Book 1

1. On the difference between world cartography and regional cartography

World cartography[1] is an imitation through drawing of the entire known part of the world together with the things that are, broadly speaking, connected with it. It differs from regional cartography in that regional cartography, as an independent discipline, sets out the individual localities, each one independently and by itself, registering practically everything down to the least thing therein (for example, harbors, towns, districts, branches of principal rivers, and so on), while the essence of world cartography is to show the known world as a single and continuous entity, its nature and how it is situated, [taking account] only of the things that are associated with it in its broader, general outlines (such as gulfs, great cities, the more notable peoples and rivers, and the more noteworthy things of each kind).

The goal of regional cartography is an impression of a part, as when one makes an image of just an ear or an eye; but [the goal] of world cartography is a general view, analogous to making a portrait of the whole head. That is, whenever a portrait is to be made, one has to fit in the main parts [of the body] in a determined pattern and an order of priority. Furthermore the [surfaces] that are going to hold the drawings ought to be of a suitable size for the spacing of the visual rays[2] at an appropriate distance [from the spectator], whether the drawing be of whole or part, so that everything will be grasped by the sense [of sight].

[1]We thus translate *geōgraphia* in accordance with the restricted sense that Ptolemy defines for the word in this chapter. "Regional cartography" represents Ptolemy's *chōrographia*. Other Greek authors, such as Strabo, use *geōgraphia* to mean a written geographical work.

[2]What Ptolemy is asserting is that when making any picture, one should decide how big it should be in accordance with the level of detail and the expected distance of the spectator. He expresses the fact that the eye perceives less detail with greater distance in terms of the concept of visual rays found in Euclid's *Optics*. The rays were supposed to radiate from the eye to the object of vision and to transmit color to the eye. Euclid assumes that there are a finite number of rays separated by spaces that widen with increasing distance from the eye; the gaps explain loss of resolution when one views an object at a distance. In his own *Optics*, Ptolemy rejects these discrete rays in favor of a continuous visual cone that emanates from the eye. See Smith 1996, 91–92.

In the same way, reason and convenience would both seem to dictate that it should be the task of regional cartography to present together even the most minute features, while world cartography [should present] the countries themselves along with their grosser features. This is because with respect to the *oikoumenē*[3] it is the geographical placements of countries that are the main parts, [namely] the ones that are well placed and of suitable sizes [for a map], whereas the various things contained in these [countries have the same relationship] with respect to [the countries themselves].

Regional cartography deals above all with the qualities rather than the quantities of the things that it sets down; it attends everywhere to likeness, and not so much to proportional placements.[4] World cartography, on the other hand, [deals] with the quantities more than the qualities, since it gives consideration to the proportionality of distances for all things, but to likeness only as far as the coarser outlines [of the features], and only with respect to mere shape. Consequently, regional cartography requires landscape drawing, and no one but a man skilled in drawing would do regional cartography. But world cartography does not [require this] at all, since it enables one to show the positions and general configurations [of features] purely by means of lines and labels.

For these reasons, [regional cartography] has no need of mathematical[5] method, but here [in world cartography] this element takes absolute precedence. Thus the first thing that one has to investigate is the earth's shape, size, and position with respect to its surroundings [i.e., the heavens], so that it will be possible to speak of its known part, how large it is and what it is like, and moreover [so that it will be possible to specify] under which parallels of the celestial sphere each of the localities in this [known part] lies. From this last, one can also determine the lengths of nights and days, which stars reach the zenith or are always borne above or below the horizon,[6] and all the things that we associate with the subject of habitations.[7]

[3]Literally, "the inhabited [part of the world]." This technical term of Greek geography is sometimes used interchangeably with "the known part of the world," although the concepts are not strictly equivalent.

[4]This passage makes it clear that the "regional cartography" that Ptolemy has in mind not only covers smaller areas of the world than his world cartography, but also follows different principles. It seems to have been something closer to landscape drawing, incorporating lifelike images of features of the area portrayed. The closest counterparts we have from antiquity are mosaic maps such as the Madaba mosaic; see Dilke 1985, 148–153.

