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REFEREED PAPER

The Error in Longitude in Ptolemy's *Geography* Revisited

Dmitry A. Shcheglov

Saint Petersburg Branch of the Institute for the History of Science and Technology, St Petersburg, Russia
Email: shcheglov@yandex.ru

It is well known that all longitudes in Ptolemy's Geography *are cumulatively overestimated, so that his map is excessively stretched out from west to east in comparison with the modern map. In recent years, a hypothesis have been advanced that this stretching can be explained as a result of the change in the value of the Earth's circumference from a larger one proposed by Eratosthenes to a lesser one by Posidonius. This explanation has two necessary presuppositions: (1) that Ptolemy's map is stretched out by a factor of ~1.4 which coincides with the ratio between Eratosthenes' and Posidonius' values, and (2) that Ptolemy's error in longitude grows almost linearly. This article argues that the situation is more complex and nuanced. In fact, the error in longitude on Ptolemy's map (and the stretching factor of the map, accordingly) varies considerably depending on longitude, latitude, and region. In particular, the error grows most slowly in the Eastern Mediterranean, which is probably due to the fact that this region was the centre of the ancient world. Therefore, Ptolemy's error in longitude cannot be explained by one universal cause, but only by a combination of different factors.*

Keywords: Ptolemy, Ptolemy's Geography, Ptolemy's coordinates, Ptolemy's maps, history of maps, map comparison, spatial distribution of longitude differences

A HYPOTHESIS EXPLAINING PTOLEMY'S ERROR IN ESTIMATING LONGITUDES

It is well known that the values of all longitudes in Ptolemy's *Geography* (*ca* 150 A.D.)[1] are cumulatively overestimated, so that his map is excessively stretched out from west to east by a factor of ~1.4 in comparison with the modern map (Figure 1)[2]. For example, the longitudinal difference between the extreme points of Ptolemy's map, *viz.* the Fortunate (the Canary) Islands in the west and the Sera Metropolis (the capital of China) in the east[3], is ~180° instead of the actual ~125°[4]. This error had a profound influence on all subsequent history of geography up to the eighteenth century and, in particular, indirectly inspired Christopher Columbus' expedition.

In recent years, a number of scholars (Rawlins, 1985; Rawlins, 2008; Russo, 2013a; Russo, 2013b; Tupikova and Geus, 2013; Tupikova, 2013), working independently of one another, have come up with essentially the same hypothesis: that the stretching of Ptolemy's map can be explained by the change in the value of the Earth's circumference. Admittedly, Ptolemy rejected a larger value proposed by Eratosthenes (252,000 stades)[5] in favour of a lesser one suggested by Posidonius (180,000 stades). This change did not affect the latitudes of the key points which were long-established and traditionally expressed in degrees. But longitudes in the pre-Ptolemaic geography were expressed for the most part as distances in traditional linear units (e.g. stades or miles), as Ptolemy himself (*Geogr.* 1.4.2) openly points out (Cuntz, 1923, p. 110; Thomson, 1948, p. 343; Neugebauer, 1975, pp. 667–668, 938; Tupikova and Geus, 2013, p. 2). As a result, distances that were previously supposed to be measured on a sphere with Eratosthenes' circumference were converted to angular coordinates on a sphere with Posidonius' circumference and became overestimated by 40% in comparison with their actual (modern) values[6]. This hypothesis rests on two general observations. Firstly, the ratio between Eratosthenes' and Posidonius' values for the Earth's circumference coincides with the average factor of stretching of Ptolemy's map in comparison with the modern one (or, in other words, the ratio between longitudinal intervals between the same points on Ptolemy's map and on the modern), *viz.* 1.4[7]. Secondly, the error in longitude on Ptolemy's map grows linearly (by 'error' I mean the difference between Ptolemy's and modern values, though this term is not quite correct in a strict sense because the starting point for the error estimation, *viz.* Greenwich, is taken arbitrarily). In other words, Ptolemy's map seems to be stretched out surprisingly uniformly[8].

The latter observation requires additional explanation. Why the fact that the error in longitude on Ptolemy's map grows linearly seems to be unusual? Firstly, there is a general reason: it would be more natural, if different regions showed distortions of different nature, because each of them had its own specificity that influenced the accuracy of information. Secondly, the peculiarity of Ptolemy's map reveals itself through the juxtaposition with modern

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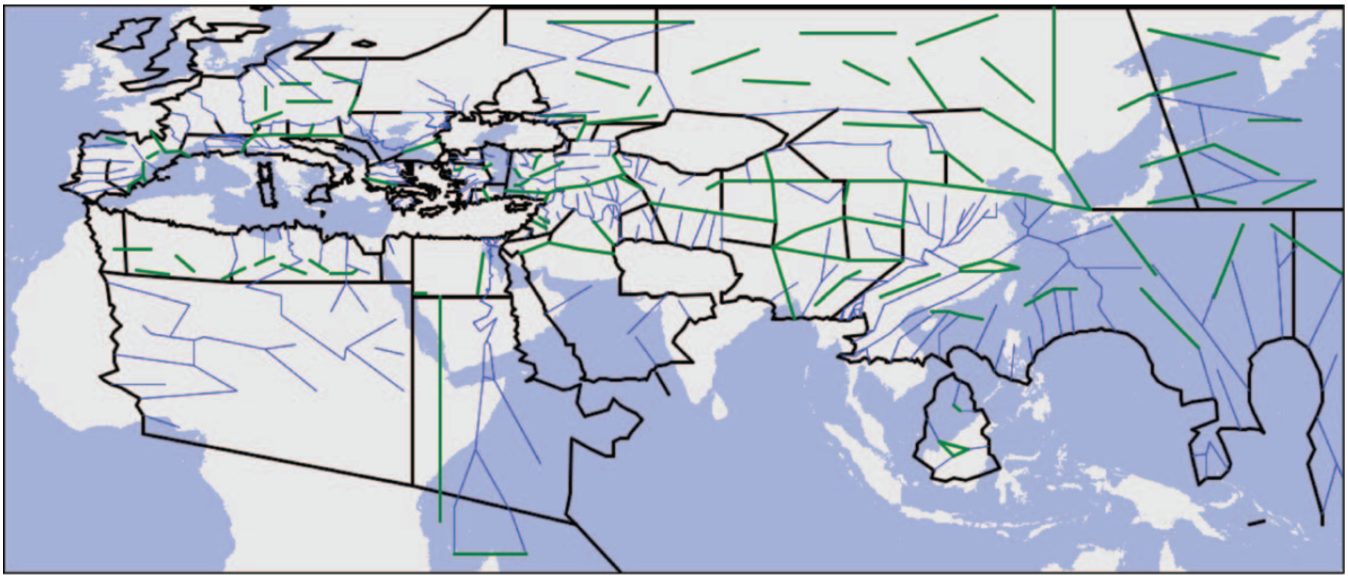

Figure 1. Ptolemy's map versus the modern one (projection WGS84, maps coincide at Calpe/Gibraltar)

European cartography. Gustav Forstner in his fundamental study 'Längenfehler und Ausgangsmeridiane in alten Landkarten und Positionstabellen' (2005, pp. 185–189, *et passim*) gives detailed graphs showing the growth of the error in longitude on various maps of Europe, from Ptolemy to the atlases of the nineteenth century. These graphs demonstrate that in most cases the error grows exponentially: the farther from the main meridian, the faster it grows (regardless of precisely what meridian is accepted – Hierro, Lisbon, Greenwich, Paris or others). The most conspicuous

