GREEK AND ROMAN MAPS

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correspond with the names of Etruscan deities on the liver; but no general correspondence can be worked out, and the orientation is less satisfactory. The Piacenza liver, one may infer, is not a map: at best it may be described as a schematic model.

In the Graeco-Roman areas no world maps of the early period, or approximations to them, have been discovered. If they, or even *periploi* (p. 130), had existed then, poets might not have recounted the sea voyages of such heroes as Jason, Odysseus or Aeneas as so circuitous. But something akin to a map is described by Homer in the *Iliad*. It is a well-known feature of Homeric epic that some descriptions mirror in poetic language Mycenaean institutions of many centuries earlier. This may be the case with what seems to us a somewhat unusual description, that of Achilles' shield.[35] It was made for that hero, the poet tells us, by the craftsman god Hephaestus, of golden, tin and bronze plates. On one of the bronze plates he engraved countless subjects:

> Earth, sky and sea, the never-tiring sun,
> The moon when full, all stars that deck the sky:
> Orion's might, Hyades, Pleiades,
> The Bear, known also to us as the Wain,
> Which, circling round, watches Orion close,
> Alone not sinking into Ocean's stream.[36]

After this he is said to have engraved two fine cities, one of peace and one of war. Agricultural scenes, dancing and merry-making are among the aspects of everyday life depicted. Round the whole is the great strength of the river Ocean.[37] We cannot know whether this description reflects actual usage of any kind. The only shield-map known to us, the Dura Europos shield (p. 120), dates from some one thousand years later and served a practical purpose. But the idea of one celestial scene, with the constellations depicted, perhaps to enable one to find one's way at sea, and one terrestrial, with cities surrounded by the Ocean, does suggest early attempts at map-making which may have been partly misunderstood in the Dark Ages that followed the Mycenaean period. Homer is said to have lived either on the west coast of Asia Minor or on an adjacent island. Since Miletus was the birthplace of Greek map-making, and since Homer not only showed a keen awareness of geography but evidently lived not far from there, it is appropriate that many later Greeks should have thought of him as the father of geography.

CHAPTER II

EVIDENCE FROM ANCIENT GREECE

It is unfortunate that so little remains from what was clearly a great early period of the development of mapping. This may be due to the perishable or reusable materials on which maps were drawn. What evidence there is suggests that these were normally either painted on wood or more rarely engraved on bronze. Manuscripts of Greek authors of the Classical and Hellenistic periods, copied mostly from the ninth to the fifteenth century, survive either without maps or, in the case of Aristotle's *Meteorologica*, with medieval maps which may or may not reflect classical sources.

It is from the early philosophers that Greek mapping concepts spring. Although Greek colonization has left conspicuous traces of urban and rural land division, there is no evidence that surveyors of these colonies used maps. Moreover the part played by Greek navigators in map-making is disputable: Greek *periploi* appear to have been verbal instructions. The Ionian philosophers and their successors were interested in theoretical rather than practical cartography; though it will be seen that their researches could have practical effects. Their study of cosmology led a number of them to map the heavens as much as the earth. Although this book is in principle concerned with terrestrial maps, the achievements of the Greeks cannot be completely understood without some recognition of the work of their philosophers and mathematicians on the mapping of the heavens.

CELESTIAL MAPPING

Evidence of early interest in celestial cartography is scanty. When we are told by Diogenes Laertius that Anaximander (see below), the first acknowledged cartographer, was also the first to construct a sphere,[1] we may imagine that this was a sphere of the heavens.

Something similar may have been designed by Parmenides or the Pythagoreans in southern Italy. But the real step forward came with Eudoxus of Cnidos (*c.* 408–355 BC), the well-known astronomer, who was a pupil of Plato's.[2] His great achievement was to construct a globe showing the sky as seen from outside. He explained this globe in his works *Phaenomena* and *The Mirror* (*enoptron*). Its impact on Greek and Roman readership was assured much later when Aratus of Soli (*c.* 315–240 BC) wrote a verse rendering of the *Phaenomena*.[3] From this we can see that the chief feature was the location on the globe of conventional signs for the heavenly bodies depicted. Aratus' version was so popular that it was several times translated into Latin verse. No fewer than three of these renderings are extant, by Cicero, Tiberius' nephew and adopted son Germanicus, and Avienius (p. 141). A very generalized idea of the appearance of the globe may be obtained from the Farnese Atlas in the Naples Archaeological Museum.[4] The supporting of the sky by the giant Atlas was a favourite theme of Greek art, and this is a Roman copy of a Hellenistic original.

