Ptolemy's *Geography*: A Reform that Failed

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In the year AD 146 or 147, a rather unusual inscription of thanksgiving was erected in a temple at Canopus, a suburb of Alexandria. The inscription has not survived – Canopus is now under the sea – but some time around AD 500 someone connected with the still-flourishing philosophical school of Alexandria transcribed it, and manuscript copies preserved it through the Middle Ages. It begins, 'To the saviour god, Claudius Ptolemy (dedicates) the first principles and models of astronomy'; and what follows is a catalogue of numbers that define a complete and precise system of celestial mechanics governing the motions of the sun, moon, planets, and stars.[1]

Ptolemy had devoted a quarter of a century to the observations, analysis, and calculations that contributed to his astronomical system, and the detailed write-up of which the *Canobic Inscription* is as it were an abstract was surely almost ready for publication. Two or three afterthoughts, and then the *Mathematical Syntaxis*, or as we call it familiarly, the *Almagest*, gave the world not only a rigorous *more geometrico* deduction of the true motions of the heavenly bodies, but also tables for computing every significant astronomical phenomenon. A few years later, Ptolemy republished the tables by themselves in a more convenient format. The *Handy Tables* were Ptolemy's best-seller in antiquity, the only production of his pen that has so far been discovered on papyri.[2]

One of the first tables in the *Handy Tables* is an essential tool, a list of localities with longitudes in degrees from the westernmost meridian of the known world (the meridian through the 'Isles of the Blest') and latitudes in degrees from the equator.[3] Knowledge of

1. Text in A. Jones, 'Ptolemy's *Canobic Inscription* and Heliodorus' Observation Reports', *SCIAMVS*, 6, 2005, pp. 53–97, revising J. L. Heiberg, *Claudii Ptolemaei opera quae exstant omnia*, II, *Opera astronomica minora*, Leipzig, 1907, pp. 149–55. For the contents and chronology see also N. T. Hamilton, N. M. Swerdlow, and G. J. Toomer, 'The Canobic Inscription: Ptolemy's Earliest Work', in *From Ancient Omens to Statistical Mechanics: Essays on the Exact Sciences Presented to Asger Aaboe*, ed. J. L. Berggren and B. R. Goldstein, Copenhagen, 1987, pp. 55–73. The closest parallel to Ptolemy's *Canobic Inscription* is the c. 100 BC astronomical inscription from Keskintos (Rhodes), *IG* 12.1 no. 913, for which see A. Jones, 'The Keskintos Astronomical Inscription: Text and Interpretations', *SCIAMVS*, 7, 2006, pp. 3–41.

2. *Almagest*: text in J. L. Heiberg, *Claudii Ptolemaei opera quae exstant omnia*, I, *Syntaxis mathematica*, 2 vols, Leipzig, 1898–1903; English translation in G. J. Toomer, *Ptolemy's Almagest*, London, 1984. The only edition of the *Handy Tables* is very unsatisfactory: N. Halma, *Commentaire de Théon d'Alexandrie sur le livre III de l'Almageste de Ptolemée; Tables manuelles des mouvemens des astres*, Paris, 1822, continued in *Tables manuelles astronomiques de Ptolemée et de Théon*, 2 vols, Paris, 1823–5. For papyri of the *Handy Tables* see A. Jones, *Astronomical Papyri from Oxyrhynchus*, 2 vols in 1, Memoirs of the American Philosophical Society 233, Philadelphia, 1999 (I, pp. 38–40).

3. E. Honigmann, *Die sieben Klimata und die* πόλεις ἐπίσημοι, Heidelberg, 1929 (esp. pp. 72–81), and P. Schnabel, 'Die Entstehungsgeschichte des kartographischen Erdbildes des Klaudios Ptolemaios', *S. B. d. Preussischen Akademie der Wissenschaften, phil.-hist. Klasse*, 14, 1930, pp. 214–50 are the most important (albeit highly speculative) discussions of the table. Transcriptions of two manuscripts of the table in Honigmann, pp. 193–224.

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one's own latitude on the terrestrial globe was a prerequisite for translating one's local solar time reckoned in seasonal hours (twelfths of the variable interval from sunrise to sunset or from sunset to sunrise) to a time reckoned in constant hours (twenty-fourths of a mean day) counted from noon; then one needed to know one's longitude to convert this local time to the Alexandria Mean Time of Ptolemy's tables. The geographical table was useful as well for calculating parallaxes, eclipses, and planetary visibility phenomena.

A browse down Ptolemy's 'Table of Noteworthy Cities' is an eyebrow-raising experience. From the outset one senses that Ptolemy had immodest expectations for the diffusion of his tables. The first cities listed are in Ireland and Great Britain, and the catalogue progresses eastward and southward through the European continent. Then it sweeps, again west to east, across the Roman provinces of North Africa, and, after reaching Alexandria and other cities of Ptolemy's native Egypt, it surprises us by plunging far south of the Roman frontier. Then with the cities of Asia Minor we are in more plausible territory; but the table marches inexorably on eastward, and one asks oneself with growing incredulity, did Ptolemy expect his tables to penetrate past Mesopotamia to Persia, to India, to China and Southeast Asia?

With the 'Table of Noteworthy Cities' Ptolemy tied up one of the few loose ends in the *Almagest*. After discussing astronomical geography at a theoretical level in that work, Ptolemy had written (*Almagest* II.13) that a list of places with their positions relative to Alexandria would be desirable, but would appropriately belong to a separate geographical treatise, which Ptolemy had evidently not yet written. It is tempting for us with hindsight to identify this promised work with the *Geography*, but quite likely Ptolemy had in mind at this stage a quite different kind of book. The *Almagest* itself is perhaps the second of four major writings by Ptolemy that attempt a thorough, from the ground up, treatment of an entire scientific field. In the *Harmonics*, which I believe to be Ptolemy's first large work, he did this for the theory of musical tones and intervals; in the *Almagest* he did it for the phenomena of the heavenly bodies; in the *Tetrabiblos*, which soon followed the *Almagest*, he did it for the theory of celestial influences on the terrestrial environment and human lives; and in the *Optics* he was to do it for visual perception. I would guess that Ptolemy had in mind a comprehensive presentation and perhaps reform of the empirical and mathematical foundations of positional geography.

