3 The Ptolemy GEOGRAPHY’S Secrets

[Which GEOGRAPHY Secrets Were Secret from Ptolemy?]

Distillate from 3 Decades of DR Researches into

Zero Longitude Revealed: Cape Verde Isles
Old Egyptian Accuracy vs Greek
Marinos’ Date and Authorship
Astrologers’ Handiest Tables

In Memory of a Brilliant Friend
AUBREY DILLER 1903-1985

A Why a Network of Exactly 360 Sites’ Geographical Hours?

A1 The famous Ptolemy Geographical Directory (henceforth “GD”), popularly called “The Geography” or “Geographia”, is in eight Books. It was commissioned in the 2nd century AD for the use of Serapic astrologers (§D5). We will here adopt the fine English edition of its text by Berggren & Jones 2000 (henceforth “B&J”). But don’t miss the lovely new complete Stückelberger & Graßhoff 2006 edition (henceforth “S&G”). If you know German. And even if you don’t. The GD begins with explanatory Book 1, which tells of Ptolemy’s incorporation of thousands of sites’ geographical places from the work of an earlier geographer, Marinos of Tyre. Then, Books 2-7 list about 8000 sites’ positions, expressed consistently in degrees to 1/12th degree precision: longitudes in degrees east of the Blest Isles (Cape Verde Islands: §F4), and latitudes in degrees north or south of the Equator. The GD then concludes with what DR contends (§A4) resembles and—or partly constitutes the data-base grid-network computationally (eq.1) underlying the precision-corrupted (§§D1, D5, & K10) positions of GD Books 2-7, namely: Book 8, whose data are expressed entirely in hours (not degrees), a list of 360 sites’ longitudes in hours west or east of Alexandria (not the Blest Isles); and, instead of latitude, longest-days $M$ (for Summer Solstice) in hours, where parallels at 1$^{1/2}$ or 1$^{1/2}$/2 intervals of $M$ were called “klimata”. E.g., longest-day $M = 14^{1/2}/1/2$ was called the Rhodos klima where $L = 36^\circ$ (via eq.1).

These investigations were posted on the DIO website in 2006-2007, at www.dioi.org/gad.htm.

Unless otherwise indicated, GD section-numbering here follows that of Karl Nobbe 1843-5 (henceforth cited as merely “Nobbe”), numbering which is also followed as closely as possible by the excellent new edition, Stückelberger & Graßhoff 2006 (henceforth “S&G”).

Note that the present paper forgoes the use of accents for Greek words. Diller himself pointed out accents’ superfluous, since classical-era Greek lacked them. During a DR 1987/6/1 visit to the Vienna Papyrus collection, the same view was expressed by the collection’s chief, as well as by the able Dutch scholar Peter Sijpesteijn, who happened to be visiting the same day.

DIO’s people are amazed at a long tradition of suggestions that the GD may well be the earliest geographical work ever to use spherical coordinates. This is less scholarship than a relic of Neugebauer-salesmanship for Ptolemy. (Origin: Neugebauer 1975 pp.337, 846, & 934; and see p.280 for parallel celestial semi-claims for the Almajest, despite the 2nd century BC Hipparchos’ Comm’s listing of dozens of stellar Right Ascensions & Declinations.) Long before Ptolemy, Strabo reported a Nile map consistent (Rawlins 1982N) with use of spherical geographical coordinates, and which goes back at least to Eratosthenes (3rd century BC) — a map so antique that it does not even use degrees.
A2  Aubrey Diller was (1983/3/6 letter to DR) the 1st scholar to point out the 360-site total and to suggest its deliberateness.3

A3  The longest-day M (in hours) at a site is a sph trig function of latitude L (in degrees) and the Earth’s obliquity ε (also in degrees), by an equation known at least since the 2nd century BC (Hipparchos [DIO 5 & DIO 16 §3]) — a remarkable historical revelation, primarily owed to the mathematical investigation of Aubrey Diller 1934. [Readers not into sph trig may now skip from here to §B.]

The equation for computing each klima (§A1) attested for the 2nd century AD at Almajest 2.3:

$$\cos(15M/2) = - \tan L \tan \varepsilon$$

(1)

(Where obliquity ε was usually taken to be 23°1/2° or [the discovery of Diller 1934] 23°2/3°.)

A4  Why different data-format for GD 2-7 vs GD 8? Two potential answers:

[1] Books 2-7, like the Important Cities part of Ptolemy’s HanTabl, are in the form of Marinos’ manual or map, presumably after his (though see §C1) systematic tectonic mass-arrangement (GD 5.8.5 D & B). So, as to force macro-geographical accord (through eq.1) 460 of the above-hypothesized (§A1) network-grid-basis, which had been severely pre-corrupted by rounding by (§D1&D5) in tables long used by astrologers. Remarks at, e.g., GD 1.18 suggest that, like (following?) astronomer Hipparchos, Marinos clumped (§D4) cities under parallels. Also, Marinos gave primacy (GD 1.203 & 24.3; and below at §M) to Hipparchos’ 36° parallel (arc θ-κ-λ in Fig.1 [p.50]) through the easter-Mediterranean island of Rhodos, suggesting both an astrological-tradition connexion and even the possibility that Marinos’ table of rounded-longest-day parallels (for at least the Mediterranean-region) was a hand-me-down from Hipparchos, whose main observatory was located on Rhodos (D149), probably just north of the town of Lindos. (See Rawlins 1994L §F [pp.42-45].)

[2] The data of Book 8 are not for a map — but are in precisely (§D2) the hour-based form for astrologers’ convenience in using a computation for a horizon for a site other than Alexandria (D149), which was obviously the standard meridian for astronomical & astrological ephemeries in the Hellenistic world.4 So GD 8 could have been called the Handiest Tables — perfectly set up for astrologers’ convenience. [Some versions of the Handy Tables operate likewise: Neugebauer 1975 p.938 n.9.] Listing cities by longest-day superficially appears odd & cumbersome, and it gave no special aid when using data for maps. (To the contrary: §D3 [b].) However, astrological tables of the outdoor-invisible “Ascendant”

3See Aubrey Diller 1984’s scrupulously-wrought establishment of the text of the entire contents of Book 8 at www.dioi.org/gad.htm. The total of his site-lists is 359. Nobbe’s total is 358. But Nobbe omits Tarentum and Sousaleos, while Diller semi-omits Limyra. (Though, see end of this fn.) Merging the lists, we have exactly 360 sites in 26 sections, corresponding to GD 2-7’s 26 maps. Sections: 10 of Europe (118 GD 8 sites), 4 of Africa (52 GD 8 sites), 12 of Asia (190 GD 8 sites).

I propose scholars’ agreement upon a conventional numbering of all 360, based upon the sequence of Diller’s XZ Codices, dovetailing with the UNK Codices (to cover sites either skipped), which follows Diller’s desire to give primacy to the former. We use prefix D, to number every GD 8 site, so that “D x” refers to the xth site. Adding to Nobbe’s edition of GD 8: Tarentum (GD 3.1.12, 8.8.4) as site D53, Sousaleos (GD 3.3.4, 8.9.3) as site D63. (Note that we are dovetailing these two sites into Nobbe in passages that [exceptionally] already list more than one site — which may help explain these two oversights.) To Diller’s version, we add Limyra (GD 5.3.6, 8.17.25) as site D193, Diller XZ Codices Asia-Map 1 site #22→#22a, “Myra”, whose coordinates are identical to Nobbe’s “Limyra” at GD 8.17.25. D192 is UNK’s item#22, whose coordinates are identical to Nobbe’s GD 8.17.23, “Myra” (GD 5.3.6). Note that one finds “22a” in Diller’s hand in the left margin of his p.X13, showing that he suspected the need to add this site as the final touch to perfecting his epochal document. I.e., even at age eighty-plus, his sharp eye was still missing nothing!4

The very choice of longest-day (instead of latitude) as GD 8’s measure of northerliness tips us off to the astrological connexion. (Hardly a stretch: recall that Ptolemy compiled the superstitious horoscope-delineation book that is still astrologers’ bible: the Tetrabiblos. Note that the geographical table in his astrologer-oriented Handy Tables was at this stage still inconveniently in degrees.)

(Almajest 2.8) — the corner-stone of astronomical “house”-division for horoscopes — were simply easier to computationally construct in the 1st place (math provided at ibid 2.7), for longest-day values than for latitude values, back in the ultra-longhand-calculation days of early use of sph trig. The computational utility of longest-day is easy to show: for A = Ascendant, and ST = Sidereal Time, one can calculate:

$$\cot A = (\cos(15M/2) - \sin ST) \cos \varepsilon / \cos ST$$

(2)

— simpler than using latitude L with a formula combining the foregoing 2 equations:

$$\cot A = - (\tan L \sin \varepsilon + \sin ST \cos \varepsilon) / \cos ST$$

(3)

Thus, most available ancient astrological tables of houses (e.g., Almajest 2.8) were arranged (§D2 [1]) by klimata (§A1&D4).

A5  Astrologers’ other key invisible celestial point was the “Midheaven”. But the Midheaven MH is latitude-independent. So, for any latitude, one need only consult (in Alm 2.8’s tables) the “Sphaera Recta” columns (Toomer 1984 p.100), which tabulate the relation MH = tan ST/ cos ε. [Note added 2018. See DIO 22 §3 §§K&S for origin of & problems caused by klimata.]

B  The Greek GD’s Best Latitudes: Non-Greek Egypt & Phoenicia

B1  Fortunately, some cities’ accurate latitudes appear to have survived; two particular groups are consistent (if we include 2° stellar refraction & 1°12 rounding) with that optimistic conjecture. In Lower Egypt (Rawlins 1985G p.260; GD 4.5.53-55): Memphis (DIO 1 & al.; On [Heliopolis].)

Note (in the context of astronomy-based latitudes): these 3 sites cluster around the most accurate astronomical-surveying-orientated ancient building, the GreatPyramid, whose rounded latitude is correct at GD 4.5.54 (Cairo [Babylon], thus adjacent Giza): exactly 30°00’.

In Phoenicia (modern Lebanon):

5It will help to provide an example, using the Almajest 2.8 table for Rhodos (D189) at Sidereal Time (the Right Ascension of the meridian, or Hour Angle of the Vernal Equinox) 21°23’36” = 320°54’ (which is chosen to avoid interpolation in step 1, as will be evident):

Adding 6° or 90° gives 50°54’ (the rising point on the Equator). Then, find 50°54’ in the Almajest 2.8’s “Accumulated-Time-Degrees” column for Rhodos (longest-day M = 14°1/2, the basis of this column’s ancient computation and arrangement): Almajest 2.8 (Toomer 1984 p.101). The value on the same row in the column “10° Intervals” is zodiacally 10° of Gemini or 10° GEM 00’ = ecliptically 70°, so that is the Ascendant. The Descendant (ecliptical point that is setting) is opposite: 250° or 10° SGR 00’ (10° of Sagittarius). The Midheaven (polar longitude of transitting zodiac point) is then found by linear interpolation on Toomer 1984 p.100: in the “Accumulated Time-Degrees” column, under the “Sphaera Recta” heading, we find 312°32’; 320°54’ (ST) exceeds this by 8°22’ of the 9°58’ interval corresponding to the 10° interval between 10° AQR 00’ and 20° AQR 00’ (in the column “10° Intervals”), so: add 10° (8°22’9°58’ = 8°24’) to 10° AQR 00’, which yields Midheaven = 18° AQR 24’ (18° 4 of Aquarius) on the zodiac or ecliptical longitude 318°24’. The Nadir is opposite: 138°24’ or 18°LEO 24’. (This establishes the 4 cardinal points of the astrological houses for the chosen place & time. Division of each quarter into 3 parts then establishes the 12 astrological houses, but said division differed between house systems. Tables of houses, presumably though not demonstrably sph trig-based, go back at least as far as Theodosios of Bithynia’s “Houses”, 2nd century BC.) Finding Ascendant & Descendant (and thus house-divisions) is the sole use most modern astrologers have for geographical latitude. (Ancients also used latitude to enter parallax tables, but such scrupulousness is rare among today’s astrologers.)

