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# The *Liber de existencia riveriarum* (c.1200) and the Birth of Nautical Cartography

JOAQUIM ALVES GASPAR 

**ABSTRACT:** The earliest known historical clue to what might be a primitive nautical chart is in a medieval manuscript of c.1200, the *Liber de existencia riveriarum et forma maris nostri mediterranei*, which describes the Mediterranean Sea. The body of the manuscript consists of an account of the Mediterranean and Black seas and the Atlantic coasts of Europe and northern Africa organized in 45 regional sections, each introduced by a short text setting out the orientation and size of the region, followed by a portolan-like listing of contiguous coastal localities with the distances between them. These are complemented by additional tracks across the open sea (pelagic tracks) for which both distances and directions are provided. Two distinct types of directions can be distinguished: those not affected by magnetic declination, which indicates that they were probably determined by astronomical methods, and those affected by systematic errors that could only have originated in observations made with a marine compass. It is suggested that some of the pelagic courses in the *Liber* were compiled from an existing chart or sketch based on astronomical directions, which may have been used as a general reference for the work. The implication is that the genesis and technical evolution of the medieval portolan chart were more complex than has hitherto been thought by map historians, who have based their analyses on the few extant exemplars from the end of the thirteenth and beginning of the fourteenth centuries, all based on compass directions.


**KEYWORDS:** portolan chart, portolan, magnetic compass, navigation in the Middle Ages, medieval cartography, medieval Latin manuscripts.

Of the many unresolved questions relating to the history of maps and charts, the genesis of the portolan chart of the Mediterranean is one of the best known. Emerging into the historical record more than a century before Ptolemy's *Geography* was translated into Latin, the portolan chart is among the most intriguing of medieval artefacts, not least for its unprecedented accuracy and detail. Since Adolf Nordenskjöld completed his classic essay on the history of nautical charts more than a century ago, the issue of their

origin has been the object of numerous scholarly studies and the inspiration for various theories.<sup>1</sup> A brief survey of the key literature of just the last three decades, though, is enough to provide the context for the discussion presented here.

## *Recent Literature*

At present, the literature is dominated by two major studies: the chapter by Tony Campbell on

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medieval portolan charts in the *History of Cartography* (1987) and a hefty tome by Ramón Pujades i Bataller, *Les cartes portolanes* (2007).<sup>2</sup> The two publications are complementary as far as the approach to the problem of origins is concerned. While Campbell reviews the various conflicting theories regarding the date, place and construction of the earliest charts, including those postulating a pre-medieval origin, Pujades assumes that the portolan chart is a medieval creation and is content to describe the historical context in which the earliest exemplars may have been produced.

Campbell's concern over the question of the birth and construction of the earliest prototypes is underlined by his comment that 'among the research problems connected with the portolan charts, the question of their origin is perhaps the most intractable'.<sup>3</sup> Although his historiographical review mostly focuses on the hypotheses of the charts' medieval origin, he consistently expresses doubts about related aspects, such as the use of the magnetic compass and a map projection in their construction. Several theories on this last point coexisted at the time of his study, ranging from the use of the *plate carrée* (the cylindrical equidistant projection centred at the equator) to the Mercator projection. However, as Campbell himself pointed out, most historians had already rejected the possibility that a map projection was deliberately used in the construction of the charts.<sup>4</sup> On the possibility of the charts having been compiled from compass directions, he was cautious, calling for 'full-scale cartometric analyses' in order to 'confirm that localized distortions on the earliest charts coincide with the pattern of regional magnetic variation'.<sup>5</sup>

In contrast, Pujades considers that medieval nautical cartography was based on compass directions, as demonstrated by the tilt of about eight to nine degrees affecting all charts until the end of the sixteenth century.<sup>6</sup> For Pujades, charts could not have been produced before the beginning of the thirteenth century, when specific advances in mathematics took place in Europe. He argues that the first charts were constructed from the courses and distances collected by pilots, which were adjusted to a common scale before being transposed onto a diagram of sixteen winds. This process was facilitated by the introduction of the decimal system, including Arabic numerals and the positional value of the nought, which are materialized in the distance bars of all portolan charts.<sup>7</sup> He also finds confirmation of the close connection between the sailing directions (the portolans) and the nautical charts, as well as the involvement of seamen

in their making, in an early thirteenth-century text entitled the *Liber de existencia riveriarum*, the subject of the present article, but unknown at the time Campbell was writing.<sup>8</sup>

A pioneering step in the establishment of a connection between the chart's geometry and the navigational information contained in the medieval portolans was made by Jonathan Lanman in 1987, the same year as Campbell's *History of Cartography* essay. Lanman used information from two portolans, on distances and courses between places along the Mediterranean shore, to construct two maps that he then compared with two portolan charts and a modern map.<sup>9</sup> However recognizable in general terms the resultant outlines of the Mediterranean Sea, their accuracy and detail are hardly comparable with those of the charts they were intended to replicate.<sup>10</sup>

Yet another study was being completed at the same time as Campbell's and Lanman's, unknown to either and still unpublished. This was Scott Loomer's doctoral research on the geometrical properties and construction of portolan charts.<sup>11</sup> In the course of his work, Loomer carried out a systematic cartometric analysis of 26 portolan charts, which he presented in his thesis. The results of the analysis pointed to a high degree of correlation between the geometry of the charts and the Mercator projection, from which he concluded that they were based on loxodromic course bearings, rather than distances, probably using some form of triangulation.<sup>12</sup>

Finally, two novel complementary approaches are now being brought to bear on the charts. One is the use of geomagnetic models capable of estimating the spatial distribution of magnetic declination in ancient times. These make it possible to demonstrate that the average tilt of all portolan charts before about 1600 matches approximately the average value of magnetic declination in the Mediterranean in the first decades of the thirteenth century.<sup>13</sup> This supports the hypothesis that the earliest prototype charts could have been produced some forty to sixty years before the first extant chart, the *Carte Pisane*.<sup>14</sup> The match is also an important step towards fulfilling Campbell's requirement that a connection should be demonstrated between local charts' distortions and regional magnetic declination before definitively establishing that portolan charts were constructed on the basis of compass directions. The second novel approach is the adoption of the new digital techniques of cartometric analysis and numerical modelling aimed at characterizing the geometry and simulating the construction of old charts.<sup>15</sup>

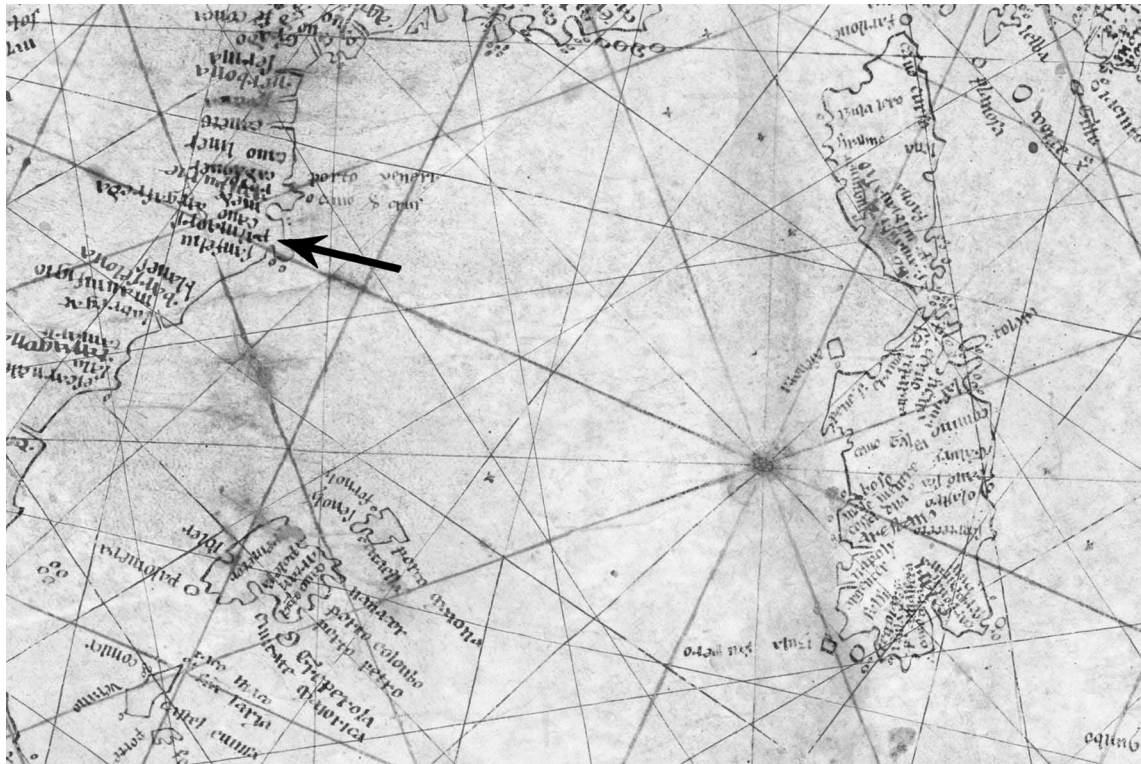


Fig. 1. The Carte Pisane. Detail showing Corsica and Sardinia on the right and the eastern coast of Spain on the left, with the town of Palamos arrowed. The parchment has recently been dated by radiocarbon to 1170–1270 (95% confidence), with a most probable dating of c.1245, but in view of the representation of Palamos, which was founded in 1279, it could not have been completed before this date. Paris, Bibliothèque nationale de France, Rés. Ge. B 1118. (Source: gallica.bnf.fr/BnF.)

The combination of these tools has permitted clarification of the connections between chart geometry, on one hand, and navigational data and methods of chart construction, on the other. Specifically, it made it possible to demonstrate that the main geometric features of portolan charts are explained by assuming that the navigational data—compass courses and estimated distances—used in their construction were transferred directly onto the plane of the chart irrespective of the fact that the measurements had originally been made on the earth's spherical surface.<sup>16</sup> While no medieval text confirms this hypothesis, early modern texts explicitly refer to charts of the Mediterranean being constructed by using compass courses and estimated distances collected by pilots.<sup>17</sup>

#### *The Earliest Charts*

The oldest surviving nautical chart is the anonymous and somewhat damaged manuscript known as the Carte Pisane, kept in the Bibliothèque nationale de

France (Fig. 1). It represents the Mediterranean and Black seas and shows part of the Atlantic coasts of Africa and Europe, including the British Isles. The parchment has been recently given a radiocarbon date of 1170–1270 (95% confidence), with c.1245 as the most probable date.<sup>18</sup> However, the representation of Palamos, founded in 1279 on the eastern coast of Spain near the Pyrenees, suggests that the chart could not have been completed before that year at the earliest. Thus, for the present at least, three interpretations are possible: a parchment was prepared but remained unused for some decades; later additions were made to the chart; the chart is a palimpsest. It is possible that a satisfactory answer to the question might be found through multispectral analysis of the manuscript.

Three other charts have survived from the last years of the thirteenth or, more likely, the beginning of the fourteenth century: the Cortona chart and the Avignon chart (newly come to light), both provisionally dated c.1300, and the chart from Lucca (c.1310).<sup>19</sup>

Although none is dated or signed, all are thought to mark the end of the so-called 'formative period', during which geographical accuracy was improving and the graphic conventions that characterize all subsequent charts were being introduced.<sup>20</sup> The end of the period is marked by the charts produced by Pietro Vesconte and Angelino Dulceti (c.1311–1340), on which these features are consolidated.

