

A GIS Approach to Finding the Metropolis of Rhapta

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The *Periplus of the Erythrean Sea* is a description of trade networks in the western Indian Ocean written as a guide for merchants (Casson 1989: 5). This text provides a description, varying in detail, of a multitude of regions, including the geographic features, settlements, ports, and peoples to be found in each. The original text, dating to approximately 30–40 CE, no longer survives, but a copy, believed to date to the tenth century, has been preserved and is currently housed in Heidelberg (Graf 1994: 143). The southernmost location mentioned in the text is the port of Rhapta, on the East African coast. This port is also mentioned in Ptolemy’s *Geography*, a second-century CE geographical account, in which it is termed a *mētropolis* and located “a short distance from the sea” (*mikron apothē thalassēs*), that is, at the mouth of the Rhaptos river which flowed into the Indian Ocean (4.7.12). The exact location of Rhapta has been the subject of a lengthy historical debate owing to a lack in the text of any description of recognizable geographic features associated with, and the absence of any notable archaeological sites that can unequivocally be attributed to, the port (Hoyle 1967: 95; Horton 1990: 97; Kirwan 1986: 99).

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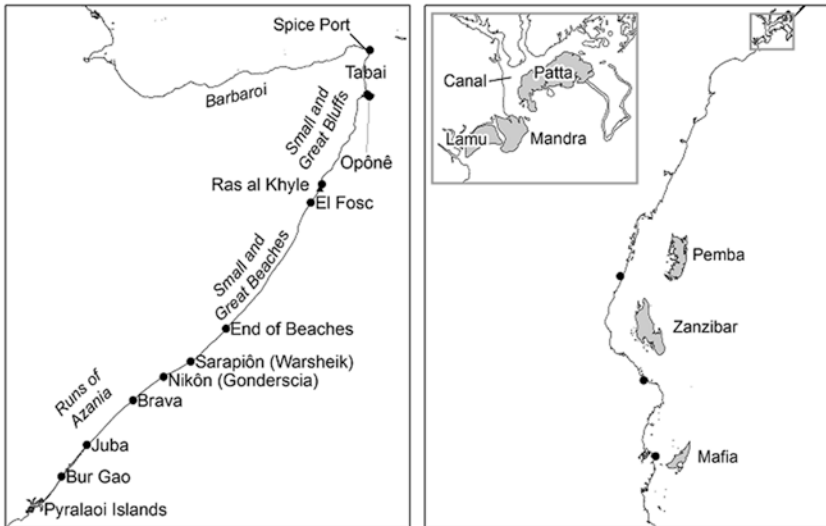
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It is universally accepted that Rhapta was located somewhere on the Indian Ocean littoral of Azania (as East Africa is termed in the text) (Casson 1989: 141; Dato 1970a: 66), a region corresponding to the southern extent of the modern Swahili coast, between the Somalia–Kenya border and northern Mozambique. It is also known that the name “Rhapta” comes from the ancient Greek *rhapta ploiaria*, meaning “sewn boats” (*Periplus* 16), the typical mode of transport employed at the time in this region (Casson 1989: 61). Moreover, it is apparent that Rhapta was a very important commercial port in the Indian Ocean World (IOW) in the first two centuries CE which the author notes was a major source of tortoise shell and soft ivory, as well as a lesser source of rhinoceros horn and nautilus shell (*Periplus* 17; Casson 1989: 61). The tortoise shell found in Rhapta was a popular commodity because, as the author notes, it was considered second in quality only to that obtained from India (*Periplus* 17), while a depletion of ivory sources available to Red Sea ports in the period the *Periplus* was written made this port a major source of soft ivory for IOW markets (Dato 1970a: 73). The importance of this settlement as a center of trade is further indicated by Ptolemy’s designation of it as a *mētropolis*, a term used to refer to the most important city in a region, and thus usually also to major commercial hubs (Liddell et al. 1940: s.v. *mētropolis*, A.III). The various modern commentaries on the *Periplus* have indicated three possible locations for Rhapta, all of them in modern Tanzania: the environs of Dar es Salaam; Pangani; and the Rufiji delta (Hoyle 1967: 95; Horton 1990: 97; Kirwan 1986: 99; Dato 1970a: 66). By examining the information found in the *Periplus*, comparing it to that furnished by the later *Geography* of Ptolemy, and analyzing the resulting data in GIS, we will demonstrate the most likely modern site of Rhapta, as well as the locations of several nearby sites mentioned in both texts.

The *Periplus* is divided into 66 chapters, starting at the northern edge of the Red Sea. As the chapters progress, the author describes sites along the route heading south, reaching the Horn of Africa by chapter 12; in chapter 18, the description of the African coast is concluded with the region around Rhapta. From chapters 19 to 66, the author then describes his travels to and around India, beginning again from a port in the Red Sea. The description of the east coast of Africa begins at the tip of the Horn of Africa with a site referred to as the Spice Port (*to tōn Arōmatōn emporion*), corresponding to the last promontory of the north Somalia coast. The geography of the area fits the description of the text in that it is exposed to the north but protected from the south. The location of the

so-called **Spice Port** was likely the modern village of Daamo on the Horn, at which pottery of eastern Mediterranean origin dating to the Roman period has been discovered (Chittick 1979: 275; Reade 2013: 449–450) (Map 6.1).

