

# 13 • The Role of Charts in Islamic Navigation in the Indian Ocean

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The existence of indigenous navigational charts of the Indian Ocean is suggested by several early European sources, the earliest of which is the brief mention of mariners' charts by Marco Polo. First, in connection with Ceylon Polo mentions "la mapemondi des mariner de cel mer,"<sup>1</sup> a reference that can only refer to a nautical map of some sort. Second, in connection with the Indian west coast he refers to "le compas e la scriture de sajes mariner."<sup>2</sup> This first word has been translated as "charts," and strangely enough it is the very word (*al-qunbāṣ*) used by Aḥmad ibn Mājīd (fl. A.D. 1460–1500) in connection with portolan charts.<sup>3</sup>

The other sources are Portuguese and come from the period when that country had reached these parts. The Portuguese mention these charts in some detail. According to João de Barros, Vasco da Gama was shown charts of the coast of India at Malindi before he set out for the first time to cross the Arabian Sea. The text states that a

Moor of Guzarat, named Malemo Cana . . . had shown him a map of all the coast of India, with the bearings laid down after the manner of the Moors, which was with meridians and parallels very small (or close together), without other bearings of the compass; because, as the squares of those meridians and parallels were very small, the coast was laid down by those two bearings of north and south, and east and west, with great certainty, without that multiplication of bearings of the points of the compass usual in our [Portuguese] maps, which serves as the root of the others.<sup>4</sup>

Barros also notes that certain Moorish charts show the Maldives beginning on the latitude of Mount Eli (in Malabar) and continuing on to join the land of Java and the coast of Sunda.<sup>5</sup>

A chart was also mentioned by Ludovic Varthema in his *Itinerario* when he traveled between Borneo and Java sometime before 1508. Here the captain of the ship he sailed in "had a chart which was all marked with lines, perpendicular and across."<sup>6</sup>

It is interesting that only the account of Barros respecting Vasco da Gama's voyage includes the note about the Arab charts; they are not mentioned by Correia or Lopes de Castanheda, who published earlier accounts of the

voyage.<sup>7</sup> Barros wrote in the 1540s and could have read Varthema's work, which was in many editions by that date, including an edition in Spanish published in Seville in 1520. There are other occasions when Barros seems to have incorporated later materials into his version of the earlier Portuguese accounts of the Indian Ocean, so some doubt is cast on the accuracy of his statement.

In 1512 another possible local chart is mentioned by Afonso de Albuquerque in a letter to the Portuguese king Manuel. He reports that he had seen a large chart belonging to a pilot on which Brazil, the Indian Ocean, and the Far East were shown. This chart can only have been very sketchy, for the Portuguese pilot Francisco Rodrigues (who had seen and copied this Javanese chart) produced charts about 1513 in which the coasts not already sailed by the Portuguese were shown in a very imperfect way.<sup>8</sup>

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1. Marco Polo, *Il milione*, ed. Luigi Foscolo Benedetto (Florence: Leo S. Olschki, 1928), 176 (MS. fol. 77d), and *The Book of Ser Marco Polo the Venetian, concerning the Kingdoms and Marvels of the East*, ed. and trans. Henry Yule, 3d rev. ed., 2 vols. (New York: Charles Scribner's Sons, 1903), 2:312–13.

2. Benedetto's text, 209 (fol. 93a), and Yule's translation, 2:424 (note 1).

3. For Ibn Mājīd, see below and also Gerald R. Tibbetts, *Arab Navigation in the Indian Ocean before the Coming of the Portuguese* (London: Royal Asiatic Society of Great Britain and Ireland, 1971; reprinted 1981), 272.

4. Gaspar Correia, *The Three Voyages of Vasco da Gama, and His Viceroyalty: From the Lendas da India of Gaspar Correa*, trans. Henry E. J. Stanley (London: Printed for the Hakluyt Society, 1869), 137–38 n. 2, quoted from João de Barros, *Asia: Década I*, bk. 4, chap. 6 (1552), by Stanley in a footnote to Correia's text.

5. From João de Barros, *Asia: Década III*, bk. 3, chap. 7 (1563); mentioned by Avelino Teixeira da Mota, "Méthodes de navigation et cartographie nautique dans l'Océan Indien avant le XVI<sup>e</sup> siècle," *Studia* 11 (1963): 49–91, esp. 71.

6. Ludovic Varthema, *The Travels of Ludovico di Varthema in Egypt, Syria, Arabia Deserta and Arabia Felix, in Persia, India, and Ethiopia, A.D. 1503 to 1508*, trans. John Winter Jones, ed. George Percy Badger (London: Printed for the Hakluyt Society, 1863), 249.

