ARAB WAYFINDING ON LAND AND AT SEA: AN HISTORICAL COMPARISON OF TRADITIONAL NAVIGATION TECHNIQUES

BY

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Master's of Arts

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Chairperson

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ARAB WAYFINDING ON LAND AND AT SEA:
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Abstract

This thesis investigates the historical significance of traditional Arab navigation technology (after the advent of Islam), drawing upon Arabic primary sources and other relevant literature. Modeling wayfinding as a geographical activity in which members of a culture use its technology to interact spatially with the physical environment, it systematically compares the techniques, tools and other features of Arab wayfinding in two environments, sea and land, forming a transportation network from Mecca in Arabia westward to Spain and eastward to China. It also considers Arab and neighboring cultures as innovators in navigation and geography, including the compilation of maps and text for Al-Idrisi's Book of Roger, which summarized Arab geographical knowledge for the European king, Roger II of Sicily, in 1154 A.D. It concludes by reflecting upon the diffusion and lingering significance of Arab learning in Mediterranean Europe and Africa, suggesting further research to bridge gaps in the historical record.

Acknowledgements

It is a pleasure to thank the many people who made this thesis possible.

It is difficult to overstate my gratitude to my MS supervisor, Dr. George F. McCleary, Jr., for his enthusiasm, his inspiration, and his great efforts to explain things clearly and simply during the development of the ideas in this thesis. I have especially appreciated his helpful comments on the text, his guidance, support, and encouragement throughout the writing of this thesis, and for introducing me to different learned institutions and various leading scholars. This thesis would not have been possible without the support of Dr. Karen S. Cook, so I dedicate my special thanks to her encouraging me from the very beginning to pursue this field of study. She has helped me to overcome all obstacles both at home and abroad. Throughout my thesis-writing period, she provided assistance in translating many French sources. Her excellent advice on content, her tireless work in compiling, editing and document management, her good teaching, good company, and lots of good ideas have all been invaluable. I would have been lost without her. I also wish to thank my Professors Dr. Kevin Price and Dr. Stephen Egbert, who kindly read many parts of my thesis, drew my attention to many points, gave wise advice and provided much emotional support. I would like to thank Dr. Ahmad Massasati for many suggestions on the topic. I am grateful to the librarians at the University of Kansas for assisting me in many different ways. I wish to thank my United Arab Emirates University for providing me with scholarship funding and for assisting me in every possible way to make my study successful. Lastly, and most importantly, I wish to thank my family: my mother and my sister. My mother has been an inspiration throughout my life. She has always supported my dreams and aspirations, and if I do say so myself, I think she did a fine job raising me. I'd like to thank her for all she is, and all she has done for me. My sister, Najwa, has helped me get through the difficult times and has always supported and believed in me.

Thank you for all those not specifically acknowledged here, but who have made a significant difference in my life. Many of you know who you are, but there are also many of you who don't appreciate your positive impact on my life. Thank you so much for caring about me, my goals, and my dreams.

Preface

As the bibliography indicates, the information for this thesis came from a wide range of primary and secondary sources. Working with these sources has been rewarding, but also challenging for a number of reasons.

The references are in different languages, mainly Arabic, English and French, reflecting the international scope of this research project. Although my native language is Arabic, the primary sources in old Arabic were difficult to understand.

Some early Arab geography books have been published in entirety in translation or as facsimiles, but often only as selected passages of text. Some books were available in the KU Libraries, but others had to be ordered through Inter-Library Loan. Other Arab geography manuscripts, as yet unpublished and preserved in distant libraries, could not be consulted at all. Although I did visit several universities, libraries and learned institutions in the United Arab Emirates during a trip there in June 2005, I received a mixed reception. Some of them were very helpful and welcomed me, while others were not cooperative.

During the same trip I was also able to interview a retired Arab navigator who had spent many years working as a pilot. I was able to obtain some information about navigation techniques and their history from him However, I found him to be somewhat suspicious of my motives and reluctant to answer some questions.

Nevertheless, using available time and resources it was possible to gather sufficient information regarding this thesis topic. In fact, I was surprised to find that so much primary source material survives and could be consulted in facsimile through the KU Libraries services. Doing this research and studying the writings and maps of early Arab geographers and navigators has been a tremendous experience for me personally, giving me an opportunity to learn much more about my Arab heritage.

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Chapter 1. Introduction

The Arab peoples, who had originated as desert nomads in Arabia, developed following the rise of Islam in the 7^{th} century A.D. into merchants and pilgrims who travelled a network of land and sea routes extending from Mecca, the spiritual and commercial urban center of Arabia, eastward to India and China and westward to northwest Africa and to Spain in Europe. Until the Portuguese first sailed around Africa to India in 1498, heralding a shift toward European domination of sea trade, it was the Arabs whose travel activities formed a vital link between Eastern and Western cultures. Ideas, as well as people, animals and material goods, moved along those transportation routes. Among the ideas carried by Arab travellers were advances in science and technology, including the techniques and tools of travel itself. Focusing on the latter, this study will show how the Arabs developed and disseminated navigation techniques suitable for wayfinding in the varied geographical environments crossed by their travel routes. This study will highlight three main topics: Arab sea navigation, Arab land navigation, and Al-Idrisi's world map of 1154 A.D., which serves as an outstanding example of Arab geographical knowledge transmitted to Europe.

Chapter two will cover Sea Navigation. The first part of this chapter deals with traditional sea navigation instruments and techniques used by Arabs, other factors in route selection, the personnel who navigated the ship, and the contribution of a famous Arab navigator, Ibn Majid.

Chapter three will be about Land Navigation. This chapter covers techniques used for wayfinding, other factors in route selection, how the caravaneers used different techniques and information to guide the caravan, and the example and experiences of a renowned Arab traveler, Ibn Battuta.

Chapter four will be about Al-Idrisi and his extensive contributions to different aspects of geographical knowledge. His original contributions to geography included economic, physical and cultural aspects. His world map was engraved on a sheet silver weighing 400 kilograms for the Christian King Roger II of Sicily. He also described the world in 'Al-Kitab al-Rujari' (Roger's Book), also entitled “'Nuzhat al-Mushtaq fi Ikhtiraq al-Afaq'” (Amusement for Him Who Desires to Travel Round the World). This is a geographical encyclopedia of the time, containing information on Asia, Africa and also Western countries, as well as detailed maps.

This thesis compares traditional Arab navigation techniques, instruments, and methods for wayfinding on land and at sea. In so doing, it tests the hypothesis that Arab sea and land navigation techniques differed significantly due to cultural and environmental factors.

During the Middle Ages there were strong relationships between the formulation of geographical concepts and the extension of travel and exploration. It has been pointed out that there were many Arabic-Islamic travelers and explorers who contributed to the formulation of geographical knowledge of the land and of the sea.

When the Abbasid Caliphate was established at Basra in the 8th century A.D., it became the meeting place of seafaring men, merchants and explorers who were responsible for the dissemination of geographical knowledge. The Arab travelers navigated in the eastern seas up to the coast of China. These travelers described all the seas, the islands, and the countries in their travel accounts. They also described the products as well as the manners and customs of the people in these places. An example of these travelers was Al-Maqdisi (942-1000 A.D.) who described the dangerous places, anchorages and islands in the Arabian Sea. Also, Al-Masudi (10th c.) described the East African coast as far as Sufala and Mozambique.

In regard to exploration by land, the Arab geographers were better acquainted with many more countries and regions than the Greeks and Romans. The Arab explorers penetrated the interior of Sahara and established friendly relations with Sudan. Moreover, they reached Senegal and Niger and explored the secrets of the upper Nile valley. The most authentic information on this part of Africa is supplied by Al-Masudi (10th c.) and Al-Idrisi (12th c.). Also, the Arab geographers supplied detailed information about central Asia and the Indian region. These regions were unknown to the people of west Asia because the difficulties of travel. The establishment of Muslim rule in central Asia and the Indian region improved the communication system and facilitated travel there (Alavi 1966, 71).

Even before Islam, the Arabs possessed an enormous amount of knowledge about geography, and also about the astronomy of the Arabian Peninsula, Syria, the Red Sea region, and the Indian Ocean. This knowledge was recorded in their folk tales and poetry. Arab travelers crossed the Arabian Peninsula without using a map or any modern instruments since they were experts in using astral navigation to determine directions and to locate places.

After Islam began in 610 A.D., it provided new incentives to travel. The first order in Islam was to "read" in order to learn and discover the universe. Islam has five pillars; the second pillar is regular prayer, so the Muslims needed to know the exact time and direction of Mecca. For this they needed to have a complete knowledge of the sun and moon's movements.

The Qur'an (written in the seventh century) included some geographical information, like ocean depths, the sun, the moon, other celestial bodies, the shape of the earth, and other geographical phenomena. The Qur'an had a great effect on the Arabs and made them aware for the first time of the importance of science, including the value of geography. In the centuries to come, while science languished in medieval Europe, Islamic intellectual life flourished and through it, the products of the civilizations of the Greeks, Persians, East Indians, and others were translated into Arabic and preserved.

Arab geographers knew the term "geography" through the translated works of Ptolemy and Marinos of Tyre. The use of the word "geography" was introduced in the twelfth century in "Rasa'il Ikhwan Al-Safa" (Epistles of Ikhwan Al-Safa'). Geography in Arabic literature could be found in four distinguished branches: "Taqwim al- Buldan" (The Science of Cartography), "'Iim al-Atwal wa-al-'Urud" (The Science of Latitude and Longitude), "Ajaib al-Buldan" (The Wonders of the

World), and “Al-Masalik wa-al-Mamalik” (The Science which deals with fixed geographical position of places) (Massasati 1997, 1).

Arab concern about scientific development reached its peak during the reign of the eighth caliph of the Abbasid line, Al-Mamun (813-833 A.D.), who took active interest in the work of translators and scientists. The “Bita al-Hikamah” or (House of Wisdom) was established under Caliph Haroun Al-Rashid and supported by Al-Mamun. This house was established in order to carry out the great task of translating from Greek, Persian, Indian, and Chinese sources. Al-Mamun ordered the collection of important scientific works and translators were paid the weight of books in gold. The most excellent contribution made by Muslim scholars at Al-Mamun’s time was the measurement of the earth’s circumference that took place in the plain of Musa ben Shakir. It was the first time that an actual measurement of the earth’s circumference was attempted by Arab astronomers and surveyors. In actual fact, the calculation of the earth’s radius at 3818 miles by Ibn Rustah (d.923 A.D.) is very close to our present calculations (approximate polar radius = 3949 miles and equatorial radius = 3963 miles). The Arab and Muslim contribution to geography was not restricted to astronomical and mathematical geography, but rather covered a wide range of the branches of the discipline known at the present time (El-Bushra 1999, 97).

The Arabs engaged in travel for the purpose of commerce and trade long before Islam, but after the rise of Islam, travel acquired a new meaning and dimension. It became important for several reasons: spreading the faith, Hajj (pilgrimage to Mecca), learning, trade, and collecting information about other countries. For travelers to achieve their objectives, they had to be well-acquainted with sea and land routes they had to follow. Their knowledge of the sea routes in the Red Sea, Indian Ocean and China Sea made them masters of these waters, and they were able to dominate commercial activities in the vicinity of these seas. Arab culture became dominant throughout Southeast Asia, as well as extending westward along North Africa to Spain.

As the bibliography indicates, the information for this thesis came from a wide range of primary and secondary sources. Working with these sources has been rewarding, but also challenging for a number of reasons. The references are in different languages, mainly Arabic, English and French, reflecting the international scope of this research project. Although my native language is Arabic, the primary sources in old Arabic were difficult to understand. Some early Arab geography books have been published in translation or as facsimiles, but often only selected passages of text. Some books were available in the KU Libraries, but others had to be ordered through Inter Library Loan. Other Arab geography manuscripts, as yet unpublished and preserved in distant libraries, could not be consulted at all. Nevertheless, using available time and resources it was possible to gather sufficient information regarding this thesis topic.

Chapter 2. Sea Navigation

Arab sailors used diverse methods and instruments to navigate through the Indian Ocean, Arabian Sea, Red Sea, and Persian Gulf. They can be grouped under the headings: astronomical and magnetic position finding, orientation methods, landmarks and environmental cues, oral and written sailing directions, and mental and analog maps.

Astronomical and Magnetic Position Finding:

Stars & Sun:

For thousands of years, navigators have relied on the sun and stars to orient themselves. When no landmarks or other aids to navigation are visible, navigators can use the position of the sun or stars in the sky to fix their ship's position.

Using stars for navigation at night will be discussed first. Long before navigation instruments were invented the Arabs sailors were using the stars for guidance in the Red Sea. An Arab from Spain, Ibn Jubair (1145-1217), who traveled to Mecca and back in 1183-1185, said the sailors on the ship on which he traveled from Ayzab to Jidda lost their way in a dark storm until a few stars appeared to show them their direction (Shihab 1994, 69). Later Arab navigators took along mathematicians to point out the directions by measuring the stars and to calculate latitude and longitude (Nadvi 1966, 108).

Ibn Majid (ca. 1435- 1500), one of the most famous Arab navigators, mentioned a list of books very important for navigators in "Fawaid" (The Book of Profitable Things Concerning the First Principles and Rules of Navigation). The books he recommends cover geography, astronomy, latitude, longitude, and the constellations. The North Star was the most essential star for the Arab navigators (Nadvi 1966, 108). The word for North, “al-jah”, was also the name of the North Star, while South was called “Qutb” (Murad 1990, 53). According to Ibn Majid, there were 48 constellations. Twenty one of these are in the northern sector of the sky: Ursa Major, Ursa Minor, Draco, Cepheus, Virginis, Corona Borealis, Hercules, Cygnus, Pegasus, Sagitta, Delphinus, Cassi Opeia, Equuleus, Aquila, Auriga, Serpens, Andromeda, Lyra, Ophinchus, Perseus, Triangulum. The southern sector of the sky includes 15 constellations: Cetus, Orion, Lepus, Eridanus, Canis Major, Canis Minor, Corvus, Hydra, Lupus, Corona Australis, Ara, Centaurus, Crater, Pisces, and Puppies. The Arab astronomers employed a twelve-pointed zodiac with six points located in the northern sector: Aries, Taurus, Gemini, Cancer, Leo, and Virgo and the other six located in the southern sector: Libra, Scorpius, Sagittarius, Capricornus, Pisces, and Aquaruis (Shihab 1984, 43) (Fig. 2.1).

Besides observing the stars at night, the Arab navigator observed the sun during the day to determine the ship’s latitude. After the navigator measured the altitude of the sun at noon, the captain used that figure to calculate the distance from the Equator. He looked it up in a “Rahmani” (nautical book) with a sun table giving the latitude at which the sun is overhead on each day of the year (Fig. 2.2). As Figures 6-12 show, there were seven cases of ship position relative to the sun and the Equator that the Arab navigators utilized in determining the ship’s latitude.

Rahmani were written by Arab navigators at least from 990 A.D. onward. The seven cases (after Shihab 1984 & Al Haduri 1994, 89) are as follows:

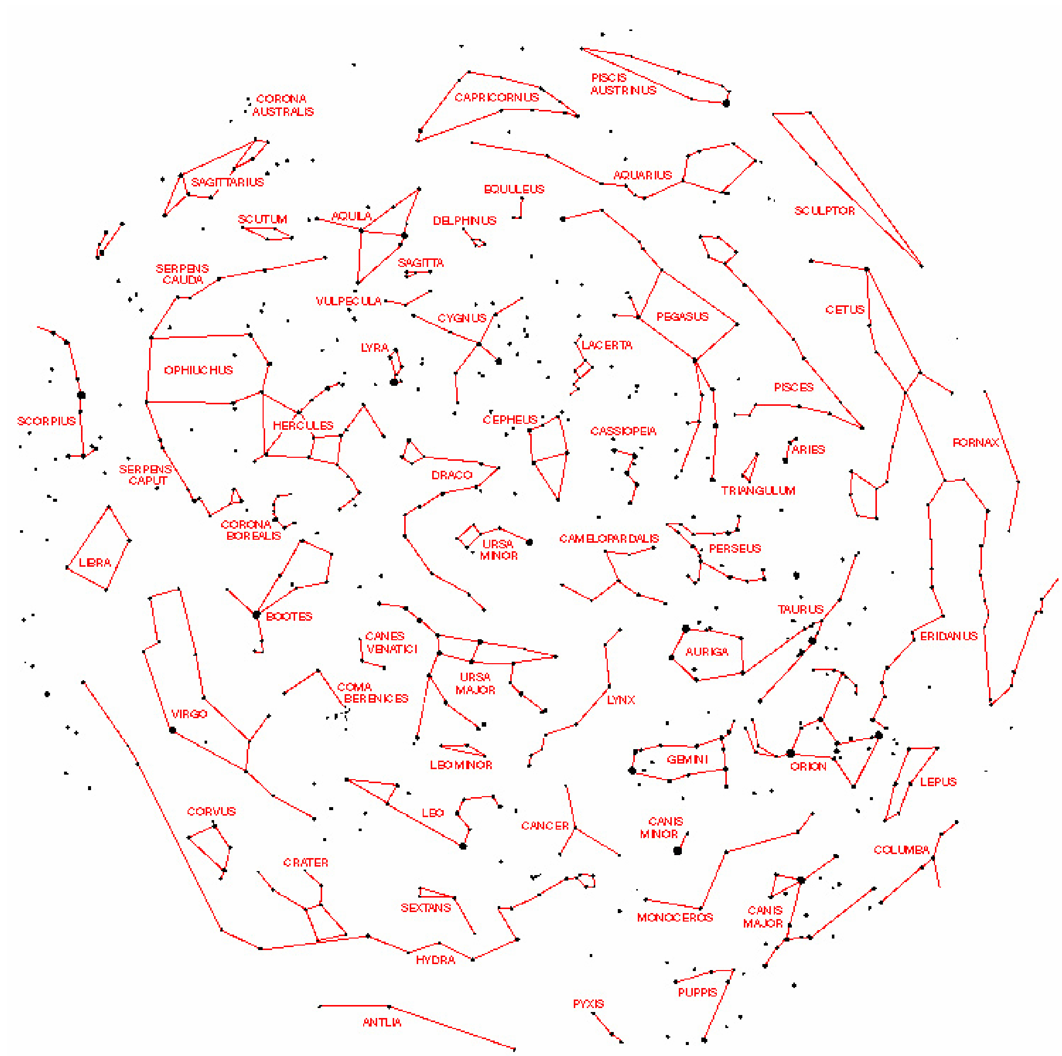


Figure 2.1. Constellations listed by Ibn Majid. "Constellation Star Map" (sps.la.asu.edu/ upcoming/zone/with.html, 10/13/2005).

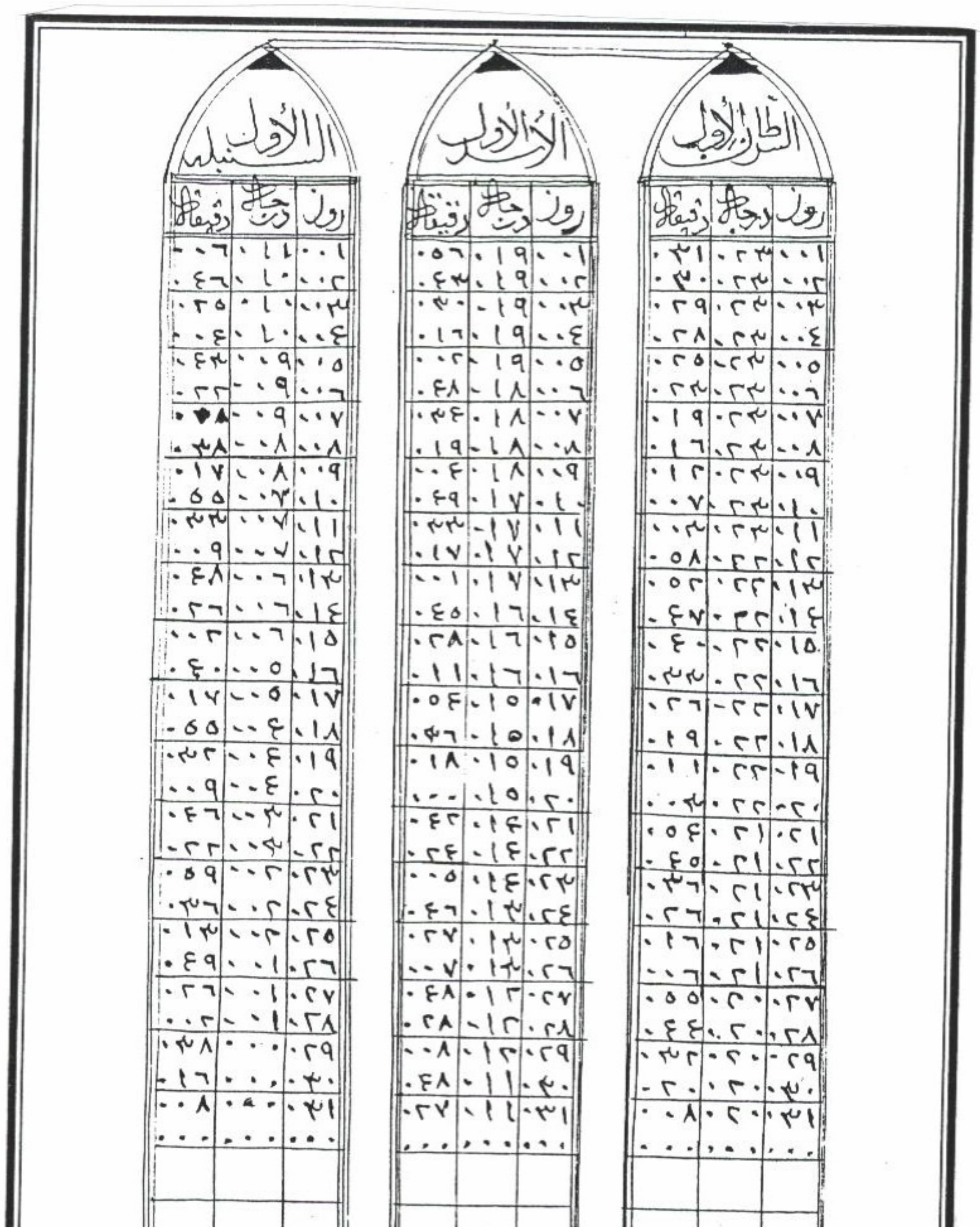


Figure 2.2. Part of the sun table from a “Rahmani” (nautical book). Each column gives information for one sign of the zodiac. Reading from right to left, the 3 sub-columns give the date and the degrees and minutes of latitude (Al-Hadori 1994, 115).

1. If your ship is south of the Equator and the sun is north of the Equator, first take the altitude of the sun at noon, second use the sun table in the “Rahmani” to determine the position of the sun on that date.

For example, if the altitude of the sun is 20° 07', and it is the first day in the Virgo portion of the zodiac, the angular distance of sun from the Equator is 11° 07'. Subtract 20°, 07' from 11° 07' to get your ship’s latitude which is 9° (Fig. 2.3).

2. If your ship is the north of the Equator, and the sun is south of the Equator, you can find your latitude as the first case (Fig. 2.4).

3. If your ship is between the Equator line and the sun is either north or south of the Equator, you can find your latitude as the first case (Fig. 2.5).

4. If the sun is directly overhead the ship at noon, the angular distance of the sun from the Equator given in the sun table in the “Rahmani” will be your ship’s latitude (Fig. 2.6).

5. If your ship and the sun are on the Equator, your latitude is 0° (Fig. 2.7).

6. If your ship is on the Equator and the sun is not directly over your ship, then the declination from vertical of the sun observed from the ship and the angular difference in sun table will be equal, so your latitude is 0° (Fig. 2.8).

7. If the sun is on the Equator and your ship is north or south of the sun, the ship’s angular distance from the sun will be equal the ship’s latitude (Fig. 2.9).

The navigators of the Indian Ocean were conscious of the significance of knowing the direction of one’s course at sea. Their regional knowledge of the positions of the rising and setting stars relative to the circular horizon was enough to make an excellent star compass. The navigator mentally divided his ship into parts so that he could follow his course by relating the rising of specific stars to parts of his ship without having to consult any kind of a compass (Brauer1985, 37). The star compass was later combined with the magnetic compass and that important development will be discussed later on, in the section on the “Magnetic Compass”.

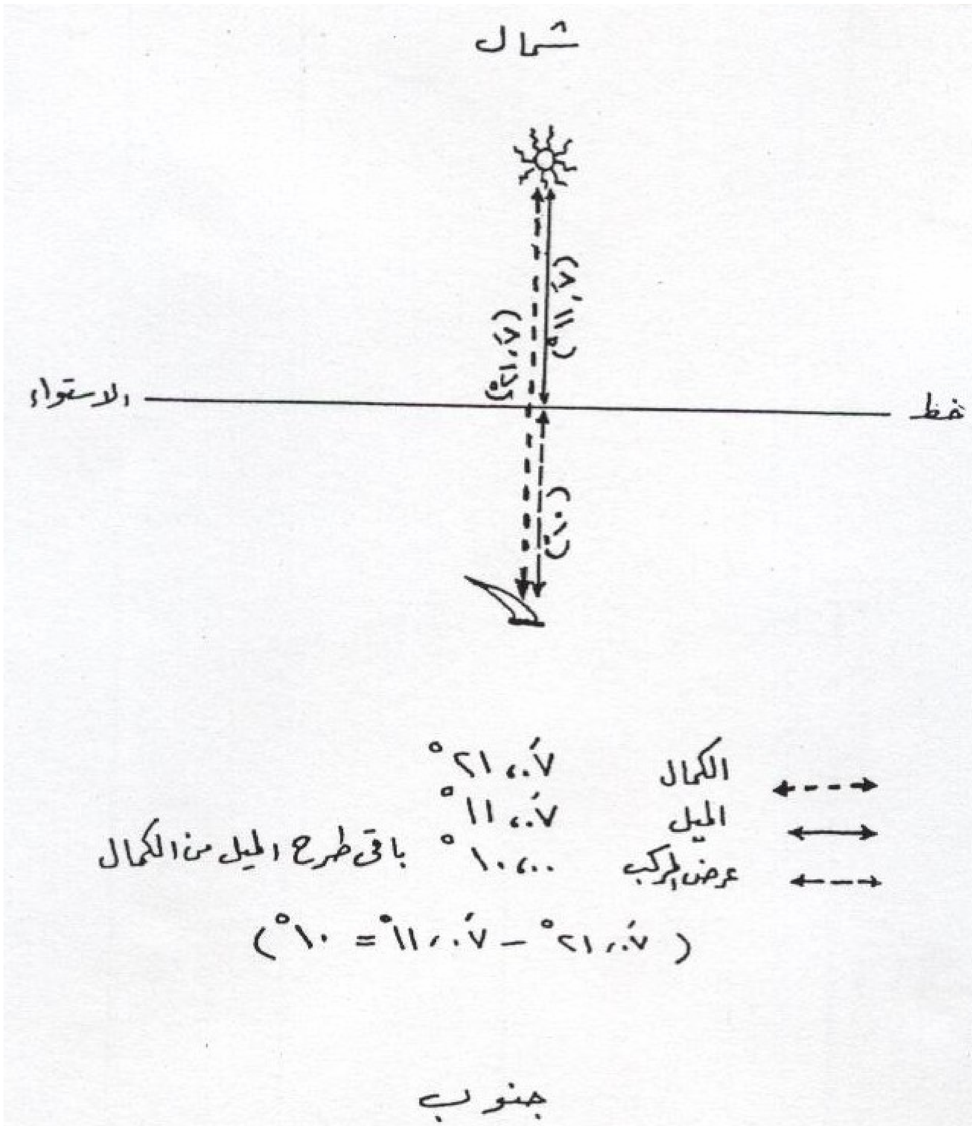


Figure 2.3. The first case of the ship's position relative to the sun and the Equator (Shihab 1984, 100).

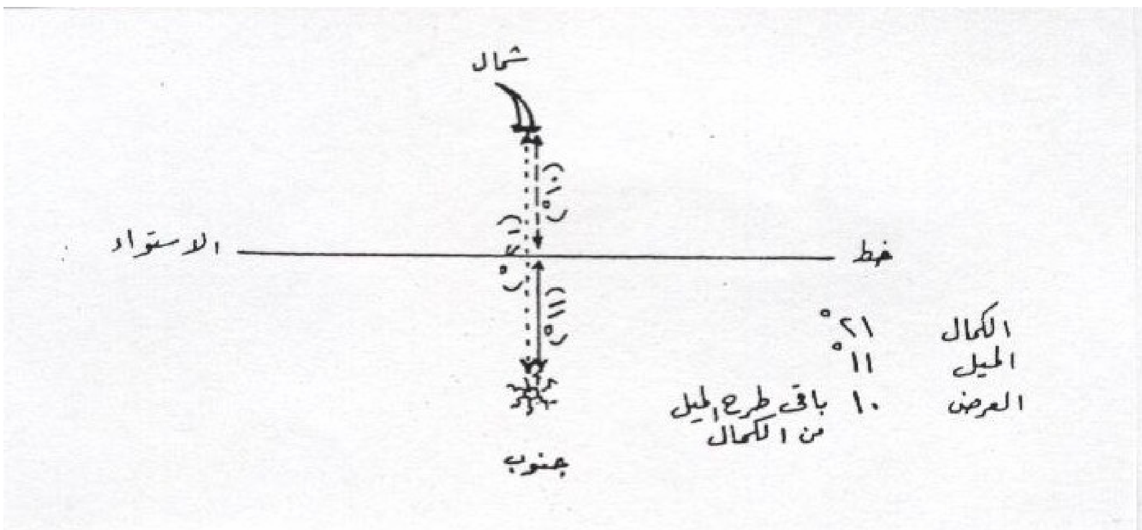


Figure 2.4. The second case of the ship's position relative to the sun and the Equator (Shihab 1984, 102).

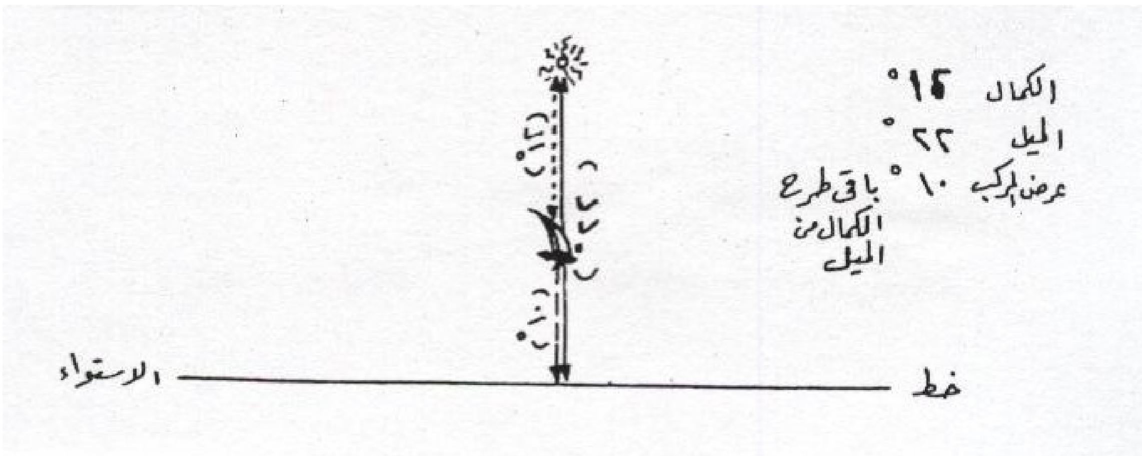


Figure 2.5. The third case of the ship’s position relative to the sun and the Equator (Shihab 1984, 102).

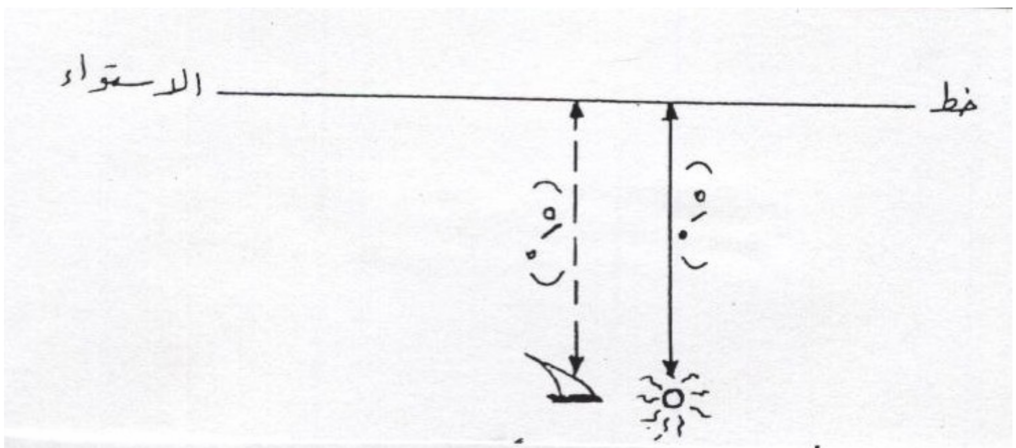


Figure 2.6. The fourth case of the ship's position relative to the sun and the Equator (Shihab 1984, 103).

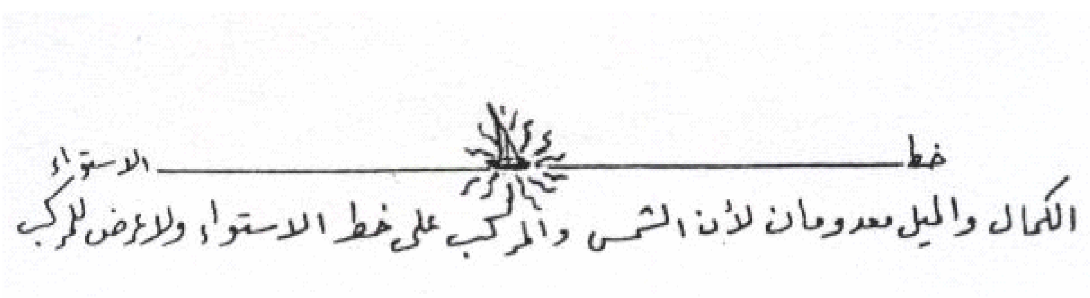


Figure 2.7. The fifth case of the ship's position relative to the sun and the Equator (Shihab 1984, 103).

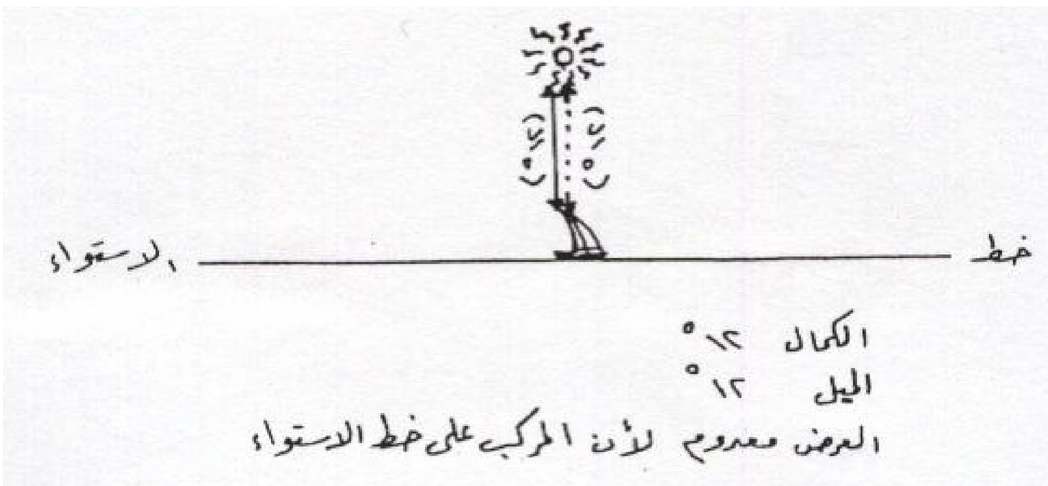


Figure 2.8. The sixth case of the ship's position relative to the sun and the Equator (Shihab 1984, 103).

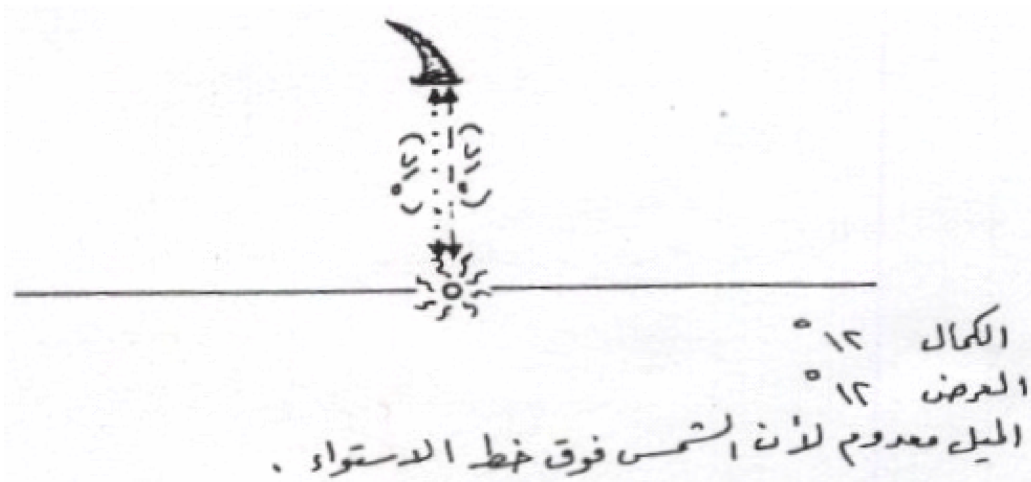


Figure 2.9. The seventh case of the ship's position relative to the sun and the Equator (Shihab 1984, 104).

Qiyas:

Early Arab navigators used the arm, hand and fingers to measure the positions of the sun and stars relative to the horizon, a method called the qiyas (measure of length). Ibn Majid used a method to measure the stars that employed the fist of the closed hand and the outstretched arm. The method was as follows: in order to measure the latitude of the star, the observer stretched out his arm and closed his hand into a fist (Fig. 2.10). By this means he created a "ruler" consisting of the four "isba" (fingers). The little finger was aligned with the horizon, and the index finger with the pole star. Also, the Arabs are thought to have used the little finger on an outstretched arm for sighting, aligning the palm line with the horizon and the upper joint with the North Star (Fig. 2.11).

However, human fingers differ in size, so the navigators invented an instrument with standard units of measure to improve the qiyas method (Ibn Majid & Tibbetts 1971, 312). In the Indian Ocean navigation, it helped the "rubban" or ship's pilot to determine his position and the distance sailed (Shihab 1982, 133). The qiyas was the technique most used by Arab navigators for determining latitude by means of stars.

Ibn Majid wrote in the 15 century that the "isba" or one joint of a finger was the unit of measure used in the qiyas. The total length of the qiyas, called the "dhubban" was divided in quarters, each quarter being equal to one finger joint. Thus, the dhubban became their "ruler", and the sailors cut their measuring stick according to the length of the dhubban (Murad 1990, 63) (Fig. 2.11).

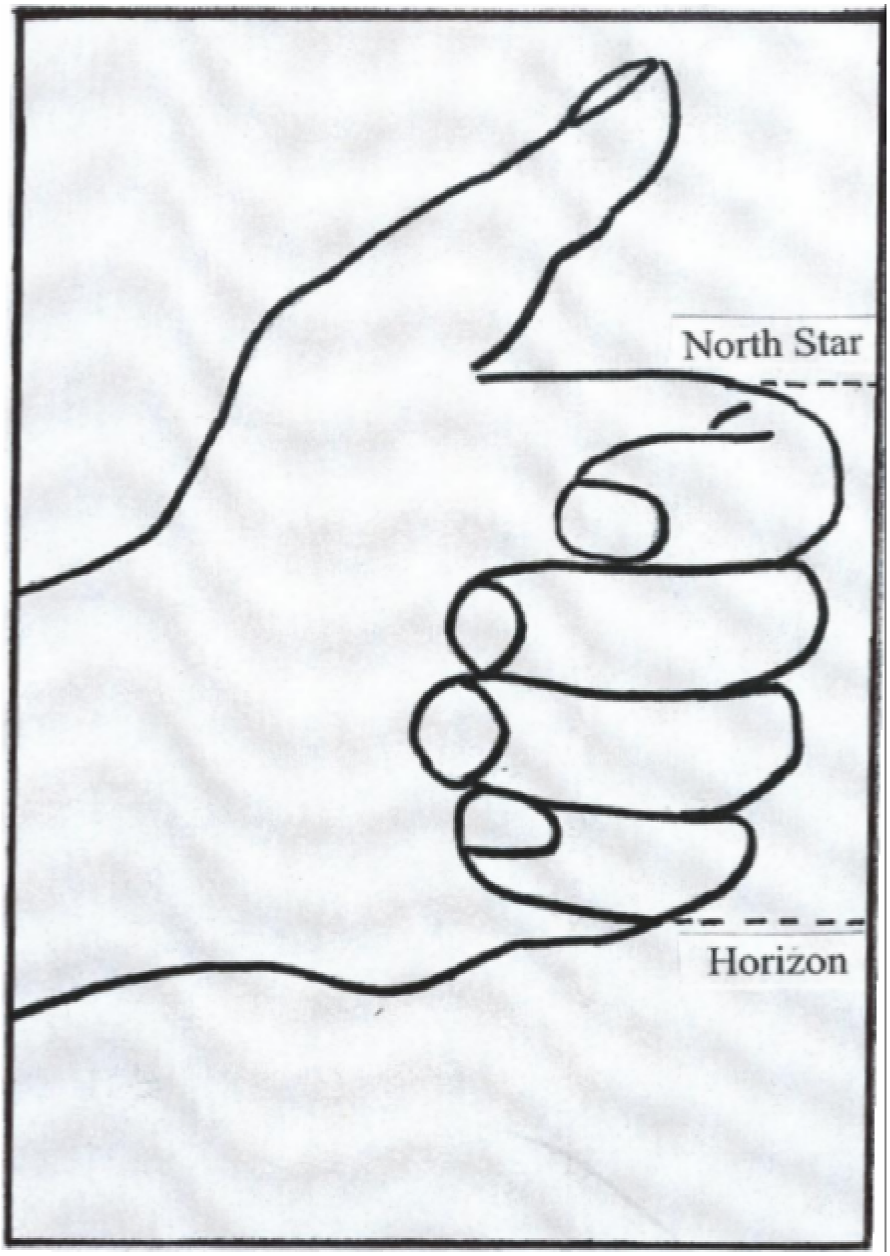


Figure 2.10. The Qiyas method employing a closed fist.

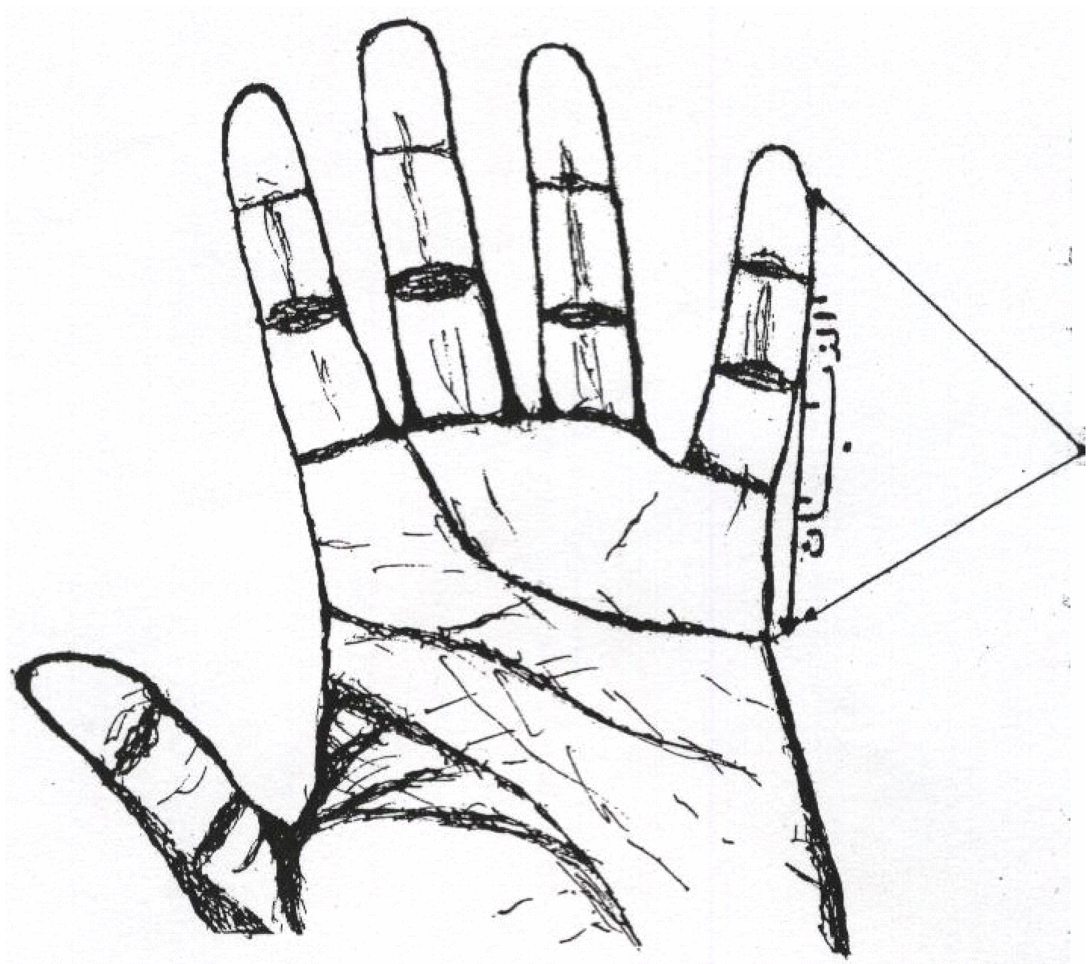


Figure 2.11. The “dhubban”, the total length of the qiyas (Shihab 1982, 135).

Apparently the design of the qiyas varied somewhat, Tibbetts mentions that the one isba was also divided into eight units known as "zam" ("watch" of three hours). The navigator reckoned the rising of the pole star by one isba above the horizon as equivalent to one day's sail due north (Tibbetts 1969, 10). Shihab says that the qiyas included twelve sticks or a spread of 12 fingers. Ibn Majid grouped the sticks according to their length, each group consisting of four sticks:

1. Long sticks: This includes sticks numbered nine to twelve. In using this group the "muallim" (captain or pilot) stretches his hand out as far as he can when measuring the altitude of a particular star.
2. Medium sticks: This includes sticks numbered five to eight. In using this group the observer does not need to stretch his hand out so far.
3. Short sticks: This includes sticks numbered one to four. In using this group the observer brings his hand as close as possible when measuring the star altitude, the opposite of the big sticks group. Each group is used by the navigators in different circumstances.

Ibn Majid gives many instructions for taking good qiyas measurements. The observer must 1) wash his face in cold water before taking the qiyas, 2) open his right eye and close the left eye, 3) hold the stick in his right hand, 4) have good vision, and 5) take the measurement in good weather conditions (Shihab 1982, 136).

