Es1 ERATOSTHENES, **HIPPARCHUS AND STRABO, "GEOGRAPHIA"**

The length of the oikoumene measured on an aslant alignment.

SYNOPSIS

This paper analyses the text recorded by *Strabo,* as attributable to *Eratosthenes'* and *Hipparchus,* and concludes that there has been a misinterpretation by *Strabo* of the details. The prime example of misinterpretation is the length of the oikoumene, the longitudinal measure. This, when coupled with his non cross- referencing to supplementary statements of measure, particularly the statements that lines are wobbly or aslant, indicates a misquoting or miscomprehension of the data. When plotted, the shape of these lines leads to only one conclusion, that *Eratosthenes* did not draw proper latitudinal and longitudinal / meridional lines upon his world map. *Strabo* in his text does however appear to use the 157.5 metre *stadion*. The research is within two sections, the Length or longitude and Breadth or latitude of the oikoumene.

INTRODUCTION

Eratosthenes' of Cyrene, c285-194BCE[1], accepted the invitation of *Ptolemy III Euergetes* to become royal tutor and to succeed *Apollonius Rhodius* as head of the Great Library at Alexandria. He was an eminent mathematician and geometrician and was accepted by his peers as an equal to *Archimedes*. His works include, '*On Geometrical Means; on the Duplication of the Cube; on the Measurement of the Earth* and, *Geographia'*. There were also books on philosophy and poetry. Thus, we may conclude *Eratosthenes* was rigorous in his research and would ensure the correctness of his distance-measures and use a mathematical basis for that research.

Hipparchus of Nicaea[2] was an astronomer who flourished in the second half of the second century BCE, and thus had only the written works of *Eratosthenes* to aid his deliberations. He was an eminent astronomer, systematic and careful, inventing several astronomical instruments. His geographical treatise, a polemic against the '*Geography of Eratosthenes,'* is known mostly from *Strabo's* text. But when the recorded text is analysed, it is less a 'polemic against' and more an 'adjustment of distance- measures', bringing conflicting data to bear on the subject. He was the instigator in Greek cartography of the 360 degree subdivision of the world globe, and had agreed with *Eratosthenes* that the world measure was 252 000 *stadia*.

Strabo of Amaseia[3] was born c64/63BCE and by 44BCE was in Rome. From c25 to 20BCE he was in Alexandria. His '*Geographia*[4]' was written between 9 and 5 BCE, with revisions in AD18-19. Thus we can surmise that the information for his seventeen books of '*Geographia'* was obtained from other treatises in the Great Library. Therefore, the information used is mainly second or third hand, and he has no basis for criticising distance-measures, other than those of his personal journey from Amaseia to Alexandria. He has been considered amateurish by scholars who have studied his text concerning mathematics and cosmology by preferring the practical to the theoretical. But, in recording these details, which had he not it is doubtful we would have so much historical knowledge, we must acknowledge the '*Geographia'* as an extra-ordinary achievement.

It is therefore prudent to analyse the text of *Strabo* without allowing the major attention grabbing distance-measures to cloud our judgement, and to look for the nuances contained in the whole text, all seventeen books, to explain the so obvious contradictions.

ORIGINAL TEXT ANALYSIS

(Note: within the text of *Eratosthenes'* and *Strabo* the descriptive nouns, 'length and breadth' of the oikoumene are at variance to our own terminology. The length is an east-west measure i.e. longitudinal, and the breadth is a north-south measure i.e. latitudinal.)

Many researchers have used the text of Strabo[4], Book 1, chapter 4, to discuss the knowledge of *Eratosthenes* and thus the extent of the known world or oikoumene.

These are the oft quoted distance-measures, alignments and places:

'1.4.2':*breadth of world, 38 000 stadia,* i.e. North/South.

'*1.4.5*': *length of world, 73 800 stadia,* i.e. East/West, and, '*I mean from the extremities of India to the extremities of Iberia*'

     This statement indicates that there was no definite point with which to delineate those extremities, and we must look to the geography there.

'*1.4.6*': '*if it be true that the circle that runs through Athens, along which I have made the said reckoning of stadia from India to Iberia, is less than 200 000 stadia in circuit*'

     This statement is perhaps the crux of the mis-understandings within the research of previous papers. It should not be read as meaning- 'that which follows is that reckoning'-, it merely refers to the original calculation, which is actually nowhere fully explained in the text.

However, we then read in Book 2, chapter 1

'*2.1.1*': '*Then the line is produced in an approximately straight course*' (diag.1)

'*2.1.2*': '*the most southerly capes of India rise opposite to the regions about Meroë*'

     This places them on or about the same latitude, c16N to c17N.

     '*Patrocles, says the distance is 15 000 stadia—Meroë/Athens distance*'

     This is an accurate measurement, 16.96N to 38N = 14728 *stadia*.

'*2.1.11*': '*neither can we say whether the slant of the mountains lies in a parallel line*'

'*2.1.24*': '*now Eratosthenes says that it is only thus in a rough outline way*'

     This is a definitive statement for it leads to the conclusion that there were few if any actual parallels or latitudinal lines actually used as the next statements confirm.

'*2.1.33*': '*for he draws the length of the inhabited world through the Taurus Range and the Mediterranean Sea straight to the pillars on a line that passes through the Caucasus, Rhodes and Athens*'

'*2.1.35*': '*Eratosthenes himself declares that the differences of latitude are observable even within an extent of 400 stadia; for example, between the parallels of Athens and Rhodes*'. (Note; Athens to Rhodes is 1400 *stadia* or two degrees and 400 *stadia* is only 63 Km, or 4/7 of a degree.)

'*2.1.39*': '*and therefore it is a roundabout way that measures the 10000 stadia which Eratosthenes reckons on a straight line from the Caspian Gates to Thapsacus*'

From the above text we can establish that the lines indicated and described by *Strabo* are definitely not true geographical graticules, but rather methods of establishing basic distance-measures and relative distances. As stated, we must use the whole text of *Strabo*, each distance-measure given, and build a picture of those relationships which are severally given for most major geographical distances.

     To focus upon *Book 1, chapter 4, paragraphs 2 and 5* will give a completely misleading view of *Eratosthenes* 'work. It is quite possible to surmise that a conflation by *Strabo,* of *Eratosthenes'* original Book 2 details, has led to the many mis-interpretations in print today.

     However, before we can analyse these details it is necessary to agree the world circumference and length of the *stadion* that has been utilised. In a letter written by *Heron of Alexandria*[5] in the second century CE he states;

"The perimeter of the earth is 252 000 stadia, as Eratosthenes, who investigated this question more accurately than others has shown in the book he wrote 'On the Measurement of the Earth' ".

     The length of the *stadion* is more problematical. In the texts of many authors[6] it has been discussed and quantified to various lengths, but *Aubrey Diller*[7] pointed out the link to *Pliny*[8] and the derivation via the Schoenus[7] at 157.5 metres. That is the measurement used in this text to compare *Strabo's* quoted *stadia* lengths to actual or geographical distance-measures.

