Ancient Lighthouses - Part 2: The Mariners

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***Abstract**: This paper considers how humans first came to use water for transport and how they developed systems of navigation. The development of lighthouses is a key element of the analysis.*

The Birth of Humanity and the Origins of Seafaring

If we are to appreciate fully the origins of lightstructures and lighthouses, we need to re-examine the context in which they would have been valuable aids to navigation. To have travelled by water, humans would have needed certain cognitive abilities and knowledge. Therefore, before I discuss the building of lightstructures, I shall spend some time considering the earliest origins of humans and review the state of present knowledge about their activities and the development of their primitive societies. I shall discuss the ways in which humans have gone about their business on water and it may then be possible to make conclusions about when our ancestors first used lighted aids to navigation.

It is necessary to point out that, at such an early stage in history, the physical shape and structure of a lighthouse is not at all like it is today, and the use of the word lighthouse in this paper at any point from now on does not imply any similarity to the lighthouse of today.

The subject matter contained herein constitutes a field of active research, and is continuously being clarified by new techniques of archaeology and DNA analysis that have revolutionized evolutionary biology since 2000. It is likely that there could still be much change in the details of our understanding of the earliest years of humankind, but perhaps we might expect the matter outlined below to continue to be relevant for the time being, at least.

Fig. 2-1 presents an approximate time-line of events covered in this book.

Objectives

The objectives of this paper are:

1. To review the development of the human species and to consider how and when humans first used water as a means of transport.

2. To describe the various means of human water-borne transport used in ancient times.

3. To review methods of navigation available to ancient peoples and to propose definitions suitable for making conclusions about lighted aids to navigation.

4. To identify the points in history when artificial aids to navigation might have been used, and, in particular, to identify a possible time when lights were used for navigational purposes.

Homo, the Human Genus

The date at which the first member of the genus *homo* (man) evolved from the chimpanzee is thought to be around 6000 kya (six million years ago), a date that is during the period of history known as the Pliocene.[1] This was, for our purposes, the first human or hominin. (The word 'hominin' is today preferred to the word 'hominid', which has been given the broader meaning that includes all Great Apes.[2]) Over the course of the next three or four million years, evolution of the offspring of this ancestor led to variations in the DNA of her descendants such that a new sub-genus was created within the *homo* genus that led to *homo sapiens* (wise man). So we find that a succession (not necessarily derived one from another) of new distinct sub-genera of hominins called *homo habilis*, *homo rudolfensis*, *homo ergaster*, *homo erectus*, *homo antecessor*, *homo heidelbergensis*, *homo neanderthalensis*, *homo floresiensis*, *homo naledi* and *homo sapiens* came to life.[3] In 2003, a publication in the top science journal, *Nature*, described the discovery of a new closest ancestor to us, which was given the sub-species name *homo sapiens idaltu* (earlier wise man).[4] This early human has been dated from around 150 kya, whilst the discovery has meant that we needed to distinguish ourselves still further with the renaming of our own sub-species as *homo sapiens sapi-*

Correlation of Human Activity with Navigation (kya = thousand years ago)

2 kya	Roman Empire	Ports and Harbours with Lighthouses	0 BCE
2.28 kya	Alexandria Pharos	Lighthouse	280 BCE
2.6 kya	Carthage Power	Sanctuaries and Temples Cadiz, La Coruña Harbour lights: Thasos (Stage 3)	600 BCE
3.2 kya	Troy VII: Trojan Wars	Achilles Tomb Sigeum, Sestos, Abydos	1200 BCE
6 kya	Troy I		4000 BCE
8 kya	Sails on the Nile Bronze Tools Improved Ships	Lighted Aids to Navigation provided by Religious Ceremonies	6000 BCE
10 kya	Migrations East and West by Sea (Thor Heyerdahl)		8000 BCE
			Ice Age
41-39 kya 50-45 kya	Neanderthals extinct Population of Sahul (Australasia)		
50 kya	Sudden Increase in Human Skills	Sea Travel by Night Navigation by Moon and Stars	
80-60 kya	Second Dispersals - Homo Sapiens	Navigate By Fire (Stage 2)	
200 -300 kya	First AMH		
600-400 kya	First use of fire by H. erectus	Navigate By Fire (Stage 1) Navigate by Daymarks	
800 kya	Canoes/Reed Boats	Cross Rivers With Passengers	
	Flotation	Cross Rivers Solo	
1800 kya	First Dispersals - Homo	Cross Shallow Streams	
6000 kya	First Homo From Ape	Travel on Land Only	

Fig. 2.1: Table correlating years and events with human activities. (kya = thousand years ago)

ens - a really wise man! The earliest humans to be described as *homo sapiens* are presently thought to have evolved 1800 kya, whilst our own sub-species began evolving about 200 kya and is known to paleoanthropologists as Anatomically Modern Human (AMH).[5] *Homo erectus* (upright man) was an especially long lived species, their ancestors having migrated to eastern Asia where they lived for over 2 million years. It is a mistake to think that each species evolved from the previous one. It may be true in some cases, but there are numerous times during which different species of *homo* existed together. The precise taxonomy of humans is complicated and still being determined.

Humans from the species *homo neanderthalensis* (Neander Valley man) are thought to have evolved in western Eurasia, during a period of glaciation around 400 kya. They were particularly suited to the harsh, cold climate, and were both bigger and more muscular than us.[6] Although some Neanderthal remains have been identified in the Levant and northeastern Africa, this species of human is considered to be descended from the earliest humans to have left Africa, *homo heidelbergensis*. A similar species called *homo sapiens Denisova* was discovered in Siberia[7] and may have played a role in the population of southeast Asia.

Human Activities

The very first humans would have had a lifestyle similar to the Great Apes, but the most significant biological difference - the brain - enabled hominins to discover new possibilities and to learn new skills. Of these, one of the most significant was to use tools to improve their life chances.
It was about 3 to 4 million years after that first human child that hominins first began to use tools. A new period in our planet's history had begun, and today we refer to it as the transition from the Pliocene to the Pleistocene period. This is put at 2500 kya.[8] The whole of this period of human life took place in Africa, in a region of land that today is part of Eritrea, Ethiopia and East Sudan. Using traditional Western nomenclature, we might safely call this land the Garden of Eden, and in case extra clarity is needed, no humans lived anywhere else on Earth at this time.

The making and use of fire has been crucial to human development. The first controlled use of fire is still a subject of debate, with some saying that fire was used 1500 kya, but archaeologists continue to gain understanding in this area. The latest evidence is for a site in the Levant at a time around 790 kya[9] although a widely accepted time for *homo erectus* to have used fire is 600 to 400 kya.

Because the first tools were stones that were scattered around and ready to hand, it is a stage in the development of humans that has been commonly called the Stone Age. There are three divisions of the Stone Age: Palaeolithic (early), Mesolithic (middle) and Neolithic (late) periods. The Stone Age was over when humans began to use metals on a regular basis. This period, beginning at about 5.5 kya is known as the Bronze Age, although there are some places - parts of West Africa, for example, where it was iron that was used first. This is an indicator of the main problem with this kind of time description because the years associated with an Age are different in different parts of the world. Consequently, some historiographers (those who chart the course of history) choose now to call the period following the Stone Age as the Metal Age. The nature of each Metal Age was obviously dependent upon which metals and skills were available at the time.

The period that spans the Stone Age is very long indeed, and much happened that is significant to this analysis. Thus, before rushing headlong into the age of metals I intend to discuss issues that are directly relevant to our ancestors becoming mariners - the establishment of lighted aids to navigation - and which have not received adequate consideration in a dedicated work of this kind.

The Palaeolithic period was a time when the most primitive stone tools were used. Food was obtained by the practice of hunting and gathering, and those humans who may have occupied land on the edges of the sea collected shellfish. Archaeologists have identified settlements belonging to these peoples by means of piles of discarded sea shells in what are called 'shell middens'.

During Mesolithic times, humans employed bows and arrows, with arrowheads being found in excavations. The oldest known arrowheads so far discovered belonged to the Natufian culture of the Levant region at 14.5 to 11.5 kya. Of most significance to this work, we note that the Mesolithic period also corresponded with the invention of the canoe. The Natufian culture immediately preceded the time of the Neolithic period that was the commencement of domestication of plants and animals and the beginnings of agriculture. People became less nomadic and more settled in specific locations. Houses were constructed on ground level instead of being partially below it.

The First Dispersal

We shall now consider an outline of human development that is focused upon their use of water for travel, presented in a topic taxonomy or logical tree structure, often referred to as a mind map, Fig. 2-2.

When hominins first migrated out of the East African Rift around 1.8 million years ago, it was a natural fanning out along the easiest land routes, almost certainly favouring the route of the Nile because of the benefits of living close to the river. It is generally believed that apes do not swim and avoid entering water. Therefore, if our ape ancestors preferred to be on land then our earliest human ancestors would do the same. There are exceptions to all cases, and in 2013 two biologists reported examples of apes who had been taught to swim.[10] Raised with humans, these animals were in an artificial environment, so perhaps two things can be concluded. (1) The earliest humans would not have chosen to enter water (apart from the shallowest water for washing or drinking) (2) It would have taken time for them to learn to swim and to teach it to others.

Water obstacles vary in size from a trickle to a river, from a sea to an ocean. Some of the obstacles the migrants faced might cause wet feet; others needed to be swum. Even the act of learning to swim must have taken many years of evolution. The skills of swimming, together with the realization that wooden objects float and might therefore be used to overcome water obstacles occurred in times parallel to other very early skills. These skills might have been acquired in the same period as the manufacture of bows and canoes. Perhaps not.

Having travelled the length of the Nile, humans could leave Africa by the so-called 'northern dispersal route', through the land of Suez and Sinai from where they could travel north into the Levant or east into Arabia. There is no reason to believe that water-borne travel was involved in any way, apart from the easiest of river crossings that might involve swimming or floating on logs. There is no question of people setting out to cross water when they could not see the other side.

However, a second 'southern dispersal route' also existed across the Red Sea. (Of course, they could also travel to southern Africa, as well as westwards along the coast of north Africa, but it is the African exodus that is under discussion.) Even at its narrowest point, the Bab Al Mandab Strait, it would seem to have been a formidable obstacle to these early humans, but we should remember that some two million years ago the sea level was much lower than it is today. The very low sea levels play a crucial part in understanding how the Red Sea might have been crossed. The southeastern tip of the Arabian Peninsula became an early destination for those leaving Africa, for here the distance from shore to shore was greatly reduced perhaps to as little as one or two kilometres. (It is thought that the sea never disappeared entirely, but this cannot be discounted.) The very low sea levels would have created large amounts of new land that assisted the early humans; these dispersal 'corridors' avoided mountains, desert and harsh weather conditions that would have impeded progress further inland. Unfortunately, this part of the story of the Pleistocene period is missing from the historical record because it is now underwater and may even have been destroyed.[11] It brings sharply into focus the need for underwater archaeology around coastlines.

Having migrated along the coast of north Africa, humans might also have crossed to Europe by means of the Strait of Gibraltar. Not only was the sea level very low, but there is also geological evidence that the Mediterranean Sea was closed to the Atlantic Ocean, in which case early humans could walk across what is known as a land bridge to southern Europe. Otherwise, population of western Europe took place by migration anticlockwise around the Mediterranean Sea from east to west, with southern Spain being land settled last. This matter is not yet resolved.

In any case, humans migrated east, overland to Russia, Siberia and China. These settlers were mostly *homo erectus*. Others, mostly Neanderthals, passed through southern Asia to reach the lands of what is today Indonesia. All of this took place in the history of humans that excluded us, since we had not yet evolved. There was no need for sea journeys that extended beyond what could

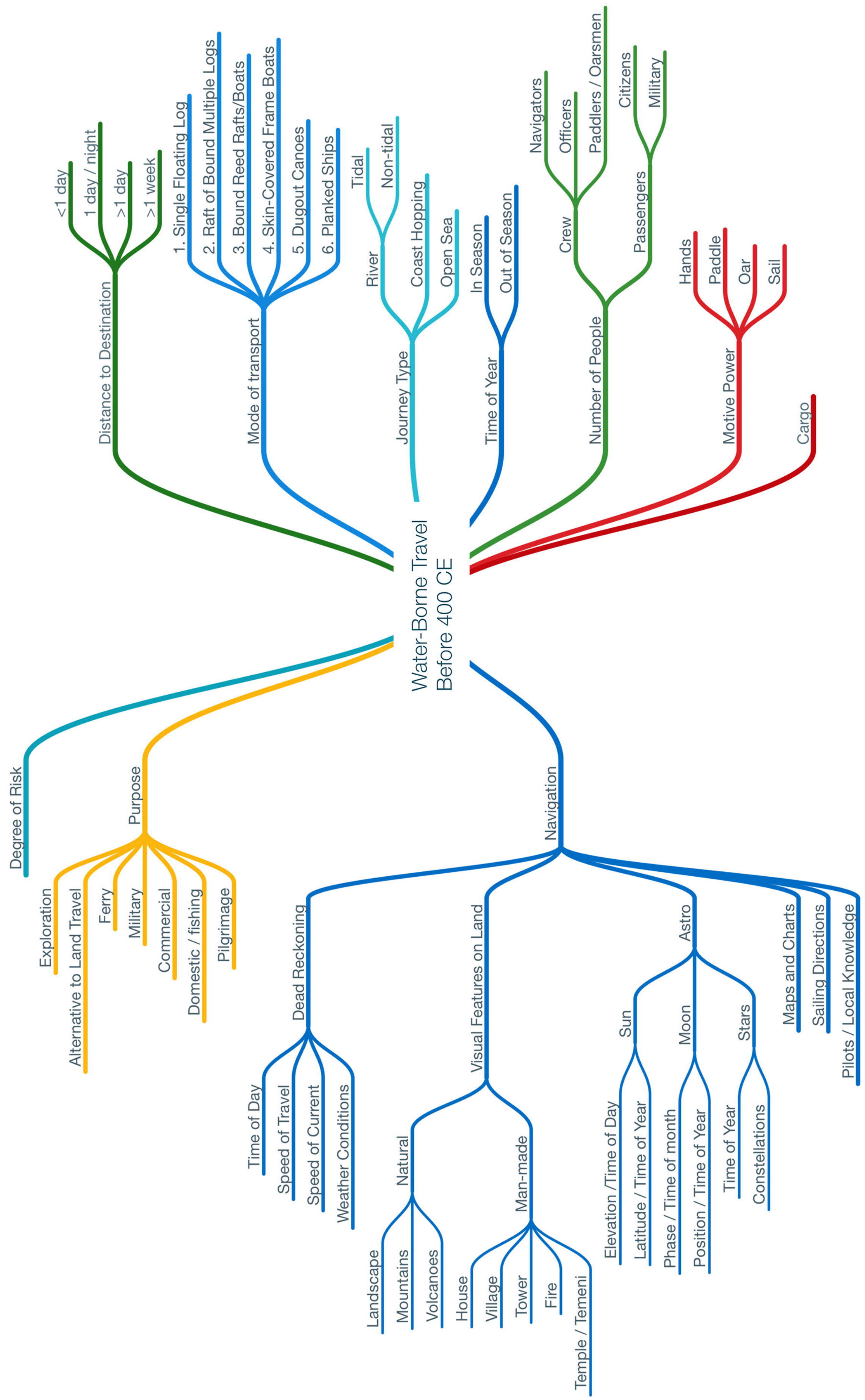


Fig. 2-2: A logical structure - a topic taxonomy or mind map - for Water-Borne Travel.

