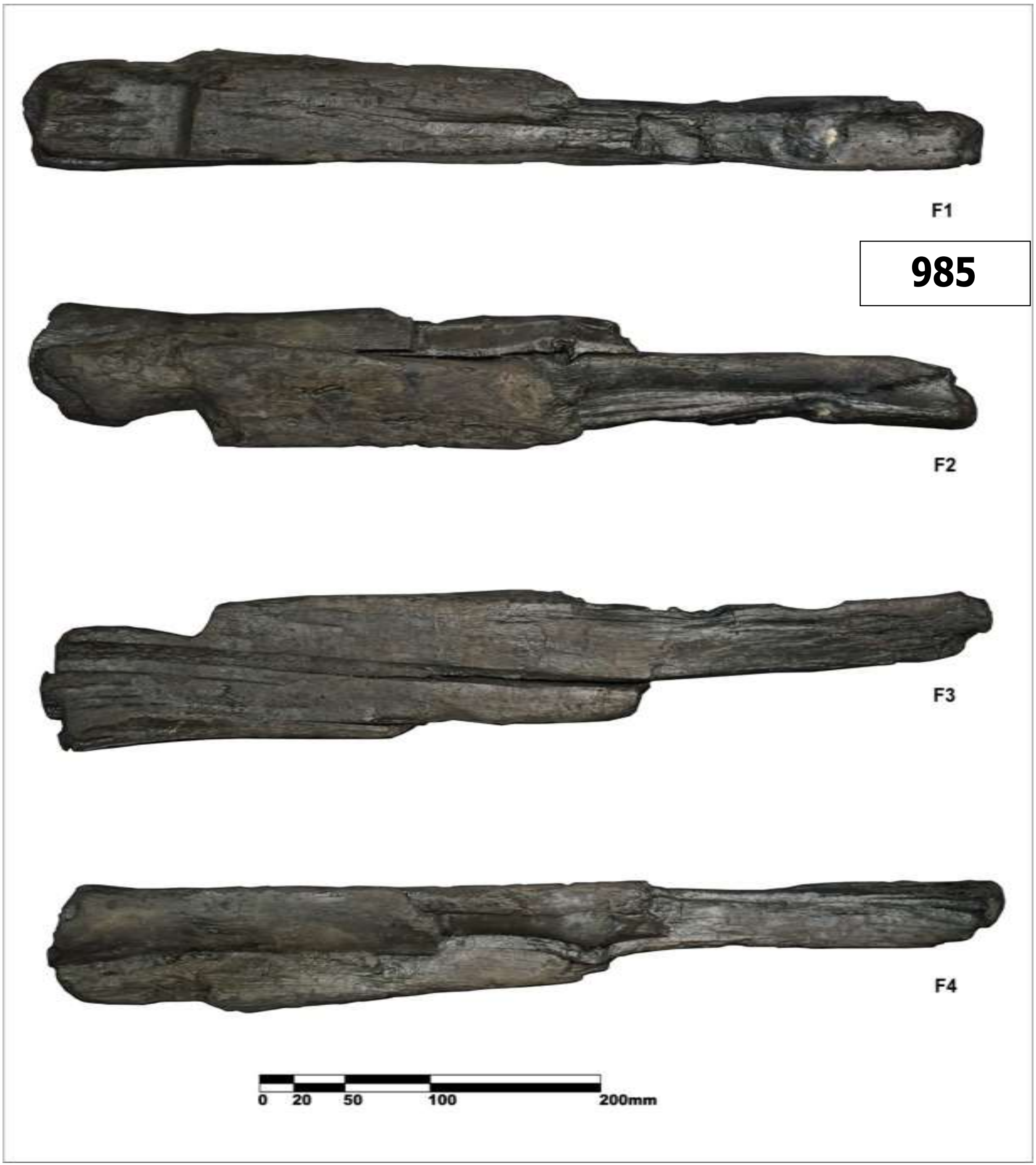
Nil

MARKS AND COATINGS:

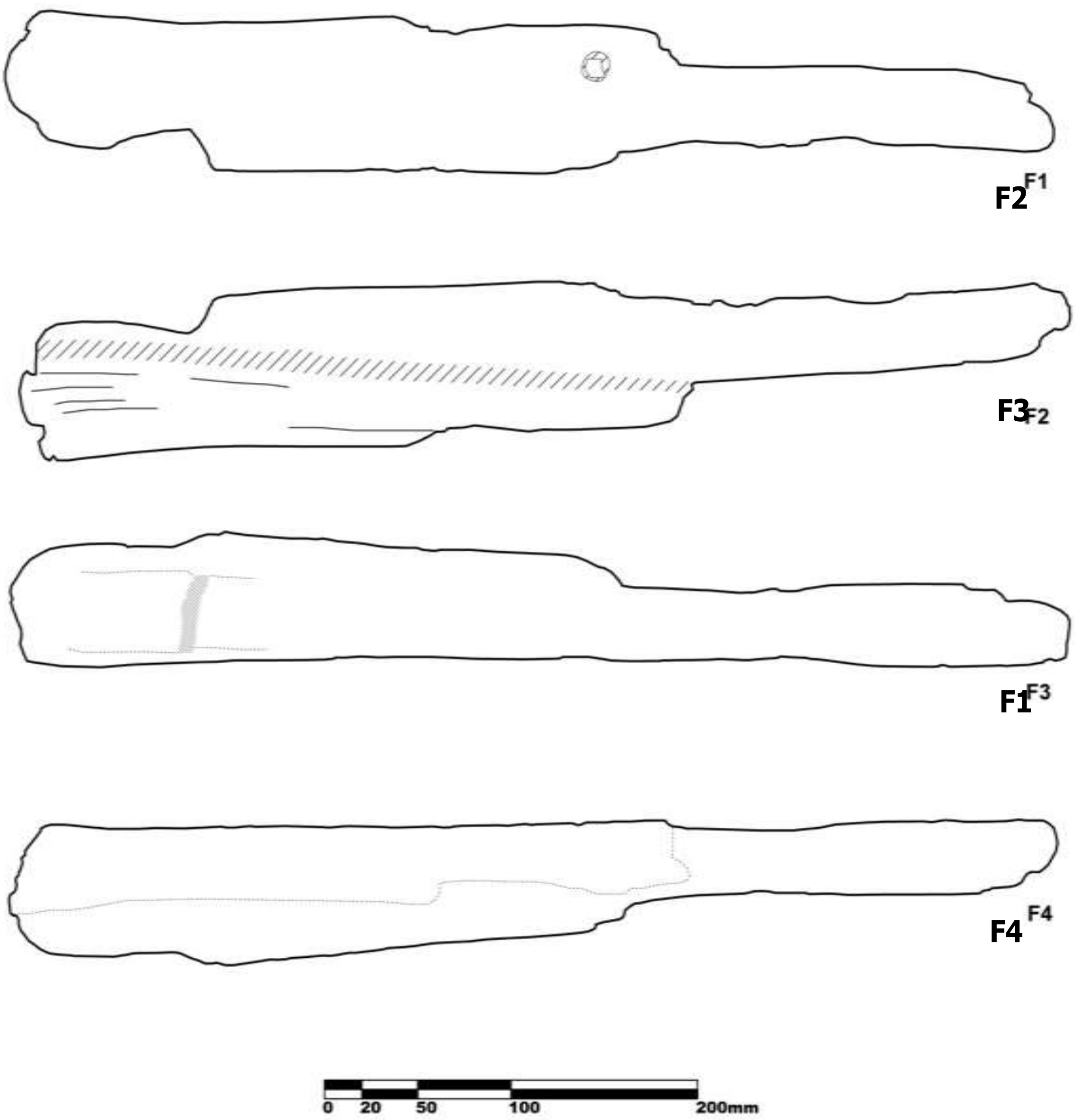
Tack hole: 4 x 4mm, Circular impression diameter: 12.7mm

COMMENTS:

It is degraded and there are broken edges on five of its profiles. The timber is thicker at one end and narrows from the midpoint. There are no obvious signs of carpentry or joinery. The only noticeable feature is a single square hole. The hole consists of a square hole in the middle of a circular depression.


F1
985
F2
F3
F4
0 20 50 100 200mm

985



***SHAH MUNCHER* TIMBER RECORD**		**REGISTRATION NO:** PB2-D11-B121-1017
DATE:	**CATALOGUER:**	**FUNCTION:**
20 Nov 2021	Michael Ng	Graving piece

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good as all sides are complete. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	370		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	73		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	33		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

MARKS AND COATINGS:

Tack hole: 8 x 4mm, 8mm x 5mm, 6mm x 7mm. Circular encrustation diameter: 30mm, 40mm, 60mm. Horizontal spacing: 128mm, 153mm

COMMENTS:

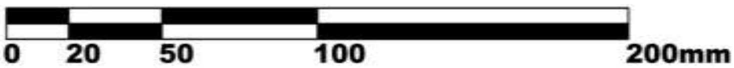
The timber has a trapezoidal shape. There are three circular encrustations found on Face 1 of the timber. On Face 2, there are three small square holes which may be related to the circular encrustation found on Face 1.The holes seemed to be aligned on a horizontally.

1017

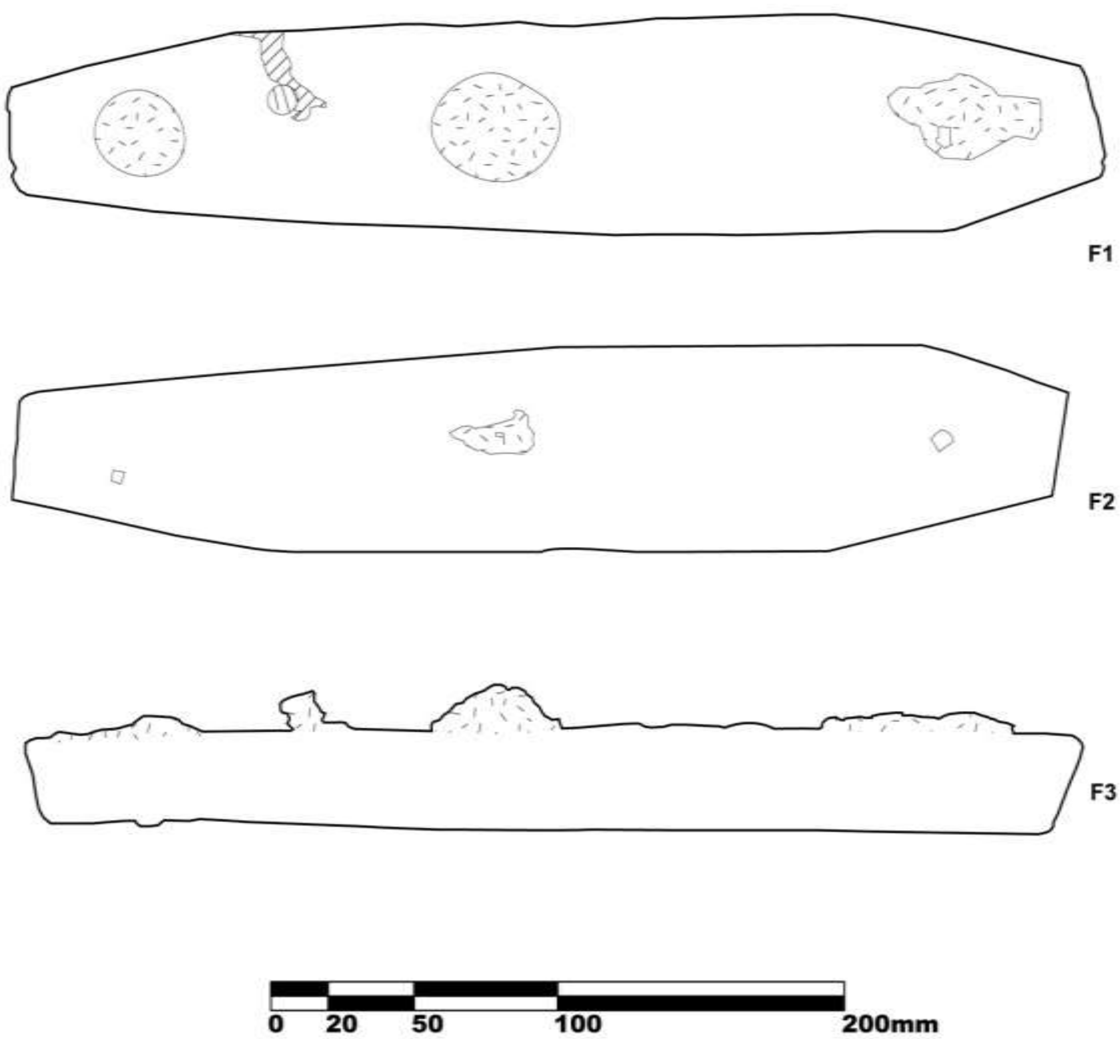
F1

F2

F3



1017



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D12-B130-1018
DATE:	**CATALOGUER:**		**FUNCTION:**
20 Nov 2021	Michael Ng		Unknown timber
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is fair as all the sides seemed to be worn and have one broken end. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	340		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	110		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	25		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

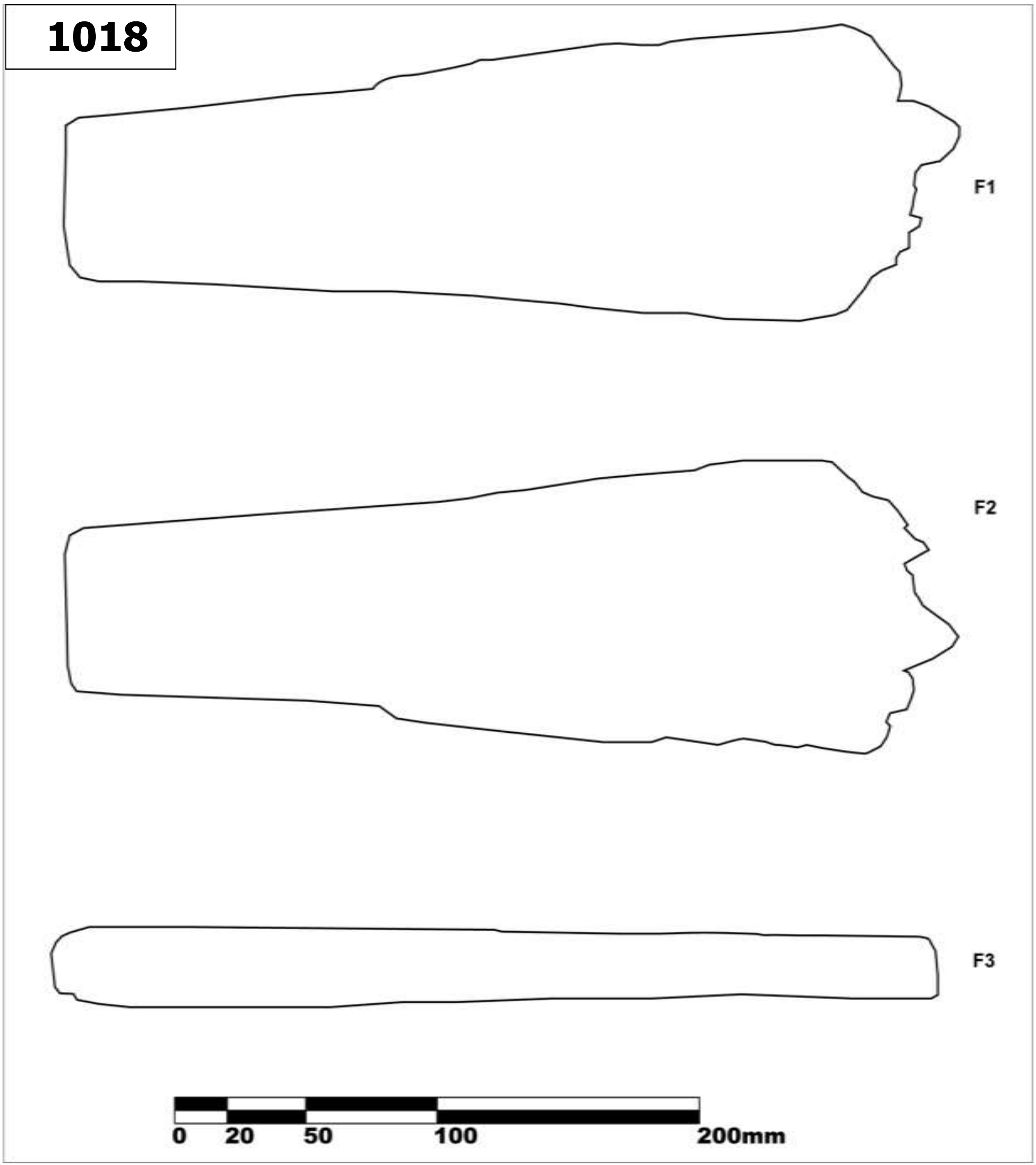
MARKS AND COATINGS:

Nil

COMMENTS:

It seemed to be have been shaped. It is flat on Face 1 and slightly curved on Face 2. No observable diagnostic features.

1018



1018
F1
F2
F3
0
20
50
100
200mm

SHAH MUNCHER **TIMBER RECORD**		**REGISTRATION NO:** PB2-D12-B130-1019
DATE:	**CATALOGUER:**	**FUNCTION:**
20 Nov 2021	Michael Ng	Graving piece

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good as all sides are complete.Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	138		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	58		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	25		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

MARKS AND COATINGS:

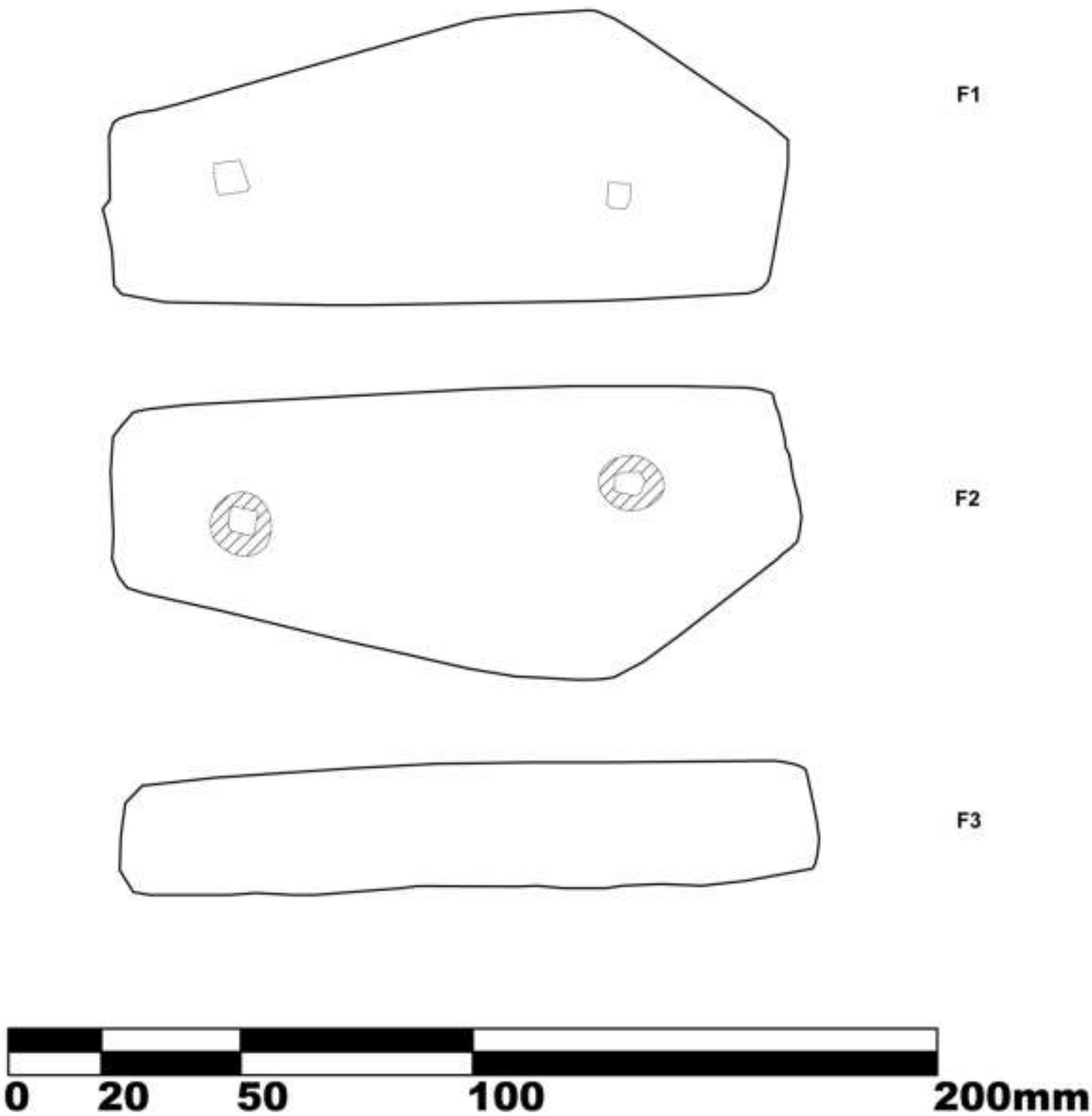
2 tack holes observed.
Tack hole dimension: 7 x 7mm, Circular diameter impression: 8mm, 8mm

COMMENTS:

The timber has a trapezoidal shape have two holes which extends through the timber. On Face 2, the two holes are square within a circular depression. On Face 1, the holes are square.

1019

1019



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D11-B117-1038
DATE:	**CATALOGUER:**		**FUNCTION:**
20 Nov 2021	Michael Ng		Unknown timber

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber condition is fair as all sides seemed to be worn down and broken. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	157			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	12			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	27			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

Nil

MARKS AND COATINGS:

1 holes observed. Diameter on F1 = 15mm, Diameter on F2 = 20mm

COMMENTS:

There is a hole in the timber which could be formed from a knot or from a tack. Face 1 shows the curved surface of the timber while Face 2 shows a flat surface.

1038

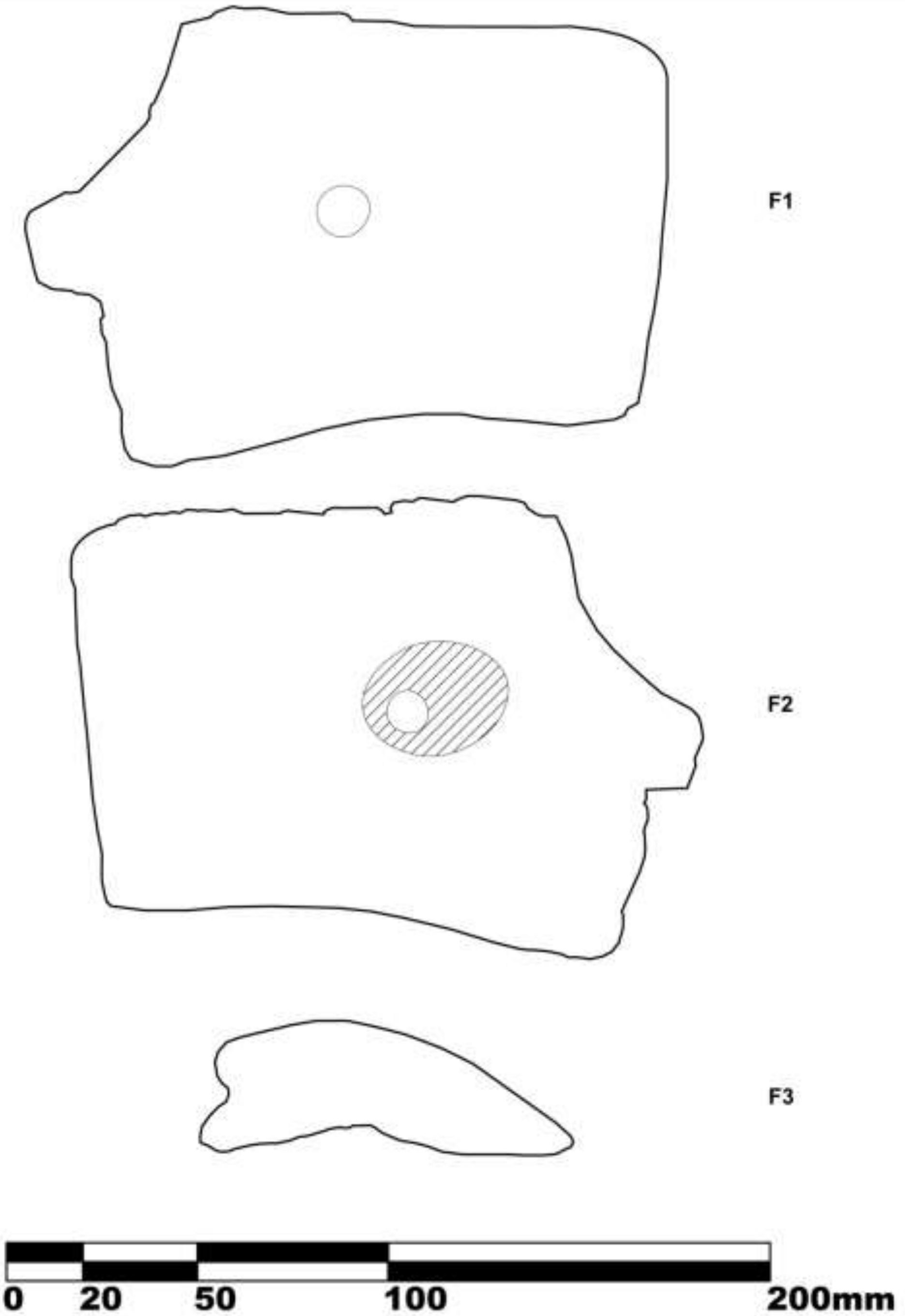
F1

F2

F3

0 20 50 100 200mm

1038



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D10-B118-1040
DATE:	**CATALOGUER:**		**FUNCTION:**
21 Nov 2021	Michael Ng		Graving piece
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good as all sides are complete. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	157		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	12		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	27		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

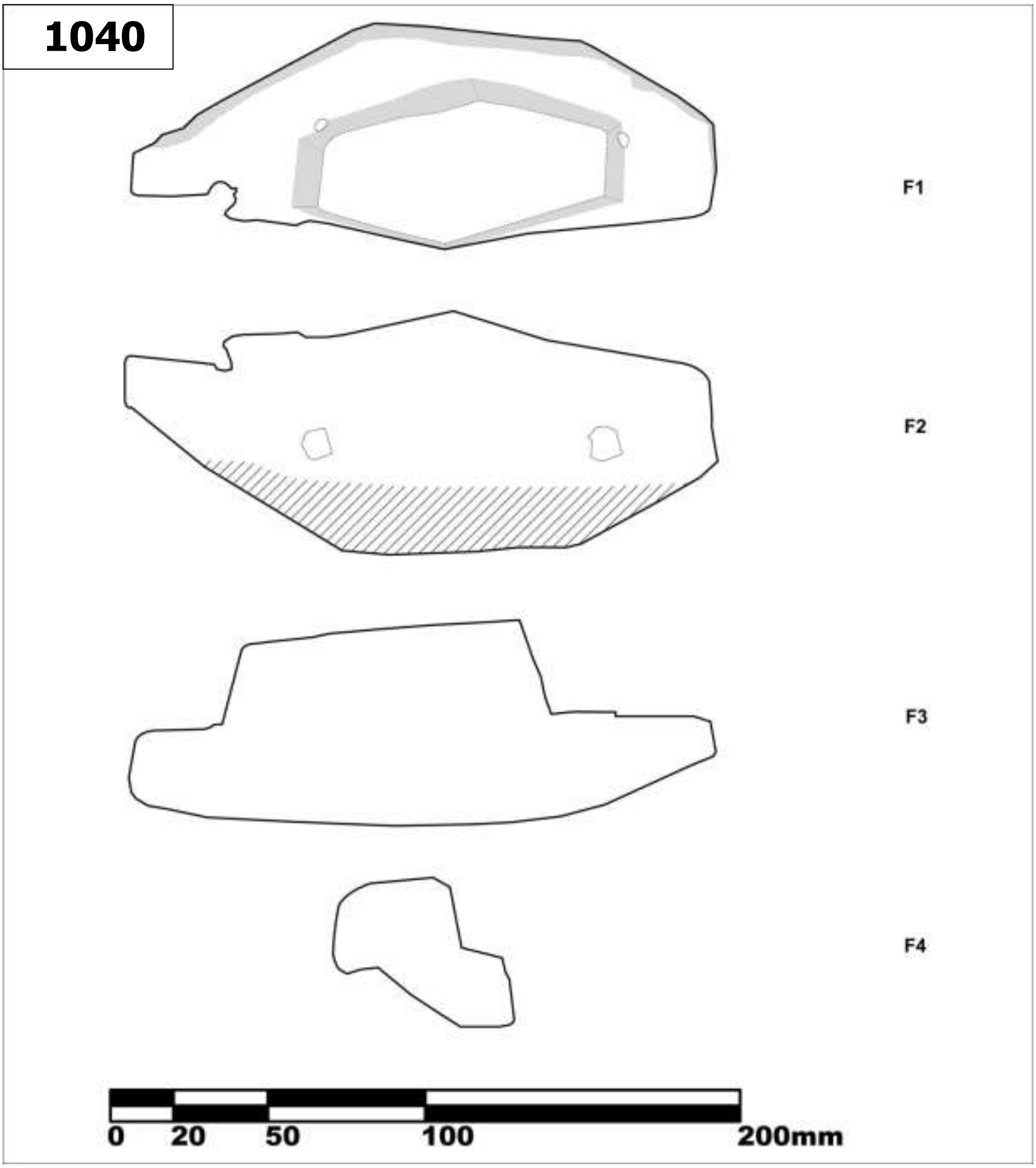
MARKS AND COATINGS:

2 holes observed. Square tack holes: 9 x 9mm, 9 x 9mm. Diameter on F1 = 4mm, 8mm. Horizontal spacing = 84mm.

COMMENTS:

The timber has a trapezoidal shape with a raised portion in the middle. The raised portion is also trapezoidal, 84mm long, 70mm wide and has a height between 26mm to 32mm. There is also a round hole on one of its edge and 2 round holes on the surface of Face 1. Face 2 has two square holes which are related to the 2 round holes on Face 1.

1040


1040
F1
F2
F3
F4
0
20
50
100
200mm

SHAH MUNCHER **TIMBER RECORD**			**REGISTRATION NO:** PB2-D8-B034-1045
DATE:	**CATALOGUER:**		**FUNCTION:**
21 Nov 2021	Michael Ng		Plank
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is fair as edges seemed to be worn and have broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	507		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	77.5		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	23		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

3 extant tacks with missing heads. Dimensions of 2 tacks: 6mm, 5mm, 5.6mm.

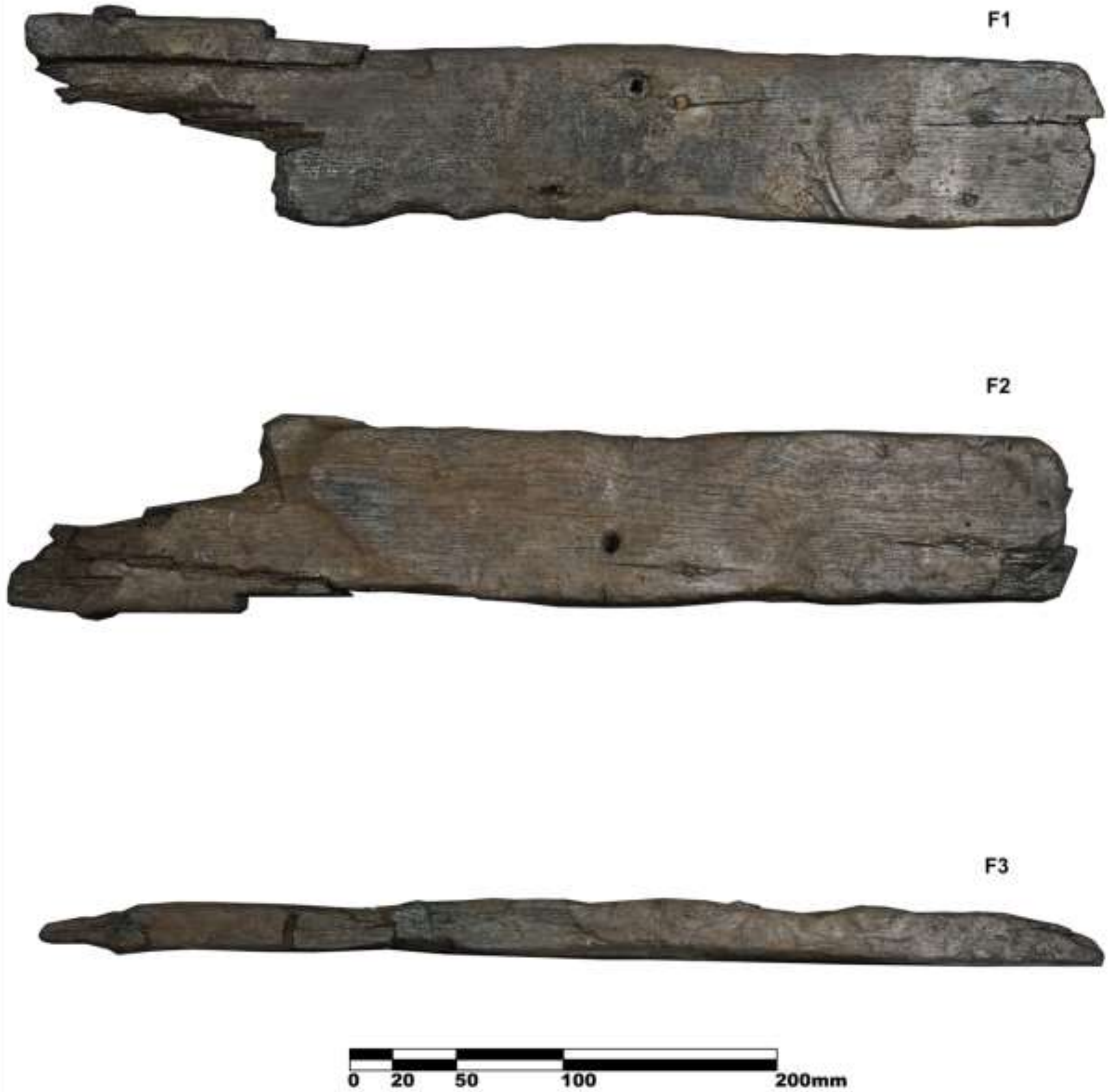
MARKS AND COATINGS:

4 holes observed. Circular hole impression = 11mm. Vertical spacing = 34mm, Horizontal spacing = 155mm, 188mm. Tack hole dimensions: 5 X 6mm, 5 X 7mm, 4 X 9mm, 6 X 6mm.