     It is also possible that *Eratosthenes'* second book was akin to a synopsis or résumé of the information further explained in his third book. This could account for the at times, disjointed presentation within *Strabo's* text, of information which should really be aligned. We must also be aware that this information has already been synthesized to provide a flowing text. In '2.5.9' we read,*" Its length, however, is estimated at about 70 000 stadia: and this is, from west to east, the distance from the capes of Iberia to the capes of India, measured partly by land journeys and partly by sea-voyages*". Thus we lose 3 800 *stadia* (see 1.4.5 above) by a simple comment, but gain confirmation of the methods of measurement utilized. They are sea and land itineraries. But, why should Strabo make such a statement, he knows the reality.

THE MEASUREMENT OF THE OIKOUMENE   **Diagrams ES1D01 and ES1D02**

Eratosthenes' third book is discussed by *Strabo* in Book 2 chapter 1. There, in 41 paragraphs is a veritable compendium. The most important details being not only those previously indicated, but, that which is clearly stated in '2.1.1', that the east/west line was not a parallel but a wobbly line across the globe. If we commence in the west, the capes of Iberia (note plural) are at 37N; the mouth of the Nile at 31N; the Indus at 24N and the capes of India (note plural) at 16N, the product of which is an alignment, overall akin to the plane of the ecliptic, and is somewhat contrary to the parallels and meridians mentioned in the text. The original comment in '1.4.6' which states that the '*said reckoning of the stadia from India to Iberia',* was made on the parallel of Athens, at c38N is also one which is perhaps, as this parallel is hardly mentioned in the text for any actual measurements, a mis-understanding or mis-representation. But before that can be explained it is necessary to investigate the basic reckoning of *Eratosthenes*, who was, after all, an accomplished mathematician. He has decided to use sixtieths as the divisor, being fully aware of the Mesopotamian sexagesimals[9], and thus with a world of 252 000 *stadia*, each 1/60th would be 4 200 *stadia*. However, it is the latitudinal circle measurement of each parallel which is important, so that itinerary measures when converted to sixtieths on any latitude could be reconverted to an actual measure on any other. To achieve that, we must look for a divisor capable of determining their individual lengths. *Eratosthenes'* states, that the parallel of Athens is less than 200 000 stadia. But, he required conceiving a ratio equivalent to the cosine of the actual latitude (c38N) to calculate that figure. That necessity for a ratio applies equally to all parallels. If *Eratosthenes* had simply reversed the two figures, 1/60 and 4200 and then used as a divisor, 42, the length of the major parallels he has chosen will reduce from the equatorial measure by 6 000 *stadia,* i.e. 90/42= 2.14286 degrees or 15/7 degrees, the equivalent of 6000 *stadia.* Thus, each major parallel he uses for his distance-measures is simply rationalised.

The following is an abstract of appendix table 1:

Eratosthenes   *157.5m stadion*

Location	Latitude	Ratio	Geog lat	Length/circle
Arctic Thule	66N	17/42	66.124N	102 000 *stadia*
Thule	63N	19/42	63.103N	114 000 *stadia*
Borysthenes	c46N	29/42	46.332N	174 000 *stadia*
Hellespont	c40N	32/42	40.368N	192 000 *stadia*
Athens	38N	33/42	38.213N	198 000 *stadia*
Rhodes	36N	34/42	35.951N	204 000 *stadia*
Alexandria	31N	36/42	31.000N	216 000 *stadia*
Syene	24N	115/3 x 42	24.119N	230 000 *stadia*
Meroe	16.857N	241/6 x 42	16.98N	241 000 *stadia*
Torrid	12.57N	41/42	12.53N	246 000 *stadia*
Equator	00.00N	42/42	00.00N	252 000 *stadia*

Thus each of *Eratosthenes'* reckonings can be made with ease on the parallel chosen, by dividing the length of circle into 60, or 360 parts for a single degree of longitude, and when it is necessary to move across parallels, adjustments are easily made, and the length of each 1/60th or 1/360th easily determined.

DETAILED ANALYSIS   **Diagrams ES1D01 and ES1D02**
        Note: most degrees given are quoted at two decimal places only.
        Although *Eratosthenes'*, or *Strabo,* lists the length of the oikoumene from the east, the capes of India, to Iberia in the west, it will simplify the comparative research to reverse the list and use the geographical terminology of degrees from Greenwich. Thus Iberia, Cape de Roc and Cape St Vincent, 9.35W & 9.00 W, to the Capes of India (96.08E), is a total of 105.43 degrees geographical which is the equivalent of *Eratosthenes'* given length of 73 800 *stadia*. And here we see serendipity playing its usual role. If we calculate 105.43 degrees as *Eratosthenes'* **equatorial measure**, i.e. 105.43 x 700 *stadia,* we have precisely 73 800 *stadia*. However, *Eratosthenes'* line of measure commences at 37/36 N, and is then aslant. *Strabo* also clearly states in '2.1.35' that *Eratosthenes* is fully aware that there is a difference in latitude between the parallels of Athens and Rhodes. Therefore, the text concerning the parallel of Athens, and an east/west alignment from the '*Pillars to Issus,'* and thence to India, should be considered confused and unacceptable. We must examine individually the sections of *Eratosthenes'* line to establish

how the final distance-measure was arrived at, and what the repercussions are for the overall length of the oikoumene.

INDIVIDUAL SECTIONS OF CALCULATION **Diagrams ES1D03, ES1D04, ES1D05 & ES1D06**
1) Capes of Iberia (plural) to the Pillars of Hercules; 9.35W to 5.35W, or 4 degrees Geographical.
Eratosthenes, 3 000 *stadia*; Geog. distance, **2280 stadia,** and at Athens parallel = 2200 *stadia.* The distance measure at the equator would be 2800 *stadia*, but, given the authors propensity for rounding out figures we may assume that the 3 000 is possibly correct.

The plural of cape is quite significant, both here in the west and at the east end of the alignment. It signifies a multiple and is not a mere figure of speech or text.

2) Pillars of Hercules to Carthage; 5.35W to 10.2E or 15.55 degrees Geographical.
Eratosthenes, 8 000 *stadia*; Geog. Distance, **8866**; at Athens parallel= 8550 *stadia.*
This is not an entirely accurate measure, which at the equator would be 10385 *stadia.*
But, as 2280 + 8866 = 11146, and 3000 + 8000 = 11000 stadia, it is quite accurate.

3) Carthage to Canobic Mouth of Nile; 10.2E to 30.05E or 19.85 degrees Geog.
Eratosthenes, 13500 *stadia;* Geog. Distance, **12400;** at Athens parallel =11000 *stadia.*
There is of course the difference in latitudes to account for between 38N and 31N.
In '2.1.40' the distance-measure between Alexandria and Carthage is given as 9000 *stadia*. It is therefore plausible to accept this alignment includes an element of measure by water, sailing south from Sfax and the Iles Kerkonna, prior to crossing the Great Syrtis (Surt) to Banghazi and then to Alexandria. The southerly distance is Carthage to Cyrene, geographically 37N to 33N, some 2800 *stadia.* Thus, the stated distance is quite plausible as the diagram 3 illustrates. But in '2.5.38&39' we deduce that Carthage to Cyrene is only 900 *stadia*, (an obvious mistake), and thus Carthage to Canobus would be 21 degrees of 600 *stadia*; (i.e. the degree length at 31N), and is therefore in total 12600 *stadia.* However, this is also a reasonable estimate.