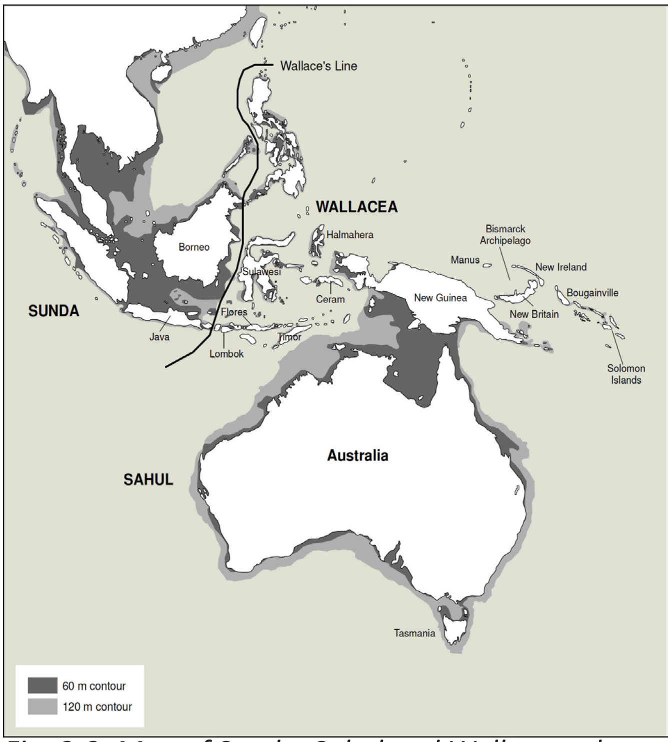


Fig. 2-3: Map of Sunda, Sahul and Wallacea, showing the 60 m and 120 m sub-sea level contours.[61]

easily be accomplished in daylight.

There are claims that Neanderthals of southern Europe possessed the skills of primitive seafarers between islands in the Ionian group from about 110 kya[12] Migrations across water to Crete are now reported to have occurred at least around 130 kya.[13] The shortest leg of the journey is one of 30 km, which means that Crete could not have been reached without sailing beyond the horizon. For our non-hominin ancestors to make what to them must have been a journey into the unknown seems unlikely. However, that long sea journey lasting longer than the daylight hours of one day was clearly achieved at some point by *homo sapiens*, from which time a primitive group might make a decision to colonize the island. For a group to partake in repeats of the same journey by water implies that certain individuals from amongst the group took upon themselves the role of acting as 'specialist operatives', by which I mean that certain individuals would have thought of themselves as 'seamen', perhaps offering their services to others without the same skills. This is a bold assumption to make, but is an important step because it is the repeat actions of taking to the water that are likely to identify the need for navigational aids, rather than single journeys in which the risk is taken just once. Part of the decision to colonize would have been the setting up of fires at the points of landfall along the way. The knowledge that shoreline fires were of great assistance to mariners must surely have been known by this time and we find ourselves at around 100 kya believing that lighted aids to navigation must now be in use.

If we accept that all these things are possible and that there were times when journeys extended into the hours of darkness, then we must also accept that Neanderthals may have used fires to identify their destinations, i.e. the use of Stage 1 or Stage 2 night navigational aids. (See Conventions and Terms section at the front of this book.) The progression from Stage 1 to Stage 2 seems a very small, even insignificant step, but we should not treat it lightly. Perhaps we do our Neanderthal cousins a disservice by assuming that they could achieve Stages 1 and 2 but not 3. Nevertheless, we could conclude that, if the data about Neanderthals is correct, then they could have used the most elementary aids to night navigation, stopping short at building lightstructures.

The Population of the Sunda Shelf and Sahul

Sahul is a term used to denote a composite region consisting of ancient Polynesia, Indonesia and Australia. For several million years, fluctuations in sea level in this ancient geographical grouping have repeatedly exposed large areas of the surrounding continental shelf. They resulted in the creation of a single continuous landmass extending from New Guinea in the north to Tasmania in the south, as shown in Fig. 2-3. The Sunda Shelf is another continuous land mass that lies west of Sahul. In current geography it is described as the Malay Peninsula and the islands of western Indonesia. Here, reductions in sea level of some 60 m created a peninsula of land that extended from mainland southeast Asia to the east via Borneo and Java.

After the first dispersal of hominins out of Africa and the long migration east across south and east Asia, members of early human species reached Sunda where they lived for around two million years, without (as far as we know) ever making the crossing to Sahul. Between Sunda and Sahul lies a 1500 km-wide string of islands referred to as the Wallacean Archipelago. The periodic reductions in sea level diminished the overall extent of the islands, as well as increasing the size of many of them. However, the punctuation of sea obstacles between the islands was never bridged by dry land during the period of existence of early *homo*. Even at the lowest sea levels, 120 m below current levels, the island group measured well over 1000 km from west to east. The generally accepted early method of sea travel was island-hopping, and this could take place along either of two main routes across this distance. Depending on the route chosen, it always required between 8 and 17 separate crossings, and a route always included at least one water crossing of more than 70 km and at least three of more than 30 km, all of which were out of sight of the land of departure.[14]

A number of important points must be made about this event in pre-history. One of the methods available for achieving such a remarkable sea journey is the mathematical minimum by which a single pregnant woman floats accidentally on a log to land in Sahul, from which a breeding colony is established. This is considered to be at least implausible by some and impossible by others.[15]

In a second method, the migration could have been achieved by a single chance journey by a reed boat carrying a number of men and women with sufficient rations of food and water to survive the journey. Other favourable conditions such as wind, weather and tides are also necessary, but O'Connell reports that careful modelling has shown that this method is not biologically likely to result in the establishment of a successful colony.[14] O'Connell's thesis is that there is clear evidence for the population of Sahul by a purposeful colonization by means of a programme of planned journeys, not a series of chance events. He says that this process was made by means of marine craft that were more sophisticated than any design in the archaeological remains found so far in Australia. Furthermore, he argues that because of a tightly defined dating of this event to around 45 kya, it was achieved in a rapid space of time, which indicates that it was made by modern humans (*homo sapiens*) and not by members of any other human species. Of course, it is entirely possible that a small group building a colony in a land the size of Australia might have been too pre-occupied with survival to preserve the skills of building relatively sophisticated boats. This would explain the absence of archaeological evidence. However, it also indicates a serious problem with archaeological studies of all ancient coastal regions: the fact that the rise and fall of sea levels over many thousands of years has badly damaged or indeed eradicated any archaeological remains in those parts of the land that are now submerged by the sea.[14] Nevertheless, we are at a point in pre-history where we must seriously consider that this proposed, purposeful colonization was achieved by people with good skills in boat-building, seamanship and navigation, and that they were assisted along the way by numbers from their group who were prepared to assist by lighting fires in strategic positions along the route. Surely the circumstantial evidence is now sufficiently great for the jury to make a positive decision in favour of Stage 2 lighted aids to navigation?

Populating Islands in the Mediterranean

The early story of Cyprus is extremely illuminating for several reasons, not least of which was its position, hidden from the view of mainlanders and beyond the reach of those limited to waters close to the shore. Once it had been seen by those brave enough to travel far out to sea, it was inevitable that it would be reached sooner or later.

We have seen that the population of Sahul in the Pacific led to the population of Australia around 45 kya. We can now be sure that open sea crossings occurred in the Mediterranean also at a time just after the end of the Pleistocene period (the last Ice Age). Broodbank writes that people made lengthy crossings of the Mediterranean Sea from around 12-13 kya, the 11th millennium BCE.[16] At Aetokremnos in south Cyprus on the Akrotiri peninsula, a site was excavated in the late 1980s that showed much evidence of human activity. Buried among the evidence of humans were large quantities of bones that showed the early inhabitants had enjoyed a diet of pygmy hippopotami, long extinct from the island. Radio-carbon dating showed that the bones were from a time range of 11-9000 years BCE. By far the most important conclusion to be made from this discovery is that an island such as Cyprus was settled by humans at such an early time, despite being well beyond the horizon from any mainland viewpoint.[17] It seems that the hippopotami were wiped out by the

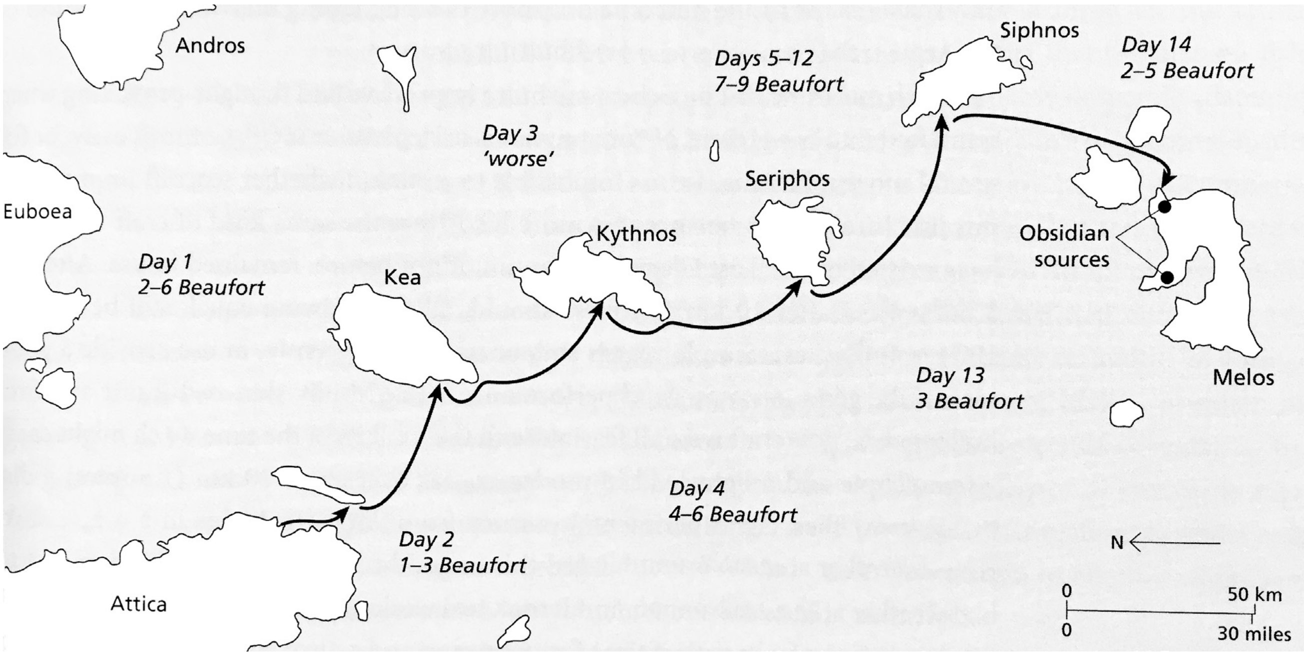


Fig. 2-4: Populating Islands in the Mediterranean.[62] *Broodbank suggests a method by which earliest mariners explored the seas by leaving the mainland of Attica, bottom left, and making a series of short journeys that eventually resulted in reaching sources of obsidian. These methods were used extensively for the exploration and settlement of the island-rich waters of the Aegean.*

presence of the islanders, who in later millennia had to look to farming and agriculture to survive. Broodbank cites this as critical first direct evidence of colonization of an island by means of significant open sea crossings. With distances between the mainland and the island ranging from 60 to 100 km, it is clear that in those early times, the mariners must have used well made dugout canoes that were capable of carrying more than one person, as well as substantial cargoes. The need for new land to settle may not be obvious at first, and readers might feel that there must surely have been space available on the mainland. However, there was a serious incentive to discover sources of obsidian. This material is only found in certain kinds of volcanic regions and was one of the best for producing sharp cutting edges. It could also be polished to make mirrors. So, it was probably the search for obsidian that took the first canoes and their paddlers to Cyprus. Once found, its size and climate was enough to provide the first inhabitants with many of the items they needed for island survival. They stayed.

In the Aegean Sea at around the same time, Melos was also found to be a source of obsidian, but its discovery required a very calculated series of steps between islands, a typical distance from the mainland being 250-300 km in around five steps. The likelihood of discovering this source at a very early phase of a search of such a complex array of small islands is very low, and Broodbank suggests that this discovery indicates that an extensive search across many islands must have taken place long before the hunters discovered Melos. This is further clear evidence of significant sea travel in very basic boats as long ago as the end of the last Ice Age, around 11.5 kya. Broodbank calls this "true seafaring by hunter-gatherers" and marks it as a major advance compared to journeys made by coast-hopping. He also points out that, allowing for bad weather, reconnaissance, quarrying time, and such like, it would have taken canoes with six paddlers at least a month to complete the whole exercise. This new seafaring skill caused the development of civilization to accelerate because it created new contacts for those who were otherwise isolated.

> *"Such links could start to breakdown the barriers between people living in the sequence of peninsulas and sub-basins along the northern side of the Mediterranean, whose only connection until now had been their far-distant northern roots in continental Europe."*[18]

Broodbank says that this ...

> *"... unveils the reach and potential of maritime movement by early farmers … for viable numbers of people and five species of sizeable animals plus a suite of crops had to be shuttled across sea gaps of at least 65 to 70 km ... the most likely sea craft by this time were no longer permeable reed boats but watertight dugout canoes made out of great trees from the nearby mountains. There is no sign of any more powerful seagoing technology for almost another five millennia, and such craft would still be lucky to make the crossing in less than a couple of days."*[19]

The transfer of farming technology to Cyprus took place gradually from Anatolia and the northern Levant over thousands of years, a long change that is only recently being satisfactorily explored on the island. Broodbank gives clear evidence of continued communication between Cyprus and the mainland in these very early millennia. Other factors show that the cross-water contact diminished over 4000 years to the point where Cyprus was almost isolated once more and left behind developments on the mainland.

During the fifth and fourth millennia BCE, many of the smaller islands in the Mediterranean became populated by methods akin to those illustrated in Fig. 2-4. Evidence for this has been found in remains of animals such as sheep, goats and pigs in Malta, Lampedusa and elsewhere. These were islands which were beyond visibility from the shore. It goes without saying there were many others visible from the shore that were also populated.

Broodbank says this was a great age of in-island settlement, building on a long tradition of seafaring, exploration, visits and pioneer habitation. Most of the densely packed Dodecanese and other eastern islands were settled, and, springing from there, some of the Cyclades were occupied during the fifth millennium BCE.