The last scientist in a politically independent Greek state, Archimedes of Syracuse (287–212 BC) was famous as inventor of the theory of displacement, but he did contribute much to celestial mapping.[5] He made many spheres; one of these seems to have been a solid globe which showed the people, animals etc. after which all constellations were named.[6] It was very accurately designed and in bright colours. Another was a machine akin to an orrery, imitating the motions of the sun, the moon and five planets. It was specially contrived to show solar and lunar eclipses after the correct number of revolutions. Archimedes was unfortunately killed by a Roman soldier at the siege of Syracuse as he was making geometrical drawings in the sand. But he and his drawings were a major military target, as it was he who had devised cunning war-machines used against the Romans. The 'orrery' went as spoils to the commander-in-chief, M. Claudius Marcellus. Archimedes' work was obviously appreciated, as his globe was placed on public view in the Temple of Virtue in Rome.

TERRESTRIAL MAPPING: CLASSICAL

Later Greeks considered that the first map-maker was Anaximander of Miletus (*c.* 611–546 BC), whose master Thales was said to

have visited Egypt to consult priests, and to have predicted an eclipse of the sun. Miletus, as a Greek city[7] in Asia Minor, was well placed to absorb aspects of Babylonian science, including possibly the gnomon, the upright member of a sundial, though Anaximander is said himself to have invented it. He is also said to have set up a sundial in or near Sparta.

Anaximander was the second philosopher of the Ionian school, which was particularly interested in cosmology. The shape and size of his map are difficult to envisage from the accounts.[8] It was evidently a map of the known world, and Strabo and Agathemerus call it a *pinax*, a term used particularly of painted panels but sometimes also of bronze panels. Diogenes Laertius says that it portrayed an outline (*perimetron*) of the land and sea.[9] But when the same author tells us that Anaximander believed in a geocentric universe with a spherical earth, he is suspect, since the spherical concept was not devised early, and others attributed to Anaximander the different concept of a cylindrical earth.[10] Nevertheless, he may indeed, as Diogenes Laertius claims, have been the first to construct a sphere, though more likely celestial than terrestrial.

The practical map-making which developed from Anaximander's map may be illustrated from a well-known story in Herodotus.[11] In 499–8 BC, Aristagoras, tyrant of Miletus, made a tour of important cities on mainland Greece looking for allies against Darius I, King of Persia. He took with him on this tour what Herodotus calls 'a bronze tablet [*pinax*] with an engraving of a map [*periodos*, literally "going round"] of the whole world with all its rivers and seas.' Among his contacts was King Cleomenes of Sparta, and on it he showed him all the areas on the way from Ionia to Susa, capital of Persia. The last region of Asia Minor on the proposed march, Cilicia, is described as 'opposite Cyprus', implying that Cyprus too appeared; and the regions east of Asia Minor are given as Armenia, Matiena, and Cissia with the city of Susa. Like many other maps in antiquity, however, this presumably had no scale; for Cleomenes, two days later, asked 'How long would such a march take?' 'Three months', was the reply, whereupon despite attractive offers of money he refused. This map was probably developed from that of Anaximander. But we may presume that it also contained the course of the Royal Road, which Herodotus describes in some detail immediately after, giving the number of staging-posts and the distances. This road had been carefully measured for the Great King by road surveyors; and the general proportions of Aristagoras' map, particularly the section relating to Asia, may well have been guided by such survey work on it. A plausible theory is that the geographer and mythographer Hecataeus of Miletus (*fl.* 500 BC) was the indirect promoter of this map, based on Anaximander and on his own travels in Asia and Egypt. His *Periodos Gēs*, 'Journey round the world', dealt with Europe in Book I, Asia (in which he included Africa) in Book II.[12] Some three hundred fragments exist, but they are mostly brief and not very informative as recorded by Stephanus of Byzantium. When we are told that he enormously improved Aristagoras' map, this probably means that he criticized it in his text rather than re-drew the map.[13]

To judge from the term *periodos*, 'way round', Aristagoras' world map is likely to have been circular. In another passage (iv. 36), Herodotus remarks: 'I am amused to see so many people producing circular maps for no good reason. We are shown the Ocean flowing round the earth perfectly circular as if turned on a lathe, with Europe and Asia the same size.' He, like some other Greeks of the Classical period, thought that Europe was much larger. The idea of an encircling Ocean was a very old one, perhaps inherited from early Babylonian maps and reinforced by Greek mythology as interpreted by Homer. These early Greek maps had Greece in the centre, perhaps with Delphi occupying the central position. This was not only because it is fairly centrally situated in mainland Greece, even claiming to be the *omphalos*, 'navel', of the earth: it was also the chief religious meeting-place of the Greeks, where Apollo's oracle advised on such matters as colonization.[14] Herodotus' criticism enables us to see that map production by the time he was writing (*c.* 444–430 BC) was fairly large, even though repetitive.

A few chapters later (iv. 42) Herodotus expands on his view of how maps should be modified. Before surrounding Europe and Asia with the Ocean, he says, we should examine what is known about them. In the case of Africa, which he calls Libya, Pharaoh Neco (609–594 BC) had sent Phoenicians who in several ships circumnavigated it in three years, thus proving that except at the Isthmus of Suez it was surrounded by water. When, after their clockwise circumnavigation, they returned to Egypt via the Pillars

of Hercules (Straits of Gibraltar), they reported that they had the midday sun on their right. Despite this obvious evidence of sailing south of the equator they seem to have been disbelieved. Herodotus' views of the extent of the three continents are discussed on pp. 57–8 below.