Kamal:

The "kamal" was another basic device used by the Arab sailors. The word "kamal" is of Arabic origin and means "perfection" in general use. The kamal is a simple instrument used by the early Arab navigators of the Indian and eastern seas to find the altitude of the polar and circumpolar stars (Fatimi 1980, 283). The shape of the kamal was a small parallelogram measuring about one by two inches. It was made of wood threaded on a length of rope or string through a hole in the center of the piece of wood. The rope or string had nine separate knots. This was used as follows: 1) the piece of wood was held against the horizon in an outstretched hand and the end of the rope was held in the teeth by the knot, 2) the user aligned the lower edge of the wood with the horizon, and 3) the wood was moved along the string until the upper edge touched the star being measured (Murad 1990, 70) (Fig. 2.12).

According to J.Prinsep, in his "Note on the Nautical Instruments of the Arabs" in 1836, the rope of the kamal was divided according to isba:

> There is a rope, the length of which is five times the side line, through the plate centre. Divide the rope into twelve equal parts and make a knot at the division nearest to the plate, which is called eleven Issaba. In this way count to four Issaba, there are altogether nine knots on the rope
>
> (Guanqi, & Qiulin 1995, 28)

According to an Arab navigator whom I interviewed, sometimes the navigator, before leaving home port, would tie a knot in the rope so that, by holding it in his teeth, he could sight the North Star along the top of the instrument and the horizon along the bottom. To return to home port, he would sail north or south as needed to bring the North Star to the altitude he had observed before he left home; then he would sail down the latitude to home port. Navigators recorded which knot on the kamal corresponded to the altitude of the North Star for each port they frequently visited (Personal communication, Ismail, June, 2, 2005) (Fig. 2.13).

The kamal developed later on into the modern sextant, which is an instrument used to measure the angular distance between two objects (Fig. 2.14). By calculating the angular elevation of the sun or other celestial bodies, a navigator can determine his latitude.

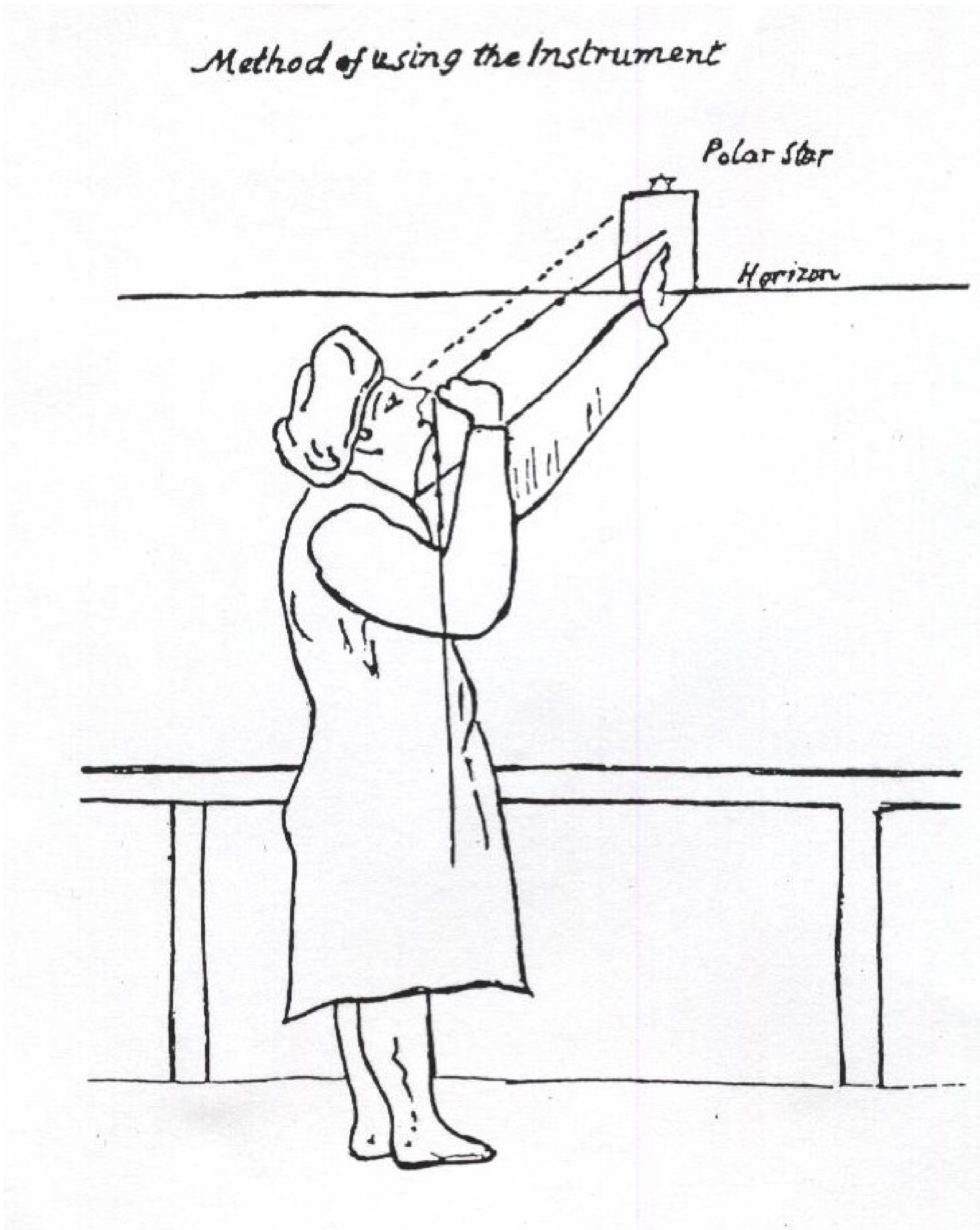


Figure 2.12. The method of using the kamal instrument (Randier 1980, 284).

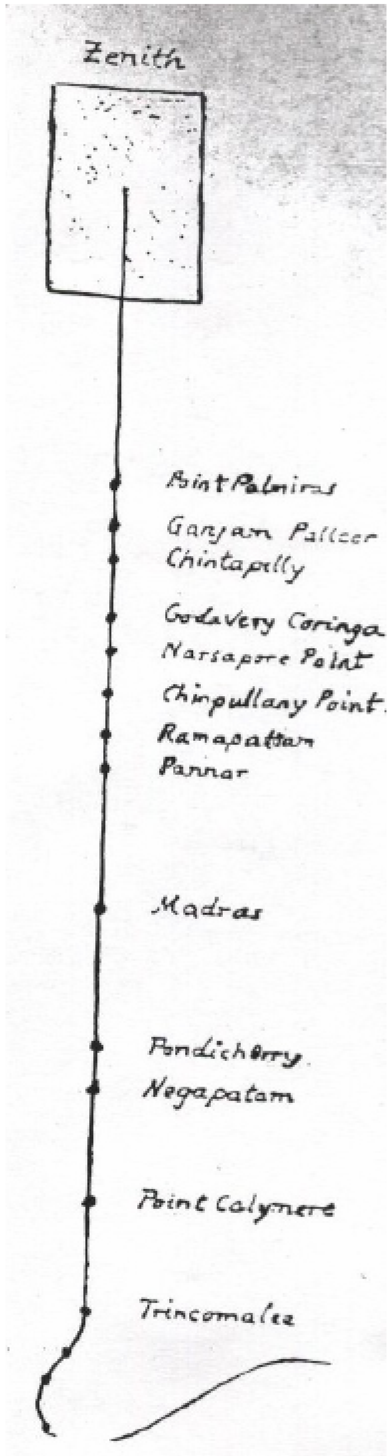


Figure 2.13. A kamal instrument with knots for different ports (Randier 1980, 285).

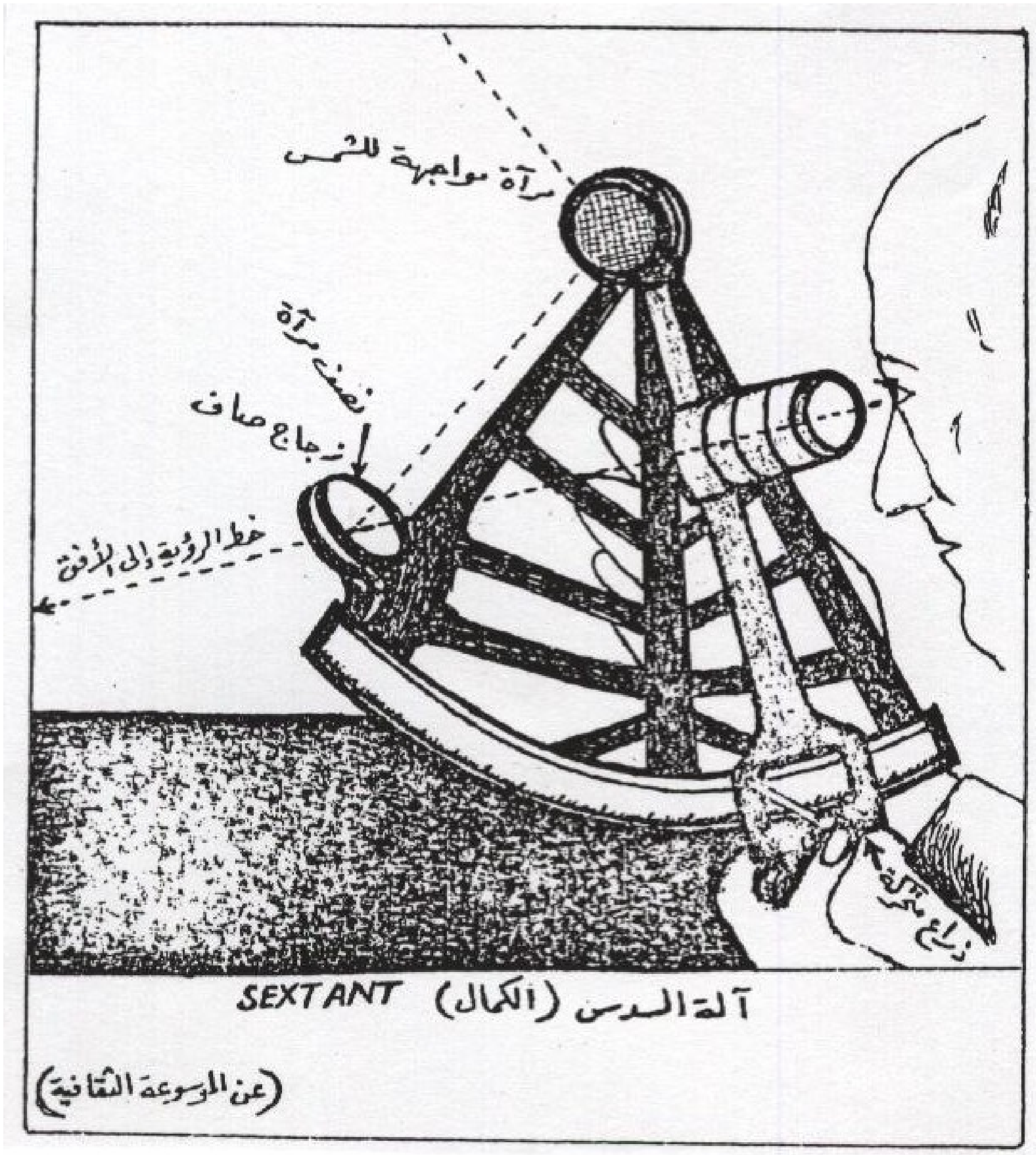


Figure 2.14. The modern sextant, successor to the Kamal (Shihab 1984, 101).

Astrolabe:

The astrolabe was also much employed by the Arabs in navigation. It was used to determine latitude by measuring the angle between the horizon and the North Star. The word "astrolabe" comes from the Greek "Astor" meaning "star" and "labe" meaning "to take" or "to find". An astrolabe is a considerably more elaborate navigation tool than the qiyas and the kamal and is said to be the first true scientific instrument used for navigation. It is believed that the astrolabe originated in ancient Greece and was later "refined" by the Arabs into a more accurate and versatile instrument (Murad 1990, 17).

The astrolabe consisted of a circle or section of a circle, marked off in degrees, with a movable arm on a pivot at the center of the circle (Fig. 2.15). With the astrolabe latitude was determined by measuring the height of the sun or the North Star (Murad 1990, 16). When Vasco da Gama voyaged from Portugal to India in 1497, he showed Arab navigators the kinds of the astrolabes that he had. However, they had been in use by the Arab navigators even longer, and it was Vasco da Gama who learned much about navigation from them (Nadvi 1966, 110).

The astrolabe was quite difficult to use at sea, because the rolling of the ship made it hard to determine the vertical line accurately. However, it was often used on shore, and the latitude of every port and headland was recorded in the "Rahmani" or nautical manuals (Hourani 1958, 278). In the seventeenth century Arab sailors were still commonly using the astrolabe for the direct measurement of the altitude of the sun (Ahmad 1944, 179).

Figure 2.15. Arabic astrolabe 1647-1648 (Stephenson, Bolt and Friedman 2000, 64).

Magnetic Compass:

The true origin of the magnetic compass is unknown. The Chinese had discovered that the magnetic stone indicated the direction of north by the first century A.D. Their first use for it seems to have been in geomancy, finding propitious orientations for buildings and tombs. During the third century they began to use the magnetic compass in land navigation for finding direction. The magnetic compass was not used in sea navigation in China before the 11 century.

There is an old tradition mentioned in one early manuscript that the inventors of the compass were the Arabs. The author who wrote an article, however in the *Encyclopedia Britannica* (11th edition) about the history of compass was reluctant to believe that the compass is an invention of the Arabs (Nadvi 1966, 111). Probably the Arabs learned of the magnetic compass through their trade with the Chinese. There is much evidence that the Arabs had early knowledge of the magnetic compass. The compass was used by the Arabs by about the eleventh century, but they hid the instrument from prying infidel eyes (Murad 1990, 15).

The earliest Arab reference to the compass is 1232 A.D and to its definite use in navigation about 1282 in the time of Marco Polo. In 1232 A.D the Arab navigators of the Arabian Sea called the compass a “circle” or “abode of the needle” (Brauer1985, 37; Tibbetts 1969, 7). European sailors in the Mediterranean were probably using the magnetic compass by the mid-13th century, having learned of it from the Arabs in the Near East during the Crusades. Used by them in Europe waters where thick cloud and fogs were common, it was particularly valued (Nadvi 1966, 111). By 1497 Vasco da Gama saw Arab navigators on the African coast using the compass, other nautical instruments and sea charts.

1. Star Compass:

The star compass is older than the magnetic compass. The Arabs, Chinese, and Indians all used the stars in sea navigation. The Arab system established and improved by them in the Indian Ocean differed, because some of the stars used in their system are not visible in the Mediterranean or Egypt. The Arabs had different names for the star compass rose: "bait al-ibra" and "daira" (Tibbetts 1969, 7). The Arab star compass rose system was based on 32 "akhnan" (rhumbs) spaced 11 1\4° apart for a total of 360°. They were divided into eastern and western halves separated by the North Pole "al-Jah" and the South Pole "Qutb". Each half was further divided into northern and southern quarters. In each quarter were seven rhumbs. The rhumbs of stars in the eastern half were called "matla" (rising stars) and included fifteen rhumbs. The rhumbs of stars in the western half were called "mageb" (setting stars) and also included fifteen rhumbs. Many stars names were not Arabic; for example, "al-jah" is Persian in origin and means the Pole Star. The 32 rhumbs were named after prominent stars whose risings "matla" and settings "mageb" were approximately on those rhumbs (Fig. 2.16):

1. (N by E 11°15'), the rising of "al-farqadan" (Ursa Minor). Setting also used for rhumbs for N by W.
2. (NNE 22° 30'), the rising of "al-Nash" (Ursa Major). Setting also used for rhumbs for NNW.
3. (NE by N 30° 45'), the rising of "al-Naqa" (the camel). Setting also used for rhumbs for NW by N.
4. (NE 45° 0'), the rising of "al-Aiyuq" (Capella). Setting also used for rhumbs for NW.

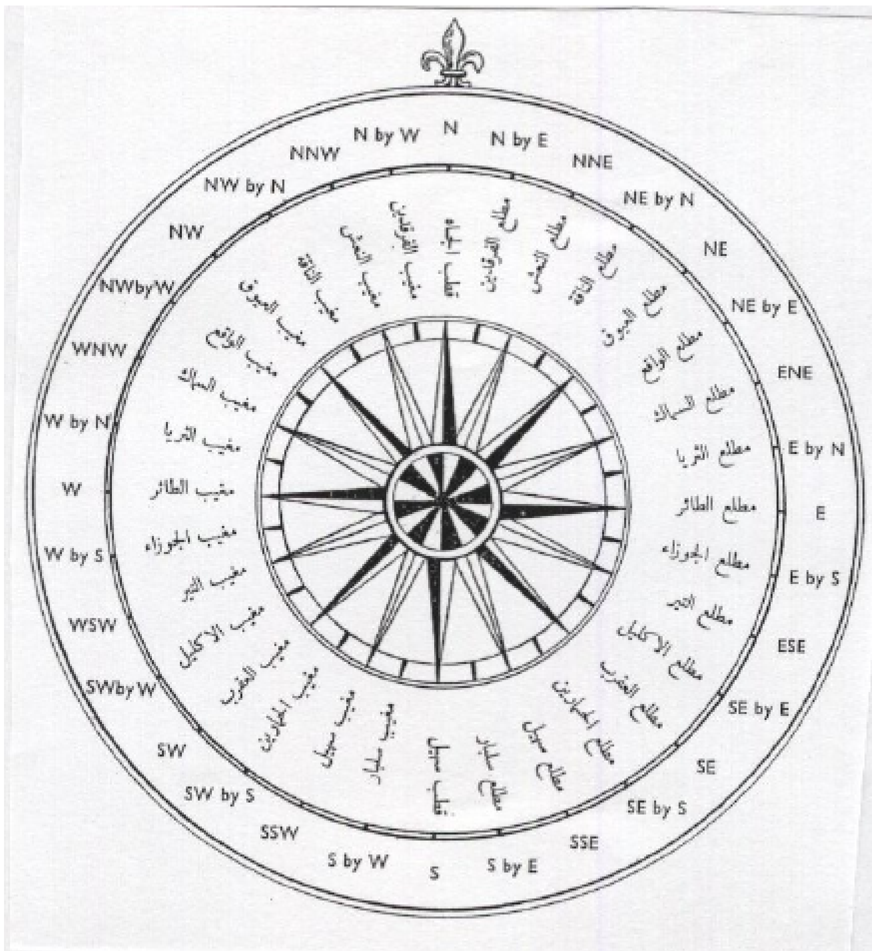


Figure 2.16. The thirty-two rhumbs of the Arab compass system (Ibn Majid & Tibbetts 1971, 297).

5. (NE by E 56° 15’), the rising of “al-Waqi” (Vega). Setting also used for rhumbs for NW by W.
6. (ENE 67° 30’), the rising of “al- Simak al-Ramih” (Virginis). Setting also used for rhumbs for WNW.
7. (E by N 78° 45’), the rising of “al-Thurayya” (Pleiades). Setting also used for rhumbs for N by W.
8. (N 90°), the rising of “al-tair” (Altair). Setting also used for rhumbs for W.
9. (E by S 101° 15’), the rising of “al-Jauza” (Orion). Setting also used for rhumbs for W by S.
10. (ESE 112° 30’), the rising of “al-Tir” (Sirius). Setting also used for rhumbs for WSW.
11. (SE by E 123° 45’), the rising of “al-Iklil” (Corona Borealis). Setting also used for rhumbs for SW by W.
12. (SE 135°), the rising of “al-Qqrab” (Scorpio). Setting also used for rhumbs for SW.
13. (SE by S 146° 15’), the rising of “al-Himaran” (Centauri). Setting also used for rhumbs for SW by S.
14. (SSE 157° 30’), the rising of “Suhail” (Canopus). Setting also used for rhumbs for SSW.
15. (S by E 168° 45’), the rising of “al-Sulbar” (Eridani). Setting also used for rhumbs for S by W.

Thus each star name was used twice, e.g. “matla al-aqrab” (the rising and setting of Scorpio) for SE and SW respectively (Al Haduri 1994, 97). Every “khan” (rhumb) except the North Pole and South Pole was named according to the nearest star to it or to the star that faced it (Shihab 1994, 69).

2. Magnetic Needle:

There were two parts to the magnetic compass: the magnetic needle and the compass card. The magnetic needle had different forms. Early forms of Arab compass included a hollow iron fish floating on water (1242 A.D.), a piece of lodestone placed inside a floating wooden fish (1399 A.D.), and a dry form (Murad 1990, 15).

The design of the compass changed over time. In the mid-thirteenth century, an Egyptian writer, Bailak-Qabjaqi, refers to the magnet, that is, the magnetic stone in his book “Kanz Al Tojar fi Marefat Al Ahjar” (The Merchant’s Treasure in

Knowledge of The Stone). He wrote that the magnetised needle floated on water by means of a splinter of wood or a reed was used in the Syrian Sea from Tripoli to Alexandria. He added: “ they say that the captains who navigate the Indian seas use, instead of a needle and splinter, a sort of fish made out of hollow iron, which, when thrown into the water, swims upon the surface, and points out the north and the south with its head and tail (Nadvi 1966, 113).

Still later, Maqrizi (1364-1441) mentions the magnetic compass in his “Khatat-Misr” (Egypt Plans). He says:

> “In the darkness of night, when there is no star to guide and indicate direction, the pilots in the Indian Ocean utilize a hollow iron thinly constructed and shaped like a fish. They place a magnet in the mouth of the fish. When the fish is placed in the water, it turns its mouth to the South Pole and its tail points northwards. It is one of the wonders of nature; when the north and south are known, the east and the west are easily fixed…Then from knowledge of these four points they discover the position of countries and their course.”

Ibn Majid wrote that he added some new features to the magnetic compass: the needle, the box (the abode of the needle) and the compass rose. He said: “For the purpose of navigation we have invented magnets, which are contained and adjusted in a box with great skill…” (Nadvi 1966, 113).

Even so, many factors could cause defects in the compass, such as a faulty lodestone, careless work of the helmsman, poor carpentry of the “huqqa” (box), badly balanced compass pivot, cold weather or the compass box not being level (Murad 1990, 15).

Such errors would likely have been caught when the sun and stars could be seen, because the magnetic needle was combined with the traditional Arab star compass. The use of the Banat al-Nash (Ursae Majoris) to indicate direction appears in the early Indian Ocean travel work "Akhbar al-Sin wal Hind" (News of Sin and India) dated about 840 A.D. The star compass rose system seems to be used by the Arabs in the early tenth century. (Murad 1990, 15).

3. Combination of Magnetic Needle and Star Compass:

The magnetic compass needle was combined with the "daira bait al-ibra" (star compass card) which had 32 points. The compass was placed in "huqqa" (box) on the ship, and the points of the compass were called akhnan al-huqqa. The huqqa was placed in a position convenient for the helmsman to see on what may have been a binnacle. Ibn Majid divided the horizon into 32 divisions and similarly divided the boat, deck or the gunwale (Fig. 2.17). The divisions on the horizon were the "akhnan" (rhumbs), and these corresponded to the 32 divisions on the compass card. The Arab names for the rhumbs on the star compass card were taken from the names of prominent stars that rose and set approximately on these rhumbs. This system is different from the European system employed in the Mediterranean using names of winds for the rhumbs (Murad 1990, 15).

Ibn Majid compared the Arab pilots of the Indian Ocean with the Egyptian sailors of the Mediterranean Sea, and he said:

> "They have a Compass on which lines are drawn, but our Compass has thirty-two rhumbs. We have "tirfat", "azwam", and "qiyasat" which they have not. We know their arts, but they do not know ours. We take their ships and pass from the Indian Ocean to Atlantic. This is corroborated by books as well by conjecture, but they have no book nor conjecture, nor any knowledge except the Compass. They have no fixed distances in miles. It is very easy for us to use their ships in their seas. Some of them debated with us, but when they knew of our knowledge they had to admit our wider information, and

confessed our proficiency in the art of navigation. We travel easily in the length and breadth of the seas, because we sail by the Qutab Numa, and base all our reckoning on its principle. They have only a box but no reckoning by which they may sail hither and thither with known distances. So they had to admit our superiority."

(Nadvi 1966, 117)

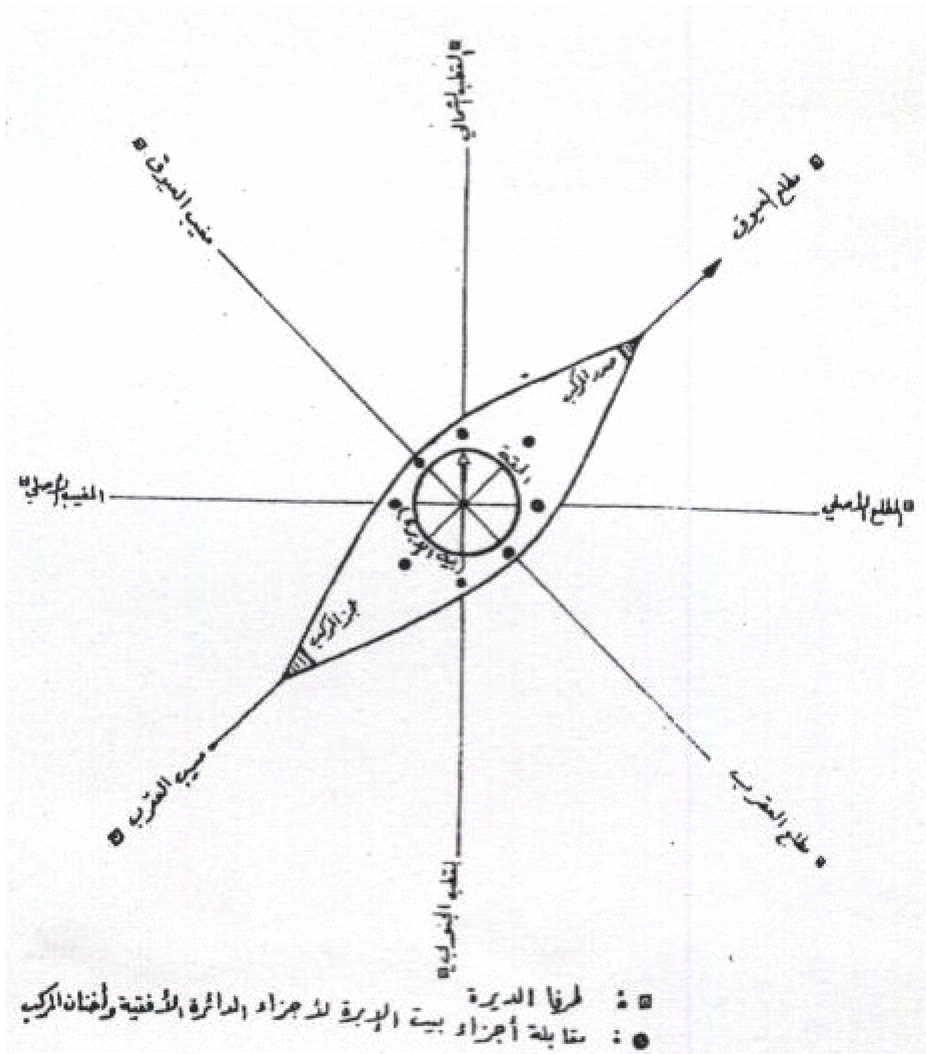


Figure 2.17. The position on Arab ship of the "huqqa" (box enclosing the magnetic compass) and the alignment of the points of the star compass card with different parts of the ship according to Ibn Majid (Shihab 1982, 130).

Landmarks and Environmental Cues:

Monsoon Winds:

Early Arab mariners studied the directions of the monsoon and other winds to orient themselves at sea. Navigation of sailing ships in any sea depended on the "mawasim" (seasonal winds) and the direction of the winds. In the Indian Ocean, sailing from east to west depended on the northeast winds, called "Ayzab" or "Qobely" (Fig. 2.18). Sailing from west to east depended on the southwest winds, called "Kaws" or "Dabur" (Fig. 2.19). Also, there are some seasons when winds called "Shamal" (north) blow from the north and northwest in the northern seas, such as the Red Sea and the Arabian Gulf. In addition, another wind called "Janub" (south) blows from the south and southeast (Shihab 1991, 141).

The Mawasim al-Riyah (season of the wind) was measured by the Nairuz system, which numbered the days from 1 to 365 without using divisions for months. The period for traveling by the southwest monsoon (Kaws) wind was from May eleventh until October eighth. The vessels had two periods of time when they could travel by this wind.

The first period is short, about a month. It occurs at the beginning of the season called "Ras- al Rih" or "Ghalq al mawasim" (closed season). During this period navigators can travel from the east coast of Africa to India, Oman, and Red Sea.

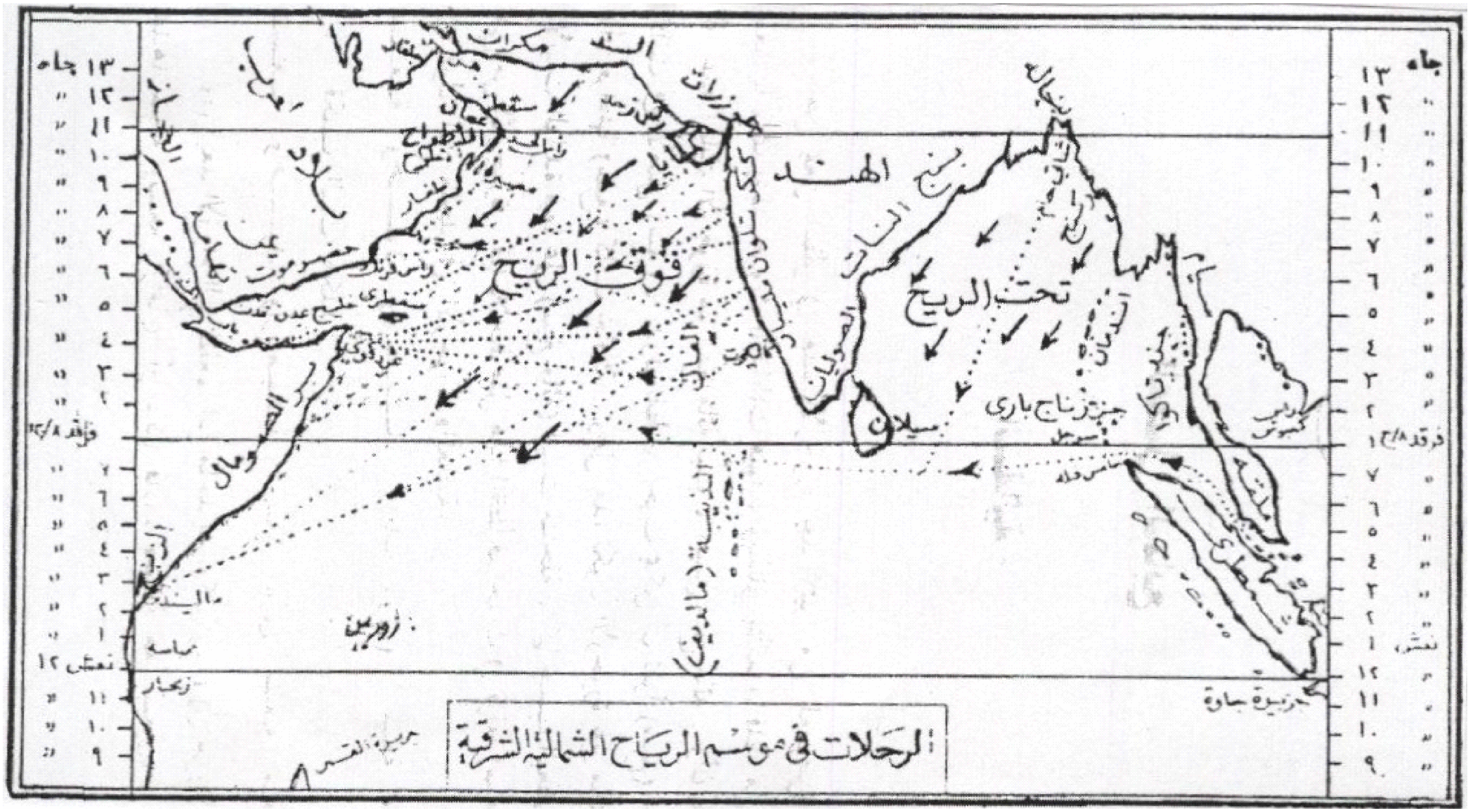


Figure 2.18. The northeast monsoon winds in the Indian Ocean (Shihab 1994, 114).

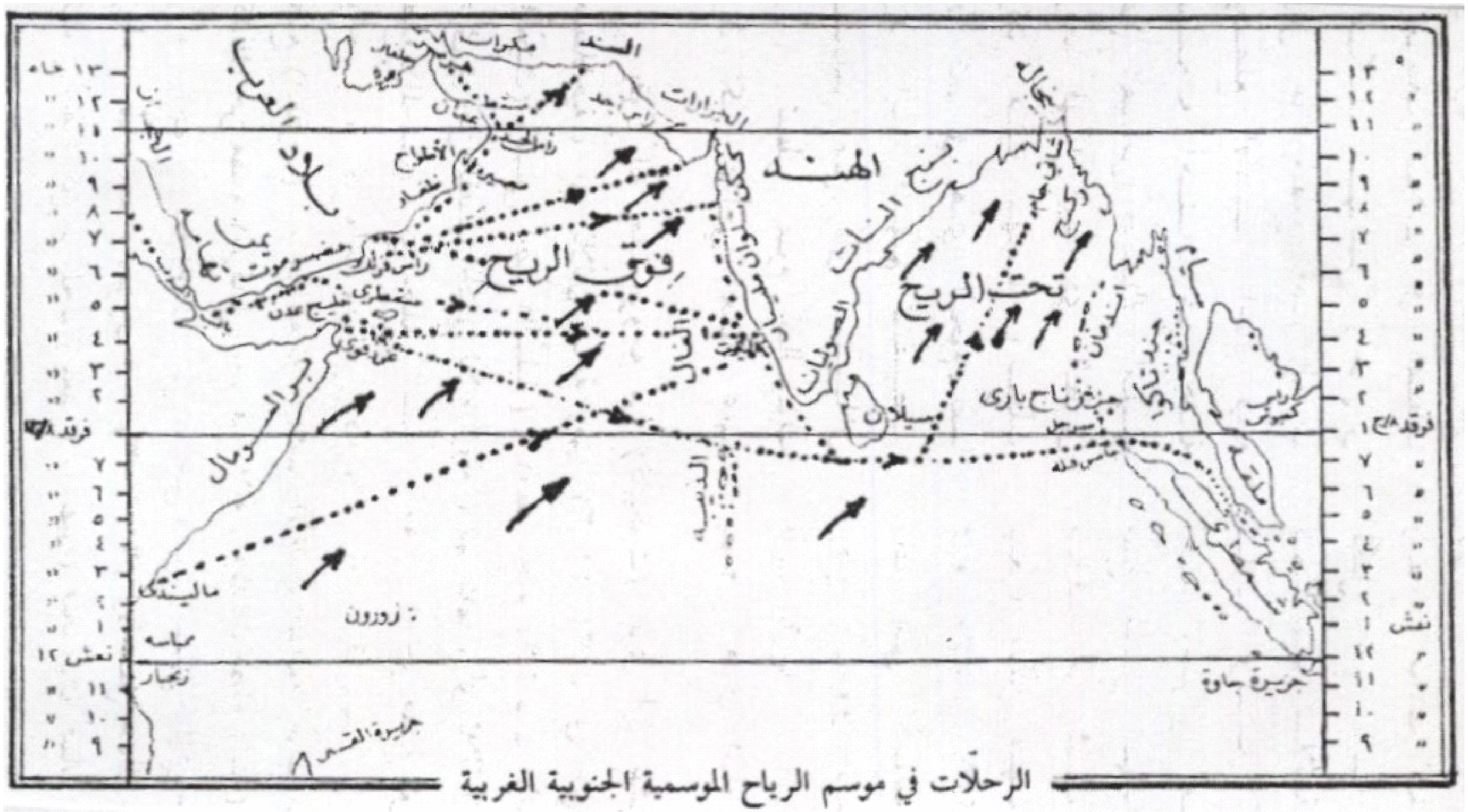


Figure 2.19. The southwest monsoon winds in the Indian Ocean (Shihab 1994, 90).

After this short first period travel stopped for 90 days in the Indian Ocean. The kaws wind causes huge swells, and brings the rainy season to the west coast of India, creating bad weather conditions for traveling.

The second period for travel occurred in the final two months of the Kaws wind, when the travel season is longer than during the first period. This second period was called "Diman" or "Mafateh al bahar" (open season), because the Indian Ocean was open for travel. Then vessels could travel to India from the east and west coasts of Oman, Yemen, the Red Sea, Somalia and the African coast.

Ships could also travel during the northeast monsoon (Rih Ayzab), which lasts from October until March. The period of Ayzab wind lasts much longer and is easier for sailing than the Kawas wind. Vessels can use this wind to travel from India, Oman and the Gulf countries to Yemen, the Red Sea, and Somalia. Also, they can travel from Indonesia and the Bay of Bengal to Oman, Yemen, the Gulf countries, the Red Sea and East Africa.

The only interference to travel during this period would be storms, especially typhoons (tufan) and tornados (Shihab 1991, 141). However, as Al-Mahri, a fifteenth-century Arab navigator, said, the dangerous typhoons in the Indian Ocean do not happen every year. Also, there are weather signs to warn of a coming typhoon. Navigators who have had long experience at sea are familiar with these signs: dust and rain, storms, clouds, and increase in the temperature of the sea water (Shihab 1982, 191). There are five types of typhoons in the Indian Ocean:

1. Al-Tufan al-Damani, occurring on the west coast of India, brings rain called "rain of the Elephant" about the 300th day (late October).
2. The Uhaimir, in the Gulf of Oman, Hadramut, and sometimes as far as Aden, occurs about the 340th day (early December) and comes from the southeast.
3. The Arabini in Oman occurs about the 40th day, (mid-February).
4. The Tufan of the Banat, on Masera Island and sometimes close to Aden, occurs around the 40th to 70th day (mid-February to mid-March).
5. The Tisini, the strongest typhoons, cover all of the Indian Ocean and occur about the 90th day (early April). They also occur in the Bay of Bengal around the 180th day (early July) (Shihab 2001, 9).

Ibn Majid made wise use of the winds during his voyages to India, Hormuz, and Jidda. His writings show that he understood how to use the direction of the wind around the ship in sailing. Ibn Majid had a simple method to find out the direction of the wind; he put a stick on the ship and attached a piece of silk fabric to it (Murad 1990, 93).

There are three cases of wind direction that affect the course of a ship (Fig. 2.20).

1. If the direction of the ship corresponds to the direction of the wind, the movement of the ship will be fast, because the winds push the sail from the back of the ship.
2. If the winds come from either side of the ship, the movement of the ship will be somewhat slower than in the first case.

3. If the direction of the winds is toward the front of the ship, the movement of the ship will be slowed, and the navigator usually stopped at the nearest port until the winds settle down (Shihab 1991, 141).

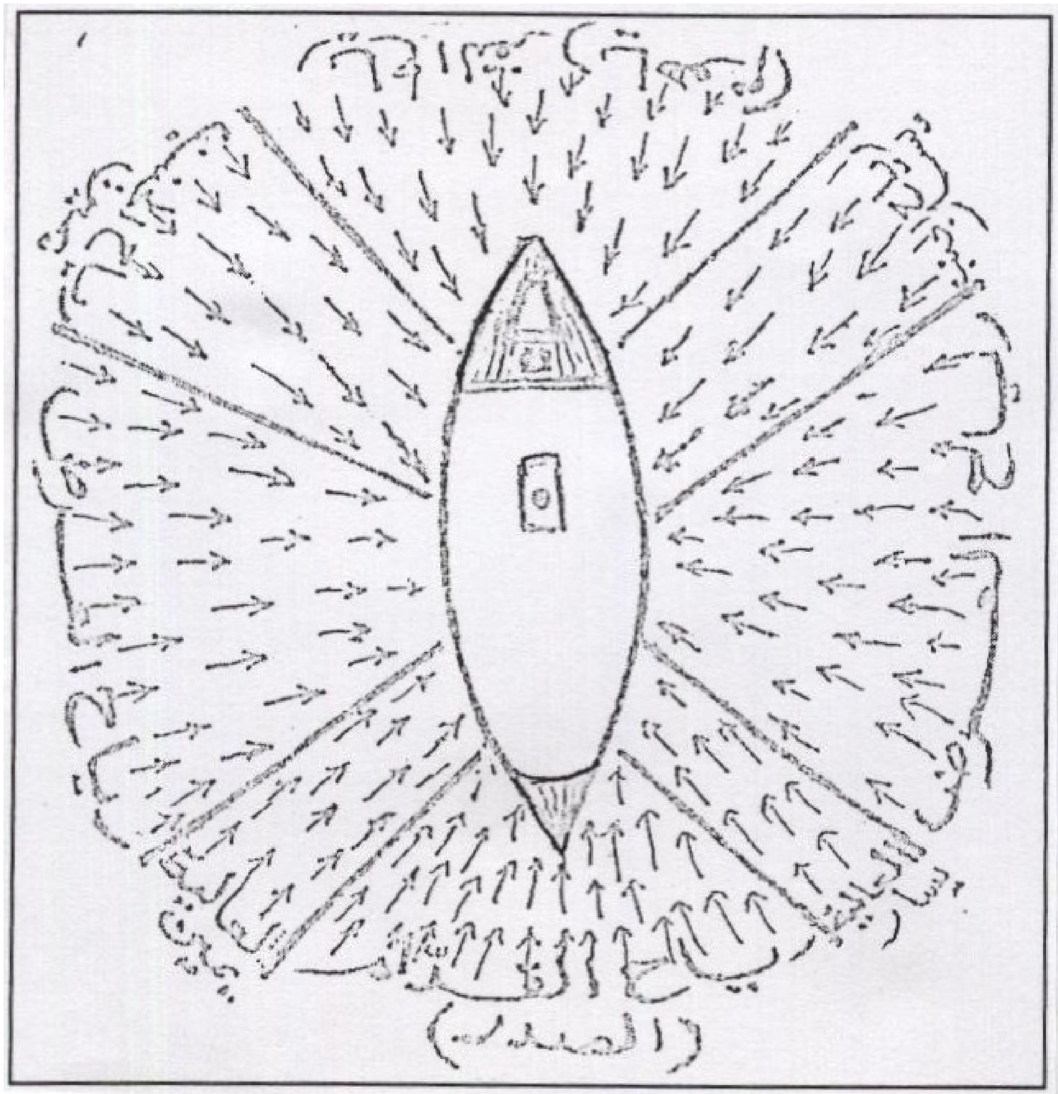


Figure 2.20. The effect of wind directions on the course of the ship (Shihab 1989, 25).

Landmarks and Environmental Cues:

Early Arab sailors used many environmental cues and landmarks when navigating at sea. Out of sight of land they derived clues about their location by observing types of birds, water snakes and fish, as well as the depth, direction, and speed of current, tides and color of the water, and also the type of the sea bottom and its odor. Such environmental cues helped seafarers to determine their location in familiar waters (Guanqi & Qiulin 1995, 27). By these they could tell if their location was near the coast or far away from it (Shihab 1982, 193). The Arab navigators called the knowledge of such "isharat" (sea signs). Ibn Majid and Sulaiman Al-Mahri mentioned in their important books for the Arab navigator that knowing these isharat was essential for the Arab navigator (Ibn Majid & Tibbetts 1971, 276). The following examples of isharat illustrate how and where they were employed in navigation:

1. Sea- snakes (mariza) are found off the west coast of India.
2. Types of birds, fish, and seaweed:
    a. Signs close to the coast of Arabia:
        (1) Birds: Kuraik and Saifak.
        (2) Fish: Tabaqa and Lazzaq.
        (3) Seaweed: Qarmat and Qulhuf.
    b. Signs close to the Somali coast:
        (1) Birds: Kuraik, Munji, Kaslan, and Daghat.
        (2) Fish: Tabaqa, Lazzaq, Faras al-Bahr, Ajam, Thamad al-Kabir, Qurush, and Iqam.
        (3) Seaweed: Qarmat and Qulhuf.
3. Tide and breaking waves:
    a. Tidal movement (maad) is an indication of nearness to land, such as an island or a cape protruding into the sea.
    b. Breaking waves (ouqod al-ma) are also an indication of closeness to the coast of an island.
4. Water-color and depth: White color (baid) is an indication of nearness to the coast.
5. Smell and type of the sea bottom: The sea bottom can consist of rocks, stones, sand, and mud. Each type of sea bottom has a particular smell.
6. Bioluminescence (Murad 1990, 78).

Various types of landmarks were also employed in navigation. The distinctive profiles of islands, mountains and hills were landmarks that could be seen from a distance (Fig. 2.21). Tall trees, such as palm trees, and distinctive buildings in coastal ports were also identifying landmarks (Ibn Majid & Tibbetts 1971, 276). The Arabs also built artificial landmarks, such as minarets and lighthouses, as guides to the sailors. Al-Maqdisi, an Arab traveler who wrote in the tenth century, said: "Long bars are planted in the sea. On them are the rooms, where men are deputed to kindle lights in the nights, so that ships may keep at a distance." Also, he mentioned that the watchmen in Alexandria's minaret lit fire pans to allow the ships to see the minaret from a distance. Masudi (895-957 A.D.), another famous Arab traveler, wrote about "kashabat al-basra" that: "these wooden poles are thrust into the sea, and are signs for ships indicating that there is a distance of three hundred furlongs from here to Uman" (Nadvi 1966, 107).

<u>Oral and Written Sailing Directions:</u>

Sea pilots in the Arab world had an enormous store of knowledge that was passed down through the generations both orally and in writing. Because few maps were available at that time, navigators relied heavily on memory and on written guides. Arab books of navigation instructions were called "Rahmani". The origin of this word is Persian, and its meaning is "route book". As well as memorising their routes, Arab navigators kept written records of routes and other knowledge important for sea navigation in the form of these "Rahmani". These were a combination of nautical manual and pilot book (Shihab 1983, 11) (Fig. 2.22, 2.23, 2.24).

