The Spice Must Flow: Roman Adaptation and Continuity of Trade Technology on the Indian Ocean

by

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I. Introduction

Following Octavian's annexation of Egypt in 30 BCE, merchants from the Mediterranean-centered Roman Empire suddenly had a direct avenue to South Arabia, India, and East Africa via the Red Sea. What was once a realm of myth and wild literary speculation had now become a concrete destination for merchant ships. Trade between Rome and Indian Ocean societies quickly grew, eventually seeing hundreds of ships setting out of the two primary Roman ports in Egypt. The voyage to India was not easy, compelling mariners to endure reefs, monsoon winds, exceptional waves, dangerous currents, and the occasional hostile attack—though each ship that survived the circuit brought back a cargo worth impossible sums. The journey was unlike anything else faced by Roman merchants and sailors, a truly new environment to which they had to adapt their ships and their sailing traditions.

Yet the Romans were not the inventors of this exchange. Pharaohs of the Egyptian Old Kingdom sent ships to East Africa as early as the 3rd millennium BCE, while Indian and Arabian merchants ventured across the Indian Ocean for centuries prior to Rome's arrival. The very ports which Roman ships sailed out of were foundations by an earlier state, the Ptolemaic Kingdom, a state which fused Macedonian, Greek, and Egyptian traditions. The majority of crews and merchants came from the rich cultural milieu of Greco-Roman Egypt, looking as much to the Nile Valley as to the Mediterranean coast. Each of the societies with which Rome interacted—the wealthy kingdoms of South Arabia, the newly-formed kingdom of Axum in Ethiopia, the competing cosmopolitan realms of Northern India, and the emerging Tamil polities of South India, had their own traditions of exchange. Rome was not the first to tackle the hazards of Indian Ocean travel.

The question, then, is twofold: how did Roman craftsmen and merchants adapt the Mediterranean traditions of shipbuilding technology to the Indian Ocean, and how were they influenced by established Indian Ocean traditions? The role of technology is to facilitate human activities, and thus will be approached from the perspective of its functionality. Survival in the desert and successful oceanic navigation were exceptionally difficult undertakings, and those operating out of the Red Sea ports would have needed to adopt or adapt technology in order to overcome varied environmental challenges with the meager resources available. Technology and tradition in the Red Sea were contextual, tailored to different economic necessities as much as to differing cultural backgrounds. Ultimately, Roman seafaring on the Indian Ocean must be understood as part of a much larger trade network—one which predated Rome, and in which Roman merchants were but one small corner of an interlocked system. Roman ships on the Indian Ocean were tailored to the niche which Roman merchants filled.

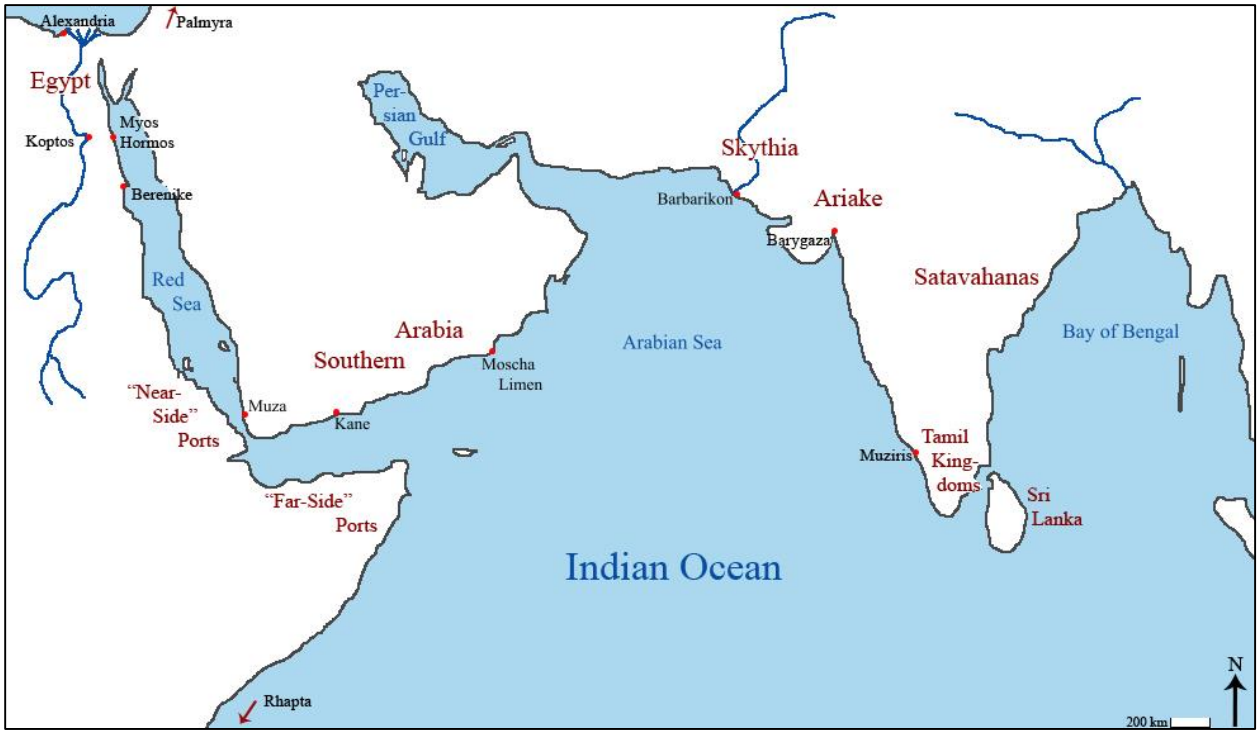

Fig. 1: Map of the Indian Ocean showing the locations of major sites mentioned in this paper

II. The Maritime Spice Route

Roman literature is replete with references to expensive "eastern" trade goods. Silk, myrrh, pepper, and precious stones were all touted as luxurious imports from nebulously defined points to the east of the Mediterranean. While Arabian and Indian products were known in the Mediterranean as early as the 2nd millennium BCE, their consumption intensified in the 1st century CE.[1] Even the natural philosopher Pliny the Elder, in his 1st century CE encyclopedia *Natural History*, could not help but express shock at the immensity of this trade, claiming that "by the lowest estimate, every year India and China and the [Arabian] peninsula deprive our empire of 100 million *sestertii*: so much do luxuries and women cost us."[2] Clearly, the figure is at best a rough estimate, meant to shock the reader and incite moralistic outrage at "effeminate" luxury spending rather than to accurately compute Rome's trade deficit, but it gives a sense of the magnitude of exchange. In the eyes of a well-connected Roman élite, Indian trade was booming.

[1] Parker 2002, 43.

[2] Pliny, *Naturalis Historia* 12.82. "minimaque computatione miliens centena milia sestertium annis omnibus India et Seres et paeninsula illa imperio nostro adimunt: tanti nobis deliciae et feminae constant." The *Sestertius* (HS) was a small silver coin, worth approximately one-fourth of a *denarius*, and the basic unit of accounting.

Indeed, ideological censures aside, the products brought into the Roman Empire through the Red Sea ports appear to have been worth vast amounts. The "Muziris Papyrus,"[3] a 2nd century CE document detailing a trade mission returning from the Indian port of Muziris, gives the taxable value of part of a cargo from the Indian port of Muziris brought through a Roman customs office. The total value of the imports is some 7 million *sestertii*, with the added note that this represents only a portion of one ship's cargo, and that before any markup for the wealthy buyers in Rome.[4] To use another dubious mathematical estimate, the 1st century CE geographer Strabo claimed that 120 ships travelled between the Red Sea ports and India every year;[5] if each ship carried cargo worth 7 million or more *sestertii*, Pliny the Elder's estimate of 100 million *sestertii* flowing into India each year starts to sound low. For comparison, his nephew the younger Pliny, who was without doubt among ancient Rome's "super-rich," bought a large estate which was worth approximately 3 million *sestertii*, a sum which he had to take out loans to pay.[6] Clearly, the ships sailing out of Egypt onto the Red Sea and Indian Ocean were a major part of the ancient Roman economy, their funding coming from the very wealthiest members of the Roman aristocracy.[7]

Yet despite this, few Roman authors describe how Indian and Arabian goods made it to Mediterranean markets. No matter how expensive their cargos, merchants were not particularly valued by élite Greek and Roman writers: Strabo squarely dismisses any testimony which Red Sea merchants could provide for the study of Indian geography, stating that they are "private individuals, and of no use for an account of locations."[8] Fortunately, one eyewitness account does survive: the so-called *Periplus of the Erythraean Sea* (Περίπλους τῆς Ἐρυθρᾶς Θαλάσσης), written by an anonymous Greek-speaking author in the mid-1st century CE. The term "Erythraean Sea" (*Mare Erythraeum*, ερυθρὰ θάλασσα), meaning "Red Sea" is something of a misnomer: the ports described in the text encircle both the Red Sea and the western Indian Ocean. Written as a pilot's guide, the *Periplus* describes landmarks, ports, and the trade goods which can be found therein. From the information provided by the *Periplus*, alongside modern meteorological, geographical, and hydrographic data, it is possible to reconstruct the numerous hazards which Roman ships sailing to India would have had to face—and thus, the problems which Roman shipwrights would have had to solve.

III. A Voyage Across the Erythraean Sea

The first region that Roman merchants crossed was the Red Sea gulf, a long and narrow sea running from north to south. Its northern limit is the Sinai Peninsula, the southern the Straits of Aden or *Bab al-Mandeb*. To the west and east are the coasts of Egypt and Arabia respectively,

[3] *SB* XVIII 13167
[4] Rathbone 2000, 49.
[5] Strabo, *Geography* 2.5.12
[6] Rathbone 2000, 49.
[7] Most luxury goods, such as ivory and silk, would have been the realm of the super-rich; black pepper, however, appears to have been a fairly cheap exception at 4 *denarii* per pound. While by no means cheap, this would not have been prohibitively expensive, perhaps explaining its common presence in both ancient cookbooks and inns.
[8] Strabo, *Geography* XV.1.4. "καὶ οὗτοι δ' ἰδιῶται καὶ οὐδὲν πρὸς ἱστορίαν τῶν τόπων χρήσιμοι."

both particularly steep and arid.[9] The water is warm, perfect for *teredo* shipworms and coral growth.[10] The entire coast is lined with coral, which is generally just barely submerged at low tide and at times extends up to several kilometers out to sea.[11] Ships needed to stick to the thin strip of deep water at the center of the gulf, or risk running aground.[12]

Seasonal winds created an additional obstacle for mariners. The wind on the Red Sea blows almost exclusively from the north in summer, while the in the winter it reverses to blow from the south.[13] Skilled sailors could have used the current, tacked sails, and the diurnal wind cycles to sail against the wind,[14] but it would have been slower and more labor intensive than departing and returning in season.[15] A papyrus letter from 97 CE, coming from the Red Sea port of Berenike, illustrates this problem: in it, a sailor laments the contrary winds he faced when his ship came into the harbor off season.[16] The sailor in this letter survived to tell the tale; some who faced similar conditions may have run aground or sunk. The strong and often contrary winds made protected harbors a necessity for maritime activity to prosper.

The Egyptian Red Sea ports provided a safe launching point for ships. In the 1st and 2nd centuries CE, the two main Roman harbors on the Red Sea were Berenike and Myos Hormos. Both were Ptolemaic foundations,[17] part of an extensive effort by the newly enthroned Macedonian kings to exert their control over the Red Sea coast. Ptolemaic efforts focused on obtaining East African elephants, which were valued for their military uses.[18]

While Ptolemaic merchants seem not to have made regular trips to India, the monsoon winds were supposedly "discovered" during the Ptolmaic period. According to the most common ancient theory, the monsoons were discovered by a Greek pilot named either Hippalos some time in the 1st century BCE.[19] The geographer Strabo, however, quotes a story by the Syrian born Greek polymath Poseidonius that it was a stranded Indian merchant who revealed the direct route to India.[20] This sailor was brought to the Ptolemaic court following a shipwreck. He acted as

[9] Lapidoth-Eschelbacher 1982, 2-4.
[10] Blue et al. 2012, 92; Blue et al. 2011, 186.
[11] Lapidoth-Eschelbacher 1982, 6.
[12] As described in *Periplus* 20.
[13] Whitewright 2007a, 78.
[14] Whitewright 2007a, 84-85.
[15] Sidebotham 2011, 8.
[16] Peppard, 2009, 197. The sailor is arriving in June, just before the beginning of the summer monsoon. He would have been traveling north when the SW winds begin to gain force.
[17] Modern *Quseir al-Qadim* and *Ras Banas* respectively. The harbors at Aila and Clysma, closer to the Sinai, only rose to prominence in late antiquity, following a period of trade collapse in the c.3rd century CE (Ward 2007, 161-163)
[18] Sidebotham 2011, 39.
[19] *Periplus* 57
[20] Strabo *Geography* II.3.4

guide for a Greek captain, Eudoxos, who brought back several cargos of gems and incense for King Ptolemy VIII "Euergetes" II and his wife and eventual successor Cleopatra III.[21]

Since the Ptolemaic kingdom was in a state of endemic civil war by the start of the 1st century BCE, it is perhaps unsurprising that this technical knowledge was not translated into an increase in actual trade until the relatively more stable Roman occupation. Both ports underwent extensive expansion under the early Roman Principate, as both trade intensity and residential population grew.[22] This was a particularly prosperous period for the Red Sea, as first suggested by Roman literary accounts and supported by archaeological record of the ports.[23] This is also when the infrastructure of the ports was at its most complex.