It is not difficult to see why Ptolemy did not end up by writing such a book. To begin with, he had a clear conception of the appropriate methodology for fixing terrestrial locations: since the earth is spherical, one ought to work exclusively with the kind of data that lead directly to a precise determination of one's position in relation to the whole sphere, and that means astronomical observations and measurements. The principles of astronomical geography had indeed been known for centuries. Four hundred years before Ptolemy, Eratosthenes had calculated latitudes from meridian shadow ratios, and three hundred years before, Hipparchus had advocated using lunar eclipses to measure relative longitude. Ptolemy had little new to offer here except for improved mathematical resources and suggestions for more convenient observational instruments, most of which he had already presented in the *Almagest*. On the other hand, few actual measurements had been carried out to any scientific standards. For example, not only were reports of simultaneous observations of eclipses in different places exceedingly rare, but those that existed were practically worthless because the eclipse times were only crudely determined. There was nothing that Ptolemy could do to improve the situation except to plead with his readers to make more observations (*Geography* 1.4).

So instead of writing for the ages, Ptolemy wrote a *Geography* for his own time, a work avowedly improving upon its predecessors and intended in its turn to be improved upon or eventually superseded.[4] Ptolemy hunted about for the most recent work on positional geography, hit upon the half-century-old writings of Marinus of Tyre, and realized that these presented detailed information about the known world that was considerably more up-to-date and extensive than anything he had known when he wrote the *Almagest* (*Geography* 1.6–17). Marinus had incorporated a great deal of information about the source materials that he relied on to establish where places were situated. Ptolemy made no attempt to repeat this evidence, but accepts the results except for parts on or near the African and Asian coasts of the Indian Ocean where he believed he had personal access to more accurate information, and except for a systematic reduction in north-south distances in the southern part of the known world and a similar reduction in east-west distances in the eastern part. He takes it for granted that any reader who wants to understand the empirical basis of his geography will have access to Marinus's books. This kind of self-insufficiency would have been incompatible with the plans of the *Almagest* and Ptolemy's other major treatises, but in geography it was acceptable because the whole foundation of the science was insecure anyway, and Ptolemy was looking forward to the day when an organized astronomical establishment would cast the whole Greek geographical literature on the rubbish mounds.

There was, however, a part of his subject in which Ptolemy could contribute something less ephemeral. At least since Eratosthenes, positional geography had been inextricably associated with cartography. The geographical books written by Eratosthenes, Hipparchus, and Marinus were justifications, or criticisms, of maps of the known world. It is not clear whether the treatise Ptolemy was contemplating in the *Almagest* was to be concerned with maps, but the book he actually wrote was so wholeheartedly devoted to cartography that he does not so much as mention astronomical applications of the positional information he has compiled for the map. Even the word *geōgraphia*, which other writers of his time used to characterize a broad range of literature, covering physical,

4. In the *Almagest* Ptolemy announces his intention to write a geographical *pragmateia*, i.e. 'treatise', whereas the *Geography*'s title is the more modest *Geōgraphikē Hyphēgēsis*, 'geographical guide'. Partial English translation and study of the *Geography*: Berggren-Jones; see pp. 52–3 for earlier editions. For most purposes these are now superseded by the splendid critical edition by A. Stückelberger and G. Graßhoff, *Ptolemaios: Handbuch der Geographie*, 2 vols, Basel, 2006.

zoological and botanical, ethnographic and anthropological, political and historical geography, Ptolemy defines as meaning strictly the mathematically abstract drawing of the known world and its major features.[5]

The first world maps of the Greeks that we hear of, dating from the time of the Persian Wars, were portable, and can hardly have shown much detail.[6] By the beginning of the Roman Empire, serious world maps had become grand public displays, sometimes with a political message like the map executed by Augustus's friend Agrippa, which was erected with an explanatory caption in a portico in Rome. Strabo, writing about this date, says (2.5.10) that a world map demands a space at least seven feet wide, or a globe with a diameter of ten feet. Marinus's map, with something like eight thousand named localities, must have been still bigger. This points to a central fact about the Greco-Roman cartographical literature: while it was of course possible for a geographical text written on a papyrus roll to be illustrated with fairly large-scale regional maps, such as the incomplete map of Spain that accompanies a chapter of the geographer Artemidorus in a recently discovered papyrus, this could be done only with considerable loss of detail or spatial distortion.[7] Only the advent in late antiquity of lavish codices with large pages, such as the Vienna Dioscorides, made it possible for a cartographical treatise to be an atlas.

While confessing our ignorance of all details, we can imagine how Marinus went about his work. First he collected whatever evidence he could bearing on the localities of the world and their relative or absolute positions. His geographical text would have been largely devoted to discussing these sources, appraising their trustworthiness, and extracting positional information from them in a form that could be applied to drawing the map. Marinus would gradually construct a provisional map, with elements scattered all over the place getting tentative locations, only to see them adjusted as other details were filled in. One source, for example, might list cities, bays, and promontories along a coast, with distances and rough directions, while another source coming later under consideration might provide an astronomically determined latitude for an inland city reported to lie due west of a harbour on that coast, forcing corrections to the way the coast had been drawn. Eventually Marinus would have a finished map along with a finished justificatory text, ready to make public. Later he would learn of more sources, write them up in a so-called 'revision of the map', and if resources permitted, he would produce also a corrected map. Ptolemy tells us that Marinus did this several times, and

5. The usage of *geōgraphia* to mean a world map is attested already in Geminus's *Isagoge* 16.4, and may have originated with Eratosthenes.

