ESSAY ON ALTERNATIVE LOCALIZATION OF THE INDO-ROMAN PORT OF MUZIRIS

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ESSAY ON ALTERNATIVE LOCALIZATION OF THE INDO-ROMAN PORT OF MUZIRIS...I
Abstract....II
List of figures....III
List of tables....IV
Declaration of authorship....IV
Acknowledgements....V
Definitions and abbreviations....V
Aim of this Essay....VI
1 The Indo-Roman ocean trade....1
2 The sources....5
Strabo....5
Pliny Naturalis Historia....8
Periplus Maris Erythraei....12
Sangam Period Sources....32
Ptolemy's Geography....41
Tabula Peutingeriana....45
Muziris-papyrus....48
Other sources....49
Recap of information from ancient sources....53
3 Ships, voyage routes, periods and duration, speed and distance....54
Type of ships....54
Monsoon regime in the Indian Ocean....58
Voyage periods, routes and ports....65
Roman ships navigation speed....68
Navigation in the Red Sea....73
Some more notes on the Red Sea....78
Navigation on the Gulf of Aden....84
Navigation on the Indian Ocean....85
4 The voyage from Berenike to Muziris....87
Route from Berenike to Ocelis....87
Two alternative routes....89
Northern route to Barigaza through Cana....91
Direct ocean crossing toward Southern India coasts from Ocelis....95
From Ocelis to Cape of Spices....96
Overcoming the Socotra peril....99
From Cape of Spices to India....101
Arriving to Muziris....104
Muziris 1....107
Muziris 2....108
Muziris 3....109
Return to Berenike....111
Conclusions....113

Many of us seek pleasant fields for research, while others deal with matters of immense complexity where one is overwhelmed and cannot see the wood for the trees.
– Pliny the Elder, Natural History

Abstract

The aim of this essay is to present an alternative hypothesis about the localization of the ancient Indo-Roman port of Muziris/Muchiri, different from the current ones that would position it in Kerala, and precisely in Pattanam or Kodungallur, on the opposite side of the Periyar river. Obviously this proposal of an alternative localization does not in any way deny the archaeological findings of the current research carried out along the Malabar coast, which at that time was rich of many port of calls of the indo-roman trade, but only and specifically deal with ancient Muziris real site.
The present study is based on two evaluations:

- The Pliny's affirmation that the travel from Ocelis to Muziris lasted 40 days: as for the veridicality of this assumption let's recall that he was the commander in chief of the Roman Fleet, stationed at Miseno Cape, and consequently he had all the means to collect reliable information both from military and merchant sources.

- The possibility of a simulation of the followed routes and time spent toward Muziris during the I century A.C., based on data about the Indian Ocean seasonally monsoons precisely evaluated by satellites, open the way for answering to the question "where are we after 40 days along those routes ?"

There, Muziris was.

List of figures

(for seeing image details zoom in)

Fig. 1.1 Coins as trade chronology 3

Fig. 2.1 Strabo's world map 5
Fig. 2.2 Arabic Sea 11
Fig. 2.3 The Red Sea 13
Fig. 2.4 Bab El Mandeb and Gulf of Aden 15
Fig. 2.5 Horn of Africa and Socotra 16
Fig. 2.6 East African coasts as for Periplus 18
Fig. 2.7 Bab El Mandeb Strait 20
Fig. 2.8 Gulf of Aden 21
Fig. 2.9 Oman coasts 23
Fig. 2.10 Northern Arabic Sea coasts 24
Fig. 2.11 India North-West coast 27
Fig. 2.12 South India coasts, Comorin and beyond 30
Fig. 2.13 Map of Southern India during the Sangam period 33
Fig. 2.14 Arabic Sea and India in Ptolemy's Geographia 41
Fig. 2.15 Posidonius Map, Library of Congress 43
Fig. 2.16 Muziris, as shown in the Tabula Peutingeriana 45
Fig. 2.17 Pompei and Oplontis, as shown in the Tabula Peutingeriana 46
Fig. 2.18 Costantinople, as shown in the Tabula Peutingeriana 47
Fig. 2.19 Muziris papyrus 48
Fig. 2.20 Geographus Ravennas world map 52

Fig. 3.1 Roman merchant ship 56
Fig. 3.2 Monsoon surface thermal mechanics 58
Fig. 3.3 Monsoon winds 59
Fig. 3.4 Sea surface temperature 61
Fig. 3.5 Arabian Sea temperatures in the past 62
Fig. 3.6 Surface currents in the Indian Ocean 63
Fig. 3.7 Wind reversal in Red Sea and Gulf of Aden, on May 6, 13, 20 65
Fig. 3.8 Ship points of sail 68
Fig. 3.9 Red Sea Winds in half May and Gulf of Aden in late June 74
Fig. 3.10 Red Sea, Gulf of Aden and Arabian coasts 75
Fig. 3.11 Red Sea wind mean values in all seasons 76
Fig. 3.12 Sheltered mooring offered by the Khors, deep inlets at the mouths of the wadis 77
Fig. 3.13 Median Portion of the Red Sea 78
Fig. 3.14 Adulis 80
Fig. 3.15 Ocelis on Bab El Mandeb Strait 82
Fig. 3.16 Bab El Mandeb, South Cross and Polaris on 4.0 am March 1, 30 B.C., HNSKY 83

Fig. 4.1 Red Sea from Berenike to Ocelis 88
Fig. 4.2 Southern Red Sea winds during the second half of May 89
Fig. 4.3 Arabian Sea wind on mid-August 90
Fig. 4.4 Gulf of Aden on early August 91
Fig. 4.5 Arabian coast and Oman Gulf on August 92
Fig. 4.6 Indian West coast on late August 94
Fig. 4.7 Gulf of Aden 96
Fig. 4.8 Gulf of Aden, week ending August 07 97
Fig. 4.9 Schematic diagram of the seasonal variation of the major ocean currents 97
Fig. 4.10 Socotra_mid-August_wind 99
Fig. 4.11 Socotra wind during the year 100
Fig. 4.12 Winds over Socotra orography 100
Fig. 4.13 Course from Cape of Spices to overcome Socotra 101
Fig. 4.14 South-West India on early September 104
Fig. 4.15 Route Kozhicode – Cape Comorin 105
Fig. 4.16 Muziris locationing hypothesis 1 107
Fig. 4.17 Muziris locationing hypothesis 2 108
Fig. 4.18 Muziris locationing hypothesis 3 109
Fig. 4.19 Possible ancient track of the Vaigai river 110
Fig. 4.20 Muziris on the Tabula Peutingeriana 110
Fig. 4.21 Arabic Sea on January 111
Fig. 4.22 Mid-way Arabic Sea on 23.00, 31 January, 75 A.C., HNSKY version 4.2.10 112

List of tables

Tab. 1.1 Roman coins found in Kerala

Tab. 3.1 Ships speeds sailing with favourable winds. 70
Tab. 3.2 Wind ship propulsion 72
Tab. 3.3 Navigation on the Arab coast in June 74

Declaration of authorship

I hereby certify that this thesis has been composed by me and is based on my own work, unless stated otherwise. No other person's work has been used without due acknowledgement in this thesis. All references and verbatim extracts have been quoted, and all sources of information, including bibliography, graphs and data sets, have been specifically acknowledged.

Since the author is not a native English speaker, the text may sometimes have a strange taste to you, destined to raise some eyebrows and make you think "With utmost respect .....".
So the author apologizes for any errors and, counting on your good will, hopes that it is at least understandable and possibly clear, which was his real goal. Furthermore any inaccuracy in the English text is the proof that this work is entirely man made and not a result of an A.I. application.
Thank you.

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The author thanks all who indirectly contributed to this work publishing their works in a open form, making them freely accessible through the web and specilised research sites.

A special thank to my brother Antonio, who is an amateur astronomer, for his help with the phenomenon of Earth axis precession.

Definitions and abbreviations

n.m.	nautical miles
PME	Periplus Maris Erythraei
tailwind, downwind, leeward	wind coming from the ship's stern
upwind, windward, headwind	wind coming from the ship's bow
broad reach	sailing with the wind at 45 °
Beam reach	sailing with the wind at 90°
to luff	to change course toward the wind.
to bear away	to turn the bow away from the wind
Stadium	equal to 0,1 nautical mile, or 185 meters
1 talent	equal to 6000 drachmas in Roman period
1 aureum (gold coin)	equal to 25 Denarii (silver coin)
1 PES, foot,	equal to 29,65 cm.
1 PASSUS (step)	equal to 5 PES – 1,48 mts.
1 STADIVS	equal to 625 PES – 185,3 mts.
1 MILIVM o MILIARIVM	equal to 5000 PES - 8 STADI - 1000 PASSUS – 1482 km.
Yavanas or Yavanar	Indian term for Greco-Roman people

Aim of this Essay

The ancient port-town of Muziris was situated on a Southern coast of India. It was famed for its spice trade, notably the shipment of pepper and malabathrum (a cinnamon-like plant, whose leaves were pressed to make a perfume), which were indigenous to the Tamil Nadu region, and also pearls, ivory, silk, nard, gemstones.
The significance of this port town in the ancient spice route is evident in literary sources, from Pliny (Natural History) and Strabo (Geographica) to the Sangam epic works of Chithalai Chathanar (Silapadikaram) and Illango Adigal (Manimekalei).
The Muziris economy depended on the spice trade. The Sangam works describe the wars that were waged between Chera and the Pandyan kingdoms to win monopoly rights to the ancient spice routes.
The Muziris-Vienna Papyrus, a second century AD parchment, speaks of the huge quantity of pepper that was traded from Muziris to Alexandria through Koptos and Berenike in a ship named Hermapollon. The parchment also describes the taxes that were imposed on these commodities, and the well-organised merchant guilds based at Muziris. This could explain the hypothesis of westerner mercenaries, arrived with the ships to protect their commodities from pirates and being stationed at Muziris. Literary sources are therefore invaluable to an understanding of the trans-oceanic trade of Muziris, which not only conveyed goods, religion, architecture and culture to and from the port, but also underpinned the state and economy of this particular place.

The aim of this essay is trying to verify the current hypothesis about the localization of the ancient Indo-Roman port of Muziris/Muchiri, that would position it in Kerala, and precisely in Pattanam or Kodungallur, on the opposite side of the Periyar river, and possibly presenting an alternative different from the current one. Obviously the proposal of an alternative localization does not in any way deny the archaeological findings of the current research carried out along the Malabar coast, which at that time was rich of many port of calls of the indo-roman trade, but only and specifically deal with ancient Muziris real site.
Since the current hypothesis is not fully convincing and doubts have arisen over time, fuelled by the uncertainty and partial contradictions of ancient sources, it would be important to identify a different verification system. It can perhaps be found by examining the routes followed by Greco-Roman ships to reach the Indian subcontinent, the relative times and reachable distances.

To this end, data on monsoon winds detected today by satellites can also be used, in the hypothesis that this recurring phenomenon has not significantly changed from the first century AD to the present day. Those data are collected and organized by specialised companies to offer detailed information about oceanic meteorological conditions. One of them is Remote Sensing Systems, which operates by processing and analyzing data collected by satellites' microwave sensors named scatterometers, and publishes the consequent results.
Scatterometers, mounted on satellites, are essentially radars that transmit microwave pulses down to the Earth's surface and then measure the power that is returned back to the instrument.
This "backscattered" power is related to surface roughness. For water surfaces, their roughness is highly correlated with the near-surface wind speed and direction. Hence, wind speed and direction at a height of 10 meters over the ocean surface are retrieved from the measurements made by the scatterometers.

In this study those data, detected by satellites employed by Remote Sensing Systems services, have been used for measuring and showing monsoon winds force and direction in different areas and seasons, which allows for determining time spent to travel along marine routes.

After having evaluated, on the basis of ancient sources, the medium performance of Greco-roman ships, the possible routes and the wind force and direction, it has been calculated the correspondent timing; this accomplishment allow to answer one question:

Where could have been the roman ships, along those routes, after the "40 days" travel reported by Pliny ? There lies Muziris

This constitutes an indirect method to identify the ancient Muziris position.

The possible conjectures about the port location can obviously also be supported by several early sources, as :
- Pliny's Historia Naturalis
- Periplus Maris Erythraei
- Old Indian Sangam literature
- Ptolemy Geografia
- Geographus Ravennas
- Cosmas Indicopleustes
- Tabula Peutingeriana, an ancient map which reports this locality in southern India.

Any possibly new localization proposed could also be confirmed by some nearby territorial features, still existing today, like lagoons, mountain and other geographical features present in ancient records relating to Muziris.

The chosen reference epoch of this research is the first century A.C. , because the best available information on Muziris was recorded during that time by Pliny and the author of the Periplus.

1 The Indo-Roman ocean trade

First recorded exploration voyage to India from a western country was that of Scylax of Caryanda, sent around 520 BC by the Persian ruler Darius I to find the estuary of the Indo river [1].
After the Alexader's expedition to India there was the Nearchus return voyage by sea narrated by Arrian of Nicomedia, but first contacts between Mediterranean civilizations and India appear to be linked only to single episodes before the epoch of the Ptolemaic Kingdom.
As a matter of fact during the early pre-Christian era sea trade between Middle East and India was in the hands of Arabs. They transported spices, incense, and oils from the East by land as well as through the Persian Gulf to Arabia. South Arabia became the great spice emporium of the ancient world.
Ongoing Greek presence in the Indian Ocean really began only with the reign of Ptolemy II in the third century BC, when he sponsored the expeditions of Eudoxus of Cyzicus and founded hunting bases on the coast of Sudan and Eritrea to transport elephants by ship to the coasts of the Egyptian Red Sea, where the new port of Berenike Troglodytica was founded. This Ptolemaic initiative, taken for war needs, anyway opened the way to sea trade toward the South and the East.
Even after the acquisition of elephants ceased to be a major concern for the Ptolemies the use of the Red Sea for commercial purposes continued, as is attested by a number of offices which were established to oversee such activity in the latter second and first century BC. It is also in the late second century BC that Posidonius claims that the Greeks first learnt how to use the monsoon winds to sail over open water to India [2], marking the beginnings of a thriving Egyptian, and later Roman spice trade. As Rome's Silla wanted a pro-Roman ruler on the Egypt throne, he sent the young Ptolemy XI to Alexandria, thus imposing the influence of Rome in 80 BC; by 40 AD Alexandria had become not only the greatest commercial centre in the world but also the pre-eminent emporium for spices.

In the early second century BC Greek merchants were probably heading to Eritrea, northern Somalia and even Aden for buying aromatics like frankincense and myrrh.
As already noted toward the end of the second century BC the Egyptian Greeks discovered how to use the monsoon winds to navigate the Indian Ocean, probably by means of contact with Indian sailors making calls in Eudaemon (Aden). In this regard Strabo cites the Poseidonius's story of Eudoxus of Cyzicus and his voyages to India, followed by his attempt to circumnavigate Africa.
Anyway by 70–50 BC there was a marked increase in the number of Greek ships sailing across the Red Sea and Indian Ocean to Indian ports, as several inscriptions and Strabo show.
Relating to the Roman world, since the second half of the II century BC took place the trade between India and Rome, at the beginning through intermediaries: peoples allied or subject to Rome and non-allied peoples, who mediated on the basis of their strong geographical position. The data provided by the pottery prove that the Coromandel coast traded with the Mediterranean as early as the second century BC.

1.1) Herodotus, The Histories, IV, 44
1.2) recorded in Strabo Geography. 2.3.4-5
1.3) Naturalis Historia VI. 26, http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.02.0137%3Abook%3D6%3Achapter%3D26

The situation changed radically with the Roman conquest of Egypt and the consequent possibility of sailing in the Indian Ocean firsthand, so starting a completely new phase of the Indo- European trade.
Also Roman merchant vessels started to use the monsoon winds, as it is proved by the author of Periplus of the Erythraean Sea that in the second half of the first century credited a sailor named Hippalus for the discovery, probably a tale like that of Eudoxus. Pliny on the contrary never cited a navigator named Hippalus, but only as the name of the wind [3].
In one of his passage Pliny tell us not only of this wind, but also of a destination port reachable with forty days of navigation: " *Indos vento hippalo navigant diebus XL ad primum emporium Indiae Muzirim*."
As we all know, the Roman Empire had an important but brief direct participation to the Indian Ocean trade, starting with the Augustus's conquest of Egypt (30 BC), lasting during I and II century AC, during which this trade even intensified, and slowly extinguishing in the middle of the third century. After that only trade with the eastern Roman Empire (Byzantium) partly continued.

The trade terminal in the Mediterranean sea was Alexandria in Egypt, from where Indian merchandise was distributed all over the Empire; the main roman port used for that trade were on the Red Sea coast of Egypt, before Myos Hormos then Berenike, at which trading merchant ships started or arrived.
Those ships mainly followed two different courses after the Red sea descent:

- one beside the Arabian coast then, after the Oman Gulf crossing, along the northern arch of the Arabian Sea up to the Hindus river delta, where the India's shoreline starts;
- the other straight East for the Ocean crossing, toward the Southern coasts of India.

As for this topic, it is possible that the first course was used by smaller ships doing coastal navigation, whereas for the oceanic crossing larger ships were employed, both for their reliability to marine conditions and because of the main part of the merchandise to be transported from South India to the Roman Empire was constituted by pepper and malabathrum (aromatic plant leaves), a light but voluminous cargo.

As for the intensity of the Roman trade during those three centuries we can refer to archaeological finds, both of amphorae, pottery or other artefacts and coins used for payment of merchandise. Merchandise was paid with silver (denarii) or gold coins (aurei) or even gold bullions, and probably also the conquest of Dacia by Trajan, with its gold mines, was an important support for that trade.

Coinage is perhaps the most visible Roman find in India, pottery is the second most frequent class of Roman material.
As for coins, the majority of these finds do not come from archaeological contexts, and they belong to private collections, making the study of this material difficult.
But some conclusion can be anyway drawn examining only a part of the thousands of roman coins found in India, mostly recovered in South India. For instance those rediscovered in Kerala [1.4] :
56 coins issued under Augustus, as well as 42 issued under Tiberius, two under Caligula, 24 under Claudius, 29 under Nero, seven under Vespasian, two under Domitian, two under Nerva, 28 under Trajan, 96 under Hadrian, 183 under Antoninus Pius and four under Marcus Aurelius.

Coins number	emitted under Emperor	Reign	Years	Coins per Reign years
56	August	23 BC-14AC	37	1,51
42	Tiberius	14-37	23	1,83
2	Caligula	37-41	4	0,50
24	Claudius	41-54	10	2,40
29	Nero	54-68	14	2,07
7	Vespasianus	69-79	10	0,70
2	Domitianus	81-96	15	0,13
2	Nerva	96-98	2	1,00
28	Trajan	98-117	19	1,47
96	Hadrian	117-138	21	4,57
183	Antoninus Pius	138-161	23	7,96
4	Marcus Aurelius	161-180	19	0,21

Table 1.1 Roman coins found in Kerala

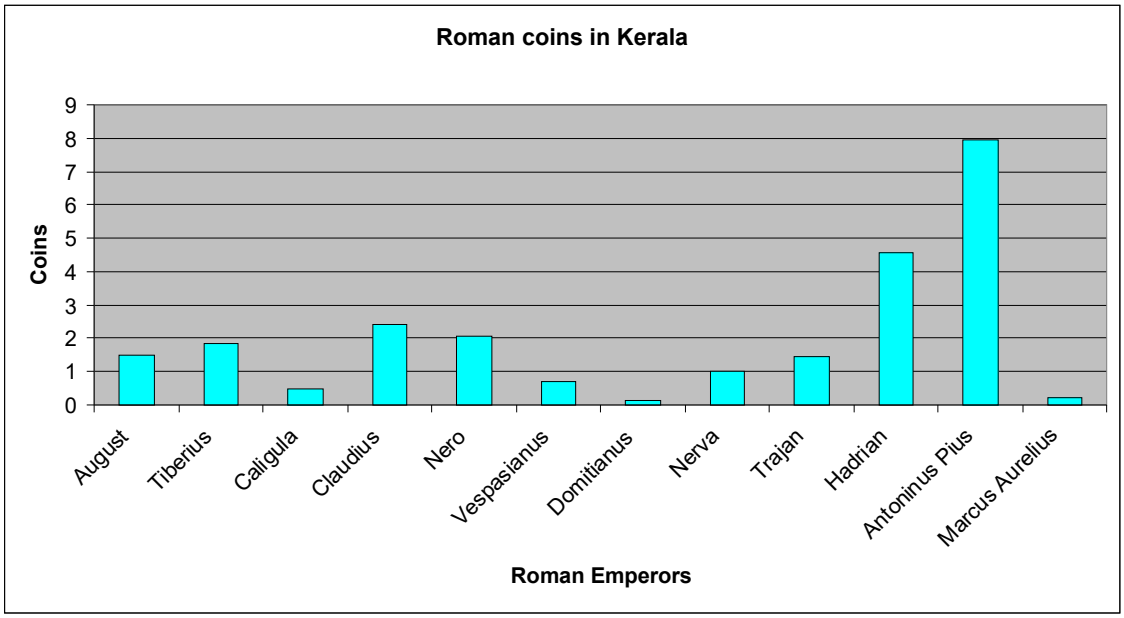


Fig. 1.1 Coins as trade chronology

1.4) From Relations économiques entre l'Inde et l'Empire romain, aux Ier et IIe siècles de notre ère. Historiographie d'un commerce marittime. Pièces Romaines au Kerala.
Auteur : Vandewalle, Chloé

This limited sample already shows that Roman trade was important from the conquest of Egypt for about one hundred years, then much more during the second century AC, as seen in the above graph.
The graphic could be interpreted like a rough measure of Roman trade during those years, but:

- Parts of the found coins are silver made denarii, part aurei; in the Roman Empire one aureus was equal to 25 denarii. This value ratio of gold to silver was not necessarily equivalent in different regions of India but undoubtedly gold was of significantly higher value. [1.5]
- Number of found coins depends not only by their diffusion in India at the time but also by chance in their discovery.
- It depends also by coinage during each Emperor Reign, that in this example is not considered, but which anyway cannot be relevant when the corresponding reign is short, like for Caligula and Nerva.
- Coins can change hands many times before being spent abroad where they are then hoarded, so the relationships between emission and final hoarding.
- Lastly it has to be reminded that not necessarily a coin spent in India during a particular reign has been emitted in the corresponding period, but it could have been coined previously. For instance during the short reign of Caligula is very probable that coins spent in India were emitted by Tiberius; this represents a sort of carry-over effect between monetary issuance and moment of effective spending.

Furthermore, the discovery of Republican coins in Kerala and other regions of India, such as Tamil Nadu and Madhya Pradesh, could support the hypothesis of trade with Roman merchants yet at the end of the Republic, before the annexation of Egypt by Augustus. This theory is also consistent with ceramic data in India, particularly with studies of the Arikamedu and Alagankulam amphorae, but it should also be considered that a number of roman coins emitted during the Republic where still in circulation during the Augustus reign, or could have been spent in India by Greek or Egyptian intermediaries.
In any case it is improbable that some Roman ship had crossed the Ocean before, when Egypt still was independent and dominated the Red Sea.

1.5) The Chronology of Roman Trade with India in the Principate, Cobb, Matthew (2015), pg 35

2 The sources

Strabo

Strabo (born in Amaseia, Pontus on 64 or 63 BC – .dead between 21 and 24 AD) was a Greek geographer, philosopher and historian who lived in Asia Minor during the transitional period of the Roman Republic into the Roman Empire.
It is not known precisely when Strabo's Geography was written, though comments within the work itself place the finished version within the reign of Emperor Tiberius (14 – 37 A.C.).
The "Geography" is the only extant work providing information about both Greek and Roman peoples and countries during the reign of Augustus, which presented a descriptive history of people and places from different regions of the world known during his lifetime.
Geography is the only extant work covering the whole range of peoples and countries known to both Greeks and Romans during that period. Its numerous quotations from technical literature, moreover, provide a remarkable account of the state of Greek geographical science, as well as of the history of the countries it surveys.

In 25 or 24 A.C., together with Aelius Gallus, prefect of Egypt, who had been sent on a military mission to Arabia, he sailed up the Nile as far as Philae. He died after having devoted his last years to compiling his second important work, Geography.
Judging by the date when he wrote his personal notes, he must have worked on the book after his stay in Egypt and then have put it aside until 14 CE, when he started the final edition, which he brought to an end about 21 CE.

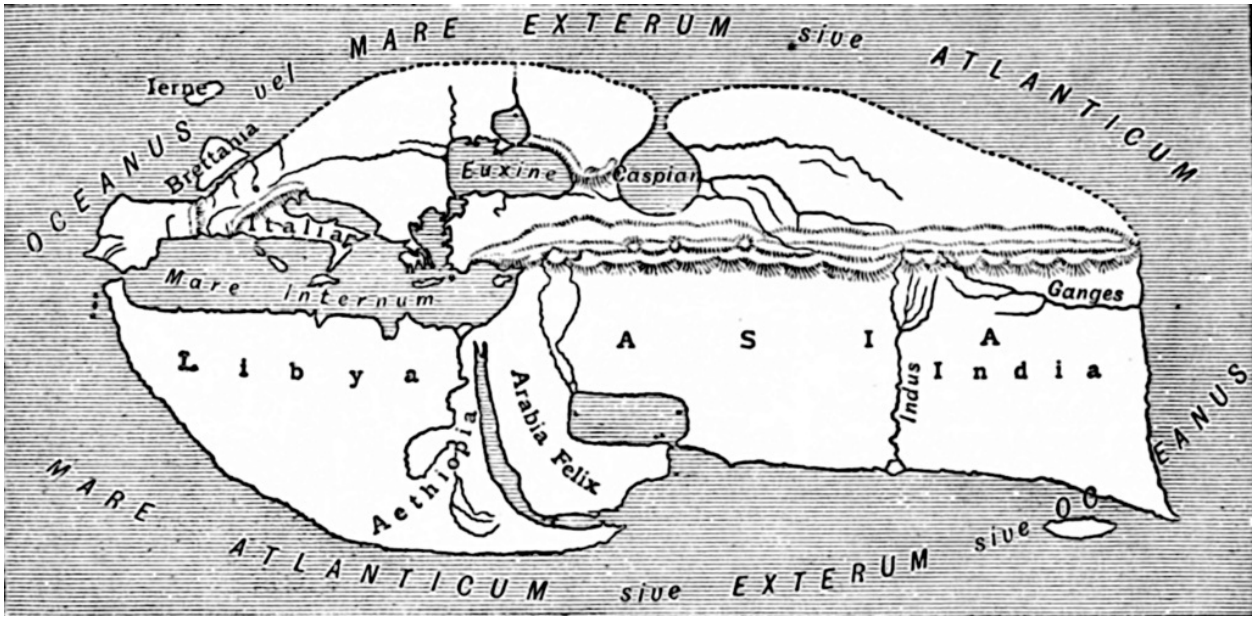


Fig. 2.1 Strabo's world map

The first two books, in effect, provide a definition of the aims and methods of geography by criticizing earlier works and authors. He praised Poseidonius, the Greek historian and philosopher who lived from about 135 to 51 BCE, for his knowledge of physical geography and ethnography, but he rejected Poseidonius's theory of climatic zones and particularly his hypothesis that the equatorial zone was habitable. He decided in favour of a descriptive type of geography, based on a map with an orthogonal (perpendicular) projection. The problem of projecting the sphere on a flat

surface is not dealt with at any length, for his work, as he said, was designed not for mathematicians but for statesmen who must know countries, natural resources, and customs.
In Books III to XIV Strabo successively described Iberia, Gaul, Italy, Danube basin and the European coasts of the Black Sea, Greece, Asian shores of the Black Sea, the Caucasus, northern Iran, and Asia Minor.
India and Persia (Book XV) were described according to information given by the historians of the campaigns of Alexander the Great (356 to 323 BCE), whereas his descriptions of Mesopotamia, Syria, Palestine, and the Red Sea (Book XVI) were based on the accounts of the expeditions sent out by Mark Antony (about 83 to 30 BCE) and by the emperor Augustus, as well as on chapters on ethnography in Poseidonius and on the book of a Red Sea voyage taken by the Greek historian and geographer Agatharchides (2nd century BCE). Strabo's own memories of Egypt, supplemented by the writings of Poseidonius and Artemidorus, provided material for the substance of Book XVII, which dealt with the African shores of the Mediterranean Sea and with Mauretania.
His material mostly dates from the time of the sources he used, as personal travel notes formed only a small part of the material put in his work. In fact, Strabo based his work almost exclusively on information collected by others, as he himself clarifies [2.1] in Geography:
"*And men who are eager to learn proceed in just that way: they trust as organs of sense those who have seen or wandered over any region, no matter what, some in this and some in that part of the Earth, and they form in one diagram their mental image of the whole inhabited world.*"
It therefore seems that he proceeded a bit haphazardly, regardless of the different eras of the sources used, paying more attention to the quantity than to the quality of the collected information, without any verification; perhaps by comparing conflicting information from different sources he will have mediated or made choices, but apparently only on the basis of his own opinion on the matter. In this way he highlighted himself more as an erudite encyclopaedist than as a true geographer.
The value of firsthand observations, chosen from the sources with care, compensates perhaps for his lack of originality and contemporaneousness.
His information on India are very scarce, and about the subject of this work the most valuable is the following [2.2] :
"*Again, since the Romans have recently invaded Arabia Felix with an Army, of which Aelius Gallus, my friend and companion, was the commander, and since the merchants of Alexandria are already sailing with fleets by way of the Nile and of Arabian Gulf as far as India, these regions also have become far better known to us today than to our predecessors.*
At any rate, when Gallus was prefect of Egypt, I accompanied him and ascended the Nile as far as Syene and frontiers of Ethiopia, and I learned that as many as one hundred and twenty vessels were sailing from Myos Hormos to India, whereas formerly, under the Ptolemies, only a very few ventured to undertake the voyage and to carry on traffic in Indian merchandise."
Another passage [2.3] that could be of some interest is the following:
"*Very few of the merchants who now sail from Egypt by the Nile and the Arabian Gulf to India have proceeded as far as the Ganges; and, being ignorant persons, were not qualified to give an account of places they have visited. From one place in India, and from one king, namely,* ***Pandion****, or, according to others,* ***Porus****, presents and embassies were sent to Augustus Caesar*".

2.1) Strabo, Geography II.5 11-12, books 1-17 in 8 volumes (Loeb Classical Library) : Horace Leonard Jones : Free Download, Borrow, and Streaming, Internet Archive
2.2) Perseus, The Geography of Strabo. George Bell & Sons. 1903., II.5.12.
2.3) Same source as above, XV.1.4

Book XV describes the regions of the Oikumene, which were not known to Strabo because he never made a visit there, but composed on the basis of preceding indirect reports.

He therefore describes them entirely on the basis of written sources of different periods and information taken from hearsay. For instance he cites an Artemidorus' information about the visit in Rome by ambassadors coming from India with gifts and a message of friendship by Porus king (a rendering of the Indian *Puru*, the throne name of the ruler of the kingdom *Paurava* in Pujab*)*.[2.4] This diplomatic initiative was most likely the consequence of the sudden huge trade initiated by Roman merchants.
In this part of the work, the merely erudite character of Geographika is even more evident than in other books.

Final observations

Summarizing the little information offered by Strabo, they are the following:

- one hundred and twenty vessels were sailing from Myos Hormos to India (any year);
- intense commerce with India started with the Augustus's conquest of Egypt (30 B.C.);
- most part of roman vessels stop before reaching the Ganges (but someone apparently entered the Bengala Gulf, also if there is not any report on this fact) ;
- An Indian king sent presents and emissaries to Augustus in Rome, starting a diplomatic relation.

These few notes prove the intensity of the Roma-India trade from the last part of the first century B.C. and the huge number of ships engaged in this oceanic commerce, as it were a Gold Rush based on spices. At that time the majority of ports of call touched by roman ships where in West India. Strabo also tells us about diplomatic missions to Rome, with Ambassadors from Indian kingdoms frequenting Augustus' court, which were a "thing never seen before" even confirmed by Aug. Res Gestae: 31:
Ad me ex India regum legationes saepe missae sunt non visae ante id tempus apud quemquam Romanorum ducem. Nostram amicitiam appetiverunt per legatos Bastarnae Scythaeque et Sarmatarum qui sunt citra flumen Tanaim et ultra reges, Albanorumque rex et Hiberorum et Medorum.

Strabo cited two kings:

- Pandyan king. This is somewhat strange, as Pandyan kingdom included the territory beyond Komar but not the Kerala governed by the Chera: if the roman trade expeditions stopped in Kerala why Pandion should have sent embassies to Rome ? Perhaps not all is known about official relations of Rome with Indian kingdoms (there have been also Chera embassies ?), or the Pandyans were in some way directly involved in that commerce and the ports used by those ships were not located in Kerala.
- Porus king. Puru was the name of the ruler of the kingdom *Paurava* in Pujab. If at that time the Indus estuary coast was under the domination of this king, the diplomatic initiative could be explained by the new Roman important trade with the port of Barbaricon.

2.4) Strabo, Geography, 15.1.73

Pliny Naturalis Historia

Gaius Plinius Secundus (AD 23/24 – 79), called Pliny the Elder, was a Roman author, naturalist and natural philosopher, and naval and army commander of the roman fleet based at Miseno cape. He wrote the encyclopaedic Naturalis Historia (Natural History), whose sixth book regards the Asian geography and contains some useful information about the voyage from Egypt till Muziris. Hereafter they follow (VI, 102-106):

At the present day voyages are made to India every year: and companies of archers are carried on board the vessels, as those seas are greatly infested with pirates.

It will not be amiss too, on the present occasion, to set forth the whole of the route from Egypt, which has been stated to us of late, upon information on which reliance may be placed, and is here published for the first time. The subject is one well worthy of our notice, seeing that in no year does India drain our empire of less than five hundred and fifty millions of sesterces, giving back her own wares in exchange, which are sold among us at fully one hundred times their prime cost.

Naturalis Historia excerpts:

VI/102

MM p. ab Alexandria abest oppidum Iuliopolis; inde navigant Nilo Coptum CCCVIIII p., qui cursus etesiis flantibus peragitur XII diebus. a Copto camelis itur, aquationum ratione mansionibus dispositis: prima appellatur Hydreuma XXXII, secunda in monte diei itinere, tertia in altero Hydreumate a Copto LXXXV, deinde in monte; mox ad Hydreuma Apollinis a Copto CLXXXIIII, rursus in monte; mox ad Novum Hydreuma a Copto CCXXXVI

Two miles distant from Alexandria is the town of Juliopolis. The distance thence to Coptos, up the Nile, is three hundred and nine miles; the voyage is performed, when the Etesian winds are blowing, in twelve days. From Coptos the journey is made with the aid of camels, stations being arranged at intervals for the supply of fresh water. The first of these stations, called Hydreuma, is distant thirty-two miles; the second is situate on a mountain, at a distance of one day's journey from the last; the third is at a second Hydreuma, distant from Coptos eighty-five miles; the fourth is on a mountain; the next to that is at another Hydreuma, that of Apollo, and is distant from Coptos one hundred and eighty-four miles; after which, there is another on a mountain. There is then another station at a place called the New Hydreuma, distant from Coptos two hundred and thirty-six miles.

VI/103

est et aliud Hydreuma Vetus — Trogodyticum nominatur —, ubi praesidium excubat deverticulo duum milium; distat a Novo Hydreumate VII. **Inde Berenice oppidum, ubi portus Rubri maris, a Copto CCLVII p. sed quia maior pars itineris conficitur noctibus propter aestus et stativis dies absumuntur, totum a Copto Berenicem iter duodecimo die peragitur.**

[Then there is the city of Berenice where the port of the Red Sea is located, 257 miles away from Coptos. But since it is hot most of the journey is done at night, and the days are spent standing still, the whole journey from Coptos to Berenice ends on the twelfth day.]

VI/104

navigare incipiunt aestate media ante canis [2.5] ortum aut ab exortu protinus veniuntque tricesimo circiter die Ocelim Arabiae aut Canen turiferae regionis est et tertius portus qui vocatur Muza, quem Indica navigatio non petit nec nisi turis odorumque Arabicorum mercatores. Intus oppidum, regia eius, appellatur Sapphar, aliudque Save. Indos vento hippalo navigant diebus XL ad primum emporium Indiae Muzirim. non expetendum propter vicinos piratas, qui optinent locum nomine Nitrias, neque est abundans mercibus; praeterea longe a terra abest navium statio, lintribusque adferuntur onera et egeruntur. Regnabat ibi, cum proderem haec, Caelobothras.

[They start sailing in midsummer before the rise of Sirius or certainly at its rise and reach Ocelis around the thirtieth day .... (Ocelis is 912 nautical miles from Berenice) or to Cane which is in a region rich in incense or to a third port which is called Muza, which is not used to sail to India except by Arab incense merchants. Inside the city, capital of the place and seat of the king, called Sapphar, and the other Save. They sail for 40 days with the Hippalo wind to India's first merchant port Muziris, undesirable due to the nearby pirates who live in a place called Nitrias [2.6], nor that it is abundant in goods; moreover the anchorage of the ships is distant from the land, and boats deliver and take away the loads. Here reigned, when I wrote about him, Caelobothras.]

VI/105

Alius utilior portus gentis Neacyndon, qui vocatur Becare. Ibi regnabat Pandion, longe ab emporio in mediterraneo distante oppido quod vocatur Modura. Regio autem, ex qua piper monoxylis lintribus Becaren convehunt, vocatur Cottonara.

[Another better port is that of the Neacyndon people, which is called Becare. Pandion reigned here, in a city far from the maritime emporium, which is called Modura. The region also, from which pepper arrives in Becare in boats made of a single piece of wood, is called Cottonara.]

2.5) The Dog Major is the constellation of the very bright Sirius, a small southern constellation very close to the galactic plane and skimming the Milky Way in its north-eastern corner. It is visible from all temperate regions of the Earth and, despite its extension (380 ° squared), it is full of bright stars, first of all the beautiful Sirius. The star Sirius was essential for many ancient peoples, especially for the Egyptians even before 2000 BC, as it allowed them to elaborate calendars, since its heliacal rising (i.e. its first appearance in the morning just before the Sun) almost coincided with the summer solstice and indicated the next flood of the Nile.

Berenike 23 ° 56'18.36 "N 35 ° 29'37.38" E, in 70 AD, on July 2 in Berenike the Sun and Sirius rose together, on June 17 at dawn Sirius is still below the horizon of 15 degrees, on July 17 Sirius is 13 degree above the horizon. Until the 2nd of July the constellation of Dog and Sirius arise after the Sun, so they are not visible in the illuminated sky. After July 2 Sirius rises before the Sun and consequently is visible for a short time before the aurora hides its light. Leaving "before the dog is raised" therefore means starting the journey before 2 July, or at the latest on that date. The next period, called canicula, was the hottest of the year.

2.6) According to Ptolemy there was a Nitra near Tyndis. Both the references were probably to the River Netravathi.

VI/106

ex India renavigant mense Aegyptio Tybi incipiente, nostro Decembri, aut utique Mechiris Aegyptii intra diem sextum, quod fit intra idus Ianuarias nostras: ita evenit ut eodem anno remeent. Navigant autem ex India vento volturno et, cum intravere Rubrum mare, Africo vel austro.

They return from India at the beginning of the Egyptian month of Tybi, our December, or in any case by the sixth day of the Egyptian month of Mechiri, which falls within our ides of January: so it happens that they return within a year. They then sail away from India with the Volturno wind and, as they enter the Red Sea, with the Africo or the Austro.

Final observations

Summarizing the information offered by Pliny they are the following:

- Merchandise is transported on the Nile from Juliopolis to Coptos in twelve days.
- From Coptos they cross the desert between the mountains in twelve days, travelling mainly by night, to arrive at the port of Berenice on the Red Sea.
- They embark and set sail by the end of June to reach Ocelis, located at the mouth of the Red Sea in the Arabian Sea (Bab El Mandeb Strait), arriving at their destination in about 30 days.
- They then sail for 40 days, driven by the monsoon wind, finally reaching the major Indian port called Muziris, dangerous because it is threatened by pirates and poor in goods.
- In total, the trip from Juliopolis to Muziris lasted at least 94 days
- The anchorage at Muziris is far from the coast and loads must be transferred to boats.
- Muziris was at the time part of the kingdom of Celobotra.
- Another good port is that of the Neacindi, called Becare, belonging to the kingdom of the Pandions, who rule from a distant city called Modura.
- The region from which the pepper reaches Becare is called Cottonara.
- They begin their return in December and in any case by mid-January, returning within a year.
- Ships also carry armed soldiers (archers) for defence.
- This information according to Pliny is worthy of trust.
- This trade costs the Roman Empire at least five hundred and fifty million sestertii every year, and imported goods are then sold for a hundred times their cost.

Among the preceding information the more debatable is perhaps his evaluation of 40 days of navigation to reach Muziris from Ocelis. However let’s recall that he was the commander in chief of the Roman Fleet stationed at Miseno Cape, and consequently he had all the means to collect reliable information both from military and merchant captains.
Was he referring to a much longer route, coasting the shores of Arabia, Iran, Pakistan and India, along the entire arch of the Arabic Sea, without a direct crossing of the Ocean ?
Most probably not, because roman direct merchant traffic with India started in 30 B.C. with the conquest of Augustus, and anyway took advantage of the experience of Egyptian and Greek sailors that yet used the direct crossing route. Pliny wrote the Naturalis Historia in 73 A.C., after about one century, hence the roman merchant vessels already had had every possibility of adopting the direct crossing as a normal and safe route.

