The Place of the Geography *in Ptolemy's Work*

Ptolemy (or, to give his full name, Klaudios Ptolemaios) was born about A.D. 100 and began his scientific career in the mid-120s, working in or near Alexandria in Egypt. He probably lived into the last quarter of the century.[12] Ptolemy's incitement to determine numerical coordinates for geographical locations throughout the known world may have come from the astronomical researches with which his scientific career began, and for which he is now best known.

We can see this origin in the *Almagest*, Ptolemy's great treatise on the mathematical theory of the motions of the heavenly bodies, which is generally regarded as his earliest major writing.[13] The *Almagest* is concerned with the apparent motions of the sun, moon, planets, and fixed stars, how to account for them quantitatively by means of models involving combinations of circular motions, and how to compute the instantaneous positions of the heavenly bodies and other celestial phenomena using tables based on these models. Geographical considerations arise in various ways in the execution of Ptolemy's project, most obviously in the fundamental problem of converting the recorded times of astronomical observations made in different places to Alexandria mean time. The same astronomical event will be observed in two places of different longitude at different intervals of time since the preceding local noons, and this difference is proportional to the difference in longitude between the two places. Moreover, ancient observers did not measure the times of observations in constant *equinoctial* hours after noon or midnight. Instead they divided the two intervals between sunrise and sunset and between sunset and sunrise into twelve equal *seasonal* hours, and described observations as having occurred at such-

[12]For a survey of Ptolemy's life and works, see Toomer 1975.

[13]The *Almagest* was finished later than A.D. 147 (Hamilton et al. 1987); in it Ptolemy cites astronomical observations that he made from A.D. 127 on.

and-such an hour of day or of night. To convert a reported time in seasonal hours to the number of equinoctial hours since local noon, one had to know the length of the seasonal hour in equinoctial hours, which is a function of both the sun's position on the ecliptic (i.e., the time of year) and the observer's latitude.

If Ptolemy had worked only on the basis of his own observations, he would still have needed to know the latitude of his locality, Alexandria. Since, however, he also used older observations made in a few other places, he needed values not only for the latitudes of these sites, but also for the differences between their longitudes and the longitude of Alexandria. Similarly, anyone else not living at Alexandria who wished to use Ptolemy's tables would have had to know his own latitude and relative longitude in order to convert his local time in seasonal hours to the uniform time of the tables, and vice versa.

In the *Almagest*, Ptolemy's treatment of matters related to the observer's geographical position is almost wholly theoretical. The relationship between longitude and time is a simple proportionality, and requires no special discussion.[14] For the more complex problems connected with latitude, Ptolemy designates a series of special parallels on the earth, computing for each parallel relevant astronomical data, including the tables of *oblique ascensions*, which are the basis for converting seasonal to equinoctial hours.[15] The complete list of parallels starts with the equator, and proceeds north at intervals such that the duration of daylight at the summer solstice increases by quarter-hours from 12 equinoctial hours at the equator to 18 equinoctial hours at 58° N, and then by larger time-intervals (because the parallels get closer together) to 24 equinoctial hours at the arctic circle (66°8'40" N). For the purposes of his tables, Ptolemy cuts this list down first to eleven parallels at intervals of half-hours of increase in longest daylight from the equator to 54°1' N (17 equinoctial hours), and later to just seven parallels (cf. Fig. 4) at half-hour intervals from 16°27' N (13 hours) to 48°32' N (16 hours).[16]

For most of these parallels, Ptolemy indicates a geographical location through which the parallel passes. In some instances this location is a city; for example, the parallel for 13½ hours is through the city Soēnē (modern Aswān). Other parallels are said to pass through less precise geographical features, or even

[14]Ptolemy states the rule (fifteen degrees of longitude correspond to one equinoctial hour) briefly in *Almagest* 2.13 (Toomer 130) and again at 6.4 (Toomer 282).

[15]*Almagest* 2.6–13. The oblique ascension associated with a given point on the ecliptic is the arc of the celestial equator that rises at the horizon of a given locality simultaneously with the arc of the ecliptic between the vernal equinoctial point, Aries 0°, and the given point. The interval in equinoctial hours between sunrise and sunset is proportional to the arc of the equator that rises above the horizon during that time, i.e., the difference between the oblique ascension of the point of the ecliptic diametrically opposite to the sun and the oblique ascension of the sun's position.

[16]In giving special prominence to these seven parallels, Ptolemy was following in an established tradition; see p. 10.

broadly defined districts; for example, that for 14 hours passes through Lower Egypt (the Nile delta). Apart from these latitudes, the only explicitly stated geographical data in the *Almagest* occur in the context of analyzing specific observations. Thus, Ptolemy gives Alexandria's latitude (30°58'), as well as latitudes and time differences from Alexandria for Babylon, Rhodes, and Rome.