But already before Herodotus the idea of a spherical earth had led to a new cartographic concept. He himself emigrated to Thurii in southern Italy *c.* 443 BC. This was not far from Croton, to which about 530 BC Pythagoras had moved from Samos to found a mathematical and philosophical community. Although Pythagoras wrote nothing, we know that he considered the sphere as the perfect shape for all bodies in the universe, presumably including the earth. This was taken up by Parmenides of Elea in southern Italy (born *c.* 515 BC), said to have been the first[15] to divide a spherical earth into five zones, one hot, two temperate and two cold. It seems likely that he illustrated his division either on a map or a globe.

If, however, a flat surface was used to portray the inhabited world (oikumene), the philosopher map-makers debated which was the best shape for such a map. An oblong or oval shape was suggested by Democritus of Abdera (*c.* 470 or 460–370 or 360 BC), who with his master Leucippus also drew up the concept of the atom. Democritus travelled very widely, consulting learned men in Egypt, Mesopotamia and even, according to one source, India. His conclusion on the shape of the inhabited world was that the proportion of its length (east–west) to its width was 3:2.[16] This proportion had some influence on subsequent cartographers of the oikumene. But it was recognized as being based on incomplete knowledge; Plato makes Socrates say that outside the world known to the Greeks there are probably a great number of people living in a great many similar regions.[17]

At this point we may consider what knowledge or use of maps the man in the street had in Classical Greek times, for example at the time of the Sicilian expedition, 415 BC. Did the ordinary Athenian know where Sicily was, and had he any idea of the details of its topography? Evidently the answer to the first question is yes, to the second no. On the one hand Plutarch tells us that just before the invasion the average Athenian could sketch the outlines of Sicily and place it in relation to north Africa in general and to Carthage in particular.[18] On the other hand we are told by

Thucydides that the man in the street generally knew little about the size or population of Sicily.[19] Evidence from Aristophanes is less satisfactory, but after all it was part of the comedian's stock in trade to exaggerate and caricature. To start with, in *Clouds* 200ff., written in 423 BC, Strepsiades the simple countryman, when he is shown a map of the world, imagines it is a plan of an allotment. Then, when he realizes what it is, he has difficulty in recognizing Athens, Euboea and Sparta; but the reasons are expressed satirically. Where Athens appears on the map, he cannot see any of the hordes of jurymen. The island of Euboea is surprisingly long on the map, but even so he reflects that it is being outpaced, i.e. politically outdistanced, by Athens. Finally, enemy Sparta looks much too close for any Athenian's peace of mind.

The allusion by Aristophanes to an allotment plan is revealing. That is the sort of plan that many countrymen might be expected to have seen. Plans are liable to be produced, among other things, for amplification of legal definitions. Such plans might well have been on papyrus; from ancient Greece, as opposed to Egypt, Herculaneum and elsewhere, no papyri have survived. The material most likely to be preserved is stone; but whether one such from the Athens area is more than a short inscription is uncertain.[20] It might also contain an extremely small plan or a monogram; its heading is 'boundary between shop and house'. At Thorikos, east Attica, just above the west parodos of the theatre, is the entrance to a fourth-century BC mine recently explored by Professor H. F. Mussche and others of the Comité des Fouilles Belges en Grèce. On the rock face immediately above this entrance is what appears to be a small plan of the mine, corresponding roughly to the 120 m section so far excavated. Such an example is very easy to miss, and there may be others similar which are as yet undetected. The interest of Thorikos in surveying is indicated by three inscriptions which read ὅρος οἰκοπέδων, 'boundary of apportionment', cut out on the rock.[21]

The fourth century BC was one of great scientific achievement. Although Eudoxus' contribution to terrestrial mapping was probably smaller than his celestial contribution (p. 22), we are told by Strabo that he was regarded as an expert in figures and 'climates', i.e. latitudes, and by Agathemerus that he regarded the length of the inhabited world as double its breadth.[22] 'Figures' (*schemata*) must refer to geometrical figures relative to terrestrial

cartography. 'Climates' (*klimata*,[23] literally 'inclinations') are not to be understood in the modern sense, but as latitudes or latitudinal zones often based on maximum hours of sunshine. This use of *klimata* descended via Ptolemy's criticism of Marinus, with modifications, to the Middle Ages and the Renaissance. Clearly the proportion of the inhabited world mentioned above was used for a long time in antiquity. In the first century BC, Geminus of Rhodes wrote: 'The breadth of the inhabited world is approximately half its length; so to draw a map to scale one should use a rectangular panel, with length twice its breadth'.[24] Whether Eudoxus had such a scheme of rectangular panels we do not know: the surviving fragments concern physical geography or are descriptive of peoples of the world. But the idea of a rectangular basis may also underlie the approach of his contemporary, the historian Ephorus.