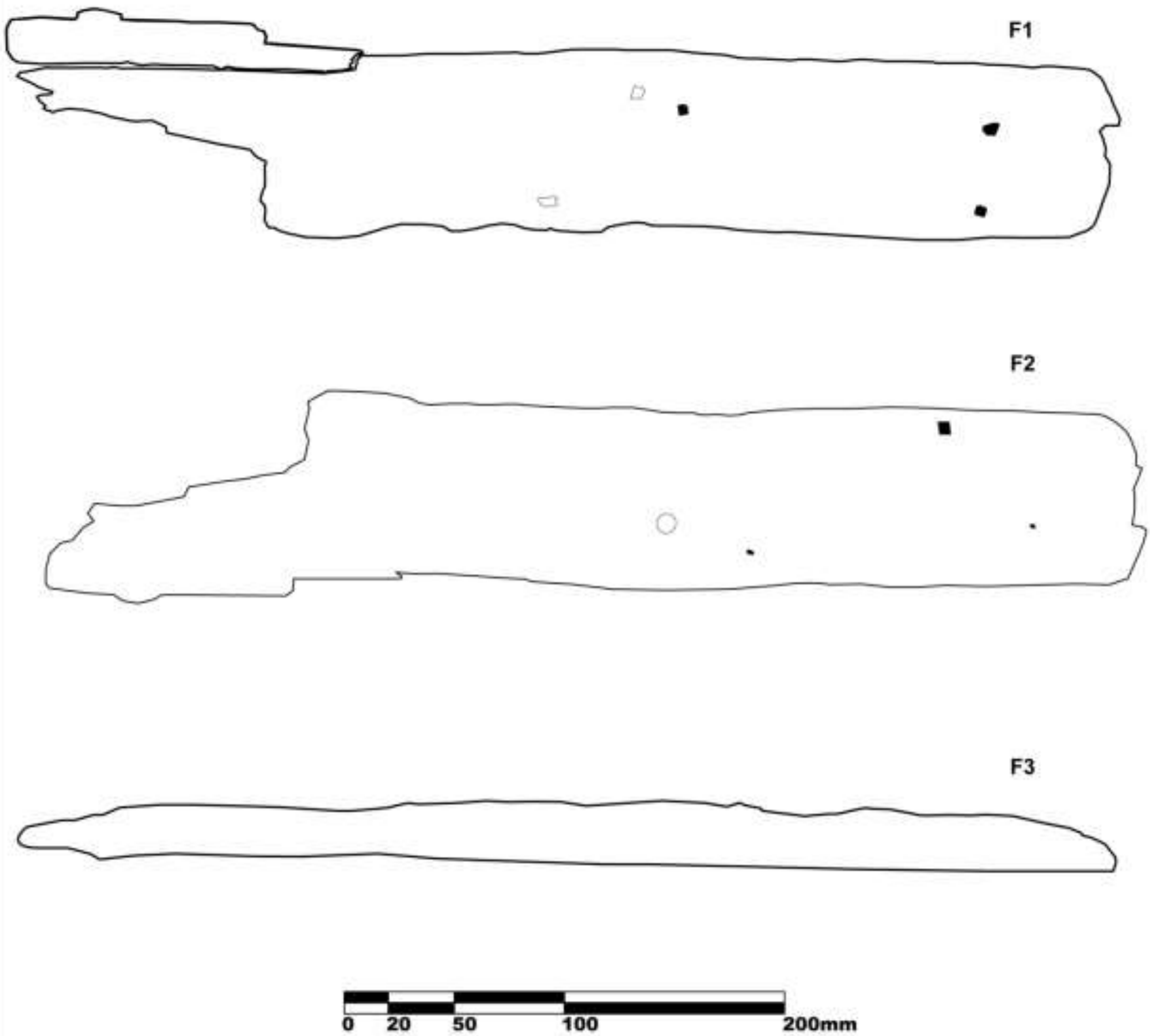
COMMENTS:

It has three extant tacks with missing head which seem to have some indications of alignment. In additional, a square hole with a circular impression was observed. The extant tacks can also be observed on Face 2. Face 2 also have a round hole.

1045



1045



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B087-1048
DATE:	**CATALOGUER:**		**FUNCTION:**
21 Nov 2021	Michael Ng		Plank
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber condition is fair as edges seemed to be worn and have broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	490			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	73			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	25			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

1 extant tack. Tack head diameter = 11mm.

MARKS AND COATINGS:

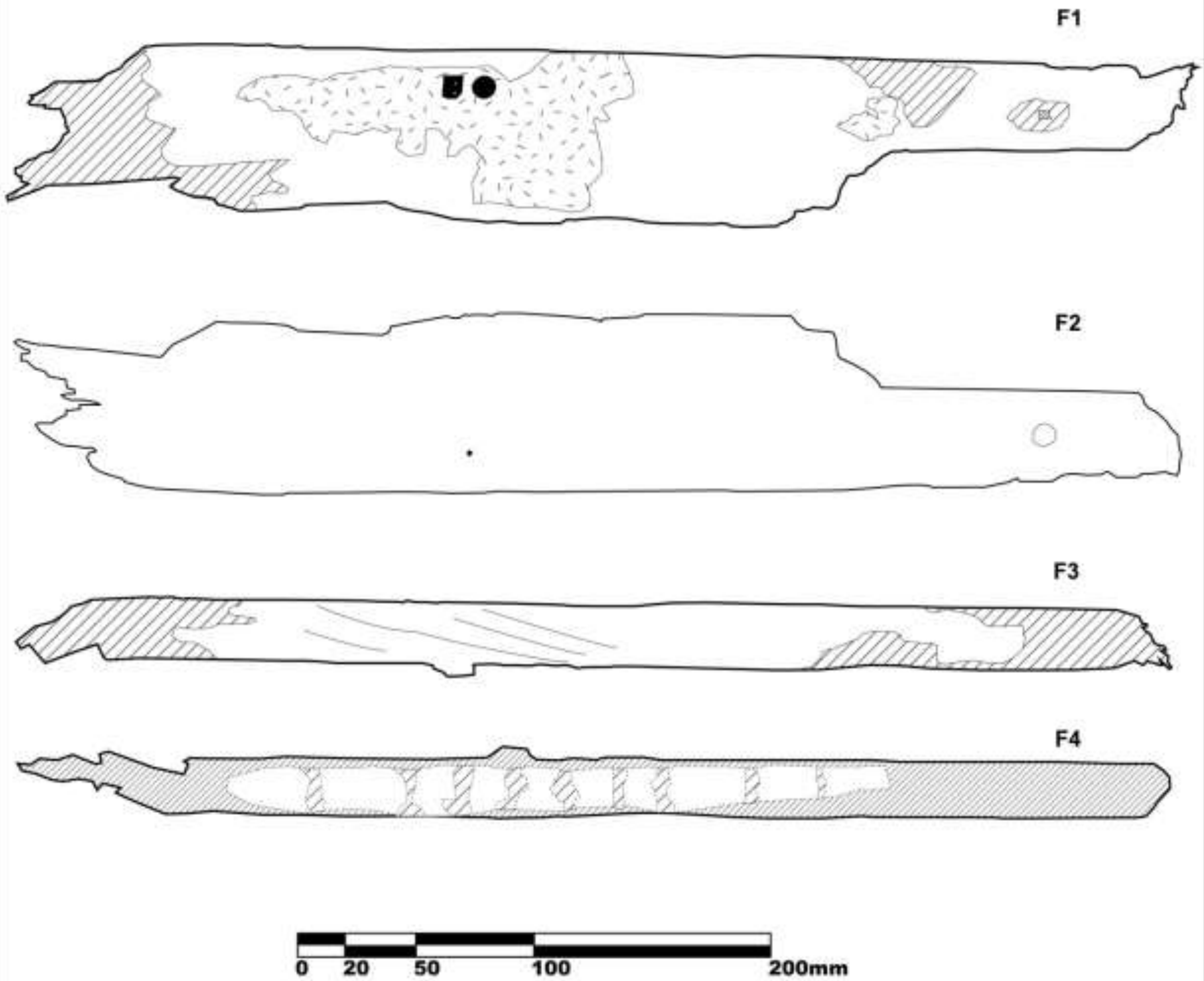
One of the edges on the timber exhibited nine notches which were approximately 4mm wide and spaced 20mm apart.

COMMENTS:

It also have two broken ends. A rectangular depression, an extant tack with a round head, and a metal piece with two holes were found on Face 1. A round hole on Face 2 could be an related to the rectangular depression on Face 1.

1048

1048



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D10-B103-1050
DATE:	**CATALOGUER:**		**FUNCTION:**
21 Nov 2021	Michael Ng		Plank
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	524		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	56		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	20		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Face 2 has a extant tack without a head. Tack dimension: 4 x 4mm.

MARKS AND COATINGS:

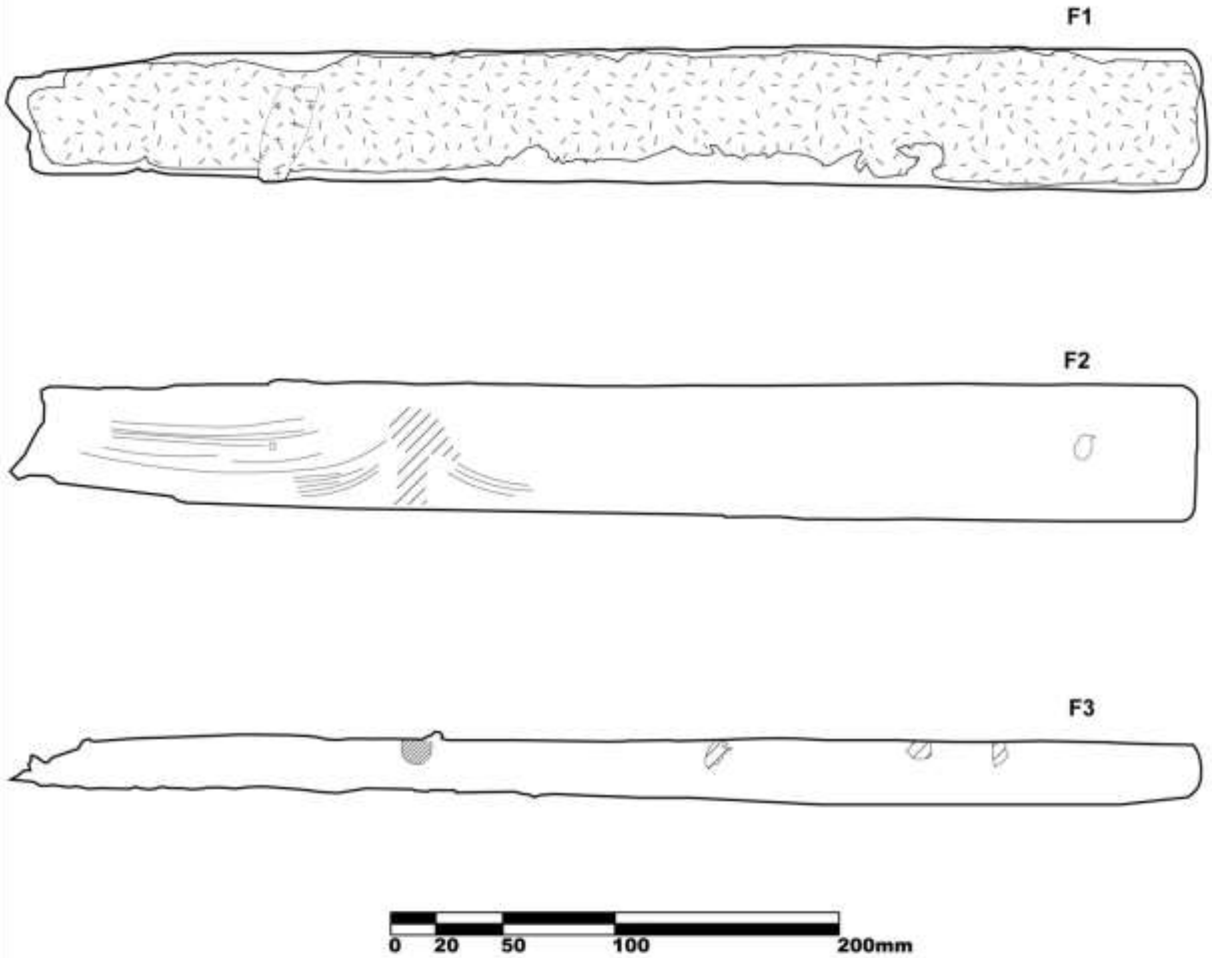
Tack hole diameter: 7mm, There are visible traces of metal encrustation observed on Face 1. A knot on the timber can be observed on this face. Face 3 has faint impressions of notches which could not be confirmed. Spacing between the two holes is 280mm.

COMMENTS:

All sides are complete except for one broken end.

1050

1050



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-D9-B105-1056
DATE:	**CATALOGUER:**		**FUNCTION:**
21 Nov 2021	Michael Ng		Plank fragment
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is fair as all sides seemed to be worn down. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	524		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	56		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	20		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

1 extant tack. Tack head diameter = 10.4mm.

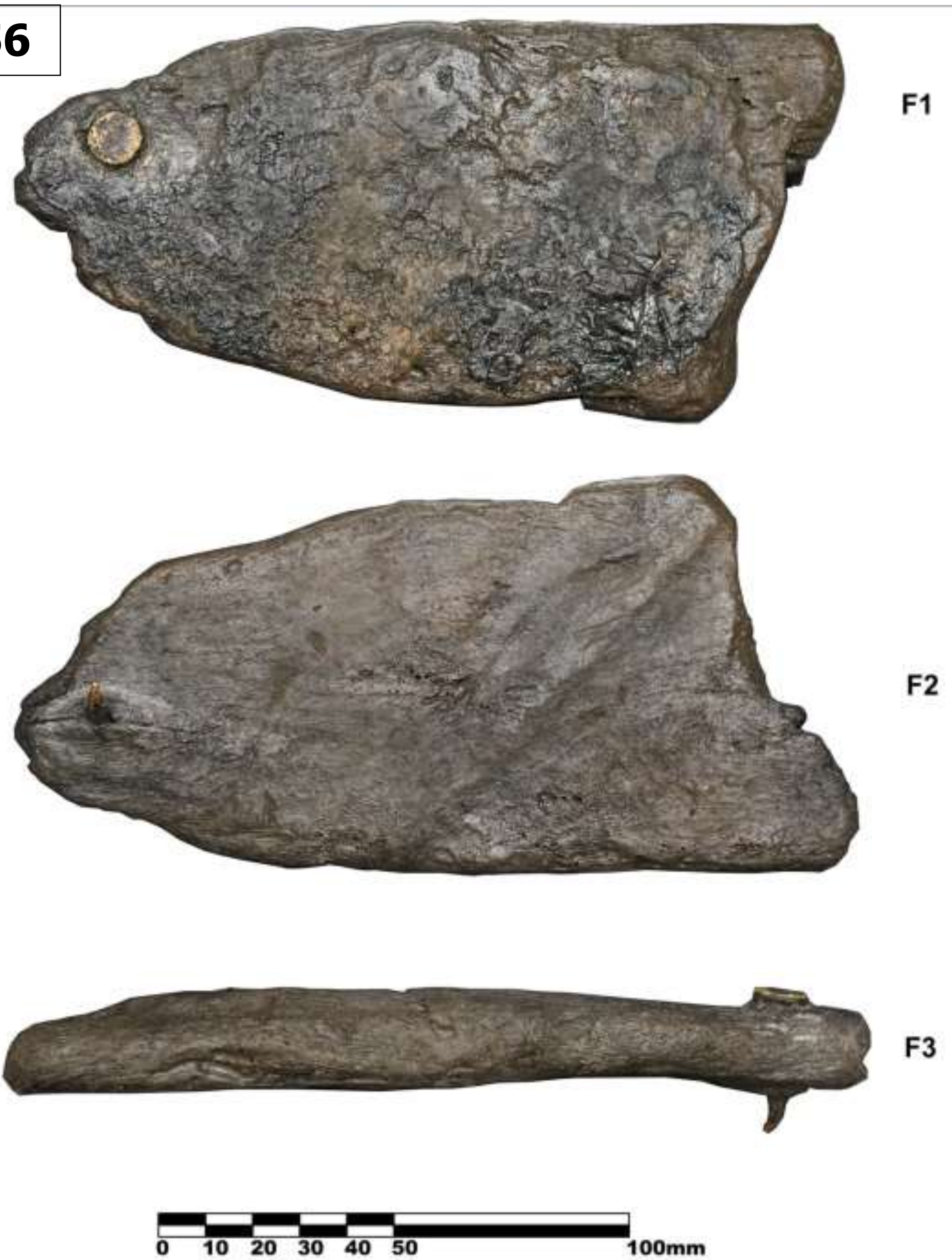
MARKS AND COATINGS:

Tack hole dimension: 3 x 3mm,

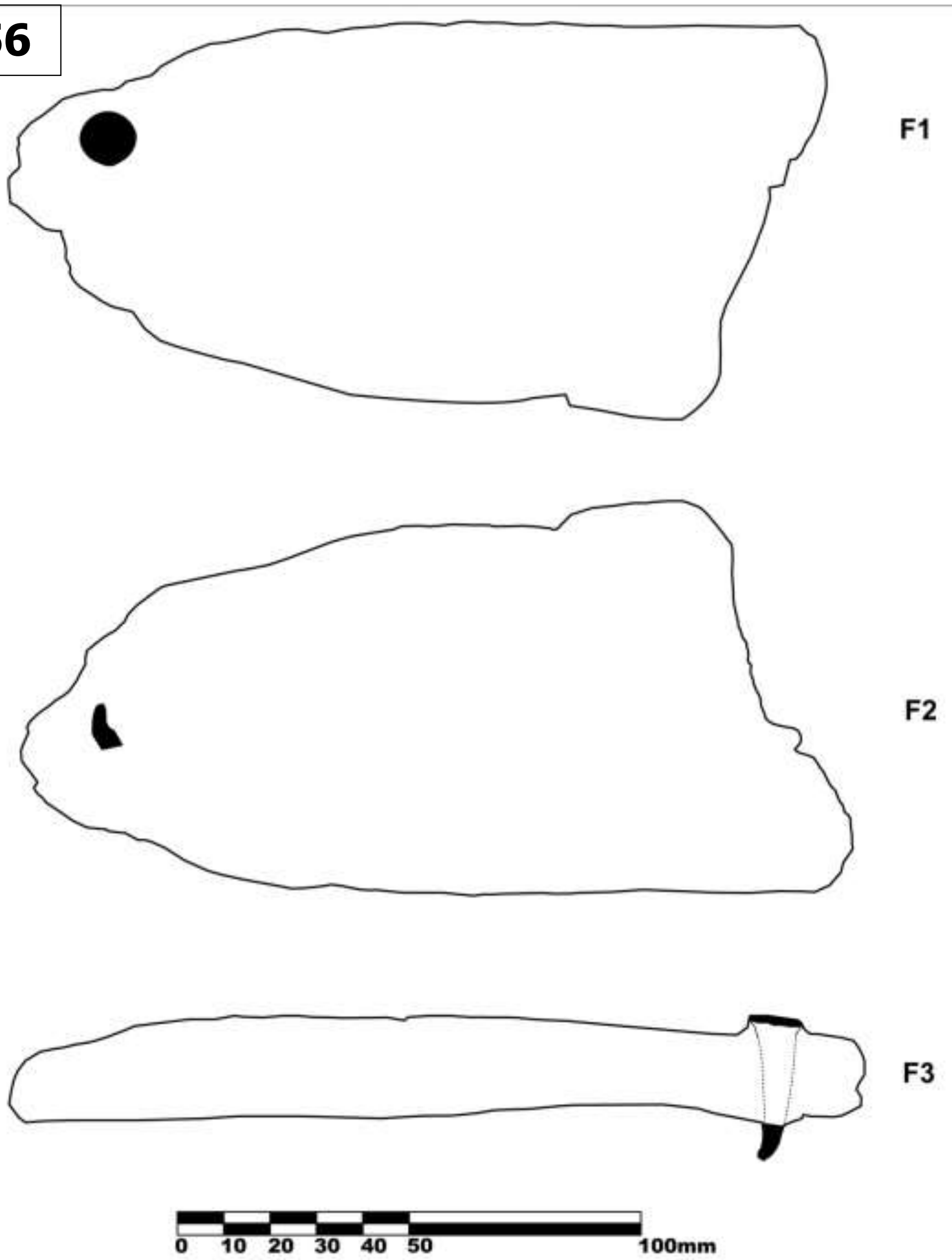
COMMENTS:

It has one extant round head tack on one of the ends of the timber.

1056



1056



SHAH MUNCHER TIMBER RECORD			REGISTRATION NO: PB2-D9-B074-1067
DATE:	**CATALOGUER:**		**FUNCTION:**
22 Nov 2021	Michael Ng		Rigging sheave
MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**	**CONVERSION:**
Timber condition is good but it has two broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain* ☒	*Whole* ☐
	92.5		*Halved* ☐
	Width (mm):	*Sapwood* ☐	*Quartered* ☐
	34		*Tangential* ☐
	Thickness (mm):	*Bark* ☐	*Radial* ☐
	31		*Uncertain* ☒

JOINERY:

Nil

FASTENINGS:

Nil

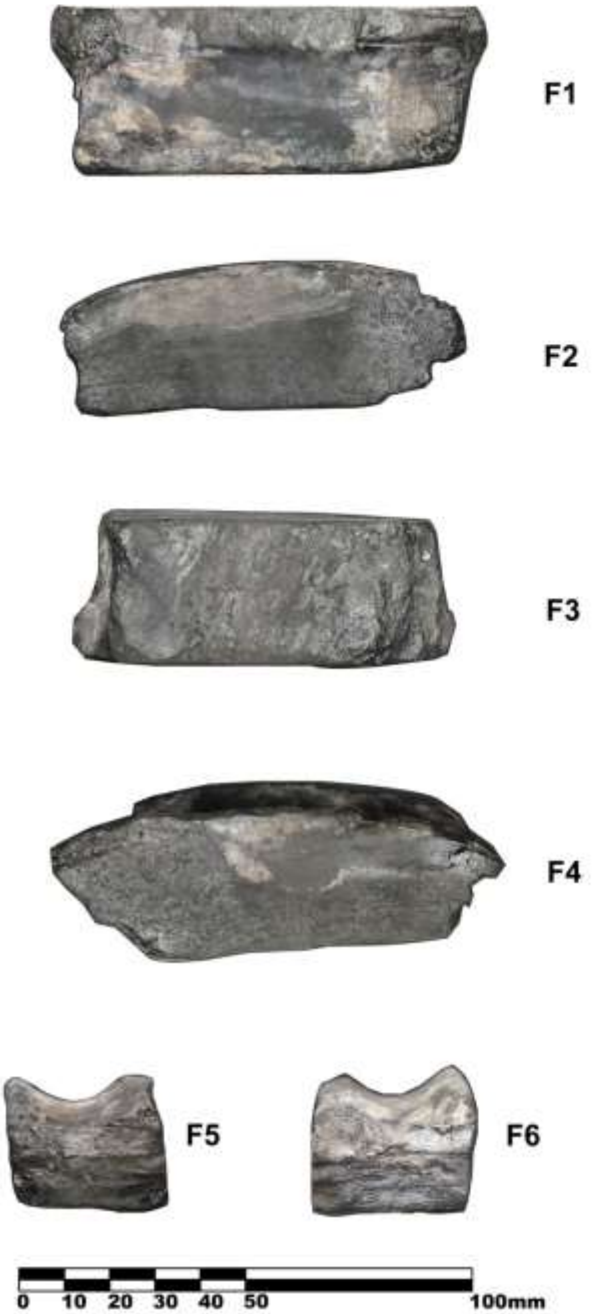
MARKS AND COATINGS:

There is a noticeable concave groove in the middle of timber.

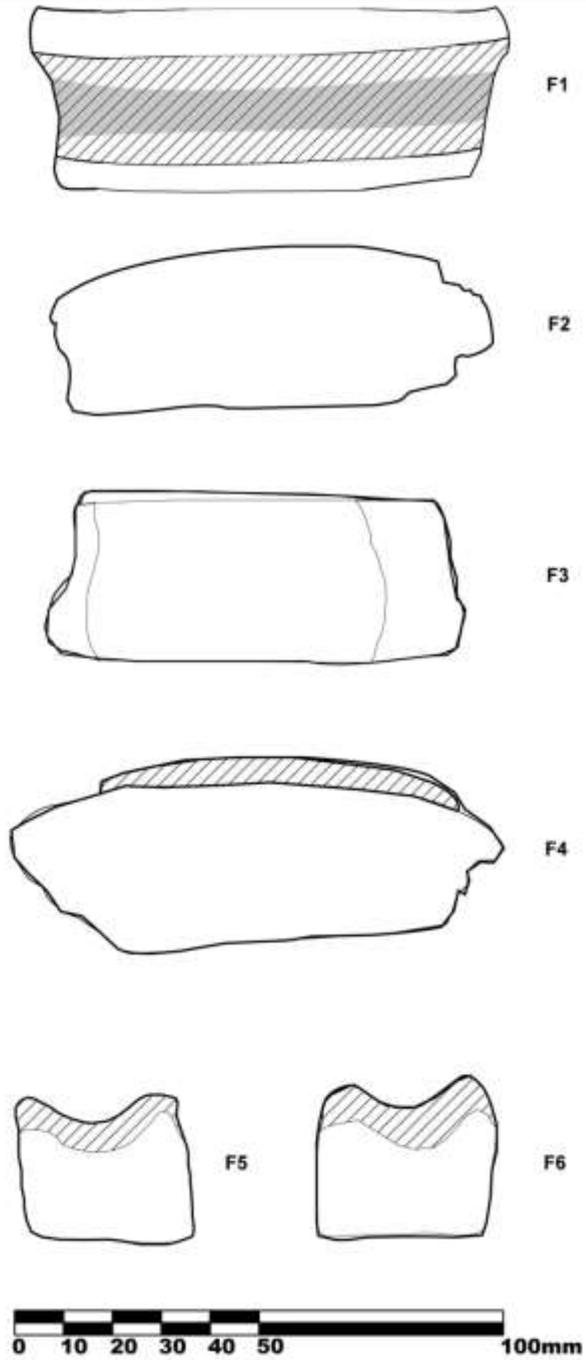
COMMENTS:

Nil

1067



1067



***SHAH MUNCHER* TIMBER RECORD**			**REGISTRATION NO:** PB2-E8-B058-1069
DATE:	**CATALOGUER:**		**FUNCTION:**
22 Nov 2021	Michael Ng		Unidentified timber

MAX. DIMENSION:	**DRAWING:**	**PHOTOS:**	**SAMPLES:**
	Yes	**Yes**	**-**

CONDITION:	**DIMENSIONS:**	**WOOD TYPE:**		**CONVERSION:**	
Timber condition is good but it has two broken ends. Waterlogged, impregnated with 10% peg, +0.05% biocide.	*Length (mm):*	*Uncertain*	☒	*Whole*	☐
	182			*Halved*	☐
	Width (mm):	*Sapwood*	☐	*Quartered*	☐
	25			*Tangential*	☐
	Thickness (mm):	*Bark*	☐	*Radial*	☐
	26			*Uncertain*	☒

JOINERY:

Nil

FASTENINGS:

1 extant tack – 4 x 4mm

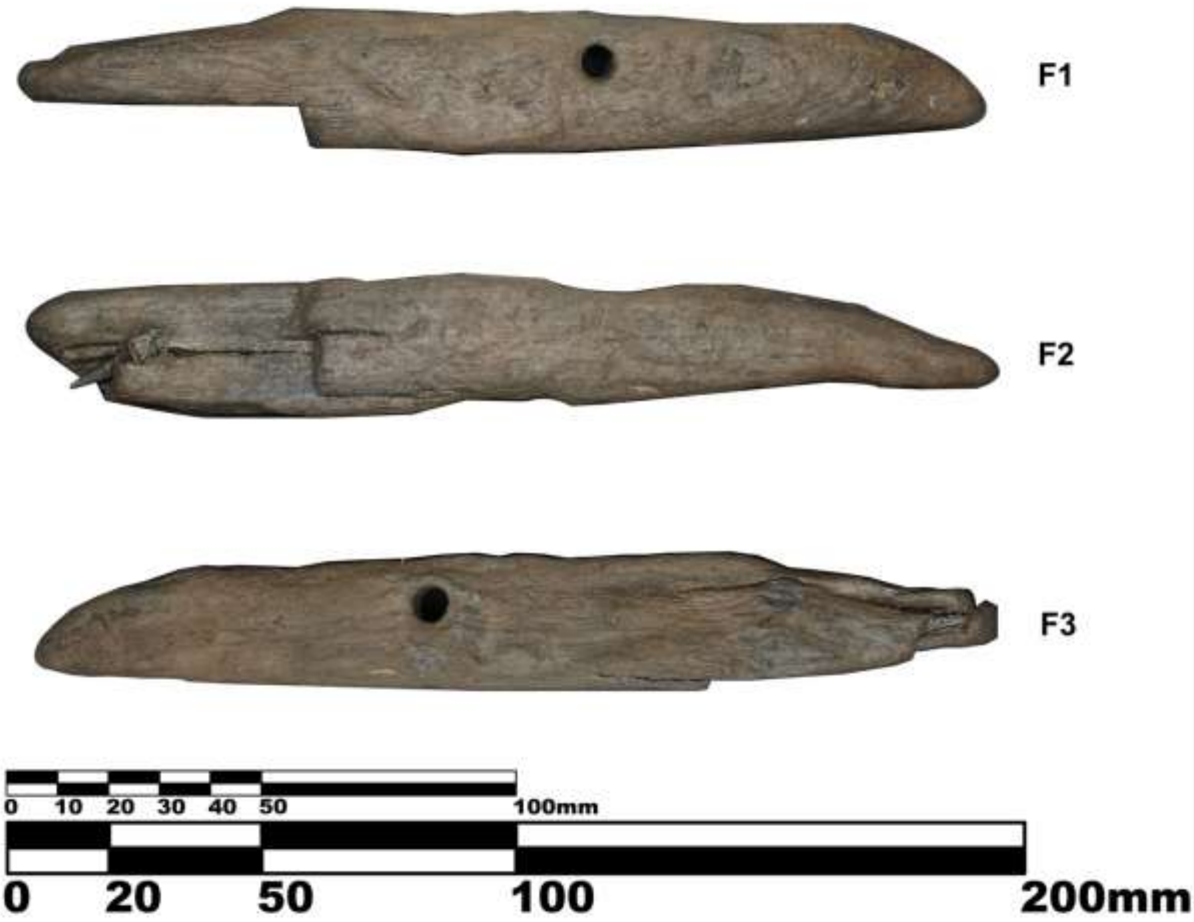
MARKS AND COATINGS:

One tack hole, diameter: 8mm

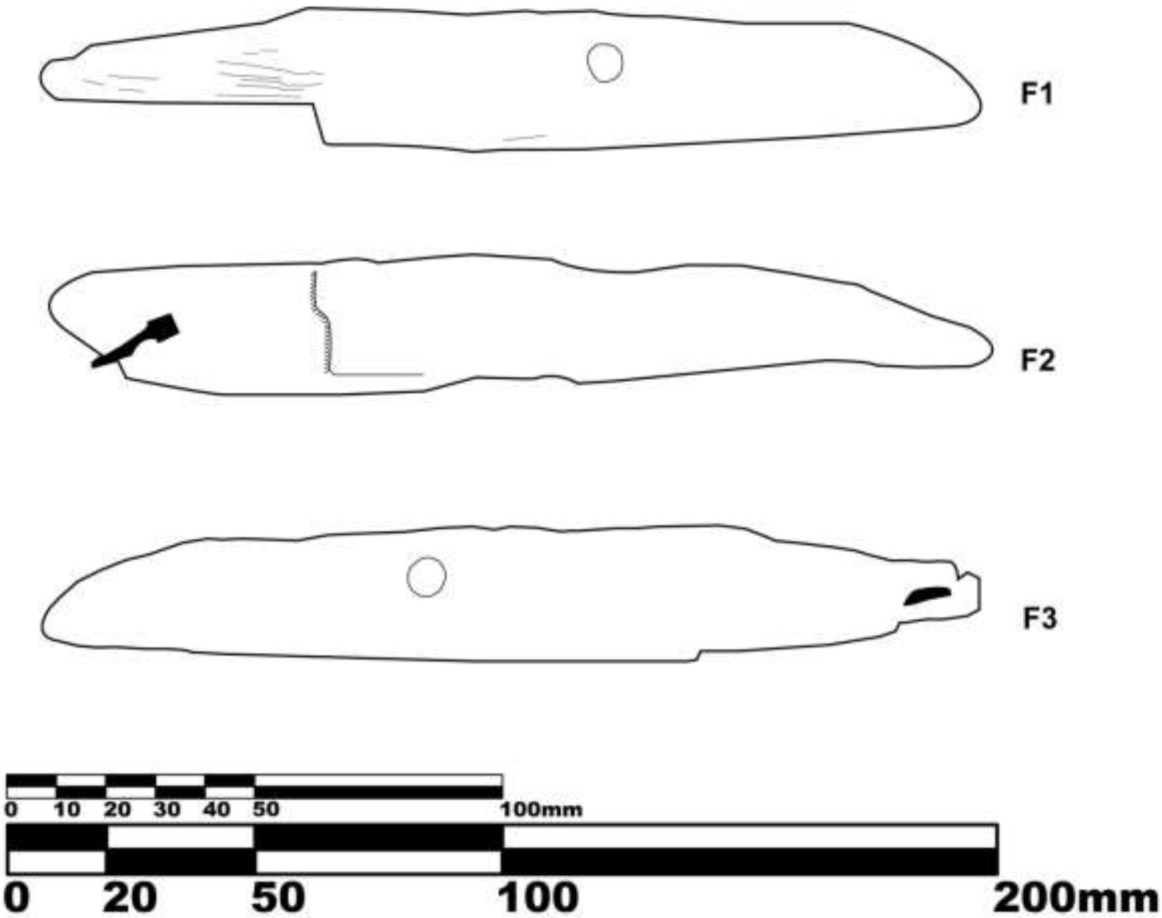
COMMENTS:

Nil

1069



1069



APPENDIX 2: WOOD SPECIES ANALYSIS REPORT

WOOD IDENTIFICATION REPORT

For Wood Analysis – Suspected species

S/N	ARTEFACT NUMBER	SUSPECTED PART	SUSPECTED SPECIES	OBSERVATION RESULT
1.	949	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
2.	950	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
3.	959	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
4.	963	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
5.	964	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
6.	965	Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis (?)* *Different at cross section*
7.	904	?Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
8.	906	?Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
9.	953	Sacrificial Timber	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
10.	956	Sacrificial Timber	*Tectona Grandis*	*Difficult to observe*
11.	971	Sacrificial Timber	*Tectona Grandis*	*LEGUMINOSAE (CAESALPINIOIDEAE)- Cassia* sp.
12.	972+974	Sacrificial Timber	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
13.	980	Sacrificial Timber	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
14.	983	Sacrificial Timber	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
15.	1067	Rigging Sheave	*Lignum Vitae*	ZYGOPHYLLACEAE - *Guaiacum officinale L.* (COMMONER LIGNUM VITAE, GUAYACÁN/ *Guaiacum sanctum L.* (HOLYWOOD LIGNUM VITAE, LIGNUM VITAE)
16.	901+903	?Stowage	*Cunninghamia*	*LAMIACEAE - Tectona grandis*
17.	945 (WS)	?Structural	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
18.	985 (WS)	?Structural/ Stowage	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
19.	1018 (WS)	?	?	PINACEAE - *Pinus* sp. https://insidewood.lib.ncsu.edu/results?23)
20.	1026 (WS)	?	?	*LAMIACEAE - Tectona grandis*
21.	1038 (WS)	?	?	PINACEAE - *Pinus* sp. https://insidewood.lib.ncsu.edu/results?23)
22.	1045	?Stowage	*Cunninghamia*	*LAMIACEAE - Tectona grandis*

S/N	ARTEFACT NUMBER	SUSPECTED PART	SUSPECTED SPECIES	OBSERVATION RESULT
23.	1048	?Stowage	*Cunninghamia*	*LAMIACEAE - Tectona grandis*
24.	1050	?Stowage	*Cunninghamia*	*LAMIACEAE - Tectona grandis*
25.	1051	?Structural/ Stowage	*Tectona Grandis*	Difficult to observe
26.	1056	?Structural/ Stowage	*Tectona Grandis*	*LAMIACEAE - Tectona grandis*
27.	1069	?Structural/ Stowage	*Tectona Grandis*	Difficult to observe

Other Possible wood:

1. *Eusideroxylon zwageri: No*
2. *Cedrus deodara: No*
3. *Shorea robusta: No*
4. *Quercus spp: No*
5. *Lagerstroemia: No*
6. *Cunninghamia: No*

Lagerstroemia

Has similarity with Tectona grandis mainly in features:

1 Growth ring boundaries distinct

4 Wood semi-ring-porous

13 Simple perforation plates

22 Intervessel pits alternate

56 Tyloses common

61 Fibres with simple to minutely bordered pits

65 Septate fibres present

69 Fibres thin- to thick-walled

86v Axial parenchyma in narrow bands or lines up to three cells wide

89 Axial parenchyma in marginal or in seemingly marginal bands

92 Four (3-4) cells per parenchyma strand
93 Eight (5-8) cells per parenchyma strand
97 Ray width 1 to 3 cells

104 All ray cells procumbent

168 Central South Asia (Brazier and Franklin region 75)
169 India, Pakistan, Sri Lanka

170 Burma
171 Southeast Asia and Pacific (Brazier and Franklin region 76)
172 Thailand, Laos, Vietnam, Cambodia (Indochina)
173 Indomalesia: Indonesia, Philippines, Malaysia, Brunei, Papua, New Guinea, and Solomon Islands
189 Tree

However, Tectona grandis does not have:

31 Vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular
32 Vessel-ray pits with much reduced borders to apparently simple: pits horizontal (scalariform, gash-like) to vertical (palisade)
80 Axial parenchyma aliform
81 Axial parenchyma lozenge-aliform
82 Axial parenchyma winged-aliform
83 Axial parenchyma confluent
85v Axial parenchyma bands more than three cells wide

136 Prismatic crystals present
142 Prismatic crystals in chambered axial parenchyma cells
143 Prismatic crystals in fibres

While the presence of crystal were not found in the specimens, therefore, the artefacts were more similar to Tectona grandis.