Heliopolis was used merely for additively converting (§D2 [3]) local time to ephemerides’ standard zero-meridian, presumably that of Alexandria.6

6All three latitudes are correct — perhaps a notable Egyptian achievement, since the GD lists Heliopolis (the Greek name for On) at the wrong latitude (exhibiting a peculiarly Greek error: −1°14’ from asymptomatic gnomon), not realizing (similarly at §K5) that it is the same place as the holy city called “On” by the Egyptians and Genesis 41.45. Suggestively, the correct latitude is associated with the ancient Egyptian name, not the later Greek one. Details at Rawlins 1985G p.260.
Acre (Ptolemaios), Tyre (§2C2) & Sidon have errors of only a few miles, not quite as right-On as the Egyptian trio, but nonetheless impressive for antiquity — and highly unusual for the GD, suggesting that Marinos in Phoenicia (like Hipparchos at Rhodes) got particularly accurate latitudes from his own observations or from those of local astronomers or navigators, even while (fn 10) absorbing and relaying ordnagé errors for regions outside of his or his associates’ direct experience. Of these 6 sites, only Memphis (D151) is listed in GD 8.

B2 The implication: those major cities not listed in GD 8 and civilized enough to afford astronomers (note §6D) show a better chance of having accurate GD 2-7 latitudes (§J2&K11) than those which don’t.

C The Unresolved Mystery of Marinos the Phoenician

C1 Why hasn’t it been previously noted that GD Book 1’s extensive critical discussion of Mediterranean-region scholar Marinos’ data fails to provide unambiguously a single Marinos latitude in degrees for any Mediterranean city? — or, indeed, any city within the Roman Empire. So, though Marinos’ longitude for the extra-Empire city Okelis (§H2) (D2B) yields 1/2 error (fn 32) — which we cannot tell for sure whether his Important City latitudes were as corrupt as the GD’s. I.e., the GD’s silence (fn 8) on Marinos’ latitudes within the Empire leaves open the possibility that his latitudes for Mediterranean or Roman Empire sites were accurate (if so, GD data-degradation occurred after his time) — and were thus suppressed for disagreeing with those of Hipparchos. (Similarly at fn 8&19.

But would encyclopedist Ptolemy expend the huge effort required for shifting 8000 data to dovetail with an underlying grid-network’s few hundred important cities? (Ptolemy does explain why GD 1.18. that much of Marinos’ data for minor cities were incomplete and/or scattered, so serious labor [on someone’s part] was required for subsequent estimation of positions’ precise longitude & latitude, whether or not accurate or [§I7] even real.) Yet, if (fn 19) Marinos were an astrologer, why would he give longitudes in degrees — and worse, in degrees from the Blest Isles, not Alexandria? (Yet, Ptolemy’s astrologer-fave Handy Tables did likewise.) With arguments available in both directions, it is hard to be sure how much responsibility for the corruption of GD 2-7’s latitudes is borne by Marinos. In favor of Marinos being a geographer, not an astrologer, is his measure of longitude in degrees from the Blest Isles. Which in turn implies that key sites’ latitude-corruption from rounded longest-day klimata was not Marinos’ doing.

C2 After all, how is it that an (apparently) eminent geographer from Phoenicia (a legendary naval center, where latitudes & stellar declinations would have been vital for navigating commercial vessels if nothing else) was ultimately — via his own or others’ phr trig — depending, for his latitudes, upon crudely-rounded (§D6) astrological tables? Of longest-day data: see below at §D1.) If he was. Note (§B1) that the Marinos-of-Tyre-based GD 5.15.5k27 latitude of Tyre is just about exactly correct (to its 1/12 precision) if founded upon observations of circumpolar stars (affected by 2° of atmospheric refraction), a wise

5 Memphis’ XZ (ms-tradition) longest-day (14°) appears independent; but the ultra-precise UNK value (13°19’20”) looks like it may have been adjusted-to (computed-from: eq.1) an accurate latitude — suggesting (fn 12) post-Ptolemy tampering. See the learned observations of B&J (p.44) upon the two ms-traditions’ relative trustworthiness and purity.

6 A deliberate omission? I have doubts on that point; however, such silence would be similar to the sphynx (see also fn 45) evident in his Almagest 3.1 suppression-silence regarding the times of the solstice-observations of Aristarchos (truncated: Rawlins 1985H) & Hipparchos (good to 1°), omissions 1° stressed by the late W.Hartner (letter to DR). See Rawlins 1991H §§A5&B3-5 [pp.50-52]. Note the key correlation: these are the only members of Ptolemy’s extensive set of times of solstices & equinoxes that do not agree with his (Hipparchos) tables, and they are the only ones for which he hides the hours. (Each disagreed with the tables by 1/4 day.

7 The actual purpose of using the Blest Isles as longitude zero was probably to eliminate east-west positional sign-ambiguities — just as NPD (§H2) does for north-south.

D Astrologers’ Handiest Tables, InterRelations, Accuracy Degraded

D1 GD 8.2.1 states that the data of Book 8 were computed (via eq.1) from latitudes & longitudes. However, a detailed mathematical case has been made by Rawlins 1985G pp.260f that — though the remote-past origin of longest-day M data were obviously computed from latitudes — the highly (§§D5, K10, & L5) corrupted latitudes of major cities listed in GD Books 2-7 must have been computed (via eq.1) from conventionally over-rounded longest-day M-data (§A4) of just the sort7 we see in Book 8. Flagrant examples appear below (e.g., Babylon (fn 16) & SE Asia (§K7). The suggestion here is that distortions in GD latitudes go back at least to Hipparchos, while the distortions in longitude probably occurred later than Hipparchos, since they involve a shift (fn 25; §1§J4) from the Hipparchos 25200-stade Earth-circumference (fn 47) to the 180000-stade Earth-circumference which fellow-Rhodian Poseidonios seems to have switched to (Strabo 2.2.2) during the 1st century BC. (Though Taisbak 1974 eruditely wonders if this switch wasn’t much later.) The Almagest was still using the larger Earth-size during the mid-2nd century AD, and the earliest rock-certain attestation of the smaller value’s use is by Marinos, around the same time.13 (Columbus’ belief, that the shortest trip to China’s Kattigara [D356] was westward not eastward, was much influenced by Marinos’ over-tiny Earth.) Conversely, 10 See Rawlins 1985G pp.255-256, as well as Rawlins & Pickering 2001; see also DIO 13.1.3 (2003) (www.dioi.org/vols/wd1.pdf) [pp.2-11]. Similarly, Hipparchos knew his own latitude, but seems (§B1) to have reported weak elsewhere, e.g., placing Athens a degree south of its actual latitude (Hipparchos Comm 1.11.3&8) and Babylon 2°1/2 north (§L6) of its — both values copied (fn 10) by the GD.

11 If Marinos had been a poet, his day data were Marinos’, not Ptolemy’s. But Marinos was an astrologer. (Possible, but — as already noted [§C1] — his reckoning longitude in degrees and from Blest Isles is contra this idea.) Were famous ancient astrologers analogous to modern popular-science writers and publications (www.dioi.sno.htm), where ubiquity, lucre, and hype obscure innumeracy, thereby nourishing blind-leading-blind multi-generational replication (e.g., www.dioi.sti56.htm#r8k) of unreliability?

12 This is not to deny that some GD calculations went in the other direction (§D1) — nor even to reject the distinct possibility that GD 8 was entirely computed from GD 2-7 (data themselves already corrupted by calculations from a prior pool of longest-day data) as alleged. But some differences (fn 7) in the two mss-traditions (Diller’s XZ & UNK) occasionally remind us that post-2£7-century AD revisions of the GD 8 values may have attempted arranging consistency, in the same spirit that latitudes in GD 2-7 were adjusted at some point (at or before Hipparchos’ era), according to the DR theory of the GD. Note that the latter theory (§D1) has here been limited to proposing the high likelihood that data of the sort (§D4) provided in GD 8 underlay GD 2-7’s major cities.

13 B&J p.14 n.10 show excellent judgement in rejecting a misguided but persistent tradition of manipulating the stade, to force disparate ancient Earth-measures to agree with each other or reality. See also §1 J1; Rawlins 1982N; Rawlins 1996C §1C14 & fn 47 [p.11]. The formerly unpopular but evidently-inconsistent fact (§1J3) that Eratosthenes’ Earth-circumference was genuinely (not illusory) high by 1/5, and Marinos-Ptolemy’s too low by 1/6, is shown by at least 5 considerations: [1] Ptolemy’s 4.5-expansion (130°— 172°2/1) of the Rome-Babylon longitude-difference, between Abn & GD. [2] The GD’s similarly large (33%-40%) systematic over-estimate of many actual longitudes. See the least-squares test of Rawlins 1985G p.264, leading to p.265’s table of reconstructions. (The first scholar to sense that ancients had multiplied longitudes by adjustment-constants when adopting new Earth-size estimates have been Pascal Gosselin (unpublished) and Jean Jouffroy des Gres 1790. See his several tables exploring the hypothesis; also Rawlins 1985G n.22, which credits Gosselin & van der Waerden for this penetrating realization.) [3] DR’s neat common explanation (using the same 185 meter stade) of BOTH C-values’ errors from atm ref of horizontal light (§1§J4 & K11) with 1/6 the curvature of the Earth. [4] Strabo 1.4.1 reports that the largeness of Eratosthenes’ C came under later scholarly attack. [5] Ptolemy’s faked GD 1.4.2 Cartilage longitude argues for expansion by 4/3 (fn 45).

All 5 of these evidences are consistent with each other and with realization that Marinos & Ptolemy (or their source[s]) adopted the genuinely smaller Earth entailed by the 700-500 stades-per-degree and effectively parallax-free-latitude-determination method which may (§B1) go back to the time of the Great Pyramid.10 Was the purpose of Marinos’ geography naval? Or natal?11
there are plenty of hints (e.g., Memphis’ 13°57′: fn 7) that the majority of GD 8’s non-major cities may have been directly computed (via eq.1) from data of the sort found in GD 2-7. (Note strong evidence that neither section was directly computed from the other: §E2.) E.g., the greater precision of GD 2-7 data is obviously often impossible (fn 26) to derive by computing from GD 8 — while the reverse is frequently possible (see §D5 for cause). Further, late copies of Ptolemy’s Handy Tables (a work probably earlier than the GD) contain a list of c.360 Important Cities’ (364 in Halma’s ed.) latitudes and longitudes in degrees, very similar (though not identical) in selection, bulk, and sequence to GD 8. It may be that Ptolemy simply computed the non-key sites of GD 8 from something like this list, as a handiest-possible (§A4) add-on to crown his GD.

D2 However GD 8 was accomplished, it was an astrologer’s-dream Handiest Tables (§A4 [2]), the only example of its type that survived from classical antiquity: [1] All latitudes expressed in longest-day, for (§A4 & eq.2) easy entry into tables of houses. [2] All longitudes expressed vis-à-vis Alexandria, and [3] in hours — for converting local time to Alexandria time, to enter Alexandria-based tables for computation of the zodiacal positions of Sun, Moon, & planets.