The scarcity of geographical data in the *Almagest* is deliberate. At the end of the section in which he computes and tabulates the astronomical phenomena for his series of parallels, Ptolemy writes (*Almagest* 2.13, Toomer 122–130):

> What is still missing in the preliminaries is to determine the positions of the noteworthy cities in each province in longitude and latitude for the sake of computing the phenomena in those cities. But since the setting out of this information is pertinent to a separate, cartographical project, we will present it by itself following the researches of those who have most fully worked out this subject, recording the number of degrees that each city is distant from the equator along the meridian described through it, and how many degrees this meridian is east or west of the meridian described through Alexandria along the equator, because it was for that meridian that we established the times corresponding to the positions [of the heavenly bodies]. For the present, however, we take the [geographical] locations for granted.

The project of compiling a catalogue of important cities and their coordinates, which Ptolemy had not finished (and perhaps had not even begun) when he wrote this, was the germ from which the *Geography* grew. On the way, however, Ptolemy's scope broadened from the establishment of coordinates for a few hundred cities to a far more comprehensive codification of thousands of elements (towns, borders, natural features) of the entire known world; and his primary purpose shifted from compiling a table ancillary to his astronomical tables to laying down new and better foundations for drawing maps of the world.

Ptolemy did not, however, lose sight of his earlier plan. Among the roughly 8,000 localities in the huge catalogue of *Geography* Books 2–7, several hundred cities and towns were marked as being of particular importance;[17] and in the captions of the twenty-six regional maps (Book 8) Ptolemy listed these "Important Cities" with their positions translated into time units: the time difference from the meridian of Alexandria in equinoctial hours, and the length in equinoctial hours of the longest daylight. And when Ptolemy published a revision of the tables of the *Almagest* as a separate work, entitled the *Handy Tables*, he included in it a "Table of Important Cities," which presents substantially the same cities that he picked out in the *Geography*, with their longitudes and lati-

[17]The important cities originally seem to have been indicated by a special symbol in the margin, a notation that survives vestigially in at least one manuscript.

tudes in degrees extracted from the main catalogue of Books 2–7 and listed more or less in the order of Book 8.[18] Aside from this table, which is more an abridgment than a revision, the *Geography* appears to represent Ptolemy's final word on geographical questions.

Ptolemy's Evolving Conception of the World

When Ptolemy wrote the *Almagest*, he accepted a geographical picture of the known, inhabited world (the so-called *oikoumenē*) that was not radically changed from that of Eratosthenes (third century B.C.) and Hipparchus (c. 140 B.C.). He accepted as a matter of course that the earth was spherical; *Almagest* 1.4 presents arguments on this point, but by Ptolemy's time scarcely any educated person would have seriously questioned it.

There is some reason to believe that at this stage Ptolemy accepted the estimate going back to Eratosthenes that the earth's circumference is approximately 250,000 stades, which was usually expressed by the equation of one degree of the earth's equator with 700 stades.[19] If, as we believe, one stade was approximately 185 meters, then Eratosthenes' measurement (which was based on heavily rounded data) was about 15 percent too large.

The whole of the *oikoumenē* fits inside one quarter of this sphere, bounded on the south by the equator and on the east and west by a single meridian circle (*Almagest* 2.1, Toomer 75). Ptolemy was willing to believe (*Almagest* 2.6, Toomer 83) that the regions along the equator had a habitable climate, less torrid perhaps than districts closer to the Tropic of Cancer because the sun was close to the zenith for a briefer part of the year; but it was his opinion that no one from the Greco-Roman world had ever been as far south as the equator, and that one could not trust tales purporting to describe what was found there. The southernmost locality to which Ptolemy refers is the island Taprobanē (Sri Lanka), which he situates on the parallel 4¼° north of the equator. No place is mentioned on the east coast of Africa further south than the Bay of Avalitēs (north of the Horn of Africa), and no place on the Nile further south than Meroē (between the junctions of the Blue Nile and the Atbara with the White Nile). At the

[18]The order in which the cities are listed in all three contexts (*Handy Tables*, *Geography* 2–7, and *Geography* 8) is determined first by Ptolemy's division of the world into the twenty-six maps, and subordinately by the logical order in which the features of each province are supposed to be drawn on the map. This fact establishes that the *Geography* must have taken its present form (if it had not actually attained its final state) before the *Handy Tables* were published.

[19]The evidence is that Ptolemy assumes smaller time differences between the meridians of Rome, Alexandria, and Babylon in the *Almagest* than in the *Geography*, roughly in the proportion that would result if the same stade distance had been converted to degrees of longitude using respectively 700 stades and 500 stades to the degree (Schnabel 1930, 219). On Eratosthenes' measurement of the size of the earth, see, e.g., Dicks 1971, 390–391.

northern extremity of the *oikoumenē*, Ptolemy states that the parallel 64½° north of the equator passes through "lands of the unknown Skythians," presumably in the Baltic regions. Parallels from 63° southward to 55° are associated in turn with the island of Thulē, the Hebrides, Ireland, and places in northern and central England. The inclusion of the British Isles and the mouth of the Rhine in Ptolemy's list of parallels is the only prominent reflection in the *Almagest* of geographical knowledge acquired since the beginning of the Roman Empire in the late first century B.C.