7. On Correia, see note 4 above; Fernão Lopes de Castanheda, *História do descobrimento & conquista da Índia pelos Portugueses*, 8 vols. (Coimbra: João da Berreyra e João Alvarez, 1552–61).

8. Afonso de Albuquerque, *Cartas de Afonso de Albuquerque*, 7 vols. (Lisbon: Typographia da Academia Real das Ciencias, 1884–1935), 1:64–65; see also Teixeira da Mota, "Méthodes de navigation," 73 (note 5).

Finally, the famous map of Pīrī Reʿīs that is dated 1513 (pp. 269ff. and fig. 14.5) mentions that one of its sources is an Arab map of India (*ʿArabi Hint ḥartisi*). The problem is that the eastern part of Pīrī Reʿīs's map has not survived. It is not possible to check this information, and his Arab map may have been similar to those of the Arab classical geographers and may have been used only for place-names. That Pīrī Reʿīs also mentions other Arab maps and maps drawn in the days of Alexander the Great leads one to suppose he might mean classical Arab maps of Ptolemaic origin. He contrasts these with Portuguese maps of India and China that are "geometrically drawn," as if the Arab maps were not.<sup>9</sup>

Thus, although neither the map of Albuquerque nor that mentioned by Pīrī Reʿīs may have been practical navigational charts, the charts mentioned by Barros and Varthema were presumed to be so by those Europeans who saw them. The references of Marco Polo may also have genuinely referred to Indian Ocean navigational charts, although they are too short to give us any practical details. They could, however, indicate that examples like those mentioned by Barros and Varthema existed almost two hundred years earlier. One might therefore expect to find remains of actual charts, traces of their influence, or even descriptions from Arab sources. Yet none of these have been forthcoming.<sup>10</sup>

At the time of Vasco da Gama, there was in circulation in the Indian Ocean a considerable amount of Arab navigational literature in the form of practical advice for navigators and pilot guides for the coasts of the Indian Ocean and China seas. A few examples of this literature have survived in the Arabic works of Ibn Mājid and Sulaymān al-Mahrī, who wrote in the later fifteenth century and the early sixteenth, respectively, and in the Turkish adaptation of Sulaymān by Sidi ʿAlī Çelebi (Seydī ʿAlī Reʿīs) written about 1550.<sup>11</sup> These works are very detailed and cover the whole gamut of navigational science as known to the Muslim sailors in the Indian Ocean during this period.

The Arabs and Persians had been sailing the Indian Ocean before the Islamic era, and once the empire of Islam had become a stable entity, ocean trade was revived and the caliphate acted as a new economic stimulus for long voyages to such places as Africa and China. The Arabs sailed throughout the Indian Ocean and are known to have frequented southern China, and according to the classical Arab geographers they even reached Korea. In Ming times the Chinese reached Africa, and in both Chinese and Arab geographical literature there is a wide knowledge of the whole ocean. In this there is much to suggest that navigation was common to all peoples of the Indian Ocean. Common methods were probably used by all those bordering on the shores of that ocean, and the Arab navigational texts on the subject were to some

extent representative of all Indian Ocean sailing.<sup>12</sup> In the same way, navigation in the Mediterranean was common to all sailors around its shores (see chap. 14). It is also clear from the texts mentioned above that Mediterranean methods were not used by Indian Ocean navigators. Ibn Mājid, a prolific writer and an experienced navigator in the Indian Ocean, wrote as if he was acquainted with Mediterranean practice and derided the use of the *qunbāṣ* and scale of miles, which were not required by the Indian Ocean pilot.<sup>13</sup> Both of these things were probably not known at all to the average pilot in the Indian Ocean, and both refer to the methods used in connection with the portolan chart. In fact, the *qunbāṣ* (comparing the information given by Marco Polo above) may be the portolan itself.

One might therefore expect these Arab navigational texts to throw some light on the existence and form of charts the Arabs used for sailing in the Indian Ocean. Some scholars have anticipated a study of these texts by

9. Afetinan, *Life and Works of Piri Reis: The Oldest Map of America*, trans. Leman Yolaç and Engin Uzmen (Ankara: Turkish Historical Society, 1975), 32. For the word *ḥartī*, see p. 206. That this is the first known use of the word in Turkish and that all early uses of the word seem to be navigational does not imply that *ʿArabi Hint ḥartisi* means an Arab chart of India. It would most likely be an Arab map of India, and I suspect the original map of Piri Reʿīs is a hybrid like that of al-Şifāqsi (see figs. 14.24 and 14.25).