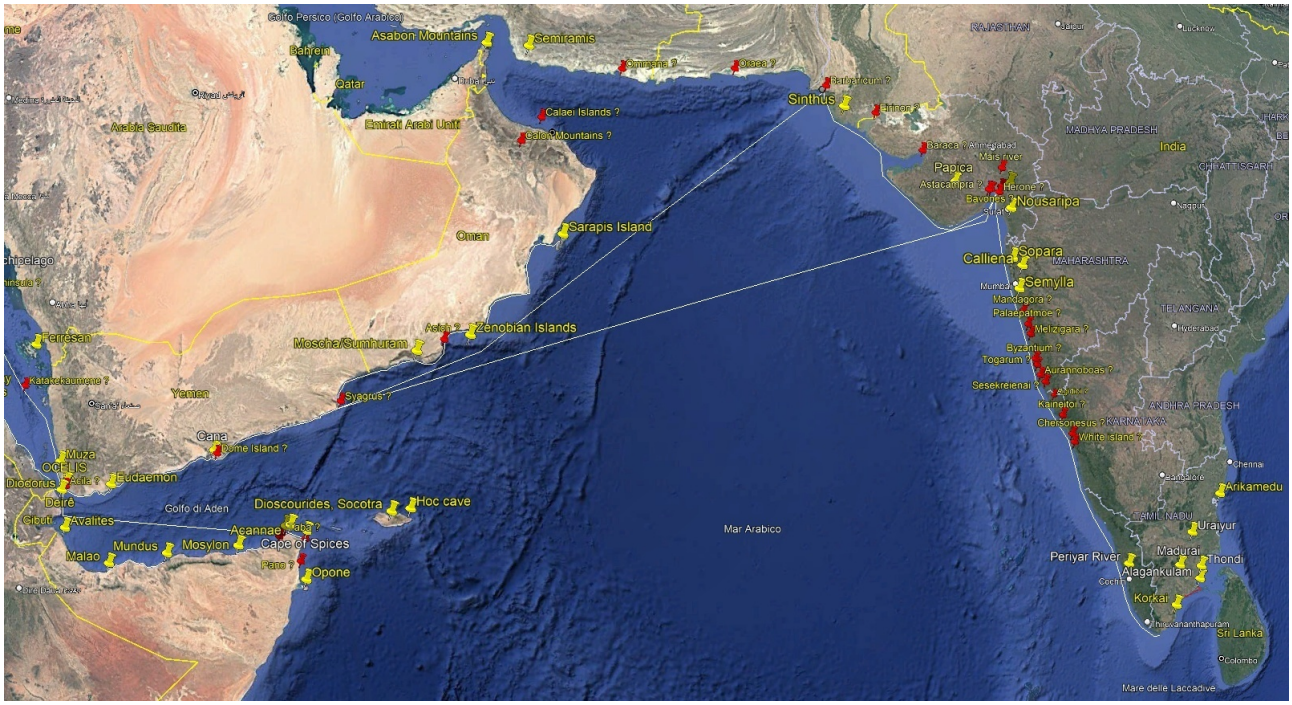


Fig. 2.2 Arabic Sea

Also the Periplus Maris Erythraei, probably written in the same epoch, affirms:
"**men formerly used to sail over in smaller vessels, following the curves of the bays..……. the winds we call "etesian" blow seasonally from the direction of the ocean, and so a south-westerly makes its appearance in the Indian Sea……. whoever are bound for Limyrike hold out with the wind on the quarter [2.7] for most of the way…….. away from the shore on the high seas, over the ocean off the land**"

On the other side is noteworthy what states the Periplus: "Muziris, in the same kingdom, owes its prosperity to the shipping from Ariake that comes there as well as to Greek shipping". This means that existed also a merchant trade coming from Arabia along the northern coast of the Arabic Sea, which first reached Barygaza and then followed the Indian shores till Muziris in the South. Obviously this longer route could explain the 40 days voyage duration.

Therefore the fact that merchant vessels crossed the ocean, heading directly Southern India is confirmed by this source, but at the same time the same source offers another possible explication, thus making the aforementioned forty days voyage duration deserving a more in-depth analysis.

2.7) Sailing with the wind on the quarter: The wind comes from abaft with an angle of about 45°.

Periplus Maris Erythraei

The Periplus Maris Erythraei ("Navigation of the Erythrean [i.e., Red] Sea"), an anonymous Greek travel book written in the 1st century CE, lists a series of ports along the Indian coast, including Muziris.

The Periplus of the Eritrean Sea, attributed with reserve by the only manuscript to Arrian of Nicomedia, is part of one of the collections constituting the tradition of minor Greek geographers – in this case the Heidelberg manuscript – which some consider to come from Arrien's personal library. This text, heavily corrupted and corrected, constitutes to this day a unicum both within ancient geography and within periplography.
He is indeed the only one to give a list of emporia rather than moorings or important points along the coast, and to indicate in detail the periods and favourable winds, sometimes the speed of navigation, and the detail of the products likely to be imported and exported from these places.
The Periplus lists the major exports of India as pepper, precious stones, pearls, tortoise shells, ivory, such aromatic plants as spikenard (Nardostachys jatamansi) and malabathrum (Cinnamomum malabathrum), and silk and other textiles. For these the Romans traded glass, copper, tin, lead, realgar (a red pigment), orpiment (a gold pigment), antimony, and wine, or else they paid in gold coins.

Periplus passages on the western India coast's ports of call , English translation of Wilfred H. Schoff from https://depts.washington.edu/silkroad/texts/periplus/periplus.html

1. Of the designated ports on the Erythraean Sea, and the market-towns around it, the first is the Egyptian port of Mussel Harbor [=Myos Hormos]. To those sailing down from that place, on the right hand, after eighteen hundred stadia, there is Berenice. The harbours of both are at the boundary of Egypt, and are bays opening from the Erythraean Sea.

2. On the right-hand coast next below Berenice is the country of the Berbers [or Barbaroi, "foreigners": traditionally designating any non-Greek speaker]. Along the shore are the Fish-Eaters, living in scattered caves in the narrow valleys. Further inland are the Berbers, and beyond them the Wild-flesh-Eaters and Calf-Eaters [Casson: "shoot-eaters", from Greek mosxophagoi: translatable as either "calf" or "shoot, twig"], each tribe governed by its chief; and behind them, further inland, in the country toward the west, there lies a city called Meroe.

3. Below the Calf-Eaters there is a little market-town on the shore after sailing about four thousand stadia from Berenice, called Ptolemais of the Hunts, from which the hunters started for the interior under the dynasty of the Ptolemies. This market-town has the true land-tortoise in small quantity; it is white and smaller in the shells. And here also is found a little ivory, like that of Adulis. But the place has no harbour and is reached only by small boats.

4. Below Ptolemais of the Hunts, at a distance of about three thousand stadia, there is Adulis, a port established by law, lying at the inner end of a bay that runs in toward the south. Before the harbour lies the so-called Mountain Island, about two hundred stadia sea-ward from the very head of the bay, with the shores of the mainland close to it on both sides. Ships bound for this port now anchor here because of attacks from the land. They used formerly to anchor at the very head of the bay, by an island called Diodorus, close to the shore, which could be reached on foot from the land; by which means the barbarous natives attacked the island.

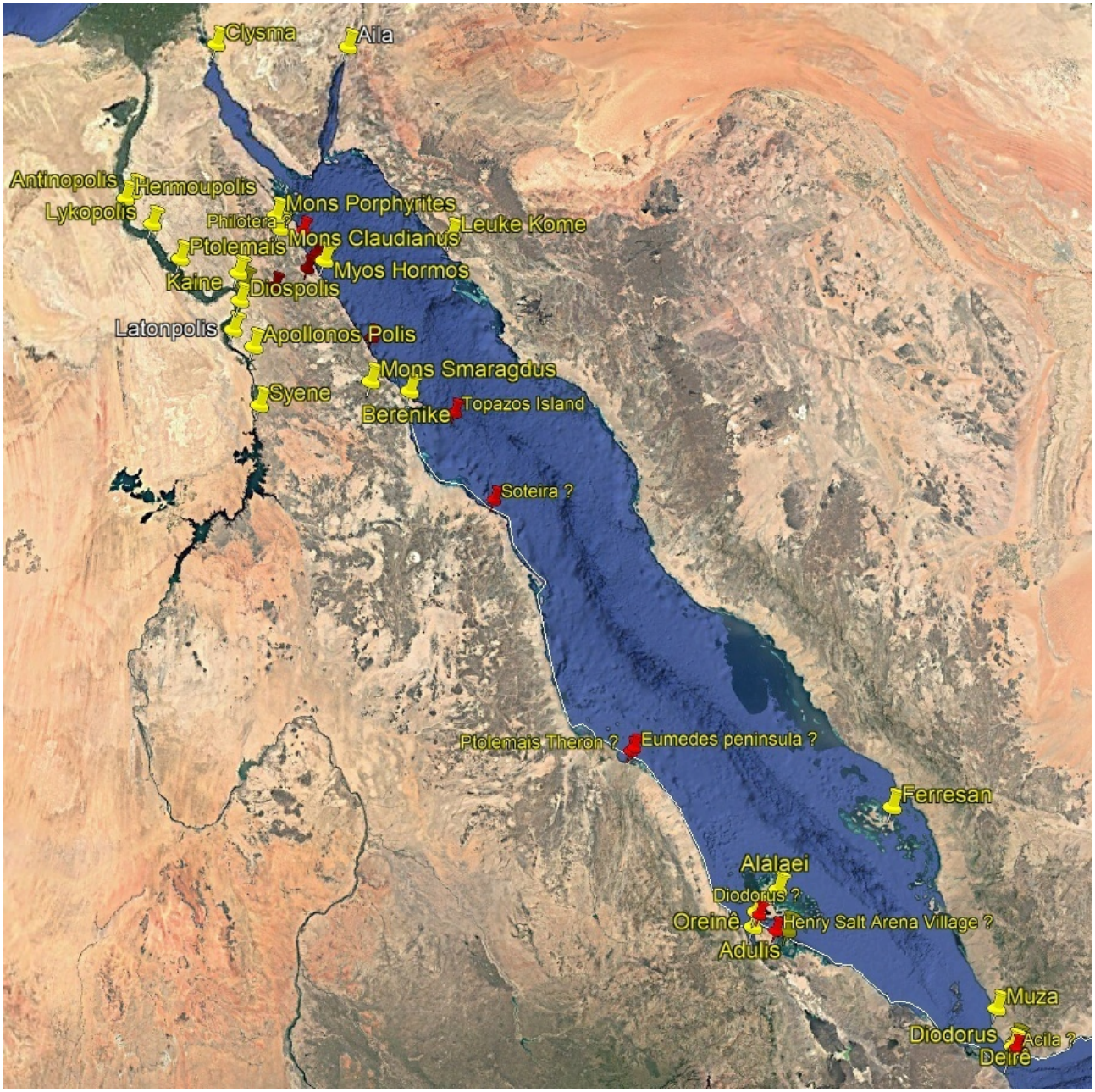


Fig. 2.3 The Red Sea

Opposite Mountain Island, on the mainland twenty stadia from shore, lies Adulis, a fair-sized village, from which there is a three-day journey to Coloe, an inland town and the first market for ivory. From that place to the city of the people called Auxumites there is a five days' journey more; to that place all the ivory is brought from the country beyond the Nile through the district called Cyeneum, and thence to Adulis. Practically the whole number of elephants and rhinoceros that are killed live in the places inland, although at rare intervals they are hunted on the seacoast even near Adulis. Before the harbour of that market-town, out at sea on the right hand, there lie a great many little sandy islands called Alalaei, yielding tortoise-shell, which is brought to market there by the Fish-Eaters.

5. And about eight hundred stadia beyond there is another very deep bay, with a great mound of sand piled up at the right of the entrance; at the bottom of which the opsian stone is found, and this is the only place where it is produced. These places, from the Calf-Eaters to the other Berber country, are governed by Zoscales, who is miserly in his ways and always striving for more, but otherwise upright, and acquainted [Casson: “well versed”; Greek: empeiros] with Greek literature.

6. There are imported into these places, undressed cloth made in Egypt for the Berbers; robes from Arsinoe; cloaks of poor quality dyed in colours; double-fringed linen mantles; many articles of flint glass, and others of murrhine, made in Diospolis; and brass, which is used for ornament and in cut pieces instead of coin; sheets of soft copper, used for cooking-utensils and cut up for bracelets and anklets for the women; iron, which is made into spears used against the elephants and other wild beasts, and in their wars. Besides these, small axes are imported, and adzes and swords; copper drinking-cups, round and large; a little coin for those conning to the market; wine of Laodicea and Italy, not much; olive oil, not much; for the king, gold and silver plate made after the fashion of the country, and for clothing, military cloaks, and thin coats of skin, of no great value. Likewise from the district of Ariaca across this sea, there are imported Indian iron, and steel, and Indian cotton cloth; the broad cloth called monache and that called sagimtogene, and girdles, and coats of skin and mallow-coloured cloth, and a few muslins, and coloured lac. There are exported from these places ivory, and tortoise-shell and rhinoceros-horn. The most from Egypt is brought to this market from the month of January, to September, that is, from Tybi to Thoth; but seasonably they put to sea about the month of September.

7. From this place the Arabian Gulf trends toward the east and becomes narrowest just before the Gulf of Avalites. After about four thousand stadia, for those sailing eastward along the same coast, there are other Berber market-towns, known as the "far-side" ports; lying at intervals one after the other, without harbours but having roadsteads where ships can anchor and lie in good weather. The first is called Avalites; to this place the voyage from Arabia to the far-side coast is the shortest. Here there is a small market-town called Avalites, which must be reached by boats and rafts. There are imported into this place, flint glass, assorted; juice of sour grapes from Diospolis; dressed cloth, assorted, made for the Berbers; wheat, wine, and a little tin. There are exported from the same place, and sometimes by the Berbers themselves crossing on rafts to Ocelis and Muza on the opposite shore, spices, a little ivory, tortoise-shell, and a very little myrrh, but better than the rest. And the Berbers who live in the place are very unruly.

8 After Avalites there is another market-town, better than this, called Malao, distant a sail of about eight hundred stadia. The anchorage is an open road-stead, sheltered by a spit running out from the east. Here the natives are more peaceable. There are imported into this place the things already mentioned, and many tunics, cloaks from Arsinoe, dressed and dyed; drinking-cups, sheets of soft copper in small quantity, iron, and gold and silver coin, not much. There are exported from these places myrrh, a little frankincense (that known as “far-side”), the harder cinnamon, duaca, Indian copal and macir, which are imported into Arabia; and slaves, but rarely.

9. Two days' sail, or three, beyond Malao is the market-town of Mundus, where the ships lie at anchor more safely behind a projecting island close to the shore. There are imported into this place the things previously set forth, and from it likewise are exported the merchandise already stated, and the incense called mocrotu. And the traders living here are more quarrelsome [Greek sklêros: “tough”—i.e., shrewd traders].

Fig. 2.4 Bab El Mandeb and Gulf of Aden

10. Beyond Mundus, sailing toward the east, after another two days' sail, or three, you reach Mosyllum, on a beach, with a bad anchorage. There are imported here the same things already mentioned, also silver plate, a very little iron, and glass. There are shipped from the place a great quantity of cinnamon, (so that this market-town requires ships of larger size), and fragrant gums, spices, a little tortoise shell, and mocrotu, (poorer than that of Mundus), frankincense [from] the "far-side", ivory and myrrh in small quantities.

11. Sailing along the coast beyond Mosyllum, after a two days' course you come to the so-called Little Nile River, and a fine spring, and a small laurel-grove, and Cape Elephant. Then the shore recedes into a bay, and has a river, called Elephant, and a large laurel-grove called Acanna; where alone is produced the far-side frankincense, in great quantity and of the best grade.

12. Beyond this place, the coast trending toward the south, there is the Market and Cape of Spices, an abrupt promontory, at the very end of the Berber coast toward the east. The anchorage is dangerous at times from the ground-swell, because the place is exposed to the north. A sign of an approaching storm which is peculiar to the place, is that the deep water becomes more turbid and changes its colour. When this happens they all run to a large promontory called Taba, which offers safe shelter. There are imported into this market-town the things already mentioned; and there are produced in it cinnamon, (and its different varieties, gizir, asypha, arebo, magla, and moto) and frankincense.

13. Beyond Taba, after four hundred stadia, there is the village of Pano. And then, after sailing four hundred stadia along a promontory, toward which place the current also draws you, there is another market-town called Opone, into which the same things are imported as those already mentioned, and in it the greatest quantity of cinnamon is produced, (the arebo and moto), and slaves of the better sort, which are brought to Egypt in increasing numbers; and a great quantity of tortoise-shell, better than that found elsewhere.

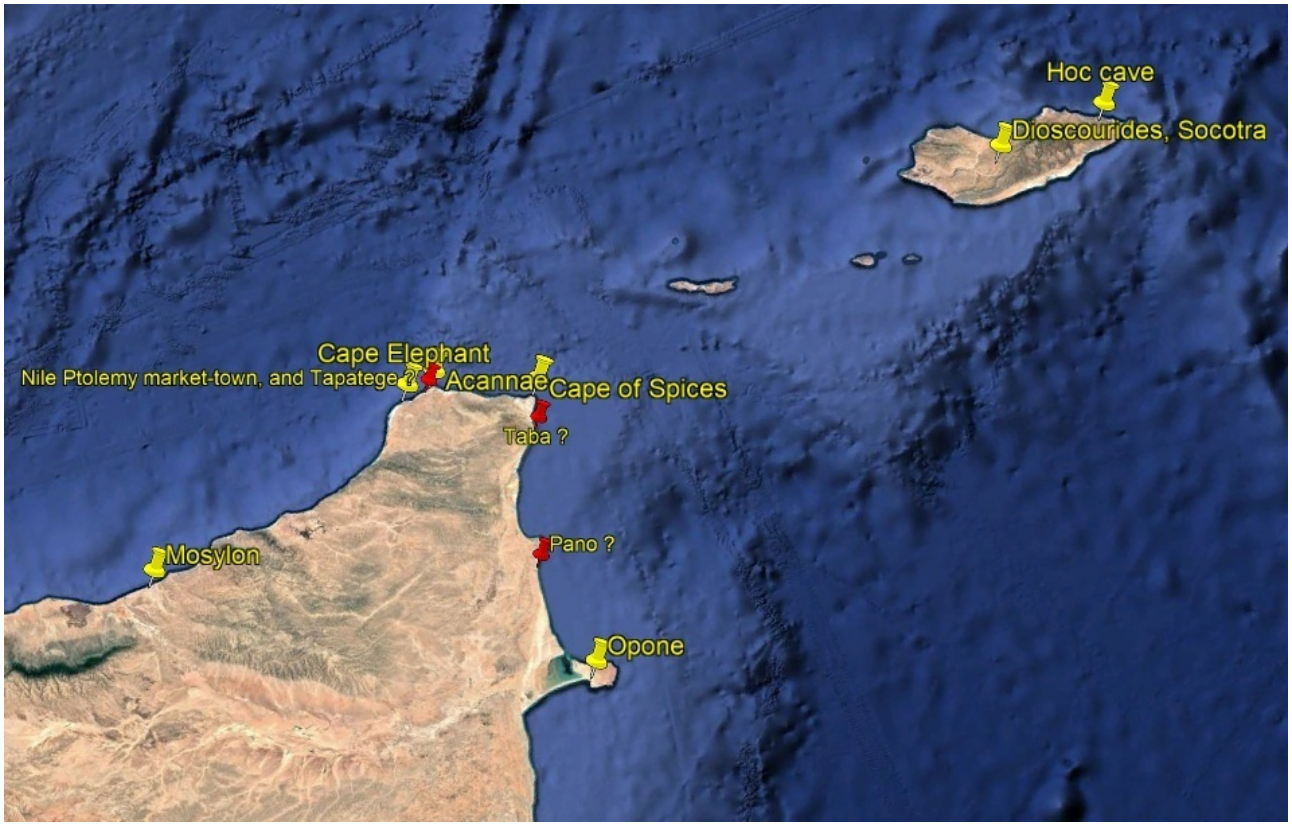


Fig. 2.5 Horn of Africa and Socotra

14. The voyage to all these far-side market-towns is made from Egypt about the month of July, that is Epiphi. And ships are also customarily fitted out from the places across this sea, from Ariaca and Barygaza, bringing to these far-side market-towns the products of their own places; wheat, rice, clarified butter, sesame oil, cotton cloth, (the monache and the sagmatogene), and girdles, and honey from the reed called sacchari. Some make the voyage especially to these market-towns, and others exchange their cargoes while sailing along the coast. This country is not subject to a King, but each market-town is ruled by its separate chief.

15. Beyond Opone, the shore trending more toward the south, first there are the small and great bluffs of Azania; this coast is destitute of harbours, but there are places where ships can lie at anchor, the shore being abrupt; and this course is of six days, the direction being south-west. Then come the small and great beach for another six days' course and after that in order, the Courses of Azania, the first being called Sarapion and the next Nicon; and after that several rivers and other anchorages, one after the other, separately a rest and a run for each day, seven in all, until the Pyralae islands and what is called the channel; beyond which, a little to the south of south-west, after two courses of a day and night along the Ausanitic coast, is the island Menuthias, about three hundred stadia from the main-land, low and wooded, in which there are rivers and many kinds of birds and the mountain-tortoise. There are no wild beasts except the crocodiles; but there they do not attack men. In this place there are sewed boats, and canoes hollowed from single logs, which they use for fishing and catching tortoise. In this island they also catch them in a peculiar way, in wicker baskets, which they fasten across the channel-opening between the breakers.

16. Two days' sail beyond, there lies the very last market-town of the continent of Azania, which is called Rhapta; which has its name from the sewed boats (rhapton ploiarion) already mentioned; in which there is ivory in great quantity, and tortoise-shell. Along this coast live men of piratical habits, very great in stature, and under separate chiefs for each place. The Mapharitic chief governs it under some ancient right that subjects it to the sovereignty of the state that is become first in Arabia. And the people of Muza now hold it under his authority, and send thither many large ships, using Arab captains and agents, who are familiar with the natives and intermarry with them, and who know the whole coast and understand the language.

17. There are imported into these markets the lances made at Muza especially for this trade, and hatchets and daggers and awls, and various kinds of glass; and at some places a little wine, and wheat, not for trade, but to serve for getting the good-will of the savages. There are exported from these places a great quantity of ivory, but inferior to that of Adulis, and rhinoceros-horn and tortoise-shell (which is in best demand after that from India), and a little palm-oil.

18. And these markets of Azania are the very last of the continent that stretches down on the right hand from Berenice; for beyond these places the unexplored ocean curves around toward the west, and running along by the regions to the south of Aethiopia and Libya and Africa, it mingles with the western sea. [2.8]

2.8) Old Herodotus also recounts the story of a 3-year expedition, sent by Egyptian Pharaoh Necho II, which circumnavigated Africa from Aden around to the Pillars of Hercules and back to Phoenicia. He then says, more or less, "but I know that's impossible — the story says that the sailors had the sun on their right hand side when sailing west, which can't be true" It's impossible in the northern hemisphere, all right — but absolutely correct in the southern one, which Herodotus never saw but the sailors did].

Fig. 2.6 East African coasts as for Periplus

19. Now to the left of Berenice, sailing for two or three days from Mussel Harbor eastward across the adjacent gulf, there is another harbor and fortified place, which is called White Village (Leuke Kome), from which there is a road to Petra, which is subject to Malichas, King of the Nabateans. It holds the position of a market-town for the small vessels sent there from Arabia; and so a centurion is stationed there as a collector of one-fourth of the merchandise imported, with an armed force, as a garrison.

20. Directly below this place is the adjoining country of Arabia, in its length bordering a great distance on the Erythraean Sea. Different tribes inhabit the country, differing in their speech, some partially, and some altogether. The land next the sea is similarly dotted here and there with caves of the Fish-Eaters, but the country inland is peopled by rascally men speaking two languages, who live in villages and nomadic camps, by whom those sailing off the middle course are plundered, and those surviving shipwrecks are taken for slaves. And so they too are continually taken prisoners by the chiefs and kings of Arabia; and they are called Carnaites. Navigation is dangerous along this whole coast of Arabia, which is without harbors, with bad anchorages, foul, inaccessible because of breakers and rocks, and terrible in every way. Therefore we hold our course down the middle of the gulf and pass on as fast as possible by the country of Arabia until we come to the Burnt Island; directly below which there are regions of peaceful people, nomadic, pasturers of cattle, sheep and camels.

21. Beyond these places, in a bay at the foot of the left side of this gulf, there is a place by the shore called Muza, a market-town established by law, distant altogether from Berenice for those sailing southward, about twelve thousand stadia. And the whole place is crowded with Arab ship-owners and seafaring men, and is busy with the affairs of commerce; for they carry on a trade with the far-side coast and with Barygaza, sending their own ships there.

22. Three days inland from this port there is a city called Saua, in the midst of the region called Mapharitis; and there is a vassal-chief named Cholaebus who lives in that city.

23. And after nine days more there is Saphar, the metropolis, in which lives Charibael, lawful king of two tribes, the Homerites and those living next to them, called the Sabaites; through continual embassies and gifts, he is a friend of the Emperors.

24. The market-town of Muza is without a harbor, but has a good roadstead and anchorage because of the sandy bottom thereabouts, where the anchors hold safely. The merchandise imported there consists of purple cloths, both fine and coarse; clothing in the Arabian style, with sleeves; plain, ordinary, embroidered, or interwoven with gold; saffron, sweet rush, muslins, cloaks, blankets (not many), some plain and others made in the local fashion; sashes of different colors, fragrant ointments in moderate quantity, wine and wheat, not much. For the country produces grain in moderate amount, and a great deal of wine. And to the King and the Chief are given horses and sumpter-mules, vessels of gold and polished silver, finely woven clothing and copper vessels. There are exported from the same place the things produced in the country: selected myrrh, and the Gebanite-Minaean stacte, alabaster and all the things already mentioned from Avalites and the far-side coast. The voyage to this place is made best about the month of September, that is Thoth; but there is nothing to prevent it even earlier.

25. After sailing beyond this place about three hundred stadia, the coast of Arabia and the Berber country about the Avalitic gulf now coming close together, there is a channel, not long in extent, which forces the sea together and shuts it into a narrow strait, the passage through which, sixty stadia in length, the island Diodorus divides. Therefore the course through it is beset with rushing currents and with strong winds blowing down from the adjacent ridge of mountains. Directly on this strait by the shore there is a village of Arabs, subject to the same chief, called Ocelis; which is not so much a market-town as it is an anchorage and watering-place and the first landing for those sailing into the gulf.

Fig. 2.7 Bab El Mandeb Strait

26. Beyond Ocelis, the sea widening again toward the east and soon giving a view of the open ocean, after about twelve hundred stadia there is Eudaemon Arabia, a village by the shore, also of the Kingdom of Charibael, and having convenient anchorages, and watering-places, sweeter and better than those at Ocelis; it lies at the entrance of a bay, and the land recedes from it. It was called Eudaemon [= “Prosperous”], because in the early days of the city when the voyage was not yet made from India to Egypt, and when they did not dare to sail from Egypt to the ports across this ocean, but all came together at this place, it received the cargoes from both countries, just as Alexandria now receives the things brought both from abroad and from Egypt. But not long before our own time Charibael destroyed the place.

27. After Eudaemon Arabia there is a continuous length of coast, and a bay extending two thousand stadia or more, along which there are Nomads and Fish-Eaters living in villages; just beyond the cape projecting from this bay there is another market-town by the shore, Cana [Kanê], of the Kingdom of Eleazus, the Frankincense Country; and facing it there are two desert islands, one called Island of Birds, the other Dome Island, one hundred and twenty stadia from Cana. Inland from this place lies the metropolis Sabbatha, in which the King lives. All the frankincense produced in the country is brought by camels to that place to be stored, and to Cana on rafts held up by inflated skins after the manner of the country, and in boats. And this place has a trade also with the far-side ports, with Barygaza and Scythia and Ommana and the neighboring coast of Persia.

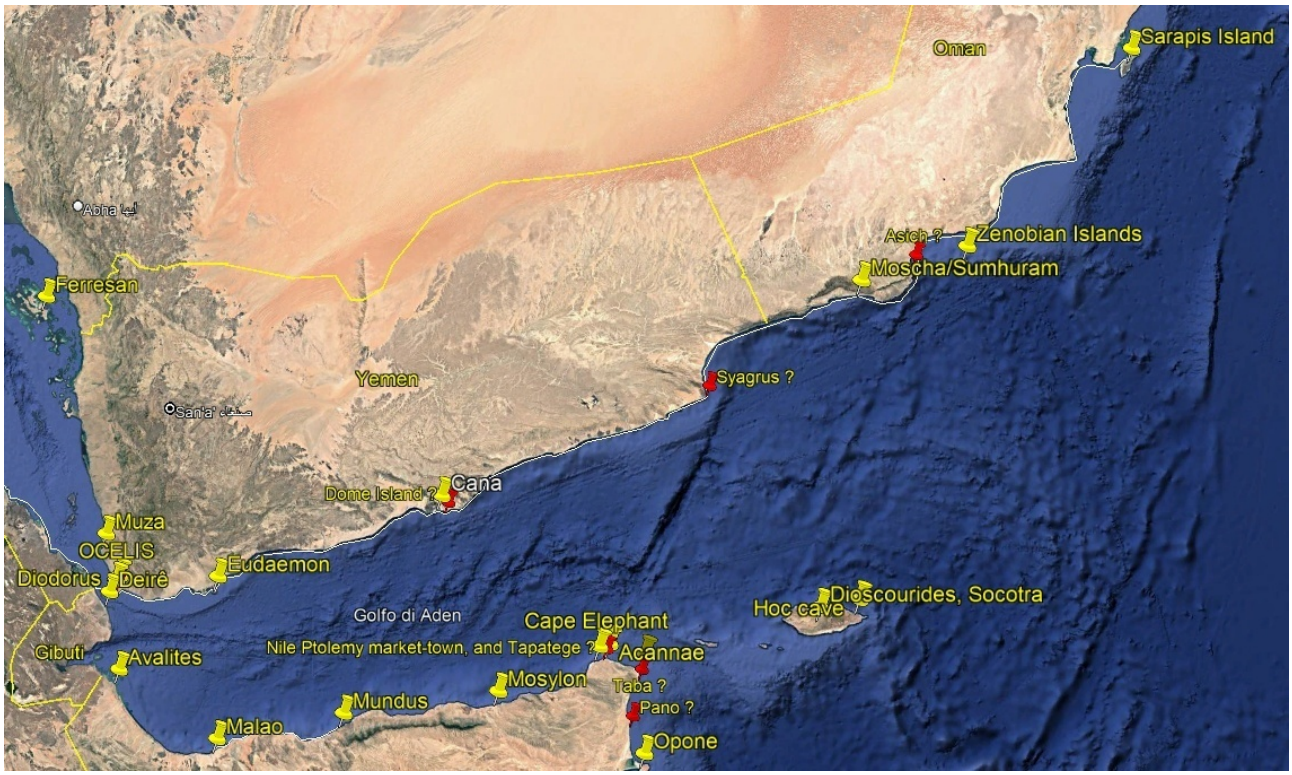


Fig. 2.8 Gulf of Aden

28. There are imported into this place from Egypt a little wheat and wine, as at Muza; clothing in the Arabian style, plain and common and most of it spurious; and copper and tin and coral and storax and other things such as go to Muza; and for the King usually wrought gold and silver plate, also horses, images [Greek andriantes: “male statuary”], and thin clothing of fine quality. And there are exported from this place, native produce, frankincense and aloes, and the rest of the things that enter into the trade of the other ports. The voyage to this place is best made at the same time as that to Muza, or rather earlier.

29. Beyond Cana, the land receding greatly, there follows a very deep bay stretching a great way across, which is called Sachalites; and the Frankincense Country, mountainous and forbidding, wrapped in thick clouds and fog, and yielding frankincense from the trees. These incense-bearing trees are not of great height or thickness; they bear the frankincense sticking in drops on the bark, just as the trees among us in Egypt weep their gum. The frankincense is gathered by the King's slaves and those who are sent to this service for punishment. For these places are very unhealthy, and pestilential even to those sailing along the coast, but almost always fatal to those working there, who also perish often from want of food.

30. On this bay there is a very great promontory facing the east, called Syagrus; on which is a fort for the defense of the country, and a harbor and storehouse for the frankincense that is collected; and opposite this cape, well out at sea, there is an island, lying between it and the Cape of Spices

opposite, but nearer Syagrus: it is called Dioscorida [=modern Socotra], and is very large but desert and marshy, having rivers in it and crocodiles and many snakes and great lizards, of which the flesh is eaten and the fat melted and used instead of olive oil. The island yields no fruit, neither vine nor grain. The inhabitants are few and they live on the coast toward the north, which from this side faces the continent. They are foreigners, a mixture of Arabs and Indians and Greeks, who have emigrated to carry on trade there. The island produces the true sea-tortoise, and the land-tortoise, and the white tortoise which is very numerous and preferred for its large shells; and the mountain-tortoise, which is largest of all and has the thickest shell; of which the worthless' specimens cannot be cut apart on the under-side, because they are even too hard; but those of value are cut apart and the shells made whole into caskets and small plates and cake-dishes and that sort of ware. There is also produced in this island cinnabar, that called Indian, which is collected in drops from the trees.

31. It happens that just as Azania is subject to Charibael and the Chief of Mapharitis, this island is subject to the King of the Frankincense Country. Trade is also carried on there by some people from Muza and by those who chance to call there on the voyage from Damirica [Casson: “Limyrikê”; i.e. Malabar Coast of south India] and Barygaza; they bring in rice and wheat and Indian cloth, and a few female slaves; and they take for their exchange cargoes, a great quantity of tortoise-shell. Now the island is farmed out under the Kings and is garrisoned.

32. Immediately beyond Syagrus the bay of Omana cuts deep into the coast-line, the width of it being six hundred stadia; and beyond this there are mountains, high and rocky and steep, inhabited by cave-dwellers for five hundred stadia more; and beyond this is a port established for receiving the Sachalitic frankincense; the harbor is called Moscha, and ships from Cana call there regularly; and ships returning from Damirica [=Limyrike] and Barygaza, if the season is late, winter there, and trade with the King's officers, exchanging their cloth and wheat and sesame oil for frankincense, which lies in heaps all over the Sachalitic country, open and unguarded, as if the place were under the protection of the gods; for neither openly nor by stealth can it be loaded on board ship without the King's permission; if a single grain were loaded without this, the ship could not clear from the harbor.

33. Beyond the harbor of Moscha for about fifteen hundred stadia as far as Asich, a mountain range runs along the shore; at the end of which, in a row, lie seven islands, called Zenobian. Beyond these there is a barbarous region which is no longer of the same Kingdom, but now belongs to Persia. Sailing along this coast well out at sea for two thousand stadia from the Zenobian Islands, there meets you an island called Sarapis, about one hundred and twenty stadia from the mainland. It is about two hundred stadia wide and six hundred long, inhabited by three settlements of Fish-Eaters, a villainous lot, who use the Arabian language and wear girdles of palm-leaves. The island produces considerable tortoise-shell of fine quality, and small sail-boats and cargo-ships are sent there regularly from Cana.

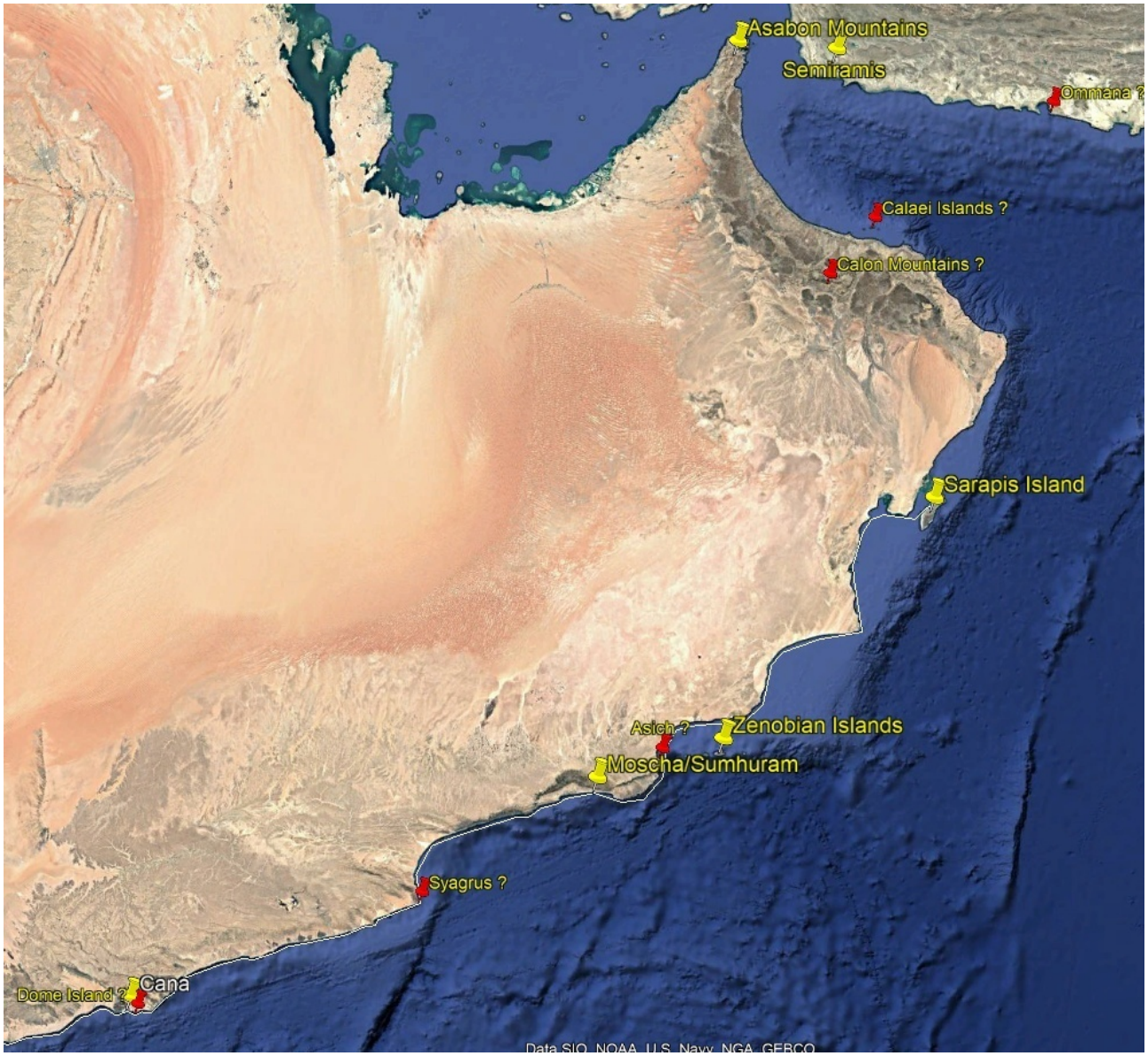


Fig. 2.9 Oman coasts

34. Sailing along the coast, which trends north-ward toward the entrance of the Persian Sea, there are many islands known as the Calaei, after about two thousand stadia, extending along the shore. The inhabitants are a treacherous lot, very little civilized.

35. At the upper end of these Calai islands is a range of mountains called Calon, and there follows not far beyond, the mouth of the Persian Gulf, where there is much diving for the pearl-mussel. To the left of the straits are great mountains called Asabon, and to the right there rises in full view another round and high mountain called Semiramis; between them the passage across the strait is about six hundred stadia; beyond which that very great and broad sea, the Persian Gulf, reaches far into the interior. At the upper end of this Gulf there is a market-town designated by law, called Apologus, situated near Charax Spasini and the River Euphrates.

36. Sailing through the mouth of the Gulf, after a six-days' course there is another market-town of Persia called Ommana. To both of these market-towns large vessels are regularly sent from Barygaza, loaded with copper and sandalwood and timbers of teakwood and logs of blackwood and ebony. To Ommana frankincense is also brought from Cana, and from Ommana to Arabia boats sewed together after the fashion of the place; these are known as madarata. From each of these market-towns, there are exported to Barygaza and also to Arabia, many pearls, but inferior to those

of India; purple, clothing after the fashion of the place, wine, a great quantity of dates, gold and slaves.

37. Beyond the Ommanitic region there is a country also of the Parsidae, of another Kingdom, and the bay of Gedrosia [Casson: “Gulf of Terabdoi”], from the middle of which a cape juts out into the bay. Here there is a river affording an entrance for ships, with a little market-town at the mouth, called Oraea and back from the place an in-land city, distant a seven days' journey from the sea, in which also is the King's court; it is called ... (probably Rhambacia) [Casson notes the name was inadvertently admitted in the manuscript]. This country yields much wheat, wine, rice and dates; but along the coast there is nothing but bdellium.

38. Beyond this region, the continent making a wide curve from the east across the depths of the bays, there follows the coast district of Scythia, which lies above toward the north; the whole marshy; from which flows down the river Sinthus [=Indus River], the greatest of all the rivers that flow into the Erythraean Sea, bringing down an enormous volume of water; so that a long way out at sea, before reaching this country, the water of the ocean is fresh from it. Now as a sign of approach to this country to those coming from the sea, there are serpents coming forth from the depths to meet you; and a sign of the places just mentioned and in Persia, are those called graea. This river has seven mouths, very shallow and marshy, so that they are not navigable, except the one in the middle; at which by the shore, is the market-town, Barbaricum. Before it there lies a small island, and inland behind it is the metropolis of Scythia, Minnagara; it is subject to Parthian princes who are constantly driving each other out.

39. The ships lie at anchor at Barbaricum, but all their cargoes are carried up to the metropolis by the river, to the King. There are imported into this market a great deal of thin clothing, and a little spurious; figured linens, topaz, coral, storax, frankincense, vessels of glass, silver and gold plate, and a little wine. On the other hand there are exported costus, bdellium, lycium, nard, turquoise, lapis lazuli, Seric skins, cotton cloth, silk yarn, and indigo. And sailors set out thither with the Indian Etesian winds, about the month of July, that is Epiphi: it is more dangerous then, but through these winds the voyage is more direct, and sooner completed.