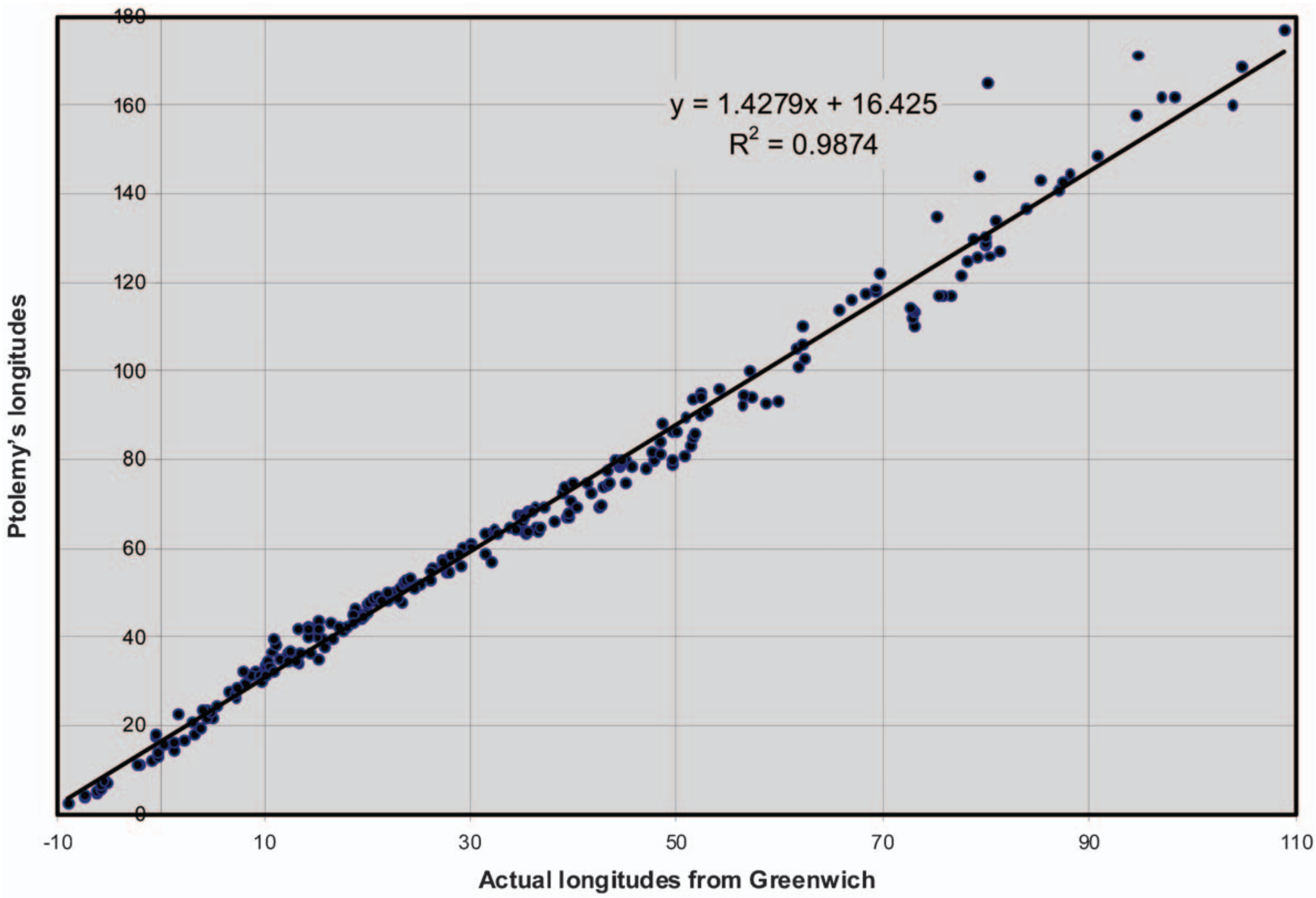

Figure 2. Ptolemy's longitudes (y) versus actual longitudes from Greenwich (x)

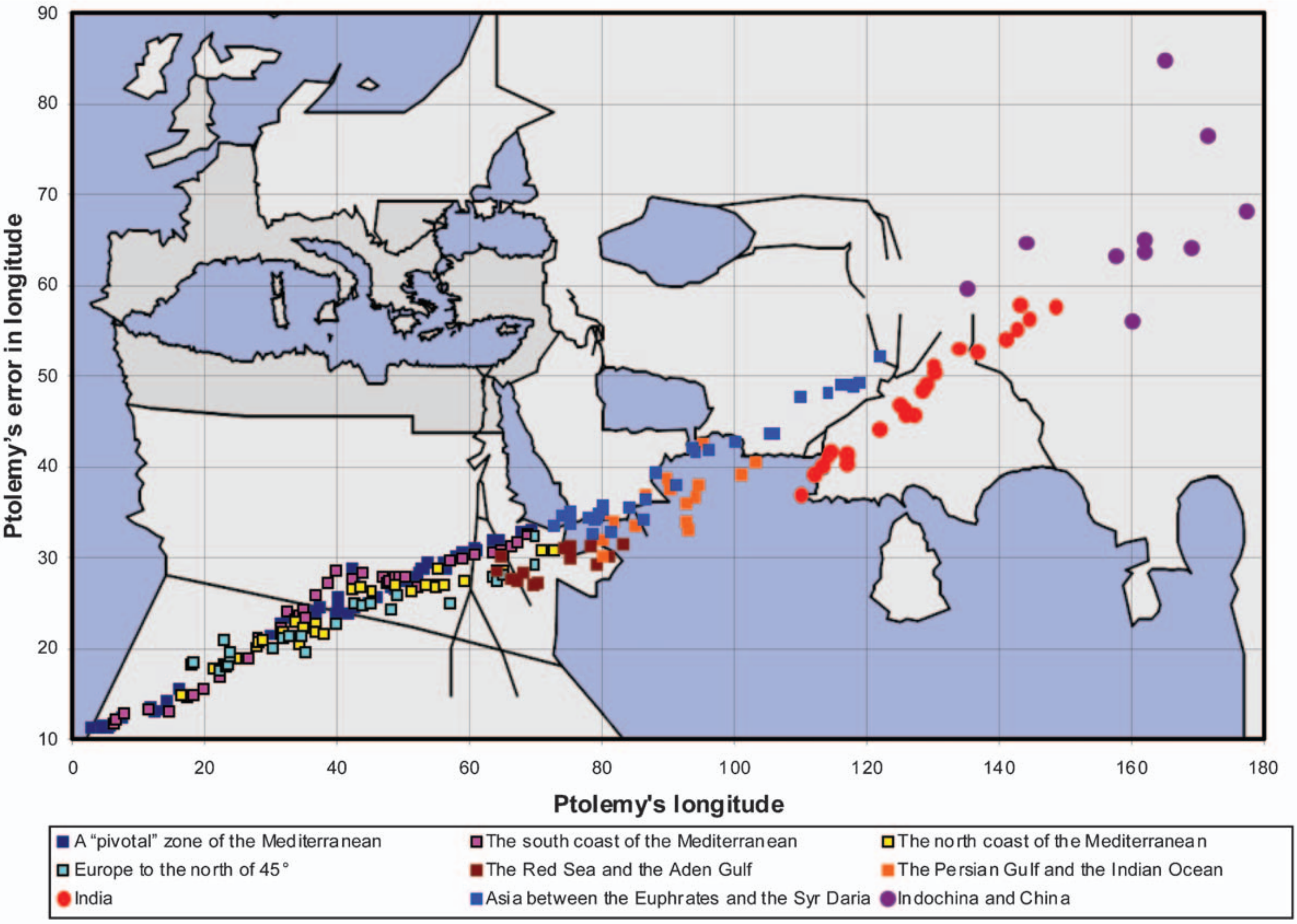

Figure 3. Ptolemy's error in longitude (y) as a function of the longitude on his map (x). The points are plotted over Ptolemy's map in order to show to what regions they belong. Dark grey indicates the territory of the Roman Empire

exception is, according to Forstners' observations, Ptolemy's map with the linear growth of the error. This peculiarity can be considered as evidence that Ptolemy's error in longitude was determined by the same factor throughout the whole map, and that this factor was of a speculative nature.