10. The reference to "charts and itineraries of mariners" reported to come from the text of the Arab geographer al-Muqaddasi's *Aḥsan al-taqāsim* (see the edition *Descriptio imperii moslemici*, ed. Michael Jan de Goeje, *Bibliotheca Geographorum Arabicorum*, vol. 3 [Leiden: E. J. Brill, 1877; reprinted 1906, 1967], 10), is a false one and of no importance to us here (see William C. Brice, "Early Muslim Sea-Charts," *Journal of the Royal Asiatic Society of Great Britain and Ireland* [1977]: 53–61, esp. 54). The text uses the word *dafatir*, which has been translated by Ranking and Azoo in their edition of al-Muqaddasi's text by the double phrase "charts and itineraries" (*Aḥsanu-t-taqāsim fi maʿrifati-l-aqālim*, ed. and trans. G. S. A. Ranking and R. F. Azoo, *Bibliotheca Indica*, n.s., nos. 899, 952, 1001, and 1258 [Calcutta: Asiatic Society of Bengal, 1897–1910], 13–14). The word *daftar* means an account book or a file and in this case probably means a log book. It cannot have the implication "map." Certainly whenever al-Muqaddasi means "map" in his text, he uses the word *şūrah* (see above, p. 95); even "those who have made 'charts'" (Ranking and Azoo translation) is *muşawwirān* (from *şūrah*) in the text. This reference is expanded in great detail by Ahmad Y. al-Hassan and Donald R. Hill, *Islamic Technology: An Illustrated History* (Cambridge: Cambridge University Press, 1986), 128, but none of their expansion appears in al-Muqaddasi's text itself.

11. A bibliography relating to these works can be found in Tibbetts, *Arab Navigation* (note 3). Important also for this subject is the work of Tomaschek and Bittner; see Sidi ʿAlī Çelebi, *Die topographischen Capitel des Indischen Seespiegels Mohit*, trans. Maximilian Bittner, introduction by Wilhelm Tomaschek (Vienna: Kaiserlich-Königliche Geographische Gesellschaft, 1897).

12. Tibbetts, *Arab Navigation* (note 3) has shown connections with Indian and Southeast Asian navigational practice and has elsewhere given comparisons with Chinese and Pacific Ocean navigation. This is mentioned again, note 21 below.

13. See Tibbetts, *Arab Navigation*, 272 (note 3).

assuming that the charts really existed and that their existence would be revealed by a detailed study of the texts.<sup>14</sup> In reality, the texts do not mention charts at all. The Indian Ocean navigators of the fifteenth century seem to have managed quite happily without what is sometimes thought to be an essential guide to navigation.

A chart was an aid to pinpointing a position on the sea, and by comparing this with the position of the destination, a course could be plotted between these two points. A perusal of the Arab pilot guides will show that this particular aid was not really required by the Arab navigator, whose plotting was done in his head. He knew the Pole Star altitude of his destination, and he used a remembered bearing until he reached this Pole Star altitude. He then sailed down the latitude line until he reached his goal. This is a simplified statement, but that is basically what every Arab pilot did. Another version of this process was to remain on the recommended bearing until land was in sight and then to make corrections using landmarks. The Arabs did not conceive of a pinpointed position on an expanse of water relative to a set of invisible coastal points or even to a set of imaginary lines. Their only visible contact with terra firma was the position of the stars relative to the horizon. This gave them their stellar altitude that let them compare their latitude with that of the coast they were aiming toward.

In translating the Arab navigational texts, stellar altitudes have been plotted against bearings and have produced some quite reasonable charts that, if corrected by continual practical use, could have been used by Arab pilots in the same way as portolan charts.<sup>15</sup> There is no evidence at all that the Arabs ever tried this method of navigation, however. The Arab pilots did not produce their guides with a visible representation of the coasts and islands in mind.

From the Portuguese accounts it appears that indigenous Indian Ocean charts were not constructed with rhumb lines, which would be necessary to produce the charts indicated in the previous paragraph in the same way that portolan charts were conceived. The supposed Arab charts would have had to be built up on a grid of lines at right angles, implying that distances could be measured both latitudinally and longitudinally.<sup>16</sup> The Arabs had a method of measuring latitude in their constant use of stellar altitudes, but they had no accurate way to measure longitude at sea, so no chart could be compiled of large oceanic areas. Also, since the longitude of the ship could not be found, it was impossible to use any chart as a later European pilot would do to pinpoint his position.