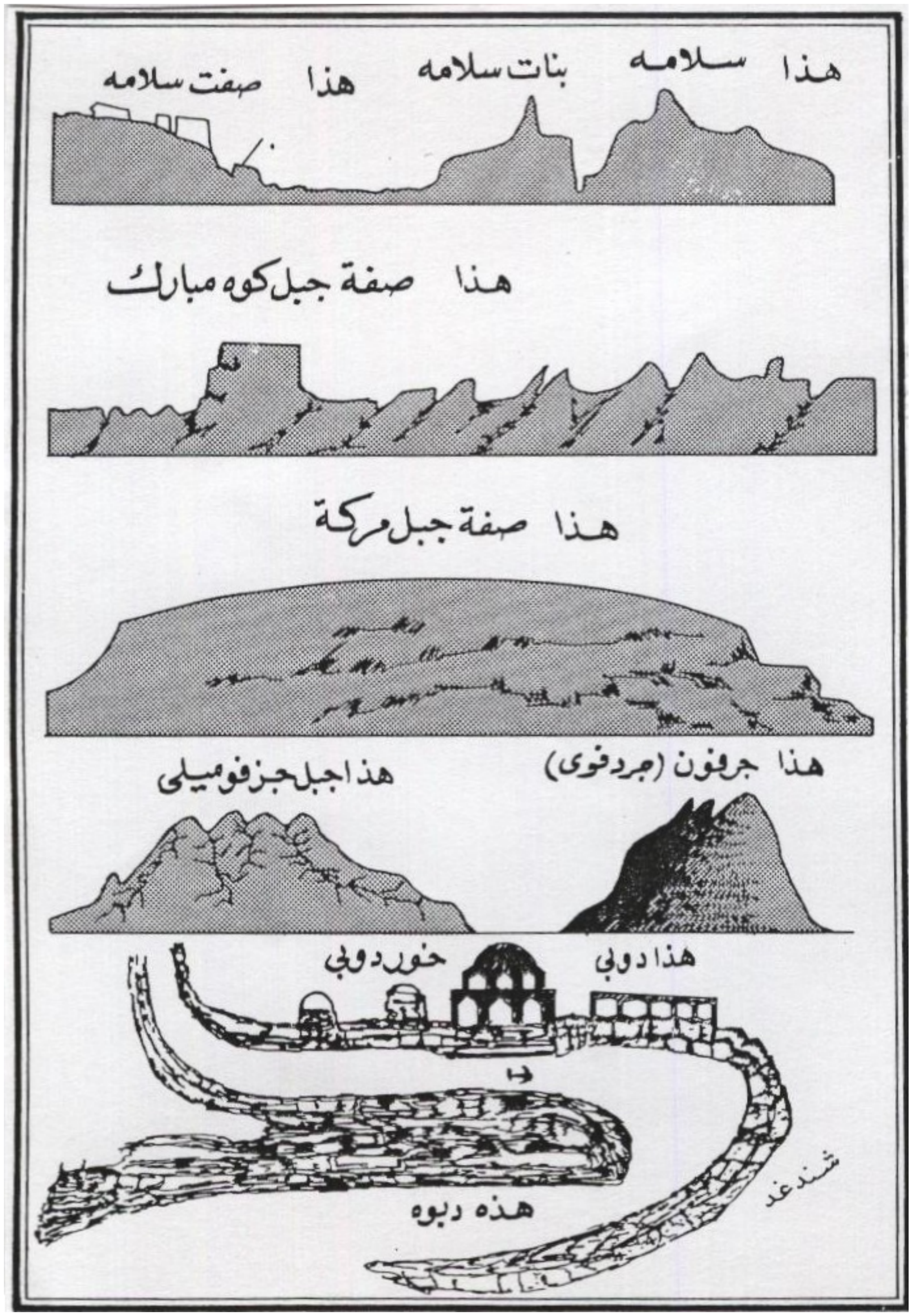


Figure 2.21. The coastal landmarks at different places. The channel leading to Dubai is at the bottom (Shihab 1983, 45).

Figure 2.22. An example of a “old” (or tradition) Rahmani page that includes a voyage description with 2 simple coastral profiles (Al-Hadori 1994, 233).

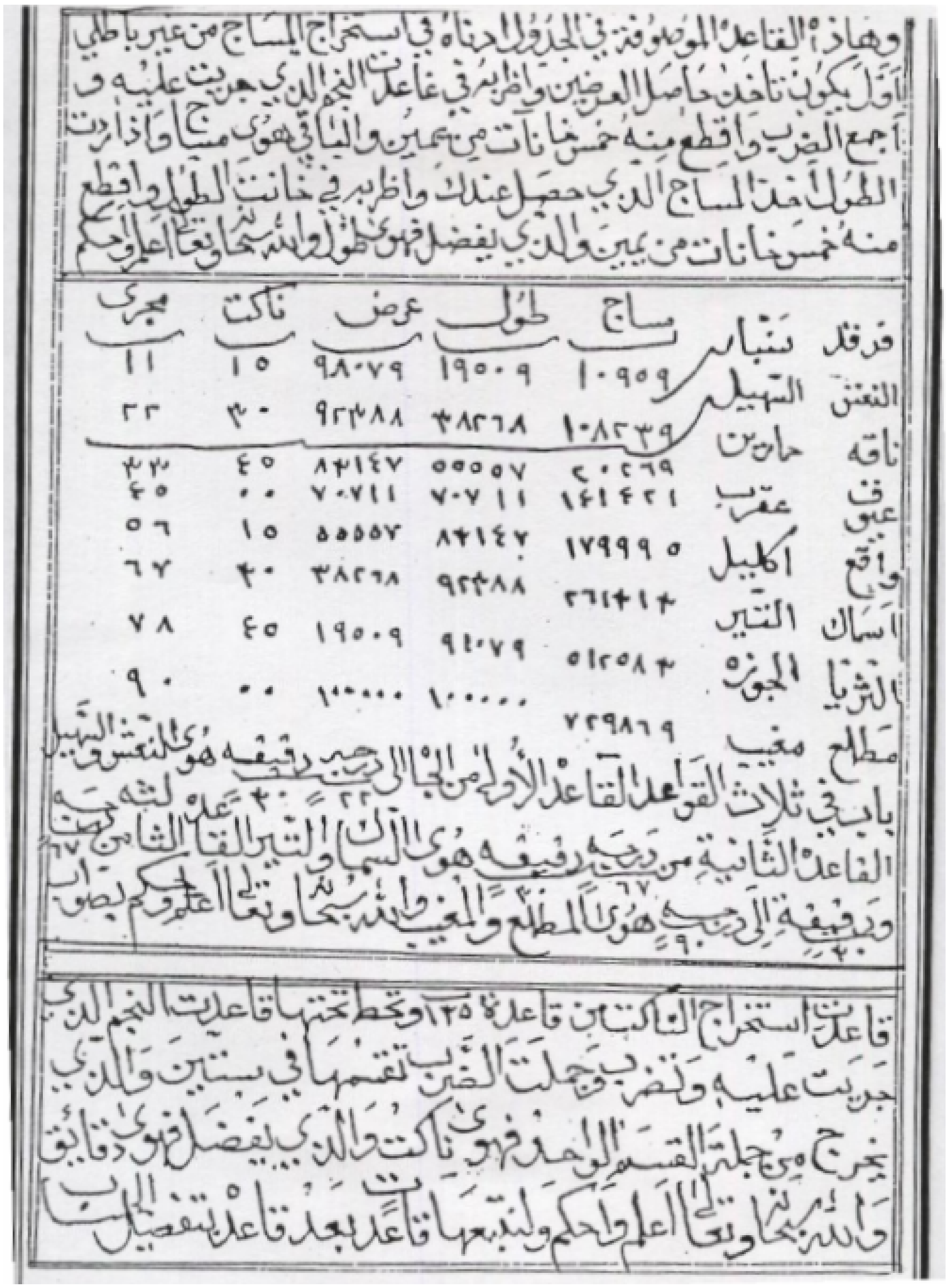


Figure 2.23. An other example of a “old” Rahmani page giving the latitude and longitude of some places (Al-Hadori 1994, 244).

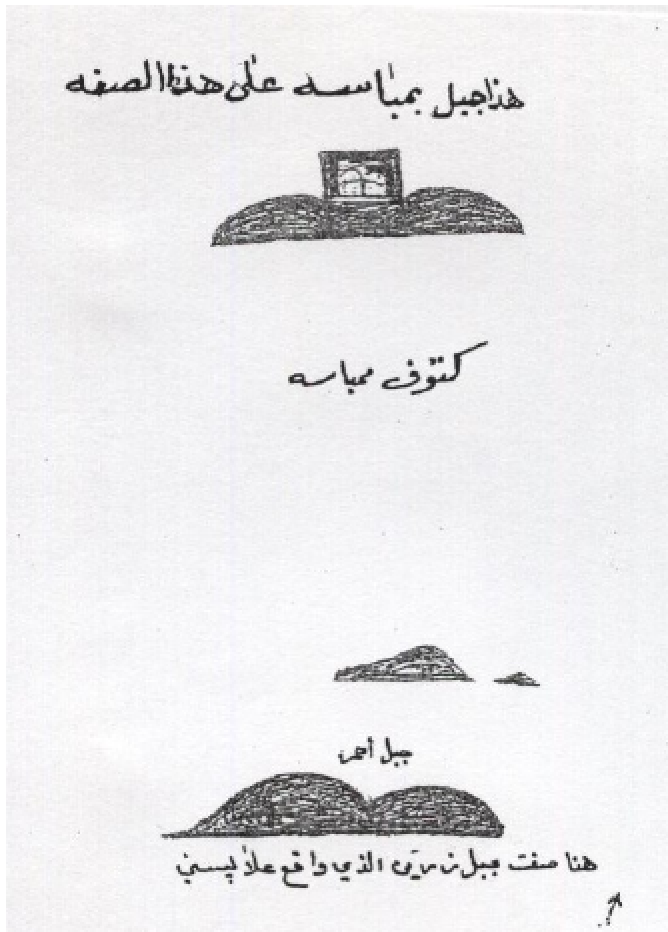


Figure 2.24. An third example of a “old” Rahmani page, one that includes drawings of landmarks (Shihab 1984, 309).

Writing in the late tenth century, Al-Maqdisi said that the Arab navigators learned from the Rahmani (Shihab 1983, 11). There are two kinds of Rahmani; one of them called "old" Rahmani which dated from 990 A.D. onward, and the other called "modern" Rahmani which dated from 1885 A.D. onward. Only a few examples of early Rahmani have survived, and they are seldom complete but rather separate texts and poems. The "old" Rahmani include: Ibn Majid's fifteenth-century book "Kitab al-Fawaid fi usul al-bahr wal- qawaid" (The Book of Profitable Things Concerning the First Principles and Rules of Navigation) and Suliman al-Mahri's fifteenth-century book (Umdat al-Mahriyafi dabt al-ilm al-bahriya). On the other hand, the "modern" Rahmani includes books by: Ibn Kamis and Ibn Mater, Al Qatami, Mansour Al Kharji, and Al Nood (or Al Nory) (Shihab 1984, 9).

Tradition was very strong in Rahmani-making, and there is little difference between the "old" and "modern" Rahmani. A navigator who became a ship's captain (muallim) would collect for himself nautical instructions and astronomical tables from different Rahmani. To these he would add some information from his own navigational experience. The information in Rahmani was passed from one generation to the next, both in written form and by memorizing the poems. The navigators and their captains often discussed and shared different topics with each other (Shihab 1984, 9).

Rahmani provided information about coastal piloting, for example, how long it took to sail from one busy port to another and how to get into that port without running aground. Also, they provided information about sailing off shore and out of sight of land. The Rahmani included a wide range of information about coasts, winds, and reefs. There were latitude and longitude tables, as well as coastal profiles. The earliest known mention of a Rahmani was by al-Maqdisi:

> "I was thus thrown in to the company of men - captains, pilots, … agents and merchants, - who, bred and born upon it, possessed the clearest and fullest knowledge of this sea, its anchorages, its winds and its islands. I plied them with questions concerning its position, physical peculiarities and its limits. I have also seen in their possession sailing directories "dafatir" which they constantly study and follow with implicit confidence."

Al-Maqdisi also mentions charts "suwar" and pictures in the Rahmani (Hourani 1995, 107).

In his book about the "Kitab al-Fawaid fi usul al-bahr wal- qawaid" (The book of profitable things concerning the first principles and rules of navigation) of Ibn Majid, Tibbetts mentions some of the poems that were used by sailors. The information in these poems was very useful for sea navigation (Ibn Majid & Tibbetts 1971, 74). Ibn Majid had a poem that describes the star of Sulbar (Eridani):

By your life, had it not been for Sulbar, the pilots
Of the fig, the date and the betel would never have been guided
No instrument which they use over Madwara is like it
As a guide; whether they measure by the Farqad or Eagle
With al-Bar and its companion, or the Plough rising
And al-Far setting. Then take this from informed ones
(Ibn Majid & Tibbetts 1971, 125)

Another poem describes Suhail (Canopus):

Suhail is the cheek of the beloved in colour
As the heart of the lover with its throbbing
Standing alone like the leading horseman
Clearly visible before the cavalry's ranks
(Ibn Majid & Tibbetts 1971, 129)

Another poem describes the four main winds known to early Arab travelers:

The wind of al-Saba comes from the rising of the Sun,
But a little towards the Pole, while Shamal slightly to the west of it (Pole)
Between Canopus' setting and the west comes Dabur
Canopus' rising shows the place of al-Janub
(Ibn Majid & Tibbetts 1971, 142)

For navigators who might have need to know about the Roman months, the seasons of the year, etc, the following lines were written:

The account of the Roman months, oh best of friends
I have set out for all peoples near and far
Thirty days hath Nisan, and the same, Haziran
And also Ailul and Tishrin al-Thani
But Shebat has one day less than these
And all the rest have thirty-one
First come the two Tishrins when you count them
The two Kanuns follow; without hiding anything
Then Shebat and Adar and Nisan afterwards
Aiyar, Haziran and Tammuz follow,
Then Ab, with Ailul last of all
While the first Tishrin, coincides, with "the Balance" (Libra)
This is the order of the months of the year
So hearken to what I say, and have made clear
Kanun with Shebat and Adar
Make up the winter with its times and season of cold
Nisan and Aiyar are two months of Haziran
Tammuz with Ab and Ailul
Make up the summer with its showery clouds
The two Tishrins go by
With the additions of Kanun, without hiding anything
These are certain, so do not contradict
But take the wisdom of a noble man, Ibn Majid
Descended from Sa'd b Qais b. 'Ailan
(Ibn Majid & Tibbetts 1971, 158)

Also, Ibn Majid has poems that mention the use of his book by sailors:

Whenever you experience something, oh captain,
Act according to it in all which concerns you
For you will only borrow things from my book
Which are true and reputable descriptions

As those of Gujerat around Jabal Jalnar
Or those of the coast of Mekran at Hasht-I Lar
(Ibn Majid & Tibbetts 1971, 47)

In other poem he mentions rhumb lines:

The rest of the rhumbs of the compass are alike
It is a numerical division which cannot mislead
(Ibn Majid & Tibbetts 1971, 75)

Besides these documents written by Ibn Majid, there were other famous Arab navigators who contributed their knowledge and experience to Rahmani. Bin Shadan, Bin Abban, Bin Kahlan, Bin Khalil, and Qandrani were active in 626 A.D.Ahmad bin Salah'ul-Irki piloted ships to Deogarh, India in 652 A.D. Bin Najdi and Ibrahim, who owned six vessels that sailed from the Indian Coast to China, were famous sailors in the eighth century A.D. Ansi and Habut were active in the tenth century A.D. Ibn Majid and Al-Mahri were the great navigators in the fifteenth century (Nadvi 1966, 128).

Mental and Analog Maps:

When one investigates the historical sources of Islam, one finds maps that accompany texts written by many geographers such as Al-Balki, Al-Istakri, Ibn Hawqal, Al-Idrisi and Al-Muqdasi during the tenth and eleventh centuries. These maps normally comprised a world map, maps of the three seas (the Mediterranean, the Indian, and the Caspian), and maps of seventeen regions of the Islamic world. These maps were based on geographical writings that described the postal routes and administrative divisions of the Islamic states. They were not based on any projection, and they lacked indication of scale (Karamustafa 1970, 574).

The map of the western Mediterranean Sea by Al-Istakhri I (tenth century A.D.) is oriented with west at the top (Fig. 2.25). At the right is Spain, shown as a circle, with the city of Cordoba at its center. At the left is the northwestern coast of Africa, extending from Morocco at the top to the western border of Algeria at the bottom. At the top is labeled the "Ocean Sea" (actually the Atlantic Ocean) believed to encompass the known world. Near the bottom are the Balearic Islands, one shown as a mountain in profile and the other as a circle (Tibbetts 1987, 118).

Arab navigators used maps to organize, record and present navigation information graphically**.** Information from all sources, whether taken directly from the environment or presented indirectly in oral, written or graphic format, became part of their mental or cognitive maps. The Arab pilots did not always use charts, and they often plotted their courses in their heads (Tolmacheva 1970, 768). A chart was an aid to determine a position at sea, and by comparing this with the position of the destination, a course could be plotted between these two points. But Arab pilots who guided ships often plotted routes in their heads (Tibbetts 1987, 258). The Arab geographer, Al-Maqdisi, writes that, after meeting a navigator, "He smoothed the ground with his hand and drew the shape of the sea …" (Castello 2002, 75).

The Arabs sailing in the Indian Ocean also pulled such information together more formally as analog sea charts, which predated the earliest known European sea charts of the Mediterranean. The Arab word for such charts, "qunbas", reflects the use of the compass for both compiling them and using them to plot routes. Arab sailors

Figure 2.25. Al-Istakhri's map of North Africa and Spain, oriented with West at the top, 1173 A.D. North Africa is at the left, Spain to the right, and there is a large mountain near the strait of Gibraltar (Harley & Woodward 1987, plate 6).

made maps of safe routes based on their long experience at sea. These maps were often kept secret from other ship captains competing for trade routes.

Maps help navigators anticipate upcoming obstacles in time to change course and to visualize their location in relation to their destination. Ibn Majid wrote about the navigational books “dafatir” and charts “suwar” that were carried on board in the tenth century. Ibn Majid’s charts were also called “Qunbas”, the same term used for the magnetic compass.

The Arabs were not able to determine longitude at sea, but they used the North Star to determine their latitude and find the latitude of their destination (Tolmacheva 1970, 768). “Marco Polo tells us that the Arab had good charts and in sailing up the west coast of India he gives the height of the Pole Star above the horizon at all the well-known ports.” (Ibn Majid & Tibbetts 1971, 4). The Arab sailing charts were used to plan routes before a voyage and to assess progress during a voyage (Brauer 1985, 24).

Arab sea charts emphasize coastal features and are relatively less detailed than maps of land areas (Tibbetts 1987, 262). European navigators who acquired Arab charts valued and used them, too. When Vasco da Gama met a navigator, the latter showed him excellent sea charts, but without the rhumb lines used on the charts that were made in Europe at that time (Brauer 1985, 24).

> After having talked with him [Vasco da Gama with the Arab pilot], Vasco da Gama was very satisfied with his knowledge, above all when the Moor showed him a map with the entire coast of India shown in the manner of Moorish maps with many meridians and parallels and no rhumbs of winds. Because the grid of meridians and parallels was very detailed the direction of the coast by the two rhumbs north-south and east-west was very certain

> without being encumbered with so many lines of the wind and the compass as on our maps, which serve as a base for others."
>
> (Ferrand 1922, 289)

Albuqurque, who was a Portuguese viceroy in India, used a nautical map made by the Arab sailor named 'Umar, and kept it with him in the Oman Sea and the Persian Gulf (Nadvi 1966, 105). From such descriptions in written documents it is obvious that there were many Arab sea charts, but unfortunately no examples survive.

<u>Other Factors in Route Selection at Sea:</u>

The following sections about the development of Arab boats, known as dhows, are intended to provide background information relevant to the history of Arab sea navigation techniques. This chapter will point out that different sizes and types of hulls were developed in India to suit coastal versus open-sea navigation and adopted by the Arabs. The development from the square sail to the more maneuverable lateen sail is likely to have taken place in the adjacent Red Sea, where the confined waters confronted Arab navigators with difficult navigation conditions. If the Indian Ocean and the Red Sea, home waters for Arab sailors, were core areas for innovations in hull and sail design, it seems possible that their activity in the same areas might also have given rise to innovations in sea navigation techniques, such as the magnetic compass and the sea chart. Given the lack of much surviving physical evidence about the latter (although there are mentions in early texts), the following discussion of the development of the dhow and the lateen sail is offered here to support the case for regarding the Arabs as maritime innovators in general.

Boat types:

Different ship designs can play a role in sea navigation, whether by seaworthiness influencing the route the ship can take (coastal or open sea) or size determining the quantity of the cargo it can carry. The materials used in building ships also influenced sea navigation. The builders of Arabs ships used teak, an easy-to-cut oily wood, which resists heat and humidity and does not shrink after it dries.

The Arab names for "ship" were "safina" and "markab". Medieval texts mention some names such as "zawraq", "qarib", and "dunij" that were used by Indian pirates. However, the name most commonly used for Arab ships is "dhow".

The origin of the word Dhow or Daw or Zaw or Zaww is unknown. Some sources indicate that it is an Arabic term for ship; especially, it was extensively used by the Arabs and Persians in the Indian Ocean before and after the time of Portuguese expeditions to the Inidan Ocean. Ibn Battutah reported that the word "Dhow or Daw or Zaw or Zaww" was derived from the Chinese, when they in the South Indian coast in the end of the thirteenth century and the first fourteenth century. But at the present time, it seems more likely to be Swahili than Arabic. The word dhow means "a wooden lateen sail ship" (Yajima 1976, 20).

This section concerns the different sizes of dhow. There were some that were small and suited to coastal sailing, while others were large and used for open-sea navigation. Also, it explains how the dhow developed from the double-ended type to the square-stern type. In addition, this section explains how the ancient dhow was constructed and what its sailing abilities were.

Dhows were the boats that sailed on the Indian Ocean and most of them used a triangular or lateen sail, which is different from the square sails that were used on the Mediterranean and also on the China Sea. Most early knowledge of dhows' construction comes from the records of Greek and early Roman historians. Also, there was a similar hull construction in the later Roman period, learned from Arab sailors. From the early days to modern times, it seems that dhow making was considered an art to be passed from one generation to another. Dhows were essentially Indian boats, and most of the wood for them came from the forests of India.

One feature that makes the dhow distinctive is its hull boards sewn together with cords, thongs or ropes of palm fiber. One reason given for using rope instead of nails was because it was believed that there was in the middle of the ocean a magnetic rock that had power to destroy the nails. The idea of sewing boat planks together has been use in many parts of the world. It dominated in the Indian Ocean up to the fifteenth century, when the arrival of the Portuguese opened the area to European methods. Marco Polo wrote when he saw sewn boats at Hormuz at the entrance to the Persian Gulf, they use "twine and with it stitch the planks of the ship together. It keeps well and is not corroded by sea-water but it will not stand well in a storm" (Marco Polo, Book I, ch xviii, translated by H.Yule, 3rd edition, London, 1903, I, p.108).

A significant feature that differentiates types of dhow is the hull shape, and this is the main criterion by which one type of dhow is distinguished from another. Basically, the dhow started with double-ended type, but later a square-stern type was developed. Yajima has classified the Arab dhows into these two main types: (Fig. 2.26):

1. Bum: this type is double-ended with a long stem and stern heads.

2. Baghla: this type has a square transom stern, long straight stem, sometimes ornamented with some geometrical or line paintings. It is a product of European influence, since Portuguese and other boats had visited the Gulf of Arabia since the sixteenth century. There were ten kinds of dhow and each kind had characteristic features:

1. a. Bum:

Doubled-ended, the Bum had a long straight stemhead colored black-and-white and a raised poop (Fig. 2.27). It carried from 60 to 120 tons of general heavy cargo from East Africa. Bums were built at Sur and Kalicut, and in the 1970s still were to be found in the Persian Gulf and the Indian Ocean (Yajima 1976, 20).

This was the best kind of ship for navigating in the Arabian Sea, the Persian Gulf, and the Indian Ocean. The bum's navigational qualities made it popular, and it spread to many ports. One navigational advantage was its convex stern which behaved well in high waves (Fig. 2.28). Another advantage was the Bum's good rudder system.

Usually the Bum carried three small boats to use for different purposes. The "al-keter" was used to transport the sailors and their goods from the ship to the port (Fig. 2.29). The "al-masho" was used as a lifeboat in emergencies (Hijji 1988, 36) (Fig. 2.30).

Baghla Type   Bum Type

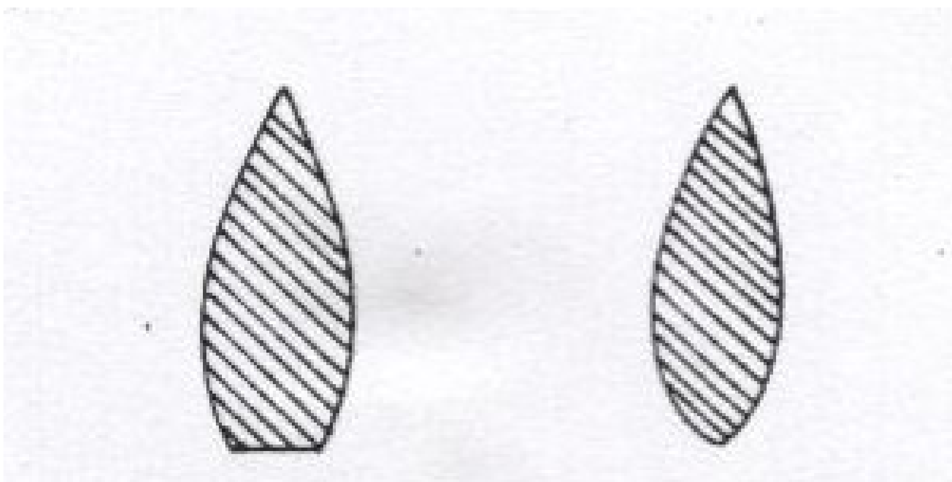


Figure 2.26. The classifications of dhow by hull shape (Yajima 1976, 22).

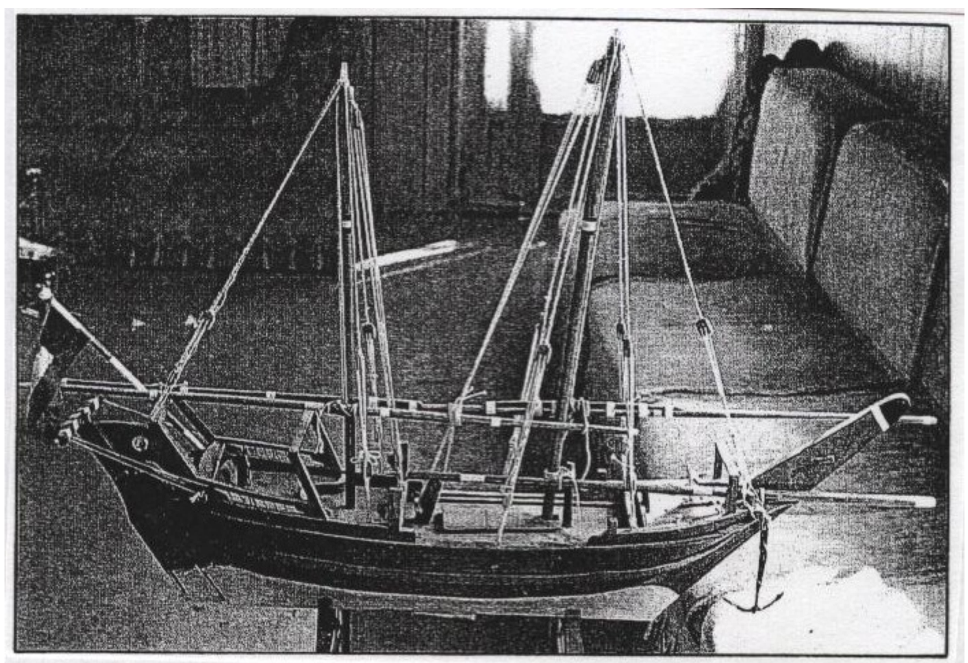


Figure 2.27. A model of a bum-shaped dhow (Hijji 1988, 42).

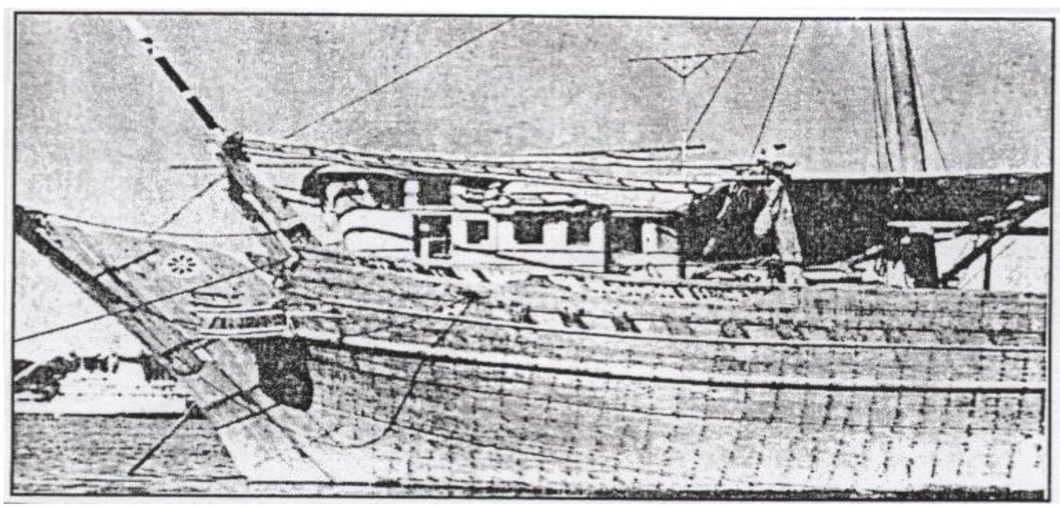


Figure 2.28. The convex stern of the bum (Shihab 2001, 56).

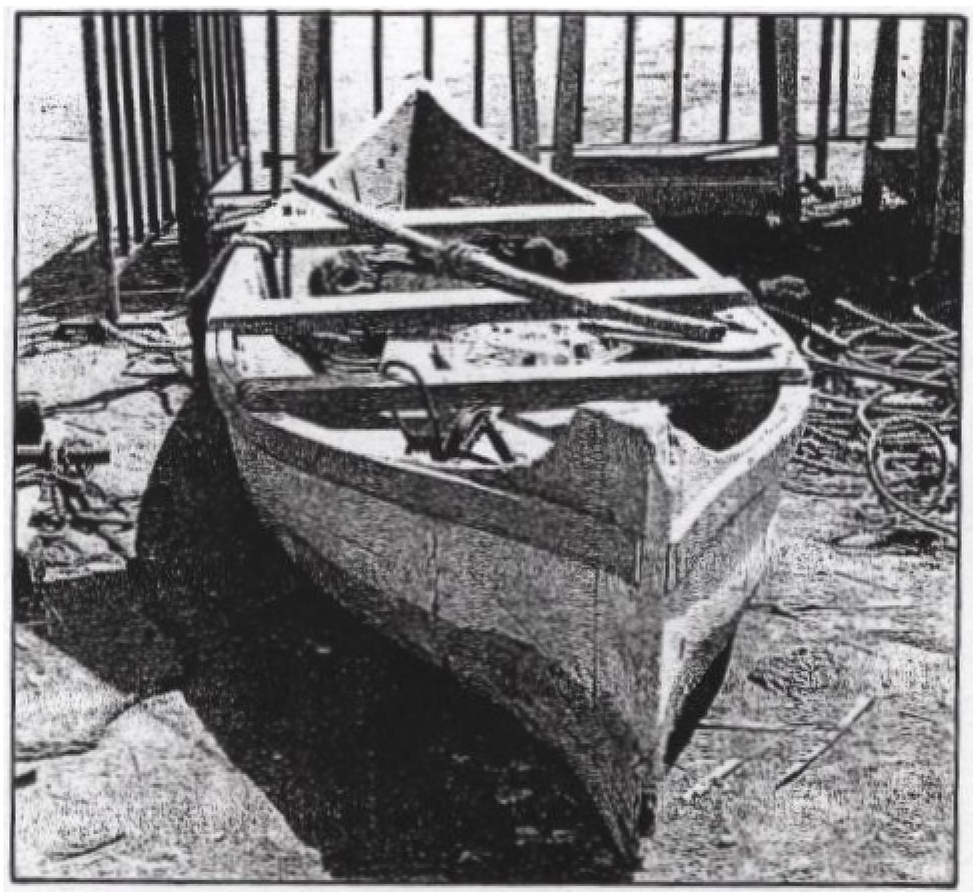


Figure 2.29. The al-keter (small boat) carried on the bum to transport the sailors and their goods from the ship to the port (Hijji 1988, 41).

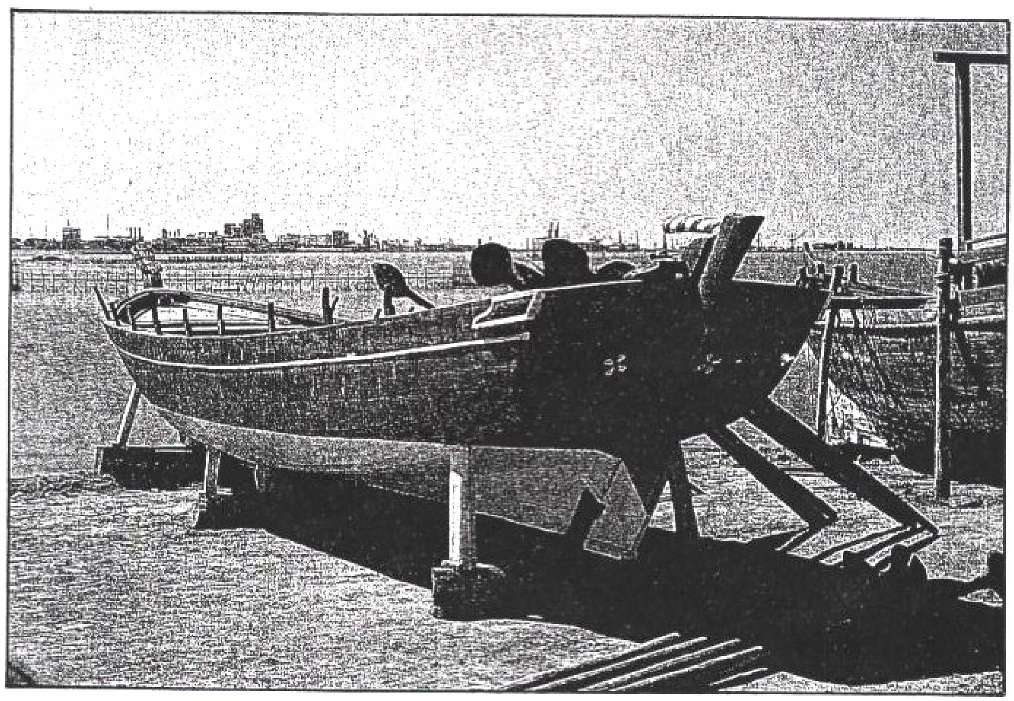


Figure 2.30. The al-masho boat carried on the bum for use in emergency (Hijji 1988, 40).

1. b. Zufari Sanbuk:

This type of dhow had a double-ended hull with a rudder, oars, one mast, and no deck. The length of this dhow was 8-12 meters. It was constructed from different parts of the coconut tree. Its planks were stitched with coconut fiber, and the gaps were painted with tar or fish-oil. The average crew ranged from 4 to 8 fishermen, who used it for sardine fishing close to the shore. It survives only on the coasts of Salala and Taqa in the Zufar region (Fig. 2.31).

1. c. Shasha:

This was a small and double-ended coastal dhow. It was constructed of date-stalks tied with coconut rope at the pointed ends of the bow, the stern, and parts of the hull. It was used for coastal fishing. It had two oars and carried one or two fishermen. Today, it is found only at Suhar and its neighboring coasts (Fig. 2.32).

1. d. Badan:

The Badan was double-ended with a high sharp bow and a straight stern. It also had double-edged bottom from fore to aft (Fig. 2.33). The method of constructing the Badan was by piercing the teak-wood plank with holes and sewing it together with coiled rope of coconut fibers. The Badan was used in pearl-fishing, but in the 1970s, it was also used for coastal fishing in Oman.

1. e. Huru:

It was a small double-ended dhow used for fishing close to the shore (Yajima 1976, 20) (Fig. 2.34).

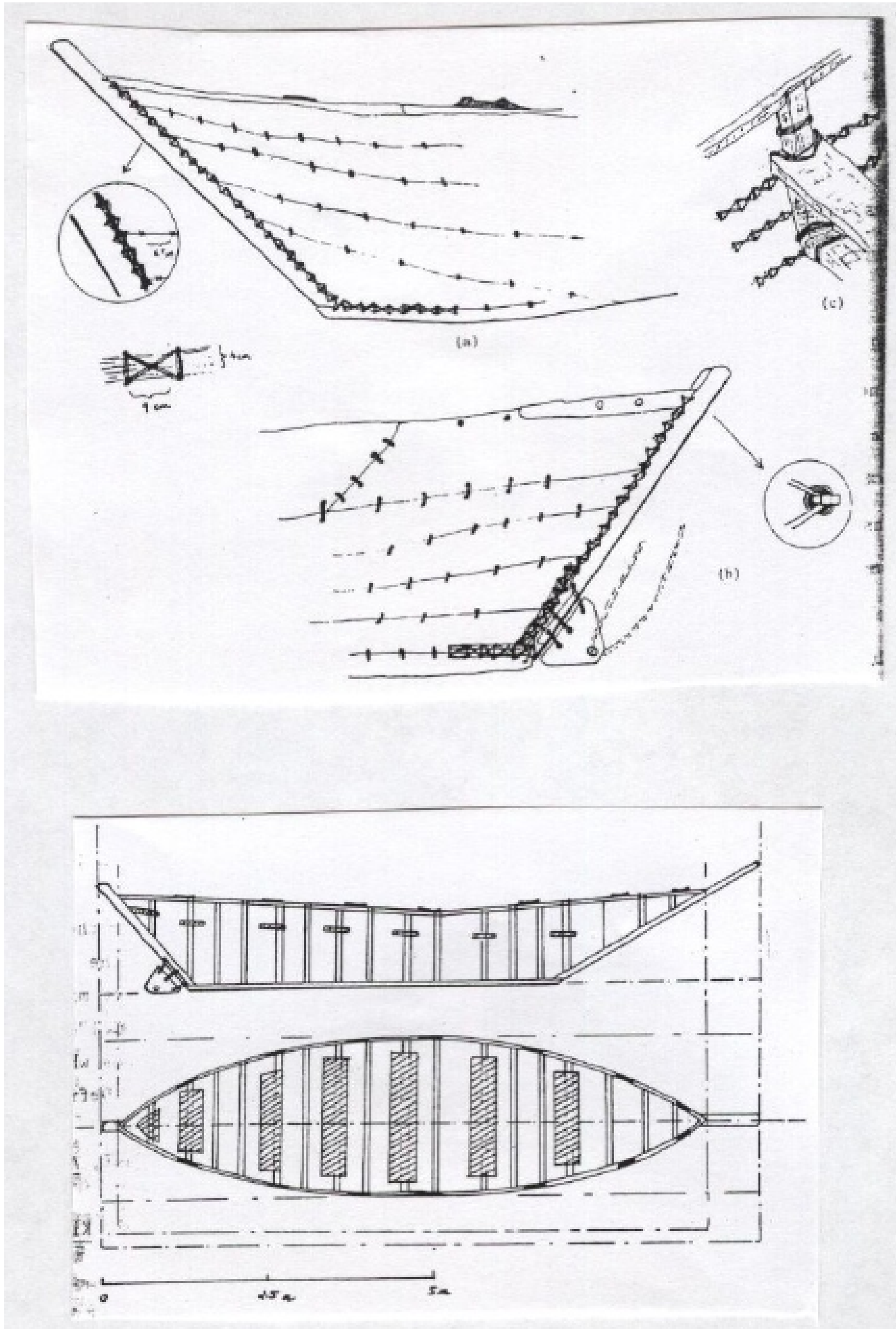


Figure 2.31. The stitched hull of the sanbuk zufari (Yajima 1976, 26).

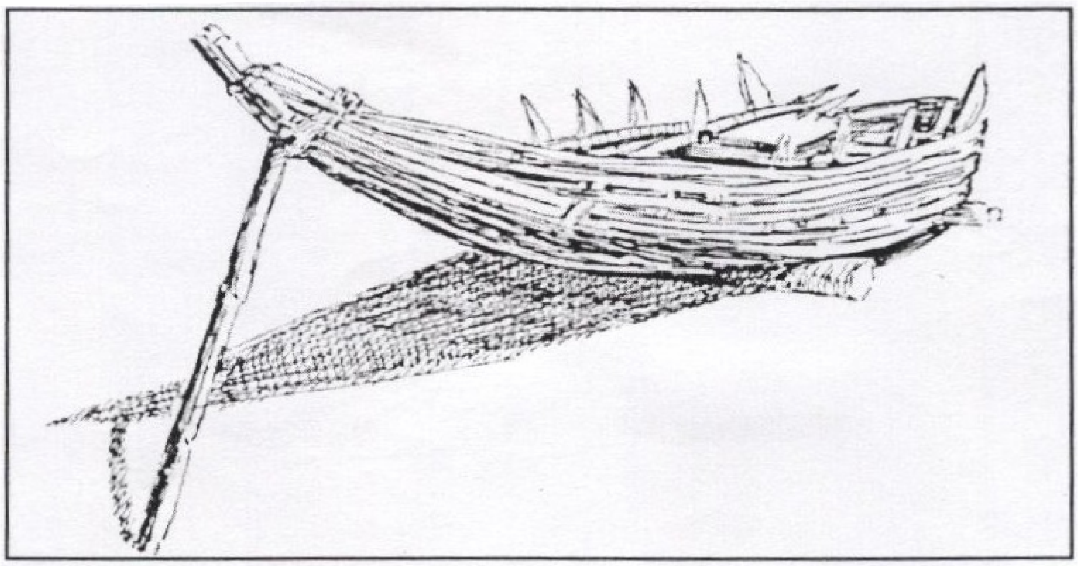


Figure 2.32. A sketch and a photograph of the shasha (Shihab 2001, 45 & Hijji 1988, 43).

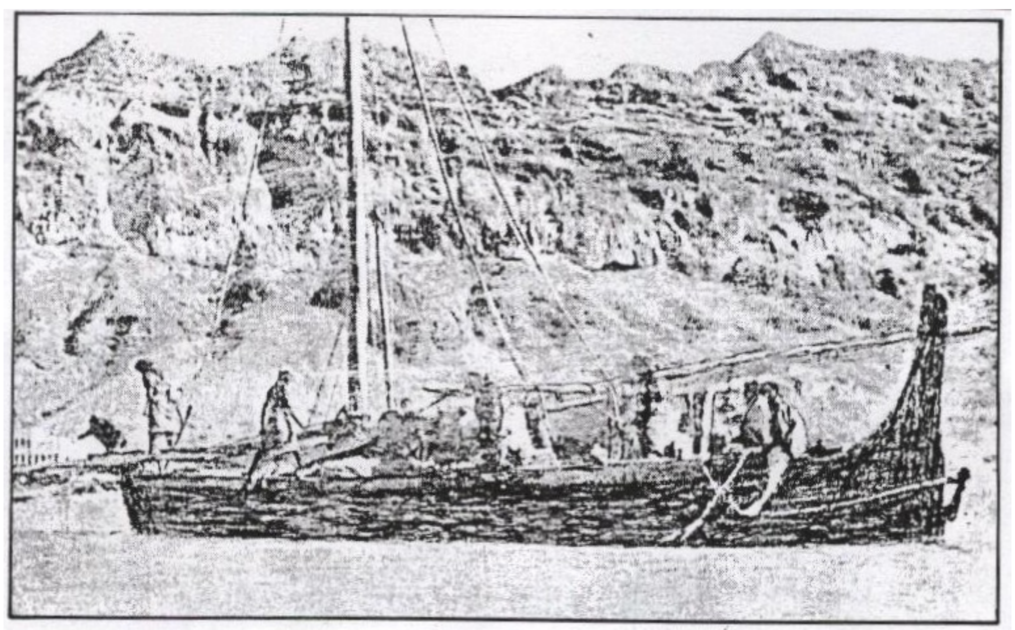


Figure 2.33. A photograph of a badan (Shihab 2001, 57).

Figure 2.34. A photograph of a huru (Taylor 2005).

2. a. Baghla:

It had a square stern and three kinds of masts. The size of the Baghla ranged from 150 to 400 tons. This ship was called the "Princess of the Sea", because it was the largest type of ocean-going dhow in the Indian Ocean before the Second World War. It was used for trading. It was able to sail long distances in the conditions found in deep and open seas. The Baghla is no longer used, even in the Persian Gulf, because this kind of ship required an extremely large crew. Also, it was not suitable for carrying a heavy cargo (Hijji 1988, 34) (Fig. 2.35).

2. b. Ghanja:

Its design was like the Baghla, but its size was smaller. The Ghanja was a square-sterned dhow with a high poop. Also, it had a curved stern-head in the shape of a ring made by a sail-rope (Fig. 2.36). The Ghanja's stem, stern and hull were painted with different colors and decorations. The carpenters and navigators said that the colors and decorations protected the dhow from accidents in the open sea and helped it to sail fast.

2. c. Kutiya:

Indigenous to Bombay and Karachi, this ship was medium-sized and had a square stern. It carried much cargo, and its equipment was light. Nowadays it is found at Ashshar port in Basra, Kuwait, Dubai, Abu Dhabi, and Matrah (Fig. 2.37).

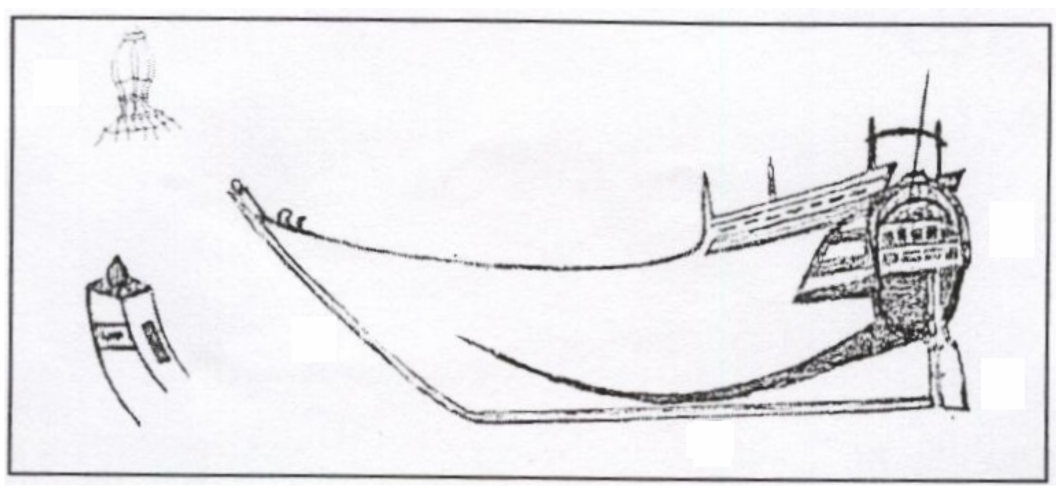


Figure 2.35. A sketch of a baghla (Shihab 2001, 54).