Fig. 2.10 Northern Arabic Sea coasts

40. Beyond the river Sinthus there is another gulf, not navigable, running in toward the north; it is called Eirinon; its parts are called separately the small gulf and the great; in both parts the water is shallow, with shifting sandbanks occurring continually and a great way from shore; so that very often when the shore is not even in sight, ships run aground, and if they attempt to hold their course they are wrecked. A promontory stands out from this gulf, curving around from Eirinon toward the East, then South, then West, and enclosing the gulf called Baraca, which contains seven islands. Those who come to the entrance of this bay escape it by putting about a little and standing further out to sea; but those who are drawn inside into the gulf of Baraca are lost; for the waves are high and very violent, and the sea is tumultuous and foul, and has eddies and rushing whirlpools. The bottom is in some places abrupt, and in others rocky and sharp, so that the anchors lying there are parted, some being quickly cut off, and others chafing on the bottom. As a sign of these places to those approaching from the sea there are serpents, very large and black; for at the other places on this coast and around Barygaza, they are smaller, and in color bright green, running into gold.

41. Beyond the gulf of Baraca is that of Barygaza and the coast of the country of Ariaca, which is the beginning of the Kingdom of Nambanus and of all India. That part of it lying inland and adjoining Scythia is called Abiria, but the coast is called Syrastrene. It is a fertile country, yielding wheat and rice and sesame oil and clarified butter, cotton and the Indian cloths made therefrom, of the coarser sorts. Very many cattle are pastured there, and the men are of great stature and black in color. The metropolis of this country is Minnagara, from which much cotton cloth is brought down to Barygaza. In these places there remain even to the present time signs of the expedition of Alexander, such as ancient shrines, walls of forts and great wells. The sailing course along this coast, from Barbaricum to the promontory called Papica, opposite Barygaza, and before Astacampra, is of three thousand stadia.

42. Beyond this there is another gulf exposed to the sea-waves, running up toward the north, at the mouth of which there is an island called Bavones: at its innermost part there is a great river called Mais.

42. Beyond this there is another gulf exposed to the sea-waves, running up toward the north, at the mouth of which there is an island called Bavones: at its innermost part there is a great river called Mais. Those sailing to Barygaza pass across this gulf, which is three hundred stadia in width, leaving behind to their left the island just visible from their tops toward the east, straight to the very mouth of the river of Barygaza; and this river is called Nammadus.

43. This gulf is very narrow to Barygaza and very hard to navigate for those coming from the ocean; this is the case with both the right and left passages, but there is a better passage through the left. For on the right at the very mouth of the gulf there lies a shoal, along and narrow, and full of rocks, called Herone, facing the village of Cammoni; and opposite this on the left projects the promontory that lies before Astacampra, which is called Papica, and is a had anchorage because of the strong current setting in around it and because the anchors are cut off, the bottom being rough and rocky. And even if the entrance to the gulf is made safely, the mouth of the river at Barygaza is found with difficulty, because the shore is very low and cannot be made out until you are close upon it. And when you have found it the passage is difficult because of the shoals at the mouth of the river.

44. Because of this, native fishermen in the King's service, stationed at the very entrance in well-manned large boats called *trappaga* and *cotymba*, go up the coast as far as Syrastrene, from which they pilot vessels to Barygaza. And they steer them straight from the mouth of the bay between the shoals with their crews; and they tow them to fixed stations, going up with the beginning of the flood, and lying through the ebb at anchorages and in basins. These basins are deeper places in the river as far as Barygaza; which lies by the river, about three hundred stadia up from the mouth.

45. Now the whole country of India has very many rivers, and very great ebb and flow of the tides; increasing at the new moon, and at the full moon for three days, and falling off during the intervening days of the moon. But about Barygaza it is much greater, so that the bottom is suddenly seen, and now parts of the dry land are sea, and now it is dry where ships were sailing just before; and the rivers, under the inrush of the flood tide, when the whole force of the sea is directed against them, are driven upwards more strongly against their natural current, for many stadia.

46. For this reason entrance and departure of vessels is very dangerous to those who are inexperienced or who come to this market-town for the first time. For the rush of waters at the incoming tide is irresistible, and the anchors cannot hold against it; so that large ships are caught up by the force of it, turned broadside on through the speed of the current, and so driven on the shoals and wrecked; and smaller boats are over-turned; and those that have been turned aside among the channels by the receding waters at the ebb, are left on their sides, and if not held on an even keel by props, the flood tide comes upon them suddenly and under the first head of the current they are filled with water. For there is so great force in the rush of the sea at the new moon, especially during the flood tide at night, that if you begin the entrance at the moment when the waters are still, on the instant there is borne to you at the mouth of the river, a noise like the cries of an army heard from afar; and very soon the sea itself comes rushing in over the shoals with a hoarse roar.

47. The country inland from Barygaza is inhabited by numerous tribes, such as the Arattii, the Arachosii, the Gandaraei and the people of Poclais, in which is Bucephalus Alexandria. Above these is the very war-like nation of the Bactrians, who are under their own king. And Alexander, setting out from these parts, penetrated to the Ganges, leaving aside Damirica [=Limyrike] and the southern part of India; and to the present day ancient drachma are current in Barygaza, coming from this country, bearing inscriptions in Greek letters, and the devices of those who reigned after Alexander, Apollodotus and Menander.

48. Inland from this place and to the east, is the city called Ozene, formerly a royal capital; from this place are brought down all things needed for the welfare of the country about Barygaza, and many things for our trade : agate and carnelian, Indian muslins and mallow cloth, and much ordinary cloth. Through this same region and from the upper country is brought the spikenard that comes through Poclais; that is, the Caspapyrene and Paropanisene and Cabolitic and that brought through the adjoining country of Scythia; also costus and bdellium.

49. There are imported into this market-town, wine, Italian preferred, also Laodicean and Arabian; copper, tin, and lead; coral and topaz; thin clothing and inferior sorts of all kinds; bright-colored girdles a cubit wide; storax, sweet clover, flint glass, realgar, antimony, gold and silver coin, on which there is a profit when exchanged for the money of the country; and ointment, but not very costly and not much. And for the King there are brought into those places very costly vessels of silver, singing boys, beautiful maidens for the harem, fine wines, thin clothing of the finest weaves, and the choicest ointments. There are exported from these places spikenard, costus, bdellium, ivory, agate and carnelian, lycium, cotton cloth of all kinds, silk cloth, mallow cloth, yarn, long pepper and such other things as are brought here from the various market-towns. Those bound for this market-town from Egypt make the voyage favorably about the month of July, that is Epiphi.

Fig. 2.11 India North-West coast

50. Beyond Barygaza the adjoining coast extends in a straight line from north to south; and so this region is called Dachinabades, for dachanos in the language of the natives means "South." The inland country back from the coast toward the east comprises many desert regions and great mountains; and all kinds of wild beasts--leopards, tigers, elephants, enormous serpents, hyenas, and baboons of many sorts; and many populous nations, as far as the Ganges.

51. Among the market-towns of Dachinabades there are two of special importance; Pathana, distant about twenty days' journey south from Barygaza; beyond which, about ten days' journey east, there is another very great city, Tagara. There are brought down to Barygaza from these places by wagons and through great tracts without roads, from Pathana carnelian in great quantity, and from Tagara much common cloth, all kinds of muslins and mallow cloth, and other merchandise brought there locally from the regions along the sea-coast. And the whole course to the end of Damirica [=Limyrike] is seven thousand stadia; but the distance is greater to the Coast Country.

52. The market-towns of this region are, in order, after Barygaza: Suppara, and the city of Calliena, which in the time of the elder Saraganus became a lawful Market-town; but since it came into the possession of Sandares the port is much obstructed, and Greek ships landing there may chance to be taken to Barygaza under guard.

53. Beyond Calliena there are other market-towns of this region; Semylla, Mandagora, Pala patma, Meligara, Byzantium, Togarum and Aurannohoas. Then there are the islands called Sesecrienae and that of the Aegidii, and that of the Caenitae, opposite the place called Chersonesus (and in these places there are pirates) and after this the White Island. Then come **Naura** and **Tyndis**, the first markets of Damirica [=Limyrike], and then **Muziris** and **Nelcynda**, which are now of leading importance.

54. Tyndis is of the Kingdom of Cerobothra; it is a village in plain sight by the sea. Muziris, of the same Kingdom, abounds in ships sent there with cargoes from Ariake [2.9] (northern route from Arabia), and by the Greeks; it is located on a river, distant from Tyndis by river and sea five hundred stadia, and up the river from the shore twenty stadia. **Nelcynda** is distant from **Muziris** by river and sea about five hundred stadia, and is of another Kingdom, the **Pandian**. This place also is situated on a river, about one hundred and twenty stadia from the sea.

55. There is another place at the mouth of this river, the village of Bacare; to which ships drop down on the outward voyage from Nelcynda, and anchor in the roadstead to take on their cargoes; because the river is full of shoals and the channels are not clear. The kings of both these market-towns live in the interior. And as a sign to those approaching these places from the sea there are serpents coming forth to meet you, black in colour, but shorter, like snakes in the head, and with blood-red eyes [2.10].

2.9 The Periplus Maris Erythraei states, “Immediately after the gulf of Barake is the gulf of Barygaza and the coast of the region of Ariake..” that is the region behind the Kambay gulf.

2.10 Most probably Hydrophis schistosus, also known as the beaked sea snake or Valakadeyan sea snake, commonly encountered along the coasts of South India; it has uniformly dark, greyish to black dorsal coloration, and the eyes appear to have a reddish tint. It is highly venomous.
Coastal areas, including sandy beaches, rocky shores, and mangrove swamps, also serve as important habitats for those snakes, using them as shelter and hunting grounds.

56. They send large ships to these market-towns on account of the great quantity and bulk of pepper and malabathrum. There are imported here, in the first place, a great quantity of coin; topaz, thin clothing, not much; figured linens, antimony, coral, crude glass, copper, tin, lead; wine, not much, but as much as at Barygaza; realgar and orpiment; and wheat enough for the sailors, for this is not dealt in by the merchants there. There is exported pepper, which is produced in quantity in only one region near these markets, a district called Cottonara. Besides this there are exported great quantities of fine pearls, ivory, silk cloth, spikenard from the Ganges, malabathrum from the places in the interior, transparent stones of all kinds, diamonds and sapphires, and tortoise-shell; that from Chryse Island, and that taken among the islands along the coast of Damirica [=Limyrike]. They make the voyage to this place in a favorable season who set out from Egypt about the month of July, that is Epiphi.

57. This whole voyage as above described, from Cana and Eudaemon Arabia, they used to make in small vessels, sailing close around the shores of the gulfs; and Hippalus was the pilot who by observing the location of the ports and the conditions of the sea, first discovered how to lay his course straight across the ocean. For at the same time when with us the Etesian winds are blowing, on the shores of India the wind sets in from the ocean, and this southwest wind is called Hippalus, from the name of him who first discovered the passage across. From that time to the present day ships start, some direct from Cana, and some from the Cape of Spices; and those bound for Damirica [=Limyrike] throw the ship's head considerably off the wind; while those bound for Barygaza and Scythia keep along shore not more than three days and for the rest of the time hold the same course straight out to sea from that region, with a favourable wind, quite away from the land, and so sail outside past the aforesaid gulfs.

58. Beyond Bacare there is the Dark Red Mountain, and another district stretching along the coast toward the south, called Paralia. The first place is called Balita; it has a fine harbor and a village by the shore. Beyond this there is another place called Comari at which are the Cape of Comari [=Cape Comorin] and a harbour; hither come those men who wish to consecrate themselves for the rest of their lives, and bathe and dwell in celibacy; and women also do the same; for it is told that a goddess once dwelt here and bathed.

59. From Comari toward the south this region extends to Colchi, where the pearl-fisheries are; (they are worked by condemned criminals); and it belongs to the Pandian Kingdom. Beyond Colchi there follows another district called the Coast Country, which lies on a bay, and has a region inland called Argaru. At this place, and nowhere else, are bought the pearls gathered on the coast thereabouts; and from there are exported muslins, those called Argaritic.

60. Among the market-towns of these countries, and the harbors where the ships put in from Damirica [=Limyrike] and from the north, the most important are, in order as they lie, first Camara, then Poduca, then Sopatma; in which there are ships of the country coasting along the shore as far as Damirica; and other very large vessels made of single logs bound together, called sangara: but those which make the voyage to Chryse and to the Ganges are called colandia, and are very large. There are imported into these places everything made in Damirica, and the greatest part of what is brought at any time from Egypt comes here, together with most kinds of all the things that are brought from Damirica and of those that are carried through Paralia.

Fig. 2.12 South India coasts, Comorin and beyond

61. About the following region, the course trending toward the east, lying out at sea toward the west is the island Palaesimundu, called by the ancients Taprobane. The northern part is a day's journey distant, and the southern part trends gradually toward the west, and almost touches the opposite shore of Azania. It produces pearls, transparent stones, muslins, and tortoise-shell.

62. About these places is the region of Masalia stretching a great way along the coast before the inland country; a great quantity of muslins is made there. Beyond this region, sailing toward the east and crossing the adjacent bay, there is the region of Dosarene, yielding the ivory known as Dosarenic. Beyond this, the course trending toward the north, there are many barbarous tribes, among whom are the Cirrhadae, a race of men with flattened noses, very savage; another tribe, the Bargysi; and the Horse-faces and the Long-faces, who are said to be cannibals.

63. After these, the course turns toward the east again, and sailing with the ocean to the right and the shore remaining beyond to the left, Ganges comes into view, and near it the very last land toward the east, Chryse. There is a river near it called the Ganges, and it rises and falls in the same way as the Nile. On its bank is a market-town which has the same name as the river, Ganges. Through this place are brought malabathrum and Gangetic spikenard and pearls, and muslins of the finest sorts, which are called Gangetic. It is said that there are gold-mines near these places, and there is a gold coin which is called caltis. And just opposite this river there is an island in the ocean, the last part of the inhabited world toward the east, under the rising sun itself; it is called Chryse; and it has the best tortoise-shell of all the places on the Erythraean Sea

Final observations

In paragraph **50** of the Periplus the author says « ***Immediately beyond Barygaza the coast runs from north to south.*** » and, as it is shown by Figure 2.10, it is exact.

In paragraph **58** he affirms ***« another district stretching along the coast toward the south, called Paralia.*** **»;** in the following line he names the port of Komar, which several academics identify as Comorin, the southerner tip of the subcontinent. Following to the south, as for the author in **59**, the Pandyan's Argaru region lays, and as of **61** there is the ***« the following region, the course trending toward the east*** »
Now we know that all this is wrong (see Fig. 2.11), not only because if Komar is Comorin the following coast turns to North-East, but also simply because in no point of the Indian subcontinent the prevalent direction of coasts is toward East.

This mistake from then on is present in every ancient geographer's map of India, except for Posidonius, as they apparently did not check the Periplus information.
But at this point another observation arises, that is the difference between the cited right direction of northern coasts and the completely wrong description of southern coasts. Sailors accustomed to guide themselves in the sea with the stars cannot ignore the direction and difference in latitude, even only for a few degrees, of a long coast that they follow repeatedly for a long time; but strangely the report of the Periplus is right for the Northern portion of Indian shores and completely wrong for the Southern ones.
Is it possible that the Periplus author had a personal experience, or talked with somebody who had a direct experience of sailing along the Northern portion of Indian coasts, but instead with nobody practised of the Southern one ?
If so, it is also possible that all the information written about South India, acquired perhaps through a long chain of confused reports, could be wrong or at least debatable.
But, if this argumentation is valid, then a lot more of doubts could arise about PME's Southern India information, in the sense that not necessarily market-towns descriptions could be wrong, but at least their positioning along the coast could have been shuffled, as a consequence of confused reports about something heard through the grapevine.

PME says that Nelcynda is distant from Muziris by river and sea about five hundred stadia, and is of another Kingdom, the **Pandian**. Then the frontier was between the two.
Moreover it should be noticed that a not negligible portion of distances cited in the PME text are not correct, being often overrated when compared with reality, another sign of confused and approximate reports.

Some vessels performed a coastal navigation along the Arabian coasts, then crossed the Oman Gulf toward India's shores and finally reached Muziris from the North. Others reached Muziris directly crossing the ocean from the West (PME 57).

Sangam Period Sources

The period roughly between the **3rd century B.C.** and **3rd century A.D.** in South India (the area lying to the south of river Krishna and Tungabhadra) is known as Sangam Period.
It has been named after the Sangam academies of Tamil poets, held during that period that flourished under the royal patronage of the **Pandya kings** of Madurai.
At the sangams eminent scholars gathered and acted as a censorship committee and the best works were collected as anthologies..
These literary works were the earliest specimens of Dravidian literature, with a total of 2381 poems from 3 to 782 verses.

According to the Tamil legends, there were **three** Sangams (Academy of Tamil poets) held in the ancient South India popularly called **Muchchangam**.

- The First Sangam, is believed to be held at Madurai, attended by gods and legendary sages. No literary work of this Sangam is available.

- The Second Sangam was held at Kapadapuram, only Tolkappiyam survives from this.

- The Third Sangam was also held at Madurai. A few of these Tamil literary works have survived and are a useful sources to reconstruct the history of the Sangam period.

In Old Tamil language, the term Tamilakam (Tamilakam, Purananuru 168. 18) referred to the whole of the ancient Tamil-speaking area, corresponding roughly to the area known as southern India today, consisting of the territories of the present-day Indian states of Tamil Nadu, Kerala, parts of Andhra Pradesh and Karnataka.
The evidence on the early history of the Tamil kingdoms consists of the epigraphs of the region, the Sangam literature, and archaeological data. Tamilakam, during the Sangam Age, was ruled by three dynasties, **Cheras, Pandyas and Cholas,** as well as other semi-independent principalities. The main source of information about these kingdoms is traced from the literary references of Sangam Period, and this constitutes the main historical information we have about that area and epoch.
The Sangam period slowly witnessed its decline towards the end of the 3rd century A.D.

Archaeology confirms the evidence of literature. The numerous discoveries throughout South India of gold and silver coins of the Roman emperors of the first two centuries A.D. , as well as the presence of the " Roman factory " (involved in the production of various goods, including beads, gems, semi-precious stones, and textiles) inferred by Wheeler in Arikamedu in the first century, confirm the correctness of the date suggested for the Sangam age.

Also unearthed inscriptions confirm some event cited in Sangam poetry, and westerners' citations in the poems can be verified with reports of the same roman and Greek authors mentioned in this work.

It is also worthwhile reminding the discussion among historians and literati about the real date of such poems, because of the recurring doubts on the epoch of extension of these texts;
As a matter of fact date of factual writing of an orally passed down poetry work is not so important, provided that wording fidelity be assured. An hypothesis that could resolve the dispute about dates of extension and veracity of those compositions is simply that probably they have been re-edited later on the base of preceding texts or oral tradition, but the historical information they contain are fundamentally credible.

Those poems are therefore important to the topic under study because within them there are citations of Muziris (Muchiri), such as:

"The savannas bring their sturdy ships, arriving with gold and
starting with pepper from the rich Muchiri." (Akananuru149, 9-11)"

The region referenced by the Sangam Poems is nowadays part of states of Kerala and Tamil Nadir. Kerala in the North-West was divided in two reigns, Musicals of Limuli in the north and the Cheraw of central Kerala and the Ay in the Tamil Nadir.
In the southern and eastern part of Tamil Nadir ruled the Pandas and the Cholas.
The Southern tip of India was then divided among the three kings of the Chera, Pandya and Chola and a number of minor chieftains who depending on their political advantage either ally to or fought for one or other of these monarchs, or else led an independent existence. One of them fighting for the Chera against the Pandyans managed to establish the new little Kingdom of the Ay.

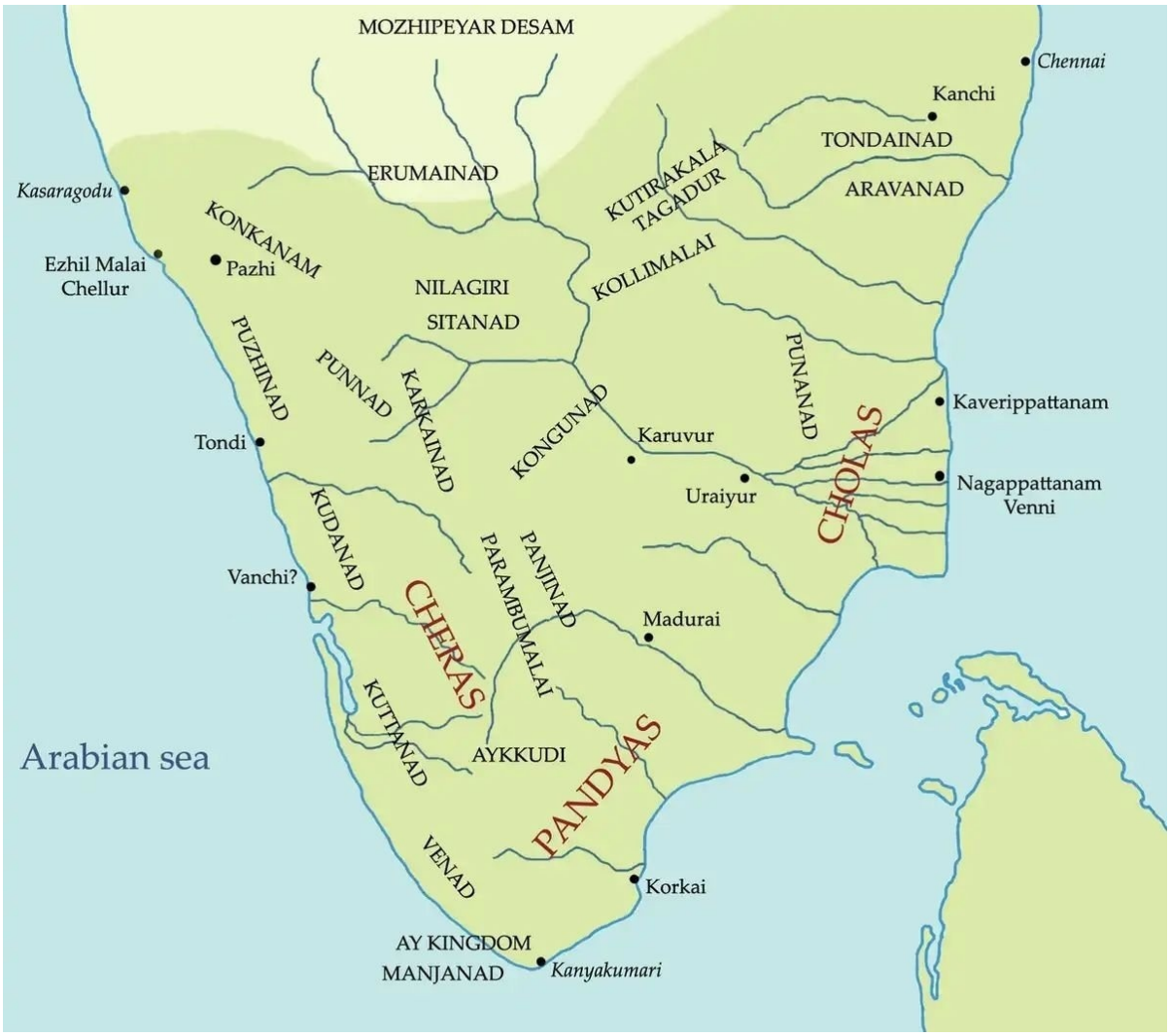


Fig. 2.13 Map of Southern India during the Sangam period (Source Wikiwand)

Cheras

Chera dynasty was an ancient Dravidian dynasty of Tamil descent that ruled the Chera country, often referred to as the land of spices. The Indo-Roman trade commenced in first century BC with the reign of Augustus and his conquest of Egypt; after Romans sailed to India with amphorae of olive oil and wines, gold and silver ingots and their renowned pottery.

Vanchi was the capital of Chera dynasty, located on the outskirts of present-day Kodungallur according to some historians, while others recognize Vanchi as Karur, located on the banks of Amaravathi river. Sirupanarruppatai, a Sangam anthology, describes the Chera capital Vanchi, but this has not been sufficient to locate it with certainty.

- The Cheras controlled the central and northern parts of Kerala and the Kongu region of Tamil Nadu.
- Vanji or Vanchi was their capital and the ports of the west coast, Musiri and Tondi, were under their control.
- The emblem of Cheras was **"bow and arrow"**.
- The Pugalur inscription of the 1st century AD refers to three generations of Chera rulers.
- The Cheras owed their importance to the trade with the Romans. The greatest ruler of Cheras was **Senguttuvan, the Red Chera** or the Good Chera, who belonged to the 2nd century A.D.

Ay

The Ay dynasty was a ruling Indian lineage that controlled the south-western tip of the peninsula, from the early historical period until the medieval period. It dominated the port of Vizhinjam, the fertile Nanjinad region, and the southern parts of the spice-producing Western Ghats.

Greek geographer Claudius Ptolemy (2nd century AD) described the "Aioi" territory as extending from the Baris river to Cape Comorin (Kanyakumari). The elephant was the emblem of the Ay.

The Tamil princedom of Ays is believed to have flourished from the early Sangam Age down to the 10th century AD with the capital at Nelkinda or Nelcynda, which was "*distant from Muziris by river and sea about five hundred stadia, and is of another Kingdom, the Pandian. This place also is situated on a river, about one hundred and twenty stadia from the sea*". These were the words in the "Periplus Maris Erythraei" about Nelcynda .
But the dominating power identity is not so sure, and what we know about lead us to deem that Nelcynda has not always been a Pandyans' ruled city.

As a matter of fact it seems that during the First Chera Kingdom one of its generals, a Chieftain named Veliyan, fought and conquered this Pandyan trade centre and was rewarded with the rule on the annexed land as a Chera vassal. This new princedom was named Ay.
Veliyan was followed by other Ay rulers, among whom are noticeably:

- Ay Antiran, the greatest Ay ruler during the Sangam Age, known above all through the Purananuru poem, according which he was the lord of the Podiyil mountain, the southern tip of the Western Ghats and a portion of region of Tamil Nadu near Madurai, the Pandyan capital on the Vaigai river.

- The next important Ay ruler of the Sangam Age was Titiyan. It seems that he settled some boundary disputes with the Pandyan Kingdom, when it was ruled by King Bhutapandya, becoming his vassal.

- Atiyan was another important ruler of the Ay princedom cited by Sangam poetry. During his reign Pasumpun, a Pandyan warrior-king, invaded the Ay territory and Atiyan could not repulse the attack. He surrendered and lost regions in Central and Southern Travancore. Despite their best efforts, the Ays could not regain the prominence which they once enjoyed. And towards the close of the early historic period, Pandya supremacy might have extended to the Ay territory.

This apparently punctilious citation about that epoch is on the contrary important, because it is linked with the topic of searching for the real Muziris location.

- Ay princedom history seems to start with a Pandya territory stealed by the Cheras, then a further expansion of territorial Cheras influence through the Ay vassal conquest of Pandyan territory, followed by the loss of Chera influence replaced by a renewed Pandyan's Ay vassalage, and eventually the almost complete erasure of the Ay princedom and a new Pandyan suzerainty on a part of that territory.

- If the identification of Nelcynda as the Ay princedom capital city is correct, we know trough the Periplus Maris Erythraei that Muziris was 500 stadia by river and sea, and Nelcynda about 120 stadia from the sea.

- On the contrary, if the Pliny's words "**Alius utilior portus gentis Neacyndon, qui vocatur Becare. Ibi regnabat Pandion, longe ab emporio in mediterraneo distante oppido quod vocatur Modura.**" are accepted, Nelcynda belonged to Pandyas, perhaps before the Cheras attack and Ay's protectorate establishment, and it and Muziris were just on the border between those two local powers.

This means that Muziris was within the territory of the Ays and very near to that of Pandyans, probably sharing in the described struggle events. As a matter of fact there are passages of the Sangam poetry that appear testifying the involvement of Muziris in the conflict between Ays and Pandyans, like the following:

"where the victory banner with the spotted ***peacock*** *is raised*
to the west of ***KuuTal*** *whose streets are filled with waving flags,*
city of ***Ceziyan*** *who has good, tall elephants and who kills in battle,*
who prevailed in a hard fight and stole the image
in the noisy ***siege of prosperous Muciri****,*
where the finely made ships brought by the Yavanar
come with gold and return with pepper, churning up white froth
*on the great river Culli of the Cheras***."** (Akananuru)

or

as elephants fell in the tumultuous killing of battle
when Ceziyan with his bannered chariots and horses with cropped manes
besieged the town of Muciri on the bay of the ancient sea.

- Located on a hill overlooking the town of Palani stands the millennia-old temple of The Palani Murugan god, whose banner is a **peacock**. Probably the winners waved the flags with the god's emblem as a thanksgiving.

- **KuuTal** is the old name of modern Maturai (Madurai), capital city of Pandyans.

- Pāndya, as their name is written in Sanskrit, became their de facto name in the later years; whereas, Old Tamil literature and epigraphs use a lot of other synonyms to point them: māṛan, vazuti, **ceziyan**/cizivan and kuṭumi are the names used in references to Pandyan kings.

According to Kamil Zvelebil – a scholar of Tamil literature and history - a few poems in the Akananuru were probably composed sometime between 1st century BCE and 2nd century CE, the middle layer between 2nd and 4th century CE, while the last layers were completed sometime between 3rd and 5th century CE. Consequently historical events cited in these works cannot be surely dated, but mentions of Yavans ships and trade of gold in exchange for pepper appear really describing Roman trade.

It is then possible to conclude that Muziris:

- initially was a Chera Kingdom trade port

- was in a location of Tamil Nadu subject to the continued conflict between Cheras and Pandyans;

- probably was in the Ay princedom territory;

- and Akananuru describes Pandya attacks on the Chera port of Muciri

Muziris finally was conquered by the Pandyans, probably by a king named Musiri Mutriya Cheliyan, as his name suggests. This episode is impossible to date, but the attack seems to have succeeded in diverting Roman trade from Muziris. It is then possible to hypothesize that in the I century Muziris was a Chera port, confirming Pliny words, and that in the III century was conquered by the Pandyans. Most important conclusion is therefore that the Muziris location was in Ay land, near the the border between Ay's territory and Pandyan's land, probably around the Cape Comorin meridian.

Pandyans

The Pandyans had a great antiquity. The Pandyans became most famous for the Tamil Sangam literature containing valuable sources on the early Pandyans of Madurai. Kautilya and Magesthenes also refer to them. The Pearls-fishery of the Pandyan Coast or the Parava Coast extended from Rameswaram (Adam's Bridge) to Kanyakumari (Cape Comorin). The Pearl-fishery occupation assured the economic prosperity and external contacts of the Pandyans. It had helped the Pandyans to develop inter-continental trade and cultural contacts through Arabian Peninsula.

- The early historic Pandyan dynasty lasted from the 3rd century BCE to the early centuries CE and ruled from Madurai (also named Kuutal).
- Korkai was their main port, located near the confluence of Thampraparani with the Bay of Bengal. It was famous for pearl fishery.
- Their emblem was the **"**Fish**"**.

Pandyans ports

Tamil Nadu, as early as the 3rd century BC, had more than 16 ports — between Chennai and Tirunelveli — that helped it maintain direct maritime links with China, Egypt, parts of Europe and Southeast Asian countries. Archaeologists say ancient Tamil literature and excavations provide evidence about the existence of such ports that played a major role in overseas trade in the past. Main ports were:

- Tyndis
- Korkai,
- Kayalpatnam,
- Kulasekarapatnam, in the Pearl Fishery Coast,
- Alagankulam
- Thondi [2.5]
- Kaveripoompattinam (Poompuhar in Nagapattinam district)

2.5 now a small village situated about 25 km from Tiruvadanai in Ramanathapuram District. It was a port town during the Sangam period. Trial excavation was conducted at a mound near Thondi Amman Temple. Potteries and bricks belonging to late period like coarse red ware were collected (Tamil Nadu Department of Archaeology).

Korkai

Korkai archaeological excavations help us establish the historicity of this centre before the 8th century B.C. The Kolhai or Colchi of the Greco-Roman and Egyptian mariners and geographers was the trading port of the Pandyans. It was one of the primary centres of Pandyan power. At the time of the Periplus it was one of the chief ports of the Pandyan kingdom, being more accessible to the capital than Nelcynda.
The site is referred to in Tamil Sangam literature, and has been mentioned by classical geographers as one of the greatest centres of pearl fishing in the ancient world. Periplus of the Erythraean Sea refers to Korkai as Colchis, “From Comari toward the south this region extends to Colchi, where the pearl-fisheries are (lets notice the geographic error) and Ptolemy calls it Kolkhai. Multiple classical works of the Sangam literature like Akananuru and Kalithogai speak of this port city’s reputation.

Owing to the deposit of silt by the Tamraparni (Thamirabarani) river the sea retired from Kolkai, and in medieval times another nearby place, Kayal (the Coil of Marco Polo), became the port. Korkai, the sea-port city of the Pandyans, became very busy in intercontinental trade mainly owing to pearl-fishing. The Pandyans seem to have made the crown prince stay at Korkai to look after the pearl-fishing activity and Sangam works apparently substantiate this view.
Korkai now is a small village in Srivaikuntam Taluk of Tuticorin (Thoothukudi) district. It is situated at a distance of 3 km to the north of the river Tamaraparani. The sea during the centuries had receded about 6 km to the east. The river Tamaraparani skimmeed this town in ancient days.

Madurai as Capital

The Pandyans had to shift their capital from Korkai to the present Madurai
(9° 55'N, 78° 7'E) situated on the Vaigai riverbed at the time of Pandyan Mudathirumaran.
A city was soon planned with a temple as its centre. On the day the city was to be named, Lord Shiva is said to have appeared and drops of nectar from his hair fell on the town. So, the place was named Madurai – mathuram meaning “sweetness” in Tamil.
As early as the 3rd century BC, Megasthanes visited Madurai. Later many people from Rome and Greece visited Madurai and established trade with the Pandyan kings.
The Pandyans had Madurai as the inland capital for safety and their secondary coastal capital at Korkai. References from Sangam Literature prove that Madurai was doubtlessly the most famous and important town in Tamilakam at this period, being the capital city of the Pandyans who were renowned as the most powerful of the Tamil kings and munificent patrons of poets.
What distinguished it however from other towns in the Tamil country were the high towers over the four gates of the fort. Hence it was familiarly known as Nan-madak-kudal or the "Cluster of four towers”. The name was sometimes shortened into Madak-kudal, or Kudal. The Madurai K-Kanchi, the longest poem in the Pattuppattu Collection datable to the second century A.D. gives a graphic picture of Madurai as a large and beautiful city with a palace, a number of temples, two large markets. Markets or bazaars Nalankadi (daytime market) Allankadi (night time market) and well laid out streets with lofty mansions. [2.6] The site of this ancient Madura or Kudal was the most probably Pala Madura (or old Madura,) now in ruins, situated at a distance of about six miles to the southeast of the modem town of Madura. The ruins are now on the northern bank of the Vaigai where as ancient Madura stood on its southern bank; but it is quite possible that the river had changed its course since the destruction of the old city.

2.6 Manimekhalai, iv, 50:3, D.Dorcas Shanthini, op.cit., pp.38-39. 33 K.Sadasivan, "Kumari Before and After the Brahmanizatiofl of Tamilaham", Paper presented in the 2nd Annual Session of Tamil Nadu History Congress, Annamalai Nagar, 1995, pp. 10-11 K.A.Nilakanta Sastri, op.cit., (1972), p.35., D.Dorcas Shanthini, op.cit., pp.33-34. 37

Cholas

- The Cholas controlled the central and northern parts of Tamil Nadu.
- Their core area of rule was the **Kaveri delta**, later known as **Cholamandalam**.
- Their capital was **Uraiyur** (near Tiruchirapalli town) and Puhar or Kaviripattinam was an alternative royal residence and chief port town.
- **Tiger** was their emblem.
- The Cholas also maintained an **efficient navy**.
- **King Karikala** was a famous king of the Sangam Cholas.

One of the most complete Roman archaeological records within the Indian subcontinent can be found in the South of India, specifically at **Arikamedu**, a major Roman trade port. Arikamedu has been identified with the port of **Poduke** mentioned in the **Periplus**. Poduke was a Tamil fishing village and former port of **the Chola Empire** specialising in bead making and had strong links with the Roman Mediterranean. The port flourished until the departure of Roman trade in the 5th century CE (Huntingford, 1980, 119). Excavations between 1937 and 1949 revealed a large number of amphorae bearing the seal of Roman pottery schools, suggesting widespread trade between Rome and the ancient Tamil country (Huntingford, 1980, 119 – 120).
Chola's merchant ships making the voyage to Chryse and to the Ganges were called colandia, and were very large.

Muziris as for the Sangam Age descriptions

Muciri was called **Muziris** by the Romans and is mentioned in documents from the first and second centuries CE. In the first century BC Muziris was one of India's most important trading ports, whose exports – especially black pepper - costed Rome huge amounts of money, starting with the Augustus's conquest of Egypt (30 BC), lasting during I and II century AC with this trade even intensified, and slowly extinguishing in the third century. After that only trade with the eastern Roman Empire (Byzantium) perhaps continued. Roman merchants established trading settlements in Chera land, specially in Muziris where the Tabula Peutingeriana records even an Augustus Templum.

As for the ports of these regions it has to be reminded of the fact that the ancient ports were situated on or near river mouths to facilitate easy entry of vessels into the mainland. Vessels in the past were not as big as they are today, and therefore river mouths were the right access points for a safe docking. Sometime there were not even any port for the ships, which moored near the shore, and merchandise was ferried along the river to the market, like in Muziris.

During Sangam era most trade was made by barter, according to Purananuru the boat sailed on the river with loads of fish and would return with rice exchanged against the former. It seems that Muziris was a shallow port and hence the ships anchored far off from the shore. The boats with loads of pepper bags sailed towards the anchored ships to exchange gold, wine and other merchandises brought by overseas traders.

Poet Paranar describes natural wealth of Muciri in Purananuru Poem 343, 7-10:

"*With its streets, its houses, its covered fishing boats, where they sell fish, where they pile up rice with the shifting and mingling crowd of a boisterous river-bank were the sacks of pepper are heaped up with its gold deliveries, carried by the ocean-going ships and brought to the river bank by local boats, the city of the gold-collared Kuttuvan (Chera chief), the city that bestows wealth to its visitors indiscriminately, and the merchants of the mountains, and the merchants of the sea, the city where liquor abounds, yes, this Muciri, were the rumbling ocean roars, is give to me like a marvel, a treasure.*"

Other descriptions are:

"*Here lies the thriving town of Muciri, where "the beautiful vessels, the masterpieces of the Yavanas (Greeks and Romans), stir white foam on the Churni river of Kerala, arriving with gold and starting with pepper from the rich Muciri*." (Akananuru149, 9-11)"

…While every day you take your pleasure as women wearing their shining bangles bring you the cool and fragrant wine carried here by the Yavanas in their excellent ships…

It is perhaps interesting to notice the different names attributed to the Muziris river in Sangam poetry, namely "Culli" or "Churni".

The great Tamil epic Silappatikaram (The Story of the Anklet) written by Ilango Adigal, a Jain poet-prince from Kodungallur during the 2nd century A.D., described Muziris as a place where western traders (Greeks and Romans) arrived in their ships to barter their gold to buy pepper and, since they had to wait months for the return monsoon, they lived in homes with a lifestyle that he termed as "exotic" and a source of "local wonder". It was perhaps because of this long stay in Muziris, motivated by monsoon periodicity, that they built the Templum Augusti indicated in the Tabula Peutingeriana. This description by a Chera prince let us believe that in the second century Muziris was under Chera influence.

A last note on the subject: all the Sangam literature is positive and even admiring the Romans traders, but Pliny apparently did not appreciate the Chera Muziris, preferring the Pandyan Bacare; could have been political reasons for this attitude after the diplomatic contacts between those kings and the Roman Empire ?

And when in the third century the Pandyans extended their influence to Muziris the Romans diverted the trade for political reasons or simply because of an impending economic crisis ?

Ptolemy's Geography

PTOLEMY (Claudius Ptolemaeus), the celebrated mathematician, astronomer and geographer, was a native of Egypt, active during the reigns of Hadrian and Antoninus Pius in the first half of II century A.C.
As a geographer he tried to base his maps on the concept of latitude and longitude, but, due to the lack of available and reliable means during his epoch, the results were inaccurate or completely wrong. Indeed we learn from Ptolemy himself that such observations for latitude were very few, while the means of determining longitudes were almost entirely lacking.
As a matter of fact they were based on the positions laid down by him on, with few exceptions, the result of computations from itineraries and the statements of travellers.

Fig. 2.14 Arabic Sea and India in Ptolemy's Geographia

Ptolemy's opera "Geographia" was essentially a description of the world map in terms of spherical coordinates (latitude and longitude in degrees) assigned to each of the listed localities.
Consequently, the term "Ptolemy's Geography" may be used synonymously with "Ptolemy's map" when referring to a map reconstructed from the coordinates recorded in the text. These coordinates are now available in an electronic database attached to the edition of the Geography by Stückelberger and Graßhoff (2006).
However, it is clear that only some of these coordinates could have been based on astronomical observations like the latitudes of the major cities. Both Ptolemy's predecessors and other possible geographic sources used only distances measured by customary units (Greek stades, Roman miles, etc.) in the Itineraria and Periploi.
Itineraria were territorial description in graphical form of the paths to be followed from a locality to other nearest ones, with information about their distances and noticeable features; they lacked completely any geographic purpose and did not represent landforms, but they only had the aim of aiding the traveller along the roads and their branches.

Periploi (sing. Periplus) is a particular genre of Itineraria describing only coastlines in the form of a linear sequence of stopping points, features and intervening distances: their purpose was that of aiding mariners to reach a location following the coasts according to old habit of skirting them. Periploi and Itineratia are considered to be "the standard basis of ancient descriptive geography". In any case they always had the form of a text (like the Periplus Maris Erythraei) or a linear graphical representation like a pictured strip, from which only succession of points (cities, ports, territorial features, monuments etc.) and intervening distances could be known.