Attempts by the Arab pilots to measure longitude are noticeable in the Arab navigational texts. A primitive attempt to use stellar risings and settings east and west is ridiculed by the navigational writers. A more sophis-

ticated way was to measure departures. The Arab navigational guides had a standard set of values for "departures" for each compass rhumb as well as a set of values for the distance sailed along the rhumb.<sup>17</sup> In both cases these were based on raising the latitude one *işba'* of the Pole Star.<sup>18</sup> Thus, sailing so many *işba'*s on a fixed course using a fixed northerly bearing from a point on the Indian west coast and returning on a known bearing to a point at the same latitude on the African coast theoretically would enable one, using these values, to measure the longitudinal distance (*masāfa*) between the two coasts. So although theoretically this kind of triangulation scheme might allow one to draw up a chart of the coasts, the practical difficulties of such a calculation were enormous.<sup>19</sup> However, if the apex of the triangle formed in such an example was a known point on the Arabian coast, things would be simpler. Large numbers of journeys over several centuries would have standardized the bearings around the Arabian Sea, and longitudes and distances could all be calculated from the standard values and the known stellar altitude values at various points. It was thus possible to plot the African coast on a chart, but only if the configuration of the west coast of India was known first. There was no way of linking this information to the earth's surface in the same way that stellar altitude could be linked to the North Pole and South Pole. In the Bay of Bengal a similar situation would occur; it could not be linked to the Arabian Sea, since the width of penin-

14. For example, Juan Vernet Ginés, "Influencias musulmanas en el origen de la cartografía náutica," *Boletín de la Real Sociedad Geográfica* 89 (1953): 35–62, who quotes various works of Gabriel Ferrand, who also expected charts to appear somewhere in the texts but failed to find them. He could only find, like everyone else, navigational statistics that might ultimately lead to charts.

15. See the charts produced in Tibbetts, *Arab Navigation* (note 3).

16. It might be noted that copies of portolan charts were made (like many medieval drawings of any size) by using a grid of lines that were usually erased in the finished chart. It is therefore possible that the Arabs also used a grid for this purpose if their charts had existed, not for the original compilation, and that on a few examples seen by the Portuguese this grid had not been erased.

17. "Departure" is the distance in linear measure traveled due east or west during an oblique sailing. It was used in connection with "raising the Pole" by a fixed interval. It was thus the horizontal distance between due north from one's point of origin and one's actual position. Arab "departures" were given in terms of the horizontal distances between two adjacent rhumbs ( $11\frac{1}{4}^\circ$ ).

18. *Işba'* was the Arab unit of measurement for stellar altitude. The word means "finger" and originally represented the angle subtended by one finger's width when held at arm's length from the eye. See Tibbetts, *Arab Navigation*, 313ff. (note 3).

19. A similar kind of triangulation system for the formation of portolan charts in the Mediterranean has been mentioned by Tony Campbell, "Portolan Charts from the Late Thirteenth Century to 1500," in *The History of Cartography*, ed. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1987–), 1:371–463, esp. 387–88, but the compass does not seem to have been used—only distances by dead reckoning.

sular India could not be measured by similar means at a similar latitude. Sumatra could be linked to eastern Africa in the same way at a lower latitude, but the large distance involved and the infrequency of making such journeys would make compiling this sort of chart virtually impossible. If one were looking for a practical chart compiled by Arab navigators, one would certainly expect bearings and star altitudes to be used as coordinates, not a latitude-longitude grid as the Portuguese seem to suggest.<sup>20</sup> Navigational treatises similar to these Arab and Turkish ones do not seem to have survived in Indian or Southeast Asian literature, and the basic principles of Chinese navigation were different. However, odd references discovered in the literatures of all these nations suggest that a navigational technique similar to that given by the Arab texts was prevalent throughout the Indian Ocean before the coming of the Europeans.<sup>21</sup> Nowhere is there any local evidence of charts.<sup>22</sup>