6. The best survey of Greco-Roman cartography remains O. A. W. Dilke, *Greek and Roman Maps*, London, 1985, to some extent supplemented by the voluminous treatment in Harley-Woodward.

7. C. Gallazzi and B. Kramer, 'Artemidor im Zeichensaal. Eine Papyrusrolle mit Text, Landkarte und Skizzenbüchern aus späthellenistischer Zeit', *Archiv für Papyrusforschung*, 40, 1998, pp. 189–208 and plate xxi; B. Kramer, 'The Earliest Known Map of Spain (?) and the Geography of Artemidorus of Ephesus on Papyrus', *Imago Mundi*, 53, 2001, pp. 115–20.

that he declared in his last update that he had not had time to construct a map following his latest revisions (*Geography* 1.17).

Now Ptolemy, who very likely never saw an actual map drawn by Marinus, quite reasonably holds that a book providing the evidential basis for a particular world map should make it possible for someone else to make a duplicate of that map (*Geography* 1.18).[8] And if Marinus wrote conscientiously and one had an accurate and complete copy of his text, one could indeed draw a map, but only by going through the same circuitous processes as Marinus himself had followed. One would have to recreate, in more or less the same order, all the partially determined stages, all the revisions. And where the sources collectively provided too little information or inconsistent information, one might end up by drawing something very different from what Marinus drew.

Ptolemy was compelled to go to all this trouble to make a map according to Marinus before he could compress the southern and eastern extremes and correct those details for which he had independent reports. But he was going to see to it that no one else would ever have to do it again. He had in fact dealt with an analogous situation before. In the *Almagest* (Books VII and VIII) he presents a catalogue of about a thousand stars in their constellations as the basis for constructing a star globe. Ptolemy gives the reader the distinct impression that he observed the position of each of these stars using a graduated sighting instrument, the armillary. While no one seems able to agree about just how Ptolemy did make his star catalogue, and how much or little of it he observed himself, it seems pretty clear that the locations of the dimmer stars could not have been independently measured with the armillary, but were perhaps estimated by unaided eye in relation to the nearby bright stars.[9] In other words, the star globe was built up by successive approximations, just like the world map (though of course the problems involved in the astronomical case were much simpler). But the written catalogue does not reflect this formative process. Instead it lists each constellation and its constituent stars in a sensible drawing order, spiralling down from north to south; and each star has two numbers to locate it on the globe, the first number measuring in degrees eastward from a fixed starting point along the ecliptic circle, and the second measuring in degrees perpendicularly north or south of the ecliptic. The two numbers are named *mēkos* and *platos*, 'length' and 'width', or if you prefer, 'longitude' and 'latitude'. Relying on these numbers, anyone possessing a text of the *Almagest* could replicate Ptolemy's globe with comparatively little effort.

This is of course what Ptolemy does for terrestrial features in the *Geography*; and while there is good reason to believe that Ptolemy did not invent the method as applied to

8. The suggestion that Ptolemy knew Marinus's work only through texts was made by H. Mžik, *Des Klaudios Ptolemaios Einführung in die darstellende Erdkunde. Erster Teil. Theorie und Grundlagen der Darstellenden Erdkunde*, Vienna, 1938 (p. 49 n. 3). Ptolemy makes no specific reference to Marinus's map as such except to criticize his cylindrical projection, which could well have been prescribed in a treatise.

9. I owe this point to J. P. Britton (personal communication), who has made trials with a modern reconstruction of Ptolemy's armillary.

portraying the celestial sphere, he does seem to have been the first to apply it to cartography. (I am not claiming here that Ptolemy invented the concepts of terrestrial longitude and latitude or their measurement in degrees, but I do believe that no one before Ptolemy had employed these numbers consistently to locate all significant points on a map.) The only important difference between the star globe and the map is that the map consists not only of disconnected points (such as inland cities) but also linear objects such as coasts, rivers, borders, and mountain ranges, each of which Ptolemy defines as a succession of points to be joined up. Almost always the points may be joined by straight lines without resulting in illogicalities in the final map, though Ptolemy probably expected the mapmaker to add innocent wiggles to give artistic verisimilitude to an otherwise bald and unconvincing coastline.

Next, since flat maps were generally more practicable than globes, Ptolemy expended much thought on appropriate ways of constructing a grid of meridians and parallels as a framework for drawing the map (*Geography* 1.24). He defines these with enough mathematical precision so that they may legitimately be described as projections. The goal of Ptolemy's two projections is, first, to maintain at least approximately the correct ratios of east-to-west and north-to-south distances throughout the map, and secondly, to give the spectator the illusion of looking at a part of a spherical surface. The first projection uses concentric circular arcs for the parallels and convergent straight lines for the meridians, with an inflection in the meridians at the equator (Figure 1). This grid was comparatively easy to draw, and by pegging a swinging ruler at the point where the meridians all meet, one could conveniently inscribe the localities in their correct places. The second grid, since it uses circular arcs also for the meridians, is much harder, but it fulfils Ptolemy's metrical and visual requirements much better (Figure 2). Ptolemy also allows for a simple rectangular grid to contain smaller-scale maps of regions selected from the world map.[10]

Wishing to leave the mapmaker at a loss for nothing, Ptolemy provides rather prolix captions for the world map and also for each of twenty-six regional maps into which he suggests partitioning the known world. The caption for the world map mostly consists of statistics about the sizes of the continents, the largest seas, the largest islands, and so forth. Those for the regional maps list the most important cities. These turn out to be the same as the Noteworthy Cities of the *Handy Tables*, so that one can see that the Noteworthy Cities extend so far from Alexandria not out of arrogance but because it was really less work to make a single selection for both contexts.