Chapter 13 begins with the village of Tabai, the author stating that after sailing a distance of 400 stades (a unit of distance to be discussed later in this chapter) along a peninsula one will reach a port of trade known as Opone. **Tabai must be in the bay of Charo Hordio** due to the distance mentioned to **Opone** (Casson 1986: 181). Excavations at the modern site of **Ras Hafun** have uncovered numerous fragments of pottery from Mesopotamia, Iran, Egypt, and the eastern Mediterranean dating to between the first century BCE and the first century CE, suggesting that this was the location of Opone (Chittick 1976: 133; Smith and Wright 1988; Reade 2013: 449). The unique geography of this site also supports this theory, as it matches the statement in the *Periplus* that along this route lies a peninsula “towards which the current sets” (*kath’ hon topon kai ho rhous helkei*; Casson 1986: 181), while the journey around it roughly equates to 400 stades.



Map 6.1 The East African Coast according to the *Periplus* (drawn by Carl Hughes of the Indian Ocean World Centre (IOWC), McGill University)

In Chapter 15, after Opone, the coast is said to trend to the south, marking the beginning of the Small and Great Bluffs of Azania (*mikra Apokopa kai megala tēs Azanias*). Based on modern satellite images and digital elevation models, it is clear that these bluffs are almost certainly those marking the Somali coastline from approximately 10 degrees down to 7.5 degrees north. At the end of these bluffs begin a series of sandy beaches, almost certainly the Small and Great Beaches, which according to the *Periplus* extend for another six “runs.” According to Guillain (1856: 103 in Casson 1989: 139), the beaches stretch a total distance of 607 km, from Ras al Khyle to a location just short of short of Washeikh, Somalia. Chittick (1976: 120) asserts, however, that the distance to Washeikh is 704 km. Each figure is a little too high to correspond to the most accurate measure for a run, 1000 stades; nonetheless, if we add the length of the Beaches and the Bluffs, their combined distance should be between 900 and 1110 km (Guillain 1856: 103 estimates 1007 km; Chittick 1976: 120 estimates 1178 km). It is likely that the beaches actually begin at a latitude of about 7.5 degrees north and end at a latitude of about 2.4 degrees, thus corresponding to a distance of 1020 km, similar to Guillain’s estimate. After the beaches come the Runs of Azania, seven in total, starting with the Sarapion Run, then the Nikon Run, and continuing on, separated by daily stops up to the Pyralaoi Islands.

The Pyralaoi Islands are the farthest southern geographic feature mentioned by the *Periplus* along the East African coast that can be identified with relative certainty. These islands are Pate, Lamu, and Mandra. The author then notes the existence of a feature associated with these islands known as the Canal, which is almost certainly the bay that forms a natural canal around Pate. From here, the text states that “a little more towards the west after two night-and-day runs, lying due west ... comes Menouthias Island, about 300 stades from the mainland” (*Periplus* 15) “a little more towards the west after two night-and-day runs, lying due west ... comes Menouthias Island, about 300 stades from the mainland.” It is from this vague passage, unfortunately corrupt, that confusion arises. In order to identify Menouthias Island, we can only rely on a calculation of the distance provided by this text, and thus we must ascertain the correct measures for a run and stade.

Kirwan (1986: 101) argues that it is impossible to quantify the distance of a night-and-day run without knowing the weather or sea conditions at the time when the trip was undertaken, because a run is simply a measurement of the distance traveled within a specific time period. Casson (1989: 278), however, referring to Bunbury (1879: 455), argues that it is pos-

sible to quantify these units based on distances calculated by Eratosthenes and Marinus. The texts of these ancient geographers mention distances in runs and stades, which had become standard geographic units of measurement by the time the *Periplus* was written. Casson (1989: 278) uses these texts to hypothesize the length of a night-and-day run as 1000 stades.

But in order to understand this measurement, we must know the length of a stade, which itself has been the subject of debate. Estimates for the length of this unit range from 157 to 185 m. Gulbekian (1987: 363), relying on Eratosthenes, argues that the length was 166 m. Casson (1989: 278) cites Engels (1985: 298) for a length of 185 m, a figure which Potheary (1995: 67) supports based on a reanalysis of the work of Strabo, who makes use of the Polybian stade. It is Hoyle's (1962: 84) conclusion that the length of the stade is 157 m, however, that holds the most credibility. This figure is derived from Dutka's (1993: 64) recalculation of Eratosthenes' attempts around the year 230 BCE to measure the circumference of the Earth by calculating the angle of the sun at two different locations. Hultsch (1971: 60), studying the evidence from a philological perspective, also arrives at this figure. Finally, the most recent attempt by Brown and Kumar to determine the value of this unit, based on known errors in Eratosthenes' measurement of the circumference of the Earth, confirms Hoyle's (1962) value of 157 m (Brown and Kumar 2011: 445).