Despite their prosperity, the ports remained isolated and dependent upon outside supply. Myos Hormos was some 180 km from the Nile valley, while Berenike was at least 340 km away; in both cases the land lying between the ports and the Nile cities was extremely arid and perennially dangerous due to both environmental and human threats.[24] Both ports were situated at the head of *wadi*s, desert valleys created by seasonal rain-flow, some of the only safe inlets in the Gulf thanks to the flow of fresh water and sediments hindering coral growth.[25] Outside of the immediate hinterland villages and the various fortresses and hydrological facilities used in overland transport, it is some 150 km from Berenike to the nearest coastal settlement, Marsa Nakari.[26] Ports were few and far between. Small groves along the coast did provide firewood,[27] but food and shipbuilding supplies had to be obtained from elsewhere.[28] Supplies and personnel could only come via the long desert tracks, but the Koptos-Berenike journey would take at least 12 days on foot, considerably more if transporting heavy cargo.[29] In effect, the ports were isolated oases of activity on a barren desert and sea.

For any pilot who did successfully navigate out of the Red Sea, the Arabian Sea was no less hazardous. This region is bounded on the west by the coast of Africa, running from the *Bab*

[21] Not to be confused with Ptolemy III Euergetes, who ruled in the 3rd century BCE. Ptolmey VIII Euergetes II ruled 182-116 BCE, while Cleopatra III ruled as regent and co-ruler for her two sons from 116 to 101 BCE, until her murder by Ptolemy X. Confusingly, Euergetes II had another wife, his sister, also named Cleopatra (II), though since she didn't rule as regent Strabo's story must refer to Cleopatra III.

[22] Sidebotham 2011, 62. Sidebotham thinks that the reign of Tiberius (14-37 CE) saw particular construction efforts. Note, however, that many of the "residents" of the ports would have been seasonal—either moving back and forth between the coast and the Nile valley depending on seasonal fluctuations in trade activity, or absent from port for half the year on trade expeditions.

[23] Sidebotham 2011.

[24] Sidebotham 2011, 126; 3.

[25] Sidebotham 2011, 9.

[26] Sidebotham 2011, 186.

[27] Vermeeren 1999, 199-202. Local acacia made the best firewood, and evidence of "puffing" in analyses of samples suggests that it was often still fresh when burned. It is also the fuel of choice for the modern Ababda Bedouins of the area (202)

[28] Sidebotham 2011, 11-12; Vermeeren 1999, 202; Blue et al. 2011, 186. Cf. Nicanor Archive of ostraca, on the transport of provisions and wine over the desert, and the "Koptos Tariff," mentioning the taxation of sailors and shipbuilding supplies crossing the desert.

[29] Data obtained via the Stanford ORBIS mapping project, http://orbis.stanford.edu/

al-Mandeb as far south as Tanzania.[30] The northern limit is marked by the coast of Yemen and Oman, as well as the southern coast of Persia and Arachosia (modern Iran). Ancient Roman mariners were well aware of the nearby Persian Gulf, and most likely did visit it, but literary sources indicate that it was of secondary importance, or at the very least a separate run from the main Indian voyage.[31] Instead, Roman ships focused on direct trans-oceanic voyages from the southern coast of Arabia, bypassing Persia and going straight to the coast of India. This route would have been fast, but it took them straight through the roughest seas.

The central Arabian Sea was and remains a region of extreme weather. As on the Red Sea, the winds are seasonal, with the southwest monsoon prevailing from April to October and the northeastern monsoon prevailing from November to March.[32] According to the author of the *Periplus*, ships intending to reach the Indian ports ideally set out from Egypt in July, a journey which the author serenely describes as "a risky undertaking but most favorable of winds and a more brief sail."[33] What the *Periplus* is in fact describing are Beaufort 7 or higher winds,[34] swells commonly of 4 meters or more ("heavy," according to the British admiralty classification),[35] frequent rain and overcast skies,[36] and coastal mist.[37] The sea would have been rough, and visibility would have been poor. The winds were gale-force, in the most literal sense of the word, while the waves were greater than any seen along the Mediterranean coasts. In sum, the summer monsoon was more hazardous than *any* conditions on the Mediterranean, even in the notoriously unsafe Mediterranean winter sailing season.[38] The voyage across the open sea would indeed have been "a risky undertaking," albeit short, due either to stiff winds running all the way to port or a sudden death at sea. Yet despite these incredible obstacles, the clearly experienced *Periplus* author considered this run to have been "favorable."

The coast of India, forming the eastern edge of the Arabian Sea, is the limit of the Erythraean Sea, and is itself usefully divided into three distinct regions by the author of the *Periplus*. The northernmost third corresponds to modern Sindh, and is defined by the Indus river delta. In the *Periplus*, it is called "Skythia," a reference to the Scythian Śaka kingdom ruling the

[30] The port of Rhapta is the furthest south that the author of the *Periplus* could confidently plot, though he or she did understand roughly that the Cape of Good Hope existed somewhere in the "unexplored" (ανερευτους) regions to the south (*Periplus* 18).
[31] E.g. *Periplus Maris Erythraei* 36: παραπλεύσαντι δὲ τὸ στόμα τοῦ κόλπου, "sailing past the mouth of the gulf…"
[32] Beresford 2013, 215-216.
[33] *Periplus* 39. δυσεπίβολος μὲν ἐπιφορώτατος δὲ ἐκείνων και συντομώτερος ὁ πλοῦς
[34] Beresford 2013, 221. 30% of all wind speeds over the Arabian Sea in mid-August, up to 50% in July, and 10% along the Arabian coast.
[35] Beresford 2013, 222. 56% of observed swells in August along the Arabian coast, 50% over the open sea, and 40% off the Indus delta and Gujarat.
[36] Beresford 2013, 230-231. Average of 5 oktas cloud cover at the Indus delta and Malabar coast in August, 6 oktas along the coast of Gujarat; average of 4 oktas even at the end of the monsoon. 30-40 days of rain per season.
[37] Beresford 2013, 232. Visibility of 8 km or less 50-60% of observed days along the Arabian coast due to mist and haze; reduced to 30-40% of observed days at the *Bab al-Mandeb*.
[38] Beresford 2013, 223, 231.

area.[39] According to both ancient[40] and modern[41] guides, the Indus river estuary is a particularly treacherous area. The author of the *Periplus* notes that while Roman ships moor at Barbarikon, the main port of this region, cargo can only be carried up-river to the royal capital on small local craft.[42] While the exact location of Barbarikon is unknown, it is worth noting that modern pilot guides for the port of Karachi, also near the Indus delta, similarly recommend against navigating without local guidance.[43]

The second, middle stretch corresponds to southern Gujarat and the Konkan coast, called *Ariake* in the *Periplus*.[44] This was another Śaka kingdom, most likely that of the *Kshatrapas* ("Satraps").[45] The Gulf of Kutch defines the northern limits of this region, and contains yet more treacherous shoals.[46] Despite the environmental hazards, this was also the site of the main trade port of the region, Barygaza. The Deccan plateau defines the south: much like the eastern coast of the Red Sea, it is for the most mountainous, prone to shoals, and provided few trading opportunities.[47] The *Periplus* again gives warnings similar to those in modern pilot guides, noting the danger of the *Eirinon* bay and *Barake* (both around Kutch), certain death for any ship which sails too close to shore.[48] Similarly, the "gulf of Barygaza" (Bay of Cambay) was notable for its reefs, another case where incoming ships required the assistance of local boats: in this instance, these vessels guided them through shoals and then towed them to designated safe harbors.[49] The tide is also dangerous, especially around river mouths, and particularly at the gulf of Barygaza.[50] Due to the force of the surges, anchors are unable to hold, leading to ships capsizing and running aground when piloted by inexperienced crew.

The final third is the Malabar Coast, running from the edge of the Ghats mountain range to the southernmost tip of mainland India. This region is both flatter and more tropical than the Deccan. Unlike the northern regions, the southern peninsula was politically fragmented between

[39] *Periplus* 38

[40] *Periplus* 38: ἑπτὰ δὲ οὗτος ὁ ποταμὸς ἔχει στόματα, λεπτὰ δὲ ταῦτα καὶ τεναγώδη, καὶ τὰ μὲν ἄλλα διάπλουν οὐκ ἔχει, μόνον δὲ τὸ μέσον, "this river has seven mouths, these are narrow and contain shoals, and all of them except the middle one have no approach."

[41] US Government 2014, 6.

[42] *Periplus* 39. τὰ μὲν οὖν πλοῖα κατὰ τὴν Βαρβαρικὴν διορμιζονται, τὰ δὲ φορτία πάντα εἰς τὴν μητρόπολιν ἀναφέρεται διὰ τοῦ ποταμοῦ τῷ βασιλεῖ

[43] E.g. US Government 2014, 6. "No vessel should approach within 2 miles of the [Karachi] harbor entrance without local knowledge."

[44] *Periplus* 41.

[45] Seland 2010, 48.

[46] US Government 2014, 23: "Caution.—The head of the Gulf of Kachchh [Kutch] between Jodiya and the entrances of Kandla Creek and Hansthal Creek is encumbered with numerous changing shoals. Local knowledge is necessary while navigating in this part of the gulf."

[47] *Periplus* 50-51; cf. US Government 2014, 39, 41 (Gulf of Cambay); 65-6 (Maharashtra coast); 76 (Karnataka coast). The *Periplus* notes that it is not only barren, but also clichédly tiger-infested.

[48] *Periplus* 40; Casson 1989, 195-196.

[49] *Periplus* 43-44; Casson 1989, 197.

[50] *Periplus* 45; cf. US Government 2014, 39, which notes both the heavy shoaling around the Bay of Cambay, the need for local guidance, and the common occurrence of sudden falls of up to 2 meters just before the start of ebb tide.

numerous Tamil kingdoms and chiefdoms. The ports were equally numerous: Naura, Tyndis, Muziris, Nelkynda, Kamara, Poduke, and Sopatma. As seems always to be the case, the coast was perennially dangerous: ships could only anchor off of Nelkynda on the open sea, due to the severity of the coastal shoaling and reefs.[51] The ports listed in the *Periplus* stop at Cape Comorin. This is a logical limit, given both the treacherous waters of the passage and the difficulty of the wind.[52] Beyond this point, the Bay of Bengal and Sri Lanka were known to ancient Roman mariners, but the evidence for their direct integration into Roman trade is scarce, at least under the early Empire.[53] In either case, travel beyond this point would require adjustment to an entirely new climatic regimen.

The *Periplus* does not, however, represent a single monolithic trade route: rather, it gives an overview of the many different ports which a ship might visit, encompassing the great variety of trade networks which existed within the Indian Ocean. These can be divided into two general groups, both attested to in the *Periplus*: small, port-to-port voyages ("*cabotage*" shipping) and long, direct, high-value voyages to a single port or geographical area.

Small ships, skirting the coast and traveling between local ports, would most likely have been the norm in ancient ports. Comparative evidence from other pre-modern ports supports this notion. In a list of ships from 13th century China,[54] for instance, less than 20% of seagoing craft had a total burden over 40 tons, despite the technical ability to construct craft with a capacity of above 1,000 tons.[55] Likewise, in the port of mid-16th century London fewer than 5% of ships were over 100 tons' burden: this is smaller than many Roman-era shipwrecks found in the Mediterranea, such as the Madrague de Giens wreck.[56] Pre-modern Mingzhou or London might not be a precise analog for Berenike or Myos Hormos, as they were less geographically isolated than these desert ports, yet the general principle seems clear: very large ships make up only a fraction of oceanic trade. Such a process was common across the Indian Ocean, according to the *Periplus*: some ships engaged in cabotage ("they take return cargo in the coastal circuit"),[57] while others focused on reaching a single target ("they sail directly").[58] Small, light, inexpensive boats were appropriate for short winter voyages between adjoining ports; heavier hulls, in contrast, served those sailing directly across the stormy ocean.