4) The Canobic Mouth to Pelusium; 30.05E to 32.55E or 2.5 degrees Geographical.
The distance-measure of 1300 *stadia* is quoted three times by *Strabo.* The second instance in '17.1.6' is given as the sea distance across the Delta, which it manifestly is not. The direct geographical distance is 1500 *stadia,* with a sea distance of 1750/1850 *stadia* dependant upon a direct or shore hugging route. Thus 2.5 degrees at the equator is 1750 *stadia,* and the quoted sea measure of 1300 *stadia* would only be correct at latitude 42N. At 31N, 1300 *stadia* equal 2.167 degrees and is actually the distance of the Bolbitine mouth of the Nile from Pelusium. The Canobic mouth, as stated by *Strabo,* is c150 *stadia* distant from Alexandria, and the Bolbitine mouth is c220 *stadia.* The c220 stadia would appear to be a sacrificial measure in the rounding out of distance-measures we find in *Strabo's* text! *Therefore, why did Eratosthenes introduce this measurement?* Is it necessary to obtain a total measure of 73 800 *stadia*?

5) Pelusium to the Euphrates; 32.55E to 38E, 5.45 degrees geog, but 31N to 36N.
Eratosthenes, 5000 *stadia:* Geog. distance **3084** *stadia* at 36N, or **3270** *stadia* at 31N.
The elbow in the River Euphrates at 36N, is on the Pillars alignment, and is at 38E. But the start point is at 31N. An itinerary route would pass through Jerusalem and Amman before arriving at the Euphrates. This route is quite accurate at 5000 *stadia*, but is actually 2000 *stadia* less for the world measure longitudinal distance.

6) Euphrates to Caspian Gates; 38E to 52E at 36N; 14 degrees Geographical.
Eratosthenes; 10 000 *stadia*; Geog distance **8000** *stadia*. ('2.1.3' also refers).
This is an itinerary route and the distance measure is documented at '2.1.24' as now quoted: *"Now Eratosthenes says that it is only thus,* 'in a rough outline way' *that he has read the third section, with its length of 10 000 stadia from the Caspian Gates to the Euphrates"*. It is in fact, from the Euphrates to the Tigris, to Arbela, to Ecbatana, thence the Caspian Gates. This is a sinuous journey north-east, south-east, north-east from 38E to 52E, moving one degree north and two degrees south to achieve the route. By

simple trigonometry it is 9300 *stadia* and thus the 10 000 *stadia* may be considered a correct itinerary distance.

6A) Prior to departing section 6 of the world distance-measure, we must investigate the other local distances quoted in *Strabo's* text '2.1.34 to 39'. Referring to the various diagrams, 2 to 6 inclusive, the distances from Babylon are indicated, which link to the Caspian Gates and River Indus, both points within *Eratosthenes'* world measure. These distances are itinerary measures and accord with the Euphrates to Caspian Gates distance, and indicate an error of over measure in the 10 000 *stadia* quoted. They also provide us with the key to resolving the overall Caspian Gates to River Indus measure of 14 000 *stadia.*

7) Caspian Gates to River Indus, 52E to 68E, but also 36N to 24N.
This distance quoted from *Eratosthenes',* 14 000 *stadia,* comprises an itinerary measure, which is actually from the Caspian Gates southerly to Persopolis, and thence south-easterly to the mouth of the Indus. The first part is c4200 *stadia*, followed by c10 000 *stadia* to the Indus. Thus we may deduce that the true east/west measure is 16^0 x 700 or **11200** *stadia* measured at the equator and 9000 *stadia* at 36N, or 10200 *stadia* at 24N.
But there, in the text of *Strabo,* is a singular piece of accurate measure no doubt provided by those itinerants who traversed the southern regions of Persia. Book '2.1.23' discusses the distances from Babylon to Susa and the Frontier of *Persis* and *Carmania,* on 'a measured highway'. The end point of this traverse after the 9000 *stadia* quoted is quite precisely the boundary between the Kerman and Sistan provinces of Iran on the northern fringe of the marsh lake at 28N, 58.75E. This boundary aligns with the ancient frontier. Where-as the overall may be suspect, some detail is quite accurate.

8) Indus to the narrowest part of India *(for the part of India that extends to its capes will increase this length by 3000 stadia)*. (*Strabo,* Book 1, Ch 4, Para 5.)
Eratosthenes measure is 16 000 *stadia* plus 3000 *stadia*, but the measures are stated in '2.1.7' as itinerary measures. The "narrowest" part of India, from the River Indus at 24N, is actually to the River Ganges at 22N, i.e. 68E to 92E, simply put Karachi to Calcutta. At 24N the geographical distance is **15 450** *stadia*. The deviation from the straight line would be around the Rann of Kutch and south to the Tropic of Cancer, then due east to the Ganges Delta. This section is discussed later at some length.

9) Capes of India, 3000 *stadia.* (Note the plural of cape is used)
The first cape area east of the Gangetic plain is south by 6 degrees to the Maudin Sun, Erawadi Delta, which forms a large cape extending from c92E to c96E and is thus a distance of some **2700** *stadia* east at 16N. There are no other capes applicable, the next being the end of the Malaysian peninsula at Singapore. The latitude is also that of Meroë as stated by *Strabo* in '2.1.2'. But this must be discussed now in detail.

INDIA, AN ENIGMA WHICH HAS BEEN MIS-REPRESENTED. Diagrams ES1D05 & ES1D06

India is described as rhomboidal, and the text appears to indicate the breadth, i.e. latitudinal measure, being larger than the length or longitudinal measure. This is of course geographical fact, but not as it has been portrayed subsequently.
In 2.1.22, Strabo endeavours to describe India utilising Eratosthenes' method of subdivision of the oikoumene. I quote, *'And so, after calling India Section First of the Southern Division, and Ariana Section Second, since they had contours easy to sketch, he was able to represent not only length and breadth of both sections, but, after a fashion, shape also, as would a geometrician. In the first place, India, he says, is rhomboidal, because, of its four sides, two are washed by seas (the southern and eastern seas) which form shores without very deep gulfs; and because the remaining sides [are marked], one by the mountain and the other by the river, and because on these two sides, also, the rectilinear figure is fairly well preserved. Secondly, Ariana. Although he sees that it has at least three sides well-suited to the formation of the figure of a parallelogram, and although he cannot mark off the western side by mathematical points, on account of the fact that the tribes there alternate with one another, yet he represents that side by a sort of line that begins at the Caspian Gates and ends at the capes of Carmania that are next to the Persian Gulf. Accordingly, he calls this side "western" and the side along the Indus*

"eastern", but he does not call them parallel; neither does he call the other two sides parallel, namely, the one marked by the mountain, and the one marked by the sea, but he merely calls them "the northern" and "the southern" sides.