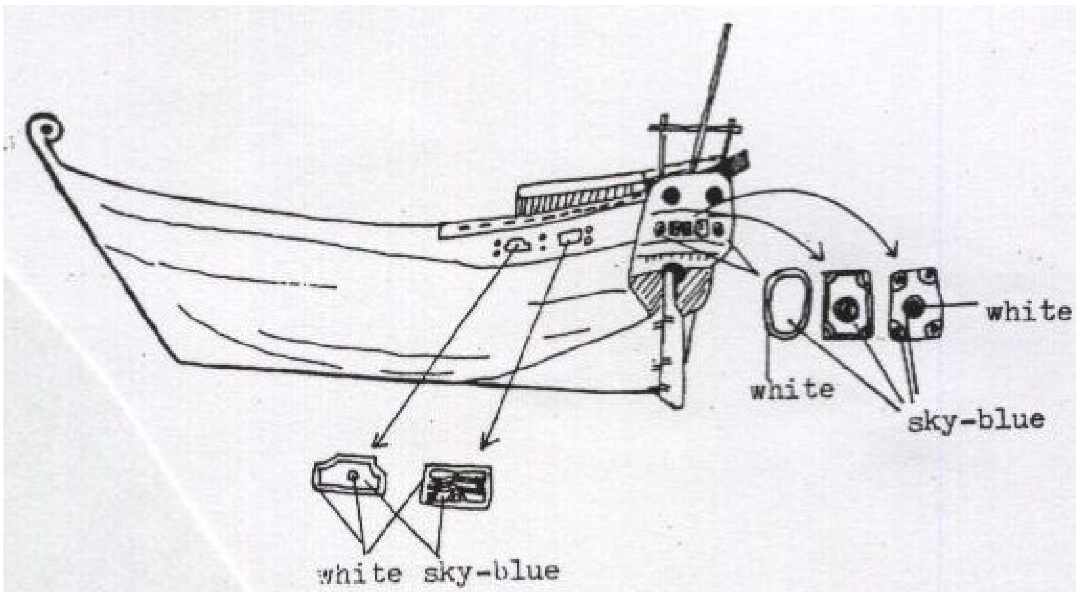


Figure 2.36. A sketch of a ghanja and its decorations (Yajima 1976, 23).

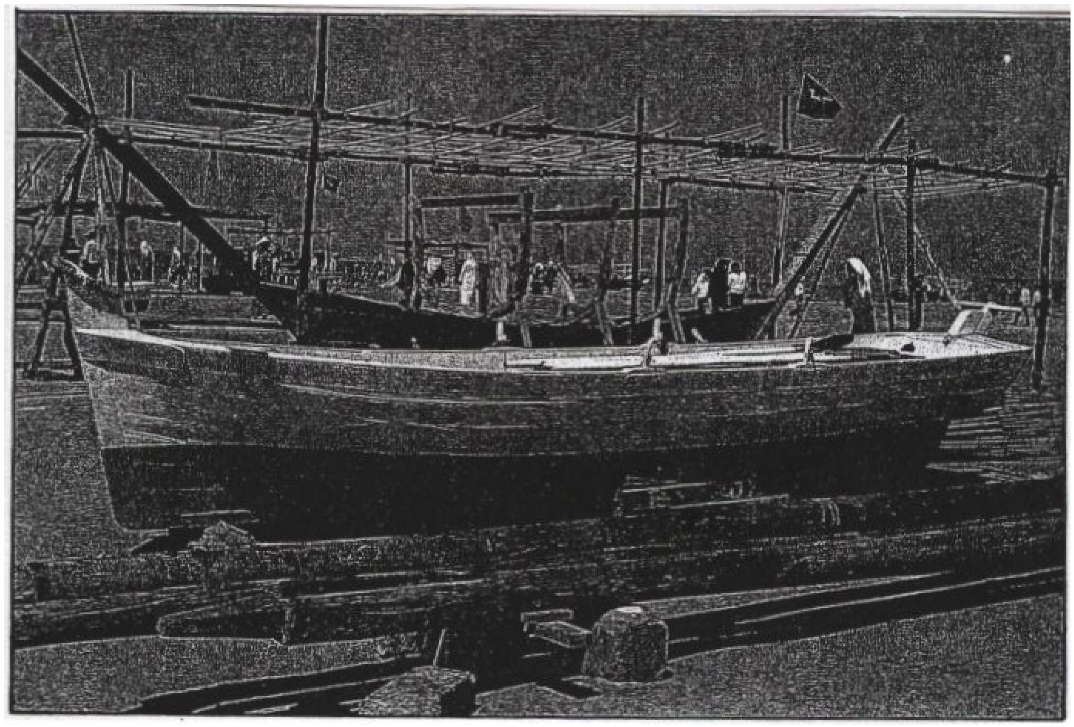


Figure 2.37. A photograph of a kutiya (Hijji 1988, 40).

2. d. Sanbuk “Sumbuq or Sanbuq”:

There are two types of sanbuk:

1) The Omani Sanbuk was a small dhow with a square stern. It carried from 5 to 15 tons of cargo. It was built in Kuwait and Sur. In the past, it was used for pearl-fishing in the Persian Gulf. However, in the 1970s it was being used for coastal fishing in the region of Sur (Fig. 2.38).
2) The Yemen Sanbuk was a large dhow that was double ended and decked, with a raised poop. It was built in South Yemen. It was used for fishing and trading in the Red Sea and Gulf of Aden (Fig. 2.39).

2. e. Jali or Jalibut:

It had a vertical square stern. It usually had two kinds of masts, one big and the other small. It extended in size from 15 to 25 tons. It was used for carrying passengers and cargo along the coasts of the Gulf Countries (Fig. 2.40). The shape of the Jalibut’s bow gave the ship more ability to push the waves away from the bow (Fig. 2.41). It could sail fast but was also very stable (Hijji 1988, 25).

Sail and rigging types:

The masts and sails of Arab ships were made of locally available materials. “Diqal or Daqal” (palm trunk) was the original material of the mast around the Arabian coasts. Later on, in the Middle Ages, masts were made of teak. The “shira” (sail) was either made of cotton cloth or was woven from the leaves of palm trees. The type of sail and rigging on the ship was an important factor in sea navigation. The lateen sail is the typical sail design traditionally used by the Arabs. It is a

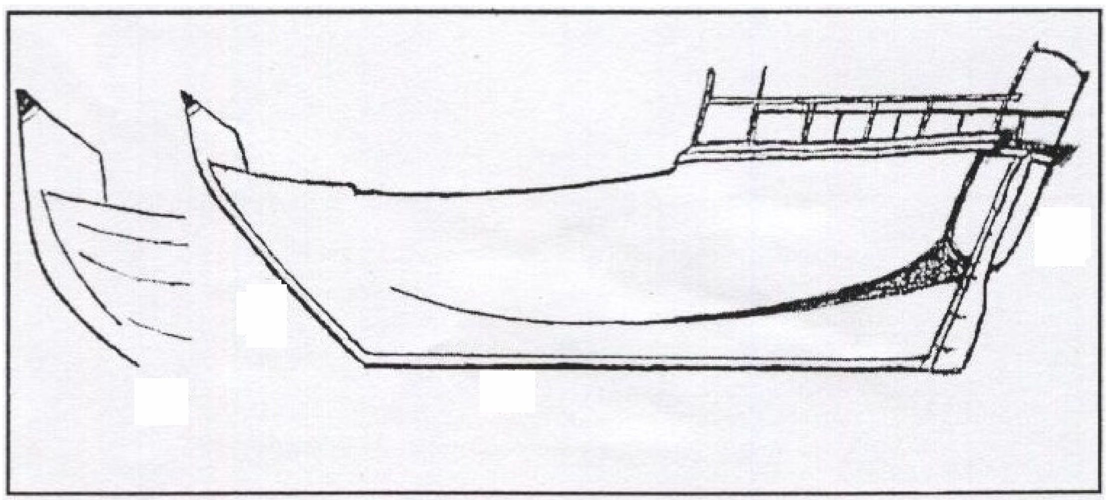


Figure 2.38. A sketch of an omani sanbuk (Shihab 2001, 61).

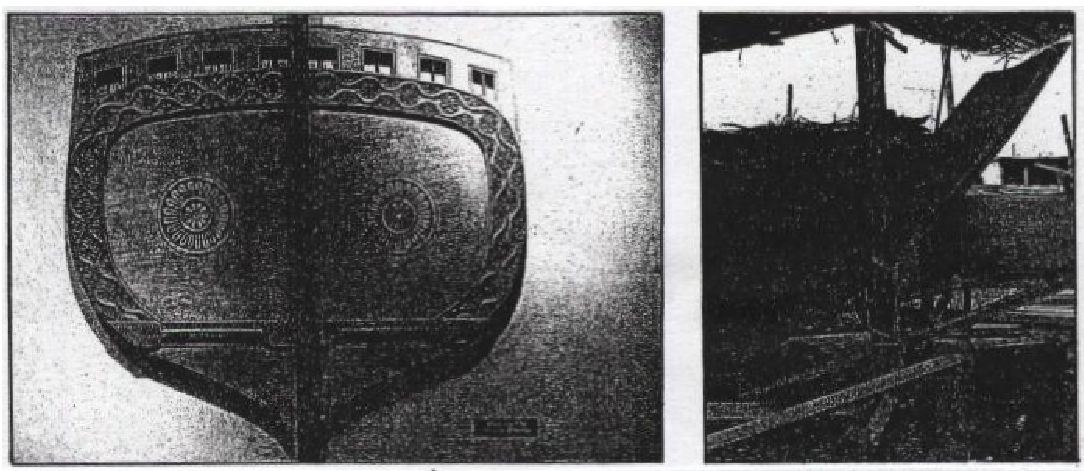


Figure 2.39. The bow and the stern of a yemen sanbuk (Hijji 1988, 27).

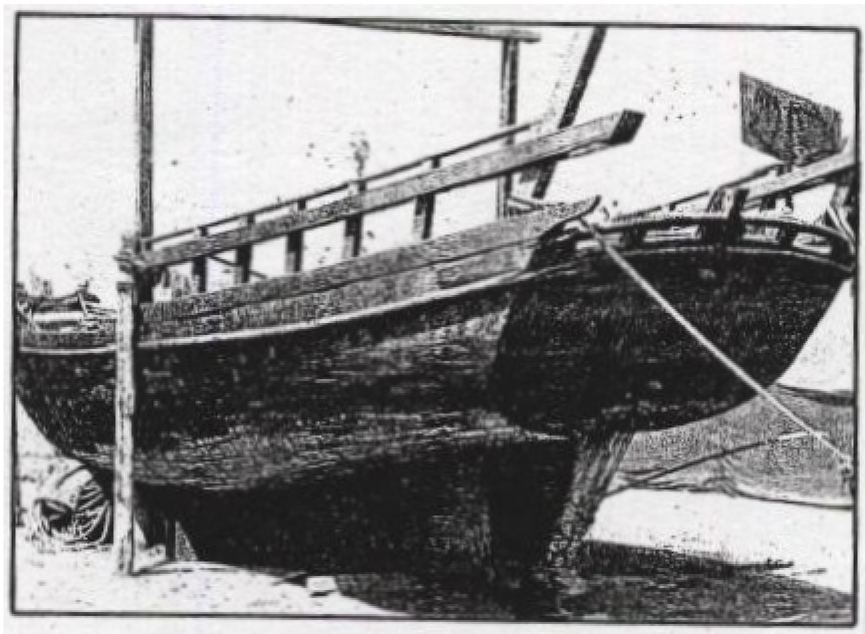


Figure 2.40. A photograph of a jalibut (Hijji 1988, 26).

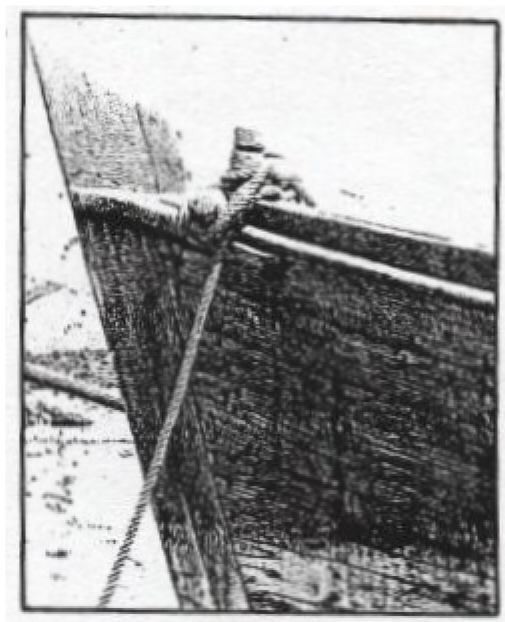


Figure 2.41. The bow of a jalibut (Hijji 1988, 26).

triangular sail, very tall with a high peak. It has been suggested that the lateen sail was not native to India and that it was developed by the Arabs (Fig. 2.42). The four main stages in the development of sails were as follows:

1. The earliest ships of the Egyptians, Greeks, Romans, and Indians used the square sail. This is based on evidence provided by ancient ship images on coins and pottery, etc. The advantage of the square sail was its stability on large ships in heavy seas. The square sail remained the basic type of sail on European ships until the end of the era of sail, although it was later combined with triangular fore and aft sails to improve maneuverability
2. The first step in modifying the square sail into a balance-lug shape was by setting the square sail fore and aft, then tilting it downward at the fore end. This kind of sail was used in sailing downstream against a prevailing north wind. Balance-lug sails are found on Sudanese, Indonesian, and Indo-Chinese ships.
3. Later on, the fore-portion of the sail was shortened, and the sail abaft was made higher to catch more wind. This type of lateen sail is found in the western half of the Indian Ocean. The importance of the lateen sail is to allow the ship to tack by wearing round, stern to wind, in place of tacking straight across the wind. Some sources say that the lateen sail originated in the Mediterranean, but other sources have said it came from the western half of the Indian Ocean. Yet another source said it was developed in the Pacific Ocean. However, the

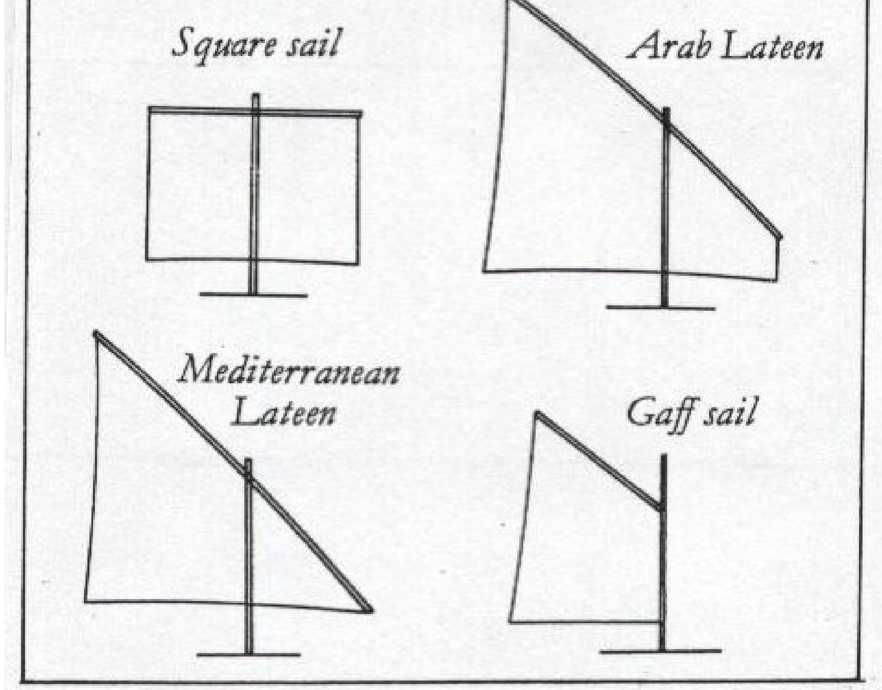


Figure 2.42. The different stages of development of sails (Howarth 1977, 33).

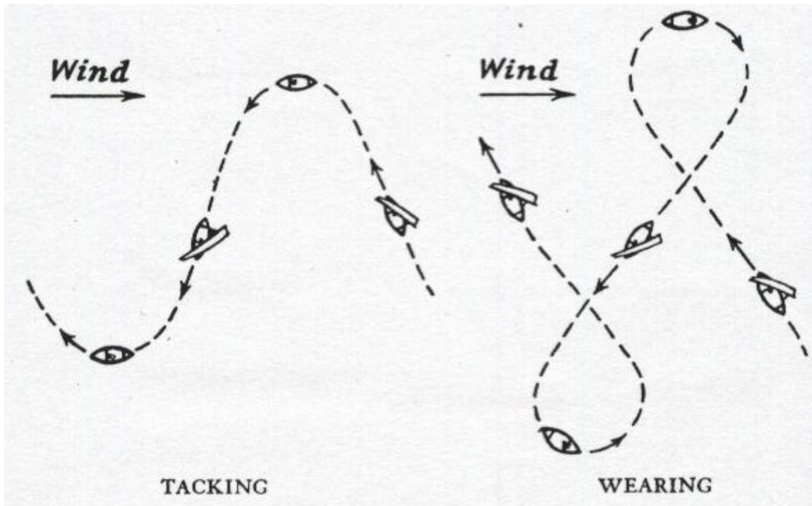
strongest theory seems to be that it was developed by the Arabs to allow more maneuverability in the confined and difficult waters of the Red Sea (Fig. 2.43).

4. In the final step, the shape of the lateen sail became entirely triangular. The fore-part of the sail ended in a point at the foot. This type of sail appeared for the first time in the Mediterranean; no one knows whether the Arabs or Greeks created this type of sail (Hourani 1958, 263).

Different numbers, size and shapes of lateen sails were used on Arab ships. Rigging the ship was the responsibility of the ship's captain and not the builder of the ship. The speed of the ship depended on the design of the sails. A ship usually carried more than one kind of sail. The kinds of sail were as follows: (Fig. 2.44).

1. Al-Quid: the largest lateen sail.
2. Al-Qalamy: similar to the Al-Quid but smaller and used in ordinary weather conditions
3. Tarket: used in difficult weather conditions
4. Al-Jeeb: a small triangular sail put up when bad weather prevented raising the Al-Quid, Al- Qalamy or Tarket sails
5. Al-Bomyah: a triangular sail raised at the bow, the smallest sail on the ship
6. Shamdy: a medium-sized triangular sail raised at the stern
7. Alqabayah: a semi-oblique lateen sail rarely used because of the difficulty of raising it (Hijji 1988, 157).

A.



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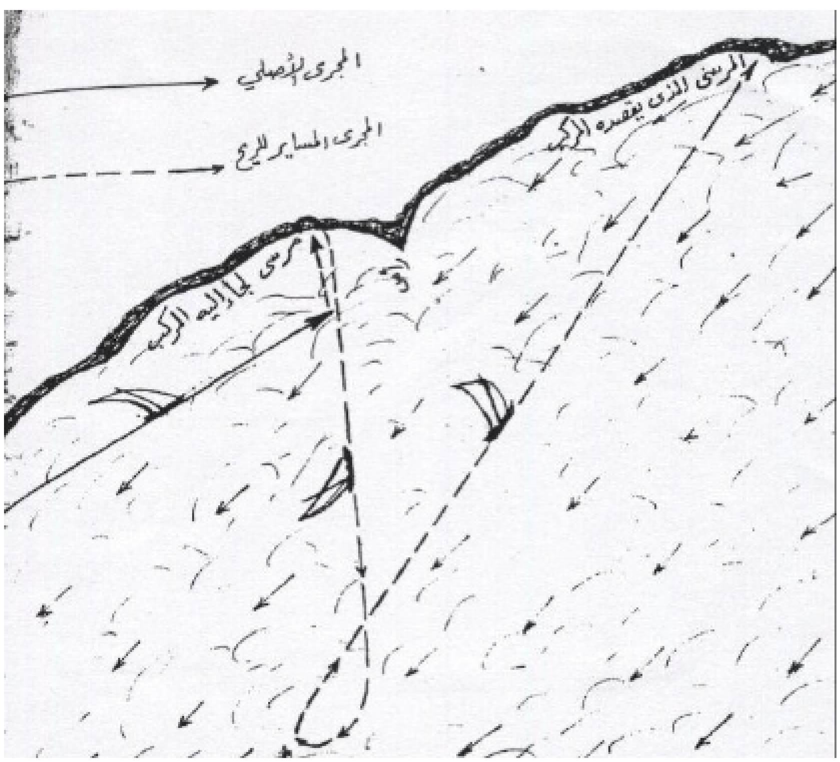

Figure 2.43. The techniques of tacking and wearing (A) and the use of wearing to sail from one port to another (B) (Hourani 1963, 110 & Shihab 1982, 160).

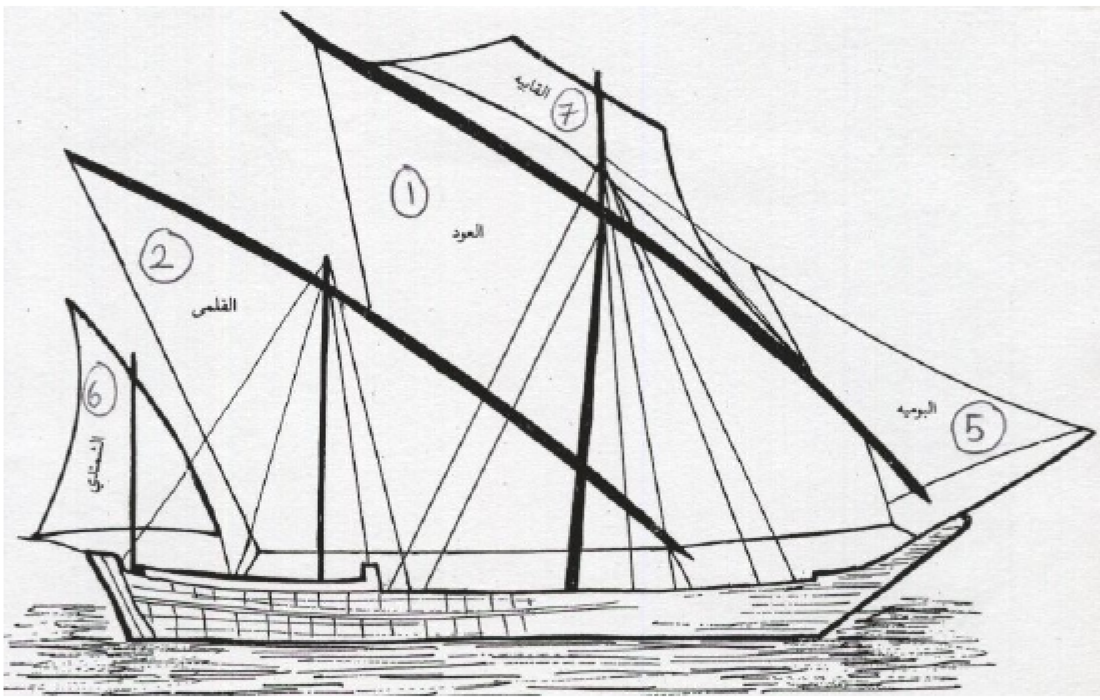

Figure 2.44. The kinds of Arab sails, numbered to correspond to the descriptions in the thesis text (Hijji 1988, 159).

Travel season:

This section will continue the discussion of the Monsoon wind, mentioned above as an environmental cue for use in orientation. The monsoon winds are the principal reason for dividing navigation trips in the Indian Ocean into two seasons:

During the northeast navigation season the monsoon wind called “Ayzab” allows the dhows to sail from India to the Gulf Countries and South Arabia, also from the Gulf Countries to South Arabia and East Africa. The season of the northeast monsoon begins in October and extends until the end of March (Fig. 2.45). This season encourages many dhows to depart from different regions around the Indian Ocean for shipping, such as picking up dates coming from Basra at Ashshar port in shatt al-Arab (Fig. 2.46). This was also the season for importing mangrove-poles from East Africa to the timber-poor Gulf countries for use in construction (Fig. 2.47).

The southwest navigation season is actually two seasons (one at the beginning and one at the end of the monsoon period) with a closed season in between (at the height of the monsoon storms).The first season, known as “Ras al-Rih” or “Kaws”, extends from the end of March or the beginning of April until July and August. The second season, known as the “Diman”, starts at the end of the August and extends until the end of September or the first of October. In this monsoon the dhow sailings are from the Gulf Countries and South Arabia to the South Indian coasts, as well as, from East Africa to South Arabia (Yajima 1976, 20).

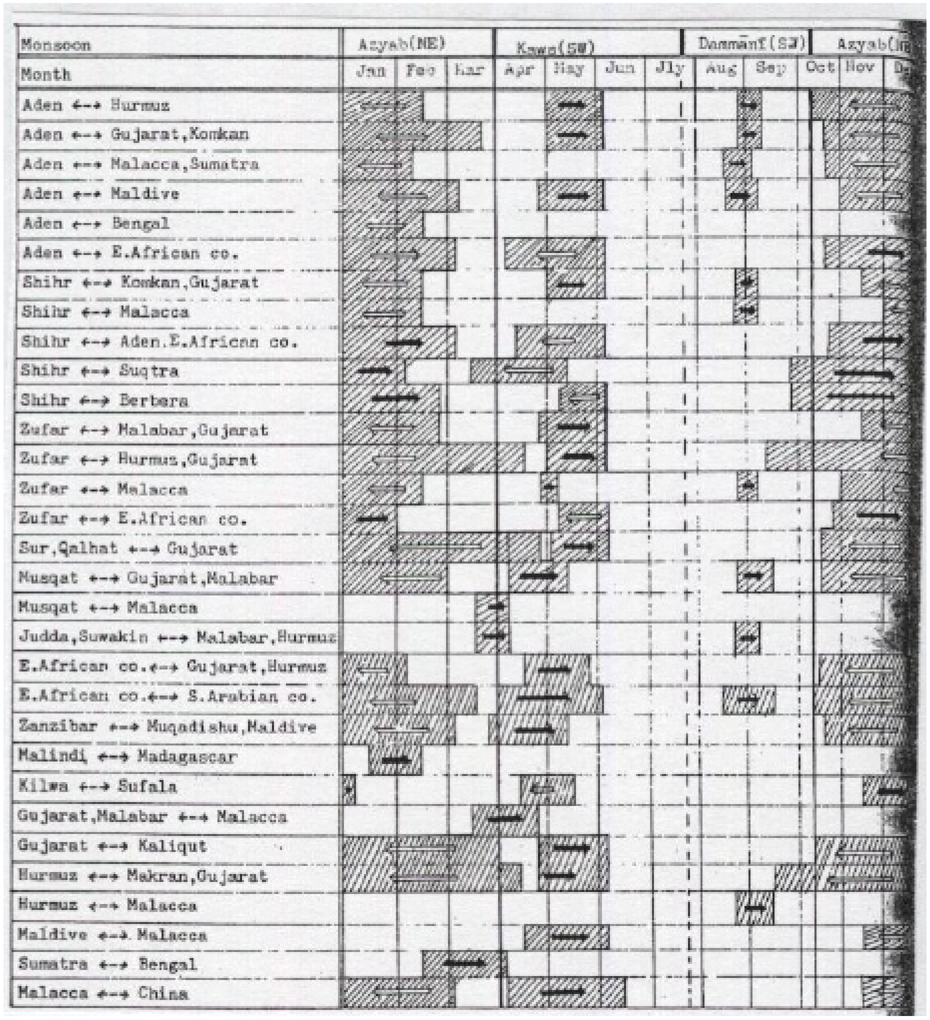

Figure 2.45. Diagram of the monsoon navigation and direction between different ports (Yajima 1976, 46).

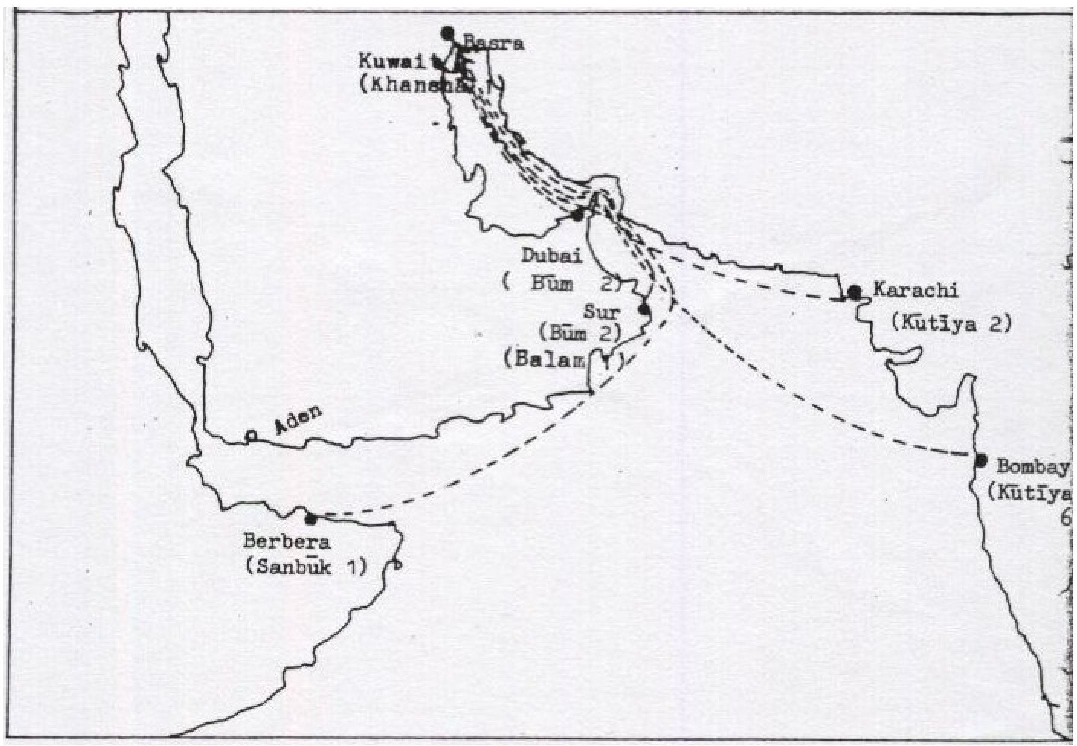

Figure 2.46. Routes of ships picking up dates from Basra (Yajima 1976, 36).

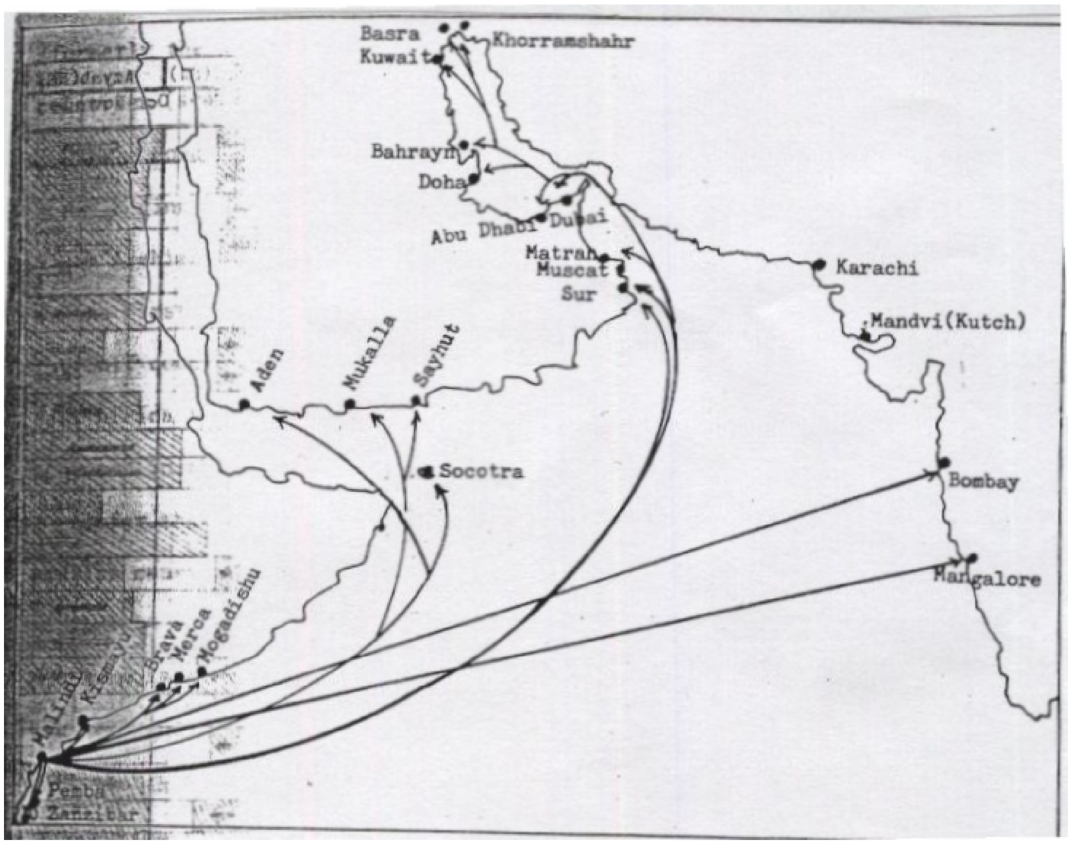

Figure 2.47. Routes of the mangrove trade in the western part of the Indian Ocean (Yajima 1976, 45).

Sea Routes:

Arab sailors followed different routes across the large open seas. The Arabs called the routes "Dir". There were three kinds of routes: Dirat al-Mul, Dirat al-Matlaq, and Dirat al-Iqtida (Fig. 2.48).

1. Dirat al-Mul means the route along the mainland coast. Such routes had to be accurate, because, as Ibn Majid and Al-Muhrai mentioned, many factors might throw a ship off course. These included distance error by the pilot, compass error, tides that could push the ship toward the land or out to sea, and waves (Ibn Majid & Tibbetts 1971, 165). Dirat al-Mul required coastal knowledge by the pilot. For example, the pilot had to be familiar with the waves and tides, know how to avoid reefs and shoals, and have a wide knowledge of landmarks and environmental cues (Brauer 1985, 44).

2. Dirat al-Matlaq means the route that links two separate places. The ships following such a route would enter and leave a port to the right or left using fixed measurements or bearings. Navigating to an unfamiliar port in this way was difficult. Success depended on the accuracy of the latitude readings of the North Star at both ends (Ibn Majid & Tibbetts 1971, 165). Dirat al-Matlaq was the domain of the true muallim who was competent in determining his latitudes (Brauer 1985, 44).

3. Dirat al-Iqtida was derived from Dirat al-Mul. This type of route was calculated so that it started and ended at a known place. Navigating such a route was relatively easy (Ibn Majid & Tibbetts 1971, 165).

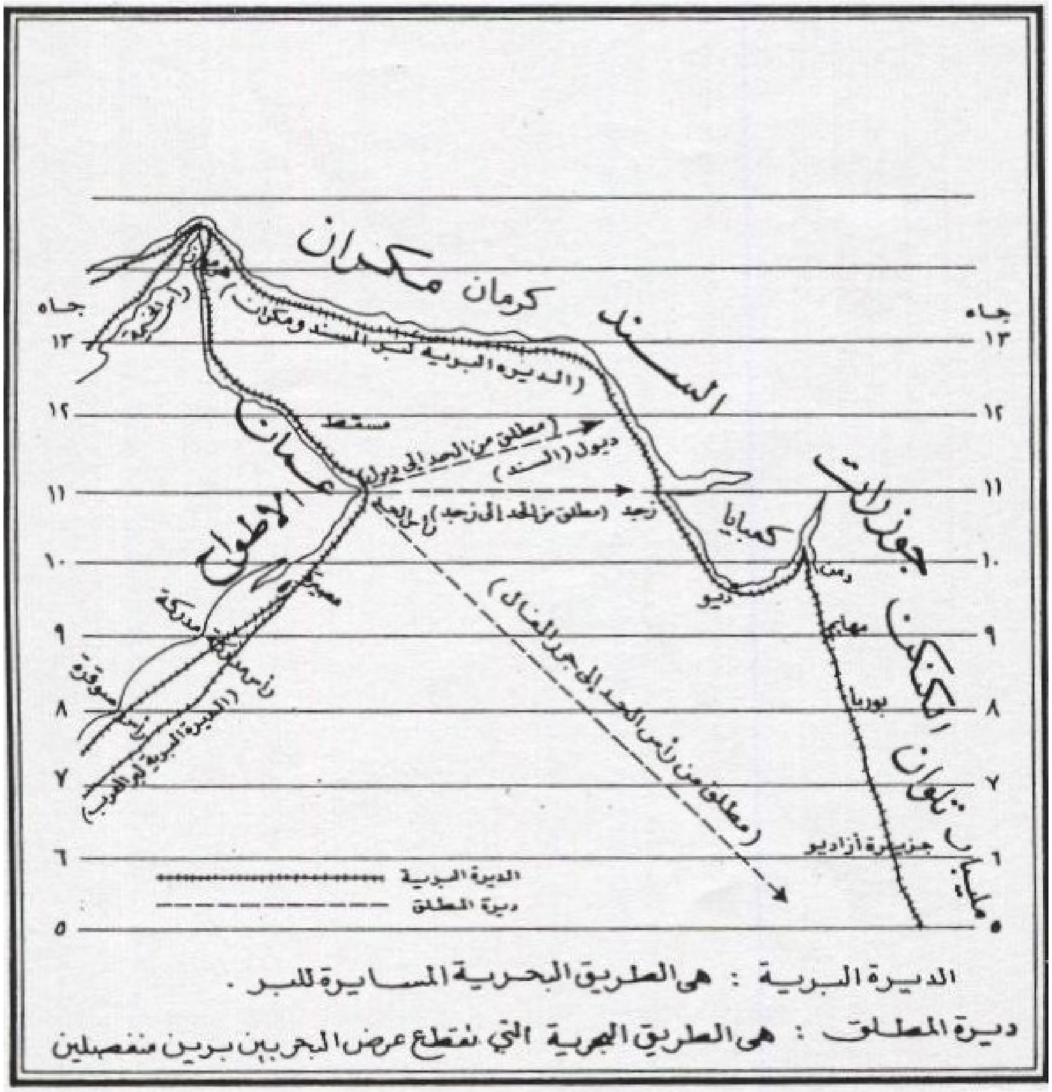

Figure 2.48. The open-sea routes (solid line) and coastal-sea routes (dashed line) (Shihab 1982, 127).

There were two popular sea routes linking the Gulf of Arabia or Persian Gulf and Oman with India. One started from the west coast of India and ended at the Persian Gulf.

The other one started from the west coast of India, stopped in Oman to take on supplies and continued to the Yemen coast (`Imadi 1997, 336). Along these routes there were very important ports as follows:

1. Al-Basra was established in 638 A.D. on the shatt al Arab. This port was a door to Baghdad (the two cities had a close trading relationship), Persia, Bahrain, Oman, East Africa, India and China. Many Arab travelers described the port of Al-Basra in their travel books (Fig. 2.49).
2. Al-Ubulla is located on the Djlah River in the northern Persian Gulf. It was named "Indian Land", because it had a strong commercial relationship with India.
3. Siraf is located in the eastern side of the Persian Gulf. It received the big ships that could not enter Al-Basrah. Siraf was competitive with Al-Basra's port for three centuries. All descriptions of Siraf's port in the Arab travel books say it was a very important trading center with wealthy inhabitants and wonderful buildings.
4. Qatar is a peninsula located in the western Persian Gulf and surrounded by many islands. It was a center for Arab sea and land commerce. It provided camels, grapes and cloth (Fig. 2.50).

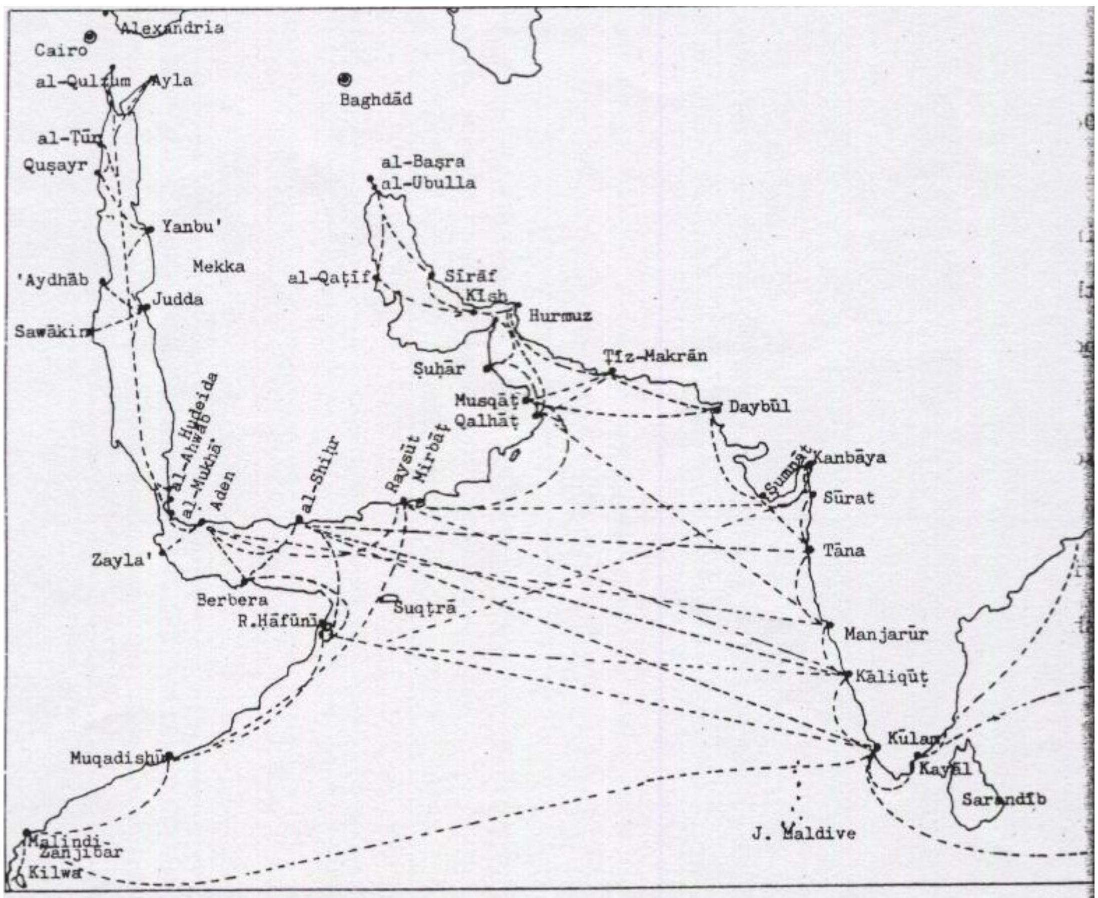

Figure 2.49. The trade ports along the sea routes in the Red Sea, Persian Gulf and Indian Ocean (Yajima 1976, 8).

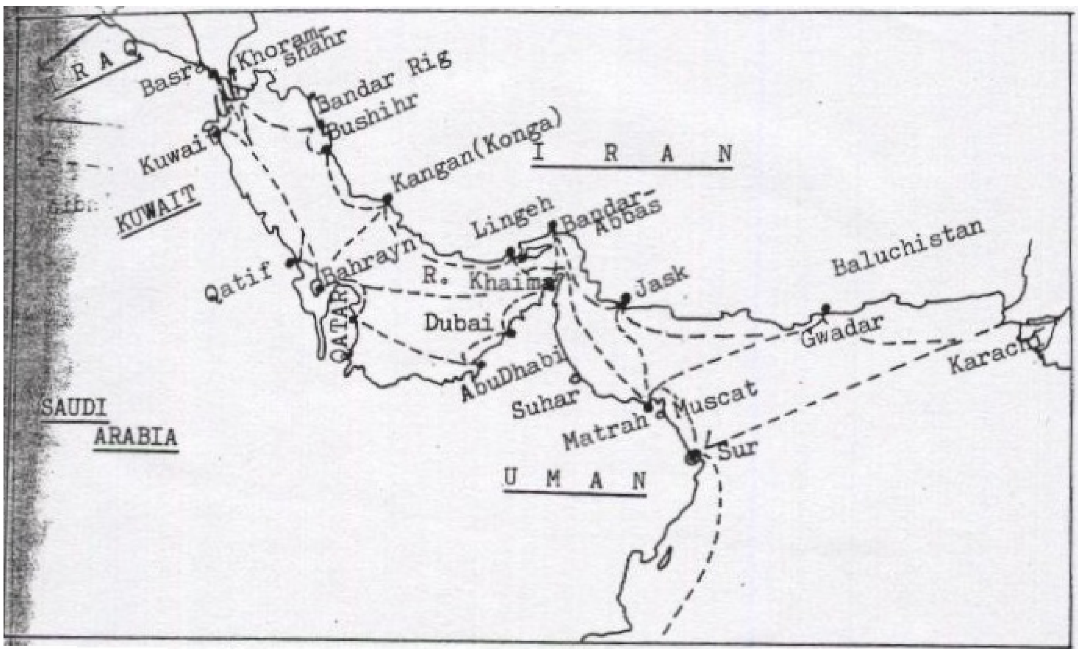

Figure 2.50. Trade ports of the Persian Gulf, including Qatar (Yajima 1976, 33).

5. Darin was a very popular port in Bahrain. It received many ships from different places. From Darin goods were distributed throughout the Arabian Peninsula.
6. Sahar was an important communication link between east and west. Persian Gulf ships departed from it and traveled to East Africa, India and China. On the return voyage they would bring goods from there back to the Persian Gulf.
7. Aden was the next biggest port in the Indian Ocean after Sahar. It was a communication link between China, India and Egypt. From Egypt goods were sent to Europe.
8. Jidda was an important station in the Red Sea, receiving the merchants and pilgrims from different areas.
9. Ayzab was located on the west side of the Red Sea. It was a very active port, because it received many big ships and pilgrims (`Imadi 1997, 273).

Members of an Arab Ship Crew:

The third chapter,"Daftar A'ini Akbari", in the 15th-century A.D. "Akbar Nameh" (Book of Akbar) contains many details about the crew of the dhow merchant ships sailing in the Persian Gulf and Indian Ocean (Hijji and Christides 2002, 260). There was a system of laws on the ship that everyone had to obey. The size of the ship's crew depended on the ship's size. The crew members were grouped into twelve classes. Each crew member had particular duties and responsibilities. The classes of crew members were:

1. The Nakhoda was at the top of the crew hierarchy. He was the owner of the ship. He supervised the ship and was concerned with every aspect of the ship and its commercial activities.
2. The Muallim was the captain or the pilot of the ship. He had a deep knowledge of sea navigation and of the waters he sailed. He knew how to use the astrolabe to observe the sun and stars and the magnetic compass to guide the ship to its destination. He was aware of the weather's changes and of the monsoon. He kept track of the course and position of the ship during the trip (Fig. 2.51).
3. The Khallasi Kharwah or Tandi was the chief of the sailors.
4. The Nakhoda-Khassab supplied the ship with wood for cooking.
5. The Sarhang supervised the docking and landing of the ship and worked for the Muallim.
6. The Bhandari provisioned the ship and had charge of the ship's stores.
7. The Karran served water to the passengers and kept the accounts of the ship.
8. The Sukkangir or helmsman steered the ship following the commands of the Muallim (Fig. 2.51).
9. The Panjar looked out from the top of the mast and reported everything he saw, such as land, storm, another ship, etc.
10. The Gunmati, who belonged to the Khallasi, bailed out the ship.
11. The Topandaz (gunner) was required in naval battle; the number needed depended on size of the ship.