Although no chart older than the *Carte Pisane* has survived, it is usually accepted that the *Carte Pisane's* detail and relatively high accuracy can be explained only by assuming an as yet undocumented period, possibly starting around the turn into the thirteenth century, when the characteristics of the extant portolan charts were being developed. Such an interpretation fits the idea that the earliest prototypes were being created at a time when the average magnetic declination in the Mediterranean matched that accounting for the tilt of the oldest extant charts, and when the magnetic compass for navigation was introduced, that is before 1200.<sup>21</sup>

#### *The Liber de existencia riveriarum*

Of all recent developments in the study of the earliest charts and their origins, the rediscovery of the *Liber de existencia riveriarum et forma maris nostri mediterranei* is arguably one of the most promising.<sup>22</sup> The title is difficult to translate with assurance (see below), but its explicit purpose is a description of the Mediterranean Sea. It was written at the beginning of the thirteenth century, probably in Pisa. Although alluded to by Roberto Almagià in 1944, it remained forgotten for fifty years until Patrick Gautier Dalché published his seminal study containing a transcription of the Latin text, an interpretation of its content and a detailed historical contextualization.<sup>23</sup>

Basing his interpretation on palaeographical considerations and the analysis of place-names, Gautier Dalché proposed that the text was produced between 1160 and 1200. He also noted the focus on certain Italian regions, and the manuscript's stated connection with a Pisan cleric further suggested that it might have been written in that Tuscan city.<sup>24</sup> Pujades, however, subsequently pointed out that the inclusion of the Black Sea in the description indicates that it could not have been completed before the fall of Constantinople to Venice in 1204.<sup>25</sup>

The text of the *Liber* opens with a geographical summary comprising a list of 159 adjacent places around the coasts of the Mediterranean with the sailing distances between them. In addition to these short maritime tracks, 22 longer routes are described with directions as well as distances (Fig. 2). Following this

summary list is a prologue explaining the purpose of the work, after which comes the main part of the manuscript. This is a systematic description, in the style of the portolans, of the Mediterranean and Black Sea coasts and those of Atlantic Europe, organized into 45 regional sections, each introduced by a short text describing the orientation and size of the region. The information on the distances between neighbouring places along the coasts is complemented by 196 tracks (referred to as *in transfretu* routes) connecting islands and places in different regions. In these, both distance and directions are given.

#### The Prologue

The prologue consists of a lengthy paragraph in which the author states his intention to describe the Mediterranean Sea *in writing*, according to the way places are situated in the world relative to the winds, meaning, that is, to geographical direction (see Fig. 2).<sup>26</sup> Because of the difficulty the text poses, it is transcribed here almost in full before we offer a translation. With very few exceptions, which are identified in the text, the transcription of Gautier Dalché was adopted.<sup>27</sup>

Incipit prologus libri de existentiâ riuieriarum et forma maris nostri Mediterranei quod diuidit Libiam et Europam et de distantia locorum eius. Mare<sup>28</sup> nostrum Mediterraneum, habens ingressum ex oceano ex partibus occidentis . . . . in scriptis redigi proponimus ex huius maris et eius riuieriarum forma, secundum quod in orbe terrarum loca eorum in partibus uentorum iacent. Quam<sup>29</sup> ad componendum in cartula mappe mundi, composueramus hoc opusculum numeri<sup>30</sup> miliariorum distantie eorum locorum, exemplantes eorum nomina moderno tempore; in quibusdam antiqua et earum<sup>31</sup> causam, iuxta noticiam librorum, ut facilius qui libros norunt intelligant, inserui. Ubi longitudo et latitudo<sup>32</sup> et angustum eorum inter utrasque partes riuieriarum Libie et Europe, iuxta quod a nautis et gradientibus illorum,<sup>33</sup> etiam in quantum uidi et peragraui, scire et inuenire potui, secundum ingenioli nostri quantitatem rationabiliter ostendi. Rationabiliter dicimus secundum distantiam locorum in milibus quam didicere potui, et existenciam eorum per partes uentorum: orientis uidelicet euri, austri, affrici; occidentis, circii, septemtrionis et aquilonis, ut loca quedam de quibus circa mare in sacris libris non ita lucide legitur, petitione cuiusdam uenerabilis et industrii mee maioris Pisane ecclesie canonici exortatus, facilius legentibus intellectum tribuerem et cum nec scripturarum narrationem<sup>34</sup> nec manus operis compositionem<sup>35</sup> predictam formam esse ueram canonicus ipse se uidisse assereret, compositum ut prenotauimus opus delectabilius atque mirabilius contemplantibus ueritate ac sua nouitate preberem. Verum si forte aut impericia nostra uel non integra memorie recordacio,<sup>36</sup> in utriusque huius operis compositione in aliquo minus rectum quis magis doctus et certus inuenerit, rogamus ut non deroget, sed ex pietate ignoscendo corrigat, propositum meum aspiciens, quia tanto hanc rectam studiosius exercere diu laboraui quanto nouam et difficillimam auroius<sup>37</sup> perficere adoptaui.



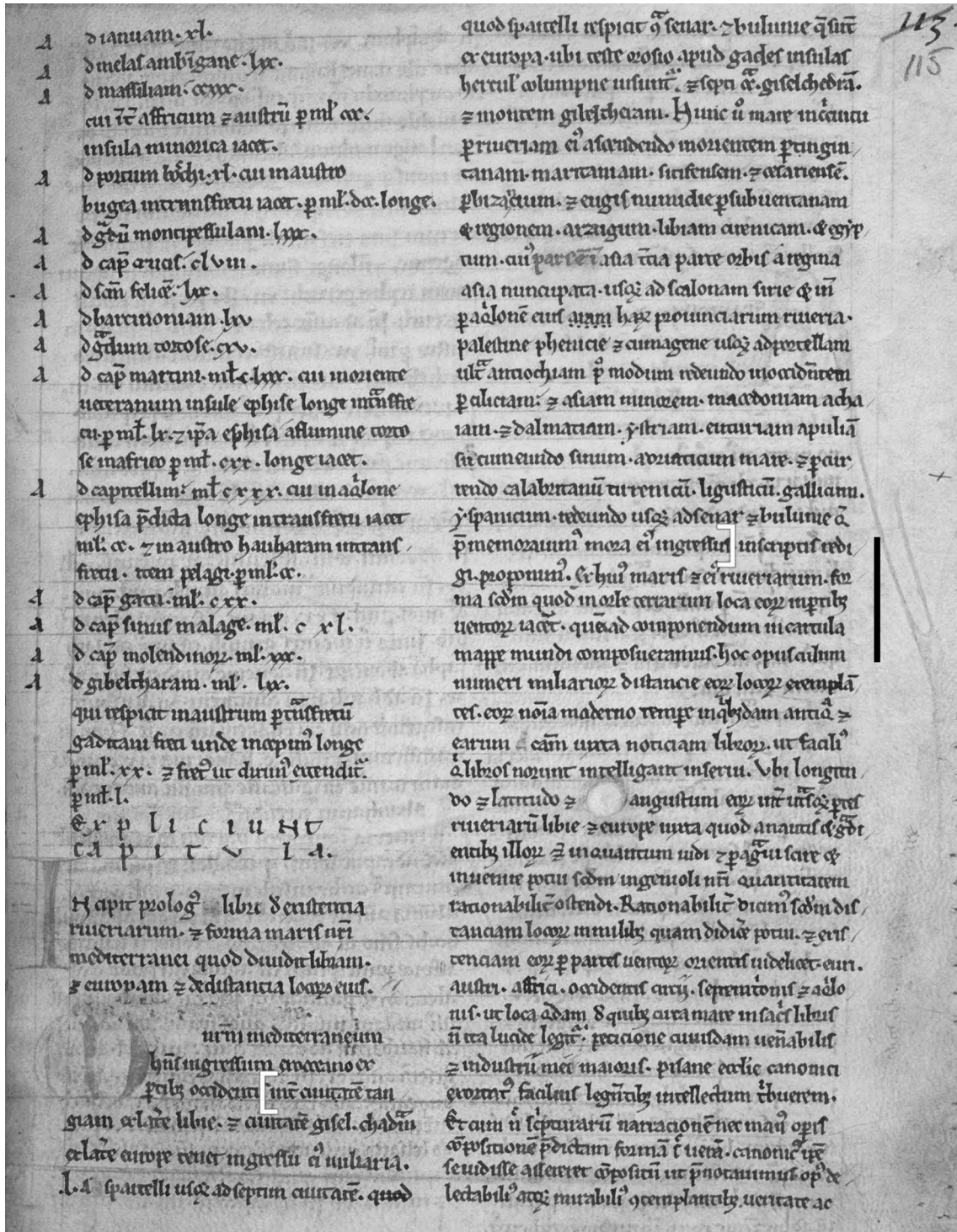


Fig. 2. Folio 115r from the *Liber de existencia riveriarum et forma maris nostri mediterranei*. Manuscript. 19.6 × 14 cm. The first column contains the end of the introductory summary of distances and the beginning of the prologue. The vertical line by column two indicates where the author starts to explain his aim to describe *in writing* the Mediterranean Sea. The 22 lines of text within the white brackets are omitted in the transcription on page 4. London, British Library, Cotton MS Domitian A XIII, fols. 114r–129v. (Reproduced with permission from the Board of the British Library.)

The lack of punctuation characteristic of medieval prose and the uncertainty of the meaning of particular terms, together with an overall lack of syntactical clarity, leaves this passage open to debate. So far, three scholars have proposed their own interpretations of selected parts: Gautier Dalché (twice), Pujades and John Pryor.<sup>38</sup> The disparities between their respective reading of the syntax and translation of specific words have a significant effect on their interpretations of the text as a whole.

Critical to the interpretation is the role of the word *forma*. Gautier Dalché first raised the question in 1995, suggesting then that it referred to a map or chart rather than to the outline of the coast, and that it implied that a nautical chart preceded the written text.<sup>39</sup> Faced with translating the text again in 2012, however, he opted to leave the ambiguous words *forma* and *cartula* in Latin, arguing that *forma* could indicate a nautical chart used in the preparation of the text and *cartula mappa mundi* the substance of the *Liber* itself, with its detailed description of the Mediterranean.<sup>40</sup> For Pujades, who translated *forma* as ‘form’ and *cartula mappa mundi* as ‘mappamundi chart’, the intention of the author of the *Liber* was to write about the Mediterranean and its shores prior to representing it on a chart.<sup>41</sup> Finally, we have Pryor’s interpretation, which suggests that the author first wrote a book and then compiled (or perhaps intended to compile) a map.<sup>42</sup>

Needing a translation guide for my own understanding of the work and its implications for the question of the origins of portolan charts, I have arrived at another version covering a larger part of the prologue. Here too the words *forma* and *cartula mappa mundi* remain in Latin.<sup>43</sup>

[Here] Begins the prologue of the book about the appearance<sup>44</sup> and the *forma* of the coastlines of our Mediterranean Sea, which separates Africa from Europe, and about the distance between its places.