[51] *Periplus* 55. The exact location of Nelkynda and its sister-port Bakare are as yet unidentified; it is worth noting, however, that the coast between Kollam and Anjengo (most likely the "Red Mountain" of the *Periplus*, just south of Nelkynda) is extremely sandy and has extensive reefs: cf. US Government 2014, 89-90.
[52] US Government 2014, 96.
[53] The author of the *Periplus* gives a very basic overview of the trade goods available in "Taprobane" (*Periplus* 61) and "Ganges," (*Periplus* 63), corresponding to Sri Lanka and Bengal respectively, but gives none of the piloting guidance seen on the West Indian coast
[54] Specifically, "Ming-chou, Wenchou, and T'ai Chon prefectures," corresponding to the modern Zhejiang province.
[55] Houston 1988, 555.
[56] Though admittedly at 40m long the Madrague de Giens wreck was of an exceptional size.
[57] τον παραπλουν αντιφορτιζονται. *Periplus* 14.
[58] "προηγουμενως…πλεουσιν*"* *Periplus* 14.

Roman crews planning on sailing from the coast of Egypt to India would thus have required a ship which could withstand the particular hazards of the Red Sea, the open Arabian Sea, and the coast of India, depending on the route which they took. Ships required hulls that could withstand gale force winds and heavy waves, and sails that could not only make use of the monsoon winds, but also gave pilots the maneuverability necessary to avoid the omnipresent shoals and reefs. Ships had to be able to moor at less-than-ideal harbors, and obtain repairs in often resource-poor locations. The Roman ships plying this route would need to be perfectly attuned to whichever environment they found themselves in.

IV. (Re)building a Red Sea Ship

Unfortunately, no complete wrecks of Roman ships in the Red Sea have been discovered to date, forcing any reconstruction to rely upon synthesis and comparison. Nonetheless, from the available evidence a clear picture emerges of the sort of vessels that Roman mariners might have sailed upon the Red Sea. In construction, they were similar to Mediterranean craft, making use of mortise and tenon joins. Like Mediterranean craft, they utilized square-rigged sails on a single mast, possibly supplemented by an "*artemon*" or foresail for added stability. The square-rigged sail was perfect for a ship running before the wind, which is exactly what a craft sailing through the summer monsoon would be doing, while the addition of brailing ropes assisted the pilot in beating against the wind should the ship face contrary winds during its return to port.

Undisturbed evidence for ships is scant. Two incomplete Roman wrecks have been found in the Red Sea: the "Fury Shoal" wreck and the "Abu Fendera" wreck.[59] Neither site is well preserved, well documented, or well published. They have so far only been studied during a brief 2010 survey of Red Sea wrecks mounted by the University of Southampton, the British Museum, and the University of Alexandria. Both wrecks are located near the ancient port of Berenike: Fury Shoal approximately 50km to the northeast, Abu Fendera approximately 150km to the southeast.[60] Of the two ships, Fury Shoal is more intact, but Abu Fendera provides more detail about the actual ship materials. Both wrecks are composed mainly of scattered amphorae of Mediterranean and Egyptian provenance, particularly the Dressel 2-4 and AE4 types: stylistic analysis of the pottery suggests that the ships date to roughly the 1st century CE.[61]

Amphorae were, of course, the hallmark ceramic container of Mediterranean shipping throughout the Roman period, and their presence in large numbers in the wrecks suggests that they were a primary means of transporting cargo for Indian Ocean craft as well. Several of the

[59] The merchantman wrecked at Black Assarca island, off of modern Eritrea, also most likely took part in Red Sea trade in the late antique period. Cf. Pedersen 2008.

[60] Blue et al. 2012, 93 (map).

[61] Blue et al. 2012, 94-96. Amphorae at Fury shoal are more uniform: 34 wine amphorae, 20 of which were Campanian Dressel 2-4, 6 Alexandrian AE4s, 1 South Arabian Organic Storage Jar, and body fragments of 7 unidentifiable Roman amphorae types. Abu Fendera is more diverse: it contains "between 21 and 42" Roman amphorae, of 5 types: 4 Dressel 2-4 wine amphorae, most likely Italian, 8 Alexandrian AE4s (Dressel 2-4 imitations), between 6 and 8 AE3s, one Dressel 20b-c oil amphora, and a "squat form with a flat ring base, short flaring neck with a beaded ring" of indeterminate western Mediterranean origin. The remaining 20 sherds are of Roman amphorae, but are non-diagnostic. The wreck also contained two bronze bowls.

Dressel 2-4 amphorae on the Fury Shoal wreck still had stoppers made of packed *pozzolana* ash in place, indicating that they contained Campanian wine at the time the ship went down.[62] Also from the cargo hold, a limited number of basalt ballast stones from southern Arabia turned up at Fury shoal.[63] The ballast stones suggest that the amphorae and their contents alone were not heavy enough to sufficiently weigh down the ship and keep it balanced; given that the ballast was from South Arabia, this may mean that the ship took on a cargo of relatively light aromatics such as frankincense or myrrh.

The wrecks also provide a few clues as to the structure of ships. In addition to the cargo remains, three iron anchors, pieces of lead hull sheathing, and copper nails survive at Abu Fendera.[64] Lead sheathing was a hallmark of Mediterranean ship-building, found on ships ranging from emperor Caligula's massive pleasure barges on Lake Nemi to the Roman merchant wreck at Madrague de Giens. In addition to serving as a form of built-in ballast, the sheathing helped protect the wooden hull from harmful shipworms. The copper nails provided the additional benefit of poisoning acorn barnacles, a hull-infesting pest which was particularly virulent in the Red Sea.[65] Sadly, neither wreck preserves any wooden remains: the warm, coral-rich shallows of the Red Sea are poor preservation areas, while any wrecks that fall into the deep central rift are simply too inaccessible to study without immense expense.[66]

Taken on their own, the wreck remains are inconclusive. The cargo and ballast stones could have been picked up at any point, and say nothing about the actual ethnicity of the crew or owner. Nonetheless, the presence of lead sheathing, a common Mediterranean construction technique, and the iron anchors, which are of a common Eastern Mediterranean design, do suggest that the Abu Fendera wreck was built according to Mediterranean traditions, while the presence of numerous amphorae suggests that the ships' cargo holds were similar enough to Mediterranean types to accommodate their storage.[67]

Far richer are the material remains from the port facilities themselves. Both Myos Hormos and Berenike have received extensive archaeological investigation in the last two decades. The site of Berenike, modern Ras Banas, was known since at least the beginning of the 19th century CE, when scholars such as Giovanni Belzoni and J.G. Wilkinson successfully identified the ruins, made preliminary maps of the site, and began exposing the most prominent features of the ancient town.[68]

The site received sporadic attention through 19th and 20th centuries, but due to the remoteness of the site, a thorough scientific excavation was not undertaken until 1994. From 1994 until 2001, a joint project by the University of Delaware, Leiden University, and UCLA,

[62] Blue et al. 2012, 94.
[63] Blue et al. 2012, 95.
[64] Blue et al. 2012, 96.
[65] Blue et al. 2011, 186.
[66] Blue et al. 2012, 92.
[67] Blue et al. 2012, 96-98.
[68] Sidebotham 2011, 16.

directed by Steven Sidebotham (Delaware) and Willemina Wendrich (UCLA/Leiden), surveyed the site and documented the smaller satellite settlements in the hinterland.[69] Excavation ceased from 2002 until 2008 due to disputes with the Egyptian military, who maintained a military base near the site.[70] Fortunately, excavation resumed with a joint expedition by the University of Delaware and the University of Warsaw (Polish Centre of Mediterranean Archaeology) from 2008 to 2011 led by Steven Sidebotham and Iwona Zych.[71] Both of these teams surveyed the surface of the site as well as dug trenches at selective areas, revealing multiple temples, the Ptolemaic and Roman era harbors, and an extensive Roman-era dump.[72] By Sidebotham's reckoning less than 2% of the site has been excavated; nonetheless, the excavations uncovered immense amounts of ancient materials, including otherwise lost organic remains like wood and rope.

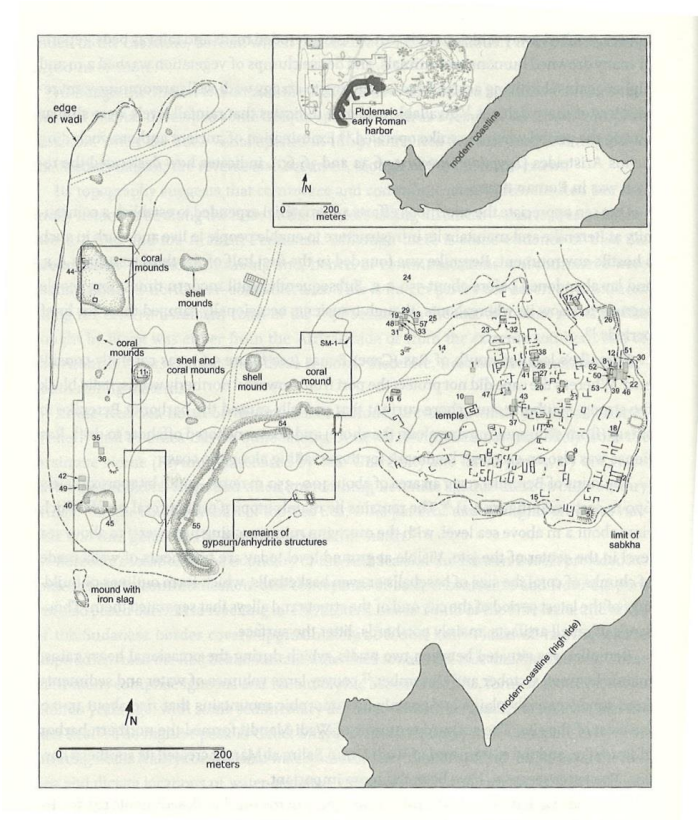

Fig. 2: Map of Berenike showing the Ptolemaic and Roman settlement (from Sidebotham 2011)

[69] For a brief overview of the excavations, see the reports provided by Sidebotham and Wendrich at "Archbase": "The Berenike Project (1994-2001)." http://www.archbase.com/berenike/english1.html.
[70] Sidebotham 2011, 19. Modern Ras Banas was for many years a modern Egyptian military base, leading to the unfortunate effect that parts of the site are also now rendered inaccessible due to a minefield.
[71] Brief overview available through the PCMA newsletter: http://www.pcma.uw.edu.pl/en/pcma-newsletter/ (2008-2011)
[72] Sidebotham 2011, 19

Myos Hormos likewise did not receive a throughout archaeological investigation until the 1990s. The modern site of Quseir al-Qadim ("Old Quseir") was long considered to be the small and fairly unimportant port of Leukos Limen, and received only cursory investigations by the Oriental Institute at Chicago in 1978, 1980, and 1982.[73] It was eventually proved to be the major port of Myos Hormos, leading to a much more comprehensive excavation by the University of Southampton from 1999 to 2003 under the direction of David Peacock and Lucy Blue. Five seasons of excavation revealed a wealth of ceramic, organic, and architectural features, including the port's harbor constructed out of recycled amphorae.[74] As at Bereike, the arid and desiccating environment of Myos Hormos proved to be perfect for the preservation of timber and rope.[75]

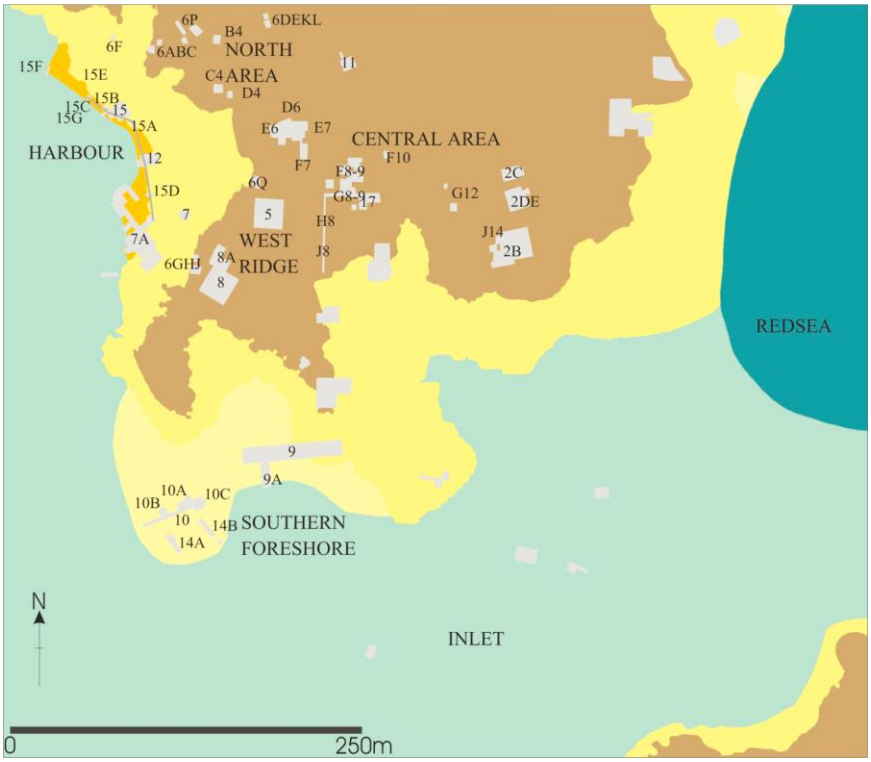

Fig. 3: Map of Roman Myos Hormos. Excavated areas are in grey, while the ancient harbor is in gold. From Thomas 2009.