An important modification of the considered hypothesis has been proposed by Tupikova and Geus (2013, pp. 4–9). All previous researchers (Gossellin, 1790; Rawlins, 1985; Knobloch *et al.*, 2003; Russo, 2013a; Russo, 2013b) directly compared Ptolemy's and the modern longitudes as if it was longitudes (or, to put it more precisely, longitudinal intervals) that were recalculated after the change of the value of the Earth's circumference. Tupikova and Geus have pointed out that, most probably, what was recalculated were not longitudes as such, but distances. Most of distances known to ancient geographers were oriented at an angle to the grid of parallels and meridians. Therefore, the recalculation of these distances would have produced a longitudinal

Table 1. Regression equations for the correlations between Ptolemy's and actual longitudes for different groups of localities

No.	Group of points	Regression equation (or the stretching factor of the map)	R^2
0.	All longitudes *en bloc*	y=1.4279x	0.9874
1.	The 'pivotal' zone of the Mediterranean	y=1.5208x	0.9941
2.	The coast of Africa and Syria	y=1.4673x	0.9805
a	The western part	y=1.8085x	0.9676
b	The eastern part	y=1.1923x	0.9903
3.	The north coast of the Mediterranean	y=1.3346x	0.9903
a	The western part	y=1.7755x	0.9925
b	The eastern part	y=1.1511x	0.991
4.	Europe north of 45°	y=1.2816x	0.9929
5.	The coasts of Red Sea and the Aden Gulf	y=1.1478x	0.9368
6.	The coasts of the Persian Gulf and the Indian Ocean	y=1.2409x	0.8366
7.	India	y=2.1083x	0.9553
8.	Asia between the Euphrates and the Syr Darya	y=1.5783x	0.9839

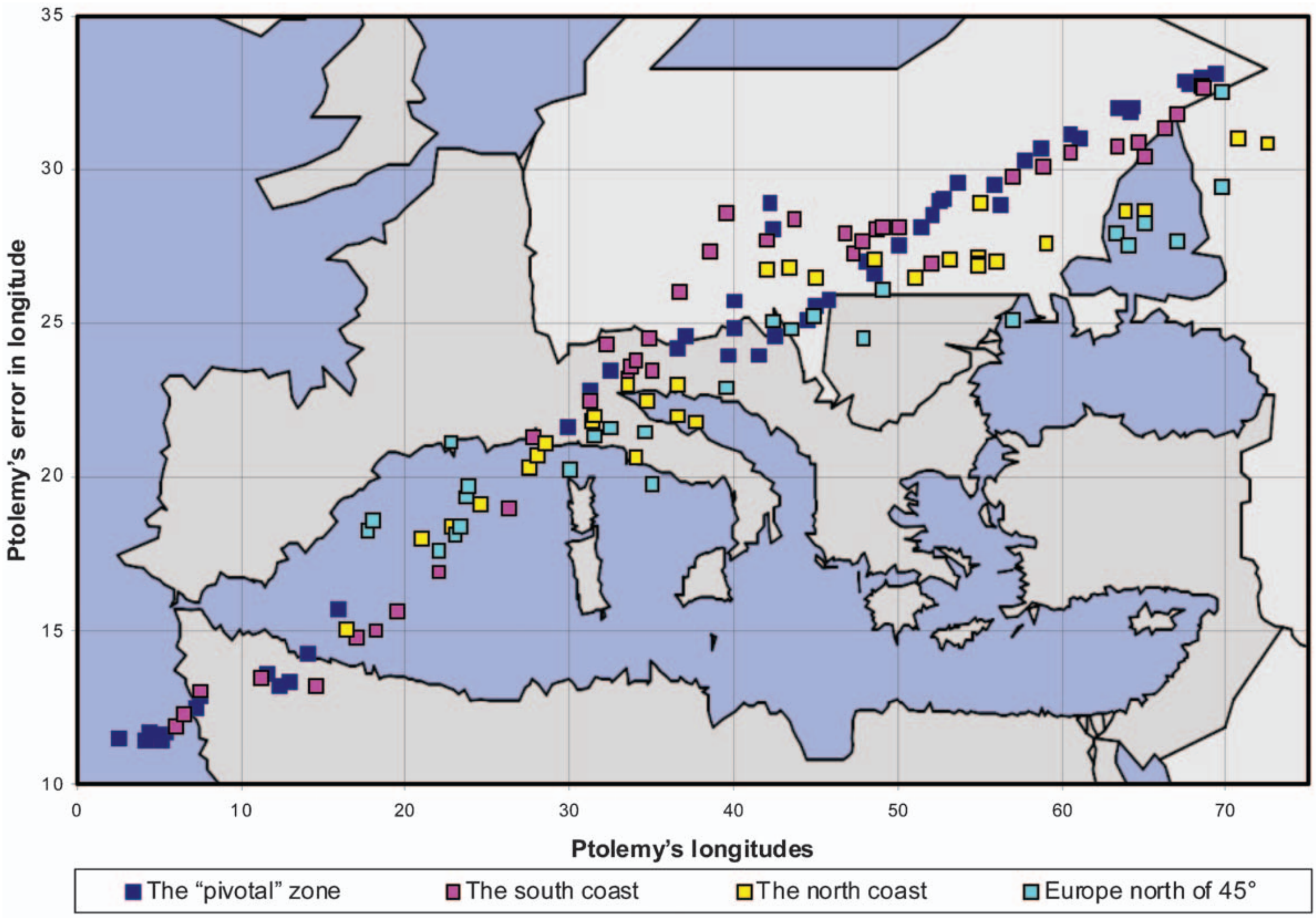

Figure 4. Ptolemy's error in longitude (y) as a function of the longitude on his map (x) for the territory of the Mediterranean and Europe

displacement with the factor less than 1.4, because the factor of 1.4 is valid only for distances along parallels (i.e. longitudinal intervals). Besides, such a recalculation of a distance could also have produced a latitudinal displacement of at least one of its endpoints, if its latitude was not firmly established before. To put it generally, there is a geometric relationship between displacements in longitude and in latitude resulted from the recalculation of distances: the less the former, the more the latter.

COMPARISON OF PTOLEMY'S LONGITUDES WITH THEIR MODERN COUNTERPARTS

The aim of this article is to test the hypothesis stated above. My contention is that a more detailed comparison of Ptolemy's longitudes with their modern counterparts undermines both observations behind it. Firstly, the growth rate of the error in longitude on Ptolemy's map turns out to be not linear, but it varies considerably depending on longitude, latitude, and region (Figures 3–5). Secondly, the ratio between Ptolemy's and the modern values of longitudes (i.e. the average factor of stretching of Ptolemy's map) considerably diverges from 1.4 in most particular cases (Figures 6 and 7).

Some preliminary remarks are required. I think, it is methodologically incorrect to combine in one sample toponyms from different regions which do not directly connect with one another (such as e.g. the opposite coasts of the Mediterranean), as previous researchers did (Rawlins, 1985; Forstner, 2005; Lukács, n.d., de Graauw, n.d., Russo, 2013a). It would be more reasonable to divide Ptolemy's data into several groups, each of which constitutes a certain natural geographical unity. It should also be taken into account that the most accurate and detailed information available to Ptolemy (according to his own confession: *Geogr.* 1.18.6) and other ancient geographers was about the coasts of the Mediterranean and the Black Sea, and, in a lesser degree, of the Red Sea and the Indian Ocean. It is reasonable to suppose that this information, in the first place, formed the basis of Ptolemy's map. Therefore, the most relevant data for comparing Ptolemy's map with the modern one are capes, the mouths of large rivers, and the best known and most securely identified cities. Areas lying too far to the north or to the south of the most explored zone should be excluded from consideration (e.g. the north coast of Europe and the inland parts of Africa, Arabia, India and Indochina). Given all the above, I single out nine groups of points on Ptolemy's map (all latitudes given below are Ptolemy's):

1. A 'pivotal' zone of the Mediterranean between the latitudes 34 and 41° which embrace the most developed areas of the Greco-Roman world. This zone adjoins to the parallel of Rhodes (36°) which ancient geographers traditionally accepted as a basis for constructing a map.