Eratosthenes' work on the circumference of the Earth served as the basis for the calculations of distances in geographical works of later writers, including Pliny, Strabo, Ptolemy, and, most likely, the author of the *Periplus* (Dutka 1993: 55). Little is known about Eratosthenes' methods, means of measurement, or actual results, however, as his works are no longer extant. There is only one known reference in major ancient geographic texts to the length of the unit of measurement employed by Eratosthenes: a statement in Pliny that "by the calculation of Eratosthenes, a schoenus measures 40 stades" (*Natural History* 12.53). Since the schoenus was an architectural measure, Hultsch, working with archeological evidence for the length of this smaller unit, was able to calculate the stade of Eratosthenes as 157 m (1971: 60). The astronomical writings of Kleomedes of the first century BCE, which provide the most detailed account of Eratosthenes' experimentation (Dutka 1993: 60), have also been used to reproduce his experiment several times, with the resulting length of a stade each time falling within 1 meter of Hultsch's original estimate (Brown and Kumar 2011; Dutka 1993; Hoyle 1962).

Dutka (1993: 55) convincingly discredits the longer distance of 185 m, argued for by Rawlins (1982: 218), as based on an incorrect attempt by

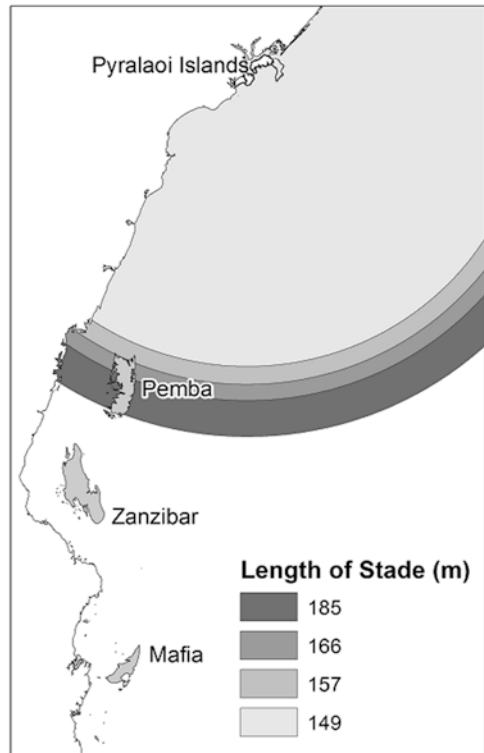
Pliny to convert the Eratosthenic stade to a homonymous Roman measure, despite the latter unit only coming into use several centuries after Eratosthenes' day. The best estimate of the length of the stade employed by the author of the *Periplus* is therefore 157 m. For the purposes of this study the entire range of values for a stade will be considered, though this value will be considered the most credible, and thus most likely to provide the highest accuracy in measuring distances.

As noted above, the *Periplus* states that Menouthias lies two night-and-day runs away from the Pyralaoi Islands, the equivalent of 2000 stades. This suggests a maximum distance of 370 and a minimum distance of 296 km, with the most likely distance being 315 km. It is evident that the northern tip of Pemba is approximately 315 km from the Pyralaoi Islands and the southern tip 370 km. As is common in the case of geographic accounts from this era, it is entirely plausible that the author measured the distance from the Pyralaoi Islands to the very first sighting of Menouthias; this distance would, then, given the southerly direction of travel, refer to the northern tip of the island, or a point roughly perpendicular to this part of the island along the coast. The distances to Zanzibar and Mafia are much greater than the estimated calculations, with even the less accurate values of a stade touching Pemba Island (with the exception of the minimum value, which falls slightly short). Based on this observation, and given that a multiple of the most reliable length of a stade best fits the distance stated to reach Menouthias, it appears that Pemba is most likely the island called Menouthias by the author of the *Periplus* (Maps 6.2 and 6.3).

Next, we are told that Menouthias lies about 300 stades from the mainland. Calculations of this distance based on different values for the stade arrive at figures ranging from 44.6 to 55 km, while a calculation based on the 157 m stade would suggest a distance of 47 km. The case for Pemba being Menouthias is thus the strongest of the three islands considering the distance measured from the northern tip of the island, which would have been the first point of contact for a merchant heading south and also corresponds to the most likely distance from the Pyralaoi Islands. It must be noted, however, that the author would have had to ignore the presence of Mafia and Zanzibar during his journey in order to produce the itinerary preserved.