Ptolemy himself emphasized (Geogr. 1.18.6) that it is much easier to indicate the positions of the coastal cities than of the inland ones. So probably he first put on the map the points at greater distance using available coordinates (astronomical observations like the latitudes of the major cities) and then completed the work with longitude data inferred from distances marked on Itineraria and Periploi.

This method could be roughly effective, but suffered by two distinct setbacks:

- If correct latitude coordinates were even available, longitude coordinates were impossible to determine at that time other than transforming known linear distances in angular differences. But his error in calculating the Earth circumference (28% lower) dragged a systematic error on longitude coordinates, with territories extension greatly exaggerated in direction East-West .

- Itineraria and Periploi data could be almost right for most known territories at the centre of the Empire, but surely inaccurate as for distant territories like India, because they were forcedly based only on second hand reports by merchants, sailors and travellers. Moreover, by his own admission, Ptolemy did not attempt to collect and check all the landform geographical data on which his maps were based. Instead, he based them on the maps and writings of Marinus of Tyre (c. 100 CE), that were even more wrong than those deducible from the Periplus.

Consequently Ptolemy superimposed erroneous longitude data on an erroneous map obtaining a distorted geographical representation, with the territories squeezed in the North-South direction and stretched in the East-West direction. In this way his map of India is more wrong than what could be understood reading the Periplus, as he located the southernmost point of the subcontinent only few degrees south of Barygaza.

The wrong depiction of the southern Indian subcontinent then could be explained by the lack of any check directly performed by him, as well as a noteworthy error on Earth circumference (contrary to Eratosthenes and Posidonius), apparently adding his mistakes to those of the Periplus author and Marinus. In this manner Ptolemy's geographic coordinates of his listed locations, including Muziris, are completely useless and only localities sequence could be utilised, which are :

Lymirica region
Tindis city
Bramagara
Calecarte promontory
Muziris emporium at mouth of the Pseudostomus river
Podoperura
Semna
Cerevra
Bacare at mouth of the Baris river

Aii region
Melcynda
Elancor emporium
Cottiara metropolis

Ptolemy in his Geographia then placed the Muziris emporium after a « **Calecarte promontory** » and North of the mouth of the Pseudostomus - literally “false mouth” – river, and Nelcynda in the Ay kingdom. Ptolemy’s East-West longitudes are measured eastward from a point 14° W of Greenwich, that is the westernmost point he catalogues in the Geography, identified as "east of the Blessed Isles" (Madeira and Porto Santo ?, Canary islands ?) . As for Muziris and Bacare, the port of Nelcynda market, he set the following coordinates :

Muziris (Muciri) emporium 117°00 longitude 14-00 latitude
Bacare (Bacaure, Bakarei) 119°30 longitude 14-30 latitude (Ptolemy puts Bacare at the North-East of Muziris, as if it was not on the Kerala coast, stretching toward the South-East)

As for the Earth circumference error, it is worthwhile to say that another ancient geographer, Posidonius of Rhodes (c. 135 – c. 51 BC), was able to avoid it based on stars elevations, finally drawing India closer to its real shape and orientation. He was a Greek philosopher, considered the most-learned man of his time, also interested in natural science, geography, astronomy and mathematics; Poseidonius spent many years in travel and scientific research, calculated the diameter of the Earth with more accuracy than Ptolemy, and apparently avoided also the Periplus error regarding the orientation of the Indian coast beyond Cape Comorin.

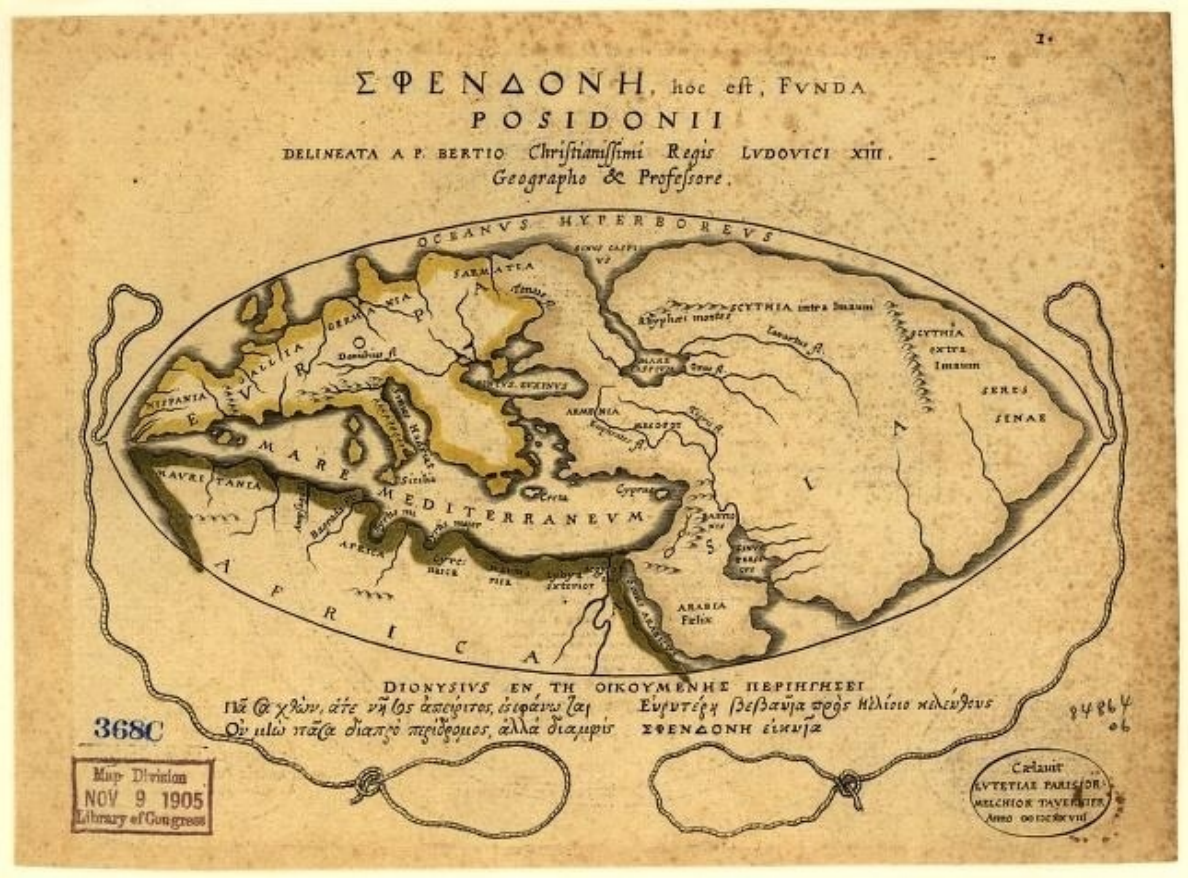


Fig. 2.15 Posidonius Map, Library of Congress

What is amazing is the fact that he lived one century before the author of Periplus and two centuries before Ptolemy, but his map, if the representation that we have of it is faithful to the original, is

much more correct; it’s also strange because apparently the Greeks knew those coasts better then the other two authors, who lived when India was directly known by Romans that went there for trading, but this did not avoid their errors.

In conclusion information contained in Ptolemy’s work “ Geographia“ cannot be accepted as they were reported on his geographic map, but rather should be considered only as those of a Roman Itinerarium.
From them and those drawn from the Periplus hence only the names and order of coastal Indian emporia could perhaps be accepted, but the apparent lack of exact information about those regions also casts doubt on that geographical knowledge, because it's probably just the result of second-hand reports, at best.

Anyway two information useful for Muziris locationing are those relative to the preceding promontory Calecarte and the fact that Bacare is located to the North-East of the lost trading port.

Anyway science owes to Ptolemy the beginning of modern Topography and Geography.

Tabula Peutingeriana

The Tabula Peutingeriana, as you know, is a large medieval copy of an ancient Roman road map (Itinerarium), containing topographic information that could date back to the 2nd century AD; it shows, at the tip of India, both Muziris and Tondis, together with a body of water near Muziris, and next to it an icon marked Templ(um) Augusti, normally understood as "Temple of Augustus", followed by a small peninsula and from an islet projected towards the island of Taprobane.
Note the fact that Tondis and Muziris are immediately adjacent on the map, but the with every probability the cited Tondis is not the Pandyan Thondi; it is rather the Chera Tyndis.
Large numbers of Roman subjects must have spent months in this region awaiting favourable conditions for sailing back to the Empire with the onset of the winter monsoon. This could explain why the Map records the existence of an Augustan temple, and therefore also the possible existence of a Roman colony in Muziris.

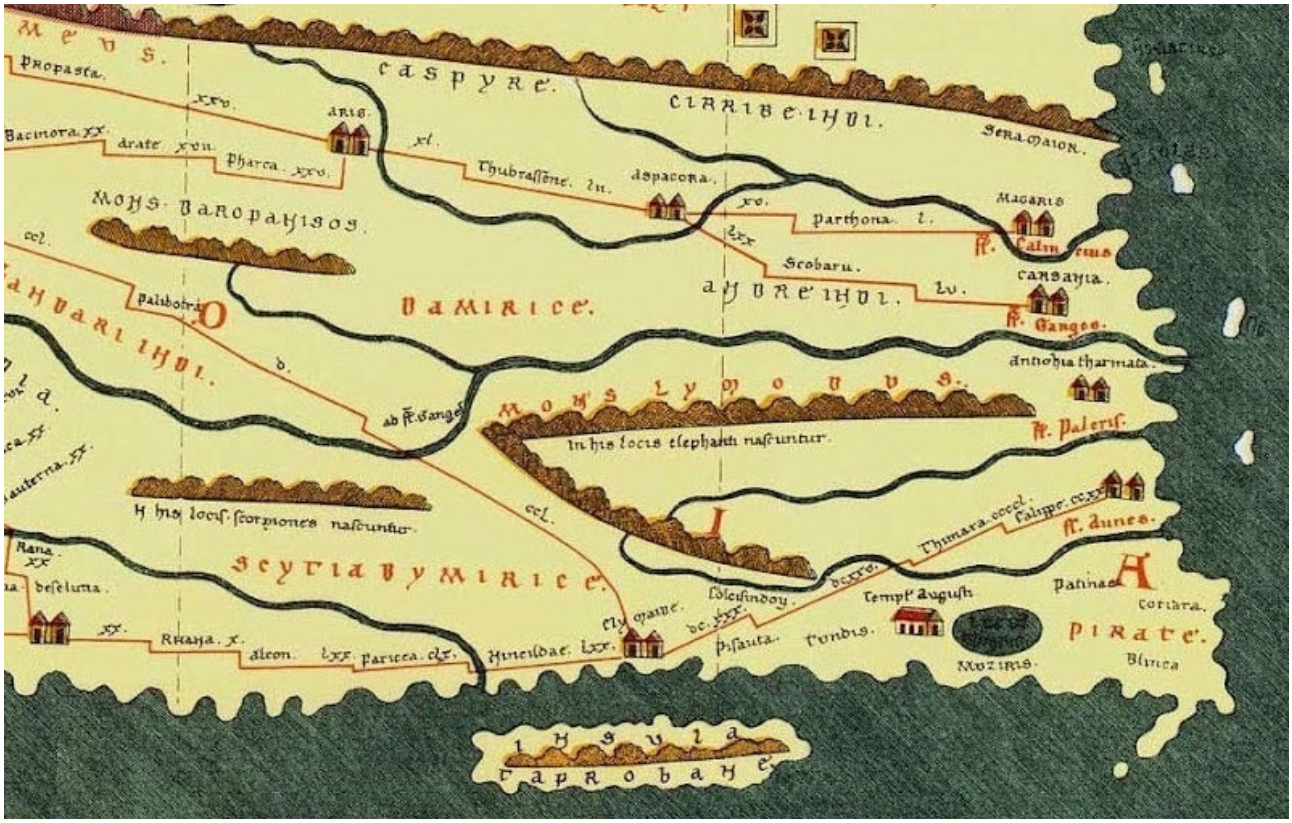


Fig. 2.16 Muziris, as shown in the Tabula Peutingeriana.

The Tabula Peutingeriana is thought to be the only known surviving map of the Roman cursus publicus, the state-run road network. The aim of the Tabula therefore was not the depiction of the regions concerned as a geographical map, but an itinerarium showing the network structure.
The map is a parchment copy dating from around 1200 of a Late Antique original.
The map consists of an enormous scroll measuring 6.75 metres long and 0.35 metres high assembled from eleven sections, a medieval reproduction of the original scroll.
To repeat the map history is here unnecessary and therefore it is given for granted.

Tabula content

The Tabula Peutingeriana offers an overview of the entire Roman Empire, and is an invaluable source for the study of ancient topography. According to R. Talbert, the original version from which the medieval copy is taken would have been created around 300 AD. However, the map was based at least in part on much older sources dating back to the 1st century AD. As a matter of fact it is thought to be a distant descendant of the map prepared under the direction of Marcus Vipsanius Agrippa [2.7]; the map was engraved on stone and put on display in the Porticus Vipsania in the Campus Agrippae area in Rome, close to the Ara Pacis building. The Tabula is not confined to the Roman Empire alone: the eastern regions of the then-known world, including India, are also depicted and, on segment XI, the city of **Muziris** is shown.

The early imperial dating for the archetype of the map is also supported by American historian Glen Bowersock, and is based on numerous details of Roman Arabia that look entirely anachronistic for a later 4th-century map. Bowersock then concluded that the original source is likely the map made by Vipsanius Agrippa. This dating is also consistent with the map's inclusion of the Roman towns of Herculanum, Oplontis and Pompeii near modern-day Naples, that were never rebuilt after they had been destroyed by the AD 79 eruption of Mount Vesuvius in which also Pliny died.

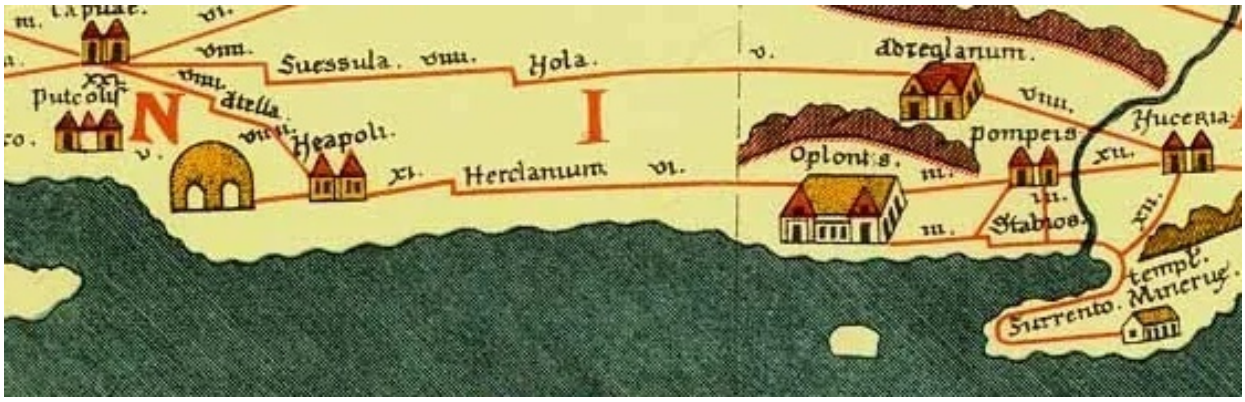


Fig. 2.17 Pompeii and Oplontis, as shown in the Tabular Peutingeriana.

The original Roman map, of which this may be the only surviving copy, was later on updated in the 4th or early 5th century. It indeed shows the city of Constantinople, founded in 328, and the prominence of Ravenna, seat of the Western Roman Empire from 402 to 476, which suggests a fifth-century revision. The presence of certain cities of Germania Inferior that were destroyed in the mid-fifth century provides the map's latest creation date.

2.7 Marcus Vipsanius Agrippa (63–12 BC) was the right arm of the emperor Augustus. According to Pliny's testimony (Natural History 3.17), he left behind an unfinished geographical work which, as most scholars believe, served as the basis for a world map displayed in the Porticus Vipsania in the centre of Rome (before AD 14). The map was accompanied by explanatory notes with an account of dimensions and boundaries of 24 regions of the world. These notes have come down to us only in fragments.

Fig. 2.18 Costantinople, as shown in the Tabula Peutingeriana.

Hence it could be presumed that the original had a certain number of revised copies between the half first century and the half fifth century.
This is exactly the time frame during which the merchant traffic between the Roman Empire – before with the whole of it , then only with its eastern surviving part – lasted, thus making the Tabula interesting for this study.

Unfortunately the Tabula is drawn up as an itinerarium, without any real geographical value in modern sense, and drafted with the only purpose of guiding the traveller through roads joining several localities, sometimes highlighting territorial features, services and accommodation available to travellers or particular monuments.

Anyway the Tabula seems putting Muziris near the extreme portion of the coast of India (drafted horizontally), with the Bengali coast drawn vertically. The small peninsula and the islet projected towards the island of Taprobane at the eastern far end of the coast strangely looks like the Adam's Bridge between the subcontinent and the island of Ceylon, arising a question about the possible rendering in the Tabula of the Gulf of Mannar as included in the depicted horizontal coast. This could open the hypothesis of a Muziris localization on this coast.
In any case the Tabula put Muziris on the southern portion of the Indian subcontinent, according with all sources.

Muziris-papyrus

In 1980 the Austrian National Library purchased a papyrus, then published in 1985, and now presently kept in Vienna; its provenance is unknown, but it is a Roman document probably compiled in middle Egypt during the reign of Hadrian in the 2nd century CE.
It contains two separate texts, one on its front (recto) and one on its back (verso), written by two different persons, a merchant and a financier.
The recto contains part of a contract about the transport of goods, coming from Muziris in India aboard the ship Hermapollon, from the point on the Red Sea where these had been unloaded (Myos Hormos or Berenike), across the eastern desert to Koptos and thence down the Nile to Alexandria. It also refers to the provisions of a loan for the acquisition of the traded goods.
The account on the verso is undoubtedly related to the agreement on the recto, both dealing with the same shipment of goods, listing them in nature and quantity. The information contained in this list allows also to evaluate the cargo both in weight and in cash value: the Hermapollon was probably a 250 tonnes ship transporting about seven million of Alexandrian drachmas value (6.911.852), an enormous amount to be further multiplied several times when sold on the wealthy Roman market. Other scholars, as F. De Romanis, measure the total tonnage of the Hermapollon up to 625 tons, a really astonishing size for that ship, which was really very large.

Unfortunately this document does not contain any information useful for identifying Muziris location, but surely confirms the importance of this Indian market-town during the first centuries C.E.. Same thing can be said about the Archives of Nicanor figlio di Panes, an Egyptian carrier.

Fig. 2.19 Muziris papyrus

Other sources

Cosmas Indicopleustes

Cosmas Indicopleustes (literaly 'Cosmas who sailed to India') was born in Antiochia during the 6° century CE, and was before a merchant in Alexandria and later a monk in Egypt. He was a Nestorian and when, around AD 550, was retired in a Sinai cloister, Cosmas wrote the Christian Topography, a work partly based on his personal experiences as a merchant on the Red Sea and Indian Ocean in the early 6th century.
Cosmas wrote about both personally visited countries and other ones of which he probably had only affordable news, like Northern Africa, Socotra, India and Ceylon; in this work he mentioned several ports of trade on the Malabar Coast and the presence there also of Saint Thomas Christians, a part of the the Church of the East, otherwise known as Nestorianism. The story of relations between those two religious orders is not simple, it developed during centuries with disintegration in several sects, but it is possible to suppose that at the Cosmas time their links were much more intense and frequent then later on. Therefore it is possible that Cosmas had affordable information on India, particularly about it southern regions and the close island of Ceylon, through those links and other believers he was in touch with. According to tradition, the beginning of Thomas mission laid in the west of the Malabar coast of India, where according to Indian tradition he stepped ashore for the first time in 52 A. D. at few miles from Muziris, so it is possible that Nestorian documents had valuable information on it.
Unfortunately The Christian Topography describes only Indian fauna and cites few localities, among them the most renowned being Calliena, on the West coast.
But other documents report about Saint Thomas in Kerala, like following: [2.8]

Thomasine Christianity is found in the southern Indian state of Kerala.
These churches of Malabar trace their roots back to St. Thomas the Apostle who according to local tradition arrived along the Malabar Coast in the year A.D. 52. Many early Christian writings, which belong to centuries especially following the first Ecumenical Council of 325, exist about St.Thomas mission.
The Seven places where St. Thomas had established Christian communities are even now see able and locatable. In almost all these place there are strong presence of St. Thomas Christian communities with their tradition, apart from the stories how they were subsequently diffused into other and surrounding localities. Similarly the port where the apostle landed in Kerala, the places where he preached and did miracles and made converts, the leading families whom he baptized and appointed as caretaker of his communities, the site where he met martyrdom are traceable, lively and important.
All these are still living evidence for the St.Thomas tradition.
Therefore all the local, physical and circumstantial evidences are in favour of the tradition witnessed by the St. Thomas Christians.

2.8 Historical study of the arrival of apostle St. Thomas in Kerala and its influence on the life of the St.Thomas christians, T. Robi, University of New Dheli, 2013

Cosmas' description of Taprobane

This is a large oceanic island lying in the Indian sea [2.9]. By the Indians it is called Sielediba, but by the Greeks |Taprobanê, and therein is found the hyacinth stone. It lies on the other side of the pepper country. Around it are numerous small islands, all having fresh water and coconut trees. They nearly all have deep water close up to their shores.

The island, being in a central position, is much frequented by ships from all parts of India and from Persia and Ethiopia, and it likewise sends out many of its own. And from the remotest countries, I mean Tzinista (China) and other trading places, it receives silk, aloes, cloves, sandalwood and other products, and these again are passed on to marts on this side, such as Male (Malabar), where pepper grows, and to Calliana (Calliana, now Kalyâna, near Bombay).

The most notable places of trade in India are these: Sindu, Orrhotha, Calliana, Sibor, and then the five marts of Male (Malabar) which export pepper: Parti, Mangarouth, Salopatana, Nalopatana, Poudopatana [names completely different from those before kwown].

Ceylon has been known by many names. In Sanskrit works it is called Lanka, an appellation unknown to the Greeks. Megasthenes, who wrote his work on India about 300 B.C., calls it Taprobanê, a compound which is generally regarded as a transliteration of Tâmraparnî, copper-coloured leaf, a name given to the island by its Indian conqueror, Vijaya. This name is found in its Pâli form, Tambaparni, in Asôka's inscription on the Girnâr rock. Some are, however, of opinion that Taprobanê is a slightly-altered form of Dwîpa-Râvana (Island of Râvana), as the country was called by Brahmanical writers. From the Periplûs and Ptolemy we learn that Taprobanê was anciently called Simoundou, but in his own time, *Salike, i.e.,* the country of the *Salai.*

A merchant called Sopatrus

Now I must here relate what happened to one of our countrymen, a merchant called Sopatrus, who used to go thither on business, but who to our knowledge has now been dead these five and thirty years past. Once on a time he came to this island of Taprobane on business, and as it chanced a vessel from Persia put into port at the same time with himself.

So the men from Adulé with whom Sopatrus was, went ashore, as did likewise the people of Persia, with whom came a person of venerable age and appearance.! Then, as the way there was, the chief men of the place and the custom-house officers received them and brought them to the king. The king having admitted them to an audicnce and received their salutations, requested them to be seated. Then he asked them: In what state are your countries, and how go things with them? To this they replied, they go well.

Afterwards, as the conversation proceeded, the king inquired: Which of your kings is the greater and the more powerful ?

The elderly Persian snatching the word answered: Our king is both the more powerful and the greater and richer, and indeed is King of Kings, and whatsoever he desires, that he is able to do.

Sopatrus on the other hand sat mute. So the king asked: Have you, Roman, nothing to say?

What have I to say, he rejoined, when he there has said such things? but if you wish to learn the truth you have the two kings here present. Examine each and you will see which of them is the grander and the more powerful.

The king on hearing this was amazed at his words and asked, How say you that I have both the kings here? You have, replied Sopatrus, the money of both — the nomisma of the one, and the drachma, that is, the miliarision of the other. Examine the image of each, and you will see the truth.

The king thought well of the suggestion, and, nodding his consent, ordered both the coins to be produced. Now the Roman coin had a right good ring, was of bright metal and finely shaped, for pieces of this kind are picked for export to the island. But the miliarision, to say it in one word, was of silver, and not to be compared with the gold coin.

2.9 Cosmas Indicopleustes, Christian Topography (1897) pp. 358-373. Book II

So the king after he had turned them this way and that, and had attentively examined both, highly commended the nomisma, saying that the Romans were certainly a splendid, powerful, and sagacious people! So he ordered great honour to be paid to Sopatrus, causing him to be mounted on an elephant, and conducted round the city with drums beating and high state. These circumstances were told us by Sopatrus himself and his companions, who had accompanied him to that island from Adulé ; and as they told the story, the Persian was deeply chagrined at what had occurred.

Other close parallel to Cosmas' travels

A very close parallel to Cosmas' travels is found in the Pseudo-Palladius or Ambrosius, De Moribus Brachmanorum. There the author recounts that his informant, one Scholasticus, "Shipping himself with certaine Merchants in the Red Sea, first came to the Town of the Adulites, or the bay Adulicus, after that to the promontory Aromata, and a mart of the Troglodytes, and hence to places of the Assumites, and many days after to Muziris, the mart of all India **on this side Ganges**, and having stayed a while there he passed over to the isle Taprobane'."

Iambulus too, a merchant, according to the account in Diodorus Siculus (bk. 11. 55), visited the coast of Ethiopia', was taken prisoner and set adrift in a boat as a purificatory offering. He reached Ceylon, and after seven years was turned out of the country as a sclave and went to India; but for all the reliable information he gives about the countries he visited, he might as well have gone to the mountains of the moon.

Strabo (XV. 4) mentions merchants of his day, unlettered men, like Cosmas according to his own confession, who sailed from Egypt to India by the Nile and Arabian Gulf.
Pliny too speaks of merchants visiting Ceylon in Claudius' reign (JV. VI. 24); and Ammianus Marcellinus (XXII. 7) of a mercantile treaty between the Romans and the people of Ceylon while Julian was Emperor.

Geographus Ravennas

The Ravenna Cosmography is a list of places and cities of the 7th century AD, representing the then known world. It is the main geographical list of its kind for overland itineraries of the Byzantine Age, comparable in importance to what the Peutinger Table represents for the Roman period.

The anonymous author consulted the works of Greek, Roman and his contemporaries. He found these resources in Ravenna, the capital of Byzantine Italy at the time.
He was a cleric in Ravenna around the seventh century AD. Textual evidence indicates that the author frequently used maps as his source. He compiled The Ravenna Cosmography, which is a list of place-names covering the world from India to Ireland. Only three copies of it survive today.
In this list two important locations of Dimirica are cited, namely **Maziris** (Muziris) and **Nilcinna** (Nelcynda).
It can be noted that the graphic representation is much less precise than the older ones: probably much geographical knowledge had already been lost at that time.

Fig. 2.20 Geographus Ravennas world map

Recap of information from ancient sources

Strabo's

- Initially under the Augustus reign merchant vessels, as many as 120 every year, left from the Myos Hormos port. Probably, above all because of the difficulty to return there against the predominant headwind, this trade location was abandoned in favour of the Berenike port already in the epoch of Pliny's report. For this reason Berenike has been chosen as normal starting point of the Roman-Indian trade hereafter.
- Roman ships headed to West Indian coast, only very few proceeded beyond toward the Ganges. Did they sail around Ceylon or at that epoch there was a sufficiently deep passage for ships through the Adam's Bridge ?
- The new Roman trade with India drove Indian diplomatic missions to Rome.

Pliny's

- Merchants embark and set sail by the end of June to reach Ocelis, arriving at their destination in about 30 days. They then sail for 40 days, finally reaching Muziris.
- Muziris was at the time part of the kingdom of Celobotra.
- Another good port is that of the Neacindi, called Becare, belonging to the kingdom of the Pandions, who rule from a distant city called Modura.

Periplus Maris Erythraei

- Direction of Southern India's coast is wrong; Muziris belong to Cheras and it is close to border with Pandyans.
- Sailors avoid sailing along the eastern coasts of the Red Sea both because of terrible navigation conditions and presence of pirates (PME 20)
- Some vessels performed a coastal navigation along the South Eastern Arabian coasts, then crossed the Oman Gulf toward India's shores and finally reached Muziris from the North. Others reached Muziris directly crossing the ocean from the West (PME 57).
- On the return way from Indian coasts, if the season is too late to reach the red Sea, some ships winter there (PME 32).
- Large ships are used along the African coasts for the cinnamon trade with Mosyllum (PME 10) and ivory trade with Rhapta (PME 16); other large vessels sail from Barigaza to Apologus and Ommana, with cargo of copper, sandalwood, teakwood, blackwood and ebony (PME 36). Large ships are also used for trading pepper and malabathrum at Muziris and Nelcynda (PME 56).
- Vessels heading to South India cross directly the ocean, while those bound for Barygaza keep along the Arabian coast then cross the Oman Gulf with favourable winds (PME 57).

Sangam period sources

- Muziris was very rich, a fact that could have caused a conflict between Cheras and Pandyans.
- It is then possible that Muziris in the second century was still under Chera influence but perhaps finally was conquered by the Pandyans in the III century.
- Westerner merchants waited months for the North-East monsoon and lived there, importing also wheat for their food and building an Augustus' Temple.

Ptolemy's

- Before reaching Muziris, sailing along the coast, there is a promontory named Calecarte.
- Ptolemy writes that Bacare, the port of Nelcynda, is located to the North-East of Muziris.

3 Ships, voyage routes, periods and duration, speed and distance

Type of ships

General assumptions have been made about the nature of vessels that were conducting Trade in the Red Sea and Indian Ocean region. They are assumed to have been similar in type, shape and building tradition to Mediterranean Roman merchant vessels, that is vessel whose hulls were constructed shell-first and whose planks were secured in place by a series of pegged mortises and tenons, and propelled by a square sail.
Thus, recent finds from Myos Hormos and Berenike so far appear to represent sails and rigging elements similar in nature to those used in the Mediterranean, possibly on ships constructed by the classical pegged mortise and tenon technique. However, these ships were not travelling in the Mediterranean but in and out of Red Sea ports, conducting trade throughout the Indian Ocean.
It would seem that ships operating in the Indian Ocean during the Roman Imperial period, the larger ones being about of 300-400 tons, were constructed and rigged in the Greco-Roman style, but in some cases at least with hulls made in Indian teak and sails also made with Indian Z-spun cotton. Brail rings, both wooden and horn, were attached to square sails and served as a guide to ropes that ran up the face of the sail in order to facilitate the furling of the sail. All the brail rings that have been recovered have one, and in some cases two pairs of small holes pierced through their edges for the purpose of attaching them to the sail. One brail ring had a piece of cotton sail cloth still attached. The sail robustness was extremely important not only because of length of the voyage, but above all for resisting the very strong winds during the ocean crossing, particularly in the Socotra area. When those furious winds stretch the sails, rigging and ropes that connect them to the ship's hull have to resist together like a wall against the air flow, otherwise the crew risks a tragedy.

The Periplus Maris Erythraei refers to the export of teak and 'a considerable amount of cloth of ordinary quality' from, amongst others, the port of Barygaza in north-west India, which perhaps were also utilised in Red Sea shipyards. About this topic it is worthwhile to consider that:

PME 36 ***"To both of these market-towns [***Apologus in the Persian Gulf and Ommana in the Oman Gulf***] large vessels are regularly sent from Barygaza, loaded with copper and sandalwood and timbers of teakwood and logs of blackwood and ebony."***

This passage confirms the fact that various types of woods were traded from India toward the West, both trough the Persian Gulf and along the Arabian coasts. From the latter it is then plausible the a part of this cargo reached also the red Sea ports for shipbuilding.

PME 41 *"**Beyond the gulf of Baraca is that of Barygaza and the coast of the country of Ariaca. The metropolis of this country is Minnagara, from which much cotton cloth is brought down to Barygaza."***

and

PME 49 ***" There are exported from these places [***Barygaza region***] spikenard, costus, bdellium, ivory, agate and carnelian, lycium, cotton cloth of all kinds, silk cloth, mallow cloth, yarn, long pepper and such other things as are brought here from the various market-towns."***

This passages confirm an important exports of cotton cloth, mainly manufactured in Minnagara, from Barygaza toward the West.

When examining the conditions in which the Indo-Roman trade was carried out, at least during the first half of the I century A.D., it is compulsory referring to the normal standard of the large part of used oneraria ships and not to a particularly efficient type of vessel, just because that trade was performed, according to Strabo, by ***"120 ships per year on average that brought oriental goods from Muziris to the Roman Empire"***. Strabo probably wrote this sentence in the early days of Augustus reign, perhaps after his voyage in Africa with the prefectus Elius Gallus, exactly when the Indo –Roman trade had an explosive beginning following the Egypt conquest and the roman domination of the Red Sea traffic. As a matter of fact he wrote also that "***formerly not even twenty vessels ventured to navigate the Arabian Gulf, or advance to the smallest distance beyond the straits at its mouth; but now large fleets are despatched as far as India and the extremities of Ethiopia*** [Africa]". Such a large number of ships could have been constituted, at least initially, only by the merchant ships normally available there, which were not enormous..
On the other hand it is also probable that with the passing of time, the trade development and the money earned, larger ships were utilized, a part of which directly built in the Red Sea using Indian teak and cotton. Consider for instance the valued tonnage of the ship Hermapollon, cited in the Muziris papyrus, being 250 or even more tons and very probably a three masted vessel.

About the topic of ships dimensions the following citations could be useful:

PME 10. Beyond Mundus, sailing toward the east, after another two days' sail, or three, you reach Mosyllum, on a beach, with a bad anchorage. There are imported here the same things already mentioned, also silver plate, a very little iron, and glass. There are shipped from the place a great quantity of cinnamon, (so that this market-town requires ships of larger size),

PME 16. Two days' sail beyond, there lies the very last market-town of the continent of Azania, which is called Rhapta; And the people of Muza now hold it under his authority, and send thither many large ships.

PME 46 (Baryzaga) The rush of waters at the incoming tide is irresistible, and the anchors cannot hold against it; so that large ships are caught up by the force of it, turned broadside on through the speed of the current, and so driven on the shoals and wrecked

PME 56 They send large ships to these market-towns on account of the great quantity and bulk of pepper and malabathrum,

PME 57 This whole voyage as above described, from Cana and Eudaemon Arabia, they used to make in small vessels, sailing close around the shores of the gulfs.

So those ships were not huge, with large hull to accommodate a great quantity of merchandise, with only one square sail named **acatus** and possibly an **artemon** on the bow and a little triangular sail at the top of the mast in case of weak winds. Even it is known that there were also **muriophoroi**, literally "carriers of 10,000 amphorae" (500 tons), considered the largest ships of the late republican and imperial period, and ships capable of carrying up to 1200 tons such as the Isis, ship of the Alexandria grain fleet described by Luciano [3.1] , which was operative during the II century AD, nevertheless if those or alike were employed in the oceanic trade they couldn't be the mainly utilized ships but only not frequent exceptions.

3.1) (Navigium, 5) 53 meters long, 14 meters wide and 13 meters high from the keel to the deck

Consequently it is better to adopt a conservative approach and consider only “normal size merchant vessels” when discussing about this oceanic trade, with a mean tonnage of 100-150 tons and a maximum of 250 tons. They could possibly be divided in two categories:

- **Contained size ships**, especially utilized for coastal navigation from the red Sea toward Arabia, Persia and northern India, or from Bab el Mandeb toward Berber ports and beyond to East Africa coasts; they probably had only one mast and in certain cases another little sail.

- **Medium and large size ships** (100 to 250 tonnes) presumably employed for long range navigation through the ocean directly toward South India for trading great quantity of cargo like pepper and malabathrum (cinnamon); they had two or even three masts and could afford an ocean crossing on deep blue sea. During the second century it is also possible that the tonnage of the larger ships could be arisen even more.
  Example of them are the two or possibly three-masted sailing ship scratched on a sherd of rouletted ware found at Alagankularn, a graffito on plaster with a two-masted sailing ship found at Khor Rori, and a three-masted ship in a rock-drawing near Myos Hormos.

Fig. 3.1 Roman small merchant ship
(from Ancient Ports - Ports Antiques)

Another important topic for the aim of this essay is the ships speed: surely one cannot expect high velocity for such type of “round ships”, whose proportion between length and width probably was 3-4 to 1. The resistance to the advancement of the hull in water is due both to viscous friction phenomena and to energy dispersion due to the creation of vortices, in addition to the energy expended by the ship to create the wave system that it itself generates. This resistance is proportional, at equal speed, to the "wet surface", or the total surface of the hull immersed in the water. Hence the needed power for propelling the ship against this resistance is proportional to the wet surface.
For instance a doubled length and beam ship with the same shape has a double wet surface and for keeping the same speed it must double the power, that is to have more sails, but doubling the sails does not double the power because a sail masks the wind to the next diminishing the thrust.
In short a larger ship needs more then the double of sails, perhaps the triple, for having the same speed of a half-size vessel. Those were the double or triple mast ships of the Yavanas so admired by the Indian people.

The possible conclusion is that probably the larger ships used for the trade had the same speed of the smaller ones, and only three advantages:

- They had more cargo capacity to use in a long voyage that lasted several months

- They were more skilled for oceanic conditions and therefore with a better resilience.

- Due to their greater volume they could also host some armed guards (probably archers) for defence from pirates, exactly as it happens nowadays too.

Obviously their employment was much more costly, in term of needed crew, lease and maintenance than that of a smaller ship, so they were used only for long oceanic voyages and great volume or weight cargos, like for instance timber transport or pepper and malabathrum trade, the latter being so extraordinarily profitable to allow and justify without problem the rent of a very large ship.

Monsoon regime in the Indian Ocean

The monsoon regime is well known from the antiquity, and certainly sailors of any epoch have taken advantage of it. By the way the word Monsoon is derived from the Arabic word ‘mausim’, meaning seasonality, and it is exactly this that characterises this winds regime, namely a seasonal shift in the winds.
The existence of the monsoon was recognized long before it was given this name. Between 2294 and 2184 BC, the Chinese Emperor Shun wrote a poem entitled “Southerly Wind”:

Gently blows the southerly wind,
That eases my people’s resentment.
Timely comes the southerly wind,
That makes my people’s wealth grow.

This is the first historical evidence of knowledge of monsoons from four thousand years ago, which were certainly already known to many people of whom there is no longer any memory.

The winds shift because the temperature of the land and the temperature of the water are different as seasons change. For example, at the beginning of summer, the land warms up faster than bodies of water. Monsoon winds always blow from cold to warm. In the summer, warm air rising off the land creates conditions that reverse the direction of the wind.