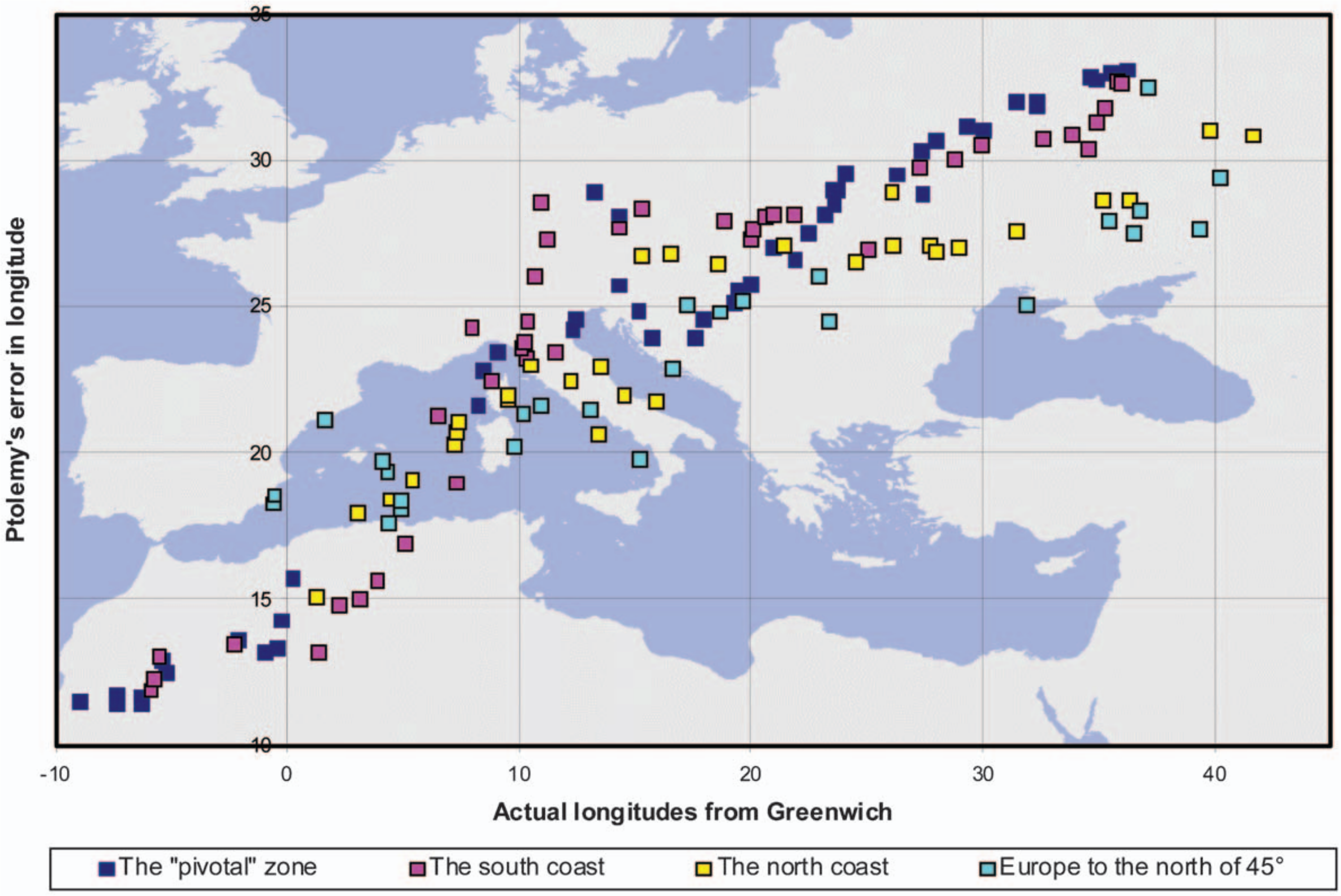

Figure 5. Ptolemy's error in longitude (y) as a function of actual longitude from Greenwich (x) for the territory of the Mediterranean and Europe

2. The south coast of the Mediterranean: Africa and Syria.
3. The north coast of the Mediterranean and the south coast of the Black Sea.
4. Internal areas of Europe north of 45° and the north coast of the Black Sea.
5. The coasts of the Red Sea and the Aden Gulf.
6. The coasts of the Persian Gulf and the Indian Ocean (Arabia and Iran).
7. India (both coastal and inland points).
8. The rest of Asia between the Euphrates and the Syr Daria.
9. The Far East: Indochina and China.

All materials are given in the appendix. Identifications of Ptolemy's toponyms, with few exceptions, are based on the *Barrington Atlas* edited by Richard J.A. Talbert (2000) and on the last edition of the *Geography* (Stückelberger and Graßhoff, 2006)[9]. Modern longitudes are based on the Google Maps. Of course, this sample is rather arbitrary and may be composed differently. The identifications and coordinates may also be amended. However, I believe that possible improvements will not significantly change the final outcome.

A comparison of the whole array of Ptolemy's longitudes with their modern counterparts shows that all points are quite well aligned along the regression line (R^2=0.9874) described by the formula y=1.4279x+16.425. The term '16.425' is the longitude that Ptolemy would have assigned to Greenwich. But since the reference longitude for the comparison of Ptolemy's map with the modern may be chosen quite arbitrarily, and for different regions, this term takes quite different values (Table 1), it is of no interest for our investigation (cf. Tupikova and Geus, 2013, pp. 9–11; Tupikova, 2013, p. 6).

The result shown on Figure 2 can create the impression that the considered hypothesis has been convincingly confirmed. However, this impression is deceptive. A more sensitive method is to consider Ptolemy's longitude error itself as a function of the longitude of his map (Figures 3 and 4).

First of all, from Figures 3 and 4, it becomes clear that the graphs considerably differ for different groups. Moreover, the graphs of at least two groups, of the south and the north coasts of the Mediterranean, distinctly fall into two parts, the eastern and the western, separated by, respectively, the cape Brachodes (38½° on Ptolemy's map; today Ras Kaboudia) and the Italian Peninsula. In the eastern parts, the error grows extremely slowly, but in the western, the growth is rapid. This divergence becomes even more apparent if we consider Ptolemy's error as a function of actual longitudes from Greenwich (Figure 5).

Therefore, it would be reasonable to consider each group separately. Table 1 and Figures 6 and 7 compare Ptolemy's