We also read in '15.1.13' concerning the River Indus-*'they all flow firstly towards the south and then continue to flow in the same direction in particular those which flow into the Indus'* and' *but the Indus empties by two mouths into the southern Sea'*, Therefore the River Indus, as diagram 5 illustrates is the western boundary of India, rising in the Caucasus and has basically a southerly route. That is not to say its course is due south, as can be read in previous interpretations[11]. The geographical route can be described as 23 degrees west of south from its northernmost point at Sazin, Peshawar. That is towards the south or southerly.

If we use this alignment*," towards the south*" and plot the rhomboid using the *breadth,* from the Indus to the Ganges, and the other given measures, a very different picture emerges. By utilising each measure as actually described, as an itinerary measure, and plotting the coastal routes, a picture emerges which illustrates India, and that its proper shape and size was well known. **Diagram 5** illustrates the narrative which follows. This new reconstruction also concludes that the island of Sri Lanka, Taprobane, was in fact considered part of Southern India. The sea-going itinerary measures indicate that the extra 3000 *stadia* precisely as the coast-line of Sri Lanka.

It also indicates that the Caucasus Mountains and the Indus River are at 36N, as *Strabo's* text describes. The original descriptions of south and east have been mis-interpreted, thus making the length (longitude) into the breadth (latitude) and therefore misplacing the capes of India. They follow the original breadth measure, which is now an east west length and thus they are east of the Gangetic plain.

From 36N, the River Indus flows southerly to the ocean covering a distance of 13 000 *stadia*. The River Ganges commences its route just south of the River Indus source and flows southerly, then easterly and finally southerly to the ocean at 22N/92E. The itinerary route is 16 000 *stadia*. From the mouth of the River Indus, the 'south' side, as an itinerary route, measures 19 000 *stadia* to the most southerly point of Sri Lanka. The 'eastern side' from the River Ganges is then a matching itinerary route of 16 000 *stadia* ending at the same point, the south of Sri Lanka. Thus we can show the ancient mariners measured the coast precisely.

India is not a rhomboidal form with the north and south sides parallel to latitudes, but a rhomboidal form appearing as a diamond, as **diagram 6** illustrates, with the capes of India to the east.

TAPROBANE, WHICH ISLAND IS IT?   Diagram ES1D07

In 2.1.14, Strabo states: *'Well, then, let us pass on to the country that rises opposite to the Cinnamon-producing Country and lies toward the East on the same parallel. This is the region about Taprobane. We have strong assurances that Taprobane is a large island in the open, which lies off India to the south. It stretches lengthwise in the direction of Ethiopia for more than five thousand stadia, as they say;---. Now if we assign to this island a breadth that is proportional to its length, and if we add thereto the expanse of the sea between it and India, the sum would be a distance of not less than three thousand stadia – as much as the distance from the border of the inhabited world to Meroë – that is, if the capes of India are to rise opposite Meroë; but it is more plausible to set down still more than three thousand'.*

If we study the text of *Strabo*, '15.1.14-15', the island of Taprobane is either eight thousand *stadia,* or five thousand *stadia* in length, and a seven day sail or a twenty day sail from southern India. We are told by *Strabo*, quoting *Onesicritus* there are other islands between Taprobane and India, *"though Taprobane is the furthest south"*. The text here is virtually the same as in *Pliny[8],* as is indicated later.

The islands of Sumatra and Java are the most likely contenders for *Strabo's* Taprobane, as diagram 7 illustrates. Sumatra is 10500 *stadia* distant from southern India/Sri Lanka and as a twenty day sail it is the equivalent of 525 *stadia* per day, or normal sailing distance per day for the times[10]. But, given it is an ocean crossing, although there are Islands in between, it is also a seven day sail with favourable winds. However, if the distance is from the capes of India, as now proposed, it is an easy seven day sail as diagram 7 illustrates. The closest point is at 95E, 5N, but it is 1700Km/10800 *stadia* in length, but can be said to stretch in the direction of Ethiopia. (The next island, Java is 1000Km/6400 *stadia* long). However the tip of Sumatra is so very nearly the same easting as *"The Capes of India"*, i.e. 96E, and thus we begin

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to see that perhaps a confusion of capes caused the data in *Strabo's 'Geographia'* to be in error. That is of course if the original error was not that of *Eratosthenes'*, confused by the same similar information.

It is within the text by *Pliny*[8] book, 6.81 that the island of Taprobane is located within the Eastern Sea, '*and stretches along the side of India from east to west'*. He also confirms that it was once thought of as being a twenty day sail, but now has been fixed at seven day sail, '*with reference to that covered by our (Roman) ships'*.

However, Pliny also states in 6.86-7, *'The nearest promontory in India is called Coliacus, four days' sail away – passing, in mid-voyage, the Island of the Sun.'* And, in 6.88 we read, '*The envoys also informed us that the side of Taprobane facing India is (1250 miles or 2011Km, from the translator) 12800 stadia long and lies south-east of India.*

Thus we may conclude that the Island of Taprobane, which *Onesicritus* an Admiral in the Navy of Alexander the Great, proved was an Island, is not the same island as is being here discussed. It is in all probability Sumatra. But, could it be that the 'Island of the Sun' is in fact the Sri Lanka of today?

LIBYA, THE ENIGMA WHICH WAS SIDELINED   Diagrams ES1D08 & ES1D09

To complete the aforementioned alignment we must consider Libya, and *Strabo's* description. The first, which is to be found in '2.5.15', and given as a minor remark, is followed by that at the end of his text in '17.3.1 & 2'. **Diagrams 8 and 9** have included there-on actual text by *Strabo* describing the coastline, and should facilitate an understanding of the complexity. But, the basic information indicates that *Strabo* knew perfectly well that Libya (Africa) was a large land mass, a continent, and that it extended well into the Torrid Zone. He also endeavours to cover that knowledge by insisting that we should – '*exclude from all consideration'*- anything which does not agree with the right-angled triangle described in '17.3.1'. Except, that he also states*, "-overlaps a considerable part of the torrid zone*"-, whilst still in other parts of his text trying to insist it should end at the Torrid Zone.

Libya when drawn as described, using the whole text, becomes the basic shape of Africa and exposes *Strabo* to the accusation of curtailing the knowledge to suit his own preconceptions. He actually commences his description with 5000 *stadia* or c800Km of the western or Atlantic coast from Coteis (Cape Rhir), at the end of the Atlas Mountains, to the straits of Gibraltar. He does not however comment that the coast must continue southerly, other than with the vague south and east route.   It is also pertinent to note that this information is placed at the very end of his *'Geographia'*, Book 17 of 17 and may well have been the 'last straw' of a monumental work, and a desire to complete it, as he does, with the Mediterranean coastline.