The history of the latitude-longitude grid in Islamic mapmaking is very obscure, as has been explained in earlier chapters. In spite of detailed tables based originally on those of Ptolemy, the idea of a grid of latitude and longitude lines does not appear on any surviving terrestrial map until the mid-fourteenth century A.D., and then it is only attached around the border of the map, with no reference to the content of the map at all. Even the maps of al-Idrisi, which are based on interconnecting rectangular sections, have no visible graticule as a base, although the top and bottom borders of the sections are meant to coincide with the climate boundaries.<sup>23</sup> Of all the maps illustrated in Miller's *Mappae arabicae*, only the Iran map from Ḥamd Allāh Mustawfi's *Nuzhat al-qulūb* (Diversion for the hearts) shows an attempt to plot localities on a grid.<sup>24</sup> The grid in these cases consists of straight lines forming a graticule of equal-sized squares. Names of localities are then entered diagonally across the relevant squares. There is only one map of this sort in each version, and in each case it is of Iran with the neighboring regions. Three manuscripts give a coastline, and a glance at this will show that the general lack of accuracy would make them inadequate as a tool for navigation, let alone that the principle of pinpointing localities is not understood and the grid is not based on any practical projection. Teixeira da Mota, in writing of these supposed Arab charts mentioned by Barros, raises the question, How could the Arabs actually use a chart based on a grid?<sup>25</sup> The Mercator projection is peculiar in that all loxodromes are straight lines and their angle to the grid is equivalent to the bearing. Thus the bearing can be measured practically from the chart. The Arabs show no sign of understanding the mathematics behind the Mercator projection, and no other form of grid could be used to the same advantage.

All this points to the conclusion that the Arabs did not

have the necessary technical traditions either to construct navigation charts onto a grid of latitude and longitude lines or to use such a chart practically were one available. It therefore seems probable that the maps shown to Vasco da Gama were similar to those given in the manuscripts of Ḥamd Allāh Mustawfi and Ḥāfiẓ-i Abrū and could only have been of academic or popular interest.

In the *Wubei zhi* (Treatise on military preparations)<sup>26</sup> is preserved the Chinese chart based on the voyages of the celebrated Ambassador Zheng He, who sailed with the fleets of the Ming dynasty. The chart shows the routes to Hormuz, the Red Sea, and eastern Africa from China and might also be advanced as evidence for the nonexistence of accurate navigational charts in pre-Portuguese times in the Indian Ocean. Zheng He's last voyage was in 1433, and he is said to have produced maps, but the extant chart is little more than a pictorial representation of the area covered. Had he seen charts of these regions

20. Henri Grosset-Grange, who has also studied these texts and who is an experienced navigator himself, has likewise failed to discover any references to charts actually used by the Arabs, although he has similarly found enough data to create charts from bearings, star altitudes, and so forth. See his "Une carte nautique arabe au Moyen Age," *Acta Geographica*, 3d ser., no. 27 (1976): 33–48, esp. 35, and also idem, "La navigation arabe de jadis: Nouveaux aperçus sur les méthodes pratiquées en Océan Indien," *Navigation: Revue Technique de Navigation Maritime Aérienne et Spatiale* 68 (1969): 437–48, esp. 447. Reinhard Wieber, "Überlegungen zur Herstellung eines Seekartogramms anhand der Angaben in den arabischen Nautikertexten," *Journal for the History of Arabic Science* 4 (1980): 23–47, has gone into great detail mathematically on how charts can be produced from the data given by the Arab navigators, but he admits that no such charts are extant. He does not explain how the Arab navigators acquired such a detailed knowledge of mathematics.

21. This has been mentioned in Gerald R. Tibbetts, "Comparisons between Arab and Chinese Navigational Techniques," *Bulletin of the School of Oriental and African Studies* 36 (1973): 97–108, and idem, *A Comparison of Medieval Arab Methods of Navigation with Those of the Pacific Islands*, Centro de Estudos de Cartografia Antiga, Série Separata, Secção de Coimbra, vol. 121 (Lisbon: Junta de Investigações Científicas do Ultramar, 1979).

22. Except for charts of the *Wubei zhi* sort found in China or similar mnemonic maps from India (see chap. 18).

23. None of al-Idrisi's maps have lines of latitude and longitude (see chap. 7).

24. These are all from the British Library: MS. Or. 7709, Add. MSS. 16736, 16737, 23543, and 23544. The two manuscripts that do not give a coastline are MS. Or. 7709 and Add. MS. 23544. Konrad Miller, *Mappae arabicae: Arabische Welt- und Länderkarten des 9.–13. Jahrhunderts*, 6 vols. (Stuttgart, 1926–30), Band 5, Beiheft, Taf. 84–86; see also p. 150 and fig. 6.13. Vernet Ginés, "Influencias musulmanas," 57–62 (note 14), also mentions these maps as the only "Arab" ones with a grid.