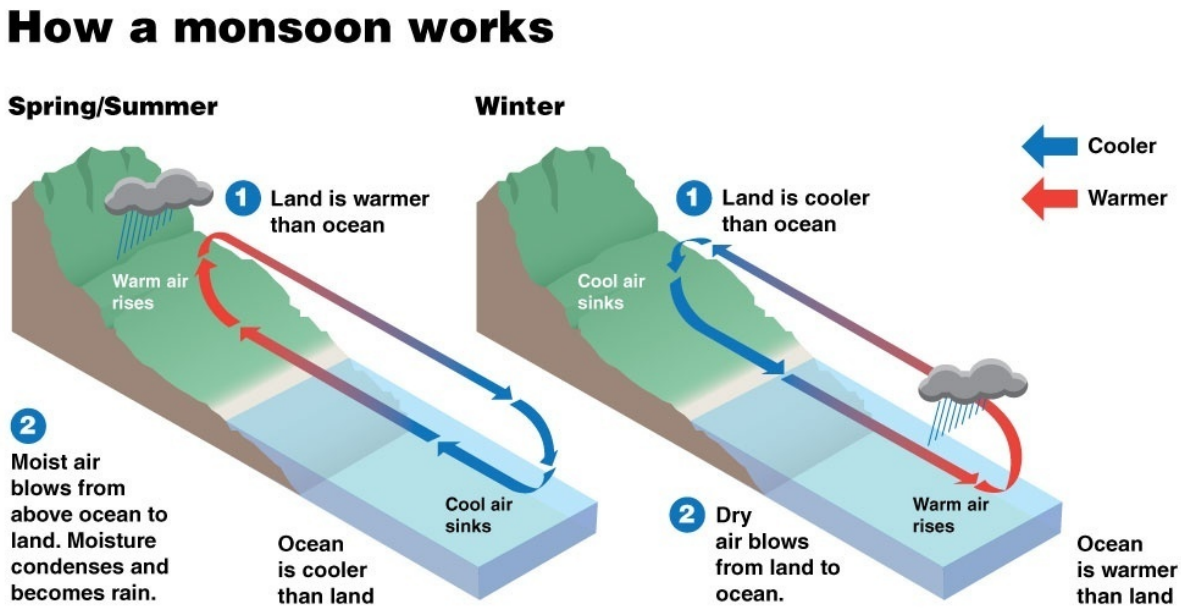


Fig. 3.2 Monsoon surface thermal mechanics (source NOAA/JPL**)**

The Indian Ocean with its 10,000 km width is the smallest of the three oceans of the planet, but that does not simplifies navigation as both geography and meteorology dictate for it particular characteristics. In the most interesting area for commercial sailing traffic of antiquity, included in the strip between the northern tip of Madagascar - South coast of New Guinea and Asian continent (Arabian Sea - Bay of Bengal), monsoons generate winds and currents that reverse during the year, mainly eastwards during the summer and otherwise during the winter. This imposes a clear six months periodicity to oceanic sailing traffic, independent of the actual distance of the destination

and the speed of the crossing. So any round trip forcibly lasted long time, cause it must adapt, in its development, not only to the frequency and direction of the winds and currents, but also to the uncertainty about the exact dates of their establishment that are dependent, with great variability, from the annual anomalies of the Pacific current El Niňo.
As it was mentioned, the wind regime is regulated by the monsoons, and can be roughly divided into four periods:

- Winter monsoon from mid-November to mid-March, winds from the North East on South China Sea and Bay of Bengal, winds from the north on the west coast of India;

- Inter-monsoon phase from mid-March to mid-May, unstable weather with the possibility of hurricanes, gradual rotation of the winds from the northeast to the southwest;

- Summer monsoon from mid May to mid September, humid and rainy weather (rainy season), prevailing winds from the Southwest both in the Indian Ocean and the South China Sea;

- Inter-monsoon phase from mid-September to mid November, unsettled weather with the possibility of hurricanes, rotation of the winds, cyclonic and messy circulation with conflicting winds;

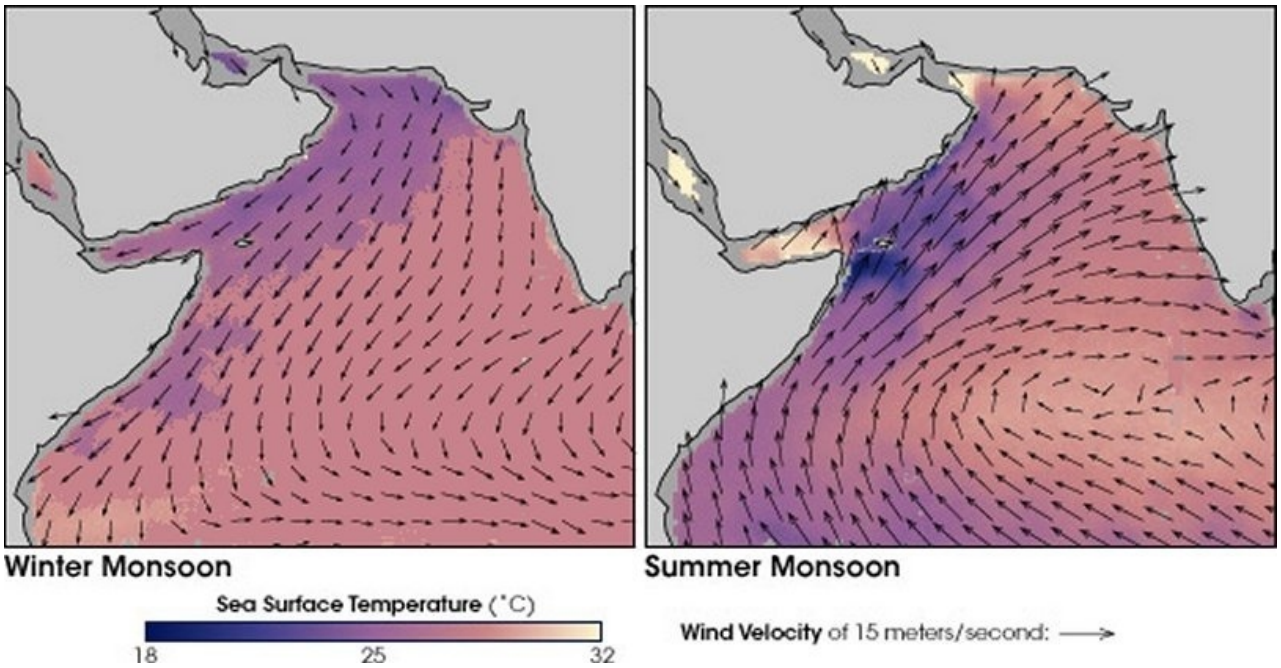


Fig. 3.3 Monsoon winds (https://earthobservatory.nasa.gov)

So the tense and constant winds characteristic of the full monsoon, with a variable force between six and ten knots and spikes up to fifteen to twenty knots, favoured in the past the sailing ships on long distance traffic, contemporaneously creating a precise calendar for the oceanic navigation.
On the other hand, both during the summer monsoon and during the winter can also occur sudden and dangerous wind strength increases (surges), with maximum of 60 knots north-east of Socotra during the summer and around 40 knots in winter, with 7 metres waves, that instead of fostering more rapid navigation were feared because of the possibility of sails tear and falling of masts or even capsizing.

It's good to point out that the seasonal monsoon onset is not as regular as a clockwork, it changes from year to year and from area to area, gradually establishing itself proceeding from north to south in the late autumn and going from south to north at the end of spring. The navigation so depended not only on time of year and traversed area, but also by the inevitable meteorological vagaries whose warning signs could only be interpreted by experienced sailors.
Not only does this seasonal cycle affect weather patterns on land, it also particularly affects the Arabian Sea itself. Because the Arabian Sea is landlocked in the north, it is largely cut off from large-scale ocean circulation patterns, allowing local winds to play a significant role in ocean temperatures. [3.2]
The preceding image shows both wind direction (arrows) and ocean temperatures (colours). Dark purple indicates cooler sea surface temperatures, and pinkish-yellow indicates warmer temperatures. Cool waters are most prominent near the Arabian Peninsula during the summer monsoon. During the summer monsoon, strong, steady winds push water on the sea surface toward land. In response to the intensified winds and resulting surface-water movement, cooler waters rise up from the ocean depths. Although temperature variations still exist during the winter monsoon, the temperature gradient is not as extreme.
Oceanographers discovered an increase in the intensity of the summer monsoon winds since 1997 after satellite data revealed large increases in phytoplankton (tiny ocean plants) in the Arabian Sea. The stronger winds drove greater upwelling of deep, cool water. Upwelling of cool waters affects phytoplankton growth because the cool waters are rich in nutrients.

Sea surface temperature is the temperature the ocean surface presents to the atmosphere, which influences weather and climate around the globe. The wind, warmth and water content of the atmosphere are all strongly determined by the distribution of sea surface temperature as the ocean interacts with the air above it.
The result of the current Earth warming is a rise of global heath, of which more than 90% is stored in the oceans, while the residual heat is manifested in the form of melting of both land and sea ice; consequently the most important elements influencing climate are the oceans and their temperatures. From the 80s the development of this phenomenon has been documented by satellites. The tropical Indian Ocean (40–120°E, 30°S–30°N) underwent basin-wide warming during the last 150 years (1871–2020). From an average sea surface temperature (SST) of 26.44°C in the 1870s, the basin-average SSTs raised to 27.2°C by the 2010s [3.3] . Moreover sea surface temperature and upper ocean heat content (OHC, upper 700 m) in the tropical Indian Ocean underwent a rapid warming during 1950–2015, with the SSTs showing an average warming of about 1 °C, with a maximum over the Western portion of it (Arabic Sea) [3.4] .
The ocean warming affects also the monsoon winds regime, but it does not appear to change uniformly their stress and direction, but rather reinforcing or weakening them differently in different areas. For instance over the equatorial Indian Ocean the zonal wind stress is reduced while it is increased over western Indian Ocean near Somali coast and Northern Arabian Sea, while the surface wind speed associated with the East Asian monsoon has significantly weakened during both winter and summer in the recent three decades. [3.5]

3.2 http://earthobservatory.nasa.gov/Study/Monsoon/
3.3 Future projections for the tropical Indian Ocean, M.K. Roxya and alias
3.4 Indian Ocean Warming, M.K. Roxya and alias
3.5 Recent Changes in the Arabian Sea Warming-Causes and Implications, Arika Amasarao; Intensification and deepening of the Arabian Sea oxygen minimum zone in response to increase in Indian monsoon wind intensity, Zouhair Lachkar and alias.

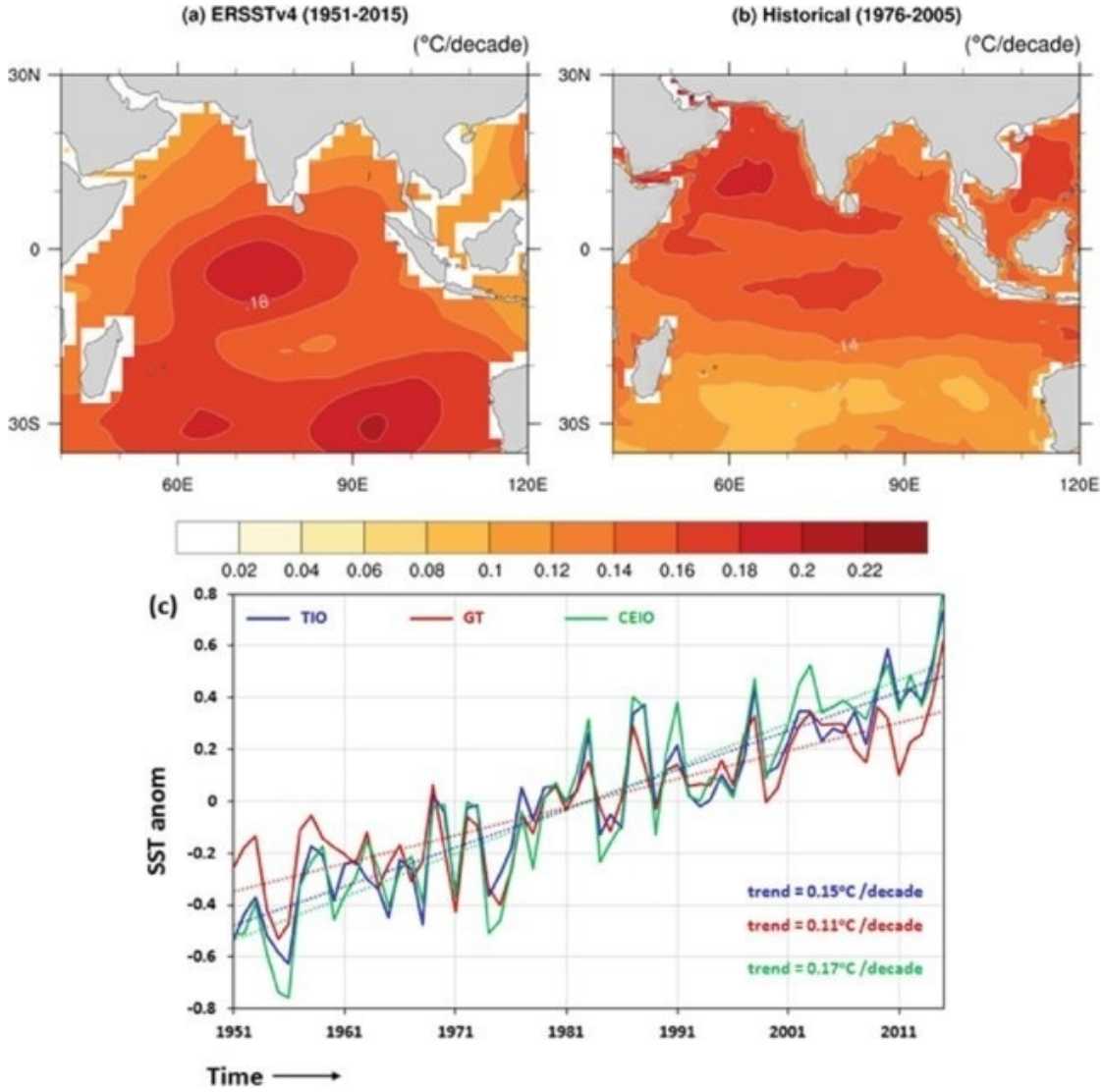


Fig. 3.4 **Sea surface temperature (SST)**
(Indian Ocean Warming, Roxy et al., 2020)

Particularly the Arabian Sea witnessed dramatic multi-decadal warming trends in surface and sub-surface waters, with an assessed slight increase of 1,6 % over the last 40 years.

Although the determinants of the changes in the intensity of the Indian monsoon winds are still unclear, both recent and paleoclimatic research suggest a strong relationship between Northern Hemisphere temperatures and the intensity of the Indian monsoon wind. Typically, increased intensity of the Indian summer monsoon has been recorded during warm periods, while reduced intensity of the summer monsoon has been found to correspond with cold periods.
Consequently the colder sea condition of western Indian Ocean 2000 years ago suggest some more wind force over the equator, and a lesser one in the Arabian Sea over which the Greco-Roman trade was carried on.

The rise in temperatures occurred in the recent past, and continued until today, is important for the present study because the intended simulation of Greco-Roman trade 2000 years ago should be the closest to conditions of that epoch. But what were the Indian Ocean weather conditions 2000 years ago ?

A possible answer comes from a study conducted by Ganssen about the Arabian Sea surface temperature ranges during the past 20 000 years, whose conclusion are exemplified in the following figure 3.5.
The Ganssen research is based on calcification of planktonic foraminifera extracted from the Western Arabian Sea, whose age is assessed with oxygen isotopes measurements.
The results indicate that over the past 20 kyr the seasonal summer temperature range has fluctuated from its present value of 16 °C to mean values of 13 °C and 11 °C for the Holocene and LGM (Last Glacial Maximum), respectively.
As can be seen in fig. 3.4 in 2011 (the publication year of the work) mean summer water temperature was variable between 15,8 ° and a maximum of 30,6 °, as the foraminifera testify. Instead 1800 year ago the summer temperature variability was rather minor, from a minimum of 17,3 ° to a maximum of 26,8 °. Then at that epoch the Arabian Sea summer temperature was a little bit warmer as minimum and fairly colder as a maximum.

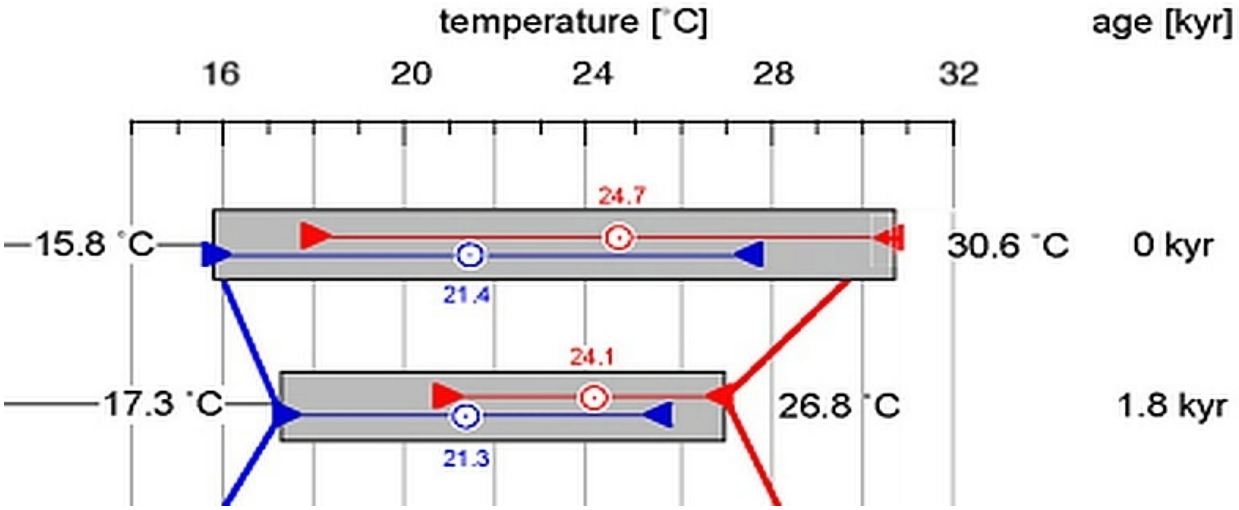


Fig. 3.5 Arabian Sea temperatures in the past [3.5]

As monsoon wind force depends from difference of temperature between sea in the South and land in the North, probably wind speed was a little bit greater during night and fairly inferior during day than that of today. Hence:

- Data used for assessing winds force and direction are those detected by QSCAT during 1999-2000, so to limit to the maximum extent the consequences derived by global warming.
- In assessing wind speed from satellite images, when some uncertainty it exists, lower value will be preferred.
- When examining coastal routes travels, carried on only during daylight, a bit lower wind force should be considered.

Other studies also argue that the rise of temperature has the effect of delaying the monsoon onset, then it is possible that 2000 years ago this could occurr some day before than now.

3.5 Quantifying sea surface temperature ranges of the
Arabian Sea for the past 20 000 years, G. M. Ganssen et al.

Even more complicated is the system of currents, with a rotating pattern and also with a semiannual cycle that reverses itself in summer and winter. In winter the North East monsoon creates rotatory currents, with a weak counterclockwise rotation in the Arabian Sea (heading to the west along the western coasts of India), while during summer currents favour ships coasting Arabia toward the North and then vessels descending India's West coast toward the South.

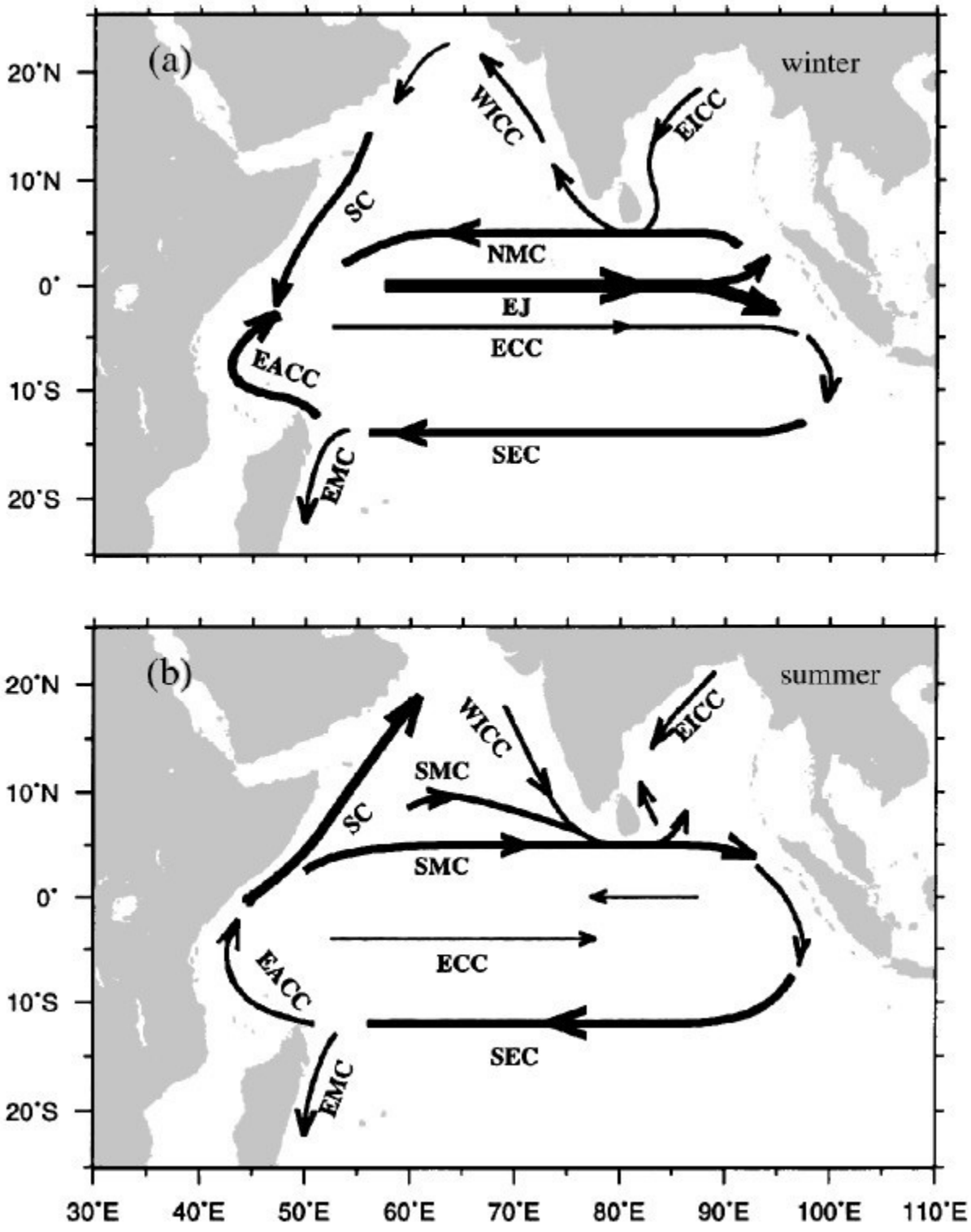


Fig. 3.6 Surface currents in the Indian Ocean during winter (a) and Summer (b) * SSC Shenoi, PK Saji and AM Almeida, Journal of Marine Research, 57, 885–907, 1999

As could be seen in the preceding Figure 3.6 the currents regime during summer supported the vessels travelling toward India along the arch of Arabian Sea northern coasts, and equally facilitated their return journey. There are no evident reason for supposing that during the first century favourable currents were not pushing vessels toward their destination, so this fact should also be taken into account when discussing travels conditions and timing.

Obviously all the preceding topics that have been examined and the observations made have absolutely not the goal to be considered as demonstrated truths, but only as the attempt to approach those meteorological conditions under which the Greco-Roman trade was implemented during the first century A.D., that nevertheless will remain historically completely unknown.

As this study intends to reconstruct routes and timing of Greek-Roman vessels toward Muziris, trying to localize this ancient port based also on the Pliny's affirmation that the voyage from Ocelis lasted 40 days, it is exactly for this reason that the monsoon winds direction and force is important to be used in the suggested research.
For this purpose and for the reasons stated above, only the data collected by the QSCAT satellites throughout 1999- 2000 over the Indian Ocean will be used.

Voyage periods, routes and ports

Periods

The direction and duration of winds in both the Red Sea and the Indian Ocean were so influential that they determined the sailing season and routes of merchant ships voyaging between the Egyptian Red Sea and the coast of India. The key Egyptian Red Seaports that were involved in eastern trade were Myos Hormos and Berenike.
Supposing that the climatic set-up in Red Sea has not changed from that epoch, the descent toward the Gulf of Aden could not start before northerly wind change direction and begin blowing toward the South, what now occur on mid-May or perhaps some day before 2000 years ago.

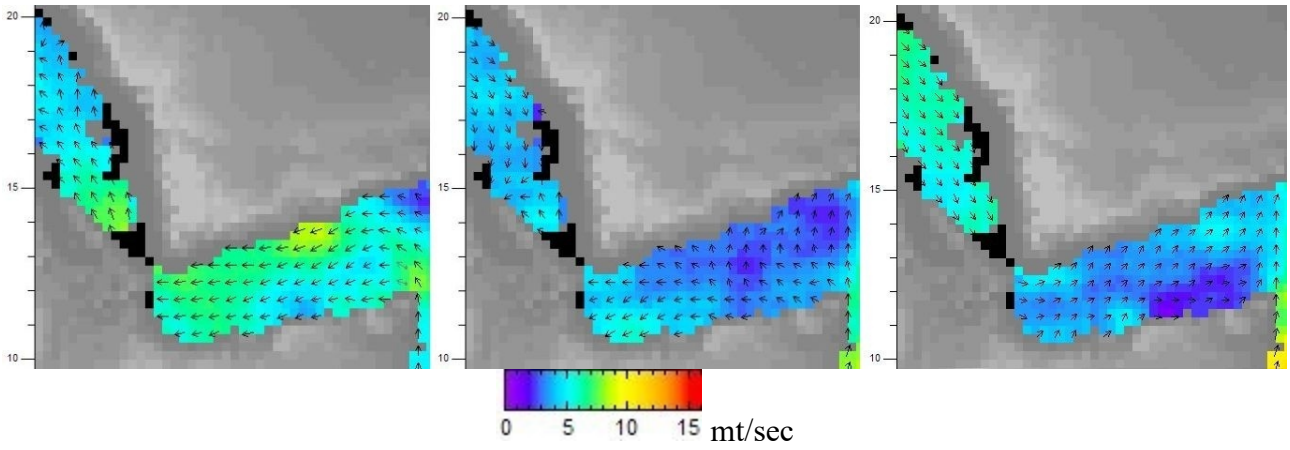


Fig. 3.7 Wind reversal in Red Sea and Gulf of Aden, on May 6, 13, 20
(source QSCAT satellites data)

There were two departure periods from Berenike for trading ships:

- Initially departed the ships heading for the Gulf of Aden and then the coast of Arabia or the Berber coast, sailing from around mid-May after the Red Sea wind reversal, reaching their destination within the month of June, and so avoiding the dangerous wild winds of July.

- Then on late June or early July began the voyage of ships heading for India, following both the route along the Northern arch of Arabian Sea coasts toward North-West India, and those heading toward Southern coast of India by crossing directly the ocean sailing toward East. So Roman ships going to India either went along the Arabian coast, diverting then the route toward the major ports of Barbarikon and Barygaza, or they took a more direct route across the Indian Ocean to southern India, to ports such as Muziris and Nelcynda

The voyage from Berenike to India took about two months, resulting in ships reaching the Indian coast in September. However, the north-east monsoons on the west coast of India did not begin until late November, therefore Roman merchants and seamen had about two-three months stay in India to accomplish their trade business and maintain their vessels, before starting their return trip.
According to Pliny ships set sail back from India in December or early January utilizing the north-east monsoons, arriving in Egypt in March or April. Accordingly, a voyage to and from India could be accomplished in less than a year.

Routes

Ships starting from Egypt, both Roman and Greek or Egyptian, were heading for different destinations in Africa, Arabia and India; the mainly followed long-range courses were:

- An African route to Berber land, Cape of Spices and down to several ports along Eastern Africa shores, till the latter known, Rhapta. Navigation was performed normally by small boats or even larger cargo ships headed to Mosyllum for the cinnamon trade (PME 10) or from Muza to Rhapta. Ships doing cabotage along the coast of the continent, probably making some intervening stops for water and food supply, during the voyage between ports distanced by two or three days sailing one from the other.
  For instance, as it will be shown in a next paragraph about that epoch ships velocity, the voyage from Malao to Mundus at a mean speed of 3,9 knots, with an almost fair wind of 16 knots on early August, allowed the route of 126 nautical miles to be covered in about 32 hours, or about 2,5-2,7 days sailing beside the coast only during 12-13 hours of daylight.

- Other ships followed a route toward Eudeamon, Cana, Moscha and Sarapis along the South-Eastern coast of the Arabian peninsula, then some continued to Barbarikon and Barygaza in India in the second half of August, detaching themselves from the coast probably after Moscha and heading straight North-East to their destinations (PME 57), with a powerful mean tail wind of 18 knots and a favourable current of at least 1 knot, reaching for instance Barbarikon (750 nm) in 7 days or the bay of Barigaza (990 nm) in 9 - 10 days at a medium speed of 4,5 knots. Some of them, after having downloaded there some merchandise, could also prosecute the navigation along the western India's coast heading for other ports in the South.
  A historically known example of this route is that of the Honainu's ship; at Palmyra, in present-day Syria, in the temple of Bel and in the agorà it has been excavated a 3rd-century AD bas-relief depicting a merchant ship of the kind that sailed in the Mediterranean and the Indian Ocean, as well as a bilingual inscription, Greek and Aramaic, dated to 157 AD; it mentioned Honainu, a captain on whose ship merchants travelled from Mediterranean to north-western India. The Palmyrenes, although they had built their fortune by providing caravans to cross the desert, sometimes led merchants themselves to the Persian Gulf and the Indian Ocean. Honainu's ships probably sailed headed to the port of Barbaricum, situated at the middle of seven mouths of the Indus. Honainu's ship is no exception, for at least one other inscription mentions a second ship-owner, Beelaios son of Kyros.

- Furthermore there were the vessels heading directly to Southern India for the pepper and malabathrum trade, which after a 30 days descent of the Red Sea stopped in Ocelis for a water supply and then headed directly toward Socotra and the open ocean crossing.
  Perhaps some ship made a stop for supply and water along the route, for instance at the Nile Ptolemy market-town Tapatege or at the Spice Port near Cape of Spices.

Ports

Unlike modern-day ports that are developed as artificial facilities along the coastline, the ancient ports were built near river mouths to facilitate easy entry of vessels into the mainland and safe docking. Otherwise, as in the case of Muziris, large ships moored before the river mouth and lesser boats transported merchandises to and from the land mart.
Often market towns where trade was performed did not correspond to the port localization but were in the land interior along a river path.

The river deltas of India are favourable for navigation and the distributaries branches associated with their mouths naturally led to the development of many **ports**. The large lagoons, lakes, etc. provided sheltered water bodies in which a large number of ports also developed.
Pattanam is a term derived from Prakrit 'Patan' which originally meant a ferry point; later it was used to refer to coastal and port towns.

About some of those ports and market towns we know names and localization, of other – like Muziris - only the name but not the position with certainty; there were also surely a great number of other ports of call whose name and position have been cancelled by the time passing and that will remain unknown for ever. It would also be considered that a certain number of all those ports could have been erased by transforming phenomena like bradyseism, quakes, tsunami, silting up and floods, so that their current unrecognisable position is under water or on plain ground. Only patient and lucky archaeologists' work can perhaps show something more in the future.

Roman ships navigation speed

During the day navigation could be guided with the sun's position in the sky, allowing to follow at least roughly a direction, provided that the sea conditions permitted it; it is so probable that the real course of a ship in high seas, without any possible terrestrial reference on the coast, was not a straight line but a wiggly one, thus increasing the duration of the voyage.
At night navigation could be controlled by the height of stars on the horizon, sighting a reference star like for instance the Polaris. This method could be also improved by confronting the height of two known constellations for appreciating possible changes in the latitude of the vessel.
The advantage was that it was not necessary to know the precise time of the night to apply it, as can be verified using any planetarium program: indeed it was enough to wait for a reference constellation had reached a suitable height in the sky and check the height of the other constellations, to ascertain whether the latitude was the one expected or if a shift had occurred, which could then be corrected on the basis of the information collected.
They were obviously crude and imprecise methods, but better than nothing and still being able, if not to make the ship's position, at least to detect significant errors of direction.

In the following discussion we will utilize some sailing expressions for describing a ship's pace, named points of sail, depending on the direction of ship's course and the wind's direction.
They are shown in the next picture.

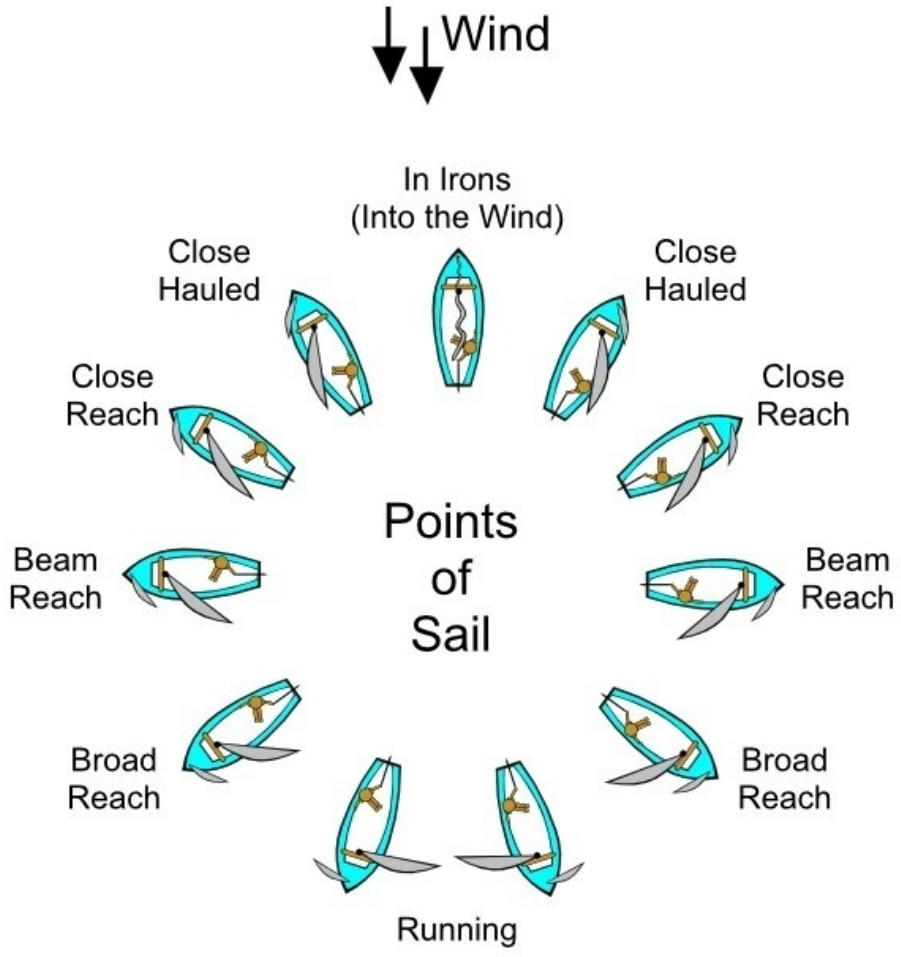


Fig. 3.8 Ship points of sail

Finally it should be considered the relationship between the force of the wind and the speed of a fully loaded merchant square sailed ship. Obviously we have not affordable information about Greco-Roman merchant ships speed, since for any voyage of which we have a recorded notice exact ship characteristics, cargo, sea and wind conditions are not known, in addition to the mere fact that sources considered them generically "favourable".
So it is only possible to refer to roughly mean evaluations on the basis of all possible data, such those resumed in the following table, using them with caution since certainly the oneraria ships were large and slow at full load.

Reference	Voyage	Nautical Miles	Length of Voyage (days)	Overall Speed knots
Livy 29.27	Lilybaeum - Cape Mercury	65	1	2,7
ND	Utica - Caralis	140	2	3
Caesar Bell. Afr. 34	Lilybaeum - Ruspina	140	3,5	1,7 *
Polyb. 5.109−10	Sason - Cephallenia	160	1,5	4,4
Acts 28:13	Rhegium - Puteoli	175	1,5	5
Procop. Wars 3.25.21	Carales - African Coast	200	3	2,8
Philostr. V. A. VIII.15	Puteoli - Tauromenium	205	2,5	3,4
Pliny's record	Ostia - Africa	270	2	5,6
Strabo 10.4.5	Cape Samonium in Crete-Egypt	310	3 or 4 (3,5)	4,3 or 3,2 ** (3,7)
Diod. Sic. 3.33	Rhodes - Alexandria	325	3,5	3,9
Appian B. C. 2.13.89	Rhodes - Alexandria	325	3	4,5
Pliny's record	Ostia - Provincia Narbonensis	345	3	4,8
Diod. Sic. 5.16.1	Pityuses - Gibraltar	390	3	5,4
Marc. Diac. Vita Porphyr. 55	Byzantium - Rhodes	445	5	3,7
Synesius, Epist. 51	Phycus - Alexandria	450	4,5	4,2
ND	Alexandria - Ephesus	472	6	3,3
Plut. Dion 25.4−5	Greater Syrtes-Heracleia Minoa	475	4,5	4,4
Thuc. 2.97	Abdera - Mouth of Danube	500	4	5,2
Pliny's record	Ostia - Hispania Citerior	510	4	5,3
Lucan 9.1000−5	Troy - Alexandria	550	7	3,3
Procop. Wars III.18.4	Epidamnus - Rome	600	5	5
Philostr. Vita VII.10	Corinth - Puteoli	680	4,5	6,3
Sulp. Severus,	Syrtes - Alexandria	700	6,5	4,5
Marc. Diac. Vita Porphyr.. 6	Thessalonica - Ascalon	800	12	2,8

Scylax, Periplus 111	Carthage- Gibraltar	820	7	4.9
Plin. HN XIX.1.3	Messina - Alexandria	830	6	5.8
Marc. Diac. Vita Porphyr. 27	Byzantium - Gaza	855	10	3.5
ND	Byzantium - Gaza	855	10	3,6
Diod. Sic. 3.33	Cimmerian Bosporus - Rhodes	880	9,5	3.8
ND	Ganges - Sri Lanka	900	7	5,4
Pliny's record	Ostia - Gibraltar	935	7	5.6
Plin. HN XIX.1.3	Puteoli - Alexandria	1000	9	4.6
ND	Gades - Ostia	1030	7	6,1
MEAN SPEED				**4,39**

Tab. 3.1 Ships speeds sailing with favourable winds.

***** The voyage from Lilybaeum cape to Ruspina, cited in Caesar Bello Africo 34, was made by a fleet of oneraria transporting troops and supplies, where the speed was dictated by the slower ship; for this reason the relating speed figure was not included in mean calculation. This is the corresponding citation:
Sallustius interim praetor a Cercinitanis receptus **magno numero frumenti invento naves onerarias** quarum ibi satis magna copia fuit, complet atque in castra ad Caesarem mittit. Allienus interim pro consule **Lilybaeo in navis onerarias** imponit legionem XIII et XIIII et equites Gallos DCCC, funditorum sagittariorumque mille ac secundum commeatum in Africam mittit ad Caesarem. **Quae naves ventum secundum nactae quarto die in portum ad Ruspinam,** ubi Caesar castra habuerat**, incolumes pervenerunt.**

Which ships, immediately encountered a favorable wind, the fourth day in the port of Ruspina, where Caesar had his camp, safe and sound arrived.

** The cited source says**: "**and the voyage from Samonium to Aegypt takes four days and nights, though some say three. Some state that this is a voyage of five thousand stadia, but others still less."
Considered the uncertainty both on the time spent and the arrival location in Egypt, the mean has been calculated with the value of 3,75 knots for this stretch.

Furthermore it should be considered what, in term of wind force, can be a "fair wind" propelling the ship. We could then refer to the traditional Beaufort Scale that in the past was expressed only as sea and wind conditions, but is now referred also to the wind speed. Various editions of this scale exist, with tiny differences among them, but as for what is considered a fair, strong sailing wind, with sea waves not already disturbing the ship's running, they substantially agree on a value between 16-17 knots till 20-21 knots [3,3], what in sailing jargon is named "fresh wind" (moderately strong); this values correspond to 8,2 - 10,8 mt/sec, the mean being 9,5 mt/sec.
Now consider that:

- ancient sources cited only fair condition or fair wind in describing weather and sea state of the voyage: we can then suppose that such conditions were equivalent to a mean fair wind, that is about 9,5 mt/sec (18,5 knots),

- previously the ancient ships mean velocity has resulted to be 4,39 knots,

then the ratio between wind speed and ships speed is on average about 4,21 to 1.

Obviously the precision of this results deeply lose importance, due to the error inevitably introduced by the lack of information on ancient merchant ship performances and recorded voyages conditions, anyway they are a better then nothing guide in figuring out times of sea crossings, provided that we know that the final results can be largely different from what happened in reality and do not necessarily be an historical evidence. Nevertheless, as we are interested only on affordable average values for all the voyages carried out by Greco-Roman ships toward India, we could also assume that errors relating to any single voyage could be reabsorbed in the overall statistic. If any correction to the resulting values should be considered necessary, let's recall that those ships were large and relatively low, running to their destination with uncertain information about position and direction, so it is more probable that the crossing time was greater rather then lesser.

So for instance if the wind force is:

- 9 knots light wind (4,6 mt/sec) the ship speed could be 2 knots,

- 18,5 knots fair wind (9,5 mt/sec) then the ship speed could be 4,4 knots

- 30 knots, a really very strong wind (15,5 mt/sec) the ship speed could be 7 knots

This agrees well also with renowned evaluations made in the past by Casson.

In the following discussion this ratio will be then considered for all sea routes stretches when evaluating the time for covering a certain distance, with continuous navigation and a tailwind. When wind does not come from the stern then appropriate corrections will be applied supposing also that the crew had set the best sail configuration for such a situation. In ancient vessels the manoeuvrability of the square sail was very limited, with the consequence of a great penalisation in case of course into the wind, which was possible only with a very slow close reach pace and continuous changes of course.
A clarification is due: when following a route close to the coasts the ancient merchant vessels, for obvious reason of prudence, sailed often with daylight: consequently in this case all travel times have to be doubled.

3.3) cf. various Beaufort wind scales published on Internet

To this aim we can take into account only the component of the propulsion, generated by wind and sail, parallel to the course direction of the ship, that is roughly:

- 100% in case of tailwind
- 75% in case of broad reach
- 50% at best in case of beam reach
- 40% or less in case of close reach against the wind

We can then summarize all what has been exposed in the following table, recalling also that 1 mt/sec =1,924 knots.

Wind Speed		**Speed in knots for any Ship point of sail**			
knots	**mt/sec**	**tailwind**	**broad reach**	**beam reach**	**close reach**
10	**5,2**	2,4	1,8	1,2	1,0
15	**7,7**	3,6	2,7	1,8	1,4
20	**10,3**	4,8	3,6	2,4	1,9
25	**12,9**	5,9	4,5	3,0	2,4
30	**15,4**	7,1	5,3	3,6	2,9

Tab. 3.2 Wind ship propulsion

For an easier reference to wind speed expressed in meters per second , the ratio between wind force and ancient ships velocity is equal to (mt/s x 1,924)/4,21= mt/s x 0,457; for instance a 5 mt/s running wind push an oneraria at a 5 x 0,457 = 2,285 knots mean speed.

All figures shown have been calculated with decimals only for the sake of accuracy, but for what has already been said they are valid only as a largely approximate value.

Navigation in the Red Sea

The **Red Sea** region is unfavourable for an easy nautical activity as it lacks natural topographic features that could be used as harbours; there are only a few suitable bays (khor) for landing along its coasts, where wadi mouths allow for a break in the reef. However, despite its unpropitious seasonally variable winds and currents, parts of the Red Sea presented favourable marine environments for sea voyaging, contact and trade.
The Red Sea is divided in three zones by two lines of coral reef, little islands, shoals, and emerging or low depth rocks, each one beside its western and eastern coasts [3.4]; so those geographic features create three possible routes for ships navigation, that is:

- A central passage between the two lines of reefs, with islands, islets, and rocks somewhere also assembled in group; another characteristic of the central passage is the presence of cross current from east or west, whose velocity increases rapidly when approaching the dangerous reefs.

- An eastern passage between the East coast (Arabia) and the oriental reefs, dense of a dangerous and continuous extension of islands, islets, and emerging rocks; it often offers a very narrow passage to ships because of shoals and reefs almost connected to the shore and difficult to distinguish.
  During March and April, the land and sea breezes are more frequent on this side of the Red Sea than the Western side, and being transverse they push gently toward the beach or toward the reef.
  From May to July there is even thick hazy weather on the Arabian coast.