Unfortunately our evidence for this is extremely late, coming as it does from Cosmas Indicopleustes (p. 171). In Book IV of his History, Ephorus of Cyme in the Aeolid (*c.* 405–330 BC) equated compass points, expressed in terms of winds, with peoples, thus:

Wind	*Direction*	*People*	*Area occupied*
Apeliotes	East	Indians	From summer rising to winter rising
Notos	South	Ethiopians	From winter rising to winter setting
Zephyros	West	Celts	From winter setting to summer setting
Boreas	North	Scythians	From summer setting to summer rising

The areas allocated to Ethiopians and Scythians indicated that they occupied a greater arc of the circle than Indians and Celts, though the whole scheme is only very approximate. Cosmas Indicopleustes says that Ephorus illustrated this concept 'with the help of the following drawing', whereupon a rectangular map follows, with Greece or the Aegean in the centre.[25] Although some of his details are either Christian in concept or too crude for Ephorus to have incorporated, we may at least conjecture that Ephorus, like Eudoxus, favoured a rectangular layout for a map of the known world.

Whereas a number of previous writers had assumed the earth to be spherical, Aristotle (384–322 BC) set out proofs of sphericity: at lunar eclipses the earth's shadow on the moon is circular; the celestial pole rises as one travels north. He adopted Parmenides' five zones, but defined them in terms of equator, tropics and arctic circles. Like Herodotus, he criticized circular maps of the oikumene, and he gave the proportions of the latter as over 5:3 (Straits of Gibraltar–India, Ethiopia–Sea of Azov). He was pessimistic about further exploration either north–south, because of adverse climatic conditions, or east–west, because of the enormous stretch of ocean between India and the Pillars of Hercules (Straits of Gibraltar). Aristotle's estimate of the circumference of the earth was 400,000 stades. We do not know what length of stade he used, but the extremes are approximately 60,000 and 80,000 km (*c.* 37,000–50,000 miles), so in any case his estimate was appreciably larger than Eratosthenes' measurement (p. 32).

The only passage in Aristotle where we know that there was a diagram akin to a map either drawn or intended is *Meteorologica* ii.6. Modern editions[26] reconstruct this, and it also exists in corrupt form in a Madrid manuscript of the twelfth century.[27] The object is to show the positions of the winds, so the centre of the map is where we live, in his case Greece or the Aegean, and the circle represents the horizon as seen from that point. By marking on the circumference, in addition to the cardinal points, the summer and

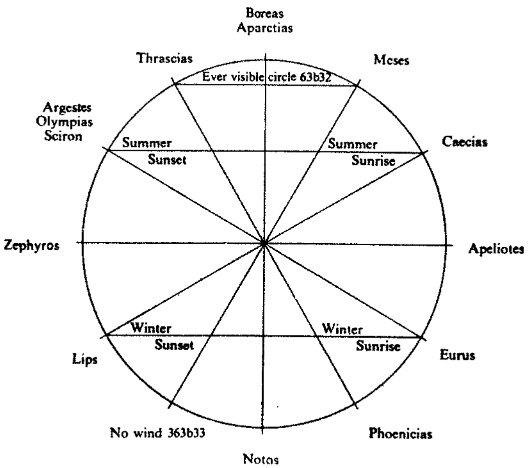

Fig. 3. Reconstruction of wind map, Aristotle, *Meteorologica* ii.7. Eleven points are indicated from which named winds come.

winter risings and settings of the sun, and joining these points, he was able in effect to depict the north temperate zone; his diagram must have been purposely incomplete, as he recognizes only ten or eleven winds, not twelve. As heirs to the tradition of this Aristotelian wind map, we may compare the Pesaro anemoscope (p. 110) and the map attached to Ptolemy's *Handy Tables* (p. 170). The same Madrid manuscript which gives the diagram from Aristotle's *Meteorologica* also has attempts at showing in map form where certain prominent mountains and rivers are situated. As these contain serious topographical errors, they are unlikely to be derived from Aristotle's diagrams: rather they must be poor reconstructions from his text of the *Meteorologica*.

This was the state of world cartography when Alexander the Great, himself a pupil of Aristotle, set out on his expedition to the East which resulted in the overthrow of the Persian Empire (334–323 BC). Although he believed himself to have a divine mission, military conquest was not by any means his sole aim. He had a genuinely enquiring mind, and wanted if possible to explore the whole land-mass to the East. He instructed secretaries to collect whatever material was available on the more inaccessible regions, and took various scholars with him to write up the areas covered. Whether the collected material included maps we are not told. But the technicians on the expedition included two road-measurers[28] whose function was to keep a record of all distances between stopping-places (the elder Pliny gives some details of these) and to describe the geography, soil, flora and fauna of all areas traversed. This information was incorporated in a daily expedition report (not extant) compiled by Eumenes of Cardia. It is clear that later topographical writers, such as Isidore of Charax (p. 124), drew extensively on the itinerary content of the expedition. Alexander's plan to go further and explore the Far East was thwarted by a revolt of his army. Rather than abandon all discovery of new territories, he substituted a land and sea journey from the Indus delta to the head of the Persian Gulf (pp. 134–5).