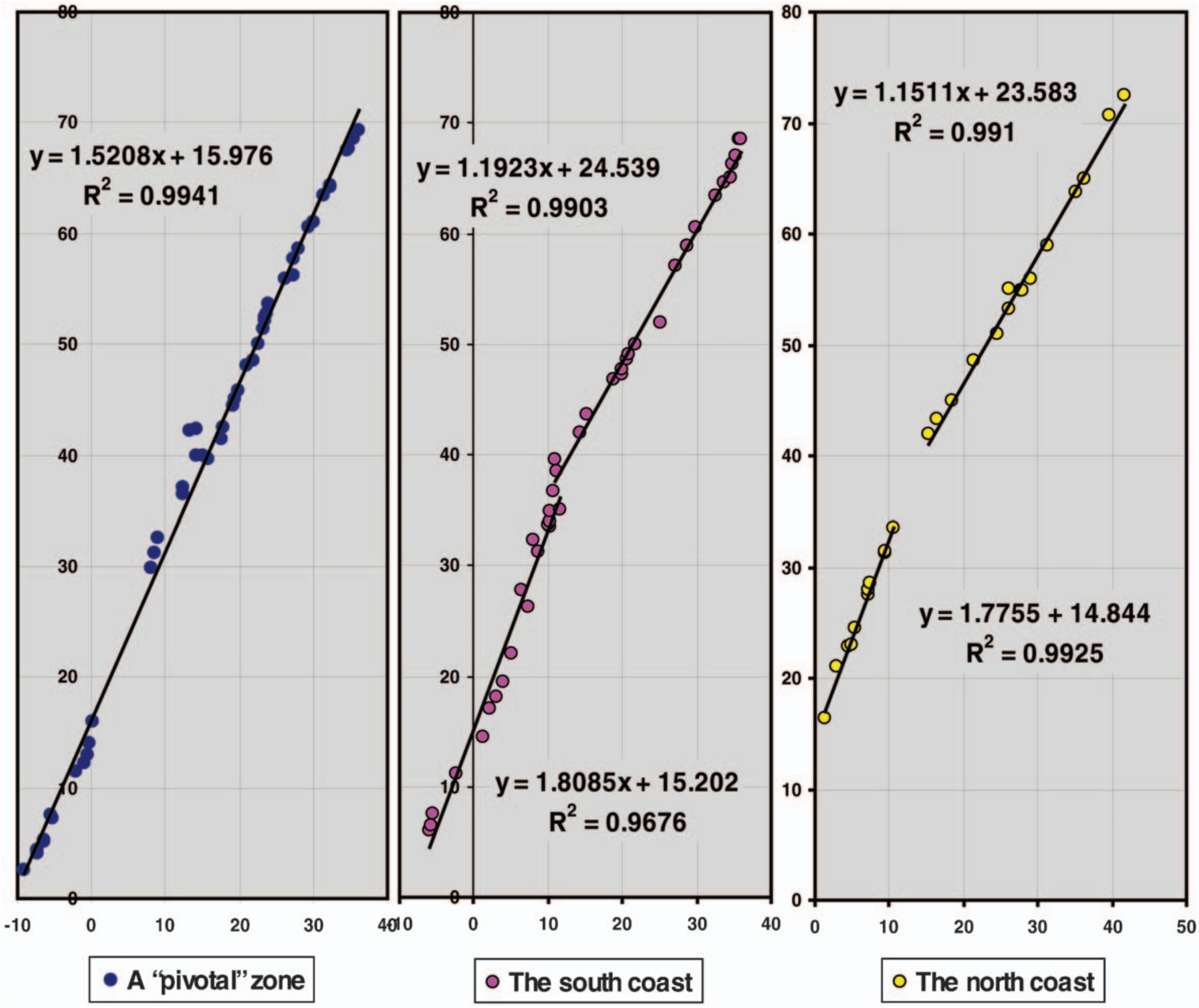

Figure 6. Ptolemy's longitudes (y) versus actual longitudes from Greenwich (x) for the Mediterranean

longitudes with their modern counterparts and give the regression equations for each group. From this comparison, it follows that the factor 1.4, calculated by previous researchers (see note 7) for the stretching of Ptolemy's map, proves to be 'an average temperature in the hospital', i.e. a simple mean between actually much larger and much smaller values.

The figures mostly speak for themselves, but some comments could be helpful. Two groups of places which play the major role in the organization of Ptolemy's map, *viz.* groups 1 and 8, have the stretching factor notably greater than 1.4: 1.5208 and 1.5783. For the coasts of the Mediterranean (groups 2 and 3) this factor is closest to 1.4. But for the western and eastern parts of each group, the values differ by 1.5 times: 1.8085 versus 1.1923 and 1.7755 versus 1.1511. Remarkably, the 'pivotal' zone demonstrates considerably higher growth of the error in the Eastern Mediterranean (i.e. south Italy, Greece, Asia Minor) than groups 2 and 3, and even than the more northerly latitudes (42–48°) of Europe (group 4; cf. Figures 3 and 4). It would be more natural to expect the opposite: the core areas of the Greco-Roman world should have shown less error than the periphery.

Interestingly, two groups with the least stretching factor are the eastern part of the south Mediterranean (2) and the coasts of the Red Sea (5). It is tempting to explain this fact by their closeness to Egypt. India most strikingly stands out from other regions (Figures 3 and 7). On the one hand, its western extremity is shifted to the west of the neighbouring countries (Arachosia, Bactria, Sogdiana). On the other hand, in India, the error in longitude grows much faster than in the Central Asia.

The most general observation that can be made from the above plots is that Ptolemy's error in longitude grows most slowly in the interval 40–80° longitude on his map or 10–35° longitude on the modern map. This interval corresponds to the eastern half of the Mediterranean from Sicily to Syria. Therefore, it comes out that Ptolemy's map did not principally differ in this respect from modern European maps considered by Gustav Forstner (2005): in both cases,

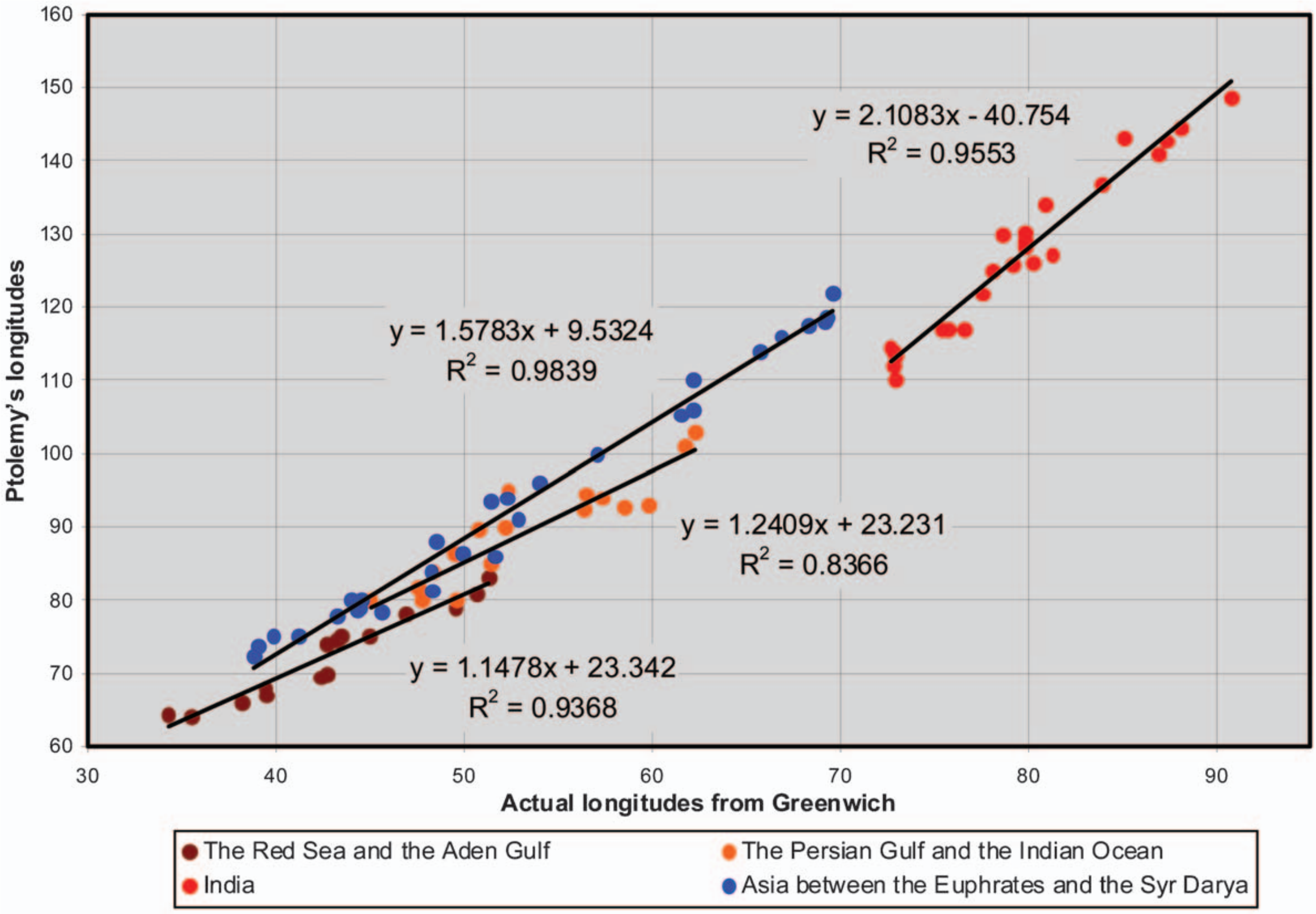

Figure 7. Ptolemy's longitudes (*y*) versus actual longitudes from Greenwich (*x*) for Asia

longitudes were the most accurate in the areas that were closer to the centre of civilization (the economically, culturally, and communicatively most developed area), and the father from this centre, the more accuracy decreased. The only difference is that in antiquity the centre was situated in the eastern Mediterranean (cf. similar explanation in Tupikova and Geus, 2013, pp. 11; Tupikova, 2013, p. 7), while in the Modern period, it transferred to the Atlantic countries of the western Europe, through which passed the main meridians in most of cartographic traditions.