Identification Results: **LAMIACEAE *Tectona grandis* L.** (TEAK, TECK DU TOGO)	
IAWA* Codes	Descriptions
1	Growth ring boundaries distinct
3v	Wood ring-porous
4	Wood semi-ring-porous
5v	Wood diffuse-porous
13	Simple perforation plates
22	Intervessel pits alternate
23v	Shape of alternate pits polygonal
25	Small - 4 - 7 µm
26	Medium - 7 - 10 µm
30	Vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell
42	100 - 200 µm
43v	>= 200 µm
47	5 - 20 vessels per square millimetre
52	<= 350 µm
53	350 - 800 µm
56	Tyloses common
58	Gums and other deposits in heartwood vessels
61	Fibres with simple to minutely bordered pits
65v	Septate fibres present
66	Non-septate fibres present
69	Fibres thin- to thick-walled
71	<= 900 µm
72	900-1600 µm
78	Axial parenchyma scanty paratracheal
79	Axial parenchyma vasicentric
89	Axial parenchyma in marginal or in seemingly marginal bands
92	Four (3-4) cells per parenchyma strand
93	Eight (5-8) cells per parenchyma strand
97	Ray width 1 to 3 cells
98v	Larger rays commonly 4 - to 10 seriate
104	All ray cells procumbent
106v	Body ray cells procumbent with one row of upright and / or square marginal cells
115	4-12 / mm
163v	Vitreous silica
168	Central South Asia (Brazier and Franklin region 75)
169	India, Pakistan, Sri Lanka
170	Burma
171	Southeast Asia and Pacific (Brazier and Franklin region 76)
172	Thailand, Laos, Vietnam, Cambodia (Indochina)
189	Tree
192	Wood of commercial importance
194	Basic specific gravity medium, 0.40-0.75
196	Heartwood colour darker than sapwood colour
197	Heartwood basically brown or shades of brown
201	Heartwood with streaks

203	Distinct odour

* *International Association of Wood Anatomists* (IAWA) (Wheeler, Baas, & Gasson, 1989)

Habitat: areas of monsoon climate under a wide range of site conditions (www.unep-wcmc.org/)

Height: to 30 m or more (AgroForestryTree Database)

Region: occurs naturally in Cambodia, India, north-west Laos, Myanmar, north Thailand & Vietnam

Cultivated: widely cultivated in the tropics

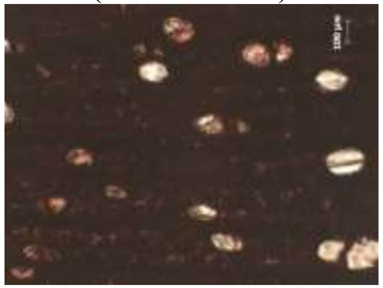
References:

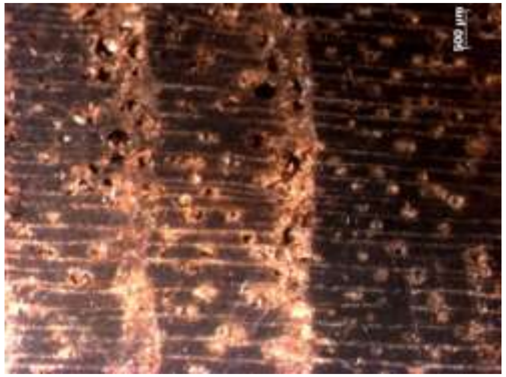
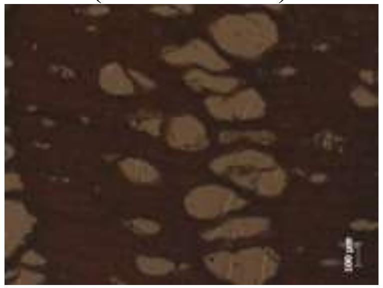
Kribs, D.A. 1968. Commercial foreign woods on the American market. Dover Publications, New York.

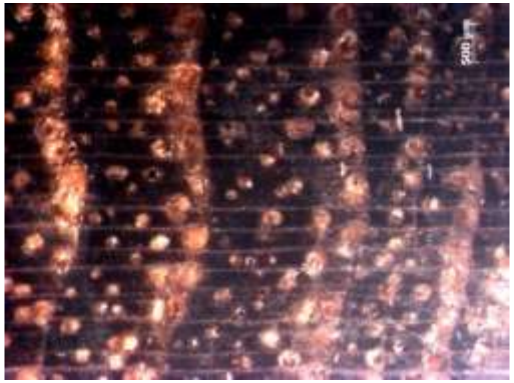
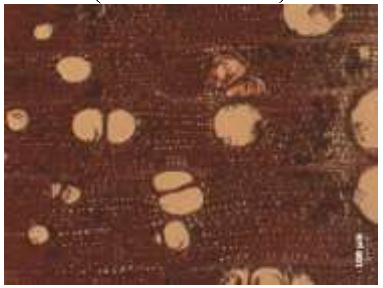
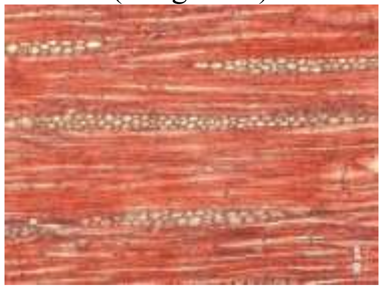
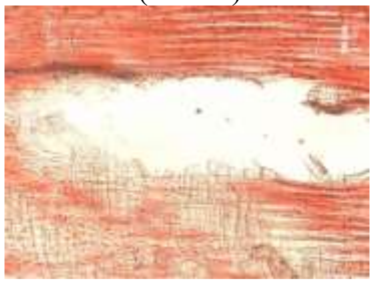
Louppe, D., 2005. Tectona grandis L.f. [Internet] Record from Protabase. Louppe, D., Oteng-Amoako, A.A. & Brink, M. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l¿Afrique tropicale), Wageningen, Netherlands.

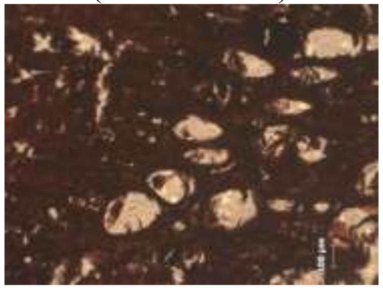
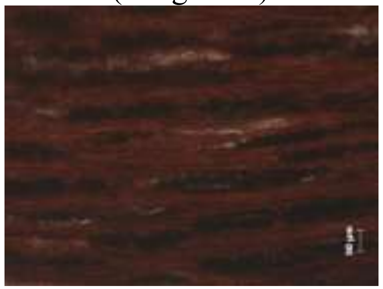
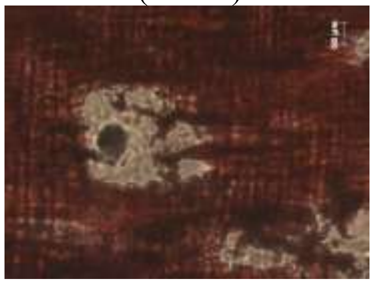
Normand, D. & J. Paquis. 1976. Manuel d¿identification des bois commerciaux. Tome 2. Afrique guineo-congolaise. Centre Technique Forestier Tropical, Nogent s/Marne, 335 pp.

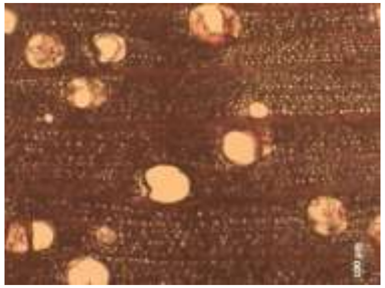
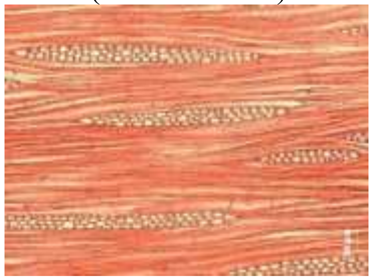
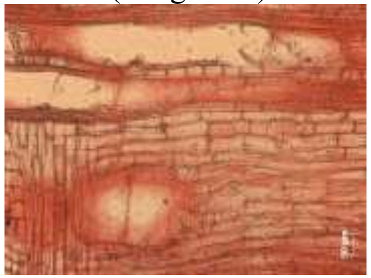
Pearson, R.S. & H.P. Brown. 1932. Commercial Timbers of India. Their Distribution, Supplies, Anatomical Structure, Physical and Mechanical Properties and Uses. Volume I. Government of India, Central Publication Branch, Calcutta, 548 pp.

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
1.	903		(Cross Section)  (Tangential)  (Radial) 	5, 13, 30, 56, 65, 69, 104	Teak (*Tectona grandis* Linn.f)

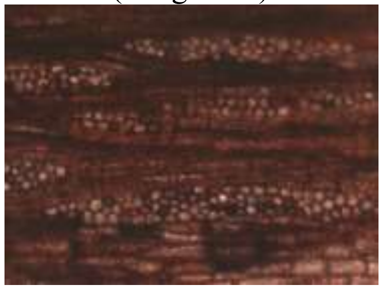
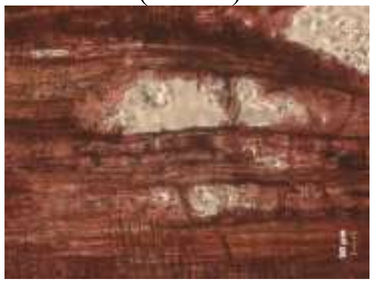
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
2.	904		(Cross Section)  (Tangential)  (Radial) 	1, 5, 13, 22, 30, 56, 79, 97,98, 104 Very close/narrow growth ring	Teak (*Tectona grandis* Linn.f)

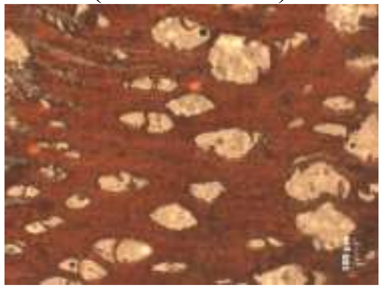
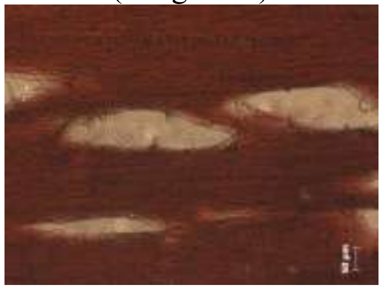
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
3.	906		(Cross Section)  (Tangential)  (Radial) 	1,5,13,22,30,56,65,89,92, 93,97,104 The most clear growth ring (normal)	Teak (*Tectona grandis* Linn.f)

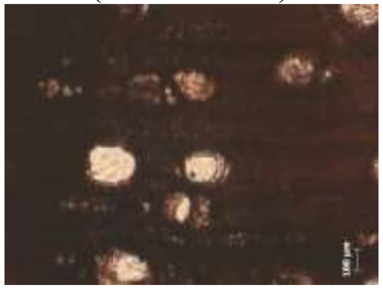
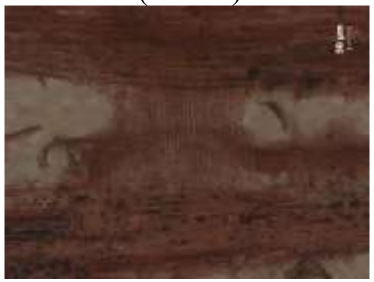
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
4.	945		(Cross Section)  (Tangential)  (Radial) 	1,5,13,56,65,97,98,104,106 Knots	Teak (*Tectona grandis* Linn.f)

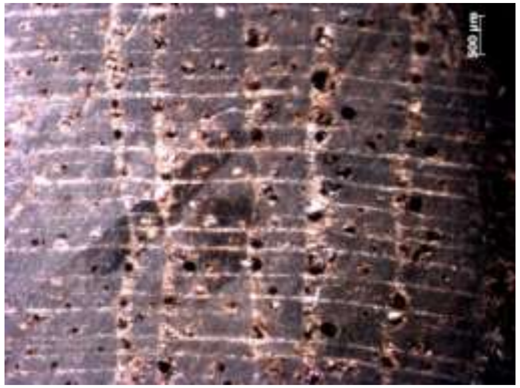
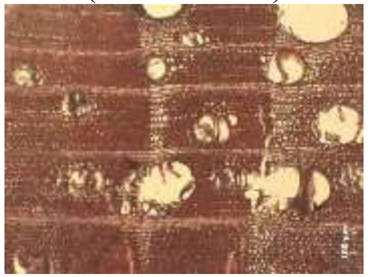
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
5.	949		 (Cross Section)  (Tangential)  (Radial)	1,4,5,30,56,65,97,98, 93,104 Normal	Teak (*Tectona grandis* Linn.f)

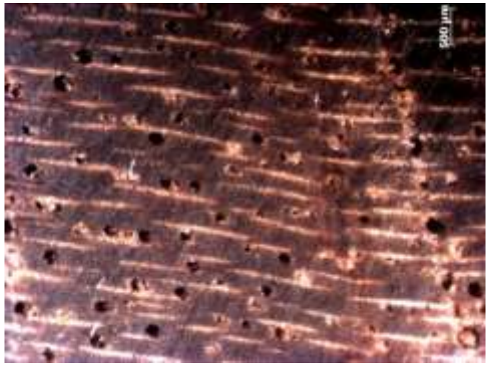
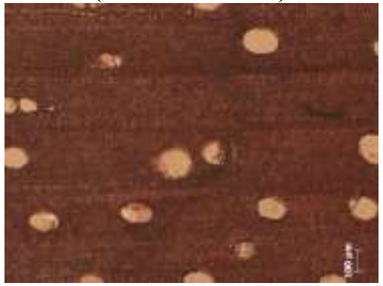
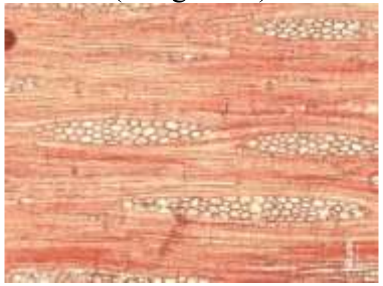
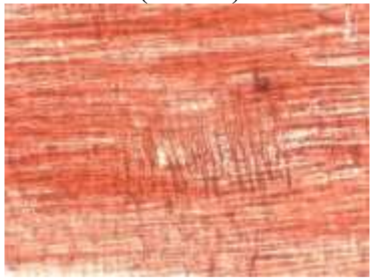
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
6.	950-1		(Cross Section)  (Tangential)  (Radial) 	104 Knot	Teak (*Tectona grandis* Linn.f)

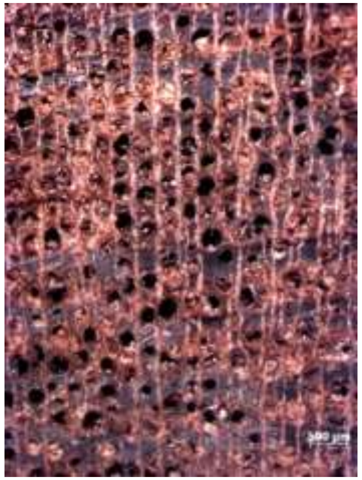
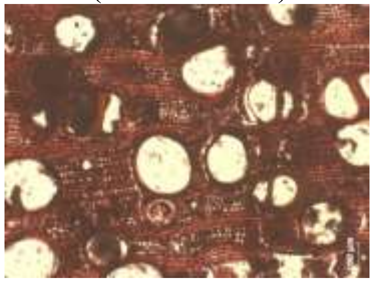
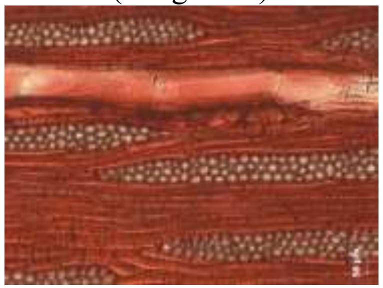
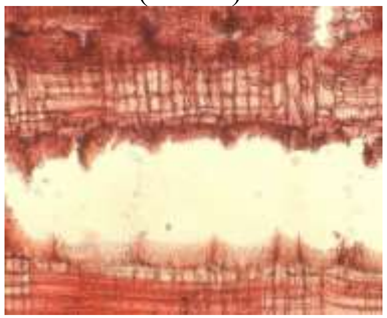
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
7.	950-2		(Cross Section)  (Tangential)  (Radial) 	1, 4,13,22, 56, 69,79,89,104,106 Narrow growth ring	Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
8.	956		(Cross Section)  (Tangential)  (Radial) 	1,4,5,13,22,31,56, 97,104 Twisted, black deposit (hypa?)	

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
9.	959		(Cross Section)  (Tangential)  (Radial) 	1,4,5,13,56,65 97,98,104	Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
10.	963		(Cross Section)  (Tangential)  (Radial) 	1,4,5,65,97,98,106 Twisted	Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
11.	965		(Cross Section)  (Tangential)  (Radial) 	65,97,98,104	

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
12.	971		(Cross Section)  (Tangential)  (Radial) 	1,30,42,43,58,61,65,69,70,85,97,98,104,120	*Cassia* sp. – Leguminosae (Caesalpiniodeae) Example 1: 1v Growth ring boundaries distinct 2 Growth ring boundaries indistinct or absent 5 Wood diffuse-porous 13 Simple perforation plates 22 Intervessel pits alternate 23 Shape of alternate pits polygonal 26 Medium - 7 - 10 µm 29 Vestured pits 30 Vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell 42 100 - 200 µm 43v >= 200 µm 46 <= 5 vessels per square millimetre 58 Gums and other deposits in heartwood vessels 61 Fibres with simple to minutely bordered pits

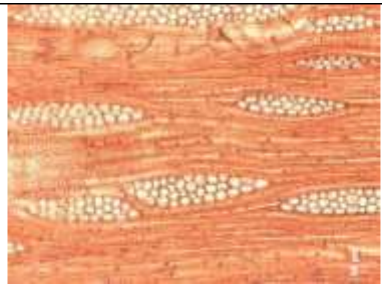
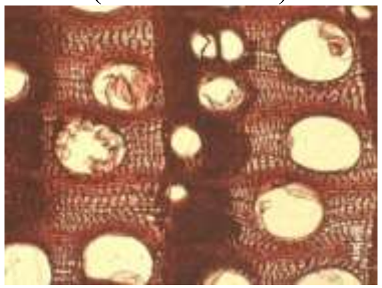
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					65 Septate fibres present 66 Non-septate fibres present 69 Fibres thin- to thick-walled 70 Fibres very thick-walled 76v Axial parenchyma diffuse 80 Axial parenchyma aliform 83 Axial parenchyma confluent 85v Axial parenchyma bands more than three cells wide 89 Axial parenchyma in marginal or in seemingly marginal bands 91 Two cells per parenchyma strand 92 Four (3-4) cells per parenchyma strand 97 Ray width 1 to 3 cells 104 All ray cells procumbent 115 4-12 / mm 116 >= 12 /mm 120v Axial parenchyma and / or vessel elements storied 122v Rays and / or axial

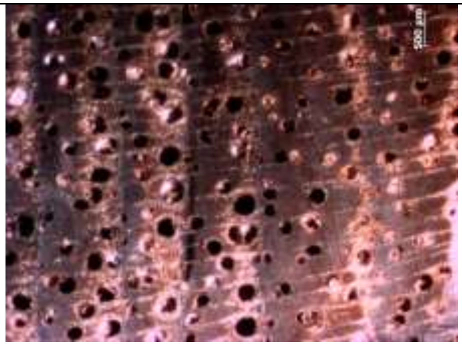
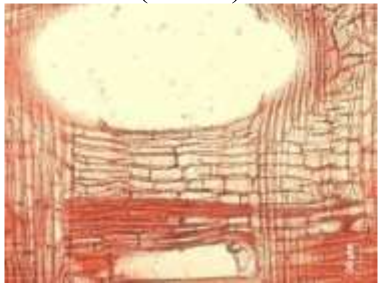
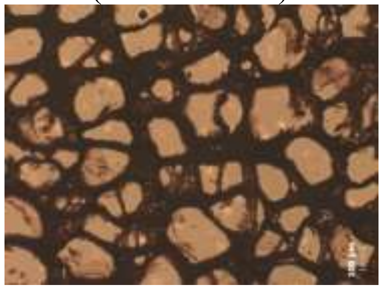
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					elements irregularly storied 136 Prismatic crystals present 142 Prismatic crystals in chambered axial parenchyma cells 171 Southeast Asia andPacific (Brazier and Franklinregion 76) 172 Thailand, Laos, Vietnam, Cambodia (Indochina) 173 Indomalesia: Indonesia, Philippines, Malaysia, Brunei, Papua, New Guinea, and Solomon Islands 189 Tree 192v Wood of commercial importance 194 Basic specific gravity medium, 0.40-0.75 195 Basic specific gravity high, >= 0.75 196 Heartwood colour darker than sapwood colour 198 Heartwood basically red or shades of red 202 Heartwood not as above

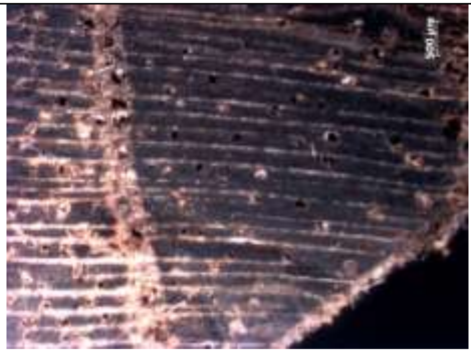
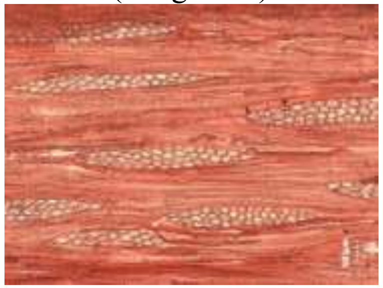
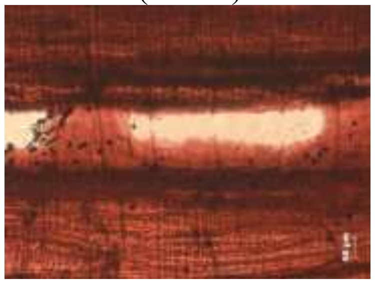
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					Example 2: 2 Growth ring boundaries indistinct or absent 5 Wood diffuse-porous 13 Simple perforation plates 22 Intervessel pits alternate 23? Shape of alternate pits polygonal 26 Medium - 7 - 10 µm 27 Large - >= 10 µm 29 Vestured pits 30 Vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell 42 100 - 200 µm 43 >= 200 µm 46 <= 5 vessels per square millimetre 47 5 - 20 vessels per square millimetre 52? <= 350 µm 53? 350 - 800 µm 61 Fibres with simple to minutely bordered pits 66 Non-septate fibres present

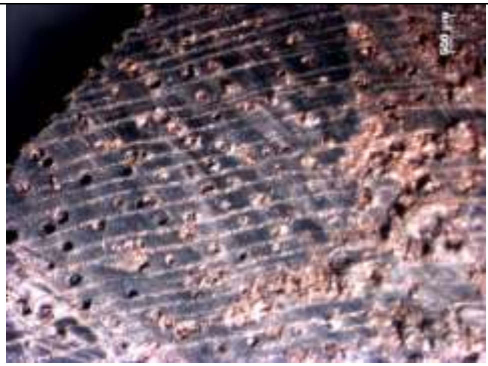
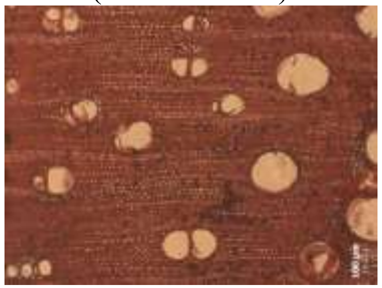
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					70 Fibres very thick-walled 71? <= 900 µm 72? 900-1600 µm 73? >= 1600 µm 80 Axial parenchyma aliform 81 Axial parenchyma lozenge-aliform 83 Axial parenchyma confluent 89v Axial parenchyma in marginal or in seemingly marginal bands 92 Four (3-4) cells per parenchyma strand 97 Ray width 1 to 3 cells 104 All ray cells procumbent 115 4-12 / mm 136v Prismatic crystals present 142v Prismatic crystals in chambered axial parenchyma cells 183 Neotropics and temperate Brazil (Brazier and Franklin region 81) 186 Tropical South America 187 Southern Brazil

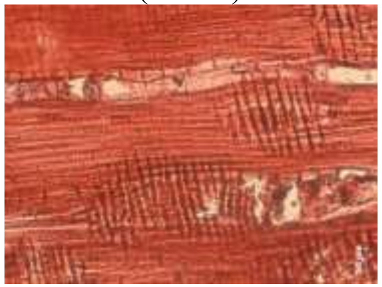
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					189 Tree 192 Wood of commercial importance 195 Basic specific gravity high, >= 0.75 196 Heartwood colour darker than sapwood colour 197 Heartwood basically brown or shades of brown 198 Heartwood basically red or shades of red
13.	972-1		(Cross Section)  (Tangential)		Teak (*Tectona grandis* Linn.f)

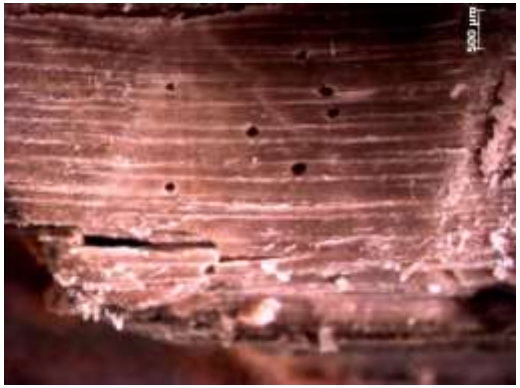
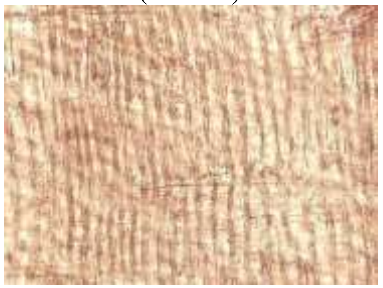
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		
14.	972-2		(Cross Section)  (Tangential)		Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		
15.	980		(Cross Section) 		Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
16.	983		(Cross Section) 		Teak (*Tectona grandis* Linn.f)

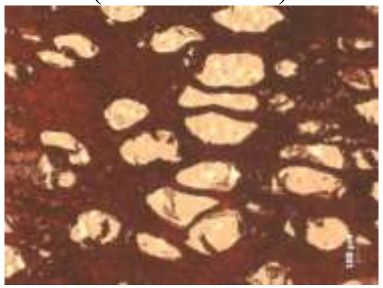
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
17.	985		(Cross Section)  (Tangential)		Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		
18.	1018		(Cross Section) 	90p 91a 107p 109p 110p 111p	*Pinus* sp. – Pinaceae https://insidewood.lib.ncsu.edu/results?23 **1) PINACEAE Pinus kesiya Royle ex Gordon (KA XI SONG, KHASI PINE, THÔNG BA LÁ)** Specimen:

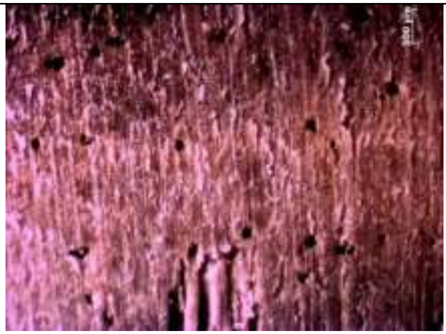
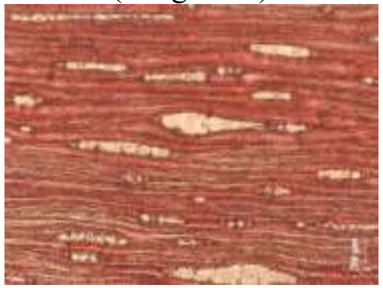
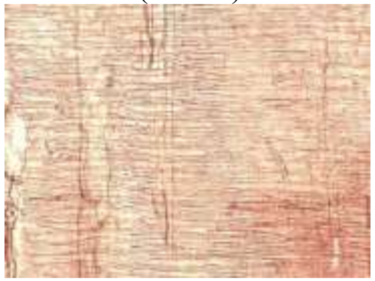
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		Kw Thai.Pin.kes - PINACEAE Pinus kesiya Features: 40v Growth ring boundaries distinct 41 Growth ring boundaries indistinct or absent 43 Gradual transition from earlywood to latewood 44 IT pitting (predominantly) uniseriate 51 LT length medium (3000 to 5000 µm) 55 LW LTs thick-walled (double wall thickness > radial lumen diameter) 56 Torus present 79 Ray tracheids commonly present 82 Dentate ray tracheid cell walls 85 Smooth (unpitted) end walls of ray parenchyma cells 87 Smooth (unpitted) horizontal walls of ray parenchyma cells 90 Window-llike (fenestriform) 91v Pinoid 97 (large window-like) 1-2 pits