- A western passage between the reefs and the western coast (Egypt), but with fewer obstacles than those presented by the East coast. This passage constitutes what is named Inner Channel, sheltered partly by small detached reefs and sunken rocks, and partly by islands and extensive reefs, but that nonetheless it is a fairy large smooth-water channel; generally it is 1.5 to 3 miles wide, then safely accessible to ancient vessels. Somewhere the Inner Channel presents inside it also shoals and islets to be avoided, or it is connected to the Central Passage by openings in the reefs, some of which are of great width. The continent coast is somewhere sandy or rocky, but always to be approached with caution.
  Excessive refraction and mirages are frequent, causing land, lights, and other features to be visible from much greater distances than would normally be expected, being also an aid to expert seamen voyaging in it but on the contrary a source of dangerous mistakes for other ones.

Guessing the route followed by the time ships is easy, because of two facts:

- The main ports of the Red Sea were on the African side of the coast, like Myos Hormos, Berenike and Adulis.

- As those vessels had no radar or GPS and there were not lighthouses or beacons for signalling dangerous places, they forcely had to sail by daylight and stop during night.

So the obvious solution was sailing beside the coast in the Inner Channell, always with an attentive gaze to possible visible and above all sunken dangers.

3.4 Information extracted from Sailing Directions - Red Sea section

In ancient times therefore ships were used to follow the coast within this dangerous lane, which consequently forced them to an only diurnal navigation because of the cited obstacles.

The monsoon also manifests itself in the Red Sea with winds in alternate directions during summer and winter, up to the latitude of the ancient Egyptian port of Aydhab (perhaps the ancient Soteira, founded by the Ptolemaic dynasty) and the Arabian port of Jeddah; to the North of this limit the winds are normally steady toward the South, constituting a serious obstacle to navigation in the northern portion of the sea. Exactly for this reason the southern port of Berenike was built.
In the Southern portion of the Red Sea winds until the end of April are going North but change direction within mid-May, with a light wind blowing toward the South until Bab el Mandeb Strait, and toward the East into the Aden Gulf from mid-June, thus favouring the sailing of the ships leaving toward the ports of South-East Arabia. So vessels bound to Eudaemon, Cana, Moscha and Sarapis could leave Berenike near mid-May, reaching Bab el Mandeb only after 31-33 days by mid-June, due to the weak wind in the last stretch of the trip, and then reaching their destinations with a gradually reinforcing tailwind before the dangerous strong winds of July could settle in along the Arab coast.

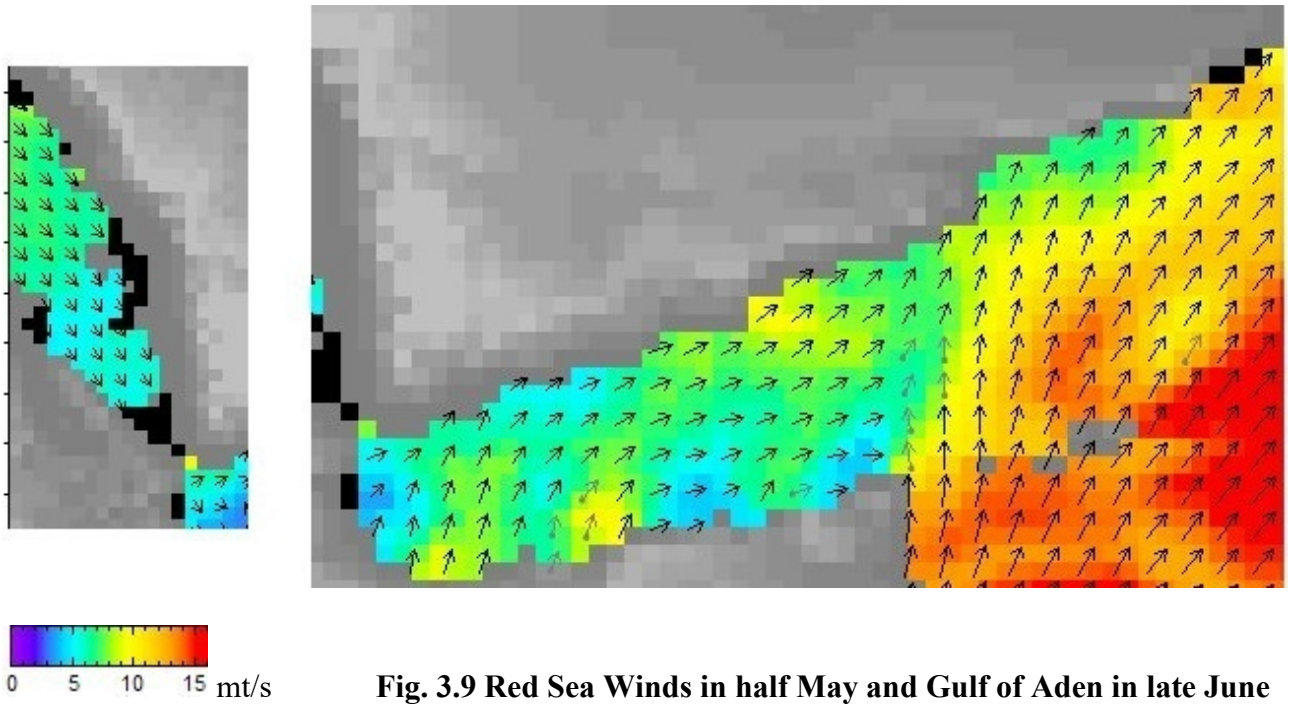


Fig. 3.9 Red Sea Winds in half May and Gulf of Aden in late June

In the following table appear calculated durations of the daylight voyage along Arab coasts from Ocelis to Moscha on the basis of length of every leg in nautical miles and wind force in mt/s:

Leg	Route Length	Mean wind	Mean Speed	Days	Total
Ocelis-Eudaemon	108 n.m.	5,5 mt/s	2,51	3,58	3,58
Eudaemon-Cana	222 n.m.	6 mt/s	2,74	6,75	10,33
Cana-Syagrus	258 n.m.	7,5 mt/s	3,43	6,3	16,63
Syagrus-Moscha	172 n.m.	7,5 mt/s	3,43	4,2	20,83
Moscha-Sarapis	398 n.m.	7,75 (max 12)	3,94	8,42	29,25

Table 3.3 navigation on the Arab coast in June

Obviously wind force, ship speed and days have to be considered only as largely mean values.

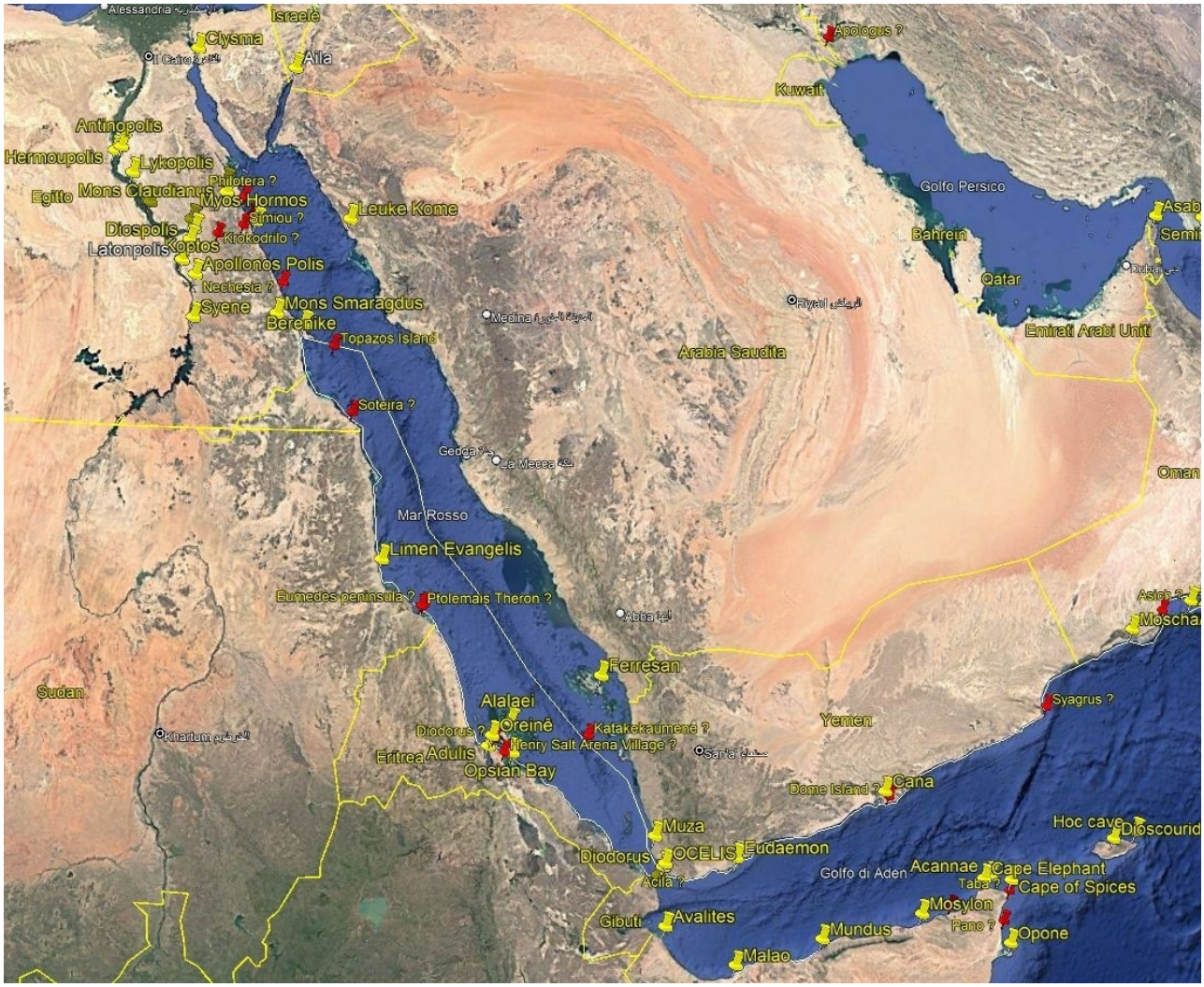


Fig. 3.10 Red Sea, Gulf of Aden and Arabian coasts

Ships bound to long-range destinations, like Indian ports, left instead on the beginning of July, reached Ocelis after 30 days of daylight sail in the Channel and then headed to Arabian coasts or directly toward the East for the ocean crossing.

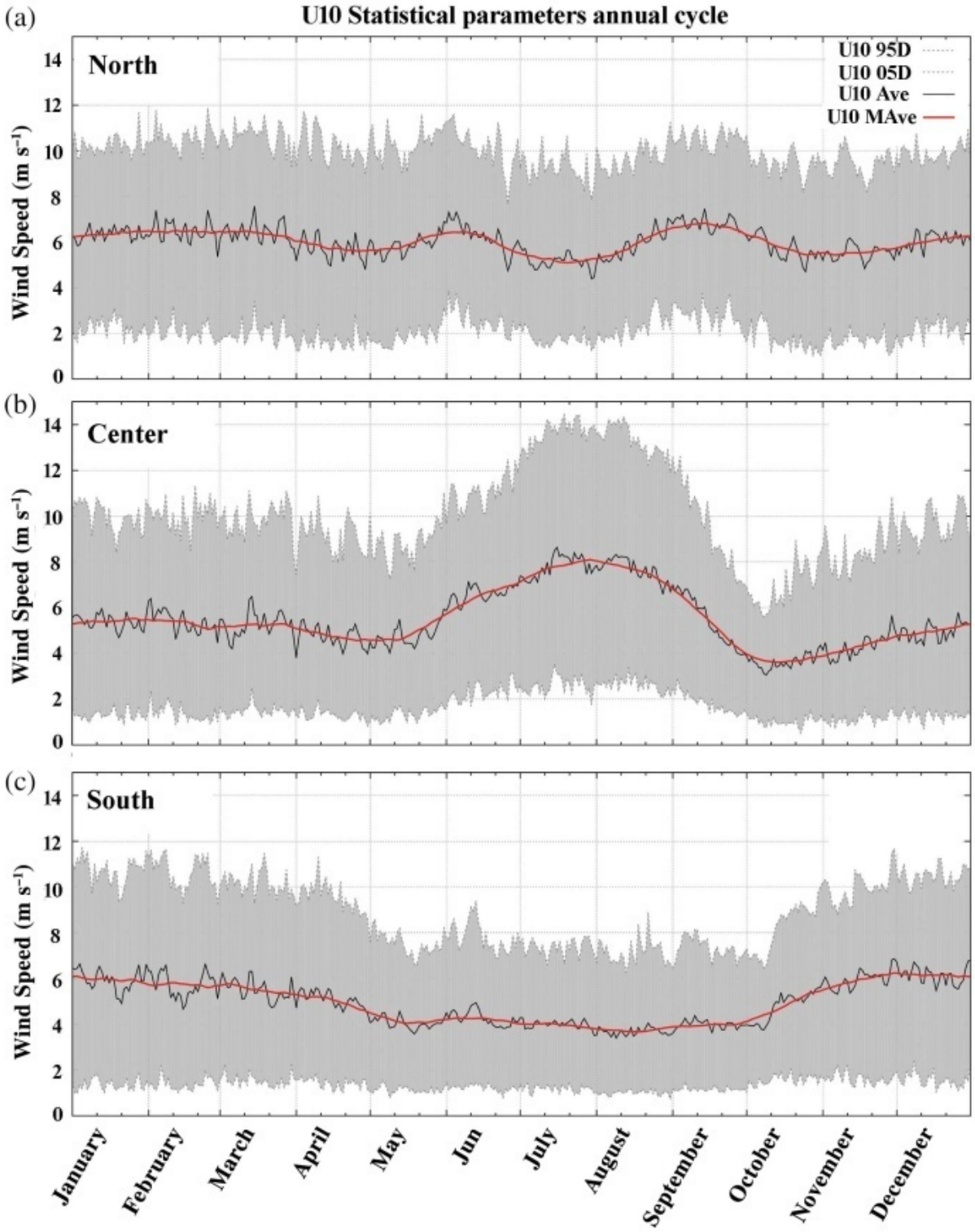


Fig. 3.11 Red Sea wind mean values in all seasons
(source The climatology of the Red Sea, Langodan et al-2017)

During the voyage in the Channell ships had to moore in safe spots at night, sailing in May with 5 mt/s mean tailwind (2,209 knots ship speed) and in July with a 5,83 mt/s mean tailwind (2,66 knots ship speed); with this conditions they employed respectively at least 34 days in May (27 nm each day without stumble upon a contrary current) and at least 29 days in July (31,5 each day) to cover the 912 nautical miles from Berenike to Ocelis.
Moreover, consider that probably the smaller ships had also to make some short stop for water supply and that the last stretch from the West coast to Ocelis on the East coast had to be covered with a lighter wind on the beam reach, so being more time consuming.
For these reasons they needed to often reach a safe spot for passing the night, that could be a khor, a shelter near an islet or a peninsula, one of the little harbours that were on that coast, like Soteira, Ptolemais Theron, Adulis.

Fig. 3.12 Sheltered mooring offered by the Khors, deep inlets at the mouths of the wadis

Some more notes on the Red Sea

Currents
The set of currents in the Red Sea is extremely variable and affected by several factors.
The velocity of currents increases rapidly in the vicinity of off-lying reefs from which it is better to stay away. Cross currents, setting E or W, are not infrequent, and are observed in all parts of the Red Sea. Occasionally during May there are NW currents also with winds blowing toward SSE.

The coast
The terrain between the mountains and the sea is low and sandy. This coast is fringed with reefs and there are numerous off-lying reefs. Excessive refraction and mirage are frequent, causing land, lights, and other features to be visible from much greater distances than would normally be expected. Vessels bound for ports on the W shore have to contend with Inner Channel, which is formed partly by small detached reefs and sunken rocks, and partly by islands and extensive reefs.

Fig. 3.13 Median Portion of the Red Sea

Noteworthy places (geographical data from Sailing Directions – Red Sea)

Geziret Zabargad (St. Johns Island, Topazos island) (23°37'N., 36°12'E.)
Topazos island or Ophiodes, due to the ancient presence of snakes, located far out at sea (Plin.HN.37.108; Strab.16.4.7.152)
This barren island rises to a sharp peak and is bordered by steep coral reefs which render it inaccessible, also because it is often covered by fog.

Strabo Geography, Book XVI, Chapter 4
"After the gulf, one comes to the island Ophiodes, so called from the fact in the case; but it was freed from the serpents by the king, both because of their destruction of the people who landed there and on account of the topazes found there. Topaz is a transparent stone that sparkles with a golden lustre — so dimly in the day-time, however, that one cannot easily see it (for it is outshone by the rays of the sun), but those who collect it see it at night, place a vessel over it as a sign and dig it up in the day-time. There was an organisation of people who were appointed by the kings of Aegypt to keep guard over this stone and the collecting of it; and this organisation was supplied by them with provisions."

The green gems from the little island in the Red Sea were uniquely defined as the Topazos of Pliny and again, almost two millennia later provided the basis for the current definition of peridot as the gem variety of the mineral forsterite.
Zabargad Island has been a source of peridot gems since the time of Greco-Roman rule in Egypt. Archaeological excavations have revealed interesting information about the commercial exploitation of these resources, and geological investigations have provided important knowledge about the formation of the Red Sea and upper mantle conditions.
Excavations in the ancient port of Berenice, as well as on Zabragad Island itself, have revealed active mining on the island since the 3rd century BC. These results are in line with the classic mineralogical literature; in particular, Pliny the Elder's Natural History (79AD) has been a much used source of information.

Marsa Halaib (ancient Soteira)
The shores of this harbor, except in front of the village, are bordered by reefs, which extend as far as 0.3 mile offshore, and there are many detached shoals.
Soteira is another name for the Ptolemaic dynasty, who ruled Egypt from the 4th to the 1st century BC.

Ptolemais Theron
According to Strabo (16.4.7), Ptolemais was founded as a base to support the hunting of elephants by a certain Eumedes (Ancient Greek: Εὐμήδης), who had been sent there by Ptolemy II Philadelphus, king of Ptolemaic Egypt. Ptolemais was only one of a series of such elephant-hunting stations along the Red Sea coast of Africa.

Ferresan archipelago
There was found a inscription commemorating the dedication of a monument to the Emperor Antoninus Pius, built on Farasān Island, probably in AD 144, by a detachment of the II Traiana Fortis legion and its auxiliaries. The dedicant is a prefect of the Portus Ferresan of the Sea of Hercules.

Adulis
was an ancient city located along the Red Sea in the Gulf of Zula, about 40 kilometers (25 mi) south of Massawa. Its ruins lie within the modern Eritrean city of Zula. It was first identified by Henry Salt, who visited it in 1810, and noted that the site was still called 'Azoole' by the natives.

Adulis was the emporium considered part of the Dâmt and Aksumite empires.
It was close to Greece and the Byzantine Empire, with its luxury-goods and trade routes.
The location of Adulis can be included in the area known to the ancient Egyptians as the Land of the Gods, and perhaps coinciding with the locality of Wddt, recorded in the geographical list of the Eighteenth Dynasty of Egypt.

Periplus 4 say: Below Ptolemais of the Hunts, at a distance of about three thousand stadia, there is Adulis, a port established by law, lying at the inner end of a bay that runs in toward the south. Before the harbor lies the so-called Mountain Island (Oreinê), about two hundred stadia sea-ward from the very head of the bay, with the shores of the mainland close to it on both sides. Ships bound for this port now anchor here because of attacks from the land. They used formerly to anchor at the very head of the bay, by an island called Diodorus, close to the shore, which could be reached on foot from the land; by which means the barbarous natives attacked the island. Opposite Mountain Island, on the mainland twenty stadia from shore, lies Adulis, a fair-sized village.

There are however topographic problems. Adulis is referred to as a port, but its ruins are at 5 km from the sea. Periplus refers that it was 20 stadia (3,7 km) from the coast. There has had to be a major coastal change in the area, which is not understood. If this city was connected to the sea by a silted river channel and if this was active in Roman and Aksumite times, an alternative explanation could be that Adulis was a fluvial rather than a maritime port.
As for the path from land to Diodorus it can also now be identified as a sandy strip under shallow waters, which perhaps at that time surfaced from the sea.

Fig. 3.14 Adulis

Katakekaumene or Burnt Island (Jabal Al-Tair)
PME 20 say: Navigation is dangerous along this whole coast of Arabia, which is without harbors, with bad anchorages, foul, inaccessible because of breakers and rocks, and terrible in every way. Therefore we hold our course down the middle of the gulf and pass on as fast as possible by the country of Arabia until we come to the Burnt Island.

The island has a large central peak which is brown in color. The other peak is conical in shape on some bearings; there is a steep rocky yellow bluff on the SE side of the island. A major volcanic eruption occurred on the island in late 2007. Sulfurous jets of steam appear at the summit of the island, but no smoke has been seen in recent years.
Perhaps this volcanic activity was present also 2000 years ago.

Jaza'ir az Zubayr (15°03'N., 42°10'E.)
are a group of islands, islets, and rocks extending about 13 miles in a SSE direction.

Jazair Hanish Archipelago (13°50'N., 42°44'E.)
The islands comprising these groups are dark brown volcanic hills with rocky eminences of various shapes. Jazirat Jabal Zuqar, Jazirat al Hanish as Saghir, and Jazirat al Hanish as Kabir are the principal islands.

Jazirat Mayyun Island (Perim) (Berim) (12°40'N., 43°25'E.),
ancient Diodorus near **Ocelis**, lying in Bab al Mandeb, is bare, rocky, and rather flat in appearance; the surface is broken into a dense layer of boulders and stones, and covered in places with windblown coral sand. It is devoid of vegetation and is grooved with water-courses.

Deirè promontory (12°28'N., 43°19'E.)
Strabo Geography, Book XVI, Chapter 4
"The straits are formed towards Aethiopia by a promontory called Deirê, and by a town bearing the same name, which is inhabited by the Ichthyophagi. And here, it is said, there is a pillar of Sesostris the Aegyptian, which tells in hieroglyphics of his passage across the gulf; for manifestly he was the first man to subdue the countries of the Aethiopians and the Troglodytes; and he then crossed into Arabia, and thence invaded the whole of Asia; and actually, for this reason, there are in many places palisades of Sesostris, as they are called, and reproductions of temples of Aegyptian gods. The straits at Deirê contract to a width of sixty stadia."

Fig. 3.15 Ocelis on Bab El Mandeb Strait

Squalls

In summer, when the sea breezes are usually light, there are many days of calm with very high temperatures. During this season, sudden squalls, forewarned by dense curtains of sand, come down from the hills.

Between July and September, squalls known locally as haboobs blowing from SE through W, however, may reach gale force. These may occur without warning or with slight warning by the approach of dust clouds from W.

During haboobs from the W, visibility decreases to less than 46m because of the dust and blowing sand; temperatures may rise to as high as 52°C. The squalls are of 30 minutes duration, and vessels should not be lying to their own anchors during their occurrence but seek shelter along the coast if possible.

Visible Stars

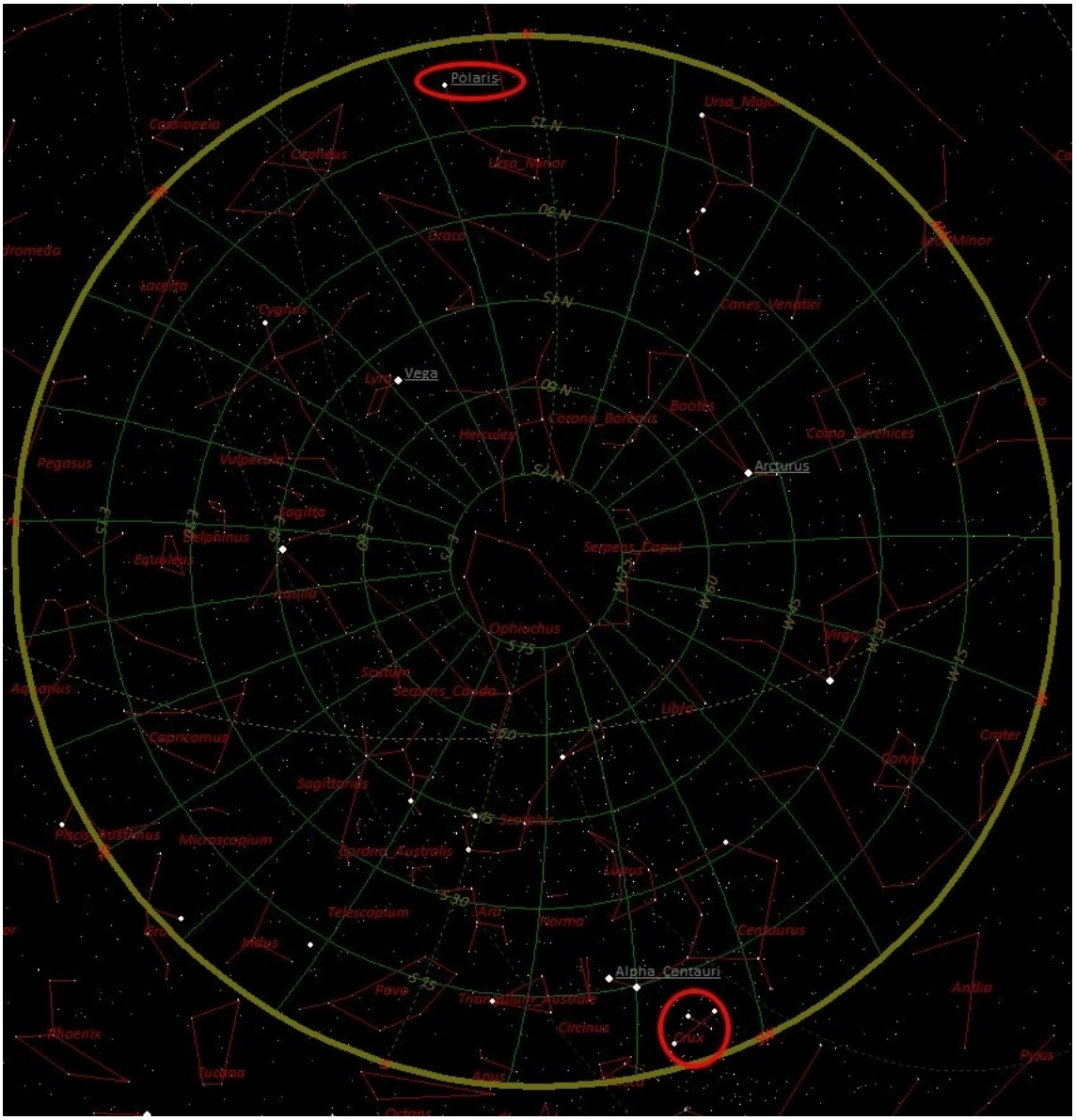


Fig. 3.16 Bab El Mandeb, South Cross and Polaris on 4.0 am March 1, 30 B.C., HNSKY

Due to the Earth axis precession, 2000 years ago during winter nights both Polaris and South Cross were visible, so aiding sailors to follow the right route when returning home.
During summer Polaris and Crux should have appeared contemporarily in the sky only on daylight, but obviously they were not visible.

Navigation on the Gulf of Aden

The Gulf of Aden is situated between Yemen, on the southern coast of the Arabian Peninsula, and the African coast of Somalia; through the Strait of Bab el Mandeb it communicates with the Red Sea and through this with Egypt and the Gulf of Aqaba. Thanks to this privileged position since ancient times the Gulf became an important maritime route that linked the Mediterranean with the Indian Ocean and the Arabian coasts producing frankincense and myrrh, giving rise to the development of many ports on its shores, the most important of which it was and still is Aden in Yemen.

As already mentioned the seasonal monsoon onset is not as regular as a clockwork, it changes from year to year and from area to area, gradually establishing itself proceeding from north to south in the late autumn and going from south to north at the end of spring. The navigation so depended not only on time of year and traversed area, but also by the inevitable meteorological vagaries whose warning signs could only be interpreted by experienced sailors.

Winds in the Gulf of Aden, throughout the year are governed by the monsoon of the Arabian Sea and the Indian Ocean. During the Northeast Monsoon (October to May), these winds assume a West direction in the Gulf of Aden and penetrating in it blow in a NW direction through Bab el Mandeb into the Red Sea. From June to September, steady SW winds prevail, blowing strongly at times out of the Red Sea, through the Gulf of Aden, to the East of Socotra, and into the Arabian Sea.

In the Gulf of Aden, from October to April, the currents set SW at speeds ranging from 0.2 to 1 knot. During June to August, the currents set ENE at speeds of about 1 knot near the middle of the Gulf of Aden and up to 2 knots close to the Arabian coast.

So there is a narrow time window, between the second half of May and the first half of June: the ships would have passed the most dangerous area before the intensification of the phenomena and would have been pushed by intense but not dangerous winds in the second part of the crossing. It was about taking advantage of that short season, preceding the summer monsoon cycle, that would provide favourable winds of increasing but not overwhelming force, especially in the Socotra area, which could have been seriously endangered the vessels.

Navigation on the Indian Ocean

Archaeological findings of Harappan Civilization, as well as the Vedic and Sangam period texts, suggest that the ancient Indian mariners were aware of the monsoon winds and currents and used them to their advantage during maritime trade with Southeast Asian countries, for a period of more than 2000 years BC; probably they were among the first to use monsoon winds and currents in maritime trade.

It appears that afterwards the Mediterranean sailors had collected information about the monsoon navigation from older sailors of the Arabian Sea, the south-west monsoon was known in the western world with the name of Hippalus.

In the most interesting area for commercial sailing traffic of antiquity, that is Arabian Sea and Bay of Bengal, monsoons generate winds and currents that reverse during the year, mainly eastwards during the summer and otherwise during the winter. This imposes a clear six months periodicity to oceanic sailing traffic, independent of the actual distance of the destination and the speed of the crossing. So any round trip forcibly lasted long time, cause it must adapt, in its development, not only to the frequency and direction of the winds and currents, but also to the uncertainty about the exact dates of their establishment that are dependent, with great variability, from the annual anomalies of the Pacific current El Niño.

As was mentioned, the wind regime is regulated by the monsoons, which are not exactly like a Swiss clock in their timing, and then can be roughly divided into four periods:

- Winter monsoon from mid-November to mid-March, mostly dry climate, winds from the North East on South China Sea and Bay of Bengal, winds from the north on the west coast of India;

- Inter-monsoon phase from mid-March to mid-May, unstable weather with the possibility of hurricanes, gradual rotation of the winds from the northeast to the southwest;

- Summer monsoon from mid May to mid September, humid and rainy weather (rainy season), prevailing winds from the Southwest both in the Indian Ocean and the South China Sea; the Southwest Monsoon is very strong and is accompanied by thick hazy weather over the area between Ras Air and Socotra.

- Inter-monsoon phase from mid-September to mid November, unsettled weather with the possibility of hurricanes, rotation of the winds, cyclonic and messy circulation with conflicting winds;

Even more complicated is the system of currents, with a rotating pattern and also with a semiannual cycle that reverses itself in summer and winter. In winter the North East monsoon creates rotatory currents, with a weak counterclockwise rotation in the Arabian Sea (heading to the west along the western coasts of India), and other stronger but more complex in the Gulf of Bengal. From September to January the latter are directed towards the south-west along the coast, from February to March they are reversed to the north; from April to August they are reversed back to South at Ceylon latitude, phenomenon that also happens in the northern Gulf, but only since July.

So the tense and constant winds characteristic of the full monsoon, with a variable force between six and ten knots and spikes up to fifteen to twenty knots, favoured in the past the sailing ships on long distance traffic, contemporaneously creating a precise calendar for the oceanic navigation. Both during the summer monsoon and during the winter can then occur sudden and dangerous wind strength increases (surges), with maximum of 60 knots north-east of Socotra during the summer and around 40 knots in winter, with 7 metres waves, that instead of fostering more rapid navigation were feared because of the possibility of sails tear and falling of masts or even capsizing.

In reconstructing possible timing and routes followed by ships it is assumed that the crossings have been carried out under the best possible conditions and in the periods theoretically more favourable from the point of view of the prevailing wind and sea conditions; however, this does not ensure any historical veracity as many other facts unknown to us may have conditioned actual navigation, such as:

- Real weather conditions before and during navigation.

- Loading conditions of the vessels (the weight sinks the hull, so increasing the wet surface and consequently the resistance to motion).

Furthermore it is assumed:

- Monsoon cycle similar to the current, for which we possess accurate data.

- The absence of strong weather anomalies compared to seasonal averages.

For all the reasons presented above the assessment of routes and related timing has then been carried out only with "medium" weather conditions during various periods of crossing.

There was also a period called "closed sea", that is the season when nobody sailed in the central Arabian Sea, since the beginning of July to mid-August, because the summer monsoon raged with winds of intense strength in the central area of the Arabian Sea, able to cause serious problems even to large modern ships today. With the end of the closure of the sea, in the period between August and September, it begins the great season almost anywhere free from bad weather. It includes the last period of the winds of Southwest favourable for sailing, the entire Northeast monsoon from October to April, and finally the prelude to the summer monsoon, which is also favourable for sailing from late April to late May.

In the following sections several figures are shown, representing in any of those periods the distribution, direction and strength of winds gauged by the satellites of the QuikSCAT system - Remote Sensing Systems, NASA Ocean Vector Winds Science Team - thus offering a representation of weather conditions and consequently a basis for the evaluation of navigation along the most favourable routes; the detected surface wind speed scale is in meters per second, and to evaluate its equivalence in knots please note that 10 mt / sec are 19.438 knots (roughly N mt/sec = 2N knots).

A final note: obviously, unless it was simply a coastal voyage with overnight stops, it is assumed that the crew was large enough to be able to organize itself into multiple guard shifts and face 24-hour navigation.

4 The voyage from Berenike to Muziris

The aim of this study is twofold, that is to verify the Pliny's affirmation that:

They start sailing in midsummer before the rise of Sirius or certainly at its rise and reach Ocelis around the thirtieth day .... They sail for 40 days with the Hippalo wind to India's first merchant port Muziris,

on this basis simulating the possible routes and through this assessment then trying to localise the Muziris location, laying in the place reached after 40 days of voyage.
As a matter of fact it is not clear if he was referring to a much longer route, about small ships coasting the shores of Arabia, Iran, Pakistan and India, along the entire Northern arch of the Arabian Sea, without a direct crossing of the Ocean, or to a direct crossing toward South India.
For this reason the simulation has to be divided in 3 sections, with different navigation's conditions, that is a common route from Berenike to Ocelis and then 2 different routes through the Arabian Sea to India, one along the north shores and another direct toward the East.

Route from Berenike to Ocelis

Which was the followed route in the descent of the red Sea and its duration ?
This descent from Berenike to Ocelis had to be made during the month of July, with two possible options:

1) Navigating near West coast of Africa in the Inner Channel, travelling only in the daylight for 12 hours and berthing during the night in khors, protected bays and coastal minor ports. It could be assumed that a slow and charged oneraria with a single sail can reach a speed equal to about 1/4 th of the propelling wind speed, provided it is navigating downwind.

2) Navigating in the central passage. This route is described in PME 20, where the author also recommends the sailors to stay well offshore because of the Carnaites pirates' attacks coming from the Arab coast. The ships following this route had first to head offshore, avoiding the Topazos Island (Ophiodes) often covered by fog and then sailing in the middle canal of the Red Sea, taking care thereafter to pass between the Dalhak Archipelago and a vast zone of low waters and shoals protruding from the Arab coast, that restrict the central passage by two thirds, until reaching the Katakekaumene or Burnt Island (Jabal Al-Tair) between the Alalei Archipelago and the Ferresan Archipelago, afterward possibly approaching the East coast toward Muza and Ocelis for avoiding next obstacles, like the Zubair Group of isles on the West side and Kamaran Island, Al Jazirah peninsula, Rashshah Islets on the East side.
A last warning about Hanish Archipelago and finally Diodorus Island (Mayyun).
This choice nevertheless could be problematic for an ancient ship, both because of the presence of isles and archipelagos or outcropping cliffs along the route, and above all transverse currents that could drift the vessel toward the coasts and their dangers. Moreover during May, also with strong winds toward SSE, NNW currents between 0,5-2 knots have been detected, but none from June.
For this reason, without today radar and lighthouse or beacons, ships navigating in the central canal too had to sail only during daytime, but doing so they should have had the problem of mooring during night on an open sea without anchorage but avoiding drifting.
On the other hand it is true that experienced sailors might try not to stop at night and continue by the light of the stars or the Moon, but in that case they would not spend 30 days to reach Ocelis as Pliny affirms. As this study is based on Pliny's affirmation the timing of about 30 days is retained.

Although the case of sailing in the centre of the Red Sea is dubious, it has anyway to be taken into consideration, so Berenike-Ocelis voyage timing is calculated in both cases:

- A slow Greco-Roman merchant ship then, voyaging in the Red Sea from Berenike to Ocelis, covered about 912 nautical miles; travelling with a 5,5 mt/s mean wind, at a speed of 2,5 knots, reached the destination not before 912/((2,5)/12) = **30,2** days.

- The route from Berenike to Ocelis, sailing in the centre of Red Sea is about 842 nautical miles; travelling with a 5,5 mt/s mean wind, at a speed of 2,5 knots, the destination could not be reached before 842/((2,5)/12) = **28 days**, mooring on the open sea at night.
  In case of continuos travelling the time was 842/((2,5)/24) = 14 days.