D3 B&J p.29 notes (as did Rawlins 1985G pp.261f) specific cases where key cities’ latitudes must have been computed14 from longest-day. Regarding the preface to GD 8: [a] The preface’s comments on map-distortions belong with parallel material back in GD 1. [b] One of the most obvious arguments against GD 8’s data being for (non-warped) maps is that longest-day data are not linearly related to latitude. (Note shrinking of klimata-bands with recession from the Equator at, e.g., S&G 2.748-751.) [c] The GD’s regional maps have come down to us. Granted, they are not originals; their geographical accuracy to the GD’s (or its type) suggest that these are the originals in essentials. Though the maps’ margins bear longest-days marks (inevitably at large latitude intervals), the densely-marked, dominant north-south co-ordinate (linearly related to up-down distance on each map) is latitude in degrees. Which is necessary because these maps depict the locations of thousands of cities (not the hundreds of GD 8’s), the great majority of whose positions are not given at all in GD 8, while all their longitudes and latitudes are in GD 2-7. More indicative yet, the maps measure longitude not in GD 8’s hours east or west of Alexandria, but in GD 2-7’s degrees east of the Blest Isles. (See the beautiful reproductions of several such maps between pp.128&129 of B&J.) So: why would GD 8’s preface be discussing the construction of regional maps actually based upon the data of GD 2-7? Is this more residual evidence (see further yet at fn 17) of patch-work authorship? What evidence connects Marianos to the construction of GD 8? The absence15 of his native coastal Phoenicia from GD 8 proves his non-authorship of it.

D4 Tyre’s absence from GD 8 only adds to the evidence (§E & §G1) that GD 8 is not directly connected to Marianos-of-Tyre’s Books 2-7. So it would be wrong to over-claim that GD 8 is the father of GD 7. Uncle or cousin might be nearer the mark: §E1 §G2. For, longest-day data (the stuff of GD 8) are obviously the basis of the full work’s flawed grid-network of Important Cities’ latitudes (§D5) — a grid which typically misplaced geographically-key cities by ordug a degree, grossly mislocating their latitudes, e.g., Byzantium (D87 [Istanbul]) by 2° (though, as B&J p.29 n.37 rightly marvel, the false GD latitude continued to be believed at religiously non-empirical Byzantion until c.1000 AD!); Carthage (D131) by 4°, a huge error (revealed at Rawlins 1985G p.263 as due to false L) that enormously distorted maps of N.Africa (up to the Renaissance, over 100016 later). Not to mention Babylon (D256) by 2° 1/2 (fn 10; Rawlins 1985G n.13.) — a discrepancy which is difficult17 to reconcile with a modern historian-cult’s non-empirical insistence (fn 46) that Greece had high-astronomy debts to Babylon. DR suspects (§A4) that the latitudinal shortfalls (of longest-day data) of GD 8’s or its type) were the basis (§G3) for the latitudinal accuracy’s corruption in GD 2-7. Uncle or cousin might be nearer the mark: [a] to the compiler’s departure (at about this point) from a map of the Roman Empire to an extra-empire map of different format (and less reliability), and this perhaps led [b] to the accidental omission of coastal Phoenicia, possibly due to the 2 maps’ different order of site-listing around the nearby seam. More patch-workery?

14 A semi-ambiguity: Almajest 2.13 predicts the upcoming GD and refers to degrees vs the Equator for latitudes (like GD 2-7) but speaks of placing sites by degrees (the measure of Books 2-7) while using (fn 43 [1]) the Alexandria (D149) meridian of Book 8 (and of E.Mediterranean astronomers & astrologers); so it conclusively favors neither side on the relation between the GD’s two data-sections.

15 In Nobbe’s edition, at GD 8.20.18 (Jerusalem D247) the spelling of “east” changes from ανατολέως [anatolēs] to εαυ [eo] for most of the rest of GD 8. If the switch (which occurs only in some mss) is meaningful, it is possible that it is connected: [a] to the compiler’s departure (at about this point) from a map of the Roman Empire to an extra-empire map of different format (and less reliability), and this perhaps led [b] to the accidental omission of coastal Phoenicia, possibly due to the 2 maps’ different order of site-listing around the nearby seam. More patch-workery?

16 It is common knowledge (§L6) that the longest-day value (GD 8.20.27) for Babylon (D256), 14°5/12, is a rounding of 14°2/5 — which is 3/5 of a day and the M basis of computation (§G2 [c]) of the revealingly inaccurate latitude L = 35°N (GD 5.20.6), 2°28’ (148 nautical miles) too far north.

17 There remains the question of whether Hipparchos was responsible for the fateful step of converting (via eq.1) crude tabular longest-day M values from hours to degrees of latitude L. In the light of DR’s 2007 realization (www.dioi.org/cot.htm#hrbc) of just how admirably accurate Hipparchos’ longitudes may’ve been, the odds that he was not the culprit are enhanced. Has the remarkable irony been noted that the Geographical Directory (at GD 8.1.1) itself scoffs at the common folly of clumping parallel-lists [like the pre-Ptolemy one of Pliny (77 AD): analysed at Rawlins 1985G p.262] waste time and space, but the statement is valuable in its suggestion of ancient currency of the very lists upon which the DR theory is founded. (Said currency could help a defense of Hipparchos as not-necessarily the unique source of the GD’s macro-errors; however, his attractive fame and his citation by both Marianos [GD 1.7-4] and Ptolemy [Almajest, passim] argue in favor of his culpability here, though see speculation above [in this fn], on his longitudes.) We needn’t speculate anyway, on the existence of lists of a few hundred key cities’ coordinates. Just such a list survives, e.g., in the Ptolemy Handy Tables, the Important Cities table of which (N.Halma 1:109f [1822]), appears closely related (§K4) to GD 8 in both quantity and sequence: 364 sites in all, with 12 not in GD 8, and 8 missing in HT. See also the Important Cities lists (fn 43) provided in E.Honigmann 1929 [pp.139]. Vatican 1291 [493 sites] and Leidensis LXXVIII [a comparable number of sites]. These lists’ positions are [like GD 2-7] given entirely in degrees east of Blest Isles and north of the Equator.

18 See [2 fn 67 & DIO 2.1 13] [C10 [p.31].
D6 Suggested Solution to Two Mysteries  As shown in the tables of Rawlins 1985G p.262, GD latitude-errors for major cities are often sph-trigonometrically consistent with the §D1 theory. See eq.1 or Rawlins 1985G p.261, for the relevant math. See also discussion (ibid.p.259) of a further revealing point: without the DR theory presented there & here (§C2), how could one reasonably explain two shocking oddities (which had evidently escaped the notice of previous commentators): [1] GD latitudes (as already noted) are two ordnags cruder than ancient astronomers’ latitude-accuracy. (Roughly: a degree vs an arcmin.) [2] The GD latitude errors’ large size (again: ordnag a degree) is comparable to that of its pre-expansion (fin 13&25) sources’ longitude errors — this, though: [a] The former should be 30 times smaller than the latter. (Or 41 times smaller, if eclipse-observations aren’t taken as raw-data pairs.) [b] Again, real astronomers knew their latitude to ordnag an arcmin.19

E GD 8’s Disconnect: GD a Hybrid  

E1 The order of data-listing for GD 2-7 and GD 8 are similar. (And the former’s 26 local maps correlate in designation and sequence with the latter’s.) This suggests (§D4) some sort of inter-causation or co-causation. (GD 8.2.1’s statement that GD 8’s data are from degree-lists does not say that they were those of GD 2-7, though that may be the implication and-or the truth.)

E2 However, throughout the GD, we find repeated instances of differences in order-of-listing.20 Which argues against GD 8 being computed directly from21 GD 2-7 or vice-versa.

E3 Decades ago, Aubrey Diller pointed out to DR that the GD never mentions Book 8 — until the reader arrives there.

E4 DR has noted something similar: throughout GD 1, there is no mention of Alexandria.22 Ptolemy’s claimed home and his Alm’s prime meridian. By contrast, GD 1 mentions such sites as: Thule (D1), Ravenna (D56), Ilybaeum (D67), Cartaghe (D131), Rhodos (D189), Canopus (Ptolemy’s true home), Syene (D154), Meroë (D165), Arbela (D261), Okelis (D281), Kattigara (D356), among many others. Since Ptolemy is a multiply-confused plagiarist (Pickering 2002A; Duke 2002C), one may ask: is it credible that

20 Rawlins 1982G p.263 in 17. Note that GD 1.2 shows awareness that astronomical observation is the most reliable basis of latitude-measure. This returns us to the question: if sophisticated cities knew their latitude (§B2), how did most of these data get corrupted by astronomers? Was there a long astronomical tradition (§C1) of geographical tables, which Marinos (note GD 1.17.2’s semi-connexion of astronomers’ klimata to Marinos) and-or Ptolemy forced felt to assent to the flawed important-cities latitudes of? Just as usually-equant-prefering Ptolemy may’ve felt forced to go along (in the Almajest) with Hipparchos’ flawed but long-pagan-sacred eccentric-model solar tables.

21 E.g., Nîmes (D29) & Vienne (D28): GD 2.10.10-11 & 8.5.7. (B&J p.106 vs.122.) Kasandra (D101) & Thessalonike (D95): GD 3.13-14 & GD 8.12-10.64. Ergonon (D178) & neighborhood: GD 5.2.14 & 8.17.10. Hierapolis (D237) & Antioch (D236): GD 5.20.13&16 & 8.20.8&7. Tenedon (D259) & Babylon (D256): GD 5.20.5&6 & GD 8.20.30&27. Kattigara (D356) & Thinai (D355): GD 7.3.5&6 & GD 8.27.14&12. See §G1. For the consistent there, were—is calculation of one section’s data from the other (in one or both directions) or scrupulous attention was paid (in 25) to math-consistency between the two sections (whether at the outset or during later editors’ touchings-up) — though there are occasional inconsistencies, e.g., the longitude of Rome (D49): GD 3.1.61 puts Rome 36°23’23” west of the Fortunate Isles, while GD 8.8.5 puts Rome 1°58’8” east of Alexandria. (Itself 60°1/2 east of Belst Isles by GD 4.5.9, or 4° [60’] by GD 8.15.10. See Rawlins 1985G n.25.) But (60°1/2 – 36°23’15”(hour) ≈ 1°7/12 < 1°58”. Similar incompatibility: Salinac (GD 3.8.7, 8.11.4, D79). See also §K3.

22 Noble 1.46 inserts Alexandria at the 14th klima (GD 1.23.9), but it is clear from Muller 1883&1901 (1883) 1:57, B&J pp.55&111, and S&G 1:116 n.4 that this was not the original, which (in GD 1.23) named only four klimata north of the Equator: Meroë [D165] (13°), Syene [D154] (13°1/2), Rhodos [D189] (14°1/2), Thule [D11] (20°). Selection repeated GD 7.5: B&J p.111. Note that Alexandria [D149] is mentioned at GD 7.5.13-14.

allegedly (Almajest 3.1) Alexandrian Ptolemy would write a preface to his Geography which never mentions his own city, when it is the prime meridian for his astronomical works, for his earlier-announced (ibid 2.13) forthcoming geography, and for GD 8?

F Blest Isles & Identified: the Cape Verde Islands

F1 Conversely, the Blest Isles, the GD ekumene’s west bound (and GD 2-7’s implicit prime meridian), have no GD 8 entry. In GD 8, this linch-pin site is only mentioned at two places, rather in-passing: at GD 8’s prime meridian Alexandria (GD 8.15.10) and at the GD ekumene’s east bound, Thinai (GD 8.27.13), where it is noted that Thinai is 8° east of Alexandria and thus 12° east of the Blest Isles.