EVALUATION OF THE DATA

Using 111Km or 705 *stadia* of 157.5 metres as the geographical measure of the world (and it will be readily accepted that *Eratosthenes* figure, 700 *stadia* of 157.5 metres or 110.25Km would suffice) we can assess the distance-measures thus:

	Eratosthenes *Distance*	*Degrees* *Geographical*	*Geog* *Lat.*	*Geographical* *Distance in Stadia*
1)	3000 *stadia*,	9.35 to 5.35W	@ 36N =	2281 *stadia*
2)	8000 *stadia*,	5.35 to 10.2E	@ 36N =	8869 *stadia*
3)	13 500 *stadia*,	10.20 to 30.05	@ 31N =	11 989 *stadia*
4)	1300 *stadia*,	30.05 to 32.55	@ 31N =	1510 *stadia*
5)	5000 *stadia*,	32.55 to 38	@ 31N =	3292 *stadia*
6)	10 000 *stadia*,	38 to 52	@ 36N =	7985 *stadia*
7)	14 000 *stadia*,	52 to 68	@ 24N =	10 304 *stadia*
8)	16 000 *stadia*,	68 to 92	@ 24N =	15 456 *stadia*
9)	3000 *stadia*,	92 to 96.08E	@ 16N =	2765 *stadia*
Total=	73 800 *stadia*	105.43 degrees		64 451 *stadia*

Therefore we can surmise that *Eratosthenes'* knew that the 73 800 *stadia* distance measure was not a true longitudinal measure at any point but the Equator. He also probably knew that if it was reduced to a measure in the region of the Mediterranean Sea, at 31N, obviously it would still be c106 degrees, but

only 73800 x Cosine 31 or 63250 of his *stadia*. The geographical distance, as indicated is 64451 *stadia*. At the Athens parallel it would be c58200 *stadia*.

The world's breadth is from 8800 *stadia* north of the Equator, the Torrid Zone at 12.57N, to the latitude of Thule at 66N, some 53.5 degrees. The basic assumption of a twofold length would be 107 degrees and that is what *Eratosthenes'* figures provide for, and he being the astronomer (and philosopher) that he was, would have been almost certain to appreciate this in full.

THE LENGTH OF THE OIKOUMENE; CONCLUSIONS   Diagram ES1D06

The rationale of *Eratosthenes*, as described by *Strabo*, ever remembering he only had access to the written word, and that may have been a scribal copy and thus subject to the vagaries of miscopying, appears to be one of-'*we can measure accurately the breadth of the world i.e. latitudinal, but we can only by itinerary measure, supplemented by some astronomical readings, thus determine the length or longitude of the world*'. Indeed, it is the conclusion of Geus[11] that, '*The circumference of the earth was measured astronomically and mathematically, but the oikoumene was measured hodologically, i.e. by means of adding up single distances which Eratosthenes found in sources such as periploi, itineraries, geographical works*.'

But there is hardly a specific note in the text of *Strabo* which explains the real longitudinal measures. From the Pillars to Carthage could be measured by both land and sea, as could the onward journey to the River Nile, precisely as *Strabo* indicates in '17.3.6' and '17.1.14'. But why in setting down the measured points in the most important calculation to be made after establishing the equatorial circle did *Eratosthenes'* use some unremarkable places as reference points? Was this in fact a deliberate ploy in order to mask the overall calculation, which in all probability was made on the equatorial line and certainly not on the Athens parallel? Then, was a pro-rata designation of actual places made within the known world which allowed some compatibility? Obviously the Pillars are one point, but the method of stating they are not the furthest point west is quite off-hand. But to use the Canobic mouth of the Nile, which is 150 *stadia* from Alexandria, as well as introducing the Delta measure of 1300 *stadia* from Canobus to Pelusium, is bizarre. This is a world measure, to be detailed by point to point distances and the foremost city, Alexandria is relegated to obscurity. The next distance measure is also strange in that it uses a nebulous point, *"The Euphrates"*, instead of the well known city of Thapsacus (used later) which is close by, and an itinerary route point. Perhaps the next point, the Caspian Gates is acceptable, being a point well established from the itineraries of Alexander the Great, but again unnecessary. From Thapsacus the itinerary route discussed by the text is via Babylon and Persopolis to the Indus, a very direct alignment. But if *Eratosthenes'* has measured the oikoumene at the Equator and is using that length measure of 73 800 *stadia,* then it was necessary to increase the itinerary route from the direct to the indirect. Hence the line remains at c36N until the maximum north/south distance can be achieved to shorten the overall measure and still achieve c106 degrees. From the Indus to the Ganges the two possible measures are; at 24N, 15 500 *stadia* and at the Equator, 16800 *stadia*. Therefore, the 16 000 quoted is accurate and not a breadth measure at all, but a length measure.

Thus the conclusions must be that the text in *Strabo,* Book 1, chapter 4, paragraph 5, is a résumé of following explanatory information and should not be taken as a definitive statement regarding the oikoumene. We must consider the text of *Strabo* as indicative only of *Eratosthenes'* words, particularly as he uses the word 'declaration'- '*I will first set down the declarations of Eratosthenes'*, but he then paraphrases those words and perhaps creates a very false impression. Then, in trying to move between authors for information, there is confusion, particularly in quoting 'a quote of a quote' such as *Strabo* quoting *Hipparchus* quoting *Eratosthenes.*

But for all that it is a marvellous work of historical importance.

However, if we complete this study of the length of the world by using *Strabo's* own distance measures, as found in '17.3.6' and '17.1.4', one of the major error factors becomes so very apparent. *Strabo's* distance measures are as follows;

	Locations	stadia	actual stadia geog
1)	Coteis to Molocath river	5000	2000
2)	Molocath to Tretum	6000	6000
3)	Tretum to Carthage	2500	2500

4)	Carthage to Great Syrtis	5000	4500
5)	Great Syrtis to Berenice	3000	3000
6)	Berenice to Alexandria	5400	6000
		26900 *stadia*	24000 *stadia*

The comparable measure by *Eratosthenes',* is from the Pillars via Carthage to the Canobic mouth of The Nile, a total of 21 500 *stadia*, whilst *Strabo* has 26 900 *stadia* of coast hugging measure. The apparent error in the first measure is in fact anomalous because as stated, *Strabo* has commenced his measure on the west coast of Libya/Africa and not as he perhaps intended at Cape Spartel/Ampelusium Prom. This would of course, if we were to remove those 5000 *stadia*, give similar figures.

This also indicates that *Strabo* must still be using the 157.5 metre *stadion* of *Eratosthenes'*. If, what is considered the Greek *stadion*[12] of 185 metres had been utilised, not one measure in the comparison of itinerary distance measures would have produced an acceptable coincidence to the geographical distances of the itineraries. It is therefore possible to conclude this measure was the Alexandrian *stadion* developed from the ancient Egyptian measures of the *Remen, Cubit and Iteru*.

THE LATITUDINAL MEASURE OR BREADTH OF THE WORLD

In Book 1, chapter 4, paragraph 2, *Strabo* explains the Meridional measurements given by *Eratosthenes'* for the breadth of the oikoumene from Aethiopia to Thule. It is given as follows: (illustrated on diagrams 10 and 11)

	Locations	Distance	700 *stadia* degrees
1)	Cinnamon Country to Meroë	3400 *stadia*	(4.857 degrees)
2)	Meroë to Alexandria	10 000 *stadia*	(14.286 degrees)
3)	Alexandria to Hellespont	8100 *stadia*	(11.571 degrees)
4)	Hellespont to Borysthenes	5000 *stadia*	(7.143 degrees)
5)	Borysthenes to Thule	11500 *stadia*	(16.428 degrees)
	Total;	38000 *stadia*	(54.286 degrees)

In the first paragraphs *Strabo* also states; *"Still, when Hipparchus plots the celestial phenomena for several inhabited places, he uses, in addition, those intervals measured by Eratosthenes on the meridian through Meroe and Alexandria and the Borysthenes after saying that they deviate but slightly from the truth"*. Thus it is possibly *Strabo* or *Hipparchus* who has conflated the meridians to a single line and we can reject previous research which infers that the meridian of Meroë is the same as the Borysthenes. We must use only the statement that follows the above list in '1.4.2' where *Strabo* quotes *Eratosthenes'* as saying that *"beginning at Meroe and measuring on the meridian that runs through Meroe"*. He does not amplify this to include other points on the meridian, which surely he would have, if had they been important markers.