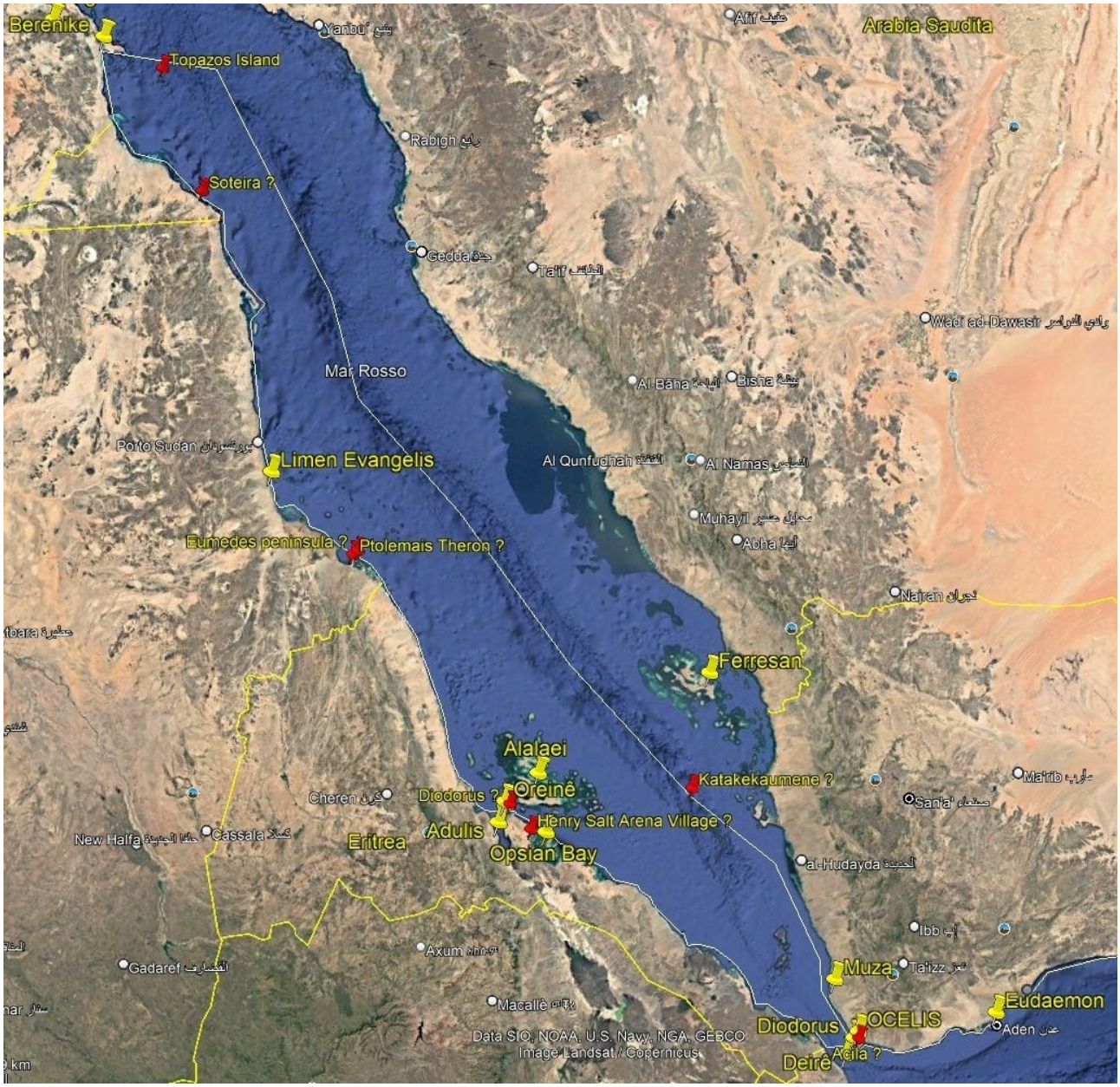
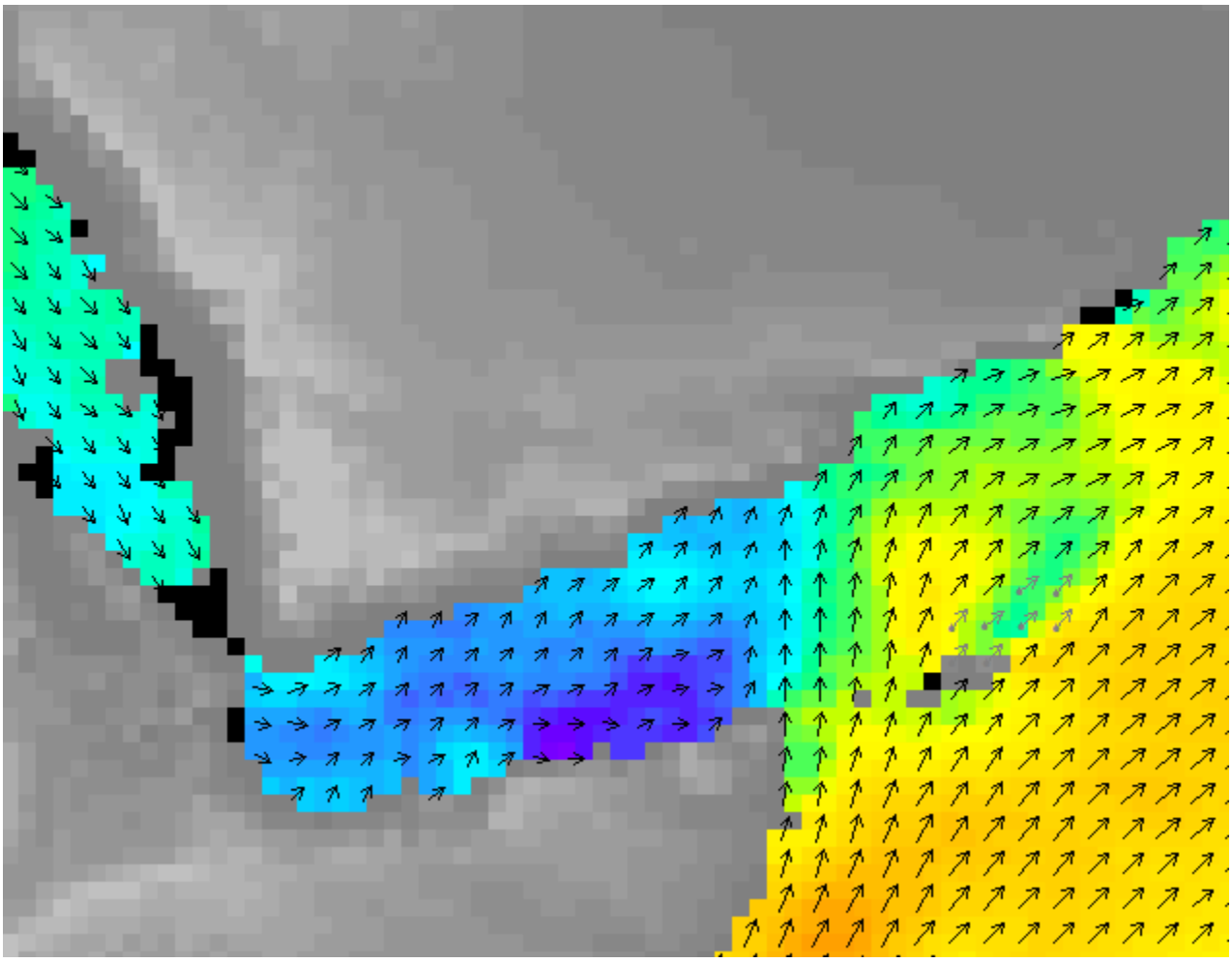


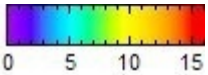
Fig. 4.1 Red Sea from Berenike to Ocelis

Two alternative routes

In the following simulations of the two cited travels to India are not considered the vessels:

- Departing early from Berenike toward Ocelis during the month of May, running with a 10 knots tailwind, which then venture into the Gulf of Aden taking advantage of the June's first winds of the summer monsoon with an equal force; this solution however is good only for a navigation parallel to the Arabian coasts, because the zone around the isle of Socotra and the central Arabian Sea in June begins to be hit by extremely strong winds that could even capsize sail ships. So this timing and course was used only for merchant ships going to Arabia, Persian Gulf and possibly only to North-West India. Thus they started on mid-May from Berenike heading to Arabian ports for spices and frankincense trade; once arrived at their destinations they could not continue toward India because of July dangerous winds, and after having loaded their cargo surely the merchants waited for the first opportunity to engage in the return trip to Egypt. On the other hand it is not probable that ships aimed at India set sail on mid-May only to stop for a month in Arabia.





mt/s **Fig. 4.2 Southern Red Sea winds during the second half of May**

- Other low size ones doing coastal navigation from mid-May to the end of June along the Berber shores; those ships made only local trading and could not go beyond the Cape of Spices because of very strong July winds that would have pushed them toward Arabia.

After the ships had spent July for the descent of the Red Sea, they reached Ocelis by the beginning of August and replenished their water reserve; after they had two distinct possibilities to head toward Southern India, following two different routes:

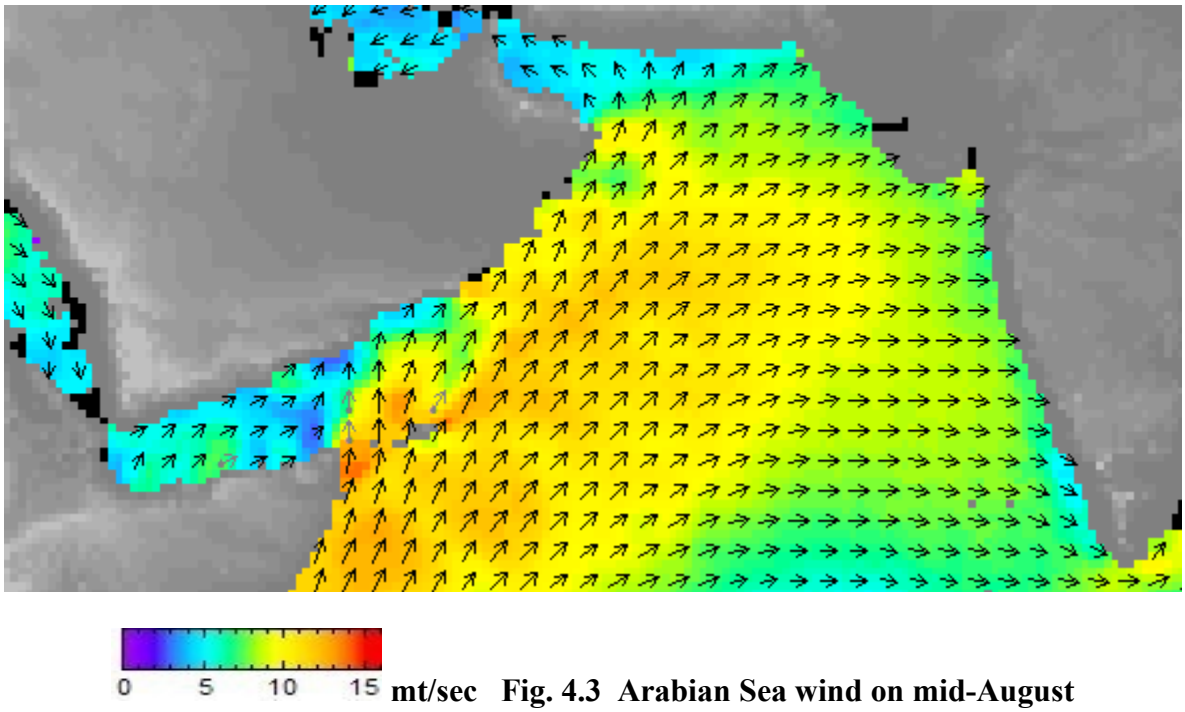


Fig. 4.3 Arabian Sea wind on mid-August

- Ships heading before to Northern India – Barbarikon or Barigaza – could follow the Arabian coast toward NE, sailing along the Northrnern arch of the Arabic Sea; after the first stops they continued travelling along the western Indian coast toward the South.
  This way would have been advantageous only in case of several trading destinations to be called at along the voyage and for limited size vessels not fit for a direct crossing on the deep blue sea.

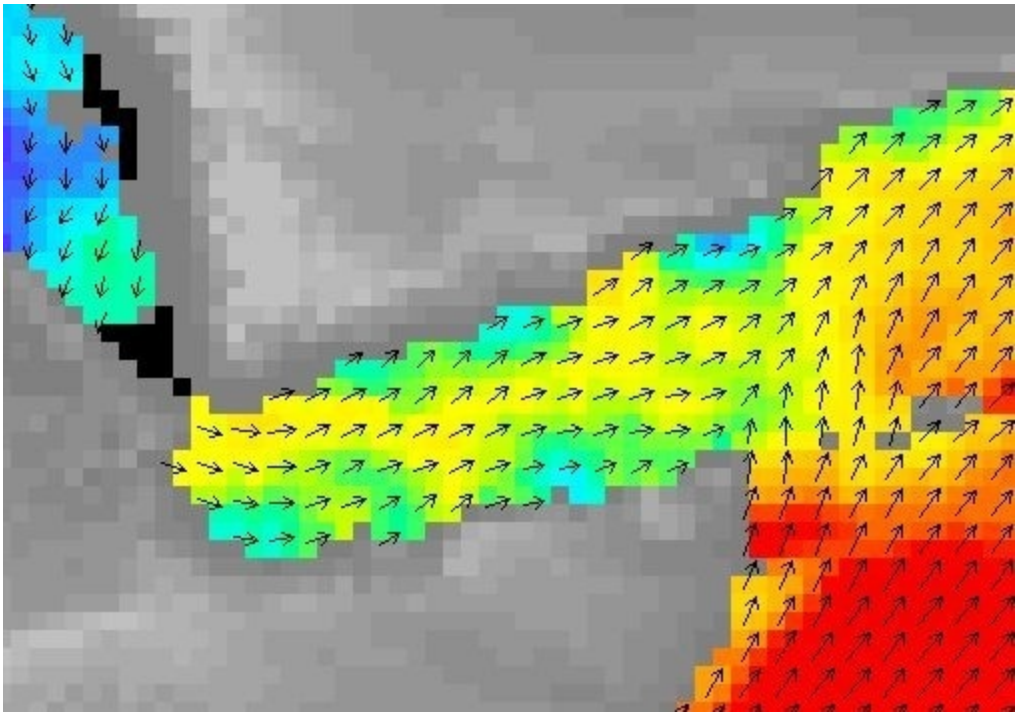
- Larger ships with experienced crew could face the direct crossing of the Arabian Sea, reaching Southern India along a straight route toward the East.

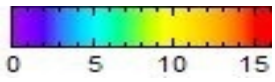
Obviously the travel time, along this routes heading to India, would have been different; as Pliny affirms that the voyage from Ocelis to Muziris lasted 40 days, it would be possible to approximately localize the destination port assessing the final position at the route end after that time.

Northern route to Barigaza through Cana

PME 56, 57 say that: **the voyage to Muziris and Nelcynda starts from Egypt about the month of July, and they used to make in small vessels, sailing close around the shores of the gulfs, or with large ships ..... ships start, he says, some directly from Cana, and some from the Cape of Spices; and those bound for Damirica throw the ship's head considerably off the wind; while those bound for Barygaza and Scythia keep along shore not more than three days and for the rest of the time hold the same course straight out to sea from that region, with a favourable wind, quite away from the land, and so sail outside past the aforesaid gulfs.**
This paragraph simulates the voyage to Muziris starting from Berenike and passing by Ocelis, Cana and Barygaza. At the end of this route, after the 40 days cited by Pliny, it is Muziris location.

A ship leaving Berenike on July first, sailing along the West channel of the Red Sea, arrives to Ocelis after 30 days, hence at the start of August; it can then continue the voyage along the Arabian shore favoured both by fair tailwind and seasonal currents up to two knots close to the coast.





mt/sec Fig. 4.4 Gulf of Aden on early August

The coast is not dangerous for ships sailing along it, as water are free, clear and deep.
Ships bound for Barbaricum, Barygaza and Scythia sailed h24 at a safe distance from the coast, probably up to Syagrus, then headed directly toward India with a strong tail wind.
The following table shows time needed for covering each route leg by adding to the wind propulsion the contribution of the **favourable coastal current, evaluated conservatively at least as 1 knot**, but that could reach even 2 or 3 knots in some areas.

Leg	Length	Mean wind	Mean Speed	Hours	Days	Total
Ocelis - Eudaemon	108 n.m.	7 mt/sec	3,2+1=4,20 knt	26	1,4	1,4
Eudaemon - Cana	222 n.m.	6,25 mt/sec	2,85+1=3,85 knt	58	2,4	3,8
Cana - Syagrus	258 n.m.	5,6 mt/sec	2,56+1=3,56 knt	72	3	6,8

Obviously those times have to be considered as simple medium times, with error depending on monsoon variability, weather conditions, actual route and possible short stops due to supply.
One more remark about the Aden Gulf navigation is that dust storms may reduce the visibility to 1 mile and refraction phenomena in all forms are common in this area. The mirage may be of a simple type or may be any of the complicated types of looming, sinking, distortions, and multiple images, common to these hot coasts where water temperatures during summer are among the highest known. All this obviously requires maximum attention from sailors carrying out coastal navigation,

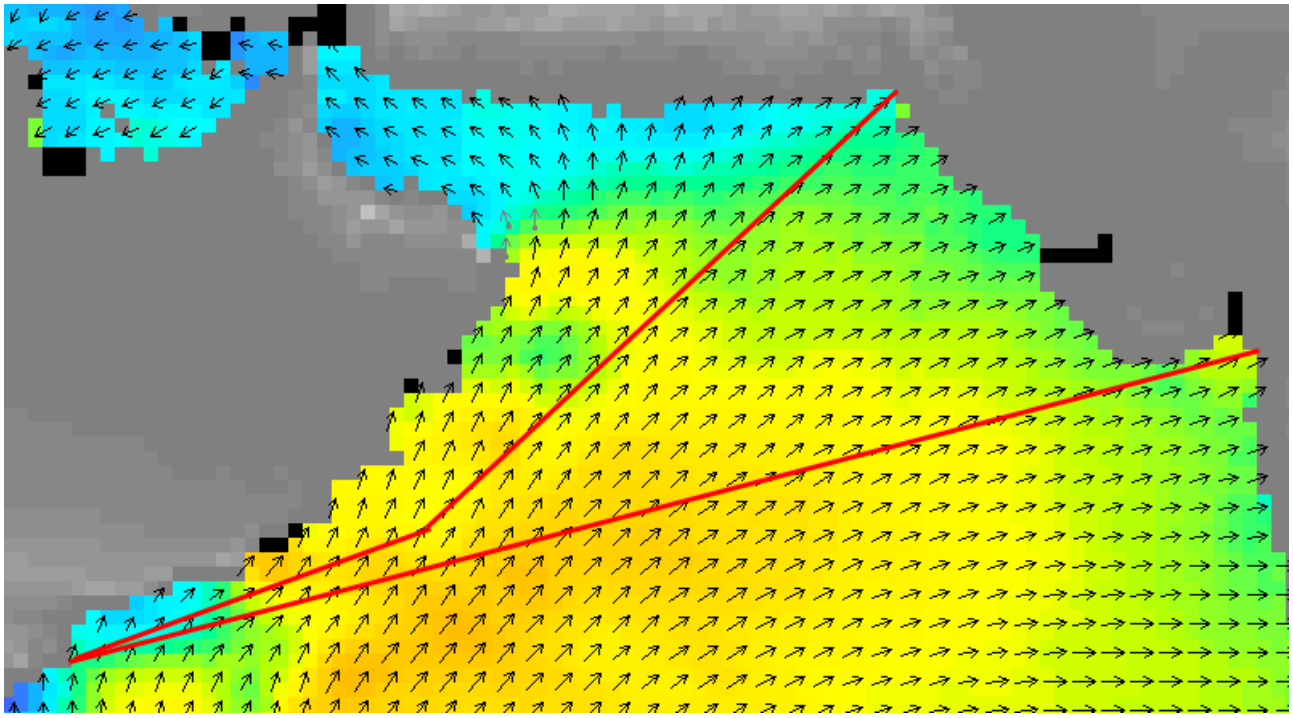


Fig. 4.5 Arabian coast and Oman Gulf on August

From a point off the Syagrus promontory the next oceanic route could be toward Barbaricum (1010 n.m.) or toward Barygaza (1230) , with the most part of vessels eventually directed to Muziris likely bound for the second one; in the following table are shown the travel times along both routes.
In the Gulf of Oman there is a warm current toward NE of at least 0,3 mt/sec [4.1] to be added for calculating ship speed. This light current bends near the continent coast heading toward South-East.

Leg	Length	Mean wind	Current	Mean Speed	Hours	Days
Syagrus - Barbaricum	1010 n.m.	7,2 mt/sec	+ 0,3 mt/sec	3,4 knots	297	12,4
Syagrus - Barygaza	1230 n.m.	6,25 mt/sec	+ 0,3 mt/sec	3,0 knots	410	17,1
Barbaricum - Barygaza	467 n.m.	5,6 mt/sec	+ 0,3 mt/sec	1,7 knots	275	11,5

It is also possible that some merchants stopped at both these ports of call, and then proceeded to Muziris. They had anyway to pay attention to the tidal currents when near to the Indian coast, that are remarkable, from 3 knots on flood and 5 knots on ebb.

4.1 Circulation Analysis in the Northwest Indian Ocean, S.S.Vitale et alias, 3.1 pg 12

From Barygaza to Muziris

So after 19 days from start of navigation at Ocelis trade vessels arrived in the Gulf of Khambat, that is on August 20 if they set sail on August 1.
Ships bound for Muziris following the Northern arch of Arabic Sea shores necessarily passed near Barygaza, one of the most important Port of Call of ancient India; after the crossing of the ocean those ships likely needed at least water supply, or had some cargo to deliver in the port and possibly another one to take on before proceeding to Muziris.
Recalling that:

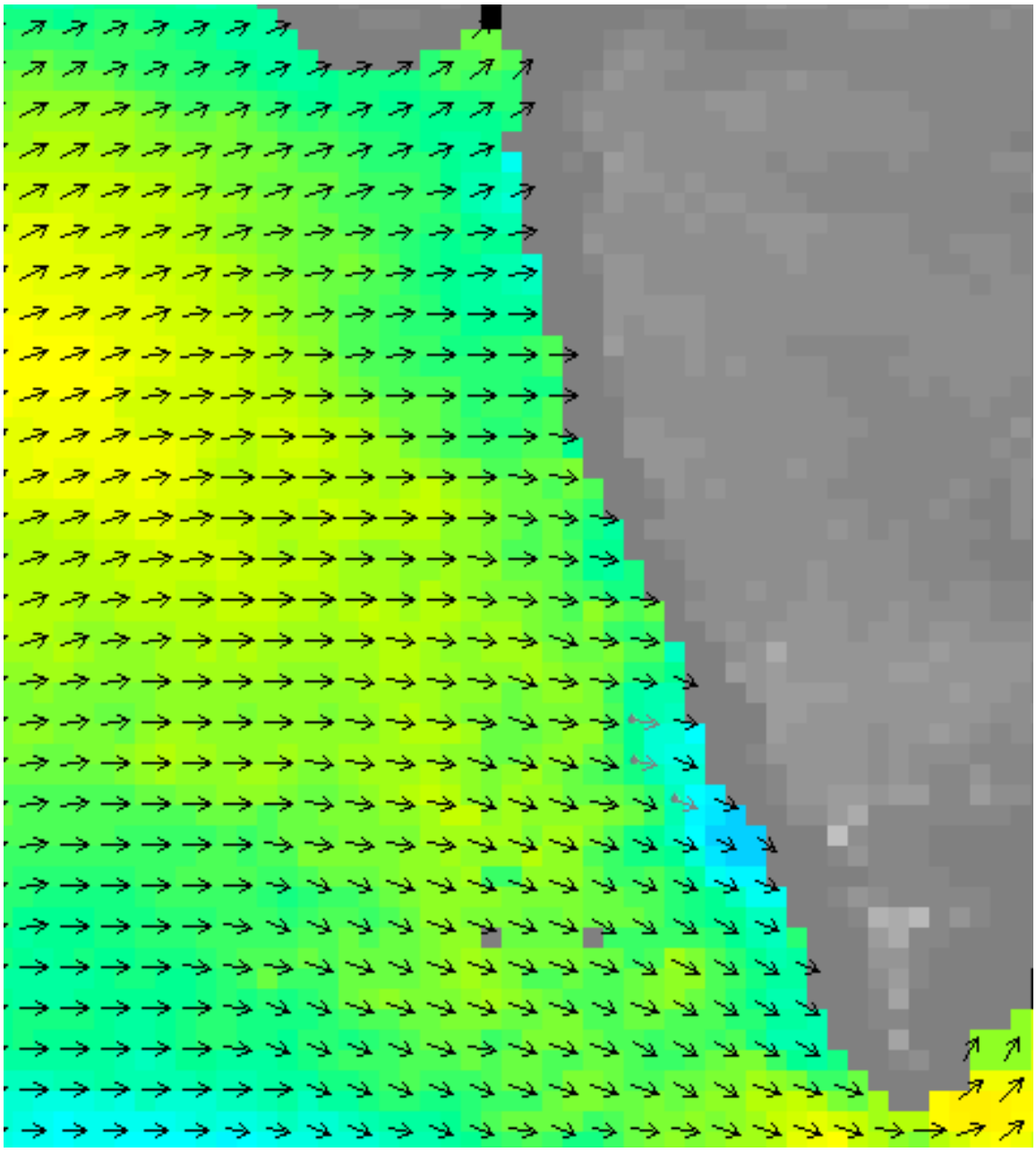
PME 43 says: This gulf is very narrow to Barygaza and very hard to navigate for those coming from the ocean; this is the case with both the right and left passages, but there is a better passage through the left.
and
PME 44 says: Because of this, native fishermen in the King's service, stationed at the very entrance in well-manned large boats called trappaga and cotymba, go up the coast as far as Syrastrene, from which they pilot vessels to Barygaza.

Therefore Indian boats went toward Greco-Roman vessels when they arrived near the Syrastrene, East coast of the Papica region (Kathiawar peninsula), likely not far from Astacampra: on this spot hence could also been performed some direct supply of the incoming ships in addition to aid those to be tugged to Barigaza. It is then possible that some vessels proceeded directly to the South and other went to the port for merchandise delivery and loading operations, stopping there at least two days before continue the voyage to the South.
When continuing travel from the Gulf of Khambat toward Muziris the ship had to briefly sail close-hauled, what slowed down them a lot for a short leg.
Wind along the Western Indian coast during summer is directed to the East, then ships descending Indian coast have it on the beam, considerably reducing their speed; a little contribution to the travel come from the Southwest Monsoon Current (SMC), that flows south-eastward along the shores of India, with a mean surface velocity up to 0,5 mt/sec. [4.2]
See about Fig. 4.4

Leg	Length	Mean wind	Current	Mean Speed	Hours	Days
Gulf of Khambat-Chersonesus	458 nm	5,4 mt/sec	+ 0,5 mt/sec	2,7 knots	170	7,1
Chersonesus-Cape Comorin	436 n.m.	2,9 mt/sec	+ 0,5 mt/sec	1,5 knots	291	12,1

From Barygaza to Cape Comorin a ship therefore could complete the route in 19 days; from Ocelis to Cape Comorin the travel would have ended after 38 days on September 8.
Hence a vessel that would have stopped two days at Barygaza could reach Cape Comorin within **40** days. Once passed Cape Comorin the wind strengthens considerably, up to10 mt/sec, then 7 mt/sec, that is a mean value of 3,9 Knots; within 1 more day a ship can cover 24x3,9 = 93 n.m., reaching even the coast of the Gulf of Mannar if it stayed only one day in the Gulf of Khambat, just for some direct supply from local Indian boats.
So the Pliny affirmation about 40 days of travel to Muziris has at least two solutions, someone near Cape Comorin and another on the Mannar Gulf shore.

4.2 Circulation Analysis in the Northwest Indian Ocean, S.S.Vitale et alias, 3.1 pg 12



mt/sec **Fig. 4.6 Indian West coast on late August**

Direct ocean crossing toward Southern India coasts from Ocelis

PME 56, 57 say that: **They send large ships to these market-towns** (Muziris, Nelcynda) **on account of the great quantity and bulk of pepper and malabathrum**. ….**ships start, he says, some directly from Cana, and some from the Cape of Spices; and those bound for Damirica throw the ship's head considerably off the wind;**

The numerous depictions and shipwrecks brought to light thanks to underwater excavations have revealed an extraordinary typological variety: from vessels used for short and medium-length coastal voyages, to large merchant ships used for long travels.
They had a length to breadth ratio of the underwater hull of about 3:1, double planking and a ballast for added stability. [4.3]
The larger ships were probably 100-250 tonnes vessels with two or even three masts, capable of withstanding the harsh environment of the ocean. Merchant ships reached their apogee from the end of republic and during the Imperial period. There were also muriophoroi ("carriers of 10,000 amphorae") above 330 tonnes.
The bow was sometimes concave, due to the presence of a cutwater, which was not a ram but rather a structural feature which improved the nautical qualities of the vessel, functioning as inverted prow, that maximize the length of waterline and hence the hull speed, and often have better hydrodynamic drag; when the water flooded over the bow, it increased the weight of the prow so limiting the pitch at the top; when instead the concave bow slid down in the wave trough, the tilt caused the outflow of accumulated water thus decreasing the weight, rise buoyancy and limiting the down pitching.
Those characteristics were particularly apt to face ocean navigation at low speed and simultaneously avoiding excessive cargo shaking. The hull sides were protected by wales and featured winglike projections to protect from increased soaking due to reversed bow, and also there was an housing which protected the side rudder system. This steering system was constituted by side rudders or steering oars, located at the stern quarters. They could be regulated by a system of cables and functioned simply by rotating them along their axis. The manoeuvre was controlled by a tiller, a bar set perpendicularly to the oar, known as the “clavus”. This ancient rudder worked on the basis of the principle of the lever, which minimised the steersman’s effort.
The majority of merchant ships were sailing vessels with one, two or three masts. The sails were square and were regulated by a complex rigging system. In addition, some ships featured a small triangular sail, the supparum, located above the yard and/or in front an “artemon” (headsail) usually set at an angle.
The crew of those vessels was constituted by dozens of men, a part of whom were archers and armed guards for defence from pirates.

4.3) Roman Shipbuilding & Navigation - World History Encyclopedia

From Ocelis to Cape of Spices

As PME says the direct crossing of the Arabic Ocean toward India began with a first leg of 471 n.m. from Ocelis to Cape of Spices, the eastmost spot of Africa.
It is very likely that, before facing the long crossing of the ocean, the vessels made there a stop spending a day for a last water supply.
But before simulating the route and its timing it is necessary to define its path, recalling that those vessels didn't have satellites, radios, radars, modern maps, watches and sextants; in this regard two possible solutions could be adopted by those ancient sailors:

- Going from Ocelis to Cape of Spices heading toward the South until the extreme right side strip of land at the mouth of the Deirè promontory aside Bab El Mandeb Strait, then turn the ship toward East and continue until reaching the African Coast at Cape Elephant, that is high and visible from a great distance, then following the shore up to Cape of Spices.
  In this way, at only the cost of some more miles to be covered, the vessels could reach the destinations relying only on the Sun at day and the stars at night.

- Another solution could have been going initially to the South until Avalites, then follow the African coast to Malao, Mundus, Mosylon, Cape Elephant and Cape of Spices, what have entailed until a 50 % increase in travel duration.

As the employed ships were supposed to be suitable for an ocean crossing the second route hypothesis can be easily discarded, as it does not offer any advantage.

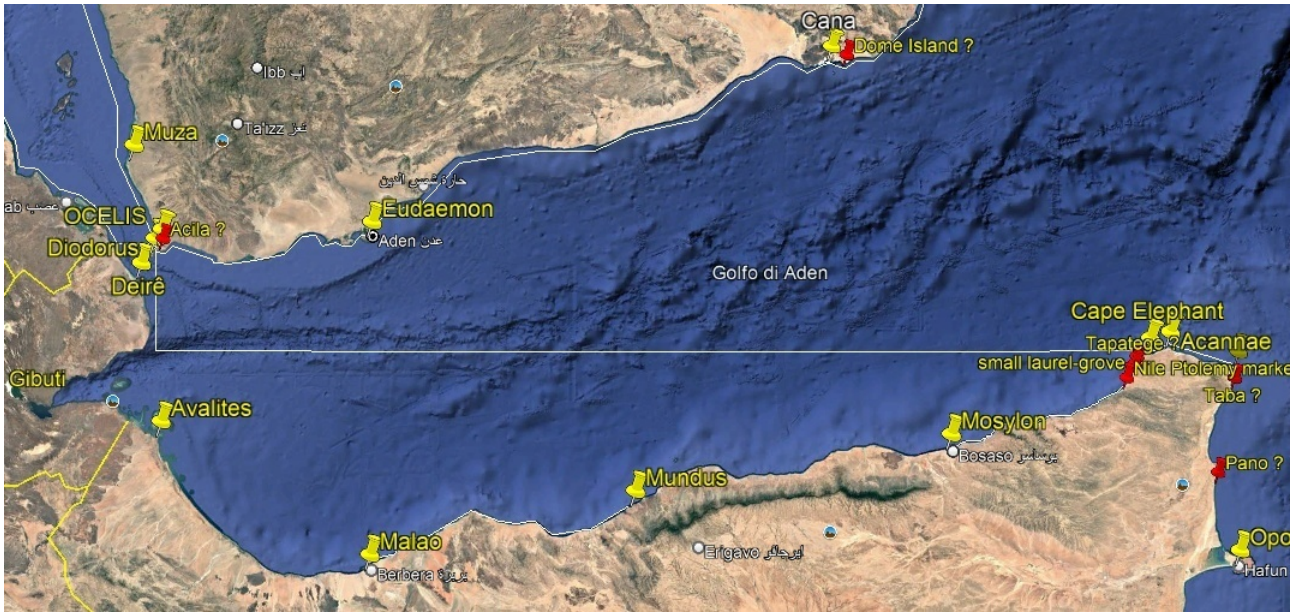


Fig. 4.7 Gulf of Aden

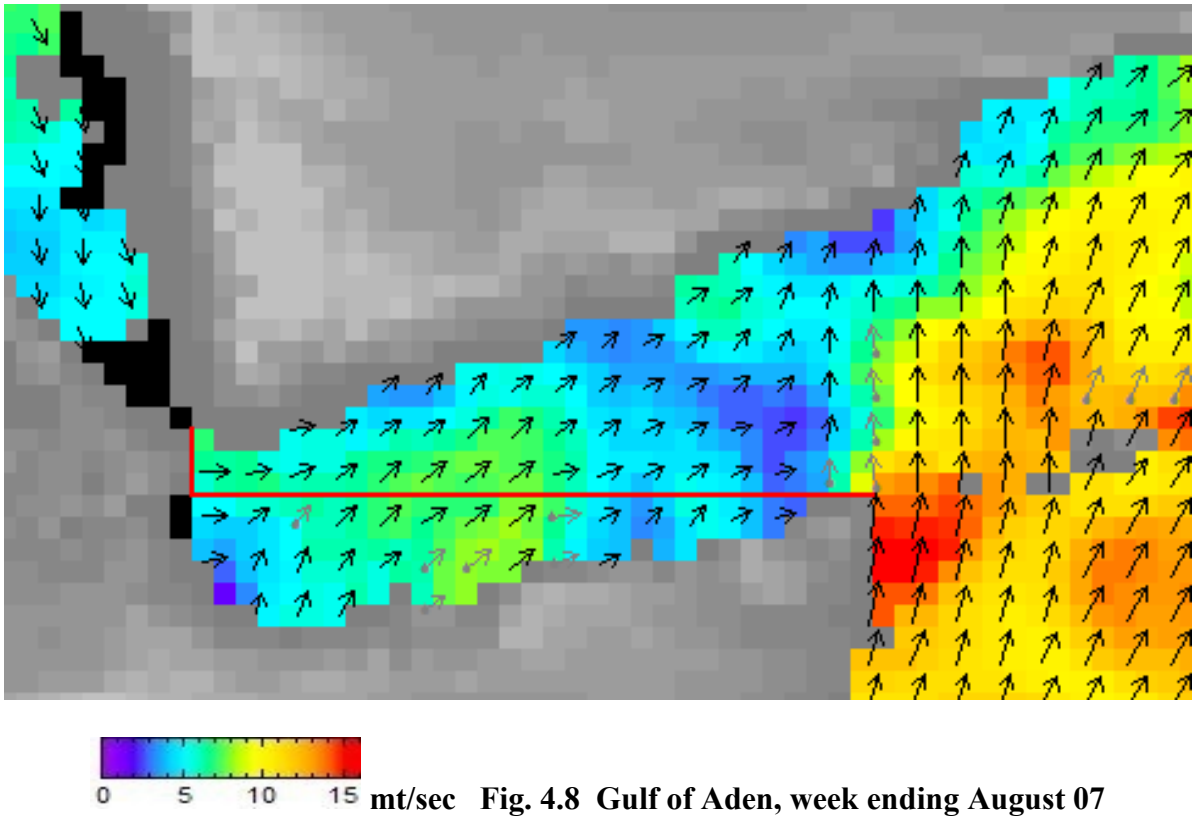


Fig. 4.8 Gulf of Aden, week ending August 07

The wind flow coming from the Red Sea meets the powerful jet coming from Somali's offshore and it is slow down at the Aden Gulf way out.
As for the currents contribution to the vessels speed, the situation during the South West Monsoon is complex; first the ships experimented probably a strong propulsive current at the exit of Bab El Mandeb when heading South, then a fair current up to 0,5 knots set toward East for at least half way to Cape Elephant, then the weakening of it until the encounter of counter-currents directed to the West, caused by the Great Whirl (GW) and Socotra Eddy (SE) shown in Fig. 4.5, above all along the route from Cape Elephant to Cape of Spices. [4.4]

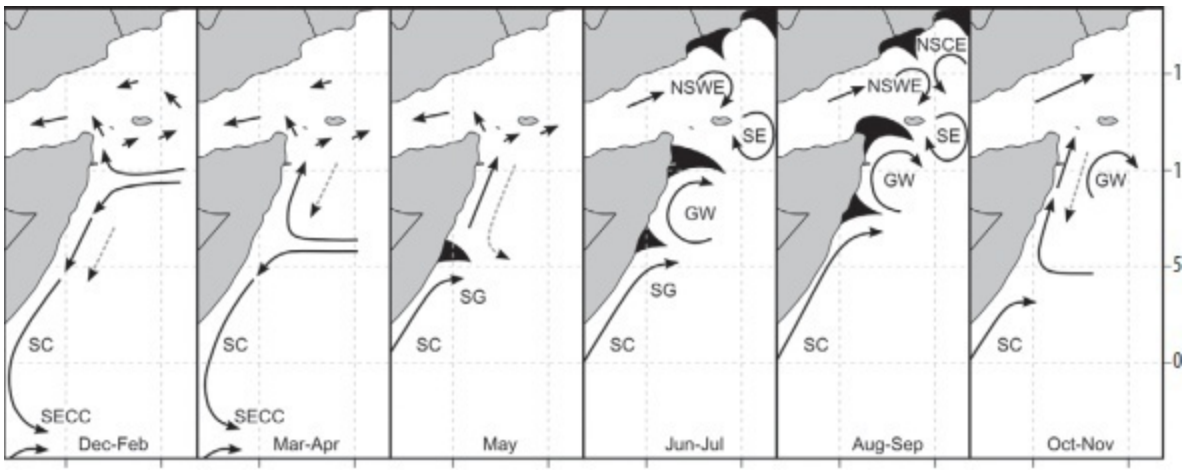


Fig. 4.9 Schematic diagram of the seasonal variation of the major ocean currents,
Socotra archipelago: fishes and fisheries in the eastern gulf of Aden, U. Zajonz

4.4 Sailing Directions-Red Sea - The Persian Gulf, Sector 10, Djibouti And Somalia, pg 193, 205, 207, 208

Consequently, for not tainting the simulation with many contrasting and scarcely assessable variables, currents have not been taken into account because their total effect probably was negligible on travel time.

Leg	Length	Mean wind	Mean Speed	Hours	Days
Ocelis – Cape of Spices	513 nm	4,7 mt/sec	2,1 knots	244	10,2

Ships then employed about 10 days to reach Cape of Spices from Ocelis, where they stop to refill the water supply before the last leg. Then they left the next day and started the ocean crossing. But they had to pass the Socotra Archipelago zone before continuing the voyage on the deep blue sea, and this was still difficult around the mid-August because of very strong winds coming from the South (see Fig. 4.4 above).
Those winds, as a matter of fact, had not only the force to tear the sails but also, as they were coming at beam reach, the ability to capsize the vessel. So it is possible that sometimes a ship stopped more than one day, if the captain judged the wind to be excessively dangerous for throwing the vessel in the ocean.
Sailing in strong winds and rough seas requires experience, preparation and good management of the vessel, above all if having the wind at the beam. That means:

- Reducing sail area: reducing sail area is essential to maintain control and avoid excessive heeling.

- Sail trim: maintain a balanced trim, avoiding overloading the boat. Trim the sails to exploit the power of the wind without losing stability.

- Using the helm: maintain a steady course and anticipate the movement of the waves to avoid sudden shocks. If necessary, sail slightly downwind to reduce the impact of the waves.

In these conditions the most important man on board is the helmsman, because reducing the sails is not sufficient to best govern the ship. He must in fact take the rhythm of the wave motion and in this way face the "ascent" and "descent" from the waves. And it is not easy because the waves are different from each other, sometimes steep, other times longer, in close series or isolated, or even crossed. When the wave arrives, slows you down and you have to luff to climb it. Once the bow is out of the water the helmsman must have already brought the boat to bear away, and by descending into the trough of the wave this will push the ship while you sail at broad reach. Then you luff again to face the next wave. Those ancient helmsmen however had perhaps a little advantage when sailing with those extreme conditions: they steered using a double oars helm, not a wheel helm that is geared down, and luff and bear request above all timely speed and immediacy of manoeuvre.

This pace involves greater resistance to advancement and an "undulating" path, a sort of "serpentine", that necessarily increases the time spent compared to a straight route.

Overcoming the Socotra peril

To correctly frame the situation that the ships were facing and to imagine the best way to overcome this dangerous area, it may be useful to examine in greater detail the distribution of the winds and their strength in the area of interest.

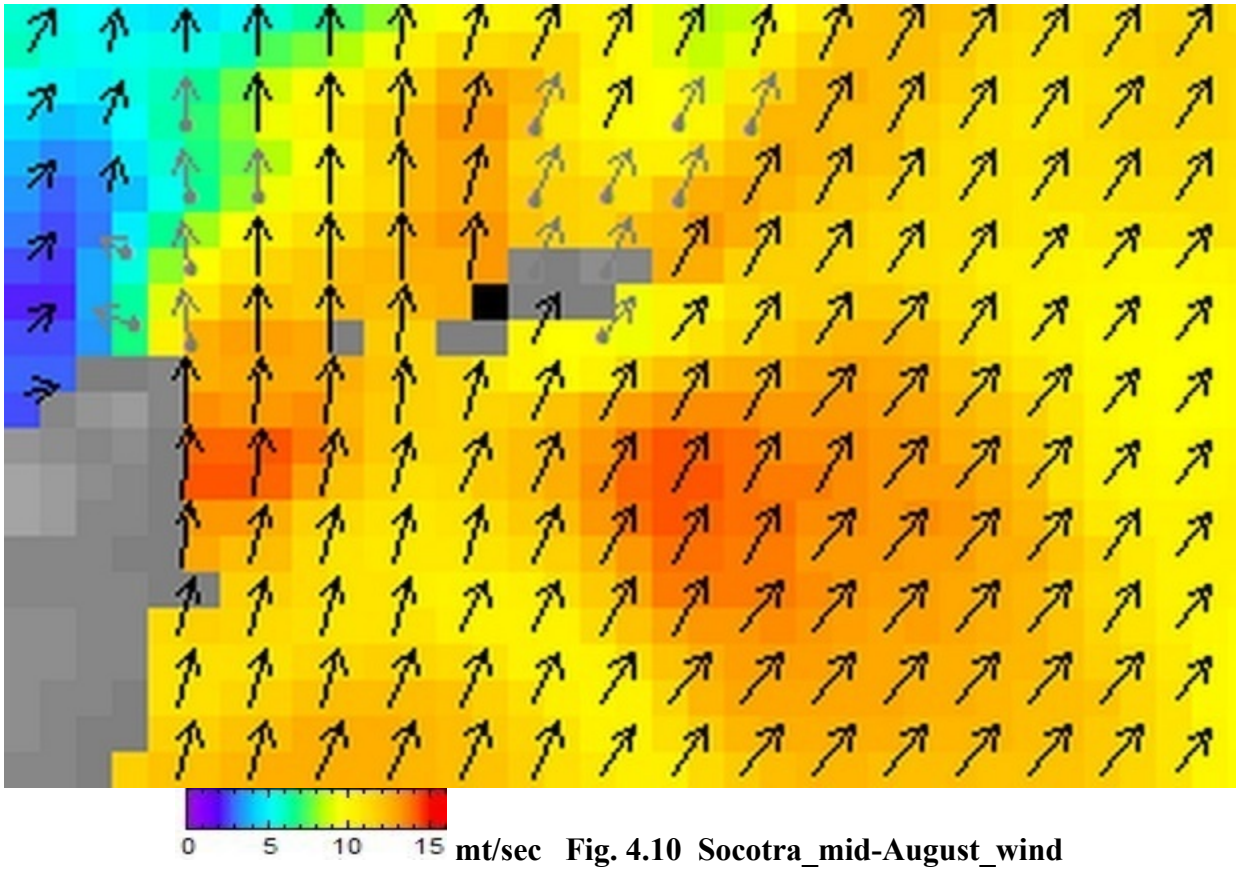


Fig. 4.10 Socotra_mid-August_wind

In this image three grey areas can be distinguished, from left to right, and they are:
Abd al Kuri island, Samha and Darsa islands (the Brothers) and finally at the upper centre Socotra.
As can be seen immediately after Cape of Spices the vessels faced a strong wind of 13 mt/sec until Abd al Kuri, then weakening to 12 until the Brothers, and finally a 10 mt/sec wind along the Southern coast of Socotra. Looking at the Northern coast of the island it is immediate to realise that over there the wind is stronger, that is 12 mt/sec. As can be seen in Fig. 4.7 this values are conservative, some years winds are even stronger (16 mt/sec) and more dangerous. Also wave hights are huge in this season, reaching up to 8 metres.
Obviously the advice is of overcoming Socotra sailing offshore of its Southern coast.