Our Mediterranean Sea, having its entrance from the Ocean, from the western parts, . . . . we propose to put it in writing, on the basis of the *forma* of this sea and of its coastlines, in accordance with how their places are situated, in the orb of the Earth, in the directions of the winds. For arranging it [the *forma*] on a *cartula mappa mundi*, we composed this opusculum [little work] of the number of miles of distance between those places, transcribing their modern names; in some, I have inserted the ancient [names] and their reason,<sup>45</sup> according to the information of the books, so that those who know the books may understand more easily. As for the length and breadth and narrowness between one and the other parts of the coastlines of Africa and Europe, I have shown [them] in accordance with what I have been able to know and discover from mariners and travellers of those [places],<sup>46</sup> even in as much as I

have seen and travelled, on the basis of calculation, according to the extent of our talent. On the basis of calculation, we say, according to the distance of the places, in miles, that I could learn, and their disposition in the parts of the winds, namely the east, southeast, south, southwest, west, northwest, north and northeast, so that, exhorted by the request of a venerable and industrious canon of my major church of Pisa, I could give to the readers a better understanding of some places around the sea, about which the sacred books do not talk clearly enough. And because the cleric himself asserted that he had noticed that the above-mentioned *forma* was not correct, neither in the written descriptions nor in the composition of the handwriting,<sup>47</sup> I wished to show the composed work, as we noted before, in a more enjoyable and admirable form, because of its truth and novelty, to those who are contemplating it. But if, by chance, because of our ignorance or imperfect memory, someone more knowledgeable and certain finds in the composition of each of these works something less right, we request that he, considering my purpose, not reject but correct it, forgiving out of pity, because just as much as I have worked long and rather diligently to execute this correct [composition] so much as I have more eagerly chosen to finish a new and very difficult one.<sup>48</sup>

The first point to notice is incontrovertible: the author states clearly that he is about to describe the Mediterranean *in writing* and not, it is thereby understood, graphically. The likely reason for him to call attention to this detail is that the Mediterranean had already been described in a drawing. At the same time, he says his description will be in accordance with the situation of the coasts in the *parts of the winds*, meaning they are to be oriented in relation to the eight wind-rose directions. The author then gives his methodology; in order to represent those coasts on a *cartula mappa mundi*, he has prepared a little work (*opusculum*) containing the names of places with the distances between them, as well as the distances that separate Europe from Africa. For this, he has made use of data collected from mariners and travellers to supplement his own researches and studies, which had been conducted with the encouragement of a Pisan cleric critical of the way that the Mediterranean’s *forma* had been described in previous writings.

Here I disagree with Gautier Dalché, who considers that the *opusculum* was the geographical summary preceding the prologue, which had been previously submitted by the author of the *Liber* to the cleric, together with a chart—the *forma*.<sup>49</sup> An alternative interpretation is that the use of the diminutive *opusculum* is an expression of modesty and the word simply refers to the text of the *Liber*. In my opinion, the cleric was not criticizing any previous version of the *Liber*, comprising text and map, but the extant descriptions of the Mediterranean’s *forma*, which he considered to be

incorrect. Hence his encouragement to the author to prepare something better and describe more satisfactorily the places around the sea that are referred to in the sacred books. Taking good note of the suggestion of the cleric, the author then prepared a more enjoyable and admirable version of the work, namely the one we have today.

For Gautier Dalché and Pujades, the *Liber de existencia riveriarum* represents convincing evidence that nautical charts were being produced at the dawn of the thirteenth century, anticipating by almost a century the oldest extant exemplars.<sup>50</sup> Exactly how those nautical charts related to the manuscript hangs on the author's intended meaning of *forma* and *cartula mappe mundi*. Uncertainty over these words prevents our arriving at an agreed interpretation of crucial parts of the text that could possibly have been referring to the use, or preparation, of a chart.

Since the word *forma* appears three times in the prologue, it is worth reiterating these occasions. In the first paragraph of the prologue we read: *Incipit prologus libri de existentia riueriarum et forma maris nostri Mediterranei*; that is '[Here] begins the prologue of the book about the appearance of the coasts and the *forma* of our Mediterranean Sea'. In the second paragraph, where the author states his intention, we have: *Mare nostrum Mediterraneum ... in scriptis redigi proponimus ex huius maris et eius riueriarum forma* [Our Mediterranean Sea, having its entrance in the Ocean, from the western parts, ... we propose to put it in writing, on the basis of the *forma* of this sea and coastlines]. Finally, towards the end of the prologue, when noting the cleric's criticism, the author writes: *Et, cum nec scripturarum narratione nec manus operis compositione predictam formam esse ueram canonicus ipse se uidisse assereret* [And because the cleric himself had asserted that he had noticed that the above-mentioned *forma* was not correct, neither in the written description nor in the arrangement of the work nor in the composition of the handwriting].

Assuming that the intended meaning of *forma* is similar in all instances, the only translation that makes any sense in the three cases is 'form' or 'shape', that is, the *configuration* of the Mediterranean Sea and its coasts, which the author intended to put into writing. As noted by Gautier Dalché, however (personal communication, 2018), the word *forma* is polysemic, and it is possible that its exact meaning is not the same in the three cases. Accordingly, a clearer interpretation could be made of the third instance by translating *forma* as 'description'.

A parallel problem occurs with the expression *cartula mappe mundi*, although this appears only once in the text, when the author mentions the composition of his little work: *Quam ad componendum in cartula mappe mundi, composueramus hoc opusculum* [For arranging it (the *forma*) on a *cartula mappe mundi*, we composed this opuscule]. Here, the most obvious meaning is a 'sheet of a world map'. It is not immediately apparent what kind of representation is being referred to, and nothing in the text indicates clearly a nautical chart, except for the reference to the parts of the winds.

Finally, the way the information is organized in the text, most especially the wording of the last part where the author asks for the indulgence of his readers, suggests that this prologue may have been the last part of the work to have been written.

Taking the text of the prologue alone, it seems impossible to draw any firm conclusions about the creation or use of a nautical chart in the preparation of the *Liber*. Irrespective of the exact meaning of the text, and of how the preparation of the *Liber* might have related to a nautical chart, significant light can be shed on these questions by analysing the routes contained in the manuscript.

#### The Directions in the *Liber*

Two distinct sets of directions between places are provided in the *Liber*. There are those in the geographical summary preceding the prologue, and those contained in the main part of the text. For reasons that will become evident, I have studied the two sets separately. Both refer to a system of eight main directions, for which formal Latin names are given (Fig. 3): *septemtrio* (N) (an alternative medieval form of *septentrio*), *aquilo* (NE), *oriens* (E) and so on. These eight directions, each subdivided to make sixteen altogether, are separated from one another by an angle of 22½ degrees and correspond to the modern cardinal, intercardinal and intermediate points. In a few instances, when certain stretches of the coast are being described, the directions are refined by what appears to be a smaller interval. For example, between *Hauharan* (Oran) and *caput Bouis* (Cape Bon), on the northern coast of Africa, we find *Ab Hauharan extenditur riueria in orientem parum uersus aquilonem usque ad caput Bouis* [from Oran, the coast extends to the east and a little to the northeast, up to Cape Bon]. As Gautier Dalché points out, this method of expressing intermediate directions recalls the greater precision of the *Compasso de Navegare*.<sup>51</sup>



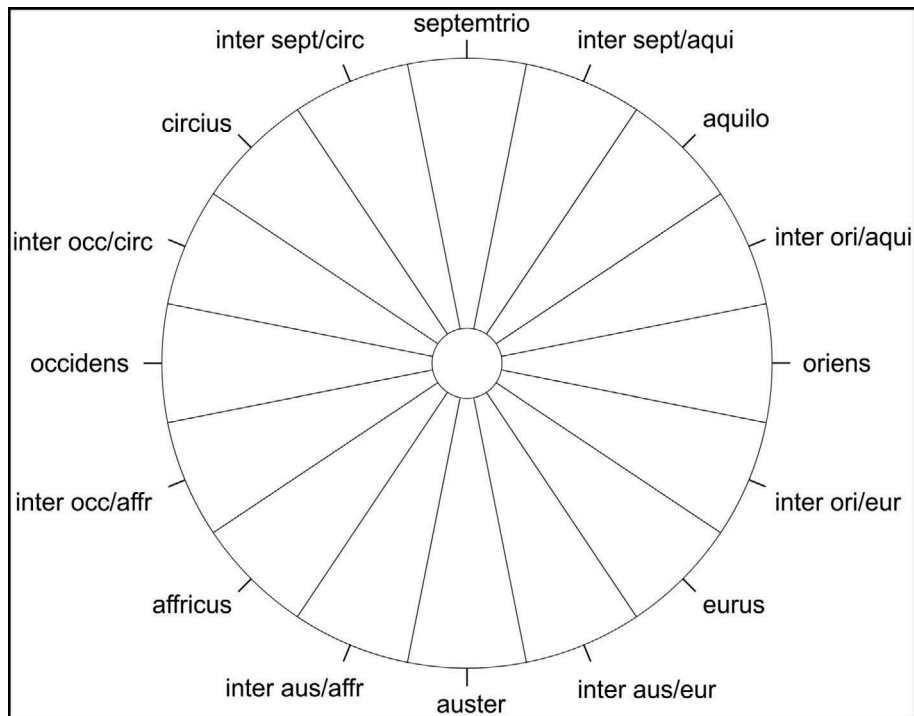


Fig. 3. The sixteen wind directions that underlie the orientation of the tracks listed in the *Liber de existencia riveriarum*. The radiating sectors, each measuring  $22\frac{1}{2}$  degrees, define the limits to which the directions apply. (Author's drawing.)

### The Geographical Summary

As already noted, the geographical summary that precedes the prologue lists 159 contiguous places, in sequential order, along the coasts of the Mediterranean, omitting the Black Sea. With the distances between them also given, each pair represents a single sailing track. As noted by Gautier Dalché, all but four of those 159 tracks are repeated in the body of the text.<sup>52</sup> Twenty-two of those tracks, mostly connecting distant places (*in transfretu*), are provided with both distances and directions.

The list starts at the Strait of Gibraltar with the statement that from Cape Spartel (the most westerly point on the northern African coast) to Ceuta (*Septi*) there are fifty miles; the second entry says that between Ceuta and Oran (*Hauharan*) there are 400 miles, and the list continues in this way anticlockwise around the whole of the Mediterranean to end at Gibraltar (*Gibelthara*). Figure 4 illustrates the full sequence of tracks (dotted lines). The first conclusion to draw from this list is that its function was a rough articulation of the intention stated in the prologue, to represent the Mediterranean Sea in writing according to the directions of the winds and the distances between places.

In addition to the coastwise routes, Figure 4 also shows the long-distance tracks connecting distant places (solid lines), such as between the southern coast of France (*portus Bocchi*) and the northern coast of Africa (*Bugea*, 700 miles), and between Alexandria and the coast of Anatolia (*Patera*, 650 miles).

Where did this information come from? It is difficult to accept that every distance between places around the entire Mediterranean littoral originated in *direct* navigational information, the author's own or given to him. A similar doubt applies to particular long-distance tracks, some of them of limited navigational relevance, or to tracks involving crossing dry land, like the one between Abydos, in the Strait of Dardanelles, and Almiro, in the Pagasetic Gulf (east central Greece). These objections suggest that the source of the information was primarily cartographical, and that directions and distances could have been measured using a wind rose and a distance bar: that is, from a nautical chart or some sort of cartographical sketch used in navigation.