While no complete hull remains exist, the preserved finds at the ports lend further credence to the idea that ships built in the Roman tradition sailed the Red Sea. Most revealing is a group of wooden planks: both Myos Hormos and Berenike contain reused ship timbers. In both cases, wood was integrated into later architecture, either in doorways (Myos Hormos) or leveling courses in walls (Berenike).[76] In addition to this, the recent excavations at Berenike have turned up a number of burnt planks from the harbor shipsheds, apparently of ships destroyed during a

[73] Blue et al. 2011, iv-1.
[74] Blue et al. 2011, 2-3, 35.
[75] Blue et al. 2011, 3.
[76] Blue et al. 2011, 179; Sidebotham 2011, 203-205

fire. In both sites, wood was primarily of teak, though in Berenike the Temple of Sarapis had a number of reused cedar beams in its roof, and the burnt planks from the shipsheds were similarly of cedar.[77]

These planks were worked using mortise and tenon joins, a common shipbuilding technique in the Greco-Roman world. "Mortise and tenon" refers to a specific set of interlocking joins between a ship's planks, and is part of the so-called "shell-first" construction technique. In this tradition, shipwrights began by joining the planks of the ship's hull, creating an outer "shell," before then fitting in frames and other interior structural supports if necessary. A slot would be carved into each plank (the mortise), into which a rectangular slat of wood (the tenon) would be fitted. Dowels would then be inserted through the tenons, locking them in place.

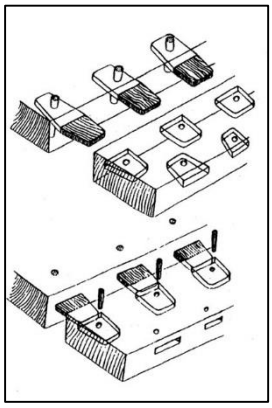

Fig. 4: Mortise and tenon joins. From Mcgrail 2009.

Rather than primarily relying upon nails or the internal skeleton of the ship for its strength, the hull was kept together by the interlocking sets of mortises and tenons. Many of the Berenike timbers show signs of dowel holes,[78] while two Myos Hormos planks have clear mortise incisions along their edges.[79] While difficult to study due to their fragility, the burnt cedar timbers from Berenike harbor were also incised with mortises.[80]

While something of a risky proposition to extrapolate, the size of these planks can give some indication of the length of the ship they came from. McGrail suggests that plank thickness tends to increase linearly with ship length, giving the example of the ancient Kyrenia[81] and the

[77] Sidebotham 2011, 205; Zych and Sidebotham, 2010, http://www.pcma.uw.edu.pl/en/pcma-newsletter/2010/hellenistic-and-graeco-roman-period/berenike-egypt/.
[78] Sidebotham 2008, 310; Sidebotham 2011, 198. Both teakwood and cedar planks contained mortise and tenon joins.
[79] Blue et al. 2011, 180.
[80] Sidebotham and Zych 2010, http://www.pcma.uw.edu.pl/en/pcma-newsletter/2010/hellenistic-and-graeco-roman-period/berenike-egypt.
[81] Planks 40mm thick, ship 14m long

Madrague de Giens[82] wrecks.[83] Extrapolating from this, the Myos Hormos planks, 50mm and 30mm thick respectively, would belong to ships approximately 15m and 5m long.

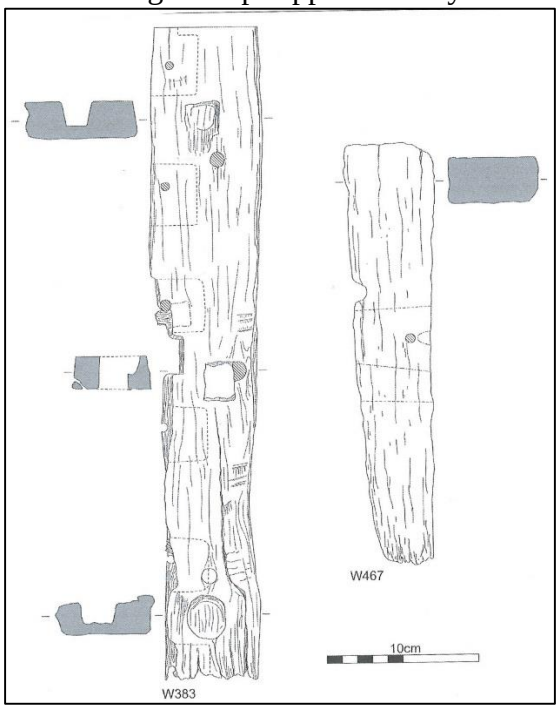

Fig. 5: Incised timbers from Myos Hormos. From Blue et al. 2011.

The first length is entirely reasonable for a small Mediterranean-style merchant craft, as it is very close to the well-studied 3rd century BCE Kyrenia merchant wreck from Cyprus. The calculation of 5m seems suspect, as McGrail's formula is derived from 14+ meter craft rather than small vessels, but if correct it would perhaps correspond to a small fishing or transshipment craft, like the 1st century CE Fiumicino 5 wreck from Ostia.[84] Also of interest is the spacing and depth of the mortises: compared again to the Kyrenia and Madrague de Giens wrecks, the mortises are smaller, but much more close set, in all creating a much closer ratio of mortise width to mortise spacing.[85] While the width of the burnt timbers is not clear, some were over 3m long, suggesting fairly large ships.[86] The longest cedar timber from the Temple of Sarapis at Berenike was 2.33m long.

[82] Planks 99mm thick, ship 40m long

[83] McGrail 2009, 156.

[84] Boetto 2010, 119. The Fiumicino 5 wreck was approximate 5.6m in length, and similarly constructed with mortise and tenon joins. The Fiumicino wreck had planks even thinner than the one found in Myos Hormos, being on average 20mm thick. This would seem to indicate that McGrail's formula is not applicable to craft below 14 meters or so, as one would not otherwise expect a craft with such thin planks to be as long as it was.

[85] Cf. McGrail 2009, 156. The Kyrenia wreck has a ratio of 43mm mortise width to 117mm interval between mortises (37%), while the Madrague de Giens had ratios of 57mm width to a 150mm interval (37%, exterior shell) and 85mm width to a 150mm interval (55%, interior shell). The larger of the two Myos Hormos planks has mortises 60mm wide at an interval of 80mm (75%).

[86] Sidebotham and Zych 2010, http://www.pcma.uw.edu.pl/en/pcma-newsletter/2010/hellenistic-and-graeco-roman-period/berenike-egypt.

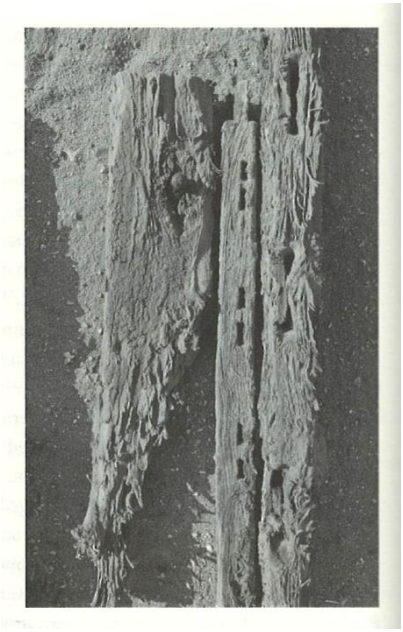

Fig. 6: Incised timbers from Berenike. From Sidebotham 2011.

The end result is a hull that would have been considerably stronger than any yet found in the Mediterranean, while still maintaining the same general proportions of a Mediterranean merchant ship.[87] The construction effort would no doubt have been proportionally more labor intensive, but the monsoon seems to have warranted it.

Since teak is native to India and cedar to Lebanon, these planks would have needed to be imported. The trees native to the Red Sea coast—acacia, mangrove, palm, and tamarisk—were largely inappropriate for shipbuilding. Therefore, owing to the unfavorable environment, imported wood or planks were the only option. The presence of teak wood-shavings, woodchips, and other carpentry byproducts in Myos Hormos, alongside the Mediterranean design of the joins, makes the existence of a Red Sea shipyard seem the most likely explanation for these planks.[88]

The alternative to a Red Sea workshop would be an Indian Indian workshop, nearer to the source of the raw timber, followed by the planks' deposition in the port when the ship was decommissioned. If produced in an Indian workshop, the mortise and tenon joins in the Roman style could be explained by a shipwright trained in the Mediterranean tradition who lived abroad, or simply by a locally trained shipwright who successfully imitated the preexisting joins on a ship during repairs. The *Periplus* mentions that Barygaza, in modern Gujarat, was a primary exporter of teakwood, though the author does not list it among the products that a merchant

[87] The durability would only have been compounded by a double hull, such as the Madrague de Giens wreck had (McGrail 2009, 156). It would not be possible to determine if Red Sea ships shared this design without the recovery of an actual hull.

[88] The presence of mortise and tenon joins along the plank edges clearly indicate that these were worked hull planks

might be interested in.[89] Teakwood was an excellent shipbuilding material due to its durability and resistance to termites, rot, fungi, and mildew, but the wood itself is oily and not easy to carve—thus, the comment in the *Periplus* may indicate that teakwood was of interest to captains for use on their ships, but not itself a major trade commodity. Since there was clearly an extensive exchange of raw materials, it seems logical that there might have been an exchange of craftspeople as well, facilitated by expatriate communities.

There were likely expatriate communities of various communities throughout the Indian Ocean ports. The existence of Indian cooking ware and other domestic goods at Berenike attests to an Indian presence in Egypt, though it is unclear where in India these residents originated.[90] Inscriptions from Berenike and Myos Hormos indicate that merchants from both the Tamil south and the central Deccan region of India reached the Egyptian ports.[91] As previously mentioned, there is a tradition that Mediterranean sailors first learned to use the monsoon winds from a shipwrecked Indian sailor, suggesting a certain amount of knowledge exchange between Egypt and India. Sidebotham suggests that an Indian-made bamboo screen found at Berenike may represent a form of ship-bourn shelter, though as it comes from the Roman trash heap its true context is hard to reconstruct.[92]

Likewise, there is evidence that Roman communities existed within India. The first indication of this is within the *Periplus*, in which the author notes that the Tamil ports import wheat "such as suffices for those involved in shipping (ναυκλήριον), due to the fact that the local merchants don't consume it."[93] Expatriate communities appear to have consumed their native diets in both India and Egypt, as also seen in the importation of non-native rice species into Berenike.[94] Wheat was the preferred grain of Greeks, Romans, and Egyptians in the Red Sea ports, and thus the consumption of wheat by a foreign community in south India points to a Roman trade diaspora.[95]

Tamil sources give more detail to this community. In the Tamil *Sangam* poems, there are a number of reference to "Yavana" merchants, the term used for Greek and Roman merchants throughout India.[96] These Yavanas were first and foremost merchants, arriving by sea with gold and departing with pepper, but communities of Yavana craftsmen and mercenaries appear to have been present in southern India by the 1st century CE as well.[97] From Central India come a

[89] *Periplus* 36.
[90] Sidebotham 2011, 75.
[91] Salomon 1991, 733-735.
[92] Sidebotham 2011, 240.
[93] *Periplus* 56. "σῖτος δὲ ὅ ἀρκέσει τοῖς περὶ τὸ ναυκλήριον διὰ τὸ μὴ τοὺς ἐμπόρους αὐτῷ χρῆσθαι."
[94] Sidebotham 2011, 79.
[95] Ibid.
[96] Ray 1988, 313. The term "Yavana" is from the Sanskrit form of the Persian word "Yauna," itself derived from the term "Ionian," referring to the Greeks of Asia Minor. In ancient times it referred to both Greeks and Romans, while by the early medieval period it was expanded to include Arabs and other generalized "Western" ethnicities.
[97] Ray 1988, 314. Yavana ceramics appear to have been a favorite in Sangam literature, especially lamps—which were a Roman specialty.

number of votive offerings at Buddhist shrines, dedicated by Yavanas with typically Indian names like Dhamadhaya and Indragnidatta.[98] While it is possible that these "Yavanas" were not Greeks or Romans at all, it is also possible that these were western traders and craftsmen who adopted local religious practices and names while abroad. Such locally-integrated individuals could have acted as an interface between Mediterranean craftsmen and traditions and their Indian counterparts.