Thus from '1.4.7, 8 and 9' we can extract the following information:

1.4.7/line 5   Eratosthenes Equator, 252, 000 stadia
1.4.7/line7   parallel of Syene-summer tropic-four sixtieths (i.e. 24 degrees)
1.4.7/lines 10/12; as above plus Syene to Meroe, 5000 stadia. (i.e. 7.143 degrees)
1.4.7/line13   3000 stadia south by straight line from Meroe to the Cinnamon   country parallel. (i.e. 4.286 degrees and contrary to previous   3400 stadia)
1.4.7/line16   Syene to Equator, 16800 stadia (i.e. 24 degrees)
1.4.7/line 20   8800 stadia inhabited world to Equator (i.e.12.571 degrees)
1.4.7/line 21   21800 stadia Equator to Alexandria (i.e. 31.143 degrees)
1.4.7/line22   Alexandria to Rhodes sea route, straight line with course of Nile.
1.4.8/line20   Rhodes to Byzantium, 4900 stadia (i.e. 7 degrees)
1.4.9/lines1/2 Rhodes to mouth of Borysthenes +4000 stadia, 12700 stadia (18.143)
1.4.9/lines 2/3 Rhodes to south limit of inhabited world 16600 stadia (23.714 degrees)

Now we can construct a linear diagram of latitudinal distances, evaluate their veracity and indicate the errors of either transcription or mis-understanding. *Eratosthenes* has used certain parallels in his comparisons more than others; i.e. Meroe, Syene, Alexandria, Rhodes, Athens, Borysthenes and Thule. He has also, if *Strabo's* figures are correct, altered distances by at least 100 or 500 *stadia.* The

longitudinal measures are all obviously 'rounded out' units from itinerary measures. From the list, the most striking error is the distance given from Alexandria to the Hellespont, 8100 *stadia*. This is accurately 7000 *stadia* and would appear to be a sailing distance which has not been converted to a latitudinal measure. The misplacing of Byzantium and Rome is another example of an error, by the inversion of the 1500 *stadia* differential quoted. However, from the Equator we can construct the main latitudinal measures and compare their geographical positions which accord rather well with *Eratosthenes' (and Hipparchus)* overall scheme. Using the details which can be deduced from '2.5.38 to 42', we can infill the intermediate points and clarify just how much information *Eratosthenes'* had gathered in c225BC.

We can also, at this juncture, conclude the story-line of the measurement from Syene to Alexandria. If it followed the course of the Nile, as is clearly stated in '2.5.7', and is given many times as 5000 *stadia*, and, from the Equator to Syene is 16800 *stadia* or 24 degrees, then, from the Equator to Alexandria is 21800 *stadia.* Alexandria is at 31.143 degrees north, (i.e. 21800/700,) and thus 7.143 or 7 1/7 degrees north of Syene. Therefore, we have the simple arithmetical sum of: 7 1/7 = 5000 *stadia* and thus 360/7.143 = 50.4 and 50.4 x 5000 equals 252000 *stadia*. Why was it necessary to add 2000 *stadia* to the figure of 250000 *stadia* when the simple mathematical calculation is so clearly identifiable?

THEORETICAL MATHEMATICS

It is from *Cleomedes*[13] that *Eratosthenes'* derivation of the world circle is gleaned, by his stated use of the text of *'Measurement of the World'* (just as *Strabo* uses *Eratosthenes' Geographia*) and thus we must question the precise figures attributed thereto. Was the $7 + 1/5^{th}$ actually $7 + 1/7^{th}$ as *Eratosthenes'* figures appear to indicate? Was the 5000 stadia measure from Syene to Alexandria far easier to multiply out, as follows?

$360/7+1/5^{th} = 360 \times 5/36 = 10 \times 5 = 50$; and $50 \times 5000 = 250\ 000$

Or thus, $360/7+1/7^{th} = 2520/50 = 252/5$ and then $252/5 \times 5000 = 252 \times 1000$.

Surely not! Would *Eratosthenes,* a mathematician of some note, not have realised that in carrying out the first equation (if in fact he did that work) and possibly arriving at 250 000, that by substituting 252 000, thus ensuring a 60 or 360 divisor, the angular difference could be calculated exactly and the seventh part would be noted within the figures for the degree at 700 *stadia* and the sixtieth part at 4200 *stadia.*

From *Cleomedes* text it is hard to determine the veracity of the methodology. But we can conclude that the latitudinal measures taken by either the Skaphe or star sights have provided a rather remarkable set of accurate figures which *Eratosthenes* has translated into actual distance measures. The questions that require to be answered are: *1),* can a Skaphe or larger gnomon, detect the difference between 7.14287^{0} and 7.2^{0} when they were originally ratio figures? In modern parlance the difference is 0.05714285 or 57 thousandths of a degree! *2),* and, could the Skaphe really be that accurate? A large gnomon with graduations there-on to ensure the ratio measure (actually the tangent of the angle) was as accurate as possible, would appear to be the more likely instrument. But, has our use of a handheld calculator, capable of producing accuracy undreamt of in ancient times blinded us to simple written mathematics? The two calculations made above are so very simple for such an eminent mathematician as *Eratosthenes.*

THE BREADTH OF THE OIKOUMENE; CONCLUSIONS DRAWN

The use of the Gnomon or Skaphe and the ratios generated by the shadow, when converted as above to give *Eratosthenes* world measure of 700 stadia per degree has produced an acceptably accurate latitudinal scheme for the world. The difference between *Eratosthenes'* measure of 252 000 x 0.1575Km or 39 690Km, compared to the geographical measure of 40 009Km Meridional, is negligible. It is in fact within 99.8 per-cent of reality and would be capable of use for general measures. That difference is 700or 705 *stadia* of 157.5 metres per latitudinal degree.

The *stadion*, which is so disparaged by many researchers at 157.5 metres, comprises 420 Remen or 300 Royal Cubits of 525mm. The Aegyptians measured[14] the world long before Greek mathematicians, and when *Eratosthenes* was in Alexandria, only some 80 years after the start of the Greek Ptolemaic era, most measurements would have still been in the ancient Aegyptian metrology.

By using the *stadion* of 157.5 metres, each of the measures of *Eratosthenes', Hipparchus and Strabo* can be shown to equate to geographical distance measures of today. The positioning of the Tropics at 24N equating to the then perceived angle of the ecliptic, produces a constant picture of the world which

enables later cosmographers or cartographers to build upon the work of *Eratosthenes'* producing ever more accurate maps.