25. Teixeira da Mota, "Méthodes de navigation," 70 (note 5).

26. For a modern study on this map, see Ma Huan, *Ying-yai sheng-lan: "The Overall Survey of the Ocean's Shores,"* ed. and trans. Feng Ch'eng-Chün, introduction, notes, and appendixes by J. V. G. Mills (Cambridge: Published for the Hakluyt Society at the University Press, 1970), 236–302 (appendix 2), where Mills calls it the Mao K'un map. See also the Chinese section of the *History of Cartography*, vol. 2, bk. 2.

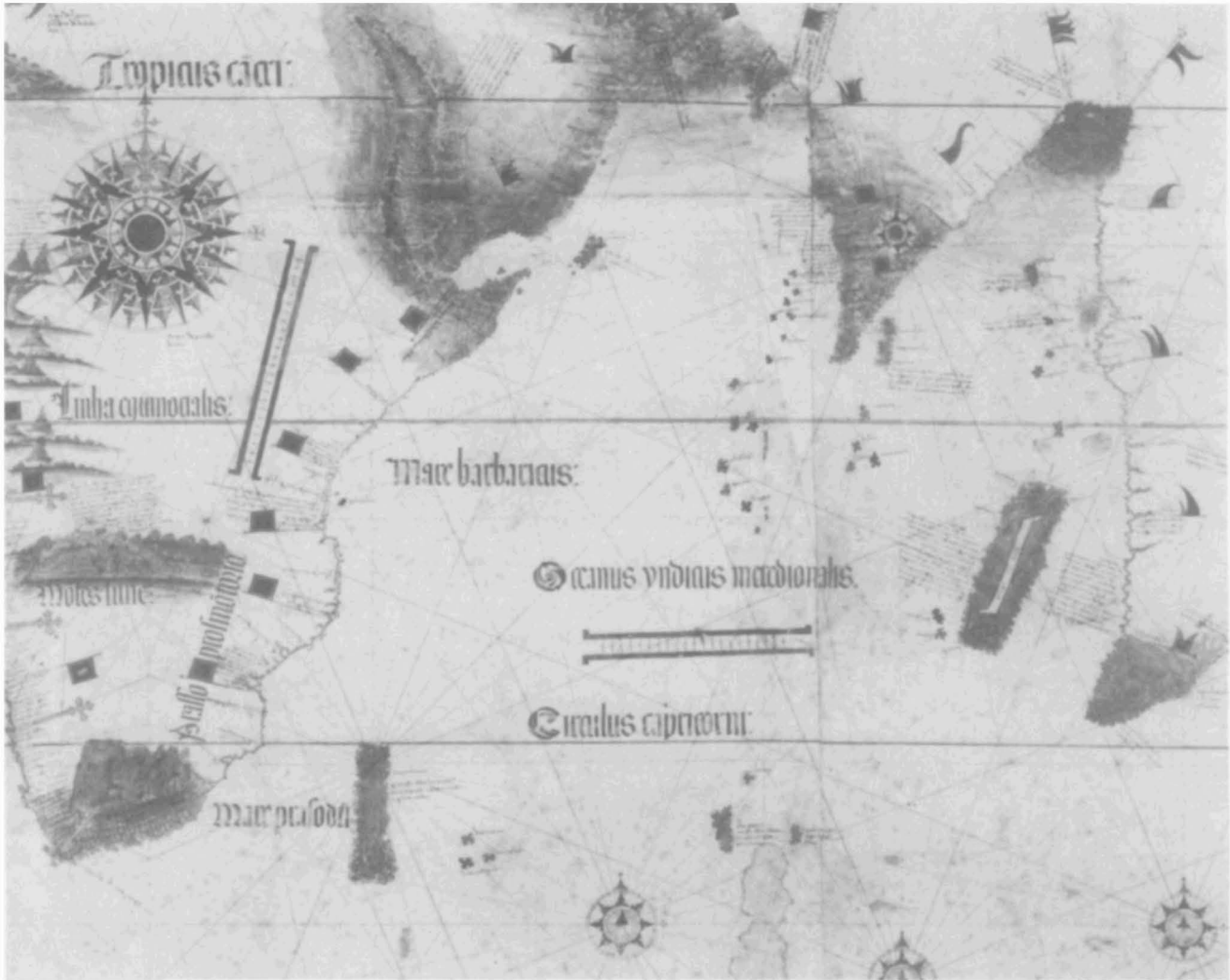


FIG. 13.1. THE INDIAN OCEAN FROM THE CANTINO MAP. The map was compiled between 1498 and 1502, and this detail of the Indian Ocean is about one-sixth of the entire map.