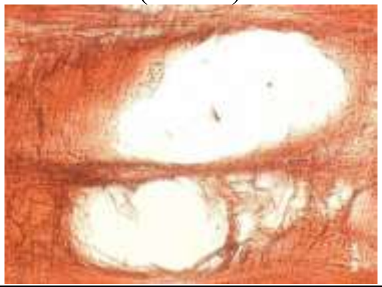
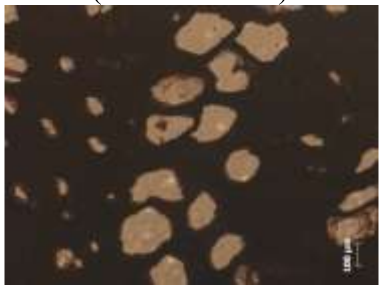
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					per cross-field 98 1-3 pits per cross-field 103 Average ray height medium (5 to 15 cells) 107 Rays exclusively uniseriate 109 Axial canals 110 Radial canals 111v Traumatic canals (axial or radial) 117 Thin-walled epithelial cells 8 Southeast Asia and Pacific 9 Thailand, Laos, Vietnam, Cambodia (Indochina) 10 Indomalesia 26 Brown or shades of brown 27v Red or shades of red 28v Yellow or shades of yellow 33 Heartwood colour distinct from sapwood colour 37 Less than 0.48 g/cm3 38 0.48–0.60 g/cm3 39 Above 0.60 g/cm3 **2) PINACEAE Pinus koraiensis Siebold & Zucc. (KOREAN PINE) Specimen: Kw ETSI - PINACEAE Pinus koraiensis** Features:

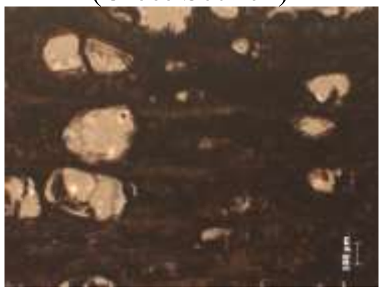
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					40 Growth ring boundaries distinct 43 Gradual transition from earlywood to latewood 44 IT pitting (predominantly) uniseriate 46 IT pitting opposite 54 LW LTs thin-walled(double wall thickness < radial lumen diameter) 56 Torus present 79 Ray tracheids commonly present 81 Smooth ray tracheid cell walls 85 Smooth (unpitted) end wallsof ray parenchyma cells 87 Smooth (unpitted) horizontal walls of ray parenchyma cells 90 Window-llike (fenestriform) 91v Pinoid 97 (large window-like) 1-2 pits per cross-field 98v 1-3 pits per cross-field 103 Average ray height medium (5 to 15 cells) 107 Rays exclusively uniseriate 109 Axial canals

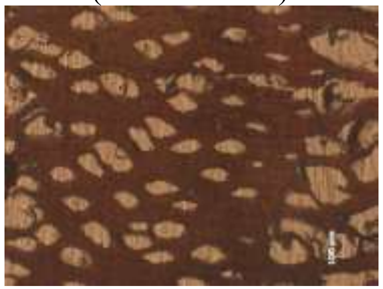
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
					110 Radial canals 111v Traumatic canals (axial or radial) 117 Thin-walled epithelial cells 1 Europe and temperate Asia 4 Temperate Asia (China, Japan, Russia) 26 Brown or shades of brown 27 Red or shades of red 33 Heartwood colour distinct from sapwood colour 35v Odour distinct 37 Less than 0.48 g/cm3
19.	1026		(Cross Section)  (Tangential)		Teak (*Tectona grandis* Linn.f)

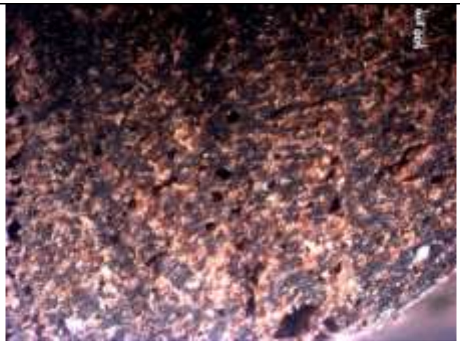
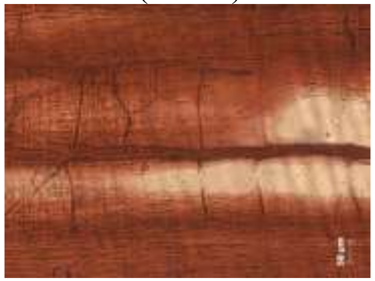
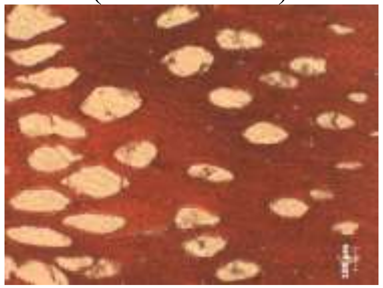
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		
20.	1038		(Cross Section) 	90p 91a 107p 109p 110p 111p	*Pinus* sp. – Pinaceae https://insidewood.lib.ncsu.edu/results?23

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
21.	1045		(Cross Section) 		Teak (*Tectona grandis* Linn.f)

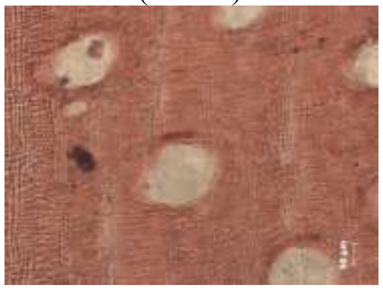
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
22.	1048		(Cross Section) 	Twisted	Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
23.	1050		(Cross Section) 		Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
24.	1051		(Cross Section) 	Twisted	Teak (*Tectona grandis* Linn.f)

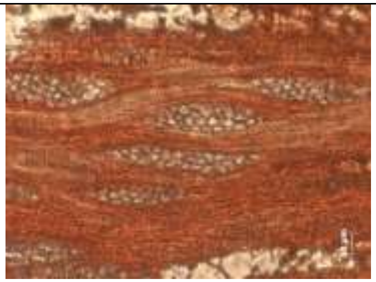
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
25.	1056		(Cross Section) 	Twisted	Teak (*Tectona grandis* Linn.f)

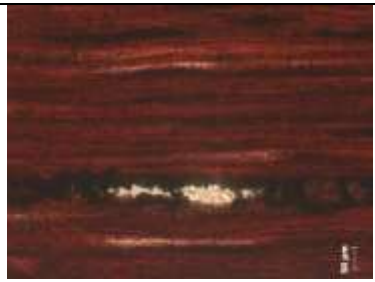
No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 		
26.	1067		(Cross Section) 	2 Growth ring boundaries indistinct or absent 5 Wood diffuse-porous 9 Vessels exclusively solitary (90% or more) 13 Simple perforationplates	ZYGOPHYLLACEAE - *Guaiacum officinale L.* (COMMONER LIGNUM VITAE, GUAYACÁN/ *Guaiacum sanctum L.* (HOLYWOOD LIGNUM VITAE, LIGNUM VITAE)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			(Tangential)  (Radial) 	22 Intervessel pits alternate 23v Shape of alternatepits polygonal 24 Minute - <= 4 µm 30 Vessel-ray pits with distinct borders; similar to intervessel pits in size and shape throughout the ray cell 41 50 - 100 µm 42 100 - 200 µm 45v Vessels of two distinct diameter classes, wood not ring-porous 47 5 - 20 vessels per square millimetre 52 <= 350 µm 58 Gums and other deposits in heartwood vessels 61 Fibres with simple to minutely bordered pits 66 Non-septate fibres present 70 Fibres very thick-walled 71 <= 900 µm 76 Axial parenchyma diffuse 77 Axial parenchyma diffuse-in-aggregates	

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
				78 Axial parenchyma scanty paratracheal 86 Axial parenchyma in narrow bands or lines up to three cells wide 90 Fusiform parenchyma cells 91 Two cells per parenchyma strand 96 Rays exclusively uniseriate 104 All ray cells procumbent 115 4-12 / mm 116 >= 12 /mm 118 All rays storied 120 Axial parenchyma and / or vessel elements storied 121 Fibres storied 136v Prismatic crystals present 142v Prismatic crystals in chambered axial parenchyma cells 183 Neotropics and temperate Brazil (Brazier and Franklin region 81) 184 Mexico and Central America	

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
				185 Carribean 186 Tropical South America 189 Tree 192 Wood of commercial importance 195 Basic specific gravity high, >= 0.75 196 Heartwood colour darker than sapwood colour 197 Heartwood basically brown or shades of brown 201 Heartwood with streaks 202 Heartwood not as above 210 Ethanol extract fluorescent	
27.	1069		(Cross Section)  (Tangential)	70,85,	

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		
28.	953	0	(Cross Section)  (Tangential)		Teak (*Tectona grandis* Linn.f)

No	Artefact No	Macroscopic Features	Microscopic Features	Notes	Wood Species
			 (Radial) 		

APPENDIX 3: METAL ANALYSIS REPORT

Dr Wendy van Duivenvoorde

Associate Professor

Maritime Archaeology Program

Flinders University
GPO Box 2100

Adelaide SA 5001

Tel: 08 8201 5195 (w)

0412 481 080 (m)

E-mail: wendy.vanduivenvoorde@flinders.edu.au
CRICOS Provider No. 00114A

20 July 2022

REPORT ON THE RESULTS OF THE SEMI-QUANTITATIVE ELEMENTAL ANALYSIS OF THE *SHAH MUNCHER* SHIPWRECK METAL SAMPLES
By Wendy van Duivenvoorde and Mike Ng

Introduction

Two fragments of sheathing, a strap and two tacks were analysed to determine their elemental composition. These samples were collected from the shipwreck site of a country ship named *Shah Muncher* (sank in 1796) in Singaporean waters (Table 1).

Table 1 Samples analysed for elemental composition, *Shah Muncher* shipwreck

Sample number	Description
0971	Ship's hull sheathing
0983	Sheathing tack
1056	Sheathing tack
1069	Sheathing tack
1156	Ship's hull sheathing
1171	Strap
1175	Ship's hull sheathing
PB2 Pintle 1.1	Pintle
PB2 Pintle 1.2	Pintle

Semi-Quantitative Elemental Analysis

The metal samples were analysed at Adelaide Microscopy, South Australia, using a FEI Quanta 450 FEG Environmental Scanning Electron Microscope (ESEM) (Fig.1).[1] The FEI Quanta 450 is a High-Resolution Field Emission Scanning Electron and is used to image and analyse surface topography, collect backscattered electron images and characterise and determine a sample's elemental composition through x- ray detection with an SDD EDS detector.

Sample preparation for the sheathing and tacks from the *Shah Muncher* shipwreck included embedding a small fragment of each tack and sheathing sample in phenolic hot mounting resin for general use (brand: Struers MultiFast). The resin was added and set in a Struers CitoPress-10 hot mounting machine (Fig. 2). The mountedsamples were then polished using a Struers TegraPol-11 diamond polisher to get clean, uncorroded surfaces for analyses (Figs 2–4).

The FEI Quanta 450 with SDD EDS detector allows for a semi-quantitative analytical method of elemental composition by spot or area testing. As this method of analysis is a localized testing method, it is not necessarily representative for the composition of an entire sample. If possible, preferably three areas per sheathing sample are

[1] https://www.adelaide.edu.au/microscopy/instrumentation/quanta450.html

tested to ensure they are characteristic (Figs 4–5). The areas chosen for elemental determination are those that display solid metal and are relatively free of any surface corrosion (Figs 4–6). For tacks only one spectrum is collected as their cross-sectional shape is easily selected in its entirety.

Fig. 1. FEI Quanta 450 FEG Environmental Scanning Electron Microscope, Adelaide Microscopy, University of Adelaide. Photograph by Wendy van Duivenvoorde.

Fig. 2. Struers CitoPress-10 hot mounting press. Photograph by Wendy van Duivenvoorde.

Fig. 3. Struers TegraPol-11 polisher. Photograph by Wendy van Duivenvoorde.

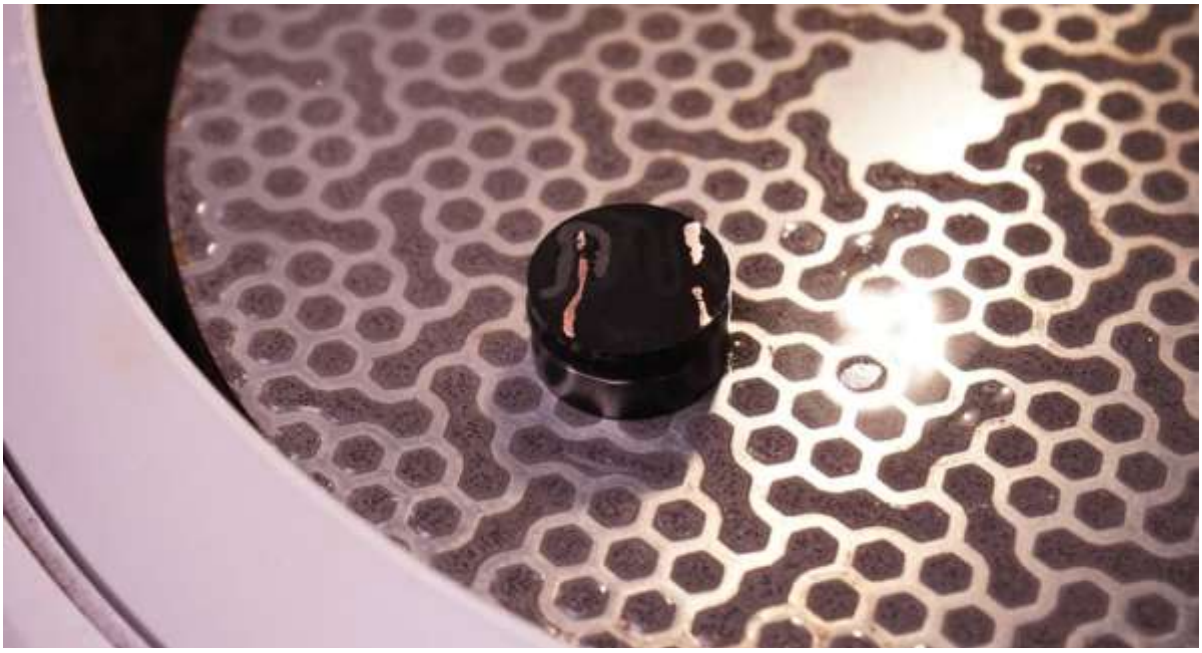


Fig. 4. *Shah Muncher* sample of strap embedded in a black-coloured resin mount, Sample 1156, after polishing. Photograph by Mike Ng.

Fig. 5. *Shah Muncher* sample of sheathing fragment embedded in a black-coloured resin mount, Sample 1175. Photograph by Mike Ng.

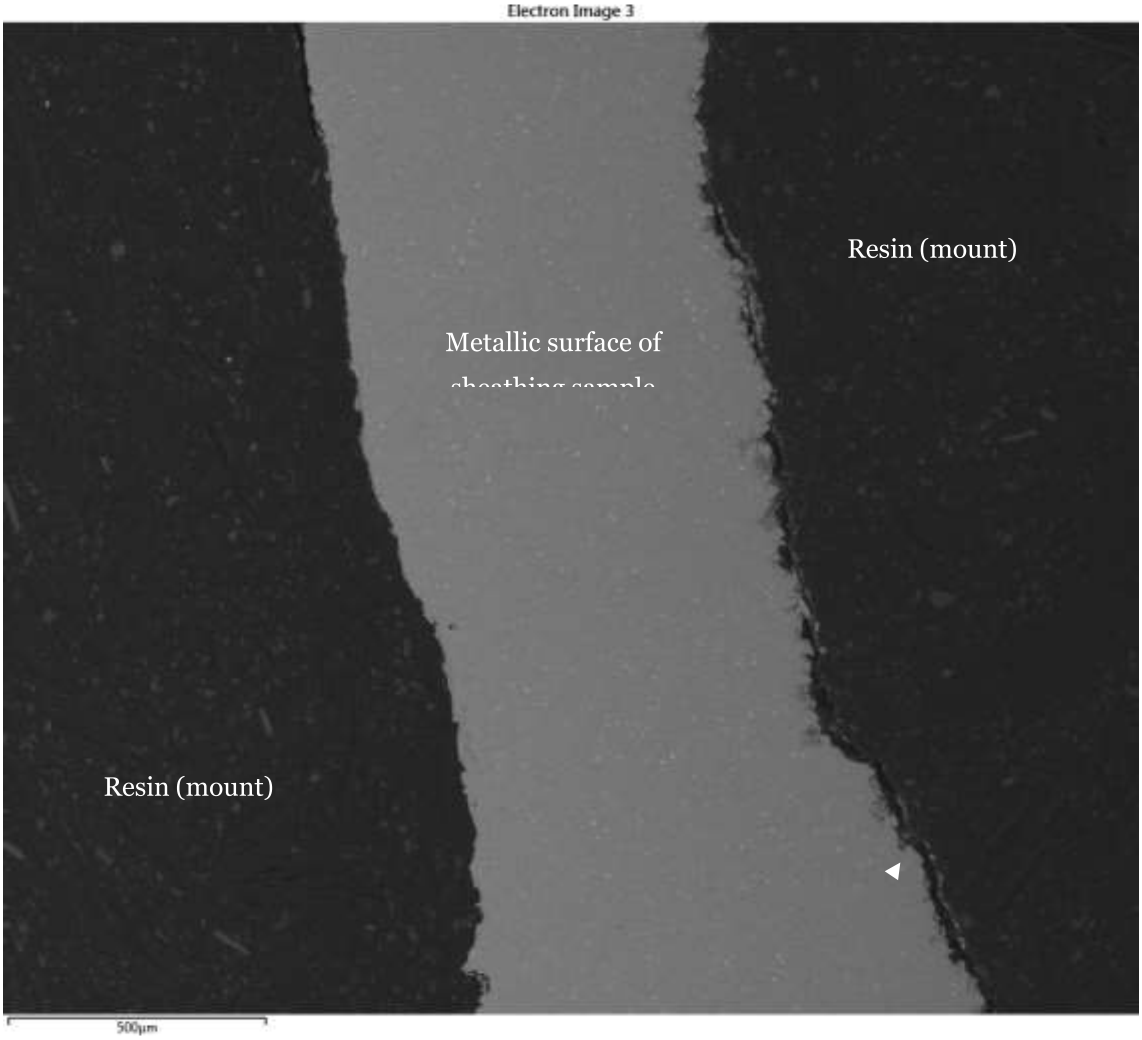


Fig. 6. Cross-section of a *Shah Muncher* sheathing fragment, showing slight surface corrosion on edges and metallic surface of the sample. The tiny black coloured inclusions in the metallic surface area are carbon, and white are lead inclusions. Micrograph of mounted sample. Micrograph by Wendy van Duivenvoorde.

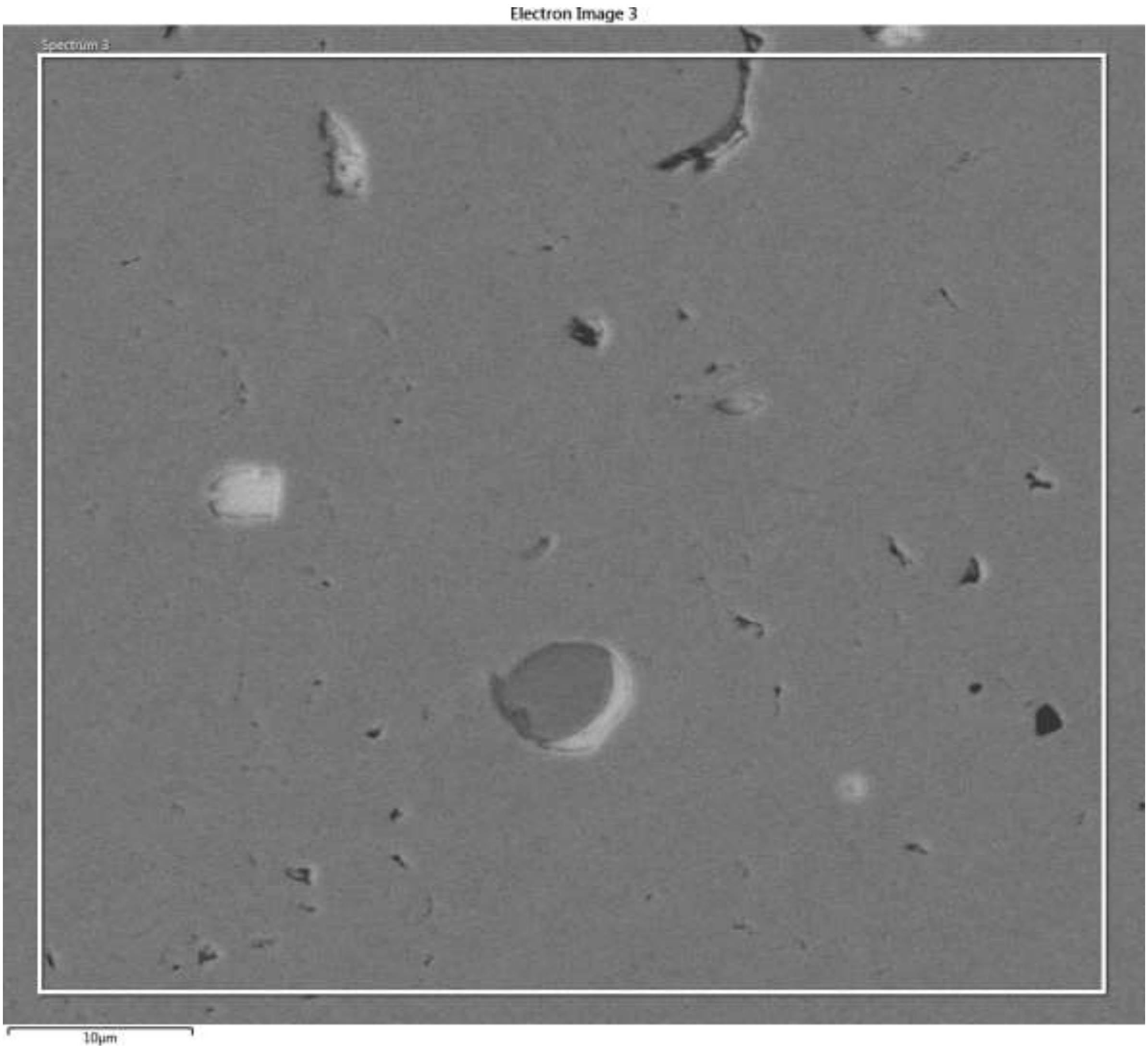


Fig. 7. *Shah Muncher* ship sheathing sample, showing black coloured carbon and white lead inclusions, Sample 0971. Micrograph by Wendy van Duivenvoorde.

The following SEM settings were used during data acquisition: High-Vacuum, Kilovoltage: kV 20, Element Normalized, SEC table: default, standardless. The time per sample analysis was automated as the Quanta 450 is the fastest SEM EDS collector in Australia. The sheathing samples tested positive for the following elements: Cu (copper) and Carbon (C). The elemental composition for the sheathing, strap, tacks and pintle samples are listed in Tables 2–6, and Appendix 1.

Results

Analyses of the sheathing fragments confirm that the *Shah Muncher* ship was sheathed with sheets of pure copper; it is not an alloy (Table 2). Some carbon inclusions are visible on the polished surfaces of the sheathing and tack samples (Figs 6–7). Carbon is a known corrosion product that can occur as isolated inclusionsin the actual metal a few millimetres below the surface (pers. comm. Animesh Bashak, Adelaide Microscopy).

Although the presence of the carbon in the sheathing is a corrosion product, it is known from 19th-century records that charcoal was sometimes added purposely or accidently to copper (Bennett 2021:293–294). For the purpose of this analytical work carbon is simply omitted to focus primarily on the metal composition and ratio of metals in alloys.

Elements such as arsenic (As), silver (Au), bismuth (Bi), iron (Fe), lead (Pb), nickel (Ni), antimony (Sb), and tin (Sn) were added manually to the spectra and they were thus tested for, as they are known trace elements in copper (Tables 3–5) (cf. MacLeod 1987). They are shown in red in the Appendix 1, which indicates that they are present in levels too low to be anything other than trace elements.

Table 2 Elemental composition of ship's hull sheathing, *Shah Muncher* shipwreck

	Wt%			Atomic %	
Description	**Cu**	**Total**		**Cu**	**Total**
Sample 0971: spectrum 1	100.00	100		100.00	100
Sample 0971: spectrum 2	100.00	100		100.00	100
Sample 0971: spectrum 3	100.00	100		100.00	100
Sample 1156: spectrum 1	100.00	100		100.00	100
Sample 1156: spectrum 2	100.00	100		100.00	100
Sample 1156: spectrum 3	100.00	100		100.00	100
Sample 1175: spectrum 1	100.00	100		100.00	100
Sample 1175: spectrum 2	100.00	100		100.00	100
Sample 1175: spectrum 3	100.00	100		100.00	100

European experimentation with the coppering of ships' hulls first occurred in the Age of Exploration and the first use of copper hull sheathing may be credited to the Dutch West India Company in the early 17th century (van Duivenvoorde 2015a:194; 2015b:354). The Dutch did not seem to continue this practice for ships' hulls below their waterlines, but they did sheath the sternposts of large ocean-going vessels with copper throughout the 17th and 18th centuries (van Duivenvoorde 2015a; 2015b). European navies applied copper sheathing to warships from the second half of the 18th century (Bingeman 2018; Bingeman et al. 2000:220; McCarthy 2005:102; Staniforth 1985; van Duivenvoorde 2015a). In 1761, the fifth-rate frigate *Alarm* was the first fully coppered warship in the British Royal Navy, but the practice only become widespread on British vessels from the 1780s onwards (Bingeman 2018; 2000 et al.:220; McCarthy 2005:102; Staniforth 1985). Archaeological case-studies of several wrecked vessels in Australasia, that were cladded in copper sheathing, include the British colonial built navy ships *Endeavour* (built in 1771 and wrecked in 1795) and *Buffalo* (built in 1813, wrecked in 1840) both wrecked in New Zealand waters, the merchant vessel *South Australian* (built in 1819, wrecked in 1837, but last re-sheathed with copper before its departure to Australia in 1836) (Bennett 2021:186–188, 209–210, 289–290; Hunter et al. forthcoming; van Duivenvoorde 2022a; 2022b; 2021a).

Table 3 Elemental composition of ship's hull sheathing including trace elements, *Shah Muncher* shipwreck

	Wt%												**Atomic%**										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**		**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0971: spectrum 1	0.06	0.00	98.26	0.00	0.83	0.16	0.19	0.00	0.51	0.00	100		0.07	0.00	98.87	0.00	0.71	0.10	0.10	0.00	0.16	0.00	100
Sample 0971: spectrum 2	0.00	0.00	98.66	0.07	0.56	0.22	0.02	0.19	0.29	0.00	100		0.00	0.00	99.13	0.07	0.48	0.13	0.01	0.10	0.09	0.00	100
Sample 0971: spectrum 3	0.04	0.00	98.54	0.40	0.88	0.01	0.00	0.00	0.00	0.14	100		0.04	0.00	98.78	0.39	0.75	0.00	0.00	0.00	0.00	0.04	100
Sample 1156: spectrum 1	0.00	0.00	97.98	0.00	0.18	0.07	0.12	0.36	1.29	0.00	100		0.00	0.00	99.15	0.00	0.15	0.04	0.06	0.19	0.40	0.00	100
Sample 1156: spectrum 2	0.07	0.11	98.40	0.09	0.33	0.00	0.00	0.00	1.01	0.00	100		0.08	0.12	99.12	0.08	0.28	0.00	0.00	0.00	0.31	0.00	100
Sample 1156: spectrum 3	0.09	0.00	98.92	0.04	0.42	0.03	0.14	0.10	0.18	0.07	100		0.08	0.00	98.06	0.04	0.49	0.05	0.26	0.20	0.59	0.23	100
Sample 1175: spectrum 1	0.18	0.03	98.10	0.00	0.11	0.23	0.06	0.00	1.29	0.01	100		0.21	0.04	99.09	0.00	0.10	0.14	0.03	0.00	0.40	0.00	100
Sample 1175: spectrum 2	0.04	0.01	97.96	0.00	0.21	0.31	0.00	0.00	1.34	0.14	100		0.04	0.01	99.13	0.00	0.18	0.18	0.00	0.00	0.42	0.04	100
Sample 1175: spectrum 3	0.00	0.25	99.19	0.00	0.00	0.14	0.00	0.00	0.43	0.00	100		0.00	0.23	98.16	0.00	0.00	0.23	0.00	0.00	1.38	0.00	100

Table 4 Elemental composition of ship's sheathing tacks including trace elements, *Shah Muncher* shipwreck

	Wt%												**Atomic%**										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**		**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 0983: spectrum 1	0.17	0.19	86.44	5.05	0.52	0.06	7.46	0.00	0.12	0.00	100		0.20	0.21	89.81	5.10	0.46	0.03	4.15	0.00	0.04	0.00	100
Sample 1056: spectrum 1	0.08	0.07	64.69	32.81	0.04	0.03	0.00	0.00	2.28	0.00	100		0.09	0.08	66.35	32.71	0.03	0.02	0.00	0.00	0.72	0.00	100
Sample 1069: spectrum 1	0.89	0.10	64.97	28.38	0.64	0.08	0.29	0.38	4.27	0.00	100		1.06	0.11	67.72	28.76	0.57	0.05	0.16	0.21	1.36	0.00	100

Table 5 Elemental composition of ship's pintle including trace elements, *Shah Muncher* shipwreck

	Wt%												Atomic%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**		**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample PB2_Pintle 1.1: spectrum 1	0.38	0.00	83.55	15.13	0.18	0.17	0.01	0.00	0.59	0.00	100		0.43	0.00	84.29	14.83	0.15	0.10	0.00	0.00	0.18	0.00	100
Sample PB2_Pintle 1.1: spectrum 2	0.38	0.26	83.44	14.26	0.27	0.00	0.44	0.18	0.78	0.00	100		0.44	0.29	84.45	14.02	0.23	0.00	0.24	0.09	0.24	0.00	100
Sample PB2_Pintle 1.1: spectrum 3	0.29	0.01	83.65	14.32	0.34	0.14	0.25	0.00	1.01	0.00	100		0.33	0.01	84.74	14.10	0.29	0.09	0.13	0.00	0.31	0.00	100
Sample PB2_Pintle 1.2: spectrum 1	0.45	0.03	79.53	16.79	0.40	0.17	0.41	0.07	1.87	0.29	100		0.52	0.03	81.36	16.69	0.35	0.10	0.22	0.04	0.59	0.09	100
Sample PB2_Pintle 1.2: spectrum 2	0.49	0.11	78.90	18.27	0.48	0.00	0.16	0.00	1.33	0.27	100		0.56	0.12	80.26	18.06	0.42	0.00	0.09	0.00	0.42	0.08	100
Sample PB2_Pintle 1.2: spectrum 3	0.43	0.05	83.09	14.77	0.51	0.00	0.40	0.00	0.76	0.00	100		0.49	0.06	84.04	14.52	0.44	0.00	0.22	0.00	0.23	0.00	100

Table 6 Elemental composition of ship's pintle, *Shah Muncher* shipwreck

	Wt%				Atomic%		
Description	**Cu**	**Zn**	**Total**		**Cu**	**Zn**	**Total**
Sample PB2_Pintle 1.1: spectrum 1	84.67	15.33	100		85.03	14.97	100
Sample PB2_Pintle 1.1: spectrum 2	85.38	14.62	100		85.73	14.27	100
Sample PB2_Pintle 1.1: spectrum 3	85.36	14.64	100		85.71	14.29	100
Sample PB2_Pintle 1.2: spectrum 1	82.55	17.45	100		82.95	17.05	100
Sample PB2_Pintle 1.2: spectrum 2	81.18	18.82	100		81.61	18.39	100
Sample PB2_Pintle 1.2: spectrum 3	84.89	15.11	100		85.25	14.75	100

Table 7 Elemental composition of brass strap, *Shah Muncher* shipwreck

	Wt%												Atomic%										
Description	**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**		**Fe**	**Ni**	**Cu**	**Zn**	**As**	**Ag**	**Sn**	**Sb**	**Pb**	**Bi**	**Total**
Sample 1171: spectrum 1	0.28	0.07	87.41	9.45	0.59	0.00	0.40	0.31	0.97	0.53	100		0.32	0.07	88.91	9.34	0.51	0.00	0.22	0.17	0.30	0.16	100
Sample 1171: spectrum 2	0.13	0.00	89.46	9.27	0.19	0.08	0.12	0.08	0.35	0.32	100		0.15	0.00	90.24	9.09	0.16	0.05	0.07	0.04	0.11	0.10	100

Sample 1171: spectrum 3	0.22	0.00	90.05	8.83	0.60	0.02	0.00	0.00	0.13	0.15	100		0.19	0.00	89.18	9.00	0.70	0.04	0.00	0.00	0.42	0.48	100

Pure copper was used in European hull sheathing until 1832, when George Fredrick Muntz developed 'Muntz metal' (also known as 'yellow metal'), a 60:40 copper-zinc alloy (Bingeman et al. 2000; Flick 1975:74). The widespread use of copper sheathing by European navies at the end of the 18th century and the transition to Muntz metal by the British from the mid-19th century onwards provides a useful tool for the general dating of hull sheathing. It aids in establishing probable construction periods of wrecked ships that contain copper or copper-alloy sheathing.

Three tacks from the *Shah Muncher* ship provided good spectra to confirm they were made of a copper alloy rather than pure copper (Table 4). One of the copper-alloy tacks (sample 983) used to fasten the copper sheathing were manufactured using 86.44% copper, 5.05 % zinc, and 7.46% tin. Fasteners are required to be harder than the sheathing itself, and the addition of some zinc, tin, and lead is consistent with sheathing tacks used in the late 18th and early 19th century (cf. *Endeavour* which wrecked in 1795) (Bennett 2021; van Duivenvoorde 2022a). The other tacks (samples 1056 and 1069) have more of a Muntz metal signature with 64.69–64.97% copper, 28.38–32.81% zinc, and a little of bit lead (2.28–4.27%). This needs to be investigated further.