Over the fourth millennium further influxes filled in many other islands in the Archipelago. Survival by fishing was very much a sideline. He refers to the wholesale introduction of the "Neolithic package"[20] which was all about supplying farming crops and animals to islands to allow the people to survive. Some islands were visited only for minerals and other resources available on them. They were never truly populated for long periods. The smallest islands were either too small to sustain life without water supplies or agricultural land, or else they were unusually far from land.

During the late fourth and third millennia BCE the smallest Cyclades islands would finally be taken in down to little Delorse, as would Ustica, just 50 km north of Palermo (Sicily) but hidden in a sea desert and until then seldom frequented. The big but remote islands of the Balearics lay empty until the late third millennium BCE, winning the distinction of being the last landmasses in the Mediterranean to become peopled.

Broodbank compares land travel between Egypt and Phoenicia versus sea travel.[21] The use of boats on the Nile he sees as pivotal in the developments of waterborne craft. The greatest advances in shipbuilding involved so much technical advancement that it could really only occur in the most advanced civilizations.

My analysis will now turn its attention to the various modes of transport used by the ancient mariners.

The Earliest Water-borne Craft

Lionel Casson was the pre-eminent source of knowledge of ancient ships during the 20th century. He wrote:

> *"In the very beginning men went down, not to the sea but to quiet waters, and not in ships but in anything that would float ... these were floats, not boats..."*[22]

It took an unknown time - maybe a thousand years or a hundred thousand years - to progress from one to the other. It might seem a trivial distinction to delineate between a float and a boat, but the amount of effort required to hollow out a log and transform it from the former into the latter was daunting when the only tools were made of flint. It is unfortunate that, unlike stone and bone, wood decays completely over thousands of years and it is highly probable that archaeologists will never be able to discover the first boat buried in the ground. Despite the difficulties of pinpointing this event in history, let us at least define the different types of craft, and then try to match their uses with stages of cultural development that might give a greater insight into the invention of lighthouses.

The earliest water-borne craft were of the following types:

Fig. 2-5: A primitive raft showing ten straight logs, each capable of carrying a single human, bound together into a raft. In principle, no metals tools are necessary.[63]

Fig. 2-6: Ethiopian Papyrus Reed Boat.[64]

Fig. 2-7: Ra II, a reconstruction of the kind of papyrus reed boat suitable for long-distance sea crossings, as proposed by Thor Heyerdahl in 1970.[63]

Fig. 2-8: A reconstruction of a traditional skin-covered boat as used by Yupik peoples of northwestern Canada and northeastern Siberia. [65]

Fig. 2-9: A skin-covered wooden framed boat known as a coracle used by Celtic peoples of northwest Europe. Similar boats are also found in India, Viet Nam and Tibet.[66]

Fig. 2-10: An early dug-out canoe found in the Netherlands in 1955 and dated to 8,500 BCE. Almost certainly needs metal tools such as adzes to scoop out so much material from a log.[63]

1. Single floating logs

It is possible that the sight of a floating log might encourage a human to sit astride it and become the first viable mode of water-borne transport. We do not know if this capability was limited only to *homo sapiens*. It might have been an option for other species of *homo* as they tried to cross minor water obstacles. There is no manufacturing; no tools are involved, only a local selection of trees, the older ones of which might be brought down in bad weather to provide a source of logs.

2. Rafts of bound multiple logs

Having identified the floating log as a mode of transport, and that it is very difficult to remain sitting on it for long, intelligent humans would eventually discover that stability would have been much improved by lashing together two or more parallel, straight logs, Fig. 2-5. The only requirement is for naturally occurring twine to use as a binding material. Perhaps a stone flint cutting tool would help to cut convenient lengths of twine. By definition, this method came *after* the single log method. With regard to the species that tried this method, the same comments apply as in 1 above.

3. Bound reed rafts/boats

In locations where there were no or few trees, reeds made an excellent alternative to logs. Clearly, they needed to be tied into bundles to create the equivalent of single logs, Fig. 2-6. However, the same arguments apply as in 1 and 2 above.

> *"Primitive river craft probably existed on the Nile by Palaeolithic times [>12 kya]: the earliest Egyptian craft were presumably papyrus reed rafts. Reed rafts, wedge-shaped bundles of reeds constructed of two conical bundles laid side-by-side and lashed together at intervals, were still used on the Nile in this [20th] century."* [23]

The binding of reeds to make rafts and reed boats was the main method behind Thor Heyerdahl's theory of great sea journeys made by ancient Egyptians, Fig. 2-7.[24]

Wachsmann[25] points out that the most important Egyptian word for 'shipbuilding' is 'to bind', an observation that shows just how important reed rafts were to this civilization. This method could have been used since the earliest times with only cutting tools required.

The oldest known remnants of a boat made with reeds (and tar) are from a seven thousand year-old seagoing boat found in Failaka Island, Kuwait.[26] This island is in the bay of Kuwait City, close to the delta of the Rivers Tigris and Euphrates, and indicates the intense activities that went on in the Fertile Crescent, a very early centre of civilization. Reed boats and canoes could easily travel more than 1500 km along these rivers from the sea of the Persian Gulf to the heart of Turkey.

4. Skin-covered frame boats, e.g. coracles, canoes

Rather more cognitive ability is required for the construction of a frame boat, since it requires the imaginative skill to design a frame in 3-dimensions that will be strong enough to allow a covering made from a hide or animal skin, Fig. 2-8, Fig. 2-9. Binding of the covering to the frame is significantly more difficult than in 1, 2 and 3 above. It seems likely that this method might apply only to *homo sapiens*. Nevertheless, the method is ideal for regions where there are no trees, as in arctic regions, for example.

5. Dugout canoes

Dugout canoes required better tools such as axes, adzes and chisels, Fig. 2-10. They could possibly be made of flint, but manufacture is greatly improved with Metal Age tools. Single or multiple logs might also be involved, together with the binding skills used in all of the above. It is debatable whether a dugout canoe is possible without recourse to metal tools. Certainly, their manufacture is far easier if metal axes for cutting a log to length and metal adzes for hollowing out the log are available, but the use of equivalent tools made from flint surely cannot be declared impossible. Our ancestors - especially the Egyptians, are well known for accomplishing very difficult tasks. There are certainly some very good pictorial representations of dugout canoes being made by Egyptians, for example, in a fifth dynasty (2498 to 2345 BCE) excavation at the tomb of Ti at Saqqara.[27]

At the time of writing, the oldest dugout canoes found by archaeologists date from 10 to 8 kya. Wood is a natural organic product and subject to decay unless there are very special circumstances so all thin canoes and dugouts would have decayed to dust many centuries ago. It is only those made from massive pieces of wood that have any chance to survive. Thus it is most unlikely that any wooden craft older than 10 ka will ever be found.

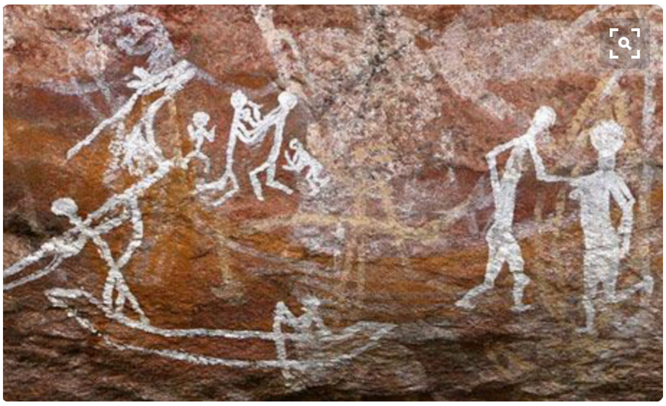


Fig. 2-11: Cave painting showing a boat.[69]

Fig. 2-12: Cave painting showing a boat.[70]

Fig. 2-13: Model of an early Egyptian planked boat, powered by stern paddle.[67]

Fig. 2-14: Model of an Egyptian trireme powered by both oars and sails (square rigged).[68]

6. Planked ships

Some of the earliest cave paintings from around 20-30 kya (Fig. 2-11, Fig. 2-12) clearly show the kinds of craft that might have been used to populate Sahul. It is unlikely they were made from planks, and they were probably dugout canoes. Wooden planks were needed to make larger craft, and metal tools were almost certainly needed to make planks for use in ships like the one in Fig. 2-13. This confines this method of craft construction to later than 8.3 kya and could have been achieved only by *homo sapiens*. The tomb of Ti at Saqqara has images of men using not only axes and adzes but also chisels to make mortise and tenon joints in planked ships.

The Cheops ship is also known as the Khufu Ship after the Pharaoh for whom it was built. (Khufu ruled from 2589-2566 BCE.) It is currently the oldest wooden planked ship ever found, although it was not used on the sea, but made especially for Khufu's burial and consigned to his tomb without ever getting wet. Thus it has survived longer than might normally be expected. It is so technically advanced that earlier development of ship design over thousands of years must be assumed. Discovered in 1952, it is an intact full-size vessel that was sealed into a pit in the Giza pyramid complex at the foot of the Great Pyramid of Giza around 4.5 ky ago. It was made of around 12 tonnes of Lebanese cedar wood, traded in large quantities by the peoples of the Syro-Canaanite coast, whom some might prefer to call Phoenicians, but who were probably not. (The Phoenicians are the subject of Part 4.) Its design and construction was so sophisticated that ship building was clearly well developed by this time. The shortest plank in its construction was 7 m in length and 120 mm in thickness. It is also very likely that ship building was well developed in other parts of the world also.[28] Wachsmann is clear that the first definite depictions of sea-going ships are in the tomb complex of Sahure who reigned during the period 2490-2477 BCE, a period that is of course *after* the time of the Cheops ship.[29]

As far as the oldest sunken ship is concerned, in 2014 an underwater exploration revealed what may yet be the oldest ever found. It is thought to be from the time of the Pharaoh from the 18th Dynasty, Maatkare Hatshepsut (1479 to 1458 BCE).

Until now, this record has been held by the Uluburun Shipwreck, a Bronze Age ship dated to the late 14th century BCE and discovered close to the east shore of Uluburun (Grand Cape), about 6 miles southeast of Kaş, in south-western Turkey. After reconstruction of thousands of fragments recovered from the seabed, the structure showed that it was a sailing ship of planked wood, although the identities of its builders remain a mystery. Analysis of the cargo seemed to show that the ship set sail from either a Cypriot or Syro-Palestinian port. It was undoubtedly sailing to the west of Cyprus, and it is thought the ship's destination was a port somewhere in the Aegean Sea when Rhodes was an important redistribution centre for the Aegean. The probable destination of the ship was one of the Mycenaean palaces in mainland Greece. This data gives an indication that the ship could have been a Phoenician trader.

Motive Power: Paddles, Oars and Sails

Propulsion of the earliest waterborne craft was by river current flow. Soon afterwards, once cupped hands had been found useful, wooden paddles would have been a natural development. No tools are required in the first instance, but later binding of two or more elements might have improved the efficiency of the paddle. Oars would seem to be a more sophisticated tool since a fulcrum is required to generate a lever action. At first, a hole in the side of the boat might have been enough. Rowlocks, however, would have proved more difficult to make from wooden materials, though they would have been much easier to manufacture in the Metal Age. The oldest depiction of a Nile boat dates from 9 kya and shows the stern of the boat with an oar affixed to a tiller, like the one shown in Fig. 2-13.[30]

The origins of sail power are also uncertain. In principle, there is no reason why early navigators could not have used a simple fabric or skin material to make sails, but it does imply an ability for stitching of some kind of binding to make a functioning sail. However, we can deduce some important points from the history of the Nile and Levant regions. Mature design and manufacture of sails on the Nile was in evidence in 3200 BCE and in the eastern Mediterranean by 2600 BCE, with regular trading voyages taking place using craft with both sails and oars in use together. Fig. 2-14 shows the kind of craft in use by people living at the end of the 3rd millennium.

Sails are a feature of the marine activities of *homo sapiens* alone. Archaeological studies of ceramics from the Cucuteni-Trypillian culture show the use of sailing boats from a time 6.8 kya. This culture, known as Cucuteni in Romanian and Trypilska in Ukrainian, is a Neolithic archaeological culture that existed in Eastern Europe from ca. 8 kya to 5.5 kya. It extends from the Carpathian Mountains to the Dniester and Dnieper regions, centered on modern-day Moldova and significant parts of western Ukraine and northeastern Romania. Excavations of sites during the period 8 kya to 6.3 kya in Mesopotamia also provide direct evidence of sailing boats. Sails on water craft in ancient Egypt are depicted around 6 kya. Reed boats on the Nile were easy to navigate downstream, but to travel upstream required the use of sail.

From Boats to Navigation

This study of human activity on water has assumed that it took place first on rivers, rather than seas. Unless some new startling archaeological discovery is made, we may never know if this is correct, but it is, surely, overwhelmingly likely. Current understanding of the development of humans themselves suggests that the Nile (or one of its tributaries) was the first body of water to support the weight of humans wishing to travel along it. Navigation on rivers is a matter of observing the banks to gain geographical knowledge of the river's course and the landmarks that can be seen along the way. Travel on open bodies of water is a different kind of enterprise.

Sea travel in ancient times was of two kinds, generally referred to as (1) coast hopping and (2) open sea voyages. Coastal travel was thought to be the preferred method because of the safety offered by the sight of land and by minimising the distance to safe harbour in the event of sudden bad weather. The principles of coast hopping came about because of the desire to navigate by visual features and to be close to a place of safety in case of emergency. Yet there were real emergencies lurking behind every coast hop, for to stay close to the shore was to sail in the presence of vicious hidden rocks and reefs, and of breakers, sandbanks, merciless rip currents and occasional whirlpools. Even a journey of a short distance along the coast was a dangerous practice that resulted in a high proportion of shipwrecks.

Paradoxically, journeys across open sea may have been safer, for well-designed ships are intended to ride out storms and are mostly free from the dangers of reefs and other underwater dangers. In the knowledge of good navigation practice, it would seem that to cross large distances of water was indeed more risk-free and that the pragmatic and practical Phoenicians recognized this. We know that open sea voyages were, indeed, made because of many archaeological finds in places where visits could only be made by crossing large expanses of sea. We have already noted how the search for obsidian motivated journeys between islands in the Aegean Sea. One of the earliest open sea crossings was made between ports in Crete and Egypt, two of the most important early trading centres of the ancient world. The stretch of open sea between the two landfalls was about 330 nautical miles (611 km); the shortest time with the benefit of optimum winds was at least two days and so navigation in a southeasterly direction using both the sun and the stars was essential. To miss the bearing was not disastrous because the ship would still reach the coast of Africa whereby the navigator could make short hops along the coast to the Nile entrance. The suggested presence of a port on the south coast of Crete, in the vicinity of Kastri, at the end of a direct road from Knossos would prove that there was a direct route in a southeasterly direction to Egypt.