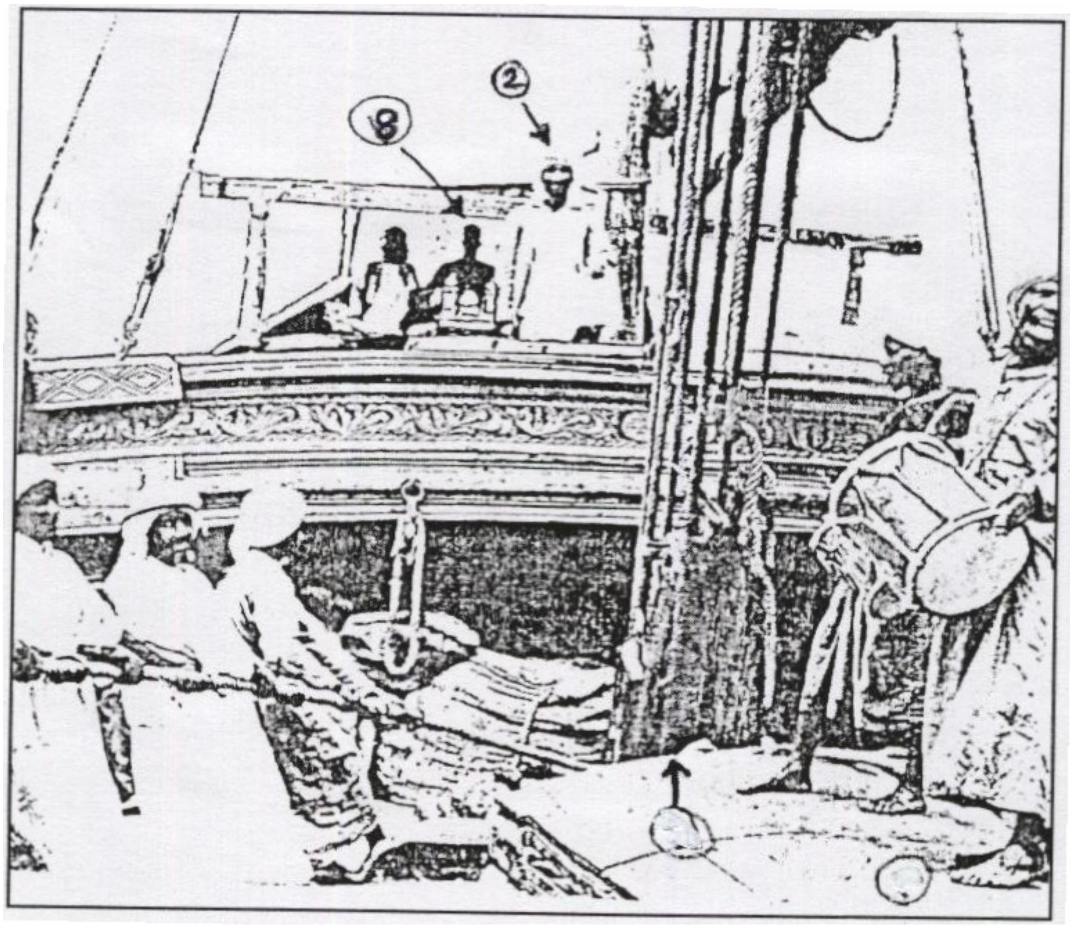

Figure 2.51. Some of an Arab ship's crew including the mualliam (2) and the helmsmen (8). The numbers relate to the thesis text (Shihab 2001, 66).

12. The Kharwah had several duties, like furling the sails, stopping leaks and rasining or lowering the anchor (Venteis 2002, 259).

Crew members were sometimes accompanied by members of their families. For example, among the ship's crew, there were young boys who became apprentices in order to gain experience in sea navigation and learn to be ship's pilots like their fathers (Fig. 2.52). Al-Qatami, an Arab navigator (b.1898), who was a ship's pilot and author of five books about sea navigation, points out that he first went to sea with his father when he was eight years old. From then on he went on every voyage with his father, learning navigation from him, and traveling widely. By the age of fourteen he could steer the ship himself, and he went on to become a famous ship's pilot in his time (Al-Qatami 1976, 193).

Ibn Majid as a Case Example:

Ahmed Ibn Majid, an Arab navigator in the fifteenth century A.D., was one of the most famous "muallim" in history. His full name was Shihab al-Din Ahmad bin Majid bin Umar bin FadI. bin Duwaik b. Yusuf bin Hasan bin Abi Ma Iaq al-Sadi bin Abi Rakaib al-Najdi. Ibn Majid came from a family of navigators; his father and grandfather were navigators. His father's nickname was "Muallim al-Barrain", which means the pilot of the two coasts (the Arabian and Sudanese sides) of the Red Sea. His father recorded his experiences of sea navigation in a poem known as "al-Hijaziya", consisting of a thousand verses describing navigation in the Red Sea. Ibn Majid learned sea navigation skills and knowledge from his father and grandfather,

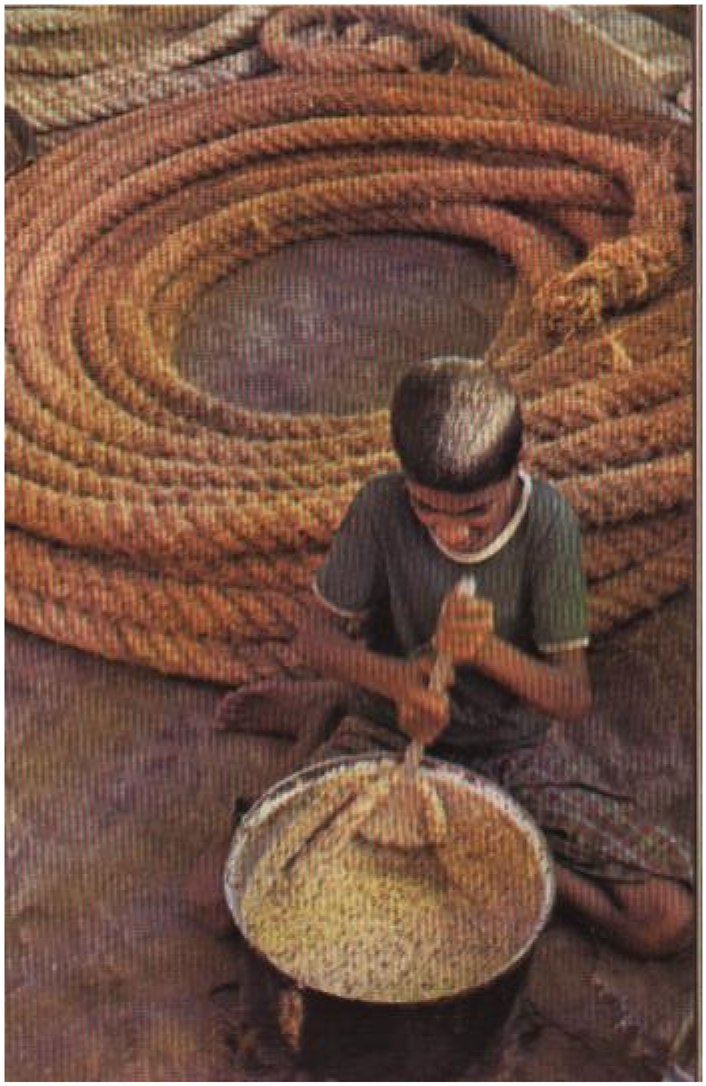

Figure 2.52. A photograph of Arab boy travelling on a ship to gain experience in sea navigation (Howarth 1977, 49).

both masters of sea navigation. He always applied their teaching in his travels, and found it very useful, as well as adding his own experience.

Ibn Majid was knowledgeable about subjects important for the art of navigation, including astronomy, geography, and mathematics, as well as knowledge of the seas. In addition, he was a poet and author. In his book “Al-Fawaid” (The book of profitable things concerning the first principles and rules of navigation) he listed books about different subjects important for the navigator to know. This indicated that he was well read. He invited many pilots, navigators, sailors and other members of the ship’s crew to participate in discussions about sea navigation. This was a way of educating the ship’s crew about sea navigation. Beside his native Arabic Ibn Majid knew many languages: Persian, Swahili, etc., learned in the foreign places that he visited.

Ibn Majid wrote most of his books in the last half of the fifteenth century, after spending a long time gathering information and gaining experience in sea navigation. His books cover everything about sea navigation. They were used as sources by later writers, such as Sidi Celebi, whose the famous book, “Muhit”, written in 1557 drew upon both Ibn Majid’s and Al-Muhri’s publications. Ibn Majid’s publications were translated into many languages. The following list includes 24 of about 40 works known to have been written by Ibn Majid:

1. “Al-Fawaid” (The Book of Profitable Things Concerning the First Principles and Rules of Navigation): this book has twelve chapters.
2. “Al-Hawiya”: this book in “rajaz” (verse) is divided into eleven sections.

3. “Al-Muarraba”: is a “rajaz” (poem) on the Gulf of Aden, consisting of 178 verses and dated 1485.

4. “Al-Qiblat al-Islam fi Jami al-Dunya”: it gives the direction of Mecca from various places in 292 verses, each with 33 lines, and is dated 1488.
5. An unnamed “Rajaz” (poem) on the Persian Gulf, consisting of 100 verses.
6. A “Rajaz” (poem) on the seven stars, consisting of 68 verses and dated 1494.
7. “Kanz al-Maalima”: the treasure of masters of navigation.
8. An unnamed “Rajaz” (poem) on the landfalls of the sea of India and the Arab coast consisting of 255 verses.
9. “Al-Mimiya”: a treatise in 64 verses dealing with certain northern stars.
10. “Urjuza Mukhammasa”: it deals with other northern stars, consists of 17 verses and is dated 1500.
11. A “Rajaz” (poem): it consists of 48 verses.
12. “Qasida Makkiya”: it deals with sailing to Mecca and Jidda from different places. It consists of 172 verses.
13. A “Rajaz” (poem): it consists of 56 verses.
14. “Dhahabiya”: this poem of 193 verses dated 1487 describes the winds, landmarks and coastal sailing.
15. “Al-Faiqa”: it consists of 57 verses.
16. A “Rajaz”: it deals with latitude measurements using Arcturus.
17. “Al-Sabiya” it is a poem with 155 verses dealing with the seven sciences of the sea and is dated 1483.

18. A group of prose sections on various subjects.
19. A short poem “Qafiya”: it consists of 33 verses.
20. “Al-Hadiya”: “rajaz” (poem) of 155 verses dealing with landfalls on the west coast of India.
21. A “Rajaz” (poem): it deals with the stars Tir and Sulbar.
22. “Al-malaqiya”: “rajaz” (poem) dealing with the route to the Far East and consisting of 273 verses.
23. “Al-Taiya”: poem about the routes in the Red Sea, consisting of 54 verses.
24. “Al-Sofaliya”: a long “rajaz” (poem) of 805 verses about the route from India to Sofala and dated 1514.

Besides his writing about sea navigation, the invention of several navigation methods and instruments are attributed to Ibn Majid. For example, he is credited with improvement in the design of the mariner’s compass, the discovery of environmental cues for navigation (such as bioluminescence) and developing new methods for measuring the stars (Murad 1990, 27).

This chapter has covered the traditional instruments and techniques of sea navigation used by Arabs, pointing out the enduring importance of the sun and stars. The development from simple devices like the qiyas and the kamal to the sophistication of the astrolabe enabled navigators to set courses to unfamiliar places. However, they usually sailed known routes to familiar ports during seasons dictated by the prevailing monsoon winds. Over the years ship captains augmented their memories by collecting written sailing directions (in books called rahmani), although the use of poetry indicates the continuing oral tradition. The rahmani texts mentioned environmental cues and also included sketches of landmarks to assist in piloting. Although written mentions of maps indicate that Arabs used sea charts, the lack of surviving copies leaves their nature in question. The probable invention of dhow hull types by the Indians and of the lateen sail by Arabs in the Red Sea identifies both of these seafaring cultures as centers of innovation, capable of designing equipment to suit local environmental conditions. Although there is no record of maps made by Ibn Majid, a famous Arab navigator, the story of his life and his writings reveal great knowledge of the sea and the impulse to share it with other crew members under his command. The next chapter will cover the same sequence of topics, but with regard to land navigation.

Chapter 3. Land Navigation

Arab Bedouins inherited a tradition of travel, because Arab civilization for several thousand years had been moving across the length and breadth of the vast Arabian empires and beyond, looking for new routes for trade, pilgrimage and military conquest and in search of knowledge. The scholars, students, merchants, pilgrims, and armies used camels and horses to transport themselves and their goods across the desert. The desert was full of troubles, discomforts, and dangers. The danger of bandits obliged travelers to band together, thus forming a caravan. Caravan travel was the common means of trading and traveling between the different countries. There were important overland routes from the Arabian Peninsula, one leading to northern, eastern and central Africa, the second to central Asia and Russia, and the third to India and China. Along these routes Arab traders established a large zone of communication and commerce that crossed both land and sea. As with sea navigation, Arabs traveling by land developed and employed different navigation techniques to guide them in their journeys.

Celestial Navigation:

Arab travelers have been watching and relying on celestial bodies to orient themselves under the night sky for thousands of years. Bedouins were also assisted by the sun to identify their direction of travel (Grant 1938, 204). The moon, the stars and the sun are mentioned in the Qur'an (which was written in the seventh century A.D.) as tools to guide the travelers. The Arabs observed the rising and setting of the stars, and they gave the constellations different names according to their shapes. They also mentioned these stars in their poems (David 1970, 126; Shihab 1982, 79). Here are examples of such poems by Muhalhil:

> My attention has been so devoted to the shining of the stars,
> That when I am away from them, they ask after me.
> When rising, one is given a greeting by them;
> My day ends with bidding them farewell
> (Ibn Majid & Tibbetts 1971, 128)

> As if Juday had asked the Banat Na'sh,
> Turning upside down his hands.
> As if the Pleiades, when Suhair was driven back,
> Were young camel yearnings for a day of rain.
> As if the stars of al-Jauza were old camels
> Having sympathy for the young ones, tired of foot.
> As if the two Shi'ras creeping towards Suhail,
> Shine like the head of a large old camel.
> As if the watercourse of the two eagles were swollen
> Over every garden and only found its path with difficulty.
> As if the poor seller were a sheikh hoping
> To overcome the misfortune of the oath of a venerable man
> (Ibn Majid & Tibbetts 1971, 126)

The Arabs preferred to travel across the Arabian Desert at night. The reason for that was not only to avoid the daytime heat of the sand and stones and the thermal winds, but also because the stars were visible in the sky to guide them. Over time the Arabs developed great knowledge of the science of astronomy and astrology, but this was also practical knowledge used in their travel in the desert (Nadvi 1966, 108). According to Hourani, the early Arabs at the time of the writing of the Qur'an used the stars for the guidance. Allah says in the Qur'an: "He it is who hath appointed for you the stars that ye guide yourselves thereby in the darknesses of land and sea; we have made the signs distinct for a people who have knowledge" (Qur'an 6:97). This passage means that reading the sky is like reading a book; no one can read the sky without knowledge (Hourani 1958, 275).

Also, the desert was like the sea in that both of them are trackless (Hourani 1958, 275). Sometimes all tracks were completely obliterated by sand deposited by dust storms or high winds. When that happened, the caravan's leader and his men set up tent and waited for night to fall, in order to get their bearings from the stars (Grant 1938, 204).

Astronomical Position Finding: the Astrolabe

Arab astronomy first began to develop into a science during the early period of the Abbasid Caliphs, especially in the time of the Caliph Al-Mamun. He established "the house of wisdom" in the year of 830 in Baghdad to translate scientific texts from Greek (the Almagest of Claudius Ptolemy and other Greek books), Persian, Indian, and other languages into Arabic (Hourani 1958, 275) (Fig. 3.1). The astrolabe has already been mentioned as an instrument used for sea navigation, but it was also used to navigate across the desert. The Greeks had invented the astrolabe about the second century B.C., but when the astrolabe came into Muslim hands in the eighth and ninth centuries A.D., it was altered and used for new purposes. It was used to solve several astronomical and time-keeping problems. It was also used to determine the five Muslim prayer times and the direction of Mecca from different geographical locations (Fig. 3.2). Added to that, it was used to develop a calendar of astrological events significant to the Islamic faith (Turner 1997, 66). In the early twelfth century, the Arabs introduced the astrolabe to Europe. The astrolabe

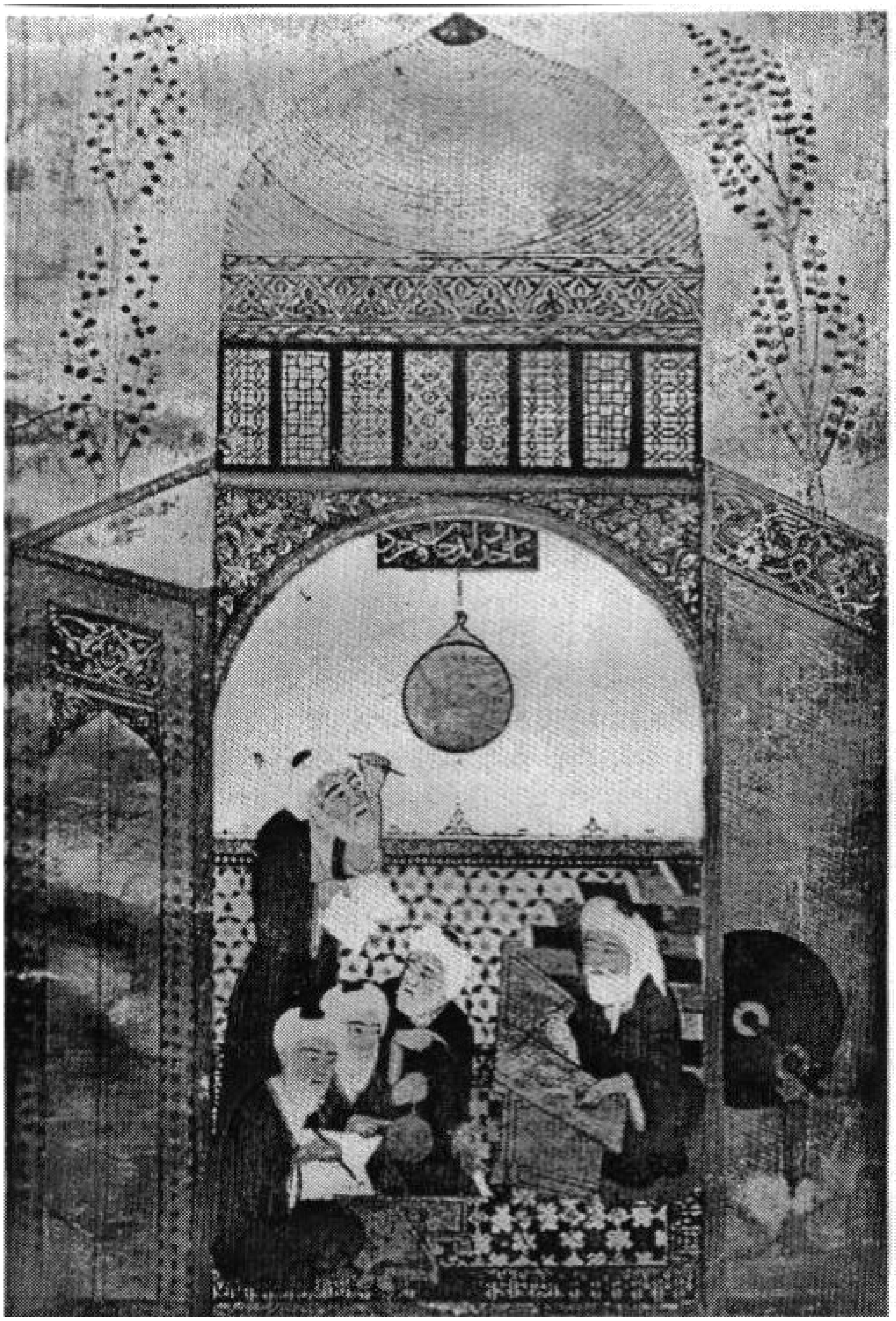

Figure 3.1. Miniature painting from a 15th-century Islamic manuscript depicting a teacher of astronomy and his students (Turner 1997, 76).

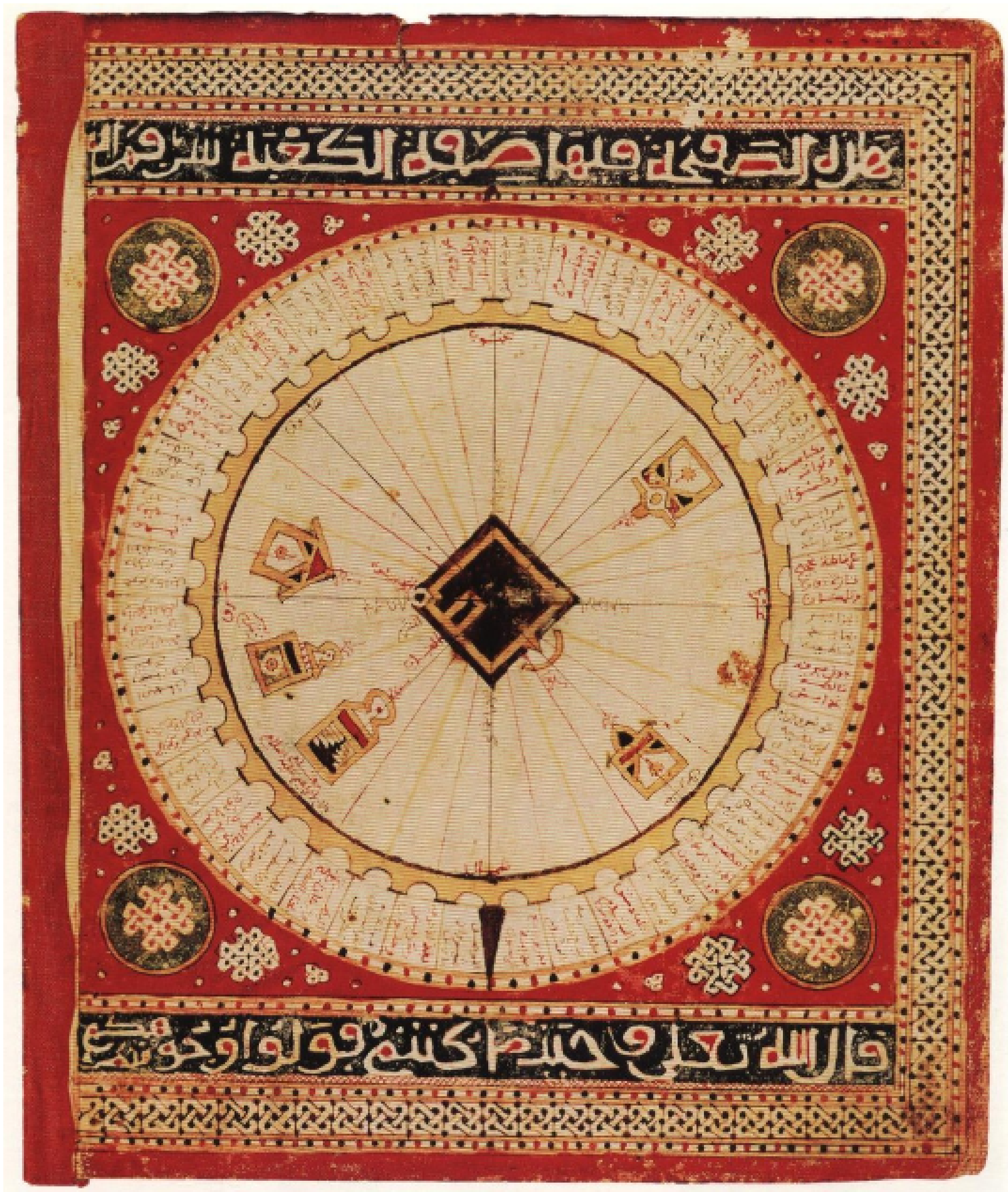

Figure 3.2. Qibla diagram from Arab sea atlas showing the direction of Mecaa from different geographical locations, 1551 (Harley and Woodward 1987, Plate 13).

was considered the most important navigation instrument up through the eighteenth century (Parry 2004, 33).

The astrolabe in its various forms was a scientific instrument much used by the Arab astronomers and geographers. It was used for taking the stellar, solar, and lunar altitude. Over the span of the Middle Ages, Islamic astronomers and astrologers designed three styles of astrolabes: a flat style derived from the Greek versions (Fig. 3.3), a linear type called the staff of Tusi (invented by Muzaffar sharaf al-Din al-Tusi) and a spherical instrument (Fig. 3.4). The flat type "was a portable metal instrument in the form of a disc, ranging in size from 3.9 inches to 7.8 inches in diameter, and had a handle (Urwa) through which passed a suspending ring (Halqa, Ilaqa), by means of which it could be suspended in a vertical position (Encyclop. Islam in Ahmad 1944, 179). Later on the Arabic astrolabe became known in Europe as the "Mathematical Jewel" or "Marvel of Convenience and Ingenuity" (Encyclop. Brit in Ahmad 1944, 179; Ahmad 1944, 178).

Observatories were set up in desert locations where clear weather permitted the best observations to be made, such as Junde-Shapur in south-west Persia, Damascus, and Baghdad (Saliba 1994, 33; Hourani 1958, 275). Early Arabs needed to survey the land, determine latitude and longitude, make geodetic measurements and other scientific work that required precision instruments (Ahmad 1944, 178). The astrolabe is small in size and versatile, so it was used a lot in traveling (Bilal 1994, 6).

Muslim instrument makers wrote books about the astrolabe, too. For example, Al-Khazin (900-971 A.D.) wrote a book called "Kitab zij as-safaih" (Tables of the

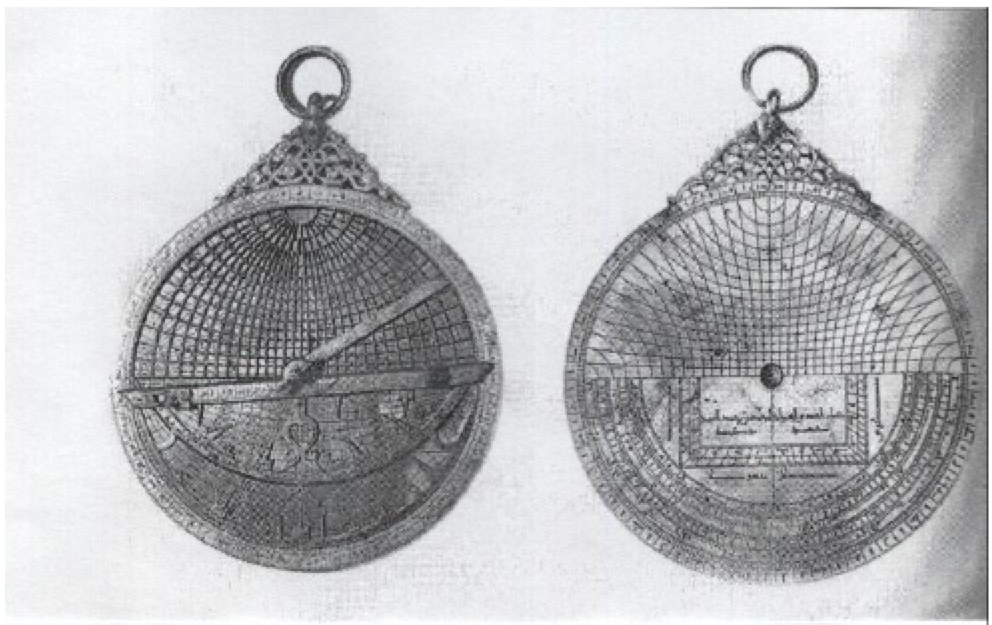

Figure 3.3. Flat style of astrolabe, made by al-Sarraj, Syria, 1328-1329 (Turner 1997, 94).

Figure 3.4. Spherical astrolabe, made by Musa, 1480-1481 (Turner 1997, 95).

disks of the astrolabe). Al-Razi (840-902 A.D.) wrote on the "Kitab Hai'at- al-Alam" (The form of the earth) and contributed a treatise on the "Risalat fi-Gurub ish Shams-Wal-Kawakib" (Setting of the sun and planets). There were many others who also made great contributions to the astronomical field. Al-Batani (877-918 A.D.), an Arab astronomer and mathematician, was well known in Europe as the Ptolemy of the Arabs. He corrected some of Ptolemy's observations, and his most famous work was "On Stellar Motion". Al-Biruni (973-1048 A.D.) was an Arab encylopedist of science who wrote books on mathematics, astronomy and astrology, geography, and history. Abul- Wafa (939-998 A.D.) was a mathematician and astronomer who introduced the use of the secant, as well as the tangent, into astronomical observations. Al-Kuhi (d. 1004 A.D.) was the designer of many instruments and the founder of the observatory at Baghdad (Ahmad 1944, 171).

Magnetic Compass:

Although it seems likely that the magnetic compass was also used in Arab land navigation to some extent, historians whose works have been consulted have not mentioned it. One primary source that came to light, however points out the usefulness of the magnetic compass when visibility was poor. Pietro Martire d'Anghiera, an Italian traveling disguised as an Arab in 1503, describes the journey from Medina to Mecca as follows:

> …we determyned to goe forward on our iourney and that by guiding of a pylot, who myght directe our course with the mariners bore or compasse, with also the carde of the sea, even as is used in saylyng on the sea…In this sea of sand we traveiled the iourney of three dayes and nyghtes: this is a great brode plaine, all covered with white sande, in maner as small as floure: If by evyll fortune it so chaunce that anye

> travaile that way southward, if in the meane time the wind come to the north, they are overwhelmed with sande. And although they shoulde have prosperous wynde, yet are they so involved with sande, that they scatter out of the way, and can scarcely see the one the other 10 paces of. And therefore th'inhabitans travaylyng this way, are inclosed in cages of woodde, borne with camels, and lye in them, so passing the iorney guided by pilots with
> maryners compasse and carde, even as on the sea, as we have sayde. In this iorney also many peryshe for thirst, and many for drynkynge to muche, when they fynde suche good waters.
>
> (Anghiera 1992, fol.364v-365r)

<u>Landmarks and Markers:</u>

On the ground many types of landmarks and markers served to identify places and guide the travelers and their caravans along the great desert routes from one place to another. The scarce watering places in the arid landscape not only influenced the location of routes, but also provided landmarks in the form of vegetation at oases and wadis (stream beds). At watering places there were also wells and buildings. The sheep's well south of Kubaisa, the abandoned mud fort at Hellah town, and the fortress palace and ancient ruined coastal at Jubb el-Ghanam were prominent landmarks on the route from Basra to Aleppo. The golden dome of Meshed Ali at Kerbela town was said to shine at a distance like a globe of fire. Less permanent structures, the black tents or "houses of goat hair" that signified places of rest for travelers, also served as landmarks. Physical features of the landscape also served to identify places. These included the "Valley of Salt" southeast of Aleppo, which was a dry salt bed in summer and was turned into a lake by the winter rains. There was also the bitumen fountain or pitch spring south of Kubaisa. Moreover, there were many hills, valleys, groves of date palms and tracks made by the camels that formed physical landmarks (Grant 1938, 193).

Early Arab caravan operators began to place “al-Sawa” (piles of stone) along routes to guide travelers. In particular, stones along the routes to Mecca were used to mark the miles. They also placed “al-Manar” (lights or beacons) and flags at the boundary between different territories (`Imadi 1997, 91). Sheikh Ibrahth- al Manar was the first ruler to employ flags, milestones (Fig. 3.5), and lanterns for this purpose, according to Al-Asmai (d. 831 A.D.) (Ibrahim 2002, 30).

Besides these landmarks, Arabs used “a’lam” (cairns) to mark roads (Yaqut 1955, 146) (Fig. 3.6). As well as cairn, the word “a’lam” can also mean a mountain or a banner (Al-Rashid 1980, 147; Ibn Duraid 1926, 138). The a’lam served as a boundary mark between territories, too (Ibn Manzur 1882, 419). Al-Harbi records in his book “Al Masalik w Amaken Toreq Al Haj w Maalem Al Jazerah” (Trails and Places of Pilgrim Routes and Forms of Peninsula) that eight cairns that were erected at an-Naqirah two for the entrance to the station, two for the way out, two cairns to mark the road to Basra, and two to mark the road to Medina (Al-Harbi 1969, 322). Although early caravan roads did not have specific markings, pilgrim roads came to be marked systematically by means of cairns. These were built on high mountains or hills on both sides of the road. The aim of creating them was to guide trade and pilgrim caravans in the correct direction. They were also used to mark the watering places and the pilgrim stations along the road. Many of these ancient way marks are

Figure 3.5. Abbasid milestone marking the pilgrim road from Kufa to Mecca (Al-Rashid 1980, 400).

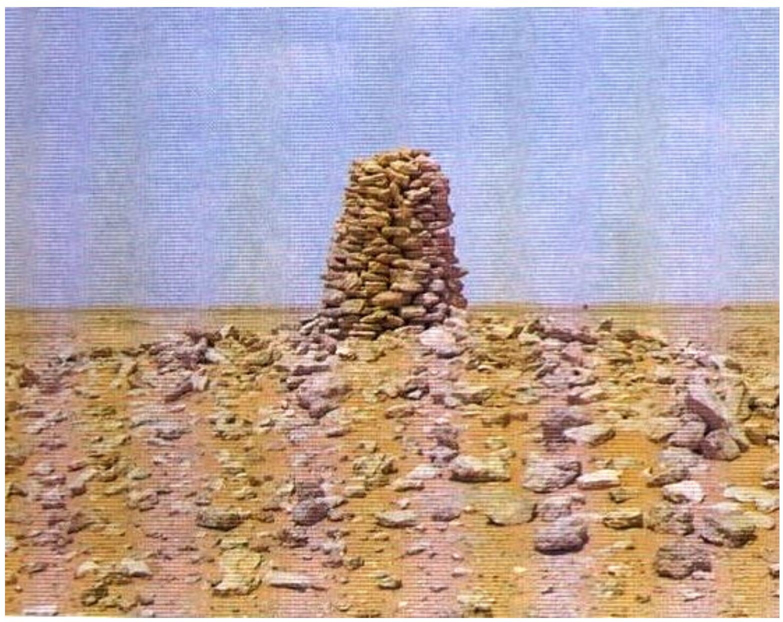

Figure 3.6. A’lam (way mark) marking pilgrim road 4 km South of Zubalah (Al-Rashid 1980, 372).

still observable. They were constructed from unshaped stones of similar size, and no binding materials (clay or lime) were used (Al-Rashid 1980, 148).

Arab travelers used several units of measure, and distances were approximate; Al-Yaqobi explained in his book “Kitab al Buldan” (Book of Countries), written in 891 A.D., that the early Arab travelers measured distance by units called “Marahala” (stages), each stage being equal to about twenty geographical miles (Al-Yaqobi 1892, 8). However, Al-Idrisi (1100- 1165 A.D.) mentioned in his book “Nozhat al Moshtaq fe Ekterak Al Afaq” (Amusement for Him Who Desires to Travel Round the World) that the “Marahala” was equal to about one day’s march (32 to 52 Arabian miles) (Ahmed 1960, 76). Ibn Rustah (d.923 A.D.) said in his book “Al-aqalk al Nafesah” (Precious Records) that another unit, the “Farsakh,” was used to measure the route distance and was equal to about three geographical miles. Four Farsakhs made up one “Al-Barid” (Post Stage), which consisted of twelve Arabian miles. The Arabian mile equals 6,474 ft or c. 1 1/15 geographical miles (Ibn Rustah 1892, 22).

From the travel books mentioned above, it seems that the descriptions of places and travel routes were similar, but different sources employed different units of measure to express distance.

<u>Oral and Written Directions:</u>

It was obviously safer to make a journey with large escorted caravans, especially if one was not a native of the desert. When foreigners visited desert regions, they hired Arab guides who were familiar with the local environment. A contract was drawn up to provide the travelers with a certain number of camels,

guides, and other necessities (Grant 1938, 174). Most of the “Quraysh” tribe from the region of Mecca worked in the caravan trade and were very skilled. The guides had expert knowledge of the desert
area’s short cuts, secret routes, water holes, safe places, and hazards. The guides determined the direction in which to travel. Many guides also came from the tribes of Kafar, Thamarah, Dohannah, Jezam, and Katam. They knew their areas so well that they could find their way blindfolded. Also, they had the ability to withstand the heat of the desert (`Imadi 1997, 91). In 1970 it was still the practice to hire desert-born Bedouin Arabs as guides for foreign survey parties (Prain 1971, 139).

An interest in the description of travel routes, places and their climates appeared after the rise of Islamic culture in the seventh century A.D. The great Islamic geographers described their own voyages and travels and those of other merchants and pilgrims traveling within Islamic countries and beyond. Such books were often called “Kitab al-Rihlat” (travel book), although other names relevant to the particular book were also employed (`Imadi 1997, 92). In addition to such books about travel by land and sea, the literature of Arab descriptive geography also included itineraries giving details of travel routes, distances and stages; descriptive treatises about regional and local geography; and historical-topographical literature about individual towns. Many Arab geographers made great contributions to geography through their writings, as well as by innovations in scientific instruments used for astronomical observations. Their interests spanned the entire field of geography as then known and extended into related fields, such as astronomy, astrology and mathematics.

The following examples show how Arabic geographical writing created a basic store of knowledge useful for travelers. Their books included accurate and detailed descriptions of numerous countries, including their physical features, climatic conditions, and the life of the people. Ibn Khuradadhbih (820-912 A.D.) traveled between the year 844 and 848 A.D. to Samarra on the Tigris and then he wrote his book “Kitab al-Masalik w al Mamalik” (The Book of Routes and Countries). This book gives a summary of the major trade-routes of the Arab world. Al-Yaqubi’s “Kitab al Buldan” (Book of Countries), written in 891 A.D., deals with the physical and human geography of important countries and cities. Ibn Hauqal traveled more extensively, starting from Baghdad in 953 A.D. and touring the Islamic countries for 30 years gathering a store of knowledge and experience. On his return he incorporated his experiences in his geographical treatise, “Kitab al-Massalik w al-Mamalik” (On Routes and Kingdoms). Another traveler of the period, Al Maqdisi, visited of all parts of the Islamic world except India and Spain. He wrote in 985 A.D. “Ahsan al Taqasem fi Marefat al Aqaleem” (The Best of Divisions for the Classification of the Climes), including personal observations of the customs, manners, and economic life of the various inhabitants of the lands of Islam. Ibn Jubair (1145-1217 A.D.) made his extensive travels in connection with his pilgrimage to Mecca and wrote “Rihlah Ibn Jubair” (Travels of Ibn Jubair). Yaqut al-Hamway (1179-1229 A.D.) compiled a geographical dictionary named “Mujum al-Buldan”

(Countries Dictionary) containing all geographical names in alphabetical order. This book is a store house of information not simply on geography, but also on history, ethnography, natural history, mathematical, physical, and political geography, as well as other topics.

Other books were written to accompany and explain maps. Al Balkhi (850-932 A.D.), who was one of the early Muslim map makers, wrote "Suwar al Aqalem" (Figures of Climes), which includes many maps. He also wrote "Kitab al-Massalik w al-Mamalik" about routes and kingdoms, a work that was compiled in 921 A.D. (Nafis 1943, 242). Also, Al-Istakhri (10 A.D.) wrote in "Al-Massalik w al- Mamalik" about routes and kingdoms. The maps that were included in his work played an important part. For example, Al-Istakhri shows the Arabian Peninsula schematically as a circular protrusion into the Persian Sea with the African coast beyond (Fig. 3.7). South is to the top left. Most of the detail in the peninsula relates to the Hijaz and Yemen. Below, it is separated from the rest of the landmass by the Euphrates and the Tigris. Routes radiate out from Mecca and Medina, from Mecca to Bahrain, Oman, and Aden and from Medina to Basra, Kadesia (Qadisiya), Reqqa, and through Taima to toward Syria (Tibbetts 1987, 117).

<u>Other Factors in Route Selection on Land:</u>

Types of Animals:

Animals played a significant role in the work done by the Arab travelers. Animals helped the Bedouin to travel from one place to another, carry goods, and to wage war. The most important animal was the camel, also called "the gift of god" or

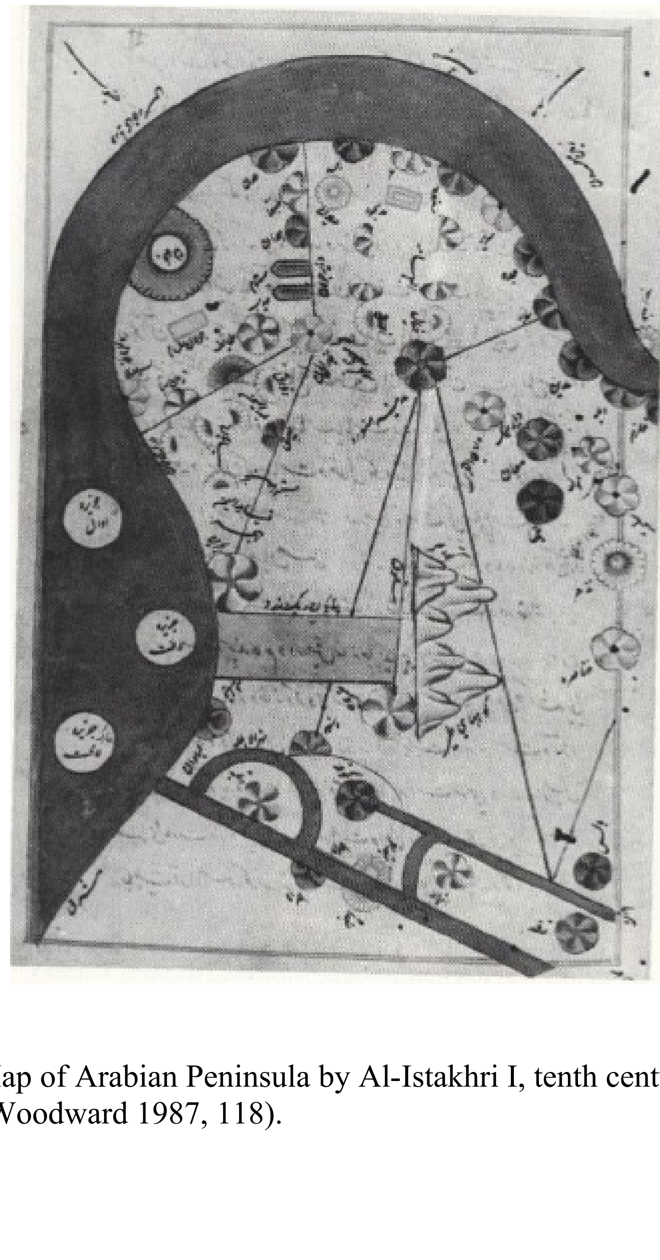

Figure 3.7. Map of Arabian Peninsula by Al-Istakhri I, tenth century A.D. (Harley and Woodward 1987, 118).

“the ship of the desert” (Fig. 3.8). Nomadic Arabs also used horses, donkeys and mules to carry their goods (Rostovtzeff 1932, 6), although camel caravans were the main mode of travel along the long-distance land routes. These caravans carried traders and their valuable goods, as well as pilgrims (`Imadi 1997, 87). The desert caravans which went to Mecca required about 2,000 to 3,000 camels (Saudi Armco 1964, 92). There were two kinds of camels that were used by the desert people. One of them was the single-humped pack camel, and the other was the fast riding camel. Both kinds were used widely in the desert,

because they are able to travel from four to ten days without water. They adapted better to desert conditions than horses which needed more food and water than the camels (Grant 1938, 15).

Travel Seasons:

As there were travel seasons for ships at sea, there were also travel seasons for the caravans. These land trade seasons depended on the needs of commerce and religion. They were also influenced indirectly by the monsoon winds that strongly affected sea travel.

The Qur’an states in the name of Allah “For the taming of Quraysh, for their taming, we cause the caravans to set forth in winter and summer, so let them worship the lord of this house, who provides them with food against hunger and with security against fear” (Qur’an, 106:1-4). The winter and summer journeys were timed to mesh with the monsoon winds on the Indian Ocean, which brought ships laden with goods from India, East Africa and China to the ports of Yemen. That allowed the caravans

Figure 3.8. Camel caravan (Thomas 1991, 4).

to regularly buy goods, which they then transported to Syria and its Mediterranean ports during the other season. For this reason, the Arab tribes owed gratitude to God, the Lord of the Ka'bah in Mecca, as mentioned in the third verse.

The annual pilgrimage to the Ka'bah, a tradition reaching back centuries among the Arab tribes, also brought wealth and prestige to the city to Mecca. Imad mentions two times for travel to Mecca, one in winter and the other in summer. Mecca played an important role in exchanging and distributing the goods coming from various places along different routes and in different directions. The merchants of Mecca were named "Tojar Quraysh" (The Merchants of Quraysh). These merchants made a contract with the princes and sultans of Yemen and Syria to travel once in summer and once in winter every year. They sent the summer caravan to Syria and the winter caravan to Yemen. The outgoing caravans carried the produce of the desert, and the goods manufactured in Mecca and the surrounding areas to sell in the markets of Syria and Yemen. In addition, there were side trips that went from Mecca to the rest of Arabian Peninsula (`Imadi 1997, 83).

The Mecca winter caravans moved out to Yemen in the winter season to meet the ships coming to the Yemeni ports from India, East Africa, China and other eastern countries. The Mecca caravans carried to Yemen and its ports dates, wool, camel hair, shortening and other goods. When the caravans returned to Sana market, located in the Yemen, they carried various goods, such as perfumes, leathers, weapons, and ores, which came from different areas. There were strong trading relationships between the Yemen people and Mecca (Fig. 3.9).

Figure 3.9. Map of Arabian Peninsulashowing trade routes and markets. Month of market is following name of city, i.e. (3) (Brice 1980, 15).

In contrast, Mecca summer caravans went to Syria every summer during the time of the southwest monsoon, when navigation movement in the West Indian Ocean was stopped. The goods that the Quraysh caravan carried to Syria from Yemen during its winter trip came from India, China, East Africa, and so on. These goods were leathers, spices, ivory, gold, gemstones, perfumes, incense, ebony, sandalwood, silk, iron, weapons, saffron and other valuable goods. On the return journey from Syria the caravans were laden with wheat, oil olive, wines, textiles, and other goods. The market of Bosra (in Syria) on the route of Mecca winter caravans was a place where they stopped to buy and sell, both on their way to Syria and on their way back to Mecca.

Mecca became a very important trading center. The Quraysh also profited by sending caravans with surplus goods to other trading centers, as follows:

1. Mecca-Abyssinia (Ethiopia): Abyssinia was the main source for incense, ivory, leather, spices, and ostrich features. In addition to sending camel caravans to Abyssinia, some merchants from Mecca used the sea to transport goods by the port of "Al-Shiabh" to Abyssia and other African ports.

2. Mecca-Iraq: Small caravans also went to Iraq to sell goods and return with new goods. These trading journeys were usually undertaken privately by wealthy merchants. They could occur in any season.

3. Mecca-Hijaz towns of "Al-Taif and Al-Madianh": Because Al-Madianh and Al-Taif were located on the route of the Mecca summer caravans, they became very important caravan stops and trading stations.

Markets or bazaars were also established in settlements located between the caravans' routes. The trading activities of Mecca were not limited to Mecca and its vicinity. They extended to different Arabic markets that took place across the Arab peninsula throughout the year. Each market had its month to be open for trade. Mecca traders went to buy and sell at the following markets (Fig. 3.9):

- Duma: It started in the first day of the third Arabic month (April)
- Oman: It was a very big market with goods from India, Persian, Abyssinia, Yemen, Higaz, and Syria. It started in the fifth Arabic month (May)
- Hobash: It took place in the seventh Arabic month. Higaz and Yemeni natives traded there (July)
- Dir Ayob and Bosra: Both were located in Syria. They started in the twelfth Arabic month (December)
- Besides these markets, there was an important market around Mecca. This market named "Ukaz" attracted Arabs from different places, such as Iraq, Bahrain, Yamama, Oman, Yemen and Shaher. It lasted from the fifteenth day of the eleventh Arabic month (November) until the twentieth day of that month. Goods traded there included wines from Iraq, and oil, raisins and weapons from Syria. When "Ukaz" closed, there were Higz markets like "Majanh," which started in the last nine days of the eleventh month (November). When it closed the people went on to other markets (Morse 2000, 77).