CONCLUSIONS

Our observations testify against the possibility to explain the overstatement of longitudes on Ptolemy's map by one universal reason. Rather, this overstatement should be considered as a result of a complex interaction of different factors, only one of which can be the erroneous value of the Earth's circumference. Among other possible factors may be considered a systematic overestimation of distances and erroneous conversion of different units of distance measurement into degrees.

Of course, the results of our investigation can be elaborated, corrected, and contested. Rather, this investigation is intended as an invitation for further discussion and has a preliminary nature. It should also be stressed that our results in no way refute the hypothesis that served as a starting point for our investigation, but only show that it is insufficient for the explanation of the deformation of Ptolemy's map. In particular, it cannot explain the east-west stretching of the map with the factor more than 1.4, as, for example, in the Western Mediterranean. I hope that this article will become a small step towards better understanding of Ptolemy's map, its internal organization and the history of its formation.

BIOGRAPHICAL NOTES

Dmitry A. Shcheglov is a senior researcher at the Saint Petersburg Branch of the Institute for the History of Science and Technology (Russia). His area of studies is the history of geography in antiquity.

NOTES

1. I rely on the recent edition by Stückelberger and Graßhoff (2006).
2. A good illustration of this stretching is afforded by the maps prepared by Heinrich Kiepert for the Encyclopaedia Britannica (1898, Vol. XV, plate VII) and by Elisabeth Rinner (2013, 12 Abb. 1, available online: http://repository.topoi.org/BACP/BACP0066/BACP0066a.pdf), and a scheme in Stückelberger and Graßhoff (2006, p. 47).
3. To be precise, Ptolemy locates the Fortunate Islands either on the zero meridian (in a unique codex X: Vaticanus graecus 191), or on the meridian 1° (in other MSS descending from the archetype Ω). Ptolemy's eastern limit of the *oikoumene* is marked by three points (1.11.1, 15.9-10) which have the following longitudes: Sera (either Chang'an, i.e. modern Xi'an, or Lyuoang) – 177°15′, Sina (a city in South China) – 180°, Kattigara (presumably, a harbor at Hanoi (Stückelberger and Graßhoff, 2006, p. 18) – 176½°.
4. Modern longitudes of the above mentioned points are the following: Xi'an – 108°54′, Lyuoang – 112°27′, Canary Islands lie between –17°21′ and –13°25′, so that the longitudinal interval corresponding to Ptolemy's *oikoumene* between the Fortunate Islands and the Sera amounts to 122°19′–128°48′.
5. Ptolemy arguably accepted Eratosthenes' value in the *Almagest*, his earlier work, as was shown by Schnabel (1930, pp. 218–219).
6. The first one to put forth this hypothesis was Gossellin (1790, pp. 118–124, Tables VII–VIII); the most complete statement of the hypothesis is given by Russo (2013a, b); see also Rawlins (1985, 2008), de Graauw (n.d.), Tupikova and Geus (2013), Tupikova (2013); cf. similar observations, but with a different explanation by Knobloch *et al.* (2003).
7. Rawlins (1985, p. 264) has obtained the stretching factor to be 1.36 ± 0.04, with the basis of a sample of 16 Ptolemy's longitudes (the most important cities of the Mediterranean). Forstner (2005, pp. 66, 79, A-3, Table 4-1-1) has obtained the value 1.42, on the basis of 38 longitudes (29 are the most important cities of Europe, 9 are the cities of the Asian part of the Mediterranean). De Graauw (n.d.) has obtained 1.339 on the basis of 44 longitudes (harbors, capes, and mouths of the Mediterranean). Russo (2013a, p. 68) has obtained 1.4277 on the basis of 80 longitudes (mostly, the important cities of the Mediterranean, and a few cities east of the Euphrates up to Merv). Cf. the factors of 1.43 and 1.41 in Carmody (1976, p. 604). Knobloch *et al.* (2003) also postulated the stretching factor of 1.4 for Ptolemy's longitudes, but explained it differently.
8. This fact is stressed by Béla Lukács (n.d.): 'I can only tell that C. Ptolemy (or a whole research group using the name as a figurehead as Nicholas Bourbaki in the XXth century) produced a phenomenally self-consistent set of latitudes and longitudes, maybe via intuitive methods completely lost for us'. Other researchers found the coefficient of determination R^2, which indicates how well the correlation between Ptolemy's and the real longitudes can be described by a regression line, to take the following values: Forstner (2005, p. 66 & *passim*) – 0.9329; de Graauw (n.d.) – 0.9935; Russo (2013a, p. 68) – 0.9878.
9. For the identification of the points in Chinese Central Asia, I follow Wurm (1926). Auzacia is located according to de la Vaissière (2009, p. 530).

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APPENDIX
Comparison of Ptolemy's and modern longitudes