At all times, day and night, it was first and foremost observations of the sky that provided navigational data from which to plot safe passage. In daylight, the position of the sun and moon, together with knowledge of the season, gave firm guidance. At night, the stars were, some might say, even more useful in determining direction since knowledge of the positions of the pinpoint beams of starlight were in many ways more accurate than the Sun. Astro-navigation at night depended upon detailed knowledge of the positions of stars, which were themselves set into clearly identifiable patterns by the naming of groups of stars known as constellations. Whilst such data had probably been collected over tens of thousands of years, and passed down from generation to generation within every significant culture on Earth, at sea it was primarily observation of a single star that was of most assistance to pilots at first.

This came about because of the way the Earth moves in its orbit around the Sun. Because of the tilt of the Earth's axis of rotation, the positions of the stars are seen to move, not just during a single night, but also throughout the calendar year. However, there is one star that moves very little because it is directly above the north pole of our planet – the point where the effect of rotation is smallest because it is on the rotational axis itself. Hence ancient pilots could tell the direction of north simply by observation of the Pole Star. All other directions were determined from this. But this was not the only data available to them. Observations of wind direction were also important in these latitudes where the Earth's climate at different times of the year imposed common patterns of winds. These could be combined with the astral observations to decide upon the correct course on which to proceed.

All of this was known long before the Phoenician culture developed significantly in the Mediterranean. The knowledge itself was one thing, but in times before the development of writing, its method of safekeeping and promulgation across the generations was quite another. There must have been specialization in human role membership for certain people to become known for their highly developed skills in navigation. This was then passed on to their apprentices. Very little is known about this aspect of civilization in the times before writing. The passing-on of cultural history in the form of storytelling is obvious, and the fine detail may become lost over time, but the accurate transmission by oral means alone of precise data such as star positions at different calendar times is fraught with risk. Thus, we might conclude that the minimum amount of detail, combined with many years of experience, was a necessary condition of successful navigation.

The art and skill of navigation was probably learned well before the days of writing, by word of mouth from master to pupil at first, and then by many years of experience. To be an experienced navigator involved feats of memory and was a great achievement indeed.

Weather

Many lives have been lost in unavoidable situations. In daytime, even the supposedly safer method of coastal navigation combines elements of luck with diligent decision-making. Luck always features prominently when dealing with the weather, and this meant that sea voyages were subject to unknown and varying degrees of risk, especially in geographical regions where there were rugged coastlines and many submerged rocks and reefs to threaten ships.

The shipwreck of St. Paul the apostle, for example, was well described in both ancient and medieval literature. Not least of these reports was the description in the Acts of the Apostles of an eye witness who said that:

> *"... for days on end there was no sign of either sun or stars, a great storm was raging, and our last hopes of coming through alive began to fade."*[31]

Their ship was eventually wrecked on Malta and St. Paul survived. The whole story is of interest to us for it concerned a long, open sea voyage from Sidon with Rome as its ultimate destination, but it clearly describes the conditions on board and of the vulnerability of sea travel when only the sun and the stars were (apparently) available to assist the travellers. We should remember that this was early in the current era when the Pharos was in full splendour in Egypt and the Romans were establishing a network of lighthouses around the Mediterranean.[32]

Even today, the most important consideration for a mariner about to set sail is the kind of weather he might expect during his voyage. The position of the Earth in relation to the sun sets up fundamental effects upon the Earth's atmosphere that give rise to seasonal patterns in our weather. These patterns are generally linked to directional airflows that we call winds and that have been recognized since earliest times. Clearly, a pattern of weather is brought by wind from a known direction that varies depending upon the position on the Earth's surface. To inhabitants of the northern hemisphere, the north wind brings cold air whilst the south wind is warm. Winds emanating from expanses of ocean bring rain, whilst those from vast continental sources tend to be dry. Since the thermal properties of land and sea are very different - land heats up and cools down at a faster rate than does the sea - so also are local weather patterns created across different regions where the ratio of sea and land areas are different. Sometimes, too, rare combinations of circumstances give rise to extreme events that can be catastrophic to sea travel, and it is this that we are becoming more aware of today under the general name of 'climate change'. The Earth's spin, at over 1000 mph at the Equator imposes shear effects upon the body of atmosphere between sea level and outer space. This creates powerful winds over the Earth that make airflows from the north turn northeast and from the south turn to the southwest (opposite in the southern hemisphere). The greater effects close to the equator give rise to greater twisting action that causes typhoons, tornadoes and hurricanes. The powerful airflows over the ocean also set up strong movements of water that, besides causing variability in the heights of tides under the gravitation of the moon, create ocean currents that interfere with a mariner's ability to navigate using dead reckoning. Adjustments to calculations of position have always been necessary to take account of the superimposed effect of these currents, the learning of which was also an important part of the pilot's apprenticeship.

Weather patterns may often be created by air flows in the lower reaches of the atmosphere, so that great capes and other tall headlands that acted as waypoints and were helpful to mariners for their visibility at great distances could also be dangerous for setting up vicious, local effects of weather and tide. Of note to mariners in the 16th century, for example, was Cape Horn, which became notorious as a scene of dreadful weather conditions and shipwreck.

Tides and Whirlpools

It is easy to think that it is safe to navigate in places close to land, but we soon realise there are many inherent dangers. As the movements of massive bodies of water beat up against irregular sea floors, especially at the coast, serious contraflows can be created in localized regions that may lead to eddies and whirlpools that are the dread of mariners. The narrow Strait of Messina that separates the island of Sicily from the mainland of Italy famously hosted some of the whirlpool conditions that sailors feared most. Homer created an enchanting narrative for his hero Odysseus as he tried to navigate between a shoal of rocks just off the Italian coast that was characterised as a six-headed sea monster called Scylla, and a whirlpool close to Sicily that he described as another monster called Charybdis. Homer, whilst describing Odysseus's attempts to navigate the narrow channel, made his leading character choose between the two monsters. Clearly both were bad choices, but Odysseus chose Scylla as he thought he would lose fewer men that way. Through Homer, the need of Odysseus to 'choose between a rock and a hard place' entered Western culture in many similar phrases and proverbs.

Other capes and headlands where there was likely to be a dangerous situation were added to the list of places for navigators to learn by heart. On most of them shrines or temples were built so that the gods could be appeased accordingly.

One question that we particularly need answered is whether they carried lights at night? If they did, then we can conclude that lighted aids to navigation were available from structures for which the primary function was not to be a navigational aid.

Where no land is visible, tides are almost unnoticeable, but they have a big effect when close to land. By the time of the Phoenicians, Mediterranean navigators were aware of the effects of tides, but not overly concerned with them because of the small rises and falls in that sea.

Outside the confines of the Mediterranean, however, it became much more important to take tides into account, not least because low tides were likely to bring submerged rocks close enough to the bottom of a ship to sink it. Fishermen and others sailing close to their home ports soon developed intimate knowledge of the routes to seek or avoid, but for navigators traversing great distances, it became an extremely difficult task to learn such a vast and growing catalogue of data. It certainly seems to be the case that such data were recorded, wherever possible, in some kind of log or document. Such a precious list was known as a *periplus* (or *periplous*),[33] but there was no substitute for taking on board any local expert who could direct the traveller safely into a port with which they were unfamiliar.

There are very early reports of this occurring in northwest India where during the voyage of an

Fig. 2-15: Engraving of the Torre Dels Vents.[71]

Fig. 2-16: The Torre Dels Vents in Athens is a well- preserved tower and a strong indicator that the shape of the central octagonal section of the Pharos of Alexandria was chosen because of its relationships to the eight winds of the compass rose, so essential to mariners of ancient times.[72]

unknown trader in about 50 CE, Indian fishermen were invited aboard to guide the ship through dangerous waters leading to Barygaza. These documents contained great amounts of precious, possibly life-saving information and were adopted throughout history, most especially since the fifteenth century, and are often called today coastal pilots, or perhaps nautical almanacs.

The Compass Rose

The rise and fall of the sun gave the first fix of direction, sunrise to the east (orient) and sunset to the west (occident). Odysseus and his friends became lost and came ashore on an island that Homer called Circe's Island.

> *"My friends ... East and West mean nothing to us here. Where the Sun is rising from when he comes to light the world, and where he is sinking, we do not know."*[34]

Without necessarily having words to identify them, early hominins made an association of east and west with the sun some time near the start of human consciousness. It was followed quite naturally with the recognition that north and south were logical additions. This led to four main points of direction that lasted across all cultures for many thousands of years. By 3000 BCE, the four points of the compass had become some of the most ancient knowledge. (We must remember that despite our natural desire to associate the word compass with an old tool that uses the rotation of a small magnet in the presence of the Earth's natural magnetic field, this device was not available until the 11th century CE.)

As the needs of navigators became more significant, it seemed natural to identify winds that were slightly off the four main cardinals, so increasing the directions either side of the four led to a rose of twelve directions, all associated with winds that were of fundamental importance to mariners. However, many mariners also concluded that it was sufficient to define directions that were midway between the four, and so an eight-point rose was also created.

To sailors in the Mediterranean, the precise directions for east and west were defined by the rise and fall of the sun on the days of the equinox in spring and autumn. Of course, there was variation in those directions from mid-summer to mid-winter and these amounted to about four degrees on either side. Thus, a twelve-point system was natural to sailors and independent of winds, although these were a fundamental part of navigation too. However, both the twelve and the eight-point system were in use during the fifth century BCE.

One of the finest reminders of this is the tower of the winds in Athens, Fig. 2-15 and Fig. 2-16, a perfect example of how the ancients divided the compass into eight directions. For future reference in our discussion of the Pharos at Alexandria, we note also that this is the reason why the octagonal shape was used for the middle section of the Pharos, and copied so extensively in lighthouse design.

Stellar Navigation

Like the sun by day, the stars at night have also been the subject of detailed observations for millennia. With the advantage of clear skies, unpolluted by man-made contaminants, especially stray light, our ancestors could see patterns amongst the stars and relate them to their own cultures. A key set of observations was made during the half-hour or so before sunrise and after sunset, when the star groups were linked to the position of the sun. We know today that as the Earth travels on its annual orbit around the sun, the star patterns, which are in effect stationary in the Universe, will appear to us in different places in the sky. During each twelfth of the year, a different group of stars will appear directly behind the direction in which the sun rises and sets, and it was the linkage of these twelve constellations to the time of year that gave us the months in our calendar. Then it was a matter of consequence that positions of these star patterns with different events throughout the year such as annual floods and droughts or shifts in wind direction became associated with gods and other supernatural beings, and the idea that bad events might be mitigated by special ceremonies or rites of appeasement. When you need to please your god and you have very little to give, the sacrifice of an animal counted as a lot - it was, after all, a sacrifice! The act of giving was the killing and burning of the chosen animal. Then, perhaps, it might be appropriate not to let it go to waste but to eat it. Fire thus became an intrinsic part of ancient religious ceremony.

The signs of the zodiac began to take on ex-

Fig. 2-17: Rotation of the stars (circumpolar) about the Pole Star, Polaris, in the northern hemisphere.[73]

panded meanings over the course of time, some of them extending well beyond the sound scientific measurements that had been made millennia before. Just as the twelve major constellations appeared to rise and fall above the horizon at different times of the year (caused, of course, by the angle of tilt between the earth and its direction of travel relative to the sun) so also there were other constellations that were always in view in the northern hemisphere, but which appeared to rotate in the sky like a wheel on a hub. These stars are today called circumpolar stars. Fig. 2-17. Of these, there was much narrative of one group, known variously as the Bear, the Plough or the Wain - the group of seven stars we now call Ursa Minor. The Greek word for both 'bear' and 'north' was 'arctos', a clear ancestor of our own word 'arctic'. *Septentrio* is the Latin word for north, and means 'seven oxen' - which would have been used for a plough, of course. At the extreme end of Ursa Minor is Polaris, the Pole Star that we observe today as being directly above our north pole. No matter where the Earth is in its orbit around the sun, the northern tip of its axis points away into the Universe towards Polaris. But the Earth's orbit about the sun is an ellipse that itself rotates around the sun, a feature that we call a precession. It has been found that this effect caused the relative position of sky above the Earth to move by one degree every 72 years. Thus, every twelfth of the year equates to a thirty-degree movement across the sky, and if the constellation of Pisces rises on the spring equinox today, in 360 years time (= 30 x 12) the next constellation to rise on the same day of the year will be Aries.

The system that we know today as the twelve signs of the zodiac was reportedly invented in Babylon, at least as early as the 4th century BCE, by which time it was already influencing Greek and Egyptian culture.[35] There are some authors who would vigorously deny this by saying that the origins are far earlier.[36] Nevertheless, we are confident that Phoenician navigators were familiar with the main features of celestial navigation.

This precessional change of the Earth's orbit around the sun, relative to the position of the sun amongst the other stars in our galaxy, means that there has been a small change over the course of millennia. Today, the Pole Star is closer to the north pole than it was three millennia ago, and so it was harder for ancient navigators to find true north than it is now. However, the observations they made of the stars and their movements in the night sky were crucial to the development of their navigational skills, so they worked hard to define the rules of celestial navigation. Navigators needed to know how the main constellations moved about the sky, how they rose and fell relative to the horizon, and how their orientation changed as they rotated around the pole star. Taylor states that Ursa Minor played an important role in Egyptian astronomy at least as long ago as 5000 BCE, and that Homer expected his readers to know about it in the ninth century BCE.[37]

It was a star called Kochab, not Polaris, that was closest to true north in the times of the ancient mariners. Still in the constellation of Ursa Minor, it is almost as bright as Polaris and known today as Beta Ursae Minoris.[38] Either way, it was well known to ancient mariners that this constellation was closest to north and that by ensuring they kept watch on it they would have a good idea of their direction of passage.

Of course, there are some stars, whose brightness is great enough for them to stand out from their constellations. To observers on Earth, these stars were watched carefully because their positions in the sky, especially the times of year when they rose and fell whilst in precise alignment to the sun, allowed for the identification of clear points in the calendar. For example, in the Mediterranean regions, it was time to plough and sow in November, at the same time when the constellation called the Pleiades (a particularly recognizable close group of seven stars) set next to the sun at sunrise. When the same constellation rose with the sun in May, it was time to harvest. The brightest star, Sirius, would rise along with the sun to announce the arrival of annual Nile floods.