- There were markets like Hadjr, which started in the fourth Arabic month (April); Al-Mashkar, which started in the sixth Arabic month (June); Sahar, which started in the seventh Arabic month (July); Duba, which started in the seventh Arabic month (July); Al-Shiher, which started in the eighth Arabic month (August); Aden, which started in the ninth Arabic month (October); Sana, which started in the ninth Arabic month (October); and Hadhramaut, which started in the eleventh Arabic month (November). All of them were important trade centers (`Imadi 1997, 105).

The pilgrim season, however was an even more profitable season for the Quraysh. The Quraysh could sell goods to the pilgrims and to the nomads who came from the semi-desert and the far villages to Mecca. Sometimes the Quraysh bought goods that those people had bought with them. The surplus goods they traded by caravans to areas away from Mecca (Morse 2000, 77). The commerce of Mecca was not limited to a specific group, but was flexible enough to accept anyone. Men and women, young and old, were free to participate (`Imadi 1997, 86).

Mecca had been the focus of pilgrims, travelers and merchants since long before Islam. From the time of the construction of the Ka'bah (according to Muslim tradition by Ibrahim) and after the rise of Islam, people from far lands visited Mecca and performed the rites of the pilgrimage. Mecca was considered not only a sacred city, but also a commercial center. The reason was its location on the ancient trade routes that connected the rich Arab states in South Arabia with Egypt, Palestine and Mesopotamia (Al-Rashid 1980, 1). It is written in the Qur'an in the name of Allah, “And proclaim the pilgrimage among men. They will come to thee on foot and (mounted) on every kind of camel, lean on account of journeys through deep and distant mountain highways…” (Qur’an 22:27). The “Hajj”, as the pilgrimage to Mecca is known, is a journey to the sacred place of Mecca as an act of religious devotion. Islam has five pillars; the Hajj is the fifth and final pillar of Islam. Performing it at least once is required of every Muslim who is able, physically and financially, to go on the Hajj journey. The Hajj set large numbers of people traveling to Mecca, the heart of Islam, and to Madinah, the city where the first Muslim community was formed and where the prophet Muhammad is buried. Pilgrims traveled to Mecca either by land or by sea (Fig. 3.10 and 3.11).

There were seven main routes for pilgrims in the Arabian Peninsula. These routes intersected or were joined with each other by means of subsidiary routes. These pilgrim routes were maintained by the Muslim caliphs and their governments. Some of these routes continued in use until recently, while others fell out of use. Along these routes there were way stations, rest areas, and caravansaries (inns), all of them provided with wells or pools, markets and mosques (Al-Rashid 2001, 1) (Fig. 3.12). The information about pilgrim routes comes from the early Muslim geographers who recorded the major routes and listed the main stations in between. They also gave the distances between the stages stated in miles, barids (Postal Stages), farsakhs or marahalas (a day’s journey). They also recorded landmarks to guide the travelers and caravans, like lanterns, stones, a’lam and flags. Some

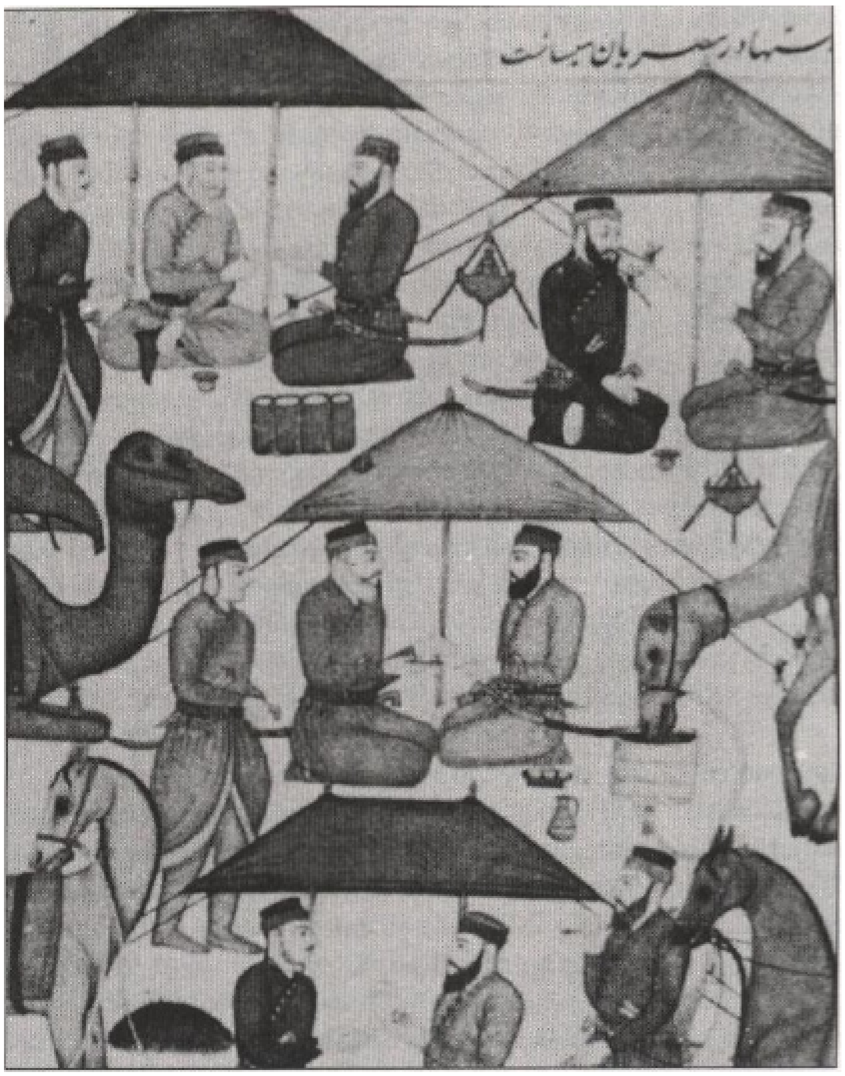

Figure 3.10. Pilgrims in caravan from Syria to Mecca at rest stop with their camels (Pearson 1996, 123).

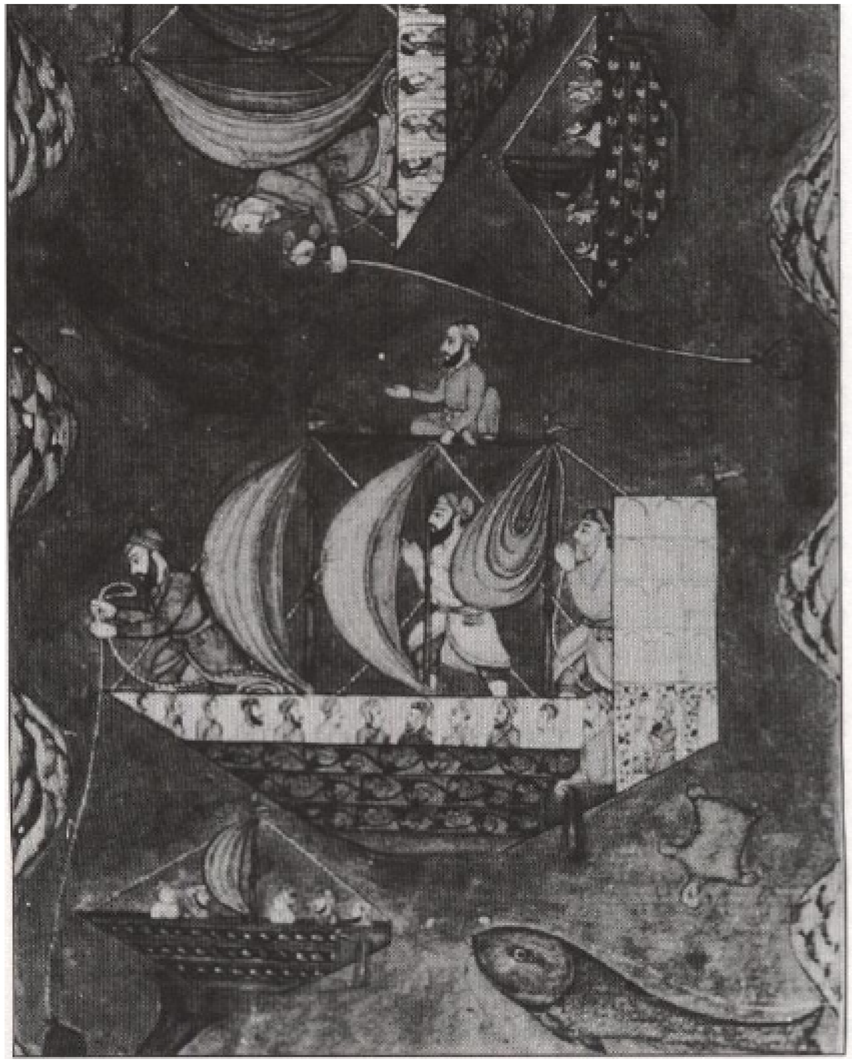

Figure 3.11. Thirteenth-century Arab painting style shows sailors on deck of ship at larger scale than row of passengers beneath them (Pearson 1996, 139).

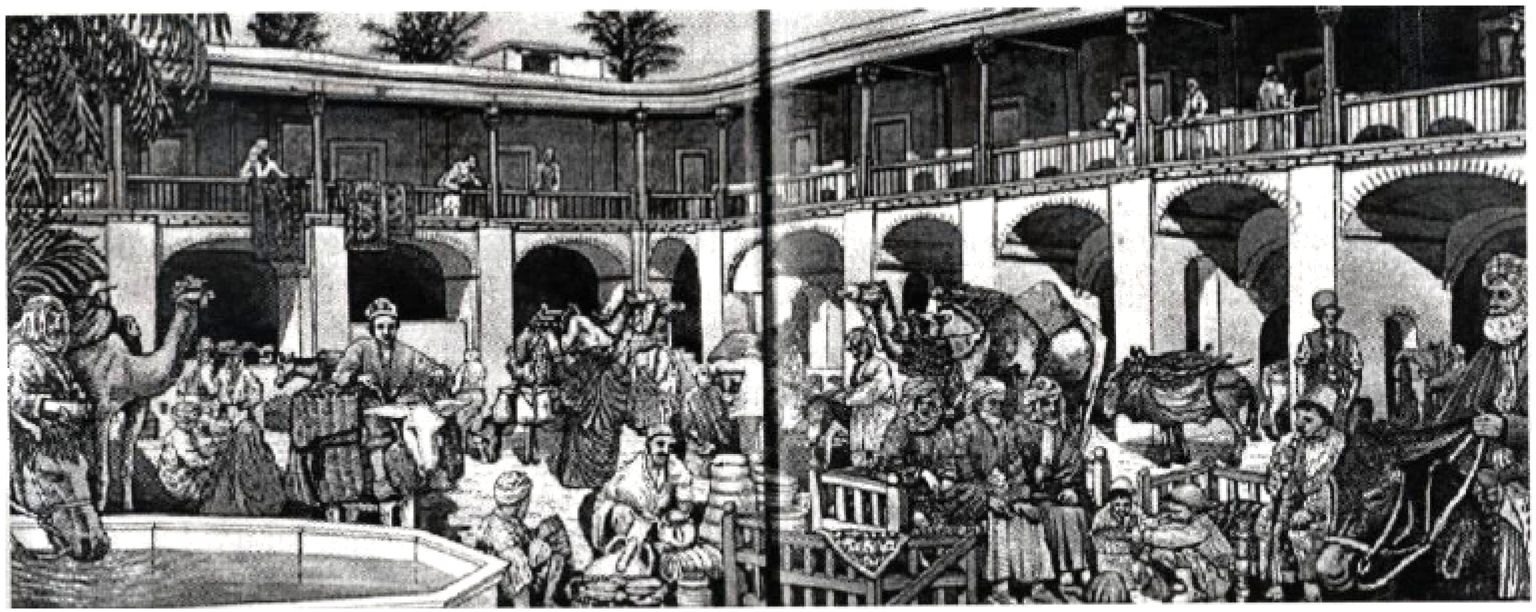

Figure 3.12. Caravan resting at caravansary (inn), which typically provided wells, pools, markets and mosques, as a well as a place to stay (Leacroft 1976).

geographers held governmental posts that gave them access to official records regarding the caravan routes. These records were concerned with trade and military interests in addition to their function for religious purposes (Al-Rashid 1980, 2).

Some of these geographers and their best-known travel books were: Ibn Battuta (1304-1368 A.D.) and his "Travels" (1356 A.D.), Ibn Restah and his "Precious Records" (900s A.D.), Almaqdsi (946-1000 A.D.) and his "The Best of Divisions for the Classification of the Climes" (in 985 A.D.), Yaqut al-Hamway (1179-1229 A.D.) and his book "Countries Dictionary", and Al-Hamadani (893-970 A.D.) and his "Surat al al-Jazerah al'Arabia" (Description of Arab Peninsula) (Al-Rashid 2001, 1; Al-Rashid 1980, 2).

The pilgrim routes were as follows:

1. Damascus - Mecca: It was the longest route, the distance from Damascus to al-Median (close to Mecca) being about 1300 kilometers. The caravan usually covered the distance in forty-five to sixty days. There were about twenty- three caravan rest stops along the route between the two towns (Fig. 3.13).
2. Al-Kufa- Mecca: This was considered the most important pilgrim route. The pilgrim caravan left from Kufa and from there passed many towns and villages until it reached Mecca. In 751, the first Abbasid caliph, "Al-Saffah", ordered several landmarks to be established along the route from Kufa to Mecca. These landmarks were fire signals and milestones. Al-Mansur followed him by ordering additional forts built. Al-Mahdi initiated upon several projects to clear the route.

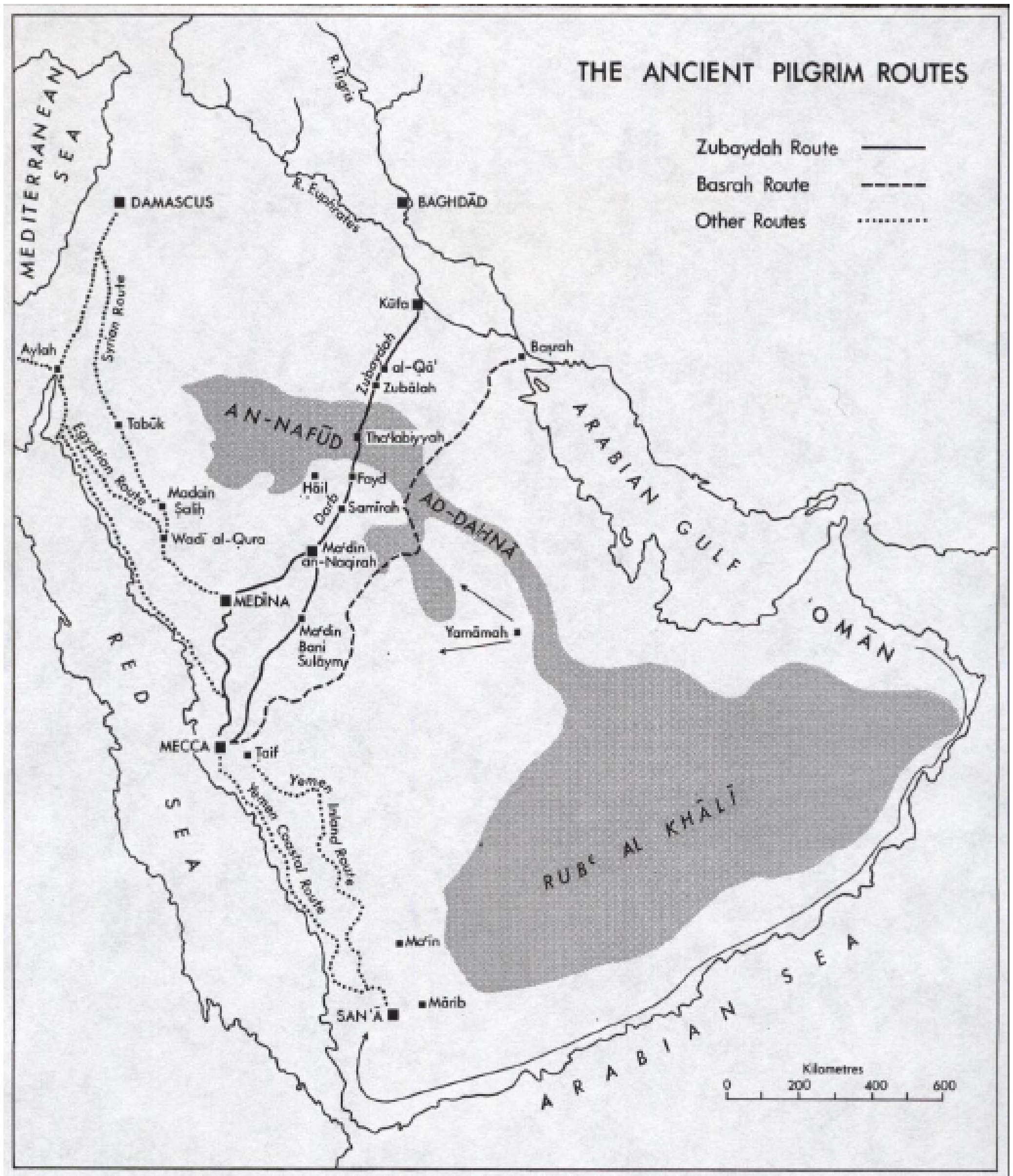

Figure 3.13. Map showing pilgrim routes to Mecca (Al-Rashid 1980, 1).

This route has been also called as “Darb Zubayda” (Zaubayda’s Way) (Fig. 3.14) after the women who made two improvements in this route: the first one established abundant drinking water in Mecca, and the second built new rest stops, water tanks and way stations along the route. In addition, the Abbasid treasury paid for hostels, fortresses, stations with wells, reservoirs or cisterns, fire signal towers and milestones (Fig. 3.15). Ibn Jubayr wrote about the Kufa-Mecca route after seeing it:

> “these tanks, pools, wells and stations on the road from Baghdad to Mecca are monuments to Zubaydah, daughter of Ja’far al-Mansur and wife and cousin of [the caliph] Harun al-Rashid, who applied herself to this throughout her life, leaving on this road facilities and useful works which from her death until today have been of service to all who every year go on an embassy [pilgrimage] to God most High. But for her generous acts in this direction this road could not have been traversed. God in His satisfaction will ensure her reward”
>
> (Ibn Jubayr 1907, 208)

The distance from Kufa to Mecca was about 1500 kilometers (Fig. 3.13).

3. Basra-Mecca: the pilgrim caravan departed from Basra and followed a shorter route to Mecca. It was smaller than the Kufa caravan; it consisted mostly of Iranians and others who did not want to travel to Kufa. Services for travelers were provided along this route. The distance from Basra to Mecca was about 1200 kilometers (Fig. 3.13).
4. Oman-Mecca: It consisted of two routes, one along the coast and the other inland.

5. Interior Yemen-Mecca: It left from Sana and followed the mountain ranges until it reached Mecca. There were twenty-five main rest stops along it (Fig. 13).

Figure 3.14. Areal photograph showing Darb Zubaydah, visible as
a fairly straight line in the plain of Sahl Kakbah (Al-Rashid 1980, 401).

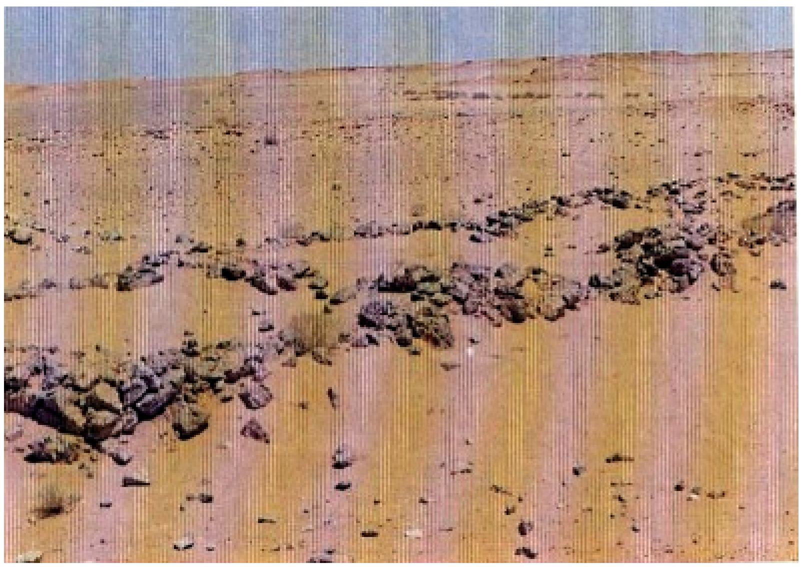

Figure 3.15. Remains of ancient stone foundations of rest houses at al-Haytham (Al-Rashid 1980, 368).

6. Coastal Yemen-Mecca: It left from Sana and followed the Red Sea coast. There were twenty-one rest stations (Fig. 3.13).
7. Egypt-Mecca: It included pilgrims from Egypt, plus pilgrims from North Africa (Fig. 3.16). There were two routes to reach Mecca. The first one started from Cairo and crossed Sinai to reach Mecca. The second one started from Cairo and turned south until it reached port of Ayzdab on the Red Sea (Fig. 3.17). From there they went by ship to Mecca. The Egyptian caravan took around forty days to reach Mecca. It was divided into thirty-four stages, each about forty-five to fifty kilometers. There were many rest stations along the route.

Besides these major pilgrim routes, there were several lesser pilgrim routes. For example, pilgrim caravans came from Iran, east and central Africa, India, and Malaya.

A journey to the holy cities was always full of danger: diseases, war, robbery, and killing. Other problems encountered were destroyed wells and abandoned or dilapidated rest stations, contributing to the danger of starvation and thirst. Natural disasters that faced them included storms, cold, heavy rain, and floods (Al-Rashid 2001, 1).

Land Routes:

The Arabian Peninsula was already crossed by networks of land routes before the rise of Islam. These routes were used for diverse purposes, especially economic (after Mecca began to flourish as a trade center in the sixth century) and religious

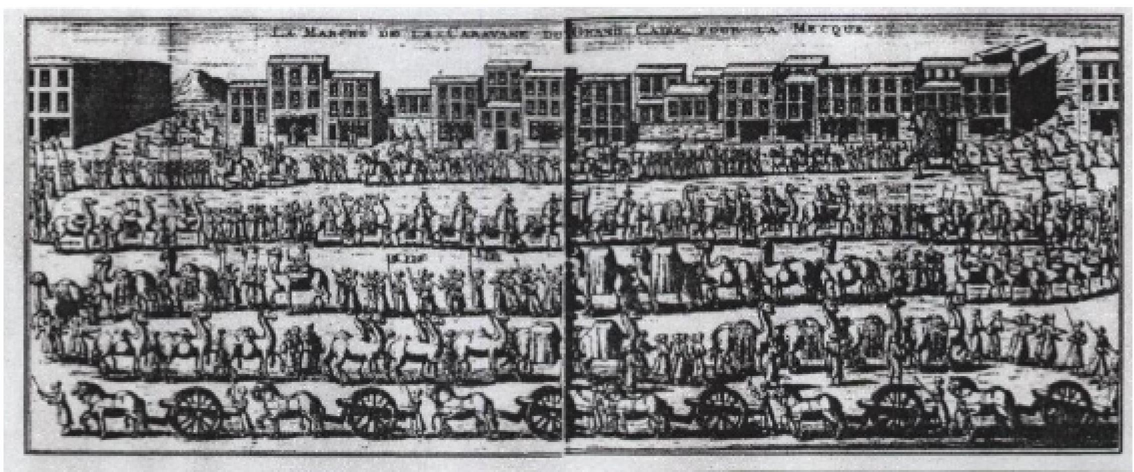

Figure 3.16. French print showing great caravan leaving Cairo for Mecca (Pearson 1994, 136).

Figure 3.17. Map showing pilgrim routes to Mecca, including routes from Cairo (Brice 1980, 22).

pilgrimage. Following the rise of Islam traffic increased, so the Arabs made an effort to improve and pave these routes. Also, the Arabs placed markers to guide travelers and caravans. At first, they erected markers to show just the beginning of the route and its end. Later on, they put markers or signs along the route. These markers consisted of lanterns or piles of stones. Another Arab innovation was to systematize the routes, dividing them into sections by building caravansaries (inns) at suitable intervals (Fig. 3.18). These caravansaries served as stopping places along the trade routes, providing caravans with food and water, and places to rest. Some of the caravansaries were large enough to house large numbers of camels and travelers. They provided sleeping rooms, bathing facilities, storage rooms for goods and a mosque for religious observance. The distances between the caravansaries depended on the availability of water, sometimes close together and sometimes far apart (`Imadi 1997, 90) (Fig. 3.19).

The most important caravansaries on the routes to Mecca and al-Madinah lay on routes which came from Egypt, Damascus, Iraq, and Yemen. These caravansaries were set at intersections (such as al-Nabaj in Najed where the route branched, one route going to Mecca and the other going to al-Madinah) or on the route between two towns (such as Fied located between al-Kufa and Mecca, also between Baghdad and Mecca) (Fig. 3.13 shows Fied as Fayd).

Fied began as a small town on the caravan route to Mecca; later in the Islamic period it became a huge town on the Iraqi pilgrimage routes from al-Kufa and Baghdad to Mecca. The Arab Caliphs made improvements at Fied, such as digging

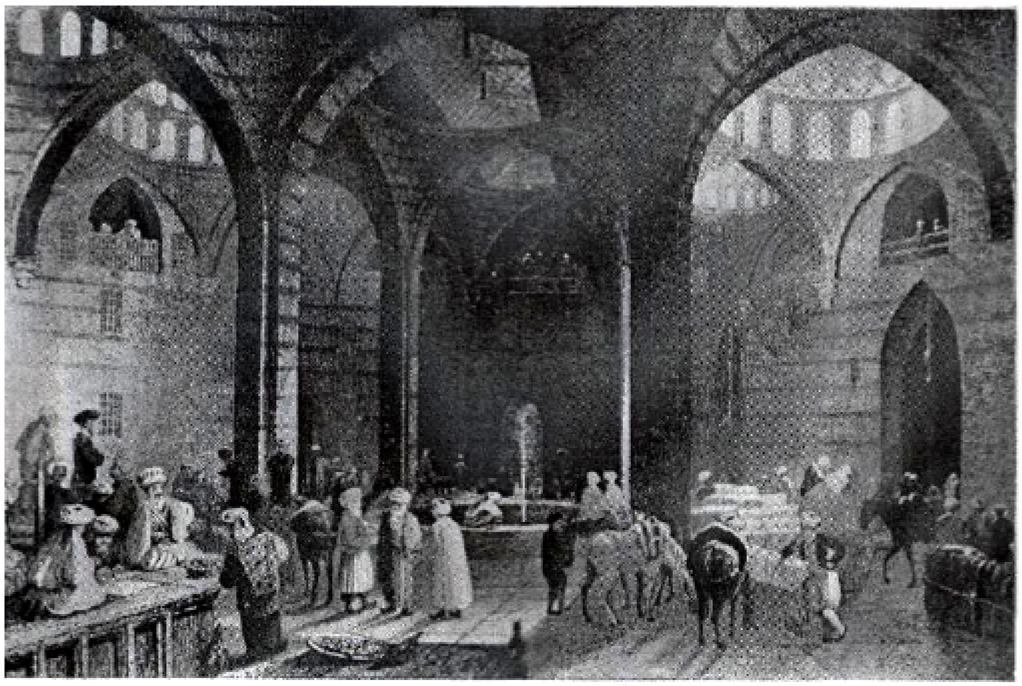

Figure 3.18. Interior view of caravansary at Damascus (Grant 1938, 145).

Figure 3.19. Caravan at water hole between Sukhna and Resafa (Grant 1938, 160).

numerous of wells to meet the requirements of the caravans (`Imadi 1997, 253). Al-Hurbi (d. 898 A.D.) in his"AlMasalik w Amaken Toreq Al Haj w Maalem Al Jazerah" (Trails and Places of Pilgrim Routes and Forms of Peninsula) said that Fied had the sultan's palace, groves of trees, forts, big mosques, fountains and pools. This description indicates Fied's importance as a stop for pilgrims on their way to Mecca (Fig. 3.20) (Al-Harbi 1969, 309).

Al-Nabaj was also a rest stop for caravans. It lay on the pilgrimage route from Basra, also becoming popular in the early centuries of Islam. It is described in the Arab geography books as a big place with markets, plentiful water, palm trees, farms and impressive buildings. Besides these rest stops, there were numerous others mentioned in the Arab travel and geography books, such as Ibn Khurdadah (820-912 A.D.) (On Routes and Kingdoms), Ibn Rustah (900s A.D.) (Precious Records), and Al Hurbi (d. 898 A.D.) (Trails and Places of Pilgrim Routes and Forms of Peninsula) (`Imadi 1997, 253).

The trade of Mecca depended on the caravans traveling different routes and tracks across the Arabian lands. Many sources mention the number of routes that link Mecca and other routes that are also followed by the trade caravans to Yemen, Syria, Damascus, Jordan and Iraq. The oldest and most popular caravan route extends from the most southern point of the Arabian Peninsula to its most northern point. This route which linked Aden in Yemen and Damascus in Syria passed through Mecca. These routes formed a radial network centered on Mecca, the commercial as well as the religious hub of Arabia (Fig. 3.17). The major land trade routes were:

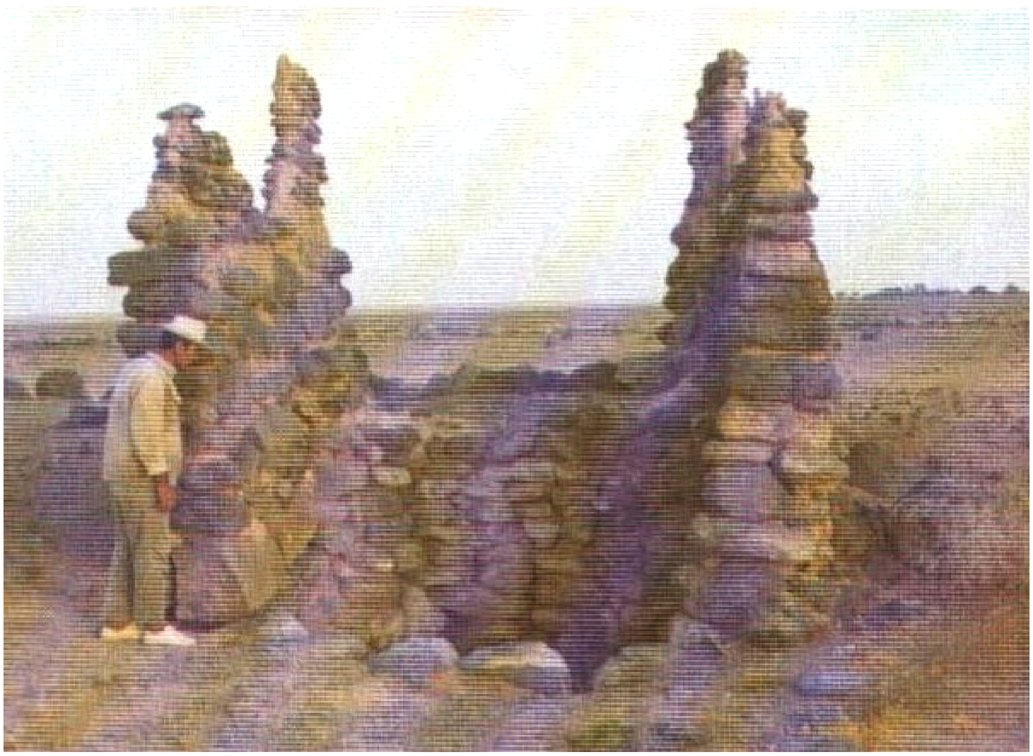

Figure 3.20. Ancient well at Fied (Fayd) still supplies fresh water (Al-Rashid 1980, 384).

1. Yemen-Mecca: There were different kinds of routes linking Yemen and Mecca. Some of them crossed the desert interior, and others followed the coast. The main route between Yemen and Mecca was called Al-Fotoq. There were many trading stations along the Al-Fotoq route. Another route over the mountain called "Al-Watr" linked Yemen and Mecca. There was also the Sana-Mecca route which started from Al-Rhaba, then continued through Rafeda, Kayawan, Saada, Al-Qasabah, Jasda, Besha, Tabla, Fatea, Bostan Ibn Amer and finally to Mecca. There was also the Aden-Mecca Route.

2. Damascus-Mecca.
3. Mecca-Iraq (several routes). For example, there was the Al-Hira-Mecca route, but the main route that linked Iraq to Mecca was called the Al-Mathqeb.
4. Najed-Mecca.
5. Yememah-Mecca.
6. Mecca-Oman (coastal route).
7. Mecca-al-Taif (two routes).
8. Mecca-al-Madinah.
9. Egypt-Mecca. As soon as this route reached the Arabia peninsula, it divided into two subsidiary routes (Morse 2000, 83; Ibrahim 2002, 41).

These were the most important routes that were followed by the caravans on their way to and from Yemen, Syria, Egypt, and Iraq. There were also subsidiary routes that linked the major routes.

The caravans that followed these routes consisted of different crew members, each of whom played a different role in the operation of the caravan.

Members of an Arab Caravan Crew:

Just as the members of an Arab ship's crew formed a hierarchy of different roles, each important for the success of the voyage, so too, the members of the Arab caravan.

1. Caravan Leader: He was called the "amir al-hajj" (Leader of Pilgrimage). In some cases, this was the caliph himself or a governor. The caravan leader had many important duties, such as overseeing the caravan, deciding the order of march, and ensuring the safety of the voyage. No one could drop out or change position without his permission. He was always a man of great personal integrity who was respected and feared by everyone (Saudi Aramco 1964, 1) (Fig. 3.21). Upon his judgment and decisions depended the success of the caravan in its business of buying and selling. As well, the caravan leader had to have the skills to guide his caravan in the trackless desert day and night. He had to know the relative position of the stars. He had to assure that water would be available during the long journey north to Syria or south to Yemen. He also had to take precautions against hazards like sand-storms and flash floods. He had to be prepared to administer "first aid" to sick or injured travelers. In other words, he had to be capable of handling any emergency on a long-distance journey (`Imadi 1997, 89).

Figure 3.21. Leader of caravan surrounded by bundles of goods (Grant 1938, 160).

2. Official guide: He was the “daleel” (guide), who saw to the details of the itinerary, watched for robbers and acted as interpreter. He set the length of each day’s travel and decided where they should camp at night. In some cases, he also played the role of military or political spy (Saudi Aramco 1964, 1).
3. Navigator: He was a professional navigator who knew the desert landmarks along the route. Such navigators usually took their sons along on the journey in order to teach them the craft, so they could one day become caravan guides (Saudi Aramco 1964, 1).
4. Couriers: There were two kinds of couriers. The “basheers” (omen) carried good news, while the “nadders” carried bad news. It was the nadder who raced to the nearest place for assistance when the caravan was in danger (Saudi Aramco 1964, 1).
5. Guard: He protected the caravans from robbery and murder by desert brigands. The numbers of guards depended on the size of the caravan and the goods that it was carrying (Saudi Aramco 1964, 1).
6. Camel driver: He owned and looked after the camels. He contracted to provide the merchants with the camels (Saudi Aramco 1964, 1).

Additional caravan crew members included medics, water carriers, torchbearers, scouts, cooks and soldiers (Tschanz 2004, 1).

Through reading about the members of an Arab caravan crew mentioned above we can see how the roles were divided between them. Each one had a specific job to do on their journeys, and they worked as a team, cooperating to achieve their goals.

Ibn Battuta as a Case Example:

Arab traders traveled widely east and west of Arabia. The traveling merchants needed maps and detailed information about the cities they visited. These traveling merchants kept detailed records of their journeys. Through their writings they shared their accounts of their experiences with other merchants or caravans. One such traveling geographer was Ibn Battuta.

Sheikh Abu Abdallah Muhammad Ibn Muhammad Ibn Ibrahim Al-Lawati is generally known as Ibn Battuta. He was born in Tangier, Morocco, in 1304 into a family who were traditionally judges. He studied law. When he was twenty one, he set out to make a pilgrimage to Mecca before completing his law studies. His travels lasted for about thirty years, after which he decided to settle in Fez, Morocco. He wrote accounts of his travel by order of the Sultan of Fez. He died at Fez in 1368 (Massasati 1997, 6).

During almost thirty years (1325-1355) he covered a total distance of approximately 73,000 miles, visiting the equivalent of forty-four modern countries (Fig. 3.22), both by land caravans and seagoing ships. Starting from his home in Tangier, he made his way across the North Africa, Egypt, Palestine and Syria. He took a year and a half to reach Mecca. After completing his first Hajj, he decided to devote himself to travel. He avoided using the same route twice in order to see new routes and places. He visited the Arabian Peninsula, Red Sea, East Coast of Africa,

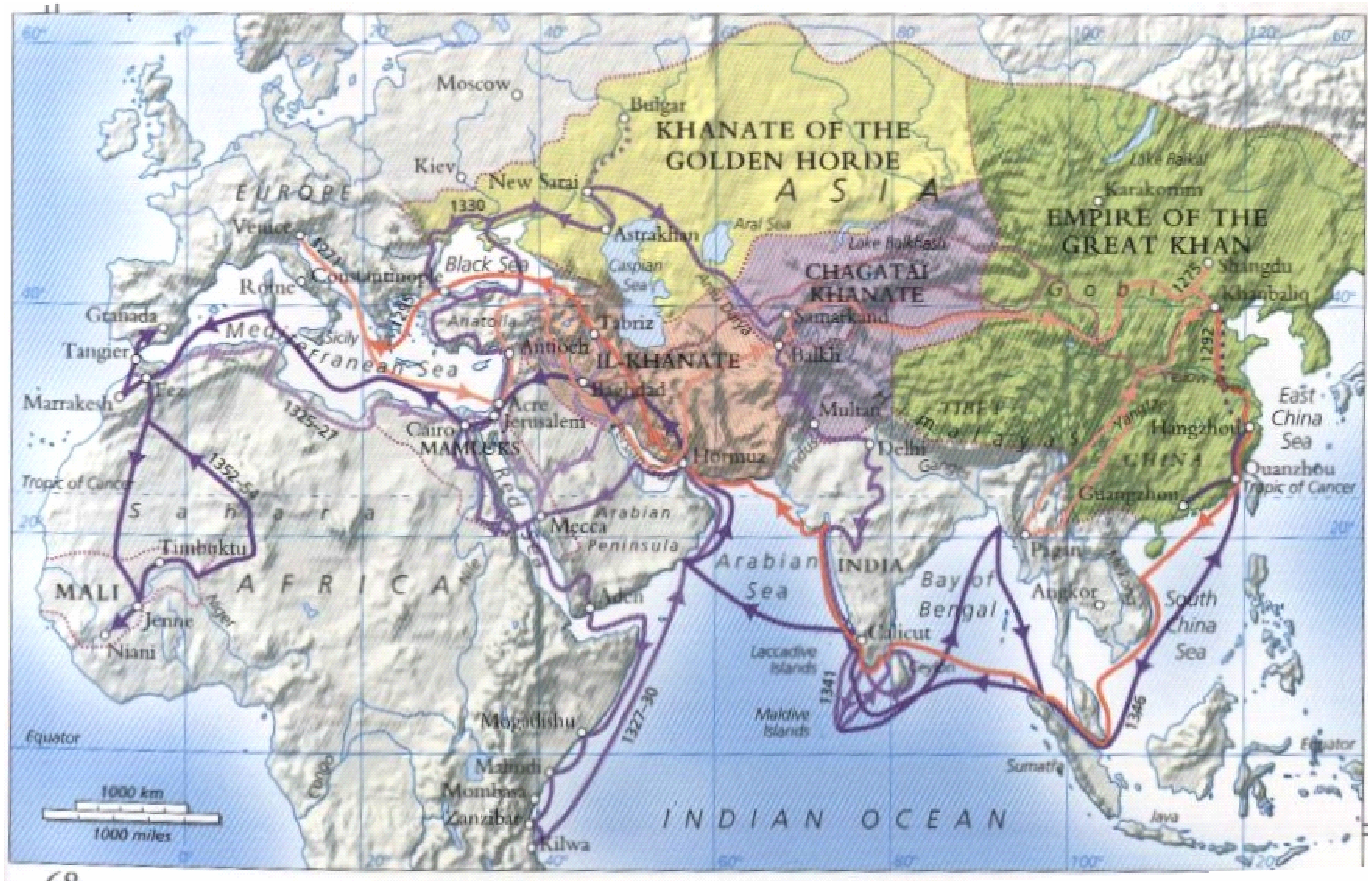

Figure 3.22. Map comparing travels of Ibn Battauta (1325-1345, purple line) and Marco Polo (1271-1295, red line) (Black 2004, 68).

East and North Baghdad, Persia, Black Sea, the Russian Steppes, Bukhara, Samarkand, Delhi, Afghanistan, India, China, Indonesia, the Maldives Islands, Ceylon, Sumatra and Spain. The rulers of the cities and countries he visited frequently employed him as a judge (Ross 1989, 1).

In 1356, at the insistence of the Sultan of Morocco, Ibn Battuta recorded the observations and experiences of his journeys in a book called “Rihala” or “Tuhfat al-Nuzzar fi ‘Aja’ib al-Amsar”(The Book of the Travel). It is a comprehensive survey of the places, governments, customs, personalities and curiosities of the Muslim world during the Middle Ages. Originally written in manuscript, this book has since been published in many languages, including Persian, German, Spanish, Hungarian, Italian, Polish, Russian, and Japanese (Ross 1989, 1). It was transcribed by the secretary of the Sultan of Fez, “Ibn Jazay”.

Ibn Battuta was one of the most remarkable travelers of all time, visiting China only sixty years after Marco Polo. In addition, he covered much more territory than Marco Polo (Chughtai 1990, 2). His observations included the first attempt to open the Pyramids in Egypt and the use of paper money in China (Massasati 1997, 6). Ibn Battuta described how the Chinese use coal: “they make fires with stones which burn like charcoal, and when then are burned to ashes, they knead these with water, dry them in the sun, and use them for cooking again until they are entirely consumed” (Nafis 1943, 258).

He was a traveler, not a navigator. He took advantage of the system of land and sea transportation and the navigational skills of others to gain geographical experience and knowledge. His travels and geographical writings were made possible by the great Arab network of commercial and pilgrimage travel routes. At the same time that he explored, traveled and experienced the travel routes, he recorded them for posterity.

Here are several examples from Ibn Battuta's accounts of land travel. Ibn Battuta leaves Hormuz by land and crosses a desert, explaining in graphic detail the danger of the samum monsoon winds in June and July:

> We set out from Hormuz [by boat] to visit a saintly man [guard] in the Town of Khunjubal, and after crossing the strait, hired mounts from the Turkmens who live in that country. No travelling can be done there except in their company, because of their bravery and knowledge of the roads. In these parts there is a desert four days' journey in extent, which is the haunt of Arab brigands, and in which the deadly samum [simoom] blows in June and July. All who are overtaken by it perish, and I was told that when a man has fallen a victim to this wind and his friends attempt to wash his body [for burial], all his limbs fall apart. All along the road there are graves of persons who have succumbed there to this wind.

Next Ibn Battuta talks about the strategy of traveling at night and resting from sunrise until late afternoon to avoid the heat of the sun. Also, he mentions a story about a person who was building hospices and entertaining travelers with money that he gained by robbery.

> We used to travel by night, and halt from sunrise until late afternoon in the shade of the trees. This desert was the scene of the exploits of the famous brigand Jamal al-Luk, who had under him a band of Arab and Persian horsemen. He used to build hospices and entertain travellers with the money that he gained by robbery, and it is said that he used to claim that he never

> employed violence except against those who did not pay the tithes on their property. No king could do anything against him, but afterwards he repented and gave himself up to ascetic practices and his grave is now a place of pilgrimage.
>
> (Gibb 1929, 120)

At the oasis of Tisarahla, the caravan replenishes its water supply and hires a desert guide, called a “takshif”:

> We came next to Tisarahla, a place of subterranean water-beds, where the caravans halt. They stay there three days to rest, mend their waterskins, fill them with water, and sew on them covers of sackcloth as a precaution against the wind. From this point the "takshif" is despatched. The "takshif" is a name given to any man of the Massufa tribe who is hired by the persons in the caravan to go ahead to Iwalatan, carrying letters from them to their friends there, so that they may take lodgings for them. These persons then come out a distance of four nights' journey to meet the caravan, and bring water with them. Anyone who has no friend in Iwalatan writes to some merchant well known for his worthy character who then undertakes the same services for him. It often happens that the "takshif" perishes in this desert, with the result that the people of Iwalatan know nothing about the caravan, and all or most of those who are with it perish. That desert is haunted by demons; if the "takshif" be alone, they make sport of him and disorder his mind, so that he loses his way and perishes. For there is no visible road or track in these parts, nothing but sand blown hither and thither by the wind. You see hills of sand in one place, and afterwards you will see them moved to quite another place. The guide there [sic] is one who has made the journey frequently in both directions, and who is gifted with a quick intelligence. I remarked, as a strange thing, that the guide whom we had was blind in one eye, and diseased in the other, yet he had the best knowledge of the road of any man. We hired the "takshif" on this journey for a hundred gold mithqals; he was a man of the Massufa. On the night of the seventh day [from Tasarahla] we saw with joy the fires of the party who had come out to meet us.
>
> (Gibb 1929, 318)

From his diary or travel book, we can tell that Ibn Battuta was not a navigator but rather a traveler who recorded his observations of his trip in his travel account.

This chapter has surveyed the different instruments and techniques of land navigation used by Arabs. It began with the traditional use of the positions and movements of the sun and stars to guide Arab travelers. It continued with the later development and use by Arabs of scientific instruments for astronomical position finding. An example of the conscious borrowing of the mariner's magnetic compass for guiding caravans in desert sandstorms was also mentioned.

However, much more widely used were the different landmarks and markers that provided travelers with guidance along established routes. Also, they hired guides who were familiar with the local environment. The use of pack animals suited to different types of terrain and the seasons for travel were also mentioned as factors in route selection.

The oral tradition was an important source of land navigation knowledge. Over the years, however, caravan leaders amplified their memories by collecting written traveling directions in books called Kitab al-Rihlat (travel book). Such travel books described travel routes, landmarks and environmental cues, and the peoples and customs of different places. Some of the travel books included maps, but the Arab travelers often used their mental maps for wayfinding. The chapter ended with one of the best known Arab travelers, Ibn Battuta, whose geographical writings display enormous knowledge of many lands gained through firsthand experience. The two chapters covering sea and land navigation have shown that Arabs employed similar techniques in both but that the relative use of the various techniques differed considerably between land and sea environments. At sea the use of landmarks and environmental cues for piloting was limited to coastal waters, while land travelers used them throughout their journeys. Although Arabs guiding land caravans followed the sun and stars, too, astronomical instruments and the magnetic compass were less significant than at sea. Ship's captains observed the sun and stars, combining the traditional star compass rose with the magnetic compass, to aid them in navigating by dead reckoning during open-sea sailing. Travel books developed out of both sea and land oral traditions, but the books of sailing directions include much more information for celestial navigation along with coastal landmarks, while the land travel books emphasize landmarks and distances along routes, as well as accommodations and commerce at trading centers. Finally, although no original early Arab sea charts have survived, the numerous land travel books illustrated with maps help to trace the development of a strong tradition of Arab geographical writing.