F2 Yet another oddity: the GD repeatedly states that the Blest Isles are the west bound of the ekumene. (Though, curiously, not at GD 7.5.2. even while soon after saying so at GD 7.5.14.) Yet the writer of GD 1 does not explicitly state that all the longitudes of GD 2-7 will be measured from the Blest Isles; and the Blest Isles have no entry in GD 8. Its position appears23 under Africa at GD 4.6.34. Additionally, one notes that there is not a single absolute longitude in GD 1 — every longitudinal value is given in strictly differential terms. Now, if one is writing a preface to a compendium that provides the longitude-east-of-Blest-Isles of 8000 sites, one would think that the east-of-BI part just might get mentioned somewhere. Instead, GD 1 is completely non-committal regarding what will be the prime meridian of the work. And GD 2.1 (the preface launching the reader into the 8000 sites) is likewise. (If one were just grabbing — virtually unedited — a preface to another work, something like this could easily happen.)

F3 In the GD, there are (§F4) a few islands near Mauretania at about the latitude of the Canaries, which are the luthero-standard-identification of Ptolemy’s Blest Isles. (E.g., S&G 1:455 n.200, which scrupulously notes that the identification of the Blest Isles with the Canaries is uncertain.) But these islands are not GD-listed at or even very near longitude zero; nor is the center of the real Canaries longitudinally beyond the real western hump of Africa, which is where the western-most-anciently-known land obviously ought to lie.

F4 GD 4.6.33 lists some non-zero-longitude off-shore islands, incl. “Kerne” at 5°E & c.26°N, latitudinally & phonetically near the Canaries which at (actually) c.28°N, are the better part of a thousand miles north of Ptolemy’s six “Blest Isles”, listed by him (Nobbe ed. GD 4.6.34) at longitudes 0° (four) or 1° (two), at latitudes ranging from 10°1/2 to 16°N: about right for the Cape Verde Islands. (Actual CVI latitudes: c.75 nmi N&S of Dakar, Cap Vert) at latitudes that are again a convincing match for the Cape Verde Islands, which are therefore firmly identified as the Blest Isles.

F5 The GD’s knowledge of the Cape Verde Islands stands as a testament to ancient explorers’ courage: they are indeed c.400 mi from Cap Vert, the mainland’s nearest point. (By contrast, eastern Canaries are barely off the NW-Africa shore.) So the islands’ discoverer was himself the nearest thing to an ancient Eriksen or Columbus. Over 1000 before sailors discovered tacking, trips there were presumably extremely rare and hazardous. Possibly galley-slave rowing-power was the key to the ancients’ knowledge of the Cape Verde islands, and perhaps they were regarded as Blest because European civilization had not yet significantly uplifted the inhabitants by the introduction of their ever-brewing wars & their ever-resultant slavery.

23Thanks to Alex Jones for reminding DR of this.

24E.g., B&J plate 6 (c.1300 AD); same in plate 1, marked as “Fortuna insula.” Also S&G 2:838 & volumes’ inside-covers. Online at http://en.wikipedia.org/wiki/Image:PtolemyWorldMap.jpg, the same six “Fortunate” islands can be seen at the west end of Ptolemy’s world map, again at a position close to that of the Cape Verde Islands. The astonishingly persistent previous confusion presumably originated with realization that the 5th of the 6 islands listed at GD 4.6.34 is named “Kanaria Nesos”.

Ptolemy’s GEOGRAPHY 2008 March DIO 14 §3
G Hours as the Route of All Evil in Ptolemy’s GD

G1 Looking at GD 1-7 and GD 8 as separate sections of the GD, one must notice that each of the two sections’ cross-citations of the other’s prime meridian is paltry at best (and could well have been from later interpolation) — so let’s keep our eye on the main point: there is no mention of the Blest Isles in the preface to GD 8, any more than there is any mention of Alexandria in the forward (GD 1) of GD 1-7. It would be hard to ask for better evidence that neither (§D1) section was the immediate direct source of the other’s totality.

G2 But let us return to the essence of the DR theory (§D1&D5, fn 12) that the data of GD 2-7 were based upon data of the type found in GD 8, and fix upon the main points regarding the source of GD 2-7’s major-site data:

[a] Whereas all latitudes were originally measured angles (method: Almajest 1.12), the inaccuracy of the latitudes in GD 2-7 show that these data had been corrupted by subjection to crude rounding (§D5) for astrolagors’ longest-day tables in hours, before being computationally converted into the latitude-degree data that ended up in GD 2-7.

[b] All astronomically-based longitudes in GD 2-7 were originally in hours,25 as noted in GD 1.4. This, because based upon comparisons of lunar-eclipse local-times.26,27 [c] Thus we have arrived at a hitherto-unappreciated realization (obvious example at fn 16): ironically, every jot of the astronomically-determined data of the basic network of cities underlying GD 2-7’s thousands of degree-expressed positions, was at some point (during its mathematical descent from its empirical base) rendered in time-units: hours. As proposed in Rawlins 1985G.

G3 And, as a result of rounded longest-days (§D5) and Earth-scale shifting (§L3), these hour-data became the semi-competent-occultist conduit (§D1) for data-corruption which tragically destroyed a sophisticated civilization’s laboriously accumulated high-quality astronomically-based ancient geographical data.

25 Wrongly (fn 45), Ptolemy believed (GD 1.4&12-13) that eclipse-based longitudes were rare. (The method of finding longitude-differences between sites by comparing local times of simultaneously-observed eclipses, as obviously well-known. See, e.g., Strabo 1.11.2 or GD 1.4.2. Least-squares tests on ancient longitudes show that the eclipse method had been extensively used by genuine ancient scientists: Rawlins 1985G §§5&9 (pp.258-259 & 264-265).)

And so he assumed that generally-accepted longitudes were primarily based upon travellers’ stade-measured distances (terrestrial) instead of eclipse-comparisons (celestial) — a crucial, disastrous error, which undid generations of competent scientists’ eclipse-based accurate longitudes-in-hours and thereby wrecked (§L3) the GD’s longitude macro-accuracy in angle. (Though not in distance: (tdem.) Note: said mis-step must have occurred before the hypothetical dovetailing (fn 21) of GD 2-7 and GD 8, perhaps (§D1) in the 1st century BC.

26 A number of network-cities’ GD 2-7 longitudes could have been calculated directly from GD 8 or its source, using Alexandria (D1.40) longitude (east-of-Blest-Isles) 60°1/2 (GD 4.5.9) or 60° (GD 8.15.10). Some examples: London (GD 2.3.27, 8.3.6, D4), Bordeaux (2.7.8, 8.5.4, D21), Marseilles (2.10.8, 8.5.7, D26), Tarentum (Diller 1984 Codices XZ Europe-Map 6 site #5) (3.1.12, 8.8.4, D53), Brindisi (3.1.3, 8.8.4, D54), Lilybaeum (3.4.5, 8.9.4, D67), Syracuse (3.4.9, 8.9.4, D68), Kyrene (4.4.11, 8.15.7, D146), Meroë (4.8.21, 8.16.9, D165), Kyzikos (5.2.2, 8.17.8, D176), Miletos (5.2.9, 8.17.13, D181), Knidos (5.2.10, 8.17.14, D182), Rhodes (5.2.34, 8.17.21, D189 — allowing for common [Rawlins 1994L 28 pp.58]).

Some examples: London (GD 2.3.27, 8.3.6, D4), Bordeaux (2.7.8, 8.5.4, D21), Marseilles (2.10.8, 8.5.7, D26), Tarentum (Diller 1984 Codices XZ Europe-Map 6 site #5) (3.1.12, 8.8.4, D53), Brindisi (3.1.3, 8.8.4, D54), Lilybaeum (3.4.5, 8.9.4, D67), Syracuse (3.4.9, 8.9.4, D68), Kyrene (4.4.11, 8.15.7, D146), Meroë (4.8.21, 8.16.9, D165), Kyzikos (5.2.2, 8.17.8, D176), Miletos (5.2.9, 8.17.13, D181), Knidos (5.2.10, 8.17.14, D182), Rhodes (5.2.34, 8.17.21, D189 — allowing for common [Rawlins 1994L 28 pp.58]).

27 However, these could as easily have been computed in the other direction. The majority of less grid-critical sites’ degree-coordinates couldn’t (§D1&D5) have been computed directly from those of GD 8 (at least in its present state), but could’ve gone the other way; e.g., Smyrna (5.2.7, 8.17.11, D179) & Pergamon (5.2.14, 8.17.10, D178).

Given the GD as it stands, if GD 8 is contended to be the direct ancestor of GD 2-7’s longitudes, one would have to argue that the underlying network-basis was far less in number than GD 8’s 360 sites — which, if we are speaking of sites whose longitudes (vs Alexandria) had been astronomically determined, would not (in itself) be an unreasonable contention.

H Precession and Aristarchos

H1 Precession is the difference in the length of the tropical and sidereal year, caused by a gradual shift of the Earth’s axis — an ancient discovery which we can easily trace back to Aristarchos (not-so-coincidentally also the 1st astronomer to publicly announce that the Earth moved).28 He is the earliest ancient cited to two different year-lengths. Aristotle flourished c.280 BC; 1 1/2 centuries before Hipparchos, hitherto generally regarded as precession’s discoverer. Both of Aristarchos’ yearlengths are provided at Rawlins 1999 §§B7 [p.33]; see also Rawlins 2002A fn 14&16 [p.8].

H2 Precession was known to the author of GD 8.2.3.29 Thus, the GD 1.7.4 discussion seems awfully strange, since it here quotes the statement of Marinos of Tyre (c.140 AD: §§11) that all the constellations rise/set in the tropical geographical regions — with the sole exception of UMi, which becomes ever-visible after a northward traveler passes latitude +12°25'. Hipparchos’ long-precessionally-obsolete NPD (North Polar Distance = declination’s complement) for α UMi, (i.e., modern “Polaris”: the brightest star in UMi, and the most northern easily-visible UMi star for us; the most southern for Hipparchos.) And α UMi’s NPD actually was 12°27' (Decl = 77°33') at Hipparchos’ chosen epoch, — 126.278 (128 BC Sept.24 Rhodos Apparent Noon: Rawlins 1991H eq.28 [p.58]). Marinos further states that this parallel is 1° north of Okelis, which he mis-places (§C1) at 11°2/5 N latitude.30 (A poor estimate, since Okelis (D281) [modern Turbah, Yemen] is actually at 12°41’N, 43°32’E.) Yet, by Marinos’ time (§H2), α UMi’s NPD had precessed down to about 11°: in 140 AD, 10°59'. So, his statements prove he didn’t account for precession. But the most peculiar aspect of this matter is that GD 1.7.4 makes no comment at all on Marinos’ flagrant omission of precession — and this though Ptolemy is (as usual) in full critical mode (alertly questioning [GD 1.7.5] whether any of Marinos’ discussion is based upon the slightest empirical research), and though the writer of the Almajest certainly knew (Alm 7.2-3) the math of precession. Comments:

H3 There can be little doubt that the authors of GD 1.7.4 and GD 8.2.3 were not the same person.

H4 If Okelis were where Marinos placed it, α UMi’s ever-visible circle would have been south, not north of Okelis.

H5 Has it been noted that, by the time of Marinos & Ptolemy, α UMi was (thanks to precession) no longer the most southern of UMi’s seven traditional stars?! — γ UMi and especially 3rd magnitude γ UMi were much more so. Indeed, for the time of the GD, γ UMi was over a degree (1°04' at 160 AD) more southern than α UMi. (Shouldn’t the “Greatest Astronomer of Antiquity” [§12 §G2] have known this? — especially since he pretended he’d cataloged the whole sky’s stars: Almajest 7.4. I.e., the GD 1.7.4 statement on α UMi disagrees not only with the sky but with Ptolemy’s own tables.31 Similar cases at fn 45.) Thus, γ UMi had long since assumed the distinction (one interjected by Marinos, ironizing of being the outermost star whose NPD determined whether a geographical region was far enough north to attain UMi-ever-viability. (Note that GD 6.7.7 puts Okelis at latitude 12°N [and false-Okelis at 12°1/2]; so, credibly, the GD’s Okelis latitude was closer to reality than to Marinos. Note also that 12° is almost exactly the theoretical
I Marinos Mis-Dated?