In the West, about 330 BC, Pytheas, a Greek from the colony of Massilia (Marseilles), explored the Atlantic coasts of Europe as far north as possible.[29] Although in antiquity geographers and others were sceptical of his findings,[30] we can see that his voyage was valuable in scientific terms. His main object seems to have been to work out latitudes for many of the remoter places, either through the length of the longest day or through the height of the sun at the winter solstice. He knew the exact location of the celestial pole, and worked out the latitude of Marseilles as 43°12′ N., very near the correct value of 43°15′.

His voyage (p. 136) took him via Cadiz, up the Spanish coast, to the Cassiterides or Tin Islands, whose location is disputed. He then circumnavigated the British Isles, and may even have sailed into the Baltic. At the furthest point north at which his observations are unquestionably recorded, Mona (here the Isle of Man[31]) and the Bight of Lübeck, the sun rose to only 6 cubits = 12° at midwinter, and the longest day had nineteen equinoctial hours. But from the geometry of the sphere he could tell that at some point the sun must be constantly visible at midsummer, giving the longest day twenty-four hours; so at that point he placed (on a map or in his text) an island that he called Thule. Since his own account has not survived, we cannot tell whether he visited such an island or whether it can indeed be related to an actual piece of land.

Dicaearchus of Messana (Messina), *fl. c.* 320 BC, a pupil of Aristotle, wrote among other lost works *Periodos gēs*, which can be taken as meaning either 'voyage round the world' or 'mapping of the world'. He started from Democritus' dimension of 3:2, and worked on a base line (*diaphragma*) from the Pillars of Hercules via Sardinia, Sicily, where he was born, the Peloponnese, where he then lived, southern Asia Minor, the Taurus mountains and the Himalayas. This base line divided the width of the known world very approximately into two equal halves. On it or branching out from it he gave estimates of lengths, thus:

From	*To*	*Stades*
Pillars of Hercules	Straits of Messina	7000
Straits of Messina	Peloponnese	3000
Peloponnese	Head of Adriatic	over 10,000

Although Strabo (64/63 BC–AD 21 or after) criticized Dicaearchus' figures,[32] the intervening three hundred years, with the resources of Rome to hand, had supplied much more careful measurements.

How far these writers made or looked at maps cannot be determined, but they were accumulating information on the framework as well as some details of lands of the known world. A sidelight on the display of maps in Athens comes from the will of

Theophrastus (*c.* 370–*c.* 286 BC), successor to Aristotle as head of the Peripatetic School.[33] Evidently with the general aim of educating the public of Athens, he requests that 'the panels [*pinakes*] showing maps of the world [*periodoi gēs*] should be set up in the lower cloister'. These were evidently wooden panels, which like pictures could easily be removed when required. This information illustrates the wide spread of world maps. Coins struck about this time on Rhodes (p. 146) and showing a small part of Asia Minor are simple forms of regional maps.

TERRESTRIAL MAPPING: HELLENISTIC

An important by-product of the capture of Egypt by Alexander the Great, and the establishment of his general Ptolemy I Soter, was the planning of Alexandria, among other things as a new centre of Greek learning. During the reign of the successor, Ptolemy II Philadelphus (308–246 BC, on the throne from 283/2 BC), the Alexandrian Library and Museum were planned. The library was particularly valuable as having a very good collection of up-to-date scientific works.[34] Apollonius of Rhodes wrote there and in Rhodes his *Argonautica*, a largely geographical epic poem. In one passage, evidently as a result of researches he had made, he claims that in early times a party of emigrants from Egypt to Colchis, on the east coast of the Black Sea, erected pillars on which some sort of map of their land and sea journey was etched.[35]

Timosthenes of Rhodes, one of Ptolemy II's admirals (*fl.* 270 BC), wrote a treatise, now lost, *On Harbours*.[36] He added two winds to the ten given in Aristotle's *Meteorologica*, and allocated remote peoples or countries to these twelve directions. Since we know that he placed Scythia beyond Thrace and Ethiopia beyond Egypt, it seems likely that he made Rhodes the centre of his windrose, which may have been accompanied by a map; this was adopted by many of his successors, and even after the fall of the Roman Empire we may compare what may be deduced from the Ravenna Cosmography (p. 174). Rhodes was a good place from which to make observations, as it had a long naval tradition and must have built up a mass of nautical information gathered over a long period. Nevertheless, Strabo was easily able to find flaws in Timosthenes' geographical descriptions; thus he placed Metagonion (Melilla, north Africa) opposite, i.e. due south of, Marseilles, whereas it should, says Strabo, be placed opposite Nova Carthago (Cartagena).