That *Eratosthenes* knew there was land south of the equator, as an extension of Libya/Africa is indicated by *Strabo's* text. Thus it is perhaps one reason why the length of the world, for no apparent reason that we are told other than *"natural balance"*, *Eratosthenes'* has increased from 73 800 *stadia* by adding 2000 *stadia* at each end! Should this southern land prove habitable, and the voyage of *Hanno*[15] perhaps indicated this, it is certainly a way of preparing the ground for future expansion in the calculated length. What other reason is there for adding 2000 *stadia* past the capes of Iberia, into the wild Atlantic and to nowhere? The bulge of Libya/Africa is at 17.5W or 8.15 degrees west of the capes of Iberia. The Canary Islands are at 14.35W or 5 degrees from those capes, but, 2000 *stadia* converts to3.5 degrees at 36N, and this would indicate Cape Juby, Tarfaya, the African mainland opposite the Canary Islands. If we study *Strabo's* text for Libya/Africa, as has been shown, he indicates a western bulge at Coteis/Cape Rhir, which could be the additional measure.

CONCLUSIONS

We must be careful when analysing the information that *Strabo* has bequeathed us, particularly when it is a synthesis of many authors' texts. But, had it not been for *Strabo* the text of *Eratosthenes'* would, in all probability, have been consigned to the dustbin of time. Even though there is the work of *Hipparchus* to utilise, we find the most compelling information in *Strabo's* text.

The world of *Eratosthenes,* based upon a *stadion* of 157.5 metres is only a miniscule error from the actuality of our Meridional world. *Eratosthenes* was 99.8 percent correct in his calculation made c225BC. His works were so influential that they were both lauded and criticised, but, also no doubt copied and mis-copied in the intervening 200 years before *Strabo* commenced his text for the 17 books of his '*Geographia'*.

The itinerary measurers, be they *Bematistai or Cord-Stretchers*[16], have excelled in their work to provide such accurate longitudinal measures. The astronomers who provided the Gnomon ratios have excelled in their latitudinal measures. We can only wonder at what has been lost in the fire that consumed the Great Library of Alexandria. If *Pytheas*[17] had been believed, the advances may have been far greater and the breadth of the oikoumene more detailed. It would also have made the Roman world survey[18] carried out between 40-18BCE an even greater achievement, and helped *Claudius Ptolemy*[19] with his world measure. They are all so very close to the actual measure, and should be congratulated.[20]

However, the work is that of *Eratosthenes',* and is of paramount importance to historians and cartographers, and, regardless of the historical comments, he is worthy of being known as *Alpha.*

M J FERRAR, 2009

END NOTES AND REFERENCES
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        "Eratosthenes", page 533
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4)   *Strabo, Geography*. (trans. H L Jones.) Loeb Classical Library

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5)   *Heron of Alexandria* quoted in Dutka, J. (1993) Eratosthenes measurement of   the world reconsidered. Arch Hist Exact Sci, v 46; pp 55-66, see p63.

6)   The *stadion.*

Engels, D. (1985), 'The length of Eratosthenes'stade', American Journal of   Philology, 106: 298-311.

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7)   Diller, Aubrey. (1948), "The ancient measurement of the Earth", ISIS,   volume XL pp 6-9.

. In 1948, *Aubrey Diller* answered a question posited by *Professor Sarton* regarding, *"a convenient summary of what was known about ancient   measurements of the Earth."* The paper duly published in *ISIS* describes the   people involved and the measurements attributed to the great circle. However,   there is one telling paragraph which must be quoted in full:

"The only direct evidence of the length of Eratosthenes' stade is a solitary, but   apparently reliable statement in PLINY XII 53; "schoenus patet Eratosthenis' ratione Stadia XL". This transfers the problem from the stade to the schoenus,   which was an Egyptian measure of 12,000 cubits. Now Egyptologists, on the basis of measurements of the pyramids and other archaeological evidence,

have long maintained that the Egyptian Cubit was about 0.525 of a metre. On   this showing the schoenus would be 6300 metres, and Eratosthenes' circumference would be 6300 schoeni or 39690 Kilometres. The result is very   near the truth but the stade involved is unknown and irrational (157.5 metres, c9.45 to a Roman Mile). This is at present one of two acceptable conversions   of Eratosthenes' measurement of the earth."

There are as *Aubrey Diller* makes plain several schoeni;

20,000 royal cubits = 1 schoene = 6.5245 miles or 10.50 Km

This measure is of course also the ITRW or ITERU previously discussed.

1 schoene = 2 parasang = 60 Greek stadia or 6.71 miles/ 10.8 Km.

1 schoene = 1 parasang = 30 Greek stadia

12,000 royal cubits = 1 schoene = 3.9148 miles or 6.3 Km.

8)   *Pliny; "Natural History",* (trans. H. Rackham), Loeb Classical Library,   Harvard and London, 1938.

9)   Ifrah, Georges. (1984), The Universal History of Numbers, The Harvill Press,   London, 1998. Chapters 12 and 13. pp121- 161 Sumeria and Mesopotamia.

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Several conversion scales were in use for high-sea navigation, mainly; 700   stadia per solar day, 1000 stadia per 24 hour day, 500 stadia per solar day. Distances taken along the coast were much more accurate (down to a one-   stadion interval!) and segmented, but seem to belong to a far larger panel of   scale-systems. In Section 3, Le probleme de la valeur du stade, is discussed.

Eratosthenes and his predecessors had plenty of nautical measurements: see   for example Herodotus on the Black Sea (switching between fathoms, stades,   and time measurements---days' and nights' sailing--- and measurements in   stadia. *Herodotus, The Histories*, (trans), A. de Selincourt and revised by A.R.   Burns, Penguin Books Ltd. In Book 4.34, Herodotus commences the section

with the words, 'I cannot help laughing at the absurdity of all map-makers-   there are plenty of them-', and proceeds to describe the known world. And 11)   Gues, K. (2004), Measuring the Earth and the *Oikoumene*: zones, meridians,   *sphragides* and some other geographical terms used by Eratosthenes of   Cyrene.In, Space in the Roman World, Its Perception and Presentation, R.J.A.

Talbert and Kai Brodersen (Eds.) Lit Verlag, Münster, 11-26

12)   Greek Stadion

Doursther Horace,"Dictionnaire universel des poids et mesures anciens",   Brussels, M. Hayez, Imprimeur de L'Academie Royale, 1840. P504

This publication contains all of the ancient Aegyptian measures, such as the   Remen, Cubit (common and Royal), Iteru, and many more. The Stadion is on   page 504 and the Schoinos page 481. The measures used by The Bematistai,   the Bême-aploun and Bême-diploun, are on page 53.

Kravath Fred F. (1987) Christopher Columbus, Cosmographer, Rancho   Cordova, California, quoted in, Christopher Columbus and the Age of   Exploration, An Encyclopdia, (edit,) Silvio Bedini, Da Capo Press New York,   1998. P233.