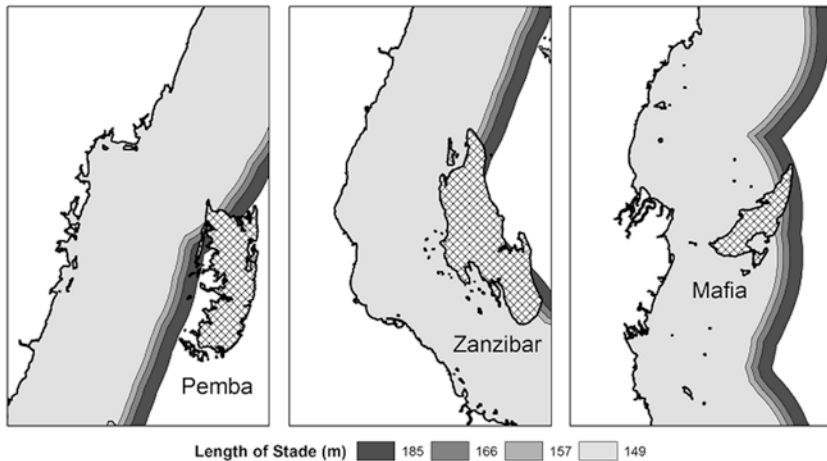
The *Periplus* also importantly provides a brief description of the physical attributes of Menouthias. This island is firstly said to be low (*tapeinē*), presumably referring to its elevation profile. A high resolution (30 m) Digital Elevation Model of the region makes it clear that all three islands could be

Map 6.2 Estimated maritime distances off the East African Coast in stades (Carl Hughes, IOWC)



considered low lying. The average elevations of the islands lie between 25 and 26 m, with the highest elevation on Zanzibar being 126 m, on Pemba 92 m, and on Mafia 53 m. Thus, because early explorers of the region could have described each of these islands as low lying, this criterion cannot be used with much certainty to locate Menouthias.

Further describing the physical features of the island, the author states that “on it there are rivers” (*en hēi kai potamoi*). Based on calculations of the angle and direction of the slopes of the terrain from an elevation model, it is possible to extract river outlines from the topography of the islands. This method can, assuming the terrain has not changed much within the past two thousand years (however unlikely this may be), provide a more reliable overview of rivers. A GIS river extraction provides a better fluvial map than hand-drawn attempts, which are prone to exclude artificially created hindrances for water flows and seasonal flows that may



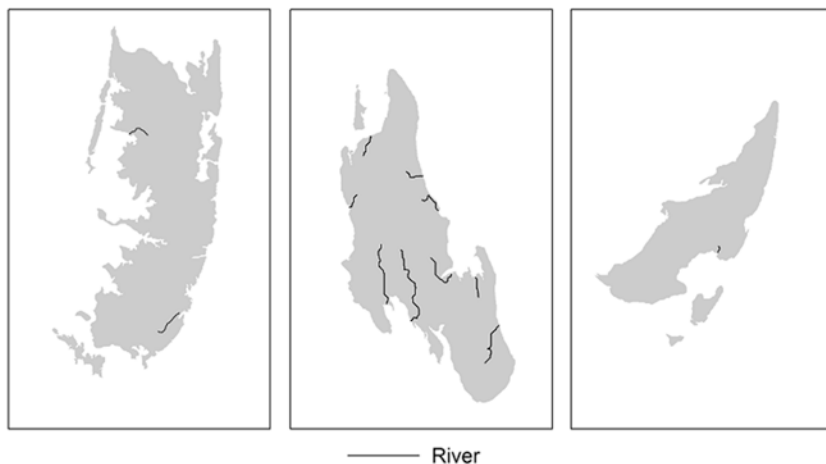
Map 6.3 Estimated maritime distances between the East African Coast and the Islands of Pemba, Zanzibar, and Mafia in stades (Carl Hughes, IOWC)

have altered original river paths. This is why nineteenth-century maps of the islands, which show a lack of rivers (Hoyle 1967: 98), should not be used.

It is obvious that Mafia has the fewest rivers, while Zanzibar and Pemba are both covered with rivers that could have been visible to a sailor traveling along the coasts of either island. But while Pemba has the most rivers and fits this description the best, it is not clear which vantage point the author had in mind when he made this vague observation; as such, the reference to rivers cannot properly identify one island or another (Map 6.4).

The *Periplus* also states that Menouthias is forested (*katadendros*). All three islands were probably heavily wooded two thousand years ago, and it is very likely that Pemba and Zanzibar were at least covered by coastal forests (Moreau and Pakenham 1941: 98). Though this description does not help to identify one island or another, it does somewhat help make the case for these two islands. Moreau and Pakenham (1941: 98) conclude that all three islands' predominant vegetation type in the past, given rainfall levels, would have been evergreen forest.

The text asserts that while the island is populated by “many kinds of birds” (*orneōn genē pleista*), there are no other kinds of animals on Menouthias except tortoises and crocodiles, the latter of which “do not harm any human” (*oudena de anthrōpon adikousi*) (*Periplus* 15). This



Map 6.4 River courses on Pemba, Zanzibar and Mafia (Carl Hughes, IOWC)

statement may indicate that the author never actually went ashore on the island. Moreau and Pakenham (1941: 110) assert that crocodiles as well as pythons and hippopotami could possibly have reached one or more of the islands, though they have not been attested in any fauna inventories carried out in modern times. Crocodiles are also not presently considered native to the three islands in any capacity, while no remains of any species have been discovered. It is more likely that these “crocodiles” were in fact monitor lizards (Moreau and Pakenham 1941: 108; Casson 1989: 140). These lizards, which are harmless, can grow up to 2 m in length, and from a distance could have been mistaken for crocodiles. Since this part of the world was largely unexplored in the first century CE, the author probably simply identified these animals as some species with which he was familiar, which in Egypt would have been the Nile crocodile. More significant, however, is the author’s claim that the island was barren of other kinds of animals. In fact, all three islands are home to native animals including primates, bats, cats, rodents, and ungulates; Zanzibar is home to 39 types of mammals, Pemba to 17, and Mafia to 12 (Moreau and Pakenham 1941: 116).