11 Nowadays, it seems to be almost universally assumed (e.g., Neugebauer 1975 pp.879 & 939) that Marinos flourished very early in the 2nd century AD, sometime during Trajan’s reign, around 110 AD.32 Which is curious, since in c.160 AD (or perhaps even later: §12) Ptolemy refers to Marinos as (GD 1.6.1 emph added): “the most recent [of those] of our time” who have attempted a large geography. Now, if you were currently writing of a geographer of the mid-1950s, would you speak of him so? (GD 1.17.1 has been taken to indicate that Marinos was retired or dead by Ptolemy’s day, but the passage is hardly unambiguous on that point — and would make more sense if Marinos’ latest publication was merely 5 or 10 years past.)

12 Moreover, Alex Jones points out (2007/5/23 conversation) that the forward dating of Marinos would help solve a problem first emphasized at Schnabel 1930 p.216: when did Ptolemy become aware that people lived south of the Equator? Almajest 2.6 says the S.Hemisphere is unexplored, though Marinos says otherwise and (§M1) the GD agrees. This implies, since the Almajest might have been compiled during Marcus Aurelius’ reign (Rawlins 1994A, Table 3 & fn 45 [p.45]), that Marinos’ date could be as late as c.160AD.

13 The argument adduced to date Marinos to much earlier (than Ptolemy) is that Marinos’ work took into account names of sites reflecting the changing Empire, e.g., Trajan in Dacia (GD 3.8, 8.11.4 [roughly modern Romania]) up to c.110 — but not later in Parthia (GD 6.5, 8.21.16-18 [roughly modern Iran]) and north Africa. But how sure is such tenuous reasoning? How strongly should it rank? — in the face of:

[a] GD 1.6.1’s plain statement of Marinos’ contemporaneity, and
[b] the incredibility of the long-orthodox implicit assumption that, in a busy mercantile empire, a succession of macro-geographers (GD 1.6.1 implies plurality) suddenly ceased for 1/2 a century!

14 Moreover, why assume that Marinos adopted all the latest name-changes? Ptolemy didn’t: his preface’s criticisms complains (GD 1.17.4) that Marinos misplaced the Indian trading town Simylla (D330) and didn’t realize that the natives call it Timoula. Yet the GD’s data-listings (GD 7.1.6 & 8.26.3) both retain Marinos’ name: Simylla, not Timoula. B&J

32Likewise, 1000 mni to the southwest of Okelis: regarding the location of the two lakes feeding the Nile, the GD astutely makes a major correction to Marinos in placing both lakes much nearer the Equator than Marinos had them. (In reality: the Equator runs through the eastern source, Lake Victoria. And the western source, lake-pair Edward & Albert, straddles the Equator.) Remarkably, the GD’s maps of Africa were still consulted by geographers in the mid-19th century, when these lakes were finally 1st reached by Englishmen. (See J Roy Geogr Soc 29:283, 35:1, 7, 12-14; Proc RGS 10:258.)

33Also fn 45. See Rawlins 1985p5260 (On vs Helios: fn 6) and p.266 & fn 6. We find similar hints of patch-workery throughout the GD, e.g., at GD 1.24.11-vs-17, as the lettering for two consecutive projection-diagrams are needlessly shuffled. (See B&J p.91 n.80.) See also another Ptolemy-compiled work, the Almajest, where, e.g., the mean motion tables’ Saturn—Mercury order of the planets (Alm 9.3-4) is the reverse of the Mercury—Saturn order followed in their fraudulently (Rawlins 1987 pp.236-237 item 5; Rawlins 2003 §K) alleged derivation at Alm 9.6-11A. For more such patch-work indications, see frequently here, and at Thornton 1998A end-note 17 [p.17] & Rawlins 2002V §C [p.76].

34Indica of such patch-workery in the GD are frequently noted here, due to the inexplicably-repeated modern claim of coherent unity for each of Ptolemy’s works.

35Quite aside from the present discussion: for compelling evidence against this date, see H.Müller’s clever discovery: §17.

n.53 (p.76) note an even more revealing careless retention.34 Marinos’ Aromata latitude. So, what should be tested isn’t whether all but whether any post-Trajan geography appears in the GD.

15 Especially since it doesn’t seem that there’d likely be many changes. After all, it’s well-known that Dacia was the last solid addition to the Roman Empire. (It may not be coincidental that around this time the Roman army was becoming predominantly alien-mercenary.) Trajan’s army was of course stronger than Dacia’s. (So, we know who ended up with Dacia’s gold, some of it possibly pictured in Fig.2.) But it wasn’t stronger than that of the Parthian Empire; thus, the attempted-rape3 victim got in all the Part’n shots, and the puppet ruler whom Trajan had placed into power at the then-capital (Ctesiphon [D262], near Babylon [D256]) passed on soon after, as did Trajan (117 AD). Trajan’s adventure in Parthia having been an expensive failure, his two successors chose not to try expanding the empire. Hadrian (117-138) did not share certain current warlords’ fiscal profligacy. Similarly for Antoninus Pius (138-161 — which takes us up to the time of Ptolemy’s geographical work). These points recommend some caution before we draw conclusions on Marinos’ date from lack of the-very-latest Parthian information.

16 Next, we note that the most notorious exception to the non-expansion policy of Hadrian occurred in Palestine. In 130 AD, he visited Jerusalem and ordered its re-building. Since Hadrian’s family name was Aelius, he re-named Jerusalem: “Aelia Capitolina”. (His supervision evidently triggered a local revolt — put down in 132-134, with Hadrian sometimes on the scene.) So, does the GD reflect the change? Yes: GD 5.16.8 lists “Ierosolomu [Jerusalem], which is called Ailia Capitolia”. And GD 8.20.18 lists “Ailia Capitolia Ierosolomu” without further comment but obviously reflecting the same up-to-date date. Therefore we have indicated that both the GD’s date-sections (GD 2-7 and GD 8), previously added to date Marinos to c.110, actually contain material from the 130s or later.37

17 An example of the fruitfulness of the foregoing: Almost 2 centuries ago, H.Müller made the brilliant observation that a GD-listed N.German town “Siatoutanda”, was probably non-existent, just (another: fn 45) Ptolemy-compilation mis-read of a foreign language: Tacitus’ Latin description (Annals 4.73) of a N.German battle-retreat (“ad sua tutanda”). This does not stop our ancient geographer from providing (§C1) highly specific coordinates: longitude 29°1/3, latitude 54°1/3 (GD 2.11.27). As is

33These situations remind one of the common modern mis-interpretation (Rawlins 2002B fn7 [p.12]) of Almajest 3.7 to mean that no Babylonian astronomical records came through to Ptolemy prior to 747 BC, though the actual statement is rather that continuous records went back that far.

34Over 4 centuries of botheration, Parthia repelled three Roman invasions: [1] swallowing the army of Crassus (suppressor & crucier of Spartacus, and member of the 1st triumvirate), [2] exhausting emperor Trajan, and (after a temporary setback at Marcus Aurelius’ hands) [3] slaying last pagan emperor Julian the Apostle (unless he was fragged). And, yes, “parting shot” is thought to come from Parthian archers’ tactic of shooting arrows even when retreating or pseudo-retreating.

35Such an explicit update is rare in the GD’s data-body. Another such passage, even more unusually discursive, is found at GD 7.4.1, where it is stated that Taprobane (modern Sri Lanka [though known as Ceylon in Diller’s & DR’s youth]) was formerly called Simondou but is now called Salike by the natives. Comments are even (very atypically) added, describing Salike’s women and local products ranging from meal & gold to elephants & tigers. It seems likely that the mention of both Ailia Capitolias and Salike to the late additions to the GD, a point we will shortly (fn 39) make of. (Note: Taprobane [GD 8.28] is the only date alteration of the GD, though [given the occasion] it should obviously have been covered before the GD listings get to China. I.e., we have here yet another symptom of a late add-on.)

36Following the revolt’s suppression, Judaea was re-named “Syria Palestine” and Rome henceforth (c.135) eliminated the term “Judaica”. The fact that it is retained in both the body (G2-G7) and Book 8 of the GD, together with the re-naming of Jerusalem leaves us with a bracket-argument in favor of dating Marinos to about 135, which is indeed of Ptolemy’s time — as he said.

37The “Siatoutanda” goof reminds one of St.Philomena, of whose “life” whole books used to be written (DR possesses a copy of one), though she never existed: “Philomena” turned out to be just an
all-too-usual in the ancient-science community, Müller’s novel and obviously valid discovery has been doubted on grounds so tenuous (in comparison to the compelling evidence in its favor) as to make one wonder whether anything ever gets resolved in this field, no matter the power of relative evidence. Against Müller, it has been argued (see sources cited at B&J p.28 n.34) that Tacitus Ann was published in 116 AD, which is after the (inexplicably-widely-believed) upper-limit date (110 AD) for Marinos. (But the 110 date is so far from firmly established that one should reverse the situation: instead of using the date to exclude H.Müller’s finding, use the HM finding to help establish a lower limit for Marinos’ date.) So we recognize that H.Müller’s discovery contributes importantly to the evidence suggesting that conventional wisdom on Marinos’ date is suspect, and thus that there is little trustworthy evidence against our proposal that Marinos was much nearer Ptolemy’s contemporaneous than is now generally understood.

J Tyre: Missing Home-City of Book 8’s Once-Supposed Source

J1 The most peculiar coincidence in the history of ancient geography will turn out to be a lucky break for scholars of the GD: incredibly, Marinos’ native Tyre is absent from GD 8. (Curiously, this telling point has been overlooked in the literature.) And, in a context of questionable authorship, we must likewise notice (§E4) that Ptolemy’s alleged home-city (Alexandria) is missing from GD 1.

J2 Marinos is clearly identified as of Tyre (GD 1.6.1). Indeed, Tyre (Phoenicia) is cited doubly and with accurate latitude — highly exceptional on each count — at GD 5.15.5&27: 6°7’ E of Blest Isles, 33°1/3 N of Equator. (The latitude is correct [see similarly at §K11] if we account for refraction of pole-star light and 5’ rounding.)

J3 Thus, we conclude that GD 8 (in the form we have it) was not compiled by Marinos.

K Landlubber Ho! Wrapped China Negates the Pacific

K1 It is well-known that the farthest-east region of the GD, China, portrays a nonexistent continuous roughly-north-to-south coast (blocking any route to the Pacific) beyond the South China Sea, near longitude 180° (12° east of the Blest Isles or 120° (8°) east of Alexandria, stretching from near the Tropic of Cancer, all the way south to Kattigara at 8°1/2 S. latitude — effectively wrapping China around the Indian Ocean’s eastern outlet. Latitude-longitude coordinates for 18 China sites are found in GD 7.3 (Renou 1925 pp.62-65).

K2 But, according to the previously-broached §D1 theory, all of this geography hinges upon the underlying grid-network: GD 8 and-or its kin. If we look at the GD 8.27.11-14 China list, we find that the situation of all China hinges upon just 3 cities’ hour-data (longest day & longitude east of Alexandria, according to Diller 1984’s XZ mss): Aspithra [D354] (13°1/8, 7°2/3), Thinai [D355] (12°5/8, 8°), Kattigara [D356] (12°1/2, 7°3/4). Anything wrong with GD’s China is wrong in this trio.

K3 For Thinai (D355), GD 7.3.6’s latitude (3°S) jars with GD 8.27.12’s longest-day 12°3/4 north, which would be correct for about latitude 12°1/2 N.