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The third chapter will discuss in detail the mid-12th-century writings and maps of Al-Idrisi, the Arab geographer whose work is generally acknowledged as representing the culmination of the Arab geographical tradition. Al-Idrisi had been comissioned by Roger II, the king of Sicily, to map and describe in accurate detail the network of routes taken and places visited by Arab traders and pilgrims traveling in a region that extended from Spain and North Africa in the West to China in the East. Whereas Al Majid was a sea navigator and Ibn Battuta primarily a land traveler, Al Idrisi's maps and text link the two traditions in a more comprehensive overview.

Chapter 4. Al-Idrisi

In the year 1138 A.D., there was a long-awaited meeting between the remarkable Christian King, Roger II of Sicily, and the distinguished Muslim scholar, Al-Idrisi, in the royal palace at Palermo, Sicily. Roger welcomed his guest, and the two men began to discuss the project for which the scholar had been asked to come from North Africa, which was to create the first accurate and scientific map of the entire known world.

Al-Idrisi was an Arab geographer whose work on the project would result in the completion of three major geographic works in 1154 A.D.: (1) a silver planisphere on which was depicted a map of the world, (2) a world map consisting of 70 sections formed by dividing the Earth north of the Equator into seven climatic zones of equal width, each of which was subdivided into ten equal parts by lines of longitude, and (3) a geographic text intended as an explanation of the sectional maps. Putting the 70 sectional maps and their descriptions together created his great work of descriptive geography, known as "Kitab nuzhat al-mushtaq fi ikhtiraq al-afaq" (Amusement for Him Who Desires to Travel Round the World) and also as Kita Rujar, or Al-Kitab ar-Rujari" (The Book of Roger). It was written in Arabic and Latin. The maps were as important as the text.

The book begins by describing the earth as a sphere, following Ptolemy in placing it at the center of the universe. Following the classical Greek tradition, Al-Idrisi divided the world into seven climatic zones or climes from south to north. These climes appear as curved bands on the small circular world map in Al-Idrisi's book (Fig. 4.1). For the purpose of describing the geography of the ecumene (inhabited world) systematically, he divided each clime into ten sections from east to west and described each in turn. The text descriptions of the sections were paired with seventy sectional maps which, when put together, made a rectangular map of the known world (Fig. 4.2). The map is oriented with south at the top, and Arabia, being the site of Mecca, was depicted at its center (Parry 2004, 29). It is worthwhile to draw attention to this great work and explain its influence on European geography.

Al Idrisi, who is best known in the West as a geographer and cartographer, was also a doctor and botanist. He was born in 1100 A.D. in Ceuta, Morocco and educated at the University of Cordoba, Spain, at the time the greatest center of learning in Europe. After studying in Cordoba, he had spent some years in travel, journeying as far north as Britain, covering the length of the Mediterranean, from Lisbon to Damascus, and also visiting central Asia.

In the early 11th century Count Roger d'Hauteville with a band of Norman adventurers invaded southern Italy and took it from the Byzantine Greeks and the Muslims, capping his career by dominating Sicily in 1101. Four years later, he passed the territory on to his son, Roger, who in 1130 was crowned king as Roger II. He ruled his kingdom with a balanced mixture of diplomacy, wisdom, ruthlessness and skill that made his kingdom, according to many historians, the best-governed European state of the Middle Ages. His court boasted a collection of philosophers, doctors, mathematicians, geographers and poets that had no superior in Europe and in whose company he spent much of his time. Al-Idrisi wrote of his patron:

Figure 4.1. Small world map by Al-Idrisi, Book of Roger, 1154 A.D. oriented with south at top (Bagrow-Skelton 1966, 57).

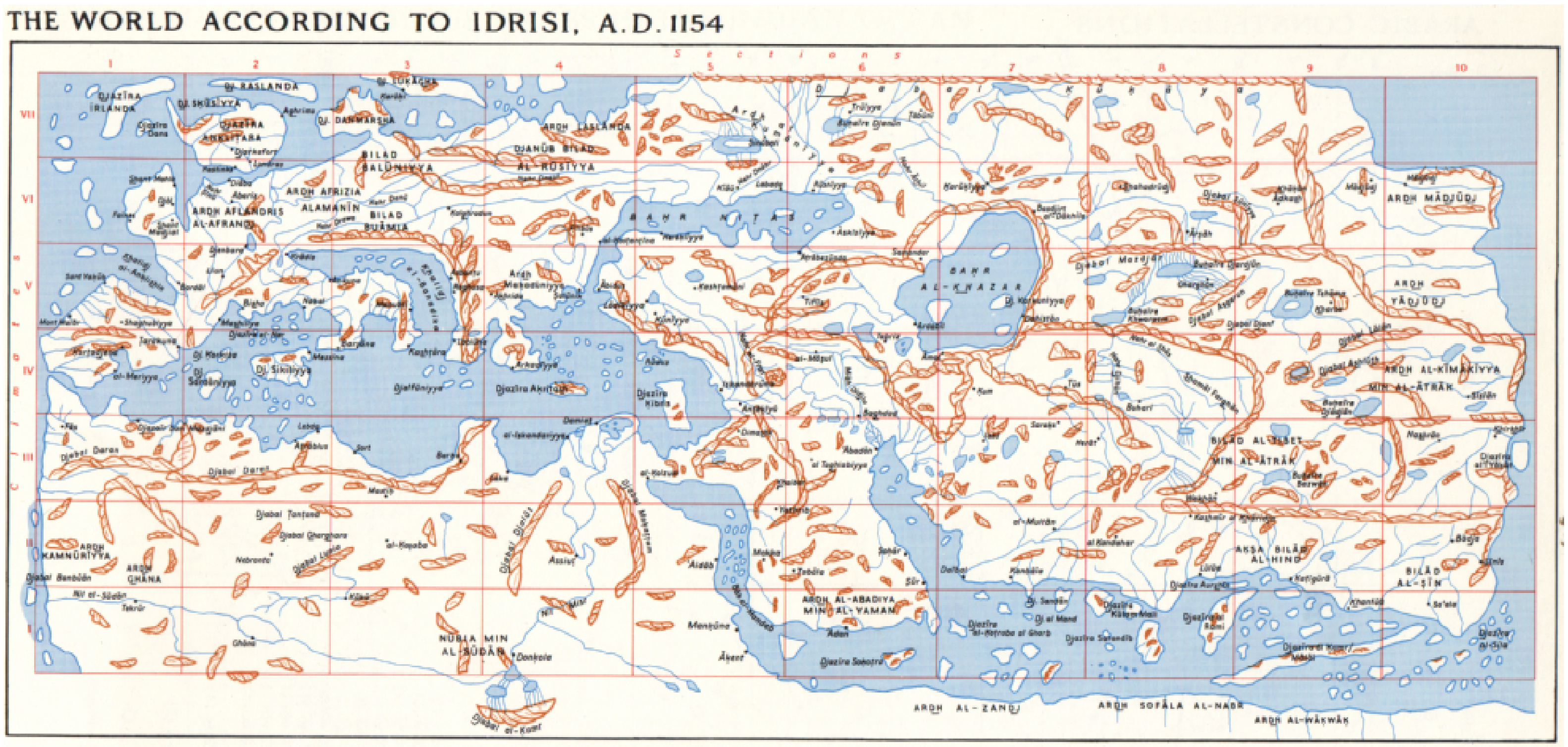

Figure 4.2. Modern index map (oriented with north at the top) showing coverage of the seventy sectional maps in Al-Idrisi's Book of Roger (Brice 1980, 6).

> "the extent of his learning cannot be described. Nor is there any limit to his knowledge of the sciences, so deeply and wisely has he studied them in every particular. He is responsible for singular innovations and for marvelous inventions, such as no prince has ever before realized."
>
> (Gies 1977, 4)

Roger's interest in geography was the expression of a scientific curiosity just awakening in Europe. He would not however have called upon a maker of Christian world maps. Christian Europe's approach to map-making was still symbolic and imaginary, based on myth and tradition rather than scientific investigation. Symbolic "mappae mundi" (medieval world maps) were used to illustrate religious books or were displayed in churches. European maps showed a circular earth composed of three continents equal in size (Asia, Africa and Europe) separated by narrow bands of water. Their content combined factual information with Biblical accounts and classical legends. The Garden of Eden and Paradise were at the top (East) and Jerusalem at the center, while fabulous monsters occupied the unexplored margins of the known world.

Some practical maps did exist, "portolan charts" (mariners' charts) showing coastlines, bays, capes, shallows, ports of call and watering and provisioning places. However, in typical medieval separation between of science and technology, these remained in the hands of navigators. Also, they were regional maps of the Mediterranean and not world maps. Information from land travelers, in the form of written itineraries, filtered only very slowly onto Christian maps.

What King Roger had in mind, therefore, was something as truthful as the mariners' charts, but encompassing the whole known world. Unavoidably he turned to a Muslim for help. During the five centuries since the founding of Islam in the seventh century A.D., there had developed a strong tradition of Islamic geographical writing and map making. Building upon the astronomical and geographical writings of the ancient Greeks, the Muslims had created their own unique form of geographical literature and cartography, which served to inform various activities, including military, government, commerce and pilgrimage.

To carry out the project, Roger established an academy of geographers, with himself as director. Al-Idrisi was brought to Palermo in Sicily in about 1138 to be its secretary and to work as a scholar updating navigational records. He was also charged with the production of a book on geography accompanied by maps. It was to contain all available geographical data on the world's main centers of population. Roger was actively involved in the project and himself interviewed geographers and travelers to gather information (Gies 1977, 4). Al-Idrisi said:

> "He occupied himself with this work for more than fifteen years without a break, without ceasing to examine all the geographical questions himself, all the while seeking the answers and the verification of facts, in order to obtain the knowledge he desired"
>
> (Al-Idrisi 1975, xx)

Roger's purpose was partly practical, but mostly scientific, to produce a work that would sum up all the contemporary knowledge of the geography of the world. He wanted to know the precise conditions of every area under his rule and of the world beyond it, for example, its boundaries, climate, roads, the rivers that watered its lands, and the seas that bathed its coasts. Al- Idrisi commented:

> King Roger II wished that he should accurately know the details of his land and master them with a definite knowledge, and that he should know the boundaries and routes both by land or sea and in what climate they were and what distinguished them as to seas and gulfs [what was the shape of the coastline] together with a knowledge of other lands and regions in all seven climates whenever the various learned sources agreed upon them and as was established in surviving notebooks or by various authors, showing what each climate contained of a specific country.
>
> (Ahmed 1987, 159)

The systematic approach to data gathering, processing and compilation began by studying and comparing the works of previous geographers, principal among them 12 scholars, 10 from the Muslim world, one Greek and one Spanish. Al-Idrisi listed them:

> Roger consulted the authorities on the subject, those who had sought to determine the extent, subdivisions and dependencies of each clime, by means the following writings dealing with geography:
> The book of marvels of Mas'oudi;
> The book of Abou-Nasser Saïd-el-Djihani;
> The book of Abou'l-Casem Abdallah-ben-Khordadbèh;
> The book of Ahmed-ben-el-A'dri;
> The book of Abou'l-Casem Mohammed el-Haukaliu el-Baghdadi;
> The book of Djanakh ben-Khacan el-Kimaki;
> The book of Mousa ben-Casem el-Cardi;
> The book of Ahmed ben-Ia'coub, known by the same of Iacfouli;
> The book of Is'hak ben-el-Hasan, the astronomer;
> The book of Kedamah el-Bassri;
> The book of Claudius Ptolemy;
> The book of Érésios of Antioch.
>
> (Al-Idrisi 1975, viii-xix)

Al-Idrisi was building upon the writings of the ancient Greeks whose translation into Arabic during the 8th century A.D. had been led by Caliph Al-Mamun. He had sent scholars to select and bring back Greek scientific manuscripts for translation. This created a base of scientific knowledge that could be read and discussed by scholars throughout the Islamic Empire.

One of the two pre-Islamic sources used by Al-Idrisi was Ptolemy, the greatest of the Greek geographers, whose Geography*,* written in the second century A.D., had been entirely lost to Europe, but preserved in the Muslim world. The other was Érésios of Antioch, a fifth-century Spaniard whose popular history book included a volume of descriptive geography.

Al-Idrisi was also building upon the four centuries of tradition of Arab travelers who had written about geography and made maps. For example, there was Ibn Khurdadhbih, an eighth-century Persian who was director of the postal and intelligence service in Iran. Al-Yaqubi, an Armenian, wrote a “Book of Countries” in the ninth century. Others belonged to a later tradition of systematic geography, like the tenth-century scholars, Ibn Hawqal and al-Mas'udi, who produced books planned as practical guides and also as additions to the fund of human knowledge. There were economic reasons behind the Muslim domination of the field of geography. While medieval Europe had become fragmented and parochial, both politically and commercially, the Muslim world was unified by a flourishing long-distance commerce as well as by religion and culture. Muslim merchants, pilgrims and officials used so-called "road books," itineraries that described routes, traveling conditions and cities along the way (Gies 1977, 4).

King Roger was unsatisfied with the geographic information about other countries that he found in earlier geographic writings, so he brought the widely traveled scholars of his day to his court:

> …they studied together, but he did not find much extra knowledge from [other scholars] over what he found in the aforementioned works, and when he had convened with them on this subject he sent out into all his lands and ordered yet other scholars who may have been traveling around to come and asked them their opinions both singly and collectively. But there was no agreement among them.
>
> (Ahmed 1987, 159)

It became clear to King Roger that better-quality information was needed to carry out the project.

> Realizing this, he sent travellers to all of his territories with instructions to find out about them. He then summoned the travellers into his presence and interrogated them by means of interpreters, sometimes in groups, sometimes separately. Whenever they agreed and were unanimous about a geographical location, he accepted it as a certainty. Whenever they disagreed. He rejected the geographical location or set it aside.
>
> (Al-Idrisi 1975, xx)

Al-Idrisi goes on to describe how the information they brought back was used by King Roger to compile the world map:

> He wished to make sure of the accuracy of what these people had agreed upon both of longitudes and latitudes [and in measurements between places]. So he had brought to him a drawing board [lauh al-tarsim] and had traced on it with iron instruments item by item what had been mentioned in the aforementioned books, together with the more authentic of the decisions of the scholars.
>
> All this he examined closely until he was convinced that the information was correct…A disk [daira] should be produced in pure silver of a large extent and of 400 Roman "ratls" in weight, each "ratl" of 112 "dirham" and when it was ready he had engraved on it a map of the seven climates and their lands and regions, their shorelines and hinterlands, gulfs and seas, watercourses and places of rivers, their inhabited and uninhabited parts, what [distances] were between each locality there, either along frequented roads or in determined miles or authenticated measurements and known harbors

> according to the version appearing on the drawing board, not differing from it at all and thus following what had been decided there without any variation. (Ahmed 1987, 159)

The silver planisphere does not survive, having been destroyed in 1160 A.D., but the small world map in the Book of Roger shows roughly what it must have been like. The seven curved zones of climes following lines of latitude suggest a spherical Earth, based on the ancient Greeks. This map shows the Earth surrounded by the Encircling Ocean. South is placed at the top, and the eastern coast of Africa extends toward the east longitudinally as far as what we call the Pacific Ocean. The Indian Ocean appears as landlocked on all sides except the east. Also, the southern quarter of the Earth is also covered by terra incognita connected with southern Africa (Fig. 4.1). This serves as a cartographic introduction to the more detailed sectional maps.

For his sectional maps, however, Al-Idrisi has employed a geographical grid composed of straight rather than curved lines. The maps are not on a projection, but each section is bounded by lines of latitude and longitude, although they are not labeled as such. These 70 rectangular sectional maps can be assembled to create an overview the world (Fig. 4.2).

These maps portray both physical and cultural geography. The sectional maps include different features, like bodies of water, represented variously by area patterns of lines, circles and dots (Fig. 4.3, 4.4). Rivers are simple lines of fairly consistent

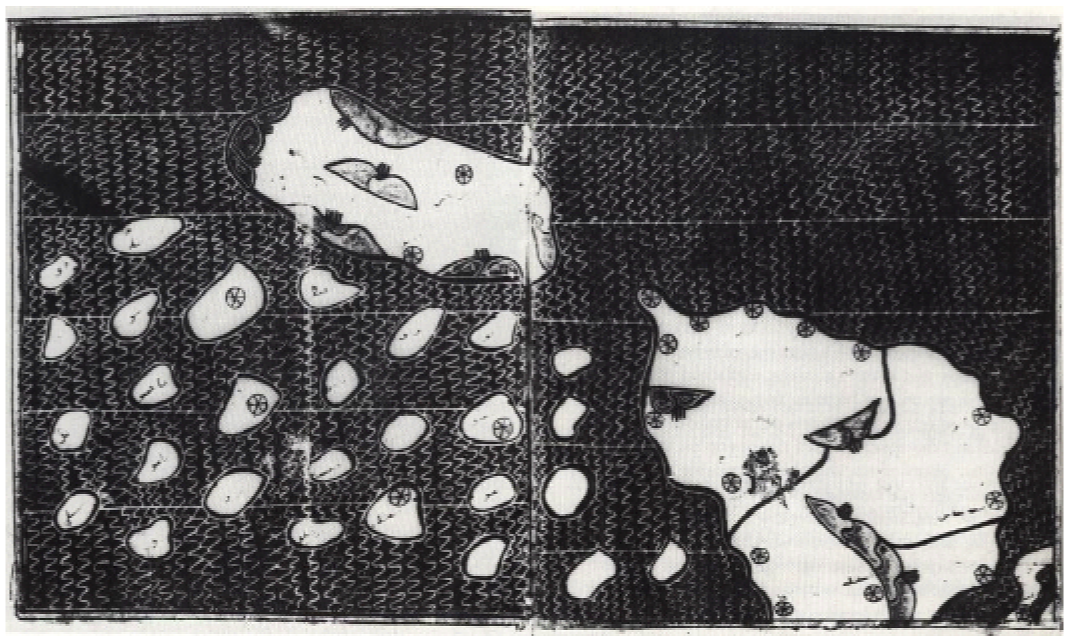

Figure 4.3. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 4, Section 4 (south at top) showing Crete and the Aegean Islands at the left and part of the Greek mainland at the right. Area pattern formed by wavy lines indicate sea (Harley & Woodward 1987, 164).

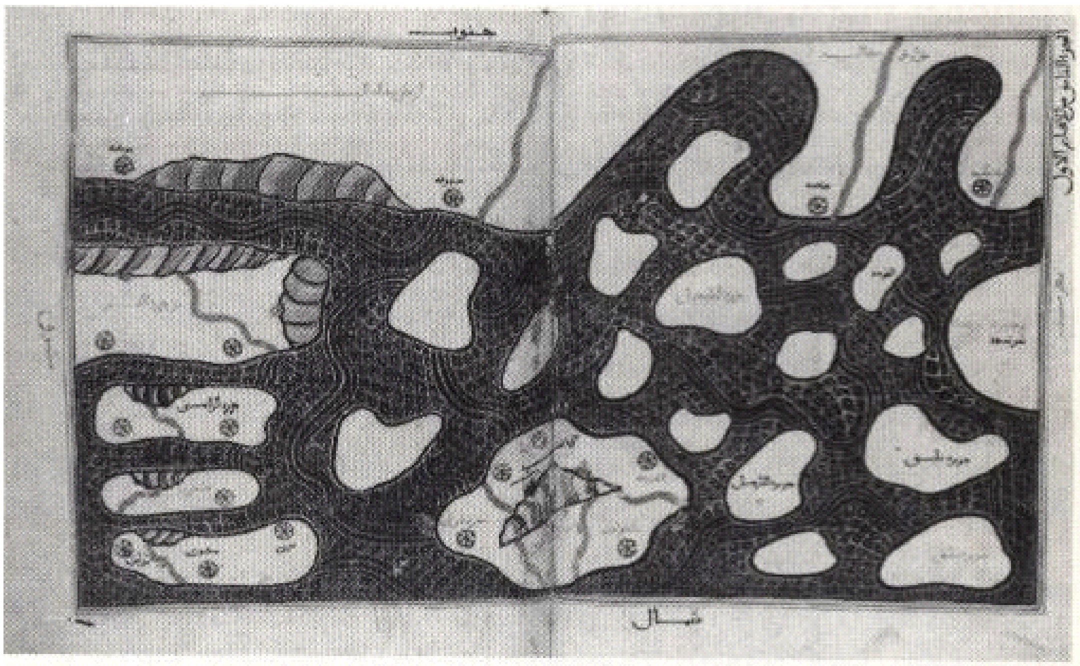

Figure 4.4. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 1, Section 8 (south at top) showing island of Sri Lanka Area pattern formed by wavy lines and dots indicates sea (Harley & Woodward 1987, 164).

width (Fig. 4.5, 4.6). Towns are represented by small circles, some plain and others by more elaborate rosettes in gold (Fig. 4.6, 4.7), or small towers (Fig. 4.8). Mountains are drawn as though seen from the side. All the mountains appear similar in general shape and size but have small intricacies of form, pattern and color (Fig. 4.9, 4.7). Mountains, rivers, towns and countries are labeled in Arabic script. Country names are combined with a line that indicates the boundary line between territories.

The map symbols used by Al-Idrisi display similarities with maps of earlier Arab geographers. For example, Ibn Hawqal's (d. 977 A.D) map of the Arabian Peninsula includes symbols for bodies of water, rivers, towns and mountains (Fig. 4.10). These depictions are similar to the symbols on Al-Idrisi's map (Ahmed 1987, 159).

In order to explain Al-Idrisi's map, Roger also ordered the writing of a book containing the complete description of the towns and territories, the types of agriculture and dwellings, and the extent of seas, mountains, rivers, plains and valleys. The book was also to describe the arts and crafts in which their inhabitants excelled, their imports and exports for trade. Al-Idrisi described the plans for the book in considerable detail:

> They should produce a book explaining how the form was arrived at, adding whatever they had missed [in the map] as to the conditions of the lands and countries, concerning their inhabitants and their possessions and places and their likenesses, their seas, mountains and measurements, their crops and revenues and all sorts of buildings, their property and the works they have produced, their economy and merchandising, both imports and exports, and all the wonderful things relating to each and where they were with regard to the seven climates and also a description of their peoples with their customs and habits, appearance, clothes, and language. The book would be called the "Nuzhat al-mushtaq fi khtiraq al-afaq" [Amusement for Him Who Desires to

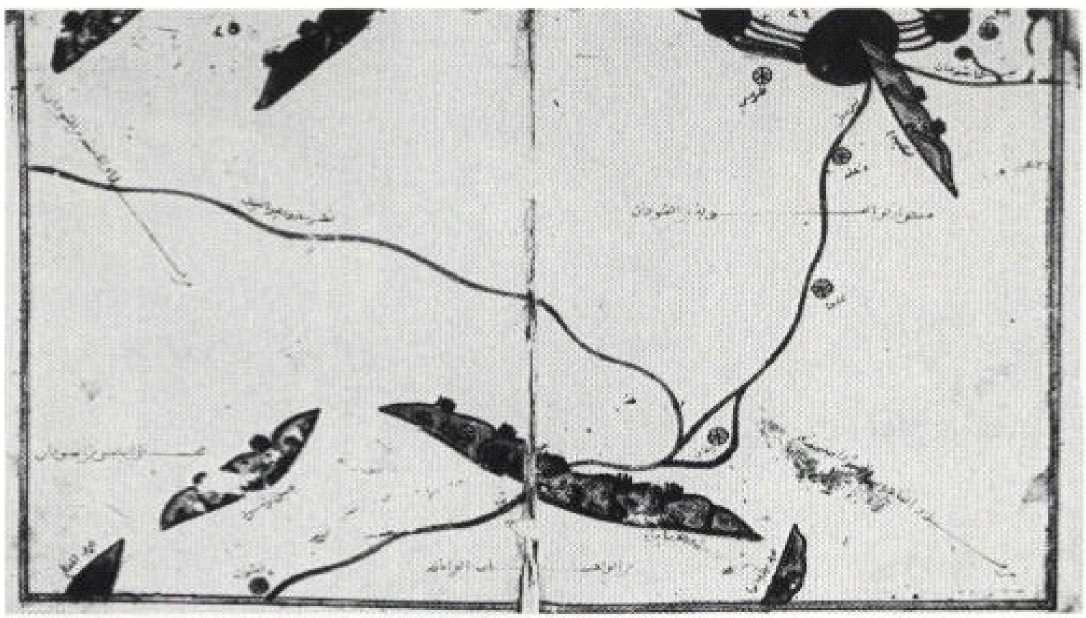

Figure 4.5. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 1, Section 4 (south at top) showing the source of the Nile River in Africa at the upper right. River is constant in width (Harley & Woodward 1987, 165).

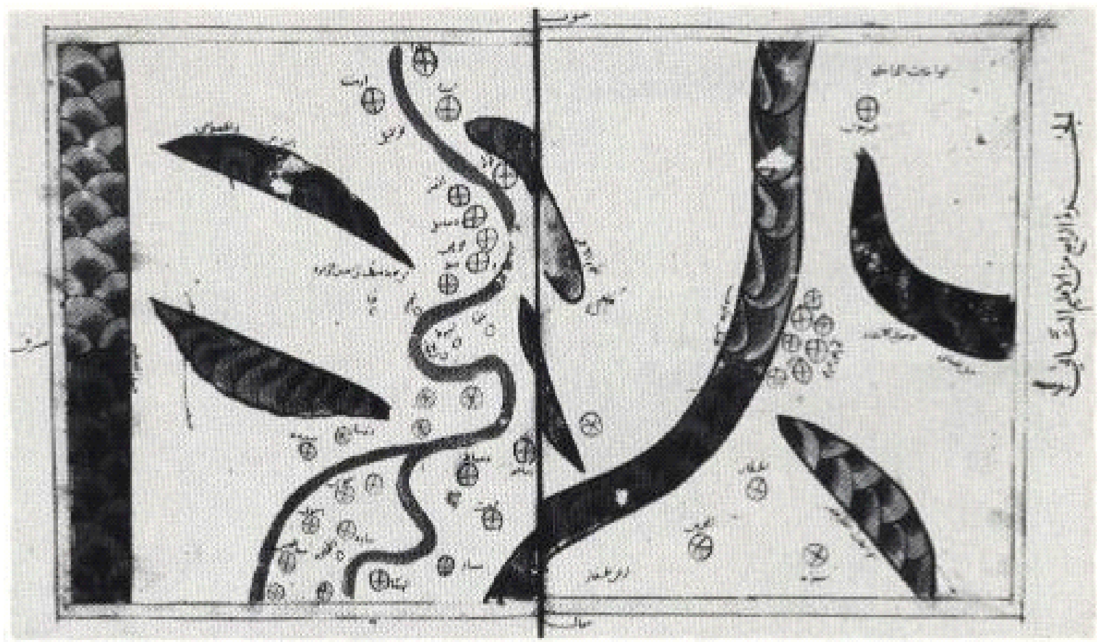

Figure 4.6. Adjacent sectional map from Al-Idrisi’s Book of Roger, 1154 A.D. Clime 2, Section 4 (south at top) showing the central portion of the Nile River and part of Egypt. Towns shown as a circle with a cross inside (Harley & Woodward 1987, 165).

Figure 4.7. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 3, Section 1 (south at top) showing north western part of Africa. Towns by a rosette (Harley & Woodward 1987, Plate12).

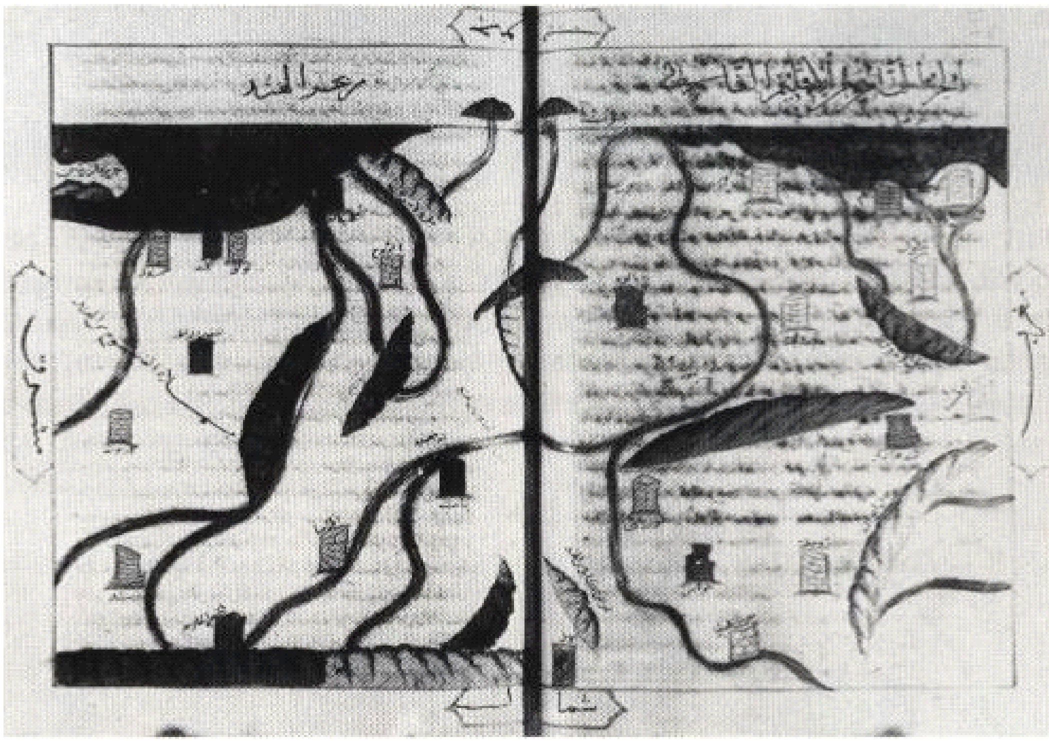

Figure 4.8. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 8 (south at top) showing southern tip of India in center top of map, and with Arabian Sea to the right and the Bay of Bengal to the left. Towns shown by small towers (Harley & Woodward 1987, 165).

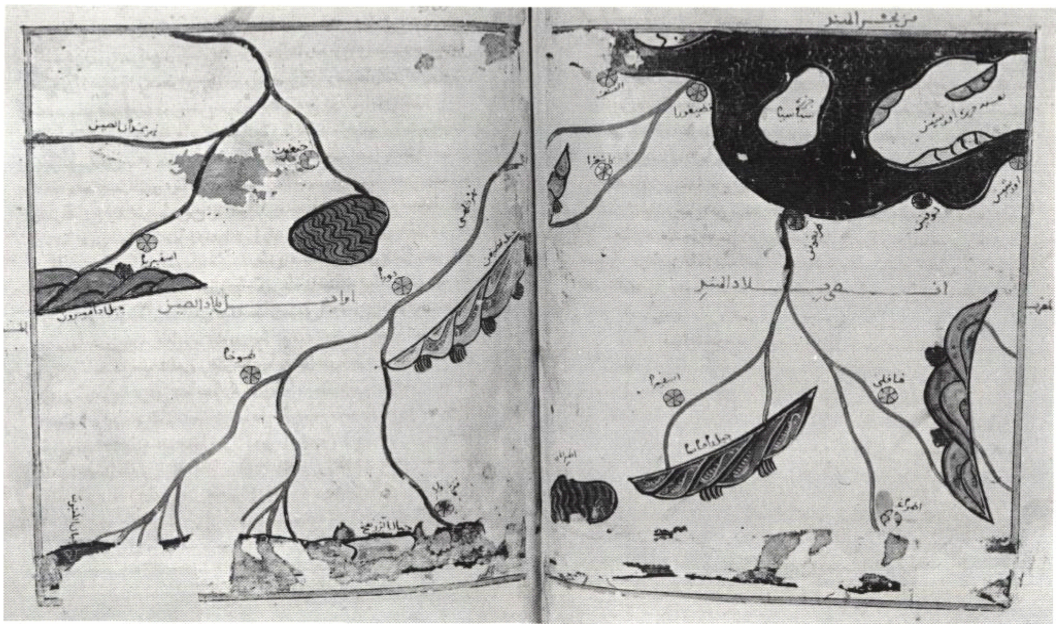

Figure 4.9. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 9 (south at top) showing China to the left and India with the Bay of Bengal to the right. Mountains shown in profile with stylized hills (Harley & Woodward 1987, 166).

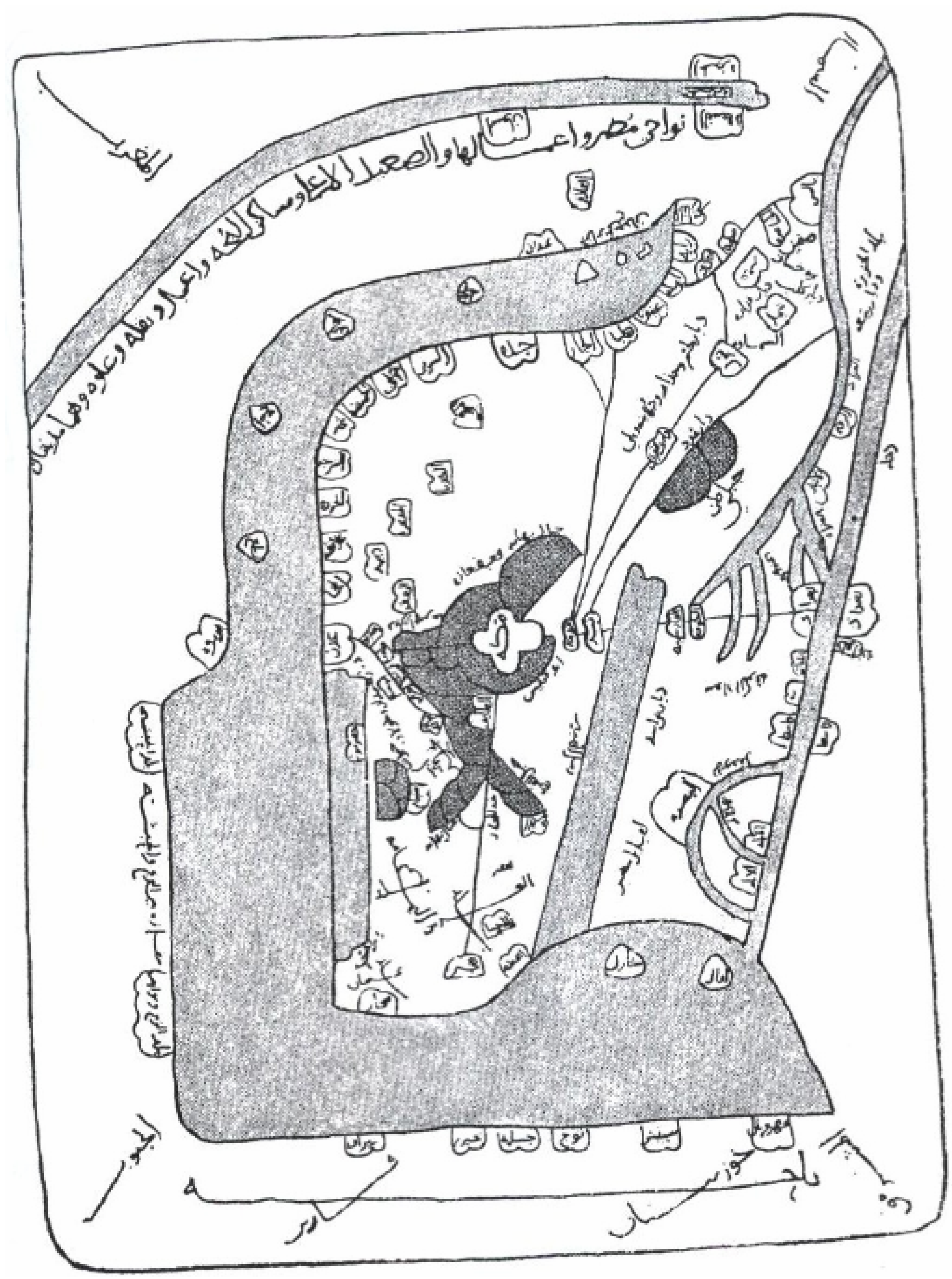

Figure 4.10. Ibn Hawqal's map of the Arabian Peninsula, 10th century A.D. (south at the top) (Kramers & wiet 2001, opposite 20).

> Travel Round the World]. This was all completed in the first third of January agreeing with the month of Shawwal in the year A.H. 548 [1153 A.D.]
> (Ahmed 1987, 159)

Al-Adrisi's book is the earliest known example of an Islamic geographical text that is so systematically organized. It is the most elaborate description of the world produced in the Middle Ages.

On the other hand, some inconsistency was unavoidable. Al-Idrisi used different units of distance in the geographical descriptions, reflecting the great extent and cultural variety of the Islamic commercial empire. He had to use information from different countries, where various units of measure were employed. Also, some units were used only for measuring land distance, while others were used for measuring sea distance. Moreover, some distances are straight-line distances, while other distances are measured along coasts or travel routes. The different units of measure that were used by Al-Idrisi are as follows:

Land Distances

1 classical Arabian Mile= 6,474 feet, or 1 1/15 geographical miles.
1 Farsakh= 3 Arabian miles.
1 Frank mil= no certain
1 Marhala = about one day's march (25 to 30 Arabian miles).
1 Long Marhala = about 40 Arabian miles.
Distance stated in terms of number of days' journey.
Distance in terms of an arrow shot= 180-275 meters.
10 Manzils= 270 Arabian miles.
1 Rashashi cubit = 3 palm lengths.

Sea Distances

1 Majra= one day's journey by sea (about 104 Arabian miles).
Muqayyad al-jary= another term for majra.
One-half a majra= 52 miles.
2Majras= 208 miles.
"Small majra"= probably less that a day's sailing
Al-Idrisi also uses miles for sea distances.

Measurement of Gulfs and Bays

Rusiya= a distance measured along the sea on a straight line between the two tips of a bay.

Taqwir (from quwwarah, “scoop”) = a distance measured along the coastline of a bay.

(Ahmed 1987, 159)

Al-Idrisi’s geography book was an excellent reference work that allowed the reader to move about the world systematically from one section to another. Each sectional map provided an overview of the coasts, rivers, countries, inhabited centers and mountains. The maps were oriented with south at the top, and the directions were indicated on each side of the map. Subsequently, the reader could consult the text to find out the distances between places and information about countries and inhabited centers, their peoples and produce, and also some information about travel (Gies 1977, 4).

Selected examples from the Book of Roger will now be discussed in order to highlight the remarkable features of this book. As has been mentioned there were seventy sectional maps which, when put together, made a rectangular map of the known world. The book describes the habitable world, beginning with the first section of the first clime at Ptolemy’s prime meridian, the Canary Islands. It proceeds from west to east and from south to north through each of the 10 sections of the seven climes. Each sectional map is followed by a descriptive text that provides more information. Each section of text opens with a general description of the region, then a list of the principal cities, then a detailed account of each city, with distances between cities.

The first example is the ninth section of the second clime, which covers India and neighboring territories. See Fig. 4.11.a and 4.11.b (1-6) which include the map and the entire text for this single section. The map of this section includes many islands, towns, mountains, lakes and rivers. The Himalayan Mountains that form the bottom (north) edge of the map are shown as the source of the rivers that flow to the south. Near the left edge of the map there is a diagonal straight line marking the border between China and India and labeled as such. Country names are combined with a line that indicates the boundary line between territories.

In this same section it seems that Al-Idrisi used different units of measure for the route distance from one place to another. In the text that follows, point 17 states the distance between Urisin and Lugin in "marhalas" (one day's march by land). On the other hand, the distance between the island of South Nasa and the sea-coast is given in "majras" (one day's journey by sea).

In his description of the places, he mentions every aspect of their geography (customs, food, weather, physical environment, economy, etc.). For example, point 16 describes the "serpents" found in the Indian Ocean and the China Sea and how the sailors can recognize them. It seems that the "serpents" (snakes) were used as isharat (sea signs) or environmental cues to guide the sailors (Al-Idrisi 1960, 69).

Al-Idrisi's description of section six of the second clime shows how he integrates information about distance, location, agriculture and trade, giving a good picture of Sahar and its place in the Arab trade network (Fig. 4.12):

> The distance from Muscat to Sahar, which both of them are Omani cities, is four hundred and fifty miles. Sahar is located on the side of the Persian Gulf,

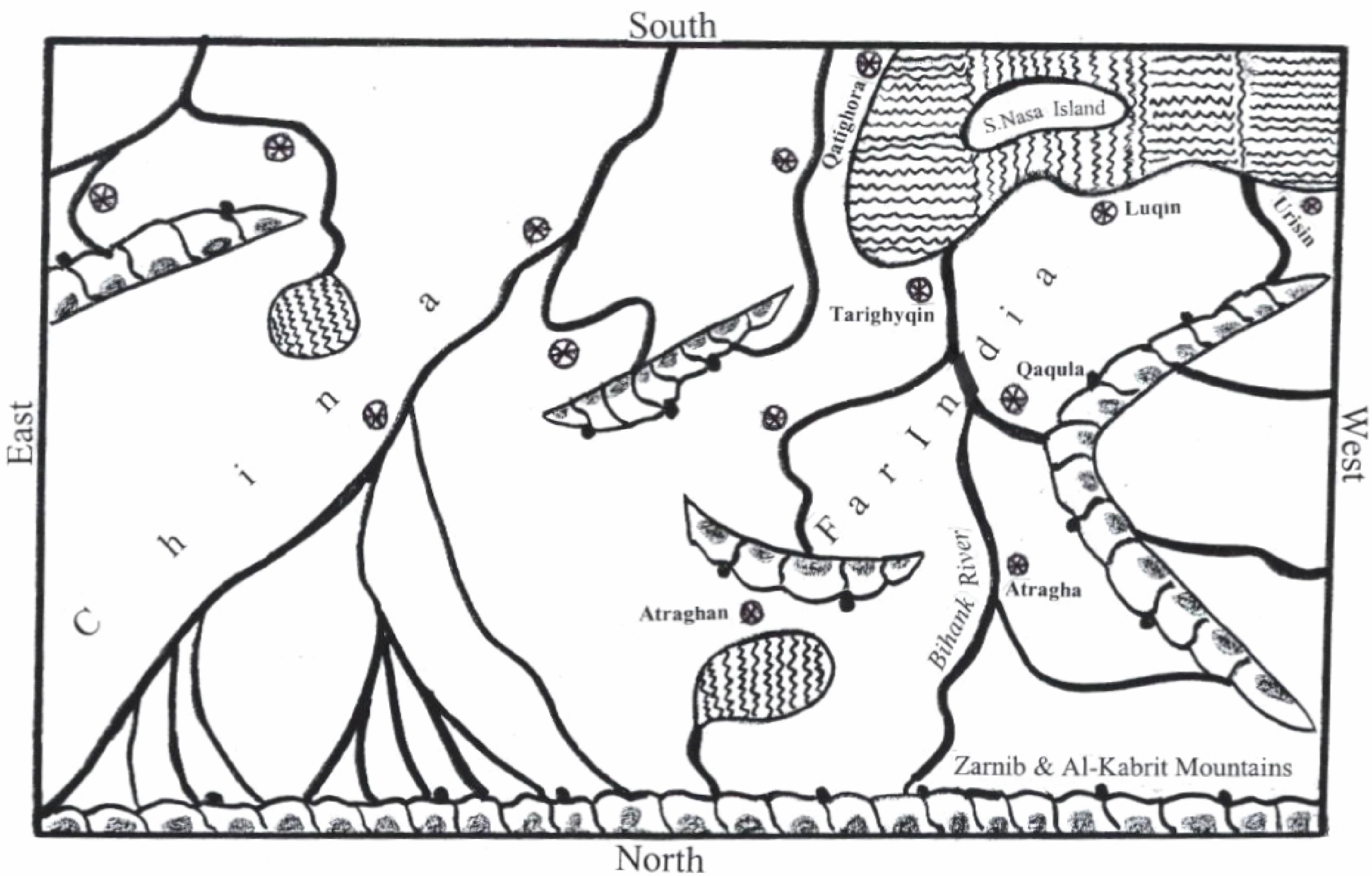

Figure 4.11.a. Sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 9 (south at top) showing the same area as Figure 9 but from another copy of the Book of Roger. Modern place names have been inserted in English in Fig.11.a. The same original map is shown in Fig.11.b. The text follows (Al-Idrisi 1960. Plate III. 69).

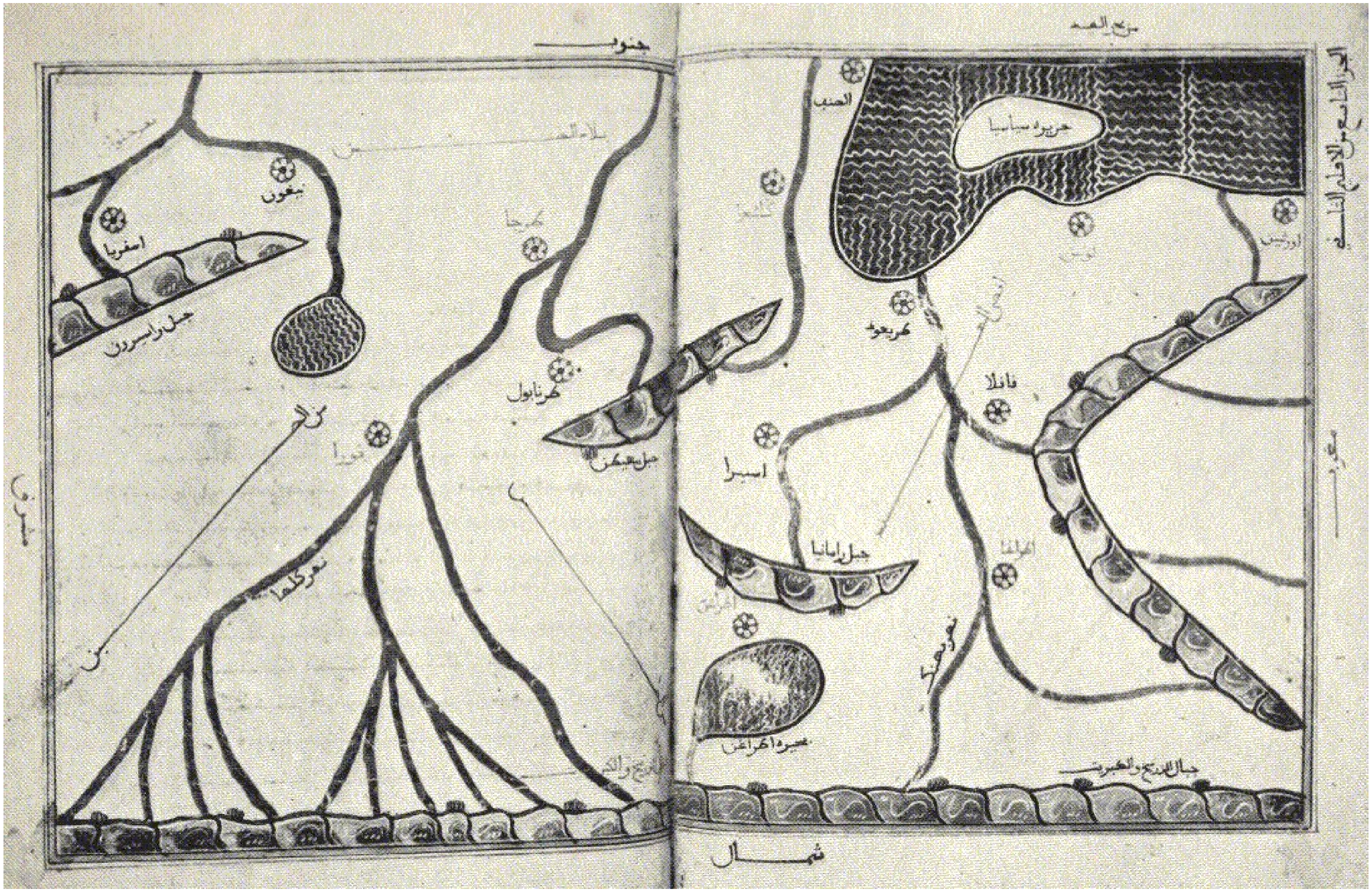

Figure. 4.11.b1

§ 82. If he travels to the east following an oblique course, his landfall (?) would occur at the town of KL.KSĀR,[1] or he would reach the end[2] of the ALĀMRĪ Mountain.[3] This is a high and extremely lofty mountain. It starts from the sea-coast and goes along in an easterly direction,[4] and the sea skirts round it forming a big gulf. From the border of this gulf to the island of SARANDĪB, it is a distance of about four *majrās*. The whole vegetation of this mountain consists of *baqqam*. It is carried from here and exported to all regions. This mountain is very well known. The roots of the *baqqam* cure snake-bites without any delay, as we have mentioned previously.[5] Praise be to God, first and last! This is the end of the Eighth Section; praise be to God, Lord of the Worlds! The Ninth Section will follow it, if God pleases.