As was noted, the *Periplus* also mentions that the island is home to mountain tortoises. It is not clear what is meant by the term “mountain tortoise” (*chetōnē oreinē*), and there is no species of mountain tortoise, in the modern sense of the term, native to the island today. The islands are

home to smaller species of tortoise, however, including the Bell's hinge back tortoise (Moreau and Pakenham 1941: 109). The author could perhaps be referring mistakenly to a type of turtle, though there is no evidence for the historical distribution of turtle species found in the western Indian Ocean, including green turtle, hawksbill, loggerhead, olive ridley, and leatherback (Pharaoh et al. 2003), in the vicinity of the islands. Since Rhapta was known for its export of tortoise shell (*Periplus* 16), it is entirely plausible that whatever species were on the island were hunted to extinction in the past with no trace yet discovered.

To return to Rhapta and its position vis-à-vis Menouthias, the text does not state anywhere that the former is located directly opposite the latter, so it is not possible to consider the pairings of Zanzibar and Dar es Salaam; Mafia and Rufiji; or Pemba and Pangani for Rhapta and Menouthias, respectively. The distances given from the mainland to the island and from the island to Rhapta are different, indicating that the locations on the mainland from or to which the distances were calculated lay at different latitudes. When calculating the position of Rhapta based on the *Periplus*' description, we can automatically ignore the area to the north of each island, since the itinerary always heads south and Rhapta is said to lie beyond Menouthias. This leaves Dar es Salaam, Rufiji, or present-day Rushungi, Tanzania as the possible locations for this settlement. The author either begins his reckoning of distance from the tip of Menouthias or the coast on the mainland at the same latitude as the tip of the island to measure the distance from this island to Rhapta; either reference could work for the journey from Pemba to Dar es Salaam, depending on the most direct route from each starting point. It is possible that Rhapta was located in the area around the Rufiji delta, but this would depend on Zanzibar being Menouthias, and, as we have seen, there is no reason to suspect this based on the other distances mentioned in the *Periplus*. It is also certain that Menouthias was not Madagascar, or at least the Menouthias mentioned in the *Periplus*. In his *Geography*, Ptolemy is almost certainly referring to Madagascar when he discusses Menouthias (4.8.2; Blench 2007: 70). The Menouthias of the *Periplus*, however, is too close to the shore (only a distance of two day-runs) to be Madagascar, which, moreover, is mountainous and is home to a plethora of wildlife that should have been visible and noted by the author.

It thus becomes apparent when using GIS to analyze the distances and descriptions in the *Periplus* that a location for Rhapta in the proximity of Dar es Salaam seems most probable. By turning to Ptolemy's *Geography*,

we will attempt to cross-reference locations mentioned in both texts, and thus provide more evidence for the location of this settlement.

The *Geography* is another ancient itinerary, though unlike the *Periplus*, this ambitious work mapped the entire world as it was known to the author. It consists of theoretical chapters providing a guide for creating a world map and locating sites based on the use of coordinates. Ptolemy's geographical grid system is based on the work of his predecessor, Marinus, though, where possible, improved or corrected based on his own work (Berggren and Jones 2001: 23). He provides coordinates for about 8000 locations across Africa, Europe, and Asia, as well as captions or descriptive labels accompanying many. Ptolemy, a Greek based in Alexandria whose geographic work developed from his research into astronomy, was likely born around 100 CE and completed his *Geography* in the 150s CE (Berggren and Jones 2001: 3).

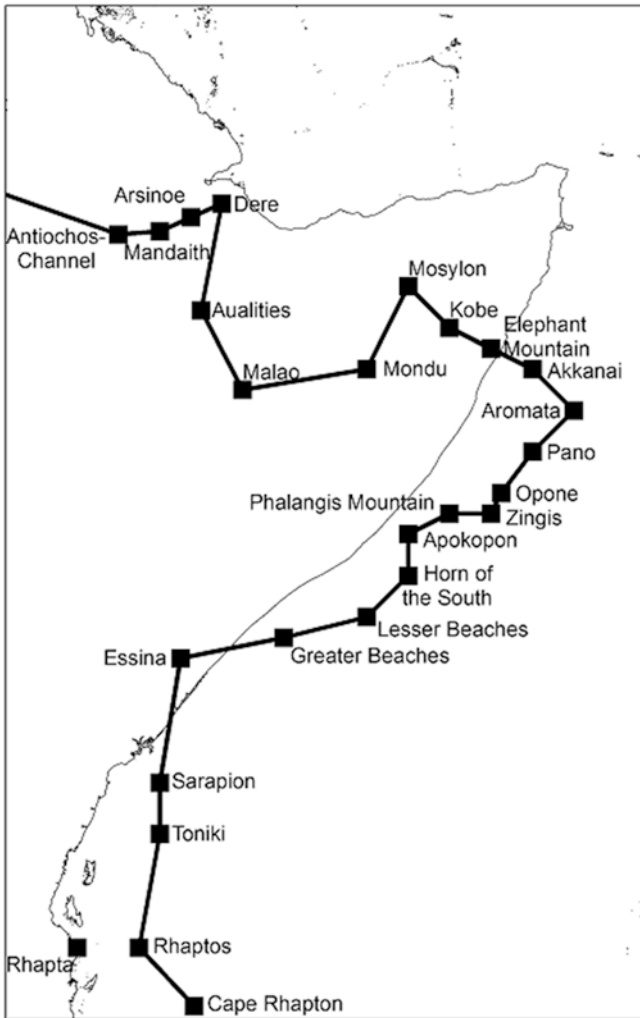
More than 53 manuscripts of the text survive, though none older than the thirteenth century (Diller 1949). Based on errors in transmission, it appears that one archetype was edited before the tenth century, but many centuries after Ptolemy's day, which became the source for all subsequent manuscripts (Berggren and Jones 2001: 42). It is likely that the maps included in many of the extant manuscripts are copies of that drawn by Maximus Planudes in the thirteenth century and not of that created by Ptolemy himself (Berggren and Jones 2001: 49).