Latitude was a geographical parameter that took longer to understand, but was well known in the time of Strabo. It should be clear that an observer at the north pole will be able to see all northern hemisphere stars throughout the year, whilst an observer at the equator will have no circumpolar stars, all visible stars disappearing below the horizon at some point during the year. In the Mediterranean, where the latitude is, say, 35 degrees north, then a circumpolar star located 35 degrees from the pole, will be seen to rotate around the pole in different places in the sky depending upon the time of year, but will reach a point where its circle just intersects the horizon, and when it does, the place on the horizon will be at due north. Likewise, it is easy to show that the angle any given star makes with the pole is the same as the observer's latitude on Earth. In this way, ancient astronomers could determine latitude. [39]

Coastal Marks

The magnetic compass is reported to have been discovered during the Chinese Han dynasty (206 BCE - 220 CE), although it was not then used for navigation. It was perhaps 850 - 1050 CE when the Chinese at last adopted it for navigation and Europeans acquired magnetic compasses perhaps two centuries later. Thus, in ancient times the only direction of benefit to the mariner was to follow the line of the coast and the sun (during the day), and the moon and stars at night.[40]

At first, travel by night was probably avoided. The navigator would expect to find safe harbours at regular distances represented by a single day's sea travel. Ideally, at intervals between there would be additional anchorages that offered shelter if the weather suddenly took a turn for the worse and a port was not close by. The addition of the fire tower to the mariner's navigational tools was of great reassurance if travel was to be extended into the hours of darkness. Added to this shared network of regularly spaced harbours and ports, fire towers, associated with sacred rites and other religious acts were established at regular intervals along the coasts of the Mediterranean by those with an interest in seafaring and trading. It would be natural to have lights in all of the ports, as well as some of the most important promontories marked with lighted beacons. Once the compass became commonplace, the need for such a tight network of fire towers quickly diminished and most of them disappeared, except those established in the most prominent positions that had proved their worth.

With as much emphasis on daytime aids to navigation at to lighted ones, Naish pointed out that travellers were often better off going by sea than by land, where their journeys were often severely hindered by geographical features like mountain, hills, rivers and forest, as well as poor roads and unfriendly locals.[41] Mariners instinctively learned all of the landmarks so as to negotiate their route reliably and safely. High points on land were sometimes deliberately marked with easily recognizable features. Where the coastal strips were low-lying, however, more reliance was placed upon built features such as religious buildings and fortifications, most of which were taller than small dwellings and more easily recognized. If they were lit at night, that was a bonus.

These days, the role of the Pharos as a lighthouse has become the predominant one to the exclusion of other purposes. Naish makes a strong argument that the Pharos was built as much for defence and prestige as for navigation. Such a great building that could house contingents of soldiers, as well as giving them elevation to launch projectiles towards enemies from great distances was a powerful asset against potential enemies. Then there was the deterrence that such a massive construction offered. Clearly, such a permanently manned fortress would be visible by night as well as by day, so the Pharos need not have been solely designed for navigational reasons. Nevertheless, all three purposes were served: prestige, defence AND navigation.[42] Indeed, this composite purpose seems to have been applied to almost all of the lighthouses of the Roman era, if not those that came before.

Naish suggests that the land along these shores of Egypt was mostly low-lying and so it was more important than elsewhere to have built structures that could be visible from the sea. The River Nile is thought to have had a beacon to offer safe entrance into the Nile, which was clearly a vital navigational route.[43]

Naish discusses the development of leading lines for navigation into narrow channels. Following the collapse of Rome, people who lived in the lagoons that would later see Venice constructed became expert at building houses on mud-banks and by:

> *"...driving vertical piles into mud and achieving a firm base for wood, stone or brick structures. It is inconceivable that they would not also have used vertical pole beacons to mark the edges of the narrow channels which criss-crossed the lagoon."*[44]

Naish states that there is no evidence of the use of channel-marking buoys, but he found evidence from the thirteenth century of such a practice in the River Guadalquivir from Seville to Chipiona.

With no reference he gives writes of a leading line being used at Acre - one of the oldest sites in the world to be found just north of Haifa in Israel. Safe steerage was obtained by following the line from the Constable's House to the Tower of Flies, a strong fortification on a small island at the entrance to the harbour.[20]

De Graauw argues the following[45]:

(1) The coastline of the Mediterranean is approximately 25,000 nautical miles in length.

(2) Even though (from Phoenician times) it was possible to travel up to 100 miles per day by sea, safe anchorages and places of shelter against sudden bad weather were needed at intervals of approximately 10 miles.

A simple calculation reveals that some 2500 locations might be found along the Mediterranean coastline. Since de Graauw has identified some 3000 sites, he believes that the coverage of the subject in his catalogue is, if not complete, at least comprehensive.

It was surely necessary for pilots to carry deep knowledge of the many day marks along the coasts, and for accurate knowledge of the safe routes into and out of harbours. These would have taken the form of obvious geographical features such as headlands, mountains, promontories and the like.

For those entering and leaving the Mediterranean, the great towers of rock that formed the Pillars of Hercules were memorable for their risks to navigators, as too was Cape St. Vincent (Cabo de São Vicente), a point to be rounded for voyages to the northern lands. Many such points were recognized in ancient cultures as special places that required the payment of respect to the relevant gods. Cape St. Vincent is a site especially known as a place of noted religious activity.

As well as natural features to help with position-finding, there were artificial landmarks such as villages and other settlements. From the sea, one village may well have looked much like any other, but the combinations of these sightings with local geography greatly assisted unambiguous identification. So also were specific landmarks such as fortifications or religious buildings.

There is a strong Greek tradition of building places of worship in positions right next to the sea; some are in lofty locations, others at lower levels. Buildings in strategic high level locations were obvious day marks. The tradition goes back to at least the first millennium BCE, especially in the Greek culture where ancient temples and shrines in

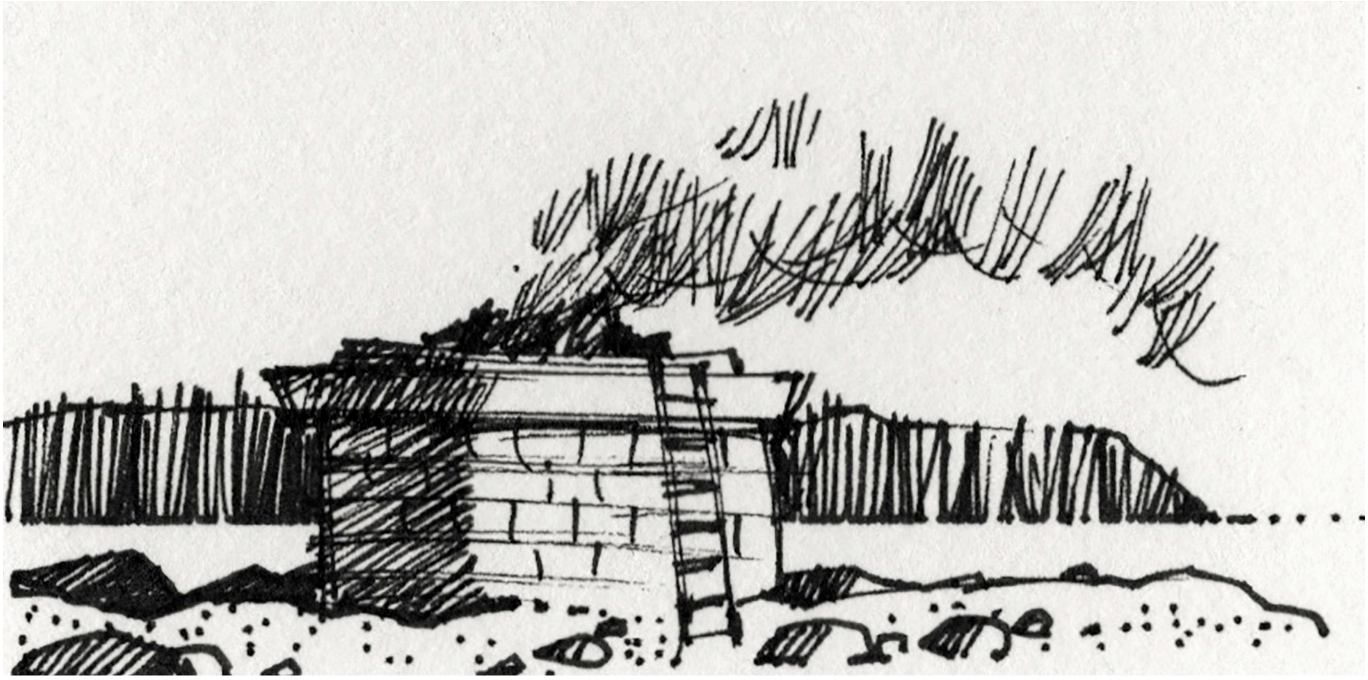


Fig. 2-18: A lightstructure - a simple cylindrical stone platform bearing a fire for assisting ships into port.[74]

marine locations were dedicated to Poseidon, god of the sea. There have been few studies regarding the use of lights around Greek religious sites at night, but recent work suggests that when activities of sacred intent did take place at night, lights were commonly used. There is a clear possibility that a building as important as a temple, though closed to ordinary people at night, was the focus of activity outside it by night and by day, and that it may have been lit 24/7, thus fulfilling the role of a lighthouse as well as a day mark. The best example found so far is the Temple of Poseidon on Cape Sounion (see Part 3).

A Punic temple was excavated at Ras il-Wardija near San Lawrenz on the southwest tip of Gozo, Malta in the 1960s. It is discussed in Part 4. In a remarkable position on top of precipitous cliffs, it maintains a strategic viewpoint over a part of the central-southern Mediterranean in which Phoenician activities were prolific for centuries. Despite our woeful lack of understanding of Punic religious practices, we must ask if this site was used as a lighted aid to navigation by virtue of its role in Phoenician culture. There is at least one place at the site that may have been used as the site of a significant fire, and if it was indeed used as such we might propose that it is the first real evidence of a Phoenician lighthouse in the times before the Pharos.

Buildings were not necessarily grand or large. Many smaller shrines were constructed in positions where, with a light burning at night, they were useful to mariners. Those at low level would have been particularly useful for providing a guide into port at night, for example.

On the Greek island of Thasos two structures of similar design (Fig. 2-18) cast their shadow over the last rocky outcrops at sea. One of them (Fig. 3-8) dates from the 5th century BCE, and is a cylindrical tower 3.5 m in diameter and about 2.54 m high. It was topped with sandstone slabs on which a fire was maintained. Built of stone, the structure seems to have been destroyed by an earthquake. It has a dedication indicating that it was erected for the safety of those at sea. Was this a wealthy family's monument in loving memory of a member deceased at sea, offered for the safety of many others? Christiansen believes it was a lighthouse indicating the presence of a safe harbour.[46]

We do not yet know how many of these towers once existed and are now destroyed. They would have made excellent beacons for ships engaged in coast-hopping, especially amongst the hundreds of small harbours of the Aegean Sea.

There is a noticeable similarity with the top section of the Pharos of Alexandria that was used for carrying the fire. There is a strong possibility that the inspiration for the Pharos can be found here. (Compare Fig. 3-8 with the top of Fig. 5-8.)

In the quest to identify the origins of lighthous-

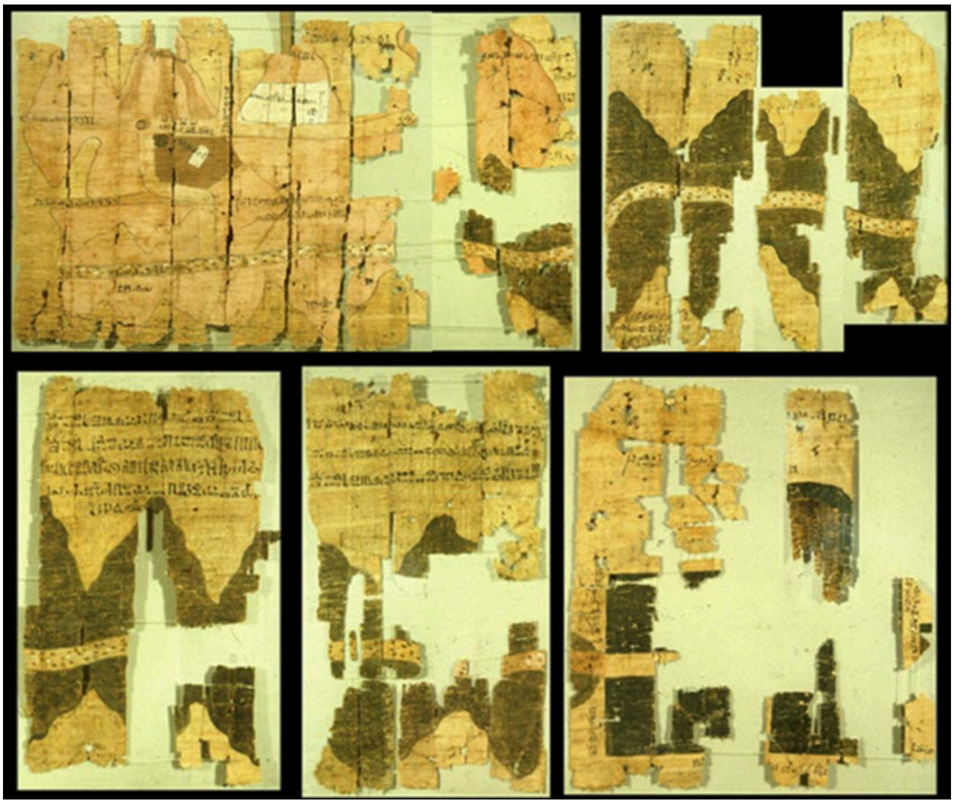


Fig. 2-19 The Turin Papyrus Map of Egypt, dated to 1160 BCE.[75]

es, it seems likely that pilots seeking identifiable marks along coastlines, for whatever purpose, would have gladly made use of any lights shown at places of known religious activity, and that these locations would have become part of the catalogue of aids to navigation pertinent to that area. Since it was an association of a light with a specific building – in this case, a religious structure of some kind – the concept of a light in a building at night became so commonplace in the science of navigation that it ceased to attract any attention in the written literature. I suggest that lighted aids to navigation became so ordinary that they were obvious to all and entirely unremarkable until the integration of the practice into the phenomenal structure at Alexandria shone a bright spotlight on the whole idea. The fact that there had been no word in any language to specifically describe a lighthouse apart from the use of the term 'fire-tower' highlighted the omission, and the name of the island of Pharos became as synonymous with a lighthouse as Hoover did with a vacuum cleaner.

In ancient literature, there are no references to lighthouses before the great Pharos of Alexandria was built. Does this mean that one of the world's most amazing buildings was conceived in a moment of pure inspiration? Perhaps the idea of building a great lighthouse came about because it was already a fundamental part of culture that navigators at sea looked for landmarks by day and lights by night. The provision of lights to assist navigators was such a fundamental part of life that it was taken for granted in the great civilization of the Greeks that the keeping of lights in shrines and temples would be of great assistance to humanity.

In the absence of any kind of purpose of the State for the provision of navigational aids, it was left to those with an interest in human welfare to provide such aids. Wherever it was carried out, navigators were delighted to benefit from the daytime landmarks as well as the lights they provided at night.

Maps and Charts

We frequently turn to maps for assistance without thinking too much about how they are made, especially these days when in-car Sat-Nav is becoming ubiquitous. Maps are fundamental in the process of navigation, whether we need to go back to the place where we last found that small group of deer or whether we need to paddle our canoe home from a fishing trip.