Cedar wood, on the other hand, was used in traditional Egyptian craft on the Red Sea. Planks found at the more northern site of Wadi Gawasis date back to the late 3rd or early 2nd millennium BCE.[99] Records from the Pharaonic Old Kingdom and onwards describe frequent voyages to Punt (modern Eritrea), corresponding to the *Periplus*' "Near-side ports." The cedar plank found at Berenike, much like the Egyptian planks found at Gawasis, would have required transportation overland across the harsh Eastern Desert. This overland transportation is revealed through the 1st century CE "Koptos Tariff," a lengthy inscription created under the auspices of the Roman military prefect of Berenike, recording the tax due on the various personnel and equipment frequently brought across the desert. This includes a mast (ἱστός) and a sail-yard (κέρας), the two biggest individual wooden components on a ship.

Another complication is the canal at Clysma, a link between the Red Sea and the Nile River made operational by the Emperor Trajan at the beginning of the 2nd century CE.[100] The port at Clysma was certainly flourishing by the 4th century CE, though there is no indication that the canal was ever used to transport timber or other ship materials to the Red Sea coast.[101] As such, it remains a mystery as to what role the Trajanic canal served in supplying the ports, and what if any fees were exacted on materials brought through it.

The other ship fittings from the ports are similarly Mediterranean in their blueprint. Iron anchors and lead sheathing, like those found on the Abu Fendera wreck, appear in Berenike, though the lead sheathing is from an area identified with Ptolemaic-era metalworking.[102] More firmly dated are the copper tacks and lead sheathing from Myos Hormos, found in an apparent c.2nd-3rd century CE foundry.[103] Holes in the plates show that the tacks were applied in a typical Roman "quincunx" pattern.[104] In addition to the lead sheathing, pitch seems to have been applied

[98] Ray 1988, 315. These could also be Indo-Greeks from Afghanistan, though the late date of the inscriptions (early 2nd century CE) suggests not—the last Indo-Greek kingdom collapsed by about 10 CE.
[99] Ward 2012, 25.
[100] Tomber 2008, 66. The canal was first constructed by the Persian Shah Darius I (522-486 BCE), and remained in use during the early Ptolemaic period, but had become unusable by the time of the Roman conquest. It was dredged by Trajan, rather than completely rebuilt.
[101] Tomber 2008, 66-67.
[102] Sidebotham 2011, 205; Sidebotham 2008, 307.
[103] Blue et al. 2011, 186. Copper sheathing would have been an even better option, and was famously used by the British Royal Navy from the 18th century onwards. It appears not to have been used at Berenike or Myos Hormos, however—any improvements in speed and discouraged barnacle growth would have been more than outweighed by the increased cost of importing copper over the desert.
[104] Cf. the Hellenistic shipwreck at Serçe Limanı, off the southwestern coast of Turkey.

to the planks at both sites.[105] In fact, the excavators at Myos Hormos recovered a pitch pot with the application brush still stuck in it, as well as several pitch-covered barnacles with wood impressions on them.[106] As previously mentioned, barnacles could be discouraged from growing on ship hulls through the addition of lead sheathing and copper tacks; pitch could likewise discourage growth as well as help waterproof the hull. The Red Sea ports seem to have been well equipped to perform regular anti-fouling procedures on ships. The foundry could have been used to heat pitch for application to the hull, as well as for the forging of small metal components. Ropemaking for rigging appears to have taken place for the most part in the Nile valley, rather than in the ports, but as Myos Hormos had some sort of carpentry zone, it could have easily handled all other repairs and ship construction.[107]

Myos Hormos also furnishes copious examples of the rigging materials, whether the ropes running through them were locally produced or not. Excavators recovered 169 brail rings, seven block sheaves, a deadeye, and a toggle in the Roman-era *sebakh* deposits. Every object recovered has parallels in Mediterranean Roman wrecks. Multiple deadeyes appear in the 2nd century CE Grado wreck, albeit half the size of the Red Sea example;[108] the sheaves are comparable to those on the 1st century BCE Cavalière wreck;[109] and similar brail rings are also found on the Cavalière wreck.[110] Deadeyes are typical of square-rigged sails, while brail rings are similarly common in Mediterranean rigging practices.[111] One brail ring was even still attached to a portion of Indian cotton sailcloth.[112] Brail rings are a particularly important find, as they indicate that Red Sea ships could adjust the shape of their sails. By running ropes through the brail rings, ancient mariners could raise and lower either side of their sail, much like the way a modern Venetian blind works.[113] This would have increased their ability to catch winds which were not blowing from directly behind the ship, while still using the familiar square-rigged layout.

Comparison is difficult for the sailcloth remains from the area, due to the simple fact that there are few other surviving examples of Roman sails in the archaeological record. The only real examples are at Myos Hormos, Berenike, and the Nile city of Edfu.[114] While the Edfu sailcloth was made of linen and flax rather than cotton, both the Edfu sailcloth and the examples

[105] Blue et al. 2011, 186.
[106] Blue et al. 2011, 290; 186.
[107] Blue et al. 2011, 289-293.
[108] Cf. Beltrame and Gaddi 2005, 80; Blue et al. 2011, 189. The Myos Hormos deadeye has three holes, is elliptical, and is approximately 214 mm long and 144 mm wide, and 55 mm thick. The three-holed Grado deadeye is similarly elliptical, but only 147 mm long and 92 mm wide, and 26 mm thick.
[109] Cf. Charlin et al. 1978, 57-58; Blue et al. 2011, 190. The Myos Hormos sheaves measured between 46 to 81 mm in diameter; the Cavalière sheave were 115 mm in diameter.
[110] Cf. Charlin et al. 1978, 57; Blue et al. 2011, 191-193. The Cavalière rings are 4-5 cm in diameter, comparable in size to numerous wooden brail rings from Myos Hormos. Charlin et al. give no indication of the diameter of the attachment holes for the rings, which were 4-7 mm at Myos Hormos.
[111] Whitewright 2007b, 287. See, however, the Egyptian evidence further on.
[112] Blue et al. 2011, 196-197.
[113] The obligatory simile, as used by both Casson and Campbell.
[114] Whitewright 2007b, 286.

from the Red Sea show signs of reinforcement with cloth web, a supplement to the support with the ropes run through the brail rings would have provided.[115] Such reinforcement would allow the sails to survive high winds, acting as a means of strengthening the sail as well as a way to prevent long-term distortion due to stretching.[116] Yet from what scant evidence remains, the sails are typologically identical to their Mediterranean counterparts. Despite continued use of Indian materials, the rigging and sail of the ships at the Red Sea ports seem to have been of traditional Mediterranean designs.

Economic necessities would also have influenced ship design in the ports. This is again best illustrated by the Koptos Tariff. The Tariff sets out the fees owed on the transport not only of materials, but on the passage of personnel and animals as well. Helmsmen cost 8 *drachmai* to pass, foredeck hands and ship guards 10 *drachmai*, while sailors and shipwrights only cost 5 *drachmai*; by far the most expensive journey was for "sailors' women," who needed to hand over 20 *drachmai* to pass.[117] Prices are only given for the largest components of a ship, the mast and yard arm, but presumably timber, rope, and metal components were likewise taxed. The use of teakwood and Indian cotton were thus not just a recognition of those materials' high quality, but also an appreciation of their reduced transportation costs. While no information is available on the makeup of crews on Roman ships, perhaps foreign crewmembers were also brought on board not just for their expertise and local knowledge, but also to avoid Roman fees. This would also have favored foreign craftsmen in the ports, as they could avoid the desert tolls.[118]

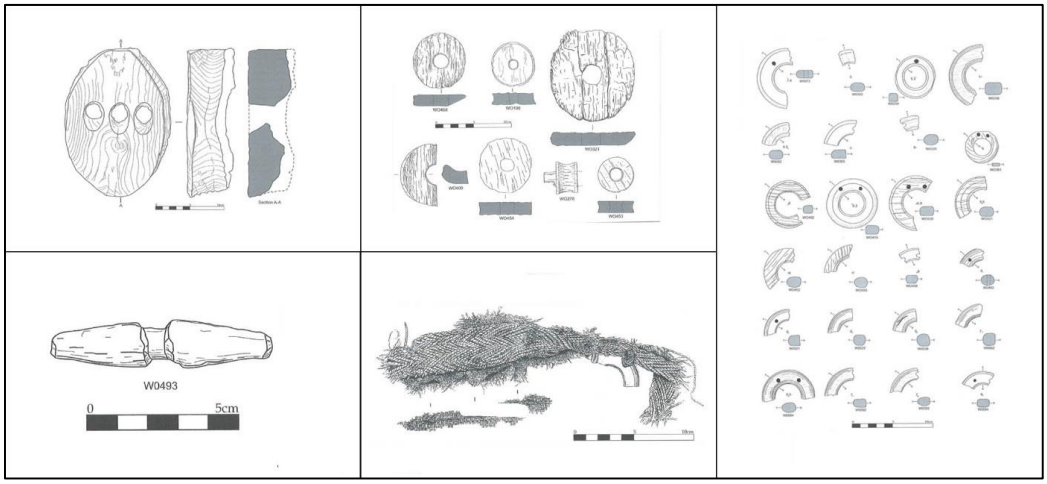

Fig. 7: Ship components from Myos Homos. Clockwise from the top left: deadeye, block sheaves, brail rings, cotton sail cloth, and a wooden toggle. Not to scale. After Blue et al. 2011.

[115] Whitewright 2007b, 290.
[116] Whitewright 2007b, 290.
[117] OGIS 674: the Greek terms are κυβερνήτος Ἐρυθραικός (Red Sea helmsman/skipper), πρωρεύς (bowman), ναύτος (sailor), ναυπηγός (shipwright), and γυναῖκες εἰσπλεουσῶν ("sailors' women")
[118] Though the military presence in the ports taxed goods coming in by sea as well—while as yet undocumented, it is possible that an incoming merchant or craftsman would have to pay a similar entrance fee.

The archaeological evidence from the ports is further complicated by two artistic depictions of Indian Ocean vessels. The first is a rough sketch of a ship etched into an *ostracon* (potsherd), found in the 1st century CE Berenike trash heap. It depicts a vessel facing to the left, its sails apparently furled. No details are discernable about the planking itself, though the line running across the hull about two thirds of the way up may represent a lead sheathing. It has a central main mast, as is expected of a square-rigged craft, and at least one side-mounted steering oar. Intriguingly, while the Berenike ostracon is broken part way through the ship's prow, two lines clearly indicate some form of fore-rigging, most likely an *artemon*. The *artemon*, a sail usually placed upon an inclined foremast, was designed to help ships run the wind: it served to stabilize the craft in harsh weather and acted as a navigational supplement to the steering oars.[119] In all, the ship depicted on the Berenike ostracon fits with the archaeological evidence and the standard Mediterranean tradition of shipbuilding. It would have been well suited for the strong and consistent summer monsoon winds.

Fig. 8: graffito of a ship scratched onto an *ostracon*, Berenike, 1st century CE (from Sidebotham 2008)

[119] Sprague de Camp 1959, 61.

Evidence for another type of ship, however, is to be found in an unlikely place: Palmyra. As an inland city-state located in the center of modern Syria, it is at first glance not a promising source of information on Roman shipping in Egypt; it was, however, deeply involved with the Indian Ocean trade.[120] A 3rd century CE inscription from Koptos attests to a number of "Palmyrene *naukleroi* of the Red Sea" active in the area.[121] The term "*naukleros*" is somewhat ambiguous, referring to ship-owners, captains, or skippers, depending on the context. Given that the inscription commemorates the dedication of a substantial addition to their guild hall, and that elsewhere "Palmyrene co-merchants" are mentioned, an identification of these Palmyrenes as well-off shipowners seems likely—perhaps they have invested jointly in a trading ship.[122] Whatever the case, Palmyrene merchants were directly involved with trade out of the Red Sea ports, setting up their headquarters at the most important staging point for the trek across the Eastern Desert. Since landlocked Palmyra presumably did not have a long-standing maritime tradition of its own to draw on, it seems logical to assume that Palmyrene *naukleroi* of Koptos would have commissioned ships from local shipwrights, and thus used Roman ships.