In his theoretical chapters, written as a critique of Marinus' projection, Ptolemy presents two methods for drawing a world map, one on a spherical and the other on a planar projection (*Geography* 1.18–24). The spherical approach is similar to a modern simple conical projection, which incorporates straight meridians with circular parallels about the poles to keep the spherical look; proportionality of bounding arcs (parallel of Thule and the equator); and longitude and latitude relative about Rhodes (exaggerated further north or south). The second approach is similar to a pseudo-conical projection which was designed to view hemispheres about a central meridian and the Summer Tropic with arcs reflecting on either side; preserves the proportionality of the parallels; features meridians that are not converging straight lines but parallels that are still circles; and distorted distances along non-central meridians. The comprehensive coordinate list provided breaks the world into 80 districts grouped into three continents, with locations ordered west to east and north to south. Coordinates are recorded in degrees, minutes, and seconds, with a resolution of five minutes, or 1/12th of a degree. Ptolemy used the Blessed Islands, likely the modern day Canary Islands, as the prime meridian.

Some of the locations mentioned in both the *Periplus* and the *Geography* texts include the Spice Port (*Periplus: to tōn Arōmatōn emporion*, 12; *Geography: Arōmata emporion*, 4.7.10), Opone (*Periplus: emporion Opōnē*, 13; *Geography: Opōnē emporion*, 4.7.11), the Small and Great Beaches (*Periplus: Aigialos kai mikros kai megas*, 15; *Geography: Mikros aigialos, Megas aigialos*, 4.7.11), Sarapion (*Periplus: [ho dromos] Sarapiōnos*, 15; *Geography: Sarapiōnos hormos*, 4.7.11), Menouthias (*Periplus: Menouthias... nēsos*, 15; *Geography: nēsos... Menouthias*, 4.8.2), Rhapta (*Periplus: ta Rhapta*, 16; *Geography: Rhapta mētropolis tēs Barbarias*, 4.7.12), and perhaps Nikon (*Periplus: [ho dromos] Nikōnos*, 15; *Geography: Toniki[a] emporion*, 4.7.11; see Casson 1989: 134). Ptolemy's coordinates for these locations have been plotted in order to compare them with the locations predicted from the account of the *Periplus* in the hope of narrowing down the search for Rhapta. Map 6.5 presents the raw coordinates of these locations from the *Geography*. From this map, it is obvious that the coordinates are representative of the described locations. What is quite notable is the geometry of points, clearly delineating the Horn of Africa, while many of the location names also overlap or are proximate to the predicted *Periplus* locations.

Several attempts have been made to map the coordinates provided by Ptolemy for other regions of the world using modern mapping techniques. For locations in Europe, Livieratos (2006) performed an n-order transformation on the coordinates, yielding quite accurate results. Filatova et al. (2009) employed a two-dimensional regression model to locate sites in West Africa, a method which produced fairly good results in that region as well. Marx (2011) analyzed the spatial accuracy of the coordinates and concluded, based on the distribution of the minute value measurements of the coordinates, that it is necessary to accept a much lower resolution for any map based on the *Geography* than is stated in the text. He found that a higher distribution of values could be expressed with multiple denominators; using this method, he calculated the relative resolution of the points and concluded that in East Africa the resolution was on average actually only 33 km. Before proceeding, previous attempts at locating the sites mentioned in the *Geography* are considered. For this purpose, the lower resolution of 33 km is utilized in a GIS transformation of the points provided.