The two samples from the *Shah Muncher* ship's pintle were also made of a copper-zinc alloy consisting of 81.18–85.38% copper and 14.62–18.82% zinc (Tables 5–6). This indicates a pre-1832 alloy (cf. analyses on the gudgeon and capstan from the 1830 *Cumberland* shipwreck, McLeod 1987).

One sample of a copper alloy strap was analysed and made of brass consisting of 87.41–90.05% copper and 8.83–9.45% zinc (Table 7).

References

Bennett, K. 2021. Shipwright artistry: cultural transmission of British colonial ship design and construction during the eighteenth and nineteenth centuries. PhD thesis, Humanities, Flinders University. https://theses.flinders.edu.au/view/3fc4cd57-9116-46cb-9e24-f6e0029c4129/1

Bingeman, J.M. 2018. Copper and Muntz metal sheathing: a global update. *International Journal of Nautical Archaeology* 47.2: 460–471. https://doi.org/10.1111/1095-9270.12299

Bingeman, J.M., J.P. Bethell, P. Goodwin, and A.T. Mack 2000 Copper and other sheathing in the Royal Navy. *International Journal of Nautical Archaeology* 29(2):218–229. https://doi.org/10.1006/ijna.2000.0315

Flick, C. 1975. Muntz metal and ships' bottoms: the industrial career of G.F. Muntz. *The Transactions of the Birmingham and Warwickshire Archaeological Society* 87:70–88.

Hunter, J.W., R. Bullers, K. Hosty, I. Malliaros, A, Paterson, C. Wilson, T. Zapor, K. Jerbic and W. van Duivenvoorde. (2022) Unearthing South Australia's oldest known shipwreck: The barque *South Australian* (1837). *Historical Archaeology*, special issue 'Maritime Archaeology in Australia', edited by M. de Ruyter and W. van Duivenvoorde.

MacLeod, I.D. 2018. Qualifying the effects of site conditions on the long-term corrosion of bronzes on historic shipwreck sites. *Australasian Journal of Maritime Archaeology* 42: 65–74.

https://search.informit.org/doi/10.3316/informit.351865047866301

MacLeod, I.D. 1987. Secondhand metal: conservation and industrial archaeology of shipwreck artefacts. In *Archaeometry: Further Studies*, edited by W.R. Ambrose and J.M.J Mummery, pp. 280–291. Occasional Papers in Prehistory 14. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.

McCarthy, M. 2005. *Ships' Fastenings: From Sewn Boat to Steamship*. College Station: Texas A&M University Press.

Staniforth, M. 1985 The introduction and use of copper sheathing—a history. *Bulletin of the Australian Institute for Maritime Archaeology* 9(1–2):21–48. https://search.informit.org/doi/10.3316/informit.054000906721139

van Duivenvoorde, W. 2015a *Dutch East India Company (VOC) Shipbuilding: The Archaeological Study of* Batavia *and Other Seventeenth-Century VOC Ships*. Texas A&M University Press, College Station.

van Duivenvoorde, W. 2015b The use of copper and lead sheathing in VOC shipbuilding. *International Journal of Nautical Archaeology* 44(2):349–361. https://onlinelibrary.wiley.com/doi/10.1111/1095-9270.12118

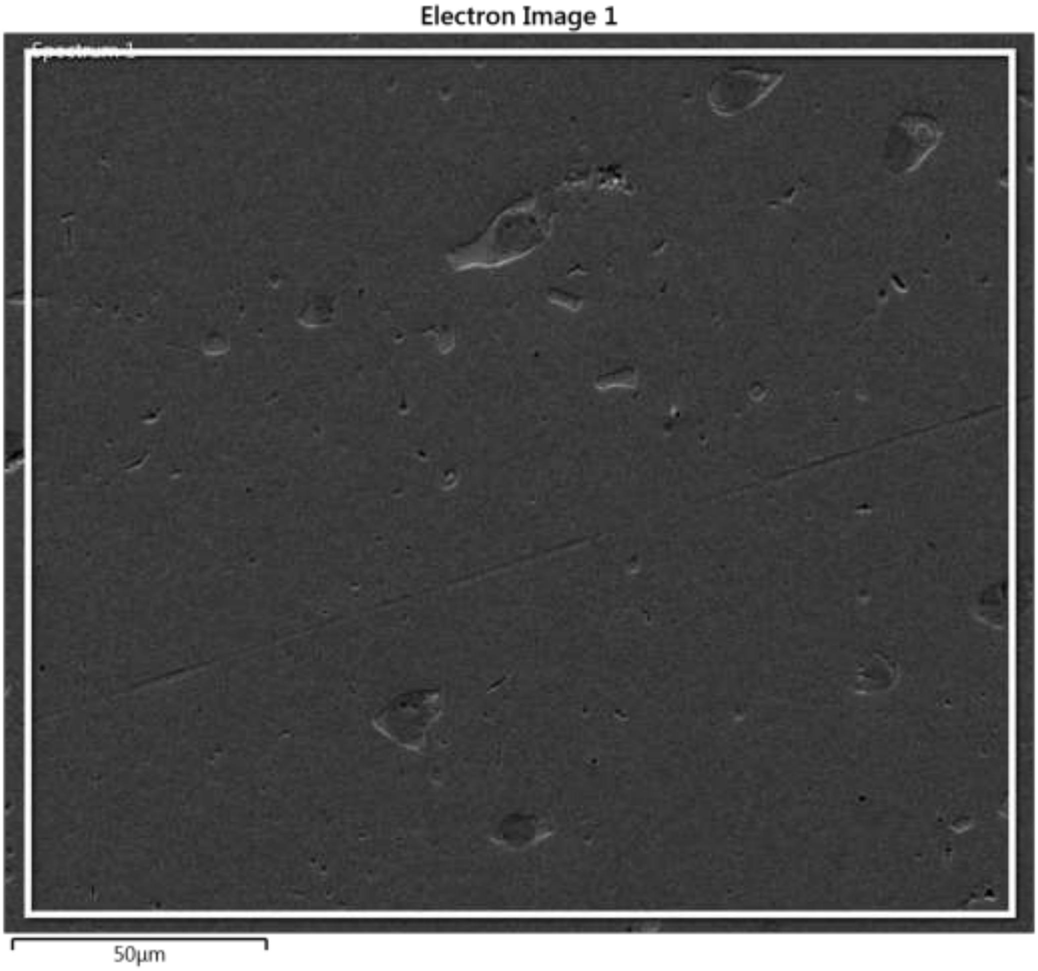
van Duivenvoorde, W. 2022a Report on the results of the semi-quantitative elemental analysis of the *Endeavour* ship metal samples. Unpublished report prepared for Flinders University.

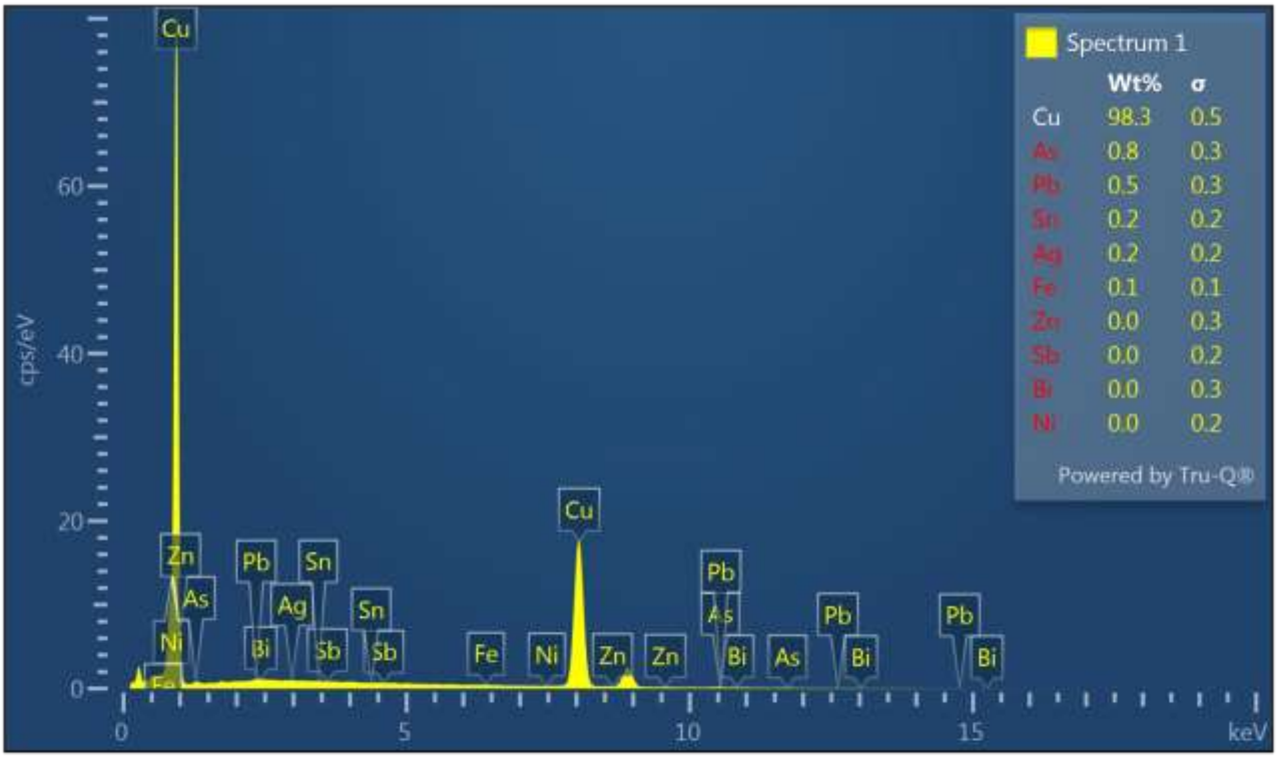
van Duivenvoorde, W. 2022b Report on the results of the semi-quantitative elemental analysis of the *Buffalo* ship metal samples. Unpublished report prepared for Flinders University.

van Duivenvoorde, W. 2021a Report on the results of the semi-quantitative chemical analysis of the *South Australian* shipwreck metal samples. Unpublished report prepared for Flinders University.