A vital contribution to reality in mapping on a world scale came with a scientific estimate of the circumference of the earth. Its originator accepted that the earth was a sphere, and assumed that that sphere was perfect. Eratosthenes (*c.* 275–194 BC), who was born at Cyrene and studied in Athens, was invited by Ptolemy III Euergetes, King of Egypt 246–221 BC, to come to Alexandria as tutor to his son and, shortly after, director of the Library. His relevant works, neither of which has survived, were *On the Measurement of the Earth* and *Geographica*:[37] Cleomedes summarizes the former and Strabo criticizes the latter. While still keeping to the geocentric views of the universe, he started from the assumption that the sun was so distant that for practical purposes one could consider its rays parallel anywhere on earth; and it was this theory that enabled him to arrive at a remarkably accurate calculation. He assumed that Syene (Aswan), where at midday on the summer solstice the sun was exactly overhead, was on the same longitude as Alexandria, though there is a difference of 2°. He worked out the angle, at Alexandria on the summer solstice, between the vertical and the angle of the sun at midday as 1/50 of 360°. Then the angle subtended at the centre of the earth by Alexandria and Syene would be equal to this angle. If these places were approximately 5000 stades apart, the circumference of the earth would be $50 \times 5000 = 250{,}000$ stades. But as a mathematical ploy, in order to achieve a number divisible by 60 or 360, so as to correlate stades with his subdivisions or degrees, he emended this to 252,000 stades.

A stade (*stadion*), originally the distance covered by a plough before turning, was 600 feet of whatever standard was used.[38] Scholars have disputed what length of stade was used by Eratosthenes. A late writer, Julian of Ascalon, says that Eratosthenes and Strabo both had $8\frac{1}{3}$ stades to a mile. This is not true of Strabo, who had 8 stades to a Roman mile.[39] Eratosthenes never reckoned in miles, but we may presume Julian was defining an Olympic stade of 178 m 60, which would make the circumference of the earth 45,007 km (27,967 imperial miles) as against the actual equatorial circumference of 40,075 km (24,902 miles). An alternative suggestion, made in the nineteenth century, which is based on Egyptian measurements and is thought to have

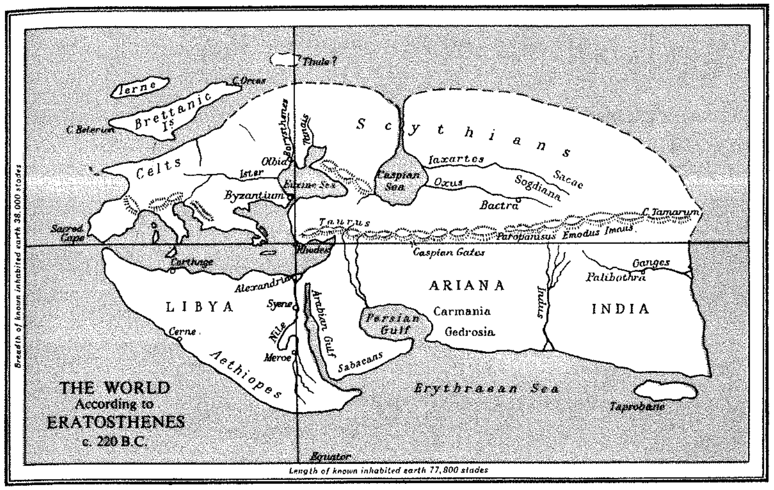

Fig. 4. Simplified reconstruction of Eratosthenes' map of the oikumene, based on north–south and east–west lines intersecting at Rhodes.

applied to land distances in Egypt, is that Eratosthenes may have used a stade of 157 m 50. This theory, well summarized by J. Oliver Thomson,[40] gives a much closer equivalent to the actual measurements, namely 39,690 km (24,663 miles).

Once this value of 252,000 stades was accepted, it was feasible also to work out the circumference of any parallel circle. Thus Eratosthenes calculated that the parallel of Rhodes, 36°N., was under 200,000 stades in circumference. To obtain the equivalent in stades of one degree of latitude he had only to divide by 360, i.e. 700 stades; to obtain the equivalent of one degree of longitude at Rhodes he could divide, say, 195,000 stades by 360, i.e. $541\frac{2}{3}$ stades. Thus there was the basis of fairly accurate co-ordinates for any sectional mapping of the Mediterranean based on the Rhodes parallel.