K4 Fortunately, Vat 1291’s Important Cities (fn 17) lists the same 3 cities (only for China. (Honigmann 1929 p.206: cities #443-#445; no China listings in Leid.LXXVIII.) And on Thinai, it provides confirmation of GD 8 (not GD 7), listing Thinai at 13°N. Which suggests that the 3°S of GD 7 is either a scribal error (missing the iota for ten) or perhaps is differential: 3° south of Aspithra (16°1/4N). Either way, it seems that 13°N is correct, as listed by Vat 1291. (S&G 2.734 for Thinai has GD 7.3.6’s 13° latitude.)

K5 Finally, we observe that Kattigara’s latitude in degrees is the same in both Vat 1291 and GD 7.3.3 — but in the former it is north latitude (which makes way more sense for a Chinese city), correctly contradicting the impossible southern latitude of both GD 7.3.3 & GD 8.27.14. The matter gets even more interesting when we check our latitudinally-corrected position for Kattigara: 177°E (of the Blest Isles) & 8° N — that is precisely the GD 7.3.2 position of Rhabana. Therefore (not for the 1st time: §H5), the GD may have used two (or more) names for the same place.

K6 Thus, when we examine the underlying-grid trio for China, the two negative (southern) latitudes both appear so shaky that we can dispense with all negative signs for China — which eliminates the above-cited fantastic N-S coastal-bar to the Pacific.

K7 There is a disturbing pattern to the GD 7 latitudes of the only four cities in the Southeast Asia region which are listed in GD 8 (in order N-to-S): Aspithra, Thinai, Kattigara, Zabai. These cities’ GD 7.2-3 latitudes are, resp, about equal to: 16°1/4, 13°, 8°1/2, 4°3/4 — which are suspiciously close (though not exactly equal) to what one would compute — which are suspiciously close (though not exactly equal) to what one would compute indoors via sph trig (eq.1) from a quarter-hour-interval klimata table: Aspithra (D354) 13°. Thinai (D355) 12°3/4, Kattigara (D356) 12°1/2, Zabai (D348) 12°1/4. (And, indeed, these are the values Diller found in GD 8’s UNK mess-tradition.) This looks even fishier when one recalls (above) that these are the only 4 SE Asia cities east of the Golden Peninsula which are listed in GD 8, where only longest-days (the stuff of klimata-tables) are provided for N-S position. (Even the precise 13°1/8 variant discussed in fn 44 for Aspithra, perfectly matched what may [ident] have been merely a scribal error: 18°1/4.) Obviously assuming exactly-correct latitudes here is risky when dealing with such rounded data. Conclusion: we must also use verbal descriptions, if we wish to have any chance of solving this section of the GD.

43 Tyre’s absence from GD 8 has several non-neatnesses. While Tyre is also missing from the Important Cities lists in late copies of Ptolemy’s Handy Tables (Halma ed.), Tyre does reside in two 9th century copies (published in Honigmann 1929), which are far older than our earliest mss of the GD, and each contains (fn 17) c.100 more sites (than GD 8). Tyre is city #367 in Vat 1291, #160a in Leid.LXXVIII. In the latter ms, Tyre is counted secondarily; which suggests that, if paring occurred, Tyre was expendable. The superficially attractive interpretation is to wonder if GD 8 is a Byzantine-era add-on, which reflected a shrinking of the number of sites from nearly 500 to just 360. The problem with that theory is format: GD 8 differs generically (from all other surviving Important Cities lists, which uniformly are in longitude degrees east of the Blest Isles and latitude degrees north of the Equator) by: [1] using Alexandria (in fn 14) as prime meridian (astrologer Ptolemy’s preference); and [2] providing data entirely in hours, just as ancient astrologers preferred (§G2 [a]). This argues strongly that GD 8 goes back in time at least as far as Ptolemy.

44 The same Vat 1291 list gives 18°1/4 N latitude for Aspithra (not the 16°1/4 N latitude of GD 7.3.2, corresponding to longest-day 13°1/8 [§K7], the very Aspithra longest-day value listed in Diller’s XZ-tradition mss. (One is tempted to ask if 18°1/4 N latitude [ident] was the true original latitude — or was later forced to agree with M = 13°1/8? But it could have just come from a scribal error.) In Nobe, GD 8 lists Aspithra at longest-day “about” 13°, which corresponds to latitude 16°+ —, agreeing with the GD 7.3.5 Aspithra latitude in Nobbe and Renou: 16° and 16°1/4 N, respectively.
K8 Ptolemy's Geography refers to Kattigara (which has a 1st syllable like Cathay's) as a Chinese harbor, near walled cities and mountains. So it is on the Asian mainland. [Note: The rest of this section explicates this particular reconstruction was nontrivially re-analyzed and revised in 2009. See DIO 5 in 68 for numerous SE Asia site-identifications.]

Our interpretation of GD 1.13.9 (B&J p.75): Marinos is saying that an ancient sea voyage from Malay's Sabara-Tamala region (Phuket, Malay) to the Golden Peninsula (Sumatra's NW tip) is roughly 200 mi, which is about right. (Marinos' sailing direction [c.S.E] is ignored here, since based on his distorted map.) GD 1.14.4 says the rest of the trip to Zabai (Singapore) takes 20°. Going around Sumatra (instead of sailing between Malay&Sumatra) would require c.20°. (Speed c.100mi/day: already established at B&J p.76 via GD 1.14.4: Aromata to Prason. Made more exact by checking Phuket-to-Singapore.) The original report is due to “Alexandros” (geographer? explorer? admiral?) who says the trip from Zabai across to Kattigara (Saigon) takes merely “some days” (GD 1.14.1-3), roughly consistent with the c.6° it would've taken at the previous speed.

K9 The GD's supposed direction to Kattigara (left [east] of south) is obviously confused. I suspect that the ancient cause was a common land-lubber misinterpretation: “south wind” (which means wind from the south) was taken as towards the south — thus, the report of going somewhere east of a “south wind” (GD 1.14.1 B&J p.75) was mis-taken (at GD 1.14.6) to mean sailing with a wind blowing southward. (Compare to B&J p.76.)

K10 Kattigara (D353) was probably about where resides the harbor long called Saigon. (Re-named Ho Chi Minh City. For now.) The real Saigon's latitude is just north of 10°N, so the GD is off by c.2°, which is about as big an error as one will find caused (GD5) in this region by computing latitudes (eq.1) from 1°/4-interval klimata. Whoever originally cubby-holed Saigon so found that its L didn't fall exactly on a klima: the nearest such klima for rounded L = 10° would in a region rounding to 1°/4 put L at 8°1/2. This, in microcosm, is the secret of why the GD's mean latitude error is so poor: ordmag 1° (GD5), despite contemporary astronomers' achievement of knowing their latitudes ordmag 100 times more accurately. (See citations: Rawlins 1982G, Rawlins 1982C, Rawlins 1985G.)

K11 For the four above-cited SE Asia cities with klima-affected latitudes, our tentative identifications follow. Barely-inland Aspithra (D354, L: 16°1/4) = Thailand Gulf’s Chanthaburi (real L: 12°-7); more deeply inland Thinai (D355, L: 13°) =Cambodia’s Phnom Penh (real L: 11° 6’). Kattigara (D356, L: 8°1/2) = Saigon (real L: 10° 8’). Zabai (D348, L: 4°3/4) = Singapore (real L: 1°3’). The GD’s failure to notice prominent Hainan Island (which nearly blocks off the east side of the broad Tonkin Gulf) suggests that the report Marinos used did not extend beyond Saigon (which is in fact the farthest point of Alexander’s narrative), so Alexandros & thus the GD never reached Hanoi or Hong Kong.

L Brief Comments & Hypotheses on Several Subjects

L1 Parts of the GD show familiarity with the Euphrates River by name. (E.g., GD 1.12.5, 5.20.3-6) So: why does GD 5.20.6 refer to Babylon as merely “on the river that goes through Babylonia”? This appears to be just an unintended quick-info-implant from an uncited source — and yet another (see §D3, etc) hint of patch-workery.

L2 It notes that from GD 5.13, on the most trustworthy ms (A) bears no coordinate data. Since the dataless lands were acquired late (after 100 BC) if at all by the Roman Empire, one might wonder if this oddity reflects dependence of the GD’s data (up to that point) upon early Greco-Roman lists, maps, or globes. Perhaps of Hipparchos’ epoch.

L3 Marinos’ ekumene was overbroad: a 225°-wide known-world, 5/8 of a wrap. This was justly revised at GD 1.12-14 and a smaller and much more accurate half-wrap breadth of 180° (see fn 48 or GD 1.14.10), though B&N n.53 (p.76) rightly note the over-roundness here: Ptolemy aimed to get 180° — “by hook or by crook”.

Had Marinos-Ptolemy not implicitly trusted (§1 §J4; Rawlins 1985G n.14) E-W stade-measures over eclipse-measures of longitude (contra priority promo-announced at GD 1.4) and thus altered all degree-longitudes by a constant Earth-size-shift factor (B&J p.76 via GD 1.14.1-3), roughly 1/4) +. This was overbroad: a 225° wide known-world, 5/8 of a wrap. This was justly revised at GD 1.12-14 and a smaller and much more accurate half-wrap breadth of 180° (see fn 48 or GD 1.14.10), though B&N n.53 (p.76). The real Saigon’s latitude is just north of 10°N, which is about as big an error as one will find caused (GD5) in this region by computing latitudes (eq.1) from 1°/4-interval klimata. Whoever originally cubby-holed Saigon so found that its L didn’t fall exactly on a klima: the nearest such klima for rounded L = 10° would in a region rounding to 1°/4 put L at 8°1/2. This, in microcosm, is the secret of why the GD’s mean latitude error is so poor: ordmag 1° (GD5), despite contemporary astronomers’ achievement of knowing their latitudes ordmag 100 times more accurately. (See citations: Rawlins 1982G, Rawlins 1982C, Rawlins 1985G.)

L4 We met a similar surprise earlier in finding (§D6 [2]) original longitude error-noise not worse than that in latitude. The upshot of both findings is an important broad insight: the merits of the GD are more geographical than astrotheological.

L5 Some scholars aver that an ambiguous discussion at Strabo 2.1.34-35 shows that Hipparchos knew Babylon's true latitude, 32°1/2. But the argument is vitiated by the high sensitivity of its key triangles’ north-south sides, to slight uncertainties of ordmag 100 stades in other sides. Confirmatorily lethal: Strabo’s very next paragraph (ibid 2.1.36) unambiguously, unsensitively reports that Hipparchos placed Babylon over 2500 stades north of Pelusium (D150), which was well-known (in reality [31°0’N] & at GD 4.5.11 [31°1/4’]) to be near the same 31° parallel as Alexandria (GD 4.5.9). (Opposite sides of the Nile Delta: Alexandria-Canopus on the west, Pelusium on the east. Contiguous entries in GD 8.15: items 10&11 = D149&150, respectively.) At Hipparchos’ 700°” scale (Strabo 2.5.34), this puts Babylon (D256) rather north of 31°1/4 + 2500 stades/700 stades/1° = .34°5/6-plus — i.e., at 35°N, just the grossly erroneous value we find at GD 5.20.6 and (effectively) at GD 8.20.27 (fn 16) and on all other extant ancient Greek Important-City lists. More germane to our investigatory finding: this leaves still-uncontradicted our proposal (Rawlins 1985G p.261) that Hipparchos was (in fn 10) the ultimate source of the corrupt state of the GD’s network’s key latitudes.