Historiographic Interpretation	Stade/metres length	composition unit x number
Herodotus/Gossellin	99.75	200 assyrian cubits
Pliny/Macrobius	148.2	500 Pelasgic feet
Pliny/d'Anville	148.2	Schoenus/40
		300 assyrian cubits
Pliny/Hultsch	157.5	Schoenus/40
Pliny/Dreyer/Stahl	157.5	300 royal cubits
Lehman-Haupt	165	600 plinian feet
		300 talmud cubits
Polybius (Pelasgic)	177.9	600 pelasgic feet
Strabo/Pliny, Olympic	185.2	600 olympic feet
		625 roman pedes
		500 egypt remen
Drabkin Philetarian	197.6	400 assyrian cubits
Ptolemaic/Royal/Hultsch	210	400 royal cubits
Lehman-Haupt	296.4	600 assyrian cubits
Babylon/Assyrian Ush	355.68	720 assyrian cubits
Klein's superstadion	1896	???

13)   *Cleomedes*; "De Motu Circulari Corporum Caelestrum Libri Duo"; (trans H.states later,' As for Libya, we know that it is washed on all sides by the sea except where it joins Asia, as was first demonstrated, so far as our knowledge goes, by the Egyptian king Neco, who, after calling off the construction of the canal between the Nile and the Arabian gulf, sent out a fleet manned by a

Phoenician crew with orders to sail round and return to Egypt by way of the Pillars of Heracles. Ziegler), Teubner, Leipzig, Germany, 1891.

An English translation of Book 1, chapter 10, appears in Cortesao, (see 1) "History of Portuguese Cartography", 1;141-43.

14)   Egyptian World measures.

Zeidler, J. (1997), Die Länge der Unterwelt nach ägyptischer Vorstellung. Gottinger Miszellen 156, 1997, 101-112.

General notes.The text at the beginning of the Amduat states, 'This god enters the western gate of the horizon. Seth stands along the shore. It is 120 iteru coming to this gate, before the bark reaches the

netherworld dwellers. One then continues to Urnes (i.e. once equated with Ouranos).' An early division of the Duat is the Urnes, 309 iteru long. The other divisions are of equal length, and produce an overall length of 12 x 309 = 3708 iteru, to which must be added the distance for Egypt. The length of Egypt is stated as early as the Middle Kingdom as 106 iteru. Thus we have a total of 3814 iteru, or 3814 x 20000 x 0.525m = 40047Km.

The Egyptian ITRW or Iteru is found in inscriptions called a 'river unit': an early source for this unit is the White Chapel of Sensuret 1 at Karnak. It corresponds to 20000 cubits. The Greek term for this measure is *Skhoinus.* The New Kingdom, about 1550 to 1069BCE, has written sources referring to a smaller unit, the 'cord measure' (Egyptian = xt n nwH), corresponding to 100 cubits.

15)   Hanno. In the first half of the sixth century BCE, the Carthaginian admiral Hanno made a long voyage down the west coast of Africa (Libya of Strabo). His logbook contains a description of a fully active volcano and the first   known report of Gorillas. *Herodotus* in his "Histories", part 4.196, written ca.480-425BCE, quotes some of the history taken from the record inscription found in a Carthaginian Temple, as noted in 10.

"The Voyage of Hanno" is available at, www.livius.org/ha-hd/hanno and at http://www.metrum.org/mapping/hanno.htm. Both recently accessed in 2009.

Pliny the Elder , Natural History 2.169A states, *"When the power of Carthage   flourished, Hanno sailed round from Cadiz to the extremity of Arabia, and   published a memoir of his voyage, as did Himilco when he was dispatched at   the same date to explore the outer coasts of Europe*.

Ramin, J. (1976), Le Périple d'Hannon---The Periplus of Hanno. BAR   International series,3. British Archaeological Reports, Oxford.

16)   Bematistai, O C D, p238

Bematists, the surveyors of Alexander the Great. Of known Bematists, PHILONIDES of CRETE was a celebrated distance runner and others (notably Baetus and Diognetus) had literary aspirations. Their measurements of key distances in the empire comprised an archive, later controlled by Seleuces.

Individual Bematists published their observations in monographs termed   Stathmos (stages), which combined precise calculations of distance with more exotic reports of the flora; fauna and customs of the empire The latter tended to the outrageous but the measurements were of lasting value and provided Eratosthenes with the framework for his geography of Asia.

See, F Jacoby. (1923) "Fragmente der Griechuchen Historiker." F. Gr. H. pp119-22; Berne Alexanderreich 2, Nos. 195-800.

17)   Pytheas; Cunliffe, Barry. (2001-2002.) "The extraordinary voyage of Pytheas the Greek". Penguin Books, London.

18)   Roman world survey. Wiseman T P, (1992), Julius Caesar and the Mappa Mundi in 'Talking to Virgil', section 3, pp22-42, and appendices pp227-230.   Univ. of Exeter Press, Exeter. This section discusses the survey commissioned   by Caesar and carried out after his death. It took place between 40 and 18 BCE   and was finally completed by Marcus Agrippa and Augustus. The data comes from the Mappa Mundi of Hereford, Cornwall and Ebstorf (original now lost). It is recorded in two ancient texts, by Julius Honorius and Aethicus.

19)   Claudius Ptolemy. OCD, page 1273

The Geography of Claudius Ptolemy, (trans) Stevenson, E.L. (1932). The New York Public Library. The text is a complete translation, with errors, and includes his measurement of the world. It is given as 180 000 stadia, but the length of the stadia is not quoted, neither is there a cross reference to it.

20)   Roman World Measure. The basic degree of latitude in the Roman world was 75 Roman Miles, or Mille Passus of 5000 Pes. The Pedes is a known length of 11.64706 statute inches, and is normally written as 11.65 inches. Therefore the Roman world is basically 360 x 75 RM or 360 x 110.933 Km = 39936 Km.

Egyptian world = 40047 Km : Eratosthenes world = 39690 Km.

APPENDIX 1

The list of 'forty-second parts' of the quadrant of the Earth provides for an easy method of determining distance measures at any given latitude. They are listed from the Arctic Circle to the Equator. See also table and notes in main body of text.

1/42 part	decimal	latitude	parallel measure/circle
17/42	0.4048	66.124	102 000 *stadia* Thule/Circle
18	0.4286	64.623	108 000
19	0.4524	63.103	114 000 Thule
20	0.4762	61.563	120 000
21	0.5	60.000	126 000
22	0.5238	58.412	132 000
23	0.5476	56.796	138 000
24	0.5714	55.150	144 000
25	0.5952	53.470	150 000
26	0.6190	51.753	156 000
27	0.6429	49.995	162 000
28	0.6667	48.190	168 000
29	0.6905	46.332	174 000
30	0.7143	44.415	180 000
31	0.7381	42.431	186 000
32	0.7619	40.367	192 000
33	0.7857	38.213	198 000 Athens
34	0.8095	35.951	204 000 Rhodes
35	0.8333	33.557	210 000
36	0.8571	31.003	216 000 Alexandria
37	0.8809	28.242	222 000
38	0.9048	25.209	228 000
39	0.9286	21.787	234 000
40	0.9524	17.753	240 000
41	0.9762	12.528	246 000 Torrid zone
42			252 000 Equator
115/126 0.9127		24.119	230 000 Syene
241/252 0.9563		16.99	241 000 Meroë

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