One such ship may be depicted in relief on the tomb of C. Aurelius Marona in Palmyra. Dated to the 3rd century CE, it is roughly contemporaneous with the Palmyrene *naukleroi* at Koptos. It appears to depict a sail-powered ship, facing right, outfitted with a curved stern and beaked prow known as a cutwater. Like the Berenike ship, this vessel had side-mounted steering oars. The Berenike ostracon ship, however, was largely symmetrical, other than the *artemon* foresail, whereas the Palmyrene ship's sharp prow makes it decidedly asymmetrical. Yet despite this, the Palmyrene ship's hull follows a Mediterranean pattern. The 1st century BCE Madrague de Giens wreck, one of the largest Roman merchantmen yet found, had a distinctive asymmetrical "concave" prow, which increased the strength, stability, and speed of the ship.[123] The Madrague de Giens wreck was a full 40 meters long and with a capacity of 375 tons, far bigger than the ships suggested by the Myos Hormos planks, though it is entirely possible that such a ship could have sailed the Red Sea and simply left no currently known material remains.[124]

[120] As well as overland trade (the famous Silk Road) and trade out of the Persian Gulf
[121] "Παλμυρηνῶν ναυκλήρων Ἐρυθραικῶν." Bingen 1984, 356, 358.
[122] "Παλμυρηνοὶ συνέμποροι"
[123] Pomey 1982, 145-146.
[124] Ibid.

Fig. 9: Relief depicting a ship from the tomb of C. Aurelius Marona, Palmyra, 3rd century CE. From Seland 2013.

Another possible quirk of the Palmyrene ship is its unusual sail. All the evidence up to this point has indicated that Red Sea vessels were square-rigged: that is, with rectangular sails set perpendicular to the ship's keel, best used to catch a wind blowing from directly behind. The Palmyrene ship's sail looks more triangular, and while the mast is difficult to discern, it looks more off-center than one would expect of a square-rigged sail. This could represent a lateen sail or a spritsail: more triangular or quadrilateral sails designed to run *parallel* to the ship's keel. Square-rigged sails are reliable but not exceptionally maneuverable, good in a favorable wind but requiring more complex maneuvering when the wind is not blowing in the desired direction. A fore-and-aft rig, on the other hand, can more easily be rotated around the mast, permitting the ship to catch wind from a greater variety of directions. On the other hand, fore-and-aft rigs provided relatively less stability when running a strong wind and were more difficult to furl during a storm.[125] Lateen sails often served as a secondary power source, complementing a set of oars; the Palmyrene ship appears to have an oar box just behind the prow (though no oars are visible). Importantly, lateen sails had become the preferred sail on the Indian Ocean by the Late Antique or early Medieval period, most famously seen in the archetypal Arab *dhow*.

[125] Campbell 1995, 19.

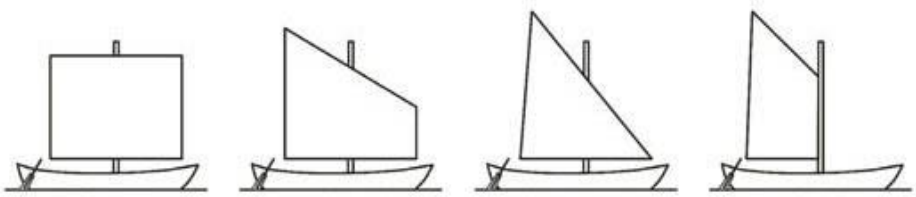

Fig. 10: Square-rigged sail, lug sail, lateen sail, and gaff sail (similar to a spritsail). After Whitewright 2011.

So far as I am aware, only one scholarly image of this relief is available; given recent events in Palmyra, the possibility of obtaining new photographs from the Tomb of Marona is doubtful.[126] If the mast is set at the very edge of the sail, that would seem to indicate a spritsail. A more centrally-placed mast, however, would be more fitting with a "lug" sail setup, an "intermediate" form between a square-rigged and lateen rig.[127] The spar to which the sail has been attached does appear to be at an angle, as in a lug or lateen rig. On the other hand, the lines running across the sail seem indicative of brailing, which would be more typical of a square-rigged sail—the odd shape of the sail may simply be an attempt at perspectival art. However, from the few depictions of Roman-era lateen rigs, it seems that these sails were likewise sometimes covered in a rope grid, or at least it was the artistic convention to do so. In any case, whether it represents a square-rigged sail, a lateen sail, or a lugsail, the Palmyrene ship is clearly not of the same type as the one depicted at Berenike, indicating a great variety of forms within the "Roman" tradition.

[126] So far, there is no confirmation as to the state of the Tomb of Marona. According to a recent ASOR report, the area west of the tomb was bulldozed in order to create an artillery emplacement by the Syrian army in 2013. Following the occupation of Palmyra by the terrorist group ISIL in 2015, numerous ancient and Islamic tombs were desecrated. I have so far found no indication that the Marona was among those intentionally destroyed, though it is extremely likely that the site was looted of any art objects. The Southeast Necropolis shows numerous signs of plundering. As of 2016, Palmyra has been reoccupied by the Syrian and Russian armies, protecting it from intentional iconoclasm though not from antiquities looters or other military damage. Cheikmous, A. 2015. http://www.asor-syrianheritage.org/palmyra-heritage-adrift/; Cuneo et al. 2016. http://www.asor-syrianheritage.org/4290-2/.

[127] Campbell 1995, 2.

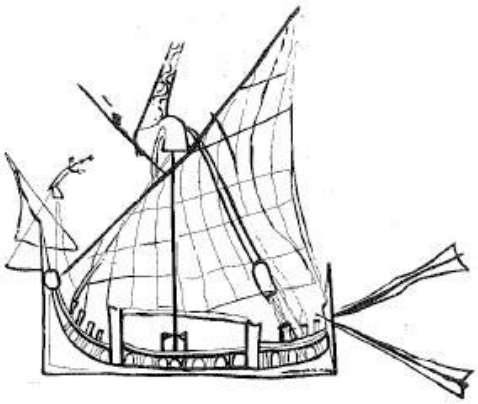

Fig. 11: Early 7th century CE depiction of a Roman/Byzantine lateen rigged ship, from Kellia, Egypt. From Whitewright 2011.

One other obvious issue with this depiction is the fact that Palmyra traded through both the Red Sea and the Persian Gulf. Marona himself was a merchant, though there is no indication as to which route he plied; the inscription from the tomb itself gives only very basic information.[128] The reliefs include both the ship and a depiction of a camel caravan, mostly broken off; a camel could indicate either the famous Silk Road route through Central Asia and Persia, the overland incense route through the Arabian Peninsula, or the desert route between the Red Sea ports and the Nile valley. All three routes were of interest to Palmyrene merchants, and Marona could very well have had investments in all three routes. The tomb seems to have been constructed in 236 CE, some 12 years after the rise of the Sassanid shahs in Persia, a time during which tension and outright war between Rome and Persia was common, and during which Palmyrene trade through the Persian gulf seems to have all but ceased.[129] In a time of such instability in Mesopotamia and Syria, characterized by frequent raids by both empires punctuated by cyclical attacks and counterattacks, the Red Sea route seems the much safer option for a merchant like Marona to be using.

No matter the form of these ships, it appears almost certain that many of them were constructed in the Roman Red Sea ports. As previously mentioned, the ports were equipped with the workshops necessary for ship construction: carpentry areas to work planks and make mortise and tenon joins, and metalworking areas to create nails and lead hull sheathing.[130] The fact that the Koptos Tariff mentions the transportation of modular ship components is another indication

[128] Cf. Mon.fun.Palmyre 201.65 (CIS 2.4209). The inscription gives Marona's name, family, a date, and expresses his desire that the tomb be passed on to his children and grandchildren—entirely formulaic language. τὸ μνημεῖον τοῦτο σὺν ὑπογείῳ ἐξ ἰδίων ᾠκοδόμησεν Ἰούλιος Αὐρή[λιος Μ]άρωνα [Μαλῆ τοῦ καὶ] Μεζαββάν[α τοῦ] Ἀδριανοῦ εἰς τειμὴν αὐτοῦ καὶ υἱῶν καὶ υἱωνῶν εἰς τὸ παντελὲς ἔτ[ους ζμφ΄] μηνεὶ Δύστρῳ (This is followed by a text in Palmyrene Aramaic)

[129] Zuchowska 2013, 385. The date is from Starcky 1946, 334. Palmyra used the Seleucid calendar, which has 312/311 BCE as its start date; inscriptions from the tomb date it to "Year 547," corresponding to 235/6 CE, though the date provided in the Greek inscription is a restoration by the editor. Since I have been unable to locate an image of the original inscription, I cannot verify the accuracy of the restoration.

[130] Blue et al. 2011, 186-187; Sidebotham 2011, 205.

of either ship construction or ship repair at the ports. Even more interesting is an *ostracon* text found at Krokodilo, one of the Roman military posts along the Koptos-Myos Hormos route.[131] In it, Artorius Priscillus, the "Prefect of roads" in the desert, commands the local garrison commander to prevent caravans from "abandoning" the wood meant for shipbuilding in the desert.[132] Not only does the text note that wood—raw wood, rather than prefabricated components—is being imported into the ports specifically for shipping needs, but it might even suggest a form of black market economy. All goods brought across the desert were heavily taxed, as the Koptos Tariff shows, so perhaps this wood is being left in the desert for pickup by smugglers, circumventing the checkpoint at Krokodilo. This would explain Artorius Priscillus' concern for such a seemingly unimportant action, unrelated to any security concerns: he wanted to ensure that he continued to get his cut of the profit.

If the ships of Myos Hormos and Berenike were generally built using Roman construction techniques, these techniques must have provided some benefit for Red Sea sailing. The planks, unfortunately, do not give any indication of the actual hull shape, meaning that it is unclear whether the ship depicted on the Berenike ostracon or the one on Marona's tomb was more common. But the mortise and tenon joins do make one thing clear: the hulls in use on the Red Sea were exceptionally strong. Which type of sail or which ship layout a crew used would no doubt depend on the specific context of their activity.

V. Red Sea Ships in Context

Since context is key to understanding Indian Ocean merchant activity, it only makes sense to next survey the maritime traditions of the broader ancient Indian Ocean. The most logical starting point is in the Red Sea ships of Egypt. Egyptian crews manned many of the Roman ships sailing out of Berenike and Myos Hormos, both as sailors and as captains. All available evidence points to the author of the *Periplus* being a resident of Egypt too, though that says nothing about the author's actual ethnic background.[133] The two Roman ships mentioned in texts have very Greek names—*Hermapollon* and *Gymnasiarchis*—but the names of the individuals associated with them are decidedly Egyptian—Serapion and Pisipmous.[134] In some ways, the Roman trade on the Red Sea is a continuation of the older Egyptian trade routes,

[131] O.Krok. 1.41

[132] The relevant lines are 17-26: Ἀρτ[ώ]ρις Πρ[ίσκιλλος κ[ουρ]άτορσι [πρα<ι>]σιδίων [ὁδοῦ Μυσορ]μιτικῆς χαίρ[ειν.] ξύλα τὰ πε̣ρὶ τ̣ῆς χρήσε̣[ως τῶν] πλοίων φερόμενα εἰς Μ̣ύσ̣[ορ]μον εἰώθασιν ο̣ἱ ἁμαξηλάτα[ι] ἐν τῆι ὁδῶι καταλεινπάνε[ι]ν παρανγέλλωι οὖν μὴ . . . ἀφῆτε γενέσθαι ε. . . περὶ [τ]ούτ̣ων ἀποδώ̣[σ]ε̣ί̣ μοι λόγο[ν]… "Artorius Priscillus to the commander of the garrisons of Myos Hormos road, greetings. The wood which is carried to Myos Hormos for the use of ships, the wagon-men have made it a habit to abandon it on the road; so, don't… abandon it to be (unguarded?)… concerning these things, send me word…" The rest is lost. Translation is my own; lacunae are as I found them in the text as provided in the HGV (see http://aquila.zaw.uni-heidelberg.de/tm/88631). I have been unable to find an image of the original ostracon to see if any of the gaps are recoverable.

[133] Casson 1989, 7.

[134] Both mentioned in O.Berenike.1.86, in which Serapion is requesting permission of a Roman *Quintanensis* for one of his men to load wine provisions onto the *Gymnasiarchis*. It's unclear whether Serapion is the captain, but he clearly has some sort of authority.

though with the profits and goods now diverted to the Roman aristocracy and administration. Pharaonic expeditions set the stage for Roman activity.