Size of the entire map: 200 × 105 cm. By permission of the Biblioteca Estense, Modena (C.G.A. 2).

capable of being used practically, he might have incorporated them in his own attempts, and some slight influence might have penetrated into the *Wubei zhi* survival. However, this chart cannot have been used except for mnemonic purposes: no measurement could be taken from it.<sup>27</sup>

Attempts have been made to detect the influence of local maps or navigational charts on Portuguese cartography of the period.<sup>28</sup> There is, in fact, one type of map that does clearly show local Indian Ocean influence, although this influence becomes weaker as the Portuguese learn more about the Indian Ocean firsthand, until it is eliminated altogether. This type begins with the world map of 1502 of unknown authorship, named after Alberto Cantino, and includes the map of Nicolò de Cavriero of 1505 and the woodcut *Carta Marina* of Martin Waldseemüller (1516). The Cantino map, of course,

comes from a time when the Portuguese had reached no farther east than the west coast of India. It shows considerable detail in the area beyond Cape Comorin, and it has always been suspected that this detail came from local sources (fig. 13.1). In 1897 Tomaschek compared this map with the navigational works of the Turkish admiral Sîdî Çelebi, and similar comparisons have been made more recently with the works of the Arab Ibn

27. See Ma Huan, *Ying-yai sheng-lan*, 290–91 (fig. 5) (note 26), for a reproduction of part of this chart.

28. For example, Luís de Albuquerque, “Quelques commentaires sur la navigation orientale à l’époque de Vasco da Gama,” *Arquivos do Centro Cultural Português* 4 (1972): 490–500, and Luís de Albuquerque and J. Lopes Tavares, *Algumas observações sobre o planisfério “Cantino,” 1502*, *Agrupamento de Estudos de Cartografia Antiga, Série Separata, Secção de Coimbra*, vol. 21 (Coimbra: Junta de Investigações do Ultramar, 1967).



FIG. 13.2. FOLIOS FROM AN ARAB NAVIGATIONAL TEXT. These pages include a section on the *masāfāt* in the Bay of Bengal from the *Minhaj al-fākhir* (The splendid path) by Sulaymān al-Mahrī.

Size of the original: not known. By permission of the Bibliothèque Nationale, Paris (MS. Arabe 2559, fols. 80b–81a).

Mājīd and of Sulaymān al-Mahrī, and the influence of the tradition in which these authors wrote was found to be extremely strong.<sup>29</sup> The place-names of the Cantino map are found to be in agreement in many cases with those of the navigational texts. The map gives Pole Star altitudes for a number of places that, although they do not actually agree in every case with the values given in the extant navigational works, are reasonably close and could possibly have been taken from some similar set of values occurring in a text or a tradition that has not survived. In the same way, the longitudinal distances across the Bay of Bengal bear a resemblance to the Arab *masāfāt*, although they cannot be said to agree accurately with the Arab values (fig. 13.2). All that can be said is that if the Arabs drew a straight line north and south for the coast of Burma and measured off the distances across the bay to obtain the Indian east coast, a roughly similar picture would be obtained. But even then the resulting

Arab map would have shown the change of direction in the Indian coastline in the neighborhood of the delta of the Godavari River, which the Cantino map fails to do.

Now, whereas the African coasts on the Cantino map are based on material similar to that used for portolan charts, so that this area can be used to some extent as a practical navigation chart, the eastern part of the map could never have been successfully used as a chart by anyone. If the author of the Cantino map had possessed Arab charts that were used for practical navigation in this area, he would have been able to produce a much more accurate version of the Bay of Bengal. One must therefore conclude that he took miscellaneous facts from written Indian Ocean pilot guides and used them with a certain amount of guesswork to continue his planisphere as far

29. See Albuquerque, "Quelques commentaires sur la navigation," and Albuquerque and Tavares, *Planisferio "Cantino"* (note 28). Tomaschek's work appears in *Die topographischen Capitel* (note 11).