Such an interpretation is reinforced by the way some parts of the coast are described in the main part of the *Liber* as if the author were reading from a map,

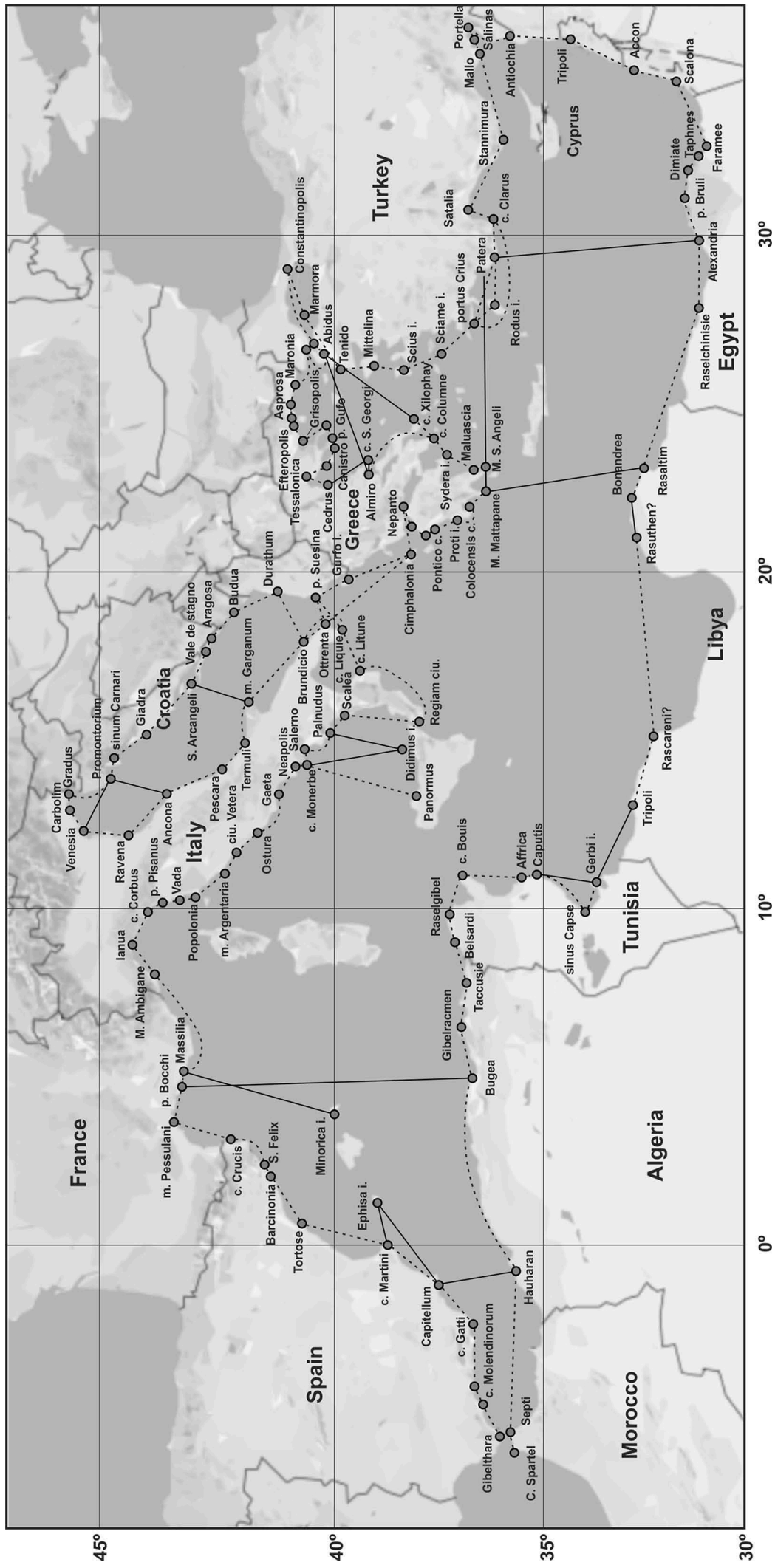


Fig. 4. Map of the Mediterranean Sea with the sailing tracks listed in the geographical summary of the *Liber de existentia riveriarum*. The dotted lines link the places for which only the distances are given. These start at Cape Spartel, in the western extremity of the Strait of Gibraltar, and follow the southern shore of the Mediterranean anticlockwise to return along the coast of Spain to Gibraltar. The solid lines represent the longer sailing tracks (*itransfretu*) for which directions are also supplied. (Author's drawing.)

as explained below. That maps of the world and regional maps already existed by the time the *Liber* was written is beyond doubt. The Mediterranean features prominently in, for example, al Idrisi's *Tabula Rogeriana* [*Book of Roger*]<sup>53</sup>—usually considered to be the most accurate medieval depiction of the world before the emergence of portolan charts—which would have been in circulation at least since 1157, when the book was completed (Plate 1).<sup>53</sup>

Table 1 summarizes the 22 long-distance tracks listed in the geographical summary with an indication of wind directions. The Latin names of the winds have been converted into modern terminology (column 4).<sup>54</sup> In column 5, true geographical directions are given for the rhumb-lines that connect the pairs of places with, in brackets, the closest sector of a wind-rose system. Column 6 contains the corresponding errors expressed in degrees, that is, the differences between the directions in the *Liber* and the true values, while in column 7, the errors are expressed in points; that is, in intervals of 22½ degrees.<sup>55</sup> The following four tracks were omitted from this analysis: *Mallo* to *Raseleganzir* (uncertain location of *Mallo*), *Cedrum* to *C. San Georgi* (unknown location of *Cedrum*), *c. Xylophay* to *inter Sozantium et Sciuis* islands (unknown location of *Sozantium*) and *S. Archangeli i. to mons Garganus* (unknown location of *S. Archangeli* island).

The analysis in the table indicates that the directions given in the geographical summary of the *Liber* are not affected by any significant systematic error. Since magnetic declination in the Mediterranean in 1200 ranged from about 4 to 10 degrees east, we would have expected an inevitable negative bias had the directions been measured with a marine compass (Fig. 5). Yet 13 out of 18 directions are exact when expressed in terms of a wind rose of sixteen points (see column 7). Furthermore, the 13 null-error directions include most of the tracks of 200 miles or more, as well as the two longest routes of all, those from *Alexandria* to *Patera* (650 miles) and from *portus Bocchi* to *Bugea* (700 miles). Some of the errors, especially in the shorter tracks, can be explained by uncertainty over the exact orientation of courses when one or both places are located on islands or when the exact locations of a place is uncertain, as in the case of the routes between *Gerbi* island and *Caputim*, *Tripoli* and *Gerbi* island, and *Rasuthen* and *Bonandrea*.

Had a nautical chart been the basis of the *Liber's* route descriptions, it would have been a primitive model not related to the *Carte Pisane* or any other extant portolan chart built up from

compass courses. It is elementary to insist on the fact that long-distance navigation in, and even beyond, the Mediterranean had been carried out since ancient times. If most shipping kept close to the coast, this was often because these were the most convenient, or safest, routes between ports of call. At the same time, there is plenty of evidence, archaeological and literary, to confirm that traversing long stretches of open sea was not only at times inevitable, but also not uncommon. Navigation by the sun and stars was well developed before the marine compass was introduced, and sailors were skilled at holding a course even out of sight of land.<sup>56</sup>

For over perhaps one third of the Mediterranean Sea land is out of sight even in optimal atmospheric conditions (Fig. 6).<sup>57</sup> The area involving the greatest problems for early long-range navigation was the eastern Mediterranean, especially for routes linking southern Europe and its islands with the African coast. A ship departing, for example, from *Patera*, Anatolia, heading approximately south would sail for 305 nautical miles (566 km) without sighting land until approaching the African shore. An error of 5 degrees in the course would make it miss its destination by about 50 kilometres. Medieval sailors, however, had various ways of controlling their ship's course in addition to following the direction of sun and stars, such as by keeping a constant angle between the ship's heading and the direction of the swell and taking note of the direction of the prevailing wind. Whatever instruments and techniques were used, open-sea courses between distant places were reasonably accurately known by the time the *Liber* was written.

Cartographical depictions of the Mediterranean were available by the thirteenth century, although these were in works unlikely to be found on the quayside let alone in a navigator's hands. Moreover, when the information given in the *Liber* is compared with al-Idrisi's representation of the Mediterranean, we see that it is unlikely that the map in the *Tabulae Rogeriana* was used in the compilation of the *Liber* (see Plate 1). The east-west orientation of the Adriatic Sea on al-Idrisi's depiction, probably imported from a Ptolemaic-based source, and the crudity of his representation of the northern coast of Africa also point away from any other known traditional map as the source of the *Liber's* information.

This leads us back to consider the source of the non-magnetic directions listed in the geographical summary of the *Liber*. If this was indeed a

Table 1. The long-distance (*in transfretu*) sailing tracks containing directions, as described in the geographical summary of the *Liber de existencia riveriarum*. The wind directions given in the manuscript ('Directions *Liber*') were compared with the actual values ('Directions true'). The correspondent errors were expressed in degrees and in points of 22½ degrees. Uncertain place-names are shaded. Distances are in miles.

From	To	Distances <i>Liber</i>	Directions <i>Liber</i>	Directions (true)	Errors (degrees)	Errors (points)
Hauharam	Capitellum / Carthagenia	200	N	355.5 (N)	4.5	0
Gerbi i.	Caputim	70	NNE	005.6 (N)	16.9	+1
Tripoli	Gerbi i.	200	W	293.8 (WNW)	-23.8	-1
Rasuthem	Bonandrea	60	NE	074.9 (ENE)	-29.9	-1
Alexandria	Patera	650	N	004.7 (N)	-4.7	0
Mallo	Raseleganzir	40	E			
Abidus	Almiro	300	W	252.1 (WSW)	17.9	+1
Cedrum	C. S. Georgi	100	S			
c. Xilophay	Sozantium / Sciuis	150	E			
c. Xilophay	Abidus	400	NE	034.4 (NE)	10.6	0
c. Maleas Mattapan	Crius /Rodus	400	E	089.2 (E)	0.8	0
c. Maleas Mattapan	Rasaltim	400	S	172.1 (S)	7.9	0
S. Archangeli i.	mons Garganus	150	SW			
Promontorium	Ancona	100	SSW	194.4 (SSW)	8.1	0
Promontorium	Venesia	100	WNW	301.6 (WNW)	-9.1	0
Palnudus	Didimus i.	100	S	193 (SSW)	-13	-1
c. Monerbe	Vulcani i.	250	SSE	167 (SSE)	-9.5	0
Massilia	Minorica i.	300	SSW	199.7 (SSW)	2.8	0
portus Bocchi	Bugea	700	S	179.4 (S)	0.6	0
c. Martini	Veteranum	60	E	080.8 (E)	9.2	0
Capittelum	Ephisa i.	200	NE	050.8 (NE)	-5.8	0
Capitellum	Hauharam	200	S	178.8 (S)	1.2	0

nautical chart, it is reasonable to assume that such a chart was not the first of its kind but the outcome of a lengthy development process.<sup>58</sup> The possibility that the information contained in the

initial summary in the *Liber* derived from a textual source has also to be entertained, but the same terms would apply to the genesis of any such work.