Roman merchants on the Red Sea coast dealt with the hazards of the environment in much the same ways as Egyptian expeditions once did. This is perhaps best exemplified in the Pharaonic port of Wadi Gawasis, called *Sawu* in Egyptian. The site was in use periodically for centuries, but the period of greatest activity seems to have been during the Middle Kingdom's Twelfth Dynasty, roughly corresponding to the 20th and 19th centuries BCE.[135] The site was first surveyed by Abdel Monem Sayed (University of Alexandria) in the 1970s; since 2003 it has been excavated under the direction of Kathryn Bard (Boston University) and Rodolfo Fattovich (University of Naples "l'Orientale). Located to the north of the later Roman ports, Sawu was in much the same situation as Berenike: isolated, barren, accessible only through the desert, and serving little real purpose beyond trade. The architecture of Sawu was somewhat more austere, composed of little more than storage caves, a packed earth shore embankment, a small residential area, and scattered industrial and religious zones, but the principle was the same: Sawu was a place to construct boats, store materials for repairs, and load or unload cargo.

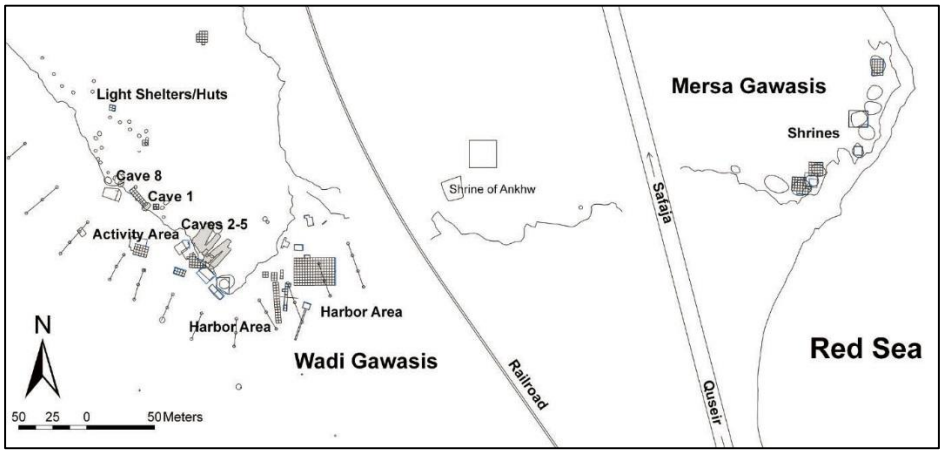

Fig. 12: Map of Wadi Gawasis (*Sawu*). From Bard and Fattovich 2010.

The ships were transported across the desert in pieces, then reassembled in port; the primary construction material was cedar, though the planks were fastened using a native Egyptian style of mortise and tenon joint.[136] The component parts were most likely manufactured in Koptos, which served as a royal shipyard.[137] While the Roman Koptos Tariff gives no indication as to whether the ship materials originated in Koptos or not, it does seem a striking similarity that both groups brought prefabricated, modular ships through the same point. Similar to the Roman tradition,

[135] Pharaohs Senusret I (mid-20th century BCE), Amenemhat III (mid-19th century BCE), and Amenemhat IV (late-19th century BCE) are all attested to in epigraphic remains (Bard and Fattovich 2010)
[136] Ward 2012a, 28. Specifically, the mortises are "unlocked," meaning that the mortise and tenon joint does not have a dowel holding it together. Ward's experimentation has shown that this technique was still very seaworth. The joins are also much more widely spaced than those seen in the Myos Horomos hull remains.
[137] Ward 2012b, 220.

Pharaonic sails were square-rigged, as seen on the famous Punt ship relief at the funerary temple of Hatshepsut at Deir el-Bahri. The relief also seems to show oarsmen along the length of the ship, suggesting that like the Palmyrene ship it could have switched over to human propulsion when needed. And finally, just as the Romans did, from the New Kingdom period onwards Egyptian shipwrights the technical capability of adding brailing to sails.[138]

Fig. 13: Rigging and oarsmen from the ship relief at Deir el-Bahri. From Ward 2012b

All the evidence points to Egyptian ships being designed to mitigate the hazards of the Red Sea Gulf specifically. The brailing and oars would both have increased maneuverability, especially in less than idea wind and shallows. In her experimental reconstruction of an Egyptian Red Sea ship, Ward recounts how the oars were particularly useful in avoiding coastal reefs.[139]

The unlocked mortise and tenon design used by Egyptian shipwrights may have sacrificed some theoretical strength in favor of economy, but the salient point seems to be that, in the context of Egyptian voyages to Punt, such added durability was unnecessary. A voyage to Punt would have been entirely within the Red Sea gulf, and thus in the absence of a long open ocean trek across the Arabian Sea the reinforcements of a Roman craft would only have increased the time and effort expended in constructing and maintaining it. Instead, Egyptian shipwrights created ships that were very easy to disassemble without damaging the planks.[140] Ships would have been large: two steering oars at Gawasis suggest craft 20 and 30 meters

[138] Based on iconographic depictions. No brailing has yet been found in the archaeological record of Wadi Gawasis, leaving this capability purely theoretical. Cf. Vinson 1993 for a discussion of the exact time frame for brailing appearing in Egypt.
[139] Ward 2012b, 224.
[140] Ward 2012b, 219.

long.[141] Perhaps, since the effort of getting to the coast was so labor intensive, expeditions preferred to send larger craft at less frequent intervals.

Likewise, the kingdoms of South Arabia built ships according to the needs of their economic and geographic context. At the time of the *Periplus*, the coast of what is now Yemen and Oman was divided between two kingdoms: Saba-Himyar in the west and Hadramawt in the east. Both kingdoms shared a few central features. The kingdoms were centered on highly urbanized capitals located inland in the mountainous, rainy highlands, but both had coastal outposts through which they integrated into the maritime spice route.[142] Geographically, both kingdoms were at the intersection of all major trading parties on the Indian Ocean: Rome, India, Persia, Ethiopia, and East Africa were all nearby, and merchants traveling from one region to the other would necessarily have to pass by the Arabian ports.

The South Arabian ports themselves served a dual purpose. These ports were first and foremost collection centers for each kingdom's primary export. Saba-Himyar had a virtual monopoly on the maritime export of myrrh, while Hadramawt was the biggest exporter of frankincense. [143] Archaeological expeditions to the Hadramawti ports of Sumhuram (Moscha Limen) and Qana (Kane) have revealed the remains of large warehouses; at Sumhuram, the larger of the two, grains of frankincense are found scattered throughout the ancient layers.[144] Incense was a profitable commodity which royal agents could monopolize, thus presumably increasing its value through scarcity.[145] Thus on one register, the trade of the South Arabian kingdoms was of frankincense and myrrh for Roman wine and worked gold vessels: an exchange of symbolic luxury goods between the élite of one society and the élite of the other.[146] On a second register, however, one sees the import of much more humble goods, such as undecorated clothes, unworked metals, and grain.[147] Trade extended beyond the simple luxury-for-luxury

[141] Ward 2012b, 222.
[142] Saba-Himyar (really two kingdoms, forming a sort of dual monarchy under King Charibael) was centered around the twin capitals of Marib and Zaphar; Hadramawt was ruled from Saubatha. The main ports of Saba-Himyar were Muza and Okelis, with the once prosperous Eudaimon having fallen into decline by the time of the *Periplus*. Hadramawt traded out of Qana (Kane) and Sumhuram (Moscha Limen, modern Khor Rori). Cf. Seland 2010, 18-31.
[143] Seland 2010, 24-29.
[144] Avanzini 2007, 24; Seland 2010, 29.
[145] Cf. *Periplus* 32, in which the loading of frankincense at Moscha Limen is specifically handled by royal agents ("παρὰ τῶν βασιλικῶν"); the author previous claimed (*Periplus* 29) that frankincense was harvested royal slaves and convicts ("ὑπὸ δούλων βασιλικῶν καὶ τῶν ὑπὸ τιμωρίαν πεμπομένων"). The author's rather fanciful description of frankincense plants as exuding a "harmful miasma" suggests that they never actually visited the frankincense bearing areas of Hadramawt, but if their description of the labor conditions is at all accurate, it shows royal control of frankincense at every stage of production.
[146] Seland 2010, 25. Wine and expensive vessels were both part of aristocratic drinking rituals, similar to the classical Greek *symposion*. Aromatic incense is technically not an "élite" product, as it had religious meaning; however, certainly by the Roman period the conspicuous consumption of large amounts of expensive incense could be considered an élite display. Cf. Pliny *NH* XII.41, in which Pliny claims that the Arabian incense crop "cannot equal in an entire year's crop as much as emperor Nero cremated on that final day of his Poppaea." As in his Indian trade comment, the fixation is on the trope of "expensive women," but the anecdote certainly illustrates the treatment of incense as a luxury good.
[147] *Periplus* 24, 28

exchange, and extended into small-scale ventures. South Arabian ships should therefore reflect the two key points of their context: a geographically central location near to their trading partners, and an exchange of often small, low-value cargos.

As with Roman ships of the Red Sea, there are no complete ancient Arab ships, and any discussion must draw upon comparison. A cache of medieval timbers found at Al-Balid, a site in Oman close to Sumhuram, show clear signs of stitching with coconut fibers.[148] The use of sewn coconut fiber in ships is described in Medieval Arabic literature, while sewn plank construction is attested to in modern ethnographic studies from western India and Arabia.[149] While the joins may have been more permeable, the wood was still high quality: at least two of the recovered planks were of teak.[150] Wrecks of ships in this sewn plank design are found as far east as Indonesia, most notably the 9th century CE Belitung ship. This was a fairly large sewn-plank ship of 20 or more meters, utilizing teak beams for the interior structure, though the hull planks themselves were made from a relative of the mahogany tree.

Fig. 14: Sewn plank construction on the Belitung shipwreck. From Pedersen 2004.

Structurally speaking, sewn planks would have been weaker than mortise and tenon joins; despite this, it is important to note that the sewn plank technique outlived the mortise and tenon tradition on the Red Sea by an entire millennium. The hull drawbacks could be mitigated by remaining in coastal waters and not sailing during the rough summer monsoons. Ancient Arab ships seem to have sailed in the milder northeast winter monsoon, then sheltered at ports like Moscha during the heavy winds of the summer monsoon.[151] Sewn plank construction would have been relatively cheap, at least compared to labor-intensive shell-first construction techniques, and would have had few problems performing port-to-port trade (*cabotage*) between the ports of Arabia, Egypt, East Africa, and India.

The *Periplus* records a bustling port at the South Arabian city of Muza, near the Straits of Aden, which seems indicative of a coastal network. Muza was notable for its *naukleroi*, like the Palmyrene shippers seen in Koptos; here the term seems to be applied at least in part to shipwrights, who furnish "their own naval equipment" for trips abroad.[152] These would be locally made ships, presumably in a local style. At least one type of ship sailing out of the Arab harbors, again specifically noted as being a "local" type, was made out of sewn leather bags.[153]

[148] Belfioretti and Vosmer 2010, 111. The timbers date to the 10th through 15th centuries.
[149] Hourani 1951, 91-92; Beresford 2013, 224; Pomey 2011, 140.
[150] Belfioretti and Vosmer 2010, 112.
[151] Seland, 2008, 284.
[152] "συγχρῶνται... ἰδίος εξαρτισμοῖς" *Periplus* 21.
[153] "σχεδιαις εντοπιαις δερματιναις εξ ασκων." *Periplus* 27.

The *Periplus* authors comments would seem to indicate that the South Arab sailors are sailing on sewn plank ships—the very fact that the *Periplus* author marks out the ships being "their own" type suggests that there was something "different" about their construction, at least from a Roman perspective.

Using these ships, merchants from Muza could sail along the East African coast. The whole coast from Somalia to Tanzania was punctuated with harbors and inlets, described as being "divided into stations and a day's running."[154] This suggests a journey along the coast, rather than on the open seas: ships travel from port to port, each conveniently spaced a day's sailing apart. The local ships are all of sewn hides, and the southernmost port is called Rhapta, meaning "Sewn," named after its seafaring tradition.[155] Merchants from Muza went to Rhapta to collect tribute and trade, employing Arab crews who frequently intermarried with locals.[156] The image is thus of numerous small Arab and East African ships ("ἐφόλκια," as the *Periplus* author describes them) sailing from coastal port to coastal port, employing crews who have special knowledge of the local communities. By bringing crews who spoke the local languages and understood local customs, these ships could trade more easily at smaller-scale anchorages: they would not need to rely upon the presence of expatriate merchants to act as translators and guides when they brought their own in the form of the ship's skipper.

The final trade context, India, is the most complex as well as the most frustrating. While all of the designations used thus far—Roman, Arab, East African—are ambiguous in their exact meaning, by far the most nebulous term is "Indian." This term is used casually by Roman authors, but refers to a vast number of groups differing in language, religion, urbanization, political organization, and simple geographic distribution. Any attempt at defining a universal "Indian ship" must acknowledge this fact. Thus, it is perhaps better to examine the purposes for which trade ships were used, using a select number of diagnostic examples. From these it will be clear that the same trade patterns as seen elsewhere in the Indian Ocean were present in ancient India.