Let us return now to the great catalogue of places, which amounts to about two thirds of the bulk of the *Geography*. We saw how Ptolemy greatly simplified the drawing of the

10. Ptolemy's so-called 'third projection', a grid similar to the second projection but designed for incorporation in a portrayal of the entire terrestrial globe surrounded by rings representing the principal circles of the celestial sphere, is described in a long digression in *Geography* 7.6. For Renaissance approaches to the '3rd projection' see A. Cattaneo's essay in this volume.

world map by separating the empirical justification for the details of the map from the data for drawing the map. Now Ptolemy had no intention of suppressing the empirical part; but almost all of it was in Marinus's books already, and Ptolemy had no reason to repeat it. In fact Ptolemy expected people to go on refining the map, and he writes (*Geography* 2.1) that he laid out the catalogue in such a way that his successors could easily write in improved longitudes and latitudes in the space beside his numbers. He did not realize that he lived at an intellectual cusp, and that the following centuries would be a time of narrowing geographical perspective as well as narrowing scholarship. The world map, meant to be a work-in-progress, became a frozen image encoded in a list of place names and numbers; and when Marinus's writings were lost, Ptolemy's map could no longer be an object of rational criticism. One could merely take it or leave it.

It is a fortunate fact for us that ancient texts were often copied for no good reason. Probably very few scholars in the Greek-speaking world used the *Geography* as Ptolemy intended it to be used for a thousand years after his time, though a handful of authors managed to extract varying quantities of geographical information from it. We have no copies of the book older than about 1300, which is rather late for the earliest copies of a Greek scientific text. Some of these earliest manuscripts have maps: a world map employing one of Ptolemy's projections, and 26 regional maps. Unless these maps descend by a chain of graphical copying from Ptolemy's own maps, which on the face of it seems improbable, someone must have attempted to execute his instructions.

Let us try to put ourselves in the situation of this person. We have not been impetuous. We have read right through the readable (non-catalogue) parts of the *Geography* before trying to draw maps, and we realize that it makes good sense to try our hands at regional maps before venturing on the full world map. An easy place to start would be an island, say Crete which forms part of Ptolemy's tenth regional map of Europe (*Geography* 3.17). Our manuscript of the *Geography* looks something like Figure 3, a minimum of connective prose linking lists of place names with their longitudes and latitudes.[11] Ptolemy always begins each district by describing the parts of its boundary that have not already been given in earlier chapters. For Crete the outline is all coast, and this is broken down into a series of promontories, bays, river mouths, and cities. Once this is drawn, we get a list of interior cities, mountains, and offshore islands. Later in the *Geography* we get the caption for the regional map, which identifies which cities are especially noteworthy, and these perhaps call for a special marking on the map. The map of Crete that we reconstruct following our manuscript looks very plausible (Figure 4).

But a friend has got his hands on another manuscript of the *Geography*, and when he tries to draw the map of Crete, the results are a bit less satisfactory (Figure 5). The coastline gets tied in knots, cities are in the sea, and islands are on shore. This is surely not what Ptolemy's map looked like! But of course there have been copying errors (as is

11. I have chosen for this illustration *Vat. gr.* 191, a c. 1300 copy that does *not* contain maps.

obvious also from the numerous variations in the spelling of place names), and if we intend to draw a map that makes sense, we have to fix this manuscript by changing numbers, reordering points, or simply leaving out problematic features. By doing this we will not necessarily get closer to what Ptolemy had – indeed we are more likely to introduce new divergences than to undo old ones – but we at least obtain a text that can be converted into a map.

A third manuscript gives us as little trouble as our first one did (Figure 6). The coastline is plausible, and everything that is supposed to be inside it is so, while the islands are appropriately in the sea. But this Crete is much fatter than the one derived from our first manuscript. Which should we believe in?

It is hard to make a judgement on a single island. But as we try out more parts of the geographical catalogue, we discern a pattern of behaviour. Manuscript One usually gives reasonable results, but from time to time we get minor or gross illogicalities. Manuscript Two is very frequently incoherent. Manuscript Three seems never to slip. How can it be so sure-footed? Frequent transcription errors are a statistical certainty when the text to be copied consists of place names and numerals, and errors will frequently result in inconsistencies; for practical purposes these will only be detected by drawing the maps. Manuscript Three actually contains maps, and these are also almost perfectly consistent with the text. This is a text that has been repaired through the process of mapmaking.

The earliest *Geography* manuscripts with maps are *Urbinas graecus* 82, our Manuscript Three, and a regrettably damaged manuscript in Istanbul, both of which were executed about 1300. Both manuscripts come very near to perfectly fulfulling Ptolemy's intentions (their world maps conform to Ptolemy's first and second projections respectively).[12] But as we have seen, it was surely not in Ptolemy's mind that the maps should accompany the text of the *Geography*. The integration of maps and text, whether it dates from late antiquity or nearer to 1300, was an important innovation in many ways, including one that deserves closer study: the effect the presence of maps had in provoking mutations in the text.[13] So long as the text was transmitted without maps, errors tended to accumulate randomly. With the maps added, the process of copying had the potential to become considerably more complex.

The simplest scenario has the text straightforwardly copied from its exemplar, and the maps also copied by eye from the exemplar, so that the map is thought of as part of the

12. Colour reproduction of the world maps of *Urb. gr.* 82 and Istanbul *TSK gr.* 57 respectively in Berggren-Jones, plate 1, and D. King, *World-Maps for Finding the Direction and Distance to Mecca*, Leiden, 1999, p. 29. A. Diller, 'The Oldest Manuscripts of Ptolemaic Maps', *Transactions of the American Philological Association*, 71, 1940, pp. 62–7, argued that these manuscripts, and a lost third of which a single bifolium survives as *Fabricianus gr.* 23, were products of a single atelier.