To date, only one attempt at locating Rhapta using the coordinates provided in the *Geography* has been made, by Horton (1990). The results of this analysis are rendered invalid, however, by the author's confusion of the order of ports along the coastline. Additionally, Horton does not mention



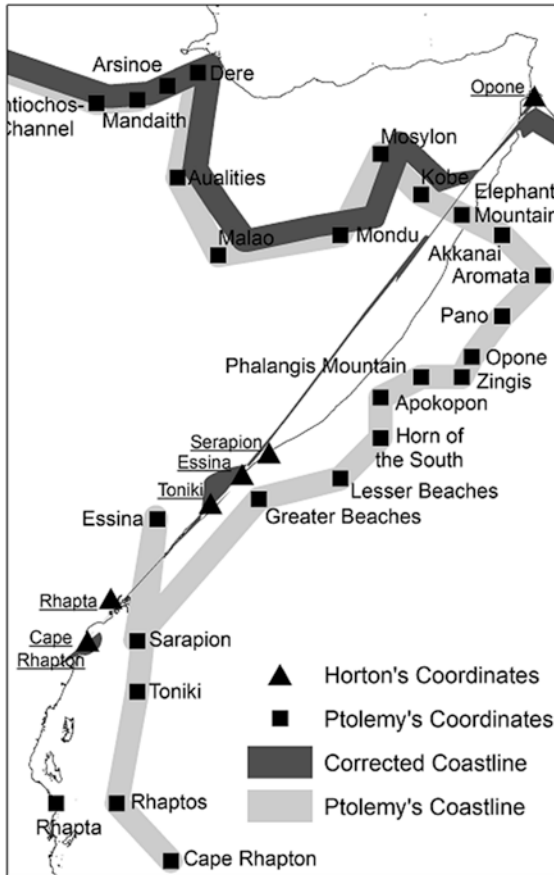
Map 6.5 Raw geographical coordinates for the East African Coast from Ptolemy's *Geography* (Carl Hughes, IOWC)

what edition of the *Geography* he used; it is likely that he worked with the only modern English translation of Ptolemy's work, by Stevenson (1932), which has been extensively critiqued for its numerous errors. Horton firstly assigns the Cape of Sarapion to a location without a cape or promontory and confuses the order of the same cape with Essinia (1990: 97). Secondly, he correctly identifies Menouthias with Madagascar in Ptolemy's account, but then claims that this discredits the accuracy of the *Periplus*, and that its author at the first sight of sewn boats along the coast simply stopped and claimed that location to be Rhapta (1990: 98). He then asserts that it is possible that there are multiple Rhaptas, and that the name of the location is meaningless, despite the fact that Ptolemy states that Rhapta was a *mētropolis* (4.7.12)—hardly a frivolous designation. It is unlikely that Ptolemy would have assigned the same name to a *mētropolis*, and also the final port along the route he was traveling, as he did to other minor ports without recording these other Rhaptas. Finally, Horton claims that Cape Rhapton (*Rhapton akron*) lies south and west of the mouth of the river Rhaptos (1990: 98), but, based on Ptolemy's coordinates, this cannot be possible, even employing coarser spatial resolution with the rubber sheeting geometric correction of the coordinates (discussed below).

In order to identify the modern locations of Ptolemy's points, a geometric correction must be applied that compensates for the imprecision of his coordinates. Until now, most approaches to correcting Ptolemy's coordinates were done by hand, an incredibly inefficient method that often produces errors. To retain the historical value of Ptolemy and allow for comparison with modern maps, a more suitable conflation technique is required. Doytsher (2000) proposed the piecewise rubber sheeting method as an effective technique, which has been used by Shimizu and Fuse (2003). This method utilizes control points matching a historical point with a known modern day location. A mathematical algorithm, related to the n-dimensional transformation, is then applied to the entire historical spatial dataset such that the control points align perfectly while the unmatched portions are stretched, rotated, and compressed to fulfill this condition (Map 6.6).

This method is usually used to match historical maps with modern maps. It would not be productive, however, to use any of the illustrated maps included in manuscripts of the *Geography* for two reasons. Firstly, as already noted, Ptolemy's own map no longer survives. Secondly, all premodern renditions of his geographic description are fairly rudimentary and do not accurately represent his given coordinates. Instead, a map created by running his original coordinates through a modern GIS will be used. Due to the fact

that in the area we are concerned with the text plots locations along the smooth African coastline, errors in the actual shape of the coast should be minimal, and once the transformation is applied, curved coastline features will be accounted for. Features such as beaches and bluffs do not require any control points, since these are not point features, though their position is described in both texts with a great degree of certainty; as such, attempting simply to recreate the shape of these features in the rubber sheet transformation would be inaccurate for the geometry of that part of the coast.