Between the *Almagest* and the *Geography*, Ptolemy wrote an important astrological treatise known as the *Tetrabiblos*, in which there is a chapter (2.3, Loeb 129–161) setting out his version of the traditional topic of astrological geography, correlating the supposed characteristics of various peoples with the influences of the zodiacal signs and the planets. Again Ptolemy situates the *oikoumenē* inside a half of the northern hemisphere, and he further partitions this into four quarters divided by a parallel passing through the Mediterranean and along a range of mountains extending eastward through Asia, and by a meridian passing through the Sea of Azov, the Black Sea, the Aegean, and the Red Sea. If this meridian was intended to bisect the *oikoumenē* longitudinally, then it may be inferred that the world known to Ptolemy did not yet extend eastward much beyond the Ganges, although the countries listed include Sērikē, the "Silk country" that represents the Chinese terminus of the Silk Road. In the southerly direction, Ptolemy now knows of Azania, a stretch of the East African coast south of the Horn that he was to situate just south of the equator in the *Geography*. Unfortunately, the seventy-two countries named in the *Tetrabiblos* are arranged in schematic groupings that correspond to their geographical locations only in a loose way, so that we cannot reconstruct an underlying "map."

The *oikoumenē* portrayed in the *Geography* is more extensive than it is presented, not merely in Ptolemy's earlier writings, but in any other classical text before or after Ptolemy, except for those few authors who adapted Ptolemy's work. By this stage Ptolemy was convinced by investigations that are otherwise unknown to us (and of which he gives no details) that the earth was a smaller globe than Eratosthenes had thought, so that only 500 stades corresponded to one degree of the equator, and the earth's circumference amounted to 180,000 stades.[20] Hence in contrast to Eratosthenes' estimate, Ptolemy's is about 18 percent too small.[21] His *oikoumenē* still fitted within the 180° of longitude

[20]Ptolemy also uses this smaller value for the size of the earth without comment in the *Planetary Hypotheses*, an astronomical work written after the *Handy Tables*; see Goldstein 1967, 11.

[21]It is often stated in modern discussions that Ptolemy took his figure of 180,000 stades for the circumference from a lost geographical work of Posidonius (first century B.C.). Ptolemy does not say so, and the only ancient source that appears to ascribe the number to Posidonius (Strabo 2.2.2, Loeb 1:361–365) contains a serious numerical inconsistency at just this point (Taisbak 1974). The

bounded by a single meridian circle, but only just; and it now stretched from the old northern limit at 63° to a southern limit more than 16° south of the equator. One of the more remarkable features of the map he draws inside this frame is that most of the edge consists of land, not ocean: Ptolemy was one of the few ancient geographers willing to admit that the theoretically habitable land mass of the world extended indefinitely beyond the limits of knowledge of his time.[22]

Ptolemy's *oikoumenē* is divided into three great continents, Europe, Libyē (our Africa), and Asia. To an eye accustomed to modern maps of the world, Ptolemy's Europe is the most instantly recognizable continent. The outline of the European mainland is complete as far north as the east coast of the Baltic. Distortions of direction and scale are obvious in the more remote parts toward the north and west, as in the outlines and relative positions of the British Isles; and even in the Mediterranean there is a surprising error of orientation in the shape of Italy. The accuracy of the Mediterranean and Red Sea coasts of Ptolemy's Libyē falls off somewhat as the Horn of Africa is rounded, but it is the Atlantic coast, with its straight north-south orientation terminated by a bend toward unknown lands to the southwest, that renders this continent strangely unfamiliar. Asia exhibits greater and greater distortions as one progresses further east, the most obvious faults being the north-south compression of the Indian subcontinent so that its western coast is made to run parallel to the equator, and the exaggerated size of the island of Taprobanē (Sri Lanka). At the eastern edge, where the lands represent central China and Southeast Asia, it is virtually impossible to identify any of the features on Ptolemy's map with real counterparts. At his eastern limit Ptolemy draws the coast of Asia as turning south and then west, eventually to join the east coast of Africa, thereby making the Indian Ocean a vast enclosed sea unconnected with the Atlantic Ocean.[23]

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assertion (no less common) that Eratosthenes' measurement was remarkably accurate and Ptolemy's grossly in error results from supposing that the geographers' stade was much smaller than the Attic stade.

[22]Compare Strabo, writing a century and a half before Ptolemy, who maintains (1.1.8 and 2.5.5, Loeb 1:17–19 and 431–433) that the known *oikoumenē* is entirely, or almost entirely, surrounded by sea; and similarly, in the mid-first century A.D., Pliny the Elder (2.166–170, Loeb 1:301–305).

[23]Claims that mariners from Egypt or Spain had succeeded in circumnavigating the southern part of Africa were typically met with disbelief in antiquity (Herodotus 4.42, Loeb 2:239–241 and Strabo 2.3.4, Loeb 1:377–385). Hipparchus (cf. Strabo 1.1.8–9, Loeb 1:17–19) and Polybius (3.38, Loeb 2:89) had previously considered it possible that the Atlantic and Indian Oceans did not join south of Africa. Ptolemy does not actually provide coordinates for the coast of the unknown land linking Africa and Asia, but he refers to it verbally in 7.3, 7.5, 7.7, and 8.1.