13. Berggren-Jones, pp. 45–50, maintained that the maps in the earliest extant manuscripts were original reconstructions from Ptolemy's text, and likely the work of Planudes and his circle. For a summary of a persuasive case that the map tradition extends back to antiquity, see F. Mittenhuber, 'Die Relation zwischen Text und Karten in der Geographie des Ptolemaios', in *Text-Bild-Karte. Kartographien der Vormoderne*, eds J. Glausner and C. Kiening, Freiburg i. Br., 2007, pp. 69–93.

transmitted text. This approach will inevitably cause the text and the maps to diverge in some details. The text may pick up some inconsistencies, whereas whatever distortions happen to the map, it will of course continue to make sense on its own terms. At the other extreme, the maps can be entirely reconstructed from the text, with no references to the maps in the exemplar. This, as we have seen, leads to deliberate alterations to the text. And of course a mixture of the two approaches is possible.

In *Urb. gr.* 82 we saw a case where the correspondence between maps and texts is so close that we can be sure that the maps were drawn, if not from the text pages of this manuscript itself, at least from a manuscript closely related to it. Our Manuscript Two, which is the fourteenth-century BL Burney 111, tends to the opposite end of the spectrum. Its map of Crete, for example, differs from the map we reconstructed from the text, not only in that it is untangled, but also in several details of the coast where the text version manages to stay coherent. In fact the maps in Burney 111 were copied out of a different exemplar from the source of the text.[14]

As an intermediate example, consider a printed Ptolemy, the Ulm Latin edition of 1482. The text for Crete, while certainly not messed up as badly as in Burney 111, has illogicalities that become apparent when we draw a map from it (Figure 7): two consecutive places on the coast are assigned identical longitude and latitude, and an offshore island turns out to be right on the coastline. A third anomaly shows up when we come to the caption for the regional map in Book 8, which lists a 'noteworthy city', Knossos, that is missing from the text (*Geography* 8.12).

The map in the Ulm edition is really quite close to the text (Figure 8). But the problem island is now well offshore, and the two places that had identical coordinates are distinct on the map. Knossos, however, is missing. We can probably conclude that the map and text both descend from a copy in which the maps and text were carefully reconciled, but that between that copy and the printed version there has been ample opportunity for new errors of transmission.

Little has yet been established about the extent of transmission directly from map to map in the tradition of manuscripts and printed editions of the *Geography* during the period since the earliest extant manuscripts. That this kind of transmission played a part even in the drawing of some of the most carefully executed maps is easily demonstrable from an extreme case in which the chain runs all the way from the Urbinas codex to the printed atlas editions. Ptolemy, as is well known, indicated that he, no doubt following Marinus, held that the Indian Ocean is enclosed by land joining the southern extremity of Africa to the southeastern extremity of Asia.[15] For the linking coast, however, he gives no outline or instructions on how to draw it. In the *Urbinas* and Istanbul world maps, this coast is drawn closely paralleling the southern limit of the map. The line is essentially

14. A. Diller, 'De Ptolemaei Geographiae codicibus editionibusque', foreword to reprint (Hildesheim, 1966, pp. v-xv, esp. ix) of C. F. A. Nobbe, ed., *Claudii Ptolemaei Geographia*, 3 vols, Leipzig, 1843–5.

15. The relevant passages include *Geography* 7.3, 7.5, 7.7, and 8.1.

due east-west, but in the Urbinas map it has little wiggles interspersed with five larger 'polyps' at more or less equal intervals. These polyps keep turning up in later copies of the world map, for example in the rather crudely drawn one in the Burney manuscript, the lavish *Vaticanus Urbinas Latinus* 277 (dated 1472), and the Nicolaus Germanus maps from which the Ulm 1482 maps were produced (Figure 9). Of course this is an instance in which there was no textual coordinate list to compete with the graphic exemplars as models for drawing the coast, but it suffices to demonstrate something that stands to reason, that even the most conscientious Ptolemaic cartographers preferred to work with both the text and the maps as guides.

As an attempt to reform cartographical practice, Ptolemy's *Geography* was on the whole a failure. His hope that it would be a vehicle for registering progress in geographical knowledge was never realized, first because geographical knowledge in later antiquity actually regressed, and later because there had been too much change in the cities, towns, and place names of the world he recorded.[16] Nor did he succeed in rooting out the practice of reproducing maps by graphic imitation, partly perhaps on account of indolence on the part of the copyists, but above all because he did not anticipate the difficulties that textual errors would make for the cartographer who tried to follow his method. What is remarkable is that a few faithful disciples in Byzantium and humanistic Europe did make the effort, in the process both repairing and guaranteeing the preservation of Ptolemy's text.*

16. These remarks do not wholly apply to the Islamic tradition, where Ptolemaic coordinates did find themselves incorporated in more up-to-date lists of localities, though the usual context was astronomy rather than geography; for details see E. S. Kennedy, *Geographical Coordinates of Localities from Islamic Sources*, Frankfurt, 1987.

*Postscript (June, 2010). On the problems discussed in this article, the essential study is now F. Mittenhuber, *Text- und Kartentradition in der Geographie des Klaudios Ptolemaios, Eine Geschichte der Kartenüberlieferung vom ptolemäischen Original bis in die Renaissance*, Bern Studies in the History and Philosophy of Science, Bern, 2009. A supplementary volume to the Basel edition of the *Geography* mentioned in note 4 has appeared, in which Ptolemy's Table of Noteworthy Cities receives a critical edition.