At its most primitive level, I have an image inside my head that I can use to remember something I did before. An innate ability to sense and

Fig. 2-20 The ancient Babylonian Map, the Imago Mundi, dated to around 450 BCE.[76]

delineate north from south and east from west resides in many human minds, assisted by casual observations of the position of the sun and moon. I may wish to transcribe my idea into another format that I can use as a personal mnemonic, and I make a map when I do so. At a higher level, a map is a collection of symbols marked on a physical medium - lines in the dirt, dye strokes on an animal skin, indentations carved into a stone, ink on papyrus or some other flat, light-coloured medium such as paper. Ideally, there is a common symbology that other people can understand too.

A map of part of Egypt drawn on papyrus (Fig. 2-19) is held in the Turin Museum and is thought to be the oldest topographical map of Egypt. It was drawn around 1160 BCE by a designer of tomb art. It is thought that the map was made for geological purposes to show where Rameses IV could find the kind of stone he needed for sculpting statues of himself.

One of the oldest known maps is the cuneiform map of the Babylonian world (Fig. 2-20), known as the *Imago Mundi*, found in Iraq close to the location of the ancient city of Babylon on the banks of the Euphrates. It is thought to have been made around 450 BCE. In the history of world maps, one of the most famous is Hecataeus's map (Fig. 2-21) that was derived from information contained within the works of Homer. This was also drawn around 450 BCE.

Even if these mapmakers did not know that the Earth was a sphere floating in space (and there is no evidence that they didn't) there was a clear opinion that the world was in some way round, and that if you set off in an easterly direction you would return from the west. Even if the map seems to show a circular shape on a planar base, the similarity between Hecataeus's map and the one we get from Google Earth is uncannily similar (Fig. 2-22).

It was in the sixth century BCE that people first seriously put forward the idea that the world was round. The idea gained much credence because of a story passed down through the generations. It concerned a mission set up by King Necho II (610-595 BCE) in which he ordered a group of Phoenicians to circumnavigate Africa (or Libya, as it was then called) ca. 600 BCE. Herodotus discussed it in his work:

> *"Libya is washed on all sides by the sea except where it joins Asia, as was first demonstrated, so far as our knowledge goes, by the Egyptian King Necho, who, after calling off the construction of the canal between the Nile and the Arabian gulf, sent out a fleet manned by a Phoenician crew with orders to sail west about and return to Egypt and the Mediterranean by the way of the Straits of Gibraltar. The Phoenicians sailed from the Arabian gulf into the southern ocean, and every autumn put in at some convenient spot on the Libyan coast, sowed a patch of ground, and waited for next year's harvest. Then, having got in their grain, they put to sea again, and after two full years rounded the Pillars of Heracles in the course of the third, and returned to Egypt. These men made a statement which I do not myself believe, though others may, to the effect that as they sailed on a westerly course round the southern end of Libya, they had the sun on their right - to northward of them. This is how Libya was first discovered by sea."*[47]

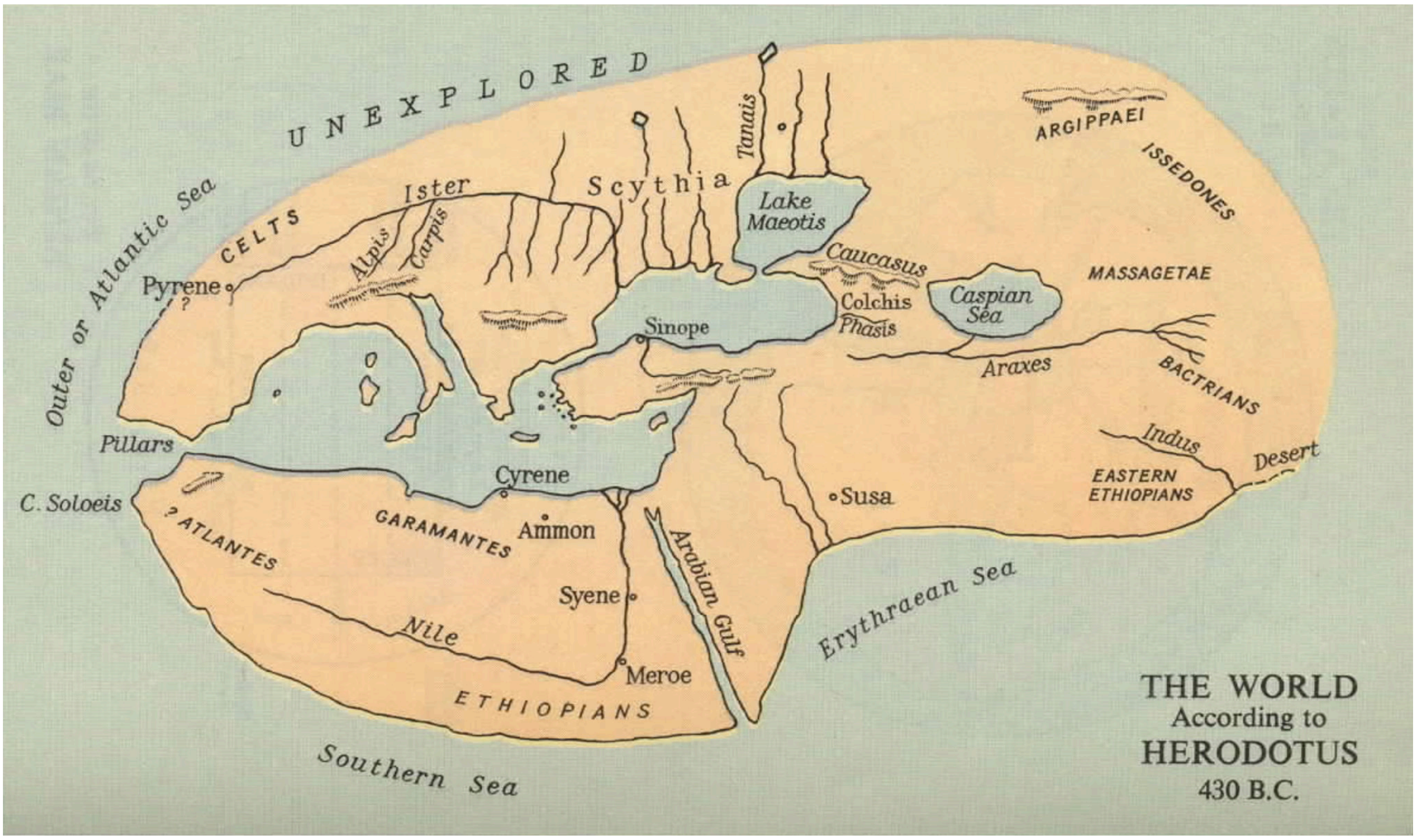
Consensus today is that the voyage probably did take place. A key element is the fact that, in the southern hemisphere, the position of the Sun is in the north, not the south as it is in the northern hemisphere, but there were many who still interpreted the situation as of a circular world on a flat plane, surrounded by ocean, that is, 2-di-

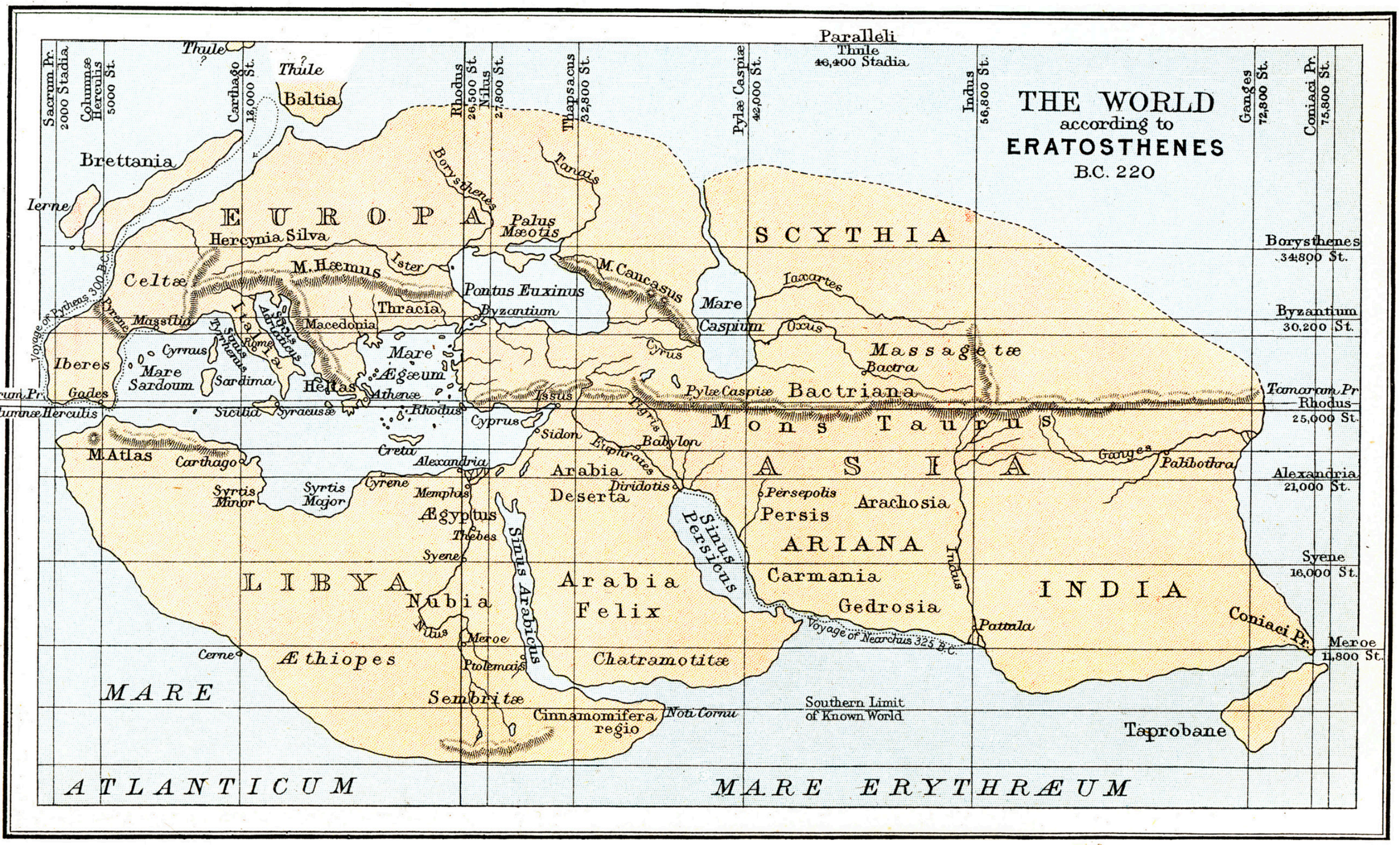
Fig.2-21 Top left:
The map of the known world drawn by Hecataeus (550-476 BCE) was an improvement upon an earlier attempt by Anaximander (610-546 BCE). Even at this very early stage of geography, there was a distinct feeling that the Earth was in some way round - though not necessarily spherical. [77]

Fig.2-23 Top right:
The world according to Herodotus of 430 BCE shows some improvements upon that of Hecataeus, notably a revision of the route of the Nile, and the inclusion of names for surrounding oceans.

Fig.2-22 Bottom left:
Inspection of the maps such as the ones by Hecataeus or Herodotus with the actual comparable view of planet Earth from space display uncanny similarity, although this must surely be coincidental.[78]

Fig. 2-24 Bottom right:
Eratosthenes was a Greek astronomer from Hellenistic Libya (276–194 BC). He believed that the Earth was round and made one of the earliest calculations of the Earth's circumference in approximately 240 BC. His answer came to 250,000 stades. The length of a 'stade' is not precisely known, but his answer is between 2% and 20% of the actual value of 40,008 kilometres (24,860 mi). He was able to place parallels and meridians on his map as a first indication of what later became latitude and longitude.


UNEXPLORED
Outer or Atlantic Sea
CELTS
Pyrene
Ister
Alpis
Carpis
Scythia
Tanais
Lake Maeotis
Caucasus
Colchis
Phasis
Caspian Sea
ARGIPPAEI
ISSEDONES
MASSAGETAE
Sinope
Araxes
BACTRIANS
Indus
Desert
EASTERN ETHIOPIANS
Susa
Pillars
C. Soloeis
Cyrene
? ATLANTES
GARAMANTES
Ammon
Syene
Arabian Gulf
Erythraean Sea
Nile
Meroe
ETHIOPIANS
Southern Sea
THE WORLD
According to
HERODOTUS
430 B.C.


THE WORLD
according to
ERATOSTHENES
B.C. 220
Paralleli
Thule
46,400 Stadia
Sacrum Pr. 2000 Stadia
Columnæ Herculis 5000 St.
Carthago 18,000 St.
Rhodus 26,500 St.
Nilus 27,800 St.
Thapsacus 32,800 St.
Pylæ Caspiæ 42,000 St.
Indus 56,800 St.
Ganges 72,800 St.
Coniaci Pr. 75,800 St.
Thule
Thule
Baltia
Brettania
Ierne
EUROPA
Hercynia Silva
Celtæ
Borysthenes
Tanais
Palus Mæotis
Ister
M. Hæmus
M. Caucasus
Pontus Euxinus
Thracia
Byzantium
Macedonia
Massilia
Iberes
Gades
Sacrum Pr.
Columnæ Herculis
Mare Sardoum
Sardinia
Sicilia
Syracusæ
Hellas
Athenæ
Mare Ægæum
Rhodus
Creta
Cyprus
Issus
SCYTHIA
Iaxartes
Mare Caspium
Oxus
Cyrus
Massagetæ
Bactra
Pylæ Caspiæ
Bactriana
Mons Taurus
ASIA
Borysthenes
34,800 St.
Byzantium
30,200 St.
Tamarum Pr.
Rhodus
25,000 St.
Alexandria
21,000 St.
Syene
16,000 St.
Meroe
11,800 St.
M. Atlas
Carthago
Syrtis Minor
Syrtis Major
Cyrene
Alexandria
Memphis
Ægyptus
Thebes
Syene
Sidon
Euphrates
Tigris
Babylon
Arabia Deserta
Diridotis
Persepolis
Persis
Arachosia
ARIANA
Sinus Persicus
Carmania
Gedrosia
Indus
Pattala
Voyage of Nearchus 325 B.C.
Ganges
Palibothra
INDIA
Coniaci Pr.
Taprobane
LIBYA
Nubia
Nilus
Sinus Arabicus
Arabia Felix
Meroe
Ptolemais
Chatramotitæ
Cerne
Æthiopes
Sembritæ
Cinnamomifera regio
Noti Cornu
Southern Limit of Known World
MARE ATLANTICUM
MARE ERYTHRÆUM