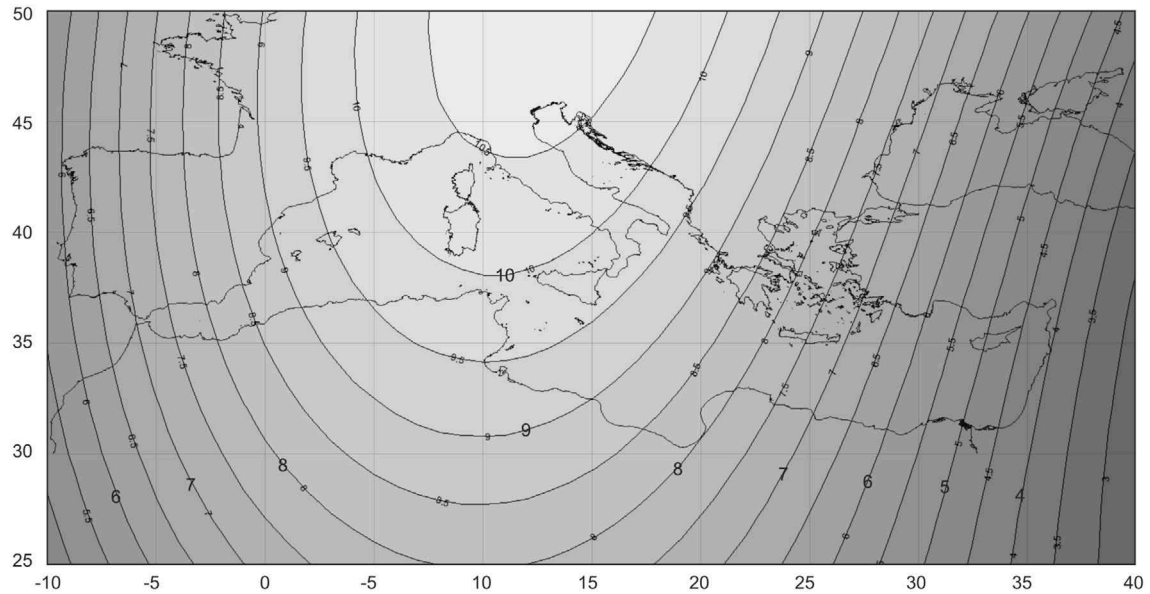


Fig. 5. The distribution of magnetic declination in the Mediterranean in 1200, as calculated by the CALS7K geomagnetic model proposed by Korte and Constable, 2005 (see note 13). (Author's drawing.)



Fig. 6. Visibility in the Mediterranean Sea. The shading indicates stretches of the sea from which no land can be seen even in optimal atmospheric conditions. The lack of high mountains behind the African coast in the eastern basin, from Tunis and the Bay of Sirte on, means that for a ship heading north land is out of sight almost immediately. (Author's calculations, after an idea of William Schüle (see note 57).)

### The Main Text of the *Liber*

The main part of the manuscript consists of a systematic description of the coasts of the Mediterranean and Black seas and the Atlantic coasts of Europe and northern Africa. This is organized in forty-five

regional sections, of which forty are dedicated to the Mediterranean coasts and islands, one to the Black Sea, and four to the Atlantic coasts of Europe and Africa. Each section is introduced by a short geographical description of the region, followed by an orderly list of distances between adjacent places

along the coast. These are complemented by some other tracks (*in transfretu*) connecting a place on the coast, or an island, to another place or island in another region, for some of which directions are also given.

Once again, the conclusion that some of this information was read from a map seems inescapable. We read, for example, in the general description of the coastal stretch between Oran and Cape Bon (section 4 of the *Liber*), that ‘from Oran, the coast extends to the east and a little to the northeast, up to Cape Bon’ [*ab Hauharan extenditur riueria in orientem parum uersus aquilonem usque ad caput Bouis*], and that ‘To Cape Roux [it is] 40 miles, in front of which, by 30 miles, is Galita island, distant 300 miles from Bugia, between east and southeast. In the middle of which way, between the shore of the island to the said Cape Roux, is a certain dangerous shoal between two waters [*Ad capud Rosse ml. .xl. contra quem per ml. .xxx. est insula Galatha longe a Bugea inter orientem et aquilonem ml. .ccc. In quo itinere medium ab insula riueriam ad capud predictum Rosse est quoddam siccum periculosum inter duas aquas*]. The shoal alluded in this text, whose modern name is Écueil des Sorelles, is about 15 nautical miles east-southeast of the Galite Islands and is represented in all early portolan charts, including the Carte Pisane.

Of all the tracks listed, long and short, 195 include directions. This information was compiled by Gautier Dalché, who compared, as far as was possible, the directions given in the *Liber* with those in the *Compasso de Navegare*.<sup>59</sup> Of the tracks transcribed by Gautier Dalché, only 153 feature in the analysis presented here, the others are either unidentifiable or the directions are erroneous.<sup>60</sup> My analysis involved comparing these 153 directions, which refer to a sixteen-wind rose, with actual values, and expressing the differences (that is, the errors) in both degrees and points of 22½ degrees. For example, the direction given in the *Liber* for the track connecting *Hunei* (Hounaine, in Algeria) to *Septi* (Ceuta) is westward (270°) and the true value is 283.7°; thus, the error is –13.7 degrees, which corresponds to –1 point. Figure 7 illustrates the routes for which the errors were calculated; a black segment indicates a negative error and a white segment indicates a positive error, the errors being expressed in degrees.<sup>61</sup>

The next step was the calculation and analysis of the errors. The distribution of the errors in classes of wind-rose points is illustrated in Figure 8 (left). Of the 153 tracks considered in the analysis, 62 (41 per cent) are concentrated in the central class (null error) while 68 (44 per cent) are in the adjacent

classes of +1 and –1 points. All values with errors of –2 or +2 points (23 instances) correspond to tracks shorter than 70 miles, often connecting places of uncertain location.<sup>62</sup> The symmetry of the distribution around an average value slightly below zero is notable and suggests that the directions in the *Liber* are not affected by any systematic error caused by magnetic declination.<sup>63</sup>

However, the hypothesis appears to be challenged by a close inspection of Figure 7, where most of the tracks with negative errors (the black segments) appear to be concentrated in the central Mediterranean. To go deeper into this apparent anomaly, the data for all 153 tracks were divided into three subsets according to longitude, respectively western (west of 10° E), central (10°–20° E) and eastern Mediterranean (east of 20° E). The visual impression given by Figure 7 is confirmed by the statistics, which demonstrate that the average errors do indeed vary with longitude: +0.067 points in the western Mediterranean (+1.5 degrees); –0.377 points in the central Mediterranean (–8.5 degrees); and –0.029 points in the eastern Mediterranean (–0.6 degrees). The distribution of the errors for the central Mediterranean alone is illustrated in the histogram in Figure 8 (right). This is a clearly asymmetrical distribution, with the number of negative errors (26) being much larger than the number of positive errors (9), which suggest that some of the directions were measured with a marine compass.

These results appear to support the medieval author’s account that several sources were used in the compilation of his book. They demonstrate that at least two sets of data were incorporated: one containing directions determined by traditional astronomical methods, and the other with directions measured with a marine compass. Two independent factors may explain the concentration of negative errors in the central Mediterranean: the usually accepted hypothesis that the marine compass was first introduced in Italy, from where it spread to other regions; and the spatial distribution of magnetic declination at the beginning of the thirteenth century, with the larger values up to about 10 degrees east in the central Mediterranean gradually decreasing to the east and to the west, as illustrated above in Figure 5.

#### *The Introduction of the Marine Compass*

It is known from the writings of the English monk Alexander Neckam (1157–1217) that in the last decades of the twelfth century pilots were using magnetic compasses whenever the sun or the Pole

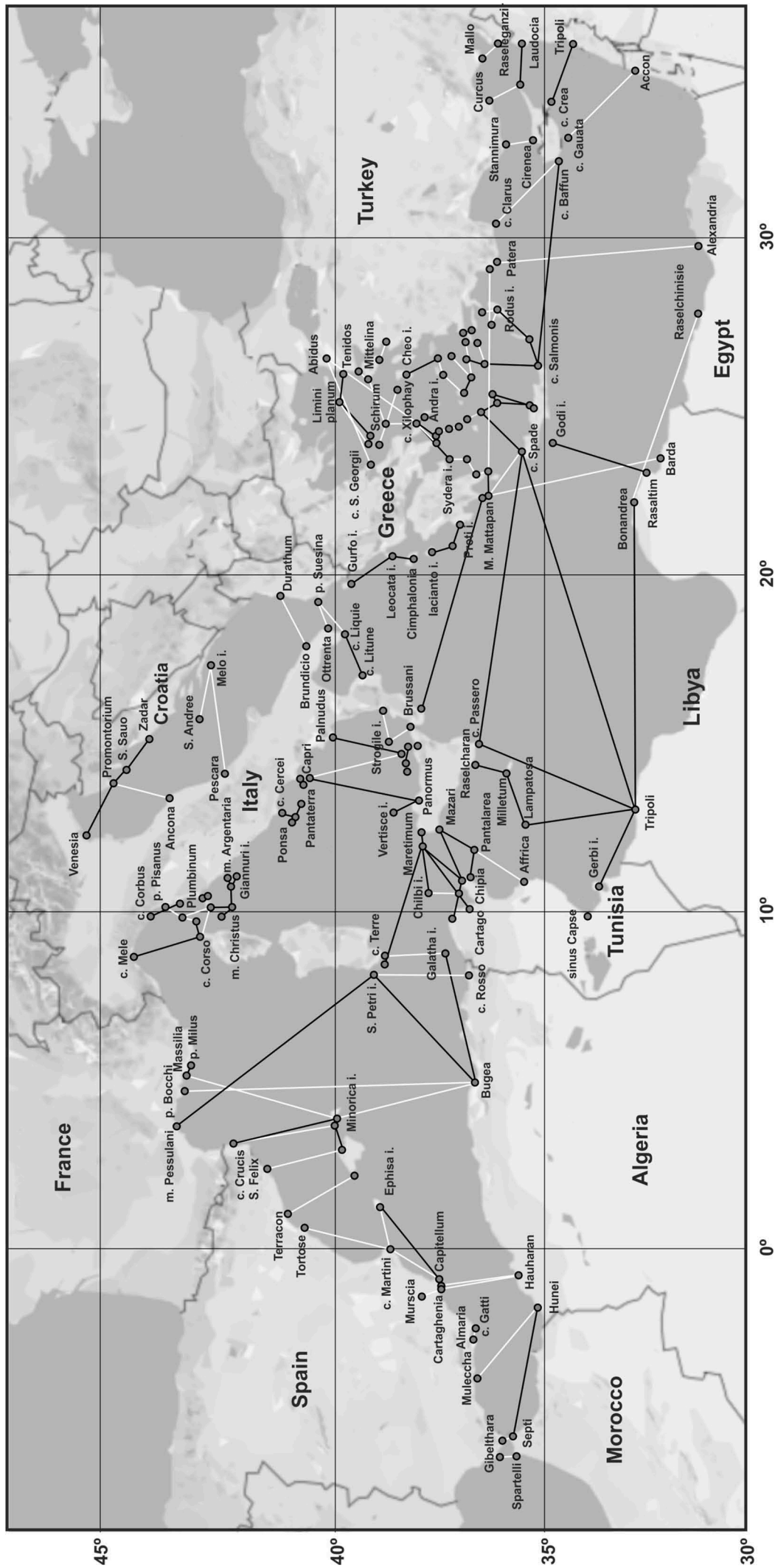


Fig. 7. Map showing the longer *in transfretu* tracks across the Mediterranean Sea, for which direction as well as distance is given in the body of the *Liber de existencia riveriarum*. Black segments indicate negative errors in the directions, expressed in degrees; white segments indicate positive errors in degrees. Not every place listed can be identified and some directions are clearly erroneous in the text. (A author's drawing.)