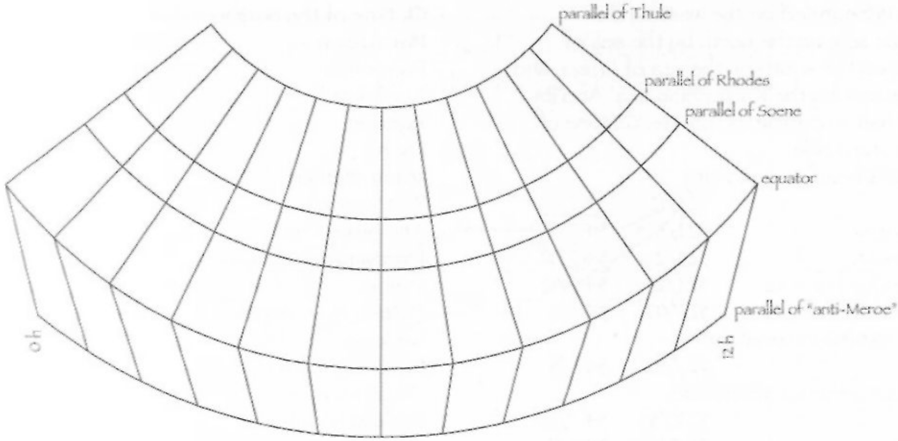

Figure 1. Grid for Ptolemy's first projection.

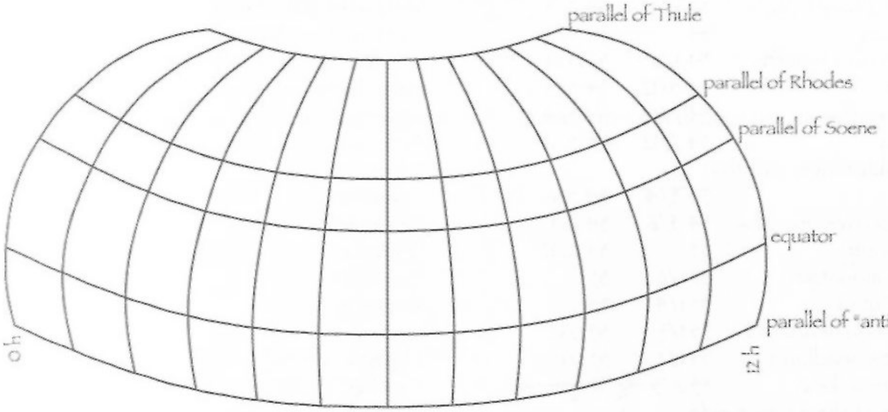

Figure 2. Grid for Ptolemy's second projection.

Crete is bounded on the west by the Adriatic sea; on the north by the sea of Crete; on the south by the sea of Libya, and on the east by the Karpathian sea. And its coast has an outline as follows. Outline of the western side:

Korykos headland and city	52 1/12	34 2/3
Phalaarna	52 1/3	34 2/3
Peninsula	52 1/2	34 7/12
Rhamnous harbour	52 1/2	34 7/12
Inakhorion	52 7/12	34 1/2
Kriou Metopon headland	52 7/12	34 1/3

Outline of the southern side:

Lissos	52 2/3	34 7/12
Tarba	52 5/6	34 2/3
Poikilasion	53	34 2/3
Hermaia headland	53 1/4	34 2/3
Phoinikous harbour	53 3/4	34 5/6
Phoinix city	53 7/12	34 3/4
Messalia river mouths	53 3/4	34 2/3
Psychion	54	34 3/4
Elektra river mouths	54 1/6	34 3/4
Matala	54 5/12	34 3/4
Leon headland	54 7/12	34 3/4
Lebena	54 7/12	34 5/6
Katarakton river mouths	54 3/4	34 5/6
Lethaiou river mouths	54 5/6	34 11/12
Inastos city	55	34 11/12
Hieron mountain	55 1/6	35
Hiera Pytna	55 1/4	35
Erythraion headland	55 1/3	35 1/12
Ampelos headland	55 1/2	35 1/6
Itanos headland	55 2/3	35 1/4

Outline of the eastern side:

Samonion headland	55 5/6	35 5/12
Minoa harbour	55 1/3	35 1/4
Kamara city	55 1/6	35 1/3
Oloulis	55	35 1/3
Peninsula	54 11/12	35 1/3
Zephyrion headland	54 3/4	35 1/3

Outline of the northern side:

Herakleion	54 2/3	35 1/4
Panormos	54 1/3	35 1/4
Apollonia	54 1/6	35 1/4
Kytaion	54 1/6	35 1/4
Dion	53 5/6	35 1/6
Mantomatrion	53 3/4	35 1/12
Rhithymna	53 1/2	35 1/12
Amphimalis bay	53 1/4	35
Drepanon headland	53 1/6	35 1/6
Minoia	53	35
Pyktou river mouths	52 5/6	35
Kydonis	52 3/4	35
Kisamon headland	52 1/2	35
Diktamnon	53 1/12	34 5/6
Psakon headland	52 1/3	34 5/6
Kisamos city	52 5/12	34 3/4

The following noteworthy mountains are in Crete:

the ones called Leuka mountains	52 2/3	34 2/3
and Ide mountain	54	35
and Dikte mountain	55 1/2	35 1/4

The following inland cities are in it:

Polyrrhenia	52 2/3	34 3/4
Aptera	53 1/12	34 11/12
Artakina	53 1/12	34 3/4
Lappa	54	34 11/12
Soubrita	53 2/3	34 11/12
Eleuthera	54 1/2	35
Gortyna	54 1/4	34 5/6
Pannona	54 2/3	35 1/6
Knossos	54 3/4	35 1/6
Lyktos	55	35 1/6

The following islands lie near Crete:

Kaudos, in which there is a city	52 1/2	34 1/2
and Letoa	54 1/2	34 1/2
and Dia	54 1/2	35 2/3
and Kimolos, in which there is a city	54 2/3	35 2/3
and Melos, in which there is a city	54	35 1/2

Figure 3. Translation of coordinate list for Crete (*Geography* 3.17) from *Vat. gr.* 191 fols 149v–150r, approximating the format of manuscript copies.