In his *Geographica* Eratosthenes discussed the best method of drawing a map of the inhabited area of the earth as known.[41] Then he calculated the distance along the Alexandrian meridian from the Cinnamon country in the south to Thule in the north as approximately 37,600 stades. The way he expresses this in detail is by distances north of the equator, of the tropic, and of various parallels; but in simplified form it works out as follows:

From	*To*	*Stades*
Equator	Cinnamon country	8800
Cinnamon country	Meroe	3000
Meroe	Syene	5000
Syene	Alexandria	5000
Alexandria	Rhodes	3750
Rhodes	Lysimachia	4250
Lysimachia	R. Borysthenes	5000
R. Borysthenes	Thule	16,500

His meridians, from west to east, may have been somewhat as follows:

Meridian	*Distance E. of the preceding in stades*
Western capes of Europe	—
Pillars of Hercules	3000
Straits of Messina/Carthage	8000
Rhodes/Alexandria	15,000
Issos	5000
Caspian Gates/Persian Gulf	10,000
R. Indus	14,000
Eastern frontier of India	16,000
Furthest capes of Asia	3000

As with earlier map construction, the length of the oikumene greatly exceeds the width, though by what proportion depends on how much of the northern, eastern and southern extremities was regarded as inhabited. It is clear from Strabo that Eratosthenes used an orthogonal projection. Rather than a rectangle, he thought of the oikumene as tapering off at each end of its length, like a *chlamys* (short Greek mantle). Moreover Strabo tells us that to the above total of 74,000 stades Eratosthenes, using another mathematical ploy, added 2000 at each end, to prevent the width being more than half the length. Germaine Aujac points out that on the parallel of Rhodes this total of 78,000 stades corresponds to about 140° longitude, which is roughly the distance from Korea to the west coast of Spain. But ancient methods of reckoning longitude were

unreliable compared with those for latitude obtained from solar or stellar observations. Although in those times it was known that simultaneous eclipse observations could give a reliable result, how could scholars or practical seamen easily communicate and correlate such results?[42] On the whole the ancients used reported east–west land and sea measurements, and it was scarcely possible to keep these on the same parallel.

As approximations to sizes and shapes of parts of the world, Eratosthenes first divided the inhabited world by a line going from the Pillars of Hercules to the Taurus mountains and beyond, then subdivided each of these two sections into a number of irregular shapes. The word which the Alexandrian Greeks used for these was *sphragides*. *Sphragis* literally means 'a seal', especially an official seal; but the word was extended in the first place to a plot of land numbered by a government surveyor, then by extrapolation to a numbered area on a map. India he suggested drawing as a rhomboid, Ariana (the eastern part of the Persian Empire) as an approximate parallelogram. We do not know the total number of *sphragides* and have shapes recorded only for some.

This map of the known world was a very striking achievement and may be considered to be the first really scientific Greek map. Though we do not know its dimensions, as it was presented to the Egyptian court it may well have been fairly large. It must have been drawn as closely as possible to scale, and its influence on subsequent Greek and Roman cartography was tremendous. Indeed, with Ptolemy's inaccurate alterations to the overall dimensions of the world and the oikumene, it can be said to have affected world maps right down to the Age of Discovery.

THE SECOND AND FIRST CENTURIES BC

Under the influence of the so-called 'Scipionic Circle', a group of Roman philhellenes headed by Scipio Aemilianus, important cultural contacts between Greece and Rome, especially in the sphere of literature, were made. A Greek friend of Scipio, the historian Polybius (*c.* 200–after 118 BC), went on a voyage of exploration in the Atlantic after the destruction of Carthage in 146 BC. For his writings on geography, see p. 60. Like Eratosthenes, he maintained that the equatorial zone might be cooler than surrounding areas.[43] He added that it is very high, and therefore has a high rainfall, the clouds from the north causing precipitation at the time of the Etesian winds. (F. W. Walbank, in *A Commentary on Polybius* iii.576, rightly renders the superlative ὑψηλοτάτη thus, not as the highest point in the world.)

It is tempting to think of Polybius' treatise on the equatorial region as having in part been a criticism of the treatment of that area in a globe manufactured not long before. About 168 BC the Greek polymath Crates of Pergamum, who wrote among other things on Homer and the wanderings of Odysseus, visited Rome. He was professionally interested in the city's drainage system, but while exploring the Cloaca Maxima broke his leg. He used the period of recovery to give lectures in Rome, which are said to have created a great impression.[44] His view of terrestrial mapping was that the shape could only be right if it was drawn on a globe, and evidently that the scale could only be effective if the globe was at least 10 feet in diameter.[45] In designing his 'orb', if indeed he put his theory into practice, Crates favoured an unusual form of symmetry. There were, he said, separated by two intersecting belts of ocean, four symmetrical land-masses: (a) Europe, Asia and the part of Africa known at that time; (b) south of them, that of the Antoikoi, 'dwellers opposite'; (c) west of them, the Perioikoi, 'dwellers round'; (d) south of the Perioikoi, the Antipodes. The break between the land-mass known at that time and that of the

Fig. 5. Reconstruction of the inhabited area of Crates' Orb, a terrestrial globe made *c.* 170–160 BC to illustrate Homeric geography.