(NINTH SECTION OF THE SECOND CLIME)

§ 1. Of the Indian and Chinese towns that this Ninth Section of the Second Clime includes, the towns of India are: ŪRĪSĪN, on the coast of the SALT SEA, then LŪQĪN, QĀQULĀ, and AṬRĀGHĀ . . .

§ 2. . . . In the portion of the sea [included in it], there are the islands of ŪRĪSĪN and S.NĀSĀ. Each of the towns [of this Section] has special characteristics, not found in the others. We are now going to mention each of those, with the power and assistance of God.

§ 3. As for the town of ŪRĪSĪN,[6] it is a small town situated on the sea-coast.

§ 4. But its island is more reputed, because it is very large in size, and has numerous mountains and plants. A large number of elephants are found on it. They are hunted and their tusks are exported from here.

§ 5. As for hunting elephants, there are different views on it, and much has been said about it. There are some people who say

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[1] *Ibid.*: 'If it is necessary to go towards the east, the landing must be at Kaikasár'. The text reads: (Variant:نصفيته) فانما تقع تصفيته.

[2] *Ibid.*: 'foot of'.

[3] *Ibid.*: 'Umri'.

[4] *Ibid.*: 'stretches towards the north'. See text, variant: الشمال.

[5] *Ibid.*: 'The root of the sapan quickly soothes the pain caused by . . .'

[6] See Commentary: Ūrīsīn, under *Islands*.

Figure. 4.11. b2

that the elephant-hunters go to the spots where they rest at night and to the places where they usually live. There they dig out for them ditches like the ones dug out by the Berber people for hunting lions. As for the shape of such a ditch, its top part is wide, while the bottom part is narrow. They then cover these with thin pieces of wood and straw, and spread earth over it, levelling it, till the ditch is concealed; so that, when the elephants come to their resting grounds, where they usually pass the night, or to the paths leading to their watering-places, where they are accustomed to drink water, and when they pass over the ditch, one of them drops head first [into it]; and the rest of the elephants run away headlong. The hunters stay in their hideouts, from where they watch the elephants drop in; and the moment they see them [falling in], they race towards the object fallen in the ditch. Then, they cut open their flanks and slit their stomachs and leave them to die. Then, jointly, they cut them up and take them out from the ditches piece by piece. They take out their tusks and acquire their ankle-bones.

§ 6. It is related in many accounts of India that in that country the elephants march in file. They pass the night in thickets [in gangs] of two or three or four in each. As for their [habit of] sleeping, they reach the trees and recline against their trunks [lit.: roots], and sleep, reclining one against the other, while standing, because of the thickness of their pasterns and the length of their limb-joints. Then, again, the hunters go to these thickets in the day-time and fell most of them and leave the trees standing in a fatal [position]; after dusk falls, when the elephants as usual come to the trees that they habitually use as support for sleeping, they go on piling up the weight one against the other, until the tree gives way at its base, and the elephants fall with the fall of the tree. And they are not able to stand up again. The hunters then jump towards them with sticks [in their hands], and start beating on their heads until they die. Then, they extract their tusks, which are sold to merchants for large sums, and are carried to different parts of the world. They are utilized in many goods of inlaid work. Many a person has reported that the two big tusks of an elephant weigh two *qinṭārs*, sometimes even more, and sometimes less.

§ 7. As for the birth of elephants, merchants visiting India

Figure. 4.11. b3

Cl. II, s. 9 TRANSLATION 71

relate that the females bear their young in still waters. Thus, they bring forth the young, which drop in the water. So, the mothers hastily hold them in the water on their trunks, and lift them out of it. They keep on licking them till they get dry. Then they gradually bring them to the state of walking until their birth becomes complete. May God, the most beautiful of Creators, be blessed!

§ 8. From among the quadrupeds that God has created, no animal is known to be more intelligent or more fit to acquire training than the elephant. One of the virtues of the elephant is that it never looks towards the private parts of human beings.

§ 9. The kings of India compete with one another in the acquisition of elephants, and exceed one another in their prices. The kings look after them with great care. They are brought when they are young to their elephant-houses; so, they grow up getting accustomed to human beings.

§ 10. They are used in battles; because on the back of a single big elephant fitted with a coat of mail, twelve persons can fight with leather shields, swords, and clubs made of iron. On the head of each of these elephants there is an elephant driver, who urges it ahead with a goad (*mikhṭāf*) with which he pulls its trunk, and beats on its head with a stick or rod (*miṣfaʿ*) especially made for this purpose; with this the elephant is made to turn. The elephants in the battle[-field] are made to charge one against the other, so that the stronger tramples over the weaker, and their movements include attacks and retreats. All these [facts] about elephants are well known and are observed in India.

§ 11. Elephants are found in great numbers in the island of ŪRĪSĪN. They breed there, and are carried from there to all parts of India.

§ 12. In this island, there are iron mines.

§ 13. In most of its mountains, rhubarb grows, but the rhubarb which comes from China is superior because it is firmer, more deeply coloured, and more effective in curing the liver and in all its uses.

§ 14. In this island there is a tree resembling the castor-oil plant in quality, except that it is full of thorns. Its thorns protrude, preventing one from touching it. It is called *al-shahkīr*. It has black

Figure. 4.11. b4

roots. The kings of China and India procure it and prepare deadly poison out of it. It is very well known.

§ 15. The Indians and the Chinese do not kill any member of their family or their servants or anyone against whom such a contrivance is possible except by means of poison.

§ 16. In the seas opposite to every estuary of India and China, there are to be found serpents [1] of variegated colours and with different kinds of spots. The sailors know them and recognize them, and as they know their special qualities, they can recognize the serpents of each of these estuaries and also the country in which they are found. Thus they seek guidance by means of them. This is also a well-known fact. These serpents are called *al-mīzara* [2] in the Indian language.

§ 17. From ŪRĪSĪN to LŪQĪN, it is three *marḥalas* along the sea-coast. It is a beautiful town situated on the sea and on the bank of a sweet-water estuary, and boats enter it.

§ 18. From here to the town of ṬARĪGHYŪQIN, it is four *marḥalas*. It is a populated town situated on the coast of the SALT SEA.

§ 19. Opposite to this town in the sea is the island of S.NĀSĀ. It is a populated town and is visited by many [travellers] who come in and go out. Between it and the sea-coast, there is less than half a *majrā*.

§ 20. It is said that in this island, there is a well [volcano?] from which burning fire comes out from time to time and dies down again.

§ 21. From here to QAṬĪGHŌRĀ, it is six *marḥalas* . . .

§ 22. . . . From LŪQĪN, situated on the sea-coast and belonging to India, to QĀQULĀ, it is seven days' journey.

§ 23. It is situated on the bank of a small river flowing into the River BIHANK of India.

§ 24. In the town of QĀQULĀ, silk is found in abundance, and its inhabitants rear silk worms in large numbers. It is after this town that *Qāqulī* cloth and *Qāqulī* silk are named.

§ 25. From the town of QĀQULĀ to the town of QASHMĪR, it is ten *marḥalas*.

[1] Jaubert, I, p. 187: 'reptiles'.

[2] *Ibid.*, p. 188: المِزراه. See Commentary: al-Mīzara, under *Flora, fauna, etc.*

Figure. 4.11. b5

§ 26. Again, from QĀQULĀ to the town of AṬRĀG͟HĀ, it is four *marḥalas*. AṬRĀG͟HĀ is a big town belonging to one of the kings of India. It is situated on the bank of the River BIHANK.

§ 27. Here there are large armies, infantry, and military equipment. They [the inhabitants] fight against the Turks. It has rice and [its soil] is fertile. From AṬRĀG͟HĀ to AṬRĀG͟HAN, it is ten *marḥalas*.

§ 28. In this section, among the rivers of India, there is the River BIHANK . . . As for the River BIHANK of India, its source lies in the mountain surrounding the extreme north of India. [1] It then passes to the eastern side of the town of AṬRĀG͟HĀ, then to the place of confluence with the River of QĀQULĀ, until it reaches the sea and flows into it. This takes place at the town of ṬARĪG͟HYŪQIN.

§ 29. Among the Indians, there is a sect known as *Jalahaktiya*. [2] They believe that the angel *Jalahakt* dived into this river, and that many a time he appears to them in it.

§ 30. So, when anyone of them commits any sin, he comes to this river, and enters it until he reaches the centre of it. [3] There he stays for an hour or more, [4] holding various kinds of odoriferous plants in his hand. [5] He then breaks these into small pieces and throws them one after the other on the river water and goes on praising [God] and reciting [hymns]. [6] When he wishes to return, he stirs the water with his hands, and holding some in them, he pours it over his head and his back. [7] Then he prostrates himself and returns [8] . . .

(TENTH SECTION OF THE SECOND CLIME)

§ 1. . . . It is related in authentic books of information that the kings of China and most of the kings ot India do not give up the

---

[1] See Commentary: The Surrounding Mountain, under *Mountains*.

[2] Cf. Jaubert, I, p. 192: جلهكى; see Commentary: Jalahaktiya, under *Religion*.

[3] Cf. *Gardīzī*, p. 636.

[4] *Gardīzī*, *l.c.*: 'for more than two hours'.

[5] *Ibid.*: 'He holds sweet basil (*sipargham*) in his hands'.

[6] *Ibid.*: 'throws into the water as he swims (*ashnā*) and sings something'.

[7] *Ibid.*: 'the parts of the body which are not submerged'.

[8] *Ibid.*: 'Then he goes, after a prostration before the water'.

Figure. 4.11. b6

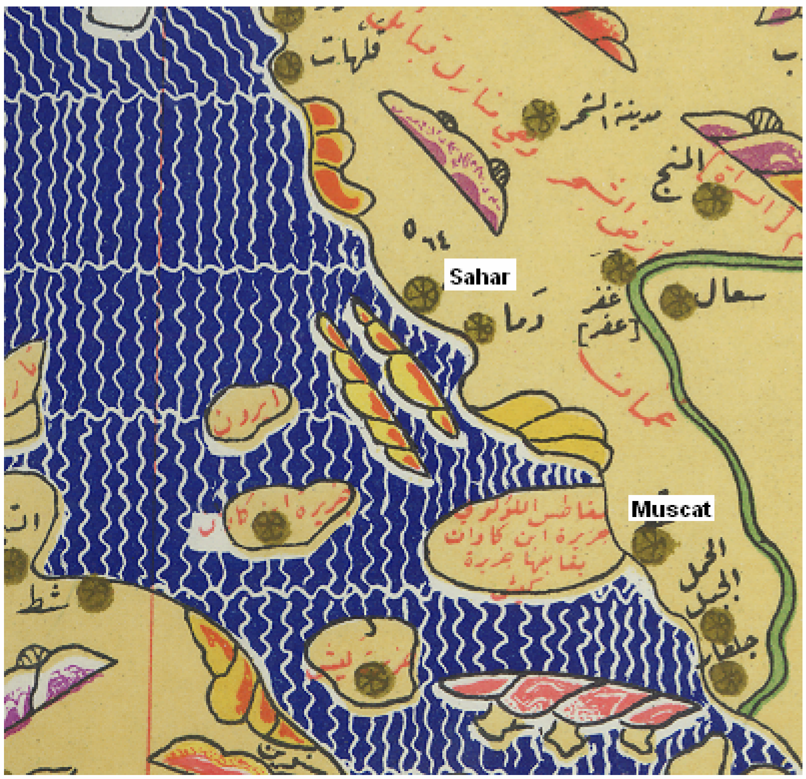

Figure 4.12. Detail of sectional map from Al-Idrisi’s Book of Roger, 1154 A.D. Clime 2, Section 6 (south at top) showing the Persian Gulf in the center and the eastern coast of Arabia at the right with seaports including Sahar [sohar] and Muscat [maskat] (El-Drisi 1951, detail).

> and it is the oldest Omani city and it’s the richest. Every year, merchants import and export goods to Sahar from different places, especially from Yemen. Moreover, it has many agricultural wonders like palm trees, fruits and vegetables. Many Chinese ships travel from Sahar, and have done so for a long time.
>
> (Al-Idrisi 1990, 161)

Al-Idrisi describes section six of the first clime (Fig. 4.13) by saying:

> Aden city is a small city; however it is popular because it is considered as a famous port. From its port the ships travel to the India and China, and from these places it comes back with valuable goods like, iron, musk, perfume, pepper, coconuts, spate, cinnamon, ivory, cloth, bamboo and other important goods. Aden is surrounded in the north direction by a mountain. At each ends of this mountain there is a door allowing one to travel through the interior of the mountain. And from one door to the other door through the mountain is four day’s journey. One day’s journey inland from Aden there is a big town called Thi-Jablah and it has a very big strong fort.
>
> (Al-Idrisi 1990, 54)

This example shows how Aden played an important role as a port where the ships travel to the India and China. He mentions there is a long tunnel in Aden. The text description and the map representation of Aden match very closely. The examples just discussed, India, Sahar and Aden, are examples of general geographical description without special mention of navigation.

The remaining examples will be discussed more selectively, focusing on the information they provide about navigation techniques. Section four of the third clime covers the Mediterranean coast of Egypt. The map shows the famous lighthouse of Alexandria, and the text explains how it works (Fig. 4.14). The lighthouse was a landmark that guided travelers by day and by night. Although Al-Idrisi’s

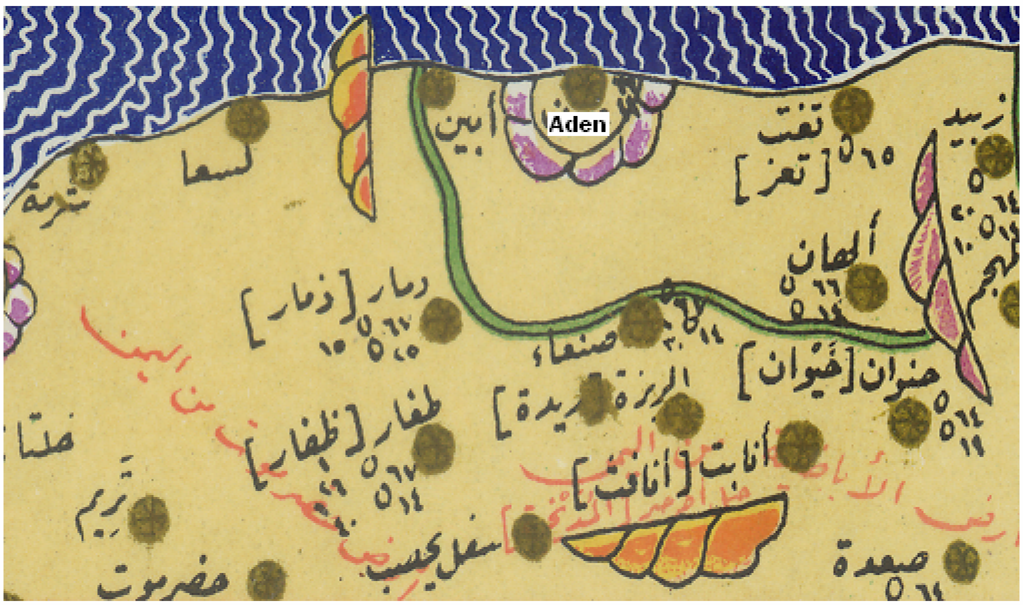

Figure 4.13. Detail of sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 1, Section 6 (south at top) showing southern coast of Arabia with seaport of Aden (El-i-Drisi 1951, detail).

Figure 4.14. Detail of sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 3, Section 4 (south at top) showing northern coast of Egypt with lighthouse at Alexandria [Iskander] to the right (El-i-Drisi 1951, detail).

comments about navigation are occasional and generally brief, here he makes much of the lighthouse, because it was one of the great wonders of the world.

> Alexandria is a town which was built by Alexander so that is why it is Alexandria today called. It is located on the salt sea. In Alexandria there is a lighthouse which is a unique building in the entire world. From this lighthouse, the town is a mile across the sea, and three miles by land. This lighthouse is considered to be one of the greatest wonders in the world because of its height, strength and usefulness. There is a fire that brilliantly shines in the day and night, so ships and their crews can travel during any season. Also, the lighthouse appears from a far distance because it looks like a star in the night, and in the day, there is a smoke that comes from it. And without this lighthouse the people of these ships would lose their direction because Alexandria is surrounded by desert and has no mountains or any landmarks to guide the people except these fires.
>
> (Al-Idrisi 1990, 319)

The next example shows how routes are described as sequences of segments, each distinguished by a village or other stopping place. Al-Idrisi notes the location of wells between towns to provide water for travelers, and the wells moreover, served as landmarks. This is section six of the second clime, which covers the route from Yamamah in the Arabian Peninsula to the city of Basra in Iraq (Fig. 4.15):

> Who wants to travel from Yamamah to Basra? He starts from Hazramah to Al-Sal by one marahala, then to Salmiah which is also one marahlah, then cross the desert until he reachs Marab, which is a small village inhabited by many Arab tribes. After three marahala there are water wells. And after three other marahala, he reaches Al-Saman which is also a small village.
>
> (Al-Idrisi 1990, 156)

Al-Idrisi goes into much more detail about sea navigation in the Red Sea in his description of section five of the second clime (Fig. 4.16):

> Qulzam Sea, or the “Red Sea” is a hard sailing sea; it has mountains and several islands. Most ships of this sea are stitched by sewing the hull boards

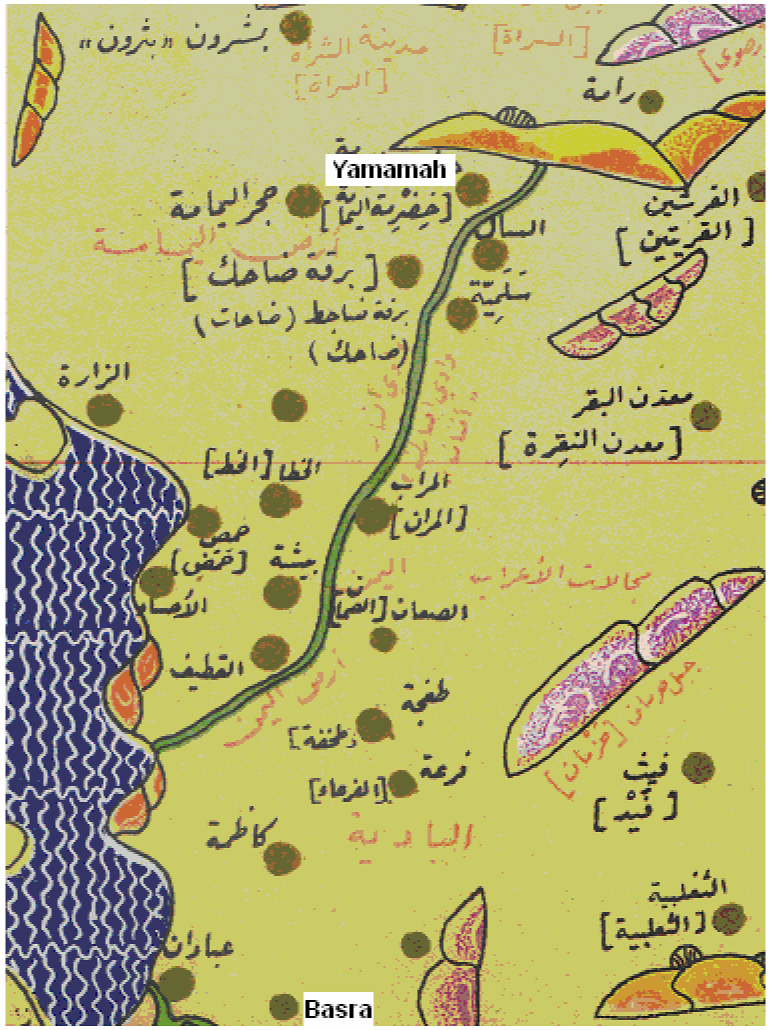

Figure 4.15. Detail of sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 6 (south at top) showing the Persian Gulf at the left and the Arabian Peninsula to the right, with the city of Basra [el basra] near the northern end of the Persian Gulf (El-i-Drisi 1951, detail).

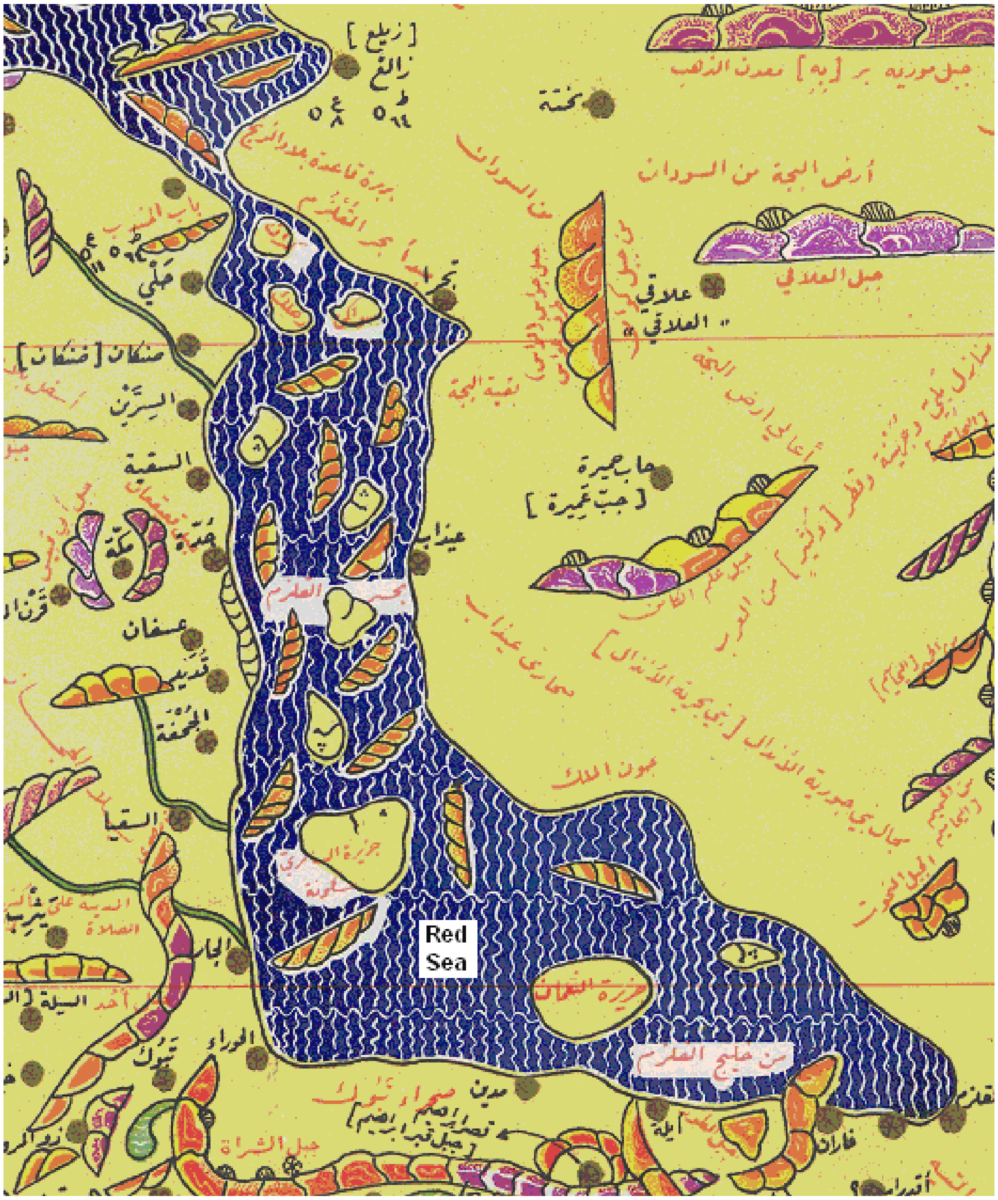

Figure 4.16. Detail of sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 5 (south at top) showing Red Sea (EL-i-Drisi 1951, detail).

> together with fibers and cords and painted by dogfish oil. The sailors in these ships have accurate instruments, and one of the sailors has to get up to the mast, which is in the ship's bow, to look forward to see any landmarks that guide them, and also to discover any obstacle that might stop their sailing, and after that he reports to the helmsman who steers according to everything the lookout sees, such as land, storm, another ship, etc. And without this method no one can cross this sea. The sailors can not sail through the night time so they spend their night in any safe place until the sunrise comes and they continue their journey.
>
> (Al-Idrisi 1990, 135)

The sewn construction of the boats indicates that the boats used in the Red Sea were Arab dhows. He mentions how difficult it is to sail there, and goes on to describe the techniques that were used by the sailors to avoid dangers. These techniques included both use of instruments and landmarks to determine position. Apparently, sailing in these confined waters was so hazardous that ships could only travel in daylight and had to anchor overnight. In other sea areas where there was more room to maneuver, they could continue sailing at night, but not in the Red Sea.

In regard to the lands bordering the Red Sea, Al-Idrisi also describes travel across the desert (Fig. 4.17):

> Section five from the second region includes the places that are located on the Qulzam Sea coast, or "Red Sea coast". An example of these places is Ayzab city, and the desert that surrounds it. This desert does not have a known route and nothing to guide the travelers except the mountains and the stones which spread out in the desert, because most of the desert landscape is sand. Sometimes even the expert guide can lose his way. Also, there is another type of guiding sign and very useable: the stars in the night and the sun from sunrise to sunset.
>
> (Al-Idrisi 1990, 132)

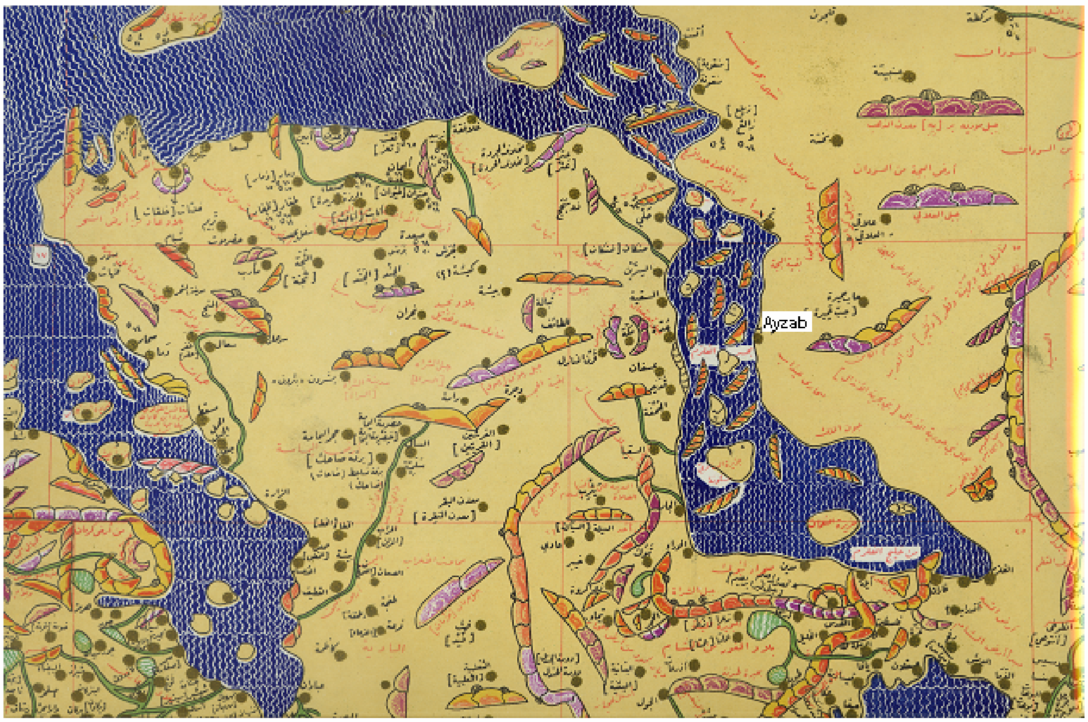

Figure 4.17. Detail of sectional map from Al-Idrisi's Book of Roger, 1154 A.D. Clime 2, Section 5 (south at top) showing the Red Sea in the center with the seaport of Ayzab [aidab] to the right on the Egyptian coast and the Arabian Peninsula and the Persian Gulf to the left (EL-i-Drisi 1951, detail).

Thus this example shows the techniques that were used by travelers to navigate both at sea and on land.

The Book of Roger with its maps was completed in 1154 A.D, just a few weeks before Roger died. Al- Idrisi composed a more detailed text and map in 1161 for Roger's son William II. It was called "The Gardens of Humanity and the Amusement of the Soul." It does not survive, except in the form of a shortened version produced in 1192. Consisting of 73 maps in the form of an atlas, the latter is titled "Garden of Joys" but is now known as the "Little Idrisi".

Summing up Al-Idrisi's contribution to Arab geography, it is clear that his work was very innovative and important. Building upon the Greek geographical texts translated into Arabic during the eighth century A.D. and upon the work of earlier Islamic geographers, Al-Idrisi's work characterized the third important period of Islamic geography, which has been called the Norman-Arab period. It has also been called the Idrisi-period, since it saw the production of Idrisi's notable work, the Book of Roger completed in 1154 A.D. He took existing Arab and European material and reshaped it in his own way. Later on many people copied him, but chief credit for the Book of Roger goes to him as its designer and architect (Bagrow1960, 55). Al-Idrisi's book is one of the most exhaustive medieval works in the field of cultural, physical, descriptive and political geography. It is dominated by descriptions of towns and places with their distances and directions. Al- Idrisi's style of descriptive geography book illustrated with maps was copied by Arab geographers in North Africa. This was its most lasting, and directly traceable, impact.

At that time, European world maps were largely concerned with representing the Christian world view with the holy city of Jerusalem at its center. The portolan sea charts of the Mediterranean in use from the 13th century onward were practical in purpose and combined with written sailing directions, but they focused on the seacoasts and often left the land interior largely blank. It was not until the Renaissance period that European civilization, building upon classical knowledge preserved by the Arabs, began to explore and objectively record the world, both at home and abroad, in the form of geographical text and maps. The great atlases of Mercator and Ortelius published in northern Europe during the 16th century were the Renaissance equivalent of Al-Idrisi's Book of Roger. However, because they were produced in the age of printing and intended for commercial sale, they would be disseminated more widely than the manuscript Book of Roger and its later versions and copies.

This chapter has discussed Al-Idrisi's contributions to different and complementary aspects of geography. One of his great achievements was the systematic mapping of the known world, using the best information sources available to produce sectional maps that combine information about the sea and the land. This map is accompanied by a book that adds descriptive detail to complement and enhance the graphic impression provided by the maps. This chapter has also contrasted the Arab geographical tradition represented by Al-Idrisi's Book of Roger with the ethnocentric and spiritual Christian focus of the mappaemundi that represented the height of European cartography at that time. The next and concluding chapter will pull together and interpret the deeper significance of the information in the previous thesis chapters.

Chapter 5. Conclusion

This conclusion will begin by comparing and contrasting traditional navigation techniques used by Arabs in two different geographical environments, the desert landscape traversed by camel caravans and the sea crossed in dhows. The chapters on traditional Arab land and sea navigation have followed the same topical outline in describing the character, origin and use of the navigation instruments and techniques, as well as the modes of transport and the personnel involved in navigating. These are listed below.

		Sea	Land
1	Astronomical & Magnetic Position Finding	a. Stars & Sun Location b. Qiyas c. Kamal d. Astrolabe e. Magnetic Compass	a. Stars & Sun Location b. Astrolabe c. Magnetic Compass
2	Landmarks & Environmental Cues	a. Landmarks & Environmental Cues b. Monsoon Winds c. Sea Routes (Coasting, Open-Sea)	a. Landmarks & Markers b. Land Routes
3	Oral & Written Directions	a. Oral Traditions b. Nautical Manuals or Rahmani c. Local Guides	a. Oral Traditions b.Voyaging Documents & Books c. Local Guides
4	Mental & Analog Maps	a. Mental Maps b. “Qunbas” or Compass Charts	a. Mental Maps
5	Other Factors	a.Boats-Types & Sails & Rigging- Types b. Travel Season	a. Animals- Types b.Travel Season (Summer,Winter, Pilgrimage)
6	Members of Arab Ship & Caravan Crews	(Pilot, Assistants, Sailors, Cooks, Merchants, Local Guides, etc...)	(Leader, Guards, Merchants, Mathematicians, Local Guides, etc...)

7	As a Case Example	Ibn Majid	Ibn Battuta

This parallel structure facilitates the following comparison of these two theaters of navigation activity. The similarities and differences under each topic will be discussed in turn.

1	Astronomical & Magnetic Position Finding	a. Stars & Sun Location b. Qiyas c. Kamal d. Astrolabe e. Magnetic Compass	a. Stars & Sun Location b. Astrolabe c. Magnetic Compass

Whether Arabs were traveling on land or at sea, the sun and stars were equally visible and useful in navigation. The navigators had intimate experience with navigating by sun and stars starting in childhood, learning from their fathers. Over time the Arabs developed from simple to more sophisticated techniques and instruments for calculating latitude using the sun and stars. The human hand, both open and closed, provided the first means of measuring the altitude of the sun or stars. This was developed by the Arabs into the qiyas method, using sticks of standard length instead of the divisions of the hand for measuring. Then the kamal was invented, clearly before the 10th century, but still used in traditional Arab sea navigation until recent times. It permitted the individual navigator to mark the latitude of a key port on his kamal by means of a knot. These techniques were used in combination with piloting using environmental cues and coastal landmarks.

The astrolabe was also used and improved by the Arabs; it was used somewhat at sea but was more convenient to use on shore, because of the rolling of the ship that made it hard to determine the vertical line accurately. On land it seems to have been used more for scientific observation, such as in observatories, than by traveling caravans. The caravans relied on roads and landmarks, continuous systems of features not available in sea navigation. Al-Maqdisi (10th century A.D.) said "The desert is like the sea, and you may travel on it in any direction you wish, if you know your course. However, the roads we have shown on our map have become well-known and much used, because of the domed cisterns that are maintained there." (Collins 1974, 285).

However, there were weather conditions on land and at sea when sun and stars and landmarks were not visible, whether at night or during storms or fog. This problem was overcome by use of the magnetic compass. The magnetic compass was probably brought from China on Arab ships, and its design was improved by Arab mariners. They combined it with their age-old star compass. The magnetic compass was less used on land, but one example has been cited of a caravan using the magnetic compass in an area where desert travel was difficult. There was conscious borrowing and adapting of a seagoing navigation technique for use on land.

2	Landmarks & Environmental Cues	a. Landmarks & Environmental Cues b. Monsoon Winds c. Sea Routes (Coasting, Open-Sea)	a. Landmarks & Markers b. Land Routes

Both on land and at sea travelers used physical and man-made landmarks to guide them, a technique known as piloting. Their long and extensive travels built up their accumulated knowledge of such landmarks. The navigators crossing the open sea used dead reckoning. Close to the coast they used landmarks and environmental cues to guide them. The landmarks and environmental cues were concentrated along the margins of the seas, and they enabled the navigators to avoid coastal hazards, as well as to find their way to port. On the other hand, the travelers on land used the landmarks found along the network of routes that crossed the desert, linking different ports and inland trading centers. Thus, although the use of landmarks in piloting was similar, their geographical distribution was different on land than at sea due to the nature of the physical environment.

Traveling during the day or in the night was influenced by both the mode of transport and the nature of the environment. For example, the passengers and crew of a ship can sleep all the night, while a small number stay on watch, except in dangerous areas like the Red Sea. However, a caravan has to stop at night to allow the people and animals to rest and wait until the landmarks become visible in daylight.

As well as providing motive power for the dhows, the monsoon winds, which blow constantly from one direction in their season, served as environmental cues. When the monsoon wind in season brought the ships to particular ports, the caravans would come from different areas of the land to get the goods carried by the ships and take them back to sell in their home markets. Markets in different places in the land were timed to take advantage of this seasonal availability of trade goods. It is clear that the monsoon wind played a determining factor in creating a commercial communication network. The seaports where the trade goods were transferred from ships to caravans formed the contact points between the sea and land portions of this network.

3	Oral & Written Directions	a. Oral Traditions b. Nautical Manuals or Rahmaani c. Local Guides	a. Oral Traditions b.Voyaging Documents & Books c. Local Guides

It is obvious that oral traditions were strong in both sea navigation and land navigation from early times. Boys often traveled at sea or on land from childhood to gain experience and learn how to navigate. Both in sea and land travel local guides, who were hired because of their expert knowledge of the geography of the area, were frequently employed. These oral directions were later documented in nautical guide books for sea navigation and travel books for land navigation. However, the nautical books emphasized and gave detailed information about navigation at sea, while travel books included a wider variety of facts. Although they often give distances between towns, they also describe the various aspects of the different places that the traveler visited.

4	Mental & Analog Maps	a. Mental Maps b. "Qunbas" or Compass Charts	a. Mental Maps

In sea navigation the Arabs used sea charts and mental maps to guide their ships. There is much written evidence that the Arabs used sea charts in sea navigation, but unfortunately no such early charts survive. Hard use at sea and the effects of the hot climate were major factors in the destruction of such perishable documents. As the Arab dhow had originated in India, and there were close contacts between Arab and Indian navigators, it seems possible that their sea charts could also have been related. Like the Arab sea charts, hardly any Indian sea charts have survived. However, one Gujarati chart of Aden and the Red Sea given to a European traveler in 1835 does survive (Fig.5.1). The presence of stellar rhumb lines with constellation symbols at each end indicating sailing direction is totally different from European-style portolan charts, whose rhumb lines indicate constant magnetic compass direction. Given the use of the star compass by Arab navigators, it seems likely that their charts and Indian ones might have shared this feature.

At the same time, Arab navigators used their mental maps to navigate at sea. For example, Al-Maqdisi (10^{th} century A.D.) saw different representations of the same coastline on many Arab sea charts, every representation different from the others. He became confused and wanted to know which map was correct. One day he met with Sheikh Bin Hazim, an expert in sea navigation, and asked the Sheikh to give him a description of the sea. The Sheikh smoothed the sand with the palm of his hand and drew a representation of the sea, showing it with an irregular coastline including several inlets and gulfs. Then the Sheikh said: "This is the shape of this sea; it has no other form." (Collins 1974, 149). Of course it was his mental map that guided the Sheikh's finger, enabling him to draw the ins and outs of a coast that he knew intimately from vast practical experience. In addition, in land navigation the travelers depended highly on the mental maps of their local guides, as did ship captains with local pilots.

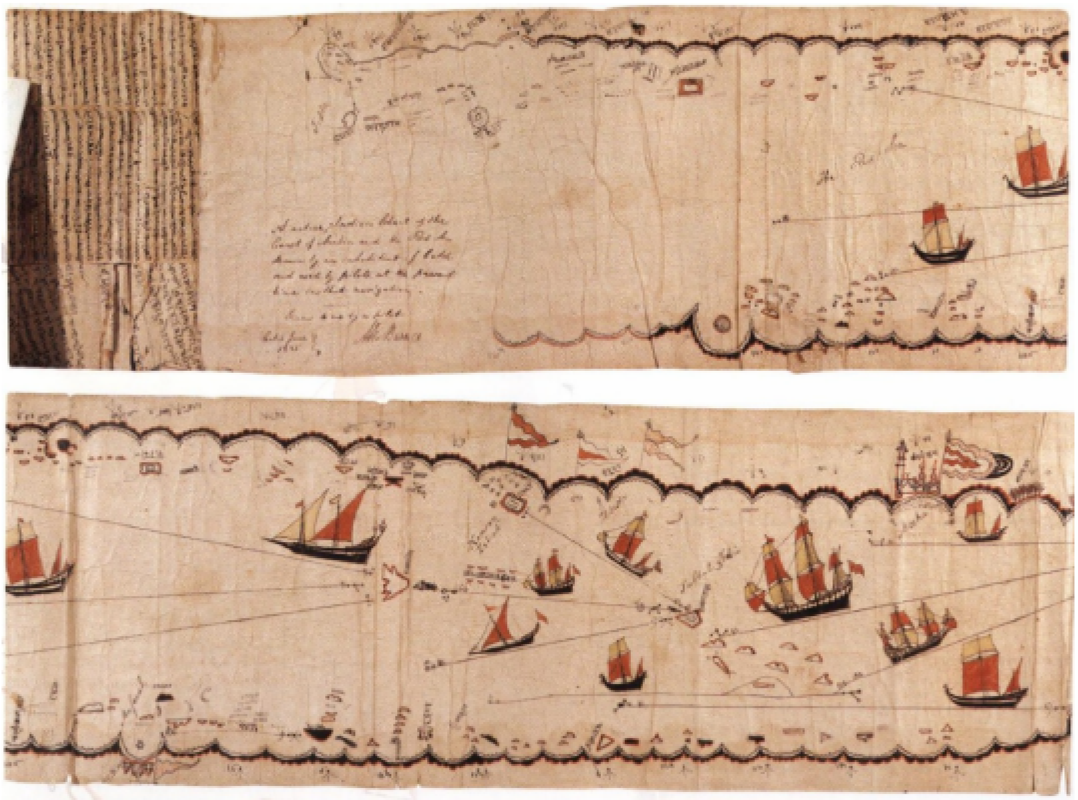

Figure 5.1. Native Indian (Gujarati) Sea Chart of the Red Sea and the Gulf of Aden, 1790s. Stellar rhumb lines indicating sailing directions have constellation symbols at each end (Blake 2004, 75).

5	Other Factors	a. Boats- Types & Sails & Rigging- Types b. Travel Season	a. Animals- Types b.Travel Season (Summer, Winter, Pilgrimage)

In the Indian Ocean various types of dhow were developed for use in sea navigation. The size and shape of the hull and the types of rigging were designed to suit the length and purpose of the voyage. Some dhows were used just in the coastal waters, but others were used on open sea routes. A similar differentiation in mode of transport was found on land, where riding and pack animals were used in different types of terrain to which they were suited. For example, the camel, with its ability to go without water, was best suited to desert conditions, while the horse and the donkey could be used in colder climates and more rugged terrain.

6	Members of Arab Ship & Caravan Crews	(Pilot, Assistants, Sailors, Cooks, Merchants, Local Guides, etc...)	(Leader, Guards, Merchants, Mathematicians, Local Guides, etc...).

There were similarities in the hierarchical organization of the ships and caravan crews, whose members performed comparable tasks working as a team. For example, the operators of both modes of transport were leaders, navigators, guards, drivers, and water servers. The Arab ship and caravan crews formed well-organized paternalistic groups in which each member knew his place and which functioned like a family. The leader of the crew was responsible for everything, and his word was law. This type of organization goes back very far in Arab culture, stemming from their origin as groups of desert nomads, each led by a sheikh who gave all the orders.

7	As a Case Example	Ibn Majid	Ibn Battuta

The case examples selected were famous Arab travelers. Ibn Majid was a great navigator who made great contributions to sea navigation, while Ibn Battuta was an important traveler who wrote about the lands he had visited. Both of them wrote travel books, but Ibn Majid was more of a navigator and his writings are concerned more with sea navigation. In contrast, Ibn Battuta was a traveler who used the travel network of Arab commerce to visit many areas by sea and by land. His travel book is considered as a geography book that describes the facilities, resources, products and people of the places that he visited. He frequently mentions distances between places but only occasionally mentions other aspects of navigation.

The third case example, Al-Idrisi, lived at a later time, and his work built upon geographical description represented by Ibn Battuta and the tradition of sea navigation represented by Ibn Majid. Al-Idrisi's map combined information from sea charts and land maps. In compiling his great map, he drew upon earlier Arab and Greek writers, but he was most concerned to obtain the most accurate and complete current information. Al-Idrisi had personal experience as a traveler, but he also sent out many travelers with instructions to get information about the areas to be covered in his map. The Book of Roger, with its closely linked and systematically presented sectional maps and geographical text was a unique achievement that was ahead of its time. Its creation at King Roger's request represented the presentation to a European King of the culmination of Arab geographical knowledge accumulated over five centuries. However, King Roger's territorial expansion represented the early beginnings of the nation state in Europe, and the rest of feudal Europe was not yet ready to take such an approach. Several centuries later the Renaissance turned the European vision from spiritual matters to the real world. The emergence of kingdoms with centralized national governments meant that European kings would begin to devote resources to systematically surveying, mapping and describing their kingdoms in the interest of better administering and utilizing their national physical and cultural resources.

However, Al-Idrisi and the Arab tradition of map making and geographical and navigational writing did have more immediate influences that can also be identified. Al-Idrisi returned to his homeland of Morocco to spend his last years, and it is probably not coincidental that a school of Arab geographers arose there and continued to emulate his work for several centuries (Bagrow, History of Cartography, 53). In regard to sea charting and navigation, Arab and Jewish cartographers who took their skills from the Near East to the Mediterranean contributed significantly to the early production of portolan style Mediterranean Sea charts.

Although this thesis has brought together information about traditional Arab navigation, geography and cartography and explored their significant historical contributions, it has also raised a number of interesting questions and revealed other aspects of this topic that merit further study. For example, how did the original and most accurate images of Al-Idrisi's 1154 A.D. sectional maps change as they were copied by hand and revised in different versions? Was the informational content improved or degraded? Another idea would be to use GIS techniques to overlay a modern map and graticule on Arab maps in order to study their patterns of distortion and relative accuracy, an approach that should shed light on their construction.

Nowadays, modern technology and methods of position finding and navigation, as well as modes of transport, have replaced early instruments and techniques described in this thesis. Early Arab travelers used the sail and the camel for motive power, but now the engine does this work. They used the compass to discover their position, but now there is GPS and other electronic equipment that does this job. But even though we have all of these modern techniques, we cannot ignore the significant role of the early geographers, navigators and cartographers. Studying traditional Arab navigation by sea and by land has revealed how much akin to the present day were their goals of utility and accuracy and their methods, even though the state of technology and human civilization limited and shaped the end product of their work into books and maps that at first glance seem very remote from those of today.

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