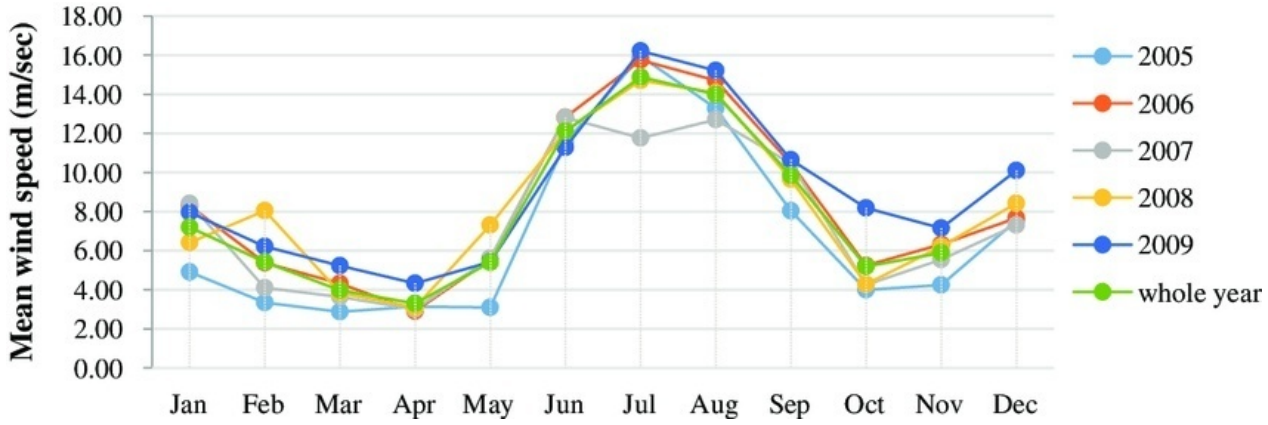


Fig 4.11 Socotra wind during the year, from Analysis and Assessment of Wind Energy Potential of Socotra Archipelago in Yemen, Fahd Al-Wesabi & alias

The reason of the difference in wind force on the two coasts is simple, because the flux of air that constitutes the wind begin to rise at a certain distance from the isle for overcoming the mountains and the air layers yet above them, while after passing the orography, where it accelerates, the air current plummets down the slope toward the sea setting up a stronger wind.
Moreover in this particular zone could also form dangerous vortices named rotors.
The phenomenon is well described by the following Fig. 4.8.

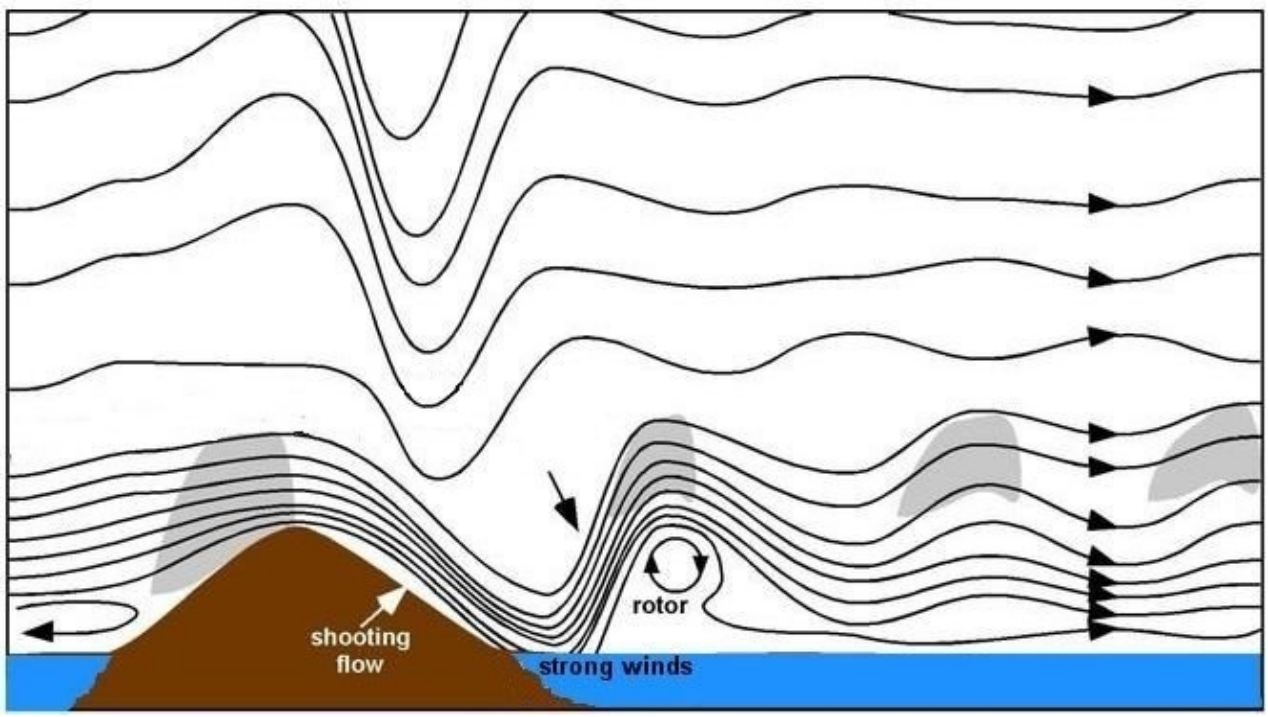


Fig. 4.12 Winds over Socotra orography

Best course probably was heading North-East toward the western tip of Abd al Kuri, then straight toward East; the strong wind running over the ships on the beam risked to push them toward the Socotra rugged coasts, hit by savage waves. So it was important keeping a certain distance from them. In case ships encountered very strong wind they probably waited before leaving Cape of Spices, so the times hereafter calculated have to be considered as minimums.

From Cape of Spices to India

As already said there is a period in which sail crossing of the Arab Sea is practically impossible, above all along the direct course toward the East passing by the region of the Socotra Island, starting with June until August; during this time only coastal navigation along the Arabia is possible for merchant ships directed to the Persian Gulf and possibly beyond toward the North-West coasts of India, or along the Berber coast, and that's why the most of sea trade was carried out from August to September toward the Indian pepper marts.

Thus they descended the Red Sea during July, reaching Ocelis at early August and the Cape of Spices at mid August, then facing the crossing of the Arab Sea for reaching the Indian coast with a direct transoceanic route.
The crossing could roughly be divided in 3 stretches, that is:

1- Initially a dangerous course of 395 n.m. from Cape of Spices to the longitude 57°, shown in the following Fig. 4.9 .
May be was during this leg that those ancient sailors saw the phenomenon of milky sea, that has its maximal frequency exactly in those waters.
"The sea … glared a brilliant and bright green. So brilliant in fact that neither white caps nor swell waves could be distinguished from what appeared to be a perfectly flat sea", said MV Westmorland captain Price in 1976; this glow is likely a by-product of high concentrations of microscopic bioluminescent bacteria called Vibrio Harveyi according to recent studies.

Fig. 4.13 Course from Cape of Spices to overcome Socotra

The first leg of this course to N-E, long 52 n.m. , would also have offered the advantage of having the strongest wind (13 mt/sec) pushing vessels not on the beam reach but on the broad reach, resulting in a greater speed and lesser capsizing risk.
Then the second leg of 145 n.m. until the longitude or the easternmost tip of Socotra, always with strong winds (12 mt/sec) except than close to Socotra coast (10 mt/sec), pushing vessels on the beam reach with a continuous pace of luff and bear away.
Finally a third leg of 198 n.m. until the 57° longitude with a 12,5 mt/sec wind on the broad reach and a fair navigation speed.

During the Southwest Monsoon, the currents set strongly N along the coast at the South of Cape of Spices, then arrive at the mouth of the Gulf of Aden and overcome the Cape, closely round it on the left setting to W, and to the right at short distance from it the currents set to the N and ENE, at a velocity of 0.5 to 1.5 knots in the direction and around Abd al Kuri.
All the course was travelled with a pace alternating luff and bear, drawing a serpentine on the sea, with the combined effect of the current and hydrodynamic resistance generated by waves and vortexes. Assess the final result is not easy at all, both because current force and wave counter effects are variable and perhaps mutually balancing; instead it could be easier trying to asses the serpentine of the course in those conditions, because during the southwest monsoon, **intermediate-period swells** dominate, with wave periods typically ranging between **8 to 12 seconds**. Given the relationship between wave period and wavelength, these swells can have wavelengths ranging from **100 to 200 meters.** This means that at least the serpentine to be performed is of 50 mts at 45° on the right and then 50 mts on the left, then an advancement of about 71 mts for any zig-zag instead of 100 mts straight ahead. Resulting speed could then valued to be 71% of that otherwise possible, while distance travelled and time spent have to be increased of 41% at least.

Leg	Length	Mean wind	Mean Speed	Hours	Days	Notes
Cape of Spices - Abd al Kuri	52 nm	13 mt/sec	3,15 knots	16,5	0,7	Speed value =71% of 75 % = 0,53 x 0,457 knots
Abd al Kuri – Socotra East tip	145 nm	12 mt/sec	1,92 knots	75,5	3,15	Speed value =71% of 50% = 0,35 x 0,457 knots
Socotra East tip – Longitude 57	198 nm	12,5 mt/s	3 knots	66	2,75	Speed value =71% of 75% = 0,53 x 0,457 knots

So this course could be completed in about 6,6 days.

2 - A second stretch of simpler navigation covering about 470 nautical miles until the longitude of 65°, with the ship proceeding under 20 knots mean winds at broad reach. Evaluating the ship speed in such conditions is not so easy, also because of possible high waves crosswise which could cause a gradual northern drift and continuous course correction for maintaining the bow directed toward the East. Furthermore, the huge and long waves forced, at least for the initial stretch, to continuously tack, luffing and bearing away in a continuous struggle against the sea conditions.. That's why this also has been taken into account until 60° E.

Leg	Length	Mean wind	Mean Speed	Hours	Days	Notes
57° - 60° E	176 nm	11,2 mt/sec	2,71 knots	65	2,7	Speed value =71% of 75 % = 0,53 x 0,457 knots
60° - 65° E	294nm	9,8 mt/sec	3,36 knots	87	3,6	Speed value = 0,75 x 0,457 knots

From 60° to 65° E the wind loses strength stabilising about 10 mt/sec and the ship can take a more affordable and speedy pace toward India.
This second leg of the crossing last then about 6,3 days.

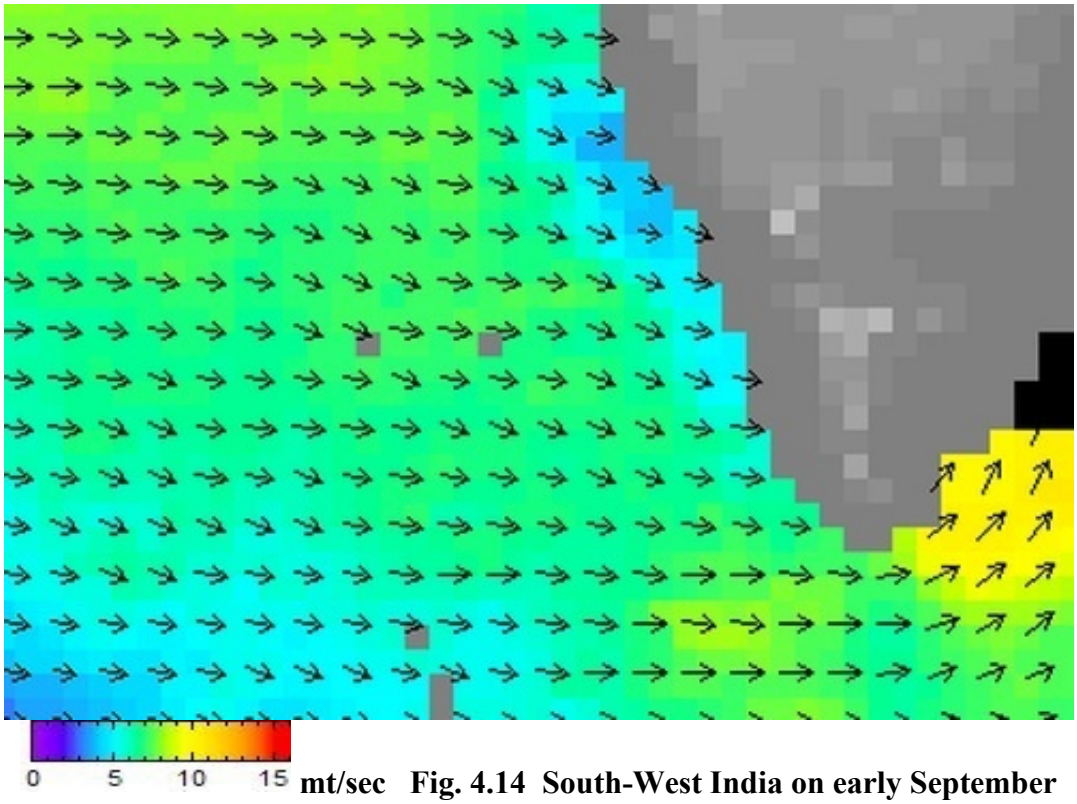
3 – The final stretch of route toward Indian coast is a quiet 412 n.m. travel with a fair 14 knots tailwind, pushig ships at slithly more than 3 knots until 72° longitude, when it slows at 10 knots toward ESE; after the vessels can follow that weak wind for 227 n.m. , so that they arrive to see India around the position of current city of Kozhicode (ancient Calicut).

Leg	Length	Mean wind	Mean Speed	Hours	Days
65°-72° East	412	7 mt/sec	3,2 knots	123	5,1
72°- Kozhicode	227	5 mt/sec	2,3 knots	99	4,1

The ocean crossing could then be completed in 22,1 days that summed up to 10,2 for the first stretch from Ocelis to Cape of Spices result in 32,3 days.
The entire 2017 nautical miles crossing from Ocelis to the Indian coast of Karnataka could then be completed in 32-33 days at best, arriving to India's shores on the first day of September: this cannot however be a precise figure because the monsoon winds vary both in force and timing in every sea area from a year to the next. This inevitable uncertainty thus sum up to our ignorance of greco-roman merchant ships performing features. Moreover it coud happen a problem with the crew, the ship or the supply, all causes of delay.
Anyway this error probably is limited to some more day as timing, but as a minimum time to reach destination the calculated values could be considered affordable: as a matter of fact when the force of the wind some year is greater than normal the ships have to wait before leaving or to perform manouvers of repeated luff and bear away, as it has been said for the Socotra area, and the time spent to reach destination consequently increases.

Arriving to Muziris

From now on the navigation continue along the West-Southern coasts of the Indian subcontinent with weak wind on the broad reach; to arrive to Cape Comorin a ship still has to travel 230 n.m. This travel is carried out in two equal legs, the first with 5 mt/sec wind, the second with 7 mt/sec wind, that is respectively about 10 and 14 knots wind velocity.



mt/sec Fig. 4.14 South-West India on early September

Leg	Length	Mean wind	Mean Speed	Hours	Days
1	115	5 mt/sec	1,7 knots	67	2,7
2	115	7 mt/sec	2,4 knots	48	2

Vessels then could arrive in the Comorin area at best after 37 days from Ocelis departure: actually they perhaps arrived at this position in 37- 39 days, due to casual route deviations or drift.
After Cape Comorin the wind takes a new force at 10 mt/sec, pushing ships up on the east coast at a good speed of 4,5 knots, that means 110 n.m. a day. So exactly like in the case of a northern route to Muziris, that mart could have been near Comorin or even on the Mannar Gulf coast.

The conclusion is that Pliny was right, Muziris was reachable with 40 days of travel from Ocelis, both via the Northern route through Barygaza and the direct crossing of the ocean, but the result is threefold: two Muziris locations in the area of Cape Comorin and another on the Gulf of Mannar. Even though the first are more probable, the other cannot be dismissed without some more in-depth analysis, for instance considering other known features of this locality, like the cleft lip river Culli, the close lagoon shown in the Tabula Peutingeriana, the close Nelcynda and Bacare, the dark red mountain cited in PME 58, the Ptolemy's Calecarte promontory and the short distance from the border between Chera and Pandian territory.
Hereafter those solutions are commented, Muziris 1, Muziris 2 and Muziris 3.

Fig. 4.15 Route Kozhicode – Cape Comorin

The carried out study suggest that Muziris location was near or even after the Cape Comorin, Southern tip of the Indian sub-continent, on the West coast or even on the East coast.
As it is still not possible to use the “40 days criteria” for Muziris’ locationing, only a few more clues remain for possibly identifying the precise site.

They are:

- the cleft lip river Culli mouth
- the Ptolemy's Calecarte promontory preceding Muziris on the coast
- the close lagoon showed in the Tabula Peutingeriana
- the dark red mountain cited in PME 58: "Beyond Bacare there is the Dark Red Mountain"
- the short distance from the border between Chera and Pandian territory
- the close Nitrias (According to Ptolemy there was a Nitra near Tyndis), Tyndis, Nelcynda and Becare, in addition to the following locality of Comari (Kanyacumary, Southernmost tip of India ?)

As for the first four, being geographical features, it is possible, at a certain degree, to rely on them as plausible hints, always considering that, due to the long time passed, many geophysical characteristics could have been modified because of:

- bradyseism, both up and down,
- river's silting up,
- catastrophic floods,
- quakes and tsunami changing the coast profile.

As for the last two their positions is too much undefined to be of any help, in addition to their respective distances, reported in PME 54, and the Ptolemy's position of Becare, at the mouth of Baris river, reported as to the NE of Muziris. As for the cited distances it could arise a doubt about the actual distance of Nelcynda, since PME 54 affirms that "**Nelcynda** is distant from **Muziris** by river and sea about five hundred stadia", but does not clarify if the river path includes either Culli and Baris rivers or only the last.
The difference between those two paths is anyway of only 20 stadia and hereafter it is not included.

Relating to the distances between those locations, we know that Tyndis was on the sea at 480 stadia (89 km) from the cleft lip river mouth, while Muziris was 20 stadia (3,7 km) in the interior; the distance from Muziris to Nelcynda, by river and sea, was 500 stadia (92,7 km), while Becare was at 120 stadia (22,2 km) from Nelcynda and then 380 stadia (70,5 km) from the cleft lip river Culli mouth.

Although all the available information is clearly not sufficient to localise Muziris, even so some tries can be made, and are showed in the following paragraphs. Obviously they do not claim any historic validity, being only some possible archaeological proposals.

Muziris 1

If the Komari site from the PME is actually Kaniakumary, both Bacare and Muziris are preceding it.

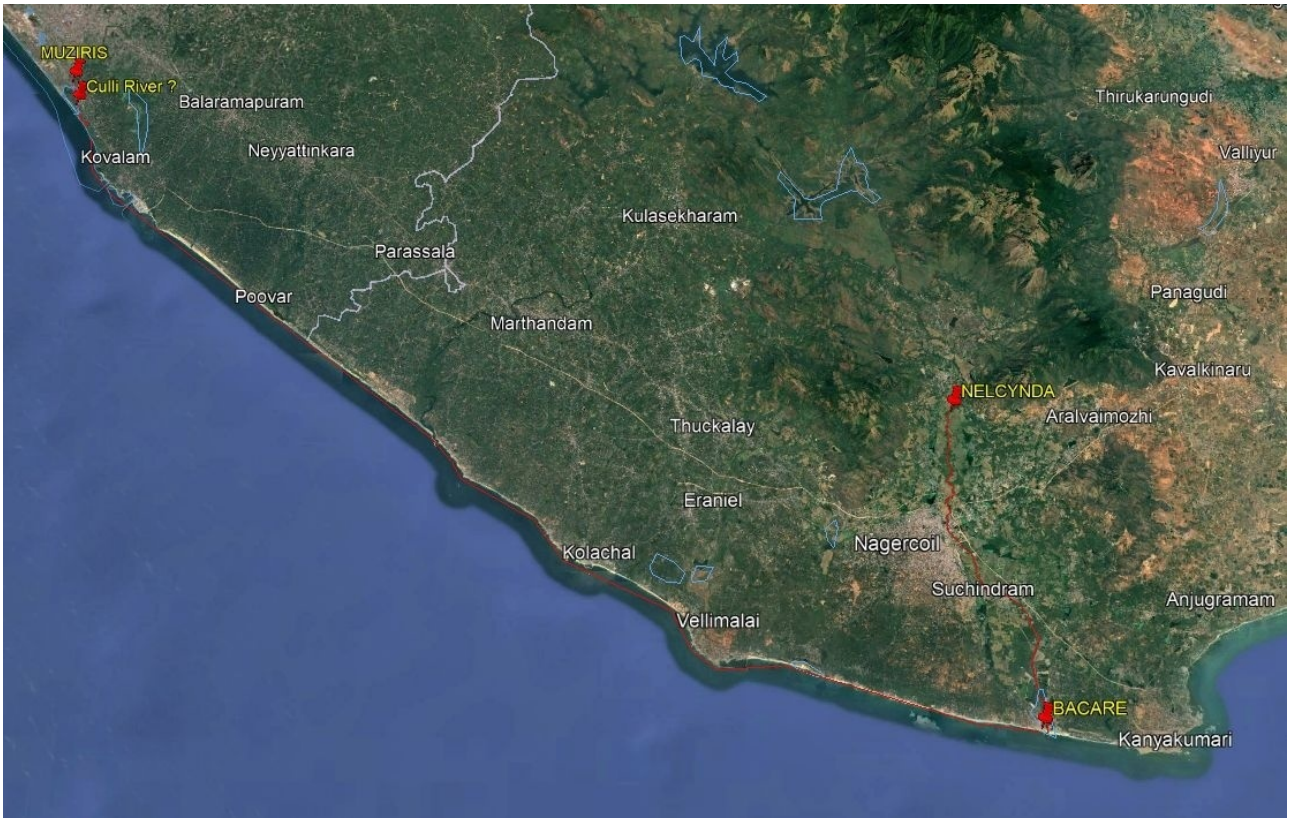


Fig. 4.16 Muziris locationing hypothesis 1

The PME 55 says, about the river from Bacare to Nelcynda, that “the river is full of shoals and the channels are not clear”. Currently the river Pazhayar is plenty of shoals covered with mangroves, and then could be the Ptolomy’s Baris river that was used to transfer merchandise from Bacare to Nelcynda. If the current Manakudy was the ancient Bacare, then the cleft lip river Culli mouth was about 380 stadia (70,5 km) up on the coast, what brings the attention on the mouth of the current river Killy, perhaps the ancient Culli, and the site of Muziris up 20 stadia (3,7 km) along the river, corresponding to today Thiruvallam. In this case Nelcynda would have been on the current location of Seethapal, Nagercoil, Tamil Nadu 629901.

The close lagoon shown in the Tabula Peutingeriana may be the Vellayani lake, and the Dark Red Mountain cited in PME 58 could be the Thekkumalai (780 mts) in the Western Ghats.
What instead lacks is the Ptolemy’s Calecarte promontory preceding Muziris on the coast; as a matter of fact the only faint hint of very little promontory is Thangassery near Kollam, 65 km up North along the shore. Curiously enough in ancient Greek “Tyndis” meant “backwaters with flowers”, and that site has a great lagoon at it shoulders (TS Channel).

Muziris 2

It should be located between a promontory on the coast and the Comari location, then it could lie between the Muttom promontory and Kanyakumari.
In this stretch of the coast the only river sufficiently large and capable of supporting a riverboats' traffic of wares is the Pazhayar, that now flows into the Mankudy Lake and the sea.
If that was the Culli river then Muziris was at was 20 stadia (3,7 km) in the interior, about the current location of Thamaraikulam.
Bacare in this case would have been near Manapad, a little bit to the North-East of Muziris, like Ptolemy affirmed, but located after Comari contrary to the PME.
From Manapad going upstream on the Karumeni river, rich of shoals near the mouth and with several different channels upstream, a second possible location of Nelcynda could be near Satanpagolam.
The Dark Red Mountain cited in PME 58 could be the Theri Kaadu, not a peak but simply a hill 85 meters high, at the centre of a vast area of dark red sands; anyway all the elevations in this region are made of brown-reddish rock.
A surprising coincidence: in this hypothesis the calculated Tyndis position at 480 stadia from Muziris corresponds with the coastal area named "Thumba", because it is plenty with the homonymous plant. "Tyndis" in ancient Greek meant "backwaters with flowers".

Fig. 4.17 Muziris locationing hypothesis 2

Muziris 3

A final but daring hypothesis could be locating Muziris, always near Kanyakumari, but supposing that PME and Ptolemy's localities order has been shuffled due to a lack of thorough information about a so distant region. In this case also the possibility that Muziris laid after Comori arises, for instance at the very end of the forty days voyages – both along the Northern arch of Arabic Sea and directly crossing the Indian Ocean - that have been previously reconstructed.
That means locating Muziris on the Mannar Gulf shore after a day more of navigation.
At about 90 n.m. from Kanyakumari there is the mouth of the Gundar river, a place immediately preceding the Brahmanankulam lagoon, today named Mookkaiyour.

Fig. 4.18 Muziris locationing hypothesis 3

At 380 stadia from the mouth of the Gundar river, voyaging by sea, one reach the Alagankulam area, where is now the mouth of the Vaigai river, rich of shoals near the mouth and with several different channels upstream, the same that passed through the Pandyan capital city, Madurai.
Those are the Gundar-Vaigai basin two main rivers, while Virusuliyaru, Kottakariyaru and Upparu are other minor rivers; they all are only seasonal watersheds flowing and draining during the raining season from October to December; in the other seasons the water is much more limited or even absent.
Looking at this area in more detail (Fig. 4.15**)** one can see a sequel of ponds and a stretch of water bodies, going from the final Vaigai curve toward South-East, running to the Nochiyurani lagoon and after through the Sattakkonvalasai area as a little river. Could it be the ancient print of the Vaigai river, once flowing to the Southern coast instead of the Northern one ?
In that case Bacare could have been on the extreme tip of the Mannar Gulf shore, and Nelcynda upstream the Vaigai river toward Madurai, today Valuthur 20 km away.
Bacare was also a little bit at the North-East of Muziris, like Ptolemy said.
There was also the Ptolomy's Calecarte promontory before Muziris, namely the ancient Tuticorin, today Thoothukudi.
The Dark Red Mountain could have been one of the reddish elevations around Sivaganga.
The Brahmanankulam lagoon could be the water body drawn near Muziris in the Tabula Peutingeriana.

May be. But all other known written information should be false or highly confused.

Fig. 4.19 Possible ancient track of the Vaigai river

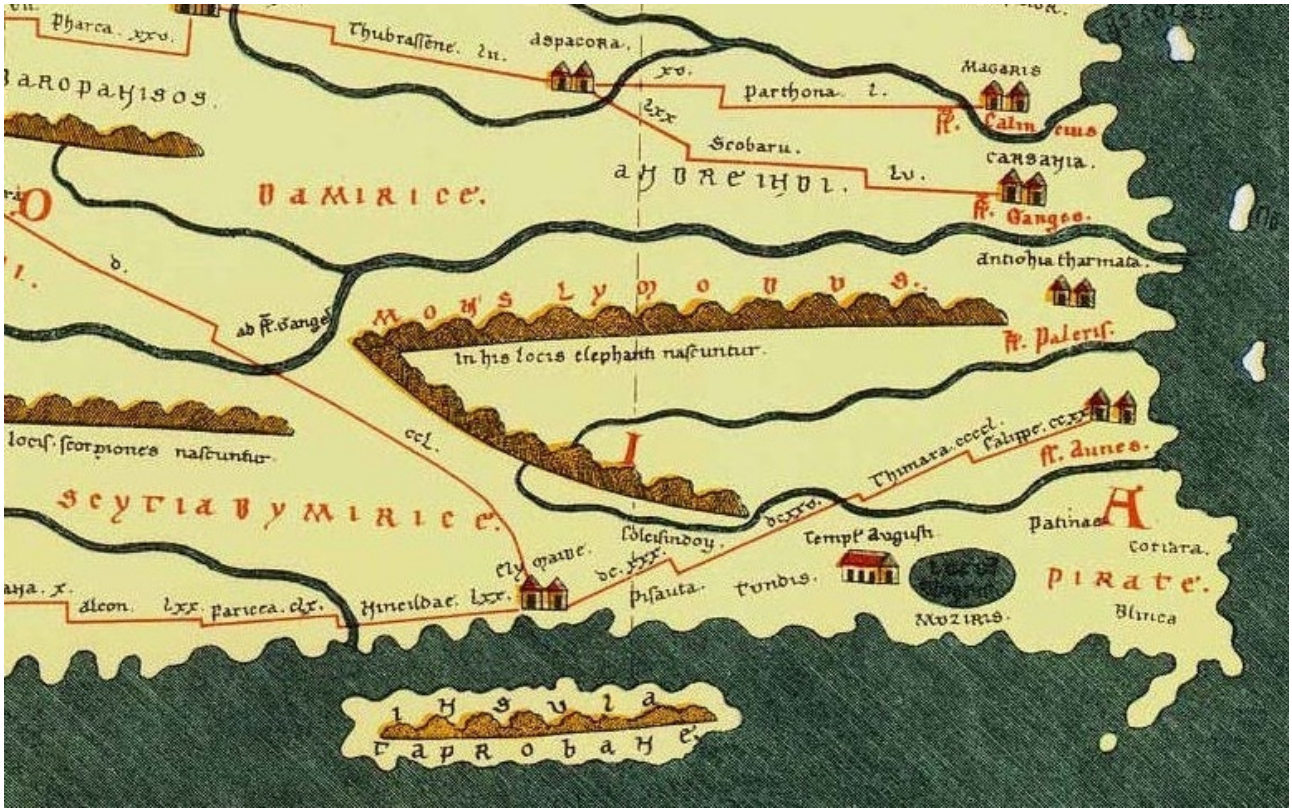


Fig. 4.20 Muziris on the Tabula Peutingeriana

Return to Berenike

During the winter monsoon, from mid-November to mid-March, the winds blow from the North East on South China Sea and Bay of Bengal, and from the north on the west coast of India and Arabic Sea; in Tamil Nadu the rainy season usually starts in October and lasts until December. During this period, the state receives heavy rainfall and the rivers swell with water.
Pliny said that at the end of December, and anyway within mid January, roman vessels left Muziris and went toward Berenike.
Anyway ships navigating on the northern arch ran into weak and then strong winds always in iron, thus sailing slowly until the Oman Gulf; only after they started to be pushed by rather weak winds along the Arabic Peninsula toward the Red Sea.
About that here is a strange passage in PME (31-32) about ships coming from Damirica, that being late on their course, stopped in Moscha spending there the winter. Roman vessels returning from Muziris and following the northern arch of the shores, having at best the wind coming from the North at the beam reach, proceeded slowly and some of them could have been late on thei route but had no reason to stop, because they transported mainly pepper and malabathrum and had all the interest to arrive at Berenike whichever was the time to be spent. Only ships coming from Barigaza carrying rice, wheat and Indian cloths could have an interest to stop there for trading them with frankincense, or may be Indian ships returning home from Arabia. [4.5]

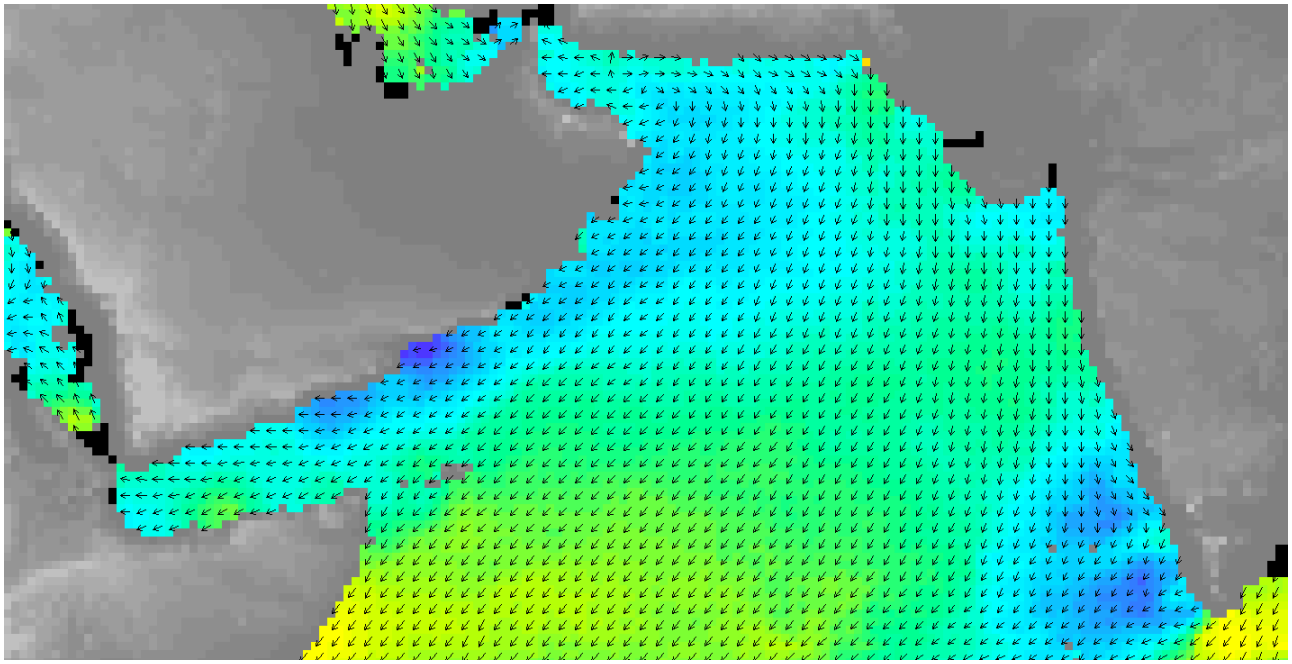


Fig. 4.21 Arabic Sea on January

But other larger vessels crossed anew the ocean directed to the mouth of the Red Sea, possibly making also a first stop in Socotra: they had at that time also an advantage that today few considered. Due to the Earth axis precession, 2000 years ago during winter both Polaris and South Cross were simultaneously visible, so aiding sailors to follow the route when returning home. They had only to keep the Polaris on the right and the Cross on the left and they could follow the route also during night. During daylight they had simply to keep dawn at the stern and dusk on the bow.

4.5 Proceedings of the seminar for Arabian Studies, Volume 38 2008, London 19-21 July 2007, pg 283-288, Eivind Heldaas Seland

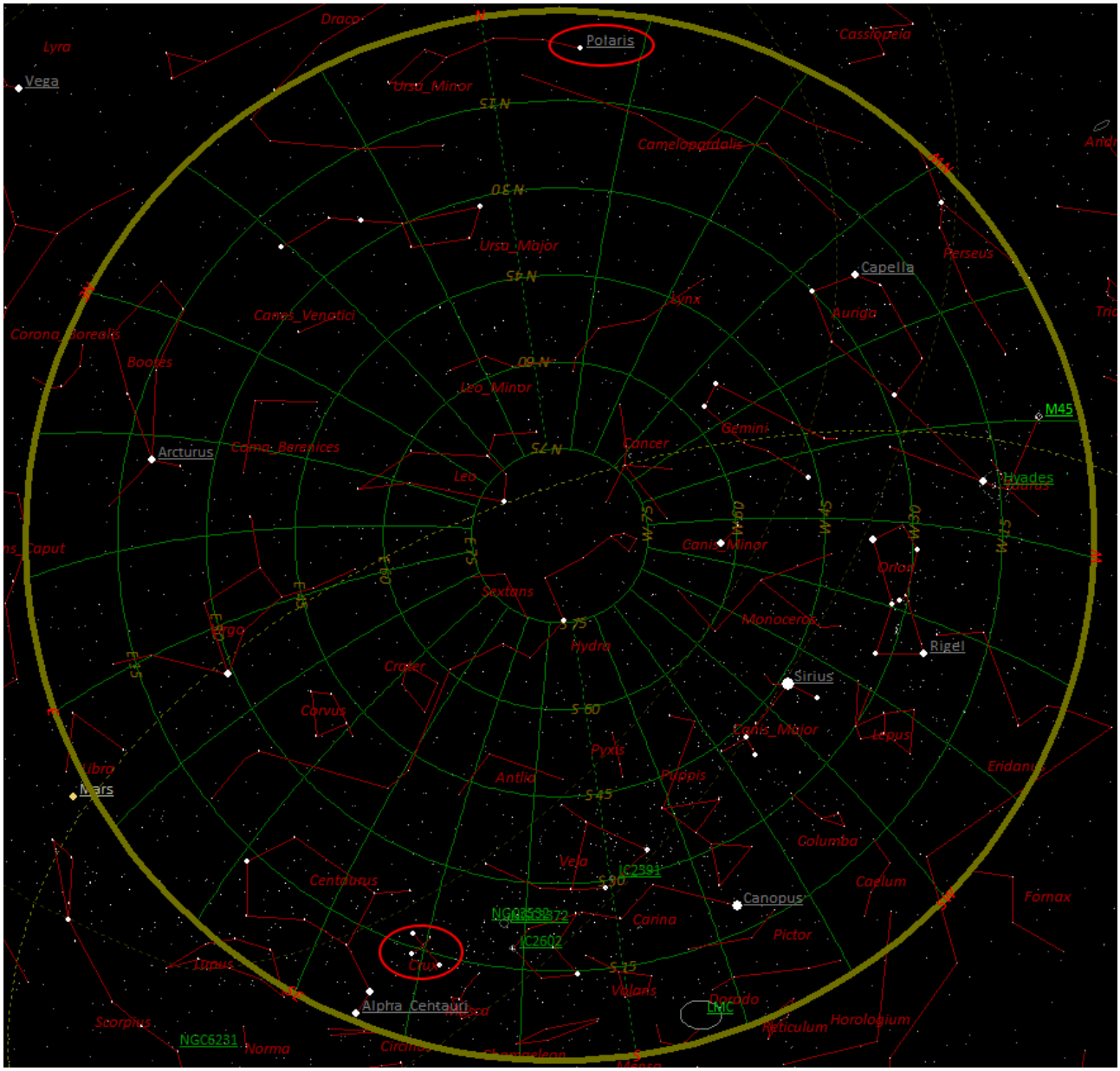


Fig. 4.22 Mid-way Arabic Sea on 23.00, 31 January, 75 A.C., HNSKY version 4.2.10

The first land encountered after the crossing was Socotra, where is probable that a certain number of ships made a stop on the northern coast, if only for some supply. So that island was an important stage for many sailors of many different origins, testified today by the Hoq cave. First discovered in 2001, a corpus of more than 200 graffiti from the cave Hoq on ancient Dioscourides constitutes an invaluable resource, shedding a rare light on trade routes and people meetings of the ancient Indian Ocean. Buddhist monks and Yavanas, Persians and Indians, from Roman Egypt, Palmyra, Axum, Hadramaut, Western India, Bactria and Gandhara, went there apparently in pilgrimage, leaving to us the sign of their lives. [4.6]

Socotra contributed to this sea trade with tortoise shells and resins of Myrrh, Frankincense, Aloe and dragon tree, a highly prized and fragrant incense, widely used in medicine and cosmetics.

4.6 Cave of Revelations, Indian Ocean Trade in light of the Socotran Graffiti, Kasper Evers, Journal of Indian Ocean Archaelogy 10-11

Conclusions

The aim of this essay has been trying to verify the current hypothesis about the localization of the ancient Indo-Roman port of Muziris/Muchiri, by examining the routes followed by Greco-Roman ships to reach the Indian subcontinent, the relative times and reachable distances.

To this end, data on monsoon winds detected today by satellites can also be used, in the hypothesis that this recurring phenomenon has not significantly changed from the first century AD to the present day. In this manner routes and corresponding timing have been reconstructed, then on the basis of Pliny the Elder's Naturalis Historia affirmation that ships arrived at Muziris with 40 days of travel from Ocelis, the place where the journey ended
Muziris location.

Results obtained show the area around Kanyakumari, the southernmost tip of the Indian subcontinent, as the nearest to ancient Muziris mart, exactly there or at some distance before or beyond. Only further in-depth archaeological investigations will be able to provide better indications.

Unfortunately very little is known about the diplomatic relations between the Roman Empire and the various potentates with which trade developed; these contacts may have made use of ambassadors and much more probably of exchanges of information entrusted to the merchants themselves who travelled from one end of the ocean to the other.

Moreover it should be remarked that, as the find of the Muziris Papyrus testifies, more results can be found in the future with accurate and in-depth library research: stories and reports about western merchants in India are yet known, as those told by Cosmas Indicopleustes, Palladius (Bishop of Aspuna), Diodorus Siculus, Pliny and Ammianus Marcellinus.
Therefore it can not be excluded that somewhere a document from one that epoch merchant – of Greek, Roman, Persian, Egyptian or whatever origin – survives forgotten.

In the meantime and without any claim of historical veracity, three different hypotheses have been put forward as examples only, one before Comorin Cape, one in correspondence to it and a third beyond it.

This work, in the author's intentions, is not finished, but should be completed in the future with an analysis of the more favourable trade routes converging on Muziris for each merchandise traded there; this could add some more hint to this research, because there should have been important commercial or political reasons for the leading importance assumed by the Chera Muziris, despite the known pirates' threat, the difficult mooring conditions and the possible competition by the Pandyan Nelcynda.

The author thanks all the people who have devoted their attention to this work.