The Godawaya wreck represents a small Indian craft from the edge of the space known by the author of the *Periplus*. The Godawaya wreck is one of the most recent archaeological discoveries in the Indian Ocean. The wreck was found in 2003 by a pair of Sri Lankan divers, but excavation only began in earnest in 2012 under the auspices of the Institute of Nautical Archaeology, led by Osmund Bopearachchi (CNRS-Paris), Deborah Carlson (Texas A&M) and Sanjyot Mehendale (Berkeley).[157] The wreck sank to a depth of about 30m in a particularly stormy region, requiring a logistically difficult underwater excavation, still ongoing as of 2016.

[154] "διῃρημένοι κατὰ σταθμοὺς καὶ δρόμους ἡμερησιους πλείους" *Periplus* 15.
[155] *Periplus* 15, 21.
[156] *Periplus* 16. The *Periplus* author singles out skippers (κυβερνήται) as being knowledgeable, though the crew in general (χρειακοί) are included.
[157] Carlson and Trethewey 2013, 9.

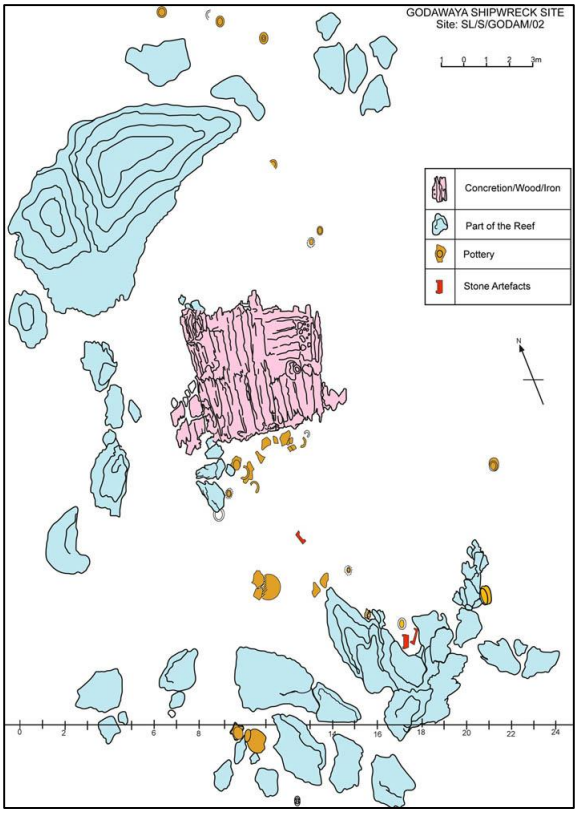

Fig. 15: Plan of the Godawaya wreck. From Muthucumurana et al. 2014

Found off the southern coast of Sri Lanka, the Godawaya wreck is not on any of the trade routes described by the *Periplus*; in fact, the entire island of Sri Lanka is something of an empty space in the *Periplus*, as while it is acknowledged as existing it never receives the political, social, and geographical detail seen elsewhere.[158] Roman traders did eventually reach Sri Lanka, but it seems to have remained peripheral thanks to its distance.[159] Nonetheless, the island was still actively engaged in trade, thanks in part to its strategic position between East Asia and the western Indian Ocean.[160] Like Arabia, therefore, it had ease of access to multiple markets, and could act as a central nexus for multiple trade routes.

[158]*Periplus* 61 gives what little description there is; Sri Lanka is called "Taprobane" and "Palaisimundu" (Ταπροβάνη, Παλαισιμούνδου).

[159] Pliny (*NH* 6.24.84-85) tells the story of a freedman, Annius Plocamus, who is carried accidentally to the as-yet unknown Sri Lanka by the "northeastern" winds (Latin "aquilo," suggesting the winter monsoon). Annius impresses the island's king with the quality of Roman coins, and ultimately convinces the king to send an embassy to the Roman emperor Claudius. For a different sort of evidence, cf. the late antique Greco-Egyptian author Cosmas Indikopleustes, who wrote the *Christian Topogrpahy*. While the primary aim of the work was to disprove the theory of a spherical earth as a "pagan" heresy, it also dealt with Cosmas personal experience in the Indian trade routes. Cosmas seems to have visited Sri Lanka himself before retiring from trade.

[160] Muthucumarana et al. 2014, 42.

As with Arab shipping, the Godawaya wreck suggests that non-luxury trade was also common in southern India. As is the case with all ancient wrecks in the Indian Ocean, the physical remains of the Godawaya ship are not substantial: at best, the hull exists only as a few scattered scraps of non-diagnostic wood.[161] What does exist is not enough to determine whether the ship was constructed with mortise and tenon joins or sewn planks. Instead, the primary remains are the cargo. These consist of a number of raw glass ingots, a smaller amount of unworked copper, ceramic vessels, and large quern stones used for grinding grain.[162] The pottery was of a type found throughout the southern Indian ports.[163] The quern stones were similar to ones found in central India, though since they were made of basalt, found in South India, they may have been made there as well.[164] Glass was produced throughout India, suggesting that the glass ingots were produced within the nearby region as well.[165]

The cargo of the Godawaya wreck was thus fairly mundane: raw materials, pottery most likely containing agricultural products, and grindstones. All could have been produced locally, and none were prestige or luxury goods. While the ship could have been carrying perishable luxuries which have been destroyed by time, the wide variety of common goods does seem more indicative of a ship taking part in small-scale *cabotage*. The trade routes shown in the *Periplus* were only a few of the great many which would have crossed the Indian subcontinent, which represented only the exchange which was of interest to Roman merchants. Sanskrit inscriptions seem to support the existence of these small, coastal routes, referring to certain classes of ship as *pravahana*, or coastal ships. They are contrasted with *vahitra*, a type of ship associated with open-ocean voyages. Both *cabotage* and direct sailing were valid economic practices in ancient India. Yet if long-distance ocean routes existed, there must have been Indian ships capable of surviving them.

While no shipwreck exists to illustrate them, numerous artistic representations attest to large, long distance ships sailing out of the ports of India. Perhaps most striking are the Satavahana ships. The Satavahana dynasty ruled over Andhra, on the east coast of India, between the 2nd century BCE and the 3rd century CE. Their ships are depicted in two sources: coins issued in Andhra, and in a graffito from Sumhuram. Both clearly depict a large, symmetrical ships with twin masts. This is obviously unlike any design seen among the Roman ships of the Red Sea, yet it would have helped with a problem faced by the Romans: contrary winds. The double masts would have allowed greater control of the ship's direction when sailing against the wind.[166] On the coins, the placement of sailyards perpendicular to the masts suggests a square-rigged sail; the graffito omits sailyards, but the rigging looks similar enough to that depicted on the coins to safely presume a square-rigged sail there too. As an even more extreme example, albeit one from

[161] See Muthucumarana et al. 2014, 48. A number of "logs" were found on the sea floor, but due to their small size no formal analysis was carried out other than carbon-14 dating.
[162] Muthucumarana et al. 2014, 49.
[163] Muthucumarana et al. 2014, 51.
[164] Muthucumarana et al. 2014, 52-54.
[165] Muthucumarana et al. 2014, 55.
[166] Sprague de Camp 1959, 61.

the early medieval period, a painting from the Ajanta caves of the Deccan plateau depicts a triple-masted ship, though its sails appear too stylized to be definitively classed as square-rigged. In sum, by increasing the number of masts while maintaining a square-rigged sail, Indian shipwrights craft in Andhra and the Deccan created craft which were capable of beating against an unfavorable wind, but still able to make full use of a favorable one.

Fig. 16: 2nd century CE coin of Satavahana king Vasisthaputra Pulumayi, Andhra, India. From Patra 2013.

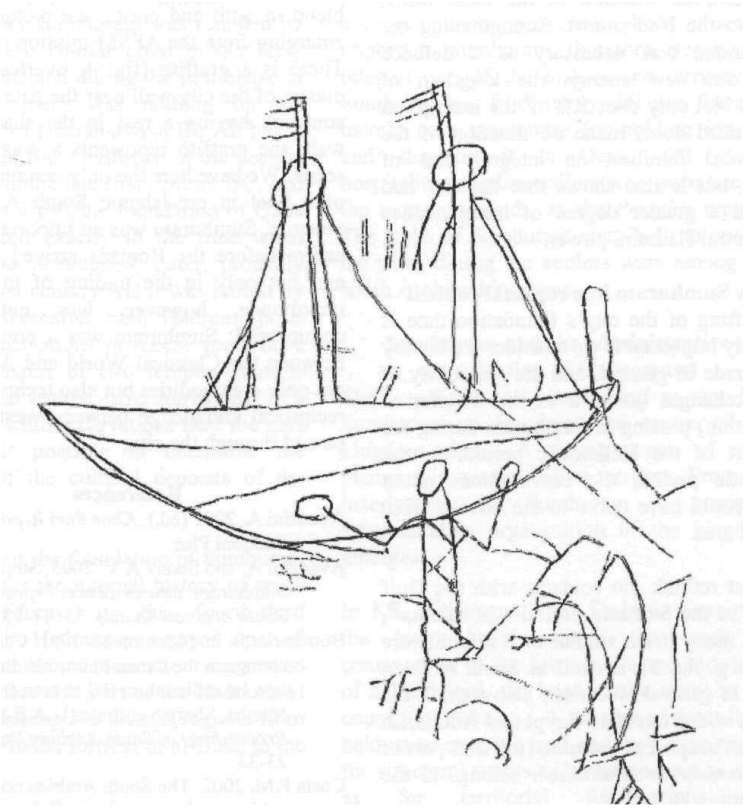

Fig. 17: Graffito, probably of a Satavahana ship, from Sumhuram (Moscha Limen), Oman. From Avanzini 2007.

Fig. 18: "Ajanta Ship," Ajanta, India. From Patra 2013

Indian oceanic craft are also attested to in literary sources. Fa Hsien, a Chinese Buddhist who travelled throughout South and Southeast Asia at the beginning of the 5th century CE, recounts how he crossed over the eastern Indian ocean. Upon arriving in Bengal, at the port of Tamralipta, Fa Hsien booked passage on a ship sailing directly to Sri Lanka: this is a voyage of over 2000 kilometers, in which the ship crossed over the open ocean. Once in Sri Lanka, Fa Hsien booked passage on yet another ship, this time to Java and ultimately back to China.[167] The Arabian Sea in the west was only one face of the maritime spice route. At the same time as Roman merchants ventured out of Egypt to Arabia and India, Kalinga merchants ventured across the Bay of Bengal to Indonesia and the southern coast of China.[168] In both cases, ship technology facilitated long-distance direct trade.

VI. Conclusion

It is entirely too easy to place the Roman merchants in the Indian Ocean in isolation, a sort of curiosity due to their unique situation outside of the Mediterranean. It is true, the ships used by these merchants were technological marvels, sturdy enough for travel through strong winds and harsh conditions, yet versatile enough to remain maneuverable. Roman shipwrights successfully adapted the maritime traditions of the Mediterranean Sea to the Indian Ocean, making use of square-rigged sails, mortise and tenon joins, and various stabilizing features such as the *artemon* sail and cutwaters. These ships made use of timbers available in both the Mediterranean and the Indian Ocean worlds, building hulls which were both high quality and economical. The goods brought by Roman merchants were also clearly valued, as seen in the praise for "Yavana" wine and gold in Tamil literature, and the demand for imported Roman luxuries by South Arabian and Indian élites. But the Romans were just one branch of a massive trade network spanning three continents.

Rather than existing in isolation, the Romans filled one particular niche in the economic ecosystem of the Indian Ocean. Due to their resources, tradition of exceptionally strong hulls, and adaptable sail technology, the Romans were able to construct ships which could make use of the winter monsoons; due to the demand for luxury goods by élites in Rome and the Indian Ocean world, these dangerous direct voyages remained profitable. Roman ships were molded by the demands of Roman markets. A big ship, capable of surviving the monsoon and bringing back a full load of Indian spices and Arabian incense, was worth the investment of extra time and effort to build when the payoff for a single voyage was worth 7 million *sestertii*. Roman trade on the Indian Ocean may have been focused on luxuries, but the "Maritime Spice Route" was not a Roman luxury trade route. Rather, the luxury trade existed as one of a number of commercial practices. Parallel to this, the Roman tradition of shipbuilding was just one of many traditions coexisting in the Indian Ocean, each one tailored to local economic and geographical concerns. Egyptian, Arab, and Indian shipbuilding traditions developed their own solutions to ocean

[167] Chakravarti 2003, 56.
[168] Patra 2013, 256-7, 278.

hazards, each predicated upon the role which their ships played in trade. Each context was unique, but their interplay reveals the complex web of connection spread across the ancient maritime world.

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