Antoikoi came, according to him, at a belt on each side of the equator, and there were Ethiopians (Aethiopes, 'black-faces') on each side of this water divide. Homer had written of

the Ethiopians, split in two,
Some in the East, some by the setting sun.[46]

Later Greek writers interpreted this passage in various ways.[47] No doubt as a Homeric scholar Crates was more concerned to give a plausible account of Homeric descriptions than to investigate explanations which suggested the existence of a continuous African land-mass stretching across the equator. The idea, however, was taken up by Cicero in the 'Dream of Scipio' (*somnium Scipionis*) which he incorporated in his *De re publica*. When Macrobius (p. 174 below) wrote a commentary on the *somnium Scipionis* about AD 390, he defended and amplified Crates' theory, aspects of which thus found their way into medieval cartography; the Perioikoi and Antipodes were then omitted, although discussed by Cicero and Macrobius.[48]

It remains to consider what criticisms Greek writers, in the follow-up to the Hellenistic Age, had to contribute to the theoretical side of terrestrial cartography. The two names which stand out in this connection are those of Hipparchus and Posidonius. Hipparchus of Nicaea (*fl.* 162–126 BC), who made astronomical observations in Rhodes, is chiefly known for his astronomical writings.[49] But some sixty-three fragments of his work *Against the 'Geography' of Eratosthenes* survive, mostly in Strabo. According to Strabo, Hipparchus was prepared to accept Eratosthenes' figure of 252,000 stades for the circumference of the earth, but claimed that many other distances quoted by him were either contradictory or mathematically impossible.[50] According to Pliny, on the other hand, Hipparchus added almost 26,000 stades to Eratosthenes' figure.[51] One theory is that he chose a figure between 252,000 and 300,000 stades, which latter Archimedes quoted as an earlier estimate;[52] another suggestion is that Pliny was confused by two measurements of Eratosthenes, one dividing the circumference at the equator into quarters, each measuring 63,000 stades,[53] the other estimating the breadth (north–south) of the oikumene as 38,000 stades.[54]

Strabo also criticizes Hipparchus' regional treatment. This concerns the distances in Eratosthenes' third *sphragis*,[55] covering the eastern part of the former Persian Empire. Here some, but not all, of Hipparchus' calculations are defended by Dicks against Strabo's allegations of manufacturing evidence.[56] From one fragment it is clear that Hipparchus followed the evidence presented by Pytheas for the sun's elevation and the maximum number of daylight hours in the north-west.[57]

Finally there is the significant, though misleading, criticism of Eratosthenes' measurement by Posidonius of Apamea (*c.* 115–51/50 BC), who lived mainly in Rhodes and among his many interests wrote on world geography. He studied Atlantic tides at Cadiz, was interested in geology, and supported Polybius on the equatorial zone (p. 61). He established that the star Canopus was on the horizon at Rhodes, while at Alexandria it reached an elevation equal to 1/48 of the great circle. He clearly considered Rhodes and Alexandria as being on the same longitude, but in fact Rhodes is 28°14′ E., Alexandria 29°51′ E. If the distance between the two was 5000 stades, as he first thought, the circumference of the earth would, on his wrong assumption about longitudes, be 240,000 stades. But later he accepted a revised estimate for Rhodes–Alexandria of 3750 stades, which reduced the figure to 180,000 stades. If the length of a stade was the same in his work as in Eratosthenes, which is not certain,[58] this would reduce the length of a degree of longitude at the equator from Eratosthenes' figure of 700 to 500 stades. Posidonius also believed that the east–west length of the known world was 180°. Both these suggestions, as will be seen, were taken up by Ptolemy, with unfortunate results because cartographers of a very much later period tended to take Ptolemy's word as law.

CHAPTER III

AGRIPPA

ROMAN MAPPING BEFORE AGRIPPA

There are only scanty records of Roman maps of the Republic. The earliest of which we hear, the Sardinia map of 174 BC, clearly had a strong pictorial element, and as such is discussed on p. 148 below. But there is some evidence that, as we should expect from a land-based and at that time well advanced agricultural people, subsequent mapping development before Julius Caesar was dominated by land survey; the earliest recorded Roman survey map is as early as 167–164 BC. If land survey did play such an important part, then these plans, being based on centuriation requirements and therefore square or rectangular, may have influenced the shape of smaller-scale maps. This shape was also one which suited the Roman habit of placing a large map on a wall of a temple or colonnade. Varro (116–27 BC) in his *De re rustica*, published in 37 BC, introduces the speakers meeting at the temple of Mother Earth (Tellus) as they look at 'Italy painted' (*Italiam pictam*). The context shows that he must be talking about a map, since he makes the philosopher among his group start with Eratosthenes' division of the world into North and South. This leads him on to the advantages of the northern half from the point of view of agriculture. The speakers compare Italy with Asia Minor, a country on similar latitudes where Greeks had experience of farming. After this they discuss in more detail the regions of Italy. As a visual aid to this discussion, the temple map will have been envisaged as particularly helpful. But whether it was only intended to be imagined by readers or was actually illustrated in the book is not clear. The same applies to possible cartographic illustration of Varro's *Antiquitates rerum humanarum et divinarum*, of which Books VIII–XIII dealt with Italy. But at least we know that he was keen on illustration, since his *Hebdomades vel de imaginibus*, a biographical work in fifteen books, was illustrated with as many as