48 Would linguistic problems (in the babel of antiquity) have contributed to these errors? (Marinos likely wrote in Greek; otherwise, Ptolemy could not have used him for a whole book.) For Ptolemy, it probably wouldn’t have been the 1st time. He appears to have sloppily misordered (GD 1.4.2) simple, well-known data regarding the famous lunar eclipse that occurred shortly before the Battle of Arbela (D261 [modern Irib, lately a north Iraq hot-spot]) also seen at Carthage (D131), by (www.doi.org/cot.hn/tptx) screwing-up Latin text of (or like) Pliny’s accurate description of that ~330/9/20 event, thereby attaching Arbela’s eclipse-time to Carthage! Despite lunar eclipse after lunar eclipse occurring in Ptolemy’s lifetime (three recorded at Alexandria in under 3° at Almagest 4.6: 133-136 AD), this antique record was his sole example (!) of how to determine longitude astronomically. (See fn 25.) Further suggestion of patch-workery (also §L1): the Ptolemy account of these eclipses is is clearly written with not just the real sky but also with his own lost-solar-tables. See similar situations for Polaris at fn 31 and for Venus at Rawlins 2002V §B3 (p.74). And his solar fakes also show the same propensity to swift-simple, not-even-tabular fraud and plagiarism. (Anyone researching Ptolemy should keep ever in mind that he was shamelessly capable of every brand of deceit. See, e.g., fn 8; also Thurston 1998A §1.2 (p.14.) This eclipse was so famous that one would suppose it was widely-written-of. Thus, it is doubly weird that Ptolemy could make such an error. The suggestion here is that, as an astrologer for a Serapic temple, he was isolated from real scientists. (As perhaps Hipparchos had also been: §B1.)

49 A consideration which alone could serve to gut the entire long-orthodox Neugebauer-group fantasy (§D4) that high or even low Greek math-astronomy was derived from Babylon. Note that the same Strabo passage shows that Eratosthenes’ latitude for Babylon was as erroneous as Hipparchos’ but in the other direction. I.e., the entire Greek tradition had no accurate idea of where Babylon was, despite by then long-standing contacts that but just as good, e.g., invaluable Babylonian eclipse records. (Dicks 1960 p.134 notes that Babylon had no interest in geographical latitude, not even its own.) It has been remarked that the Strabo 2.5.34 intro to his discussion of Hipparchos’ klimata appears to state that Hipparchos was computing celestial phenomena every 700 stades (i.e., every degree) north of the Equator. But since the lengthy klimata data immediately following are instead almost entirely spaced at quarter-hour and half-hour intervals, DR presumes that the original (of the material Strabo was digesting) said that Hipparchos was providing latitudes (for each klima) in stades according to a scale of 700 stades/degree, a key attestation that Hipparchos had adopted Eratosthenes’ scale.
M Ptolemy’s 1st Planar World-Map Projection
From Where-in-the-World Arrived That 34-Unit Vertical Strut from Its Top (ε) to Its “North Pole” (η)?
Ancient Averaging. And Weights?

M1 In GD 1.24, Ptolemy twice attempts to design a planar portrayal of a broad spherical geographical segment, representing the known world — the ekumene — covering 180° of longitude from the Blest Isles (0° longitude) to easternmost China-Vietnam (180°E. longitude)48 and 79°5/12 (GD 1.10.1) of latitude from Thule [Shetlands (Mainland)] (63°N. latitude) to anti-Meroë (16°5/12 S. latitude, a klima as far south of the Equator as Meroë is north of the Equator). It is the 1st of his two projections (GD 1.24.1-9) which will concern us, since it involves a hitherto-unsolved mystery. This projection (page opposite: Figure 1) (xN11). Thus, all north-latitude arcs. (Versus fn 51.) The fan is fairly neatly placed within a rectangle about twice (fn 55) as wide as high, as we see from Fig.1, where the four corners of the rectangle are (clockwise from upper left) points α, β, δ, γ.

M2 For the 1st Projection’s conversion of the spherical-segment ekumene to planarity, the degree-distance \( T = 63° \) from Equator to Thule is made (§M4) into \( T = 63 \) linear units; likewise for the \( S = 16°5/12 \) from Equator to anti-Meroë, etc. In Fig.1, representations of several latitude-semi-circles are depicted as Ptolemy’s source intended (fn 54):

- the Thule semi-circle (latitude 63°N) = \( ξ - o - π \);
- the Rhodes (§M6) semi-circle (latitude 36°N) = \( θ - κ - λ \);
- the semi-Equator (latitude 0°) = \( ρ - σ - τ \);
- the anti-Meroë semi-circle (latitude 16°5/12 S) = \( μ - ζ - ν \).

(Repeating §M1: though each arc in Fig.1 is only c.98 units long as its northern equivalent, the Meroë parallel (latitude +16°5/12).

M3 Beyond the Equator, instead of continuing to extend the radiating meridians of his fan-projection, Ptolemy decides to bend all meridians inward — resulting in the oddly-shaped, dark-bounded ekumene of Fig.1. This kink-step enables Ptolemy to force (GD 1.24.7) the length of the anti-Meroë parallel (south of the Equator: latitude –16°5/12) to be exactly49 as long as its northern equivalent, the Meroë parallel (latitude +16°5/12).

M4 Ptolemy’s angular–linear duality here is effected by two rough expedients:

[a] Defining the fan’s units by forcing the distance \( T \) from Equator to Thule circle — 63 degrees of latitude — to be 63 units of space.

\( T = 63 \) is henceforth both a distance and an angle-in-degrees.

[b] Making the distance \( H \), from the Thule circle to the fan’s pseudo-N.Pole (point \( η \) in Fig.1) proportional to cos 63° — i.e., equal to cos 63° in units of \( R \), the fan’s radius from “N.Pole” (point \( η \) to Equator. Simply put:

\[
\frac{H}{R} = \cos 63°
\]

These conditions produce \( T = R - H = R - R \cos T = R(1 - \cos T) \). Thus:

\[
R = \frac{T}{1 - \cos T} = \frac{63}{1 - \cos 63°} \approx 115.38 \ldots \approx 115
\]

(The rounding is Ptolemy’s.) Which produces the radius \( H \) of the Thule latitude-circle (centered at the pseudo-N.Pole \( η \)):

\[
H = R - T = 115 - 63 = 52
\]

48 Ptolemy rightly scaled-down (§L3) Marinus’ eastern limit from c.225° (15° = 5/8 of circle) to 180° (12° = 1/2 of circle); southern limit, from c.24° (Tropic of Capricorn) to 16°5/12 (anti-Meroë).

49 This length-fidelity (perfectly reflected in our Fig.1 — and creating the absolute magnitude in eq.6) renders all other southern parallels of the GD ekumene virtually equivalent (in length, though not radius) to their northern counterparts.
Letting \( S \) the south latitude of anti-Meroë, Ptolemy further defines
\[
E = R + S = 115 + 16 \frac{5}{12} = 131 \frac{5}{12}
\]  
(7)

This establishes all the fan’s dimensions.\(^{50}\) We next turn to the more puzzling question of how wide-open the fan will be.

**M5** The openness of the fan is immediately determined when Ptolemy states (\( GD \ 1.24.2 \)) that he will choose a vertical strut \( Y = 34 \) units, extending from \( \epsilon \) (the top of the rectangle bounding the fan) to the pseudo-N.Pole \( \eta \), which is the fan’s radiating center. And then — a very strange step appears.

**M6** Since Ptolemy follows Hipparchos and (\( GD \ 1.20.5 \)) Marinos in taking the Rhodos latitude (36°) or klima (14°1/2) as canonical for the mid-ekumene, he chooses (\( GD \ 1.24.3 \)) the Rhodos parallel at latitude 36°N as the one along which he will (allegedly) adjust longitudinal distances precisely, just so that this parallel’s curved length (\( \text{west} - \text{east arc} \)) has the correct proportion (4:5 \( \cos 36° \): \( GD \ 1.20.5 \& 24.3 \)) to the fan’s already-determined north-south radial distances (§M4).

**M7** That step is odd because, when he earlier (§M5) established \( Y = 34 \) units, this rigidly fixed the fan’s openness, and thus the proportion along the Rhodos parallel — i.e., there is no fan-openness flexibility left, once \( Y \) is set at 34 units.

**M8** Well, you may suppose: Ptolemy must have chosen \( Y = 34 \) with this very point in mind — this of course has to be the precise value for \( Y \) which will ensure proper Rhodos-parallel proportionality. But, no. He didn’t, and it isn’t. We can tell so by just doing the math.

**M9** If we let \( L \) be the latitude of Rhodos or any other place, the following equation finds that value of \( Y \) which will guarantee the desired proportionality at the given \( L \)’s parallel:
\[
Y = H \cos \frac{16200 \cos L}{\pi(R - |L|)}
\]  
(8)

(\( L \)’s sign-insensitivity in this equation is due to Ptolemy’s kink-step: §M3.)

**M10** But the truth swiftly reveals itself when we substitute Rhodos’ \( L \) (36°) into this equation: we get \( Y \approx 31 \) units\(^{51}\) (nearly 32 without Ptolemy’s eq.5 rounding) — not 34 units. But \( Y = 31 \) corresponds to fan-spread 106° (not the 98° of §M1), since
\[
F = \text{Fan-Spread} = 2 \arccos(Y/H) = 32400 \cos L/|\pi(R - L)|
\]  
(9)

so for \( L = 36°, F = 32400 \cos 36°/79\pi \approx 106°.\)

\( ^{50} \) A list for ready reference. If we go up the mid-vertical of Fig.1, we find:
\[
\begin{align*}
\alpha - \eta & = \text{of length } H = 52 \text{ (as is } \xi - \zeta); \\
\sigma - \alpha & = \text{of length } T = 63 \text{ (as is } \rho - \xi); \\
\sigma - \eta & = \text{of length } R = 115 \text{ (as is } \rho - \eta); \\
\zeta - \sigma & = \text{of length } S = 16 \frac{5}{12} \text{ (as is } \mu - \rho); \\
\zeta - \eta & = \text{of length } E = 131 \frac{5}{12} \text{ (as is } \mu - \eta). \\
\end{align*}
\]
We recall that \( \epsilon - \eta \) is of length \( Y \). Note that \( \zeta - \epsilon \) is of length \( Z \) (§N3), as are the sides of the 2-1 rectangle. \( \gamma - \alpha \) & \( \beta - \delta \); also equal to \( Z \) are: \( \alpha - \epsilon, \epsilon - \beta, \gamma - \zeta, \zeta - \delta. \)

\( ^{51} \) This accounts for the non-fitting & unintended aggravation that points \( \xi \) & \( \pi \) lie above the top (\( \alpha - \beta \)) of the rectangle in several modern depictions of the situation. (The discrepancy has long been recognized; see, e.g., Wilberg & Grashof 1838-1845 p.78.) The screwup is not by the drafters but by Ptolemy, who did not realize (§M12) that \( Y = 34 \) units is not for the Rhodos parallel (corresponding via eq.9 to the 106° fan-spread used by the non-fitting diagrams just cited) but was designed as an average fit (§M14) to all ekumene parallels. \( L \). Note that for \( L = 0° \) (Equator) or 63°* (Thule), fan-spread \( F \) would be 90° by eq.9 (\( Y \approx 37 \) by eq.8). The average of 106° & 90° is 98°, which fits \( Y = 34 \) (the average of 31&37;: §M13).

---

\( ^{52} \) If we eliminate the southern latitudes, we yet find \( Y = 34 \), except for the non-weighted average with rounding, where \( Y = 33 \frac{1}{3} \) instead.

\( ^{53} \) See, e.g., B&J p.38.
N Impossible Dream: Symmetric-Rectangle-Bounded Ekumene Fan

N1 There is an attractive alternate theory of the origin of \( Y = 34 \): the suggestion (§N6) that the 2-1 rectangle (§M1) bounding Ptolemy’s ekumene influenced the openness of the fan (Fig.1): “The length of 34 units . . . seems to have been empirically chosen to accommodate the largest map in the given [2-1] rectangle without truncation of the corners [\( \rho \& \tau \)]” (B&J p.86 n.68.) We will now explore this theory, which takes us in a very different (but equally fascinating) direction from the previous section, §M.