	Toponym		Longitude		
No.	Ptolemy's	Its modern counterpart	Ptolemy's	GoogleMaps	Difference (Ptolemy's error)
I. A 'pivotal' zone of the Mediterranean					
1	Sacred promontory	Cape St Vicent	2.5	−8.994	11.49
2	Anas (the western mouth)	Guadiana (the western mouth)	4.08	−7.394	11.48
3	Anas (the eastern mouth)	Guadiana (the eastern mouth)	4.33	−7.394	11.73
4	Baetis (the western mouth)	Guadalquivir	5.08	−6.35	11.43
5	Gades	Cádiz	5.17	−6.283	11.45
6	Baetis (the eastern mouth)	Guadalquivir	5.33	−6.35	11.68
7	Barbesula	Torre de Guadiaro	7.25	−5.277	12.53
8	Carteia	El Rocadillo	7.5	−5.408	12.91
9	Cape Charidemus	Cape Gata	11.5	−2.1	13.6
10	Carthago Nova	Cartagena	12.25	−0.983	13.23
11	Cape Scombraria	Cape Palos	12.92	−0.413	13.33
12	Sucro (the mouth)	Júcar (Xúquer)	14	−0.295	14.29
13	Cape Tenebrium	Cape de la Nau	15.92	0.217	15.7
14	Cape Gorditanian	Cape Falcone	29.83	8.201	21.63
15	Sulci	Sant'Antioco	31.25	8.45	22.8
16	Carales	Cagliari	32.5	9.058	23.44
17	Ostia	Ostia Antica	36.5	12.286	24.21
18	Cape Lilybaeum	Cape Lilibeo	37	12.425	24.58
19	Cape Skylla	The rock of Scilla	39.67	15.7	23.97
20	Cape Pachynus	Cape Pássero	40	15.131	24.87
21	Neapolis	Naples	40	14.258	25.74
22	Cape Lacinium	Capo Colonna	41.5	17.533	23.97
23	Tarentum	Tarent	42.17	13.221	28.95
24	Cape Iapygia	Cape Santa Maria di Leuca	42.33	14.25	28.08
25	Brundisium	Brindisi	42.5	17.933	24.57
26	Acroceraunian Mountains	Karaburun	44.42	19.29	25.13
27	Dyrrhachium	Durrës	45	19.45	25.55
28	Cape Poseidium	Cape Skala	45.75	19.97	25.78
29	Ambrakia	Arta	48	20.983	27.02
30	Cape Akritas	Cape Akritas	48.5	21.875	26.63
31	Cape Taenarum	Cape Tainaron	50	22.483	27.52
32	Cape Malea	Akra Maleas	51.33	23.2	28.13
33	Corycus	Gramvousa	52.08	23.568	28.52
34	Cape Scylleum	Cape Skileon	52.5	23.523	28.98
35	Athens	Athens	52.75	23.717	29.03
36	Cape Sunium	Cape Sounion	53.58	24.03	29.55
37	Cape Samonium	Cape Sideros	55.83	26.301	29.53
38	Cnidus	Datça	56.25	27.375	28.88
39	Ephesus	Ephesus	57.67	27.342	30.32
40	Rhodes	Rhodes	58.67	27.964	30.7
41	Patara	Gelemis	60.5	29.314	31.19
42	Myra	Demre	61	29.977	31.02
43	Side	Selimiye	63.42	31.389	32.03
44	Cape Akamas	Cape Arnauti	64.17	32.276	31.89
45	Selinus	Kale Tepe, Gazipaşa	64.33	32.285	32.05
46	Cape Kleides	Cape Apostolos Andreas	67.5	34.597	32.9
47	Tarsus	Tarsus	67.66	34.896	32.76
48	Mallus	Kiziltahta	68.5	35.487	33.01
49	Issus	Dörtyol	69.33	36.224	33.11
II. The south coast of the Mediterranean: Africa and Syria					
50	Cape Cotes	Cape Spartel	6	−5.906	11.91
51	Tingis Caesarea	Tanger	6.5	−5.8	12.3
52	Exilissa	Ksar es-Seghir	7.5	−5.559	13.06
53	Malua	Wadi Moulouya	11.17	−2.342	13.51
54	Cartennae	Ténès	14.5	1.304	13.2
55	Iol Caesarea	Cherchell	17	2.197	14.8
56	Sauos (the mouth)	Wadi El Harrach	18.17	3.137	15.03
57	Serbes (the mouth)	Wadi Sebaou	19.5	3.855	15.65
58	Saldae	Bougie	22	5.067	16.93
59	Ampsaga	Wadi-el-Kebir	26.25	7.25	19
60	Cape Treton	Cap Bougaroun	27.75	6.467	21.28
61	Thabraca	Tabarca	31.25	8.758	22.49
62	Rubricatus	Wadi Mafragh	32.25	7.945	24.31
63	Cape of Apollo	Ras Sidi Ali el-Mekki	33.5	10.28	23.22
64	Utica	Henchir Bou Chateur	33.67	10.062	23.6
65	Bagradas	Medjerda	34	10.217	23.78

No.	Toponym: Ptolemy's	Toponym: Its modern counterpart	Longitude: Ptolemy's	Longitude: GoogleMaps	Difference (Ptolemy's error)
66	Carthage	Carthage	34.83	10.331	24.5
67	Cape Hermaia	Cape Bon	35	11.555	23.45
68	Hadrumetum	Sousse	36.67	10.639	26.03
69	Cape Brachodes	Ras Kaboudia	38.5	11.156	27.34
70	Meninx	Djerba	39.5	10.883	28.62
71	Leptis Magna	Lebda	42	14.291	27.71
72	Cape Cephalae	Misurata/Misratah	43.67	15.275	28.39
73	Arae Philaenorum	Graret Gser et-Trab	46.75	18.793	27.96
74	Northern Cape	Ras Taiunes	47.25	19.95	27.3
75	Berenice	Bengazi	47.75	20.067	27.68
76	Arsinoe	Tokra	48.66	20.572	28.09
77	Ptolemaïs	Tolmeta	49.08	20.95	28.13
78	Cyrene	Shahhat	50	21.85	28.15
79	Chersonesus Magnus	Ras et Tin	52	25.037	26.96
80	Paraetonium	Marsa Matruch	57	27.217	29.78
81	Cape Derris	Ras Gibeisa	58.83	28.753	30.08
82	Alexandria	Alexandria	60.5	29.92	30.58
83	Pelusium	Tell Farama	63.33	32.545	30.79
84	Rhinocoroura	El-Arisch	64.68	33.803	30.87
85	Ascalon	Ashkelon	65	34.567	30.43
86	Caesarea	Qaisariye	66.25	34.908	31.34
87	Tyrus	Sur	67	35.196	31.8
88	Laodicea	Latakia	68.5	35.783	32.72
89	Seleucia Pieria	Kapisuyu	68.58	35.922	32.66
III. The north coast of the Mediterranean and the south coast of the Black Sea					
90	Tarraco	Tarragona	16.33	1.25	15.08
91	Narbo	Narbonne	21	3.004	18
92	Rhodanus (the western mouth)	Petit-Rhône	22.83	4.396	18.44
93	Rhodanus (the eastern mouth)	Grand-Rhône	23	4.849	18.15
94	Massilia	Marseille	24.5	5.37	19.13
95	Varus	Var	27.5	7.2	20.3
96	Nicaea	Nizza	28	7.266	20.73
97	Tropaea Augusti	La Turbie	28.5	7.402	21.1
98	Mariana	La Canonica	31.33	9.495	21.83
99	Aleria	Aleria	31.5	9.513	21.99
100	Cape Populonium	Piombino	33.5	10.497	23
101	Aquileia	Aquileia	34	13.367	20.63
102	Ravenna	Ravenna	34.67	12.2	22.47
103	Ancona	Ancona	36.5	13.517	22.98
104	Emona	Ljubljana	36.5	14.508	21.99
105	Poetovio	Ptuj	37.66	15.867	21.79
106	Iader	Zadar	42	15.228	26.77
107	Salonae	Solin	43.33	16.485	26.85
108	The Bay of Rhizon	The Bay of Kotor	45	18.53	26.47
109	Scupi	Skopje	48.5	21.392	27.11
110	Oescus	Gigen	51	24.483	26.52
111	Aenus	Enez	53.17	26.083	27.08
112	Apollonia Pontica	Sozopol	54.83	27.700	27.13
113	Odessus	Varna	54.85	27.917	26.93
114	Perinthus	Marmara Ereglisi	54.85	27.955	26.89
115	Tenedus	Bozcaada	55	26.05	28.95
116	Byzantium	Istanbul	56	28.955	27.05
117	Heraclea Pontica	Eregli	59	31.415	27.59
118	Sinope	Sinop	63.83	35.15	28.68
119	Amisus	Samsun	65	36.334	28.67
120	Trapezus	Trabzon	70.75	39.733	31.02
121	Phasis (the mouth)	Rioni	72.50	41.636	30.86
IV. Internal areas of Europe north of 45° and the north coast of the Black Sea					
122	Mediolanum	Saintes	17.66	−0.633	18.29
123	Burdigala	Bordeaux	18	−0.578	18.58
124	Nemausus	Nîmes	22	4.361	17.64
125	Gesoriacum	Boulogne-sur-Mer	22.75	1.615	21.14
126	Vienna	Vienne	23	4.878	18.12
127	Lugdunum	Lyon	23.25	4.842	18.41
128	Augustodunum	Autun	23.66	4.299	19.36
129	Durocortorum	Reims	23.75	4.035	19.72
130	Brigantium	Bregenz	30	9.749	20.25
131	Amisia	Geismar	31.5	10.166	21.33
132	Augusta Vindelicorum	Augsburg	32.5	10.9	21.6
133	Iulium Carnicum	Zuglio	34.5	13.033	21.47