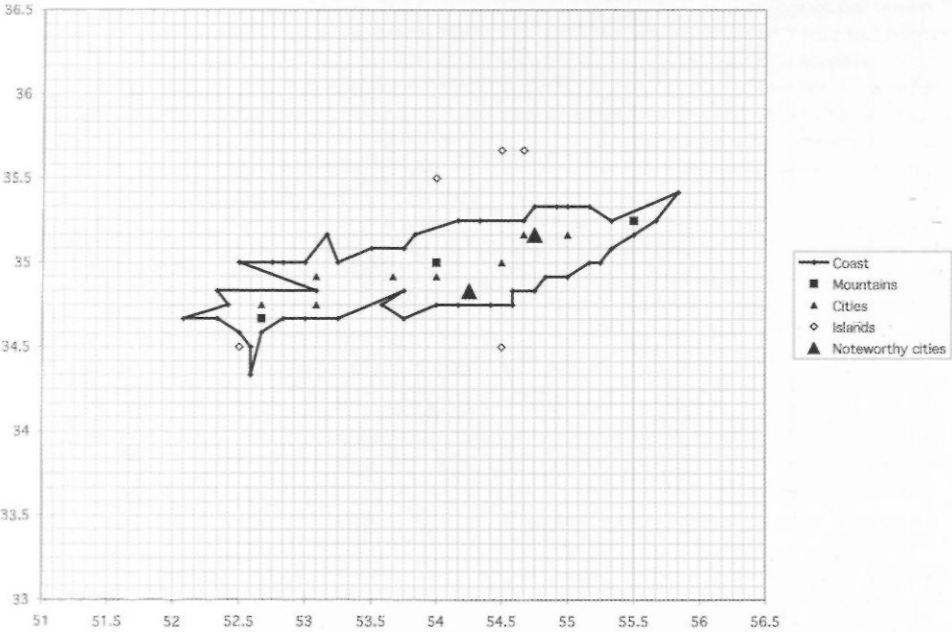

Figure 4. Map of Crete (omitting place names) based on coordinate list in *Vat. gr.* 191.

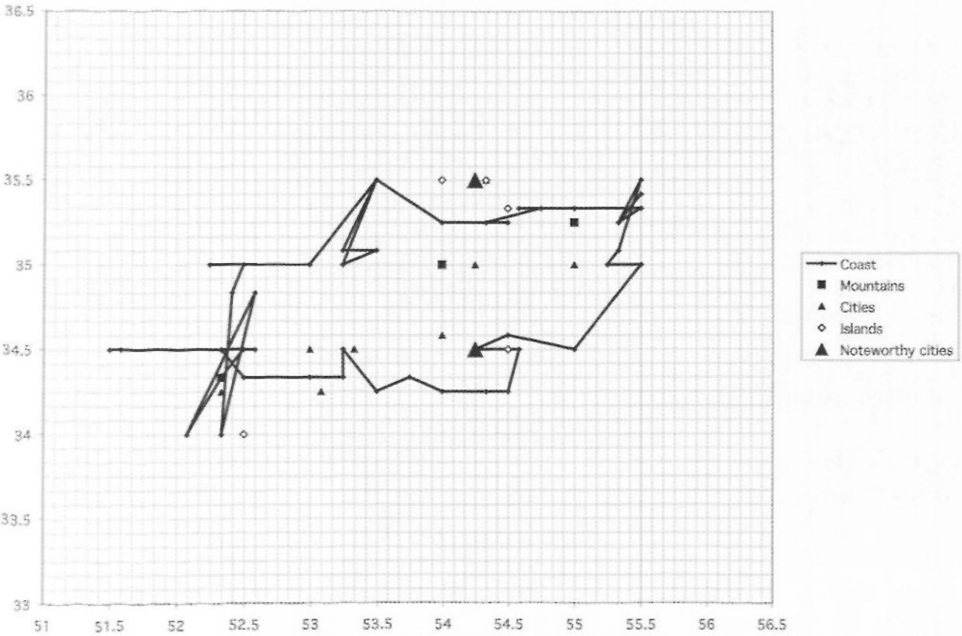

Figure 5. Map of Crete (omitting place names) based on coordinate list in *Burney* 111.

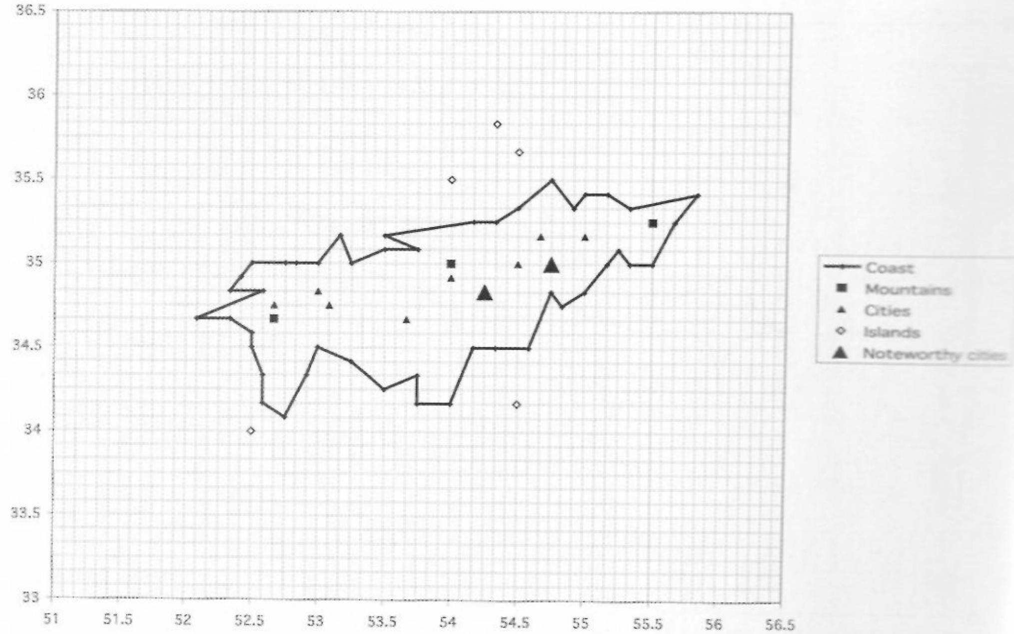

Figure 6. Map of Crete (omitting place names) based on coordinate list in *Urb. gr.* 82.