N2 Ptolemy says his projection nearly (§N6) fits neatly into a 2-1 landscape-oriented rectangle: see Fig.1. Since the fan-projection is symmetric about the mid-vertical (\( \epsilon - \zeta \)), the rectangular condition can be equated with fitting the left or right half of the ekumene into a split-off square. (Splitting the rectangle into halves, we will use the left square during the following analysis.) Fitting the half-ekumene into a square will henceforth be referred to here as: the split-ekumene

N3 Having arranged that each half of Fig.1’s rectangular bound is a perfect square\(^{54} \) of side \( Z \) (in 50), we take half of the horizontal straight line between \( \rho \) & \( \tau \) and call it \( B \). Note: if The Split-condition is met, then \( B \) should equal half of the rectangle's top border (\( \alpha - 3 \)). But it obviously does not, for reasons to be seen: §N7.

Our aim is to (as closely as possible: §N21) meet the Split-condition, which can be expressed simply as:

\[ Z = B \quad (11) \]

N4 We then search for the value of \( Y \) which ensures that Ptolemy’s ekumene-fan will satisfy The Split. The equation is (using the inputs already defined):

\[ Y = \frac{E + (R/H)\sqrt{R^2 + H^2 - E^2}}{(R/H)^2 + 1} \quad (12) \]

N5 Ptolemy starts (§M5) by assuming that the meridian-radiating center of the fan (the pseudo-N-pole: point \( \eta \) in Fig.1) is \( Y = 34 \) units (GD 1.24.2) above the top of the rectangle that he proposes to contain his ekumene projection. (To repeat, we are saying that in Fig.1 the distance from \( \eta \) to \( \epsilon \) = 34 units.)

\(^{54} \) Notice to those checking via-ruler the rectangle of the Nobbe 1843-5 p.47 illustration of Ptolemy’s 1st projection (reproduced at www.dioi.org/gad.htm#nobm, with the ekumene bounded in green): its halves are accidentally drawn not quite square, though very close. Also, many modern diagrams have failed along the anti-Meroë parallel. Creditable exceptions are those of Wilberg & Grashof 1838-1845 Fig.8 [p.96c2], B&J p.36, S&G 1:122-123, 2:748-749. The present illustration (our Fig.1) is perhaps the 1st rigorously accurate illustration of the anonymous ancient cartographer’s full intended map-rectangle concept. (Where compatible choice of \( Y = 34 \) and fan-spread 98° allows meant area-proportionality while \( \xi \) & \( \pi \) lie on line \( \alpha - 3 \) : §§M14-M15.) Fig.1 is designed in pure Postscript (as was §1’s Fig.1).

\(^{55} \) For the 2nd projection, there is no such qualifier (GD 1.24.17), even though there might as well have been — since for both projections the 2-1 rectangular bound is slightly wider than necessary. But for the 2nd projection, there is no appearance that an adjustment might render the ekumene exactly twice as wide as high. Its definition is quite different from the 1st, and results in a fan opened only about 61° (vs the 1st projection’s 98°: §M1), with a pseudo-north-pole c.180 units above the Equator (vs the 1st’s 115 units: eq.5).
N9 When the Fan Fit The Split
So the 2-1 theory has exploded in disaster: no choice of \( Y \) will satisfy Ptolemy’s \( S = 16 \ 5/12 \) and allow the fan-projection to fit the symmetric 2-1 rectangle. Indeed, the maximum \( S \) that will permit satisfaction of The Split (for any choice of \( Y \)) is found via the equation:

\[
S_{\text{max}} = T \frac{\sqrt{1 + \cos^2 T} - 1}{1 - \cos T}
\]  

(13)

which for \( T = 63 \) (fan’s north bound at Thule) yields \( S_{\text{max}} \doteq 11 \ 5/12 \).

N10 Things get even more intriguing if we assume (as some non-adamantly have: §N1) that \( Y = 34 \) was an empirical adjustment to The Split (the 2-1 rectangle condition: eq.11). We can test the theory by finding (§N21) the value of \( Y \) which best satisfies The Split.

Answer: \( Y = 21 \) — a value not even close to 34.

\( Y = 21 \) satisfies The Split to within 5%: that is, \( Z/B < 1.05 \). But Ptolemy’s \( Y = 34 \) cannot satisfy the 2-1 rectangle condition to better than 11%, i.e., \( Z/B > 1.11 \).

N11 However, let’s keep exploring the theory that the 34 was chosen for The Split. (If Ptolemy was seeking any other type of symmetry, the obvious and nearby alternative would have been to make the fan-spread angle \( \xi: \eta - \pi \) equal to exactly 90° — not the seemingly pointless and peculiar [roughly 98°] spread we actually find: see fn 55 or Fig.1.) A 90° spread would make all longitude slices neatly 1/2 their real angular thickness.\(^5\)

N12 Our math for an attempted Split-inspired reconstruction of the process behind \( Y = 34 \) will, up to a point, be the same as Ptolemy’s — only simpler.

We round \( R = 115.4 \) to 115 (just as in eq.5 or GD 1.24.4) but then use a simple fan — i.e., without\(^7\) Ptolemy’s equatorial kink.

N13 Once we dispense with Ptolemy’s clever kinky-projection scheme, we may easily find the \( S \) that produces \( Y = 34 \):

\[
S = H^2 \sqrt{1 - (Y/H)^2} + 1 - R
\]  

(14)

Substituting Ptolemy’s values, \( Y = 34 \) (§M5 or GD 1.24.2) and \( R = 115 \) \& \( H = 52 \) (eqs.5&6 or GD 1.24.4), we find:

\[
S = 24.7
\]  

(15)

A provocative result, since that is virtually right on the southern tropic (24°).

N14 However, as noted: \( S = 24^° \) is Marinos’ value — according to Ptolemy himself (GD 1.7.1-2 & 9.6). Thus, we have found a potentially fruitful alternate-possibility for the source of the problematic \( Y = 34 \): a non-kinked fan-ekumene, with Marinos’ latitudinal breadth of the known world, though Marinos is said (§N17) not to have used a fan-projection.

N15 Having thus found an \( S \) that could have led to GD 1.24.2’s \( Y = 34 \), we may simply invert the process to follow in the hypothetical math-footsteps of the hypothetical ancient scholar who hypothetically deduced said \( Y \). If we also dispense with intermediate variables, to show dependence purely upon the ekumene’s northern & southern limits (\( T \) & \( S \), resp), the inverse of the previous equation gives us what we need:

\[
Y = \frac{S + T/(1 - \cos T)}{1 + \left[ 1 + 2(1 - \cos T)/T \right]^2}
\]  

(16)

\(^5^6\)The corresponding \( Y = H/\sqrt{2} = 37 \), obviously not Ptolemy’s choice.

\(^5^7\)That is, we do not immediately follow Ptolemy in suddenly bending all meridians inward after southward-crossing the Equator. That step eliminated (for Ptolemy: §M3) the extreme-outside points \( \mu \& \nu \). But we instead (§N15) keep it simple by letting lines \( \eta - \rho \) and \( \eta - \tau \) in Fig.1 extend right straight out to \( \mu \) and \( \nu \), respectively — and leave them be (i.e., no kink) — just as these two points are shown (slightly outside the 2-1 rectangle in Fig.1).

N16 Substituting (into the above equation) \( T = 63 \) (Thule) and \( S = 24 \) (southern tropic), the hypothetical ancient computer (of the \( Y \) that has come through to us) found

\[
Y = 34
\]  

(17)

(Barely less than 34 1/2 without Ptolemy’s rounding [eq.5] of \( R \) to 115; or about 34 1/8, if that rounding is adopted.)

N17 But GD 1.24.4-5 denies that Marinos used the fan-scheme. If this report is to be trusted and if the Split-hypothesis is valid, then: at an early stage in the history of the development of the fan-approach, a scholar (working sometime between Marinos and the final version of GD 1.24) tried out a simple (no-kink) fan using Marinos’ southern limit (\( S = 24 \)).

N18 However, had he adopted \( S = 16 \ 5/12 \) without\(^5\) kinking his projection, he could easily have found (using eq.16) that for this case the appropriate \( Y = 36 \), which would in fact effect a perfect-Split circumscription of the (non-kinked) fan by the preferred symmetric 2-1 rectangle.

N19 So, if the Split-theory is valid, \( Y \) must have been frozen at 34 before any steps were taken to abandon either

[1] assumption of \( S = 24 \) (Marinos: fn 48), or


N20 If Ptolemy adopted \( Y = 16 \ 5/12 \) before kinking his fan, then he could easily have arrived at \( Y = 36 \) by the same means that 34 was arrived at. (As already shown above: §N18.) Since 36 is not what survived, it would follow that Ptolemy instead kinked his fan before bringing his southern boundary from \( Y = 24 \) up to 16 5/12.

N21 However, either way, he at some point would be faced with the problem of finding out what \( Y \) would most closely effect The Split if the kinked version of his ekumene projection were adopted. For this search, he had best be aware that the eq.11 Split-ratio (\( Z/B \)) is extremal when (on Fig.1) a line drawn from \( \zeta \) to \( \xi \) is perpendicular to the radial line \( \eta - \mu \). Thus, the best fit to The Split occurs when:

\[
Y = \frac{H^2}{E}
\]  

(18)

For \( S = 16 \ 5/12 \), this equation yields, as noted previously (§N10), \( Y = 21 \), which corresponds (eq.9) to fan-spread 132°. For \( S = 24 \), \( Y = 20 \) — corresponding to fan-spread \( F = 135^° \).

N22 Even if the foregoing Split-theory isn’t historical (and the prior §M development — much-preferred by DR — obviously assumes that it is not), the mathematical development of it here has been thoroughly enjoyable.
Aubrey Diller is generally acknowledged to have been the 20th century’s leading authority on ancient geographical mss. We will be ever grateful that he in 1984 bequeathed to DR his final work: 1st establishment of the text of crucial Book 8 of Ptolemy’s Geography.

Further thanks are due to DIO Editor Dennis Duke for getting our GD Book 8 project re-started early in 2006, as well as for restoring the original 1984 Diller ms (DIO 5 [2006], www.dioi.org/diller8/diller8.htm) to a publishable state. And expert advice from Alex Jones and Len Berggren headed off potential mis-steps in the foregoing.

Also to be thanked: a longtime family friend, the late Prof. Emeritus Jimmy Poultney (for many years one of the stars of the Classics Dep’t of Johns Hopkins University), who kindly oversaw DR’s early work on Diller’s final opus; and our friend David Rockel, who patiently assisted in the collection of materials used in DR’s research.

References

Ernst Honigmann 1929. Sieben Klimata und die Πόλεις Επισημοι, Heidelberg U.
C.Müller 1883&1901. Claudii Ptolemai Geographia, Paris. (Bks.1-5 of GD, plus maps.)
O.Neugebauer 1975. History of Ancient Mathematical Astronomy (HAMA), NYC.
Keith Pickering 2002A. DIO 12:3.
D.Rawlins 1982N. ArchiveHistExactSci 26:211.
D.Rawlins 1991H. DIO 1.1 36.
D.Rawlins 1999. DIO 9.1 3. (Accepted JHA 1981, but suppressed by livid M.Hoskin.)
D.Rawlins 2002A. DIO 11.1 1.
D.Rawlins 2002B. DIO 11.1 12.
D.Rawlins 2002V. DIO 11.3 36.
Louis Renou 1925. La Géographie de Ptolémée: l’Inde, Paris. (Bk.7.1-4.)
Hugh Thurston 1998A. DIO 8 1.
Gerald Toomer 1984, Ed. Ptolemy’s Almagest, NYC.
Friedrich Wilberg & Carl Grashof 1838-1845. Claudii Ptolemai Geogr, Essen. (Bks.1-6.)