[5]Ptolemy uses the term "mathematics" not only for the abstract sciences of numbers and geometry but also for subjects such as optics, harmonics, and astronomy, in which physical objects are investigated from the point of view of their mathematical properties.

[6]Literally, "below the earth."

[7]"Habitations" (*oikēseis*) means the determination of the astronomical phenomena characteristic for particular terrestrial latitudes. Book 2 of the *Almagest* is largely devoted to a theoretical treatment of this topic.

These things belong to the loftiest and loveliest of intellectual pursuits, namely to exhibit to human understanding through mathematics [both] the heavens themselves in their physical nature (since they can be seen in their revolution about us), and [the nature of] the earth through a portrait (since the real [earth], being enormous and not surrounding us, cannot be inspected by any one person either as a whole or part by part).[8]

2. On the prerequisites for world cartography

We shall let this serve as a brief sketch of the purpose of anyone who would be a world cartographer, and how he differs from the regional cartographer. Our present object is to map our *oikoumenē* as far as possible in proportionality with the real [*oikoumenē*]. But at the outset we think it is necessary to state clearly that the first step in a proceeding of this kind is systematic research, assembling the maximum of knowledge from the reports of people with scientific training who have toured the individual countries; and that the inquiry and reporting is partly a matter of surveying, and partly of astronomical observation. The surveying component is that which indicates the relative positions of localities solely through measurement of distances; the astronomical component [is that which does the same] by means of the phenomena [obtained] from astronomical sighting and shadow-casting instruments.[9] Astronomical observation is a self-sufficient thing and less subject to error, while surveying is cruder and incomplete without [astronomical observation].

For, in the first place, in either procedure one has to assume as known the absolute direction of the interval between the two localities in question, since it is necessary to know not merely how far this [place] is from that, but also in which direction, that is, to the north, say, or to the east, or more refined directions than these. But one cannot find this out accurately without observation by means of the aforesaid instruments, from which the direction of the meridian line [with respect to one's horizon], and thereby [the absolute directions] of the traversed intervals, are easily demonstrated at any place and time.

[8]This rather obscure peroration entwines two ideas: that astronomy and geography are parts of a single rational science, and that whereas astronomy can make its demonstrations using the heavens themselves as a visible object of study, geography must make use of maps. We are inside the celestial sphere, and can behold half of it at once. By way of contrast, our position on the surface of the earth prevents us from taking in the earth's form at a glance, and it is too large for any single person to explore.

[9]A sighting instrument (*astrolabon*) is one that permits the direct measurement of the apparent position of a heavenly body through a diopter, for example, Ptolemy's armillary spheres (the *astrolabon* described by Ptolemy in *Almagest* 5.1 or the *meteōroskopeion* mentioned below in 1.3). A shadow-casting instrument could be a simple *gnōmōn* or upright stick, used to determine the sun's altitude.

In the next place, even when this [direction] has been given, having a measurement of distance in stades does not guarantee that the [interval] we find is the correct one, because one seldom encounters rectilinear journeys on account of the numerous diversions that are involved in both land and sea travel. For land journeys one has to estimate the surplus [in the reported distance] corresponding to the kind and magnitude of the diversions and subtract this from the total of stades to find the [number of stades] of the rectilinear [route]. For sea journeys one also has to account for the variation in speed corresponding to the blowing of the winds, since at least over long periods these do not maintain constant force. But even if the interval between the localities traveled through has been accurately determined, this does not also yield its ratio to the whole circumference of the earth, or its position with respect to the equator and poles.

The [method] using the [astronomical] phenomena determines each of these things accurately, since it shows the magnitudes of the arcs that the parallel and meridian circles drawn through the given localities cut off on each other—the arcs, that is, that the parallels [cut off on the meridians] between themselves and the equator, and [those that the meridians cut off] between themselves on the equator and on the parallels. [The astronomical method] also reveals the size of the arc that the two localities cut off along the great circle drawn through them on the earth. [This method] does not even need reckoning in stades, either to get the ratios of the earth's parts [with respect to each other and the whole], or in the entire process of map-making. It is enough to assume that [the earth's] circumference comprises any arbitrary number of units, and then to show how many [such units] make up the specific intervals along the great circles drawn on [the earth].