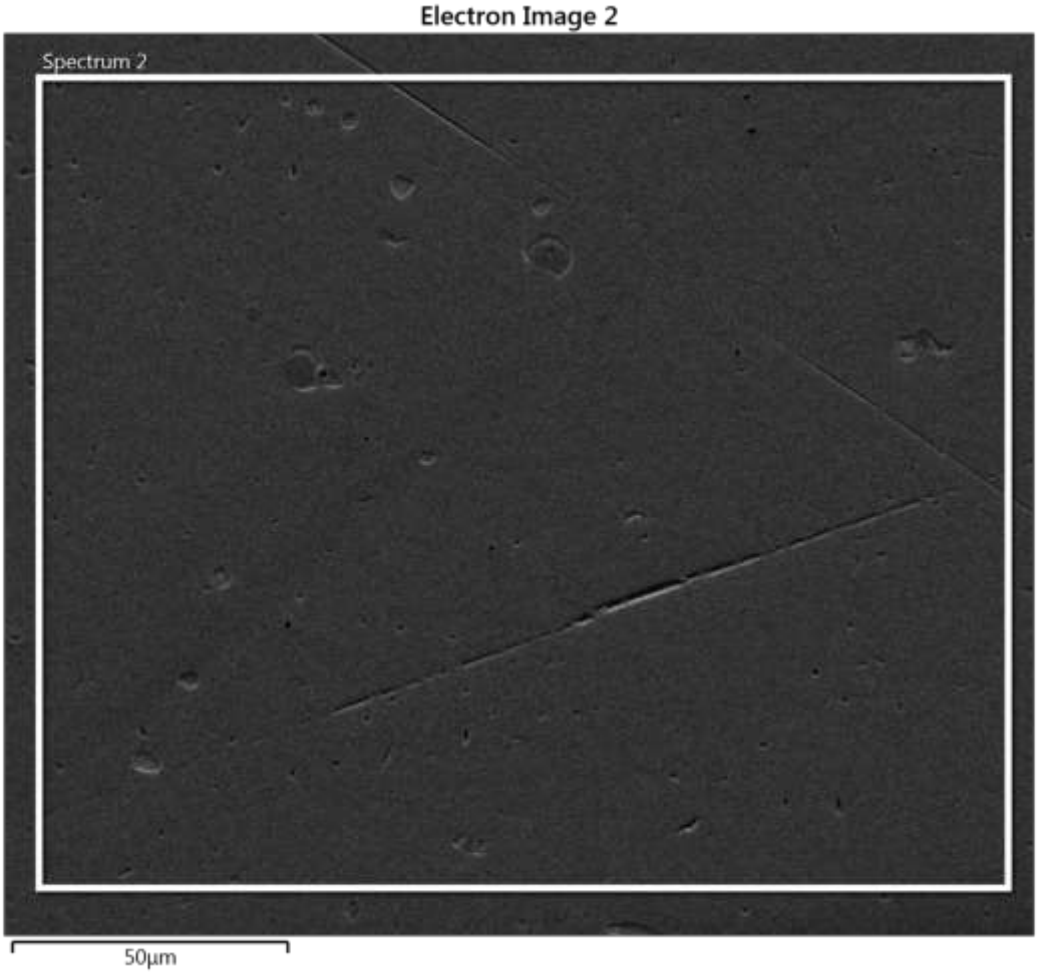
APPENDIX I

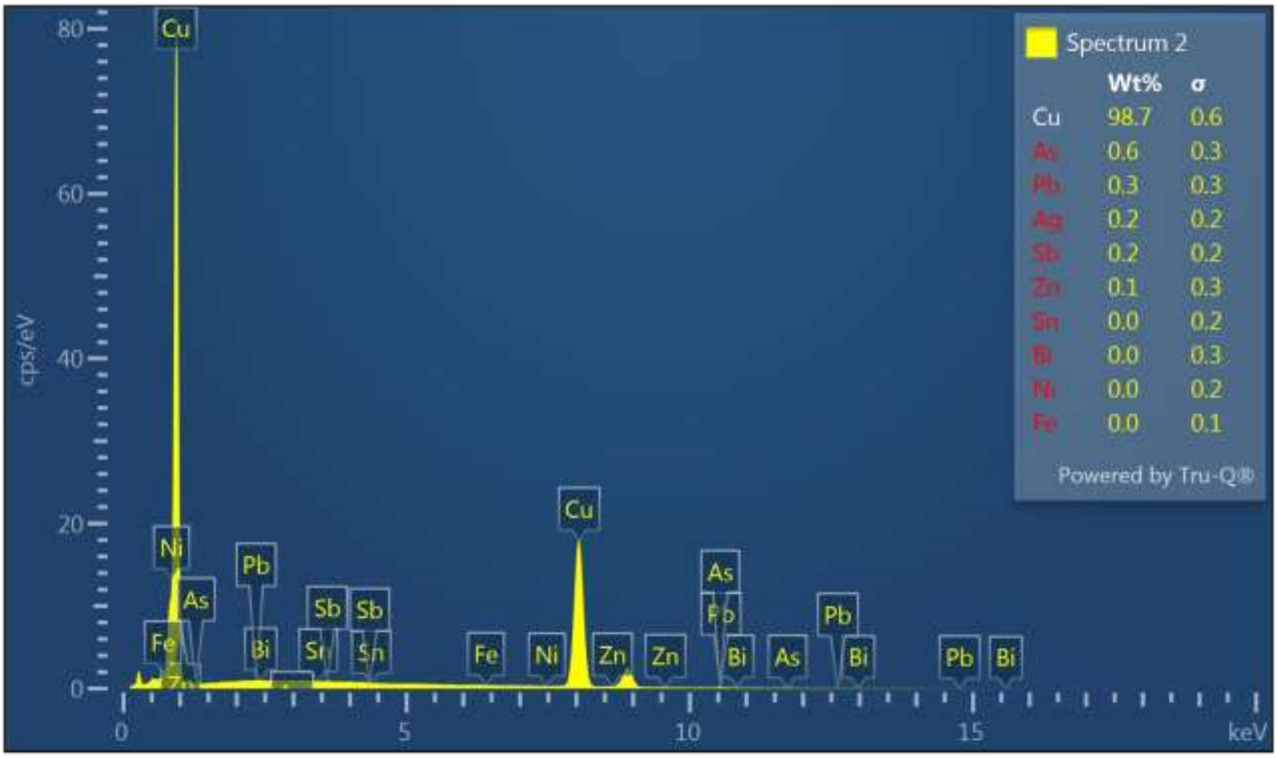
Sample 971, Spectrum 1



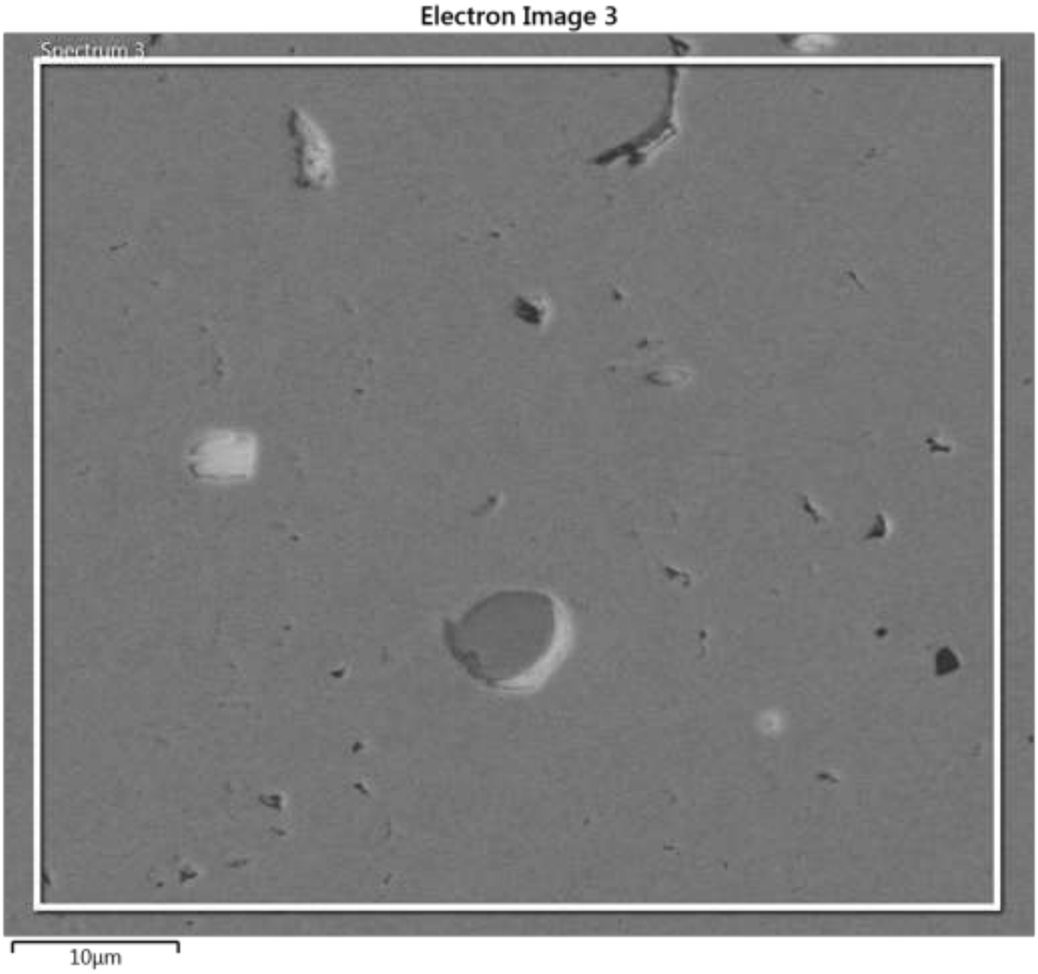


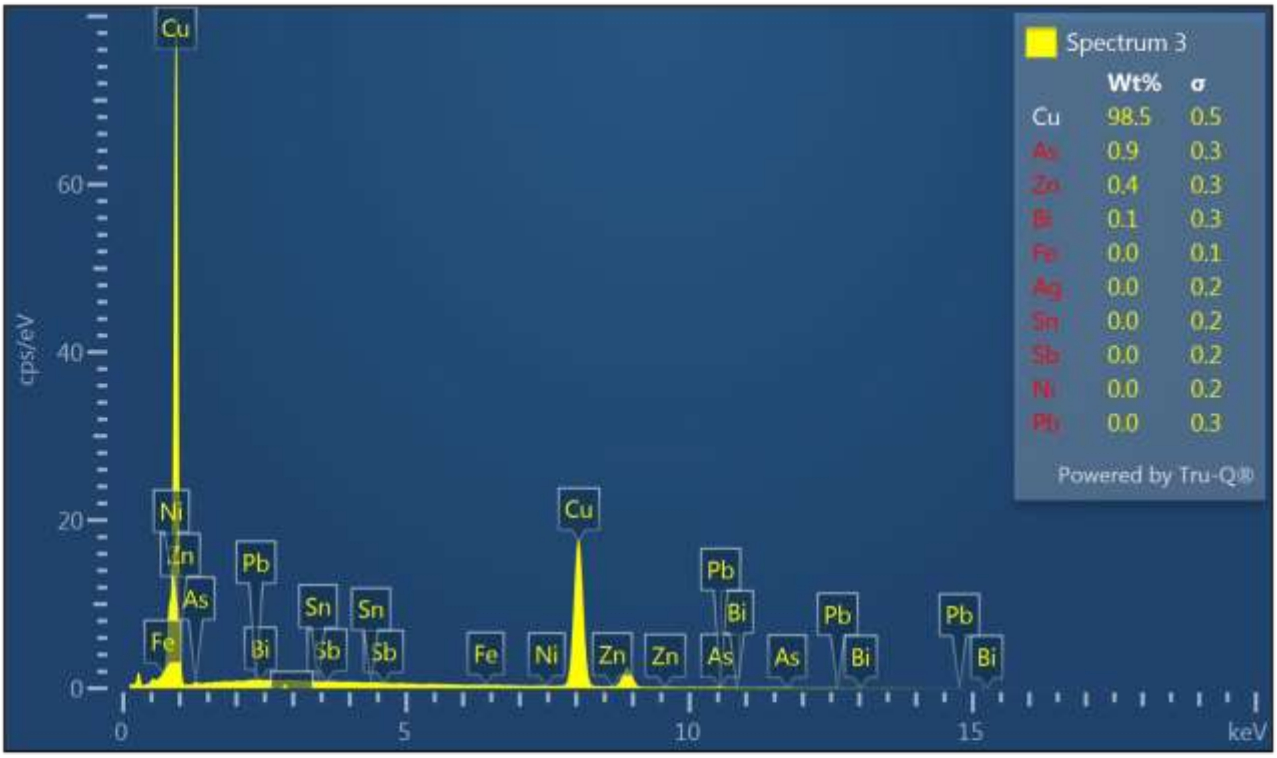
Sample 971, Spectrum 2



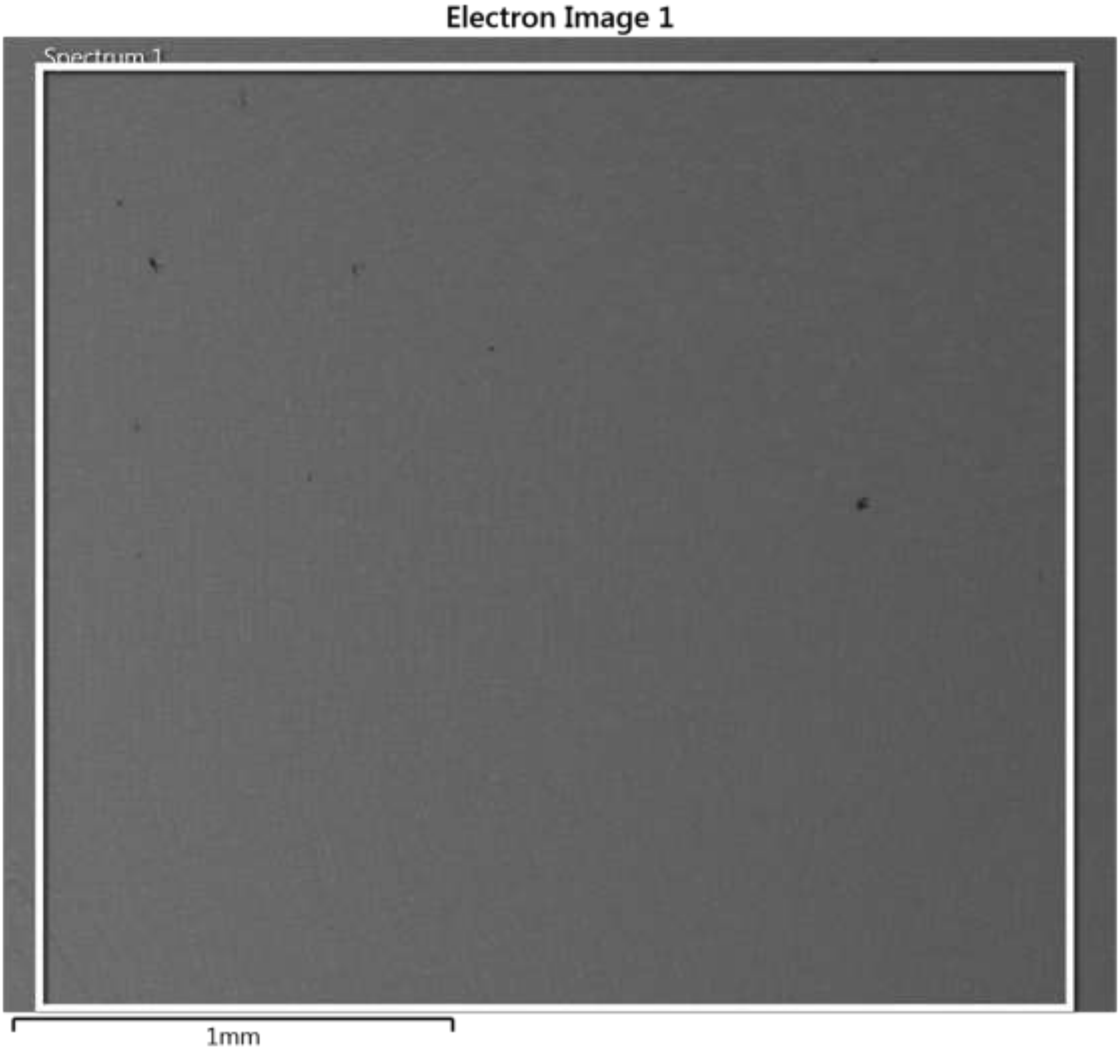


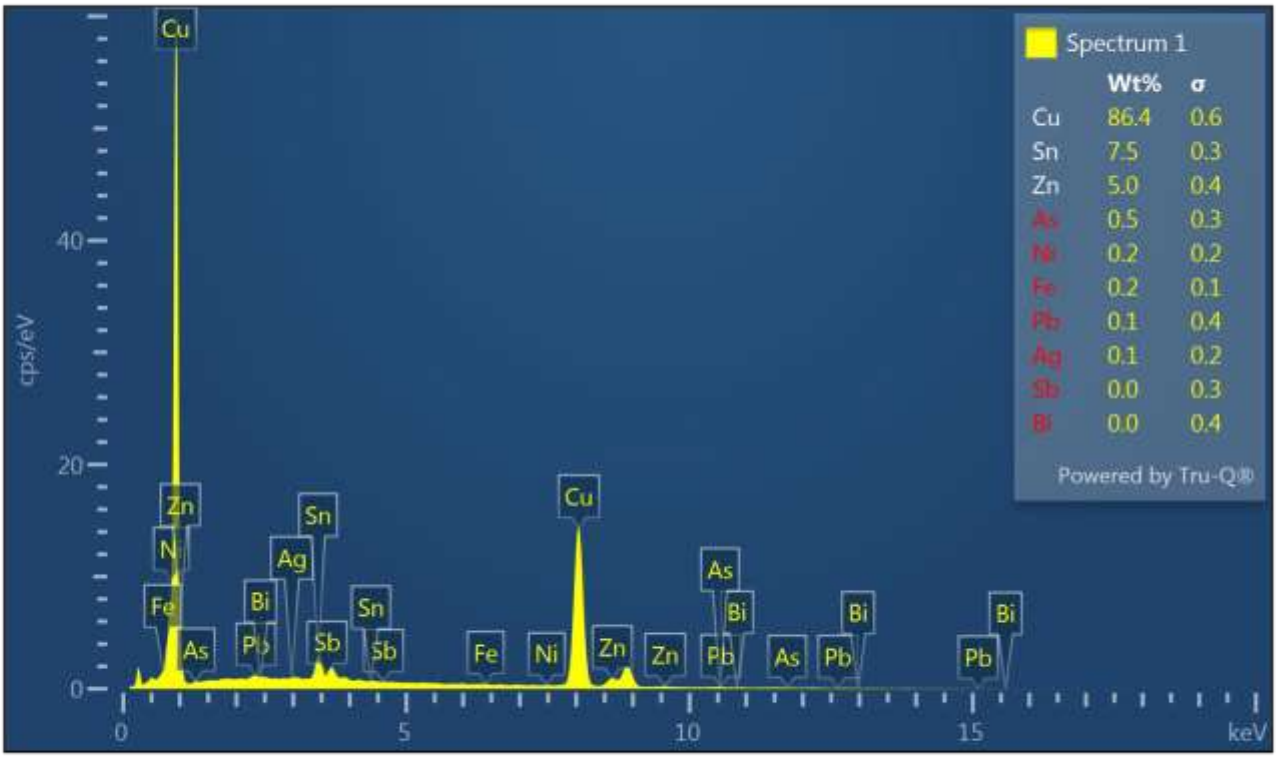
Sample 971, Spectrum 3



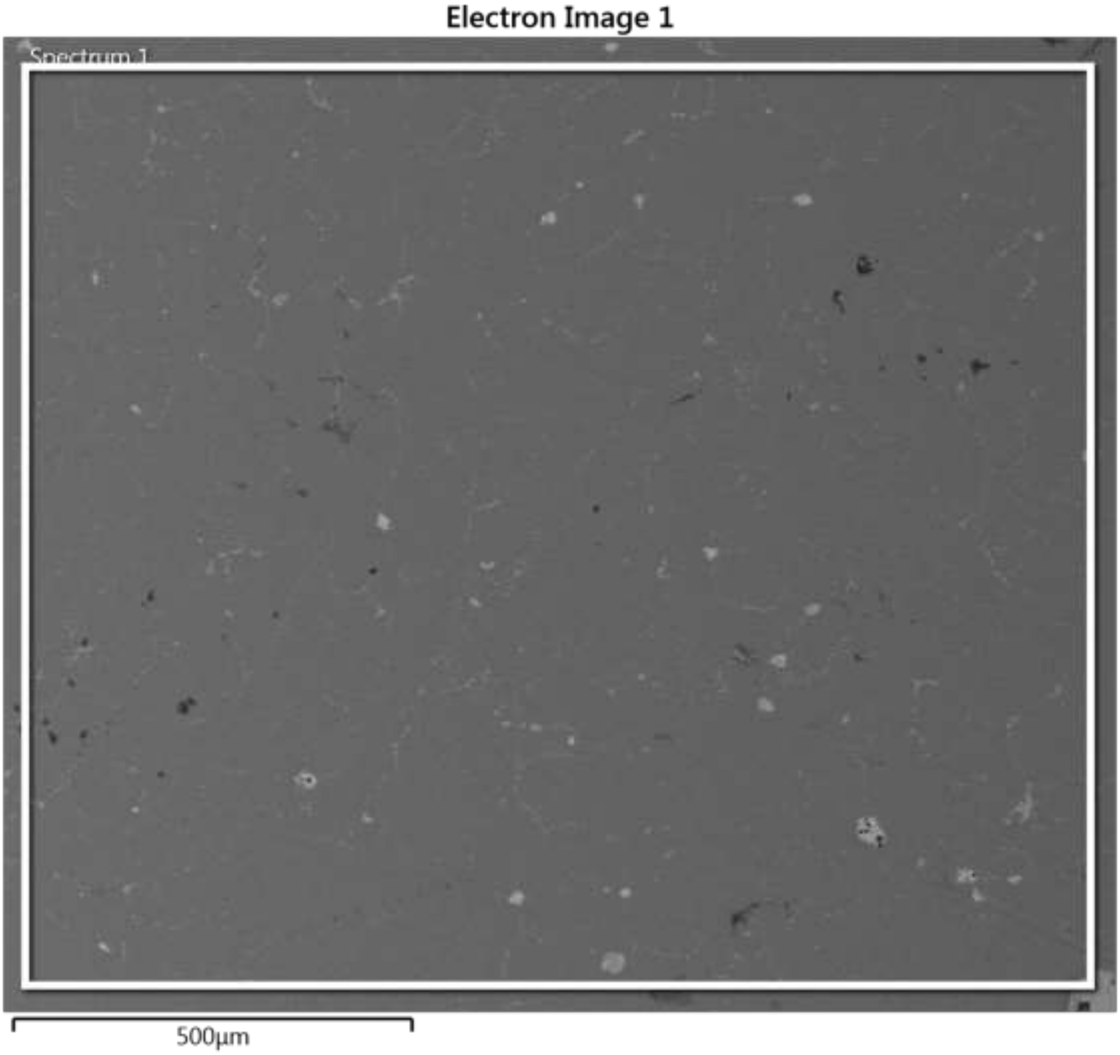


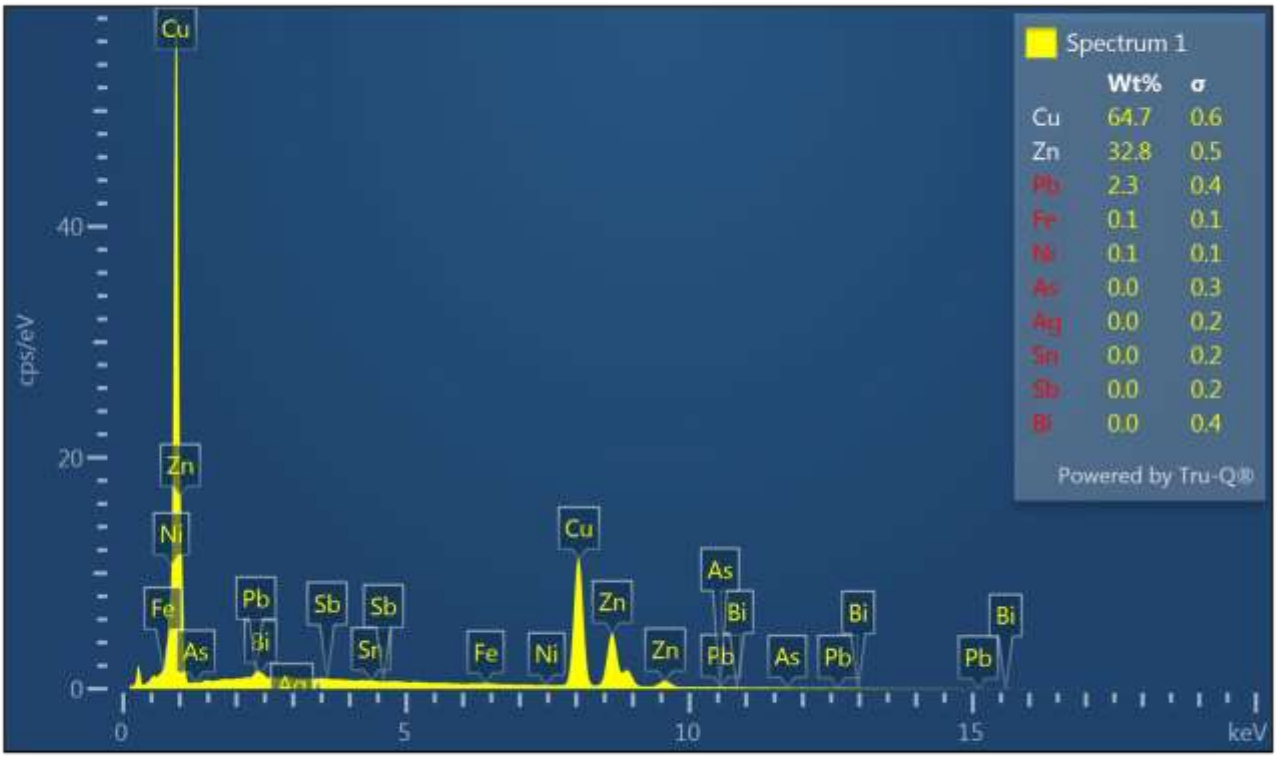
Sample 983, Spectrum 1



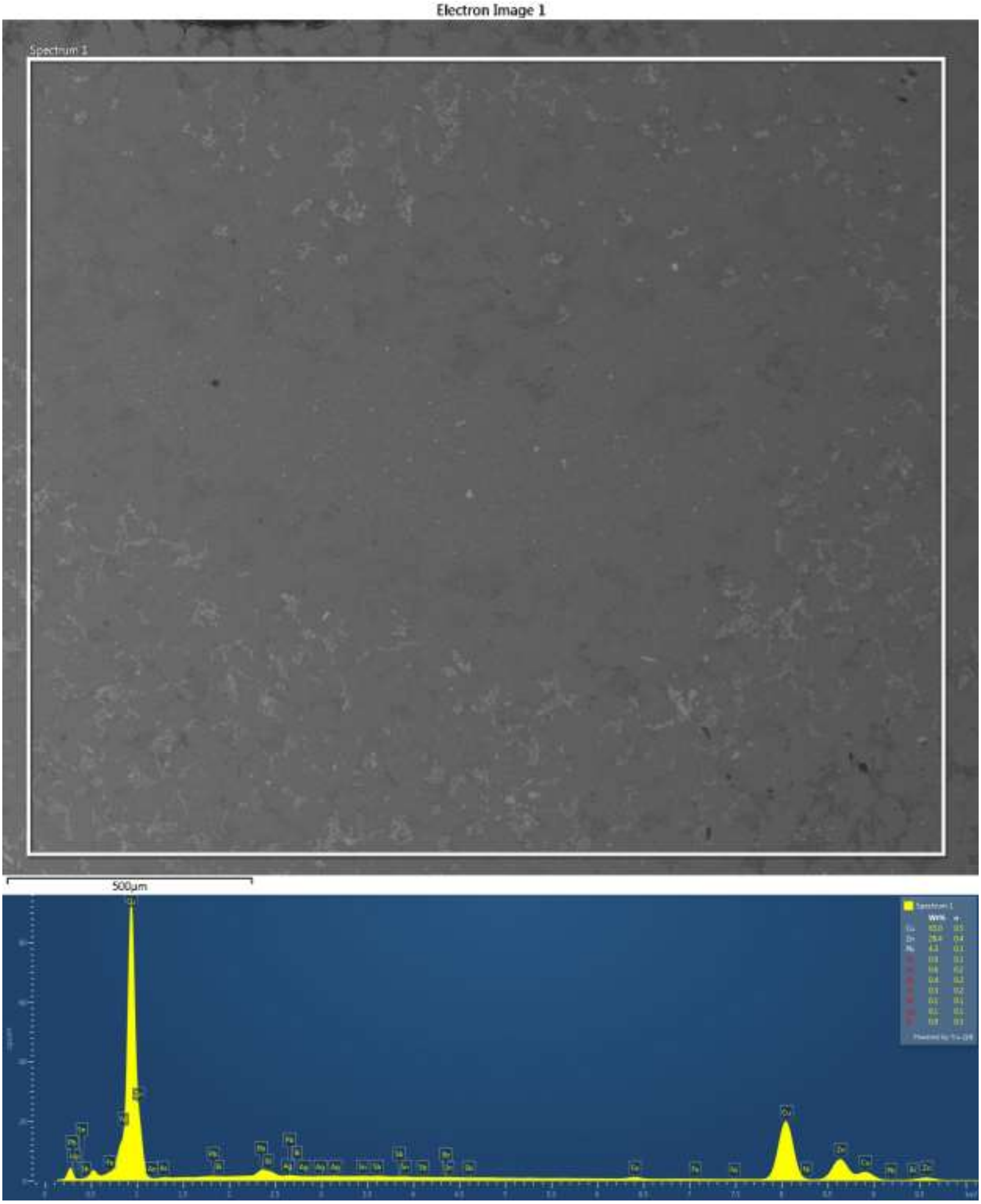


Sample 1056, Spectrum 1

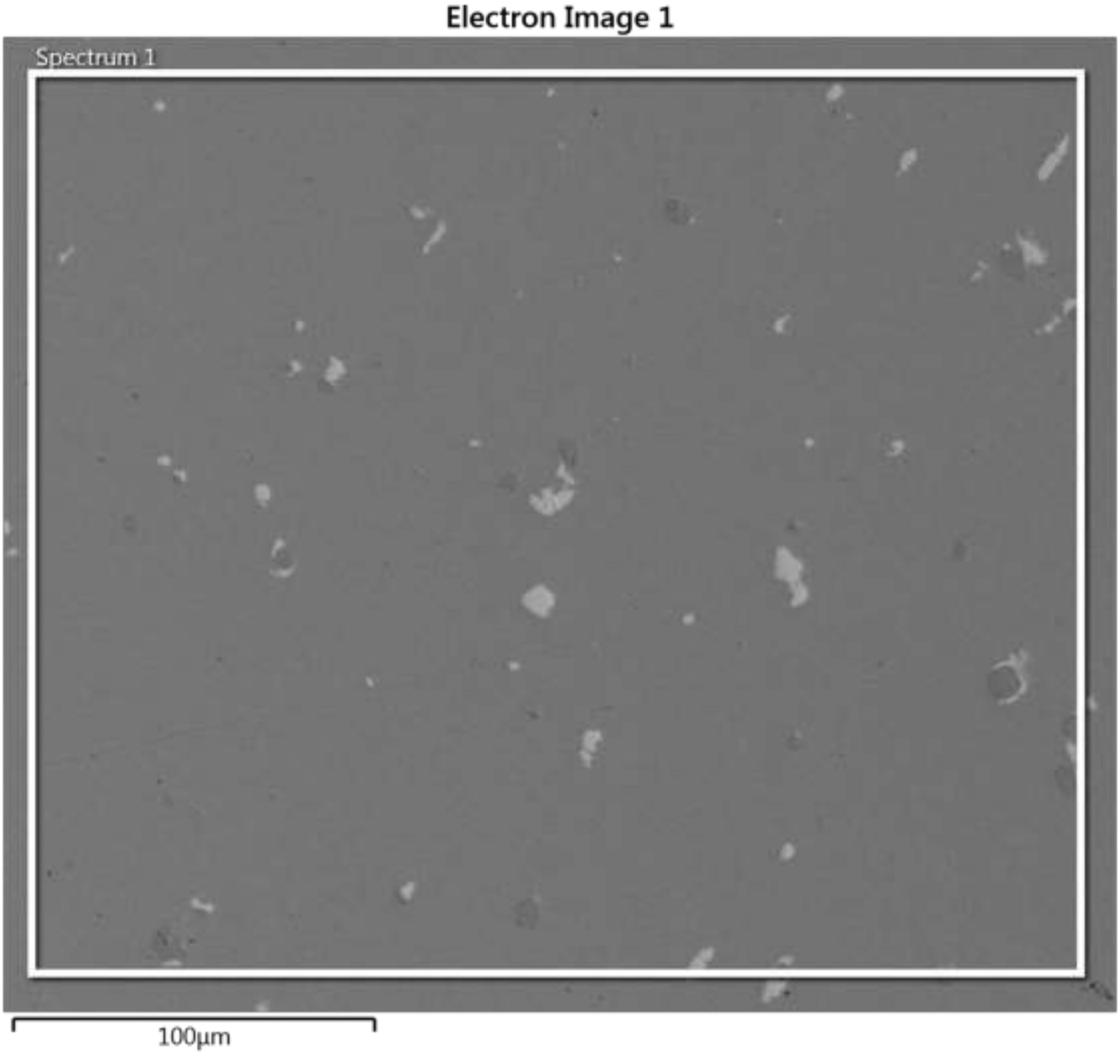


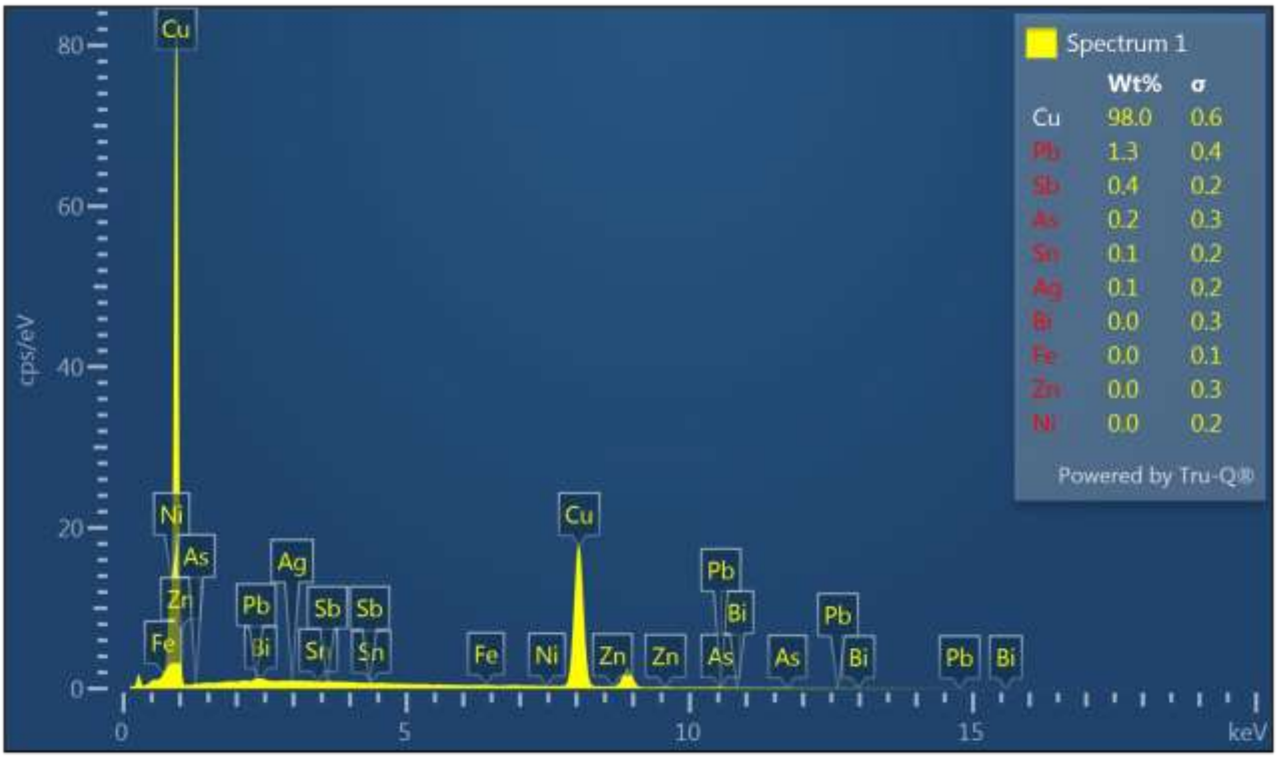


Sample 1069, Spectrum 1

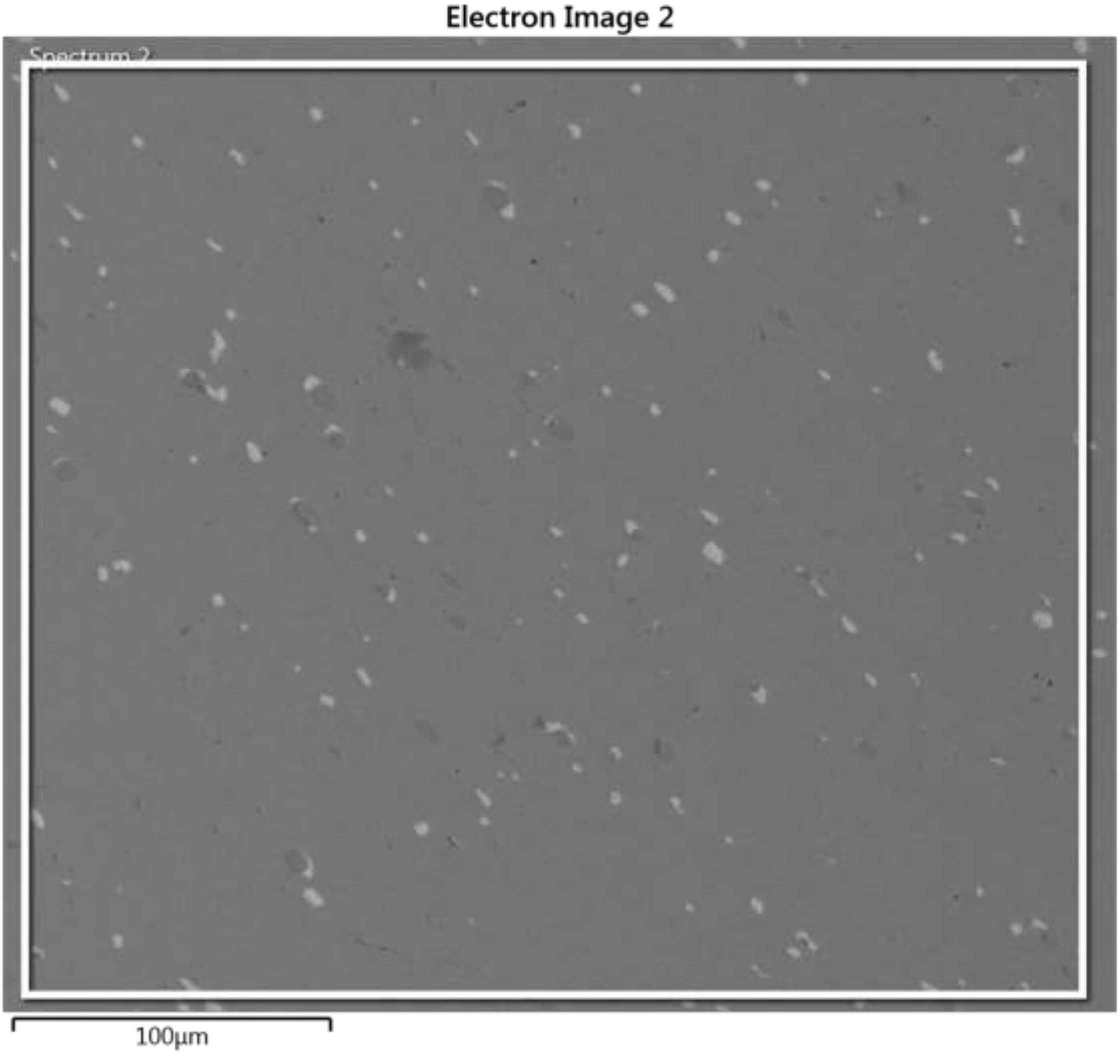


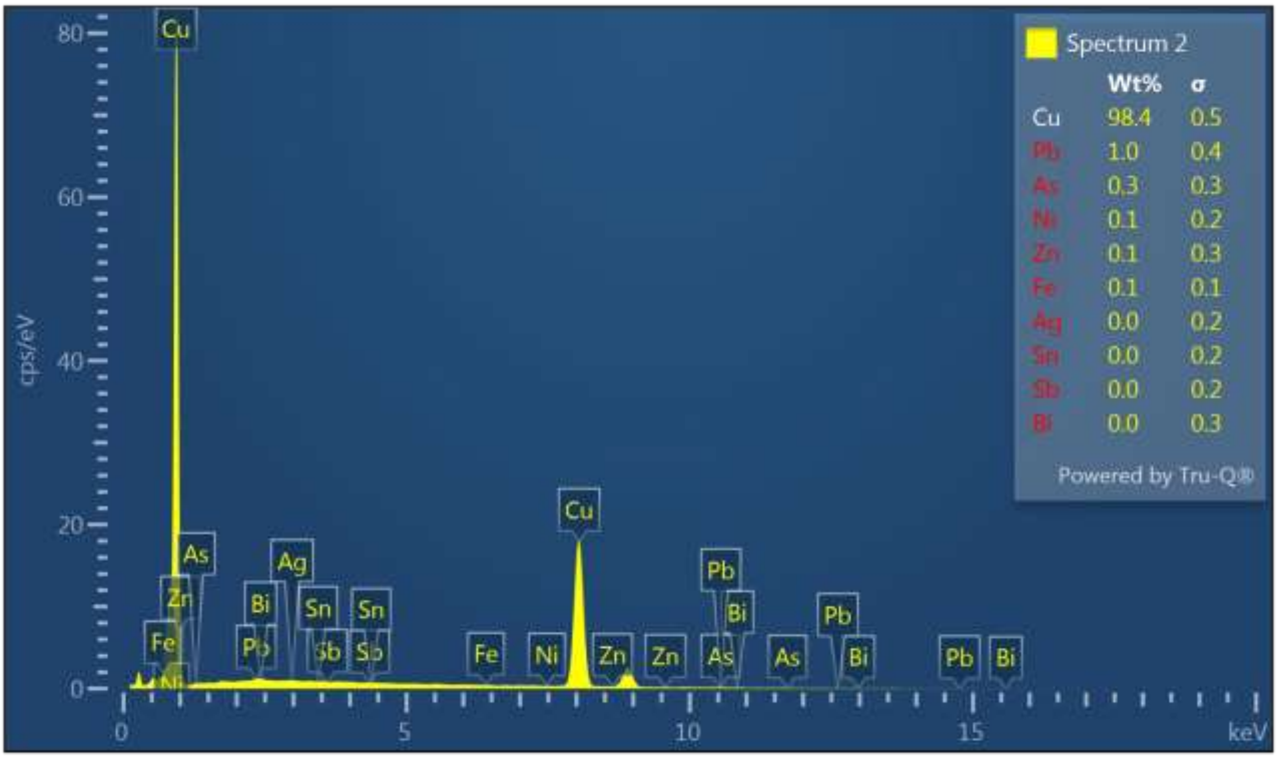
Sample 1156, Spectrum 1





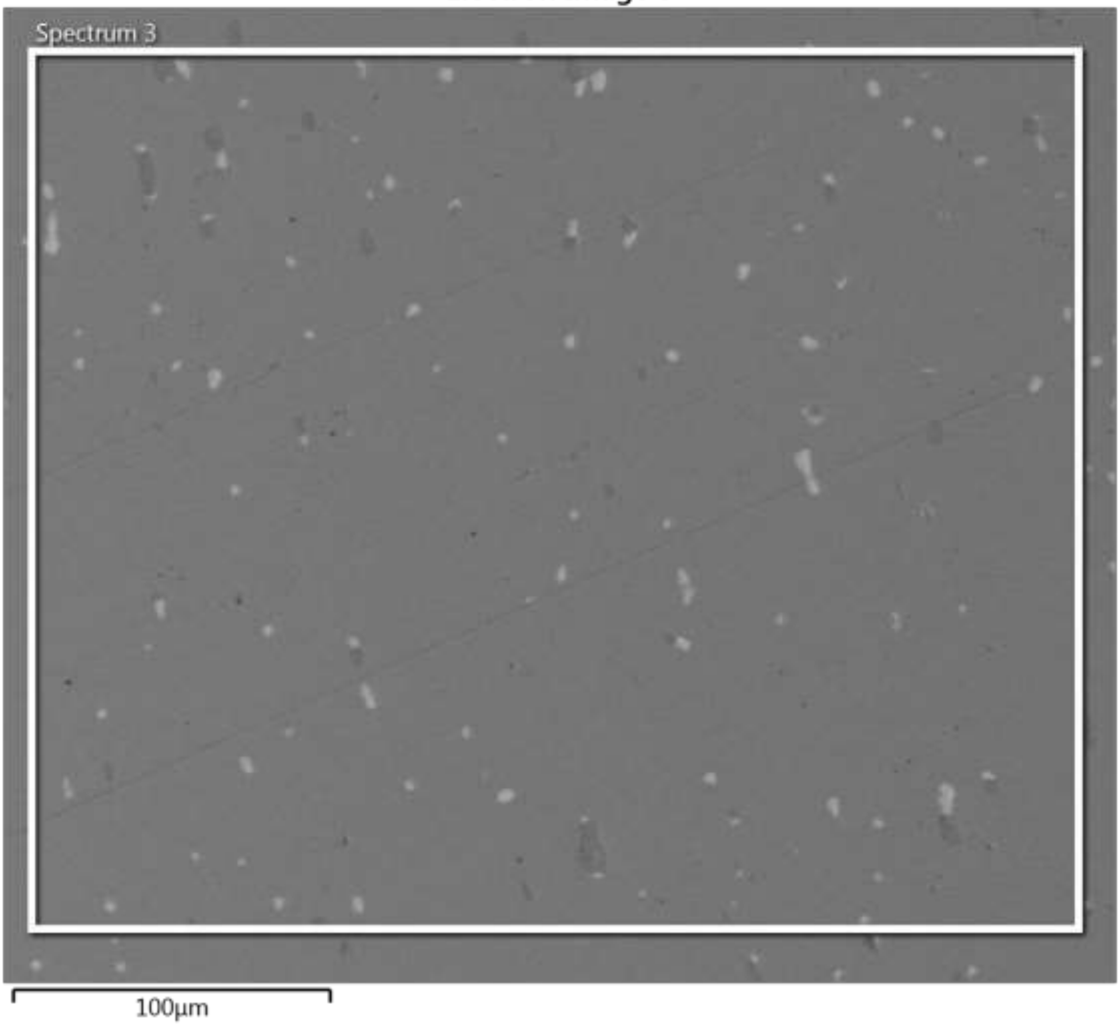
Sample 1156, Spectrum 2