THE INHABITED WORLD ACCORDING TO STRABO

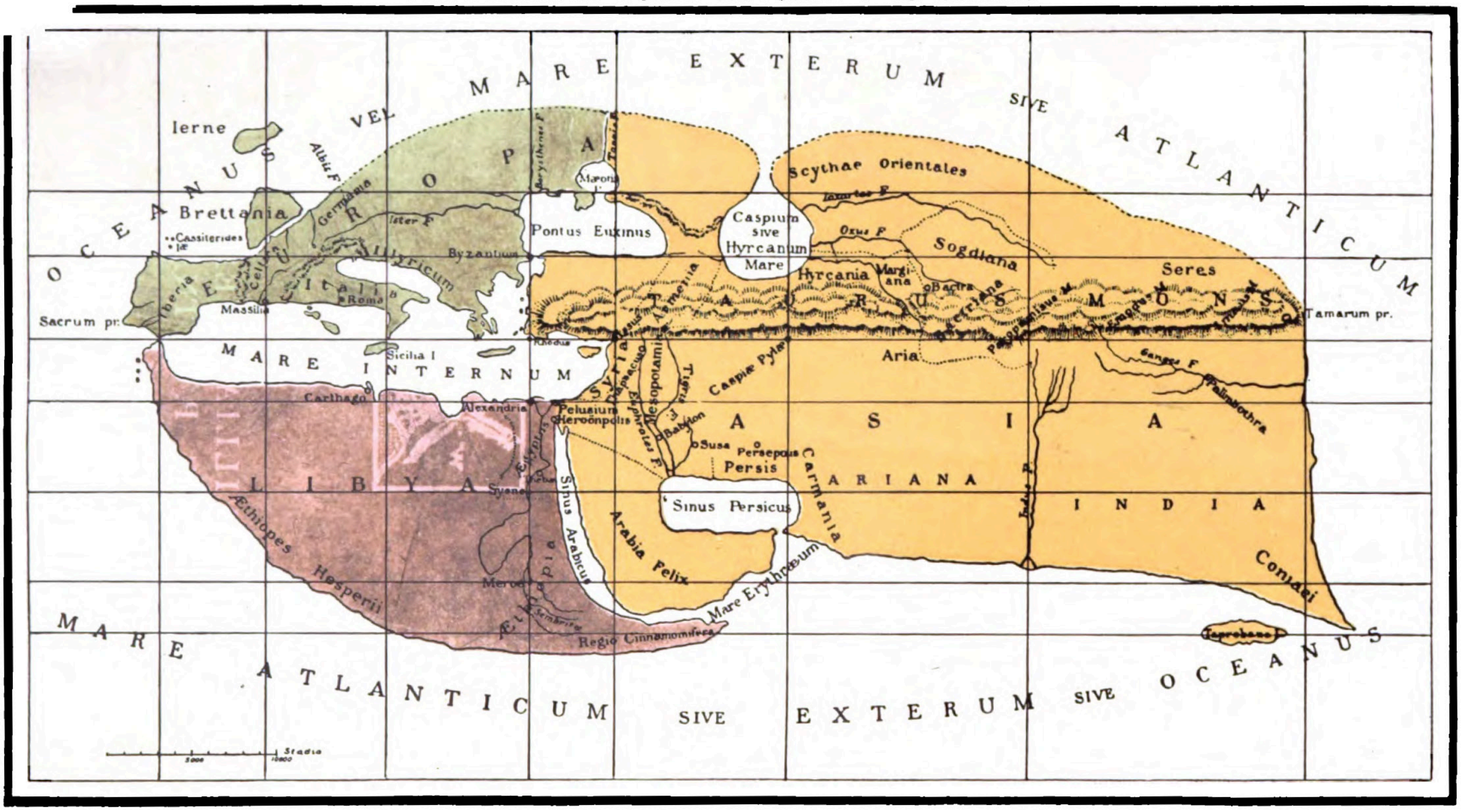


Fig. 2-25 Top left: Strabo's work, Geographica*, was written between (approximately) 20 BCE and 20 CE. It was extremely influential, yet his map drew upon the works of previous geographers such as Eratosthenes. Maps of this era started to include Britain (Albion) and Ireland (Ibernia), sometimes Iceland (Thule) and the important island group known as the Cassiterides (the Isles of Scilly of West Cornwall, UK) where tin was to be found.*

Fig. 2-26 Below left: Ptolemy's map of the world (ca. 150 CE) was based upon measurements of latitude and longitude, but some errors led to distortions of size. Originals have been long lost, but the data was used to make others over many centuries. The map shown was drawn in the 16th c.

mensional, not three. Map makers were faced with the problem that has haunted us ever since - how to represent a 3-dimensional spherical world on a flat surface. The results that we see in the various maps in this paper simply reinforced the idea amongst those unable to grasp the issue that the world, if actually 'round' was still flat!

Nevertheless, there were those who remained convinced that the Earth was a globe suspended in the vast space of the Heavens, and the great minds of the five centuries BCE were able to make great leaps forward in the understanding of our planet.

So, the fifth century BCE was an especially productive time for geographers and map makers. For example, Herodotus contributed a great deal to contemporary knowledge of geography and history by carefully documenting his extensive travels around the known world (or *ecumene*). His knowledge went a long way to providing support for his own world map of around 450 BCE (Fig. 2-23).

Another big leap of progress occurred thanks to Eratosthenes (276-194 BCE) who, grasping the solution to the spherical Earth issue, not only calculated with a good degree of accuracy the diameter (and circumference) of the Earth but also distances to the Sun and Moon. His map of around 220 BCE was highly influential among generations of geographers who succeeded him (Fig. 2-24).[48]

Strabo's work, Geographica, was written between (approximately) 20 BCE and 20 CE. It was extremely influential, yet his map drew upon the works of previous geographers such as Eratosthenes. Maps of this era started to include Britain (Albion) and Ireland (Ibernia), sometimes Iceland (Thule) and the important island group known as the Cassiterides (the Scilly Isles of West Cornwall, UK) where tin was to be found, Fig. 2-25.

By the time of Claudius Ptolemy (100-170 CE), a Greek astronomer, mathematician and geographer living in Alexandria, the principles of latitude and longitude were well enough understood that map making had become a process with a more scientific basis. Unfortunately, there were errors in some of the data used to create his world map (Fig. 2-26). Nevertheless, Ptolemy's work was translated into Latin and Arabic, and his maps redrawn over centuries that followed. They undoubtedly had a great influence over decision makers for more than a thousand years.

Lack of demonstrable progress in map making during the first four centuries of the modern era seems to indicate that the Romans were little interested in map making, so after the fall of Rome, the Dark Ages in the western world created a void in

Fig. 2-27: Map of southeastern Sardinia (not oriented to north) ca. 1580 showing positions of two lighthouses at Cape Carbonara (top centre) and an unnamed site (centre).[79]

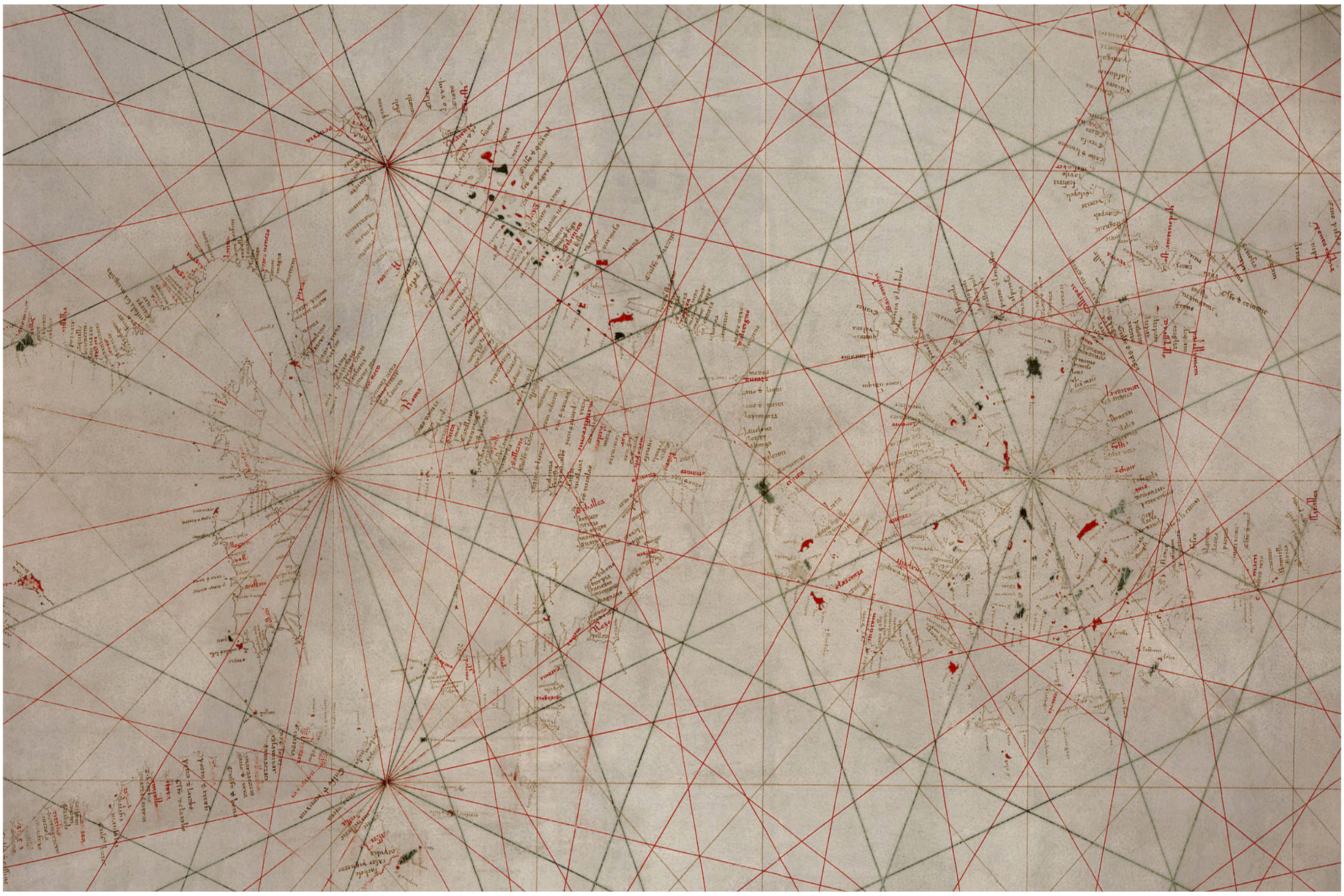


Fig. 2-28: Part of a late 14th c. Portolan Chart held in the Library of Congress, Washington D.C.

the understanding of geography and map making. However, in Asia and the Muslim world, scholars made a lot of progress.

Only by the middle of the second millennium do we begin to find maps that show positions of lighthouses. For example, the Gallery of Maps is located in the Vatican and contains a series of paintings that blend the principles of mapping with pictorial representations of topographical details. The paintings were based on drawings by geographer, Ignazio Danti. The gallery was commissioned by Pope Gregory XIII and it took Danti three years (1580–1583) to complete the 40 panels of the 120 m long gallery. Fig. 2-27 shows a part of Sardinia, and we note that not only is it a map (with a somewhat random orientation) but the topographical information shows the locations of two lighthouses, indicated with appropriate symbols, at Capo Carbonara and another unspecified location.

Throughout the process by which cartography was being developed, several principles of navigation were being established. Clearly, in the first case, the extent of the land and the sea was being clarified on the grand scale, an understanding that was most advantageous to those with strategic interests. However, from a mariner's point of view, he was much more interested in the finer detail - the small scale information that would help to keep him and his passengers alive. This viewpoint is a view from the sea, rather than from the land, and we begin to understand the difference between a map and a chart for the latter is specifically used for the view from the sea. This vital information needed to navigate safely from one place to another may well have remained locked inside the navigator's head, priceless knowledge that was too complicated, too difficult, or simply too much to set down on papyrus or tablet. In practical terms it could only be passed down across years of intense apprenticeship. Consequently we have no knowledge of sea charts, and certainly nothing showing the location of a lighthouse until Portolan charts were first drawn in the 13th. c. (Fig. 2-28).

Beyond the Mediterranean

At some point in time, the original Eden had become advanced enough to be considered as a civilized community, and this is commonly referred to as the Land of Punt. To be precise:

> *"Most scholars today believe Punt was located to the southeast of Egypt, most likely in the coastal region of what is today Somalia, Djibouti, Eritrea, northeast Ethiopia and the Red Sea coast of Sudan. However, some scholars point instead to a range of ancient inscriptions which locate Punt in the Arabian Peninsula. It is also possible that the territory covered both the Horn of Africa and Southern Arabia."*[49]

Wachsmann wrote:

> *"Egypt was the only country to trade in both the Mediterranean and the Red Sea during the Bronze Age; much of the extant information on Egyptian seagoing ships derives from the trade with Punt."*[50]

The chronology is still vague, but Punt was not the original Eden. It came more than a million years after the first dispersal of hominins some 1800 kya. Most likely is that it arose out of the settlements in Eastern Sudan and Ethiopia that were left behind as people migrated down the river Nile. By this time, the Arabian Peninsula was well populated and so Punt could have included the south-western corner of Arabia which was in constant contact across the Red Sea waterway. There seems no doubt that the seas were busy with traders operating along the coast of today's Yemen and Oman, across the Persian Gulf to Iran, Pakistan and India, lands that were called Magan, Dilmun and Meluhha. It is entirely possible that Stage 2 aids to navigation were being used.

A great trade route was established that bridged river, land and sea, from the Nile and Punt via the Red Sea, if necessary. Casson described the Red Sea routes as "tricky". He wrote that it:

> *" ... had few points where a ship in trouble could take shelter, and was the spawning ground of a virulent breed of pirates."*[51]

Without adding any dates, he describes the first recorded shipwreck through a first-hand report. This is a description of a very mature business, for the report's author is in command of a ship some 55 m (180 ft) in length with a crew of 120. It sailed from an Egyptian mine in Sinai, probably Ezi-on-Geber, destined for Punt, but the ship was lost in a storm and the author was the only survivor. Casson remarks that the report predates the next known shipwreck by around four hundred years.[52]

It has become clear in the past two decades that the rises in sea level that have occurred during more recent human history have resulted in the loss of many early human habitats. This has greatly limited our archaeological knowledge of the peoples of these early times. There is a need for underwater archaeology in the shallow waters adjacent to Mediterranean and Middle-East coastlines where new finds might provide evidence of ancient seafaring activities. Fortunately, such studies are presently gaining momentum, but are still largely new.[53] A great deal is known about Egyptian history and of the methods of navigation used by their seamen, but there is no direct evidence of any specific structures that might have provided lighted aids to navigation. Indeed, had there been a word for 'lighthouse' in the Egyptian language in 280 BCE it would surely have been used for the structure at Alexandria. This fact alone is a strong indicator that structures identifiable as lighted aids to navigation did not exist in the wider Mediterranean / Black Sea region in the geometrical forms we think of today. Additionally, although the Egyptians were prolific users of water transport, their ships were obtained despite the lack of suitable timber in the Nile hinterland. Ships were either purchased elsewhere or made from timber bought from external sources.