Admittedly, [the astronomical method] will not [also be able to yield] the division of the whole circumference or its parts into the established and familiar measures of length [used in] our distance measurements. For this sole reason it has been necessary to match a single rectilinear route [on the earth] to the [geometrically] similar great-circle arc on the surrounding [celestial sphere] and, having determined the ratio of this [arc] to the circle by means of the [astronomical] phenomena, and the number of stades in the route beneath it by means of distance measurement, to produce from the given part [of the circumference] the number of stades in the whole circumference. For it has already been mathematically determined that the continuous surface of land and water is (as regards its broad features) spherical and concentric with the celestial sphere [*Almagest* 1.4–5], so that every plane produced through the [common] center makes as its intersections with the aforesaid surfaces [of the terrestrial and celestial spheres] great circles on [the spheres], and angles in [this plane] at the center cut off similar arcs on the [celestial and terrestrial great] circles. As it happens, although the number of stades in intervals on the earth (if they are straight) can be determined from distance measurements, their ratio to the whole circumference cannot [be determined] at all from [distance measurements] because of the impossibility of making the comparison.[10] But [this ratio can be determined] from the similar arc of the circle on the surrounding [celestial sphere], because one can determine the ratio of this [similar arc] to the circumference [i.e., the great circle] to which it belongs, and this [ratio] is the same as that of the similar segment along [the surface of] the earth to the great circle on [the earth].

3. How the number of stades in the earth's circumference can be obtained from the number of stades in an arbitrary rectilinear interval, and vice versa, even if [the interval] is not on a single meridian

Now, our predecessors looked not just for a rectilinear interval on the earth to treat as an arc of a great circle, but also one that was directed in the plane of a single meridian.[11] Using shadow-casting instruments, they observed the zenith points at the two ends of the interval, and obtained directly the arc of the meridian cut off by [the zenith points], which was [geometrically] similar to [the arc] of the journey [between the two locations]. This is because these things were set up (as we said) in a single plane (since the lines produced through the [two] ends [of the journey] to the zenith points intersect), and because the point of intersection is the common center of the circles. Hence they assumed that the fraction that the arc between the zenith points was seen to be of the circle through the [celestial] poles [i.e., the common meridian of the two locations] was the same fraction that the interval on the earth was of the whole [earth's] circumference.

We, however, have established by means of the construction of a meteoroscopic instrument[12] that the [same] object can be achieved even if we

[10]Ptolemy means that because of the immensity of the terrestrial globe, one cannot directly measure its circumference or apprehend that a given measured distance is a particular fraction of the whole circuit.

[11]I.e., one place of observation was assumed to be due south of the other. This is true of Eratosthenes' famous measurement of the size of the earth based on the interval from Alexandria to Soēnē, as well as the similar method ascribed to Posidonius, based on the interval from Alexandria to Rhodes. See Neugebauer 1975a, 2:652–654; and Taisbak 1974.

[12]Ptolemy described his "meteoroscope" (*meteōroskopeion*) in a lost work known to us through references by Proclus and Pappus. It was an armillary sphere with nine rings, i.e., two more than the *astrolabon* of the *Almagest*. Ptolemy's armillary sphere had three rings for the ecliptic system, three for the equator system, and one sliding ring for sighting. From the present context it is clear that Ptolemy had added to his earlier instrument further rings for the horizon system. For an attempted reconstruction and discussion of how the instrument could have performed the tasks described in this chapter, see Rome 1927.