as he could obtain suitable information from these local sources. The Arab influence on the Cantino map is limited to three things. The first is the use of Arab place-names, but even some of these are taken from classical Arab sources and not from the navigational texts. The second is the use of Pole Star altitudes. In some cases values are actually given, but their use is very haphazard. What is more noticeable is that places having the same Pole Star altitudes in the navigational texts, for example, on both sides of the Bay of Bengal, are placed on the same latitudes on the Cantino map. There is no complete system, however, and the places are not spaced proportionally down the coast. Also, this map has equated eleven *işba's* of the Pole Star with the Tropic of Cancer and zero *işba's* of the Pole Star with the equator on the western part of the map—which is not true and could not have come from Arab sources. Third, it is possible that the author of the Cantino map utilized the Arab longitudinal distances (*masāfāt*): for instance, to produce his shape for the Bay of Bengal. At least four pairs of places at equal stellar altitude are given *masāfāt* by the Arab texts. The distances across the bay on the Cantino map, however, are not in proportion to those of the texts. As I said above, a similar map using Arab figures would have shown the bend in the Indian east coast near the Godavari Delta and also given some idea of the Gulf of Martaban, neither of which is noticeable in the Cantino map.

One must therefore conclude that the author of the Cantino map could not have used practical Arab charts when compiling his map. He has, however, used Arab maps appearing in literary texts, as can be seen from his nomenclature, and these may have influenced his general shape of Southeast Asia. Information from Arab navigational texts was sufficient to give him a fairly accurate idea of peninsular India, but in Southeast Asia the information in the texts was less detailed and often confusing. This is where the maps in literary texts, with their Ptolemaic approach to the southeast, become obvious. The shape of the Malay Peninsula on the Cantino map is very similar to that on al-Idrīsī's map of 1192,<sup>30</sup> although most of the material inserted on the former is from the navigational texts.

Teixeira da Mota has also pointed out that another map, that of Lopo Homem of 1519, shows the continuation of the Laccadives and Maldives in Java and the Sunda Islands, mentioned above as being a concept seen by Barros in certain Indian Ocean charts. There is no real evidence apart from this in the Homem map to suggest Arab influence. That this map illustrates Barros's statement may be purely coincidental, especially as the map is considerably earlier than the statement. Teixeira da Mota has observed that this concept fits in with the idea

given in the Arab navigational texts that Java and the Sunda Islands continue the line of Sumatra in a south-eastern direction. However, it is quite clear from these texts that these lands are continuing the line of the Andaman-Nicobar Islands and that the Laccadive-Maldivian chain is quite separate.

An Islamic equivalent of the Cantino map is the surviving world map of 'Alī ibn Aḥmad ibn Muḥammad al-Sharafī al-Şifāqsi, which is dated 1579 (see plate 24).<sup>31</sup> This is fundamentally a version of al-Idrīsī in which the Mediterranean part of the latter author is replaced by portolan chart material. It has no grid, but the rhumb lines of the portolan chart are continued across the map to cover the Idrīsī portion of Asia. Like all Islamic maps, the detail is on land and not coastal, and this to some extent confirms that Arab charts of the Indian Ocean were not available even to Muslims when they might have been required in 1579.

One final example is the passage from the Portuguese André Pires' *Livro de marinharía*: "If by chance you come across a Moorish chart."<sup>32</sup> This is followed by an explanation of how to convert the Arab *işba's* (*polegadas*) to European degrees (*graus*). However, from the language of this passage it appears that Pires had probably never come across a Moorish chart. This further confirms what we would expect from the evidence already presented.

All in all, the evidence for indigenous maps (pre-1500) in the Indian Ocean that could be used for practical navigation seems to be entirely negative. The so-called charts shown to the Portuguese were much more likely to have been literary compositions similar to those that survive today in Arabic manuscript atlases and geographical works. Had the Portuguese seen something more useful, it is most likely that its influence would have been more apparent in Portuguese cartography, and the Cantino map and those of Francisco Rodrigues would have revealed something of it and been considerably different than they actually are. Perhaps we should really have been able to solve the problem if the eastern parts of the Pīrī Re'īs map of 1513 had survived. We would at least have been able to see what contemporary Islamic marine cartography had made of the area.

30. Miller, *Mappae arabicae*, Band 1, Heft 3 (note 24), who calls it the "Kleine Idrīsī."

31. Carlo Alfonso Nallino, "Un mappamondo arabo disegnato nel 1579 da 'Alī ibn Aḥmad al-Sharafī di Sfax," *Bollettino della Reale Società Geografica Italiana* 53 (1916): 721–36. On this family of map-makers, see pp. 284–87.

32. See Luís de Albuquerque, *O livro de marinharía de André Pires*, *Agrupamento de Estudos de Cartografia Antiga*, Secção de Coimbra, vol. 1 (Lisbon: Junta de Investigações do Ultramar, 1963), 220, and Teixeira da Mota, "Méthodes de navigation," 74 (note 5).