Many writers have offered the Arab peoples as unquestionably good navigators, but as yet there is no evidence to suggest that the waters of the Erythraean Sea were made safer by lighted aids to navigation before the existence of the Pharos. As far as we know, the peoples of far eastern origin were not sufficiently active at sea for them to have used lights for navigation during these very early times. So, in view of the peculiar absence of lighthouses prior to 280 BCE, let us consider that we may not find structures that look like lighthouses, but that the function of lighthouses may have been provided in other ways. We need to examine the wider context of seafaring and the ways that early humans went about their business on water.

It is easy for us to become caught up with the many fascinating aspects of Mediterranean history, and to forget about the wider maritime sphere of activity. Besides the ancient port of Punt there are many more sites to consider. I shall return to this subject on several occasions below, but it is appropriate at this point to broaden the scope of Greek maritime activities.

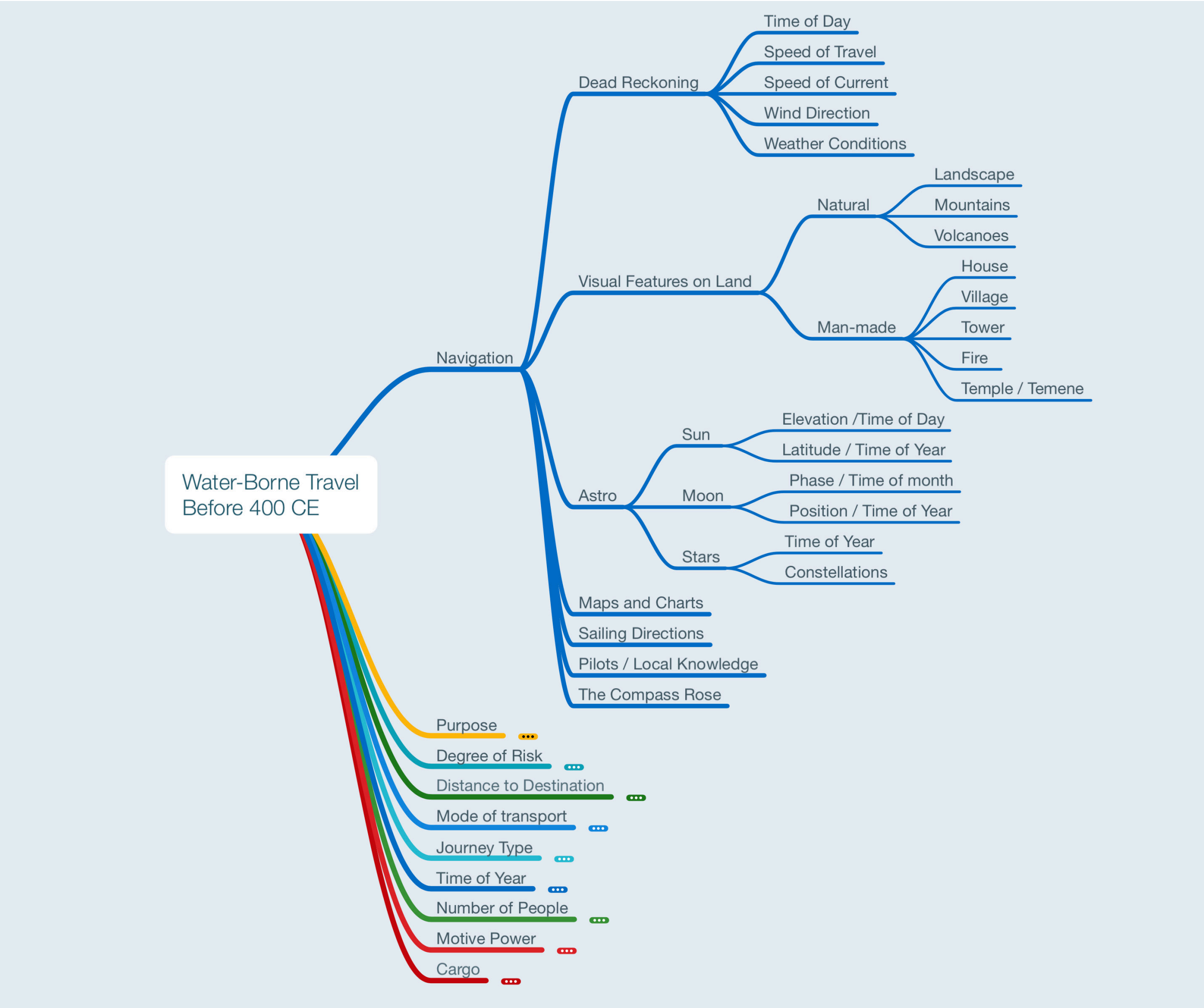


Fig. 2-29: A topic taxonomy or mind map - for Navigation.

It was Alexander the Great who opened up the doors to the east for Western civilization. In no more than ten years he had dominated much of Europe and the eastern Mediterranean, as well as the middle east as far as the Indus valley. Yet the sea routes from the Red Sea to India and beyond were the domain of Arab traders who, later with the Indians, were keen to preserve the secrets of their livelihoods in the same way that the Phoenicians had protected theirs. Thus, even though the Greeks were the dominant force in the Mediterranean from 500 BCE to 300 BCE, the Red Sea and beyond were largely off-limits.

From 310 BCE, Alexander's new kingdoms were the subject of great cultural influences so that much of the known world fell under the description of Hellenistic. Antioch and Alexandria turned from buds into flowers, with the latter becoming the most important port in the world.

Pytheas of Massalia was born around 350 BCE into a Greek colony in what is now the French southern city of Marseilles. About 325 BCE he made the first documented voyage to Britain, which he circumnavigated, after investigating the Cornish tin sources. He was able to define the island of Ireland for the first time and then went further north, either to Iceland or southern Norway, before exploring eastern Europe. His adventures were written down and became well known in ancient times, but the diaries have not survived. Perhaps he was stimulated to make such a journey by the age-old tales of the Phoenicians making these long journeys to determine the sources of tin in the Cassiterides. The Phoenicians were well-known for keeping their sources secret and despite efforts by many others to discover these sources and thence to cash in on them, they remained a mystery until Pytheas finally made his journey.[54]

Despite the discoveries of Pytheas, it was to the east that the greatest benefits of exploration were to be found, but Arab seamen controlled the Red Sea and all routes around India. By sailing from the Red Sea in May to September a ship could benefit from wind assistance and reach India comfort-

Fig. 2-30: The only known worked surface outcrop of tin-bearing rock presently to be seen in Cornwall. This rock shows signs of hand-tools used to remove black veins of tin ore as long ago as 1800 BCE. Prehistoric 'Tin Streamers' extracted the heavy tinstones (Cassiterite) from the river Cober - then the richest source of alluvial tin in West Cornwall. Tinstones were then crushed to a fine powder. The granite outcrop was used in the same way we use a pestle and mortar. The Tin Streamers used a heavy round stone known as a 'Bully' to crush the tinstone and then grind it to a powder. The action of grinding the tin ore resulted in round depressions in the granite. The tin powder, known as 'Concentrate' was mixed with charcoal, and the mixture heated in a primitive furnace to turn the black tinstone into the silver-coloured metal.[80]

ably. During November to March, the winds were reversed, so the return journey could be made just as easily. However, the Arabs kept this a closely guarded secret so that most Greek ships looking for new routes to the east could not benefit - on the contrary, they found travel there very difficult. Over time, however, the Greeks and later the Romans pushed back the frontiers of their sea routes by the second century CE to India, Ceylon and beyond as far as Java. Contact with the Chinese and the true far east was still very much made by overland routes. And all of this - apparently - without lights to guide them.

Fig. 2-31 is a map compiled in modern times using information contained in the Periplus. This wonderful ancient document gives a very good account of a typical journey of circumnavigation around the Erythraean Sea.[55] At the time of writing the Periplus, commonly agreed to be around 50 CE, the seas would have been very busy with all kinds of trading vessels of all communities. There are clear indications that some parts had ports and safe anchorages - others did not. It was essential to have knowledge of the kinds of reception a trading vessel might receive if it ventured near to or called into the shore and it was well recognized that in some parts it was necessary to keep out of sight of the shore dwellers.

> *"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.*

Fig. 2.31: Locations, names and routes of the Periplus of the Erythraean Sea (1st century CE) [81]

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 Carnanites. Navigation is dangerous along this whole coast of Arabia, which is without harbours, 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." [56]

"The market town of Muza is without a harbour, but has a good roadstead and anchorage because of the sandy bottom thereabouts, where the anchors hold safely." [57]

Cana, in Yemen, was an ancient port city, mainly a trading port of spices from India and Eastern coast of Africa. It was described in the Periplus:

"After Eudaemon, Arabia (present day Aden) there is a continuous length of coast, and by extending 2000 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, of the Kingdom of Eliazus, 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 with the neighbouring coast of Persia. [58]

"There are imported into this place from, Egypt, a little wheat and wine, as at Muza (present day Mocha, Yemen); 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, 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."[59]

Conclusions

1. There is no proof that *homo neanderthalensis* used water-borne transport, but there is a high likelihood of him using logs, rafts and boats that could be manufactured from flint tools.

2. Studies have shown clear evidence of the continuous control of fire by Neanderthals in Europe dating back roughly 400,000 years.[60]

3. It is possible that Neanderthals used the most basic elements of navigation during their time spent travelling by water. This includes the use of fires ashore (Stages 1 and 2) to identify waypoints and destinations.

4. Evidence has been produced that religious sites - temples, *temene* and sanctuaries - exhibited lights that, as a secondary function, were useful as lighted aids to navigation.

5. Open sea voyages lasting longer than 24 hours are proposed to have taken place around 50 kya, probably when the population of Sunda, Sahul and Wallacea occurred. In the Mediterranean, it is known to have occurred from the start of the Pliocene period concurrent with the search for obsidian in the Aegean. It is very likely that Stage 1 and Stage 2 navigation by fire took place.

6. Before the building of the Pharos, there is plenty of evidence that fires were used as aids to navigation (Stage 1 and 2), but almost no evidence that humans constructed towers or elevated structures for the (Stage 3) primary function of a lighthouse. Thus far, only small cylindrical platforms have been identified as possible lightstructures at the entrances to ports and harbours.

Notes

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22 Casson (1991), p3.

23 Wachsmann (2009), p9.

24 Heyerdahl (1972).

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26 Wikipedia, Reed boats, 20160723.

27 Wachsmann (2009), pp229-30.

28 Wachsmann (2009), pp219-20.

29 Wachsmann (2009), pp12.

30 Usai (2007).

31 Bible (1970), Acts 27:20.

32 Taylor (1956).

33 https://zethio.files.wordpress.com/2014/04/the-periplus-of-the-erythraean-sea.pdf; A Periplus (Periplous) is a circumnavigation, and Erythraean

means “of or relating to the sea that in ancient geography comprised the Arabian sea, the Red sea, and the Persian gulf.”

34 Homer, Odyssey, 10, 190-1.

35 Sachs (1948).

36 Hancock (1988).

37 Taylor (1956), p9.

38 Wikipedia, Beta Ursae Minoris, 20160831.

39 Taylor (1956), p12.

40 Wikipedia, Compass, 20170828.

41 Naish (1985).

42 Naish (1985), p16.

43 Naish (1985), p17.

44 Naish (1985), p20.

45 de Graauw, (2016), Vol I.

46 Jonatan Christiansen, private communication.

47 Herodotus, The Histories 4.42; trans. Aubrey de Selincourt. http://www.livius.org/he-hg/herodotus.hist01.html. (Phoenician circumnavigation of Africa.)

48 Seventeen hundred years after Eratosthenes, Christopher Columbus studied Eratosthenes’s findings before sailing west for the Indies. However, ultimately he rejected Eratosthenes in favour of other maps and arguments that interpreted Earth’s circumference to be a third smaller than reality. If, instead, Columbus had accepted Eratosthenes findings, then he may have never gone west, since he didn’t have the supplies or funding needed for the much longer voyage. Wikipedia Spherical Earth, 20170430.

49 Wikipedia, Land of Punt, 20160728.

50 Wachsmann, (2009).

51 Casson, (1991), p10.

52 Casson, (1991), p11.

53 Bailey, (2010).

54 Wikipedia, Pytheas, 20180129

55 Wikipedia, Periplus of the Erythraean Sea, 20180129

56 Schoff (1912), pp29-30, §20.

57 Schoff (1912), p30, §24.

58 Schoff (1912), p32, §27.

59 Schoff (1912), p33, §28.

60 Villa (2011).

61 O’Connell (2010).

62 Broodbank (2015), p153.

63 Photo: B Jacob (2013).

64 Photo: IRO, University of Montreal.

65 Photo: Anchorage Museum (2007).

66Unattributed photo, downloaded from www.ecosnippets.com 20180204.

67 Unattributed model and photo: http://www.ducksters.com/history/ancient_egypt/boats_and_transportation.php

68 Unattributed model and photo.

69 Photo: Rick Stevens, National Geographic News; https://news.nationalgeographic.com/news/2008/10/photogalleries/australia-aboriginal-art-photos/photo4.html.

70 Photo: Bradshaw Foundation; www.bradshawfoundation.com

71 Engraving of the Torre Dels Vents.

72 Image: Joanbanjo (2011). Reproduced under Creative Commons License.

73 Unattributed Photo.

74 Image: ©Mark Lewis (2017).

75 The Turin Papyrus Map of Egypt, dated to 1160 BCE.]

76 The ancient Babylonian Map, the Imago Mundi, dated to around 450 BCE. The Latin term *Mappa Mundi* means literally ‘Map of the World’. The term Ecumene or Oecumene is derived from Greek that means ‘the Inhabited World’. It is used with the understanding that there is a part of the world that is uninhabited, or perhaps more accurately, unknown or unexplored. These terms are for use in the general context, but are often applied to specific works.

77 Redrawn artwork reproduced under the Creative Commons License.

78 Google Earth (2017).

79 Photo: ©Ken Trethewey (2002), Gallery of Maps, the Vatican.

80 Photo: ©Ken Trethewey (2016). Information taken from English Heritage National Monument at the Poldark Mine, Wendron, near Helston in Cornwall, UK.

81 Wikipedia Commons Image: Topographic30deg N0E60.png by PHGCOM (2007). Reproduced under the GNU Free Documentation License.

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Conventions used

1. References are given in the usual format: Smith (2002), p123. Multiple citations having the same author and year are given the suffix a, b, c etc.

2. A reference given as Smith (online) has no date if it is continuously updated. Specific information downloaded from the Internet is given a date of download.

3. Entries in the Bibliography are considered relevant to the content of this book, but are not necessarily to be found in the references.

4. Entries are in alphabetical order of the first author's last name. Unnamed authors are assigned the usual 'Anon'.

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