	Toponym		Longitude		
No.	Ptolemy's	Its modern counterpart	Ptolemy's	GoogleMaps	Difference (Ptolemy's error)
134	Arelape	Pöchlarn	35	15.2	19.8
135	Scarbantia	Sopron	39.5	16.583	22.92
136	Servitium	Bosanska Gradiska	42.33	17.25	25.08
137	Mursa	Osijek	43.5	18.68	24.82
138	Sirmium	Sremska Mitrovica	44.85	19.617	25.23
139	Sarmizegetusa Regia	Hunedoara	47.85	23.309	24.54
140	Raitiaria	Arcar	49	22.915	26.08
141	Borysthenis	Parutino	57	31.9	25.1
142	Theodosia	Feodosija	63.33	35.379	27.95
143	Panticapaeum	Kertch	64	36.468	27.53
144	Hermonassa	Tmutarakan	65	36.714	28.29
145	Tanaïs	Nedvigovka	67	39.347	27.65
146	Oinanthea	Gagra	69.66	40.217	29.44
147	Tyrambe	Stanitsa Peresyp	69.66	37.13	32.53
V. The coasts of the Red Sea and the Aden Gulf					
148	Berenice	Umm el ketef	64.08	35.475	28.61
149	Myos Hormos	Quseir al-Qadim	64.5	34.281	30.22
150	Ptolemais Theron	Marsa Aqiq	66	38.167	27.83
151	Adulis	Massawa	67	39.45	27.55
152	Colobus Mountain	Ras Harb	68	39.441	28.56
153	Baitius	Wadi Baisch	69.5	42.41	27.09
154	Badeo	Al Madaya	70	42.73	27.27
155	Aualites	Assab	74	42.733	31.27
156	Deire	near Ras Siyyan	74.50	43.283	31.22
157	Muza	Mauza	74.50	43.28	31.22
158	Okelis	Seih Said	75	43.5	31.5
159	Malao	Berbera	75	45	30
160	Mondu	Heis	78.25	46.93	31.32
161	Mosylum	Ras Antarah	79	49.55	29.45
162	Elephant Mountain	Ras Filuch	81	50.65	30.35
163	Aromata	Cape Guardafui	83	51.286	31.71
VI. The coasts of the Persian Gulf and the Indian Ocean (Arabia and Iran)					
164	Arabia	Aden	80	45.033	34.97
165	Teredon	Basra	80	47.817	32.18
166	Gerra	Hajar, Al-Ahsa	80	49.622	30.38
167	Apphana	Abadan	81.33	48.304	33.03
168	Charax Pasinou	Dshabul	81.66	47.578	34.08
169	Cane	Hisn al-Ghurab	84	48.333	35.67
170	The Island of Dioscorides	Sokotra	85	51.417	33.58
171	Oroatis (the mouth)	Zohreh	86.5	49.52	36.98
172	Chersonesus	Bushehr	89.67	50.81	38.86
173	Syagrus	Ras-al-Fartak	90	52.22	37.78
174	Asabon	Ras Oman	92.5	56.333	36.17
175	Cryptus	Muscat	92.67	58.54	34.13
176	Cape Corodamon	Ras Al-Jinz	93	59.8	33.2
177	Cape Carpella	Ras al-Kuh	94	57.3	36.7
178	Harmuza	Hormus	94.5	56.453	38.05
179	Amarotha Amarusa	Amol	95	52.351	42.65
180	Cape Alambater	Jiwani	101	61.733	39.27
181	Badara	Gwadar	103	62.3	40.7
VII. India					
182	Simylla	Chaul	110	72.927	37.07
183	Narmades	Narmada	112	72.812	39.19
184	Barygaza	Bharucha	113.25	72.97	40.28
185	Syrastra	Surat	114	72.825	41.18
186	Nanagunas	Tapti	114.5	72.683	41.82
187	Muziris	Cranganur	117	76.614	40.39
188	Ozene	Ujjain	117	75.777	41.22
189	Baithana	Paithan	117	75.38	41.62
190	Comaria	Cape Comorin	121.75	77.55	44.2
191	Modura	Madurai	125	78.119	46.88
192	Cape Cory	Rameshwaram	125.67	79.152	46.51
193	Northern Cape	Point Pedro	126	80.233	45.77
194	Maagrammon	Tissamaharama	127	81.278	45.72
195	Chaberis	Tranquebar	128.33	79.84	48.49
196	Chaberus (the mouth)	Kaveri	129	79.829	49.17
197	Orthura	Uraiyar	130	78.678	51.32
198	Poduke	Virampatnam	130.25	79.81	50.44
199	Maisolus (the mouth)	Krishna	134	80.9	53.1
200	Palura	Dantapura	136.67	83.92	52.75

No.	Toponym		Longitude		Difference (Ptolemy's error)
	Ptolemy's	Its modern counterpart	Ptolemy's	GoogleMaps	
201	Dosaron (the mouth)	Brahmani	141	86.95	55.28
202	Adamas (the mouth)	Subarnarekha	142.67	87.392	55.28
203	Palimbothra	Patna	143	85.144	57.86
204	Ganges (the westernmost mouth)		144.5	88.083	56.42
205	Antibole (the mouth)	Hooghly River	148.5	90.815	57.69
VIII. The rest of Asia between the Euphrates and the Syr Darya					
206	Edessa	Urfa	72.5	38.8	33.7
207	Nicephorium	Raqqa	73.83	39.017	34.82
208	Dumetha	Dumat Al-Jandal	75	39.868	35.13
209	Nisibis	Nesibin	75.17	41.217	33.95
210	Labbana	Qalaat Sergat	77.83	43.263	34.57
211	Orchoë	Warka	78.5	45.636	32.86
212	Borsippa	Birs Nimrud	78.75	44.342	34.41
213	Babylon	Hillah	79	44.421	34.58
214	Seleucia	Tell Omar	79.33	44.333	35
215	Arbela	Erbil	80	44.009	35.99
216	Ctesiphon	Al-Ma'aridh	80	44.581	35.42
217	Apphana	Abadan	81.33	48.304	33.03
218	Susa	Shush	84	48.258	35.74
219	Aspadana	Isfahan	86	51.65	34.35
220	Amardus (the mouth)	Sefīd-Rūd	86.5	49.942	36.56
221	Acbatana	Hamadan	88	48.516	39.48
222	Persepolis	Persepolis	91	52.891	38.11
223	Europus	Ray	93.67	51.433	42.23
224	Caspian Gates	Damavand	94	52.33	41.67
225	Hecatonpylus	Shahr-e Qumis	96	54.0375	41.96
226	Karmana	Kerman	100	57.083	42.92
227	Nisaia	Nisa	105.25	61.533	43.72
228	Antiochia Margiana	Merv	106	62.193	43.81
229	Alexandria in Areia	Herat	110	62.203	47.8
230	Alexandria	Kandahar	114	65.717	48.28
231	Bactra	Balch	116	66.874	49.13
232	Oxeiana	Takht-i Sangin	117.5	68.285	49.22
233	Kabura	Kabul	118	69.167	48.83
234	Kapisa	Begram	118.67	69.2928	49.37
235	Alexandria Eschate	Chodshent	122	69.617	52.38
IX. The Far East: Indochina and China					
236	Stone Tower	Tashkurgan (Wurm, 1926)	135	75.2167	59.78
237	Auzacia	Uqturpan (de la Vaissière, 2009)	144	79.223	64.78
238	A cape in India	Cape Purian	157.67	94.416	63.25
239	Sabana	Singapore	160	103.833	56.17
240	Besyngas	Sittoung River	162	96.945	65.06
241	Issedon Serica	Kashgar (Wurm, 1926)	162	98.3	63.7
242	Ottorakora	Khotan (Wurm, 1926)	165	80.016	84.98
243	Great Promontory	Ca Mau Cap	169	104.738	64.26
244	Thogara	Dunhuang (Wurm, 1926)	171.333	94.6667	76.67
245	Sera Metropolis	Xi'an	177.25	108.9	68.35