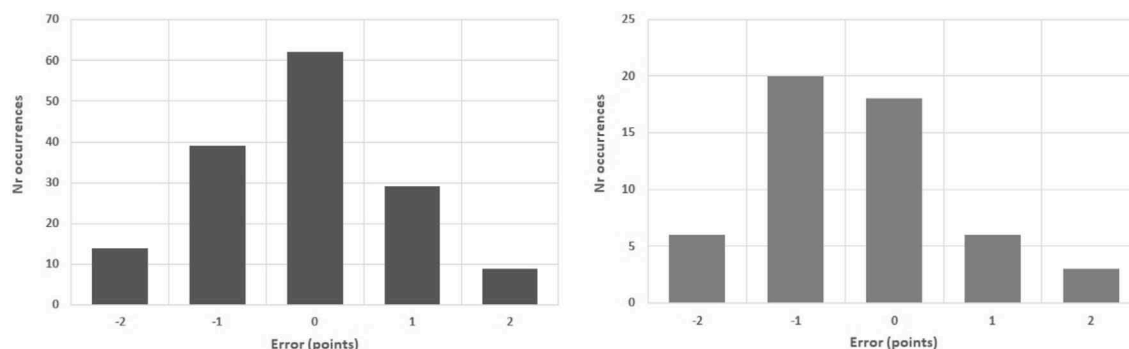


Fig. 8. Directional errors in the main part of the *Liber de existencia riveriarum* in classes of wind-rose point differences, calculated by comparing the information in the *Liber* with the actual values (see Fig. 4). The histogram on the left shows all identifiable *in transfretu* tracks, that on the right gives the values in the central Mediterranean only. While the error distribution for the whole data set is weakly asymmetrical and centred near zero, the corresponding distribution for the central Mediterranean shows a clear negative bias, which is an indication that compass directions affected by an eastward magnetic declination were incorporated for that area. (Author's drawing.)

Star was not visible. In two of his treatises, published around 1190, Neckam wrote:

When, in cloudy weather, the sailors can no longer profit by the light of the sun, or when the world is wrapped up in the darkness, . . . they touch the loadstone with a needle, which is whirled round in a circle until . . . it points direct to the north (*De Naturis Rerum*).

[Among the other stores of a ship, there should be] a needle mounted on a dart which will oscillate and turn until the point looks to the east, and the sailors will thus know how to direct their courses when the pole star is concealed (*De Utensilibus*).<sup>64</sup>

It is clear from the two texts that the contemporary use of the marine compass on board ship was complementary to the traditional method of navigation based on observations of the position of the sun and the Pole Star. It is also implied that the use of the magnetic needle was not new and that having such an instrument on board was common, if not actually required.

A satirical poem by Guyot de Provins, from about 1204, describes what were probably floating magnetic needles.

The mariners employ an art which cannot deceive,  
By the property of the lodestone,  
An ugly stone and brown,  
To which iron joints itself willingly  
They have; they attend to where it points  
After they have applied a needle to it;  
And they lay the latter on a straw  
And put it simply in the water  
Where the straw makes it float.  
Then the point turns direct  
To the star with such certainty  
That no man will ever doubt it . . .  
And the mariners are taught  
To follow the right way.  
It is an art which cannot fail.<sup>65</sup>

A further indication that marine compasses evolved during the thirteenth century comes from a letter of Pierre de Maricourt (Petrus Peregrinus) written in 1269 in which is described a cased compass consisting of a dry pivoted needle, a circle graduated in degrees and a pointing alidade.<sup>66</sup> Although this particular instrument was intended to measure the azimuth of the sun and stars, it may be accepted that similar models were later adopted by mariners. Such a technical improvement would explain the superior accuracy and precision of the directions in the *Compasso de Navegare* and *Carte Pisane* when compared with those of the *Liber*.

It has been argued that nautical cartography could not have developed before the dry-pivot compass was introduced. The negative errors affecting some of the directions in the central Mediterranean indicate, however, that courses measured with some sort of marine compass were indeed included by the author of the *Liber*. Given that the precision and accuracy of the earliest extant portolan charts and portolans (like the *Compasso de Navegare*), which used a 32-point wind rose, could not possibly be achieved with a floating magnetized needle, the conclusion reached above seems reasonable. What is lacking in this line of thought is the possibility that much less accurate nautical charts, based on either astronomical directions or directions measured with those primitive instruments, may have preceded the *Carte Pisane*, a hypothesis that current research is directed towards solving.



### Chart Origins and the Liber

The *Liber de existencia riveriarum* is a document of extraordinary importance for the history of nautical cartography. Not only does it contain a portolan-like description of the Mediterranean, completed several decades before the *Compasso de Navegare*, but we can infer from it that a primitive type of nautical chart, one not based on compass directions, was used in the preparation of the text. Although the main purpose of the *Liber*, as expressed in the prologue, had nothing to do with navigation, most of its information is of a navigational nature and reflects an origin connected to maritime matters.

As we have seen, the chronology suggested by the prologue starts with the author of the *Liber* being exhorted by a cleric in Pisa critical of existing descriptions of the Mediterranean to prepare a better one. In order to fulfil the task, the necessary information was then duly collected from all available sources, including pilots and travellers, as well as from the author's own investigations and voyages, with the object of preparing a written description of the regions and, in due course, of constructing a map. There is no reason to conclude from further silence on the matter that such a map was never completed. Nor does the text give any hint that the anticipated map would have been a complete novelty. On the contrary, everything points to the likelihood that a proto-chart based on a 16-point wind rose and on astronomical directions was consulted in the compilation of the directions and distances given in the *Liber*.

The idea that the earliest portolan charts were created from portolans, whether these were specifically for use by pilots or for the wider benefit of *literati* and patrons, has been long dismissed.<sup>67</sup> A more likely scenario is that simple cartographical sketches for individual basins coexisted for a long time along with written sailing directions before any attempt was made to combine the disparate information into a single representation of the entire Mediterranean Sea, guided by the outlines on older world maps.<sup>68</sup>

The research reported above was based primarily on the analysis of quantitative information as opposed to an attempt to understand the prologue's arcane text. It seems to me that, pending agreement on the meaning of some Latin words, concerns over the interpretation of certain parts of the text, or the correct sequence of the events narrated by author of the *Liber*, are relatively minor issues.

What the actual situation was at the time the *Liber* was written may never be discovered in any detail. While it seems likely that some form of nautical representation may have been used to compile the text, no evidence exists that such a representation would have been a fully-fledged nautical chart like those that are extant. My analysis of the directions given in the *Liber* suggests that this was a time of technical improvement in navigation and cartography, when traditional astronomical methods of keeping the ship's course were being slowly replaced by the new marine compass. Between the writing of the *Liber* and the construction of the oldest surviving portolan charts, like the *Carte Pisane*, there was a formative period of several decades during which the floating needle gave place to the dry-point compass and magnetic directions were systematically incorporated into nautical cartography.

What is beyond doubt is that the genesis and evolution of the portolan chart was a much richer and more complex process than the previous generation of map historians envisaged. The *Liber de existencia riveriarum* has an important role to play in shedding light on that elusive process.

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### NOTES AND REFERENCES

1. Adolf Erik Nordenskjöld, *Periplus: An Essay on the Early History of Charts and Sailing-Directions* (Stockholm, P.A., Norstedt, 1897).
2. Tony Campbell, 'Portolan charts from the late thirteenth century to 1500', in *The History of Cartography*, vol. 1: *Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean* (Chicago, University of Chicago Press, 1987), 371–463; Ramón Pujades i Bataller, *Les cartes portolanes: la representació medieval d'una mar solcada*

(Barcelona, Institut Cartogràfic de Catalunya, 2007). Tony Campbell continues to complement his 1987 chapter with a series of online-studies headed *A Critical Re-examination of Portolan Charts with a Reassessment of Their Replication and Seaboard Function*. These contain corrections to and updates of the original chapter, with essays on specific aspects such as the cartographical innovations introduced in the earliest charts, the dating of the Carte Pisane, and the study of conventional shapes and colours in the representation of islands and estuaries: <http://www.maphistory.info/portolan.html> (last consulted August 2018).

3. Campbell, 'Portolan charts from the late thirteenth century to 1500' (see note 2), 380.

4. *Ibid.*, 385.

5. *Ibid.*, 384.

6. Pujades, *Les cartes portolanes* (see note 2.), 514.

7. *Ibid.*, 514–15; 517–18. My opinion, however, is that maps drawn to scale already existed before the earliest portolan charts were constructed (for example, those in the 12th-century *Tabula Rogeriana* and, to a lesser extent, in the 11th-century *Book of Curiosities*), which demonstrate that this particular innovation was not strictly necessary in the genesis of the portolan chart.

8. Pujades, *Les cartes portolanes* (see note 2), 512–15.

9. Jonathan Lanman, *On the Origin of Portolan Charts* (The Hermon Dunlap Smith Center for the History of Cartography, Occasional Publication No. 2, 1987). Lanman used the navigational information on courses and distances between adjacent ports along the shores of the Mediterranean in *Lo Compasso de Navegare* (1296) and in the *Parma-Magliabechhi Portolano* (15th century) to reproduce its coastlines. He then compared the results with the corresponding outlines on a modern map and with two portolan charts, the Carte Pisane (c.1280) and the Matteo Prunes chart of 1559.

10. In my view, Lanman's results would have benefited from better information on the spatial distribution of magnetic declination in the region (unavailable at the time) and by referring to the routes between distant places. The use of the short distance tracks only—those between adjacent coastal places—in the reconstruction of a chart is historically unconvincing. It is my conviction that the earliest nautical sketches of the Mediterranean were made using pelagic tracks, that is, tracks connecting places across large stretches of open water.

11. Scott Allen Loomer, 'A Cartometric Analysis of Portolan Charts: A Search for Methodology' (unpublished doctoral dissertation, Madison, University of Wisconsin, 1987).

12. It must be stressed that Loomer emphatically stated that in his view the medieval cartographers did not consciously adopt any formal map projection. What he said was that the construction method may have preserved characteristics of the underlying data which could be inferred from the properties of the best fitting projection. See Loomer, 'A Cartometric Analysis of Portolan Charts' (note 11), 107.

13. For the description of a recent model for estimating magnetic declination in ancient times, see M. Korte, F. Donadini and C. G. Constable, 'Geomagnetic field for 0–3 ka: 2. A new series of time-varying global models', *G3—Geochemistry, Geophysics, Geosystems* 10:6 (2009, online); M. Korte and C.G. Constable, 'Continuous geomagnetic field models for the past 7 millennia: 2. CALS7K', *G3—Geochemistry, Geophysics, Geosystems* 6:1 (2005, online).

14. The average tilt of the charts remained approximately constant to the end of the 16th century despite

the changing secular variation of magnetic declination. See Joaquim Alves Gaspar, 'Dead reckoning and magnetic declination: unveiling the mystery of portolan charts', *e-Perimtron* 3:4 (2008): 191–203.

15. For a general description of the methods of cartometric analysis and numerical modelling alluded here, see Joaquim Alves Gaspar, 'From the Portolan Chart of the Mediterranean to the Latitude Chart of the Atlantic: Cartometric Analysis and Modeling' (unpublished doctoral dissertation, Lisboa, Universidade Nova de Lisboa, 2010), 45–84; *idem*, 'Using empirical map projections for modeling early nautical charts', in *Advances in Cartography and GIScience*, vol. 2: *Selection from ICC 2011*, ed. A. Ruas (Paris, Lecture Notes in Geoinformation and Cartography 6; Berlin and Heidelberg, Springer Verlag, 2011), 227–47.

16. Gaspar, 'Dead reckoning and magnetic declination' (see note 14).

17. This method of construction continued to be employed in nautical cartography up to the middle of the 18th century, when the longitude problem was solved, and the Mercator projection was fully adopted for navigation. An early textbook discussing the geometry and construction of portolan charts is Pedro Nunes, *Tratado en defensam da carta de marear* [Treatise in defence of the nautical chart], in Pedro Nunes, *Obras*, vol. 1: *Tratado da Sphera* (1537; Lisboa, Academia das Ciências de Lisboa & Fundação Calouste Gulbenkian, 2002), 120–84, at 134–35.