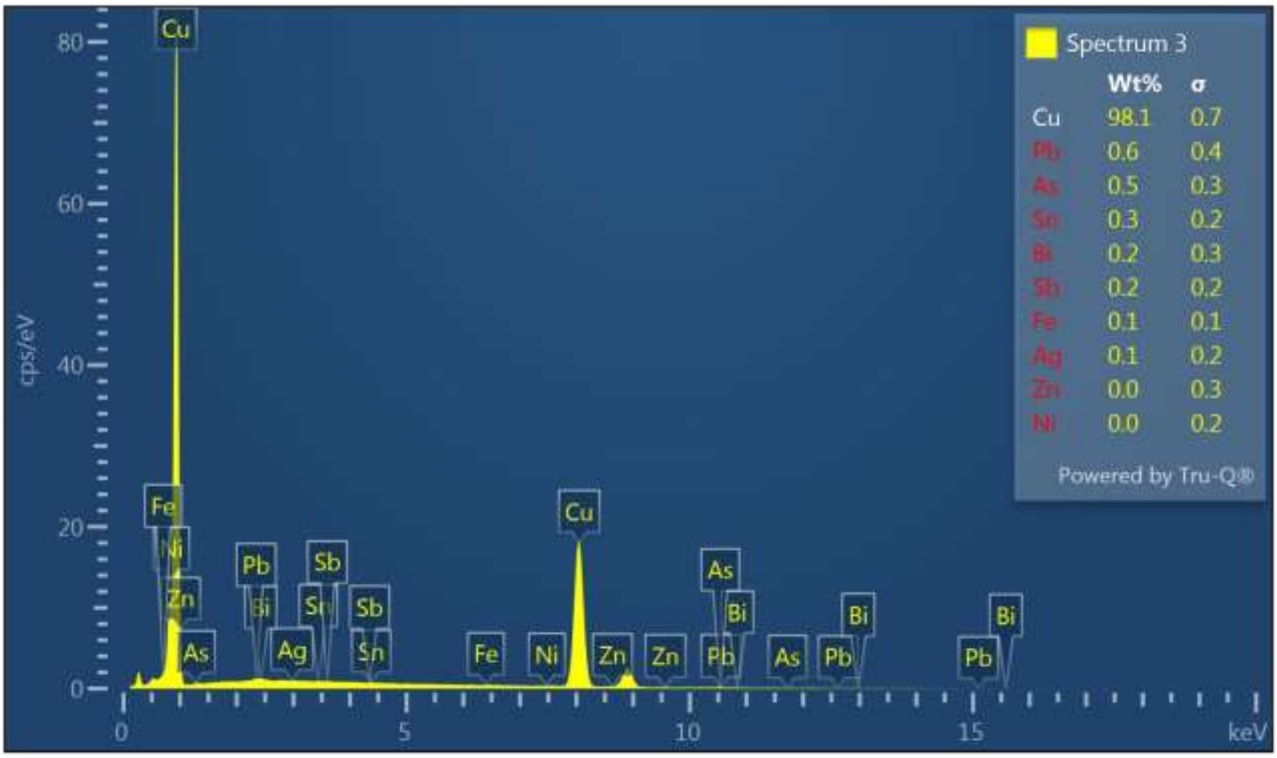




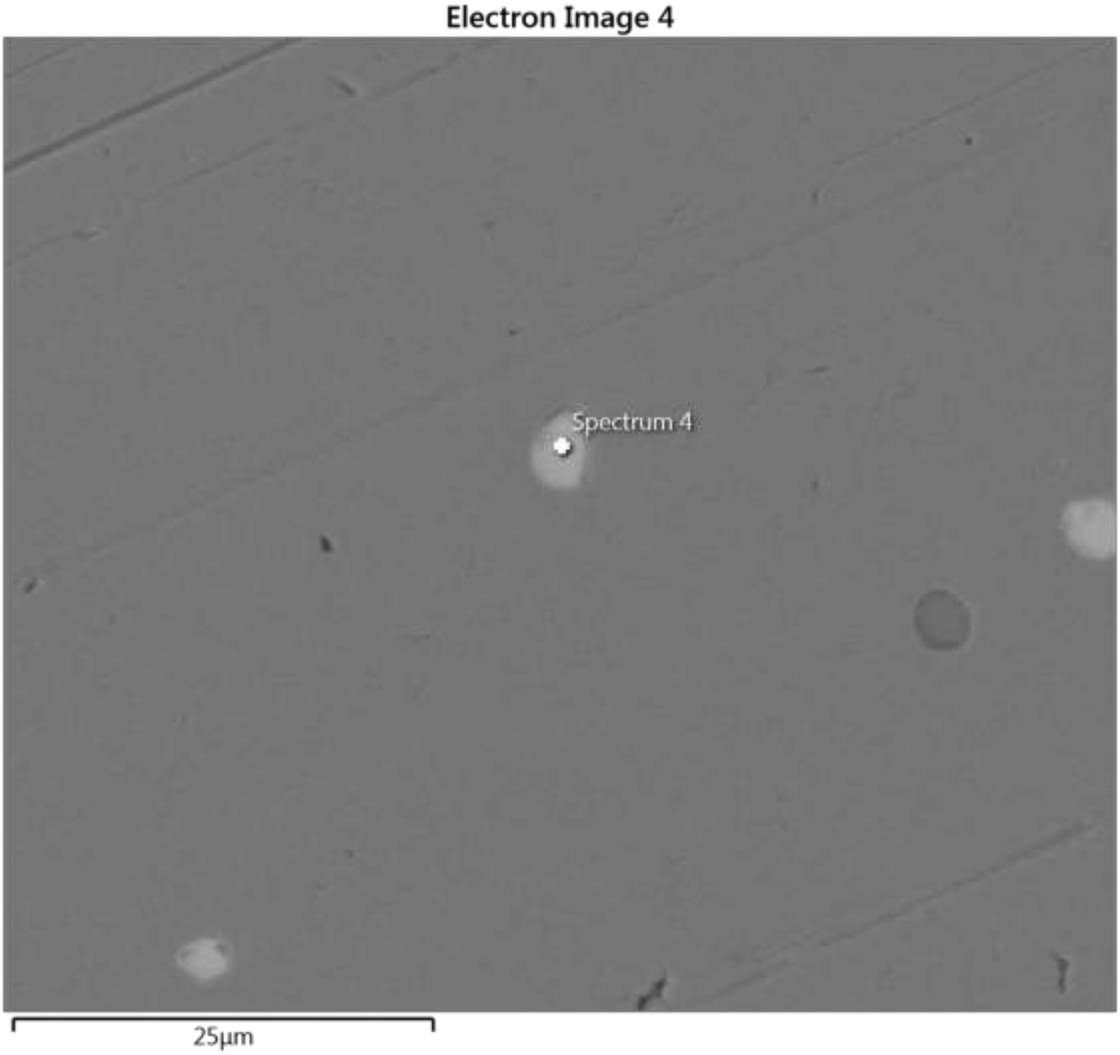
Sample 1156, Spectrum 3

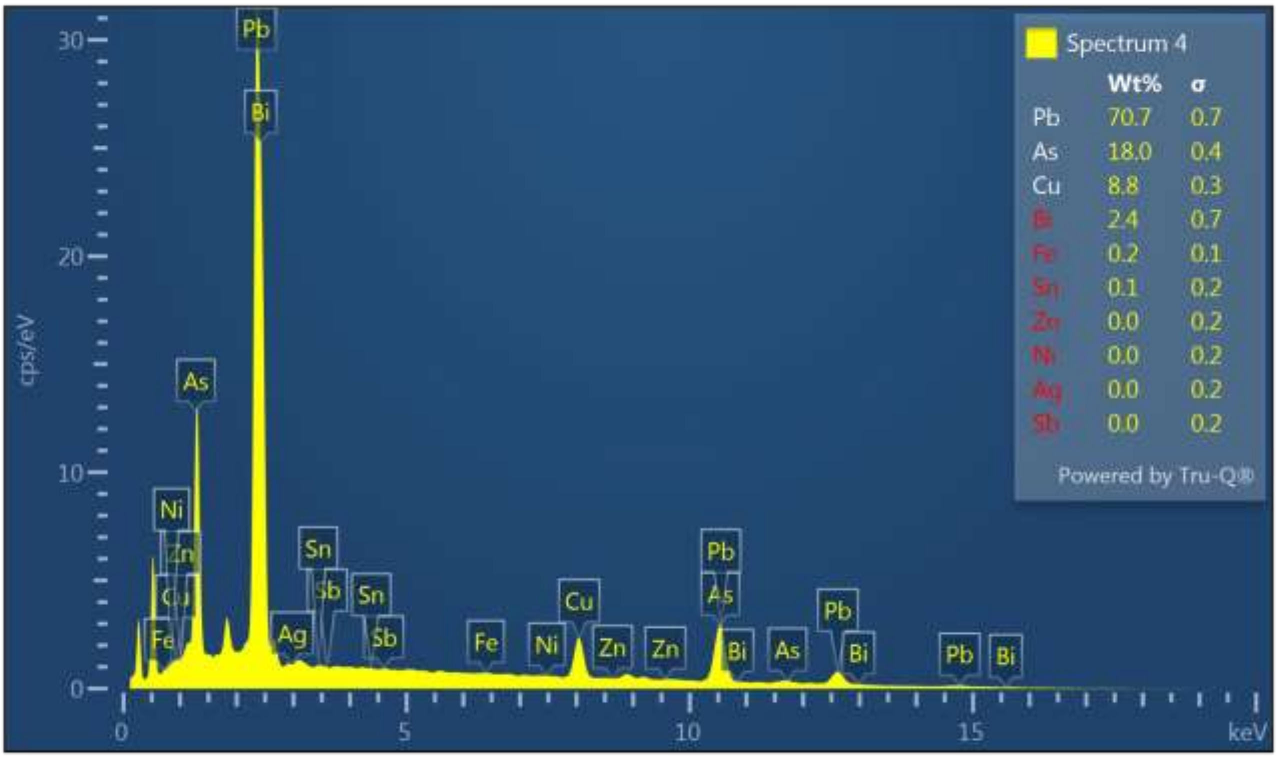
Electron Image 3



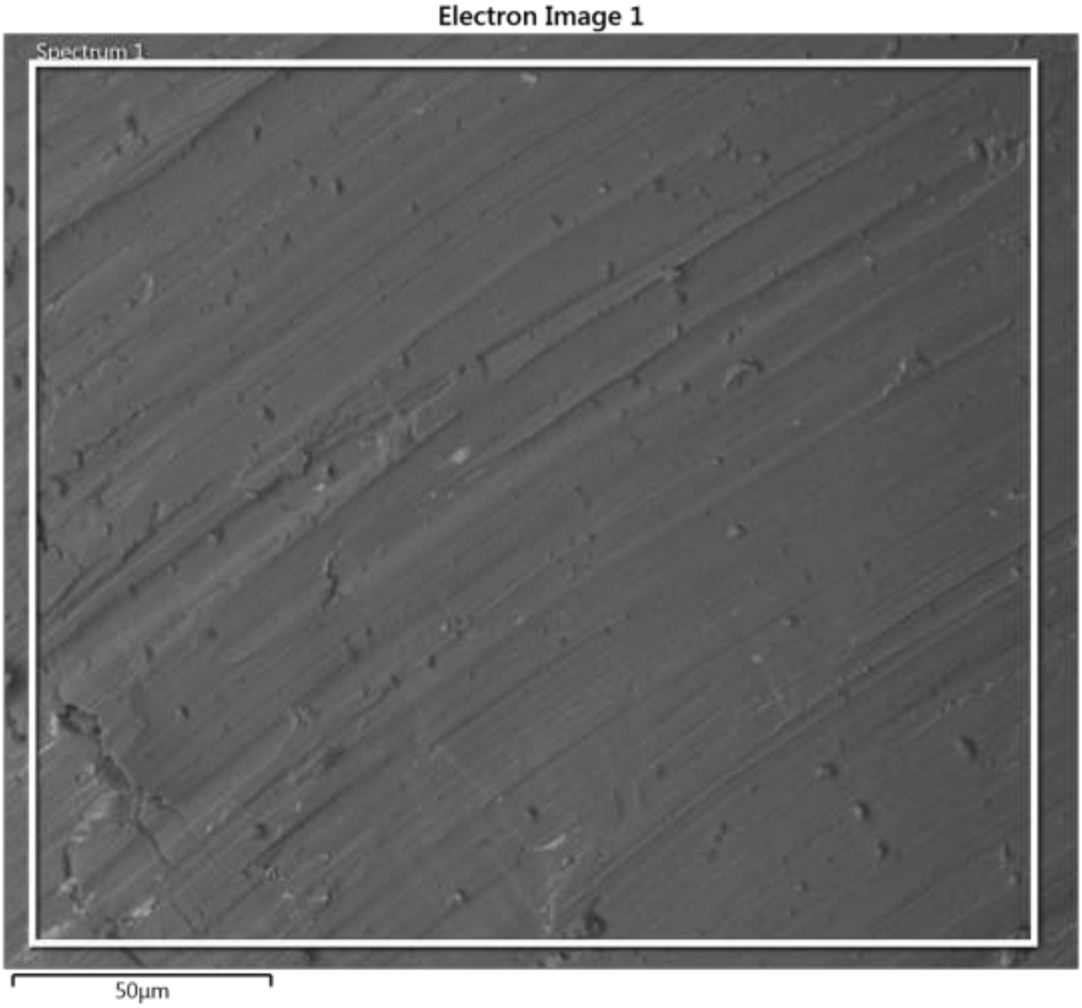


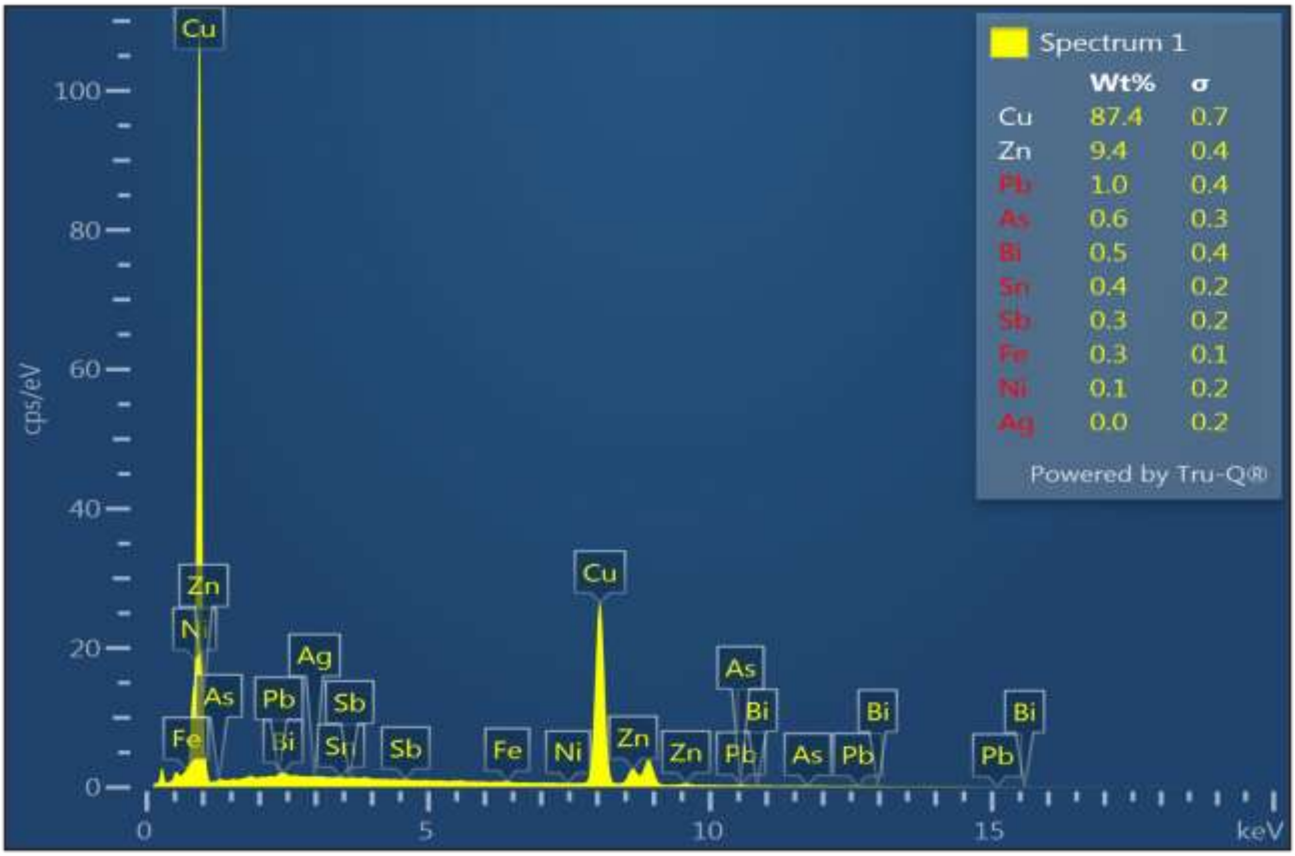
Sample 1156, Spectrum 4



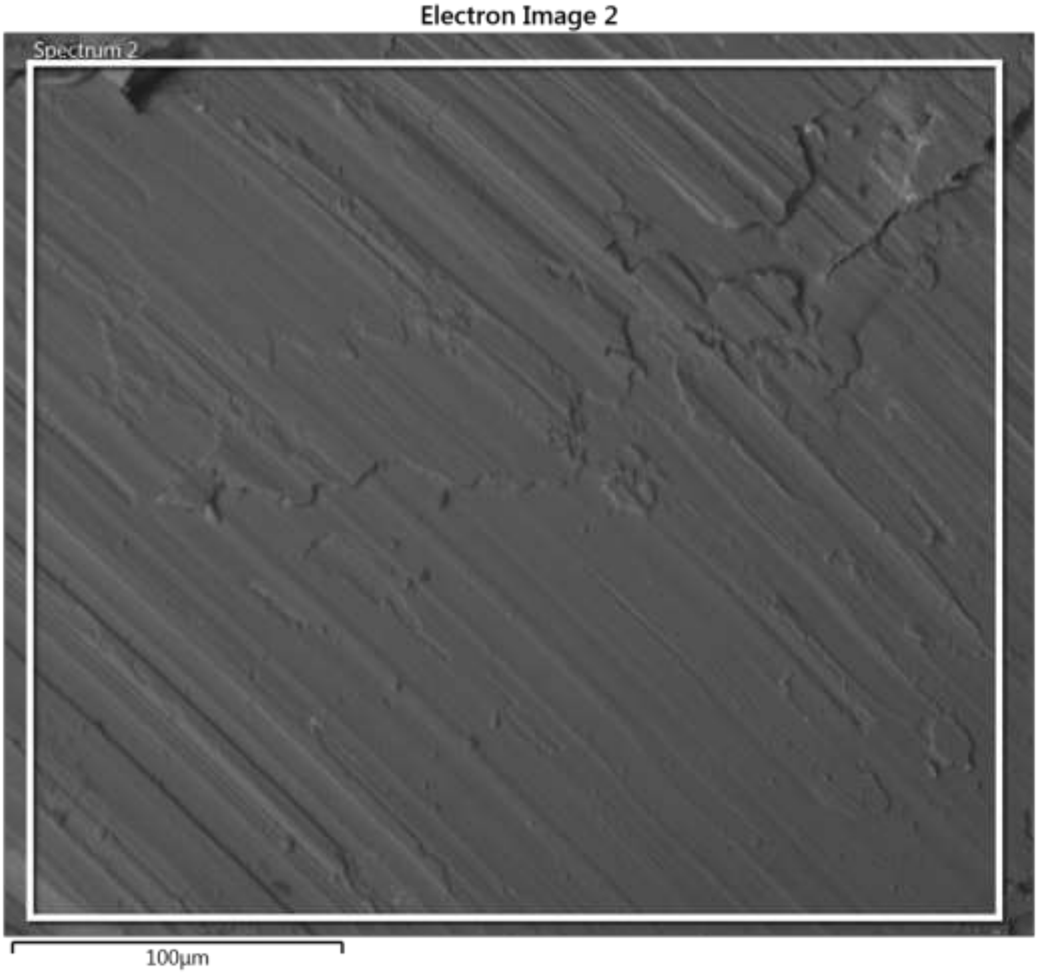


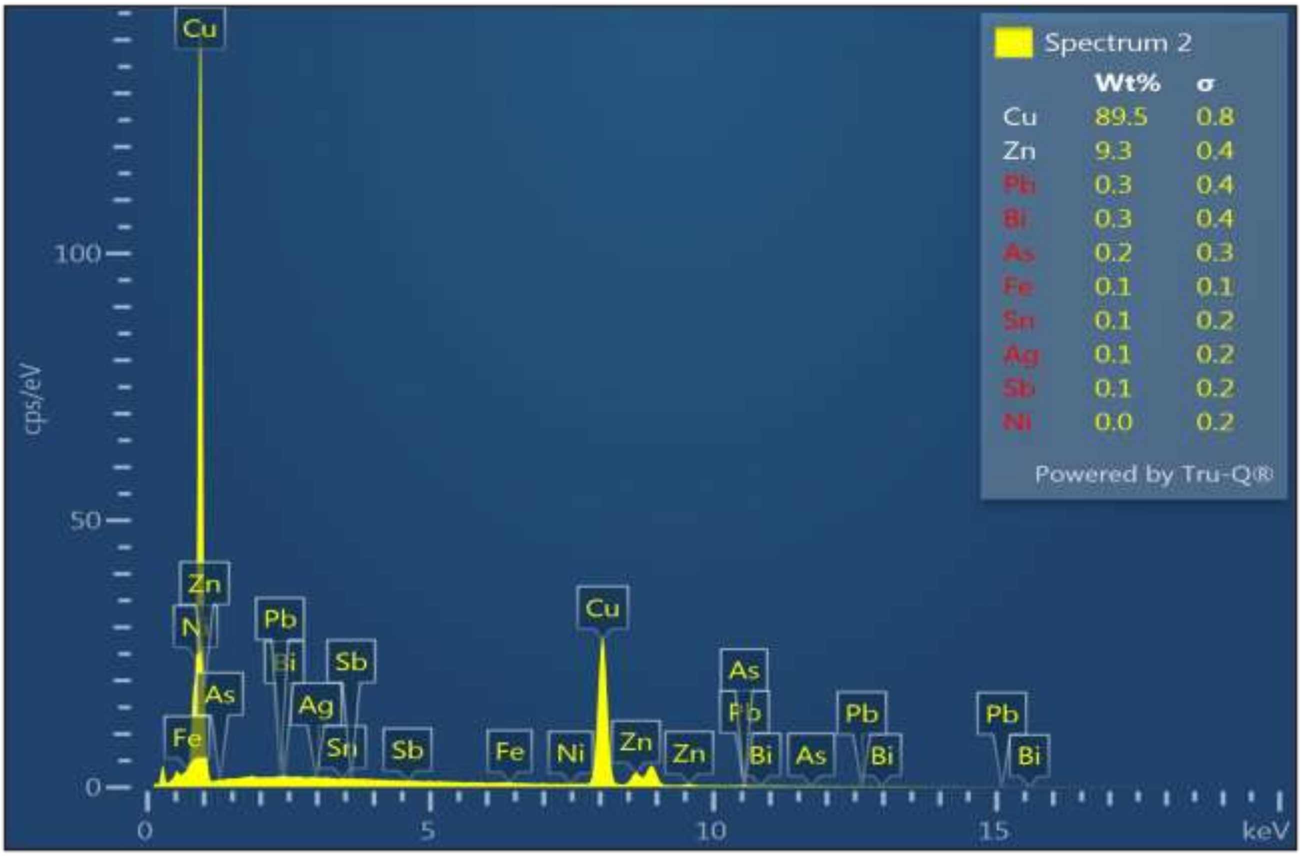
Sample 1171, Spectrum 1





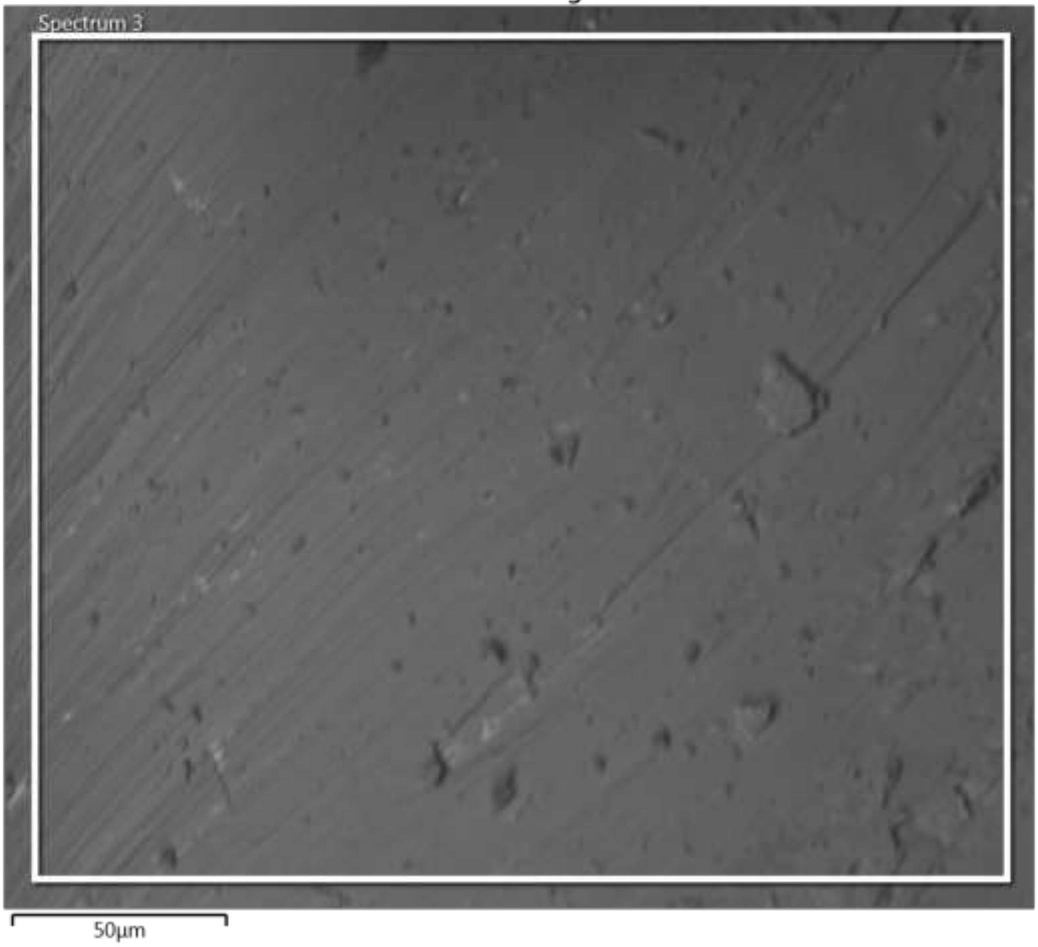
Sample 1171, Spectrum 2

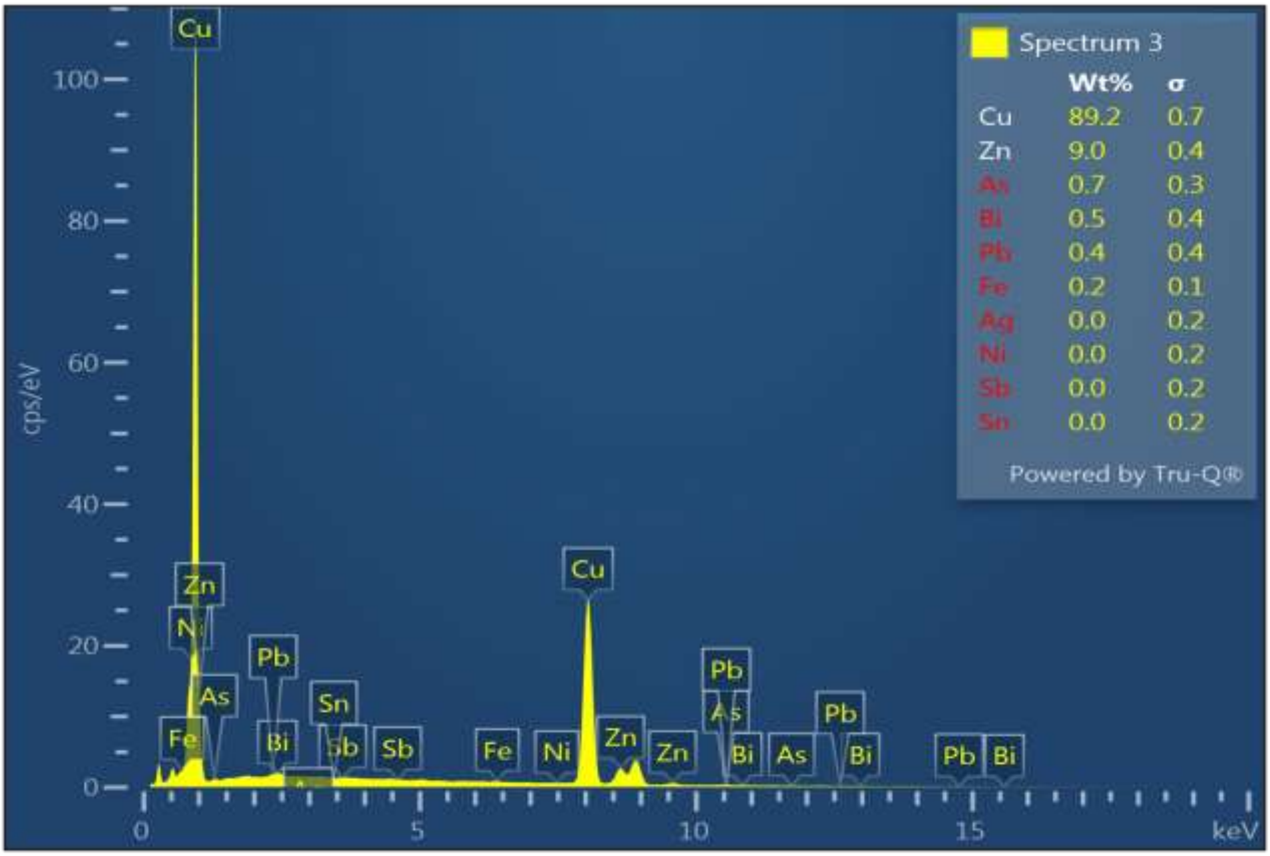




Sample 1171, Spectrum 3

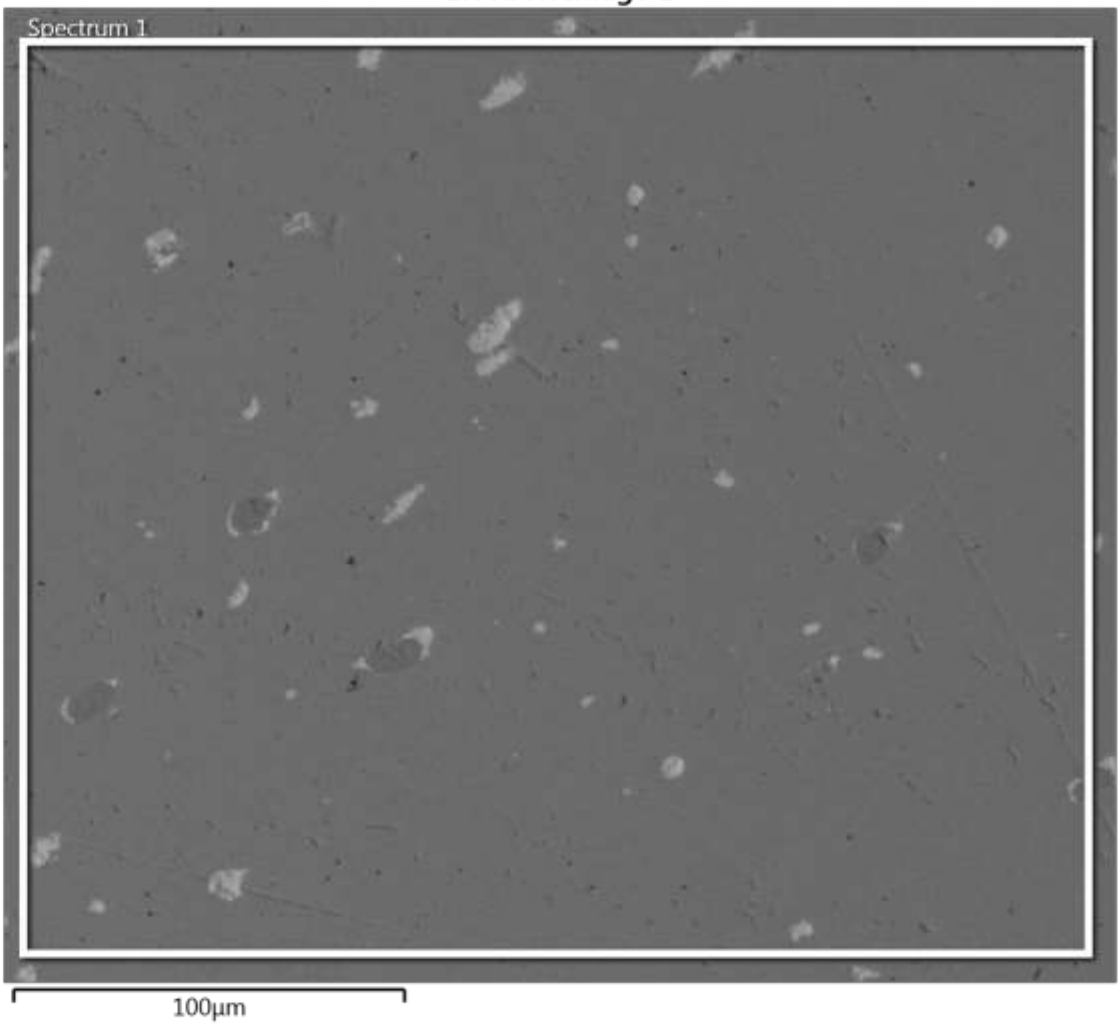
Electron Image 3

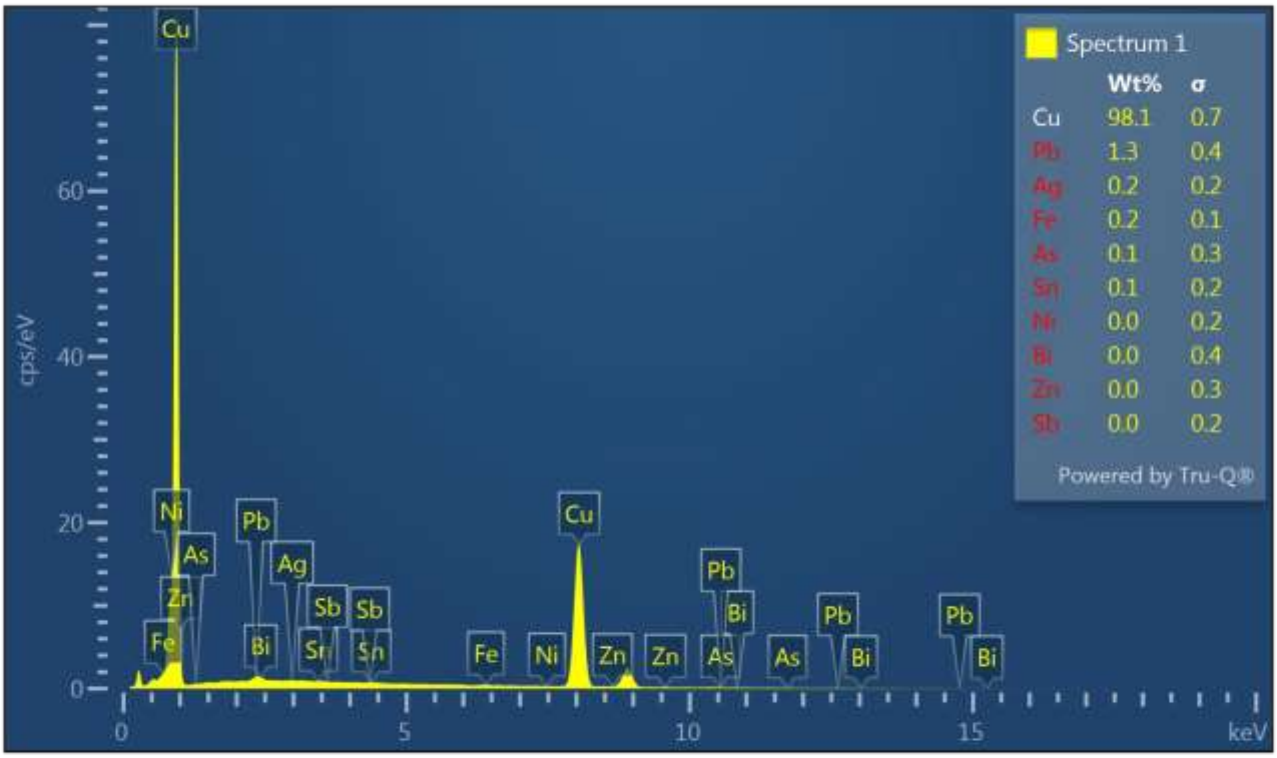




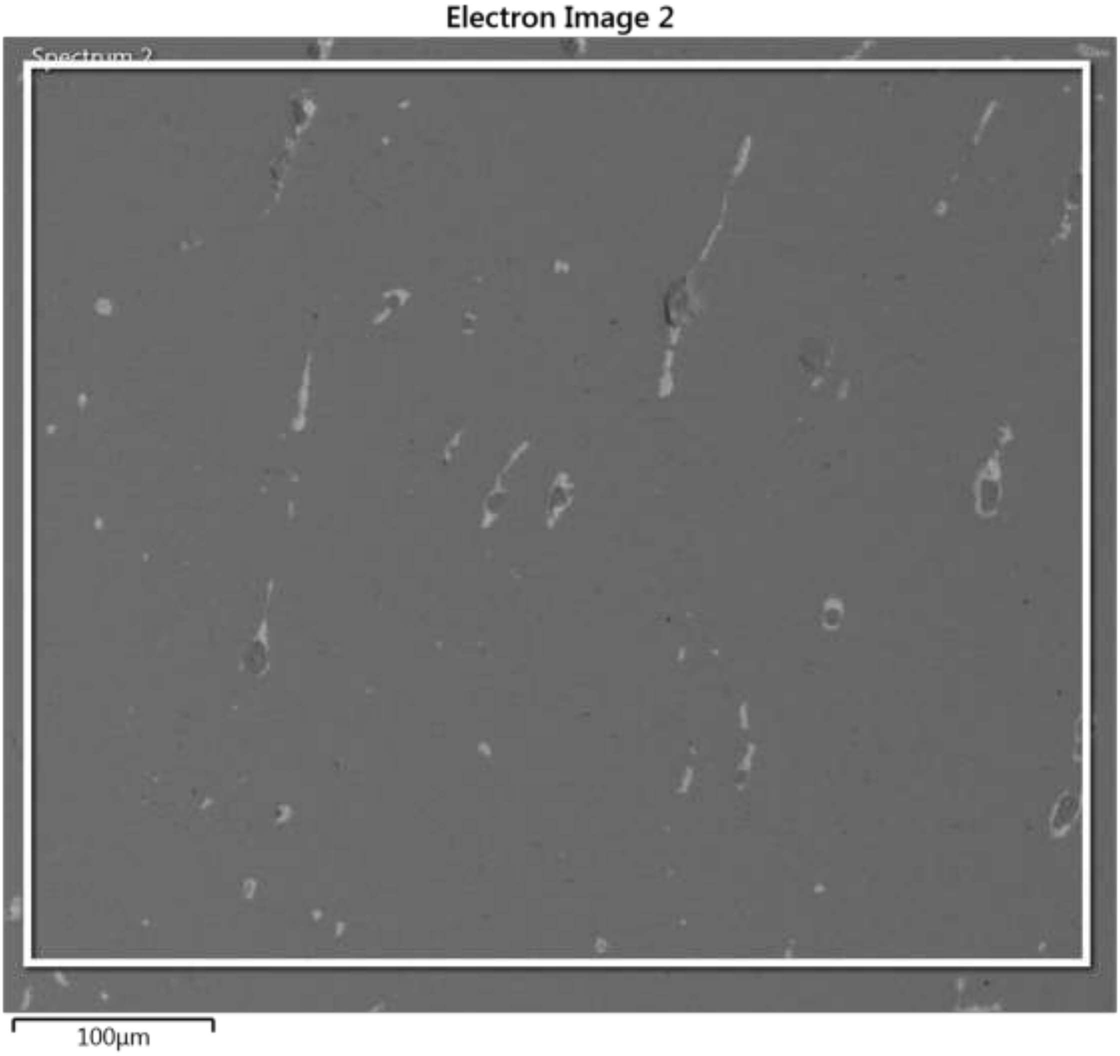
Sample 1175, Spectrum 1

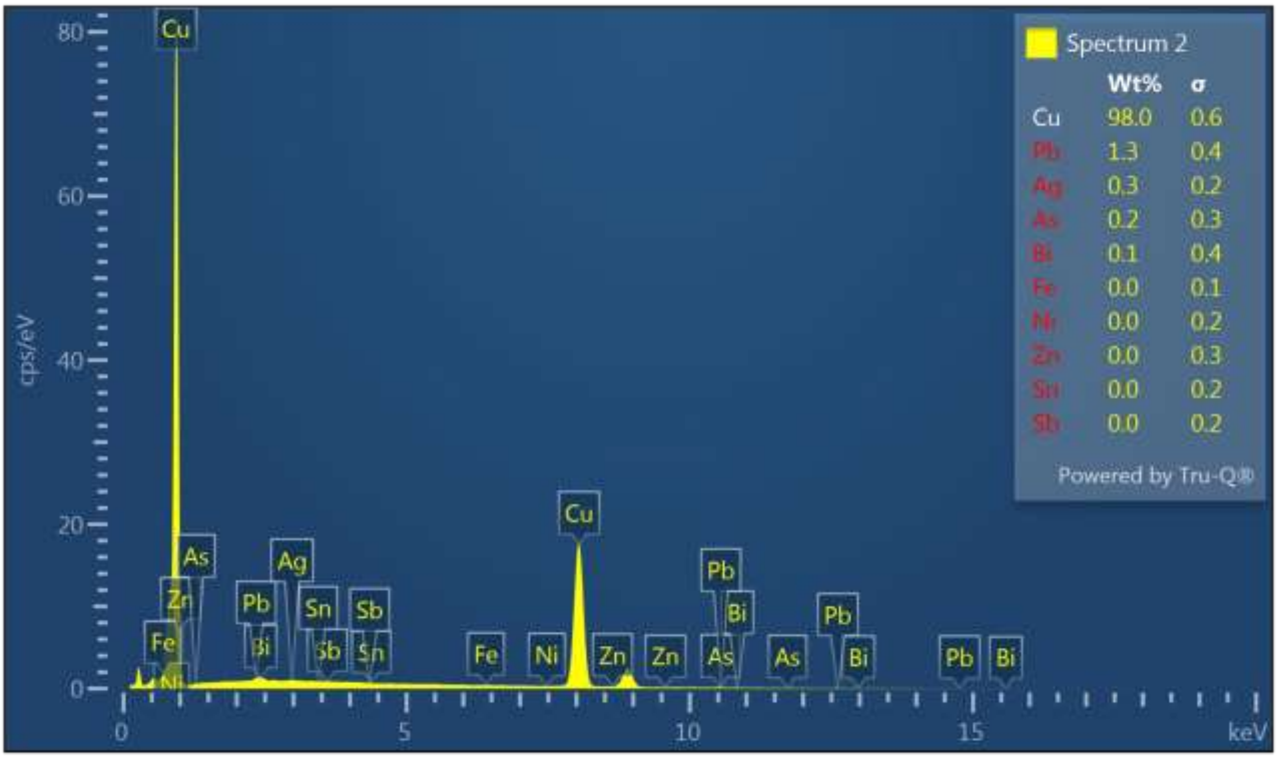
Electron Image 1