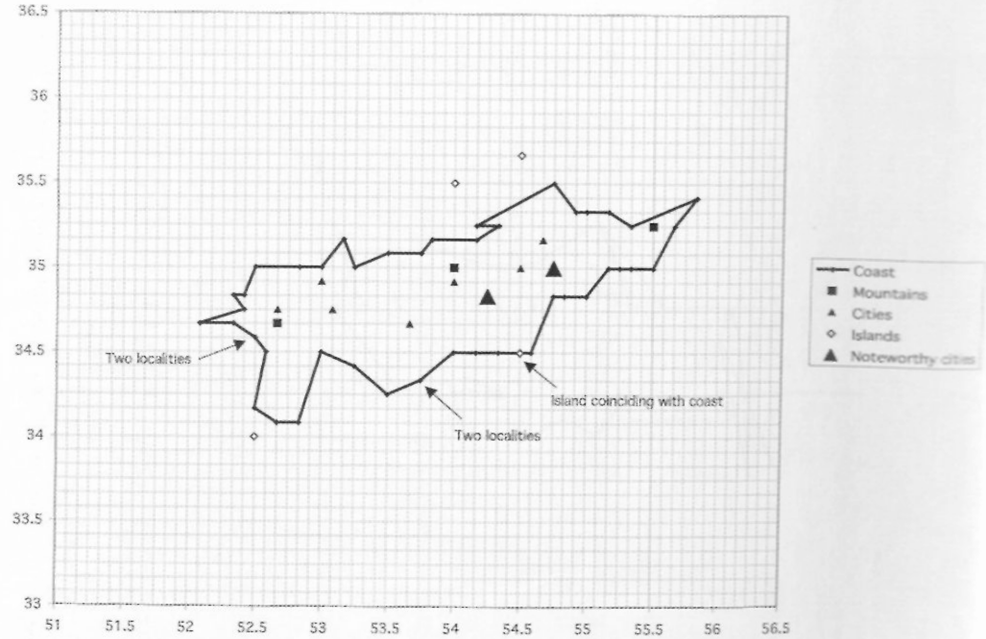

Figure 7. Map of Crete (omitting place names) based on coordinate list in Ulm 1482 edition.

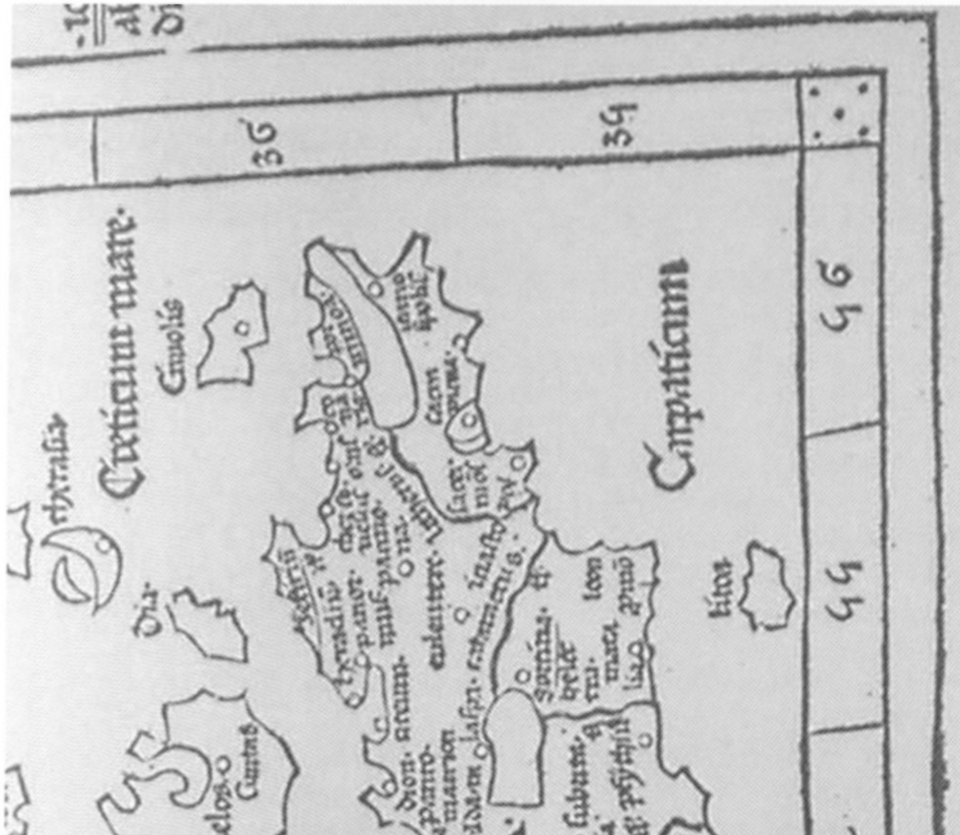

Figure 8. Detail of the tenth regional map of Europe in the Ulm 1482 edition.

Figure 9. The 'unknown land' to the south of the Indian Ocean in the world maps of *Urb. gr.* 82 (left) and the Ulm 1482 edition (right).