Map 6.6 Geometric correction of Ptolemy's geographical coordinates for the East African Coast (Carl Hughes, IOWC)

To perform an accurate transformation, the control points need to be known modern point locations. An emphasis on the precision of the results at these locations will ensure that point locations lying between these points are most accurate after the transformation. At the Horn of Africa, Ptolemy's Aromata must refer to the *Periplus*' Spice Port on Cape Guardafui. Next, the location of Pano sits somewhere between Aromata and Opone, though it is not necessary to know exactly where since both texts refer to the same Opone, providing the next known control point. The following identifiable feature is a cape known as the Horn of the South (*Notou keras*), located after two unknown locations (Zinge and Phalangis Mountain) between the Bluffs (*Apokopon*) and Small and Great Beaches (*Mikros aigialos* and *Megas aigialos*). As for the Beaches, although the coordinates provided for these are not accurate, it does not matter since, as already mentioned, such features should not be identified with one set of points anyway. From here, three locations are listed before Rhapta, namely **Essina, Sarapion, and Toniki, of which the latter two are listed as promontories.** These three locations must be the ports along the Runs of Azania in the *Periplus*, though each reference does not necessarily refer to the same location (Casson 1989: 134). After this, the point for Menouthias will be excluded because it refers to Madagascar. Next, instead of using the site of Rhapta as a control point, the mouth of the Rhaptos river will be used; while, however, we know Rhapta is only a short sail up from the mouth of the river, we do not know on which side of the river it lay or the course of the river at the time. In order to determine which of the three possible sites of Rhapta (Dar es Salaam, Pangani, and the Rufiji delta) is most likely this ancient site, the head of the Dar es Salaam natural harbor, Pangani River, and Rufiji River, respectively, will be tested as the river Rhaptos. Finally, the *Geography* describes a Cape Rhapton located just south of the mouth of the river. This cape must be a notable promontory due to its designation as such by Ptolemy and will be tested both with Rhapta as Dar es Salaam and Pangani at Buunyi village at -7.1 degrees south, and with Rhapta in the Rufiji delta as the tip of an unnamed peninsula at -7.9 degrees south.

In ArcGIS, these known control points were plotted and joined with a 33 km-wide buffer line. The control points were then transformed to their known coordinates. The transformation adjusts the entire polygon as one object, stretching, rotating, and compressing in sections to ensure the control points lie in their proper location. If the transformation is a good fit, the width of the polygon representing the coastline should remain fairly constant and similar to the original width between control points. In

regions where the fit is not as good, we would expect for the polygon to be distorted geometrically and for its width to become very narrow. The transformation was performed three times for each pairing of the river Rhaptos and Cape Rhapton based on the predicted locations of Rhapta (Maps 6.7 and 6.8).

The port of Sarapiôn is situated in close proximity to the same location from the *Periplus*. Toniki also appears to lie close to the Pyralaoi Islands

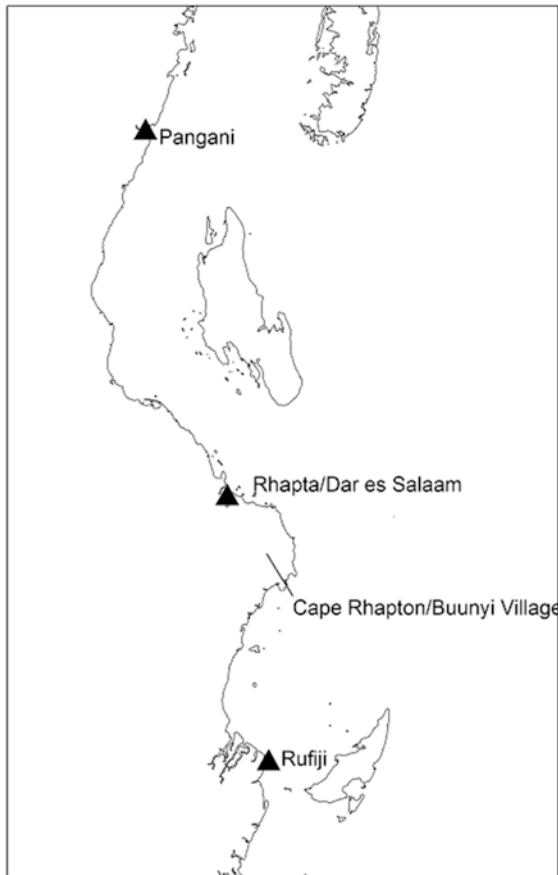


Map 6.7 The East African Coast: ArcGIS corrected coastline buffer version A (Carl Hughes, IOWC)



Map 6.8 The East African Coast: ArcGIS corrected coastline buffer version B (Carl Hughes, IOWC)

and not in the same area as Nikon, as mentioned in the *Periplus*. This makes sense because Toniki is supposed to be a market place (it is called an *emporion* in *Geography* 4.7.11), and this location would have provided a good supply of freshwater and a reasonably good harbor. The area south of Dar es Salaam is the only part of the Azanian coast which matches the description in the *Periplus* of the coastline after Rhapta, said to bend to the west. The coast around modern Buunyi village extends out, turns south, and then bends back to the west; as this is the first section of this coast to



Map 6.9 The probable location of Rhapta (Carl Hughes, IOWC)

display such a drastic change, it could easily have appeared to the author of the *Periplus* to mark the end of the African coast (Map 6.9).

Based on a cross-reference of the distances and geographic description of the *Periplus* with the coordinates of locations furnished by the *Geography*, it is thus most likely that Rhapta was located in the proximity of present-day Dar es Salaam. This conclusion is derived primarily from the fact that the island of Pemba best matches the description of the island of Menouthias, but also from the geographic description of the *Periplus* that the coast beyond Rhapta bends to the west, in a location that could only be the Cape Rhapton mentioned in the *Geography*.

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