18. The large confidence interval results from the uncertainty of the calibration curve used in the dating process. The most probable date of c.1245 is merely the median of the probability curve, which is asymmetrical. See Catherine Hofmann, 'Is the Carta Pisana still the oldest known marine chart? The results of laboratory analysis and radiocarbon dating' (unpublished paper presented at the International Workshop for the Origin and Evolution of Portolan Charts, Lisbon, 6–7 June 2016). For a discussion of the dating of the Carte Pisane see Ramon Pujades, 'The Pisana Chart: really a primitive portolan chart made in the 13th century?', *Cartes et géomatique* 216 (June 2013): 17–32; and Tony Campbell, 'Dating the Carte Pisane', cartographic innovations by the early portolan chart makers', <http://www.maphistory.info/PortolanChartInnovations.html#pisane> (consulted in August 2018). A more detailed study by Campbell, based on the analysis of toponymy, hydrography and drafting conventions, is 'Does the Carte Pisane need to be redated?' <http://www.maphistory.info/CartePisaneMenu.html>.

19. The Cortona chart is in the Biblioteca dell'Accademia Etrusca in Cortona, Italy. Its usual dating, to the first decades of the fourteenth century, was recently challenged by Jacques Mille, who considers that it may pre-date the Carte Pisane: see Jacques Mille, *The French Mediterranean Coasts on Portolan Charts* (self-published and presented at the International Workshop on the Origin and Evolution of Portolan Charts, Lisbon, 6–7 June 2016), 25–28. The Avignon chart, of which a fragment was rediscovered in 2002, depicts the western Mediterranean with part of the European Atlantic coasts including the east coast of Britain. Jacques Mille and Paul Fermon consider that the chart was likely to have been completed c.1300; see Jacques Mille and Paul Fermon, *Une carte portulan récemment découverte. Peut-être une des plus anciennes conservées? La carte d'Avignon*, published online by the Brussels Map Circle: <http://www.bimcc.org/history-of-cartography/avignon-chart> (last consulted August 2018);

Jacques Mille and Paul Fermon, 'A recently discovered portolan chart. Maybe one of the oldest extant? The Avignon chart', *Maps in History* (Brussels, Brussels Map Circle) 59 (September 2017): 19–25. The Lucca fragment, discovered in 2000 and now in the Archivio di Stato of Lucca, Italy, was studied by Philipp Billion, who suggested a date of before 1327: Philipp Billion, 'A newly discovered chart fragment from the Lucca archives, Italy', *Imago Mundi*, 63:1 (2011): 1–21.

20. The term 'formative period' is Tony Campbell's; see <http://www.maphistory.info/CartePisaneTEXT.html#methodology>.

21. This possibility is reinforced by the fact, mentioned above, that the average tilt of the extant charts remained more or less constant until the end of the 16th century, indicating that it had not been adjusted since the first prototype charts were produced. The earliest known mention of the use of magnetic compasses in the Mediterranean is in the two texts compiled c.1190 by the English monk Alexander Neckam: *De Naturis Rerum* and *De Utensilibus*. See Thomas Wright, ed., *De naturis rerum libri duo* (London, Longman, Green, Longman, Roberts, and Green, 1863); 'The Treatise De Utensilibus of Alexander Neckam', ed. Thomas Wright, in *A Volume of Vocabularies* (London, 1857), 96–120.

22. The *Liber de existētia riveriarum et forma maris nostri mediterranei* is London, British Library, Cotton MS Domitian A XIII, fols. 114r–129v.

23. Roberto Almagià, *Monumenta Cartographica Vaticana*, vol. 1: *Planisferi, Carte Nautiche e Affini Dal Sec. XIV al XVII Esistenti Nella Biblioteca Vaticana* (Città del Vaticano, Biblioteca Apostolica Vaticana, 1944), 133 ff; Patrick Gautier Dalché, *Carte marine et portulan au XII<sup>e</sup> Siècle. Le Liber de Existencia Riveriarum et Forma Maris Nostri Mediterranei (Pise, circa 1200)* (Rome, Palais Farnèse: École Française de Rome, 1995).

24. Gautier Dalché, *Carte marine et portulan* (note 23), 7–16.

25. Pujades, *Les cartes portolanes* (note 2), 519, n.76. Gautier Dalché later acknowledged Pujades's remark in 'Les cartes marines: origines, caractères, usages. À propos de deux ouvrages récents', *Geographia Antiqua* 20–21 (2012): 215–27, at 217.

26. The whole prologue was transcribed by Gautier Dalché, *Carte marine et portulan* (note 23), 115–16, who later introduced some minor amendments: Gautier Dalché, 'Les cartes marines: origines, caractères, usages' (note 25), 219). A partial transcription of the prologue was made by Pujades, *Les cartes portolanes* (see note 2), 512–13.

27. To make the unpunctuated original text easier to follow, Gautier Dalché inserted some punctuation into his transcript, which has not always been adopted in the version given here.

28. The letters following *M*, in the manuscript, have been erased.

29. *Quem*, in Gautier Dalché's later transcription ('Les cartes marines' (see note 25), 219). The original script appears to have been amended, either from *quam* to *quem* or from *quem* to *quam*. I have accepted the feminine *quam*, in which case it can refer only to *forma*.

30. Should read *numeris*.

31. Should read *eorum*.

32. In Gautier Dalché's view, the reading should be *longitudinem et latitudinem* (*Carte marine et portulan* (see note 23), 116).

33. Here *illorum* (of those) should refer to *locorum* (places), above. Gautier Dalché takes it to refer to

*gradientibus* (*Carte marine et portulan* (see note 23), 81). See note 46 below.

34. Should read *narracione*.

35. Should read *composicione*.

36. Should read *recordacione*.

37. Unknown word. Gautier Dalché, *Cartes marine et portulan* (note 23), 116, proposes *curiosius* instead.

38. See Gautier Dalché, *Carte marine et portulan* (note 23), Pujades, *Les cartes portolanes* (note 2), 512–13; Gautier Dalché, 'Les cartes marines' (note 25), 217–20; and John Pryor, 'The preface of the *Liber de existencia riveriarum*', in Roel Nicolai, *The Enigma of the Origin of Portolan Charts. A Geodetic Analysis of the Hypothesis of a Medieval Origin* (Leiden, Brill, 2016), Appendix H: 517–19.

39. Gautier Dalché has also made the point on several occasions that some descriptions are couched as if the author were reading a map. See Gautier Dalché, *Carte marine et portulan* (note 23), 23–38.

40. It would seem that Gautier Dalché has subsequently consolidated his ideas and revised his reading of the Latin syntax at the start of the prologue, making it identical to Pujades's. The original French translation, in Gautier Dalché, 'Les cartes marines' (note 25, 219), reads: *Notre mer Méditerranée . . . nous proposons de la mettre par écrit à partir de la forma de cette mer et de ses côtes, selon la façon dont ces lieux sont situés dans le monde habité dans les parties des vents. Afin d'assembler [ce monde habité] en une petite cartula de mappemonde, nous avons composé ce petit ouvrage du nombre des milles et de la distance qui sépare ces lieux, en reproduisant leurs noms de l'époque moderne; dans certains (cas), j'ai inséré des choses antiques et leur cause, selon la référence des livres, pour que ceux qui connaissent les livres comprennent plus facilement.*

41. Pujades' translation (*Les cartes portolanes* (see note 2), 513) reads as follows: 'We propose to write about our Mediterranean Sea, about the form of the sea itself and its shores, in accordance with how its places are located in terms of the winds on the globe of the earth. In order to represent it on a mappamundi chart, I drew up this brief text on the number of miles that separate its places, giving their modern names; in some places I also gave their ancient names according to the books (the Bible) so that those familiar with the Scriptures might recognize them more easily'.

42. The proposed partial translation by John Pryor is the following: 'We propose this sea . . . to be rendered in writing from the shape of this sea and of its coasts, according as their locations lie in the orbit of the lands in the directions of the winds; for arranging which [the orbis] on a chart of a *mappa mundi* we had composed this little work on the number of miles of distance of their places, copying their names in modern times. In certain of which I inserted the ancient [names] and the establishment of them according to books so that those who know books may understand more easily'. From which he considered that 'The author wrote the book first and then compiled a map (or perhaps intended to compile a map)'. See Pryor, 'The preface of the *Liber de existencia riveriarum*' (note 38), 517–19.

43. I have been at pains to avoid as far as is possible being influenced by any preconceived ideas about the genesis of nautical cartography. This was not always easy, given the necessity of putting the work into the context of what is known about the subject. In the long process that culminated with the present English

version, I arrived at the conclusion that, despite its overall lack of clarity and the presence of a few errors, the original text must have been prepared by someone with a good knowledge of Latin. That was not Gautier Dalché's opinion in 1995 (Gautier Dalché, *Carte marine et portulan* (note 23), 87)), which he retracted in 2012 (Gautier Dalché, *Les cartes marines* (note 25), 219), saying: *Mon jugement selon lequel le style est caractérisé par la maladresse est peut-être à abandonner ... le Latin du prologue, marqué par une grande artificialité stylistique, paraît hypersavant, ce qui peut être aussi bien le propre d'un personnage qui manie la langue de façon experte (et maniérée) ou de quelqu'un qui souhaite montrer avec une évidence particulière une maîtrise d'une culture qu'il ne domine pas totalement avec le naturel requis. Je ne saurais décider.* As in other medieval and modern works, we noted a marked contrast between the complex and somewhat contorted style of the prologue and the simplicity of expression in the rest of the work. The square brackets in the translation are conventional and were added for clarity.

44. The common meaning of *existencia* (existence, manifestation) makes scant sense in the present context. More appropriate words would be 'appearance' or 'disposition'.

45. That is, their origin. See Gautier Dalché, *Carte marine et portulan* (note 23), 20.

46. According to Gautier Dalché and Pujades, *gradientibus* is likely to refer to the mariner's nautical guides (portolans), an interpretation I do not accept, especially in the light of the advice I have received from other Latinists. In my view, *gradientibus illorum* (from the travellers of those) refers to *eorum locorum* [of those places], above. If it referred to *partes riveriarum* [the parts of the coastlines] then *illorum* should be amended to *illarum*. Thus, our proposed translation 'and [from] the travellers of those [places]' not only respects the form of the manuscript but also makes sense.

47. The Latin word *manus* (usually meaning 'hand') may also mean 'handwriting'. The expression *manus operis* suggests the interpretation that the cleric's criticism might have been directed at both the *content* and the quality of the *calligraphy* of the texts describing the Mediterranean.

48. Following the indication of Gautier Dalché, *Carte marine et portulan* (see note 37), I have replaced the unknown word *aurious* with *curiosius*.

49. According to Gautier Dalché, such *opusculum* preceded the final work and comprised a text and a chart (*forma*). See Gautier Dalché, 'Les cartes marines' (note 25), 219–20.

50. Gautier Dalché, *Carte marine et portulan* (see note 23), 23–37, 103–6; Pujades, *Les cartes portolanes* (see note 2), 513.

51. In the *Compasso de Navegare*, each interval of 45 degrees can be subdivided in 16 parts. This portolano is dated 1296 but is usually considered to be a copy of an older original, probably of c.1250. See Gautier Dalché, *Carte marine et portulan* (note 23), 75. The *Compasso de Navegare* is Berlin, Staatsbibliothek Preuss, Kulturbesitz, MS Hamilton 396.