take the circle along the measured interval such that it is not through the poles,[13] but [is instead] any great circle, by observing in the same way the elevations [of the celestial pole] at the [two] endpoints [of the terrestrial interval] as well as the direction that the interval has with respect to one of the meridians [through the endpoints]. Using [the meteoroscope] we can easily obtain, among many other extremely useful things, the elevation of the north [celestial] pole at the place of observation on any day or night, and at any hour the direction of the meridian and [the directions] of routes with respect to [the meridian] (that is, the size of the angles that the great circle described through the route makes with the meridian at the zenith point).[14] With these [quantities known] we can show right on the meteoroscope the arc in question [of the great circle through the two locations] as well as the [arc] on the equator that the two meridians (if they are distinct) cut off.[15] Hence by this procedure the total number of stades of the [earth's] circumference can be found from just one rectilinear interval measured on the earth, and thereby also [the number of stades] of the other intervals without measuring the distances, even if they are throughout not rectilinear or along a single meridian or parallel, so long as the general trend of the direction and the elevations [of the celestial pole] at the endpoints have been carefully determined. This is because one can conversely compute the number of stades [of such an interval] easily from the established circumference of the whole [earth] using the ratio of the arc subtending the interval to the great circle.

4. That it is necessary to give priority to the [astronomical] phenomena over [data] from records of travel

These things being so, if the people who visited the individual countries had happened to make use of some such observations, it would have been possible to make the map of the *oikoumenē* with absolutely no error.[16] But Hipparchus alone has transmitted to us [observed] elevations of the [celestial] north pole for a few cities, [i.e., few when] compared to the multitude of [cities] to be recorded in the world cartography, and [lists of] the [localities] that are situated on the same parallels.[17] And a few of those who came after him [have transmitted] some of the localities that are "oppositely situated"[18] (not [meaning] those

[13]That is, if we take two points of observation on the earth that are not on the same meridian.

[14]Actually, the angle between the meridian and the *celestial* great circle directly above the terrestrial interval is meant.

[15]See Textual Notes (Appendix G).

[16]On the astronomically determined positions available to Ptolemy and the use he made of them, see pp. 28–30.

[17]Literally "under the same parallels," the parallels being thought of as on the celestial sphere.

[18]Ptolemy uses *antikeisthai* ("to lie opposite") as a technical term for "to lie on one meridian."

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that are equidistant from the equator, but simply those that are on a single meridian, based on the fact that one sails from one to another of them by *Aparktias* or *Notos* winds). Most intervals, however, and especially those to the east or west, have been reported in a cruder manner, not because those who undertook the researches were careless, but perhaps because it was not yet understood how useful the more mathematical mode of investigation is, and because no one bothered to record more lunar eclipses that were observed simultaneously at different localities (such as the one that was seen at Arbēla at the fifth hour and at Carthage at the second hour),[19] from which it would have been clear how many equinoctial time units separated the localities to the east or west. It would therefore also be reasonable for one who intended to practice world cartography following these [principles] to give priority in his map to the [features] that have been obtained through the more accurate observations, as foundations, so to speak, but to fit [the features] that come from the other [kinds of data] to these, until their positions with respect to each other and to the first [features] stand as much as possible in agreement with those reports that are less subject to error.

5. That it is necessary to follow the most recent researches because of changes in the world over time

The foregoing would provide a plausible basis for the project of drawing a map. But in all subjects that have not reached a state of complete knowledge, whether because they are too vast, or because they do not always remain the same, the passage of time always makes far more accurate research possible; and such is the case with world cartography, too. For the consensus of the very reports that have been made at various times is that many parts of our *oikoumenē* have not reached our knowledge because its size has made them inaccessible, while other [parts] have been described falsely because of the carelessness of the people who undertook the researches; and some [parts] are themselves different now from what they were before because features have ceased to exist or have changed. Hence here [in world cartography], too, it is necessary to follow in general the latest reports that we possess, while being on guard for what is and is not plausible in both the exposition of current research and the criticism of earlier researches.

6. On Marinos' guide to world cartography

Marinos of Tyre seems to be the latest [author] in our time to have undertaken this subject, and he has done it with absolute diligence. He has clearly laid his

[19]On this eclipse, see pp. 29–30.