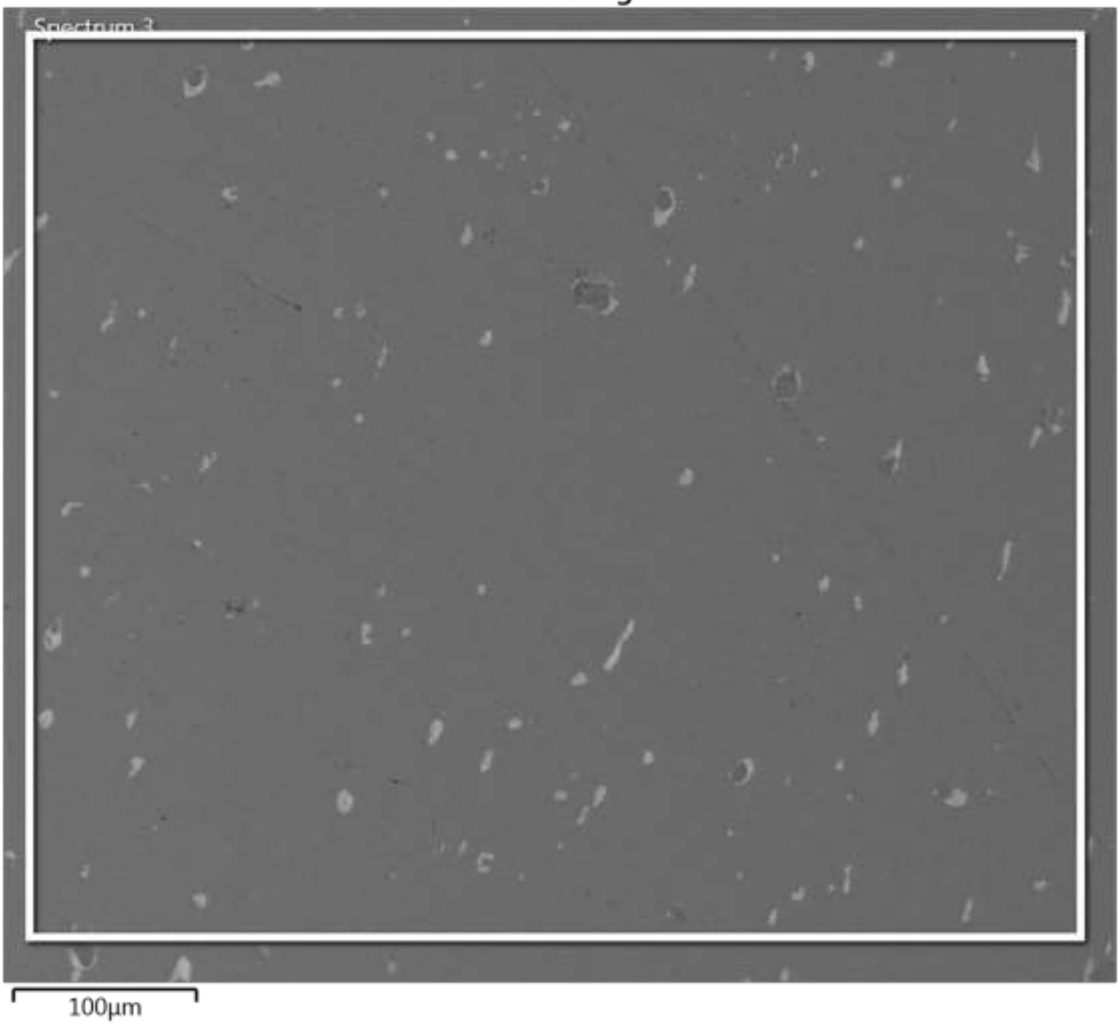
Sample 1175, Spectrum 2

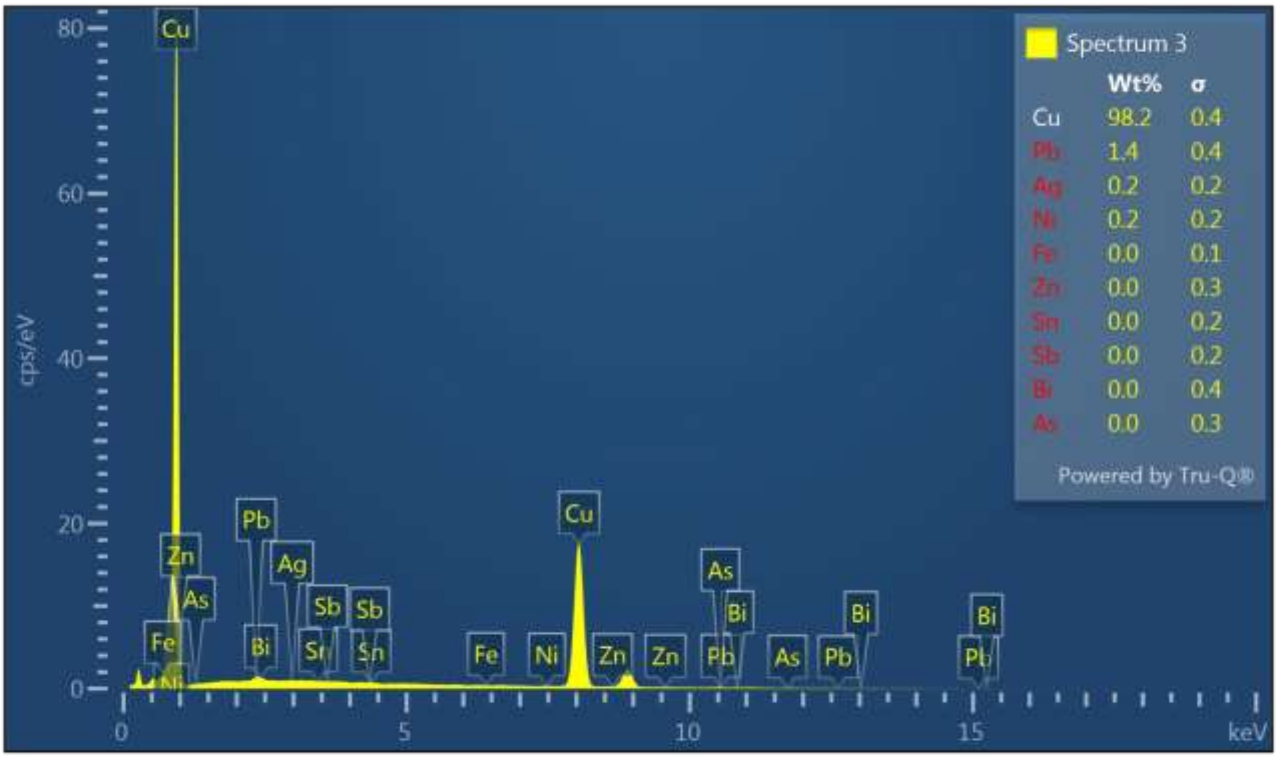




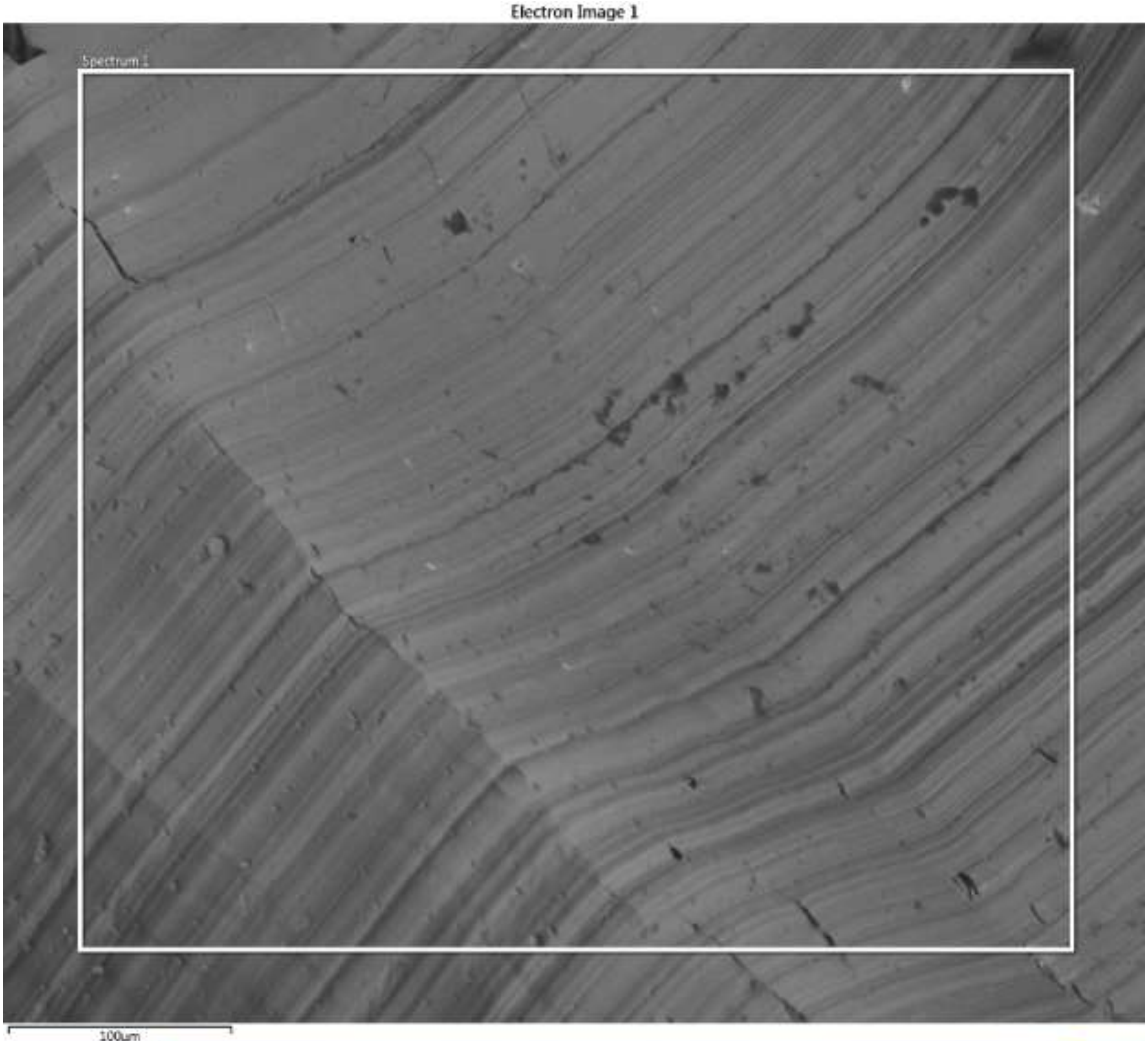
Sample 1175, Spectrum 3

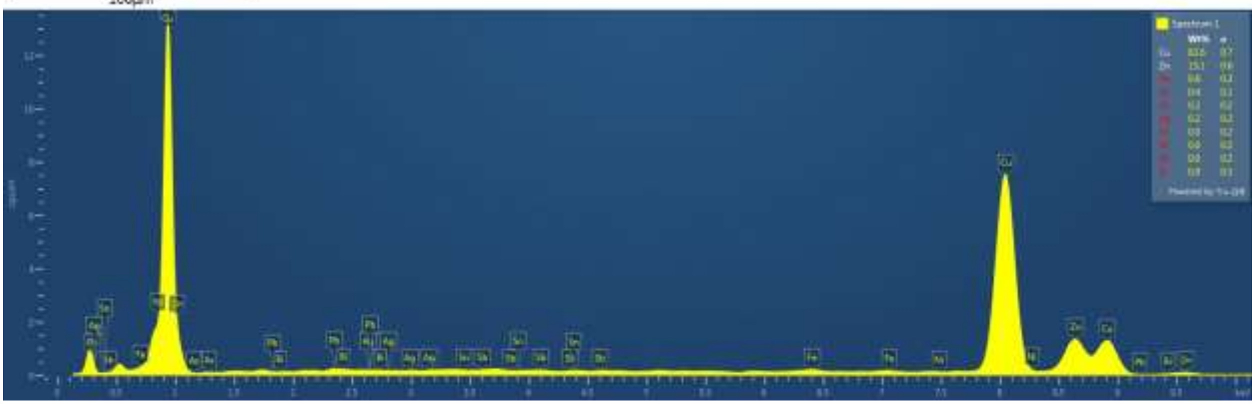
Electron Image 3



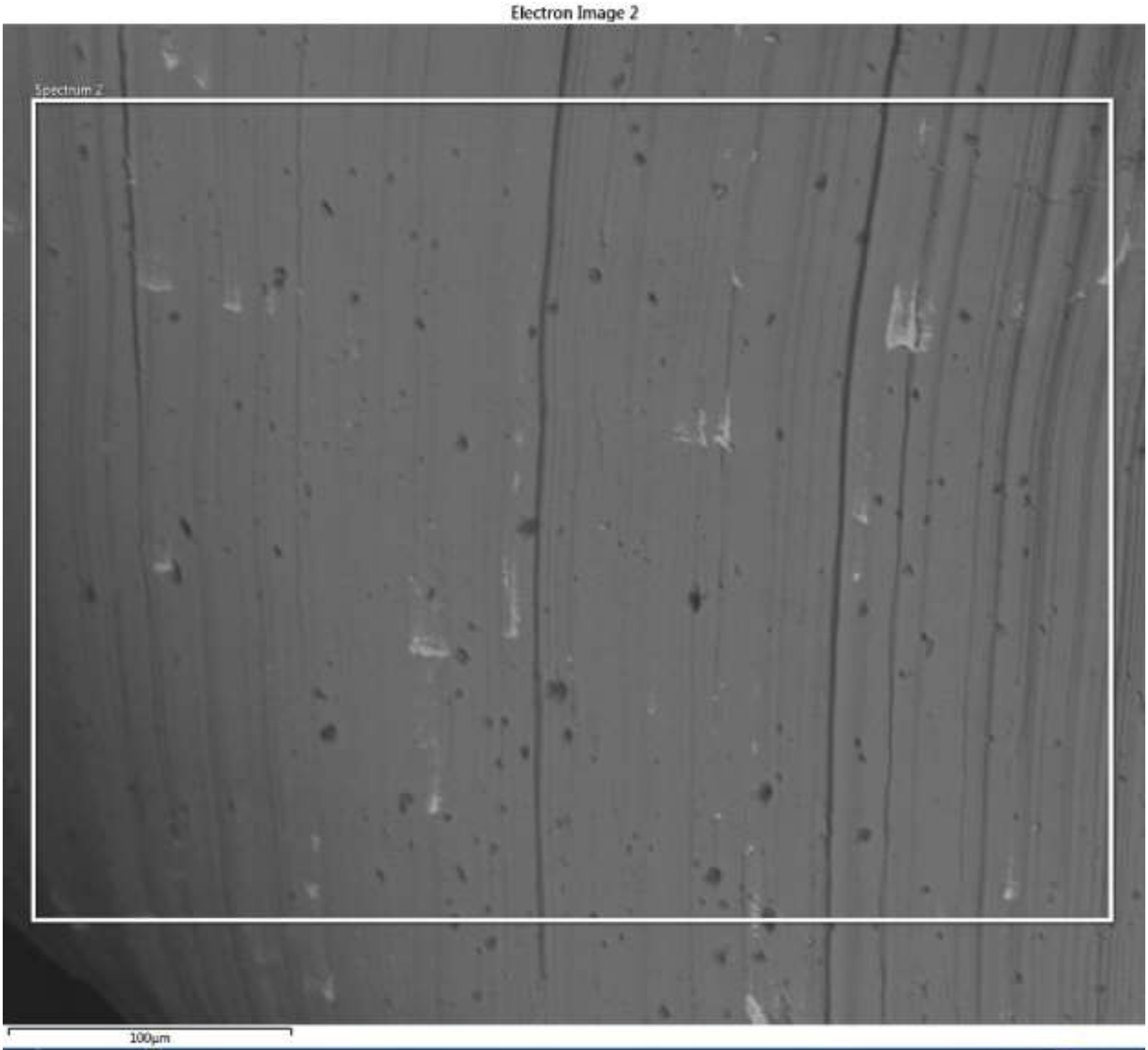


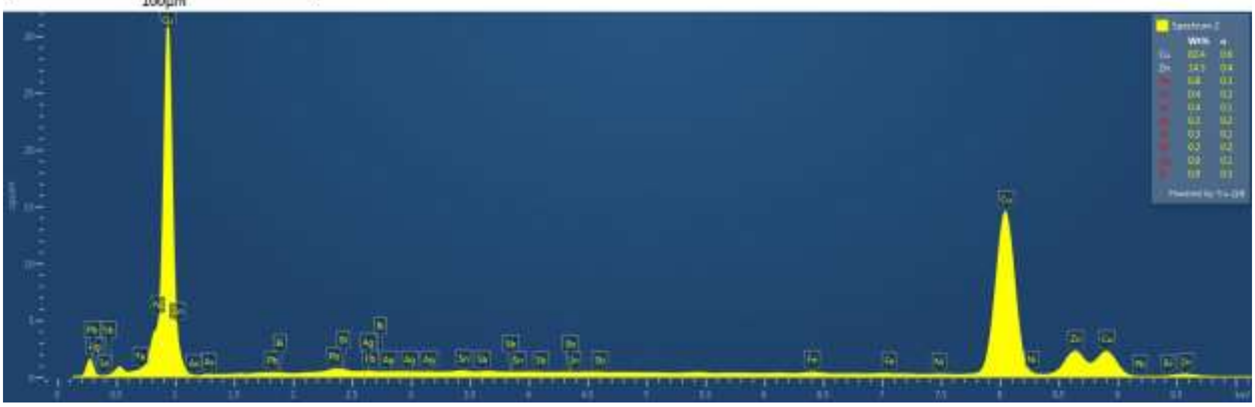
Sample PB2_Pintle 1.1, Spectrum 1



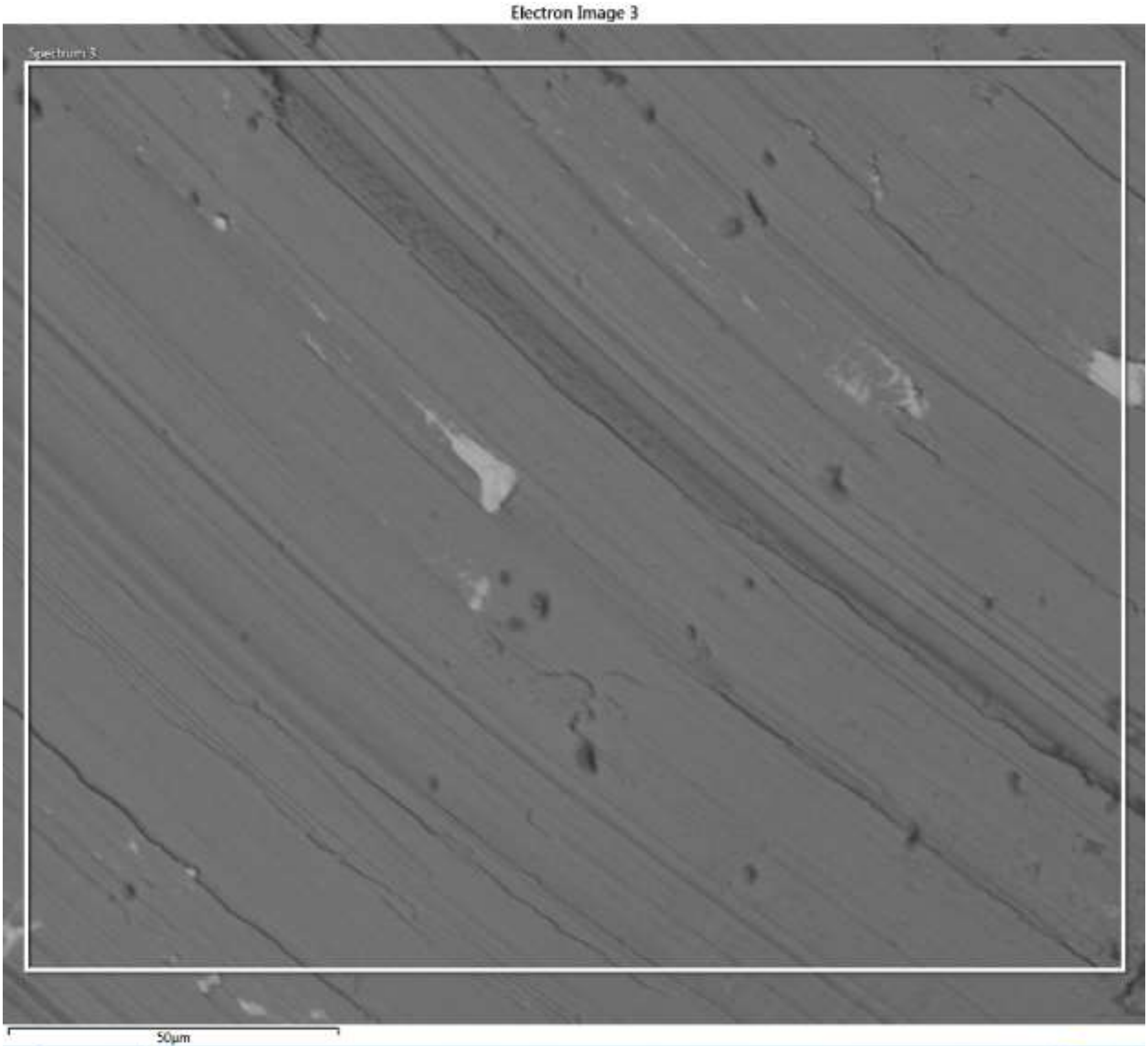


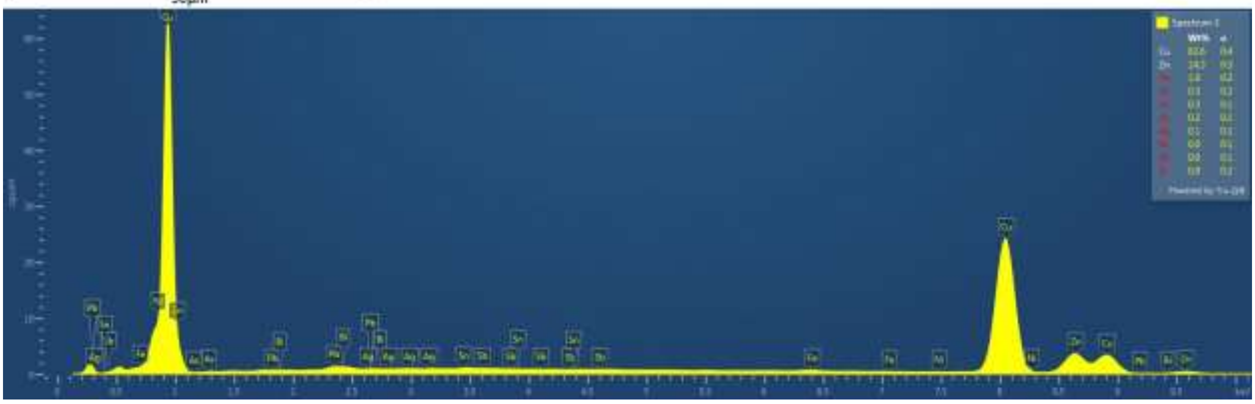
Sample PB2_Pintle 1.1, Spectrum 2



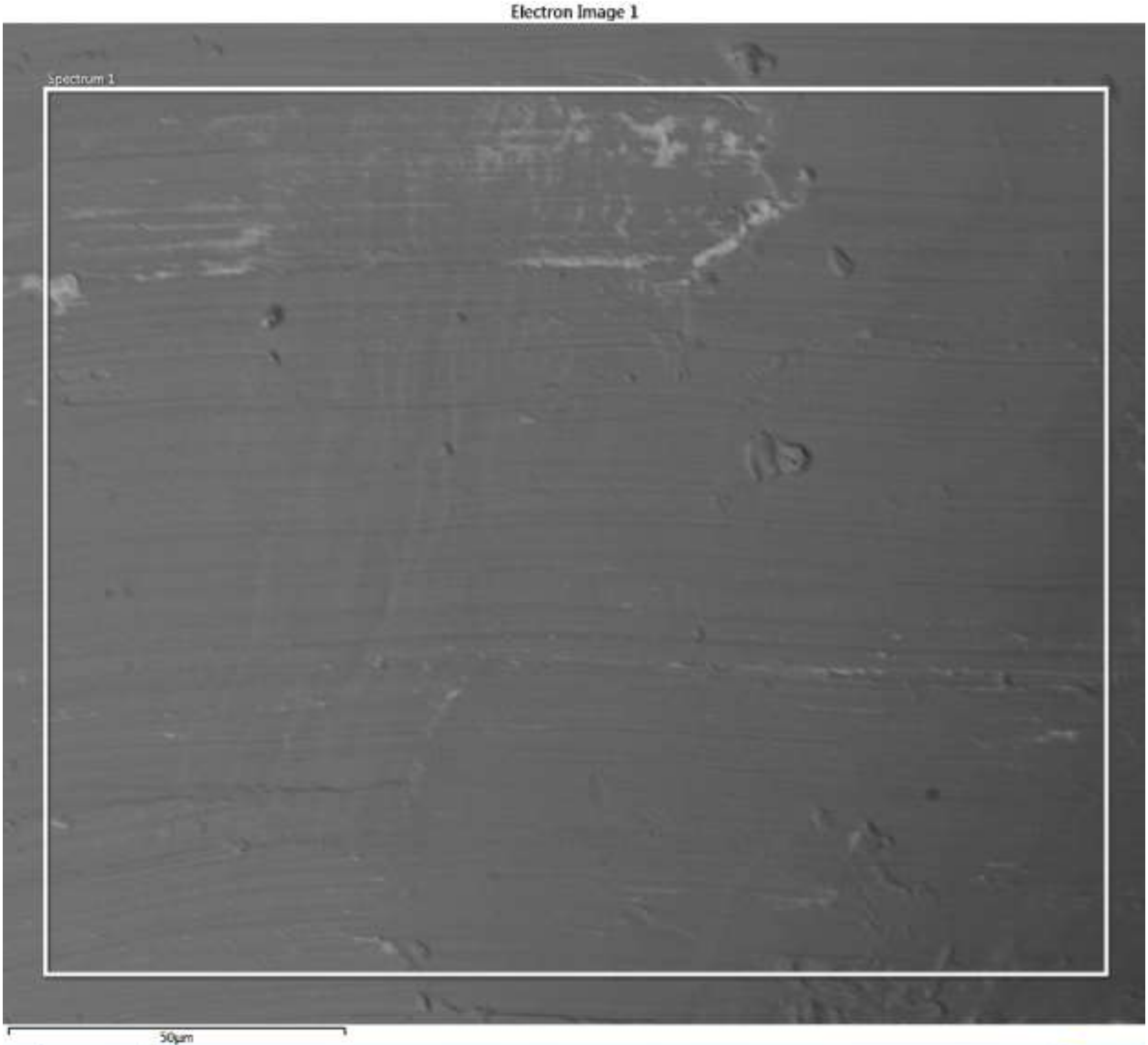


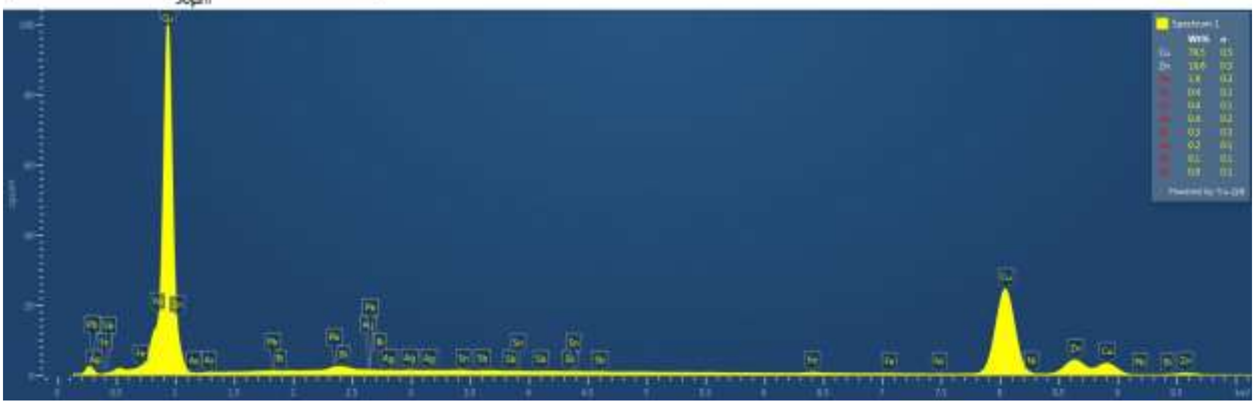
Sample PB2_Pintle 1.1, Spectrum 3





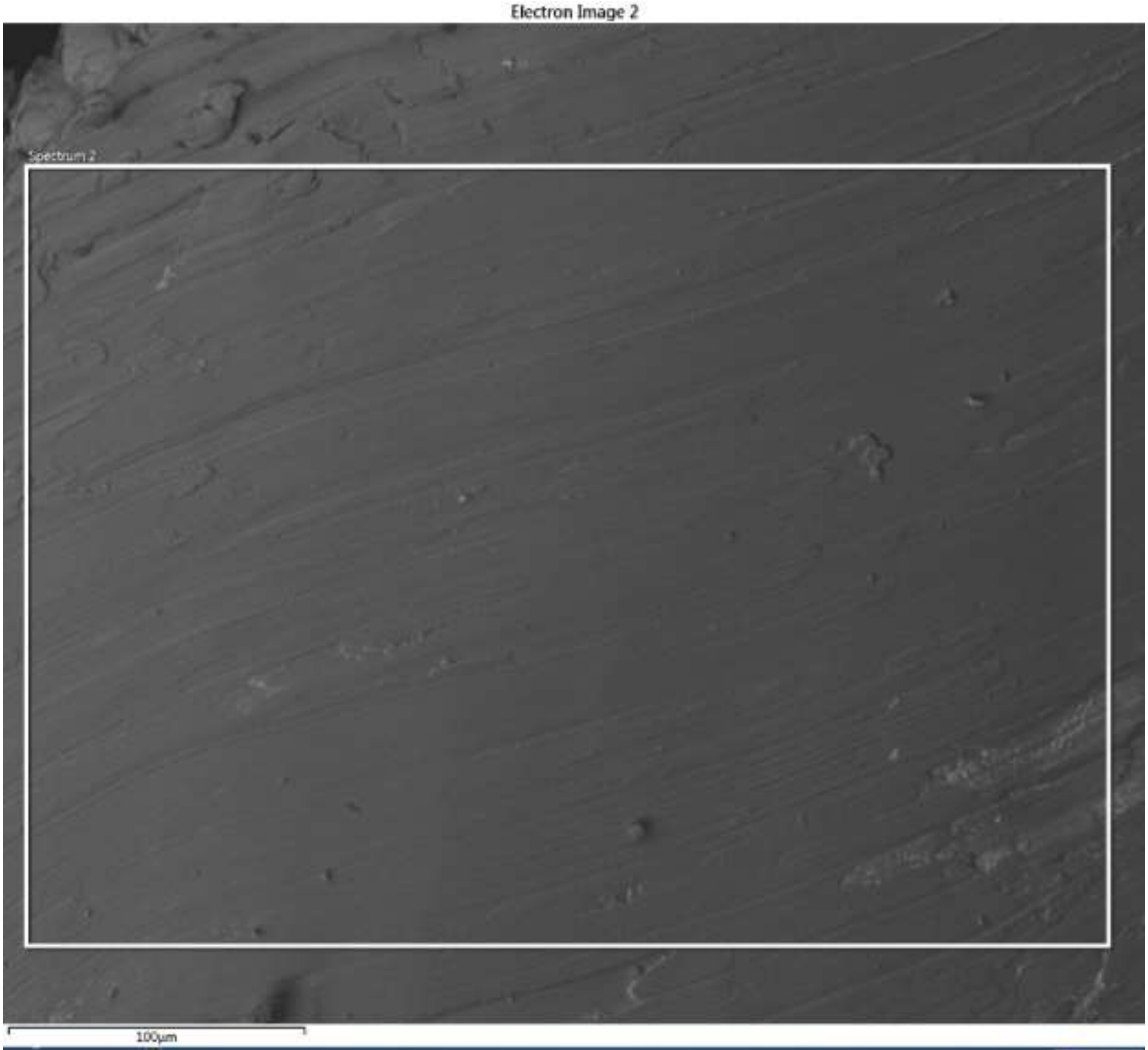
Sample PB2_Pintle 1.2, Spectrum 1

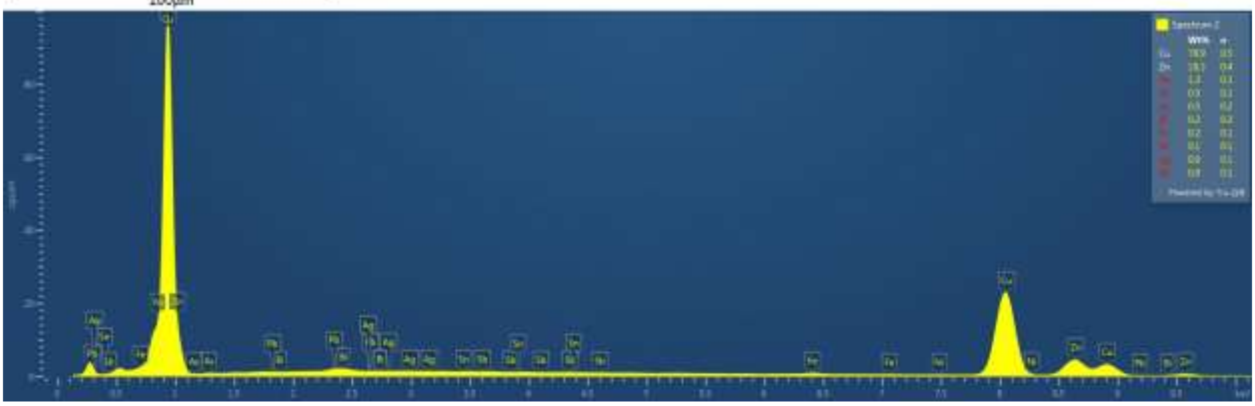




Sample PB2_Pintle 1.2, Spectrum 2

Electron Image 2





Sample PB2_Pintle 1.2, Spectrum 3