52. Gautier Dalché, *Carte marine et portulan* (see note 23), 19.

53. Al-Idrisi's book *Nuzhat al-mushtāq fi'khtirāq al-āfāq*, also known as *Tabula Rogeriana* or *Book of Roger*, was commissioned by the King of Sicily, Roger II. It comprises a written description of the world, in Arabic, divided into seven climates, each one

subdivided into ten sections. The text is accompanied by seventy sectional maps that can be assembled into a world map. Ten manuscript copies are extant, eight containing maps. See S. Maqbul Ahmad, 'Cartography of al-Sharīf al-Idrīsī', in *The History of Cartography*, vol. 2, book 1: *Cartography in the Traditional Islamic and South Asian Societies*, ed. J. B. Harley and David Woodward (Chicago, University of Chicago Press, 1992), 156–74. For an up to date analysis of al-Idrisi's geographical writings and maps and Roger II's involvement in the translation of Arab scientific and other works, see Tarek Kahlaoui, *Creating the Mediterranean: Maps and the Islamic Imagination* (Leiden: Brill, 2018). On the circulation of Arab manuscripts in western Europe from the tenth century onwards, see Charles Burnett, *The Introduction of Arabic Learning into Europe* (The Panizzi Lecture for 1996; London, The British Library, 1997). Current thinking supports the suggestion made in this article that Arab representation of the Mediterranean might have been seen by Europeans from the tenth century onwards, giving them the *idea* of a detailed map of the whole area, as in al-Idrisi's map of the Mediterranean.

54. According to the transcription of Gautier Dalché, *Carte marine et portulan* (note 23), 111–15.

55. It would have been inappropriate to use the differences in degrees in the analysis given the fact that the original directions are expressed in intervals of 22½ degrees.

56. See E. G. R. Taylor, *The Haven-Finding Art: A History of Navigation from Odysseus to Captain Cook* (London, Hollis & Carter, 1958), 35–64; Fernando Pimenta, 'Astronomy and navigation', in *Handbook of Archaeoastronomy and Ethnoastronomy*, ed. C. L. N. Ruggles (New York, Springer, 2017), 43–65. For a comprehensive survey of the prehistoric evidence, see Barry Cunliffe, *On the Ocean: The Mediterranean and the Atlantic from Prehistory to AD 1500* (Oxford, Oxford University Press, 2017).

57. Because of the curvature of the earth's surface, a ship sailing away from the coast progressively loses sight of it, starting with the lowest lying land. Exactly at what distance a given feature (a specific mountain or other landmark) disappears below the horizon depends on its elevation above sea level and on the altitude of the observer. Effective visibility at sea is also dependent on the transparency of the air, which is affected by the weather. See Pimenta, 'Astronomy and navigation' (note 56), 52, after William Schüle, 'Navegación primitiva y visibilidad de la tierra en el Mediterráneo', in *LX Congreso Nacional de Arqueología* (Mérida, 1968), 449–62.

58. According to Gautier Dalché, there is no reason to believe that the history of a chart for navigation does not go back to well before the mid-13th century (*Carte marine et portulan* (see note 23), 105): *loin de naître dans la deuxième moitié du XIII<sup>e</sup> siècle, comme on l'admet d'habitude, cette cartographie non seulement existe un siècle auparavant, mais rien n'empêche qu'elle ait à cette date déjà vécu une longue existence.*

59. Gautier Dalché, *Carte marine et portulan* (see note 23), Appendix III, 204–19. Gautier Dalché did not attempt any conclusion from the comparison.

60. A few routes include an overland section, which could suggest that the information had been copied from a chart rather than taken from a text. See Gautier Dalché, *Carte marine et portulan* (note 23), 80.



61. I have chosen to represent the errors in degrees on the map, rather than in points of 22½ degrees, to make the representation more expressive. Otherwise most of the values would be zero.

62. In fact, the absolute value of the errors in the whole data set is negatively correlated to the length of the tracks, that is, larger errors are associated with shorter distances. This feature, already noticed in the geographical summary, was also mentioned by Lanman when he analysed the distances compiled from the *Compasso de Navegare*. See Lanman, *On the Origin of Portolan Charts* (note 9), 11–14.

63. No such symmetry is found in the directions of the *Compasso de Navegare* compiled by Lanman, where the average errors range between –6.8 and –10.4 degrees depending on the region of the Mediterranean. This result is expected considering that the directions in the *Compasso* are affected by magnetic declination. See Lanman, *On the Origin of Portolan Charts* (note 9), 19.

64. Alexander Neckam, *De Naturis Rerum* (see note 21), 183; idem, ‘The Treatise of De Utensilibus’ (see note 21), 114. Translations were adapted from those by Thomas Wright, 1857. The mention of the needle pointing to the east, instead of to the north, is probably an error of the author or an early copyist.

65. John Orr, ed., *Les Oeuvres de Guiot de Provins* (Manchester, Imprimerie de l’Université, 1915), 20–30. The original reads: *un art font que mentir ne puet par la vertu de la manate; une pierre laide et brunet ou li fers volentiers se joint*

*ont, si esgardent lor droit point; puez c’une aguile l’ait touchié et en un festu l’ont afichié, en l’augue la mettent sens plus et li festuz la tient desus. Puis se forme la pointe tourney contre l’estoille, si sens doute que ja por rien n’i fauceraït ne mareniers ne douterait . . . Contre l’estoille va la pointe por ce sont li marenier cointe de la droite voie tenir. C’est uns ars qui ne puet mentir.* The English translation given in the text here is taken from Arnold Pierre, *The Letter of Petrus Peregrinus on the Magnet, A.D. 1269* (New York, McGraw-Hill, 1904), 38–39.

66. *Ibid.*, 25–31.

67. See Campbell, ‘Portolan charts from the late thirteenth century to 1500’ (note 2), 383. Concerning the possibility of preparing a chart using only the information in the text of the *Liber*, a visual inspection of its routes makes clear that such a task would have been impossible for obvious lack of data.

68. I have already demonstrated that the main geometrical features of portolan charts can be satisfactorily explained by assuming the use of navigational information (pelagic courses and distances between places) in their construction. See Gaspar, ‘Dead reckoning and magnetic declination’ (note 14); idem, ‘From the Portolan Chart of the Mediterranean to the Latitude Chart of the Atlantic’ (note 15), 73–84. Precisely which tracks were used to construct the earliest charts is not, and probably cannot be, known because the final geometry of a chart is only weakly dependent on the set of routes used in the construction, assuming that they covered the charted area uniformly.

#### *Le Liber de existencia riveriarum (vers 1200) et la naissance de la cartographie nautique*

L’indice historique le plus ancien de ce qui pourrait être une carte nautique primitive se trouve dans un manuscrit daté d’environ 1200, le *Liber de existencia riveriarum et forma maris nostri mediterranei*, qui décrit la mer Méditerranée. Le corps du manuscrit consiste en une description de la mer Méditerranée, de la mer Noire et des côtes européennes de l’océan Atlantique, organisée en 45 sections, chacune introduite par un bref texte qui décrit l’orientation et la taille de la région, suivi d’une liste de paires de localités côtières, avec les distances entre elles, à la manière d’un portulan. D’autres paires de lieux concernent des parcours en pleine mer (parcours pélagiques), pour lesquels sont fournis à la fois les distances et les directions. Deux catégories différentes de directions peuvent être distinguées: celles qui ne sont pas affectées par la déclinaison magnétique, ce qui indique qu’elles ont probablement été déterminées par des méthodes astronomiques, et celles qui sont affectées par des erreurs systématiques, qui ne peuvent trouver leur origine que dans des observations faites à la boussole. Il est suggéré que certaines des routes de pleine mer dans le *Liber* furent compilées à partir d’une carte existante, qui aurait pu être utilisée comme source générale pour l’ouvrage. Ceci implique que la genèse et l’évolution technique de la carte-portulan médiévale fut un processus plus complexe que ne l’ont pensé jusqu’à présent les historiens de la cartographie, qui avaient fondé leurs analyses sur les quelques exemplaires existants de la fin du XIII<sup>e</sup> et du début du XIV<sup>e</sup> siècle, tous construits d’après les directions de la boussole.

*Das Liber de existencia riveriarum (um 1200) und die Geburt der Seekartographie*

Der früheste bekannte historische Hinweis auf ein Dokument, das man als einfache Seekarte ansprechen könnte, befindet sich in einem, das Mittelmeer beschreibenden Manuskript aus der Zeit um 1200, dem *Liber de existencia riveriarum et forma maris nostri mediterranei*. Den Hauptteil des Manuskripts bildet die Beschreibung des Mittelmeeres, des Schwarzen Meeres sowie der europäischen Atlantikküste in 45 regional differenzierten Sektionen. Diese bestehen jeweils aus einem kurzen Text, in dem die Orientierung und die Größe der Region behandelt werden und einer Liste von entlang der Küsten gelegenen Ortspaaren mit der Angabe ihres Abstandes ähnlich den Portolanen. Weitere Listen kombinieren paarweise Örtlichkeiten, die durch offenes Meer getrennt sind, mit der Angabe von Richtung und Entfernung zwischen diesen. Zwei unterschiedliche Typen von Richtungsangaben können festgestellt werden: solche, die nicht durch die magnetische Deklination beeinflusst werden, was darauf hinweist, dass sie vermutlich mit Hilfe von astronomischen Methoden bestimmt wurden und solche, die systematische Fehler erkennen lassen, die nur durch die Verwendung eines Schiffskompasses verursacht worden sein können. Es ist davon auszugehen, dass einige der Routen über offenes Meer im *Liber* aus einer existierenden Seekarte übernommen wurden, die eventuell als grundlegende Quelle für das Werk diente. Die Folge ist, dass Entstehung und technische Entwicklung der mittelalterlichen Portolankarten auf einem wesentlich komplexeren Prozess basieren, als das bisher von Kartenhistorikern angenommen wurde, deren Analysen vor allem die wenigen Exemplare vom Ende des 13. und des beginnenden 14. Jahrhunderts in den Blick nahmen, die alle auf der Verwendung von Kompasskursen aufbauen.

*El Liber de existencia riveriarum (c.1200) y el nacimiento de la cartografía náutica*

El primer indicio histórico conocido de lo que pudo ser una primitiva carta náutica se encuentra en un manuscrito medieval de c.1200, el *Liber de existencia riveriarum et forma maris nostri mediterranei*, que describe el mar Mediterráneo. El conjunto del manuscrito consiste en una descripción de los mares Mediterráneo y Negro y las costas europeas del Atlántico, organizado en 45 secciones regionales, cada una introducida por un texto corto describiendo la orientación y tamaño de la región, seguido por una especie de portulano que lista parejas de localidades costeras con la distancia entre ellas. Otras parejas de lugares relatan las vías a través del mar abierto (vías pelágicas) para las cuales se proporcionan distancias y direcciones. Se pueden distinguir dos tipos distintos de direcciones: aquellas no afectadas por la declinación magnética que indican que probablemente han sido determinadas por métodos astronómicos, y las que han sido afectadas por errores sistemáticos que sólo podrían haberse originado en observaciones hechas con la brújula. Se ha sugerido que algunas de estas rutas pelágicas en el *Liber* fueron compilados de una carta original que puede haberse usado como referencia general para el trabajo. La implicación es que la génesis y la evolución técnica de la carta portulana medieval fue un proceso más complejo de lo que hasta ahora habían pensado los historiadores de la cartografía que habían fundado sus análisis en unos pocos ejemplares del final del siglo XIII y comienzos del XIV, todos basados en las direcciones de la brújula.





Plate 1. Detail of al-Idrisi's map of the world from the *Tabula Rogeriana* (1157) showing the Mediterranean and part of the Black Sea. From Konrad Miller's facsimile (1928) rotated to show north at the top. Despite the relatively crude outline, especially when compared with the sailing tracks given in the *Liber*, the map is a reminder that the general shape of the Mediterranean had been known since antiquity. Library of Congress, G3200 1154.B 1928. See p. 10.